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1.25 Gbit/s indoor radio link extension of a Gb-Ethernet CWDM access network

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Outline

• Introduction and motivation
• High-capacity fibre-based access network
• Gb/s picocell radio link
• System test and demonstration
• Conclusion
Target indoor communication scenario

- Broadband network access with high-performance movable terminals
- Sharing of Gb/s capacity
Motivation of work

• Fibre-based access network
  – Exploitation of CWDM technology for high-speed access networks
  – Bandwidth on demand (up to Gb/s) for FTTx systems

• Broadband wireless link
  – Exploitation of licence-free 60 GHz frequency band
  – Wireless Gb/s link e.g. between CPE-ONU and high-performance user terminal(s)

• Integrated system
  – Provision of wireless Gb/s access
  – Full-duplex end-to-end test on application layer using standard Gb-Ethernet protocol
Network scheme

Central office

Feeder ring (up to 18 CWDM channels)

Remote node (RN)

Opt. line terminal (OLT)

Distribution ring (1 CWDM channel)

Opt. network unit (ONU)

Access point (AP)

Customers premises

Movable terminal (MT)

to / from metro backbone

Customers premises

Opt. network unit (ONU)
Full spectrum CWDM access network

• Dual fibre passive CWDM network in fixed configuration of wavelength channels
• $\lambda$-sharing in the feeder area, GbE-sharing in the distribution area
• Protection on Layer 2
• Dual channel RNs (OADMs based on TFF technology) = trade-off with respect to insertion loss and $\lambda$-distribution
• Set-up using commercially available components
• Performance
  – up to 20 km reach using low water peak fibre or SSMF
  – fully exploited CWDM band $\rightarrow$ 18-channels x 1.25 Gb/s
  – up to 9 passive RNs
60 GHz radio link

- Picocellular indoor scenario → full coverage of typical offices (1-10 metres)
- Single carrier transmission with robust DBPSK modulation (easy to demodulate)
- Low complexity heterodyne transceiver
- Full duplex link: FDD @60 & 65 GHz
- Line-of-sight transmission using
  - separate low-directivity antennas for down & uplink at AP
  - single high-gain antenna at MT (to be aligned with AP)
- Directional transmission with few multipath components → channel equalization not necessary (at first)
Scheme of duplex radio link (FDD)

Access-Point (AP)

Movable terminal (MT)

**Downlink**

**Uplink**

- **PC1**:
  - DBPSK-Encoder
  - 1.25 Gb/s
  - 56.25 GHz
  - Power-Amplifier
  - LP-Filter
  - DBPSK-Decoder

- **PC2**:
  - 8.75 GHz
  - DBPSK-Encoder
  - Power-Amplifier
  - IF-Amplifier
  - 56.25 GHz

- **IF-Amplifier**
  - 60 GHz Filter
  - 65 GHz Filter

- **Pre-amplifier**
  - 60 GHz

- **Power-Amplifier**
  - 65 GHz Filter

- **LP-Filter**
  - 60 GHz

- **Power-Amplifier**
  - 65 GHz Filter

- **DBPSK-Decoder**
  - 1.25 Gb/s

- **Access-Point (AP)**
  - 3.75 GHz

- **Movable terminal (MT)**
  - 1.25 Gb/s
  - 8.75 GHz
  - DBPSK-Encoder
  - IF-Amplifier
  - 56.25 GHz
Movable terminal set-up

- High-gain antenna
- Local oscillator @ 56.25 GHz
- Diplexer
- Low noise amp.
- IF-amp. (Receiver)
- Power amplifier
- DBPSK decoder (delay line discriminator)
Wireless link performance

- Downlink @ 60 GHz
- Uplink @ 65 GHz
- Uncoded BER down to $10^{-9}$
- Small downlink performance degradation caused by Tx/ Rx crosstalk at MT
Radio link extension of CWDM access network

- Movable client – remote server scenario
- Standard GbE interfaces @ Hub/OLT, ONU, AP, MT
- Error-free end-to-end GbE-transmission
- Down & upstream fully utilised (986 Mb/s) simultaneously
Conclusions

• FTTP system with picocellular radio extension demonstrated end-to-end on Gb/s-level
• Gb/s channels fully exploited with standard PCs (using jumbo frames)
• CWDM technology is ready for use in FTTx access networks
• Picocellular Gb/s radio transmission possible in unexploited license-free 60 GHz frequency range
• Simple design of a robust single carrier radio system
• Non-directional transmission (NLOS) with channel equalization (OFDM) expected in the future
Acknowledgement

- This work was carried out in the framework of
  
  - EU-IST project
    *Multi Service Access Everywhere*  
    ![](https://example.com/muse.png)
  
  - German R&D project
    *Broadband Access and Indoor Network Architectures*  
    ![](https://example.com/bainet.png)