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A Grounded Theory of Requirements Documentation in the Practice of Software Development

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A thesis submitted for the degree of Ph D
Declaration:

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed: Norah Power

Candidate

Date: 25 July 2002

ID Number: 96970162
It is no linguistic accident that 'building,' 'construction,' and 'work,' designate both a process and its finished product. Without the meaning of the verb, that of the noun remains blank.

John Dewey, *Art as Experience*, 1934
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Abstract

This thesis is concerned with the concept of a “good enough” requirements document. It takes the position, based on empirical observations, that standard prescriptive approaches have failed to identify the necessary and sufficient characteristics of a good requirements document, because what is good enough in one situation may not be desirable or acceptable in another. Therefore, no single set of criteria can define “a good requirements document.”

The thesis presents a grounded theory which attempts to explain the diversity of styles of requirements documents found in practice, in relation to the variety of situations in which software products and systems are developed. It identifies the factors that might be useful to categorise situations from the point of view of requirements documentation.

Requirements documents are widely used in software development, an activity typically carried out in an organisational context. Organisational theory suggests that the best approach in any situation depends on the factors that affect that situation.

In the research, it was found that experienced practitioners employ a wide variety of constituent elements, structures, and styles when documenting requirements. This is in contrast with much of the literature on requirements engineering.

The contribution of this research is in three parts (a) an analysis of requirements documents as texts, (b) a scheme for classifying system development situations with respect to the requirements documentation process, and (c) a framework matching typical requirements documents with the types of situations identified in (a).

As a grounded theory, it is the result of a detailed and systematic investigation into the role of requirements documents in the practice of software development. Its status as a theory implies that it is tentative and provisional. An outline of how the theory might be validated for its usefulness, applicability, and generality is presented in the concluding chapter.
11 What is a good requirements document?

This thesis is concerned with the notion of quality in a software requirements document, and especially with how this might vary in different situations. Many authors have tried to define the concept of quality in a requirements document in the same way that software quality has been defined, by listing the essential attributes of a good requirements document. Many of these lists derive from the IEEE Recommended Practice for Software Requirements Specifications which lists the desirable qualities of a requirements specification. According to this, a Software Requirements Specification (SRS) should be:

a) Correct,
b) Unambiguous,
c) Complete,
d) Consistent,
e) Ranked for importance and/or stability,
f) Verifiable,
g) Modifiable,
h) Traceable (IEEE, 1998)

These characteristics are often quoted as absolute desiderata, as if the more a specification has of each of these qualities, the better it will be. However, some of these qualities can conflict with each other. Sometimes you can have too much of something that would be desirable in smaller measure. For example, if requirements statements are broken down too much, in order to make them traceable or modifiable, they may become inconsistent or difficult to verify. Attempts to formalise a requirements document, to make it unambiguous, may lead to making it impossible for the people who are in a position to tell if it is factually correct to understand what is says. Too much detail in a document has the same effect.

Instead of asking what are the desirable characteristics of a requirements document, or whether a particular document conforms to an absolute standard of quality, a more appropriate set of questions might be:

- What is a good enough requirements document?
- Is this a good enough requirements document for the purposes for which it is used?

Quality has been defined as fitness for purpose, so it is pertinent to consider the different purposes for which a requirements document may be used.
12 Uses of requirements documents

It is widely agreed that requirements documents have a number of useful purposes. They are a means of communication between the end users and the developers of the system. They form the basis of a contract between the developers and their clients. They should allow the developers to assess the feasibility of the system and they should form the foundation of the design and implementation of the system. The IEEE standard for requirements documents lists the following purposes:

1. Establish the basis for agreement between the customers and the suppliers on what the software product is to do
2. Reduce the development effort by revealing omissions, misunderstandings, and inconsistencies early in the development
3. Provide a basis for estimating costs and schedules
4. Provide a baseline for validation and verification
5. Facilitate transfer of the system to new users or other parts of the organisation

The first of these, “the basis for agreement” is very important, since two different parties are involved, the ones who have the requirements, often called the customers, and the ones who are going to satisfy them, often called the suppliers, so there is a need for agreement and therefore communication between them. Most of the other purposes are related to the systematic coordination and control of the system development project. One of the most important aspects of this is the need for an orderly approach, and the requirements document is often seen as the baseline on which everything else proceeds.

The term “requirements document” is used throughout this thesis to cover any written document, whether formal or informal, that forms the basis of the agreement between the parties in a software development project. An alternative term, the “(software) requirements specification” is often used in the literature, but the word “specification” has particular connotations, and, as shall be reported in Chapter 4, several other terms are also used in practice, for this type of document, so the broad term “requirements document” is employed.

13 Users of the requirements document

The users of a requirements document are often divided into the customers and the suppliers, a division which reflects the fact that the document is the basis of a contract. However, there are other ways of categorising the different kinds of people who read and write requirements documents. Gotel and Finkelstein (1994) identified three distinct roles in the writing of requirements:

1. The principal, or person who motivates the document, and is responsible for the consequences
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2 The author, who chooses the content and structure, and is responsible for the semantics

3 The documentor, who records/transcribes the content, and is responsible for the appearance of the document

These roles may be played by the same person or different people, depending on the circumstances (Gotel and Finkelstein, 1994)

A much wider set of people and roles are involved in reading and reviewing a document. Depending on the situation, the audience or circulation list for a requirements document often includes marketing personnel, designers, programmers and other developers, testers, other analysts, project managers, product managers, as well as end-users, their representatives and their managers. Each of these has a different perspective on the requirements document, as well as different ways of regarding its usefulness, and consequently, its desirable properties.

The people involved in a project are often called stakeholders because they have an interest in the outcome of the project. This is a role that is played in relation to a particular development project. The same person may play two or more stakeholder roles at once, including sponsor, customer and user (Wieringa, 1996). The sponsor is the organisation or person that pays for the development organisation and its process. The customer pays for the developed system. In many cases, these are the same, but in others, they are different.

1.4 A means to an end

A requirements document is a means to an end, but it is often regarded as an end in itself. This is reflected in statements such as “the purpose of requirements engineering is to produce a complete and consistent statement of requirements,” and is due to a tendency in software engineering to focus exclusively on the products of the system development process. Christiane Floyd (1987) identified this dominant product-oriented paradigm of software engineering and contrasted it with the emerging process-centred perspective, in which system development is seen as a learning process for the developers and users alike, becoming part of an overall ongoing process of organisational change. In this perspective, the system is never completed, being subject to an iterative evolutionary process interleaving use and development. The requirements document is instrumental in this process, but is similarly never complete (Floyd, 1987).

A similar, though more technical, perspective on the evolution of software is evident in the work of M. M. Lehman, who made the distinction between E-type and S-type programs.
From empirical observation of several large systems, he identified E-type systems that were embedded in a real-world context and needed to evolve in order to remain useful in those environments. He distinguished such systems from S-type programs which are simply required to satisfy a given specification. He argued that the majority of software in use is E-type software and that the software life cycle is an inherently iterative process, with the entire development phase simply initiating this process of evolution. A requirements document, in this type of situation, is not a product, but a heuristic tool in the initiation phase of the life-cycle process of an E-type system.

1.5 A contingency approach

The term “contingency theory” was coined by Lawrence and Lorsch in 1967 in the report of a study they did on organisational structure, in which they concluded that the structure of a successful organisation is closely related to the environment in which it operates (Lawrence and Lorsch, 1967). This principle is often stated as “There is no one best way to manage. It depends on the situation” (Scott, 1987).

Similarly, it could be said, there is no “one best way” to document requirements. Many different kinds of situations exist in practice, and many different approaches to requirements documentation are used. How is a practitioner, therefore, supposed to know what is the best way to document requirements in any particular situation, if all situations are different?

The answer may lie in identifying the situational factors that influence the use of requirements and the role of the requirements document in different kinds of situations. The possible factors include the organisational context of use, the organisational context of development, the application domain, the system architecture, the contractual arrangements, and the relationship between the developer and the customer or client. The question which is addressed in this thesis revolves around these and other situational factors, and how they might be used to explain observed differences in the ways that requirements for systems and software are documented in practice.

1.6 The research question

So far, the question has been raised, what is a good enough requirements document, and an answer has been proposed, that it depends on the situation, because the document is a means to an end, a tool that must be useful in the situation. One way in which system development situations differ is in the variety of relationships that can exist between the developers and the people or organisations who will buy and use the software. These relationships are explored in the thesis. Another probable source of variation is the problem situation,
because software is used in many different application domains. Other sources of variation will be introduced later, as they arise in the findings of the thesis.

16.1 Customers, developers, and other stakeholders

The terms customer and client are often used interchangeably, both in the literature and in practice. Customers are defined as the people or organisations who pay for and deploy the software, and clients are defined as the people or organisations who pay for the development (Robertson and Robertson, 1999). Users are people who will use the system, and may be important stakeholders in the development project, depending on the situation. Other stakeholders may include product managers, marketing people, testers, and technical writers.

Some situations are market-oriented, which means that the relationship between the developers and the customers is not as close as it would be in other situations, which are more solution-oriented. Some situations involve a formal contract between the developers and their clients, which affects the nature and content of the requirements documents while other situations are based on a much less formal relationship between the developers and their clients.

16.2 Different problem situations

Another area of variation which might influence variations in requirements documentation is the application domain. Software applications can be applied to the solution of many different types of problems, from medical devices that diagnose and cure disease to lethal weapons, and systems that intercept and neutralise such devices. Software is used for the communication and dissemination of information, or to protect privacy and unauthorised access to buildings or information. Information systems themselves form a large proportion of all software-based systems, from transaction processing, through office automation, to decision-support, online analytical processing and data mining.

Different attempts have been made to divide up application domains. For example, real-time, event-driven systems can be distinguished from data intensive systems, but that is not a very satisfactory distinction. Some real-time systems are embedded in specialised hardware, while others simply run on real-time operating systems.

Glass and Vesey (1995) have compiled a collection of different taxonomies of applications. These include different industrial taxonomies from software or solution vendors, as well as academic and research classification schemes. They point out that different taxonomies have different uses, which lead to different organising principles. None of these lends itself to...
matching development methods to problem domains, which is what the authors had in mind. They conclude that a systematic approach to the classification of problem domains has yet to be done.

The collection of industrial taxonomies surveyed in (Glass and Vessey, 1995) is extremely comprehensive and extensive, listing hundreds of applications. However, it is doubtful that each application needs a dedicated approach to development. Apart from the fact that it would not be practical, it would ignore the basic similarities underlying different applications.

Experienced practitioners often report that similar types of problem tend to occur in different application areas. For example, one developer found that his earlier experience of developing invoicing systems was useful later on when he was working on the problem of issuing parking fines. This insight is congruous with Michael Jackson's recognition of the problem frame as a starting point in analysis (Jackson, 1995).

Different problem frames have been identified which suggest that certain problems share certain basic similarities which can help with the task of solving them, by outlining what needs to be known in order to adequately describe the problem. Problem frames also suggest that the adequacy of a given description to describe a problem is related to the problem at hand, rather than being independent of it.

1.6.3 Specifying requirements

The first part of the research question has been introduced, namely what are the different situational factors or variables that influence the variation in requirements documentation. Stakeholder relationships and problem situations are two probable areas that might be involved. How requirements are specified in the document is another area of variation which will serve as the dependent variable in this research question. This is an area of requirements theory and practice where very little agreement exists.

This is reflected in the wide range of requirements specification techniques and notations that are used for specifying requirements, but none is as widely used as plain English, or natural language. Many notations and modelling techniques have been proposed, but in many cases, requirements documents are written either mainly or entirely in natural language. The obvious drawbacks and criticisms of natural language as a means of specifying requirements have often been reiterated. A typical example by Jackson (1983) lists redundancy, lack of precision, difficulty of evaluating completeness, inability to
evaluate internal consistency, inability to reveal the implications of requirements among the
disadvantages of "narrative requirements." Nevertheless, most requirements documents rely
on natural language for understanding, for flexibility, and for supplementing and tying
together whatever is specified in the more formal notations.

Another reason may be that software documents are essentially textual documents, because
software is essentially a textual medium.

"The most distinctive feature of software development is that it consists entirely of textual
manipulation. From the first verbalization of an application concept, whenever a system or
part of it is developed, fixed, enhanced, adapted or extended, text is added, changed and/or
eliminated to achieve the desired result." (Lehman, 1989)

1.7 Research, theory, and practice

This thesis is concerned with trying to explain (or structure an explanation of) the diverse
ways that software requirements are documented in practice. To date, this diversity has not
been examined or analysed by any empirical study or theoretical framework. This is
reflected in the literature where most approaches to requirements specification seem to be
presented as application-independent, or context-independent, as if they were universally
applicable. This is not the case in practice.

There seems to be a large gap between the research and the practice of software engineering
in general. Many authors, for example, (Fitzgerald, 1996), have identified a gap between
theory and practice in the fields of information systems and software engineering. This has
led to a debate in the information systems literature now known as the debate on Rigour
versus Relevance. But the real gap is between research and practice, not theory and practice.
Researchers do not have a monopoly on theory, because it can be argued that most people,
including practitioners, engage in theory building as part of their work.

The act of theorising is often considered to be a part of everyday thinking, and this has
sometimes been used in explaining the genesis of more formal theory. Gilbert Ryle in The
Concept of Mind, presents theory building as an activity which all people of any educational
level engage in at some time (Ryle, 1949). Peter Naur in writing about programming as
theory building espoused this sense of the word "theory" (Naur, 1992). Towards the end of
his life, Albert Einstein put it the other way around: "The whole of science is nothing more
than the refinement of everyday thinking."
George Kelly’s personal construct elicitation techniques (Kelly, 1955) are based on the idea that everybody is engaged in constructing their own theories to make sense of the world. Chris Argyris and Donald Schon (1978) coined the term “theories of action” (to cover espoused theories and theories in use). Schon later observed that reflective practitioners have their own theories of action that guide their professional behaviour (Schon, 1983). Organisations also engage in theory building or sensemaking, as it is called (Weick, 1979, 1984a).

This thesis sets out to examine the conjecture that the variety of approaches to requirements documentation used in practice is related to the situation of use, and therefore can be understood by looking at the different situations and asking what approaches have been found to work in practice in those situations. The answers are expressed in a theory which is expressed as a conceptual framework which seeks to explain the variety of documentation practices in relation to the variety of situations. The research, therefore, begins with practice, and ends with theory.

18 Structure of the thesis

The thesis is divided into four parts. This chapter has introduced the research question that will be addressed in the remainder of the thesis. Part One contains two further chapters. Chapter 2 deals with the method of enquiry, which is inductive rather than deductive, and positions it within the range of alternative research methods. Chapter 3 outlines how the research was carried out, and explains how the findings were reached.

Part Two contains the main findings of the thesis. Chapters 4, 5, 6, and 7 present the proposed theoretical framework, which analyses and seeks to explain the variety of different types of requirements documents used in practice, in terms of their situation of use.

Chapter 4 sets forth a taxonomic analysis of the different textual elements or components of requirements documents. This explores the variety of different kinds of requirements statements that are used in documenting requirements, and reflects the wide variety of uses to which they are applied. Seven different categories of requirements statements are distinguished, and these are grounded in the interview data.

Chapter 5 presents an ontological analysis of requirements concerns, the substantive issues that influence and give rise to requirements themselves. These concerns are grounded in the interview data, and the analysis is presented as a graph showing the precedence relationships among the different concerns that may exist in different situations. It identifies eight root
Part One Introduction

cconcerns and their dependent concerns The analysis is supported with quotations from the interview data

Chapter 6 proposes a classification of requirements situations which is based on the root concerns identified in Chapter 5 Seven typical situation profiles are presented, illustrated and supported by suitable quotations from the interview data

Chapter 7 is a situation related classification scheme for requirements documentation This consists of profiles of prototypical requirements documents based on the documentation model of Chapter 4 and the situation types presented in Chapter 6

Part Three has two chapters that give theoretical support for the framework presented in Part Two Chapter 8 is a review of established organisational theories and perspectives on the way people working together in organisations use documents as resources for action, as reflected in the situations identified in Part Two of the thesis Chapter 9 looks at established concepts and current research on representation and modelling in the field of requirements engineering, and how these are reflected in the different types of requirements statements found in the empirical study

Part Four is an attempt to assess the theoretical framework as a contribution to the field Chapter 10 compares the framework to previous and current literature on requirements documentation, and Chapter 11 summarises the work, looks at what needs to be done with it, and presents some conclusions on the contribution and relevance of it
Early in the development of software, practitioners recognized that the process of creating software was inherently empirical. They observed the results of their work and, based on these observations, they would modify their methods or tools to improve efficiency or quality. The empirical approach was particularly useful in the early stages of software development when there was limited knowledge about how to create software effectively. By conducting experiments and analyzing the results, developers could gain insights into what worked and what didn't, allowing them to refine their processes and tools. This empirical approach to software development is central to the concept of empirical research in software engineering.
Another advantage of experiments is that they can be replicated, although this is not commonly done. However, some notable experiments have been carried out and replicated in the area of testing and inspection, including the inspection of requirements documents (Basili, 1996, Perry et al., 2000, Seaman and Basili, 1997, 1998).

2.3 Field experiments

The pitfalls of experimental studies are well-known, e.g., the problem of biased samples, unrepresentative subjects, etc. But the main weakness of laboratory experiments is that they take place in artificial settings, removed from the real world context and conditions of software development. Therefore, some researchers have adopted the practice of what is called "Industry as Laboratory" whereby real-world experiments would take place in natural settings. However, it is hard to find suitable sites for such studies, better known as field experiments, and in principle, they would be impossible to replicate, for it would be impossible to control all the various factors that might interfere with the outcome.

Another well-known obstacle to the success of field experiments is the Hawthorne effect, so-called after a series of productivity improvement experiments in the Hawthorne telephone relay plant in the early twentieth century. The subjects seemed to improve their productivity no matter what experimental treatment was applied, thereby invalidating any conclusion that a specific treatment would improve productivity. This led to the recognition for less obtrusive methods of observation, with the consequent ethical issues intrinsic to such methods.

However, despite the difficulties, some attempts have been made at establishing the pursuit of field experiments in software engineering. Some of these are aimed at formally evaluating the outcomes of applied system development practices (Fenton et al., 1994, Potts, 1993). The field experiments that are increasingly carried out in software engineering belong to the general methodology of field research, which already has a strong tradition in the discipline of Information Systems and includes a broad variety of different types of studies, action research, case studies, longitudinal studies, etc., as well as the more conventional survey research.

2.4 Survey research

A common approach to field research in information system development is to design a specific enquiry such as a questionnaire study, asking a sample of people to respond to a structured set of questions, either orally or in writing. This approach suffers from two...
serious drawbacks, the problem of choosing an appropriate sample, and the problem of asking the right questions

Because it is a practical impossibility to question everybody who might be able to respond, it is normal to choose from the target population a representative sample of respondents, and hope that they will provide an adequate response rate. This is similar in purpose to sampling for a laboratory experiment, but much harder to control. The inevitable problems of postal and email survey research are well known and include low response rates, self-selection by the respondents, and the need for follow-up contact.

Another perennial problem of this kind of research is the problem of questionnaire design. You cannot be sure that your respondents will understand the questions and interpret them in a uniform way. For example, it was reported that in a regional survey of ICT (Information and Communications technology) companies, several respondents working in ICT companies did not understand or recognize the term ICT, or realize that it applied to their company, when in fact the researcher considered that it did, and had chosen them as such. In my own investigation, at an early stage, I found my interview respondents used the term “formal methods” (a term I avoided in questioning them) quite loosely compared to my own more strict academic interpretation of the term. This confirmed my decision to adopt a more exploratory approach to the investigation.

A properly conducted field survey can be very useful in testing hypotheses which have been generated by a good theory of the phenomenon being studied, based on variables and concepts which are well understood, and generally applicable. It is not suitable for investigations which seek to identify such variables, or create such theories, or studies where interpretation and context are important factors.

2.5 Qualitative research

This research into requirements documents is concerned not just with people’s perceptions and intentions, but also with the work they do over extended periods of time, and the people they work with, all of which are situated in specific contexts that cannot be replicated in laboratory experiments. Nor can it be effectively addressed by traditional survey-based methods, such as questionnaires based on pre-determined questions. It requires a research instrument that is sensitive to the perceptions and intentions of the actors involved, and qualitative field research methods seem to be the only ones that can fulfill this need (Lee et al., 1997).
Qualitative research is best explained by distinguishing it from quantitative research. Qualitative research is exploratory research. As Seaman and Basili, in their study of the way that organisational factors influence software inspection meetings, put it:

"The aim of this study is not to test or validate hypotheses about relationships between these variables, but to explore what relationships might exist and try to explain those relationships." (Seaman and Basili, 1998)

Very often, the idea is to identify the variables themselves, as well as the relationships between them. Also, many types of qualitative research offer the possibility of systematically generating new theories (theory building) rather than simply the means to test existing ones. There is an undoubted need for both types of enquiry because they are complementary to each other.

The best example that I have come across of this type of research applied to software requirements is called "A Field Study of the Software Design Process for Large Systems" (Curtis et al., 1988). Despite the title, this study deals with the requirements process in seventeen large projects. Project personnel were interviewed in order to find out their perspectives on the process, focusing on how requirements and architectural design decisions were "made, represented, communicated and changed" as well as how these decision processes affected productivity and quality.

The authors of this field study call their approach "ecological," not qualitative. But, they contrast it with quantitative and experimental methods, which they judge to be insufficient for providing the insights needed in what they call "problem-driven" research. Comparing their approach to the field research methods of sociology and anthropology, they say:

"The need for expedient results dictated the short, intensive study of a broad cross-section of projects, rather than the longitudinal study of a single project." (Curtis et al., 1988)

2.6 Varieties of qualitative research

Qualitative research, which is sometimes called intensive research, covers a range of different types of strategies, varying in their level of intensity or involvement with the subjects they study. Case study research is one of the most intensive, being the study of a single instance or a small number of instances of a phenomenon, in a natural setting, with a view to understanding, description and explanation, hypothesis generation, but not testing. Sometimes the results of a case study may be used to challenge or question existing theories, but that is not their purpose. Case study researchers usually employ a variety of means of data collection, because the number of sites is limited, the cases must be looked at from as
many points of view as possible, so interviews, video recordings, observation, document analysis, or any other technique may be used. The results are in the form of a rich description of the phenomenon being studied. Comparisons and contrasts may be made between cases, but statistical reports are not used.

Action research is similarly intensive, because the researcher is actively involved in a given situation, introducing some new technique or practice, with a view to improving the work carried out in that situation and evaluating its effects in that situation. Its advantages and disadvantages are similar to those of case study research, with the added problem of the possibility of bias on the part of the researcher. Therefore, it is difficult to generalise the results of action research, a more serious objection in these studies than in case studies generally.

A longitudinal study is a case study that takes place over an extended period of time, with a view to understanding the changes and the processes that take place over time in a given situation. The researcher is engaged with the situation even more intensively than in an ordinary case study.

The typical case study focuses on an organisation, a project, a site, or a particular group of people. But qualitative research is not always quite so intensive. More extensive qualitative enquiries are carried out which aim to gather data more widely, in order to systematically study many different cases of a phenomenon. This approach may be called multi-case qualitative research, or a qualitative survey. In this vein, investigations into system development methods, tools, techniques, practices, and organisational structures have been undertaken in which qualitative field data is systematically collected from multiple sites. Such studies are carried out with a view to covering as many different cases as possible, but without necessarily applying quantitative analysis to those cases. Examples already referred to in this chapter include Curtis et al., 1988, Seaman and Basili, 1997 and Seaman and Basili, 1998. Multi-case qualitative approaches contrast with in-depth case studies in targeting a variety of cases rather than deep engagement with a single case. They contrast with traditional quantitative surveys in terms of both the data collection methods used and the interpretation of the data.

Qualitative studies are sometimes called interpretative studies, in recognition of the fact that they deal with data that must be interpreted. The writers on qualitative studies often contrast this "interpretivist" stance with the logical positivist stance which is more appropriate to survey-based quantitative research, but different methods and types of qualitative research.
vary in this regard. Researchers using qualitative methods may adopt different philosophical positions. What unites qualitative researchers is that they are dealing with data that is textual rather than numerical, rich and varied rather than regular and stratified, context sensitive rather than context-free. A qualitative approach is open to the varieties of meaning and interpretation that may be present in a situation, while adopting either a positivist view of the situation or a more interpretative epistemological position.

2.7 Assessing the validity of qualitative research

Perhaps the most critical distinction between qualitative and other types of research is how the results are evaluated/validated. Quantitative research is always validated according to the criteria of scientific method.

**Internal** validity is concerned with the conduct of the experiment or survey, the reduction of the possibility of bias or error, etc. (Are there any other explanations of the behaviour than the hypothesis being tested?)

**External** validity refers to the potential to generalise the results of the enquiry to the whole population (Are these results applicable outside the sample studied?)

These are important questions because quantitative research is always concerned with hypothesis testing. But qualitative research is not (or not necessarily). Lincoln and Guba (1985), in their influential book, *Naturalistic Enquiry*, have laid down an alternative set of criteria for assessing the trustworthiness or validity of qualitative research. These criteria are:

1. Credibility (which corresponds to internal validity, but has different techniques for establishing it. They suggest five techniques.)
2. Dependability (which corresponds to reliability)
3. Confirmability (corresponding to objectivity) and
4. Transferability (corresponding to external validity, but very different from it.) The transferability of any piece of qualitative research must be established, not by the researcher who produced it, but by anyone who seeks to apply it to some other context (Lincoln and Guba, 1985)

The case for the qualitative approach to research may be summarised as follows:

It is exploratory, concerned with theory building, the generation rather than the testing of hypotheses. It is context sensitive, more intensively engaged with the subject than any kind of survey research. It gives more attention to interpretation than quantitative research does, deals with more varied data than quantitative research, but it is subject to different criteria for acceptability than quantitative research.

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2.8 Research methods in qualitative research

Laboratory experiments and survey-based field research are often classified as quantitative approaches because the methods of data collection and analysis that they use are typically quantitative. Qualitative approaches, on the other hand, are associated with a variety of alternative methods of data collection and analysis. Both types of approaches use interviews as a means of data collection, for example, but the quantitative approach to interviewing is more structured, with a greater number of closed questions than open-ended questions, and uses questions requiring fairly short answers that can easily be coded, while the qualitative approaches use either semi-structured or unstructured interviews, allowing and encouraging the respondent to answer at length.

The specific data collection methods used in qualitative approaches include observation, participant observation, interviews, game-playing, focus group discussions, card-sorting, etc. as well as document searching and video-recording and the collection of verbal protocols (sometimes called “thinking aloud”). Weick (1984b) gives a different list of methods, but as he says, “Methods are simply ways to systematise observation.”

However, some methods are more elaborate, and go further than that, giving specific guidelines on how to systematically gather data, analyse it, and use it to generate theory. One example is George Kelly’s method of triads, better known as Personal Construct Elicitation (Kelly, 1955). Another method, which provides a systematic way to gather data, analyse it and generate theory from it, is called Grounded Theory (Glaser and Strauss, 1967; Strauss and Corbin, 1990).

2.9 Grounded theory

The particular research method I used was that of grounded theory. This systematic method has been widely used in studies of medical and nursing practice, teaching and education, organisational and management studies, as well as some recent research into information systems and software development which I review later in this chapter.

Grounded theory provides a systematic method of discovering categories and relationships in empirically collected data and building theories based on them, which are, in turn, grounded

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1 I am following the usage employed by Galliers (1991) and others in distinguishing research methods from the more generic concept of research approaches. “Different approaches are a way of going about one’s research.” Methods are more specific ways of collecting data and analysing it.
The method encompasses three distinct activities: data collection, coding or categorising the data, and the writing of theoretical memos. Used in parallel, and iteratively, these techniques lead the researcher to discover a refined theory to describe, explain or elucidate a given domain of study. The process is inductive, not deductive (Gummesson, 2000). Deductive research starts with an existing theory and draws some conclusions or hypotheses from it, in order to test them, thereby testing the theory. Inductive research, on the other hand, begins with empirical data and looks for patterns, explanations and meaning.

The aim is to construct or refine a theory rather than to prove or disprove it. The essential status of the resulting theory is a plausible description, or explanation, etc. However, internal verification of the proposed hypotheses is facilitated by providing a measure of groundedness or saturation. Theoretical saturation is a complex concept related to the range of variety found in the supporting data and the extent of that support.

The generation or discovery of grounded theory is done through a process of three parallel activities:

1. Data collection
2. Coding (or the naming and analysis of theoretical categories and their relationships)
3. Memoing (or the writing of short pieces of theoretical analysis)

This process proceeds in a cyclical manner, as the emerging theory guides the search for further data and convergence of categories.

Groundedness should not imply that a theory is solely based on empirical data and not informed by any previous theoretical knowledge. Existing theoretical knowledge can contribute much to an emerging grounded theory or can itself be refined or extended by using the grounded theory method. The original formulation of grounded theory (Glaser and Strauss, 1967) argued, “Let the data speak for themselves.” This is best regarded as a reaction against an earlier prevailing trend in sociology that favoured overly quantitative and inappropriately positivist research. Later publications such as (Strauss and Corbin, 1990) allow for the role of existing theory in contributing to the emerging grounded theory.

### 2.10 Levels of analysis

Grounded theory has three distinct types of coding which vary in use with the progress of the emerging theory.

1. **Open coding** is relatively free of constraints, and subject only to whatever patterns are emerging in the data. This is essentially the identification and naming of categories. The categories or codes themselves may be present in the data, as terms
used by the participants, these are called in-vivo codes. Alternatively, they may be more theoretical codes, created or named by the researcher. These names may be suggested by patterns in the data, by terms used in practice, or by theoretical constructs from previous theories.

2 Axial coding is the linking and integration of categories, giving rise to clusters of theoretical ideas. It is more selective than open coding, and usually involves formulating relationships between selected categories, making them denser, and richer in explanatory power.

3 Selective coding is concerned with selected "core categories" and their relationships. At this stage of coding, the emerging theory dominates the coding process, and all coding becomes subservient to the core category, which is not only central to the emerging theory, but also stable, saturated and highly associated with the other codes.

Another important feature of grounded theory is that it encourages the search for differences as well as similarities in situations. The constant comparative technique supports the identification and naming of categories, while suggesting the existence of counter-examples and variations, extending the search for variety, through a process called "theoretical sampling." Guidelines on qualitative research suggest that analysis should be done from the outset of such studies to help sharpen the focus of enquiry and guide the research process. This is particularly true of the grounded theory method. Data collection, coding, analysis and theory generation should proceed iteratively, until a point of saturation is reached.

Saturation is said to occur when a particular concept or code has so much supporting data associated with it that no significant changes to it can reasonably be expected, and additional data no longer contribute to discovering anything new about it. This requires judgement on the part of the researcher, who is creating the theory from the analysis of the data.

At the heart of grounded theory lies a specific technique called theoretical sampling which guides the search for variation in the data. Theoretical sampling is sampling directed, not by population size or any other a priori criterion, but by the emerging theory in the hands of the researcher, seeking events, cases or situations to flesh out the bones of the theory, either confirming or refining the category under consideration, casting the net wider, in order to have a richer, more saturated explanation.
Levels of theory

The grounded theory method of theory building allows the researcher to choose the level of theory that is appropriate to the question under investigation. Any number of levels is therefore possible, but Maykut and Morehouse (1994) selected three distinct levels of reporting, that illustrate the range of possibility. Their levels are described as follows:

1. The journalist, reporting the facts and "letting the participants speak for themselves"
2. The weaver, "constructing a recognisable reality" by selecting and interpreting data
3. The "theory builder," arriving at more abstract organising concepts based on the data (Maykut and Morehouse, 1994)

In the area of software engineering research, grounded theory has been used to build theory at different levels. It has been used to build descriptive theories of a substantive domain, such as software architecture, (Grinter, 1999) as well as more sophisticated explanatory and causal theories of the factors surrounding the inspection of software, and the adoption of CASE tools (Cronholm and Goldkuhl, 1994, Orlickowski, 1993, Seaman and Basili, 1997, 1998).

The notion of causality is central to scientific research, as demonstrated in disciplines such as physics and chemistry. But most things have multiple causes, and beyond the level of physical phenomena, cannot be explained simply in terms of cause and effect. The meta-model paradigm of grounded theory provides a set of concepts for explaining situations, including the notion of causal conditions, intervening conditions, and intervention strategies, and interactions between them. In other words, it recognises the multiplicity of causes, and the interaction of causes and effects, and provides a theoretical framework for explanations of such complexity, in the form of the conditional matrix, to be discussed later in this thesis.

Miles and Huberman (1994) explore the notion of causality and its relationship to explanation. They do not recognise a clear boundary between description and explanation, or between explanation and causality, but they encourage the search for explanation within cases, and that includes causality. Nevertheless, they recognise that causality may not be an appropriate concept to apply to human behaviour. As Gilovich illustrates in his book on the fallibility of human reason in everyday life, most people readily assign simple, seemingly rational, causes to what are in fact random events (Gilovich, 1991).

Whether causality can be applied to organisational behaviour which is multifaceted is another matter, but is not discussed by Miles and Huberman. Weick discusses how organisations engage in sense-making to find retrospective explanations for previous events.
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(Weick, 1984a), but that is a separate issue from finding a theoretical explanation for organisational situations.

Miles and Huberman (1994) review a number of different views of causality, going back to the philosopher, Hume. In encouraging the search for causal explanations with cases, they advocate looking for the reasons why, for the process of causality, the mechanisms of causality, as well as the independent and dependent variables. In a study based on a single case or a small number of cases, this would be documented in the form of a rich description of each case, outlining the complexity of the processes involved. In a more extensive investigation, requiring what they call multi-case analysis, they recommend that explanations should be documented in matrix form. This gives a picture of the possible variety of causes over a range of cases, but it does not give a more general explanation of situations.

2.12 The grounded theory meta-model

As well as being a method of enquiry, grounded theory also provides a meta-model of the theories that it might be used to generate (Strauss and Corbin, 1990). Some researchers following the method seem to ignore this meta-model, or maybe modify it to suit their purposes, but some use it effectively as a template to format their theories in terms of the significant types of relationships that the grounded theory meta-model suggests.

The meta-model might be considered a framework of built-in types of codes. These include conditions, consequences, actions, context, etc. The consideration and search for these patterns of codes leads to the discovery of specific examples of these and of more particular substantive codes, specific to the data. The built-in relationships of grounded theory include is a condition of, is a consequence of, etc. Again, these lead to relationships that are more specific to the subject or topic under investigation.

Orlickowski’s case study is a good example of applying the meta-model to a practical situation (Orlickowski, 1993). Her theory is presented in the form of a set of categories and related concepts showing how the institutional context influences the interplay of conditions, actions, and consequences of adopting CASE tools in an organisation. This reflects the classical grounded theory meta-model of conditions, actions and consequences affecting a phenomenon.

Seaman and Basili (1998) also report using grounded theory in their research into software inspections, but their results are presented in the form of a network showing the relationships between independent and dependent variables. This is a much stronger statement than the
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kind of theory built into the grounded theory meta-model, which avoids the suggestions of causality inherent in dependent and independent variables, preferring to explain situations and phenomena in terms of the more complex interactions of conditions, actions, and consequences

2.14 Summary

This chapter has reviewed a number of different approaches to empirical research that have been applied to research problems and topics in the area of information systems and system development. There is a clear need in these areas for research that is relevant and context-sensitive, because system development is a human activity that takes place in complex organisational situations. Qualitative approaches complement quantitative approaches in allowing for exploration and interpretation to take place.

In choosing the right approach, it is important to consider the purpose of the research, whether it is to validate existing theories or to discover new concepts and relationships. Studies that focus on hypothesis testing use an approach that is different from those studies that are aimed at the discovery of theory, at exploration, explanation, or description.

Systematic, repeatable research requires the use of an appropriate method, which must be documented before and after the fact. Grounded theory provides a systematic, well-documented method for carrying out exploratory research which is aimed at theory-building, for discovering the salient variables in a particular type of situation, and for exploring the complexities of different types of situations.

A qualitative approach was chosen for the research described in this thesis, because the research question was couched in terms of exploration and explanation, rather than testing and validating existing theories. Grounded theory was chosen as the research method for similar reasons, but also because it provided a systematic yet iterative way of dealing with multiple cases, allowing the variety and some of the complexity of organisational situations to be incorporated in the results rather than being simplified out of the picture. It also provided a means of gradually moving from description through analysis to theory building. The next chapter describes how this particular method was employed to investigate the practice of requirements documentation and to analyse the results of that investigation.
Chapter 3 Investigation and Analysis

"It is better to take advice from an experienced (person) than from an expert"

(Arabic saying)

3.1 Introduction

I set out with the objective of finding out as much as possible about the ways software requirements are documented in practice and, also, how experienced practitioners view the role of written requirements in the overall process of system development. Therefore, a field study of some kind was clearly the correct approach to use, but not a conventional survey based on a predetermined questionnaire. I was seeking to gain knowledge and understanding of the actual practices used in the field of requirements, and not trying to test some prior hypothesis. I was working on the assumption that formal standards and recommended practices for requirements documentation (current theories) do not sufficiently account for the variety of different practices that can be observed in practical situations.

I therefore embarked on a series of interviews with experienced practitioners in the field, with a view to building a descriptive theory from the cases studied in this manner. It is not good enough to suggest that practitioners are not applying proper procedures, if they are not doing things “by the book.” Such theories do not take account of the contingencies that affect practical system development situations. If observed practices in requirements documentation differ from expected patterns, then we need a richer theory to explain this variety.

The main data source used in the study was this collection of semi-structured interviews, with twenty-eight experienced system developers, conducted at various stages of the investigation. I also used specimen requirements documents that I received from the participants, where these were available. Some participants tended to illustrate what they were talking about in the interviews with rough sketches of diagrams, and other brief outlines, and I included these in my field notes. However, the transcripts and tapes of the interviews provided the main source of data for the investigation.

Any alternative research design, such as an intensive case study, would not have suited the research question, so, from the outset, I intended the data collection process to be as extensive as possible. With hindsight, it is now possible to distinguish three principal stages in the investigation, though that structure was something that only emerged during the course.
of the investigation, rather than being a conscious design decision at the outset. These three stages were:

1. An early pilot study, which covered a small but wide-ranging set of participants.
2. A more focused series of interviews concentrating on the requirements documents of one particular software company and its customers.
3. A wider main study, aimed at increasing the diversity of system development situations studied.

3.2 The initial study

This was undertaken as a pilot study, aimed at opening up and exploring the research question.

Seven practitioners were chosen and interviewed at this stage. They came from a variety of backgrounds, representing manufacturing, telecommunications, financial services, a public utility company, a government department, and an aerospace company. Four of them worked for indigenous Irish companies, of which three were successfully operating in the international market. Two others worked in multi-national companies, one American, the other European. Each of them had at least eight years of experience of system development, some considerably more than this. Most of them had already worked for a number of companies, three of them had worked at some stage in consultancy, but most of them currently worked in reasonably large organisations (employing hundreds of people). However, they represented a wide variety of approaches to system development, from extremely formal well-defined processes to extremely informal ad hoc approaches. These interviews are summarised in the first seven rows of the table in Appendix A.

Great care was taken at this stage to find experienced practitioners who would be confident and authoritative in their responses, people who would not feel that they were being evaluated, just because they were being interviewed, and tend to give text-book answers instead of frank accounts of how they actually used documents in their work. It was also important to choose articulate individuals who would be able to make explicit to some extent the tacit knowledge that they use in their everyday work practices.

The first person interviewed was someone I knew professionally, and knew to be the kind of practitioner that I wanted to interview, who agreed to be a guinea pig for my first interview. Each of the others was recommended by someone else who had worked with the person concerned, and who vouched for their professionalism, their ability, and their having been involved in, and to some extent responsible for, projects that were considered successful.
This proved to be a good selection strategy, as I was able to use my personal contacts, but not have to rely on interviewing people I knew personally. I aimed to interview practitioners from a wide variety of backgrounds, and was successful in this. The strategy also yielded a set of excellent informants. In each case then, I approached the person by letter and/or telephone, and explained what my objectives were, and they agreed to be interviewed. A copy of a letter I used at the time is reproduced in Appendix B.

The interviews, like all the interviews in the succeeding stages, were semi-structured, that is to say they were not confined to a specific set of questions. Instead, they were based loosely on a set of guiding questions, designed to elicit open-ended responses and to allow the practitioners to discuss whatever aspects they considered relevant. The interview guide that was used for these interviews is reproduced in Appendix C. At this stage, I was interested to find out what aspects of 'quality' practitioners considered important in a requirements document, and also how they approached the notion of having a 'complete' statement of requirements.

These were not fruitful questions, because these were not issues that the practitioners considered important, but the overall set of responses was instructive. Practitioners were not interested in the idea of a requirements document as an end in itself, and therefore its attributes, such as 'quality' or 'completeness' were of no interest to them. Instead, they generally regarded the document as a means to an end, although they varied widely in the uses to which the document was put, and also in the extent to which they relied on written documentation of requirements in the software development process.

As a result of the initial study, I found that in practice the term "requirements document" covers a variety of different types and formats of documents that are used in system development, essentially to record requirements, but having a variety of roles and uses. More significantly, its perceived importance in the overall process of system development also varied widely from one situation to another.

The interviews were all recorded on audiotape and subsequently transcribed verbatim. This was important, because, although I always took notes during the interviews, these were for the purpose of the interview itself. The significance of what was being said did not always occur to me until later, on listening to the tapes over again, or examining the transcripts during analysis. Many of the transcripts continued to yield interesting insights even in the subsequent stages, using the theory that emerged later on as a "lens."
In this first stage, analysis was done manually, literally, with a pair of scissors, using printed copies of the interview transcripts. I used a procedure called constant comparative analysis. The purpose of this is to see what the data has to say, rather than looking for evidence of any particular concepts. It was an effective way to learn how to do open coding.

I printed out a transcript of each interview, and working with one interview at a time, began to select short passages from the transcript, in which the informant was making some point that seemed interesting, or well made. I annotated the quotation with the identifier and page number of the interview before cutting it out from the transcript. Each transcript was thereby dissected into short extracts or quotations, varying from one sentence to a few paragraphs. Each quotation on being cut out was compared with each of the others that had been extracted thus far, and grouped with similar extracts by theme.

When a few transcripts had been analysed in this way, I had begun to make little piles of the extracts, based on themes. For example, one of the themes that emerged from the practitioners was the difficulty of writing requirements that are clear. This theme or pile contained a collection of statements like the following:

"Essentially, you are aiming at an audience so you are trying to write something that another person can understand. You don't necessarily want to bury it in detail but you want to certainly get the concepts across."

"I still think it would be hard to write a document that the users will understand. Without being disparaging to users, it's just that they are not used to reading great reams of text and being sure that they understand exactly all the implications."

"Don't go into the task documents as they are impossible to read, most of them."

The next stage of this procedure was to label the piles, in order to have an effective way of determining, for each new extract, which, if any, ready-made pile of extracts contained similar material, or whether a new pile or theme needed to be started. Instead of using brief codes at this stage, I decided to label the piles with propositions, each written on a post-it label. The propositions were very general, such as the following statement:

- The detailed contents of requirements documents are not always understood by their supposed audience.

At the end of this procedure, I had assembled evidence from the seven interviews for thirty-five propositions, each supported by at least five quotations, the transcript references for which I entered into a notebook, along with the propositions. This notebook enabled me to write a working paper based on the propositions, supported by selected quotations from the
However, these propositions were all of a very general nature. Many of them were also very tentative. Here are some further examples:

- *One of the most important roles of the requirements document is as an aid in ‘getting to agreement’ between the parties involved in system development.*

- *Whether it is written or not, the concept of agreement is central to the process of finding out requirements.*

- *Requirements documents have different uses in different situations.*

The full list of propositions is reproduced in Appendix D.

The working paper presented evidence that practitioners use a variety of formats for documenting requirements, that although different system development methods dictate what should be documented, and how, that methods themselves are used in an *a la carte* manner, rather than followed precisely, that each organisation has its own way of doing things, and that beyond the level of the organisation, published standards and guidelines have very little impact on the way requirements are documented. I found considerable variety in the situations of use of requirements documents, with many different roles for the document, that practitioners viewed a requirements document as a means to an end, rather than an end in itself, and that the extent to which organisations relied on the written documentation of requirements also varied considerably. These findings were at variance with much of the conventional literature on requirements engineering, much of which seeks to define the generic requirements process without reference to the need to vary it to suit the situation.

However, all of this was very general, and based on a small number of interviews. There was no notion of a theory that would explain it all, no conception what the independent variables of such a theory might be, or even what the dependent variable might be, no coherent explanation of the diversity found in practice, other than the proposition that practitioners were doing what worked for them in their own situation. I needed a concept of what might be meant by ‘situation’ in the context of software requirements, and I also lacked a clear concept of the phenomenon of a requirements document, as it exists in practice.

At the end of this first stage, I needed to focus the investigation, and I was presented with an opportunity to do so by the next practitioner I approached. Rather than looking at a variety of documents in different contexts, as I had been up to this, I was now able to concentrate on one particular format of requirements document and investigate its variety of uses in different organisations.
3.3 The second stage

This stage of the investigation was based around a series of interviews with the clients of Blackbird Data Systems (BDS), a small company supplying warehouse solutions, consisting of hardware and software, on a contract basis, to large and small customers in Ireland and the rest of Europe.

All of Blackbird's clients are alike in that they require a warehouse application, but their needs are all sufficiently dissimilar that a standard product will not satisfy them, hence they need a tailored solution. Blackbird has a glossy brochure and video describing their 'product' called Harvest, but few of their customers buy it "off-the-shelf." A requirements document, called a Specification, is written from scratch for each new client. The required solution is then developed by reusing standard software components and developing new ones from scratch. The format of the Blackbird document is described in Appendix E.

I first interviewed the Blackbird Software Development Manager, who was the architect of the Blackbird requirements document, and also responsible for the requirements on some of the projects I would later look at. He supplied me with a specimen document, and explained the format and the rationale behind it. He was interested to find out how his clients (or customers, as he called them) regarded the document and the whole process of doing business with Blackbird, and agreed to put me in touch with clients who would be willing to be interviewed about their experiences. I subsequently interviewed five different client representatives about their perception of the Blackbird document and their overall experience of the company's particular approach to establishing and documenting their requirements.

It was very useful at this stage to be able to focus on the documentation process rather than the document, and it was interesting also to see how the same kind of document worked in different situations. Some of the client companies were large organisations with considerable experience of outsourced software projects, one was relatively inexperienced in this area, another was a relatively small Irish company, in the business of supplying large multinational companies based in Ireland.

All of the clients that I interviewed were the people responsible for the Blackbird project in their own company. Three of them were engineers, with considerable experience of project management, another was the IT manager of a large indigenous Irish company, responsible for several business units in Ireland. To get a different view, I requested to be put in touch with a non-technical stakeholder, so the fifth interviewee was the manager of a large commercial undertaking which was relatively new to computerised information systems.
I produced two documents as a result of this case study. The first one was a report for BDS on how their clients experienced the process of working with Blackbird on their respective projects, and on how they regarded the format and contents of the requirements document. The second was a working paper based on the same data but focusing on the role of agreement in requirements documents.

