Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Indoor network for heterogeneous mobile services including 5G/6G (THz)

Date Submitted: May 09, 2024

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Abstract: This contribution presents the configuration of a RoF-based DAS that can provide heterogeneous mobile communication services in an indoor environment and some experimental results to prove it's feasibility.

Purpose: Information of SC_THz

ETRI

Indoor network for heterogeneous mobile services including 5G/6G (THz)

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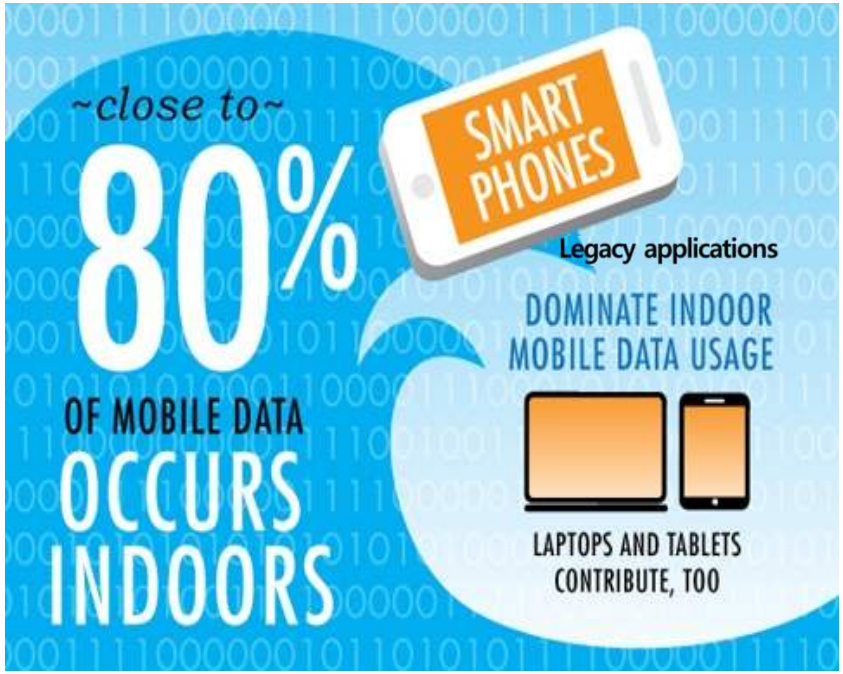
May 13, 2024

Outlines

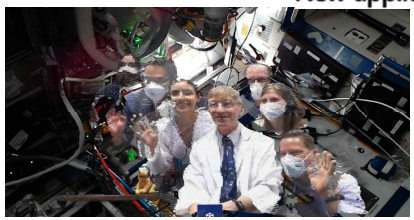
- Motivations
- Indoor Network Architectures for Heterogeneous Services
- Experimental
- Discussions
- Summary

Motivations (1/2)

