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5G Transport and Broadband Access Networks: The Need for New Technologies and Standards

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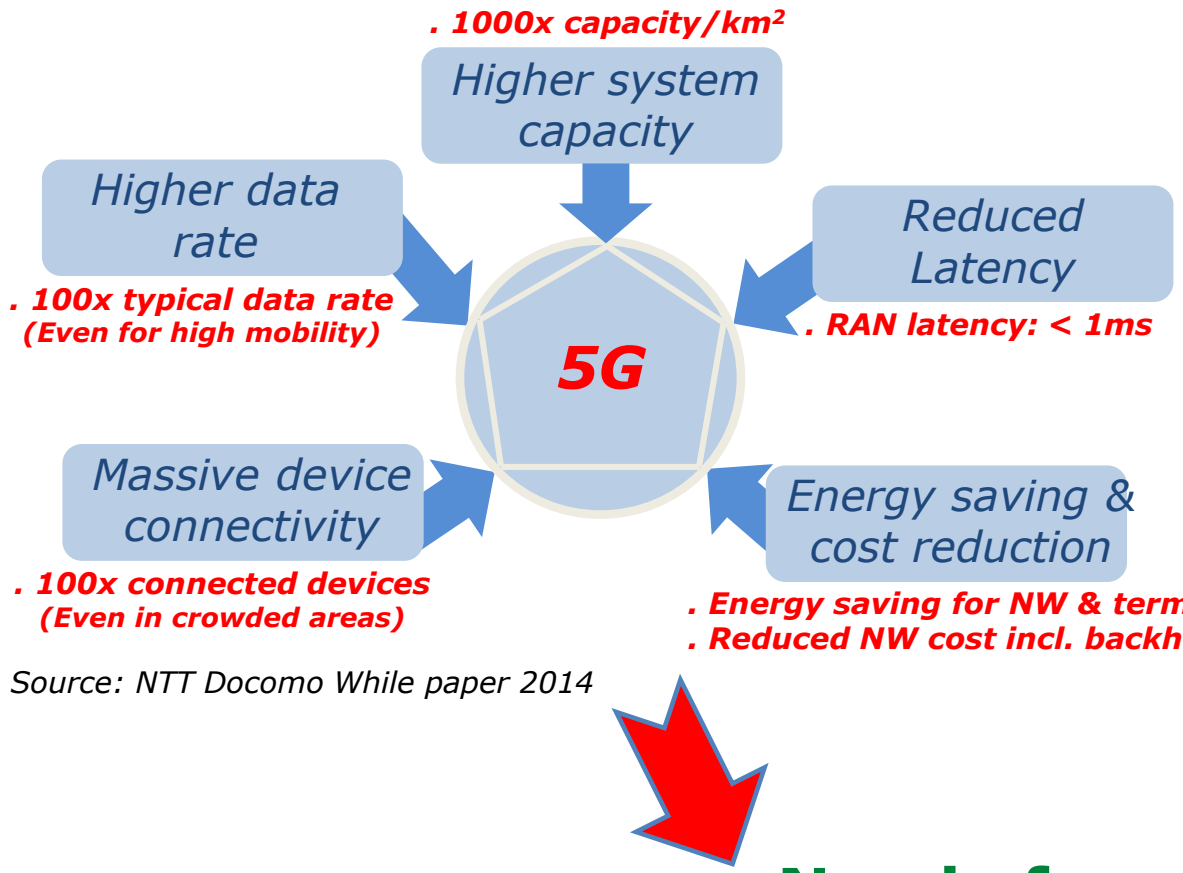
Outline

- Motivations
- 5G transport challenges
- Proposed technologies:
  - Analog radio over fiber (ARoF)
  - Intermediate frequency over fiber (IFoF)
  - Radio on radio (RoR)
  - Seamless convergence of fiber and millimeter-wave
- Standardization activities
- Conclusion and outlook

