Flexible Converged Photonic and Radio Systems: A Pathway toward Next Generation Wireless Connectivity

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Abstract: The development of ultra-dense mobile networks is contingent on effective co-design of optical and wireless systems. This work proposes the convergence of emerging photonic/radio technologies to form a platform for future wireless communications. © 2021 The Authors

1. Introduction

As the research focus shifts to beyond 5G, it is clear that data rate scaling, reduced latency and wide-scale use of millimeter-wave (mmWave) communications will be key network characteristics which will drive the development of next generation communication systems [1]. At the same time, the evolution toward network centralization through advanced radio access networking (RAN) technologies and the pervasiveness of cloud-based services is increasing the reliance of wireless networks on high-speed optical access and data-center (DC) networks.

Continued deployment of centralized (C)-RANs, which facilitate radio-over-fiber (RoF) transmission between centralized mobile equipment and a remotely deployed antenna sites, marks a departure from the proprietary short-reach links in use today; offering greater transmission distance, reduced remote antenna deployment costs through centralization and the option to incorporate optical access networking functionality such as wavelength division multiplexing (WDM) [2, 3]. Considering the levels of antenna deployment expected in the coming years, a great deal of importance will be placed on the ability of these access networks to facilitate scaling in terms of both data rate and number of connected users. From the perspective of DC network evolution, flexible optical technologies such as photonic switching and tunable laser sources are actively being researched [4, 5] to help facilitate network scaling which is increasingly being driven by mobile user demands [6].

These network trends, involving increased pooling/centralization of resources and the further leveraging of flexible optical networking technologies to provide high-speed, low-latency pathways between the mobile users and the cloud point, toward a super-convergence of emerging technologies encompassing optical DC, access and RoF systems. As these future network segments are often considered as separate entities with their own distinct challenges, there is a requirement to examine how these systems may be co-operated and/or co-designed at a physical level in order to provide a truly converged networking platform for next generation wireless communications. This presentation will focus on recent progress made in this area through the COMPhLEX project which explores the use of flexible DC and optical access technologies for the provisioning of high speed microwave and mmWave services.

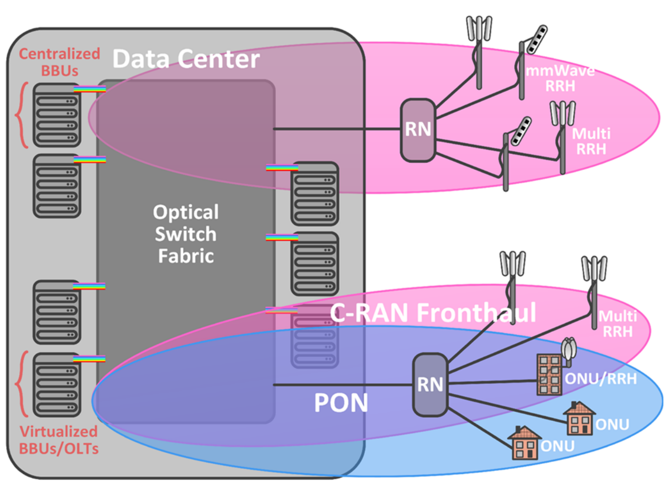

Fig. 1: Envisioned converged optical Data Center/Access/Fronthaul network, adapted from [3].

2. Photonic and Radio System Convergence

Fig. 1 (which is adapted from [3]) shows an envisioned converged optical network incorporation centralized baseband units (BBUs) at the DC site, all optical DC switching, and a RoF optical distribution network. The figure also shows the option for connection to a dedicated C-RAN, or one which is converged with an existing broadband access passive optical network (PON). In the latter case, optical line terminals (OLTs) may be co-located with BBUs at the DC site, while connected remote sites consist of optical network units (ONUs) and/or remote radio heads (RRHs). Clearly, the ability to leverage optical convergence for the provision of next generation wireless services in this manner depends on the successful co-implementation of a number of key flexible photonic technologies. In the context of optical convergence, this presentation will discuss practical transmission system implementations with a particular focus on the co-operation of the following enabling technologies:

- *Analog (A)-RoF:* While current digital (D)-RoF technologies offer a robust form of transmission, it suffers from an inability to scale well with increased date rates and number of connected users. A-RoF can alleviate these issues by providing much higher spectral efficiency while reducing the deployment cost of RRHs.

- *All-optical switching:* By minimizing (or completely avoiding) optical-electrical-optical (OEO) conversions, all-optically switched networks vastly improve the total throughput and latency in DCs. The continued growth in both intra and inter-DC capacity demand makes the deployment of these switching technologies crucial.

- *Optical/mmWave generation:* Photonic generation/distribution of mmWave carriers has long been investigated for communications and other applications [2]. Considering the impending extended use of this frequency range for 5G and future (6G) wireless communications, a converged optical/mmWave networking approach offers the potential for the development of a high bandwidth centralized mmWave distribution platform.

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