In general, the opinions the clients had of the Blackbird document were very favourable. Some of them suggested minor changes, for example, the inclusion of screen layouts, or some graphics (the document was mainly textual, supplemented with tables), but others were completely satisfied with this aspect of their interaction with Blackbird.

The most important recommendation I was able to make had to do with the Terminology section of the document, essentially a table of terms and their meanings. Although it provided for the explanation of various technical terms, it did not cater for the fact that the clients very often had their own local terminology for warehouse operations and data which differed from the Blackbird usage and interpretation.

One of the main problems that clients reported to me in relation to reviewing the initial drafts and revising them was problems with terminology. Blackbird personnel tended to write the initial draft using standard Blackbird (or Harvest - the name of the product) terminology. Some Harvest terms, such as *lot-number* and *delivery*, tended to have different names or different meanings in the clients' everyday local usage. There was no provision in the requirements document for aligning these different terminologies, although, as a company, Blackbird was quite prepared, where feasible, to tailor any aspect of Harvest's functionality or user interface to the client's requirements.

The second outcome of this stage was a paper dealing with the different kinds of representations that might be used in a requirements document. Having a common document format in each situation gave a kind of uniformity to the investigation, at this stage. The fact that a standard format was in use facilitated the task of investigating the different uses of the document and its role in the process of discovering, refining, and agreeing requirements. The analysis of this set of interviews in combination with the previous ones helped to redefine and re-focus the research question.

At the beginning of this stage of the investigation, the focus of the research was on the purposes and uses of requirements documents, rather than the attributes of the documents.
themselves. This perspective regarded the requirements document as an instrument in the process of establishing, representing and agreeing requirements, rather than an end in itself. This was in common with the views of all of the practitioners and stakeholders interviewed thus far, and in contrast with much of the conventional literature on requirements.

At the end of this stage, there were two major strands to the research question:

1. What is the role of context in determining the different uses of requirements documents, and how can contexts be differentiated from each other in a way that is relevant to the process of requirements documentation?

2. The question of why abstract models, which were so constantly favoured in the theoretical literature on requirements engineering and system development, were so infrequently and sporadically used in documenting requirements in practice.

3.4 The third Stage – the main study

The objective at this stage was to find some theoretical variables that would help to explain the observed differences in the style of requirements documents used in different situations, and to find some way of describing different styles of documents. The best analogy that I had for the notion of a ‘requirements document style’ was the idea of an architectural style from the domain of software architecture (Shaw and Garlan, 1996). Another aim was to explore, as far as possible, the incidence of variety in requirements documentation.

3.4.1 Variety

The practitioners I interviewed came from as wide a variety of situations as possible. All of them worked in organisations, varying from small to very large. While a few of them were working at developing systems in-house for the organisations in which they worked, most of them were working in a more formal contractual situation, developing systems for clients or customers in other organisations.

The application domains that they reported on were also very varied. While some respondents were involved with business applications, for example financial and manufacturing, others were concerned with developing embedded systems. Several of them worked in the field of telecommunications systems. The respondents from this domain represented a wide range of different types of applications, dealing with billing, network management, etc. as well as the typical switching and transmission systems.
These situations displayed a variety of contractual situations, from bespoke systems to software products but excluding the production of a shrink-wrapped software product for the open market.

3.4.2 Two areas of focus

In addition to aiming for variety of situations in choosing people to interview, I also decided to concentrate on talking to a few more practitioners involved in some particular areas, which had been particularly interesting in the pilot stage of the investigation. Telecommunications was one. This is an important application area, particularly telecommunications switching, which has a relatively long tradition of engineering that predates the era when telecommunications became a software rather than a hardware application. In the event, this area yielded a variety of perspectives, including that of the most experienced practitioner that I interviewed.

Another area that I concentrated on to some extent was that of ERP (Enterprise Requirements Planning) systems. There were two reasons for this choice. One reason is that such systems are first developed as highly configurable packages which are then tailored to fit the requirements of the particular situation, thereby shifting the emphasis at the users' site to the requirements gathering and analysis phase, away from considerations such as design and programming, which are done in advance.

I was able to look at these systems from two perspectives, that of the company developing and supplying the software, and that of the organisation customising it for their clients. I had already interviewed a practitioner working in a client company in the pilot study. The requirements specification for the package itself has a much larger scale of complexity which has to be managed quite differently.

Another reason for concentrating on this area is that though the idea of configuring a package is not new, this has become the dominant trend in all areas of business applications in recent years, including university administration. In this domain, I interviewed a key user in a client organisation, a university administrator who had been seconded full-time for a year on a project the university was carrying out with an external software company. The aim of this project was to re-structure and develop a commercial student records package that could be customised for use in his organisation. This project, and the university's involvement in it, arose out of severe difficulties they had already experienced in trying to customise the previous version of the package to suit the requirements of the university.
3.5 How I approached coding and theory building

3.5.1 Manual coding

The manual analysis strategy initially used for the interviews was outlined earlier. This is best described as open coding, as it was guided only by the data itself. This was my first experience of either coding or doing grounded theory, so I was only learning how to do it at that stage.

Having printed out a copy of each interview, and working with one interview at a time, I began to select short passages from the transcript, annotating them with the identifier and page number of the interview, cutting them out with a pair of scissors, and assigning them to little piles on the desk. I used the technique of making “constant comparisons” with the contents of the existing piles.

I continued in this way until all the transcripts had been sliced up, and I had thirty-five piles each labelled with a proposition concerning the role or use of requirements documents. Each proposition was supported by five to ten quotations from the data, which I copied into a notebook. The main advantage of this approach was the way it helped me to learn to let the data control the analysis process. Without any predetermined codes, or even any notion of what the codes might be, it facilitated finding the meaning that was present in the data.

The cutting up of the pages had a serious disadvantage. I could only use each quotation once, and many of them could have been used several times over, or more usually, some part of a cutting could have been assigned to a different pile (proposition). Alternatively, I could have continued by starting again with another copy of each transcript, and cut out a different set of quotations, but computer-aided data analysis provided a better way to proceed.

3.5.2 Computer-aided analysis

Some researchers use a simple approach to computer-aided qualitative data analysis, for example Seaman (1999) gives a detailed description of her way of working with interview transcripts. A word processor can be used to search the text for specific keywords, leading to the identification of paragraphs which can then be annotated with a suitable code, preferably in a different font to distinguish it from the original transcript. In this way, as many codes as desired can be attached to a particular paragraph.

Before computers were widely adopted in qualitative research, codes were typically annotated in the margins of a copy of the typed transcript. But now there are several sophisticated qualitative data analysis packages on the market, facilitating sorting, searching,
and selection of data and codes in various ways. The one I used is called Atlas/TI. The letters TI stand for textual interpretation, but Atlas can also be used for graphic and sound data, as well as the more usual text (Muhr, 2000).

This package allowed me to organise and keep track of hundreds of codes and hundreds of pages of interview transcripts, as well as providing the means to create axial codes that were more theoretical and core categories, graphically linking them to each other and to the relevant open codes.

The transcripts of the interviews carried out thus far, in the preceding stages, were entered into the Atlas database, and coding began afresh. This time the codes were simpler than before. Instead of propositions, they tended to be single words or simple phrases describing concepts, such as the ones illustrated in Table 3.1. The coding process on the computer consisted of reading the text of an interview transcript, selecting individual words, phrases, or, more usually, longer quotations, and assigning to the selected text a code that indexed it. The full list of codes is in Appendix F.

<table>
<thead>
<tr>
<th>acceptance testing</th>
<th>accepted</th>
</tr>
</thead>
<tbody>
<tr>
<td>accumulated changes</td>
<td>accuracy</td>
</tr>
<tr>
<td>ad hoc reporting</td>
<td>afterthefact</td>
</tr>
<tr>
<td>agreed requirements</td>
<td>agreement</td>
</tr>
<tr>
<td>agreement</td>
<td>agreement not in document</td>
</tr>
<tr>
<td>alpha test</td>
<td>an adequate design</td>
</tr>
<tr>
<td>analysis</td>
<td>answers all their questions</td>
</tr>
<tr>
<td>application domain</td>
<td>application expertise</td>
</tr>
<tr>
<td>application note</td>
<td>application problems</td>
</tr>
<tr>
<td>applying knowledge</td>
<td>architecture</td>
</tr>
<tr>
<td>architecture first</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.1 Some sample codes**

These codes were more basic and more conceptual than the previous codes, which were all propositions, and also more varied in their subject matter, dealing with the contexts, uses, and contents of requirements documents, as well as system development generally.
3.5.3 The emerging theory

The analysis carried out in the initial stage and at the case study stage was aimed at Maykut and Morehouse's level 2, what they called the weaver level, (Maykut and Morehouse, 1994) and the results were written up in the form of sets of general propositions or hypotheses regarding the role of the requirements document. For the main study, I aimed at the third, most abstract level of interpretation, the theory builder level. An outstanding example of a grounded theory reaching this level of interpretation is found in Orlickowski's (1993) study of the adoption and use of CASE tools in organisations, which presents a theoretical framework linking the social context of system development with the different outcomes of CASE tool adoption. Seaman and Basili (1998) present their results as a set of independent and dependent variables, and a network showing the relationships they identified between them. I aimed to have something more abstract than a set of propositions, but for a long time, I could not envisage a causal model of requirements documentation that would be based on a set of independent and dependent variables.

The notion of causality is central to scientific enquiry, but, beyond the level of physical phenomena, most events cannot be explained simply in terms of cause and effect. I reasoned that the inherent complexity of situations involving system development could not be reduced to a few causal variables. The meta-model paradigm of grounded theory provided a more appropriate set of categories for explaining things in terms of situations, based on the conditional matrix, but I did not rely on this. I tried to follow the advice of Miles and Huberman (1994) who recommend that in a multi-case analysis, explanations should be presented in matrix form. This gives a picture of the possible variety of causes over a range of cases, rather than a general explanation of the factors pertaining to situations.

3.5.4 A classification framework

The idea of a matrix form of explanation, and the idea of a document style came together in the form of a classification framework. Mary Shaw and Paul Clements (1996) had published a feature-based classification of architectural styles in the form of a single matrix, covering all the different styles found in the literature analysed using a common framework of features. The main features of software architectural style they included were Constituent Parts, Control Issues, Data Issues, and Control/Data Interaction, in effect, a theory of what were the salient dependent variables of software architecture.

So, I began to aim at the idea of proposing a classification framework, in particular a faceted classification (Star, 1997), identifying the factors that seem to be related to the variation found in different kinds of requirements documents and explaining the kinds of documents.
that tend to be used in different situations. Such a classification would lend itself to being
tested, verified and amended as theoretical sampling proceeded.

I envisaged the resulting classification as a table, or rather as two related tables, one
indicating the features of situations that would make a significant difference to requirements
documentation practices, the other indicating the style of document appropriate to the
situation. As it turned out, there were two main problems with this vision. It was impossible
to put in a few plain words the values of the variables I was coming up with for the first
table, so that they would both fit in the cells of the table and make sense. Secondly, a
faceted classification turned out to be impractical, because the facets were not completely
independent of each other, being drawn from a network of related concepts which formed
one of the main strands of the supporting theory.

This network of codes was the result of axial coding using the results of open coding of the
growing collection of interview transcripts, and therefore the most grounded part of the
theoretical framework. In the next section of the thesis, in Chapter 5, it is introduced. Then it
is used as the basis of a framework for classifying situations for the purpose of documenting
requirements, presented in Chapters 6 and 7. But first, Chapter 4 deals with the other main
strand of the thesis, a grounded theory of requirements documentation.
Part Two  Findings

Overview of Part Two
What are requirements?
What do people talk about when they talk about requirements? It depends on the situation, but discussions about software requirements are not just about the capabilities and properties of software. At a more general level, software requirements are about problems and problem situations, they are also about solutions about the need to state the problem in such a way that it can be solved, ultimately, by a software solution. Christiane Floyd (Floyd, 1995) discusses the centrality of problems and problem solving in computing, and asks "What kind of entity is a problem? What is its ontological status? Does it have a way of existing on its own? Whose problem is it?" (Floyd 1995)
A similar series of questions could be asked about requirements. What kind of entity is a requirement? Can it exist on its own? Where does it come from? Where do different kinds of requirements come from? Who owns them? This thesis explores how these questions might be answered by an ontological analysis of the domain of requirements.

Two levels of the concept of requirements
In the context of system development, a requirement may be regarded as two related things. A requirement is defined as
(1) a function, capability, or property required of a proposed system and/or it is
(2) the statement of such a function, capability or property
When we talk about the elicitation of requirements we are talking about the first of those meanings, i.e., the requirements themselves. Similarly, when we discuss the issues surrounding the articulation of requirements or the need for agreement on requirements, clearly that is what we are talking about.

On the other hand, when we discuss topics such as requirements inspection, requirements validation, requirements management, or requirements traceability, we are referring to inspecting, validating, managing, etc the statements of requirements rather than the requirements themselves.

A requirements statement is a semiological object. We use it to stand for the substantive requirements we are talking about. When we want to prioritise requirements, for example, we attach priority values to the statements of requirements, not directly to the requirements themselves. We all know that requirements change, but we acknowledge this by changing
the relevant statements of requirements, because these "requirements" do not change in the same way, by themselves

Writing down requirements is a necessary part of the requirements process, but once a requirement has been written down, the expression of it, as well as representing the actual requirement, takes on a separate identity and a significance of its own

Most authors on requirements engineering do not make this distinction, so why bother? Because the expression of a requirement is not the same thing as the requirement itself Requirements engineers, particularly researchers in requirements engineering need to take this distinction on board An ontology of requirements is a small step in this direction, emphasising the ontological precedence of requirements-as-needs over the statements and models that represent them in requirements documentation

*Disambiguating "requirements"

This thesis emphasises the distinction between actual requirements (or requirements-as-needs) and the requirements statements that document them It focuses first on requirements statements or requirements-as-texts, and the diversity of ways that requirements are documented in practice It then looks at the requirements themselves, and at the different sources of requirements, and then looks at how requirements-as-needs shape the context of writing requirements-as-texts The main findings of this research are presented in the next four chapters as follows

Chapter 4 focuses on requirements-as-texts, and explores a number of different themes of variation found in the documentation practices of the practitioners interviewed This chapter uses a taxonomic approach to analysis, relating different categories of requirements statements using the usual hierarchical *isa* relationship It concludes with a simple model of different types of requirements statements

Chapter 5 looks at requirements per se, as needs rather than as texts, and uses a different type of analysis to develop an ontology of requirements The purpose of this analysis is to explore the relationships between different types of system and software requirements Rather than the more usual taxonomic relationships used in most published ontologies, these are ontological precedence relationships, linking requirements-as-needs to their ontological predecessors, on which they depend for their existence, and their ontological successors, which in turn depend on them

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In the requirements engineering literature, for example in (Greenspan et al., 1994, Mylopoulos, 1998), the idea of ontology has been used to compare and contrast the different world views embedded in different approaches to conceptual modelling. The entity-relationship approach holds that the real world consists of entities and relationships, while the object-oriented approach views the world in terms of objects and other related concepts. It is important to recognise these ontologies because they frame the way that problems and solutions are understood. A different level and type of requirements ontology deals with the way that the domain of requirements engineering itself, including problems and solutions, is construed by its practitioners. This is the purpose of the ontology presented in this thesis. It draws attention to how requirements are related to their different sources, particularly those identified as 'root concerns,' and to the contexts in which different types of requirements arise.

Chapter 6 presents a scheme for classifying different system development situations on the basis of their most important requirements concerns. It is based on the grounded ontology presented in Chapter 5, and makes particular use of the root concerns identified there. It proposes that different types of requirements situations can be distinguished by their varying emphasis on different kinds of requirements-as-needs. Seven typical situations are presented based on this classification scheme.

Chapter 7 presents seven different profiles of requirements documentation based on their situation of use. Each of the seven typical situations that were presented in Chapter 6 is here associated with a typical documentation profile. Each profile defines the role and importance of different types of requirements statements in a typical situation. This scheme is based also on the analysis of requirements statements outlined in Chapter 4.

**Explaining requirements**

The relationships between the four chapters are shown below. Chapters 4 and 5 are relatively independent of each other, dealing with the semiological and substantive aspects of requirements respectively, while Chapter 6 builds on material introduced in Chapter 5, and Chapter 7 builds on both Chapter 4 and Chapter 6.

Chapter 7 is offered as an explanation of observed phenomena. Chapters 5 and 6 introduce and develop the independent variables in the explanatory framework, whereas Chapter 4 establishes some dependent variables. Chapter 7 links them together and explains the observed diversity of requirements documentation in terms of the variety of situations in which requirements documents are written and used.
Relationships between the Chapters in Part Two
Chapter 4  A Taxonomic Analysis of Requirements as Texts

"The notion of giving something a name is the vastest generative idea that was ever conceived "

(Suzanne K. Langer, American educationalist)

4.1 Introduction

The literature on requirements engineering seems to be committed to the idea of classifying requirements (IEEE, 1998, Kovitz, 1999, McDermid, 1994, Robertson and Robertson, 1999, Wieringa, 1996). Many of these classification schemes begin by distinguishing between functional and non-functional requirements. For example, the IEEE standard for the Software Requirements Specification (IEEE, 1998) distinguishes fourteen types of requirements, divided into functional requirements and thirteen different types of non-functional requirements. The Robertsons identify seventeen different types of requirements divided into product constraints, functional requirements and non-functional requirements (Robertson and Robertson, 1999).

None of the classifications in the literature seems to distinguish between substantive and written-down requirements, although the term 'requirements' covers both of these. An essential theme of the analysis presented in this thesis is the distinction that it makes between the substantive requirements that exist in a situation (requirements as needs) and the written statements that represent or define those requirements (requirements as texts).

For these reasons, rather than begin with any of the existing classification schemes, I have taken the grounded theory approach of beginning with the interview data and employing the categories that emerge from the empirical domain to propose a different way of classifying requirements. This unorthodox way of classifying requirements has been created for a specific purpose, to talk about the main varieties of textual requirements instead of the more usual breakdown of types of requirements per se. This will allow us to examine the question of how "requirements as texts" may vary in relation to any other particular factor that we may want to consider.

The taxonomic analysis of "requirements as texts" presented in this chapter focuses on the differences between the various kinds of written statements that are used in documenting requirements. It explores the variety of ways of expressing, organising, and using requirements in a written form, before dealing with the various written components of a requirements document. Since this chapter is concerned mainly with an analysis of
empirical findings, these will be presented here, along with illustrative quotations from the interviews with the practitioners, and will not be further compared to the literature until a later stage, in Chapter 10

4.2 Domain analysis

In his books on ethnographic research methods, Spradley (1979, 1980) presents a very useful set of heuristic techniques for performing domain analysis. Domain analysis is the term given in ethnography to the analysis of a specific domain. A domain in this context can be any cultural phenomenon or area under investigation, such as kinship among a specific tribe of people. Spradley's own research was an exploration of the culture of tramps living on Skid Row (Spradley, 1972a).

One of the most important domain analysis techniques is called taxonomic analysis, a procedure for systematically discovering the variations of terminology and meaning that occur within a domain. Spradley used it to analyse the different domains in the life of an urban nomad, such as the variety of terms used for different 'flops,' places where a tramp might sleep for the night. Another example from the ethnographic literature dealt with the variety of categories of beers enjoyed by the people of Munich (Hage, 1972). I have found this analysis procedure extremely useful in searching for patterns of variation in the domain of requirements as texts.

The objective of taxonomic analysis is to produce a hierarchical decomposition of all the sub-domains within a particular domain, related by some taxonomic relationship, such as is-a-kind-of, or is-part-of. The method of analysis is essentially bottom-up, and is intended to be used to discover what are called "folk domains," which are effectively the terminology which is local to the culture being studied. In grounded theory, these terms are called 'in-vivo' codes, as distinct from the theoretical codes which are named or created by the researcher. I used it with a mixture of both types of categories.

The starting point in taxonomic analysis is to look for categories in the empirical data which are all related in that they (could) belong together, under some heading, or cover term as it is called. Examples of prototype cover terms include kinds of, or ways of, or parts of. Examples of actual cover terms include "kinds of trees," "kinds of deciduous trees," "parts of a tuna boat," "parts of the deck," etc. These are only a few examples of the most common types of cover terms. Spradley gives a list of them and points out that several more are possible (Spradley, 1979). The cover term represents a binary relationship between the
domain of the cover term and its sub-domain. These relationships between domains and sub-domains are transitive and non-reflexive, forming the basis of a hierarchical framework.

4.3 Domain analysis of requirements as texts

My empirical data for the purpose of this analysis consisted of transcripts of the interviews in which practitioners discussed their own documents and others they had worked with, plus a selection of sample documents given to me by the practitioners. Having already analysed the interview data by open coding using ATLAS ti as a tool, I then generated a code family called “requirements as texts.” This consisted of a collection of basic categories, both theoretical codes and in-vivo codes, all related to the theme of requirements as texts, as distinct from the separate theme of requirements as needs and other aspects of projects and system development generally.

In-vivo codes are more grounded than theoretical codes, because they are the terms used by the informants themselves, and presumably reflect local usage in the situation they are talking about, whereas theoretical codes are the researcher’s own terms, which may be expressions in general use in the literature, or terms coined by the researcher to capture some insight or observation about the data. In some ways, the domain of requirements engineering is like any of the “folk domains” studied by Spradley and other ethnographers, in having its own terminology, or jargon, but in a sense it is different, in that the terminology used by the practitioners was not new or strange to the researcher, although its usage and meaning in practice still needed to be explored and understood.

The main point of the analysis, therefore, was not just to find out which terms were used by practitioners to describe their documents, but to try to capture the usage and meaning of these terms among the practitioners I interviewed. Because there is a much greater exchange of ideas and terminology between the research and practice communities of requirements engineering, there is no particular value attached to capturing in-vivo codes as such, as there would be in a more typical ethnography. In my analysis, it frequently happened that a code that was collected in-vivo in one case was applied as a theoretical category to describe the same phenomenon in another case.

I set out to build a grounded taxonomy of requirements as texts, with the intention of constructing a framework that would have at least a few levels of hierarchy. I began by bringing together the codes I had collected and generated indicating different types of documents. Originally I intended to restrict the taxonomy to two types of hierarchical relationships: is-a-kind-of and is-part-of, but gradually I began to reconsider that restriction.
as I found that (a) there were other types of relationships which would help to illuminate the domain, and (b) the idea of a hierarchical structure or a strict taxonomy did not fit very well to the empirical data.

The result was rather different from the original intention, consisting of a collection of analysis themes. I explored different names and types of documents, different ways of organizing and expressing requirements, different ways of using requirements documents and different components of written requirements. In grounded theory, these categories are called axial codes. They represent the intermediate level of analysis between open coding and selective coding.

4.4 Results of the analysis

One problem in trying to understand what is going on in the practice of requirements documentation is that many different names are used for the documents, but it is not always clear which documents are the same though they have different names, or which are different though they might be called the same name. Table 4.1 shows the result of this, a list of all the different names that the practitioners used for the various requirements documents that they used.

<table>
<thead>
<tr>
<th>Different Names for Requirements Documents</th>
<th>Business Blueprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Description</td>
<td></td>
</tr>
<tr>
<td>External Specification</td>
<td></td>
</tr>
<tr>
<td>Feature Description</td>
<td></td>
</tr>
<tr>
<td>Functional Description</td>
<td></td>
</tr>
<tr>
<td>Functional Requirements</td>
<td></td>
</tr>
<tr>
<td>Functional Specification</td>
<td></td>
</tr>
<tr>
<td>Global Requirements Specification</td>
<td></td>
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<tr>
<td>Internal Specification</td>
<td></td>
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<tr>
<td>Invitation to Tender</td>
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<tr>
<td>Request for Proposals</td>
<td></td>
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<tr>
<td>Requirements Definition</td>
<td></td>
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<tr>
<td>Solution Investigation Document</td>
<td></td>
</tr>
<tr>
<td>Specification</td>
<td></td>
</tr>
<tr>
<td>System Requirements</td>
<td></td>
</tr>
<tr>
<td>Task Definition</td>
<td></td>
</tr>
<tr>
<td>User Requirements Specification</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1 Different Names for Requirements Documents

Many different types of documents are used in addition to the main requirements specification documents, and some of these are listed in Table 4.2. The extent to which these were used was related to the contents and purposes of the main requirements document. For example, some of the practitioners relied heavily on interview records in addition to the
official requirements documents as the basis for further work on the system. Several of them also relied on the minutes of meetings with clients as additional documents. Memos and emails were also mentioned, both as ways of communicating with other stakeholders and as documents that would be regularly filed along with the formal documentation of the requirements.

In some situations, and after certain stages of the project had been reached, changes to the requirements would need to be communicated using pre-specified formats, sometimes called change requests, or problem reports. In the telecommunications domain, the standard requirements for specific features were typically already documented in official standards documents.

<table>
<thead>
<tr>
<th>Different types of ancillary documents</th>
<th>Interview records</th>
<th>Minutes of meetings</th>
<th>Different types of short communications</th>
<th>Memos</th>
<th>Emails</th>
<th>Change requests</th>
<th>Problem reports</th>
<th>Standards documents</th>
</tr>
</thead>
</table>

Table 4.2 Types of Ancillary Document used in relation to Requirements

4.5 Different types of documents

Some informants explained that they typically worked with two different types of requirements document in the one project, for example an internal specification and an external specification. In such cases, it is obvious that these have complementary roles. Other practitioners worked with what they called a URS, or User Requirements Specification. It was clear that the role of URS in one case is similar to the role of external specification in another case. In fact, I have the evidence that they are similar in their contents as well as their purposes, but not to such an extent that I can say they are synonymous, because I found that every requirements document is different.

Despite the name, the URS in several cases was not written by users, or for users, or, to any extent, with input from users. In practice, the term seemed to reflect the perspective from which it was written, that being the perspective of a user who might have a limited interest in or understanding of the internal workings of the intended system, or product.

"The URS, which is the product manager's document in this he specified hardware and software requirements, user-level requirements of what he expects the product to do."

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Some system development methods divide requirements documents into two types reflecting this external/internal division. In practice, having two types of documents seemed to be related to the use of methods and the extent to which the method was being rigorously applied. However, in most cases, the practitioners reported that methods were being used *ad la carte*, or adapted in ways not intended by their originators, to suit the situation. For example, the need for two different documents was regarded as appropriate only for certain circumstances, such as large projects, and practitioners would devise a hybrid type of document to suit the situation.

"So the abbreviated specification was a combination of these two that we actually used for this project. In the particular area that I worked in, we would have used the abbreviated specification much more than the standard ones because we never really had big projects. That sort of huge time-scale."

Every requirements document is unique, because every system is different in some ways. But there are broad areas of similarity as well as differences to be found, i.e., patterns of variation in the ways the contents are organised, the ways requirements and other contents are specified, and in the types of requirements they contain.

The practitioners used a variety of ways of *organising their documents*, of which hierarchical breakdown based on functional decomposition was the most common, followed by organisational schemes based on workflow or business processes, though some used different kinds of tables and matrix or record formats to organise the requirements. However, these were very much dependent on the nature of the contents.

Most practitioners expressed a preference for "plain English" for *expressing requirements*, and this is by and large the most widely used approach. But various types of *models* were also used to represent some aspects of the requirements, especially the problem domain. Semi-formal structured models were used for requirements in some situations, while in other situations, the use of modelling techniques was postponed to a later stage of development. We will return to this point in a later chapter.

It is reasonable to suggest that different types of documents might have different roles or uses and different types of contents, and these are two areas where a considerable amount of variation occurred in practice.

### 4.6 Different uses of requirements documents

What is the use of the requirements document? Table 4.3 shows the variety of roles of the requirements document that the practitioners talked about in describing how they used the
documents in their work. Several of them emphasised the role of the requirements document as a working document, going through a succession of versions and revisions. The earlier versions, often called drafts, were mainly regarded as having the role of a discussion document.

"As for the importance of the document, they would look at it and we would talk through it and read it out to them or explore things and they would say something like 'I don't agree with that' or 'I'm not happy with this' and we would resolve this."

On the role of the requirements document as a device for documenting the agreement, the practitioners' opinions and accounts varied considerably from one situation to another. Some of them saw the document as defining the agreement, particularly in contractual situations, while others saw it as having a much more subtle role in the process of reaching agreement.

In many cases, the practitioners expressed the view that the essence of the requirements document was a tool that was instrumental in the process of getting to agreement rather than merely a means to document the agreement that had been reached.

"One purpose was to get agreement from the users on the functionality of the system."

<table>
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<tr>
<th>Different uses of requirements documents</th>
<th>as a discussion document</th>
<th>as a method of communication</th>
<th>as a working document</th>
<th>as the basis of the architecture</th>
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<th>to evaluate proposals</th>
<th>to document agreement</th>
<th>to get agreement</th>
<th>to articulate knowledge</th>
<th>to express understanding</th>
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</table>

Table 4.3 Different uses of requirements documents.

Most of the practitioners took the view that the requirements document was a means to an end, rather than an end in itself. In some cases, this view was strongly expressed in terms of its use as a means of getting to agreement, while many of them saw an important role for the requirements document in its subsequent use in one or more later stages of the development project, such as prototyping, architecture, design or testing. The specific phases to which the

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The requirements document was directly input tended to vary considerably from one situation to another.

"Our architecture design phase would take these requirements and implement a data model from them and also implement a dialogue flow, conversation control flow, for the project."

"Then we went through a stage of looking for solutions to the project, we investigated a number of packages. It was used to evaluate the various proposals that came in."

"That's a very critical point in the project because at that point, I'm then able to use this document to go to the next stage which is to produce the plan and costing and talk about money and time-scales."

The biggest area of variation, even disagreement, between practitioners regarding the use of the requirements document related to its use as a method of communication, especially for exchange of ideas with the end-users of the system. Some strongly expressed the view that, no matter how well it was written, no document could be relied on for communication with users:

"Documents, they have a place, but don't rely on them."

"I still think it would be hard to write a document that the users will understand. Without being disparaging to users it's just that they are not used to reading great reams of text and being sure that they understand exactly all the implications."

"talking through it because people are not good at writing and they are not good at reading. One is as bad as the other."

"It is very few people that I have found that when you write a document and when you talk about it afterwards with them, yes he understood what I meant."

"People simply don't have that skill to write down what exactly they mean and I suppose the converse is that a lot of people don't know how to read a document in the same way."

Other practitioners expressed more confidence in their own ability and in the possibility of writing clearly enough to be understood by everyone concerned:

"You can see here (I like to) put the thing in plain English, short sentences, little points, so even if it's not numbered one, two, three, four, then it's as little points. It's easy to read, if you feel something's important, you can easily put a ring around it or a line around it."

"There probably isn't any substitute for interaction with the users but on the other hand, if they get a good document at the start it's telling them exactly what they want, then if that's clear to them, they are clear on what they're getting."

"It's written so the customer can read it and understand it and agree to it, so it would hopefully be written in plain English using the customer's terminology. It's not journalistic, I mean it's not understandable to the world at large, it's most certainly not only understandable by ourselves. I mean we seek to avoid that in all parts of this document."
There was a certain amount of opinion offered that the usefulness and acceptability of written communications and formal documentation depended on the ethos of the organisation in which the system was being developed. One practitioner put it in the following way:

"This company is a get up and go company, and rather than planning, acting and reviewing it believes in acting. If you set out to nail somebody down on their requirements you wouldn't get a lot of sympathy from the person you were trying to nail down, or much understanding."

On the other hand, some practitioners emphasised the usefulness of having things in writing after the event, in order to explain the rationale for certain decisions that had been taken. For example:

"There happened to be a change of payroll supervisors very soon after the project went in. He wanted some changes and we were able to go back to the document and say well listen this was the reasoning and I suppose it made him go back and think about the reasoning behind it."

Another, perhaps more noteworthy, perspective on the role of the document was expressed in the insight that for some practitioners, the act of writing the document clarified their own understanding of the requirements, in giving them a vehicle that both required and allowed them to express understanding and to articulate knowledge about the application:

"Part of this was to help us to understand, to detail the stuff to get a common understanding."

"We had to try and understand everything. We had to go through from not understanding anything about the protocols that were involved, what they were talking about, to actually having done all the research to and finding out what was really going on in this area."

"We were new in the area they were asking us to work in. Part of our problem was actually finding out the information at the time, so we put down on paper what our understanding of it was, along with investigating the solution to it."

4.7 Different types of contents in requirements documents

It would seem likely that a good place to search for variations in the specific contents of requirements documents would be in the Tables of Contents found in sample documents provided by the practitioners, but this is not as straightforward as it might appear. The terminology used for contents, and the contents themselves differed widely to such an extent that they could not be directly compared. This is where the taxonomic analysis procedure became extremely useful.

In practice, there is no widely used template or even agreed list of contents for a requirements document. Some of the practitioners were familiar with the idea of using a standard Table of Contents for requirements documents. This was particularly the case.
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where a defined system development method was being used, but methods themselves vary
One practitioner found the standard Table of Contents a useful strategy for gathering
requirements in rapid application development

"Okay To start them off we'll have put together a draft table
of contents We might try and get it from say some standards
document Like the IEEE standard for requirements specs
If the company have an internal standard themselves you just
follow that"

The results of the taxonomic analysis of the domain contents of documents are summarised
in Table 4.4 A more detailed breakdown is included in the Appendices Most of the cover
terms in the table are theoretical or in-vivo codes generated from the interview data or found
in the sample documents The principal cover terms are given in the second column of the
table They are Problem Domain Descriptions, Required effects, Proposed solutions, Goals,
Constraints, Issues, and Document information

Two of these, however, are borrowed or adapted from the requirements literature The cover
term Problem Domain Descriptions is borrowed from Ben Kovitz's checklist of requirements
contents (Kovitz, 1999) Required effects is a cover term which I adapted from Jackson’s
concept of an effect, a term which is also used by Kovitz A requirement per se is defined by
Kovitz as the "effect the software is required to produce in the problem domain"

A variety of different types of Required effects were employed by the practitioners in their
requirements documents The most important categories were different types of Features,
different types of Transactions, different types of Information requirements, different types of
Behavioural requirements, and to a lesser extent, some Transformation requirements

In the remainder of this section, each principal category of contents is presented under its
own sub-heading The most significant of these, in terms of their size or volume within any
document, are the first three principal categories Problem Domain Descriptions, Required
effects, and Proposed solutions The other principal categories as outlined in the table are
more important in terms of their function in the different roles of the requirements document
explored in the previous section In the concluding section of this chapter, these main
categories will be reviewed and condensed into a simple taxonomy of requirements as texts
**Table 4.4 Types of Contents**

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<th>Different Types of Contents</th>
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<td>Types of behavioural</td>
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<td>Objectives</td>
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<td>Non-Functional Requirements</td>
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<td>List of reference documents</td>
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**4.7.1 Problem domain descriptions**

This category covers those statements, or collections of statements, that describe the problem domain, the context in which the intended system will operate. The practitioners' documents different types of statements in their problem domain descriptions, including the following categories: Business Processes, Operations, User actions, Tasks, Events, Assumptions, Rules, Terminology, Volumes, and Company Background.

The problem domain description as a whole typically deals with all the relevant aspects of the problem domain, and frequently provides the context in which the other types of requirements statements (such as the requirements per se) are to be understood. It often includes definitions of terminology, such as a glossary, or a list of explanations of acronyms.
etc. It may include relevant assumptions about the problem domain. In some kinds of applications, the existence of standards is an important aspect of the problem domain, and requirements may refer frequently and repeatedly to the relevant standards document(s).

The various types of statements under this heading in practice ranged from natural language descriptions of business functions and processes to models or other representations of equipment functions and operations. It is implicit in these descriptions that the problem domain will continue to behave in the way described, even after the intended system has been installed. For that reason, problem domain descriptions are often written in the present continuous tense. Any planned changes to the actual problem domain may be included in the description without further comment.

The statements themselves refer to objects of interest in the problem domain and the ways that they interact. Here are some examples:

From the specification for a clinical neutron therapy system:

"The isocentric treatment unit (ref to figures in the document omitted) allows patient treatments with beams coming from different directions. The radiation source, in this case the beryllium target, is mounted on a gantry arm, which can be rotated around the patient."

From the requirements document for a warehouse information system:

"Pallets containing box packs or drums are moved to the P&D locations at the end of the aisles by the Hand-Truck and then on to rack locations by Man-Up Truck."

From the RFP for an ambulance service command and control information system:

"The opening of the new Regional Ambulance Command and Control Centre in the near future will result in all emergency calls being routed through this single point. The new centre will be manned on a 24-hour basis and will have regional responsibility for emergency call management."

These descriptions are not requirements as such, but they were often, though not in all cases, an essential part of the requirements document. Where they were used, they had an important role in defining the context in which other types of requirements statements were to be:

1 defined,
2 interpreted, and
3 understood.

The problem domains referred to in the extracts above include things such as equipment, ambulances, pallets, trucks, materials, packs, and people such as patients, therapists, drivers, and dispatchers as well as signs such as serial numbers, orders, prescriptions, and events or messages such as emergency calls, etc. Business rules, which the system is intended to
enforce, and assumptions about the behaviour of entities in the problem domain, are often documented in these descriptions.

The practitioners' Problem domain descriptions were sometimes written in natural language, but they were often represented using other techniques, such as diagrams. Entity-Relationship diagrams, Data Flow Diagrams, State Transition Diagrams, and Class diagrams were the most usual types of diagram used. In those cases, some natural language description was always used to supplement the models. Or models were used to supplement the descriptions which were predominantly written in natural language. Another way which was commonly used by the practitioners to supplement the textual description of the problem domain was tables of data describing the numbers, volume, frequency or other measurements of the relevant entities and activities in the problem domain.

4.7.2 Required effects
The statements in this category express the actual particular requirements, the functionality and other observable attributes and behaviour needed or anticipated in the new system. They include Features, Transactions, Information requirements, Behavioural requirements, and Transformation requirements. All except the last of these terms are in-vivo codes, categories based on terms that were used by the participants themselves. One or other of these types of statements tended to predominate in the relevant sections of the documents discussed by the practitioners. The type of required effects seemed to be contingent on the type of application being discussed. For example, Features were strongly associated with telecommunications systems and also with market-oriented software, while Information requirements were most closely associated with database systems and with business applications.

To fully understand a statement of a required effect, it must be interpreted in conjunction with the problem domain descriptions. These statements were often presented in the form of long lists, often numbered for reference. The numbering scheme varied from straight sequential 1-n, or decimal numbering reflecting a hierarchical breakdown which was used to organise related statements into groups. Collectively, statements of required effects defined the interaction between the required system and its environment. Here are some examples.

From the RFP for an environmental health service information system:

"The system would be required to support the maintenance of an action diary for each inspector, summarising his or her planned actions."

"Required action details Property reference, EHO Code, Inspection/Visit ref, Action required, Planned revisit date."

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A required effect associated with the problem domain description given earlier for the warehouse system

"To record the movement of the pallet with its associated serials to a storage location in the racks, and to inform the Inventory system of this movement."

From the requirements for part of a telecommunications media gateway (the reference number at the end refers to the relevant standard which was being implemented)

"The system shall declare an Alarm Indication Signal defect (AU-AIS) when all "1"s are detected in the H1 and H2 bytes for three consecutive frames EN 300 417-1/B (G 783/C-1)"

From sample configuration requirements for an ERP system

"Travel Expense Processing Ability to facilitate travel processing and reimbursement Ability to assign varying levels of travel privileges Ability to handle direct deposit and cheque payment methods Ability to produce employee travel expense statements Ability to process travel reimbursements (weekly minimum) via the Payroll module or Finance module"

Required effects are so called because they express results or consequences of system activity that are observable by people or systems in the problem domain. Kovitz (1999) restricts his use of the term "effects" to effects on the problem domain, but I am using the cover term required effects to include effects in the system itself that can be observed in the problem domain. The practitioners' term for statements of required effects was typically the functional requirements, but this term is problematic, because it means so many different things. Also, the required effects can include statements of so-called non-functional requirements such as

"The system shall be fully validated to SIR level, including at least one long duration test (7 days) of a traffic bearing system without loss of service during that period."

Statements of non-functional requirements were not as extensively used in practice as might be expected given the emphasis that they receive in the literature. The requirements documents that I examined contained very few such statements. The few non-functional requirements that did occur in these documents were expressed at a very high level of detail. In general, it may be said that, unlike other required effects, statements of non-functional requirements are not allocatable to particular functions or modules of the system. More specific functions dealing with authorization, backup and recovery mechanisms tended to be used instead of high-level general attributes, making these essentially statements of required functionality or functional requirements.

The textbook distinction between functional requirements and non-functional requirements did not seem to be reflected in either the practitioners' accounts or their documents. In considering requirements statements, therefore, the use of different levels of detail in
expressing requirements is a more noteworthy distinction than whether the requirements themselves are functional or non-functional. The documents were often organised by level of detail. **Required effects** would typically be stated initially at a high level of detail, and then broken down into more detail. Statements would be collected in groups, or organised around a feature. A feature is often a very high level requirement which is broken down into several requirements statements that are more detailed. Features would sometimes, but not always, be collected into so-called bundles.

Different kinds of applications can have a mixture of these types of requirements, but the particular mix of categories will vary in different types of applications.

**Transactions** are the main types of required effects found in business or organisational information systems. Although it is possible to distinguish different levels, such as business transactions and database transactions, the concept of a transaction is well defined and understood in the area of database systems, and is often used as a notion of what a requirement is in organisational systems.

"You've got to have gone into what happens when a loan goes bad, exceptions, and how you're going to handle that. What procedures are needed to handle that. Most of the systems that I've come across have been transaction processing systems so in that context you have to have a full set of transactions."

Transactions are usually associated with business application systems, and since many of my informants were working in that area, there were many examples of transaction requirements in the interview data. Several of the other informants were working in the area of telecommunications, but these cases were more concerned with network administration, than with switches, for example. Some were dealing with intelligent networks, which are also based on transactions.

**Information requirements** were common in database-oriented systems, especially business systems. These specify the types of queries and searches that users want to perform, and reports that they need. The practitioners' documents generally did not specify all the different queries and reports that might be needed but instead were more likely to stipulate that the system be able to support common types of information retrieval based on a specific database contents and/or structure. But strictly speaking, these are not "requirements" but solutions and are classified under another heading reflecting that distinction. Typically, the practitioners saw no problem in specifying database contents as requirements.
**Behavioural requirements** was the term that practitioners working with embedded systems used for their requirements, and these are similar to **Transaction requirements** in a way. They also deal with events that happen in the problem domain.

"So a large part of the software requirements fall within the application domain in that they will specify features like, say in this player you had tray to tray double speed copy, so the application layer must manage all that." Transactions create, amend, and delete stored data in the system in response to **business events**, such as a loan being repaid, whereas **Behavioural requirements** instead respond directly to events in the problem domain with direct effects in that domain, such as switching a motor on/off, etc. These requirements typically were broken down into transitions between states in response to events originating in the device being controlled or in the user's control panel. As well as the normal transitions (intended behaviour) of the system, the requirements documents dealt with error cases (behaviour the system is meant to prevent) and what one informant called **corner cases** unusual combinations of **events** and **states**, and the system's required **responses** in these cases.

**Transformation requirements** occurred in only a few of the applications discussed by the interviewees, and these appeared to be much less common than the other types of requirements. The cover term is borrowed from Jackson (1995). Examples of these applications included the preparation and formatting of payroll data and the generation of management information statistics from factory production data.

### 4.7.3 Proposed solutions

"This section tells you a lot about how solutions were arrived at." "We are much more in the business of, they tell us what the problem is and we suggest the solution, we might try to clarify the problem, and then implement a solution." Along with **Problem Domain Descriptions** and **Required Effects**, the basic contents of the practitioners' requirements documents consisted of another category of statements that are best described as **Proposed Solutions**. In theory, a pure requirements document would not contain any solutions, but, in practice, a pure requirements document seems to be very rare. The extent to which solutions are considered appropriate content in the requirements document varies considerably from one situation to another, and will be addressed in a later chapter. In this section, the major types of solutions that were considered appropriate to requirements documentation will be looked at. Several of the practitioners stated that while detailed solutions were usually consigned to some other document, such as a design document, broad outline solutions seemed to belong quite naturally in the requirements document.
As far as the practitioners I interviewed were concerned, the requirements process seemed to be as much concerned with finding solutions as with stating the problems. Many of them described themselves as problem solvers, and some of them called themselves solution providers, regardless of whether they had a ready-made solution to apply to a problem.

Proposed solutions in the practitioners' documents were sometimes expressed at the lower levels of detail, in terms of the inputs and outputs associated with a function. These were often associated with particular required effects. Here is the solution proposed for the example given earlier of a required effect for a warehouse system:

"RF Screen to scan the pallet bar-code label, scan location bar-code label, ensure the pallet is known to be awaiting put-away, ensure the location is a valid warehouse location (reference LMmaster)"

However, solution was not just associated with the detailed requirements. It turned out to be one of the most saturated codes in the open coding analysis of the interviews I carried out. There seem to be several reasons for this. First, I found that it is not enough for a requirements document merely to state the problem; it must also provide enough of an analysis of the problem to ensure or demonstrate that a computer-based solution can be implemented. In practice, this often entails proposing an outline of the solution. The broad solution may already be decided, as is the case with ERP systems. The focus is on the solution. This is illustrated by the following practitioner who configures ERP solutions for client companies:

"We help them come up with the solution, one that is achievable using the product that they have chosen."

Secondly, unlike the textbook approach, in practice, there is no clear distinction between problems and solutions where requirements are concerned, and this relationship was sometimes reflected in the way requirements were elicited. Solutions to problems at one level become problems looking for solutions at the next level in this description of a process of Joint Application Development requirements workshop:

"Now at the next level then, we get them to write down four problems it's going to solve."

A business solution at one level becomes a problem statement in search of a technical solution at the next level:

"So, we propose a solution in technical terms, so we don't really propose the business solution. We propose a technical solution to a business problem."

One of the ways that high-level solutions were incorporated into the practitioners' requirements documents has already been referred to, and that was the centrality of the
Database Structure and Contents in many of the business application systems. Database definitions are a good example of high-level solutions.

"What I would have cared about all through that is more that the database was correctly designed so that we could produce any requirement that she came up with and that heart of the system survived, that we didn't find ourselves ripping it all apart and doing it all again."

Other similar sources of requirements included the influence of System Architecture, the use of Prototypes, and the impact of Feasibility analysis.

Although system architecture is really design in textbook terms, for various reasons, in practice, it often precedes and influences the definition of requirements in different kinds of situations. In the warehouse cases, the core system architecture existed already, so the solutions to many of the requirements could be described at that level.

In general, it may be argued that any product or solution which is to be based on a database management system already has a predefined system architecture which shapes both the requirements and the solution. In addition, once the relational data model is chosen, as it often is, the solution task becomes much clearer, especially when the contents of the database tables are defined. Clearly, database definitions are not problem domain descriptions, nor are they specifically required effects. The database definition in such cases is in fact the architectural framework of the solution, and regularly appears alongside the requirements for systems, in cases where a database solution is envisaged.