Motivations

5G mobile networks



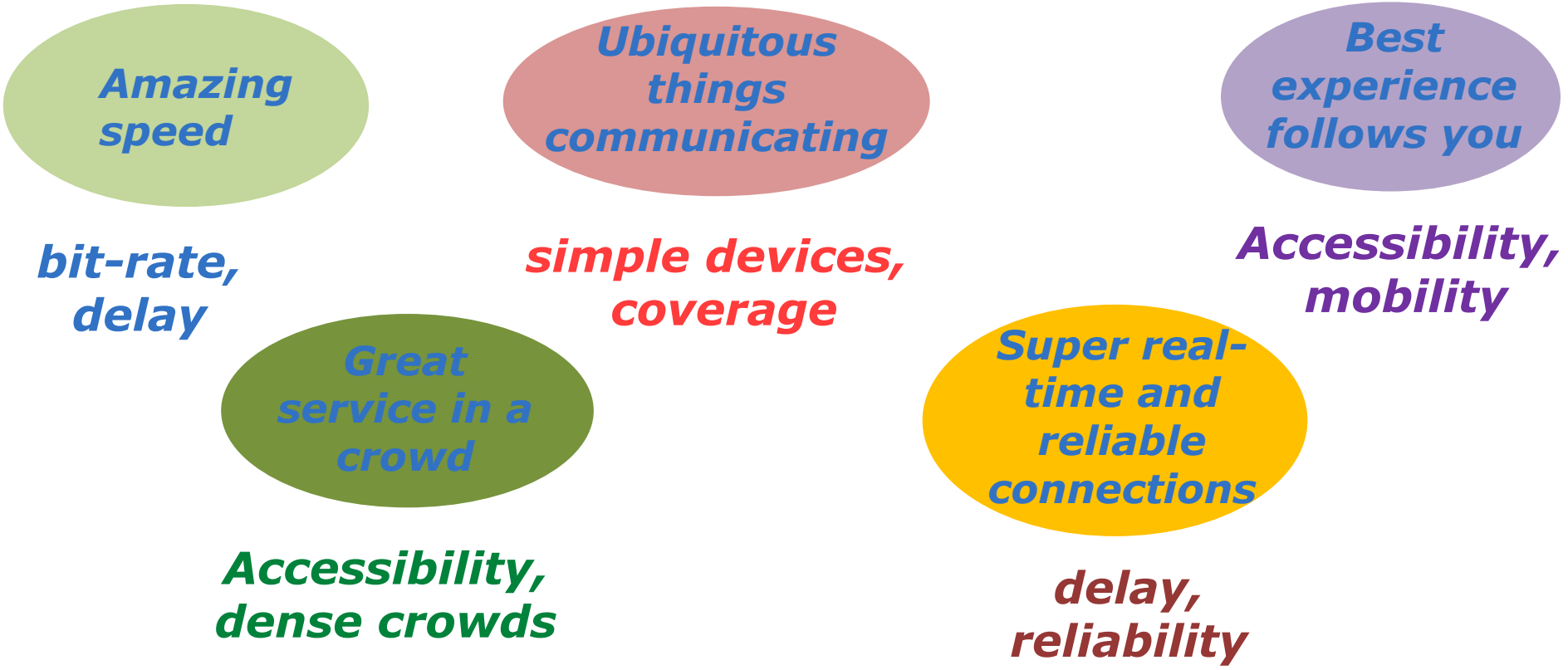
Source: NTT Docomo While paper 2014

ITU Connect 2020

- ICTs: key enabler for social, and sustainable growth.
- 2020: 90% broadband coverage for rural worldwide

Needs for new transport technologies and standards

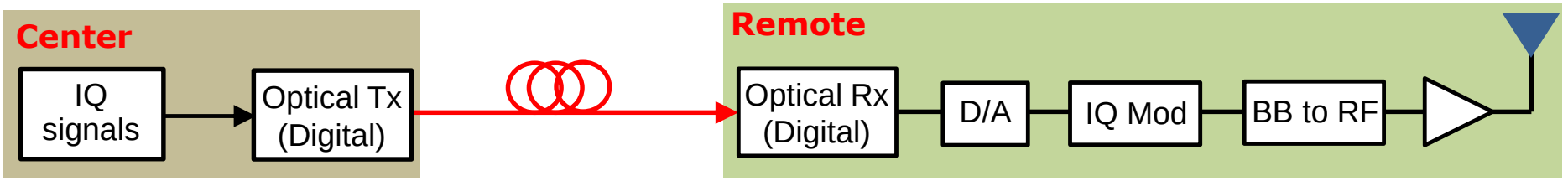
5G transport network challenges



- Transport: different requirements, low cost, simple, high data rate, flexible

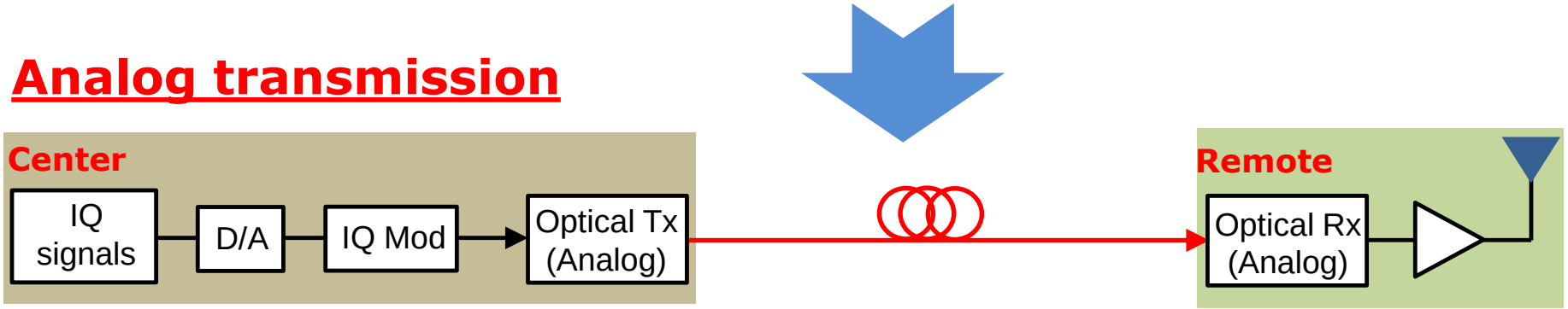
Analog radio over fiber systems-1

Digitized transmission



- **Very high** data rate; **long** latency; synchronization and jitter problems; **high–speed** D/A and A/D (**high cost**).