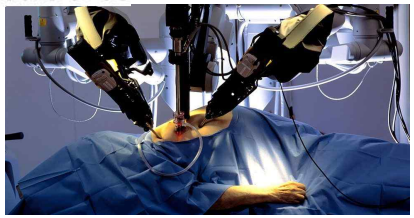
Characteristics of Mobile Data Traffic



New applications of 6G

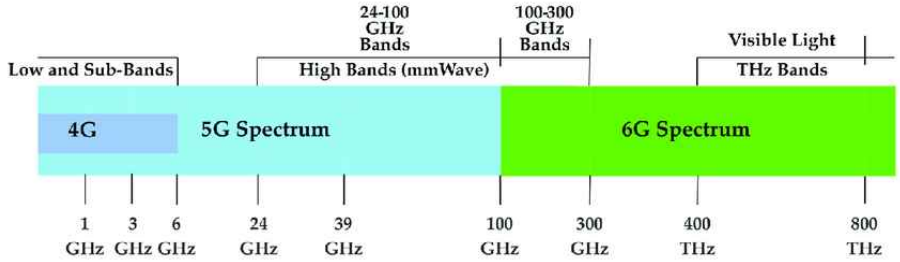


Holoportation

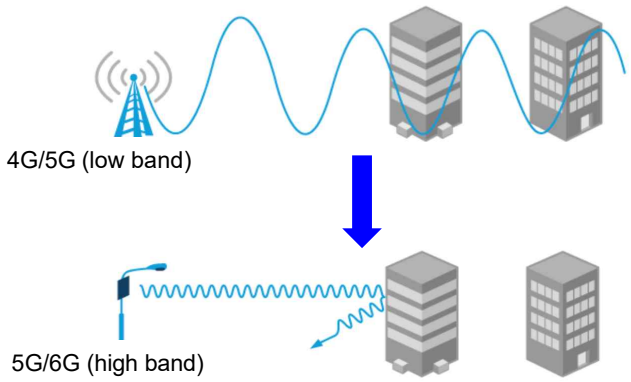


Real-time Telesurgery

Evolution of Mobile Communications



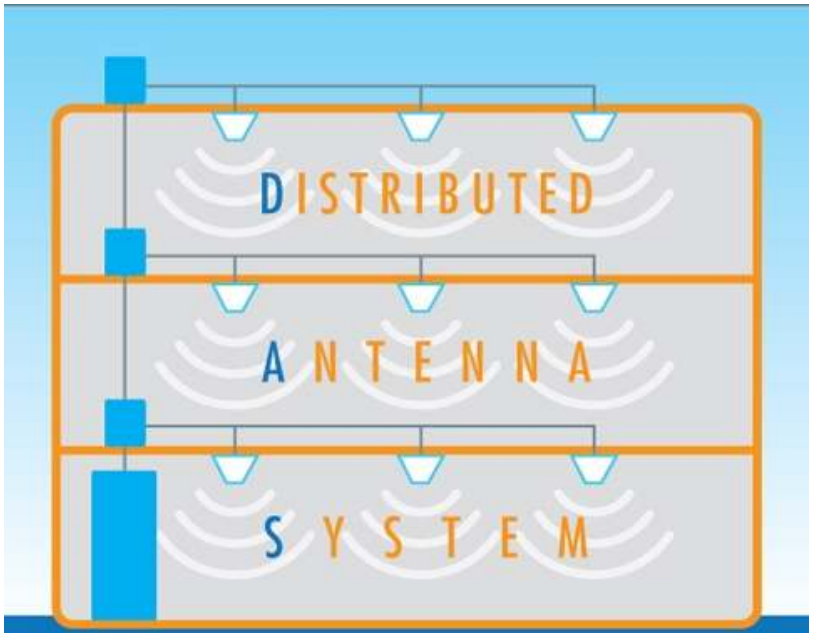
Spectrum evolution for 4G~6G



Limitations of high-band penetration

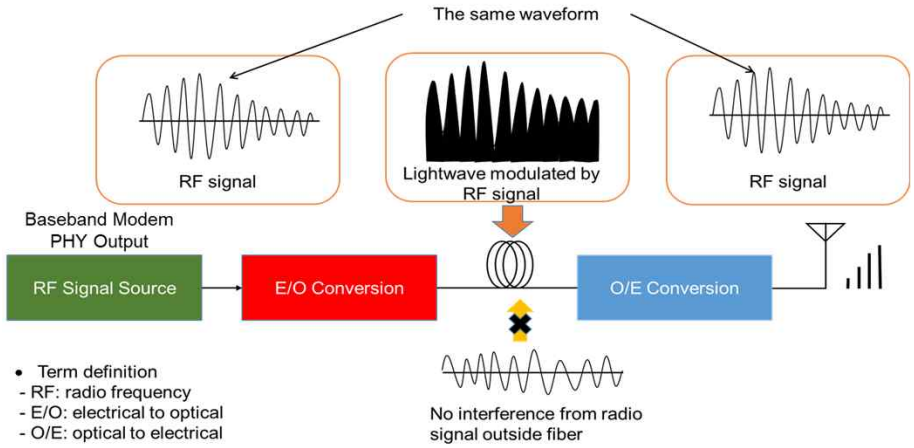
Motivations (2/2)