Another reason why proposed solutions are essentially requirements has to do with the use of prototypes in determining what the requirements really are. A prototype is a solution, not the solution, but a working model that demonstrates for the developers that the problem has some solution, and for the end users what the essential nature of the solution might be. Feasibility Analysis used to be a prelude to requirements analysis in the systems life cycle, but it seems to have been subsumed under prototyping. Prototyping has a number of benefits that do not replace the use of requirements documents and one of these is to demonstrate the feasibility of a particular idea, to show that there is a potential solution. There is no point in stating something as a requirement if there is a doubt that a solution exists for it. And no professional practitioner would give an undertaking to solve a problem unless it was stated in such a way that a solution was, if not obvious, at least reachable.

The term problem was mentioned frequently in the interviews, but in the sense of problems, for example "a problem with this..." and not at all in the sense of 'the problem' to which the
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system is a solution. For some practitioners, ‘the problem’ seemed to be the same as the problem domain, because it was documented in the problem domain description. For others, ‘the problem’ seemed to be inherent in the objectives of the system. In either case, although problem was a category in the analysis generally, it did not feature significantly in the analysis of requirements as texts. Instead, the cover term objectives appeared to be much more noteworthy as a category of requirements.

4.7.4 Objectives

Objectives are very high-level requirements. They are the main reasons why the system is needed or what the product is needed for. They are often regarded as the criteria for success or failure of a project.

“You see from our point of view in providing a solution, if the client isn’t clear on what he wants to achieve, it is dangerous for us, because it is difficult to know how we end up with a happy client.”

For some practitioners, the objectives were the most crucial element of the requirements document, even if written requirements were not important to them.

“I would have one thing I would be quite keen on which is to put the word objectives up near the front somewhere and try and state what the objectives of the system are.”

Objectives were significant to these practitioners because they guided the requirements process, and helped to define the scope of the system, so many of them considered it important to define them at the start, before any other requirements. Objectives were often associated with the achieving the perceived market benefits of a product, or with the business case for the system.

“so the business people go off and they try to establish what the business case is, what the marketing specification is, how the scheme might work.”

However, not all of the practitioners thought that it was necessary for objectives to be written down, as long as they were known and shared.

“an essential part of getting a clear definition of requirements is having a clear vision of what it is you are trying to do."  

“but the problem is that sometimes it is impossible to get it written down. The result will not necessarily be what you want it to be or do what you want it to do which is establish the shared vision.”

In an organisational context, objectives are often called goals. Organisational goals have been defined as “conceptions of desired ends,” conditions that participants try to effect through their performance of organisational activities (Scott, 1987, pg 18)

“In recent times we are only supposed to be addressing projects that actually meet the aims of the Department, the critical success factors of the corporation.”

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System objectives were frequently seen as ways to help achieve organisational goals, by saving money or by increasing business, for example, but they were also associated with non-functional requirements such as

"They want something that is more stable, more long-term and more scalable, so that it doesn't matter whether it increases to twice the size, three times the size, four times the size, it can still handle the traffic."

4.7.5 Constraints

Unlike objectives, which are about desirable but not necessary conditions, constraints are fixed conditions which must be satisfied by the system or software product. Unlike ordinary requirements, they are not negotiable.

An important criterion I used in identifying constraints in a requirements document or situation was whether they were global or not. Only global constraints, those that affected the system as a whole, were coded as constraints. I found that other types of constraints were typically embedded in the other types of requirements statements, for example, business rules in the problem domain descriptions, and cardinality constraints in the database models. These were not given any special treatment by the practitioners, who singled out behavioural constraints and design constraints. These are similar in that they both restrict the range of feasible solutions, but design constraints occurred generally, and behavioural constraints only in certain situations.

Some of the practitioners were working in the field of embedded software, used in consumer electronics and other types of special computerised equipment. This type of software was regarded by those practitioners as best described in terms of its behaviour, categorised as behavioural requirements earlier. In defining the requirements, they stressed the importance of enumerating all the different ways the software could interact with its environment:

"It's a behaviour model that tries to capture all the user-perceived states of the system."

"So we try to describe the behaviour of the player - what it will do under all kinds of scenarios."

They reasoned that it helps this task considerably if, first of all, it can be determined how that interaction or behaviour is constrained. This saves the trouble of having to consider several situations that are prohibited from occurring in any case. This was done using behavioural constraints:

"You've got to do the constraints table first, in order to make the whole thing hang together."

"So we have a constraints section - which was the bit you were looking at originally - which looks at each variable and looks at
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...each of its particular states and then see what constraints it puts on the rest of the system.

**Design constraints** are more general in their scope and application. These were aspects of the solution that were, for various reasons, determined in advance. They were associated with a range of different types of requirements situations in the interview data. Examples included such things as the hardware/software platform on which the solution was to be implemented, the memory limitations of the platform on which it would run, or the data input methods which might be used, such as RF (radio frequency) terminals, or the particular set of buttons on the user interface of a device.

"Any new piece of software, had to meet certain design rules in relation to not overloading the process, or not causing too many switches and connections."

General **design constraints** were mostly mentioned by practitioners working in large software development organisations. Those working in market-oriented situations saw the existing **system architecture** of the product as a major source of **design constraints**. The next version of a software product is in many ways constrained by the current and previous versions of it. This point was mentioned in relation to the need to maintain user interface consistency or to provide backward compatibility in the new version. It was also pointed out that intermediate **releases** of software, as distinct from major new **versions** of products, tended to address only parts of the functionality of the entire product, and therefore their requirements were strictly constrained by the overall **architecture** of the product.

**4.7.6 Issues**

**Issues** are really questions concerning requirements, which are raised by the participants in the course of meetings, discussions or reviews of a requirements document.

"It was a statement of what all the different issues were. Would we want to know what the part number of the vendor was, things like that, would we want to do, for example, to do weighted average pricing would we want to do straight list pricing, things like that, costing of the inventory that would be rather than pricing, that kind of stuff would come up."

Many of the practitioners interviewed emphasised the practice of recording the **issues** and related matters in the evolving requirements document as an integral part of the process of gathering or discovering the requirements per se. Many of them described a process whereby **issues** would arise and be documented first as **open issues** before being resolved and documented as **closed issues** along with the relevant **solutions** or **decisions** that were made to resolve them.

"So we'd list those issues and then we'd resolve those issues one by one and in the document there would be a list of the issues and what decisions were taken and why they were taken."

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In that case, issues were documented in a separate document, but typically, they were gathered in a particular section of a document, or in some cases, a section within each transaction that they referred to.

According to several of the practitioners, it was not enough for a requirements document to merely define the agreed list of requirements. They said it must also support and reflect the process by which this agreement comes about. This is the significance of the role of the requirements document as a working document:

"This is very much relevant to the process of arriving at an agreed first draft document; all the issues are in there, many of them are not even dealt with yet, obviously."

The draft requirements document is the central focus for discussions and review meetings, and each draft is in turn revised as a result of those meetings. Issues are typically raised as items for discussion, and changes are suggested and agreed. Both the resolved closed issues and the unresolved open issues are recorded in the next version of the document, along with the relevant changes which have since been incorporated into the related requirements statements. This continues in a cyclical process for a number of drafts and versions until some kind of agreement is reached. In some cases, practitioners worked within a defined process whereby intermediate drafts were interspersed with more definitive versions which had a different status:

"That version was reviewed, there were some small changes made and a new version was produced. And that's the way it was done."

Issues can arise for different reasons. Some of the reasons mentioned by the practitioners included lack of knowledge, lack of understanding, and lack of agreement. These would occur at the start of the cycle, and would be gradually identified, documented and resolved in various ways. Lack of knowledge on the part of different stakeholders would typically be resolved by the contributions of other stakeholders, in the course of writing and reviewing the document:

"So basically this is to try and sort of clarify a lot of things between us and them and also for people working on the team."

"We reviewed that document and then had a number of faxes and communications with them and also face to face meetings with them to discuss and clarify the requirements."

Different stakeholders in a project bring different perspectives and background knowledge to it. The developers, as well as the end users, can have their own issues or questions that need to be resolved:

then I tend to stick in an area for notes and stuff like that where you start putting normal questions you don't know the answers to, notes and queries, things like that."
Lack of understanding between the stakeholders can often be resolved by a process of **clarification**. The act of writing things down or re-writing a previous statement is often seen as a strategy for clarification.

> "One thing about writing is you have to write it and then somebody has to review it and then you have to issue it and somebody has to, sort of, say 'well I don't agree with this' "

> "This section tells you a lot about the exceptions and it tells you a lot about how solutions were arrived at, and part of its purpose is when people come back with questions, you can say it was raised in here, this was what we decided, perhaps even why we decided it."

### 4.7.7 Document information

The final category of information that came out of my taxonomic analysis of ‘requirements as texts’ comprises the different kinds of information that practitioners typically recorded in their requirements documents about the documents themselves. These included various items such as the **Document history**, its **Circulation list**, information about the **Authorship** of the document, as well as the **Table of Contents**, the **List of reference documents**, and related information.

The **Document history** would usually be a table used to indicate the various **versions** of it that had been issued, along with the relevant dates when it was reviewed, and in some cases, who reviewed the document. In some cases, this information would appear alternatively as a simple **Circulation list** of stakeholders involved in the project, who might have different roles in relation to reading, reviewing and agreeing to the contents.

In many cases, while going through a sequence of **drafts** and **versions**, requirements documents also went through **different stages of agreement**. For some practitioners any document (or version of it) being discussed would have a definite status in terms of whether it was an early draft, a version for review, or a near final document.

> "OK, there was a major review on the 3rd of December. Then, the following draft, there was some minor updates, some of them based on the original review. Then, at that point, the document was at proposal stage. It got moved to accepted, all the updates were done. And then, since then, it's just changed because of change requests. Or mistakes we found in it, or inconsistencies."

One of the many purposes of a requirements document is as a **record of agreement** between the stakeholders in a development project, but as already indicated, many of the practitioners felt that a more important purpose was the role of the document in **getting to agreement**. This was particularly the case in some organisational contexts. For example, in situations where a customer organisation employed a supplier organisation to work on a solution, the agreement between them was a formal **contract**. But in other situations, the **idea of a contract** was
invoked more as a mechanism to focus attention on agreement than as a way to enforce compliance by one party or the other.

"An exercise like that has to be done because you have to be able to say at the next stage 'well this is what you said you wanted' but you can't rely on it as being the final say so it wasn't a contract. Well it was, in the sense that they signed it off and we could have treated it as a contract but if a manager comes back at the design stage and says 'you can't do this,' it's no use going back and saying 'we have a contract'"

Essentially, in many situations, agreement was seen as instrumental before moving on to the next step in a project, or effort would be wasted on unwanted or inappropriate development. It was often considered more important to achieve such agreement in the minds of the people concerned than to make sure it was embodied in the document.

"The purpose of this document is to document our agreement but at the end of the day it's not enough for it just to be in the document."

Some interviewees strongly expressed the view that the agreement was not in the document, but existed as a shared vision in the minds of the people involved in the project.

"If you do a workshop and everybody gets a shared vision from that workshop you can then write that. But what is key is that everyone understands what that vision is."

The ideal concept of agreement depends on understanding and explicitness. In practice, things are never really fully understood, or are not always explicitly stated, so the pragmatic nature of agreement was recognised by many of the practitioners. As far as they were concerned, a certain level of agreement needed to be achieved in order to progress with the work of development. How much agreement was adequate seemed to vary from one practical situation to another.

The following three levels of agreement may be distinguished in the different types of requirements documents and situations that I investigated:

1. **Contract** Agreement has the force of a contract, or a formal agreement between two legal entities, and has a legal significance.
2. **Agreed** Agreement has the effect of an informal agreement between two parties within an organisation, and has no legal significance.
3. **Approved** Agreement has the significance of endorsement by the hierarchy of an organisation, represented by the reviewers of a document. Again, this has no legal significance.

### 4.8 Conclusions: A Different Classification of Requirements

In this chapter, I have presented the results of a taxonomic analysis of the domain of 'requirements as texts' based on the practitioners' accounts of their own practices and a
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selection of documents I collected in the course of interviewing them. This analysis corresponds to the second level of grounded theory analysis, axial coding. A number of different themes related to requirements as texts emerged from the analysis, the most significant of which were: the variety of different types of documents used in practice, the range of different roles and purposes of requirements documents, and the variety of requirements statements contained in the documents. The following general points summarise the findings.

The concept of a requirements document embraces a broad range of different types of documents. This is reflected in the different names that they were called by, in the different work environments. The main requirements document is often supplemented by a range of supporting documents, related to different practices and modes of use.

The requirements document has a wide variety of uses. Two of its most important roles relate to agreement. The role of the document in getting to agreement was often seen as more important than its role in recording the agreement.

A number of categories of requirements statements were identified in the analysis. There were seven main categories. The first three of these, Problem domain descriptions, Required effects and Proposed solutions, form the greater part of the requirements document. Required effects including different types of Features, Transactions, Information requirements, and Behavioural requirements, often but not always depend on there being sufficiently comprehensive Problem domain descriptions to make the interpretation of these statements intelligible and explicit. Proposed solutions cover categories such as Database structure and System Architecture.

Two other main categories, Objectives, and Constraints, are similar in that they supplement the meaning of the first three. Objectives state very high-level requirements which can generally be translated into more detailed requirements but some remain as high-level objectives that are not transformed in this way. Non-functional requirements are often stated in this way. Constraints are of two types. Those that refer to the problem domain help to clarify the relevant descriptions, and those that constrain the design limit the variety of solutions that may be included in the proposed solutions.

The category of Issues is related to the roles of the document as a discussion document and as means of getting to agreement. Typically, these arise during discussions and meetings as questions about the requirements statements in the current draft or version of the document.

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The recording of issues and subsequent changes to requirements is the means by which the process of reaching agreement is supported by the use of the requirements document.

Another important purpose of written requirements is in recording agreement. What is agreed, and whether this agreement refers to required effects, objectives, or proposed solutions, or possibly also problem domain descriptions and constraints, is subject to a variety of practices appropriate to different circumstances. It almost certainly refers to how issues were resolved due to relevant changes made to any of these. How much documentation is kept on these changes varies, though they may be traced back through different versions of the document, this is not commonly done.

The parties involved, and the level of written agreement that is considered necessary and sufficient, also varies in different situations. These are incorporated in the final main category, Document information. This covers such obvious categories as the Table of Contents and the list of related documents, but also the List of participants, which has considerable importance for the role of the document as a record of agreement. Another outcome of this analysis was the identification of three different levels of agreement that apply in different situations: Contract, Agreed, and Approved. As a result, the new category Recorded Agreement replaces the original main category of Document Information in the following proposed taxonomy of requirements statements. This is essentially a different way of classifying requirements:

1. **Problem Domain Descriptions**, exemplified by Business Rules, Terminology, etc.
2. **Statements of the Required Effects**, e.g. Features, Transactions, Information requirements and Behavioural requirements.
3. **Proposed Solutions**, such as Database structure and Contents, System Architecture, and Prototypes.
4. **Recorded Issues and Changes**, including both open and closed issues and related changes to other categories of requirements.
5. **Defined Goals and Objectives**, exemplified by business cases and market benefits, but also including non-functional requirements.
6. **Specified Constraints**, such as behavioural constraints and design constraints, and
In Chapter 7, these seven different types of requirements as texts will be brought into play as part of an explanatory framework to associate different situations with the elements of the taxonomy appropriate to them. But first, in the next two chapters, a typology of requirements situations will be developed, focusing on requirements as needs.
Chapter 5 An Ontological Analysis of Requirements as Needs

"Think Sideways"

Edward De Bono

5.1 Introduction

The previous chapter looked at 'requirements as texts,' the various types of statements that are used in requirements documents, using a taxonomic approach to analysis and resulting in a new way of classifying requirements. In this chapter, another perspective, that of 'requirements as needs' will be explored, and this will be done using a different style of analysis. The findings presented in this chapter will be based on the consideration of precedence relationships, rather than taxonomic relationships, between categories found in the empirical data.

The previous analysis began with a collection (family) of codes called 'requirements as texts.' This consisted of a large subset of the entire collection of codes from the initial open coding, the first stage of grounded theory analysis. Another, distinct set of categories, in this case, a family of codes called 'concerns,' resulted also from the open coding stage. These were substantive concepts ranging from ad hoc reporting to workflow. My conjecture was that in any particular situation, some concerns would be more significant than others, and greater emphasis would be placed on those concerns. Such variations would provide a way of differentiating between the situations, which was one of the major aims of this research.

This set of concerns formed the basis for the analysis presented in this chapter. Again, like the taxonomic analysis, this analysis corresponds to the second stage of the grounded theory approach, axial coding. The result is a conceptual network showing how different kinds of requirements, considered as needs, are related to each other, and ultimately to their sources. The network identifies eight root concerns as the main sources of requirements.

5.1.1 Sources of Requirements

Where do system and software requirements come from? What are their sources? It became clear that the family of codes I called concerns contained all the important sources of requirements such as the stakeholders, as well as types of actual requirements such as user interface requirements, and intermediate concerns such as changes to the existing system. Requirements exist because someone or something needs them, or because other requirements necessitate them. An obvious example is the existence of user interface...
requirements because of the existence of users Interfaces to other systems exist as a category of requirements because of the existence of a requirement for the system boundary, as well as the other systems. Less obvious examples of such dependencies might be found in the practitioners' accounts of their own situations. This was the rationale and the template I used in looking for relationships between the categories in the code family concerns.

5.1.2 Ontological dependency

Some things depend for their existence on other things. This is called ontological dependency (Stamper, 1994). At its most basic level, it can be expressed as a relationship between two entities, in which one entity precedes the other, the first being the ontological antecedent of the second. An entity may have more than one immediate ontological antecedent, and/or more than one direct ontological successor. Ontological dependency is a transitive, asymmetric relationship.

Stamper (1994) used this relationship as the foundation of a systems analysis technique. MEASUR (Method for Eliciting, Analysing, Specifying User Requirements) includes a step called Semantic Analysis which results in an Ontology Chart of the application domain. The method is predicated on the distinction between substantive objects and semiological objects. Ontology charts model the objects of interest in an application domain. However, the relationships between these objects are not the usual 'isa' and 'is part of' relationships normally found in requirements models, but ontological dependency relationships.

MEASUR uses ontology to distinguish between the substantive objects in a problem domain and the information we have about them. The entity 'Person,' for example, is a substantive object while 'person-record' is a semiological object or, simply, a sign. In semiotics, the study of signs, a sign is a unit of meaning which is interpreted as 'standing for' something other than itself. Information systems function by processing signs such as names and numbers which represent substantive objects that exist in the problem domain. MEASUR's ontology chart focuses attention on the substantive objects of the problem domain, leaving the semiological objects for a later stage of analysis. This distinction is central to the MEASUR approach. A similar distinction can be made in the domain of system requirements, between requirements as needs and requirements as texts, and is central to the analysis of findings presented in this thesis. Having dealt with the semiological aspects of requirements in the taxonomic analysis of the previous chapter, we now focus on the substantive aspects, requirements as needs.
The findings in this chapter are presented as a conceptual network of ontological precedence relationships among the requirements concerns revealed by the practitioners in the interviews, and identified during the open coding stage. The network was constructed using the Network editor facility in ATLAS ti.

5.1.3 Using ATLAS ti to build the conceptual network

A Primary Document (such as an interview transcript) coded in ATLAS ti can be viewed in a window side by side with another window which is a virtual margin for that document. The margin shows the codes that have been associated with the relevant sections of the primary text shown in the main window. The codes that are displayed in the margin can be filtered in different ways, to include or exclude different kinds of codes. One very useful filter is the ‘code family’ filter which allows the user to view only those codes belonging to a selected family, such as concerns. This facility was very valuable in browsing through the different interviews focusing on passages where the practitioners had brought up points about requirements as needs or sources of requirements.

Another facility provided by ATLAS ti was the ability to output, for example, frequency tables, showing the occurrence of each of the (filtered) codes in each interview, with summaries for each interview and summaries for each code. It is important to note that code frequency is not very significant in grounded theory generally, but particularly in this research where the accent was on variety. So, for example, the output table would typically contain several codes that occurred in some interviews and not in others. This underlined the variation in different situations experienced by the practitioners.

ATLAS ti also has tools for visualising the relationships between codes or other elements of the project. The Network editor allows the construction of various network views of the codes, memos, and the empirical data. Drawing a link in the chart creates the relationship between the relevant codes, and importing two related codes into a view automatically includes their relationship link. I used this facility to build an ontology chart, using MEASUR’s ontological precedence relationship, showing how all the concerns were thus related. Although different concerns and consequently relationships were found in different interviews, the idea was to look at the area of requirements as needs as a whole, to synthesise them rather than to analyse the situations. This would be done at a later stage.

The Network editor has various types of relationship links built in, such as the ISA relationship, the relationship causes, and the relationship is-a-consequence-of. A ‘relation editor’ allows the user to create new relationship types, define their appearance and menu.
text, and specify their properties, e.g. whether a relationship is symmetric, transitive, etc. The newly created relationship type then appears in ATLAS ti’s Link menu and can be used to link codes or other objects to each other. I used this option to create a transitive relationship type called Precedes, corresponding to the ontological precedence relationship. This relationship was defined as asymmetric, so its inverse represented the ontological succession relationship.

The nodes of the network thus created were all belonging to the code family concerns, and this code family was gradually reduced, from over 130 codes, to seventy-two codes by a process of proposing and testing ontological relationships between them. Each relationship was tested for goodness of fit, using supporting evidence within the primary texts. Another powerful Atlas tool, the Query tool, helped with this task. Unlike the Text Search tool which queries the data directly, this tool queries the codes, and through them the data. It can be used to look for evidence in the data to support any proposed or actual link between the codes in the network, by searching for particular combinations of codes, using specific query operators.

Three different sets of query operators are used in the Query tool: boolean, semantic and proximity. The boolean and proximity operators query the co-occurrence of codes in the data. For example, boolean operators allow searches for occurrences of Code A AND Code B, but NOT Code C. Proximity refers to the closeness in the text of the codes involved in the relationship being tested. The semantic operators, SUB, UP and SIBlings, make use of the theory expressed in the (semantic) network.

Unfortunately for my purposes, these have a built-in hierarchical bias. The UP operator specifies a query relating a code to its parent in the semantic network. This is very useful for querying the ISA relationship between a pair of codes. The SIBlings operator queries the data for confirmation of two or more codes having the same parent. The SUB operator finds confirmation for the link between a parent code and its child. SUB also works transitively to find data related to all the descendants of a particular node in the network. This facility was intended for use in ISA hierarchies, linking a node with its highest-level parent node as it occurs in the data. The Precedes relationship is different, because it is not hierarchical. It really works sideways, from left to right. The precedence network is partially ordered. It is not a tree, since it has a number of different “roots.” These appear on the left of the network, since they obviously precede their successors.
5.2 The requirements ontology

An extract is shown in Figure 1 to illustrate the structure of the Network. The nodes all correspond to codes from the code family concerns. Codes such as priorities and core requirements are marked with a tilde to denote that they have been previously merged with other similar codes denoting the same concept. The arrows representing the relationships all proceed from left to right. The intended interpretation is that the leftmost concerns come first and everything else comes after that. Project is a root concern. It has no ontological predecessors in the network.

![Figure 1 An extract from the Ontology Chart](image)

These concerns will be familiar to anyone who knows about requirements engineering, and therefore this excerpt is intended to give an idea of how the ontology is structured.

The root concerns are the most fundamental ones and are therefore all placed at the left-hand side of the chart. The other ones are Client Organisation, Users, Business Area, Application Domain, Customer, Project and Product. Each of them is linked by arrows to its ontological successors to the right. The relationships are asymmetric and transitive. Several of the non-root nodes have two or more antecedents. The rightmost concerns (or leaves of the structure) are the most dependent. These include such concerns as Ownership, Shared Vision, Changes, Errors, and Unresolved Issues. The Network chart showing all seventy-three concerns is shown in full in Appendix G.

A larger, more comprehensive ontology chart would contain additional concepts representing all the various aspects of requirements statements (requirements as texts) and requirements processes such as elicitation and validation. This ontology deals only with the substantive concerns which are the ontological antecedents of those categories.

5.3 An ontology of concerns

This section will discuss some extracts from the ontology chart and comment on them. The excerpt shown in Figure 2 deals with typical concerns arising from the fact that requirements
are located in the context of projects which are carried out in organisations. None of the extracts is stand-alone, so the complete set of relationship links for any concern is not necessarily shown. Also, in Figure 2 and in other extracts, the concerns shown (especially those on the right-hand side) have successors which are not shown there but will appear in other excerpts.

5.3.1 Project and organisational concerns
The excerpt in Figure 2 shows some dependent concerns arising from three root concerns, project, users and client organisation. Once a project comes into being, a number of other concerns arise, including the goals and objectives of that project. It also leads to the coming into being of a defined set of stakeholders.

It was not possible from the interview transcripts to find out whether the participants made a distinction between goals and objectives, or if they used the terms interchangeably. The word ‘objectives’ was used much more frequently, about three times as frequently, but the idea of a project having a goal was more clearly expressed. Therefore, I chose it as a node to precede objectives in the network, but not as a root node.

In the literature, some notable requirements techniques are concerned with goals, and some take goals as their starting point (Lamsweerde et al., 1998). As Colin Potts has pointed out, this raises some important questions, like “Whose goals are we talking about?” (Potts, 1997). This supports my finding that goals are not a root concern, they arise from different sources the project itself, the different stakeholders, or the client organisation.

The term stakeholders is a conceptual code used to categorise the many instances when practitioners discussed the phenomenon of the various people involved in projects, but not a
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term in common use by the participants in the study. Stakeholder is a role taken in relation to a particular project. Its existence depends on the existence not only of the project, but also of a set of users associated with the project.

The term users is problematic, ontologically speaking. It is also a role. However, users, as people, exist independently, despite the unfortunate implication that they only exist in relation to systems they use. Some other term would be preferable, but the term 'users' is well established in the field of system development and requirements engineering, so an alternative term would not be appropriate.

The core requirements node is a central concern which arises from the combined effects of the priorities of the stakeholders, the existence of a set of user requirements, and the goal and objectives of the project. Note that we are talking about these as concerns and not as textual components of requirements documents, although many of these codes would have that interpretation also. Core requirements is a category used here to cover the different ways this idea was expressed by the practitioners, some of whom used other terms such as ‘basic requirements,’ ‘minimum requirements,’ etc. Some of them used the term ‘system requirements’ in this sense but their use of this term in a non-technical sense conflicted with different usage by other practitioners, (see quotation) so that it was decided not to include that term in the ontology.

"the system requirements had been defined by the underlying architecture that had been defined for the previous phase of the project. They were standard and they weren’t up for negotiation. The customers had actually seen the system requirements and were happy with them. So this was purely for user requirements."

The concept of ‘Customer’ is a fundamental one in requirements engineering. Practitioners in the study frequently referred to ‘the customer’ but again, a wide variety of interpretations were associated with this term. In some situations, the customer was a member of the same organisation, and synonymous with ‘user,’ but more often the term referred to a separate organisation, particularly in cases where there was a formal contract, in which case the term ‘client’ was synonymous with customer.

To try to disambiguate these terms I have established the following three categories presented here with my working definitions, based on the variety of situations that I came across in the interviews.
Client organisation, because the client is nearly always an organisation, maybe an external organisation, or alternatively, another part of the parent organisation to which the development organisation/team belongs. There is always a client organisation involved in any significant software development. It may be represented by a person called the Sponsor. User, because the user is an individual, who may or may not be directly involved in the requirements process. The user is a person who eventually will use the system. Some systems have thousands of users.

Customer, because the software has to be paid for. The customer may be an individual or an organisation. There may be thousands of customers, or just one. In some situations, the client organisation is the customer. In many other situations, the customer is separate, and may not be engaged in the requirements process.

The practitioners who were involved in developing embedded software for consumer-oriented electronic products typically had Product Managers who represented the (potential) customer. Some of them were developing new versions of products in response to problems reported by customers who had bought previous versions of the product. In the ontology, the concept customer is placed in relation to packaged software, or Product, (see Figure 5) while the concept customer requirements is positioned in relation to the client organisation. This is because the real customer may not yet exist in some situations, though some organisational entity will be appointed to represent the customers' role in the project.

The concepts shown in Figure 2 were frequently mentioned by the practitioners concerned with systems which were intended for use in organisations. Some of their organisations were involved in non-profit activities such as government revenue collection or health administration. These practitioners reported many of the same concerns as their more commercial counterparts. Some of their additional concerns are shown in Figure 3, another excerpt from the network, showing some related concerns related to the domain of commercial business organisations.

5.3.2 Business Organisations
Traditionally, requirements analysis began with an analysis of the existing system. Many practitioners talked about requirements arising from the existing system but it was not the ultimate source of these requirements. The client organisation, whether in-house or of an external customer is a predecessor source.

The concept organisational change is shown in the diagram as an antecedent of issues. This refers variously to the need, or the suggestion, or the possibility of such change, and was
frequently mentioned in relation to issues as discussed by the practitioners who work at developing or configuring systems in organisational settings. For example:

"There was a big shake up in the structure of the management. There were some, old managers who had worked to old methods and saw the new system as a threat and there were some new guys who were very keen on changing things and also on putting their mark on what was happening.

"That wasn't happening in isolation, the whole company was changing. Some of the management had been there for years and years."

Figure 3 Business Organisations

Figure 3 shows another starting place for requirements, the business area. This often gives rise to general organisational objectives, some of which are in turn embodied in the existing system, as well as the specific organisational objectives of the client organisation. A frequent source of new requirements in a business setting is the need for the organisation to respond to new challenges or opportunities. Some very experienced developers I interviewed seemed to be quite concerned about the mismatches they perceived between organisational objectives and trends in the business area they worked in. Such differences will result in the need for changes to organisational objectives as well as changes to systems. They saw themselves as 'agents of change,' responsible for organisational needs, rather than 'order takers' merely responding to the needs of the individual users. For many system developers, these sources of requirements were more important than any individual user or manager.

"I see IS as a service not to other departments or to other people but to the company and in doing that they (we) need to be irreverent about what happens in other departments.

What in fact we've become is order takers. People will come to us and say I want a report that does this. I want to find a place to
Business information systems are associated with specific functional areas which arise out of a business area. This may also be the source of a business opportunity, a concept which was often mentioned in relation to specific business requirements. More generally, frequent mention was made of business knowledge on the part of end-users or analysts as a source of requirements. For example:

"So what we try to do here and I suppose it's what I've always tried to do is first of all understand what we, as a business, want to do. Forget the system, forget the jargon."

5.3.3 Business processes
Since several of my informants were working with tailorable packages for Enterprise Requirements Planning (ERP) systems, frequent mention was made of Business Processes. These are now seen as a central concern in many organisational systems, even outside of the domain of commercial business. As one of the informants stated, "Business processes drive the need for computer systems."

The decision to acquire a particular ERP package is often made as a business decision, for example to gain competitive advantage, rather than as a result of a detailed requirements analysis process. "First of all it was decided that it was going to be SAP, then we began the requirements analysis" is a comment that represents the typical approach to acquiring packages such as this:

"Yes, the quick way is to look at reference sites, that are similar to your business, and decide that way. That's the best way."

"There is a question of course, which has been asked, which is How do I get an edge if all my competitors are using SAP?"
Requirements analysis in the context of ERP packages is a lengthy process that involves documenting hundreds of business processes. Note that the business processes concept that was shown in Figure 3 refers to the existence of these processes in a business area. Advance knowledge of these processes is put to good use by the software vendor in making a package adaptable to the needs of many different businesses.

"We would produce a business blueprint which describes the functionality that we will configure for the client. It is very clear as to what the deliverable will be in terms of how the software will function, a fairly detailed list of functionality in terms of business processes."

5.3.4 Application domain

The concept of the application domain is another fundamental concern of practitioners who work with requirements. Knowledge of a specific application domain or applications expertise as it is called in the ontology was considered indispensable to requirements engineering, in most situations, whether in-house or contractual situations and in most application areas, particularly where technical advances were being made all the time. A good example of the latter was the area of telecommunications.

"One of the problems with customers, as well, is because they are in a fast moving, ever changing environment, some of them will say 'these products are good but no one has really used them successfully' or 'no one, that they know of, has bought them and used them', so they don't want to be the first."

"This was the protocol overview, the overview of how this works, the introduction really to this whole area. I mean you can see there, it's about six or seven pages. It's introduced all sorts of things like the suitability of the different protocols, things like the higher level of security, smart cards, the thing about putting your credit card over the web, stuff like that, about the encryption and so forth."

Applications expertise is also a main driver or source of requirements for software product development.

"We're not warehouse professionals but we've been to fifty warehouses and come from, perhaps, personally, ten or so we pool our experience, naturally. Now the company, I think we could say we know more about warehouses than most of our customers but we don't understand the detailed nature of their work but we do understand how to deal with pallets, how to deal with gravity feed systems, whatever it is."

In ERP systems, the ERP vendor's knowledge of both business processes and application domains is embodied in application reference models (Scheer, 1998). For the practitioners, these reference models are important resources for enterprise modelling, but since models are not substantive concerns, these reference models are not represented in the ontology chart.
This knowledge and expertise guides the development of tailorable packages which are then available in the marketplace for deployment in specific situations. These packages cover all but the most non-standard requirements likely to be found in a given business area or application domain. Some ERP vendors, such as Baan and QAD restrict their offerings to specific markets, called vertical markets, in order to better serve the varying requirements within that specific market.

5.3.5 Tailorable Packages

Tailorable packages are not limited to ERP systems. They are becoming common in many application domains. There are essentially three different approaches to creating a tailorable application package:

1. Customisable software which can be tailored locally by programming extensions to the code.
2. Configurable software which can be tailored by configuration tables designed for the purpose. There may be thousands of these tables in a sophisticated product. One version of SAP reportedly has 18,000 configuration tables. One of my interviewees was working with a configurable package for university student records which had 3,000 tables in it.
3. Component-based software which facilitates the deployment of specific components chosen to suit a given situation.

ERP companies see component frameworks as the future direction for their products, but most products are currently based on the idea of product configuration, with the deployment of components only being done at a very high level, using application modules.

"The point is that it is very heavily parameter driven. This process of setting all those parameters is called configuring."

"So like there are something like 2,500 tables on the system, not tables in the relational database sense but parameter tables. Each of those tables could have a number of parameters that need to be set. So the down-side of this multi-functional and highly integrated system is that because it does all things to all people, you have to tell which of those many things that you want it to do."

"Order statuses, they are again infinitely configurable, you can have as many or as few as you like and you can say that status A can only precede status B or vice versa. And status C can only happen on order types such and such. And again, order types, you can have as many and as few as you like and put whatever conditions on them that you like. And all of that was configuring."

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5.3.6 Market Concerns

Some of the practitioners I interviewed were engaged in developing software products for different kinds of markets. Many of their concerns related to market-oriented software and these can be seen in Figure 5. Markets are considered by practitioners to be made up of existing and potential customers. Rather than use market as a concern in addition to customer, I have made market opportunity (implying potential customers, or additional sales to existing customers) as another source of market requirements. In many of the cases I investigated, the product was already on the market, and the developers were bringing out a new release of the current version, or planning a new version. In general, the difference between new releases and new versions is as follows: new releases fix some of the problems found in the previous release, and are available free to existing customers, while new versions in addition provide new functionality or better performance, or a new platform, but must be paid for, even by existing customers.

In addition to the application domain and the market, the product itself could be a source of requirements, especially when existing customers report problems with the current release. Managing such reports and prioritising the resulting requirements is an important consideration.

Product expertise is another important source of requirements, and of information concerning the interdependencies of requirements with existing features of the product.

Figure 5 Market Concerns

"when you've got a mature product it's getting to where you want to be it's got everything integrated adding on that extra feature becomes more problematic because it has to be consolidated"

"A requirement is a perceived problem, a feature is a benefit"
Features are marketable requirements or groups of requirements. A feature often has several associated or dependent requirements, which customers are not aware of. Features may be treated as stand-alone, although interdependencies between features are considered to be a particular problem in ways that dependencies between other types of requirements are not. It is interesting to note that the concept of a feature exists in the product or solution, as well as the requirements. Unlike a requirement, a feature has continuity of existence, and therefore more visibility and existential integrity than a requirement, which will in most cases be subsumed, along with other requirements, into the functionality of the product or solution.

Another concept is the idea of a bundle.

"Marketable functionality: a bundle is a collection of features specific to a vertical market segment."

For example, medical and pharmaceutical manufacturers are really interested in lot traceability, much more so than food and beverage manufacturers; other discrete manufacturers are not interested in lot traceability at all. So we would put that feature, not in the core product but in the medical bundle and in the pharmaceutical bundle and possibly in the food and beverage bundle.

Like other software systems, software products evolve over time. New versions of products incorporating major new functionality appear less frequently than new releases fixing the reported problems and adding minor new features.

"There is very little difference between development and maintenance here. Certainly, if you look at our flagship product, it just grew and grew and grew."

These intermediate releases are often coordinated at an organisational level above project management, with more than one project associated with each release.

"Because we are dealing with a product that is advanced on a per-project basis, we have requirements for each project. There are usually many projects to a release."

Market opportunities do not wait for vendor companies, so product managers are under the pressure of time constraints to get new releases onto the market. There is usually a trade-off to be made between additional requirements and time constraints, which in turn affect the project deadlines.
This part of the ontology chart can be linked to the concerns shown in the first extract. Figure 6 shows how the project concerns which were shown in Figure 2 could be wrapped around to link to market concerns.

All of the root concerns have now been introduced. All the excerpts shown so far begin with some of the root concerns and do not contain any of the rightmost (most dependent) nodes of the ontology. We will now look at some of the successors to the concerns shown in the various extracts above. These include important aspects such as agreement (a successor to issues), system interfaces, and interfaces to other systems. We also return to the topic of different types of requirements.

5.3.7 Different kinds of requirements

At this stage, it is important to note that all the relationships in this ontology are ontological precedence relationships. There are no isa relationships shown at all, although they are interesting in their own right. I have had to avoid including other any types of relationships, because I want to use the chart to clarify the type of relationship shown, namely the relationship between concerns that precede and succeed each other ontologically.

Also, in order to keep the chart to a manageable size, I was forced to prune it by removing some of the nodes that were descended from some of the concerns that are shown in Figure 7, for example different concerns relating to states, such as transitions and constraints, and relating to reports, such as ad hoc reporting and standard reports. These were found to fit...
much better into a taxonomic style of analysis, using isa relationships, as presented in the previous chapter

![Diagram of requirements categories]

**Figure 7** Types of requirements

### 5.3.8 Different types of solutions

One of the initial aims in building the ontology was to try to trace the paths between problems and solutions, but this aim was not entirely achieved. One possible reason for that is that although practitioners often mentioned problems and solutions, both of these terms had different connotations in different discussions. The variety of problems and solutions might have been better handled in a taxonomic analysis. For example, there were different types of problems—those reported by customers, problems with the process, or with the method being used, problems with the documentation, and problems with proposed solutions, as well as the conception of a requirement as a problem to be solved. But such an approach would not have accounted for the relationship between the requirements as a set of problems, and the range of solutions considered at the requirements stage.

Figure 8 shows several of the ontological descendants of application domain in the ontology. According to my informants who worked in this area, a customised solution was necessary whenever there were non-standard requirements (essentially requirements that had not been anticipated in the chosen package). This was often the norm, despite the increasing popularity of standard packages, such as ERP systems. It is possible to extend many standard ERP systems by customising, but such many practitioners considered customised ERP solutions undesirable because of the likelihood of conflicts with subsequent releases of...
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the ERP product A **configured solution** is currently the preferred approach to tailoring a package

For some situations, it is possible that the requirements are so completely standard that an **off the shelf solution** is feasible, but this was not the norm. Several of my interviewees were working with one specific supplier (of a warehouse package) to customise that package to their needs. Although they were all essentially in need of a system to control a warehouse, none of these organisations could find a suitable **off the shelf package** to suit their needs. In each case, the supplier company personnel worked with the client organisation personnel to document their requirements, before customising a solution to suit their budget and needs.

**Figure 8 Different types of solutions**

Many of the practitioners saw themselves as problem solvers, or even called themselves solution providers, so they tended to look on requirements more as solutions than as problems. For example

**Figure 9 Focus on Agreement**
"We help them come up with the solution that is achievable using the product that they have chosen."

"We propose a technical solution to a business problem."

5.3.9 Agreement

One of the most important concerns discussed by the practitioners was that of Agreement.

The concerns shown in Figure 9 focus on that concern. Note that agreed requirements depended on a number of other concerns, as shown in Figure 10. Several practitioners stated quite clearly that agreement was a separate concern. It is separate from the agreed requirements, and it is "not in the document." One practitioner stated:

“If after the event the system does not meet the requirements there would not be much understanding for pulling out a requirements document.”

In another case:

“We sent back a final list of requirements which was stating the list of requirements they sent us, worded appropriately for where the clarification was necessary, identifying which of those requirements we were going to include in the system and which we felt were outside the scope of the system and they then signed off on what we called the agreed requirements list.”

Figure 10 Agreed Requirements
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5.4 What is meant by a grounded ontology?
Any ontology is a catalogue of terms. An ontology in this sense could have been built by going through all the literature on requirements engineering and picking out all the terms used in that domain, arranging them, defining them, or relating them together. The ontology presented in this chapter was the result of analysing a set of interview transcripts to find out what are things that practitioners talk about when they talk about requirements. The objective was to find out what requirements are all about, and how the practitioners construe both requirements and their sources.

The resulting network is called a grounded ontology because the collection of terms it contains and the relationships between them are derived empirical data gathered from practitioners in the field. As such, it is a grounded theory of how the things represented by the terms (the matters of concern to requirements practitioners) are related in a conceptual network. Using the grounded theory method of analysis provided a systematic approach to the construction and verification of the network.

This process extracted a collection of terms representing the requirements as needs that were talked about by the collection of practitioners interviewed. It then analysed the relationships between these concerns guided by the notion of ontological precedence. The ontological analysis was therefore bottom-up from the level of the concerns, rather than a top-down analysis on an interview-by-interview basis. The result is like a patchwork quilt of all the concerns linked together. Metaphorically, it is an attempt to construct a map charting the overall terrain of 'requirements as needs.' Different individual practitioners have first-hand experience of only parts, albeit large tracts, of this terrain, related to their particular area of practice and experience.

5.5 Conclusions the Root Concerns
It is important to note that the specific relationships explored in this chapter are ontological precedence relationships only. There are no isa relationships shown at all, although they undoubtedly would make sense, between the categories that have been discussed. The purpose of building the ontology chart was to clarify a particular type of relationship, namely the ontological precedence relationship between the requirements concerns that precede and succeed each other. The ontology as it stands focuses on the substantive aspects of requirements, on 'requirements as needs.' It intentionally ignores other aspects, such as requirements as texts, which have been treated separately in the taxonomic analysis of the previous chapter. It could be extended to include these semiological aspects as well.
extensions to include requirements as texts would appear on the right-hand side of the chart, because the relationships read from left to right.

As with any grounded theory, the result is not final or definitive, but open to further work and validation. It is grounded in the data that was available, and could probably be vastly improved by further investigation. To continue the analogy with the map of a terrain, the current ontology of requirements is very like the early medieval efforts at geographical representation showing only the three continents that were known at that time, with Jerusalem at the centre, before more accurate navigation charts began to appear, along with magnetic compasses, in the 13th Century.

The issue of validation will be discussed more fully in the final chapter of this thesis. Each relationship between a pair of codes originated as a conjecture on my part, and was tested by querying their co-occurrence in the data. Because of the varied and unstructured nature of the data, and the fact that these were not questions put to the participants, but issues that emerged from the data at a later stage, some of the relationships in the result were less strongly supported in the data, and others more so. The overall idea was to capture as much variety as possible in the network. The significance of the result is that it demonstrates the idea of an ontology based on this particular type of relationship, and draws attention to the most important sources of requirements.

These sources are essentially the eight root concerns of the ontology: Project, User, Client, Organisation, Business Area, Application Domain, Product, Customer, and Market Opportunity. These and their ontological descendants form the context and background of system and software requirements in the cases which I studied. Some of them are obviously more relevant and more influential in some situations than in others. All of them give rise to several other concerns and in due course, to requirements as needs, and eventually to requirements as texts.

As a whole, the ontology could be regarded as a theory of how the root concerns govern the other concerns. The different extracts that have been presented in the chapter are different views of the whole network, presenting aspects that are more significant in some situations than in others. Each practitioner's 'locus of concerns' if overlaid on the network, continuing the 'map' analogy, would only cover parts of it. Evidence from the interview transcripts, and the existence of gaps in the Codes/Primary Documents Table, indicates that this is likely, though practitioners were not asked about these in a structured way. One of the possible uses of the ontology would be to explore its applicability to a different set of development.
situations, and see if it could be used effectively to distinguish different situations by plotting each situation's locus of concerns and identifying the types of requirements that typically arise in that situation.

A more practical approach would be to take a list of the most fundamental concerns, the root concerns, as the point of departure, and examine how they might be used to differentiate between situations. For example, Client organisation as a concern might dominate the practitioner's concerns in some situations and not matter at all in others, while Market opportunity would stand out as a source of requirements, or not matter at all, in different situations. The matter of a Product, and whether it is being developed for a market or being configured as a solution, plays different roles in different situations, and no role at all in some other situations. The implications of this idea are applied in the next chapter, where the eight root concerns governing requirements as needs are used as the parameters for distinguishing different types of requirements situations.
Chapter 6 A Classification Scheme for Requirements Situations

6.1 Introduction

A working assumption of this research has been that the most appropriate type of system requirements documentation is contingent. That is, it depends on the situation in which the documentation is written and used. System/software development takes place in a wide variety of organisational and contractual situations. However, as indicated in Chapter 1, there is no recognised or widely accepted classification of system/software development situations or at least none suitable for the purpose, so a provisional one is presented in this chapter.

The nature of the relationship between the producers and the users of the software, for example, whether it is based on a formal contract or not, is one possible way to classify system development situations. This takes account of the organisational context of development, but it does not account for some of the different concerns that come into play, for example, when the target system consists of embedded software rather than an enterprise application. It is not useful, even if it were possible, to categorize situations by the problem frame of the target software because most systems of any reasonable size and complexity correspond to more than one problem frame (Kovitz, 1999).

Another possible way to categorize situations is by the application domain, but so far, there is no established taxonomy of software applications (Glass and Vessey, 1995). Robert Glass and Iris Vesey surveyed a number of published classifications of software applications, but found no convergence. This is possibly because, as they point out, taxonomies are specific to the purposes for which they are used.

This makes sense. Some plants are classified together for cooking and serving, but in separate categories for the purpose of propagation and cultivation. A cookery book will classify rhubarb as a fruit, and a tomato as a vegetable, whereas a gardening book will classify them as a vegetable and a fruit respectively.

The purpose of the classification of requirements situations proposed in this chapter is to identify the major concerns that drive the requirements process and thereby suggest which are the appropriate types of statements of requirements to be used in each situation.
classification is provisional, because it is based on a limited number of cases, but it is a framework capable of being extended.

Rather than a taxonomy, or hierarchical classification, it is similar to a faceted classification (Leigh Star, 1996). Faceted classification is an approach to classification in which items are allocated to different classes depending on the values they assume under each of a series of headings or facets. These headings represent the salient characteristics of the items being classified. This approach to categorization has been proposed for the classification of knowledge, as an alternative to the well-known hierarchical Dewey system of classification that is widely used in libraries (Leigh Star, 1996).

