URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Intermediate Frequency Over Fiber Technology for Radio Access Network in Millimeter-Wave/Sub-Terahertz-Wave Band

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In this paper, we review intermediate-frequency-over-fiber (IFoF) technology for radio access networks in high-frequency bands, such as millimeter-wave and sub-terahertz-wave bands. Compared with radio-over-fiber (RoF) technology, IFoF systems can provide several advantages, especially in the following use cases (Fig. 1): (1) backhaul network to highly moving objects, such as high-speed trains; (2) transmission of large-scale multiple-input multiple output (MIMO) radio access signals in high-frequency bands to antenna sites; (3) transmission of multiple ratio access technologies (RATs) in different frequency bands to antenna sites. For the first application, wavelength-division-multiplexing (WDM) RoF/IFoF systems with optical ultrafast switching technology and adaptive object tracking can help realize a seamless fiber–wireless network for handover-free communication to high-speed trains. Compared with RoF system in high-frequency bands, the use of WDM IFoF technology with a remote delivery of the local oscillator signal for electrical up-conversion at antenna sites can help realize a moving cell network with a simple signal generation and switching between antennas. In our previous work, the principle of a 20-Gb/s handover-free transmission to high-speed trains with ultra-small cell switching time of 3 μs was successfully demonstrated using a WDM IFoF system in the 90-GHz band and ultrafast tunable laser technology [1]. In the second use case, large-scale MIMO fiber–wireless system can be realized using WDM RoF or WDM IFoF systems. Although the use of IFoF system can increase the complexity of antenna sites, the generation of multiple radio signals in high-frequency bands can be easier compared to the use of a WDM RoF system. The effects of phase noise and frequency fluctuation owing to interferences between the signal streams are also smaller using the WDM IFoF system. As proof-of-concept demonstration, we successfully transmitted more than 80-Gb/s 2×2 MIMO fiber–wireless system in the W band using a two-channel WDM IFoF system [2]. The system is scalable for large MIMO signal transmission by adding new WDM IFoF channels. For the third case, to facilitate the coexistence of multiple RATs in future access networks, multiple-band IFoF systems with different electrical up-conversions at antenna sites would be promising to reuse existing infrastructure and save optical transport resources. In the system, a same LO signal can be transmitted over the transport system and frequency multipliers can be utilized at different cells to up-convert IF signals to corresponding frequency bands. This can help to simplify the transmission system and reduce the cost. In [3], we successfully transmitted three RAT signals, including an LTE-A signal in the sub-6 GHz, 25-GHz RAT, and 90-GHz RAT, over a single IFoF system. We believe that the proposed IFoF systems can be promising solutions in future access networks.

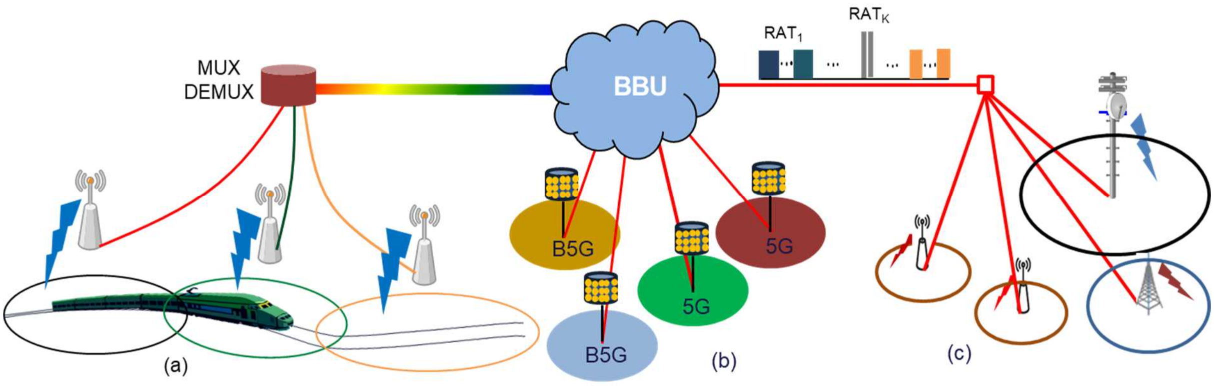

Figure 1. Use cases of IFoF system: (a) moving network; (b) MIMO radio access; (c) multiple-RAT access.

References

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