DAS for radio-wave shadowing area

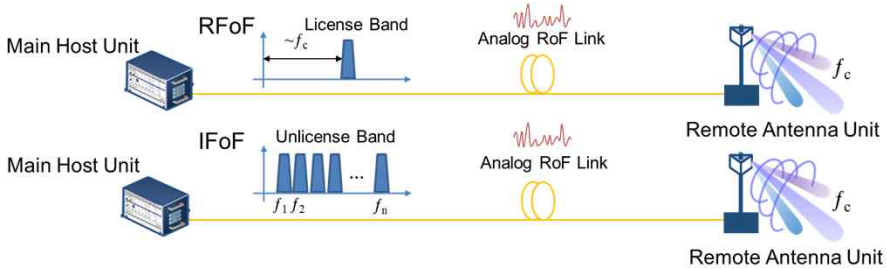


- **Definition of DAS**: A single signal source is connected to a group of antennas instead of to a single antenna.
- **Role of DAS**: It is most often used to distribute cellular network coverage to heavily populated buildings

DAS based on RoF Technology



Basic concept of Radio over Fiber (RoF) technology



Types of RoF Technology in DAS

Indoor Network Architectures for Heterogeneous Mobile Services

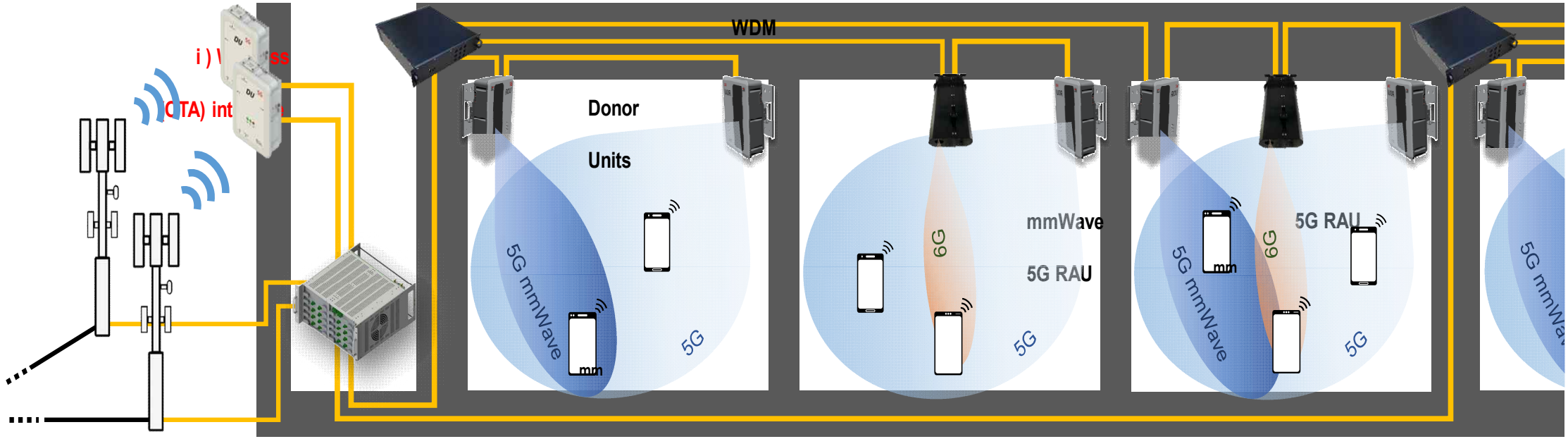


Fig. Indoor distributed antenna system (DAS) that provides the integrated support of heterogeneous mobile network environment (RU: Radio Unit, OTA: Over-The-Air, MHU: Main Hub Unit, RAU: Remote Antenna Unit, WDM: Wavelength Division Multiplexing, mmWave: Millimeter Wave).

- DAS support 3 kinds of services. i) 5G low-band(@3.5GHz), ii) 5G mmWave (@28GHz), iii) 6G THz wave (@280GHz).
- External interfaces include i) wireless interface over OTA with donor unit, ii) fiber-optic interface using RoF technology.
- MHU (main host unit) is connected with multiple RAUs (remote antenna unit) over fiber optic cable and WDM coupler.
- Zone 1: service with 5G low-band & 5G mmWave
- Zone 2: service with 5G low-band & 6G THz wave
- Zone 3: service with 5G low-band & 5G mmWave & 6G THz wave

Ref: Sang-Rok Moon et al, "Hybrid radio-over-fiber transport system to support heterogeneous indoor mobile network environments," J. Opt. Commun. Netw. 16, 71-80 (2024)