The main advantage of faceted classification is that it is much more flexible than a hierarchical system. Hierarchical classification systems are fixed. They do not readily accommodate new items, nor do they easily allow for growth and expansion. Faceted classification is much more adaptable and open to the inclusion of new items in the framework. It does this in two ways:

1. New items can be distinguished in terms of their different values under the existing headings, and
2. Additional new headings or facets can allow for more dimensions of discrimination between the items.

6.2 Making sense of situations

A situation is the set of circumstances which form the context for some phenomenon of interest. Circumstances are not orthogonal in their effects. In any situation, it is the particular combination of circumstances that makes the difference to the situated phenomenon. A set of aspects or facets therefore works reasonably well as a scheme for describing situations in terms of their circumstances.

It could be argued that each situation is unique, and that, therefore, there is no satisfactory way to classify situations. But different situations have at least some things in common, and these help, not only to describe situations, but also to classify them, for some purpose.

It could be argued that the influences or factors affecting a situation, which create that situation, are not only the immediate ones, but include a whole range of broader conditions beyond the level of the phenomenon being investigated. It could also be argued that local, individual, or personal factors also have a bearing on particular situations. In grounded theory, this is explicitly recognised and formulated as the Conditional Matrix, (Strauss and
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Corbin, 1990) This is an analytic aid containing several concentric circles representing the various levels of conditions and consequences, from the outermost international level through national, community, organisational, and group levels, to the individual and interactional levels. Any phenomenon, for example, decision-making, can be studied at any of these levels, for example, the organisational level, but in doing so, the effects of the other global and local levels cannot be ignored (Strauss and Corbin, 1990)

In order to take a broad view of system/software development situations, my assumption, based on the interview data, is that it is sufficient to look at them at an organisational level. Therefore, in order to classify such situations with regard to requirements documentation, it is necessary to focus on the sources and influences at this level that generate and shape the requirements themselves. For these reasons, the facets which are proposed for this classification of system development situations are the main areas of concern in those situations. They are the sources of the requirements. They are the main influences on the task of documenting requirements. My conjecture is that the eight root concerns developed in the previous chapter, namely, Project, Users, Client Organisation, Business Area, Application Domain, Product, Customer, and Market Opportunity can be used as the main headings of a classification system for requirements situations.

6.3 Selective coding

This is the third and final level of grounded theory analysis and is concerned with selected ‘core categories’ and their relationships. At this stage, the grounded theory begins to emerge and dominate the analysis process. The process I followed at this stage was basically as follows. One by one, I looked for and identified typical situations among the cases in the interview data that could be set apart from other situations using the eight root concerns as distinguishing criteria. The first type of situation identified I called the Problem-oriented Situation, in which the requirements document is typically created by the Customer in the form of a Request for Proposals. I found that two of the criteria, Market opportunity and Product had no relevance at all in this type of situation. However, I used this fact to help distinguish it from other situations. The other main headings, such as Project and Users, and some of their immediate ontological successors, such as the Scope, Interfaces to Other Systems, and Stakeholders were important criteria in characterising this type of situation.

As a general point, it is worth noting that some of these criteria do not always apply in all situations, and this helps to distinguish the different types of situations. Also, I found that I could use the extent to which each root concern applied in a situation, in terms of the impact of its various ontological successors on the requirements, to explain the distinctions I was
finding This confirmed the root concerns as fundamental influences that drive the requirements process, because they are the main sources and generators of requirements. To the extent that each does not have the same or equal influence in all situations, they help to distinguish situation types.

The existence of the Problem-oriented type of situation suggested that there might also be a Solution-oriented type of situation, but it was not as simple as it seemed. As it turned out, there were different types of Solution-oriented situations, that I could identify in the cases described by the practitioners. Two of them were custom-built solutions, the other being a solution configured from a product, and two of them were contract-based, the other being an in-house solution. I named the three situation types:

1. Contract for a custom-built solution
2. Contract for a configured solution, and

Problem solving could be regarded as the main focus of most system development activity, including the process of discovering and agreeing the requirements for the system. However, in practice, problems and solutions are not always clearly distinguished from each other, because they are inter-related at different levels. Solutions at one level form problems at the next level. According to many of the practitioners I interviewed, the purpose of a requirements document is not always to state just the problem, but often also to state an outline of the solution, or the constraints on the solution, or the nature of the solution.

An extreme form of solution-oriented situation is where there is a market for a certain type of ready-made solution, and this is developed to be sold to customers as a product. The function of the requirements document in such situations is to enumerate features of the product which will solve the problems of many or at least more than one customer. I called this a market-oriented situation to distinguish it from situations where solutions are developed for single clients or customers, which I called solution-oriented situations. I was able to find three different types of market-oriented situations among the situations discussed by the practitioners. I called these:

1. Product for a vertical market
2. Product for targeted customers, and
3. Product for a single customer.

The third category of market-oriented situation overlaps in some respects with the first type of solution-oriented situation, because there is a formal contract involved, but there are other aspects (concerns) which are different for this type of situation, as will be explained later in the profiles of the different situations. This category underlines a major problem with using
a hierarchical classification, and the benefits of using a faceted classification. The category is identified as a separate category because it has a characteristic profile of concerns. It does not fit neatly under one heading, such as market-oriented, or another, such as contract-based, but slots in between other situations, having some aspects in common with each of them.

However, for presentation purposes, and to help the reader to cope with the amount of detail involved, these three main types of situations may be broken down hierarchically as follows and will be presented in the following order:

A. Different types of Market-oriented situations, i.e.
   1. Product for a vertical market
   2. Product for targeted customers, and
   3. Product for a single customer

B. Different types of Solution-oriented situations, i.e.
   4. Contract for a custom-built solution
   5. Contract for a configured solution, and
   6. Custom-built in-house solution, and finally,

C. Problem-oriented situations, essentially one type
   7. Problem-oriented

In the remaining sections of this chapter, these seven different types of situations are characterised and differentiated from each other by the emphasis and priority they place on some or all of the major root concerns, such as the Users, the Customer, and the Client Organisation, and also by the impact that their respective related concerns (ontological successors) have on the requirements process and the requirements themselves. Each situation type is presented as a descriptive profile, linked to the situations described by the practitioners, and abridged in a table where I summarised the interview findings in a general way. The construction of these tables was an important part of the analysis process itself. The final section then compares and contrasts the different situations.

6.4 Seven profiles of typical situations

A key distinction between market-oriented and other situations is the focus on the customer, as distinct from the user. In market-oriented situations, it is much more important to have satisfied customers, than to have satisfied users.

Among the cases reported by the practitioners interviewed, I have identified three different types of market-oriented situations which I called:

1. Product for a vertical market,
2. Product for targeted customers, and
3. Product for a single customer
Clearly, this categorization of market situations is not complete, because I have no situations where there are many customers (e.g. mass-market products, such as office products, games and other commodity software of the type sold in shrink-wrapped boxes) I have not had an opportunity to study mass-market situations at first-hand, but have gleaned enough information from reports in the literature to know that they are different in several respects from these other market-oriented situations

6.4.1 Type 1 Situation Product for a vertical market
This situation typically occurs where software products are being developed in response to a perceived need in a particular market, either covering a well-defined application domain or a specific set of customers in a segment of a wider market The software company aims to become successful by responding specifically to the requirements of a well-defined subset of a larger, wider market The software company may in turn divide its market into a number of segments (verticals) in order to more fully address each of their needs

"We are very lucky because we have a focus on (depending on who you talk to) five or six verticals, all discrete manufacturers We have a tight focus on what these people need "

Like other market-oriented situations, the vertical market situation is characterised by projects which identify specific priorities among the requirements, and which have strict deadlines which are tied to market time constraints, for example planned marketing and advertising campaigns, upcoming trade shows, announcements, and anticipated competitors’ product releases In this type of situation it is common to have multi-disciplinary project teams consisting of business analysts, marketing people, designers, programmers, testers and others with product expertise working together to define the requirements for the evolving product

In common with mass-market software, in a vertical market, it is quite common for successful products to evolve over the years, gaining market share and additional customers as more features are added with each new release There may be several projects going on simultaneously to extend, enhance and fix the product Requirements are managed on a project-by-project basis, as well as a product basis In many of these situations, the scope of a project is much smaller than the scope of the product There may be two or more levels of planning in the organisation, typically, product planning and project planning

Market requirements have a strong influence on the requirements that are input to product planning

"It seems to be this interaction between industry analysts, market analysts, CEO’s, Forbes magazine, whatever it is These people seem to set the agenda in enterprise software They raise the
All requirements are assigned a priority value, which can be based on perceived market value. Product requirements are selected for implementation in a project on the basis of priority. Within a project, even during implementation, requirements of lower priority may be dropped from that project, i.e., postponed until a later project, in order to keep to the project deadlines.

Like other market-oriented situations, requirements definition is done without much involvement by users, who are not directly involved in the process. Although some companies may specifically address usability design, it does not seem to be important at the requirements stage. I have not come across any cases of market-oriented situations where users were directly involved. They might be represented in focus groups or by user groups for example, or their interests taken into account in other ways, but they are never genuinely involved in mandating, reviewing, or approving requirements in a market-oriented situation. This factor distinguishes Market-oriented situations from those classified as Problem- or Solution-oriented situations.

The internal client organisation seems to play an important part in the vertical market situation. A hierarchical organisation of Product steering committees and Project steering committees plans and oversees the introduction of new and improved products. The approval of these committees is an important milestone in the project.

The role of the customer (as distinct from the user) in helping to define requirements is important in the early stages of requirements process. Some customers are more influential than others, maybe having more installations of the product, or somehow, more clout in the market.

"We have core accounts perhaps, that are saying if you really want to keep our business, then you'd better develop."

The influential customer suggests a list of requirements, the marketing people have their say, the consultants and business analysts have their say, and product steering committee have their say.

"At that point we have got away from the list of things the customer would like to what we want to do, that's when we start making the hard decisions."

Product planners help to determine the cost of development and marketing people help to determine the value of each item of the list of enumerated requirements, rated for complexity and for priority, before product requirements are allocated to projects.
knowledge and product expertise are important inputs to this process, and these are embodied in various groups of business analysts and designers.

Requirements tend to be grouped in various ways, as discussed in Chapter 5, page 89. One way is to group requirements around a feature. A feature is "marketable functionality," listed in sales brochures, that tends to be supported by a number of other dependent requirements that are not mentioned in the brochure. Another way to group requirements is in bundles. A bundle is a collection of features marketed to a specific section of a vertical market as a product variant.

<table>
<thead>
<tr>
<th>Areas of Concern</th>
<th>Type 1: Product for a vertical market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Product requirements are allocated to Projects which are related to Releases. Priorities for the next release of the product are influential.</td>
</tr>
<tr>
<td>Users</td>
<td>Focus groups are often used in the discovery of user requirements.</td>
</tr>
<tr>
<td>Client Organisation</td>
<td>Different levels, for Product Planning, Project planning.</td>
</tr>
<tr>
<td>Business Area</td>
<td>Not relevant unless it is the Application Domain. If so, Functional areas and Business knowledge are important.</td>
</tr>
<tr>
<td>Application Domain</td>
<td>Knowledge of Regulations or codes of practice in the target market is an important source of Common requirements</td>
</tr>
<tr>
<td>Product</td>
<td>Each release contains selected features, so the scope of the project is much less than the scope of the product.</td>
</tr>
<tr>
<td>Customer</td>
<td>There are many customers, but not on the scale of 'mass-market' situations.</td>
</tr>
<tr>
<td>Market Opportunity</td>
<td>Products evolve in Versions in response to market opportunities Bundles of features are developed to address different market segments.</td>
</tr>
</tbody>
</table>

Table 6.1 Type 1 Market Situation: Product for a vertical market

6.4.2 Type 2 Situation: Product for targeted customers

"... the idea being that the customer will help us define a functional product. So we have to balance the needs of the first customer with the needs of the marketplace."

In this type of situation, compared to the vertical market situation, there are fewer customers in the market, and consequently they each have much more influence on the inception and development of products. Typically, there is a Product Manager, or other 'customer-facing' person responsible for the requirements. This normally involves the writing, approval and customer validation of a requirements specification. During the project, particularly the early stages, interaction with the target customers is regular and frequent, in order to ensure that there is a market for the end result.
Another contrast to the vertical (and mass-) market situations is that the product tends to be a new product, or a radical re-design of an older one. This situation tends to occur in markets where the underlying technology and what it can achieve are rapidly changing, such as in the telecommunications market.

Requirements in this situation come from two main sources:

1. External, i.e., a customer demand
2. Internal, i.e., anticipated market demand, or features defined in standards

Internal requirements can be proposed, or suggested for inclusion in the product, by product management or any development personnel, with the relevant product expertise or application domain knowledge. Typically, the process is started by an enquiry from a single customer, who may submit an Invitation to Tender. The Product Manager works closely with this potential customer to define the requirements, and with the more technical development personnel to determine the cost of the proposed product, whether a solution already exists, or to what extent the technology exists. A market analysis is undertaken to determine the value of the product, how much other demand there is for it in the market. The resulting document may be called a Business Opportunity Specification. Its purpose is to provide the basis for a decision whether to proceed to develop this product or not. If it is successful, the project goes ahead and a detailed requirements specification is prepared.

As well as the customer’s requirements, the requirements specification includes system requirements and possibly standards. In these situations, system requirements tend to be distinguished from the customer’s requirements:

"They were standard and they weren't up for negotiation, they'd actually seen the system requirements and were happy with them."

Many of the system requirements are generic, rather than project-specific, and like the standards, may be extracted from a database of requirements or they may be drawn from similar or previous products, or from system architecture designs.

The customer who submitted the initial enquiry plays an important part in the process of validating the requirements specification, and possibly the test specification, but there is no formal contract with the customer in this type of situation. However, it is important to have the initial customer’s cooperation, in order to ensure that there will be at least one customer willing to buy the finished product, but the aim is to sell the same product, more or less, to at least two or three other targeted customers. For example, key users (from the customer side) may help to define and/or validate requirements.
"So we take their ideas and their requirements and try where possible to genericise them and make them applicable to a number of other clients potentially rather than build something into the application which is particular to that first client."

If the first customer withdraws from the project, this does not mean the project will be cancelled, once it has been approved, as the market analysis has shown that there is a demand for the product.

The requirements specification goes through a process of review and revision, before being approved by the internal organisation. This approval is a milestone which establishes a baseline set of requirements, after which changes must be controlled and managed. In a dynamic market, it is important to be able to react to changing market requirements, as each extra potential customer may add considerably to the revenue from a product, but as in any project, it is important to control the scope of the requirements.

"It is an agreement of what we desire from the system. What actually gets produced depends on a couple of issues – it is not contractual."

Targeted customers agree to participate in field trials of early releases of the product.

"You basically have maybe ten to fifteen new features in each particular software release. We have a couple of customers at the moment who are in a field trial with this box."

However, these customers are not as deeply involved in the project as might be wished by the development organisation, in terms of their commitment to the product.

"I think the level of involvement within the customer organisation was yes we need to get some requirements to them and then it is their problem to build that, and we have got two or three key users and I am sure that they can make sure that the system does what it is supposed to do. But for these key users this is very much of a part-time task."
### Areas of Concern

<table>
<thead>
<tr>
<th>Areas of Concern</th>
<th>Type 2 Product for targeted customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>The requirements are subject to informal Agreement with the target customer, and subject to formal Approval by the internal Client Organisation, either at a higher level, or peer level</td>
</tr>
<tr>
<td>Users</td>
<td>Key users from the customer side may help to define and/or validate requirements. But it is difficult to get users involved</td>
</tr>
<tr>
<td>Client Organisation</td>
<td>A combination of an external client and internal organisation. Often seen as joint development</td>
</tr>
<tr>
<td>Business Area</td>
<td>A source of Common requirements for the Product</td>
</tr>
<tr>
<td>Application Domain</td>
<td>Understanding of the application domain, e.g., relevant Standards, etc. The Product is state of the art in that application domain</td>
</tr>
<tr>
<td>Product</td>
<td>Features of the Product may interact with each other, requiring a high level of product expertise</td>
</tr>
<tr>
<td>Customer</td>
<td>Few customers, compared to vertical market situation. Some of them may have considerable application expertise. Customer representatives validate requirements</td>
</tr>
<tr>
<td>Market Opportunity</td>
<td>Additional market requirements help to add value to the product. Time to market is critical. Additional platforms may be another source of system (technical) requirements</td>
</tr>
</tbody>
</table>

Table 6.2 Type 2 Market Situation Product for targeted customers

### 6.4.3 Type 3 Situation Product for a single customer

In this situation, the developer has only one immediate customer. The software is being developed for the market, but there is a contract in place, either with developer's parent company, or with a contracting customer. In contrast to the other market-oriented situations, in this case the client organisation is external rather than internal. The product manager works for the customer and represents both the customer and the user. In contrast to other contract situations, which will be dealt with later in the chapter, in this situation there are significant market-oriented concerns.

Typically, a product, or more likely, part of a product is being developed by a software house on behalf of the customer. This type of situation often pertains in the development of embedded software.

"We do basically the application layer and the team over in Belgium does the driver layer. So the customer would have a person who effectively manages all the software for the product."

The immediate customer for the software may be a larger, more well known (brand) name than the developer company, and may be represented in the project by staff who are extremely knowledgeable about the product as well as the application domain.

"They contract us to do a particular job, but the guy we would deal with is the Product Manager, so we agree with him what exactly we're going to do."

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The eventual customers for the encompassing product (often consumers) are much less directly involved than in the other market-oriented situations discussed earlier. The marketability or value of features is of much less concern to the developer company, compared to other market-oriented situations. Relative priorities among the requirements are not a major concern, or may not be considered at all.

Like other market situations, the product and, consequently, the project will be influenced by market time constraints that give rise to contractual deadlines. Compared to the other market situations, these are more likely to be strictly enforced, but without the flexibility to drop features or requirements that may be lower priority.

A single version of the product is the concern in such a situation, so the project is more of a concern to the developers than the product. It may be a new version of an existing product, so the existence of reported problems with previous versions will influence the requirements.

The relationship between the immediate customer and the developer company is typically managed by two people, generally engineers because of the type of product. There is usually a product manager on the customer side, and a project manager on the supplier side. The initial requirements statement comes from the product manager. In one particular instance, this was a document called the URS (User Requirements Specification), so-called because it was written from the point of view of a user using the equipment, in this case a recordable CD player.

"the URS, which is the product manager's document, in which is specified hardware and software requirements, user-level requirements of what he expects the player to do"

The project team then works closely with the customer's product manager to refine, elaborate, and agree requirements, because the product manager's document is not detailed enough to define the agreement between them. The more detailed document, particularly for embedded software, might be called the behavioural requirements document.

"What we agreed with the product manager is, the contract is based on this document and this document supersedes his document so we get him to review our one and if he says it's OK then this is the, kind of, if this says it should do something then it should do it"

The application domain is not usually a business area, but some other domain such as consumer electronics, industrial equipment, etc. The functionality of the product is understood in terms of its behaviour, how it reacts to a set of externally visible events.

"So, these are events that the application perceives. So, obviously, you have all the keyboard stuff, then you have events coming up from the drive as such, and then you have other..."
To the practitioners, it is important that this document be complete, in the sense that it covers every feature that the product must have and every function it must be able to do. In embedded software, this means that the product must be able to handle every event, or more precisely, every possible combination of state and event, and the document must be specify these:

"So, what we tried to do is to evaluate the response of the system to each event in all possible relevant states of the variables."

Everybody must understand and agree what the response of the product is supposed to be in every single combination of state and event:

"Now, it may happen that we either didn't cover this case, the case in contention, or he didn't understand fully what it would mean to us so then the document is taken as, kind of, complete in that is what we will produce so if he wants something different then he will put in a change request on the document."

<table>
<thead>
<tr>
<th>Areas of Concern</th>
<th>Type 3 Product for a single customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>There is a formal agreement with the Customer, represented on the Project by a Product Manager. There is an Agreed deadline and little scope for selecting requirements based on priority.</td>
</tr>
<tr>
<td>Users</td>
<td>The role of user representatives is played by developers, not real users.</td>
</tr>
<tr>
<td>Client Organisation</td>
<td>The client organisation is the external Customer.</td>
</tr>
<tr>
<td>Business Area</td>
<td>Domains other than business areas. A deep understanding of the application domain is an important source of requirements.</td>
</tr>
<tr>
<td>Application Domain</td>
<td>Product functionality is understood in terms of its behaviour, how it responds to events, and its behavioural constraints.</td>
</tr>
<tr>
<td>Product</td>
<td>The external Customer may in turn have many customers, typically consumers.</td>
</tr>
<tr>
<td>Customer</td>
<td>The project is not usually concerned with other opportunities, except as a source of new contracts.</td>
</tr>
</tbody>
</table>

Table 6.3 Type 3 Market Situation: Product for a single customer

6.4.4 Solution-oriented situations

While market-oriented software development is concerned with creating generic off-the-shelf solutions in situations that are relatively removed from the context where these solutions will be deployed and used, solution-oriented development is more concerned with delivering a solution in a specific situation of use.
Solution-oriented development seems to be particularly associated with the organisational use of systems. Organisations vary in many ways, in their goals, in how they are structured, in how they interact with their environments, and in their size and complexity. It follows, then, that organisational system requirements vary quite considerably. The systems that are used in an organisation are in a sense embedded in that organisation, and therefore, requirements for them need to be specified in situ.

One of the most important concerns in solution-oriented situations is the concept of a business area that the client organisation is engaged in, and that in turn gives rise to concern with the business need for the system. A large system might involve several business areas:

"...each subgroup being assigned a particular business area, for example, there was the Production Planning and Control and the Marketing area actually, as that was seen as being so closely aligned, there was Finance, there was Human Resources, there was Materials."

Because business organisations interact with their environments, and to a certain extent may be controlled by their environment, their requirements can derive from a wider context, for example:

"Well it very much influences the way in which we do things because we're a company with 50 people. Our partner companies are companies with tens of thousands of people. Our parent companies are companies with tens of thousands, if not hundreds of thousands of people. We don't have very much clout in terms of making them do things the way we insist on them being done."

"A regulation enforced in the EC is a regulation enforced in this country as well, so you can be driven by outside forces."

As discussed in chapter 5, pages 83 and 84, organisational change is a common source of disagreement and issues, particularly where organisational systems are being developed. This can lead to many difficulties in agreeing what the requirements are going to be, and so, the needs of different constituencies, such as different groups of managers, need to be addressed.

"The older managers were keen that they would get the same support that they were getting already. They just wanted to ensure that they wouldn't lose anything while the newer managers wanted new things."

Many organisations are now turning to standard packages to support their organisational information systems. The same “standard solution” may seemingly be deployed by organisations as widely diverse as banks, hospitals, government departments, and manufacturing companies.

It is recognised that organisations must be able to change and adapt, and to change their information systems, as their environments are constantly changing. Having a configurable
system is considered to be a great help in this regard, because the same basic system can be adapted to many different configurations, as business processes are changed. This change is often called Business Process Reengineering (BPR).

"Once you install SAP, it allows you to go ahead with BPR, because it is configurable."

However, much technical work must be done to configure the software product, and before that, to determine the organisation’s requirements, before such a solution can be deployed in the first place. Compared to market-led situations, the influence of the end users and their organisational context is much stronger in solution-oriented situations. The influence of a product is there when a standard solution is being deployed, but the influence of the project and its related concerns is stronger when there is a contract between two parties.

These situations often involve the requirement for a complementary manual system also. A considerable difficulty that is often overlooked in deploying an automated system, especially one that is embedded in an organisational situation, is the problem of making sure that it is used in a systematic way.

"The process of defining what a software system should do in many ways just involves clarification of what a procedure is. If you’re not able to do that, if you can’t define requirements."

I have identified three different solution-oriented types of situations among the cases in the interview data. These are (currently) called contract for a custom-built solution, contract for a configured solution and custom-built in-house solution. These categories are not final, as other solution-oriented situations can be envisioned.

For example, it is possible that some organisations acquire a standard package and configure it in-house, but I have not come across any instances of this. Such a situation, if it exists, would have some overlap with two of the types of situation identified above, and could be called an in-house configured solution.

All of the practitioners I interviewed who were involved with standard packages, whether as customers or suppliers, reported on projects which involved configuration, not customisation. Where a standard package is used, but needs a considerable amount of customisation, as distinct from configuration, then a situation arises similar to that where there is a contract for a custom-built system.

6.4.5 Type 4 Situation: Contract for custom-built solution

"A very good case can be made for not outsourcing, but the commercial reality is that you would be compromising on what is available outside the company."

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"But you are not going to get the best solutions without specialist skills and you get this when you are using an external company."

In this type of situation, an external software development company, such as a software house or a consultancy company, has a contract with a client organisation to develop a customised solution to meet the requirements of the client. This situation is much less common than it used to be, due to the wider availability of standard tailorable packages which cater for most common organisational and business requirements. However, many organisations continue to have non-standard requirements that for one reason or another cannot be completely satisfied by any of the packaged solutions on the market, and so, this type of situation of bespoke development continues to occur. The detailed requirements are generally agreed between the supplier and the client organisation, but they are defined by the supplier, not the customer, because

"In most cases clients haven't gone to enough trouble themselves to produce a good, clear requirements document."

The project is an important focus of concern, particularly in relation to the stakeholders and their objectives. In common with other solution-oriented situations, and in contrast to market-oriented situations, the users of the system are often closely involved in the project.

Because there is a contract between (normally) two parties, there is only one customer, and that is the client organisation, and the needs and objectives of that organisation are the main drivers of the requirements.

"In recent times we have actually set up a corporate policy of objectives and the theory is anyway and the theory I stress is that we are only supposed to be addressing projects that actually meet the aims of the organisation, the critical success factors of the corporation, right."

Typically, the organisational objectives of the client take precedence over any individual user requirements.

"Inevitably the person using the system is very immersed in the detail and they come to you with a list of requirements. The systems analyst really needs to look at the whole process."

If it is a fixed price contract, which it usually is, the supplier organisation needs to take steps to reduce the risk inherent in the project. The supplier needs to control costs, and these are related to the scope of the system, which needs to be managed. This is usually done by focusing on the solution, and how much implementation work is going to be needed.

"We are much more in the business of, they tell us what the problem is and we suggest the solution, we might try to clarify the problem, and then implement a solution."

"So we propose a solution in technical terms, so we don't really propose the business solution if that's what you are asking. We propose a technical solution to a business problem."
"At the end of our analysis phase, we should have, in business terms, what the solution is. And how it is going to function. From then on, it's implementation."

Negotiating and agreement are important concerns in any contract situation. The client personnel and the supplier personnel typically work closely together in a joint effort to establish and validate the requirements. This process takes place in the course of many meetings and discussions.

"...and there would be minutes of meetings when there were discussions about the prototype and about the functionality that was required."

"If people pushed you for one thing rather, you could say look well if we do this, you can't have the other. I mean, it was a huge negotiation exercise of, well, if you want this, you are looking at, you are going to be three months later or whatever it is."

"The best way I know, the way that requirements have normally been captured in any project I have ever worked on, was the way I have just described, which is meetings, people writing documents, circulating them, having reviews, that sort of stuff."

In a large organisation, these meetings might take place at various levels of responsibility, such as steering committees, in addition to project team meetings.

"Steering groups were set up within the organisation itself, steering groups were set up with the trade bodies, with the software houses, with our network suppliers and basically we serviced all those groups in some way."

In some cases, there may be a lack of commitment on the part of the client organisation, or parts of it, to the project, and the external company has to take control of the situation, or it will lose money on the project.

"I think the process has to be much stricter, it has to be a tougher approach, when it's two different companies. It's in our business to make money from them, and we are going to lose money if they don't provide the commitment that is necessary from them to make a success of the project.

"So there needs to be commitment on both sides, and sometimes clients, well they may be disorganised, or they may be overstretched with other commitments."
### Type 4 Contract for a custom built solution

<table>
<thead>
<tr>
<th>Areas of Concern</th>
<th>Type 4 Contract for a custom built solution</th>
</tr>
</thead>
</table>
| Project          | The Scope of the project must be managed and controlled  
|                  | There is an agreed Deadline and milestones |
| Users            | Individual User Requirements are less influential than the Organisational requirements |
| Client Organisation | Negotiating between the Client Organisation and the supplier organisation is significant  
|                  | Client Organisation IS/IT personnel may also be influential |
| Business Area    | The Existing System may be a source of knowledge about the Business Processes and Workflow  
|                  | The Solution is seen in terms of Functions |
| Application Domain | Non-standard requirements may be significant  
|                  | Application expertise on the part of the supplier may be useful |
| Product          |                                             |
| Customer         | The Customer is the Client Organisation     |
| Market Opportunity |                                         |

Table 6.4 Situation Type 4 Contract for custom-built system

#### 6.4.6 Type 5 Situation Contract for a configured solution

"The typical project we do involves putting in SAP as fast as possible."

In these situations, the commercial software product is usually selected in advance, and the aim of the project is to configure that software to the client organisation's requirements as quickly as possible.

The solution provider personnel are typically very knowledgeable about the product and its capabilities, and the requirements task is essentially to describe the client organisation’s requirements in terms that correspond to the functionality supported by the product. The users and their requirements are taken into account to some extent, but because these products typically serve to integrate enterprise applications and data, the organisational requirements are much more dominant than any individual user's or manager's requirements.

"The integration manager. That was somebody who knew all of what the package did and his job was to ensure that the business model that was going to be put onto the SAP system for materials, for example, was not in conflict with something that the finance people wanted to do, because it is a very integrated system and it is important that everybody's requirements are cognisant of everybody else's, so that was the integration managers job."

Similarly, the Business Areas which are covered by the project, in terms of their business processes and workflow, are an important influence and source of the requirements. Some form of business process engineering is typically part of the process of configuring a solution. This typically takes place as a series of group meetings, often called Workshops,
and their purpose is to focus on the different business areas and business processes of the organisation. Representative users play an important role in these workshops, together with the internal IT department and the solution provider company's personnel.

"What it involved was, we worked in big group sessions, the way we organised the people was we had what we called alpha users from each department, so there was somebody from, say finance, a long term employee of finance, and similarly materials and human resources and so on."

"What we did was we sat in a room and we said okay we are going to have materials management, we are going to have finance management, we are going to have human resources etc so it was a structured approach."

"There will have to be materials management, so what does that actually mean, so we'd break it down and we'd say well there is going to be inventory control, there is going to be reporting requirements, there is going to be receiving, there is going to be purchasing, there is going to be issuing, and then we'd break each one of those down even further."

Typically, describing these business processes leads to the identification of issues which must be resolved in relation to the capabilities and functionality of the product.

"...things like that, would we want to do, for example, to do weighted average pricing, would we want to do straight list pricing, things like that, costing of the inventory that would be rather than pricing, that kind of stuff would come up. So we'd list those issues and then we'd resolve those issues one by one and in the type 2 document there would be a list of the issues and what decisions were taken and why they were taken."

In a sense, the requirements are functions selected from the vast range of functions which can be supported by the product. This is in contrast to other solution-oriented situations. The functionality of the product embodies and represents the knowledge of the application domain, which would otherwise be a basic and immediate source of requirements. This knowledge is contributed to the project by the solution provider personnel, and combined with knowledge of the relevant business areas and business processes elicited in the workshops, is a major source of requirements for the configuration process.

"If you've made the decision that you were going to implement SAP, then it's a good idea. It's a pragmatic way of achieving an implementation."

Agreement between the parties is always an important concern in contractual situations, and contracts for configured solutions are no exception. Similarly to situations with customised solutions, project risk, costs and project scope are also significant concerns. This is similar to the customised contract situation, in that the requirements are typically described in terms of functions.

"We would produce a business blueprint which describes the functionality that we will configure for the client very clear as to
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what the deliverable will be in terms of how the software will function

"Scope is very important, so that you don't get runaway costs and also, on the other side, to make sure you're not missing anything for the client

"There is still the problem of scope creep Maybe scope creep is the wrong term for it We would give a certain amount that we never signed up for, it happens"

Requirements creep happens, probably more so for configured solutions than for customised ones, for two reasons One reason is that the effort involved in configuring extra functionality is considerably less than that involved in implementing it from scratch The other reason is the phenomenon known as IWKWIWTISI or "I won't know what I want until I see it"

"One thing you need to control with SAP, once you start working with the client and they see the functionality that is available with the product like SAP"

"When we start project it is very much led by the consultant but then later the client will begin to see what can be done and say hey we could use that and You say yes you could do, that wasn't what we are addressing"

A traditional problem that arises between system developers and users, particularly in regard to organisational systems, is the knowledge gap between them The developers understand the software, while the users do not, and the users understand the business, while the developers do not Configured solution providers aim to overcome this problem by acquiring specialist knowledge in particular business areas as well as having expert knowledge of a particular product Still, it is difficult to remember to speak to the users in the language of their own business, because the vocabulary of the product tends to dominate the solution provider's thinking As solution provider admitted, users need to remind them of this

"He said 'Would you stop talking to me about SAP and start talking to me about business?'"

"There is inevitably a language/terminology that develops around these things and the client picks this up and will be talking the same language after we finish with them"

However, this does not necessarily mean that the client organisation will have the necessary knowledge and skills to support the solution in the future, as the product evolves, as demonstrated by the case of the client that was migrating from Version 2 to Version 3 of a product

"They knew the terminology all right but they didn't know about the extra functionality"
Areas of Concern | Type 5 Contract for a configured solution
--- | ---
Project | The Scope of the project is very important. Scope creep is a significant risk. Speed of implementation is important, so there is an agreed Deadline.
Users | Individual User Requirements are much less influential than the Organisational requirements. Representative Users take part in workshops.
Client Organisation | Organisational objectives dominate the requirements, for example, integration of Business Areas. Issues often relate to mismatches between the Existing System and the Product functionality.
Business Area | Business Process engineering of the target Business Area(s) is key. Some Business Processes may need to change (BPR) in order to achieve Organisational Objectives.
Application Domain | Knowledge of the Application Domain is embodied in the Product in terms of data types and available functions.
Product | Product Expertise on the part of the supplier is an important source of Solutions. The Solution is seen as Functions provided by the Product.
Customer | The Customer is the Client Organisation.
Market Opportunity

Table 6.5 Situation Type 5 Contract for a configured solution

6.4.7 Type 6 Situation Custom-built in-house solution

Like the custom-built contract situation, this type of situation is not as common as it used to be, but most organisations still develop at least some of their own solutions in-house. In these cases, the concerns arising from the project are similar to other solution-oriented situations, and are mainly goals and objectives, rather than priorities or deadlines.

The users and, in particular, individual user requirements are extremely important concerns in this situation, compared to the contract situations, because of the flexibility and lack of formality in the situation. Business requirements and normally information requirements are important also.

"First of all you have to identify a business requirement."

Although different practitioners tended to use this term in different senses, I am using it in the specific sense of requirements that support the specific business needs and business opportunities of the organisation. Also, as one practitioner put it:

"What I'm very concerned about is the distinction between the requirements and the functional analysis, the functional specification. That is, the requirement is, what do you want to do from a business sense, and the functional requirement is, this is how I'm going to do it."

One reason why a business might decide to develop its own solutions, rather than rely on a standard package, is to try to gain a competitive advantage over its competitors.
"There is a question of course, which has been asked, which is How do I get an edge if all my competitors are using SAP?"

Whether or not a standard package is used, a company can increase its revenue, cut its costs, or improve its service by using information, in making business decisions, in ways that are not available to its competitors. That is one reason why non-standard requirements very often involve information requirements, or reporting.

"It captures a lot of raw data and it does what a standard package does. Now what they wanted to get from that system was reporting to management and it was a stats reporting system was how it was described."

"In any billing system and in ours particularly, where it's a new business, ad hoc responses to all parts of the organisation are important. Engineering, say, we think we've got a dodgy plane, could you compare the number of calls we've had from this plane versus the other aircraft and fleet?"

In an in-house development situation, the client organisation is that part of the organisation that requires and is going to use the system. This is often associated with one or more business areas, which, as in other solution-oriented situations, are a key source of requirements.

"So the first thing that I would look for is a definition of the process as it exists today, in some case like it was here, there won't be a definition of how it is today but there needs to be a definition of what the process is that these requirements are supposed to help to realise."

The existing system, changes to it, and organisational change are often important sources of issues before agreement is reached.

"thinking about what are the business processes that are going on, who are the business users of this, how will this system potentially change the business organisation?"

Although there is no formal contract between the developers and their clients, that is the users and, in particular, their managers, there may be a ritual signoff procedure once requirements have been agreed.

"We would write up the requirements document. It was signed off by the user, signed off by the systems department, say possibly signed off by the operations people."

"An exercise like that has to be done because you have to be able to say at the next stage 'well this is what you said you wanted' but you can't rely on it as being the final say, so it wasn't a contract."

"Well it was, in the sense that they signed it off and we could have treated it as a contract but if a manager comes back at the design stage and says 'you can't do this,' it's no use going back and saying 'we have a contract.'"

"Yes, there should be a signature because, like, we're in business. People have to be serious about it, they have to be given a deadline, they have to commit to something and say 'yes, that is what I want.'"
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Despite this appearance of formality, which was found in many in-house situations, because there is no involvement with an external company, the degree of formality in the actual process of discovering and agreeing requirements with the users seems to vary quite considerably. It often depends on the ethos of the company. For example, in one particular business I visited, which is extremely results-oriented, the users were perceived by the developers as impatient to be getting on with their own work and not keen to get involved in the work of requirements definition.

"They wouldn't themselves want to put a lot of effort into clarifying the requirements, but from my perspective if you set out to nail somebody down on their requirements you wouldn't get a lot of sympathy from the person you were trying to nail down or much understanding."

In other organisations doing in-house development, the requirements process tended to be more formal, more structured, or rely more on participation by users formally assigned to the project.

"Hence, a lot of the things that we dealt with and how AEP arose was through just meetings. Very little documentation."

"I believe that one of the reasons that worked was the users knew exactly what they were getting right from the start."

"This should tell the user everything he or she wants to know about the system, everything. So once the system is plopped on board three months later or three years later, there are absolutely no surprises in terms of processing, in terms of reports, in terms of screens, in terms of validation, in terms of inputs, in terms of anything."

Compared to other types of situations, the reliance on requirements documentation varied quite a lot between different in-house solution situations. It depended on factors such as the background and training of the analyst, or the system development method they were using.

"The methodology that I am experienced in is Method/1, which is the Andersen Consulting Methodology which has been used extensively world-wide for over twenty years. It was redesigned for the client server model, and therefore I was working with that and that is the sort of experience I brought in to the requirements phase in this project."

Despite appearances, the use or invocation of a specific method does not indicate the degree of formality in the requirements process to any great extent. This is because developers tend to rely on methods, more as toolboxes of techniques to be used as appropriate, rather than as sources of defined processes to be strictly adhered to. This quotation reflects a trend that has been well documented in the literature on system development methods.

"I tend to look at methodologies in terms of the tools and techniques that you use, rather than the stages you go through. I find the tools and techniques more interesting, of more practical use, anyway, than the stages."
Areas of Concern | Type 6 Custom-built In-house solution
--- | ---
Project | The Goals and Objectives of the Project are more important than the Scope, or Deadlines or Priorities. There should be a Shared Vision of the Project Objectives. Signoff may be used although there is no contract.

Users | Individual User Requirements are much more influential than in other situations. But the level of User participation in Projects varies considerably.

Client Organisation | The Client Organisation is that part of the larger organisation that requires and is going to use the system. This is often associated with one or more Business Areas.

Business Area | Business requirements are a major concern. The Existing System, changes to it, and Organisational Change are all important sources of issues to be dealt with.

Application Domain | Non-standard requirements, particularly Information Requirements are often key.

Product | 

Customer | There may be a Project Sponsor who takes on the role of Customer.

Market Opportunity | 

**Table 6.6 Situation Type 6 Custom in-house solution**

**6.4.8 Concluding remarks on solution-oriented situations**

"Signing-off" on the agreed requirements is a strategy commonly used in different types of solution-oriented situations. It seems to have at least three different purposes for the practitioners:

1. It protects the supplier’s interests in the event of a disagreement about the outcome of a project, as to whether the solution implemented fulfills the client’s needs. If the client has signed a document, then the supplier can point to the document to prove that the contract has been fulfilled.

2. It also protects the supplier in situations where there is a fixed price contract, by providing a baseline of agreed requirements, and any changes to this may incur extra charges, at the discretion of the supplier.

   "we, as a company, would have to turn around and say well I'm sorry, it's all written down, this is where you signed it, do you want to talk about changes, let's talk about them. I mean you prefer not to get into that situation."

3. In any solution-oriented situation, it encourages the client personnel who will be responsible for signing the document to ensure that the users actively participate in reading, reviewing, discussing and correcting the requirements before they are agreed and signed off. For this reason, the strategy is used as much in in-house development as in situations where there is a contract with an external supplier.
The application of methods and techniques in system development seems to vary among the different types of solution-oriented situations. In a contract situation, it is important to have some defined procedures to control the risk to the developer/provider company. A strategy used by one of the contractor companies among my interviewees was to draw up what was called a quality plan at the outset of each project. This outlined the process that would be used in the project, including the amount and the types of documentation to be produced. This was tailored for the specific situation, and involved a level of formality that was judged to be appropriate to the level of risk in the project and the ethos of the client company.

Solution providers involved in configuring SAP for clients use a proprietary method called ASAP, which is geared to implementing that product in the shortest possible timescale. In-house developers, on the other hand, seem to exhibit much greater variation in the methods they use and the level of formality adopted in projects.

649 Type 7 Problem-oriented situation

"Then we went through a stage of looking for solutions to the project, we investigated a number of packages, so the requirements (document) was circulated. It was used to evaluate the various proposals that came in."

Many organisations lack the technical resources to develop all their own software, and for this or other reasons, may have occasion to seek solutions outside their own organisations. In such cases, they often produce what is called a Request for Proposals (RFP), in which the problem is documented, and this document is sent to interested solution providers, who may respond with a proposal, either to supply a ready-made application package, or to customise a solution.

In this situation, the customer is the author or originator of the requirements. For the customer organisation, this stage is often a project in its own right. There is considerable emphasis on the goals and objectives of the organisation or that part of it that owns the problem. The scope of the problem, and of the desired solution, is another important concern, as are the necessary interfaces to other existing or planned systems.

Because it arises in an organisational situation, the users and the client organisation are important determinants of the requirements.

Depending on the type of organisation, either the business area or the application domain, or both, are important areas of concern. Related concerns include the functional areas, and/or the business processes of the organisation. The significance of these concerns is similar to...
their significance in solution-oriented situations, but there are a number of concerns that have a different emphasis in this type of situation.

For example, there is a different significance in the matter of agreement. Because there is no contract yet in existence, agreement with an external party (or between internal parties) is not a matter of concern. The situation is, in fact, similar to some of the market-oriented situations in so far as there is often a concern with getting approval of the requirements statement by a steering committee, or other authority, before the document can be circulated outside the organisation.

In some situations, for example where a public enterprise is seeking products or services, the document may have some legal status. Many public bodies are required by law to source products or services without favouring any supplier, and therefore must be careful to state their requirements in such a way that they can conduct a tendering process that is open, fair and transparent.

There is very little of concern derived from any particular product, or market opportunity in this type of situation, although awareness of the features of packaged solutions may be of significance. The main distinguishing facet of this situation, compared to solution-oriented situations, is that any consideration of the solution is much more open in this type of situation.

In producing a RFP, it is not customary to prioritise requirements. Labelling some requirements as mandatory rather than optional is sometimes used, though the use of this strategy may constrain the choice during the selection process, because requirements designated as mandatory or optional must remain as such during the selection process.

It may be noted that the problem-oriented and solution-oriented situations are reasonably similar in this framework, in that they share many similar concerns. Both are primarily driven by the needs and organisational objectives of the client organisation. However, in problem-oriented situations, a requirements document is created by the customer, prior to the selection of a solution provider and the establishment of a contract.

Several solution providers in the investigation noted that in their experience most RFPs were not detailed enough or were otherwise unsuitable to be used in solution-oriented situations. This supports the notion that these are different situations. However, further evidence was
found in cases where practitioners adopted a professional approach to the production of RFPs, and where there was organisational support for such an approach.

<table>
<thead>
<tr>
<th>Areas of Concern</th>
<th>Type 7 Problem-oriented situations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>The Scope of the Project is a central concern, as are the Goals and Objectives. Interfaces to other systems may be key. Approval of the Project within the Organisation hierarchy is an important concern.</td>
</tr>
<tr>
<td>Users</td>
<td>Users are always involved to some extent. Project Stakeholders often include Users and their managers.</td>
</tr>
<tr>
<td>Client Organisation</td>
<td>Organisational objectives are extremely important. Organisational Change may be a source of issues to be resolved.</td>
</tr>
<tr>
<td>Business Area</td>
<td>The relevant Business Area(s) are important sources, as are Business Processes, Functional areas and Workflow in the Existing System.</td>
</tr>
<tr>
<td>Application Domain</td>
<td>Application Problems and Domain Knowledge may be important sources of requirements.</td>
</tr>
<tr>
<td>Product</td>
<td>Not relevant unless a Product-based Solution is being assumed.</td>
</tr>
<tr>
<td>Customer</td>
<td>This is the only situation in which the Customer is the creator of the requirements document.</td>
</tr>
</tbody>
</table>

Table 6.7 Situation Type 7 Problem-oriented situation

6.5 Summary and Conclusions

This chapter has presented a scheme for classifying system development situations, distinguishing different situations from the perspective of system requirements. The classification scheme makes particular use of the root concerns identified in the previous chapter which argued that these root concerns are the sources of requirements, and give rise to substantive requirements, which in turn become documented requirements. This chapter was based on the inference from this that these concerns could be used as the basis of a faceted classification to distinguish the situations.

The analysis which led to the findings presented used the eight root concerns as the criteria of a search for typical situations in the empirical data that could be delineated in terms of these root concerns. The idea was to find typical situations and describe their typical profiles in these terms. Much of this work was done using tables for comparison, to highlight where the similarities and differences occurred.

This analysis resulted in seven profiles of different typical situations. The findings were presented in terms of these profiles. Each profile was presented in two ways:

1. As a descriptive profile of a situation, illustrated with supporting quotations from the interviews.
Part Two Findings

2. As a tabular profile, a set of propositions asserting the tendency of that type of situation to have certain types of concerns

Since it is based on the cases investigated empirically, the classification scheme therefore identifies some gaps in the range of types of system/software development situations that were investigated. This should be viewed as a strength rather than a weakness, since it allows for growth.

How successful is this classification? One way to judge it is to ask how clearly it differentiates one type of situation from another. This might be done by looking at the summary table comparing the different types of situations. Table 6.8 combines the seven situations showing how each area of concern varies from one type of situation to another. (This table is split over two pages, but the combined table may be found in Appendix I.)

Between the group of Market-oriented situations and the group of Solution-oriented situations, different concerns are more important than others. For example, Market Opportunity is not a concern for Solution-oriented situations, and Business area is not a major concern in Market-oriented situations. However, Market Opportunity plays different roles in each of the different Market-oriented situations. The Customer as an area of concern and a source of requirements varies in importance and identity across the table. Similarly, the table shows how the influence of Users on requirements varies from the Type 1 situation to the Type 4 situation, and contrasts these to the Type 6 and Type 7 situations.

