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Invited Paper

A review of wireless-photonic systems: Design methodologies and topologies, constraints, challenges, and innovations in electronics and photonics

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ABSTRACT

Photonic networks form the backbone for data communications. In particular, in current and future wireless communication systems, photonic networks are becoming increasingly popular for data distribution between the central office and the remote antenna units at base stations. As wireless-photonic systems become in increasing demand, low-cost implementation of such systems will be desirable. This paper describes how integrated photonics and electronics, on silicon, can be used to design such systems. Various building blocks of such silicon-photonics systems are reviewed. The emphasis is on a 60 GHz wireless system which could be suitable for the emerging 5th-generation (5G) cellular networks. The implementation discussed here uses digital baseband optical transmission as opposed to the radio-over-fibre approach.

1. Introduction

The idea of using light for transferring data has rapidly evolved since the invention of optical fibre and semiconductor laser in 1960 s. Not only optical fibre's low loss makes it a suitable medium for transferring electromagnetic waves over long hauls but also its wide bandwidth allows for broadband communication. Furthermore, Wavelength Division Multiplexing (WDM) has made broadband optical communication more pervasive. Continuous advances in photonics technology along with the decrease in its deployment cost have made optical communication more popular for both long- and short-distance broadband communication applications. For example, in Local Area Networks (LANs), conventional copper wires are being replaced by optical fibres because of their cost-effectiveness and broadband nature [1,2]. Furthermore, combining optical communication and wireless communication technologies is emerging; in such wireless-photonics systems, the communication between the access point and the central router is established using optical fibre as is shown in Fig. 1. Furthermore, wireless-photonics systems are suitable candidates for emerging network architectures, such as small-cell cloud radio networks, and thus they offer a promising approach for signal distribution in many current and future applications such as the next-generation cellular systems [3].

In wireless-photonics systems two popular communication approaches are [1,4]: Radio-over-Fibre (RoF) and digital baseband optical communication (Fig. 2). It should be noted that in this classification, RoF includes both Radio-Frequency (RF) and Intermediate-Frequency (IF) over fibre. The overall structure of typical links using these two approaches are shown in Fig. 2. As it can be seen from the figure, the digital baseband approach does not require the RF up- and down-converters and thus its design is typically simpler. It should be noted that the modulation scheme commonly used in the digital baseband approach is On–Off Keying (OOK) which is significantly simpler as compared to the one used in RoF. In RoF, often, Quadrature Amplitude Modulation (QAM) or Orthogonal Frequency Division Multiplexing (OFDM) are used [4]. Although RoF uses more complex modulation schemes, it typically requires a lower bandwidth for the same data rate; it is likely the most straightforward radio signal distribution scheme because the wireless signals are transported directly over the fibre at the radio

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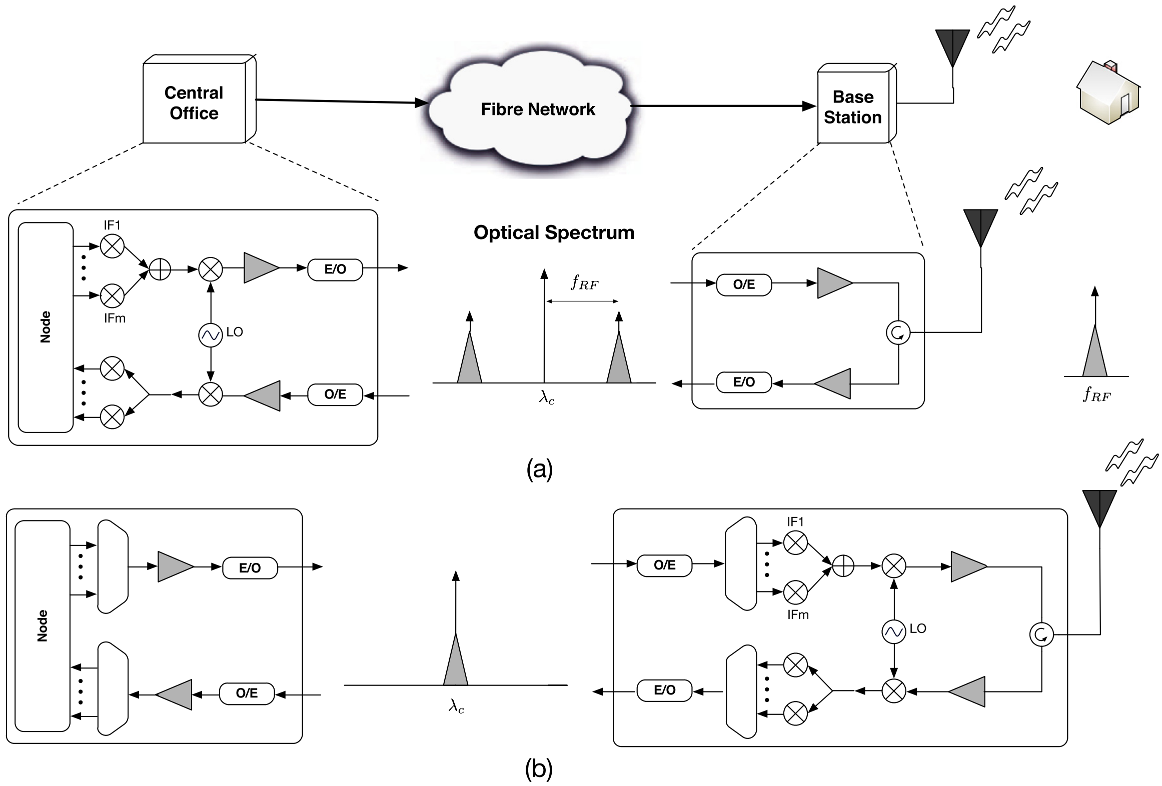