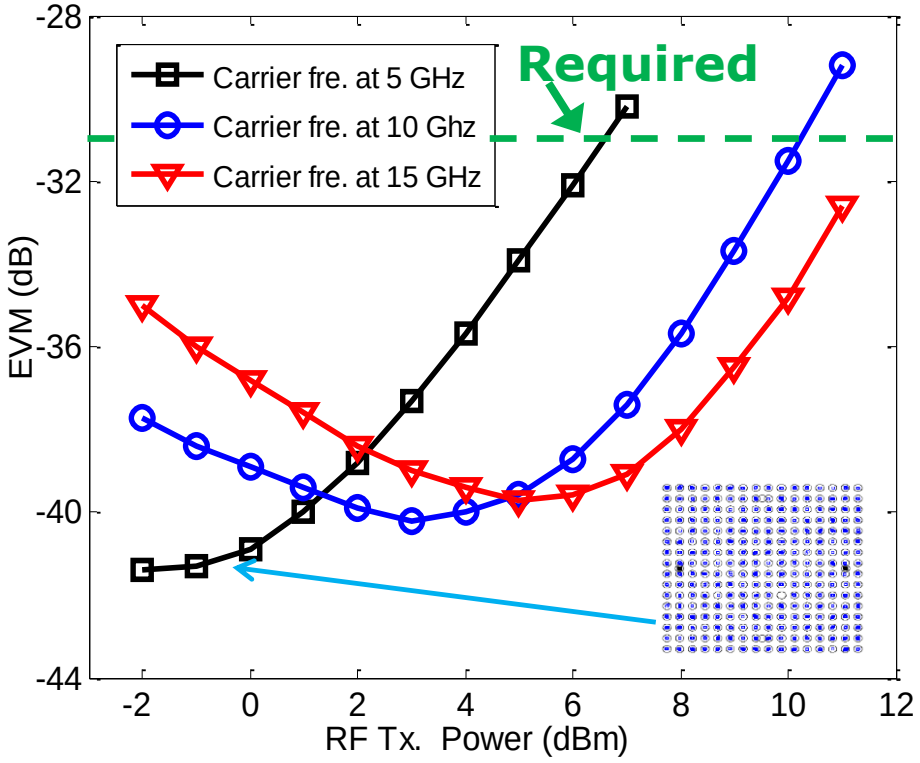
Analog transmission



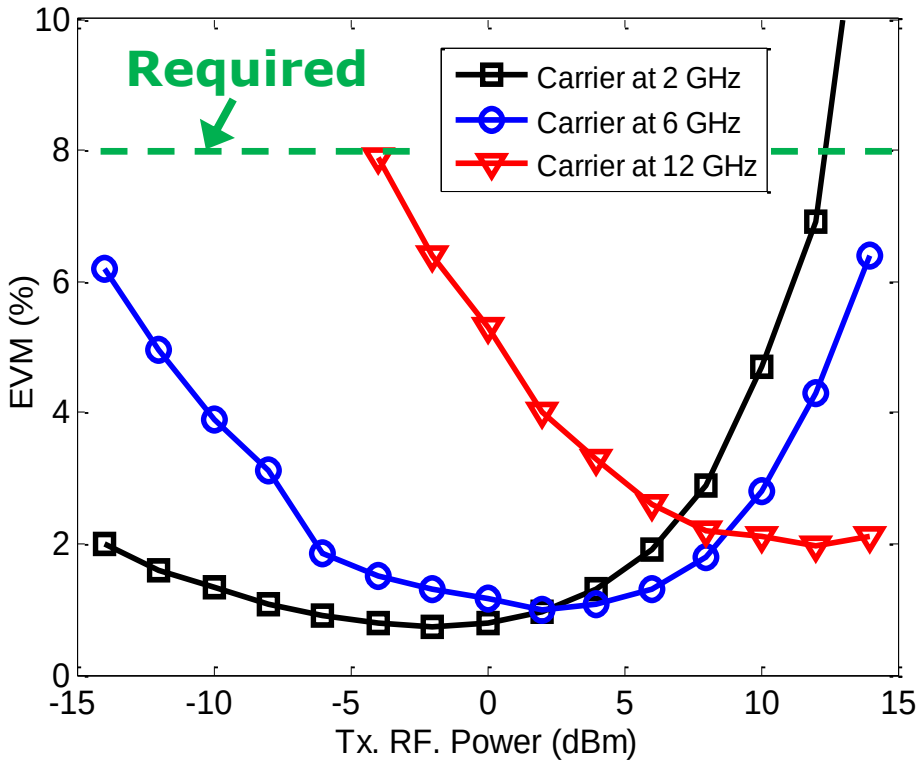
- **Low** bandwidth; **low** latency; **no** synchronization and jitter; **co-transmission**; **better** co-operation.

IQ: In-phase/Quadrature
IQ Mod: IQ modulation
D/A: Digital to Analog
BB to RF: Baseband to Radio Frequency
Tx/Rx: Transmitter/Receiver

Analog radio over fiber systems-2



WLAN 802.11 ac signal



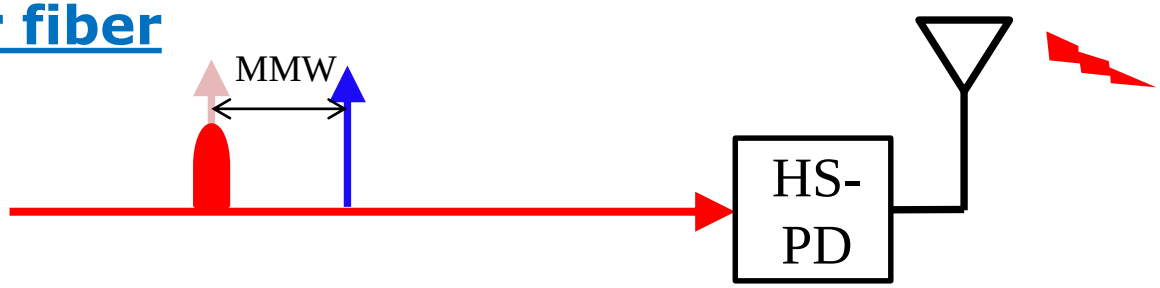
LTE-A signal

- **Satisfactory** performance; **degradation** at high fre.
- Further studies: improvement methods

