

Radio over Fiber: An Alternative Broadband Network Technology for IoT

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Abstract

Wireless broadband access networks have been positioning themselves as a good solution for manufacturers and users of IoT (internet of things) devices, due mainly to the high data transfer rate required over terminal devices without restriction of information format. In this work, a review of two Radio over Fiber strategies is presented. Both have excellent performance and even offer the possibility to extend wireless area coverage where mobile networks do not reach, or the 802.11 network presents issues. Radio Frequency over Fiber (RFoF) and intermediate Frequency over Fiber (IFoF) are two transmission strategies compatible with the required new broadband services and both play a key role in the design of the next generation integrated optical–wireless networks, such as 5G and Satcom networks, including on RAU (Remote Antenna Unit) new functionalities to improve their physical dimensions, employing a microelectronic layout over nanometric technologies.

Technological Approach

In new wireless access networks, there is an option to avoid the attenuation issue through distributed antenna systems (DAS) implementation. That is, a high-density network composed of small base stations (small cells) distributed by urban areas or industrial environments to provide good coverage over a specific area, as is shown in Figure 1. These cells, operating at millimeter waves, will need antennas of reduced size compared to current ones, which will simplify their deployment. On the other hand, reduced antenna size brings up the possibility that future base stations will be able to operate using massive multiple input–multiple output (MIMO) configurations to strongly increase the maximum data capacity, if individual channels are multiplexed over the same communications infrastructure.

A new telecommunications scenario is still being set, with fewer doubts that over most commonly used standards for IoT implementation (WiFi, Bluetooth, ZigBee, Thread, SigFox, NFC, etc.), the WiFi standard is the preferred option and has a greater development potential. In fact, there are many predictions that coincide in pointing out that the role played by the WiFi standard in IoT systems, relevant already, will become more important with time and will establish as the dominant option in the mid-term. (Lopez-Perez et al. 2019)

Wireless Broadband Integration

In the last years, mixed fiber–wireless communication DAS fed by multi-mode fibers (MMF) are gaining space as the most promising solution to achieve efficient, cost-effective, and high-capacity transmissions in short range communications. (Lim et al. 2019)

These systems are flexible and there is a good compromise between data transmission capacity, accessibility, and the overall cost of installation and maintenance, allowing a good convergence of optical fiber capacity and wireless access flexibility. In this approach, the signal is generated and processed in a base station (BS) and is distributed through MMF to several remote antenna units (RAU), which provide an optical–wireless interface as is shown in Figure 2. (Lim et al. 2010)

RAU Operation Scheme

A dense RAU devices deployment means that the key to a DAS is to employ cost-effective components in the three main elements of the communication system. This is achieved with the use of MMF (Multimode fiber), which offers electromagnetic isolation and a large capacity, along with cost-effective photonic devices, such as vertical-cavity surface-emitting lasers (VCSEL).

Lastly, a low-cost, low-power, fully integrated RAU must be designed in cost-effective technologies such as CMOS and a moderate complexity to reduce the cost of DAS. An operation scheme of an electrical/optical (EO) and optical/electrical (OE) RAU domain converter is presented in Figure 3, with a description of main blocks and key parameters.

RAU Architectures

Baseband over Fiber

The BBoF scheme follows the typical configuration of optical communication systems for long-reach applications. With this scheme, very high bit rates in the order of several Gbps can be achieved. However, this scheme requires complex RAU configuration and design, as it must perform data modulation and demodulation, as well as frequency conversion, also increasing power consumption.

Radio Frequency over Fiber

On the opposite side, the RFoF scheme, called also in some scientific literature RoF, presents the simplest RAU architecture, because the RAU only has to perform opto/electrical (O/E) and electro/optical (E/O) conversion and signal amplification. It is the most flexible RAU, since as it works in the RF domain, it is transparent to the data encoding or communication standard.

Intermediate Frequency over Fiber

Halfway between BBoF and RFoF we find IFoF. These systems present advantages over both BBoF and RFoF. As in the RFoF approach, RAUs for IFoF do not require the implementation of a modulator/demodulator. Therefore, the complexity

in the design of the RAU is much simpler than that in BBoF systems, and the power consumption is significantly lower.

Conclusiones

IFoF technology is the most promising solution for IoT network deployment due to workable electronic IC design and integration with currently available WiFi 802.11 and emerging WiFi 802.11ad/ay standards at 60 GHz. This can be the start point for future research to achieve a good RAU design and fabrication, that allow to measure the main parameters, to achieve good results employing monolithic technologies. (Paredes-Páliz et al. 2020)

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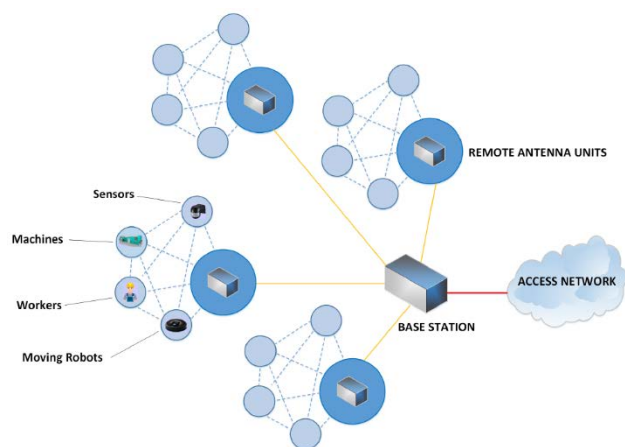


Fig. 1. Scheme of a distributed antenna system

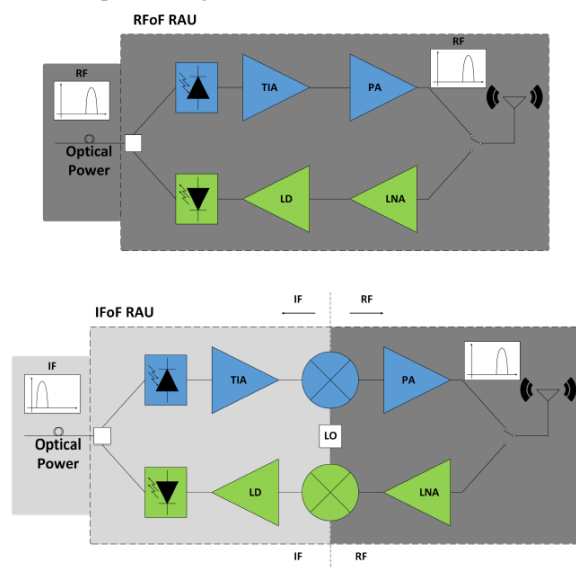


Fig. 2. RoF and IFoF architecture