Another way to test the effectiveness of the classification is to examine the relationship between the different situations it has identified and the diversity of styles of requirements documentation that are found in practice. This is the focus of the next chapter, which analyses each situation in terms of the different aspects of requirements documentation it entails.
## Part Two Findings

<table>
<thead>
<tr>
<th>Areas of Concern</th>
<th>Type 1 Product for a vertical market</th>
<th>Type 2 Product for targeted customers</th>
<th>Type 3 Product for a single customer</th>
<th>Type 4 Contract for a custom built solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project</strong></td>
<td>Product requirements are allocated to Projects which are related to Releases Priorities for the next release of the product are influential.</td>
<td>The requirements are subject to informal Agreement with the target customer and subject to formal Approval by the internal Client Organisation either at a higher level or peer level.</td>
<td>There is a formal agreement with the Customer represented on the Project by a Product Manager. There is an Agreed deadline and little scope for selecting requirements based on priority.</td>
<td>The Scope of the project must be managed and controlled. There is an agreed Deadline and milestones.</td>
</tr>
<tr>
<td><strong>Users</strong></td>
<td>Focus groups are often used in the discovery of user requirements.</td>
<td>Key users from the customer side may help to define and/or validate requirements. But it is difficult to get users involved.</td>
<td>The role of user representatives is played by developers not real users.</td>
<td>Individual User Requirements are less influential than the Organisational requirements.</td>
</tr>
<tr>
<td><strong>Client Organisation</strong></td>
<td>Different levels for Product Planning Project planning.</td>
<td>A combination of an external client and internal organisation. Often seen as joint development.</td>
<td>The client organisation is the external Customer.</td>
<td>Negotiating between the Client Organisation and the supplier organisation is significant. Client Organisation IS/IT personnel may also be influential.</td>
</tr>
<tr>
<td><strong>Business Area</strong></td>
<td>Not relevant unless it is the Application Domain. If so Functional areas and Business knowledge are important.</td>
<td>A source of Common requirements for the Product.</td>
<td>Domains other than business areas A deep understanding of the application domain is an important source of requirements.</td>
<td>The Existing System may be a source of knowledge about the Business Processes and Workflow. The Solution is seen in terms of Functions.</td>
</tr>
<tr>
<td><strong>Application Domain</strong></td>
<td>Knowledge of Regulations or codes of practice in the target market is an important source of Common requirements.</td>
<td>Understanding of the application domain e.g relevant Standards etc. The Product is state of the art in that application domain.</td>
<td>Non standard requirements may be significant. Application expertise on the part of the supplier may be useful.</td>
<td></td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td>Each release contains selected features so the scope of the project is much less than the scope of the product. Features of the Product may interact with each other requiring a high level of product expertise.</td>
<td>Product functionality is understood in terms of its behaviour how it responds to events and its behavioural constraints.</td>
<td>Domains other than business areas A deep understanding of the application domain is an important source of requirements.</td>
<td>Non standard requirements may be significant. Application expertise on the part of the supplier may be useful.</td>
</tr>
<tr>
<td><strong>Customer</strong></td>
<td>There are many customers but not on the scale of mass-market situations. Few customers compared to vertical market situation. Some of them may have considerable application expertise. Customer representatives validate requirements.</td>
<td>The external Customer may in turn have many customers typically consumers.</td>
<td>The Customer is the Client Organisation.</td>
<td>This is not a concern in solution-oriented situations.</td>
</tr>
<tr>
<td><strong>Market Opportunity</strong></td>
<td>Products evolve in Versions in response to market opportunities. Bundles of features are developed to address different market segments. Additional market requirements help to add value to the product. Time to market is critical. Additional platforms may be another source of system (technical) requirements.</td>
<td>The project is not usually concerned with other opportunities except as a source of new contracts.</td>
<td>The company sells its products through its own sales force.</td>
<td>This is not a concern in solution-oriented situations.</td>
</tr>
</tbody>
</table>

Table 6 8a Summary table comparing the seven Situation Types
### Part Two Findings

<table>
<thead>
<tr>
<th>Type 5 Contract for a configured solution</th>
<th>Type 6 Custom built In-house solution</th>
<th>Type 7 Problem oriented situations</th>
<th>Areas of Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Scope of the project is very important Scope creep is a significant risk Speed of implementation is important so there is an agreed Deadline</td>
<td>The Goals and Objectives of the Project are more important than the Scope or Deadlines or Priorities There should be a Shared Vision of the Project Objectives Signoff may be used although there is no contract</td>
<td>The Scope of the Project is a central concern as are the Goals and Objectives Interfaces to other systems may be key Approval of the Project within the Organisation hierarchy is an important concern</td>
<td>Project</td>
</tr>
<tr>
<td>Individual User Requirements are much less influential than the Organisational requirements Representative Users take part in workshops</td>
<td>Individual User Requirements are much more influential than in other situations But the level of User participation in Projects varies considerably</td>
<td>Users are always involved to some extent Project Stakeholders often include Users and their managers</td>
<td>Users</td>
</tr>
<tr>
<td>Organisational objectives dominate the requirements for example integration of Business Areas Issues often relate to mismatches between the Existing System and the Product functionality</td>
<td>The Client Organisation is that part of the larger organisation that requires and is going to use the system This is often associated with one or more Business Areas</td>
<td>Organisational objectives are extremely important Organisational Change may be a source of issues to be resolved</td>
<td>Client Organisation</td>
</tr>
<tr>
<td>Business Process engineering of the target Business Area(s) is key Some Business Processes may need to change (BPR) in order to achieve Organisational Objectives</td>
<td>Business requirements are a major concern The Existing System changes to it and Organisational Change are all important sources of Issues to be dealt with</td>
<td>The relevant Business Area(s) are important sources as are Business Processes Functional areas and Workflow in the Existing System</td>
<td>Business Area</td>
</tr>
<tr>
<td>Knowledge of the Application Domain is embodied in the Product in terms of data types and available functions</td>
<td>Non-standard requirements particularly Information Requirements are often key</td>
<td>Application Problems and Domain Knowledge may be important sources of requirements</td>
<td>Application Domain</td>
</tr>
<tr>
<td>Product Expertise on the part of the supplier is an important source of Solutions The Solution is seen as Functions provided by the Product</td>
<td>Not relevant unless a Product-based Solution is being assumed</td>
<td></td>
<td>Product</td>
</tr>
<tr>
<td>The Customer is the Client Organisation</td>
<td>There may be a Project Sponsor who takes on the role of Customer</td>
<td>This is the only situation in which the Customer is the creator of the requirements document</td>
<td>Customer</td>
</tr>
<tr>
<td>This is not a concern in solution-oriented situations</td>
<td>This is not a concern in solution oriented situations</td>
<td>This is not a concern in problem oriented situations</td>
<td>Market Opportunity</td>
</tr>
</tbody>
</table>

**Table 6.8b Summary table comparing the seven Situation Types**
Chapter 7 A Situation-related Classification Scheme for Requirements Documentation

7.1 Introduction

This chapter presents the fourth and final part of the proposed framework for requirements situations and documentation, a classification scheme which links seven typical requirements situations with the styles of requirements statements that they entail. It explains seven different styles of requirements documentation in terms of their situation of use.

Each of the seven typical situations that were presented in the previous chapter is associated in this chapter with a typical documentation profile. Each profile outlines the role, in that type of situation, of the different types of requirements statements identified in Chapter 4. The relevance and importance of each type of requirement is shown to vary from one type of situation to another. The different situations considered are:

1. for a Vertical Market product
2. for a Targeted Customers product
3. for a Product for a single Customer
4. for a contract custom-built Solution
5. for a contract configured Solution
6. for an in-house custom Solution, and
7. a Problem-oriented (solution-seeking) situation

These situations may be characterised by their varying need for and use of the following different kinds of statements in the requirements document:

1. Problem domain descriptions,
2. Statements of the required effects,
3. Proposed solutions,
4. Recorded Issues and Changes,
5. Defined Goals and Objectives,
6. Specified Constraints,
7. Recorded Agreement

These are the facets of the faceted classification scheme which was the aim of the final part of my grounded theory analysis, i.e., selective coding. This stage is generally concerned with finding relationships between the ‘core categories’ that have emerged from the empirical data. My original conception of the faceted scheme was a single table containing a row for each type of situation and columns for each facet, representing the different types of requirements as text, such as Problem Domain Descriptions (See Figure 11)
The process I followed in building the table was as follows. For each type of situation, I tried to pinpoint the relevance of each facet (different type of requirements statement) to that situation with a short code in the appropriate cell of the table. The idea was that the code would link that situation and the particular facet of requirements statements in a concise way. For example, I had found that the code Priorities was an important concern in the Vertical Market situation, and also that Statements of Required Effects are usually prioritised in the requirements document in this situation, so I used this code to represent the link between these in the table. Another example was the code System Architecture which was strongly identified with the facet Proposed Solutions in some situations, but not mentioned at all in situations.

Each code used in the table was linked in the data both to the situation and to that facet of requirements documentation. However, many of the distinctions I was making between situations could not be reduced to a code, but needed a more explanatory distinction in the form of a proposition (see Table 1, below, for examples) and therefore, the one big table, while it played a role in developing the grounded theory, was almost useless as a means of presenting it. Either the codes were too concise to convey any meaning, or the propositions in the cells in the table made it too big to be manageable.

The final part of the grounded theory is therefore presented here as a set of seven profiles representing different styles of requirements documentation. Each profile is summarised in tabular form, as a set of short propositions asserting the relative propensity of that type of situation to entail a particular set of types of requirements statements. Each profile is introduced in terms of the uses of the document in that situation, and the discussion is illustrated with some quotations from the interviews.

7.2 Requirements Documentation for a Vertical Market Situation
In a Vertical Market situation, the requirements document is mainly used as a working document and as a method of communication between the project stakeholders. The stakeholders typically act as reviewers of the document, taking part in meetings and discussions, commenting on its contents, and suggesting changes to be made.
Another role of the requirements document in these situations is to provide input to various downstream activities, such as input to project planning, to estimating the cost of development, to the allocation of project resources, and it is often used as an input to the testing phase of the development. For example,

"It was used as a basis for high level design, but not in the detailed design phase or the programming phase, for system test, this was used as a source of the system test conditions."

In a Vertical Market situation, there is very often a well-defined system development process, in which design is treated as a separate phase, and in which the requirements document is an important input to the design phase. Because of its role as a working document, it is more likely to be used to help achieve agreement, rather than to record agreement, and is not likely to be used again, once the succeeding phases of the project have begun.

Each requirements document in a Vertical Market situation is associated with a specific project, which typically only deals with a small proportion of the overall functionality of the product. Both the problem domain, and the product in general, are much bigger in scope of the project and its requirements.

Descriptions of the problem domain tend not to occur in the requirements document. The problem domain is taken to be well understood by people in the industry, according to my informants, and if not, it is described separately. For example, in the ERP market, Problem Domain Descriptions are documented separately in widely used generic reference models, which can be adapted for specific industries (Scheer, 1998). One of my informants explained the process used in his company whereby once the functionality has been determined for a project, usage scenarios are then described separately in use cases. These are not included or referred to in the requirements document.

The list of features is the most notable characteristic of the requirements document in this type of situation. Statements of required effects are often organised around features, with priority numbers, interdependencies, and other attributes. Priorities of features in effect determine the scope of the project, along with time constraints. The priority of an individual feature is based on relative estimates of development cost and market value. Proposed Solutions, goals, even non-functional requirements, or constraints do not occur in the requirements documents of the situations I encountered that correspond to this type of situation.
Issues, in so far as they occur in these situations, do not refer to organisational concerns, but may concern the priority of features, and therefore lead to changes in the priorities of features. Such changes are not traced explicitly in the documents, and are not recorded explicitly, except to the extent that they affect the scope of the project.

The agreement that is recorded in the document is essentially Approval. The document for each project must be approved by the relevant levels of the organisation before the next stage of the process is begun. The Approval given applies to the list of features included in the project and their attributes, such as Priority, etc. The document typically contains a list of the reviewers, i.e. those who may only comment on its contents, and a list of the people who have the authority to approve it on behalf of the organisation. The date on which the Approval was granted is an important element of the text.

<table>
<thead>
<tr>
<th>Style 1</th>
<th>Requirements Document for a Vertical Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem domain descriptions</td>
<td>Descriptions of the problem domain tend not to occur in the requirements document</td>
</tr>
<tr>
<td>Statements of the required effects</td>
<td>These statements are often organised around features, with priority numbers, interdependencies, and other attributes</td>
</tr>
<tr>
<td>Proposed solutions</td>
<td>These do not commonly occur in the requirements documentation of vertical market products</td>
</tr>
<tr>
<td>Recorded issues and changes</td>
<td>Issues may concern the priority of features, and lead to changes</td>
</tr>
<tr>
<td>Defined goals and objectives</td>
<td>Neither organisational goals nor system goals, such as non-functional requirements, seem to occur in the requirements document in this type of situation</td>
</tr>
<tr>
<td>Specified constraints</td>
<td>Neither solution constraints nor application constraints tend to appear in the requirements document</td>
</tr>
<tr>
<td>Recorded agreement</td>
<td>Agreement is in the form of Approval by the relevant levels of the organisation. The Approval given applies to the list of features to be included in the project, and their attributes</td>
</tr>
</tbody>
</table>

Table 7.1 Requirements Document for a Vertical Market

7.3 Requirements Documentation for a Target Customer Market

Market-oriented software is often equated with mass-market situations, that is, millions of customers, but in some markets, there are only a few very large customers. The software products they buy may be deployed widely in equipment serving millions of users, but the customers who commission or buy the software are small in number. Examples of this type of situation were given to me by several practitioners who work in the telecommunications software market. Previously, this market was strictly regulated, and most operators bought their hardware and software as a bundle from a single supplier. Suppliers had at most one customer in each country. Even in the now deregulated market, there are at most only dozens of customers, and almost as many suppliers chasing their business. Another example
of this type of market I came across in the interviews was the utilities market. Software suppliers whose customers are large utilities, such as power or energy companies, work in a very tight commercial situation. As a result, they often develop their products as a joint effort with target customers.

In this situation, similarly to the Vertical Market, the requirements document is mainly used as a method of communication between the customer and the developers, and also as a working document within the developer organisation. During its early versions, it may be used as a discussion document, prompting developers and other stakeholders to suggest features to be included in the project. It is also a means of getting the views of the target customer's personnel on the market value of different features.

"We suggested to them that they categorised requirements in three ways and we used that same categorisation back to them so there was an identification of what the business need of the requirement was. Was it essential, was it desirable or was it considered nice to have? A priority on it was either high, medium or low. A stability on it was is it likely to change, is it unlikely to change or is it an element that needed prototyping."

Similarly to the situation with vertical market software, in this situation, the final version of the requirements document is used as an input to project planning, to estimating the cost of development, and to the allocation of project resources. It may be used as the basis for prototyping the emerging product, and is often used as an input to the testing of the code.

Unlike the vertical market situation, however, the Product and the Project have the same scope in this situation. The product typically involves new technology, and the requirements document often contains elements of the solution, in that it forms the basis of the system architecture.

"So then basically we have the overview of the technology here and then we went into what we viewed as the solution. We're talking architecture here."

The problem domain in this type of situation is usually complex. It is not feasible to describe it in the requirements document. Some aspects of the application domain may be already described, for example in standards documents, in glossaries of acronyms, etc. Practitioners reported that they often create conceptual models of the problem domain in order to increase their own understanding of parts of it. These would not be included in the document.

The statements of the required effects are often organised around features. Some of these may be standard features taken from the relevant standard, particularly in the telecommunications field. Other features may be unique to the product or company.
single feature in a complex telecommunications product may have hundreds of dependent requirements associated with it. Known interactions between features are described.

Issues in a target market situation are related to specific features or lower-level requirements, and might be concerned with adherence to standards. Changes are frequent, as the document goes through several versions, which are managed at document level by version control. They are not typically recorded within the document.

Unlike the vertical market situation, which deals with a project rather than a product within the scope of a requirements document, the target market situation is normally concerned with a new product. System goals, such as non-functional requirements, are important in this type of situation, and therefore more likely to be documented along with the other requirements. Similarly, application constraints are significant in the documentation for this type of situation.

Like the vertical market situation, the role of the document in getting to agreement is more important than its role in recording that agreement, because it does not have the status of a contract with the customer(s). Agreement takes place at two levels in this situation, agreement with the customer(s) and approval within the supplier organisation. Agreement with the targeted customer(s) tends to be informal, such as a handshake. As in the vertical market situation, the document has a set of reviewers, who may only comment on its contents, as well as a set of people who have the authority to formally approve it on behalf of the organisation. This internal approval is part of a defined process, and applies to the list of features to be included in the first release of the product, and their dependent requirements.
7.4 Requirements Documentation for a Single Customer Product

In this situation, a software 'product' is commissioned by a single customer, and developed under a contract between the developers and the client organisation. Although the complete product will eventually be bought and used by many users, possibly in a mass market, the software part of the product is sold to a single customer. The typical software product in this case is embedded software, for example, the software used in electronic consumer goods. Another example is the control system used in industrial equipment. The commissioning customer pays for the software, and then embeds it on a chip in the equipment that they manufacture. The equipment is then distributed to be sold to several other customers, many of whom will be end users in the case of consumer electronics. It is important that the software performs correctly before it is embedded in the equipment, otherwise the commissioning customer will lose a considerable amount of money, not only due to lost market share, but also in the consequent waste of manufacturing resources and materials.

The main role of the requirements document, in this situation, is to document the agreement between the developer and the client. It is also used to help achieve that agreement, in the course of meetings and discussions, and as a means of communication between people working for two separate organisations. It allows them to articulate their knowledge of, and express their understanding of, the environment in which the software is required to work.

Descriptions of this environment frequently appear in the introductory chapter, rather than throughout the document. The problem domain descriptions often refer to the equipment in which the software is embedded, as well as to the situation of use of the equipment. The
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physical behaviour of the embedding equipment, described in terms of events, as well as user actions are important aspects of the problem domain that need to be described

Practitioners in this area regarded the joint construction of the requirements document as a learning process. They also emphasised the point that a fairly deep understanding of the intended behaviour of the product, and of the application domain, was an important concern for them.

An essential part of this understanding is a thorough grasp of the constraints that dominate the intended behaviour of the software, both from the operation of the user interface, and from the layer underneath that controls the hardware in which the software is embedded.

"So we have a constraints section — which was the bit you were looking at originally - which looks at each variable and looks at each of its particular states and then see what constraints it puts on the rest of the system."

"Well, once you come up with all the events and all the variables, then you can come up with a table of constraints, where you look at each variable in turn and see how it constrains the system."

Because it is a learning process, it happens that some aspects of requirements become clearer later in the process. Changes to rectify the omission, or misunderstanding, must be agreed, but once a certain point has passed, these changes can cause technical problems. In these situations, change requests are treated differently from those that occur in contract situations for organisational systems, in that they are not charged for. It is more important that the product should work correctly.

"It's either possible or not possible. So, if we can fit it in, we'll do it. If it's going to take six weeks to implement it, that means we'd miss the start of beta testing, so you know. It has fixed start of production, so, in general, they try not to miss that date."

Issues and changes are extremely important in this situation, because firstly, it is a contract, and secondly, because changes cannot be easily made to the software once the equipment is in production. Up to a certain version of the document, changes will be made without traceability, after which point most changes will be recorded with reasons for the change.

Because of the importance of correct functioning of the final product, testing is an extremely important part of the software development process in this situation.

"You could argue that the first phase of alpha testing is integration testing. You put everything together and you try to get it working before you start using formalised alpha testing plans or procedures. This project was 11 weeks in alpha testing and then about 8 weeks in beta test."

The behavioural requirements defined in the requirements document play an important role in testing. These denote features, or behavioural requirements, referring to the interaction or
behaviour of the software in its environment. Behavioural requirements include statements about states, events, transitions, etc. The more accurately and completely they are expressed, the more straightforward the testing.

"You can take each event and see how the system should react to that event."

System goals such as non-functional requirements are important in this type of document. Both behavioural constraints and solution constraints are specified. Solution constraints are important, relating to the platform, the capability of the embedding hardware, etc. Behavioural constraints may be modelled along with the behavioural requirements.

The agreement is a formal contract between two organisations, the commissioning customer and the supplier/developer organisation. The requirements document is a record of the agreement between the client's product manager and the developer organisation's project manager on the required behaviour of the software product in the specified environment.

<table>
<thead>
<tr>
<th>Style 3</th>
<th>Requirements Document for a Single Customer Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem domain descriptions</td>
<td>These descriptions frequently appear in the introductory chapter, rather than throughout the document. The problem domain often refers to the equipment in which the software is embedded, as well as to the situation of use.</td>
</tr>
<tr>
<td>Statements of the required effects</td>
<td>These denote features, or behavioural requirements, referring to the interaction/behaviour of the software in its environment.</td>
</tr>
<tr>
<td>Proposed solutions</td>
<td>A proposed or actual system architecture may be defined in the requirements document.</td>
</tr>
<tr>
<td>Recorded issues and changes</td>
<td>These are extremely important because it is a contract, and because changes cannot be made when the equipment is in production.</td>
</tr>
<tr>
<td>Defined goals and objectives</td>
<td>System goals such as non-functional requirements are important in this type of situation.</td>
</tr>
<tr>
<td>Specified constraints</td>
<td>Both behavioural constraints and solution constraints are specified.</td>
</tr>
<tr>
<td>Recorded agreement</td>
<td>The agreement is a formal contract between the customer and the supplier.</td>
</tr>
</tbody>
</table>

Table 7.3 Requirements Document for a Single Customer Product

7.5 Requirements Documentation for a Contract Custom-built Solution

Solution-oriented problem domains are concrete examples or instances, unlike their counterparts in market-oriented development. Only the specifics of the problem domain need to be described, rather than all the different possibilities that are likely to occur. This makes it more practical to incorporate the problem domain description in the solution-oriented requirements document. However, different types of solution-oriented situations entail different styles of problem domain description, because of the different uses of the requirements document in those situations.
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In any contract situation, the main purpose of the requirements document is to record agreement. In a contract situation involving a custom-built solution, another key purpose is to support the process of getting that agreement, and to act as a discussion document, to be the focus of project meetings between the client organisation and the contractor organisation.

"The purpose of this document is to document our agreement but at the end of the day it's not enough for it just to be in the document. The purpose of the document is to focus and structure the conversation when the actual agreement takes place."

The requirements document is also used in these situations as an input to project planning, particularly the allocation of resources to the project. Practitioners in this area also use the document as an input to estimating the development cost of the project.

"It contains the requirements and the plan for implementing the requirements, the reason it was done like that is that this became a contractual document so it was more or less here is what we are going to do, here is the plan for doing it, and here is what we are going to charge you."

For the developer organisation, in order to keep costs within the budget, it is important to 'pin down the scope of the project' in the document, and to get agreement on that scope at an early stage. It is also vital to their commercial success to pin down the agreed functionality which will be provided in the project. It also helps to get agreement before moving to the next stage of a project.

"Well, first of all, what the document is it's an interface between ourselves and the customer and primarily I suppose it's a contractual document if you like, that's not so much from the company's point of view but certainly from mine because it defines my job, it defines what I'm going to implement."

Problem domain descriptions are a much more common aspect of solution-oriented requirements documents than in product-oriented situations. Descriptions of business operations, procedures and functions generally form the framework for other requirements statements, and are often used in these situations to organise other statements throughout the document. Estimated volumes or actual volumes of business transactions and file sizes are also commonly stated.

However, much of this is thinly spread throughout the document, the bulk of the requirements text consisting of statements that typically describe transactions and information requirements. These generally outweigh the brief descriptions of the problem domain in which they are embedded.

Solution-oriented requirements documents often include proposed solutions, for example, the database structure and contents. These are typically used by practitioners to pin down the
Issues with the requirements are extremely important in this situation for two reasons. Where a solution is being specified for organisational use, people will have issues with changes that affect them. However, the client organisation’s issues rather than the people’s own will be uppermost in this case. The second reason is that there is a contract involved. Changes to the requirements have important consequences in any contract situation. This is similar to the Product for a Single Customer situation. Up to a certain version of the document, changes will be made without traceability, after which point most changes will be recorded along with the reasons for the change.

Also, because it is an organisational situation, organisational goals may be regarded as significant. However, the practitioners I interviewed in these situations differed widely on this. Organisational goals may be expressed in terms of a business case for the system, and are often seen as more pertinent than system goals in these situations, although these higher-level requirements may be related to the stated organisational goals in the document.

Both types of constraints appear in the documents for this type of situation. Application constraints are typically represented in the database design, or separately, as business rules. Solution constraints, such as software or hardware platforms or interfaces to other systems, may be defined in separate sections.

Like situation type 3, the agreement in this situation is a formal contract between two organisations, the customer (or client organisation) and the supplier (often called a solution provider). In particular, the requirements document is a record of the agreement reached between the client’s project manager and the solution provider’s project manager on the required functionality and scope of the solution. The documented agreement may specifically refer to changes that were made to resolve issues that were raised in the course of discussions.
### Table 7.4 Requirements Document for a Contract Custom-built Solution

<table>
<thead>
<tr>
<th><strong>Style 4</strong></th>
<th><strong>Requirements Document for a Contract Custom Solution</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem domain descriptions</td>
<td>Descriptions of business operations and functions form the framework used to organise other requirements statements</td>
</tr>
<tr>
<td>Statements of the required effects</td>
<td>Statements describing transactions and information requirements form the bulk of the requirements text</td>
</tr>
<tr>
<td>Proposed solutions</td>
<td>Often includes the database structure and contents or description of a prototype solution, such as the user interface</td>
</tr>
<tr>
<td>Recorded issues and changes</td>
<td>Issues are extremely important because it is an organisational situation. Changes are central because there is a contract, and these are documented after a particular version of the document, with reasons for the change</td>
</tr>
<tr>
<td>Defined goals and objectives</td>
<td>Organisational goals are more significant than system goals and may be expressed in terms of a business</td>
</tr>
<tr>
<td>Specified constraints</td>
<td>Application constraints may be represented in the database design, or separately, as business rules. Solution constraints such as interfaces to other systems may be defined</td>
</tr>
<tr>
<td>Recorded agreement</td>
<td>The agreement is a formal contract between the customer (client organisation) and the supplier (solution provider). The document is a record of the agreement reached between them on the required functionality and scope of the project</td>
</tr>
</tbody>
</table>

### 7.6 Requirements Documentation for a Configured Solution

The fifth type of situation in the classification is the second type of solution-oriented situation, concerning a configured solution. This is another contract solution situation, but the software product for the solution has already been selected, so the solution task is to fit (configure) the chosen solution to the problem situation.

The requirements document for a configured solution is normally part of the contract between the client organisation and the solution provider. In this situation, the requirements document, in addition to recording agreement, is used also as a working document in the process of matching the elements of the solution to the particular problem situation and also in the process of getting agreement.

The scope of the project, rather than the detailed functionality, is more of a concern here than in a custom-built contract situation, because this is used to estimate the development cost and to plan the project. It may also be used in acceptance testing of the configured solution.

Problem domain descriptions are an important part of the configuration requirements process, but are not generally included in the requirements contract. These are extremely detailed descriptions of the relevant business processes and workflow, based on an industry reference model of standard Business Process descriptions. An industry reference model of standard Business Process descriptions is often used to guide this. The chosen product may
necessitate some changes in business terminology used by the client organisation, so a glossary of business terms is often used in these situations.

The purpose of the business process descriptions is to express the solution developers' understanding of the client organisation's particular operation. The document can reuse standard process descriptions for those processes which are standard, and adapt the descriptions to document the variations.

The statements of required effects dominate the requirements document. Transactions and information requirements are written in terms of the chosen product, and are often closely tied to the proposed solution.

The proposed solution is by definition a variation of the chosen product. Specific proposed solutions are selected from the range of standard functionality and database formats which come with the chosen product, and to a lesser extent specified by tailored add-ons to cater for additional functionality that is not supported by the product.

Issues in this type of situation are related to required effects which may not be directly supported by the product. In such cases, compromises have to be made, either by tailoring a solution or by going with the functionality that is provided. Changes or reasons for changes are not explicitly recorded in the main document. In one case of this type of situation, a third type of document was used, recording the issues and changes along with the reasons for the change.

Similarly to the situation with contract custom-built solutions, the business case for the system expresses organisational goals. But these are typically associated with improved business practices supported by the functionality of the system. System goals, such as non-functional requirements, are not normally expressed.

Typically, the chosen product supports a wide range of many different application constraints, such as business rules. Defining which ones are needed is an important aspect of defining the requirements. Like the Business Process descriptions, however, these do not appear in the requirements document. There is no perceived need to specify solution constraints, as the main solution constraint is already decided, implicit in the choice of product.
The agreement is a formal contract between the client organisation and the solution provider. It is a contract to provide the specified functionality within the constraints of the chosen product. The requirements document is a record of the agreement reached between the client project manager and the solution provider project manager on the scope of the project.

<table>
<thead>
<tr>
<th>Style 5</th>
<th>Requirements Document for a Configured Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem domain descriptions</td>
<td>Detailed descriptions are made of the relevant Business Processes based on an industry reference model of standard Business Process descriptions, but do not appear in the requirements document</td>
</tr>
<tr>
<td>Statements of the required effects</td>
<td>Transactions and information requirements written in terms of the chosen product, and often closely tied to the proposed solution</td>
</tr>
<tr>
<td>Proposed solutions</td>
<td>Solutions are selected from the range of standard functionality and database formats which come with the chosen product</td>
</tr>
<tr>
<td>Recorded issues and changes</td>
<td>Issues are often related to required effects which may not be directly supported by the product. These and the changes that ensue are recorded separately</td>
</tr>
<tr>
<td>Defined goals and objectives</td>
<td>The business case for the system expresses organisational goals. These are typically associated with improved business practices supported by the functionality of the system</td>
</tr>
<tr>
<td>Specified constraints</td>
<td>Defining which of the variety of application constraints supported by the product are needed is an important task, but these are recorded separately, with the Business Processes</td>
</tr>
<tr>
<td>Recorded agreement</td>
<td>The agreement is a formal contract between the client organisation and the solution provider, a record of the agreement on the scope of the project. It is a contract to provide the specified functionality within the constraints of the chosen product</td>
</tr>
</tbody>
</table>

Table 7.5 Requirements Document for a Configured Solution

7.7 Requirements Documentation for an In-house Solution

In a solution-oriented in-house situation where the system is custom-built, the requirements document is used mainly to focus the discussions with the users, in order to get an agreement with them on the required functionality for the system. It may be used also as a discussion document, as a method of communication with users, so that they know what they are getting. It may also be used as the basis of the user manual:

"Something the users can understand, how they are going to be able to use the system. Yes, it does have to be accessible to the users. I mean, it is going to be that thick, there is going to be a good bit of detail but there should be an introduction, introductory chapters to get an idea of what they're going to get, it should have designs etc., screen designs particularly."

The in-house situations that I studied, even where they use a system development method, rarely use a defined process for system development. The techniques of the method tend to be used à la carte, and not the process that comes with the method. In these situations, I found that the requirements document has little or no downstream role, for example, as input.
Problem domain descriptions often form the bulk of the requirements document in this type of solution-oriented situation. These often focus on business processes. They also serve to organise the document, with other types of requirements embedded in the descriptions.

"It's simply a business requirements document and the sub-sections in that sort of document should be business related."

This focus on problem domain descriptions reflects the secondary purposes of the document, to articulate knowledge and to express understanding of the problem domain. I found that in this type of situation there was a much greater use of modelling techniques in the requirements document than in any other situation. Practitioners used these techniques, not so much to communicate with their clients, but to express their own understanding of the problem domain.

A drawback of using modelling techniques for problem domain description is the risk of confusing the problem domain analysis model with the system design model, because the same diagrams can be used for both analysis and design, for example, data flow diagrams or class diagrams. This risk is not a concern for practitioners in in-house solution situations, because they are not following a defined process that separates design from requirements, as happens in market-oriented situations.

Statements of the required effects are typically transactions and information requirements, often embedded in representations of the problem domain. Proposed solutions are typically also included, as database contents and/or references to elements which have been prototyped.

Issues are important in this situation, typically arising from organisational changes, and from the users' concerns about changes to the existing system. These issues may be noted in the document, along with the means to resolve them, but explicit statements about changes are not needed in this type of situation, because it is not a contract.

The business case for the system is an important section of the document. Organisational goals may be linked to high-level requirements, or specific business processes to be supported by the system. But system goals such as technical requirements do not fit into the typical document used in this type of situation.
Solution constraints are unusual in this type of document. Application constraints may be modelled in the problem domain descriptions, or separately, as business rules.

The agreement is an informal agreement reached between the developers and their clients, i.e., the users and their managers. The agreement may not even be in the document, which is often used in these situations only as a means of getting to agreement.

<table>
<thead>
<tr>
<th>Style 6</th>
<th>Requirements Document for an In-house Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem domain descriptions</td>
<td>These represent business processes and functions, user tasks and business events, and form the bulk of the requirements text</td>
</tr>
<tr>
<td>Statements of the required effects</td>
<td>Transactions and information requirements are stated, often in the context of representations of the problem domain</td>
</tr>
<tr>
<td>Proposed solutions</td>
<td>Database contents and/or database structure and references to prototypes are often included</td>
</tr>
<tr>
<td>Recorded issues and changes</td>
<td>Issues arising from organisational changes and from users' concerns about changes to the existing system may be noted</td>
</tr>
<tr>
<td>Defined goals and objectives</td>
<td>The business case for the system is important. Organisational goals may be linked to high-level requirements. System goals are not considered appropriate components of the document</td>
</tr>
<tr>
<td>Specified constraints</td>
<td>Solution constraints are unusual. Application constraints may be modelled in the problem domain descriptions, or as business rules</td>
</tr>
<tr>
<td>Recorded agreement</td>
<td>The agreement is an informal agreement reached between the developers and their clients. The document may or may not be a record of it</td>
</tr>
</tbody>
</table>

Table 7.6 Requirements Document for an In-house Solution

7.8 Problem-oriented Requirements Documentation

In a problem-oriented situation, the requirements document, or Request for Proposals (RFP), is used, first of all, to focus and direct the process of looking for solutions, and then to evaluate the proposals that are put forward by the solution providers. Once a proposal has been accepted, the RFP ceases to have much of a role, as the solution providers typically write their own solution-oriented document, so the RFP has no downstream role in design, prototyping, costing, planning, or testing.

However, it does have a significant role within the organisation in which it originates, as a discussion document, as a method of communication between different departments and levels of the organisation, whereby it supports the process of getting the members of the organisation to agree on what they want. It is also used to document that agreement.
The situation is similar to that of in-house solutions, in that the problem domain descriptions may use a variety of modelling techniques to represent business processes and functions, but essentially to outline the scope of the problem domain. The company background, and volumes of transactions and records, may be important information in the document.

The statements of required effects seen in problem-oriented requirements documents vary considerably from one case to another. They may or may not be very detailed, but if detailed they typically include transactions and information requirements. Non-standard requirements are often highlighted in these documents. Proposed solutions are not relevant. Although the authors may demonstrate an awareness of possible solutions, from the feasibility study, the purpose of the document is to elicit proposals, not propose solutions.

Issues and changes may be recorded in the various drafts, but these are not allowed to appear in the final document, unless there are still some important open issues to be resolved by the solution provider. The concept of a final document in this situation is much more significant than in many other situations, such as in-house solution situations.

The problem-oriented requirements document tends to emphasise objectives. One important section deals with the business objectives of the required solution. Another section deals with the high-level non-functional requirements. These are more significant in this situation than in the solution-oriented situations. Solution constraints are also considered extremely valuable in the document for a problem-oriented situation. However, lists of application constraints, if they appear, are unlikely to be complete, due to the nature of the requirements process used in this type of situation.

The final version of the document is approved by the people in the organisation who have the authority to spend the funds allocated to the project. There may be a formal steering committee for this function. The approval given applies to the scope and the broad functionality of the required solution. In particular, it applies to any constraints on the solution that are stated in the document.
### Part Two Findings

<table>
<thead>
<tr>
<th>Style 7</th>
<th>Problem-oriented Requirements Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem domain descriptions</td>
<td>Used mainly to outline the scope of the problem domain The company background, and volumes of transactions, etc</td>
</tr>
<tr>
<td>Statements of the required effects</td>
<td>May or may not be very detailed, but may have transactions, information requirements and non-standard requirements</td>
</tr>
<tr>
<td>Proposed solutions</td>
<td>These are not really applicable in a problem-oriented document</td>
</tr>
<tr>
<td>Recorded issues and changes</td>
<td>Not applicable in the final document, unless there are still important open issues to be resolved by the solution provider</td>
</tr>
<tr>
<td>Defined goals and objectives</td>
<td>The business objectives of the required solution and the high-level non-functional requirements are important sections</td>
</tr>
<tr>
<td>Specified constraints</td>
<td>Solution constraints are typically an extremely important section of the document</td>
</tr>
<tr>
<td>Recorded agreement</td>
<td>The final document is approved by the people in the organisation who have the authority to spend the funds allocated to the project</td>
</tr>
</tbody>
</table>

Table 7.7 Problem-oriented Requirements Document

#### 7.9 Summary and Conclusions

This chapter has presented a classification scheme that tries to account for the differences between different styles of requirements documents by relating them to their situation of use. It takes the seven typical situation types proposed in the previous chapter and analyses them on the basis of their usage of the seven basic elements of requirements documentation which were identified in Chapter 4. Based on this, a different style of document is identified with each situation type. The different styles are explained in terms of the varying primary uses and roles of the documents themselves in the different situations.

The findings of this chapter represent the conclusion of the grounded theory analysis. This analysis was based on the original conjecture introduced in Chapter 1, that there is no one best way to document requirements, as it depends on the situation. The aim of the research was to study the inherent variety of situations and the variety of requirements documentation used in practice and to find out what worked in different situations. Since the literature provides no suitable way to classify situations from the perspective of requirements, and no suitable way of classifying requirements as texts, these were introduced in Chapters 6 and 4 respectively. This chapter uses those findings to propose a set of profiles of requirements document styles that is related to their situation of use.

The concluding remarks of the previous chapter suggested that the effectiveness of the classification of situations could be evaluated by asking how clearly it differentiates one type of situation from another. A further assessment of those distinctions could be made by asking how clearly the documentation needs differ among those situations. These
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differences are to be found in Table 7.8, which summarises the seven documentation styles described in this chapter. This shows patterns of variation in problem domain descriptions, statements of required effects, and other elements, between the different styles of requirements documentation found to appropriate to different situations. The reader will notice that space did not permit the reiteration of the left-most column in part b of the table, as was done in the case of Table 6.8. Table 7.8 is reproduced in Appendix I.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem domain descriptions</td>
<td>Descriptions of the problem domain tend not to occur in the requirements document</td>
<td>The problem domain is complex. It is not typically described in the requirements document. Some aspects may be already described in standards documents or glossaries of acronyms.</td>
<td>These descriptions frequently appear in the introductory chapter rather than throughout the document. The problem domain often refers to the equipment in which the software is embedded as well as to the situation of use.</td>
</tr>
<tr>
<td>Statements of the required effects</td>
<td>These statements are often organised around features with priority numbers, interdependencies and other attributes.</td>
<td>These are often organised around features, either standard features or features that are unique to the product or company. Interactions between features are also stated.</td>
<td>These denote features or behavioural requirements referring to the interaction/behaviour of the software in its environment.</td>
</tr>
<tr>
<td>Proposed solutions</td>
<td>These do not commonly occur in the requirements documentation of vertical market products.</td>
<td>May include the proposed architecture of the product.</td>
<td>A proposed or actual system architecture may be defined in the requirements document.</td>
</tr>
<tr>
<td>Recorded issues and changes</td>
<td>Issues may concern the priority of features and lead to changes.</td>
<td>Issues relate to specific features or lower level requirements and might be concerned with adherence to standards.</td>
<td>These are extremely important because it is a contract and because changes cannot be made when the equipment is in production.</td>
</tr>
<tr>
<td>Defined goals and objectives</td>
<td>Neither organisational goals nor system goals such as non-functional requirements seem to occur in the requirements document in this type of situation.</td>
<td>System goals such as non-functional requirements are important in this type of document.</td>
<td>System goals such as non-functional requirements are important in this type of situation.</td>
</tr>
<tr>
<td>Specified constraints</td>
<td>Neither solution constraints nor application constraints tend to appear in the requirements document.</td>
<td>Application constraints such as behavioural constraints are significant.</td>
<td>Both behavioural constraints and solution constraints are specified.</td>
</tr>
<tr>
<td>Recorded agreement</td>
<td>Agreement is in the form of Approval by the relevant levels of the organisation. The Approval given applies to the list of features to be included in the project and their attributes.</td>
<td>Agreement takes place at two levels. Informal Agreement with the target customer(s) and formal internal Approval.</td>
<td>The agreement is a formal contract between the customer and the supplier.</td>
</tr>
</tbody>
</table>

Table 7.8a Comparing Documentation Styles
## Table 7.8b Comparing Documentation Styles

<table>
<thead>
<tr>
<th>Requirements Document for a Contract</th>
<th>Requirements Document for a Configured Solution</th>
<th>Requirements Document for an In house Solution</th>
<th>Problem oriented Requirements Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptions of business operations and functions form the framework used to organise other requirements statements</td>
<td>Detailed descriptions are made of the relevant Business Processes based on an industry reference model of standard Business Process descriptions but do not appear in the requirements document</td>
<td>These represent business processes and functions, user tasks and business events and form the bulk of the requirements text</td>
<td>Used mainly to outline the scope of the problem domain. The company background and volumes of transactions etc.</td>
</tr>
<tr>
<td>Statements describing transactions and information requirements form the bulk of the requirements text</td>
<td>Transactions and information requirements written in terms of the chosen product and often closely tied to the proposed solution</td>
<td>Transactions and information requirements are stated often in the context of representations of the problem domain</td>
<td>May or may not be very detailed but may have transactions information requirements and non-standard requirements</td>
</tr>
<tr>
<td>Often includes the database structure and contents or description of a prototype solution such as the user interface</td>
<td>Solutions are selected from the range of standard functionality and database formats which come with the chosen product</td>
<td>Database contents and/or database structure and references to prototypes are often included</td>
<td>These are not really applicable in a problem oriented document</td>
</tr>
<tr>
<td>Issues are important because it is an organisational situation. Changes are central because there is a contract. These are recorded after a particular version of the document with reasons for the change</td>
<td>Issues are often related to required effects which may not be directly supported by the product. These and the changes that ensue are recorded separately</td>
<td>Issues arising from organisational changes and from users concerns about changes to the existing system may be noted</td>
<td>Not applicable in the final document unless there are still important open issues to be resolved by the solution provider</td>
</tr>
<tr>
<td>Organisational goals are more significant than system goals and may be expressed in terms of a business.</td>
<td>The business case for the system expresses organisational goals. These are typically associated with improved business practices supported by the functionality of the system.</td>
<td>The business case for the system is important. Organisational goals may be linked to high-level requirements. System goals are not considered appropriate components of the document.</td>
<td>The business objectives of the required solution and the high level non-functional requirements are important sections.</td>
</tr>
<tr>
<td>Application constraints may be represented in the database design or separately as business rules. Solution constraints such as interfaces to other systems may be defined.</td>
<td>Defining which of the variety of application constraints supported by the product are needed is an important task. These are recorded separately with the Business Processes.</td>
<td>Solution constraints are unusual. Application constraints may be modelled in the problem domain descriptions or as business rules.</td>
<td>Solution constraints are typically an extremely important section of the document.</td>
</tr>
<tr>
<td>The agreement is a formal contract between the customer (client organisation) and the supplier (solution provider). The document is a record of the agreement reached between them on the required functionality and scope of the project.</td>
<td>The agreement is a formal contract between the client organisation and the solution provider. A record of the agreement on the scope of the project. It is a contract to provide the specified functionality within the constraints of the chosen product.</td>
<td>The agreement an informal agreement reached between the developers and their clients. The document may or may not be a record of it.</td>
<td>The final document is approved by the people in the organisation who have the authority to spend the funds allocated to the project.</td>
</tr>
</tbody>
</table>
Part Three  Theoretical Support for the Findings

A grounded theory begins with and continues to rely upon the body of empirical data which is the source of the concepts and relationships it contains. The grounded theory approach is about discovering categories in the data and evolving a conceptual framework that explains those findings. But it also relies on interpretation of the data, so the theoretical background and influences that the investigator brings to the analysis and interpretation of the data need to be made explicit. Most of this background is embodied in the relevant literature on the topic, in this case, the literature on requirements engineering and information system development.

The existing literature has many uses in grounded theory research, including:

1. Stimulating theoretical sensitivity (the ability to give meaning to data)
2. As a secondary source of data
3. Stimulating questions
4. Directing the process of theoretical sampling, and
5. As supplementary validation of the findings (Strauss and Corbin, 1990)

In the context of grounded theory, a set of findings that merely confirmed and reflected the existing literature would be pointless. There must be at least some extension of the existing theory, or some critique of it. Since the related literature on requirements is so diverse, it is not surprising that my findings are supported by some of the literature and at odds with the rest of it. In the final part of the thesis, I compare and contrast my findings to the standard perspectives found in the current literature. But first, in Part Three, I present a number of theoretical perspectives that have influenced, and therefore support, these findings.

In Chapter 8, I review the main sources from which I have gained some understanding of the nature of organisational situations to give some theoretical support to the classification of situations presented in this thesis. In order to achieve their goals, and get work done, organisations in different situations need to coordinate, control, and communicate the work that is going on. These mechanisms both facilitate and encumber people who are working together, particularly those doing non-routine knowledge-based work, such as system development. This chapter looks at system development situations in terms of their differing needs for coordination, control, and communication, and the implications of these differences for the task of requirements documentation.
In Chapter 9, I present the theoretical perspectives on requirements representation that have influenced and contributed to the grounded theory of documentation presented in this thesis. These include concepts and theories dealing with different forms of representation, including modelling, the different elements that need to be represented, the benefits of using models, and reasons why models are not always the best way of representing requirements.
Chapter 8 Perspectives on the Organisational Context of Requirements and Documentation

8.1 Introduction

The framework presented in Part Two is centred around the idea of a situation. It tries to identify the factors that can be used to distinguish system development situations with respect to their consequences for requirements documentation. System development is an organisational activity, taking place in an organisational situation. In this chapter, I discuss how the situations outlined in Chapter 6 may be viewed as diverse organisational situations, and review some established frameworks for understanding organisational activity that have appeared in the literature dealing with the theory of organisations in general, and of system development in particular.

System developers are generally employed in and by organisations. They work in groups, normally organised as project teams. Almost all of the practitioners that I interviewed normally work on projects. A project is a well-established way to organise a specific set of people to work towards a particular goal, over a specified time period. The composition of a project team may change over time, and people other than system developers are often involved, either full-time or part-time, but the project organisation is the normal work setting of the system developer.

As reflected in the findings, a system development project is concerned with problem solving. Its goals are to first of all define the problem, to the satisfaction of all concerned, and then to find and implement a solution. In order to do this the people concerned must communicate with each other, understand each other, and ultimately agree with each other about what the problem is, and whether the solution is acceptable. But people, being human, suffer from the problem of bounded rationality (Davis, 1982, Newell and Simon, 1972).

Bounded rationality means that people are inclined to be selective in the things they pay attention to, because they cannot attend to an unlimited number of things at the same time. Therefore, even when they try to behave rationally, they cannot do this perfectly well.