EVM: Error Vector Magnitude

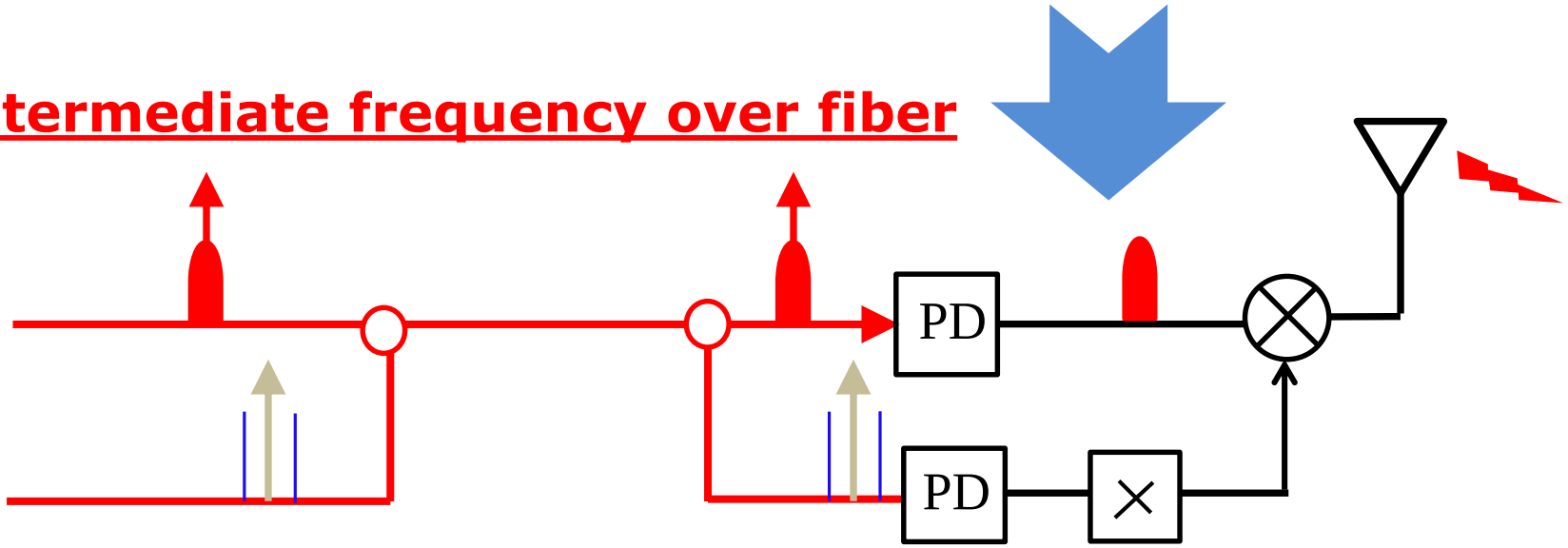
Intermediate frequency over fiber-1

Radio over fiber



- **Low** spectral efficiency, **high cost**

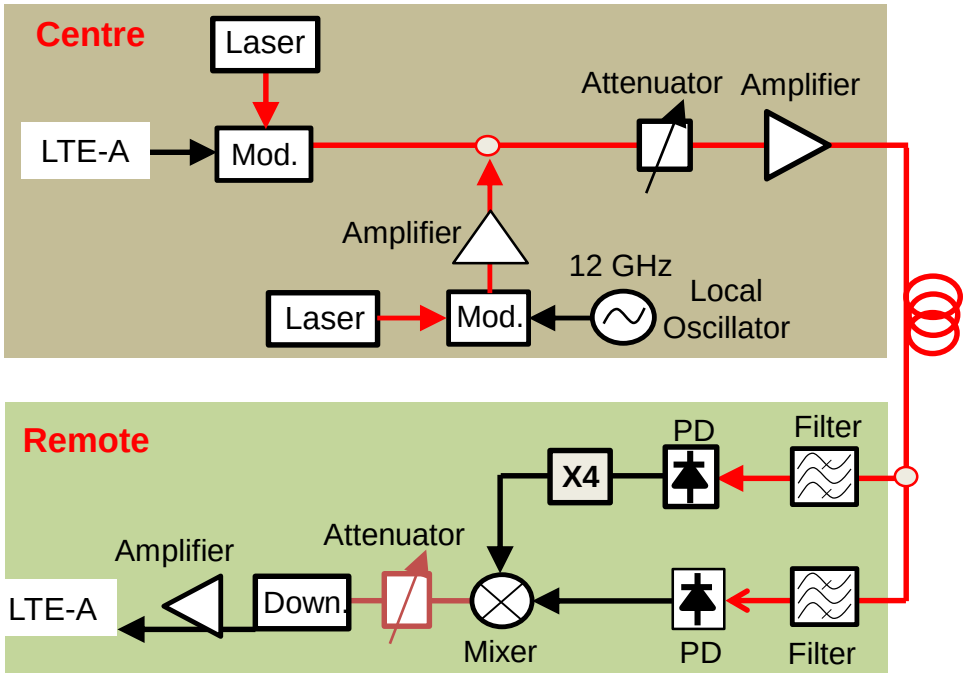
Intermediate frequency over fiber



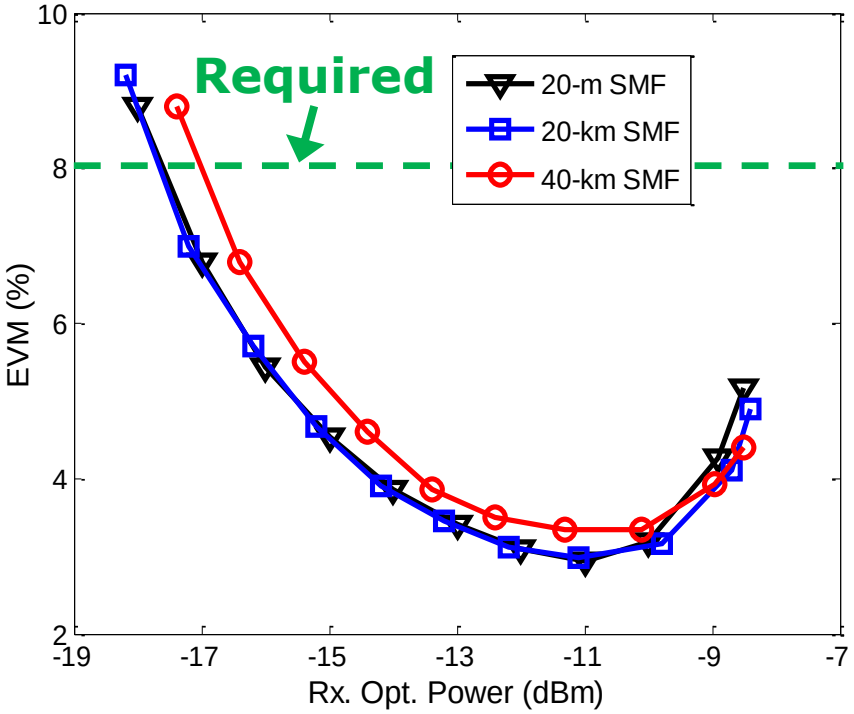
- **High** spectral efficiency, **low cost**, **matured** technology

PD: Photodiode; MMW: Millimeter-wave