Operating Principle of Indoor DAS for Heterogeneous Services

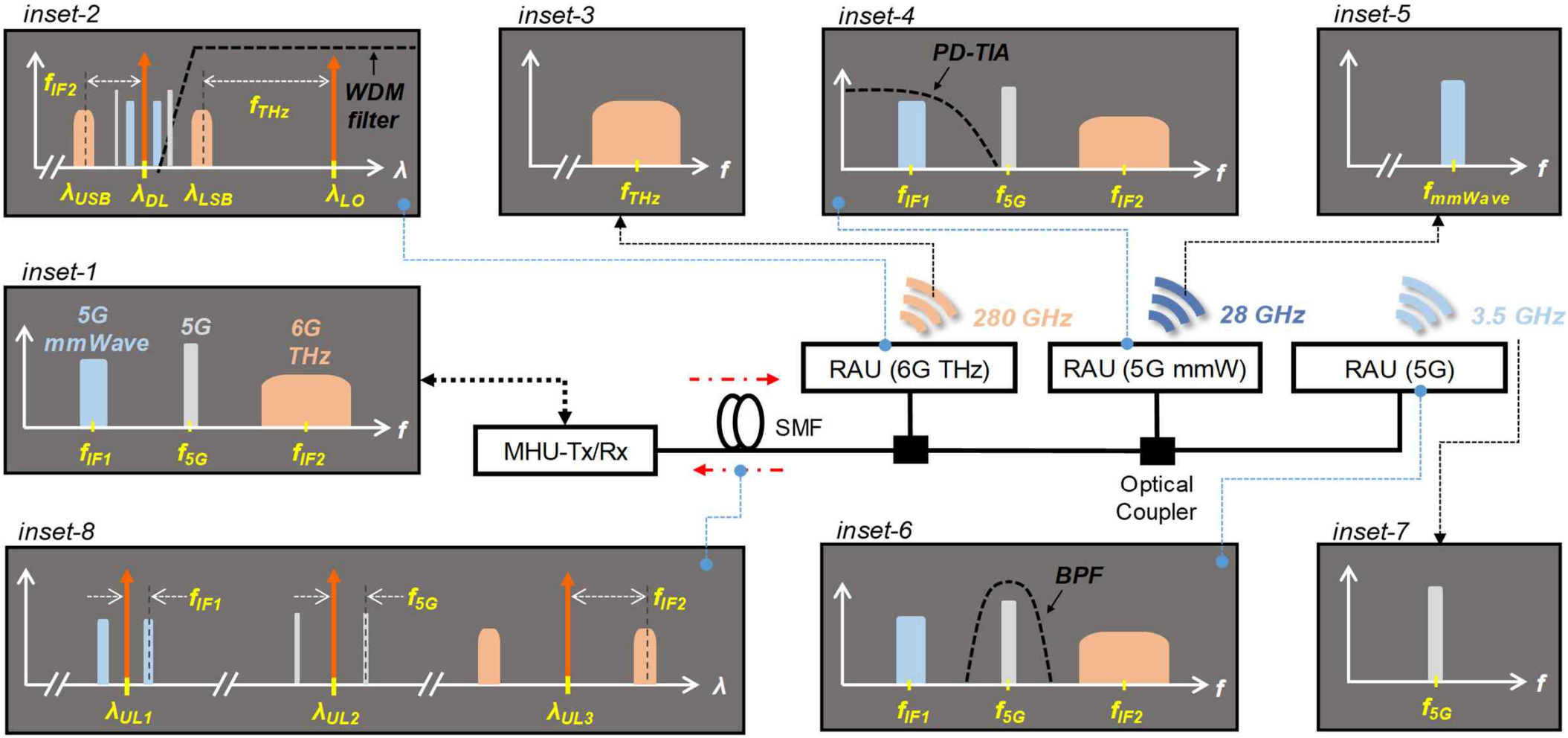


Fig. Operating principle of the indoor DAS network that supports heterogeneous mobile services with the cascade topology.