Organisations are a response to this shortcoming of people acting alone. Organisations introduce communication, shared information, and coordinated action to various kinds of human endeavours, including crime, religion, education, and business. Furthermore,
organisations often introduce routines and procedures for getting things done, which free up human attention for less routine activities and events (March and Simon, 1958)

But system development is, by and large, non-routine. A new system is being developed, even if it is not unique, it has never been developed in exactly the way same before, in this particular organisation, by these people, on this hardware platform, using this language and tools, for these particular users. System development is non-routine activity, carried out by organised groups of people who must communicate with each other, understand each other’s points of view, and come to some kind of agreement, in order to learn about, define and ultimately solve what is normally an ill-structured problem.

8.2 Contingency theory
One way to account for the variety of organisational situations is contingency theory. Contingency theory says there is no one best way to manage or coordinate the activities of an organisation. It depends on the situation. The main idea is that the internal features of a successful organisation depend to a large extent on the environment in which it exists, and hence external factors in that environment, especially uncertainty and changeability, determine the internal structure and needs of the organisation, if it is to succeed.

"The more varied the types of environments confronted by an organization, the more differentiated its structure needs to be" (Scott, 1987)

The theoretical framework presented in this thesis constitutes a contingency theory, connecting specific types of system development situations to particular documentation profiles. This is developed from the conjecture introduced in Chapter 1, that there is no one best way to document requirements, as it depends on the situation.

In a classic study of organisations in the plastics business, Lawrence and Losch, who coined the term ‘contingency theory,’ argued that organisations in complex environments develop specialised internal departments to cope with the different environmental factors, thereby creating internal problems of coordination between these departments. Successful organisations in such situations need to be able to differentiate to the level required by the environment, and integrate their operations so that they can collectively pursue the goals of the organisation (Lawrence and Losch, 1967).
Integration techniques used in successful organisations include direct managerial contact, hierarchy, a system of reports, and procedures for managing conflict. Conflict between specialised departments is seen as a natural consequence of their conflicting interests, and negotiation of such differences as part of the process by which such organisations adapt to changing environments. The more stable the environment, the more rational the organisation can afford to be.

The term 'contingency theory' is more widely used in business disciplines such as accounting and management, but the concept is not unknown in the field of system development. A number of early papers on the criteria for selecting appropriate requirements analysis methods invoked the notion of contingency theory either explicitly (Davis, 1982, Naumann et al., 1980) or implicitly.

Contingencies such as project size, problem structuredness, user task comprehension, and developer task proficiency were found to determine the level of uncertainty inherent in a project which in turn determines the need for particular strategies for requirements assurance or validation (Naumann et al., 1980). The characteristics of the object system (the problem domain), the application system, the users, and the analysts are the main categories of contingency factors used to explain differentiation in the use of problem solving methods and techniques (Davis, 1982).

Episkipou and Wood-Harper, in a paper that further develops Davis's framework, use Checkland's terminology and other sources to produce an expanded model that includes, in addition to the presence of different ideologies, available tools, and different dominant philosophical enquiry systems:

1. The characteristics of the problem owner
2. Assessment of the problem context and

The framework of situations presented in this thesis uses the idea that each type of situation has a different locus of concerns, as the findings indicate. However, there are some more fundamental characteristics of organisational situations that give additional support to the distinctions between situations that were made in Chapter 6.

Organisations are systems. As such, they exhibit particular characteristics, for example, they are goal-directed (Scott, 1987). They are composed of parts (individuals and smaller organised groups of people) which interact with each other. Like any other system,
organisations work by means of communication, coordination and control among these parts. Communication between its parts allows the organisation to share information and knowledge, and to coordinate action and monitor its results. Control in an organisation is essential, in order to ensure that the goals of the organisation as a whole, rather than any particular part of it, are pursued and achieved. The need for coordination arises when an organisation becomes more complex as its sub-units become more specialised.

However, it is clear that some situations, as social systems, demand coordination mechanisms more than control or communication mechanisms, while other situations need control mechanisms more so than communication or coordination. In the remainder of this chapter, I consider how the different types of situations outlined in Chapter 6 can be distinguished in terms of their varying balance of the needs for coordination, control, and communication. I review the relevant organisational literature which helps to explain why certain work strategies are appropriate mechanisms in some situations and not in others.

8.3 Situations that Need Effective Coordination Mechanisms

An important aspect of organisational structure is the way the organisation coordinates the activities of its members. Most organisations, except the smallest and simplest, consist of smaller sub-units which are themselves organisations. In an organisation of any considerable size, this gives rise to several levels, and consequent characteristic relationships between the parts of the organisation. These relationships are often hierarchical, although other relationships are also possible. The more complex the organisation, the more diverse and specialised the different sub-units. The more formal the organisation, the more rigidly prescribed and constrained are the interactions between its members (Olsen, 1968).

The different types of situations presented in Chapter 6 exhibit significant differences in the way they are organised. The vertical market situation (Type 1) demonstrates the classical characteristics of a hierarchical organisation, with different levels of coordination, such as product and project steering committees. There tends to be a strict division of labour, reflected in the division of the development process into formal stages, with different personnel assigned to tasks such as requirements gathering, validation, design, programming and testing.

The targeted customer situation (Type 2) is similar to Type 1 in terms of division of labour, but there is less stability and more uncertainty in the market, so the development project is structured as an alliance with the targeted customer(s). Both of these situation types were associated in my empirical study with companies that were engaged in process improvement.
initiatives and other attempts at rationalisation of organisational activity. Many of them had adopted the Capability Maturity Model, which relies on extensive documentation of both development processes and project deliverables. Another organisation, representing the Type 7 Problem-oriented situation, had also developed and adopted a well-defined process for producing its Request For Proposals (RFP) documents.

8.3.1 Rationalisation in organisations
The word “bureaucracy” is often associated with red tape and inefficiency, but it has a specialised meaning in organisational theory.

"Bureaucratisation is the process of rationalising social organisation, so as to improve operating efficiency and more effectively attain common goals." (Olsen, 1968)

This process was first studied by Max Weber who identified nine characteristics of a bureaucratic ‘ideal type,’ including the following features which are easily recognised in many system development organisations:

1. Each role has clearly identified duties and responsibilities
2. All activities are guided by formally prescribed rules and regulations
3. All decisions are made on the basis of technical knowledge
4. All activities are recorded on written documents, and preserved in permanent files

A bureaucratic organisation is one which is large, formal, and run on completely rational lines by people who derive their authority from either their technical competence or their position in the organisation, which in turn is determined by their proficiency. Scientific management, work-study, cost accounting and organisational information systems are all classic examples of the process of bureaucratisation. Business Process Reengineering, Total Quality Management and software process improvement initiatives are contemporary examples of the bureaucratic process described by Weber.

An important strategy that organisations use when carrying out projects is the policy of writing things down. Documents are regarded as indispensable tools for helping people to deal with information, to record what has been done before, to plan what is to be done, to see what remains to be done. System development may be regarded as both part of the process of rationalisation, and as an activity to be rationalised in its turn, and therefore documentation is seen as an essential part of the process of system development.
Contingency theory in general, and rationalisation in particular, are two important ways of explaining how and why organisations evolve and develop different ways of coordinating their operations, depending on the situations in which they find themselves. Rationalisation as a coordination mechanism helps to explain the role of documentation in product-oriented situations such as the vertical market situation, and the targeted customer situation. Both of these situations emphasise documentation as a coordination mechanism, coordinating the work of different groups within the organisation, and also between organisations in the case of the target customer situation.

### 8.4 Situations that Call for Effective Control Mechanisms

In situations where one organisation develops a product or solution on behalf of another organisation, control rather than coordination becomes the important issue. Goal differences between the organisations can lead to problems, unless adequate control mechanisms are in place. Two different variants of Agency Theory may be drawn upon to help explain these mechanisms.

Principal-agent theory helps to clarify the dynamics of the interaction in the following types of situations, in particular Situation Type 3, the product for a single customer, Type 4, the contract for a custom-built solution, and Type 5, the contract for a configured solution. A different formulation of agency theory, called transaction cost economics, is more appropriate to explain the dynamics in single-organisation situations, including Type 1, the vertical market, and Type 7, problem-oriented situations.

#### 8.4.1 Agency exchange

In its simplest form, Agency Theory is a model of exchange between two people, called a principal and an agent. The principal engages the agent to carry out responsibilities which usually involve decision-making by the agent on behalf of the principal. The principal is usually cast as the owner of a business, while the agent is cast as the manager. Both are assumed to be rational people, who want to maximise their utility, but they may have different goals and different attitudes to risk, though the principal is usually assumed to be risk-averse. The agent is assumed to be self-interested, but willing to expend effort in return for sufficient reward. The problem for agency theory is to devise a suitable employment contract that will ensure that the agent receives a sufficient share of the outcome of his work to motivate him to work in the best interests of the principal as well as his own best interests.

In its original formulation, agency theory is a normative theory intended to help the principal to exert control over the agent. The purpose of the model is to maximise the utility of the
principal by devising and selecting (a) the most beneficial contract of employment and (b) the most suitable way of monitoring the effort of the agent, called an information system in agency theory. (A cost accounting system would be a typical example.) Because it deals with individuals rather than organisations, classical agency theory does not apply very well to system development situations.

However, it does highlight certain issues that are relevant to any situation where the responsibility for decision-making and problem solving is devolved from one party to another. These issues include information asymmetry, asset specificity, and risk or uncertainty. We will return to the latter two issues below.

Information asymmetry occurs when one party (usually the agent) has more information than the other party concerning the effort being put in by the agent, giving the agent an opportunity to avoid effort, a situation called 'moral hazard,' or to take sloppy decisions, called 'adverse selection.' Both of these situations cause the principal to lose out, through lack of information about what is going on, and agency theory suggests that the solution is to provide either more information beforehand (ex-ante) or more ways of evaluating the performance of the agent (ex-post). Both of these strategies involve extra costs for the principal, and the problem, as far as agency theory is concerned, is to design ways to minimise these transaction costs, while maximising the information available to the principal.

8.4.2 Professional as agent

Anurag Sharma (1997) has adapted and extended agency theory to explain exchanges between professional agents and their clients. He argues that principal-professional exchanges are inherently different from the owner-manager exchanges of traditional agency theory. Rather than delegating the task to the agent, the principal engages with the agent in the co-production of a service product. This involves a division of labour based on different levels of knowledge, which he calls knowledge asymmetry as distinct from information asymmetry, and an additional cause of a power difference between the agent and the principal, in favour of the agent.

A system developer may be regarded as a professional agent often with specialised knowledge and skills which the client does not have. This is particularly the case in Type 5, the configured solution situation, and to a certain extent in other situations. For example, in Type 3, the product for a single customer situation, the client organisation may have a vast amount of knowledge, but a scarcity of resources to deal with the particular project, which is
therefore outsourced to a developer organisation. Knowledge asymmetry may then arise between the client representative, such as the product manager, and the members of the developer organisation, who are chosen for their specialist knowledge. Practitioners in such situations in the investigation indicated that this is often the case.

In situations where the agent has more expertise and knowledge than the principal, there are extra difficulties for the principal in controlling and monitoring the transaction, but Sharma argues that there are additional restraints on the behaviour of professional agents:

1. Self-control or altruism on the part of the agent
2. Control by a community of peers, codes of conduct, protection of reputation
3. Bureaucratic (or supervisory) control by the professional firm and
4. Client control

One of the client control mechanisms that Sharma invokes is the notion of exchange-specific assets, which is part of the mainstream agency framework, and was mentioned above. In the case of many professionals, the abstract knowledge they bring to the transaction has to be supplemented with a considerable investment of time in diagnosing the problem, a situation which is typical of the work of system development.

“Upfront investment of time in diagnosing the problem is akin to investing in an asset that has no value outside of that particular exchange” (Sharma, 1997)

The risk associated with asset specificity is borne entirely by the agent, but serves as a guarantee of the long-term commitment. The degree of risk that a professional agent is willing to assume is dependent on norms and traditions within the profession. He gives, as an example, lawyers who represent clients in return for a contingency fee.

A contract is basically a means of overcoming the problem of information asymmetry. However, in many contract development situations, the requirements document is a large part of the contract. It is also a major asset which is specific to the exchange. For organisations which develop products or solutions on a contract basis, this involves a significant risk, because the contract may not be agreed, even though considerable resources have been invested in drawing it up. For the client organisation, the existence of such assets is a guarantee of the commitment of the agent, according to agency theory.

In Type 6, in-house solution situations, particularly when developing organisational information systems, both agents and principals may invest in exchange-specific assets, such as requirements documentation. In a paper on participatory design viewed from the
Part Three  Theoretical Support for the Findings

Perspective of agency theory, Vivian Vimarlund suggests that shared investments made during collaborative projects result in an increase in knowledge capital, a decrease in information asymmetry, and desirable organisational change in terms of "updating work routines in a natural manner" (Vimarlund, 1998).

Unlike many other professional-client agency situations, in system development, knowledge asymmetry may arise in two different directions. Whereas the agent organisation has specialist knowledge and skills, the client organisation often has specific application domain knowledge which the agent needs to access, in order to develop a satisfactory product or solution. This means the project must often be structured as a joint effort between the two organisations, with a common goal which is understood and agreed by both sides.

The professional-agent extension to agency theory not only distinguishes the concept of knowledge asymmetry, but also describes situations where clients and agents engage in the co-production of a product or service, a state of affairs which describes most system development situations, but the solution-oriented ones (Types 4, 5, and 6) in particular. In these situations, the clients have a big stake in the solution being suitable for their needs, an outcome in which they themselves have to invest some considerable effort. Asset specificity is regarded as the most important restraint on opportunistic behaviour by professionals who engage with clients.

The additional restraints described by Sharma are all social controls based on norms rather than economic ones based on selfish utilitarian motives. They arise out the analysis that professionals are social actors, and although they have more power than their lay principals in exchange transactions, they are more subject to societal and community norms than mere economic actors would be. The social interaction perspective gives a further explanation of the exchanges between professional agents and their clients.

8.4.3 Market situations and hierarchy situations

Transaction cost economics is a complementary theory that shares many of the concepts of agency theory. It is based on the ideas of markets and hierarchies, (Coase, 1937), and Oliver Williamson's (1975) theory of organisation failures. Markets and organisations are regarded in this literature as two different ways of organising transactions. Traditionally, microeconomics regards the market as the normal method of exchange, and any departure from it, such as organisational cooperation as a 'market failure.'
Part Three  Theoretical Support for the Findings

A 'market failure' is said to occur when the costs associated with one approach, for example a contract with another party in a market situation, could be reduced by transferring to an alternative arrangement, involving cooperation within an organisation. When this occurs, it is better to make something or provide a service in-house rather than go to the market to buy it. In this model, bounded rationality replaces utility maximising as an explanation of agent and principal behaviour and interaction.

This framework is explanatory rather than normative, and allows for a wider variety of organisational structures, including the idea of the hierarchical organisation of principals and agents within the firm. These include the Type 1, Type 2, Type 6 and Type 7 situations. Compared to classical agency theory, the transaction cost economics framework pays more attention to ex-post evaluation of performance, which is more widely applicable, particularly when uncertainty is a factor in the exchange.

8.4.4 Uncertainty in organisational situations

Many system development projects deal with situations of uncertainty, particularly those that are concerned with markets and other outside organisations, including the vertical market situation, targeted customers, and different forms of contract situations. Many authors see uncertainty as a significant factor in organisational behaviour, and this recognition has two important consequences. It has moved the focus of theoretical attention away from routine decision-making towards problem-solving and it has shifted the established view of organisations from the traditional split between management and operations in routine stable situations towards a focus on joint action in uncertain and dynamic situations.

Uncertainty in agency theory is associated with moral hazard, adverse selection and what is called the state of nature. The first two of these arise out of information asymmetry, or the principal's inability to adequately monitor the effort of the agent, coupled with assumed opportunism and unwillingness to work on the part of the agent. The state of nature is outside the control of either the principal or the agent and is a category that covers all other sources of uncertainty as far as agency theory is concerned.

Nilakant and Rao (Nilakant and Rao, 1994) identify two other important sources of uncertainty, in an article that criticises the applicability and generalisability of agency theory. These two additional sources of outcome uncertainty in organisations are:

1. incomplete knowledge about the effort-outcome relationship and
2. lack of agreement about effort and outcome.
They propose a 2x2 model giving four different situations. One situation is where there is incomplete knowledge about the relationship between effort and outcome, but a high level of agreement on goals, which often happens in contract situations, and fits the agency theory perspective. Another situation is where there is high level of knowledge about the amount of effort required but conflict over outcomes, and this can happen where systems are being developed within an organisation.

Organisations which seek to develop new products or technologies operate in a domain where the relationship between effort and outcome is unknown (Nilakant and Rao, 1994). Market-oriented software development is a good source of examples of this type of situation, including Type 1, the vertical market and particularly Type 2, the targeted customer situation. It would also apply to a mass-market situation.

In complex organisations, where there are multiple agents and principals, there may be lack of agreement about goals and also about ways of achieving them. Again, this description is particularly relevant to certain system development situations, such as Type 7, problem-oriented situations, not least because part of the task is to achieve such agreement in the course of the project. It also applies to some market-oriented situations, such as Type 1, the vertical market, where different personnel represent the interests of customers and suppliers within the same organisation.

Nilakant and Rao emphasise the importance of team activities and facilitative (managerial) effort in modern organisations, concepts which are not considered in the agency theory view of organisations. More complex and dynamic work environments increase the need for facilitative effort, while at the same time, the distinction between management and operations is being eroded in situations where teams are being given more responsibility and autonomy. “The same individual may perform facilitative and operational tasks” (Nilakant and Rao, 1994).

In such situations, hierarchical control is replaced by networks of inter-dependent roles, in which reciprocity, trust and cooperation are the most important means of dealing with uncertainty.

For situations such as Type 1, the vertical market, and other in-house situations, such as Type 6 and Type 7, the transaction cost economics version of agency theory gives a better analysis of the organisational control of system development activity in general, and requirements gathering and analysis in particular. The main feature of such situations,
accordingly, is cooperation within an organisation, the need for which is stimulated by bounded rationality of the participants and uncertainty in the environment or the task to be performed.

Uncertainty is a significant and perennial problem in requirements determination. Facilitative effort by managers is recommended in such situations, along with conflict management and consensus management, giving more responsibility to individuals and autonomy to teams. This kind of approach can probably best be used in developing in-house solutions (Type 6) or in agreeing on the requirements in a problem-oriented situation (Type 7 situations).

### 8.5 Situations that Need Effective Communication Mechanisms

One particular type of system development situation exhibits more need for communication than for control or coordination of activities. This is Type 6, the in-house solution situation, where members of an organisation develop their own solution, rather than go outside the organisation to develop or acquire a product or solution. The project may be one that is mission-critical for the organisation, developing a solution that is not available in the market, that may give the organisation a competitive edge over its customers. This requires a very good understanding of the organisation, its objectives, and its environment. In such a situation, a source of difficulty may arise in the lack of understanding between the developers and their clients, the users and their managers.

#### 8.5.1 Understanding in organisational contexts

Weick (1984a) and others make a useful distinction between uncertainty on the one hand and equivocality on the other. Equivocality reduction is aimed at understanding the other person's meaning, at being able to see things from the other person's point of view. In sociology, this aspect of understanding is called *verstehen*, which is the German word for understanding.

Uncertainty, on the other hand, comes from the inherent complexity of the environment in which the person or the organisation is trying to operate, or the problem they are trying to solve. Scott (1987) gives the following list of five dimensions of uncertainty that must be dealt with in an organisational context:

1. The degree of homogeneity-heterogeneity: diversity of entities with which the organisation must deal.
2. The degree of stability-variability: the rate of change in the environment.
3. The degree of threat-security: or vulnerability of the organisation.
Part Three Theoretical Support for the Findings

4. The degree of interconnectedness-isolation: the extent to which the organisation must interact with other entities.

5. The degree of coordination-noncoordination: or the structuredness of the interactions.

Reducing this inherent uncertainty requires a means of understanding all this complexity, and the dynamics of whatever processes, physical or social, that are influencing the problem situation. In many organisational situations, the use of models, plans and other written representations is seen as an essential strategy for coping with uncertainty. System development provides many typical examples of such strategies.

In organisational contexts, the process of understanding may be regarded as a process of sensemaking. Behaviour sometimes precedes goal statements, and justification follows actions to explain behaviour. Interaction leads to retrospective interpretations of what has gone on before (Weick, 1979, 1984a). Sensemaking is aimed at two objectives:

1. Uncertainty reduction and
2. Equivocality (ambiguity) reduction.

Weick (1984a) gives a number of strategies that people use for dealing with each of these problems. Sensemaking strategies include paradigms, theories of action, tradition, and storytelling. Each organisation has its own strategies, which help it maintain and legitimise its particular view of reality, by simultaneously supporting and constraining it.

Our human experience of uncertainty, then, is a combined consequence of the complex nature of things and our bounded rationality in dealing with them. We need to be selective in what we pay attention to, we must make assumptions, because our knowledge is imperfect, and we can only deal with so many things at one time. This has significant consequences for the strategies that organisations adopt for developing systems, and especially for the analysis of system requirements.

A requirements document can be regarded as a strategy for dealing with both uncertainty and ambiguity (equivocality) in situations. It aims to reduce uncertainty by recording all the relevant information about the problem and the constraints on the solution. It aims to reduce equivocality by being clear, unambiguous, and consistent in communicating these matters. However, there is a danger that it will not be completely successful in these aims, because people are not completely rational, and often have trouble interpreting each other's meanings.
Part Three  Theoretical Support for the Findings

8.5.2 Interpretation in Organisations

As social systems, organisations are often considered to best understood in terms of the interactions of their members as human beings. These interactions are based on meaning or more precisely, on the meaning that we attribute to the behaviour of others.

In order to work together in social situations, people are continuously doing two things:
1. interpreting (or ascertaining what the other people mean) and
2. indicating to the other people (what to do, how to act).

According to Blumer, these are the two things that people do "in order to sustain joint conduct" (Blumer, 1969). This theory is called symbolic interactionism and has its roots in a long line of pragmatic philosophers such as William James, George Herbert Mead and John Dewey, as well as the work of the sociologist Max Weber. It has three basic axioms:

1. People act towards things in ways determined by the meanings those things have for them.
2. The meaning that things have is not inherent in the things, nor in the people, but arises out of social interaction.
3. These meanings are continually being modified through an interpretative process used by people in dealing with things.

Most of what we know comes from interpretation (March and Olsen, 1976). Cultural rules are the instructions we have for interpreting, constructing and otherwise dealing with the meaning of things (Spradley, 1972b). It is a social process, which frames reality as we experience it. Communication is both part of this process and constrained by it.

When people work together in organisations, they are therefore subject to significant cultural rules and pressures which help to define reality for them. Society itself is one source of these rules. Other sources include the various layers of organisations the people belong to: "The words that matter to the self, matter first to some larger collectivity" (Weick, 1984a). Weick himself quotes George Herbert Mead as saying "Social process precedes individual mind."

8.5.3 Reality Construction

Lincoln and Guba (1985) discuss four different perspectives on reality, including 'constructed reality,' which holds that even if there is an objective reality, we can never know it directly. The best we can achieve is a consensus view of what we think it is. This position has it roots in many philosophical thinkers, and corresponds to the theoretical view.
expressed in symbolic interactionism, above George Kelly, who developed a technique for collecting people's own constructions of reality, thought it was presumptuous to assume that a person's constructs were convergent with some objective reality, and is quoted as saying "the open question for man is not whether reality exists, but what he can make of it" (Lincoln and Guba, 1985)

Constructed reality allows for multiple perspectives or multiple realities to exist side by side in the same organisation. As a theory of social organisation, it is associated with Garfinkel and with Berger and Luckman (1973) who propose that social reality is a human construction that is constantly being created by a process of social interaction. Over time, actions which are repeated and are given similar meanings by the self and others are said to be institutionalised.

The implications of reality construction for requirements analysis are clear. In situations where a social process has been initiated for the purpose of knowledge acquisition, representation, understanding, decision-making, and problem-solving, by a group of people with different roles, experiences and perspectives, there is bound to be a considerable amount of reality construction going on. Communication is an important factor in this process. It simultaneously enables and constrains the process of system development.

8.5.4 System development in and for an organisational context

A substantial amount of software is developed in order to be deployed in an organisational context. The notion of reality construction then becomes extremely significant, as Christiane Floyd and others have established in their book “Software Development and Reality Construction” (Floyd et al., 1992).

Organisations are themselves social constructions, but not as firmly established as other (seemingly more concrete) parts of reality, so how they are perceived and experienced differs considerably from individual to individual. In situations where the organisation itself is a customer for the software, as well as the individuals who are going to use it, this can cause problems if new systems are perceived as being for the benefit of the organisation at the expense of the user. The possibility of multiple realities occurring in the same project then arises and steps must be taken to achieve consensus. A considerable amount of research on this problem has been done in the area of Participatory Design.

Participatory Design is a normative approach to system development. Its roots lie in the democratisation of work, particularly in the Scandinavian countries following legislation in...
the early 1970's to increase worker influence in decisions affecting their work practices and working conditions. A number of trade unions sponsored action research projects to examine how this legislation might be applied to the development of organisational information systems.

Around the same time other researchers, including Enid Mumford in Manchester and later on, Christiane Floyd in Hamburg, were responding to the perceived need within system development for better ways of promoting interaction between users and developers, in order to produce more effective, more usable, and more acceptable systems.

Like other participative design methods, the ETHICS (Effective Technical and Human Implementation of Computer-based Systems) approach embodies the philosophy that users should be able to help create systems that are "humanistic and friendly, as well as efficient and effective" (Mumford, 1993). It includes a number of tools that help groups to design work, to identify goals and constraints, problems and problem areas, to measure job satisfaction, and to identify likely changes in the internal and external environments. This approach has been used for operational system design in factories, shops and offices, and has also been used to design decision support systems and as a general problem-solving tool.

Some types of solution-oriented and market-oriented situations can benefit from adopting an evolutionary learning perspective to deal with uncertainty. The guiding principle is that over time, knowledge increases and uncertainty decreases with continued use. Newer versions of products and solutions fit better with the situation of use, even as it changes. But participants in contract-based situations, and in problem-oriented situations, typically do not have the same opportunity to rely on second-order learning to help deal with uncertainty in their immediate development task, and must fall back on more traditional strategies.

The way requirements are documented in contract-based situations is a useful strategy for dealing with both uncertainty and ambiguity. Uncertainty can be reduced to a certain extent by recording all the relevant information about the problem, thus protecting both sides in the event of a dispute over the outcome.
8 6 System Development as Situated Action

The theory of situated action says that (human) action is always situated in some set of circumstances. Situated action involves taking cues from the situation as to how to proceed, rather than following a detailed pre-defined plan (Suchman, 1987). Accordingly, a system development method is not to be regarded as a set of directives to be obeyed, but a resource to be used only as a guide. Similarly, a requirements document is not a specification for action, but a resource that people make to guide subsequent action. Different circumstances necessitate and provide for different uses of documents such as requirements documents, and these are best regarded as resources to be used as the situation demands.

According to Suchman, who is an anthropologist, because action is always situated in some set of circumstances, social as well as physical, the situation itself is critical in the interpretation of the action. Under certain conditions, people make plans that guide their actions. These plans are abstract descriptions, made either before or after the fact of some action. Plans are therefore best regarded as resources that people use, to guide but not to determine their actions in a given situation.

She suggests that situated action can be supported "by defining the processes by which efficient representations are brought into productive interaction with particular actions in particular environments" (Suchman, 1987).

This is often taken to be a criticism of any kind of predefined representation, but requirements documents and other artefacts produced during system development are like plans, resources to be used to help guide people’s actions and their interpretations of each others actions. The same could be said of the target system itself. It could perhaps be best regarded as a resource for situated action, just like the intermediate products and documents that help to bring it into being.

Another reason often cited by critics of formal approaches to system development is the use of tacit knowledge (Polanyi, 1966) in dealing with situations. Polanyi distinguished between propositional knowledge, which is shareable, and tacit knowledge which is personal and based on reflection and experience. In his book, the Reflective Practitioner, Schon (1983) argued that reflective practitioners use tacit knowledge to augment explicit technical knowledge in order to cope with unstructured situations for which their professional training does not prepare them. Systems analysts fit the description of reflective practitioners because their work constantly involves learning about and making sense of a situation, rather
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than strictly applying pre-defined technical knowledge that is defined in methods and techniques (Fitzgerald, 1996, Vitalari and Dickson, 1983)

A related concept which is possibly more relevant to the question of situated methods is the idea of espoused theories of action, that is the difference between what people say (they would do) and what they actually do (Argyris and Schon, 1978)  Shipman and Marshall analysed a number of projects in which users had difficulty adapting to new systems which required them to formalise the information that they used in the context of their work They found that users’ reluctance to make explicit certain aspects of their work tasks was related to a desire to maintain control over their work (Shipman and Marshall, 1999)

8.7 Summary
Many of the problems and challenges of system development can be attributed to the fact that it takes place in an organisational context  The different types of situations that were presented in Chapter 6 were distinguished from each other by their particular concerns, but since system development is an organisational activity, these also correspond to different organisational archetypes  Contingency theory helps to explain why organisations, including system development organisations, adopt different internal structures in order to deal with their environments  Organisational structures give us insights into some of the problems and challenges that apply to requirements analysis in the different types of situations

Organisations have evolved particular strategies, such as methodical procedures, in order to overcome the known limitations of human beings (bounded rationality) as decision-makers and/or problem solvers  Records and documentation are typical examples of these strategies  Routines (procedures) are another type of strategy that frees human attention to cope with more unusual tasks or events  Requirements analysis work is non-routine, particularly for many of the stakeholders involved, such as the managers and end-users in organisational information systems  System development methods are seen as a way of structuring and controlling that activity

Organisations by their nature try to impose structure on unstructured situations  Many organisations try to evolve rational behaviour, to cope with the uncertainty inherent in their environments  Many software process improvement initiatives are examples of attempts to control the uncertainty that is inherent in system development situations  Organisations try to do this by formulating plans and procedures for carrying out the various key activities associated with system development  System documentation and programming standards are
typical examples of how some organisations try to constrain and control the ‘work products’ of system development

Work within organisational contexts is subject to particular problems of interpretation, uncertainty, ambiguity, and equivocality. Organisations can respond to these problems by becoming learning organisations, and the people in organisations respond by becoming sensemakers. Reflective practitioners use tacit knowledge to cope with unstructured situations. System development work, particularly requirements analysis often involves sensemaking for the individual and organisational learning for the organisation.

The social construction of reality is an important principle which summarises the way that reality, particularly organisational reality, is continuously being created by a social process of symbolic interaction. It allows for the possibility of multiple perspectives, or multiple realities co-existing in different parts of the same organisation. This has important implications for the development of systems in organisational situations, particularly systems intended for use in organisations.

The notion of situated action could be taken to mean that all situations are different, and that there is no point in developing a classification of situations, such as that presented in Chapter 6. However, situated action does support the idea that situations differ, and that the differences might be understood by looking at the factors, such as concerns, that shape the context of a situation.

8.8 Conclusions

The different situations identified in this thesis present some essential differences as organisational situations. One example is the division of labour in different situations, resulting in different levels of formality, and thus, different needs for coordination of effort. In market-oriented situations, particularly Type 1 and Type 2 situations, there tends to be a strict division of labour, separating the development process into formal stages. Different personnel groups assigned to areas such as marketing, requirements analysis, design, programming, and testing, need effective means to coordinate their activities. There may also be different levels of coordination, such as product and project steering committees. The requirements document plays a role in these situations, mainly as a discussion document, as a method of communication, as a working document but also as input to downstream activities such as design and testing.
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Rationalisation of system development activities is an important feature of such situations. Many of them adopt process improvement initiatives which rely on extensive documentation of both development processes and project deliverables. In contingency theory, high levels of formalisation are associated with stability in the environment, but the Type 2 situation has more uncertainty in the marketplace, and therefore, less reliance on formal procedures. The relationship between effort and outcome is unknown in these situations, increasing the need for teamwork and joint effort by management and staff.

Type 3 (single customer) situations have some features in common with the other market situations, but are different in that the agreement is a contract with the customer. This is similar to the Type 4 and Type 5 situations, in that the requirements document as part of the contract, is aimed at controlling the interaction between the two parties. Knowledge asymmetry between the parties to the agreement is a problem identified by agency theory, but the requirements document, as well as recording the agreement, may play a role as a specific asset, an investment made by the developers which ties them in to the situation.

Solution-oriented situations, i.e., Type 4, Type 5 and Type 6 are all concerned with solutions that must fit in a specific organisational situation. This gives rise to the need for communication to uncover the multiple perspectives, or multiple realities, that exist within the organisation. But in two of these, Type 4 and Type 5, which are agent/principal situations also, there must be a balance between the need for control and the need for communication in the situation, resulting in a particular set of roles for the requirements document. These include its use both as a method of communication, to tell the users 'what they are getting,' and to document the agreement.

For situations such as Type 1, the vertical market, and other single-organisation situations, such as Type 6 and Type 7, the transaction cost economics version of agency theory gives a better analysis of the organisational control of system development activity in general, and requirements gathering and analysis in particular. This version allows for a wider variety of organisational structures, including hierarchical organisation of principals and agents within the same organisation. The main feature of such situations, accordingly, is cooperation within an organisation, the need for which is stimulated by bounded rationality of the participants and uncertainty in the environment or the task to be performed.

Type 6 situations are more concerned than any other type with communication within the organisation, and the role of the requirements document as a method of communication reflects that. However, some organisations are more formal than others in this respect, and
this is likewise reflected in the use of prescribed methods for system development, including more formal documentation. Sensemaking is a repertoire of organisational strategies for reducing both uncertainty and ambiguity. In many situations, therefore, representations such as those found in requirements documents can represent only a part of what is known and agreed by the participants.

In the next chapter, I review some of the relevant literature on representation and its role in the documentation of requirements. Three basic questions will be addressed:

1. what different aspects need to be represented in requirements documentation,
2. why models are useful mechanisms for representation, and
3. why using models for requirements representation can be problematic.
Chapter 9: Perspectives on Representing Requirements

9.1 Introduction

Chapter 4 has introduced a new way to classify requirements that is different from the established typologies of requirements that have appeared in the literature thus far. However, this classification of requirements as texts, although grounded in the taxonomic analysis of the interviews and sample documents, also has several roots in the literature on requirements representation, which will be reviewed in this chapter, and linked to the relevant elements of the classification. It will then be compared and contrasted with existing frameworks in the next chapter.

This chapter explores the nature of requirements representation, the uses of models as a form of representation, and reasons why models are not always the best ways to represent requirements. The sections and sub-sections in this chapter reflect the elements of the typology of requirements from Chapter 4. It contrasts the product-oriented perspective with the process-oriented perspective. It concludes that a process-oriented perspective is often needed in addition to the dominant product-oriented perspective that is embodied in many current approaches to requirements representation.

9.2 Requirements Representation

A representation is something that is made for the purpose of standing for something other than itself. The construction and use of representations is an essential part of system development generally, and requirements analysis in particular. The forms of representation that are used for representing requirements include various types of artefacts called descriptions, statements, specifications, prototypes, and models.

Unfortunately, these terms are mostly used rather loosely, are often used interchangeably, and are rarely differentiated in the literature where they are used. However, David Parnas (1995) makes an interesting distinction between a description, a specification, and a model:

1. A description is a statement of some of the actual attributes of a product, or a set of products.
2. A specification is a statement of properties required of a product, or a set of products.
3. A model is a product, neither a description nor a specification. Often it has some but not all of the properties of some "real product" (Parnas, 1995).

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A prototype is a good example of what is meant by a model in this scheme. A communication protocol is a good example of what is meant by the term specification. It states what is required of any product that is intended to implement that protocol. Parnas points out that to illustrate the protocol, during discussions, with a finite state machine is to replace the specification with a model, a product that is intrinsically different. Models have some but not all of the required properties, as well as having other properties that are not required, of the intended product (Parnas, 1995).

These are useful distinctions, but this use of terminology is neither standard nor widespread in the literature and practice of software development. The terms description, specification, and model are used interchangeably. For example, formal notations, such as VDM or the Z notation, are usually referred to as specification languages, though their intended purpose is for creating system models, called model-based specifications. The term product may be used by some authors to refer to any of the artefacts which are the products of the system development process, such as specifications, while others reserve this term for the final product, the intended system.

In my empirical study of system development practice, there was clear evidence that all three types of representation, descriptions, specifications, and models, are present in the practitioners' requirements documents. However, these elements were mostly combined and interleaved in the same artefact. Though they can be distinguished, the distinction is not made explicit in the documents. The term 'statement' is used in relation to all three types of representation outlined above, and accordingly has been adopted in the grounded theory to refer to any type of requirements representation.

Another, possibly more useful, distinction encapsulated in the above definitions is the difference between a statement of what is to be (which Parnas calls a specification) and a statement of what is (which he calls a description). This is an important difference for system development, which is concerned with both things as they are, that might be required to change or to stay the same, and things that are required to be brought into being. Different aspects of requirements that might need to be represented provide a more generic way of classifying different types of requirements statements than any distinction between different types of representations.

9.2.1 Separation of concerns
This distinction, between what is and what is required to be, between what happens and what is required to happen, highlights the difference between two separate aspects of requirements.
that must be represented, namely, the relevant characteristics of the problem domain and those of the intended system. Parnas has called this "the separation of concerns." This separation refers to the need to document not only the required properties or behaviour of a proposed system but also the environment or context in which the system will operate.

Parnas was writing about the specification of real-time systems. These deal mainly with readings taken from the system's environment, "environmental quantities," such as the temperature and pressure of different chemical or physical processes. Some of these quantities are to be monitored by the system, as readings taken from various instruments, and some of them are to be controlled, as values sent to other instruments.

The purpose of the specification, in Parnas's view, is to specify the relations between these quantities, and this should be done by defining two separate relations. The behaviour of the environment would be captured in a relation called NAT and the required behaviour of the computer system would be captured in a relation called REQ. In this approach, NAT is a description of the environment, and REQ is a specification of the software that is required (Parnas, 1995).

A similar separation of concerns appears in Jackson's distinction between the Application Domain and the Machine (Jackson, 1995). Jackson uses the term description in a more general sense than that of Parnas. According to Jackson, for any kind of system, you need to describe (i.e., represent) three things:

1. the problem domain
2. the machine, and
3. the connection(s) between them.

The machine is intended to implement the required behaviour in the problem domain, therefore, it will to some degree be embedded in that domain. How deeply embedded will depend on the types of connections used, among other things (Jackson, 1995).

Jackson's framework goes further than that of Parnas by maintaining that the two main descriptions (that of the problem domain and that of the machine) ought to be written in different grammatical moods, the Indicative mood for the description of the environment, and what he calls the Optative mood for the machine requirements.

This separation of concerns suggests a fundamental partitioning of the task of requirements description, a partitioning which seems to be ignored or even confused by Object-Oriented
approaches to requirements modelling Object-Oriented approaches not only use the same set of constructs for analysis and design, but also fail to recognise or support the distinctions made by Parnas and Jackson In Object Oriented Analysis, the same basic constructs are employed for modelling the problem domain and the machine, to use Jackson’s terms But these are different things, from different worlds

“The difficulty in moving from OOA to OOD is caused by the fact that OOA objects and OOD objects are inherently different things” (Kaindl, 1999)

These are two separate aspects of software requirements that need to be represented, the environment and the machine It is essential to be able to distinguish them in the representations, because one of them (the environment) is assumed to be already there and the other (the machine) is not Using different grammatical moods to describe them acknowledges this fundamental separation of concerns Jackson suggests that three different descriptions are needed E, R, and S

E is an indicative mood description of the environment or problem domain
R is an optative mood description of the required effects of the machine S in environment E
S is the specification of the machine which will produce these effects in this environment

“If a machine which has the properties described in S is installed in the environment, and the environment has the properties described in E, then the environment will exhibit the properties described in R ” (Jackson, 1997)

The analysis of requirements as texts presented in Chapter 4 draws on this distinction, and distinguishes problem domain descriptions from other types of requirements statements, such as goals and required effects This distinction is also supported by the data In practice, the most important and relevant aspects of the problem domain are typically represented in requirements documents by descriptions written in natural language, but they can also be represented by various types of models

9.2.2 Representations of the application domain

It has often been noted that experienced analysts and software engineers often have extensive knowledge of the application domain in which they work, e.g. manufacturing, finance, telecommunications switching etc For example, in their influential study into the problems of developing large systems, already referred to in Chapter 2, Curtis, Krasner and Iscoe identified “exceptional designers who could map deep application knowledge into a computational architecture” as important contributors to the success of projects This kind
of knowledge is gained through the experience of working on projects in the same application domain, rather than through formal training (Curtis et al, 1988)

923 Domain models

It seems plausible, however, that if this knowledge could be captured in such a way that it can be re-used, that this would be a good way subsequently to approach the goal of gaining knowledge about the problem domain, and in such a way that aspect of requirements specification would not need to be done again from scratch, but would be derived from some suitable pre-defined domain model.

The domain modelling "project," therefore, is based on the idea that a chosen application domain can be studied from a general point of view to discover the generic requirements of all the systems that could be required for that domain, their data, their behaviour, their functions, their requirements in general. The result of domain modelling is a normative (generic) model, which can later be instantiated to several specific domains. According to Dines Bjørner, an instantiated domain model can then be used to generate a specific requirements model (Bjørner, 1998).

924 Reference models

An excellent example of domain modelling that is widely used in practice occurs in the domain of manufacturing. Here domain models are used at various levels in the development and deployment of software. The practice began with Prof A-W. Scheer who built what he called a reference model for the area of manufacturing. This reference model is a comprehensive Entity Relationship model covering all of the application areas within manufacturing such as material requirements planning, job scheduling, inventory management, and product data management (Scheer, 1998).

The reference model is used as a starting point for modelling a specific situation, by specialising it or localising it to that specific situation. The elements of the reference model act as a checklist to decide which aspects are to be included in the resulting model and which do not apply, and are therefore omitted. The result is a model which fits the given problem domain, containing all or most of the elements that are likely to be needed in that application.

925 Requirements as effects

Both Parnas and Jackson have identified and highlighted the distinctive characteristics of requirements stated as effects. These are simply effects that are required to be produced in
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the problem domain  Parnas calls them REQ and Jackson calls them effects  Following Jackson, Kovitz calls them required effects  These contributions have given theoretical support to the widespread practice of stating requirements in terms of a Black Box, by listing the inputs and outputs of the system  This approach is also reflected in the practice of writing requirements as a list of paragraphs beginning with the phrase, “The system shall  ,” a custom which has a long tradition in industry

9.2.6 Requirements as goals

Many researchers in the field of requirements engineering seem to agree that objectives or goals have an important role to play in requirements, but there is less agreement in the literature on the extent to which goals should determine the structure of the requirements or to what extent goals should be modelled in the requirements statement  In many approaches to representing requirements, goals are not given explicit consideration at all

Axel van Lamsweerde and his colleagues have based KAOS, their approach to requirements modelling, on the idea of modelling goals  The resulting model is a hierarchy of goals and sub-goals at different levels (Lamsweerde et al., 1998)  Requirements in the sense of Parnas’s REQ and Jackson’s effects are essentially goals belonging to the lower levels of this hierarchy

KAOS is radically different from other modelling techniques such as E-R and OO in that the goals are the main modelling constructs, from which sub-goals and other requirements are derived  Again, note the possibility of derived requirements  But more noteworthy is the idea of requirements as goals, rather than as “objects of interest in the real world ”

Most other approaches to modelling in system development are predicated on building an objective model consisting of objects and their relationships that are supposed to exist in some part of the real world  Goals can be problematic, because they do not exist on their own  The problem of whose goals they are, and how goals conflict with each other, then arises

In a business organisation, the goals of the organisation may be expressed in a mission statement  Information Engineering (Finkelstein, 1989) is a method that tries to relate information systems to business goals, beginning with an analysis of the business strategy, resulting in the Information Strategy Plan (ISP)  This analysis consists of four steps

1  the business mission,
2  the long-term goals of the business
3 the problems that make it difficult to achieve these goals, and
4 the Critical Success Factors, as perceived by the management.

This approach makes a distinction between goals and objectives. Objectives are more specific than goals. They are measurable, and time-constrained, unlike goals, and related to higher-level goals.

In general, goals and objectives can be regarded as very high-level requirements. They help to evaluate solutions or proposals. Goals break down into lower-level requirements, which are in effect sub-goals that are more specific, and more measurable, and should be, to some extent, more explicit.

9.2.7 Requirements as constraints

In a sense, all requirements are constraints. By definition, each of the requirements for a system effectively restricts the set of possible solutions that will satisfy the requirements as a whole. But some requirements are considered hard constraints, and these are documented differently in many of the cases that I came across, because they are not negotiable. My analysis of requirements as texts found two main types of constraints in the documentation of practitioners, behavioural constraints and design constraints. However, business rules and application standards such as those that apply in the telecommunications domain could similarly be regarded as constraints.

Design constraints are usually treated in the literature as non-functional requirements, though some authors make a distinction between these and other types of non-functional requirements.

Much of the literature supporting the specification of constraints occurs in the area of formal specification, particularly for applications which are safety-critical or need to be dependable for one reason or another (Leveson, 1995). Techniques such as Z and VDM emphasise the specification of behavioural constraints in the context of a system model.

9.3 Requirements and Solutions

Another distinction that is often made in the requirements literature is the separation between problems and solutions. Requirements statements are supposed to be concerned with problems, not solutions. Design is supposed to be concerned with solutions. It is frequently advocated in the literature that the requirements statement should avoid any mention of design or suggested solutions, and concentrate on stating the problem. Perhaps this is
intended as a division of labour, because part of the audience of a requirements document is the users, and, by definition, they are not supposed to have any expertise in design, nor want to see it discussed in the requirements document. But problems and solutions are not so easily separated, and solutions often appear in requirements documentation, as I found in my empirical study.

Many of the practitioners I interviewed were concerned just as much with solutions as with problems. One of them even called his requirements document a “Solution Investigation” document. The problems that system development practitioners deal with in their work are nearly always problems that are assumed to have a software-based solution. In the early days of organisational system development, systems analysts did not automatically assume a software system would be part of the solution, but it became the norm. A software system is assumed to be part of the solution, and to a greater or lesser extent is often outlined in the requirements document. This intertwining between problems and solutions is recognised in the literature that associates requirements with Problem Frames, system architecture and design.

Jackson’s Problem Frames emphasize the relationship between problems and solutions. A problem frame suggests the solution task (Jackson, 1995, Kovitz, 1999). For the analyst, the use of a specific problem frame (or, in the case of in a complex problem context, combination of problem frames) helps to focus the problem more clearly by suggesting what questions need to be answered and consequently what needs to be covered in the descriptions (of the application domain, the machine, and the connections).

The description of a lending library system ought to contain different information than would be found in the description of a lift control system, because the solution to each of those problems is going to be qualitatively different. However, the requirements for a video library system will have much in common with those of a book library system. This fact is reflected in their having a common problem frame. Similarly, a lift control system will display common features with other types of control problems that match the “control” problem frame.