Fig. 1. Radio signal transport schemes for optical-wireless links : (a) RF-over-fiber, (b) Baseband-over-fiber. [1].

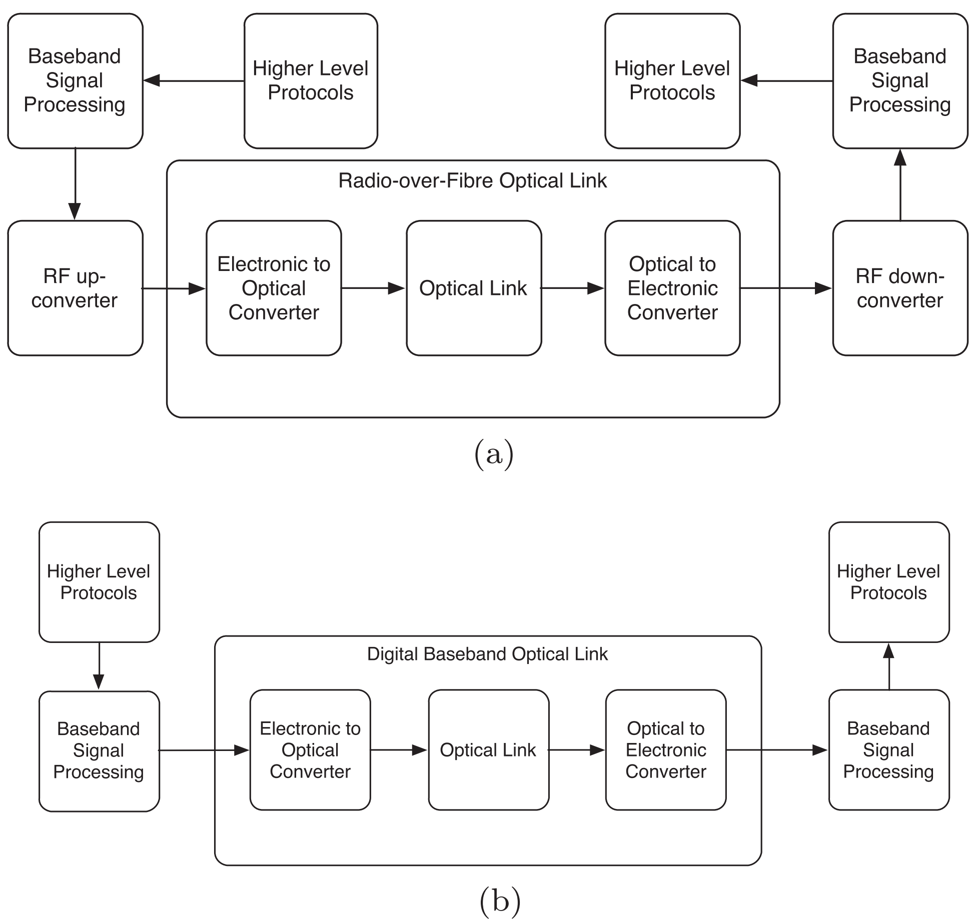

Fig. 2. Overall structure of two general topologies for optical communication. (a) Radio-over-Fibre, (b) Digital baseband optical fibre communication [4].