Ref: Sang-Rok Moon et al, "Hybrid radio-over-fiber transport system to support heterogeneous indoor mobile network environments," J. Opt. Commun. Netw. 16, 71-80 (2024)

Experimental setup and results (Downlink)

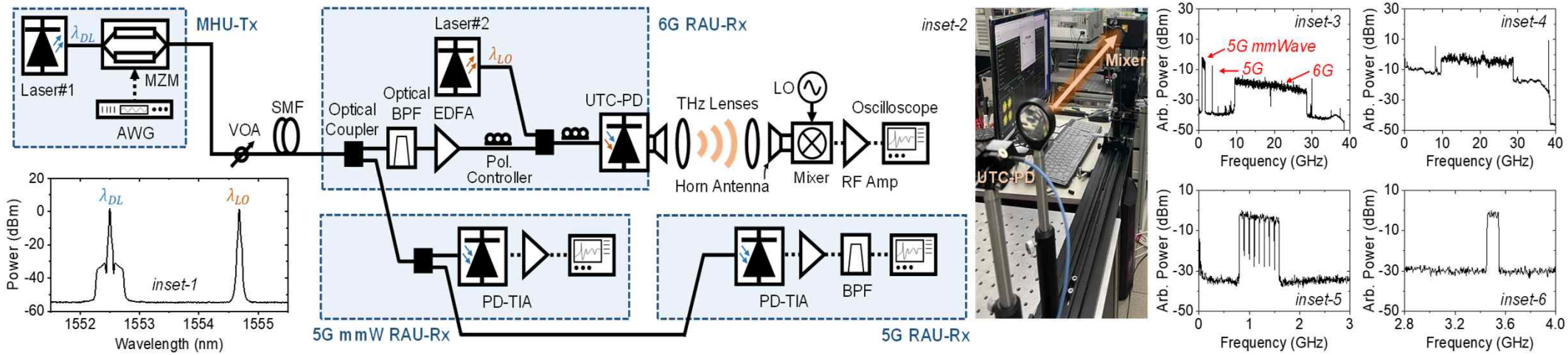


Fig. Experimental downlink setup of the RoF based distributed antenna system (DAS) that supports heterogeneous mobile network environment.

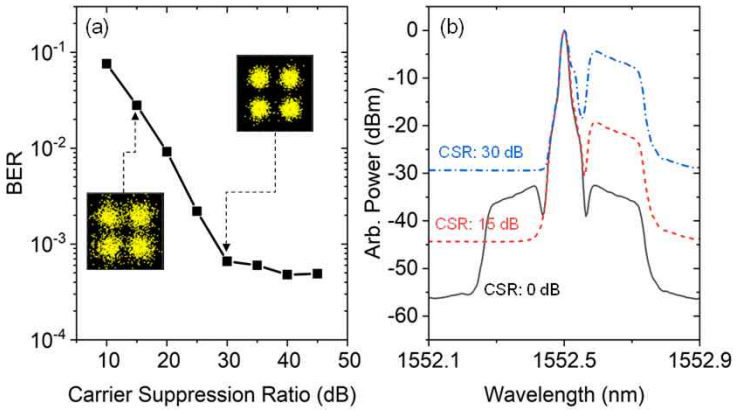


Fig. (a) BERs of the 6G signals measured as a function of the carrier suppression ratio (CSR) and (b) measured optical spectra at three different CSR values: 0, 15, and 30 dB.

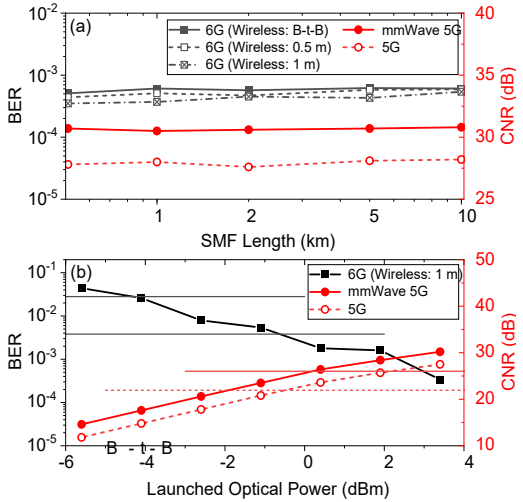


Fig. BERs of 6G and CNRs of 5G signals as a function (a) the length of SMF and (b) the launched optical power into the SMF

Experimental setup and results (Uplink)