Intermediate frequency over fiber-2



Experiment setup

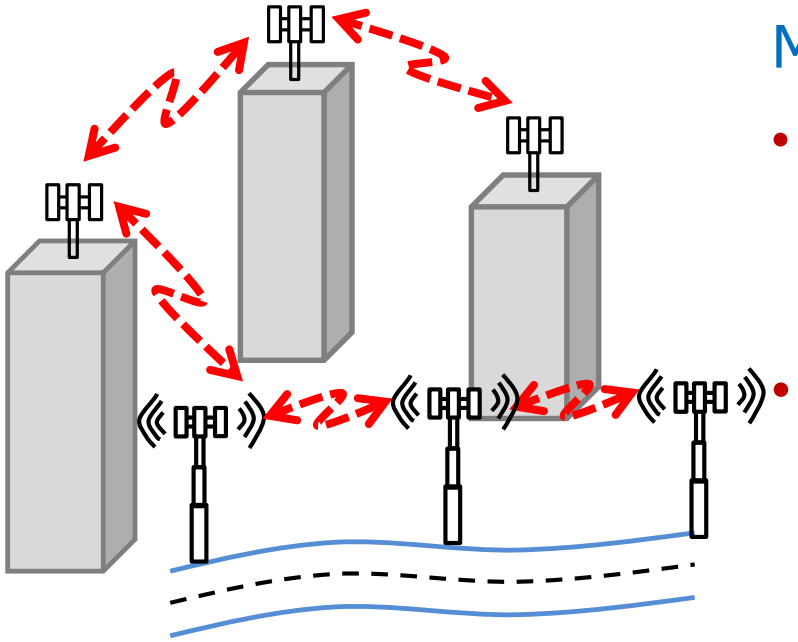


LTE-A signal

- **Satisfactory** performance, **low** fiber dispersion
- Other issues: LO signal delivery; improved methods

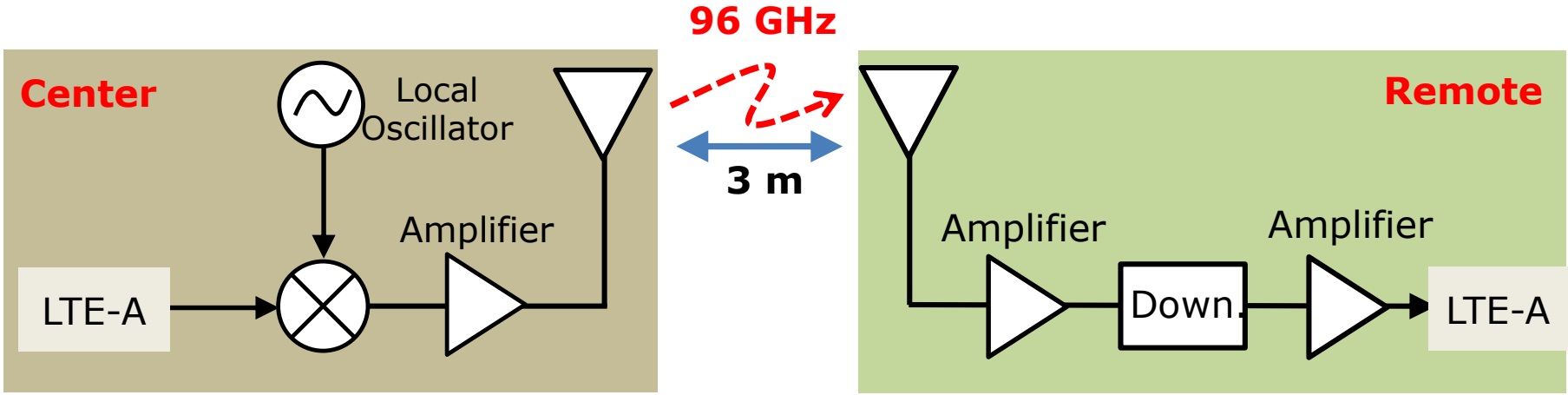
Mod: Modulator; PD: Photodiode

Radio on radio-1



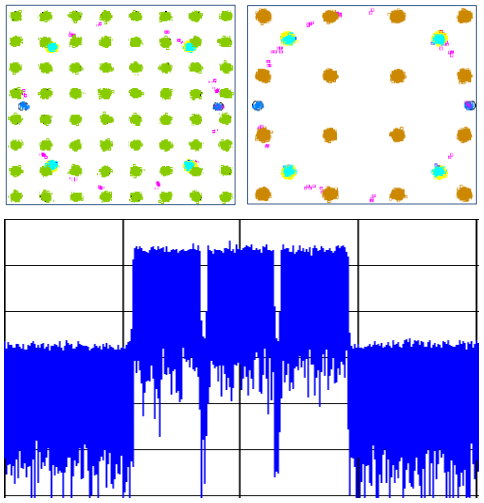
Millimeter-wave and terahertz wave:

- **Digitized transmission**: high data rate, **high cost**
- **Analog transmission (Radio on Radio): low required data rate, cost effective**

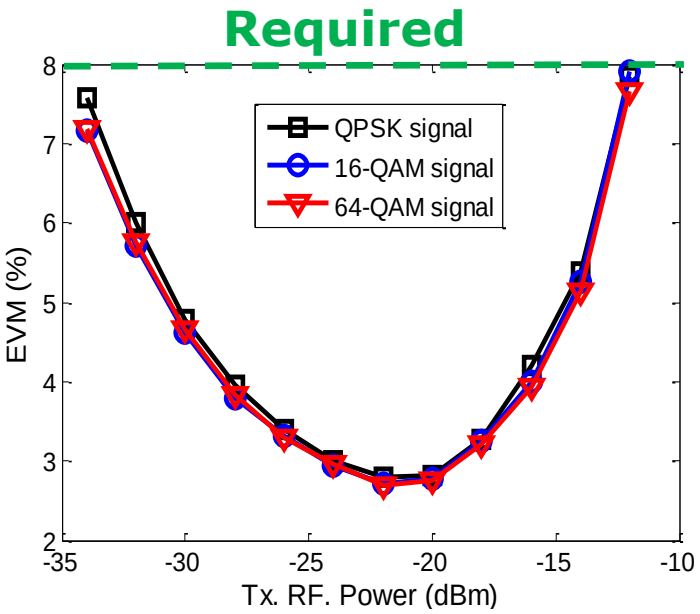


Down: down-converter

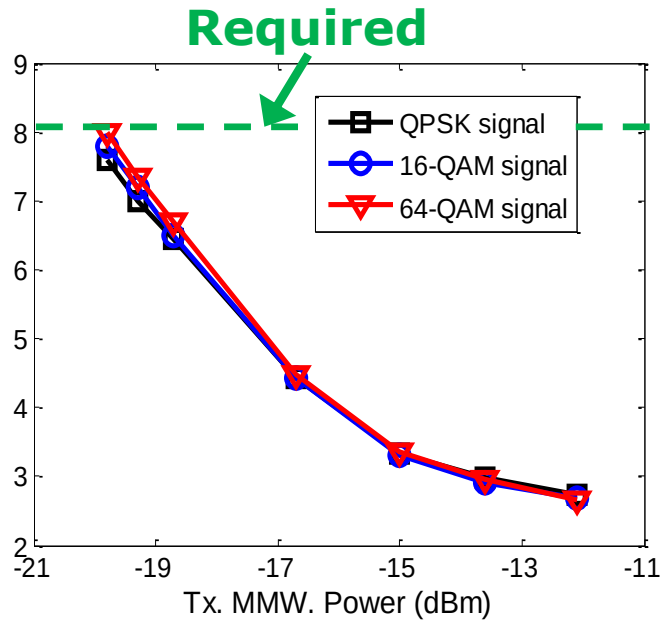
Radio on radio-2



Received LTE-A



Vs Tx. Power (LTE-A)