This is not to suggest that all problems can be categorised into a few classic problem frames, but that there are some similarities which different problems share which can help to begin the task of solving them, by outlining what needs to be described in order to adequately describe the problem so that a solution can be found. It also suggests that the question of when a given description is sufficient to describe a problem is related to the problem at hand.
rather than being independent of it. Similarly, the problem frame, or more likely the appropriate combination of problem frames should suggest what aspects of the problem need to be represented in the requirements documentation.

9.3.1 Requirements and system architecture
As well as framing how the requirements are to be represented, the problem frame may be said to determine the architecture of the solution, the system architecture. Some authors have even suggested that software architecture may be considered an integral part of requirements (McDermid, 1994).

Having a particular architecture in view can lead to particular requirements implied by that architecture, what might be called “derived requirements.” Such derived requirements may be either problematic or useful. They may cause problems if they are extraneous to the problem, but alternatively they may help the requirements task when the chosen architecture acts a vehicle for general (or generic) requirements which apply to the problem situation, and therefore do not need to be specifically mentioned.

A good example is the way that database-oriented requirements tend to focus mainly on specifying the structure of the stored data, and then on the requirements and rules for the creation, deletion, and amendment of data. In such cases, specific information retrieval or reporting requirements are not explicitly specified, once it can be demonstrated that the stored data will support them along with a query language such as SQL.

9.3.2 Requirements and design
For many years there has been a controversy in academic software development circles regarding the need for the separation of requirements and what might be called “design” (Swartout and Balzer, 1982). But it seems, from my interviews, that it is not possible to separate requirements from design, any more than it is possible to separate problems from solutions. In many cases where user interface requirements were included in requirements documents, they were indistinguishable from user interface design, for example. Also, practitioners following recognised methods of information system development tended to produce an “implementation-independent” logical database design, but this was generally implemented without any transformation, as a relational database.

Participatory design, where users are involved to a greater extent than normal in information system development, does not make any distinction between requirements and design.
Whatever users design in such contexts becomes, by virtue of that fact, the requirements (Floyd et al., 1989)

In arguing for the separation of concerns, both Parnas and Jackson seem to be making a case for the separate presentation of these aspects in different documents, or different sections of a document. I have found that this does not happen in practice, although in some cases, different aspects were tagged as such but were interleaved in the document, so that they could be read and interpreted in context, and in relation to each other. Neither Parnas nor Jackson seem to deal with this as a possible approach.

The grounded theory of documentation presented in this thesis, rather than advocating any particular approach to representation, seeks to indicate the basic types of requirements statements that might appear in a document. Both the empirical data and the theoretical arguments that are outlined above suggest three basic types of requirements statements that play a role, to a greater or lesser extent, in the requirements documents in different situations. These are:

- Problem Domain Descriptions
- Required Effects, and
- Proposed Solutions

Goals and Constraints as types of requirements are also well established in the literature on representation and modelling. A model is a product. These five elements of the classification are supported because the literature takes a product-oriented perspective. The other two elements, Issues and Changes and Recorded Agreement, both reflect a different perspective, the process-oriented perspective.

9.3.3 The process perspective

The process-oriented perspective is a paradigm of system development which stands in contrast with the dominant product-centred perspective. It supports the finding that among the most important uses of the requirements document are its process-oriented uses as a working document, as a discussion document, as a method of communication, helping to get agreement. It regards the outcome of development not as a finished product but as a tool or medium which users continue to learn about and to improve during use (Floyd, 1987).

STEPS (Software Technology for Evolutionary Participatory System Design) (Floyd et al., 1989) regards system development itself as a learning process for everybody concerned. It is evolutionary in the sense that insights into the functionality and uses of the software only emerge over time. Insights and, later, models are based on what is called perspectivity which
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refers to the different perspectives held by the participants, such as the use perspective and the development perspective. At each step of the process, a new version of the software is incorporated into use, and the anticipated reorganisation of work takes place, followed by the evaluation of the result, and mutual learning for the participants. The "anticipation of use" is an important aspect of the development process. The use of intermediate products is situation-specific, and requirements are never fixed in advance, but allowed to emerge over time, evolving as a result of concomitant organisational change.

The process perspective is an essential foundation of the grounded theory presented in this thesis. It is reflected in the different uses of the requirements documents reported in the findings, and in the following discussion of the use of models, and other representations in the process of understanding requirements, dealing with complexity, rational reconstruction of decisions, and recording the issues and changes that take place, and keeping track of the status of the evolving agreement.

9.4 Requirements modelling  Uses and Abuses

Building models is an important part of the process of requirements specification and analysis. Indeed, many approaches assume that modelling is the only way to document requirements. Some of these approaches assume that requirements models will be built from scratch, others propose using pre-defined models such as reference models or domain models. The utility of problem frames is based on the likelihood that the same or similar problems have existed and/or been solved already. However, there are not many application areas where comprehensive reference models are available, where the work of modelling has already been done to any significant extent. The research area of domain modelling aims to rectify this situation. It suggests that there is considerable scope for the re-use of application domain models in system development (Björner, 1998).

Domain models (and reference models) rely on the fact that models are useful forms of representation, because they embody knowledge in a concise manner. However, even though models are useful, as many of the practitioners revealed in the investigation, the act of building a model is even more useful.

9.4.1 Understanding requirements

The purpose of a model, such as a domain model, is to capture extensive and comprehensive knowledge of an application domain. In contrast to having to acquire this knowledge through interacting with subject matter experts, such as experienced users who have tacit knowledge of the application domain, this knowledge is available in an explicit form, so that
an analyst using the model will be able to access it and re-use it in building a specific application model. The domain modelling approach seems to presuppose that there are only two main purposes of models:

1. to embody and organise knowledge and
2. to communicate knowledge

But it does not address one of the main reasons why, according to my empirical observations, analysts build models from scratch, which is for the purpose of developing their own understanding of an application domain. Very often, developers will not expect end-users to understand their models, but they will build models nonetheless, to satisfy themselves that they understand the problem area. In order to build the model, the developer needs to achieve a very good understanding of the application domain, and for many practitioners, that is the main purpose of building a model.

"It is an attempt to indicate that you have understood the communication."

"Here's our understanding of what you told us."

"We had to try and understand everything because for us it was putting something down for us that was clear."

Requirements analysts deal with understanding on a regular basis. Their job is to not only understand situations, but to master their complexity as a matter of course. They have to make sense of situations from partial information, and often from conflicting accounts and perspectives of other people, and state the problem in such a way that it can be solved by a formal system running on a computer.

Modelling was one of the skills of exceptional designers which were deemed to be crucial in respect to understanding requirements in the Curtis, Krasner and Iscoe field study (Curtis et al., 1988). Not only were they extremely familiar with the application domain, they were also very skilled at integrating this knowledge across functional components, and with the technical knowledge that would be used to construct the solution.

"Exceptional designers were skilled at modeling the interaction of a system's different functional components, and occasionally developed notations for representing them also adept at identifying unstated requirements, constraints and exceptional conditions."

9.4.2 Dealing with complexity

In a famous article, Fred Brooks (1987) identified Complexity as one of the essential difficulties of software development. This is because the problems that software developers deal with, as a matter of routine, are non-routine problems. Over the years, as problems become better understood, and standard solutions are developed, the type of problem being
addressed by system developers has gradually progressed to more complex and difficult problems.

This essential complexity in problem situations is due, not only to the problems themselves, but also to the fact that human thought processes can only deal with a certain amount of information at a time. This is the problem of bounded rationality (Newell and Simon, 1972) which was discussed in the previous chapter, page 149. Since they can only pay attention to a limited number of things at a time, people tend to make decisions that are not entirely rational. Therefore, the best that people can do in any problem situation is to satisfy certain selected criteria that they give their attention to, while ignoring other factors, so that they never reach completely optimal solutions.

Davis (1982) explored a number of different barriers and limitations to rationality in the determination of requirements. He gave the following list:

1. Anchoring and adjustment: People tend to make judgements by making an anchor point and adjusting from that.
2. Concreteness: Using only available formats, people will not look for alternatives.
3. Recency: People are more influenced by recent than past events, giving greater weight to the former, and less weight to needs based on less recent events.
4. Intuitive statistical analysis: Humans do not make good intuitive statisticians. They draw unwarranted conclusions from small samples, they confuse causality with joint occurrence. They therefore often misjudge the need for information (Davis, 1982).

As a result, unless these problems are recognised and dealt with, requirements tend to be biased towards current procedures, currently available information, recent events and inferences based on small samples (Davis, 1982).

In general, these limitations apply just as much to system developers as to end users, but it has been found that highly rated systems analysts have cognitive styles and problem-solving methods which are essentially different from those used by poorly rated analysts (Vitalari and Dickson, 1983).

The use of abstract models is a common strategy for overcoming bounded rationality, by reducing the number of elements we have to pay attention to, while at the same time ensuring that the most important aspects of problem situation are attended to. The use of models simplifies the cognitive task of understanding problem situations and dealing with
complexity By abstracting away the details and simplifying the problem, models allow the
developer to focus on selected aspects or chunks of the problem at any particular time

Therefore, rather than using models as communication devices, which is one of the stated
purposes of models, developers often create models mainly in order to improve their own
insight into a problem situation

"One of the justifications for entity modelling is that you can show
it to the users and say 'is this correct?' I don't know if this is
always true. A lot of users, as soon as an IT person pushes a
piece of paper in front of them, no matter what's on it, they switch
off."

"To me, the main value of it is the understanding it gives me."

9.4.3 Models can be problematic
Models have certain pitfalls that can make them problematic in some situations when they
are used to state requirements. Any kind of representation can be problematic, because it
must be interpreted, and people's interpretations vary. Models, as relatively formal
representations, are supposed to have more controlled interpretations than other forms of
representation, but despite this, they are subject to two major disadvantages when it comes to
interpretation

1. Because they are abstractions, they are not directly refutable
2. Because they use specific notations, they are not universally understood

Jackson (1995) makes an important distinction between refutable descriptions and
definitions. Refutable descriptions are based on explicit designations of phenomena in the
real world. They are either true or false, unlike definitions. Definitions are similar to models
in having no possibility of being false. They are tautologies.

Everyone should be able to understand a problem description written in plain language, but if
you gave me a description in plain Greek (or Dutch or Spanish etc.) rather than plain
English, I would not be able to understand it. The use of "plain language" presupposes
facility with a specific natural language. Otherwise, the receiver is at a great disadvantage.
Similarly, a developer who is proficient in the use of UML diagrams or data flow diagrams
has a distinct advantage over a client who is not, in trying to understand, let alone criticise, a
model written in one of these notations. This advantage is called "model power" and it is
one of the main reasons why using models in organisational situations can be problematic
(Floyd, 1995)
Some advocates of Participatory Design, for example, (Gasson, 1999), reject any formal representations that may be used in conventional development methods. Consequently, it is hard for them to propose (prescribe) alternative methods, but they always favour more situated, people-centred, integrative approaches. Also, some of them do not seem to allow that rational approaches or formal notations may, even sometimes, be appropriate.

9.5 Documenting Issues and Changes

9.5.1 Rational reconstruction

System development is often supposed to be a rational process, and ideally, it is, based on objective knowledge and understanding, proceeding from an initial statement of requirements to the delivery of a system satisfying those requirements. But system development rarely follows such a smooth course. Several years ago, Parnas and Clements (Clements and Parnas, 1985, Parnas and Clements, 1986) recommended using documentation, particularly requirements documentation, as a way of faking the ideal rational process of system development. After describing the ideal development process, they finally describe how it should be faked by subsequently producing the documentation as it would have been done, had an ideal process been followed.

"The documentation is our medium of design and no design decisions are considered to be made until they have been incorporated into the documents. No matter how often we stumble on our way, the final documentation will be rational and accurate." (Parnas and Clements, 1986)

This faking strategy is widely known as rational reconstruction, an idea which was first identified by Carnap, and developed by Reichenbach, who maintained that "logic governs the result of thinking, not the process of thinking itself." (Wieringa, 1996) A similar strategy of faking occurs in mathematics, whereby the orderliness with which a proof is presented belies the method of its discovery. Likewise, the actual research process differs from the way the results are presented in a paper or thesis, which structures the research in order to try to make it more understandable for the reader.

Requirements documents often include devices that attempt to reconstruct the actual process by keeping track of what went on during the construction of the document. One way of doing this is by specifically numbering the versions of the document as it goes through various modifications and revisions. Another way is by documenting the open issues that are outstanding at a particular point in the process, and by recording how the closed issues were
Resolved  Similarly, actual changes to requirements previously documented are sometimes recorded, along with justifications for the changes made and decisions taken.

Justification is an important part of the rational reconstruction of what went on in the actual process. Parnas and Clements recommend using the documentation to record all design alternatives that were considered and rejected, and why. Such justifications can be used to answer many questions concerning the requirements and design, that might be raised during development and, subsequently, during the entire life cycle of the system.

The issues and changes that are documented are typically the ones that are considered the most important ones for the future lifetime of the system. Recording every single change and decision would be not only impossible, but also unhelpful for the purpose. Different versions of a document are produced along the way in time for specific deadlines, for the purpose of review and comment.

9.5.2 Uncertain requirements

Bounded rationality helps to explain why the system development process is not entirely rational. Requirements statements are by necessity incomplete and imperfectly understood, even at the end of a development project. Lehman formulated this as an uncertainty principle: "The outcome of software system operation in the real world is inherently uncertain with the precise area of uncertainty also unknowable" (Lehman, 1989).

Lehman bases this principle on Godel's completeness theorem which says that a set of axioms must always be either inconsistent or else it must be incomplete. He argues that in any development project, we cannot know which of the theories embedded in the system or used for its development is inadequate, because if we did, then we would consequently extend or improve it accordingly. His solution is to define and follow a disciplined process that embraces the evolution of the software during use subsequent to its release.

This characterisation of uncertainty as occurring at two levels is reflected in the nature of the learning process that is needed in order to deal with it. An evolutionary learning process is one that includes second-order learning as well as first-order learning. System development is such a learning process.

The act of building a model could be considered a learning experience for the system developer, especially if the model is not to be used for communication with the client organisation or the users. It allows the model builder to express his or her emerging...
Part Three Theoretical Support for the Findings

understanding of what might be a very complex problem situation. It also structures the learning task for the model builder.

The process of discovering requirements may also be regarded as a learning process, with many changes along the way, as issues of understanding and disagreement arise and are resolved. The practice of documenting issues and changes helps by keeping a record of why certain decisions were made, providing a knowledge base for future development and evolution of the system.

Some methods explicitly recognise the nature of the learning process involved in system development. STEPS (Floyd et al., 1989) is a systematic yet flexible method using a cyclical development process that accommodates various forms of representations, including prototyping, and different steps depending on the situation. It emphasises participation by the users at all stages and "intertwines development with use."

9.6 Documenting Agreement

Recorded agreement is perhaps the most unusual component of the documentation model presented in this thesis. Agreement is widely acknowledged as an important concern in requirements, but maybe not so much as a component of the documentation. Its place in the documentation model is pivotal. It stands for the varieties of agreement as expressed in the document information, but also expresses the varying nature of what the agreement is about. Agreement rarely refers to problem domain descriptions, or application constraints, but it could do. It typically refers to goals, required effects, and proposed solutions, and most of all, to changes proposed to deal with issues that were raised in the course of defining the requirements in the document. Open issues are explicitly those not yet agreed. Solution constraints may or may not be. The document keeps track of the status of the agreement.

Participatory design emphasises the importance of social, cultural and political factors in getting to agreement. It recognises that system development often involves a redesign of the users' work context and that this could lead to conflict. It aims to coordinate joint action by developers and end users so that each will gain a better understanding of each other's point of view. The main idea is that, through sustained interaction, developers gain a better understanding of the users' work context, and users gain more influence over the outcome, so that a better outcome can be achieved.
A collection of articles entitled “Representations of Work” (Suchman, 1995) reported on various user-centred approaches to system development modelling in organisational contexts. These approaches aim to increase understanding in collaborative efforts at system development, while recognising the problem of perspectivity, and the difficulty of “how to construct a shared information space,” given the complex social and political relationships that may exist between stakeholders. However, not all system development situations are similar to the ones for which participatory design approaches are intended, and in those situations, agreement means different things.

9.7 Summary

One of the main ideas which influenced the classification of requirements presented in this thesis is called the separation of concerns. This is sometimes taken to mean that different elements (concerns) such as problem domain descriptions and required effects must be documented in separate documents, but this is not necessary. As long as they are clearly distinguished in the text, these elements can be interleaved in the same document, as much as is necessary, to allow the required effects to be understood in the context of the problem domain description. This is what I have observed happens in practice.

Abstract models are very useful for describing the problem domain, and the proposed solution. One of their uses is to embody knowledge, in the form of domain models and reference models. The process of building a model may be a very worthwhile learning experience for the system developer, even if the model is not used for communication with the client organisation or the users. It allows the model builder to express his or her emerging understanding of what might be a very complex problem situation. It also structures the learning task for the model builder.

The relevance of problem frames and system architecture to requirements in the literature suggests that problems and solutions are ‘inevitably intertwined’. But this conclusion is still controversial. In practice, it is not possible to totally separate problems from solutions, and therefore, proposed solutions are often an intrinsic part of requirements documentation.

The use of models, plans, and other written representations is seen as an essential strategy for coping with uncertainty in many organisational situations, including system development. People use documents and models as resources when doing knowledge-intensive work in organisations. Models must be interpreted in order to be useful. The interpretation depends on many factors including the context in which they are used.
9.8 Conclusions

A model is a product. Building it can help a practitioner to capture and improve his own understanding of a problem domain or the behaviour required of a system. It is not necessarily a good method of communication yet models of various kinds are the tools most strongly advocated in research papers and textbooks, being almost synonymous with requirements representation. Elements of the requirements classification, such as Problem Domain Descriptions, Required Effects, Proposed Solutions, and to a lesser extent, Goals and Constraints, are well established in the literature on requirements representation. Much of this literature emphasises modelling, and reflects the prevailing product perspective.

The other two elements of the classification, Issues and Changes, and Recorded Agreement support a process-oriented perspective. The system development process is not entirely rational, and the different uses of requirements documents found in practice, including its role in rational reconstruction, also reflect this process perspective on system development.

The rational perspective on organisations assumes that goals are fixed, while the open system perspective allows that over time, the system, and possibly its goals, will change, depending on the experiences of the organisation and its participants. System development is a good example of learning in an organisational context. The organisation changes itself as a result of implementing a new system, often in response to the challenges in its environment, or to changes in its goals.

Both the product perspective and the process perspective are needed in order to comprehend the variety of different roles of the requirements document in different situations.
Part Four Evaluation

This thesis has proposed a framework which attempts to relate the relevance of seven different typical components of requirements documents to a variety of types of situations. It also provides a scheme to classify situations based on the presence and relative significance of eight different root concerns which are the sources of substantive requirements. In the next chapter, I try to position the framework in relation to the existing and current literature on theories, methods, and standards for documenting requirements.

In the final chapter, I summarise the findings of this research and try to assess its implications for both research and practice. This chapter includes a summary of research, a summary of the findings, the implications of these findings for practice, for research, the contribution to theory, and possible applications of the framework. It also looks at the limitations of the framework, the need for and suggested approach to validation, and recommendations for further refinement of it.
Chapter 10 Comparing and Relating the Framework to the Literature on Requirements Documentation

10.1 Introduction
The literature on requirements documentation is extensive, so this review must be selective, but it attempts to be representative, nonetheless. In order to organise this chapter, and to justify the selection of literature reviewed, I will present a grid (introduced in Table 1) which analyses the contributions according to their position in two dimensions. The first dimension analyses contributions depending on whether they belong mainly to the product-oriented perspective or to the process-oriented perspective. The second dimension indicates whether a contribution seems to interpret the term "requirements" as substantive needs or as written texts and/or representations. This latter distinction is not normally made in the literature, but which interpretation is in operation can be inferred.

<table>
<thead>
<tr>
<th>Product-oriented perspective</th>
<th>Process-oriented perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements as needs</td>
<td>Q1 Contributions that regard requirements as needs and their identification mainly as an end in itself</td>
</tr>
<tr>
<td></td>
<td>Q2 Literature that regards requirements as needs and their identification as part of a learning process</td>
</tr>
<tr>
<td>Requirements as texts</td>
<td>Q3 Authors that look on requirements as artefacts, and these or the system as ends in themselves</td>
</tr>
<tr>
<td></td>
<td>Q4 Papers and books that look on requirements texts as ‘situated tools’ in the process of evolving useful systems</td>
</tr>
</tbody>
</table>

Table 10.1 Analysing the literature

The process-oriented perspective was described and motivated by Christiane Floyd in (Floyd, 1987). A good case for adopting this perspective can be found in the work of Lehman (Lehman, 1984, 1989, Lehman and Belady, 1985) who observed that software systems change the environment in which they are used, and thereby modify the requirements that led to them.

10.2 Classifying requirements
Several authors and standards provide a typology of requirements. All of these classifications fall into quadrant 1. They adopt a product perspective rather than a process perspective, and either they do not distinguish needs from representations, or they clearly focus on requirements as needs.
It is widely agreed that requirements are either functional or non-functional. Although this distinction has been disputed, because non-functional requirements are often implemented as system functions. However, the distinction is well supported in textbooks and standards, though the term "extra-functional" has been proposed as an alternative to non-functional. Beyond this distinction, there is very little agreement in the literature regarding the classification of requirements. Non-functional requirements are most often sub-divided into different categories such as:

- performance requirements
- interfaces
- design constraints

But this breakdown is disputed by those who reject the notion of including constraints in the category requirements, although their inclusion as requirements is commonly accepted. Textbooks on SSADM recognise a breakdown that distinguishes constraints from non-functional requirements, for example, the following list comes from Ashworth and Goodland (1990):

- functions
- data
- non-functional requirements
- goals
- implementation/design constraints

The IEEE Standard Glossary of Software Engineering Terminology divides requirements as follows:

- functional
- performance
- interface
- design
- implementation
- physical

Whereas, the IEEE Standard for the Software Requirements Specification 830 (IEEE, 1998) provides a list which, in addition to functional, performance and interface requirements, includes:

- operational requirements
- resource requirements
- verification requirements
- acceptance requirements
Part Four: Evaluation

- documentation requirements
- security requirements
- portability requirements
- quality requirements
- reliability requirements
- maintainability requirements
- safety requirements

That is, fourteen types of requirements, consisting of functional requirements plus thirteen different types of non-functional requirements.

Similarly, the Robertsons (Robertson and Robertson, 1999) recognise seventeen different types of requirements. One reason for this emphasis in the literature on varieties of non-functional requirements may be that they occur across different kinds of systems, whereas functional requirements are more specific to particular types of systems, and therefore do not lend themselves so easily to categorisation across systems. Despite their importance in the literature, non-functional requirements do not weigh heavily in practical requirements documents, as far as I have observed, and are therefore not considered specifically in the framework.

Functional requirements do not seem to lend themselves to classification in the same way, though in practical situations the actual functional requirements are always sub-divided according to their specific contents.

10.3 Changing requirements

It is often noted in the literature that requirements do not remain static, but change over time. This phenomenon is often called the volatility of requirements, and has long been seen as one of the major challenges in software development; see for example, (Curtis et al., 1988) or (The Standish Group, 1995). Responses to this problem have concentrated mainly on tools for requirements management, such as DOORs, Requisite-Pro, etc. These provide mainly database functionality whereby specific requirements statements can be stored, subjected to change control, assigned values for specific attributes for priority, status, etc. and extracted into documents according to various search criteria.

There are two main reasons why requirements change. Substantive requirements do not exist a priori, but emerge from discussions and problems and are jointly constructed by the stakeholders in a situation. During this process, requirements are extremely volatile,
especially if they arise from a variety of different types of stakeholders. Requirements management tools do not support this kind of change, which is a necessary part of the process of requirements. Issue-based tools which capture design rationale are more suited to this because they keep track of changes, rather than control them. Such tools, being process-oriented and regarding requirements as needs, belong to quadrant 2 of the table.

Even after the requirements have been documented and agreement has been reached, requirements continue to change, because reality changes, and understanding changes. These are the changes that need to be controlled. Some of the changes may be seen as necessary and desirable, while other changes may be deemed undesirable, in order to maintain control over what is called often called scope creep or requirements creep. Requirements management tools are used to provide the control needed over this kind of change. They are product-oriented, and directed to the management of requirements statements, so they correspond to quadrant 3.

10.4 Representing requirements

The IEEE guide gives a list of quality attributes of requirements, a contribution which belongs to quadrant 3, being both product-oriented, and representation-oriented. According to this list, requirements (statements) should be unambiguous, complete, verifiable, consistent, modifiable, traceable, and usable after development. These desired qualities take no account of the different uses to which a requirements document might be put, which was one of the main themes of the present research. For example, absence of ambiguity is not always an important consideration.

Almost all requirements documents are written to some extent in natural language, which may be used in ways that allow room for different interpretations, leading to fruitful discussions. However, the inherent ambiguity of natural language is often cited as a reason for documenting requirements using formal notations, although these have limited applicability especially in the early stages of requirements analysis. Similarly, completeness is not always seen as a necessary attribute of requirements statements, in many situations. Desirable qualities must always be considered in light of the purposes and uses of the documentation, which in turn depend on the situation. The framework of situations includes some consideration of these purposes and uses.

Modelling requirements is an important strand of requirements research, and many different kinds of modelling techniques have been proposed. Although the IEEE guide does not specifically deal with the modelling of requirements, it provides for the inclusion of semi-
formal and formal models to supplement the natural language representations. It also warns that care should be taken to distinguish between “the model for the application and the model for the software.” Unfortunately, many of the classical and even the modern modelling techniques in use fail to make this distinction. Making distinctions between representations has been an important aspect of the documentation model presented in this thesis. Representations that describe the problem domain are different in purpose from those that describe the requirements per se and from statements that propose elements of the solution, reflecting the different roles of the requirements documentation in different situations.

Jackson (Jackson, 1995) gives an authoritative classification of different types of descriptions:

- Definitions, which are neither true nor false, but must be complete
- Designations, which are rules for describing observable phenomena in the problem domain. Like definitions, designations are neither true nor false, but define the terms used in other descriptions
- Refutable descriptions, which are either true or false, concerning the problem domain

This classification fits into quadrant 3 in the table, as it is concerned with representations as different kinds of products.

Following Jackson, Kovitz (Kovitz, 1999) gives a breakdown of different kinds of requirements associated with different kinds of problem frames. Like Jackson, he distinguishes the requirements (document) which describes the problem from the specification which describes the solution. He gives a list of contents of a requirements document (quadrant 3) to include requirements, problem domain description, expectations, preferences, invariants, platform, global characteristics, likely changes, glossary, overview, and document information.

According to Kovitz, “Requirements are effects that the computer is to exert in the problem domain by virtue of the computer’s programming.” These correspond to what would normally be called functional requirements. Kovitz breaks them down into queries, behavioural rules, mappings, operations on realised domains and correspondences between domains (Quadrant 1).

This approach explicitly recognises the distinction between the problem domain and the requirements per se, which is often glossed over in other approaches. Jackson recognises the need for three different descriptions, and warns against confounding them.
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1. The description D which is true only of the problem domain,
2. The description R which is true of both the machine and the problem domain, and
3. The description S which is true only of the machine

"To develop software is to build a machine, simply by describing it" (Jackson, 1995) To try to achieve this with only one description is to risk confusing the things in the problem domain with their analogues in the machine. The requirements refer to things in the problem domain, and only make sense in relation to those things. The machine must ensure that they are satisfied.

As far as Jackson's theory is concerned, the machine is the solution, and the requirements, while true of the machine, are not about the machine, but about the problem domain. Many authors including Jackson argue against including solutions in a requirements statement. In practice, in many situations, it is common to incorporate proposed solutions along with the requirements in a requirements document. This is reflected in the documentation model proposed in the thesis.

10.5 Domain specific approaches

Although generic approaches abound in requirements engineering, a number of efforts have been made to target particular requirements techniques to more specific domains of application.

For example, some requirements modelling techniques, such as Statecharts (Harel, 1987), might be regarded as more suited to modelling process control systems than other kinds of systems, for example, business transaction systems. But this may not be a useful distinction, at least as far as modelling is concerned (Wieringa and Jansen, 2001). It has long been recognised that state transition diagrams are quite useful for modelling user interaction with graphical interfaces, for example.

Pamela Zave in a number of early papers on PAISley, a language for state-based modelling, popularised the term "embedded system" for the software controlling a piece of hardware in which it is embedded. This definition conflicts with Lehman's definition of an E-type system which refers to a system embedded in its environment (Lehman and Belady, 1985). Most systems of any importance correspond to Lehman's notion of embedded systems.

Harel (Harel, 1987) introduced the term "reactive system." A reactive system is defined in (Wieringa, 1996) as a system whose response to an input depends on the past history of inputs as well as the current input. This definition also covers most application systems of
any significance in everyday use, including systems that react to user input from a Windows
interface

Similarly, Peter Wegner has characterised many of today's systems as interaction machines
rather than algorithmic machines (Wegner, 1997) The user does not simply provide input to
a computation, and wait for the output, as in the algorithmic model, but engages in a
conversation with the machine, allowing a larger class of problems to be solved That this
model of computation can be seen as a new paradigm is clear from the trend in Artificial
Intelligence, for example, away from input and rule-based computation towards agent-based
interaction It seems that previous distinctions between application domains no longer apply,
and therefore that domain specific requirements techniques do not make much sense in
practice

Many good examples of targeted techniques may be found in the domain of information
systems, which has a relatively long tradition of systems analysis techniques and system
development methods Information Algebra, Systematics, PSL/PSA and the NCC Standards
all predate SSADM, by decades However, much research within this field has reported that
prescriptive methods are not used in practice, at least not in the ways intended by their
authors, as practitioners prefer to use selected techniques in a toolbox or a la carte approach

One response to this can be seen in research efforts in the field of method engineering, which
aim to provide support for situated methods (Brinkkemper et al, 2001, Ralyte and Roland,
2001) Such approaches enable the selection, amendment, and assembly by the methods
engineer of different techniques or "method fragments" to suit the requirements of a
particular situation However, they have no apparent theory of what a situation might be

In a paper contrasting the arguments and pressures for formalized development methods with
the arguments and pressures against such methods, Brian Fitzgerald identified three main
pressures for new development approaches the changing nature of business environments,
the changing profile of the development environment and the pressure for rapid delivery
(Fitzgerald, 1996) These characteristics also describe the influences which have some
bearing on the ways that requirements need to be documented in different situations, as
depicted in this thesis

The evolutionary delivery process advocated by Gilb (Gilb, 1988) reflects the evolutionary
nature of software characterised by Lehman in (Lehman, 1984, 1989, Lehman and Belady,
1985) Recent research at the Harvard Business School has confirmed this trend towards
evolutionary development in which early delivery of the evolving new products to customers combined with rapid turnaround of new releases resulted in more successful products than the more traditional development process (MacCormack, 2001). In these market-oriented situations, requirements come from many different sources, and competing requirements must be prioritised for each new release. Several new techniques have been proposed for evaluating the relative costs and values of requirements in these situations.

### 10.6 Contingency theories

Contingency analysis comes from the field of organisational theory, where it is characterised in the following principle: "The best way to organise depends on the nature of the environment to which the organisation relates" (Scott, 1987). The more uncertainty in the environment, the more information is needed before deciding on any particular course of action. This approach has been applied to the selection of requirements analysis techniques by some authors in the early eighties. The resulting frameworks are called contingency theories.

In an early paper, Nauman et al. (1980) identified a list of contingency factors which might affect the level of uncertainty concerning requirements in a given situation. These include: project size, structuredness, user task comprehension, and developer task proficiency. The level of uncertainty was treated as an intermediate variable that in turn determined the requirements assurance process to be used (Naumann et al., 1980).

Gordon B. Davis (1982) gives a similar set of contingency factors, covering characteristics of the object system, the application, the users, and the analysts, and again, uncertainty is the common denominator that establishes the best strategy to use, in this case for determining information requirements (Davis, 1982).

Following on from this research, Wood-Harper and Episkopou (1986) present a framework for choosing between radically different problem-solving approaches, corresponding to different views of the world: the Checkland Soft Systems Approach, the ETHICS participative design approach, and the rational data analysis approach. The contingency variables here are: Characteristics of the Problem Owner, assessment of the problem content system (again, uncertainty is an important issue) and an assessment of the Problem Solver (to include cognitive style). They rightly criticise the earlier contingency theories as relying heavily on intuitive notions of uncertainty.
They propose a tentative Approach Choosing and Matching System (ACMS) framework which analyses different problem solving approaches on the basis of ideology, tools, inquiry system, and costs in terms of manpower and time span (Episkopou and Wood-Harper, 1986)

The ACMS framework relies on an earlier framework by Jackson and Keys (1984) which outlines a classification of problem contexts. This classifies problem contexts in terms of (a) the nature of the decision makers and (b) the systems in which the problem is located. A review of the concept of "complex systems" is given, before settling on the concepts of mechanical and systemic problem contexts, which contain relatively simple and complex problems respectively. Four different types of problem contexts are then presented:

1. Mechanical-Unitary
2. Systemic-Unitary
3. Mechanical-Pluralist
4. Systemic-Pluralist

A set of decision-makers is unitary if they all agree on a common set of goals for the whole system, pluralist if they cannot agree in advance. Agreement on goals is an important factor, whether it exists in advance or must be achieved.

Each of the contingency approaches outlined above suggests how the given framework could be applied in practice, to guide practitioners in selecting appropriate strategies. These frameworks can all be placed in quadrant 2 of the table, being process-oriented and regarding requirements as needs. They contrast strongly with Michael Jackson's more recent proposals on problem frames, which do not allow for the contingencies of problem context, but instead suggest that the problem and the solution have a common structure which indicates the essential nature of solution task (Jackson, 1997, 2000).

10.7 Agreeing requirements

Negotiation is recognised as an important part of the requirements process in many situations, and there have been a few notable research attempts to support the identification and resolution of conflicts in relation to requirements. The Win-Win environment (Boehm, 1991) allows "win conditions" for each stakeholder to be identified, and supports negotiation among the stakeholders to try to ensure that all the win conditions are satisfied. Similarly, research on viewpoints has resulted in a trend away from requirements consistency towards managing inconsistency in requirements specifications (Hunter and Nuseibeh, 1998). These approaches fit in quadrant 2 and 3 respectively.
Despite the general recognition of the importance of agreement in the requirements process, it is often omitted from the generally accepted list of activities that make up the process: elicitation, specification, verification and validation. Requirements validation therefore incorporates the achievement of agreement, but the different types and levels of agreement do not receive much attention in the current literature, although the topic of managing conflict and different viewpoints from a process point of view is well addressed (Robinson and Pawlowski, 1999, Sommerville et al., 1999).

In a special issue of IEEE Software devoted to requirements engineering, published in March 1996, guest editors Shekaran and Siddiqui declared that "the requirements-as-contract model is dead." This heralded a focus in the literature since then on market-oriented software development, aided somewhat by publications describing the development process at Microsoft. However, not all market-oriented situations are mass-market situations, and contract-based development still thrives in the more specialised sectors of software market. The idea of a contract is still alive and well within the context of solution-oriented situations, also.

10.8 The organisational context of requirements

Jonathan Grudin examined the barriers to communication in different organisational contexts of system development. He distinguished the organisational context of development from the organisational context of use, and identified three different contexts of development, the competitive contract, the internal or in-house development, and the commercial product. His particular concern was with the possibilities for user interaction with developers in these three different situations (Grudin, 1996).

Curtis, Krasner and Iscoe set out to study the design process in large projects from an organisational perspective and found that individual characteristics as well as organisational factors determine success or failure of projects (Curtis et al., 1988). There are a number of parallels between this study and the present one. It is a qualitative investigation, based on interviews with personnel in seventeen projects representing a range of different types of systems. It focuses on requirements, and recognises the influence of organisational factors on the role of documentation in the requirements process. It was concluded that "Large projects required extensive communication that was not reduced by documentation" (Curtis et al., 1988).

They give a summary of the projects they studied which indicates that they were concentrated around real-time applications. From this and many comments made in the
article, it seems that most of the project situations would be classified as market-oriented in the framework presented in this thesis, although that term is not used in the article. Some of them were in single-customer market situations, while others were producing "commercial products," corresponding to my classification of vertical market situation since internal groups such as marketing often acted as customer in these situations.

Some of the projects studied were clearly in the targeted customer market type of situation, though again such terminology was not used in the article. Requirements fluctuation was attributed to two causes. The needs of a single customer changed over time, or the different customers had separate needs (Curtis et al., 1988). The authors do not distinguish between situations where the influence of a few customers is very strong and situations where the market contains many customers whose needs can be represented by a customer-facing marketing department. Judging from the list of applications given for the seventeen projects, there were no mass-market situations represented in the projects.

Their investigation set out to study the process of design, but found that requirements and problem definition issues presented the most salient problems throughout the development process. For example:

"The time devoted to learning and coordinating application-specific information was initially buried within the design phase and could not be accounted for separately" (Curtis et al., 1988).

Although it was an exploratory investigation, it was not construed as theory building. The authors adopted a prior organisational model of software development at the outset, which they used to interpret and organise the findings they presented. However, they did use their findings to refine the theory they set out with:

"Rather, the information in our interviews forced us to account for differences among individual project members and to determine how these differences interacted with variations among situations" (Curtis et al., 1988).

Their conclusions emphasise the importance of learning, communication, and negotiation in the requirements process. Rather than the idea of a collaborative process involving all the participants in a project, they highlight the role of influential individuals, or small coalitions of individuals, people with superior application domain knowledge, in the social construction of requirements.
Though they do not refer to it explicitly, this kind of coalition is an example of the concept, first described by Cyert and March, of a loose and shifting dominant coalition that selects organisational goals (Scott, 1987, pg 107). Similarly, the power and influence that individuals exert in organisations is often thought to be related to the information that they have.

The process by which dominant coalitions exert influence over project goals and design is very well described in the paper, especially the difficulty that competing coalitions might experience in trying to influence the design. The fact that this happens even in market-oriented situations illustrates the challenge of implementing a process of participatory design in solution-oriented situations, where organisational boundaries and knowledge asymmetry could be much more significant factors than the expertise of individual participants.

They also highlight the role of "exceptional individuals" at the centre of these coalitions, who had large amounts of application domain knowledge, and took on the responsibility for transferring this knowledge to the whole team. This was made difficult by the existence of organisational boundaries, barriers to communication, which inhibited the transfer of the emerging knowledge, a situation compounded by the assumption that documents produced by one group conveyed all the information required by another group.

They preface these conclusions with a remark that the problems that they highlight have survived for decades despite being described many times by previous authors. However, they do not take the opportunity to use their findings to criticise the prevailing theories, then and now, about the role of documentation in the requirements process. The report of this study is rich in detail, however, as well as highlighting a number of important issues and problems in the requirements process as it affects market-oriented situations.

The concept of "exceptional individuals," or their role in the development process, was not explored in the investigation reported in this thesis. However, it was a working assumption that some practitioners are better than others, probably by an order of magnitude. In seeking practitioners to participate in the study, I generally first approached another practitioner in the selected area of development, and asked that person to recommend someone who, in that person's experience, was exceptionally good at their work in relation to requirements. This strategy located a sizeable number of exceptional individuals, who were able to articulate and communicate, not so much the problems of the requirements process but the practical realities of the situations in which they worked.
Under the heading of “Fluctuating and Conflicting Requirements” Curtis et al. give a number of sources of such fluctuations, which are essentially sources of requirements which correspond with the root concerns in the thesis. Their sources of changes and fluctuations are organised as Market Impacts, Company Impacts and Hidden Impacts. Market Impacts include Customers, as sources of customized needs, changing needs, add-ons, Technology, as a source of technology advances and competitors' products, as well as Regulation, in the form of regulatory agencies and Standards committees. Company impacts include Approvals (Marketing & Legal, and Financial) and Technology (R&D results and other product lines). The idea of an evolving product does not appear in this investigation, despite the focus on market-oriented development. The idea of a product release is briefly mentioned as a strategy for dealing with priorities among requirements, but the concept is not highlighted.

10.9 Requirements frameworks
The seven typical situations depicted in the framework presented in this thesis can be reduced to three basic kinds of situations, called Market-oriented situations, Solution-oriented situations, and Problem-oriented situations, based on an initial distinction between problem-oriented and solution-oriented.

There are resonances of this distinction in various strands of the software development literature. Bruce Blum, in a long series of articles on a method called TEDIUM, conceptualised information system development as problem solving. His later classification of specifications distinguishes between problem-oriented and product-oriented as well as formal and semi-formal (Blum, 1994).

Roel Wieringa (Wieringa, 1996) begins with a distinction between client-oriented and market-oriented development, while he regards both types of situations as pertaining to product development, (therefore locating this model in quadrant 1). However he does recognise that different types of stakeholder other than market or client, are possible, i.e., customer, sponsor, and user, and distinguishes the situation of use from the situation of development, though he continues with the client/market distinction in his frameworks.

The concept of situation is given a considerable amount of attention in the literature, particularly since Lucy Suchman's influential book (Suchman, 1987) which re-conceptualised plans and other artefacts as tools to be used in situated action. This seems to have evoked two different kinds of responses: exploratory research describing the intractable difficulties involved in defining in advance what needs to be done in situations (e.g., the
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The futility of defined methods) and endeavours such as method engineering which aims to allow
the definition of situated methods to suit individual projects and situations. Most of these do
not attempt to explore how situations might be characterised, which is one of the things I
tried to do in the framework.

Linda Macauley describes a framework consisting of a number of different scenarios
describing a variety of possible customer-supplier relationships, and for each scenario
suggests a typical process model, and a number of requirements techniques. Customers are
defined as “persons who commission and/or purchase a product from a supplier” and
suppliers are defined as “persons who develop the product and deliver it to the customer in
exchange for payment.” Because it focuses on different processes of requirements
elicitation, this framework belongs in quadrant 2 of the table.

Her scenarios are as follows:

1. A customer issues an Invitation to Tender to a number of potential suppliers (1-m)
2. A supplier responds directly to a customer request (1-1)
3. A supplier makes a generic product which will meet the needs of a large number of
customers (m-1)
4. A supplier has a generic product which needs to be tailored to meet a specific
customer need (1-1)
5. 6 and 7 are different variants of in-house development, depending on the internal
organisation structure.

Macauley’s model has some similarity to the framework presented in this thesis. It is
situation-related, and it proposes different approaches depending on the situation. The main
differences are:

1. Macauley’s is a framework for determining the appropriate requirements process
and elicitation techniques to be used.
2. The situation types are defined simply in terms of customer-supplier interaction. All
other aspects are considered to depend on this relationship.
3. Significant emphasis is placed on in-house development. Three of the seven types of
situation identified are different kinds of in-house development situations.
4. Market-oriented development is regarded solely as mass-market and new product
development. There is no consideration of product evolution or smaller markets.
5. The framework does not explore in any way how the different concerns that give rise
to requirements can affect a situation.
Perhaps the most comprehensive framework for requirements engineering is that proposed by Klaus Pohl (Pohl, 1994, 1996). This framework covers all four quadrants of Table 10.2, though it emphasizes the process perspective over the product perspective. It also caters very well for the diversity of practices and techniques in requirements engineering. It defines a three-dimensional framework for understanding the requirements process, consisting of the following three dimensions which are envisaged as orthogonal:

1. the specification dimension
2. the representation dimension, and
3. the agreement dimension

The specification dimension refers to the degree of completeness of the requirements specification. The representation dimension refers to the formality of the requirements models, and the agreement dimension refers to the degree to which the stakeholders agree on the requirements specification. Note that these are interpreted in terms of the requirements statements, rather than the requirements themselves. However, the ideal requirements process is defined in terms of a curve within the three dimensions: "It should ideally end up with agreement on a well-understood and formal specification from which development can proceed" (Jarke and Pohl, 1994)

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Table 10.2 Analysis of the literature reviewed in this chapter
Chapter 11 Summary and Conclusions

"What we call results are beginnings"

(Ralph Waldo Emerson)

11.1 Summary of the research

This research has been concerned with the relationship between two aspects of requirements documentation: variety and quality. It has taken as a point of departure that a good requirements document is one that is “good enough” for the situation in which it is used. Conventional approaches to defining the quality of a requirements document do not take this into account, despite the fact that requirements documentation is used in a wide variety of situations.

I set out to explore the situations in which requirements documents are written and used in practice, in order to discover what are the situational variables that govern the need for different types of requirements documentation, and how they interact to affect what is appropriate documentation to use in different types of situations.

The nature of this investigation was exploratory. Rather than directly ask the question, “what is a good requirements document?” it aimed to open up the question, and ask about the different roles and purposes of requirements documentation in different contexts. These contexts embraced the organisational context of use, the organisational context of development, the application domain, the contractual arrangements and other aspects of the relationship and interaction between the developer and the customer, client, or users.

The empirical investigation focused on finding out how experienced practitioners construe the requirements documentation they use in their work. These practitioners were drawn from a purposefully wide range of backgrounds and industries, in order to capture as much variety as possible. It took the form of a series of semi-structured interviews, the transcripts of which were analysed according to the principles of grounded theory. A computer-based tool, ATLAS ti, was used to organise the emerging theory. As is common in grounded theory analysis, the data collection and analysis phases took place in parallel, with the later interviews reflecting a purposeful sampling procedure to develop and refine the insights gained in the analysis of the interviews to date.

Although this research is focused on the product(s) of requirements definition, it has adopted a process-oriented perspective which has been incorporated into the results. Therefore, I
have come to look on the requirements document, not as an end in itself, and not even as a means to an end (which is the system looked on as a defined product), but as a device that is instrumental in a process. This is the process of discovering, learning, agreeing and managing the emerging requirements and other ancillary information needed to describe an evolving system embedded in a situation.

The research took place over the course of several years, which permitted plentiful time for reflection on it and its goals and purposes. In accordance with the canons of the grounded theory approach, the analysis and the data collection proceeded side by side. The process is described in Chapter 3. It occurred in three main stages. The pilot stage resulted in a re-framing and focusing of the research question, on an attempt to understand the organisational contexts of different development situations. The Blackbird case study phase focused on different uses in a range of similar situations and resulted in different types of requirements statements becoming a focal point, and hence the idea of the relationship between variety and quality in a requirements document. The third stage concentrated on variety of both situations and documentation, and on finding able informants in as many different types of pertinent situations as possible, in order to elaborate and extend the emerging framework.

11.2 Summary of the findings

The findings are presented as four elements of an overall framework, relating different types of requirements situations to different types of documentation.

1. A taxonomic analysis of themes of variation in requirements documentation. This is based on the interview data and sample documents obtained during the interviews. The result of this analysis is a tentative model of requirements documentation, which condenses the variety of statements found in practice to seven different types of descriptions or statements. These are: Problem domain descriptions, Statements of the required effects, Proposed solutions, Recorded issues and changes, Defined goals and objectives, Specified constraints, and Recorded agreement.