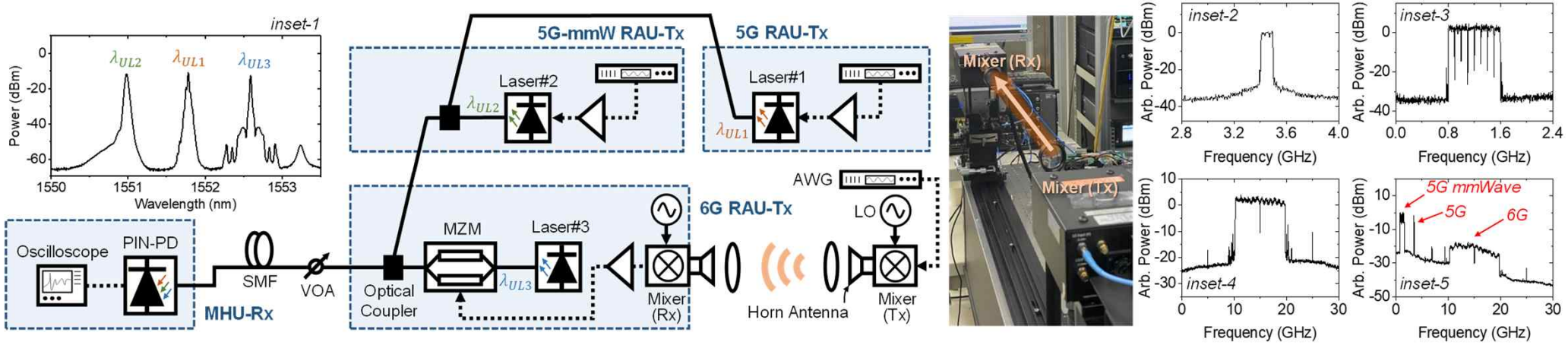


Fig. Experimental uplink setup of the RoF based distributed antenna system (DAS) that supports heterogeneous mobile network environment.

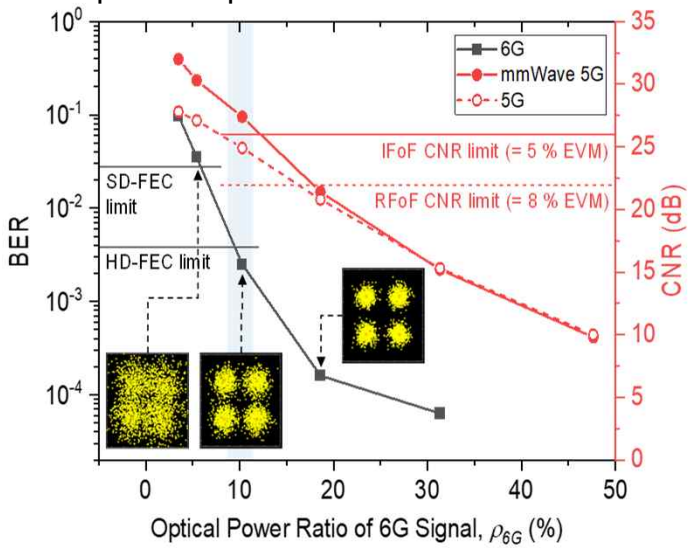


Fig. Measured BERs of 6G signal and CNR of 5G signals as a function of the optical power ratio of 6G signal, ρ_{6G}.

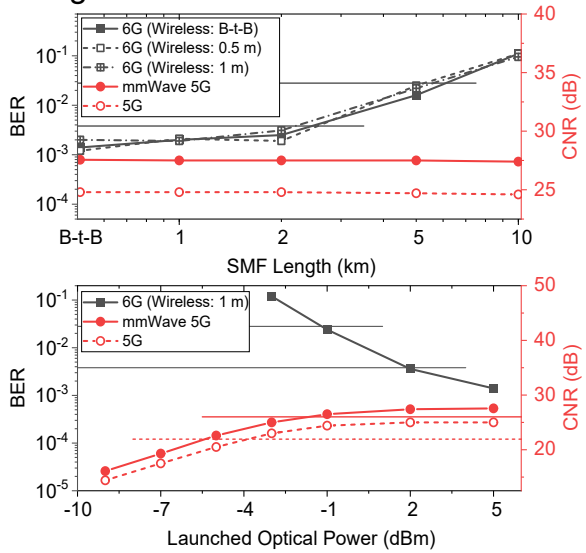


Fig. Measured BERs of 6G and CNRs of 5G signals as a function of (a) the length of SMF and (b) the launched optical power into the SMF