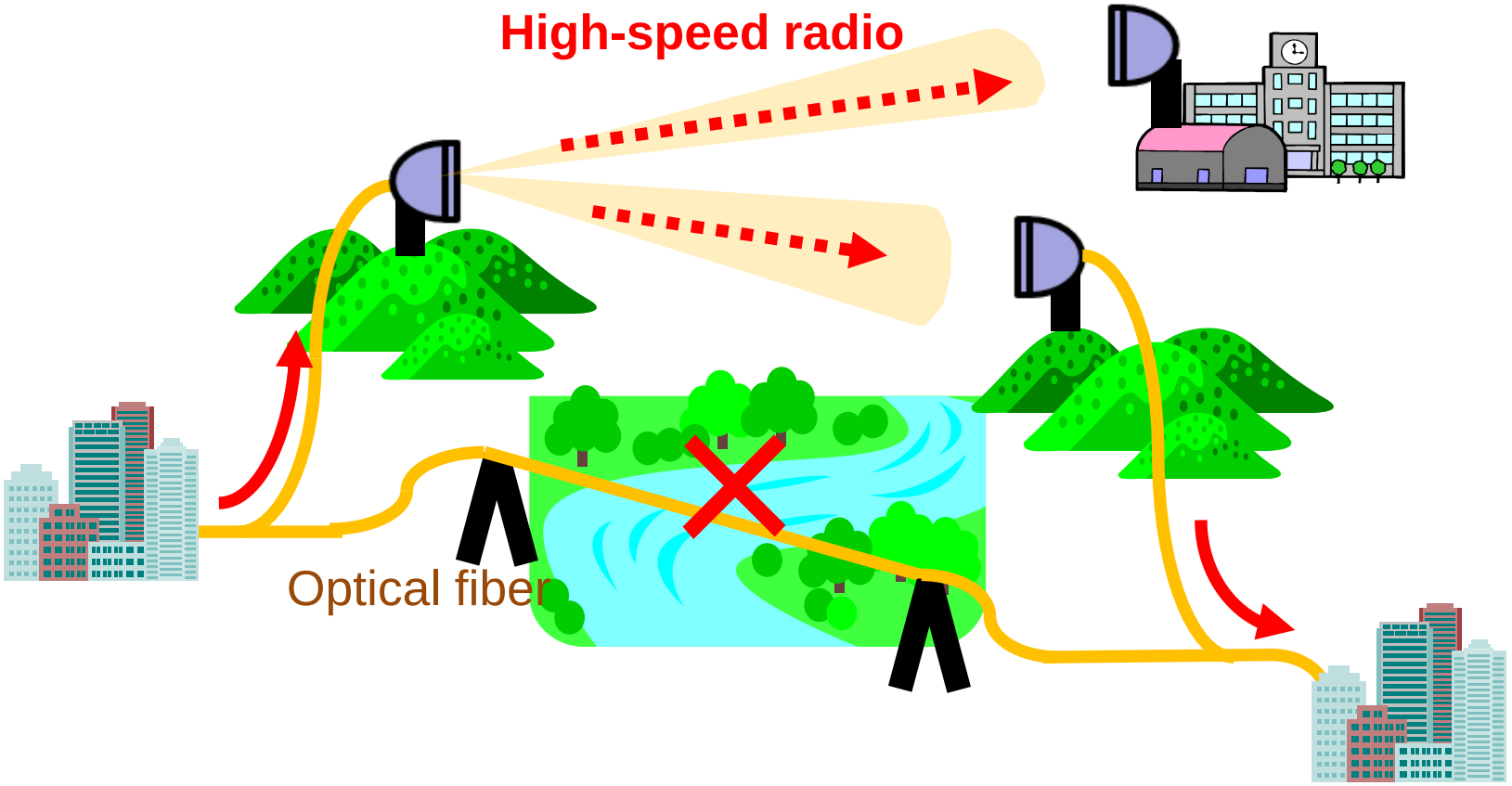


Vs Tx. Power (MMW)

- **Satisfied performance**, MMW link up to **1.5 km**
- Some signal **degradation** because of **distortions**
- Issues: compensation methods, device integration, standardizations

EVM: Error Vector Magnitude

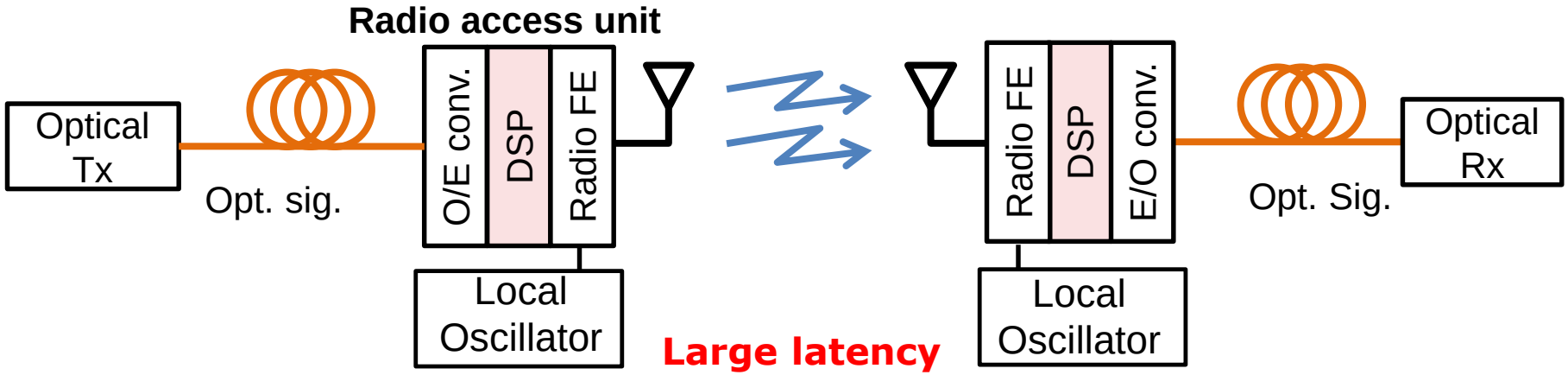
Convergence of fiber and radio-1



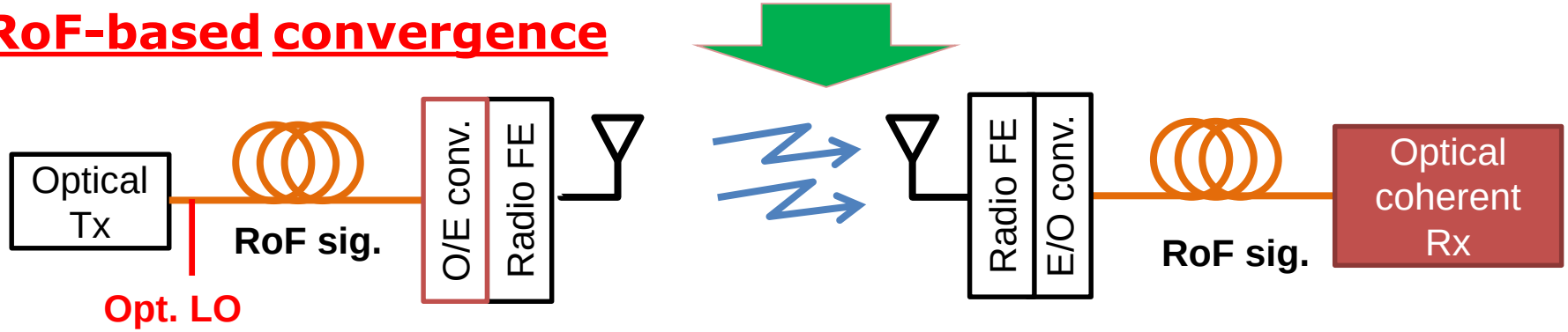
- Protection link against **fiber being cut** at disaster
- Temporal link to at **disaster recovery**
- "**Last mile**" solution until optical fiber deployment