2. An ontological analysis of requirements as needs, presented as an ontology chart. As an ontology, this is not complete, but it is grounded in the interview data. It represents the different substantive concerns that are associated with requirements, as distinct from the semio logical aspects, or signs, that are the written down requirements. It deals not just with requirements, but also with several other matters of concern in the requirements process, such as goals, customers, users, domain knowledge, business processes, tailorable packages, products, platforms, and markets. It reveals eight root concerns from which all other concerns and
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3 A classification scheme for requirements situations Situations are characterised in terms of how the eight root concerns influence and contribute to the requirements

4 A situation-based classification of requirements documentation Each type of situation is associated with a particular style of documentation, based on the model derived from the taxonomic analysis

11.3 Implications of the findings

11.3.1 Implications for practice

Requirements practitioners work with both substantive requirements and their representations. Both are equally important, but it is vital to be aware of the distinction, especially when adopting new practices or techniques. When requirements practitioners ask about or discuss “requirements metrics,” for example, do they mean measures of how many actual requirements are in the project (such as function points), or are they talking about measuring the quality (such as consistency, or completeness) of the requirements statements in the document?

Whichever sense we are talking about, requirements cannot exist on their own. They depend on prior things that are of equal concern to the requirements analyst. These concerns are not always the same, they vary depending on the situation. The ontology presented in Chapter 5 of this thesis is an attempt to chart those concerns.

For practitioners, working in a specific kind of situation, the value of an ontology such as this is that it enables them to position their “locus of concerns” appropriately and select the requirements techniques and processes appropriate to those concerns. Experienced practitioners, such as the ones who participated in the investigation, are already implicitly aware of where they are situated. Less experienced developers may benefit from having these things made explicit.

The documentation model presented in Chapter 4 could be used as concise checklist against which commercial tools for requirements management, or the existing practice of documentation in a company’s requirements process, could be evaluated.

In practice, application domain descriptions are typically not included in the requirements documentation, in many types of situations, and this practice is reflected in the relevant documentation styles and profiles in Chapter 7. One reason for this omission in practice may
be the lack of suitable representation techniques, but another possible explanation may be the need to reduce the number of different types of statement, for example to control the scale of the document in situations where the documented agreement is the basis of a formal contract.

Even in these situations, the advantages of modelling the application domain are clearly obvious, although the practical pressures of contract development may not allow for such apparent luxuries. Nevertheless, the documentation profiles reflect the situation as it is, not as it should be, or might be.

### 11.3.2 Implications for research

The implications for research are probably more significant than the implications for practice, and so, the results may be more relevant to the research community than to the practitioner. Theory which is grounded in practice may help to bridge the gap between the research and practice of requirements engineering. "Efficient practice precedes the theory of it" (Ryle, 1949)

Requirements engineering now deals with a wide range of development situations, and includes an increasingly wider variety of techniques, from formal methods to contextual approaches. An ontology such as the one presented in Chapter 5 could be used as the basis of a reference model for requirements engineering research. Any proposed RE method, tool, or technique could be positioned in relation to the reference model. For example, techniques that are intended for modelling the substantive aspects of requirements could be designated as such. There seems to be a need for such a reference model.

The best example of such a reference model that I have come across is Klaus Pohl's conceptually simple three-dimensional model of RE (Pohl, 1994). However, despite that article being continually referenced in the literature since it was published in 1994, the reference model it proposed has not had much of a perceptible impact or real influence in other people's contributions that have been published in recent years. A more complex reference model, such as that of Jarke and Ramesh (Jarke and Ramesh, 2001), is therefore unlikely to be adopted widely outside the area of sophisticated repository management tools for requirements traceability.

The documentation model presented in Chapter 4 is fairly simple, but it makes an important distinction between different aspects of a system that might need to be represented, unlike many popular notations for modelling 'the real world.' The real world in these cases often means the proposed solution as well as the problem domain. Using the same technique for
both may lead to confusion. Models of the problem domain may need to allow for a multitude of perspectives and a toleration of inconsistency not appropriate in a model of the proposed solution. Different criteria for approval and agreement apply to different documentation components, such as goals and constraints.

The ontology and the documentation model respectively deal separately with the substantive and semiological aspects of requirements. This separation is not often found in the literature, an oversight which can result in misunderstandings and the inappropriate use of models. For example, the use of Object Oriented Analysis can lead to confusion between substantive and semiological objects. Customer object and Customer-record object, for example. This is compounded by the fact that because it uses the same notation as Object Oriented Design, which entails the modelling of semiological objects in the mam. Object-oriented methods are based on a very simple ontology of the world which is more appropriate to the solution domain than the problem domain. An ontology of requirements that explicitly recognises the difference between the mainly substantive problem domain and the more semiological solution domain would be a useful contribution to this particular “separation of concerns.”

Research on requirements quality metrics often begins with such things as completeness and consistency as essential qualities of all requirements documents, but there is no evidence that these are important factors in some situations, for example, those in which organisational and business objectives are major concerns, the different types of solution-oriented situations, particularly the in-house solution situation. It should be recognised that different situations require different standards of completion and consistency, to name just two criteria, in the different components of documentation that they use.

It is likely that the validity of such criteria would vary not just between situations, but also across the various components of the documentation styles that they use. For example, different standards of completeness and consistency would apply to goals and constraints, within a situation, and different patterns of agreement on say goals would apply in different situations.

Similarly, the applicability of other kinds of research could vary between situations and across profiles. Examples include The use of ethnographic methods for requirements elicitation, the use of formal methods in (a) specifying requirements and (b) modelling application domains and proposed solutions, the use of techniques to measure the relative value and cost of requirements in order to prioritise them. These are all more relevant and appropriate in some situations than in others. A requirements-ontology-based reference
model could help to identify and indicate the most appropriate area of application of different kinds of research

**11 3 3 Contribution to theory**

The theoretical framework has its roots in a body of previous theory on organisational behaviour and knowledge-based work in those kinds of situations. These include contingency theories, bounded rationality, agency theory, symbolic interaction, the social construction of reality, and the situatedness of artefacts such as plans and documents. As such, it is an extension of those theories, in this case helping to explain the "requisite variety" of documentation styles and their uses in different situations.

Is this a contingency theory? Maybe not, a contingency model is capable of being applied, in a range of situations, along with an explicit rationale for its application. Davis, and Episkopou and Wood-Harper among others, provide contingency models, for choosing appropriate methods (Davis, 1982, Episkopou and Wood-Harper, 1986). My framework proposes to be more descriptive than prescriptive.

According to Frances Bell, a contingency framework is more prescriptive than a normative model. She gives as an example of a normative model, the NIMSAD framework for system development methods, which allows "a range of concepts, models, and techniques to be clarified, compared, categorised, evaluated, and/or integrated." (Bell, 1996). By this definition, the framework presented in this thesis is a normative model, since it allows requirements situations to be compared and categorised, and techniques to be evaluated for use in different types of situations. Suitably validated, the framework could also be applied in a prescriptive fashion, however.

Much of the literature on software engineering, including requirements engineering, is prescriptive rather than descriptive in nature. Much of it aims to improve the practice of software development. This reflects the status of software engineering as a pre-scientific rather than a recognisable scientific discipline. There are wide gaps between theory and practice. There are also many gaps between different branches of the theory of software engineering.

According to Thomas Kuhn, scientific communities go through different stages. Pre-scientific knowledge is characterised by competing points of view within a discipline, rather than a unified body of theory. Paul Wernick demonstrated that the disciplinary matrix
underlying computer-based software development indicated a wide range of different points of view and belief systems (Wernick, 1996)

Not only do different schools of thought exist side by side within software development, but also different interpretations of what is going on. Communication problems are not helped by the often empty terminology that abounds in software development. Some terms used in relation to requirements have so many interpretations as to be worthless for use in a framework such as the one presented here “user requirements”, “system requirements”, “model”, “specification”, “design”, etc.

For these reasons, it is difficult to effectively position the framework proposed in this thesis as a contribution to the overall body of theory in the requirements literature. It may be more effective to pick out some “schools of thought” within the literature that it challenges, and some others which it supports.

There is a school of thought that says requirements documents should be always self-explanatory, and not subject to interpretation. However, there is only one situation in the framework that supports this position, the problem-oriented situation. A problem-oriented requirements document ought to be self-explanatory, but only to the extent that it allows the solution providers to propose a solution, not to implement it without further ado. In all other situations, a requirements document cannot be stand-alone.

Another widely held belief is that the purpose of the requirements process is to produce a requirements specification. This looks on the requirements document as an end in itself. However, this research found that in many situations, the requirements document is a means to an end, and not an end in itself. In some situations, its role in the process of getting to agreement was found to be a more important consideration than whether its contents were correct, or complete, or fully understood.

The idea that a requirements document is first and foremost a model is also challenged by the results of this research. If a model is defined as an abstract representation of the real world, then this is not the purpose of a requirements document, which has many different purposes in the establishment of agreement on what, why and how a proposed system is required to be.

One of the most important of these roles is its role in the learning process which takes place in the context of system development. The joint construction of a document in the course of
a process that includes meetings and reviews, where much of the work of the social
creation of agreement takes place, to be rationally reconstructed in the next version of
the document, is typical of several of the situations described in the framework. This builds
on and adds support to the various segments of existing theory that view requirements
engineering as a learning process, and extends those strands that regard plans and other
documents as resources in situated action within an organisational context

11.4 Applications of the framework
The applications of the theoretical framework which was proposed in this thesis may be
summarised as follows:

The documentation model could be used as a checklist, for example to evaluate requirements
management tools, or to assess an existing or proposed requirements documentation
template, or to examine a sample set of requirements documents. For example, it could be
used to estimate the relative occurrence of different types of statements in documents
originating in similar or different types of situations.

The ontology may be used to focus on requirements as such, as well as their many sources,
rather than representations of requirements. It may be used to establish the locus of concerns
for a particular project or type of project, or situation, in order to select appropriate

The situation profiles could be used to classify a project situation, or a set of projects, with
respect to the main concerns of that situation, and the documentation needs entailed by those
concerns. The set of situation profiles could be extended and refined on the basis of further

The documentation styles themselves are intended to be explanatory rather than prescriptive.
They serve to clarify how the different types of statements are used to different extents and
purposes in different situations. For example, it is not often recognised that "agreement" in a
requirements document is something that varies with the situation, but it does, and this
variation is clearly outlined in the documentation styles for different situations.

11.5 Limitations
It could be argued that the practitioners on whom I relied for the empirical data that supports
this thesis were communicating not their actual practice, but the way they think they work in
practice. This is the difference between espoused theories and theories-in-use. It is a risk I

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have had to live with. Given the long duration of the requirements process in most situations, it would be extremely difficult to directly observe theories-in-use in requirements documentation, and even then, these theories would have to be inferred. In addition, such a strategy could not have allowed the research to take in sufficient cases to achieve the wide variety of situations needed to support the framework.

11.5.1 Need for validation

The framework needs to be validated. Research validity is often divided into two aspects: internal validity and external validity. Internal validity in qualitative research is often called credibility (Lincoln and Guba, 1985). Credibility of research results should be supported by the research process used, and I think that I can claim this for the process that I used.

Testing or confirming hypotheses is an integral part of the grounded theory method of analysis. It is built into every stage of the process. It begins with open coding. The proposed code or category is tested against the particular fragment of data, to see if it fits. If so, then that code is linked to that piece of data. If not, then some other code, or variation is constructed. In this way, the open coding process generates codes that apply to the data. Constant comparison of codes to data is a way of continuously testing the groundedness of the data. This is one of the particular strengths of the grounded theory method.

The second level of coding in grounded theory, called axial coding, is where relationships between existing codes are constructed and tested against the data. In my research, the main relationships are:

- the ontological precedence relationships between the substantive concerns and
- the taxonomic relationships between the written components of the documents.

The key idea in axial coding is to test the proposed relationships against the cases in the data.

In grounded theory, the final stage of coding is called selective coding. Compared to the earlier stages, it is less concerned with the data, and more with the codes from the previous stages, i.e., with the strands of the emerging theory. In my project, this is the stage where I put together the proposed typology of requirements documents. I can enumerate instances of each of the types in the data, but that is not the point. I need to be able to show that the particular aspects (the root concerns and the types of statements) that I am proposing are the significant discriminators between the types. What matters is not what they are called, but how to discriminate between them.

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This external validity is where the framework most needs validation or confirmation, and the key word here is applicability. The typology is fairly general, as it is supposed to be, so the point is not whether one can generalise from it, but to test it against reality to see if it applies.

This would not be a new departure, so much as an extension of the research. Kathleen Eisenhardt (1989) has written a valuable article on building theories from case studies, from a positivist rather than a naturalistic perspective. In it, she relies on the concept of saturation from the grounded theory literature as a criterion for when to stop, both for when to stop adding cases, and when to stop iterating between theory and data. Eisenhardt's article highlights the tension between confirming the theory and extending it in the same step.

Some people might argue that any theory must be a set of propositions, that are either true or false, and that these must be stated in a way that is falsifiable. Not only that, but the experiments or trials should set out to falsify the whole thing. My position on this is different, and corresponds to the pragmatist view of knowledge. The question that must be asked about any model, theory or categorisation, is not whether it is true or false, but whether it is useful. That is essentially what I think needs testing, the usefulness or otherwise of the framework.

Alternatively, it is possible to paraphrase each situation profile and each documentation style as a set of propositions. Looked at in this way, each pair of these represents a hypothetical situation and proposes a given style of document. The point of doing that would be to present the framework as a set of propositions that are stated falsifiably. The way to test them would be to look for numerous instances of each of the seven situations and find out if the documents used approximated in some measurable way to the typical document style I have identified. This would be a major research project in itself.

A more practical approach to establishing external validity would be to devise a set of trials to test the applicability of the framework. The first trial could be based on a set of scenarios, composed from a sample of the cases in the existing data, along with some fictitious ones. The second trial could ask the participants to supply their own real examples. The scenarios trial could be presented in the context of a focus group of practitioners in the requirements field. For each scenario, the participants could be presented with a set of multiple-choice questions asking them to pick out the most significant concerns related to that scenario, and then to choose the most important components of the document. As a focus group they could choose to discuss or not discuss the questions, some of them might be
Part Four Evaluation

quite straightforward, and others may be problematic. The discussion could be quite interesting.

If the framework is useful, then the feedback from these trials would cluster to some extent, showing that the variables in the theory are significant/useful/important in discriminating between different situations. The emergence of further types of documents from the validation process would not invalidate it, but strengthen the theory. Because it is feature-based, the classification allows room for growth, expansion, development, and evolution. It does not need to be right the first time.

Whatever the result, it will be useful to have another source of data, either confirming or refining the theoretical framework. This will give me some triangulation, which is another important consideration in establishing the validity of any theory, whether it originates in qualitative or quantitative research.

11.5.2 Need for refinement

The major limitation of the framework is its status as a theory, yet to be confirmed by quantitative evidence. It is a first step towards finding out the extent to which the requirements documents that are used in practice vary depending on their situation, by attempting to define how situations vary, and to define how the major documentation components might be distinguished. However, these are by no means final and will need to be revised/refined continually.

To this end, and with this in mind, both the situation profiles and the documentation profiles lend themselves to being revised in the light of further empirical evidence. For example, the addition of a profile for the mass-market situation would fill an obvious gap in the set of profiles. This type of situation was not represented in the situations that were investigated empirically for the thesis. An additional root concern, if it were identified in future research, would be accommodated in the situation profiles quite easily, and to a lesser extent also in the ontology chart. A refactoring of the documentation model could similarly be adopted without much trouble in the document styles. This ability to refine and adjust the framework should be considered a strength rather than a weakness.

11.6 Recommendations for further research

These fall into two main types, recommendations for further qualitative work to extend the framework, as outlined in the previous paragraph, and proposals for applying the framework in quantitative research on the practice of requirements documentation. These would
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proceed in different directions, one more focused on integrating and deepening the theory, the other having more focus on applying specific aspects of the framework

11.6.1 Extensions to the framework

The research has only touched on the idea of the requirements process as process of social organisation and knowledge construction. A qualitative study of the practice of recording issues and changes in a requirements document would develop this further. What gets left out? How do dominant coalitions use the requirements document to influence the course of changed requirements in a project? How does rational reconstruction operate in the process? The main idea behind the framework is the relationship between variety and quality in the practice of requirements documentation. Ways to extend the framework to better account for the variety of different situations have been suggested above. Ways to extend the framework to elaborate and expand on the idea of quality would include

Qualitative studies focusing on the way practitioners construe the quality of different types of requirements statements. Are there any differences in the way they perceive quality in problem domain descriptions, for example, compared to statements of goals, or required effects? How do acceptable proposed solutions differ from unacceptable instances of a “feature in search of a requirement”?

11.6.2 Applying the framework in quantitative research

Research efforts that would continue this work in a quantitative mode would need to focus on specific issues, such as agreement, or on components of the documentation model, such as goals, for example, in order to examine and test the implications of the framework in a systematic fashion. One survey that really needs to be done is to catalogue the different types of documents used in practice how to recognise them, given the different names, contents, uses, formats, etc. This could be done using the documentation model of Chapter 4 as a point of departure. Each type of statement would need to be given a kind of “operational definition” of how to recognise it in a document. Such a survey could attempt to measure the occurrence of different kinds of statements in the requirements documents representing different types of situations, and test the following kinds of hypotheses:

- The more formal the agreement, the fewer types of statements in the document
- The more formal the agreement, the more complete those statements are
- The less formal the agreement, the more types of statements included
- The less formal the agreement, the less complete they need to be

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Appendices

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Interview Summary Table
<table>
<thead>
<tr>
<th>ID</th>
<th>ID</th>
<th>Relationship situation (see Chap 1)</th>
<th>Main Root Concerns (in Order)</th>
<th>Application Domain Problem Frame</th>
<th>Characteristic Document</th>
<th>Organisation of Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IR</td>
<td>In-house</td>
<td>Client organisation Users Project</td>
<td>Payroll data collection MRP Transformation</td>
<td>External and Internal Specifications Textual</td>
<td>Methodology-driven, but some a la carte Signoff</td>
</tr>
<tr>
<td>02</td>
<td>HD</td>
<td>In-house working as a consultant with company personnel</td>
<td>Business Area Client Organisation Project</td>
<td>Financial Services Global System Review Information and Control</td>
<td>Requirements as text enhanced with Entity-Relationship and DFD models</td>
<td>SSADM used a la carte, Bus Proc engineering done but not called that</td>
</tr>
<tr>
<td>03</td>
<td>FOC</td>
<td>External Contract (3 parties)</td>
<td>Customer Project Product Application domain</td>
<td>Telecoms Database Information and Control</td>
<td>Functional Requirements Textual</td>
<td>Ad hoc, re-developing an existing system for an external client</td>
</tr>
<tr>
<td>04</td>
<td>BH</td>
<td>In-house but having external users</td>
<td>Application domain Business area Users Project</td>
<td>Government revenue collection Information and Control</td>
<td>Functional requirements with DFDs, Logical data model</td>
<td>Ad hoc, teamwork with multiple roles per person</td>
</tr>
<tr>
<td>05</td>
<td>GR</td>
<td>Cooperative development with targeted first customer</td>
<td>Product Project Customer Application domain</td>
<td>Utilities Maintenance planning and control package Information and Control</td>
<td>Numbered Classified Functional Requirements</td>
<td>Based on ESA model Difficulties in getting commitment from customer user groups</td>
</tr>
<tr>
<td>06</td>
<td>GP</td>
<td>In-house, informal</td>
<td>Users Client Organisation Business Area</td>
<td>Manufacturing Reports Management Information Transformation, Information</td>
<td>Minimal textual, Often combined with design</td>
<td>No formal project, though some signoff procedures</td>
</tr>
<tr>
<td>ID</td>
<td>Relationship with customers or clients</td>
<td>Main Root Concerns (in Order)</td>
<td>Application Domain Problem Frame</td>
<td>Characteristic Document</td>
<td>Organisation of Process</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>07 POR</td>
<td>In-house working with external consultants and head office persons</td>
<td>Business Area Client Organisation Project</td>
<td>Project-based ERP Aircraft Maintenance Information and Control</td>
<td>3 types Task definition (block diagrams) Issues Integration with ERP product</td>
<td>Business Process Engineering, Agreement not in the Document</td>
<td></td>
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<tr>
<td>08 MK 09 JD</td>
<td>External contract Joint project teams (BB Case Study)</td>
<td>Customer Product Application Domain Project</td>
<td>Supplying customised warehouse management software Information and Control</td>
<td>Textual document Contract Breakdown by BP Operation, Req, Proposal</td>
<td>Solution provider Fitting the solution to the problem, and vice versa</td>
<td></td>
</tr>
<tr>
<td>10MS 11SH 12CL 13CM 14JN</td>
<td>Outsourced Joint project teams (BB Case Study)</td>
<td>Project Business Area</td>
<td>Acquiring customised warehouse management software Information and Control</td>
<td>Textual document Contract Breakdown by BP Operation, Req, Proposal</td>
<td>Focus of discussions with solution provider (Blackbird Clients)</td>
<td></td>
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<tr>
<td>15 HM</td>
<td>Solution development for external customers</td>
<td>Market Opportunity Customer Application domain Project</td>
<td>Telecoms Network Management custom software, with extra targeted customers Information and Control</td>
<td>Business Requirements Market reqmts</td>
<td>Negotiating with marketing dept to streamline requirements CMM</td>
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<tr>
<td>16 AA</td>
<td>Solution development for external customers</td>
<td>Application domain Project Customer Product</td>
<td>Telecoms Network Management and embedded custom software Control Information</td>
<td>Functional requirements and design</td>
<td>Well-defined process CMM</td>
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<tr>
<td>17 GC</td>
<td>Product evolution</td>
<td>Application domain Product Customer</td>
<td>Telecoms Embedded Switching Software Control Information</td>
<td>Functional and non-functional requirements</td>
<td>Well-defined process</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Relationship with customers or clients</td>
<td>Main Root Concerns (in Order)</td>
<td>Application Domain Problem Frame</td>
<td>Characteristic Document</td>
<td>Organisation of Process</td>
<td></td>
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<td>--------------------------</td>
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<td></td>
</tr>
<tr>
<td>18</td>
<td>FD</td>
<td>In-house Business Area</td>
<td>Telecoms Special Offers and Billing database system small operator Information Transformation</td>
<td>Business case Informal Functional</td>
<td>Negotiation and agreement</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>FML</td>
<td>In-house for parent company</td>
<td>Telecoms Intelligent Networks Information and Control</td>
<td>Solution Investigation Functional and Non-functional</td>
<td>Knowledge acquisition Feasibility Study Understanding</td>
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<td>20</td>
<td>DT</td>
<td>Product development for external client</td>
<td>Embedded sw for consumer electronics Control</td>
<td>Table based Complete model of States and Transitions in Functional Spec</td>
<td>Aimed towards Completeness, Understanding of constraints and Correctness</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>DD</td>
<td>Outsourcing development to bespoke or other solutions providers</td>
<td>Acquiring health administration systems Information and Control</td>
<td>Request for proposals</td>
<td>Well-defined process</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>YY</td>
<td>Outsourcing development to bespoke or other solutions providers</td>
<td>Acquiring health administration systems Information and Control</td>
<td>Request for Proposals</td>
<td>Well-defined process for large projects Ad hoc for smaller projects</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>NG</td>
<td>Configuring and customising an ERP product for external clients</td>
<td>ERP installation esp Manufacturing Information and Control</td>
<td>Feature-oriented</td>
<td>Consultancy</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Relationship with customers or clients</td>
<td>Main Root Concerns (in Order)</td>
<td>Application Domain Problem Frame</td>
<td>Characteristic Document</td>
<td>Organisation of Process</td>
<td></td>
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<td>-------------------------</td>
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<td></td>
</tr>
<tr>
<td>24</td>
<td>Internal product development and evolution for market</td>
<td>Market Opportunity Product Project Application Domain</td>
<td>Embedded software for a family of KVM Switch products Control</td>
<td>Feature-oriented</td>
<td>Multi-site team</td>
<td></td>
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<tr>
<td>25</td>
<td>Internal product development</td>
<td>Market Opportunity Product Customers Project</td>
<td>Telecoms Switch Control</td>
<td>Feature description document derived from a DOORS database</td>
<td>Well-defined process CMM</td>
<td></td>
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<td>26</td>
<td>Bespoke development for external clients</td>
<td>Client Organisation Project Business Area Application Domain</td>
<td>Databases Information and Control</td>
<td>Derived from functional reqs stored in a spreadsheet Textual</td>
<td>Risk reducing strategy Company process guidance/support - reference materials</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Internal product development and evolution for ERP market</td>
<td>Market opportunity Product Project Application Domain</td>
<td>ERP Product Information and Control</td>
<td>Lotus database of documents Spreadsheet of prioritised features supported by use cases</td>
<td>Product steering committee, Negotiating with marketing, input from customers, focus groups, etc</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Application expert Configuring, enhancing and extending the package</td>
<td>Application domain Users Project</td>
<td>Acquisition and tailoring of an application package for student records Information</td>
<td>RFP plus various other documents written by client, Vendors std materials</td>
<td>Project Steering committee, Board and joint project team working with Vendors</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

Letter to Interviewee

Dear Mr Pinckheard,

Thank you for taking my call on Friday.

As I mentioned on the phone, I am doing research on the nature of 'requirements documents' and their role in the practice of system development. At present I am interviewing experienced practitioners on their experiences and views, in an effort to bridge the gap between theory and practice. I would be very pleased and grateful if you agree to be part of this study.

The interview will take about an hour, at a time and place convenient for you. I will be asking you to talk about your experience of writing and using requirements documents, and also seeking your opinions on their usefulness in system development.

In previous interviews I have found it useful to focus the discussion on one particular project which you want to talk about. This should be one which is considered to be successful, as I am interested in best practice rather than war stories. It is also helpful, but not necessary, to have a copy of the requirements document for the particular project handy, for reference.

I know how busy you must be, but I hope that you will be able to take part. If you have any queries, or require further clarification, I will be in touch in a few days, when I hope we will be able to arrange a suitable time for meeting.

Yours sincerely,
Appendix C

Interview Guide

Interview Guide – Version 2

1. Background
Would you like to begin by telling me a little about yourself and your role in the project/system that you are going to discuss?

2. The Project Itself
Can you give a brief description of the project? How many people are/were involved? How was it organised? Any user involvement? Roles

3. Methods and Tools
Can you tell me about the method used in the project? Was it formally defined? Process? Guidelines or standards used?

4. The Documents
I’d like you to tell me about the different documents that were produced in the course of the project (Note Title(s))

5. Focus on Requirements Document(s)
Structure?
Use of models, diagrams, tables, etc
What’s in it? Why? How much detail is needed?
Standard format? If so, how defined? Template, etc
How do you know when it’s finished?

6. Uses of the Requirements Document
Was the requirements document used later on in the project? If so how?
E.g., testing
Normally changes to requirements arise during the project. Were any such changes incorporated in the requirements document?
Did any errors in the requirements come to light at a later stage? How were these dealt with?

7. Whose Document is it?
People who use the document Different kinds of stakeholders

8. Agreement
How does a document such as this help to achieve agreement about what is required?
Is it a contract? To what extent?

9. Quality
What in your view makes a good requirements document?
Does it exist in practice? If not, why not?
Interview Guide – Version 1
This was used as a guide to start the interviews, but in nearly all cases the respondent guided the course of the rest of the interview shortly after the initial questions were addressed.

1. Respondent
Would you like to begin by telling me a little about yourself and your role in the project/system that you are going to discuss?

2. The Project Itself
Can you give a brief description of the project? How many people are/were involved? How was it organised? Any user involvement? Roles

3. Methods and Tools
Can you tell me about the method used in the project? Was it formally defined? Any formal training given? Guidelines or standards used?

4. The Documents
I’d like you to tell me about the different documents that were produced in the course of the project (Note Title(s))

5. Focus on Requirements Documents
Structure?
How much detail?
Standard format? If so, how defined?

6. Use of Requirements
Was the requirements document used later on in the project? If so how? e.g. testing

7. Changes
Normally changes to requirements arise during the project. Were any such changes incorporated in the requirements document?

8. Errors
Did any errors in the requirements come to light at a later stage? How were these dealt with?

9. Barriers to Communication
What do you think is the best way to find out the users' requirements and document them?

10. Problems
What in your view were the problems inherent in using the requirements document?

11. Quality
What do you think makes a good requirements document?

12. Practicality
Do you think it is possible to produce a requirements document that lives up to these criteria?
Appendix D

List of Propositions

These were abstracted from the interview transcript data by means of 'constant comparative analysis'. Each propositional statement is supported by a number of quotations referring to the original page of the transcript.

P1 Systems are not usually developed in isolation. There are often other systems which need to interface with the system being developed.
- e.g. data collection system (for a payroll system) IR1
- e.g. the personnel enquiry system already contained some of the data IR1
- e.g. statistics reporting system from an existing manufacturing package GP1
- e.g. system interfacing to the General Ledger HD2

P2 Systems are not always developed from scratch. There may an existing system which is being re-developed and up-dated, or a generic product or package may be developed which is based on some existing system.
- e.g. "re-engineering the core requirements" GR1
- e.g. generalised maintenance management system for power stations GR1
- e.g. generalised network administration system for PTTs FOC1
- e.g. configuration project using SAP enterprise system

P3 System development does not always take place in the context of a "project". Many systems evolve or grow over time, through a process of satisfying "requests". Small systems or additional programs are also developed in this mode.
- e.g. GP8
- e.g. GP13 first-in first out
- e.g. POR13

P4 Requirements are not always written down. Some are prototyped. Many systems do not have any type of requirements document.
- "We would have sat down and tried to understand the requirements written list of questions clarify the requirements he has explained to people what the system will do" GP8
- e.g. prototyping GP7
- e.g. discussions with the users BH4, POR4
- "There is no screen design in here, which personally I think there should be" HD4

P5 When is a project not a project?

P6 Sometimes a new system is required to formalise existing procedures.
- "the way we do things now" GR8
- "already doing a lot of it with spreadsheets" GP2
- But "We were trying to analyse business processes that didn't yet exist" POR3

P7 Many people are involved in a project. They come from different areas of the organisation, perhaps from different organisations.
- "I got contracted in" FOC1
- e.g. two organisations GR1
- e.g. client organisation plus contractor and sub-contractor organisations FOC1
Appendices

P8 deals with different job titles.

P9 System Development Methods vary in
- their maturity (GR3)
- their prescriptiveness (GR3, IR10, IR3)
- the extent to which they are imposed on an organisation (IR7, GP5)
- the extent to which they are modified by their users (IR2, IR3, GR3, HD3)

I will discuss the literature on this and refer to the resulting lack of standardisation (?) in documentation.

P10 Users may 'sign off' a requirements document though they do not understand it
- but you can't rely on it as the final say, so it wasn't a contract (GR5).

“People are not good at writing and they are not good at reading” (GR5).

P11 Key users may be managers or they may be user representatives, assigned to the project, either full-time or part-time.
- (GR5).

P12 Users may not appreciate the importance of their role in the project. They may not understand what is required of them.
- “It is not just a question of being able to write down what you got correctly, because sometimes you get very superficial information and sometimes you get irrelevant information” (HD5).

People always have their hobby horses, his was the capabilities list” (GR5).

“The user doesn’t listen to you a lot of the time, and you are living the system he is in and out of the system” (BH14).

P13 The reasons why requirements should be written down include the following:
- Method of communication with developers (GP7).
- Proof of understanding (GP7, FOC4).
- Users know what they are getting (provided it is clear) (IR8).

P14 Written requirements may be used later on for:
- High level design (GR5).
- System test (GR5, HD4).

But “They worked mainly from the design documents” (HD4).
- System design (IR9).
- User manual (IR9).
P15 But the (user) requirements document is not the only source for those subsequent stages also use interview notes for design IR12 for test, also use design document, especially for lower level conditions GR5

P16 “Errors” in requirements range from vague requirements that need refining to ones that need to be dropped From serious ones that need re-negotiation to ones that can be changed without calling a meeting e g GR6 e g FOC8 e g IR10 e g GP3

P17 Problems in requirements, when discovered in time, become changes Depending the seriousness, changes may be handled by
- a proposal
- a review meeting
- a series of negotiations e g GP6 e g GR6 e g FOC7

change request process GR5
does it make a difference whether the requirements have been signed off or not?

P18 The requirements document tends to be frozen in time and not updated with changes which instead are
- kept in a folder
- pencilled in
- added in only when the project is completed FOC7, GP6
- documented in the minutes of meetings

P19 Requirements are gathered by
- interviewing
- meetings
- looking at existing documents
- looking at existing systems (e g spreadsheets, GP) i e interacting with people interspersed with periods of “back to the desk” (IR4) e g IR3, IR4 e g FOC9

P20 Requirements gathering is an iterative process involving review meetings and negotiation “it was a huge negotiation exercise” BH2 “The actual agreement was ironed out during various committee meetings ” HD3 “ironing out wrinkles” FOC5 e g GR5

P21 Requirements gathering needs a facilitator who will balance the needs and demands of all the interested parties e g FOC e g POR12 “hobby horse” counter- examples of this GR7, GR8

P22 All requirements are not necessarily written down
There may not be a requirements document GP4
Some aspects of the system, such as the user interface, may be prototyped instead GR5
The requirements may be written in some composite document, such as the project plan FOC2

P23 Different specification documents are produced in the course of a project. The names used are not standard
- requirements definition IR6
- external specification IR6
- internal specification IR6
- abbreviated specification for short/small projects IR5
- “more detailed documents” FOC3
- project plan FOC6
- high-level design FOC6
- release notes FOC4
- list of requirements GR3
- Type 1, Type 2 and Type 3 documents POR

P24 Is there a standard layout which a company uses for requirements documents?
each one is written from scratch GP3
draft TOC based on some standard FOCI1

P25 As well as containing details, the requirements document should contain an overall picture of the required system
evidence for this? see P26

P26 The big picture is an essential part of the requirements document
GR9, GR10
wood and trees GP4
hierarchical structure FOC10

P27 Requirements may be broken down into logical groupings
“Each of these (sections) relates to a Data Flow Diagram that’s in the Appendix” HD3
logical groups FOC5
cells GR9/GR10/Gr11

P28 Sometimes breaking down requirements into sections makes it more difficult to understand
(Lack of the big picture?) IR9/IR10

P29 Requirements can be written in plain English
FOC2
GR4

P30 Requirements written in plain English may need to be clarified
“ some of the best (systems analysts) are incapable of writing a document that conveys what they mean “ POR8
GR4
FOC8

P31 The requirements document has a wide readership
circulation list GP6
FOC9
mixed audience GP7
Appendices

But “very few people will actually read it” BH

P32 Individual requirements may be numbered
HD2
FOC5
GR4
counter-example GP9
may use decimal numbering FOC5
or not GR4

P33 Individual requirements may be categorised
• by priority
• by business need
• by stability
• by status
• by source
GR4

P34 A requirements document is finished when
• everything is defined to the same level of detail FOC13
• everything is explicit FOC13
• it has no requirements marked TBD GR4
• all the users questions have been answered IR9
• “when we’ve reached what I regard as an acceptable level of detail” GR4
• when it’s signed off by the users IR9 GR4
• when we decide on all the tentative requirements GR4
We rely on the client and our own good judgement GR9

P35 The overall picture
someone who GR10
“the role of the systems analyst is important in creating that shared vision” POR7

P36 Users don’t need lots of detail in their requirements document
They need to know what they are getting IR11
“User management tend to think in terms of mechanisms and how things are going to work
This document doesn’t describe how things are going to work, it says, what do you need” HD3
But “The more specific you have to write about something the more likely it is to be understandable
The higher up you go the more nonsense it becomes” POR18
Appendix E

Format of the Blackbird Requirements Specification

This document uses a conventional natural language approach to specifying and agreeing customer requirements. The area of Blackbird's business that I studied (it also supplies specialised hardware) is the customisation of a proprietary warehouse application software system for its customers.

All of Blackbird's customers are similar in that they require a warehouse application, but their needs are all sufficiently different that a standard solution will not work for them, hence they need a tailored solution. Blackbird has a glossy brochure and video describing their 'product' Harvest, but few of their customers buy it "off-the-shelf." A requirements document, called a Specification, is produced from scratch for each new customer.

Each requirements document follows the same format. It begins with (or is preceded by) a document history, showing the sequence of drafts and revisions, giving the date on which each version was approved and the initials of the reviewers on each side.

Each new Version of the specification is discussed at a formal meeting, with intermediate drafts being produced and forwarded to the customer between formal meetings. Once agreement is reached, the customer sends Blackbird a purchase order for the system. Further versions of the document may follow after this, but only minor modifications and mostly clarifications will tend to be made subsequent to this.

In practice, there is no such thing as a 'final document' as after a certain point in the project, Blackbird uses CSRs (Customer Service Requests) which customers send in requesting changes and add-ons to what is documented in the specification, but which are not reflected in a new version of the document. Each of the changes and add-ons must be negotiated, and sometimes require an extra Purchase Order to cover the cost of implementation.

The Introduction is a fairly short section of the specification. It briefly describes the client company and their area of business, and summarises the basic functionality of the system, noting that Blackbird software will be used for the proposed solution. This is followed by a terminology section, essentially a table of terms and their meanings. The terms include the names of the names of the parties to the agreement, third parties who supply other software or services, as well as technical terms belonging to the application.
The main part of the document, called Operation, follows next. This consists of several (at least 12 or so) sections, each representing a named business operation, for example, “Put-Away,” and each divided into the following sub-sections:

- A subsection titled “The Operation” which is a description of the operation itself, usually some aspect of warehouse operation such as picking, receiving, putting away, etc.
- A subsection titled “The Requirement” which describes the requirement(s) associated with this operation, such as:
  “To record the movement of the pallet with its associated serials to a storage location in the racks, and to inform BMS of this movement.”
- A subsection titled “Proposed Solution” written in terms of the Blackbird functionality which will be provided. A list of functions is given, each one beginning with a verb such as scan, confirm, ensure, warn, display, prompt, etc.
- Other sub-sections which deal with Interfaces to other systems, Hardware required (e.g., Radio Frequency terminals are commonly used), Communications, Transaction volumes, and Open issues. The latter section records problems and questions which have yet to be discussed, and to be resolved in subsequent versions of the document, the resolutions being documented as Answers in the same subsection.

The remainder of the document contains sections on Security, Site Preparation, Implementation, and Costs.
### Appendix F

#### List of Codes

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2
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finding out
fitting the model to the situation
fixed in time
fixing bugs
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flexible design
flow
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formal methods
format chosen by customer
FRS
functional areas
functional decomposition
functional description
functional requirements
functional specification
functions
gathering information
grounded to the user
generating documentation
generic requirements
get the concepts across
getting it right
Global Requirements Specification
Global Requirements Study
Glossary
go-ahead
goal
Goals
good enough document
good relationship
greenfield situation
groups of requirements
guard against surprises
guidelines
hard requirements
hard to read
headings
here's our understanding
hierarchical breakdown
hierarchy
high throughput
Historical Rates
hobby horse
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how to begin
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imposed method
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information requirements
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input to design
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input to user manual
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integration
integration manager
integration testing
intelligent network
interaction with users
interface
interfaces to other systems
Interfaces To Other Systems
internal clients
internal specification
interpretation of requirements
interview material
interview record
interviews
invisible requirements
IS strategy
Issues
IT organisation
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iterative process
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joint projects
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key users
knowhow
knowledge
knowledge acquisition
knowledge of the business
knowledge of the package
knowledgeable customers
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lack of specification
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layered software
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levels of agreement
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List of Reference Documents
list of requirements
long document
looking for solutions
maintenance control
making a prototype
many users
mapping onto the software
market changes
market opportunity
market requirements
market variants
marketing people
marketing support
match current capability
matrix format
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Appendix G

The Ontology of Concerns
Appendix H

The Taxonomy
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<td>List of reference documents</td>
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Appendix I

Summary Tables
<table>
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<th><strong>Concern</strong></th>
<th><strong>Project</strong></th>
<th><strong>Users</strong></th>
<th><strong>Client Organisation</strong></th>
<th><strong>Business Area</strong></th>
<th><strong>Application Domain</strong></th>
<th><strong>Product</strong></th>
<th><strong>Customer</strong></th>
<th><strong>Market Opportunity</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Product requirements are allocated to Projects which are related to Releases</td>
<td>The requirements are subject to informal Agreement with the target customer, and subject to formal Approval by the internal Client Organisation either at a higher level, or peer level</td>
<td>The role of user representatives is played by developers, not real users</td>
<td>A combination of an external client and internal organisation Often seen as joint development</td>
<td>A source of Common requirements for the Product</td>
<td>Understanding of the application domain e.g. relevant Standards, etc. The Product is state of the art in that application domain</td>
<td>Features of the Product may interact with each other, requiring a high level of product expertise</td>
<td>Few customers, compared to vertical market situation Some of them may have considerable application expertise Customer representatives validate requirements</td>
<td>Additional market requirements help to add value to the product Time to market is critical Additional platforms may be another source of system</td>
</tr>
<tr>
<td>There is a formal agreement with the Customer represented on the Project by a Product Manager There is an Agreed deadline and little scope for selecting requirements based on priority</td>
<td>The Scope of the project must be managed and controlled There is an agreed Deadline and milestones</td>
<td>Individual User Requirements are less influential than the Organisational requirements</td>
<td>The client organisation is the external Customer Negotiating between the Client Organisation and the supplier organisation is significant Client Organisation IS/IT personnel may also be influential</td>
<td>The Existing System may be a source of knowledge about the Business Processes and Workflow The Solution is seen in terms of Functions</td>
<td>Non-standard requirements may be significant Application expertise on the part of the supplier may be useful</td>
<td>Product functionality is understood in terms of its behaviour, how it responds to events, and its behavioural constraints</td>
<td>The External Customer may turn have many customers, typically consumers</td>
<td>The project is not usually concerned with other opportunities, except as a source of new contracts</td>
</tr>
<tr>
<td>The Scope of the project is very important Scope creep is a significant risk Speed of implementation is important, so there is an agreed Deadline</td>
<td>Individual User Requirements are much less influential than the Organisational requirements</td>
<td>Organisational objectives dominate the requirements, for example, integration of Business Areas Issues often relate to mismatches between the Existing System and the Product functionality</td>
<td>Organisational objectives are considered</td>
<td>Business Process engineering of the target Business Area(s) is key Some Business Processes may need to change (BPR) in order to achieve Organisational Objectives</td>
<td>Knowledge of the Application Domain is embodied in the Product in terms of data types and available functions</td>
<td>Product Expertise on the part of the supplier is an important source of Solutions The Solution is seen as Functions provided by the Product</td>
<td>There may be a Project Sponsor who takes on the role of Customer</td>
<td>This is not a concern in solution-oriented situations</td>
</tr>
<tr>
<td>The Goals and Objectives of the Project are more important than the Scope, or Deadlines or Priorities There should be a Shared Vision of the Project Objectives Signoff may be used although there is no contract</td>
<td>Individual User Requirements are much more influential than in other situations But the level of User participation in Projects varies considerably</td>
<td>The Client Organisation is part of the larger organisation that requires and is going to use the system This is often associated with one or more Business Areas</td>
<td>Organisational objectives are extremely important Organisational Change may be a source of Issues to be resolved</td>
<td>Business requirements are a major concern The Existing System, changes to it, and Organisational Change are all important sources of Issues to be dealt with</td>
<td>Non-standard requirements, particularly Information Requirements are often key</td>
<td>Application Problems and Domain Knowledge may be important sources of requirements</td>
<td>There may be a Project Sponsor who takes on the role of Customer</td>
<td>This is not a concern in problem-oriented situations</td>
</tr>
</tbody>
</table>

**Notes:**
- Users are always involved to some extent Project Stakeholders often include Users and their managers
- Users are always involved to some extent Project Stakeholders often include Users and their managers
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Problem domain descriptions

<table>
<thead>
<tr>
<th>Descriptions of the problem domain tend not to occur in the requirements document</th>
</tr>
</thead>
<tbody>
<tr>
<td>The problem domain is complex. It is not typically described in the requirements document. Some aspects may be already described in standards documents or glossaries of acronyms.</td>
</tr>
<tr>
<td>These descriptions frequently appear in the introductory chapter, rather than throughout the document. The problem domain often refers to the equipment in which the software is embedded, as well as to the situation of use.</td>
</tr>
<tr>
<td>Descriptions of business operations are avoided, and the requirements form the framework used to organise other requirements statements.</td>
</tr>
<tr>
<td>Descriptions of business processes and functions, user tasks and business events, and form the bulk of the requirements text.</td>
</tr>
<tr>
<td>These represent business processes and functions, user tasks and business events.</td>
</tr>
<tr>
<td>Document: Used mainly to outline the scope of the problem domain. The company background, and volumes of transactions, etc.</td>
</tr>
</tbody>
</table>

Statements of the required effects

| These statements are often organised around features, with priority numbers, interdependences, and other attributes. |
| These denote features, or behavioural requirements, referring to the interaction/behaviour of the software in its environment. |
| Statements describing transactions and information requirements form the bulk of the requirements text. |
| Transactions and information requirements written in terms of the chosen product, and often closely tied to the proposed solution. |
| Transactions and information requirements are stated, often in the context of representations of the problem domain. |
| May or may not be very detailed, but may have transactions, information requirements and non-standard requirements. |

Proposed solutions

| These do not commonly occur in the requirements documents to specify the vertical market products. |
| A proposed or actual system architecture may be defined in the requirements document. |
| Often includes the database structure and contents or description of a prototype solution, such as the user interface. |
| Solutions are selected from the range of standard functions, or database formats which come with the chosen product. |
| Database contents and/or database structure and interfaces are often included. |
| These are not really applicable in a problem-oriented document. |

Recorded issues and changes

| Issues may concern the priority of features, and lead to changes. |
| These are extremely important because it is a contract, and because changes cannot be made when the equipment is in production. |
| Issues are extremely important because they may not be directly supported by the product. Changes and the changes that ensue are recorded separately. |
| Issues arising from organisational changes and from users' concerns about changes to the existing system may be noted. |
| Not applicable in the final document, unless there are still important open issues to be resolved by the solution provider. |

Defined goals and objectives

| Neither organisational goals nor non-functional requirements seem to occur in the requirements document in this type of situation. |
| System goals such as non-functional requirements are important in this type of document. |
| Organisational goals are more significant than system goals and may be expressed in terms of a business. |
| The business case for the system is important. Organisational goals may be linked to high-level requirements. System goals are not considered separate components of the document. |
| The business objectives of the required solution and the high-level non-functional requirements are important sections. |

Specified constraints

| Neither solution constraints nor application constraints tend to appear in the requirements document. |
| Application constraints, such as behavioural constraints, are significant. |
| Both behavioural constraints and solution constraints are specified. |
| Application constraints may be represented in the database design, or separately, as business rules. Solution constraints such as interfaces to other systems may be defined. |
| Defining which of the variety of application constraints supported by the product are needed is an important task, but these are recorded separately, with the Business Processes. |
| Solution constraints are unusual. Application constraints may be modelled in the problem domain documents, or as business rules. |
| Solution constraints are typically an extremely important section of the document. |

Recorded agreement

| Agreement is in the form of Approval by the relevant levels of the organisation. The Approval given applies to the list of features to be included in the project, and their attributes. |
| Agreement takes place at two levels: Informal Agreement with the target customer(s) and formal internal Approval. |
| The agreement is a formal contract between the customer and the supplier (solution provider). The document is a record of the agreement reached between them on the required functionality and scope of the project. |
| The agreement is a formal agreement between the client organisation and the solution provider, a record of the agreement on the scope of the project. It is a contract to provide the specified functionality within the constraints of the chosen product. |
| The agreement an informal agreement reached between the developers and their clients. The document may or may not be a record of it. |
| The final document is approved by the people in the organisation who have the authority to spend the funds allocated to the project. |