Discussions: Baud rate of 6G & Cost analysis

Baud rate dependent BER performances

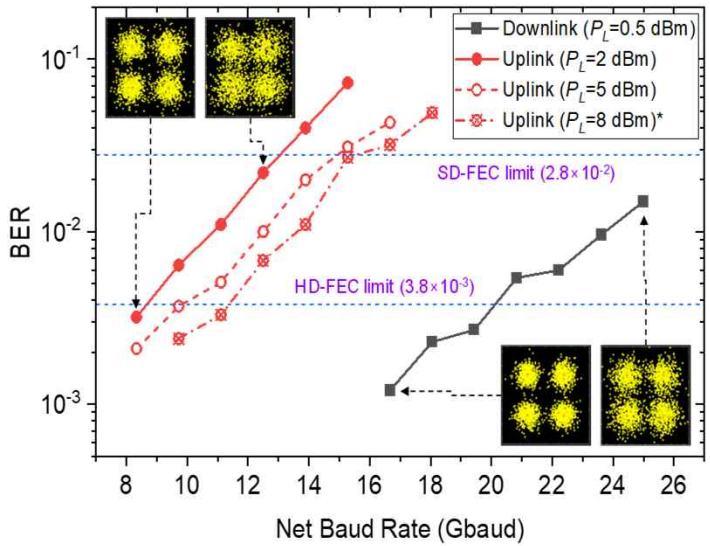


Fig. BERs of downlink and uplink transmission as a function of the baud rate.

- Initial baud rate: 16.7 Gbaud (DL)/ 8.3 Gbaud (UL)
- Link distance: SMF 2km & Free space 1m
- For DL: 25 Gbaud @PL=0.5 dBm
- For UL: 12.5 Gbaud @PL=2 dBm
- For DL: 13.9 Gbaud @PL=5 dBm
- For DL: 15.2 Gbaud @PL=8 dBm

TCO analysis

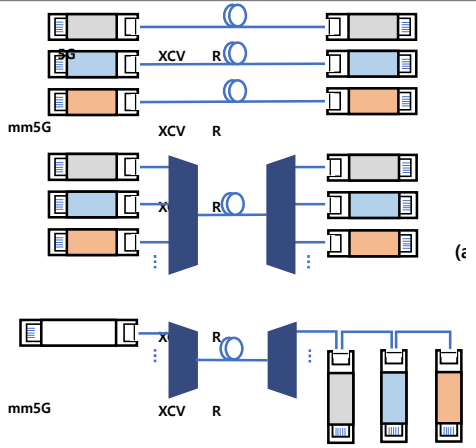


Fig. Cost calculation model: (a) point-to-point, (b) point-to-multipoint, (c) cascaded (XCVR: transceiver, mm5G: mmWave 5G).

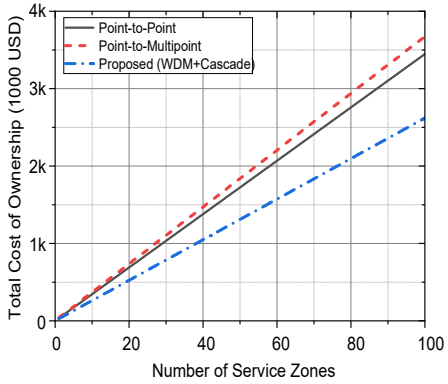


Fig. Total cost of ownership (TCO) of the optical transport system for indoor DAS as a function of the number of service zones.

Summary

- Indoor network for heterogeneous services
  - characteristics of mobile data traffic
  - evolution of mobile communications
  - DAS for radio-wave shadowing area
  - DAS based on RoF Technology
- Indoor network architectures for heterogeneous mobile services
  - architecture and operating principle
- Experimental
  - Downlink with 25 Gbaud QPSK signals using photonics
  - Uplink with 12.5 Gbaud QPSK signals with electronics
- Discussions
  - Baud rate dependency with launched optical power
  - TCO analysis

Thank you