Convergence of fiber and radio-2

Conventional system

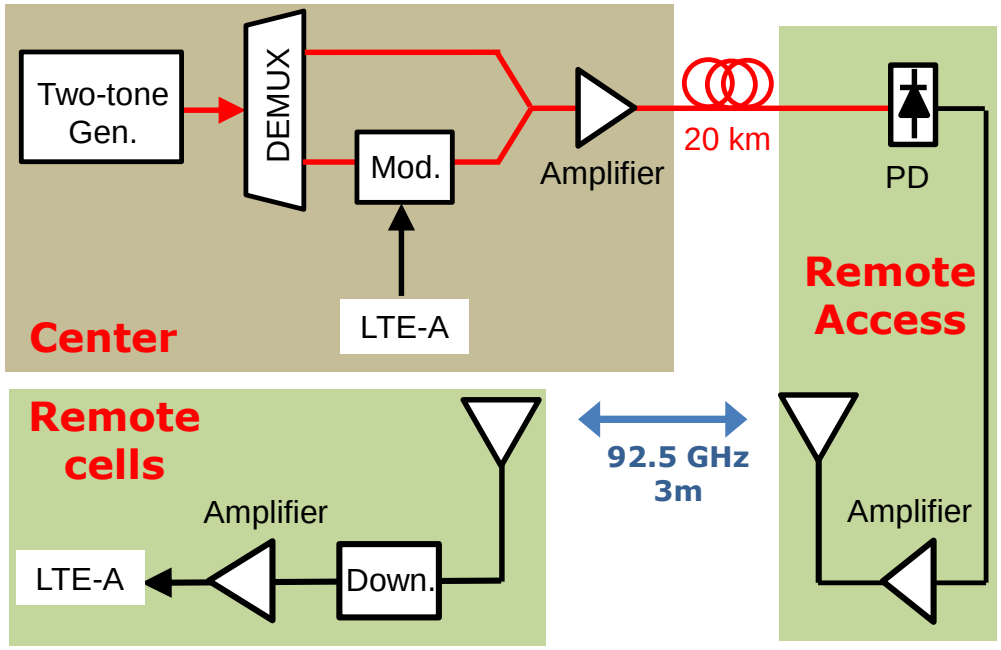


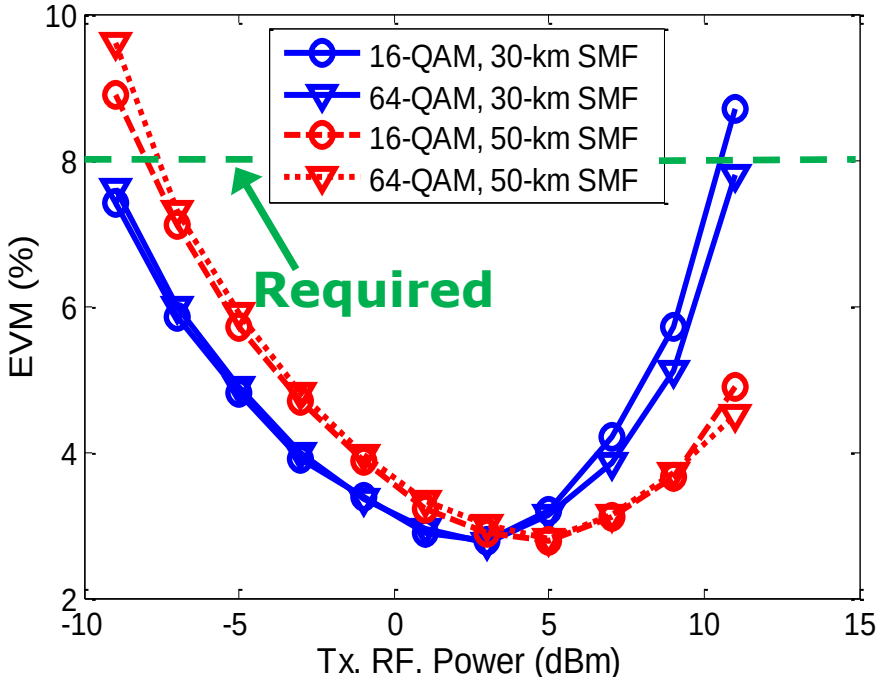
RoF-based convergence



- **Simple**, **low latency**, **low power** consumption, **simple** operation and management

Convergence of fiber and radio-3





Experiment setup

LTE-A signal performance

- **High performance**, possible high-capacity trans.
  Issues: high-speed real-time, standardizations

PD: Photodiode
Two-tone Gen.: Optical two tone signal generator

Standardization activities

Activities:

- ITU-T SG15 Q2: Passive Optical Network with RoF

Publication: ITU-T G.Suppl.55 "Radio-over-fiber (RoF) technologies and their applications"

- ASTAP EG-SACS: RoF systems for Asian pacific countries
- IEC TC103: Precise measurement techniques for RoF components
- IEEE802: .15.3d, .15 IG THz

Possible issues in standardization:

- Interfaces between RoF and digital networks
- RoF network architecture, and requirements
- Control of cells and networks
- Measurement techniques for RoF components

Conclusions

- 5G and broadband access networks poses many challenges to the transport networks.
- The need for a variety of technologies and standards to serve different use cases
- Proposed technologies for flexible, cost effective solutions:
  - Analog radio over fiber
  - Intermediate frequency over fiber
  - Radio on Radio (RoR)
  - Seamless convergence of fiber and radio

Other issues:

- Convergence of fixed and mobile networks
- Co-design, co-operation/optimization of optical and radio
- Standardization activities

Acknowledgement

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Thank you for your attention!

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