WiMAX technology: PHY simulation challenges

Alexander Sayenko,

Senior Research Engineer (Nokia-NRC/Helsinki)

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Agenda

- Brief introduction into the WiMAX technology
- WiMAX PHY levels
- New IEEE 802.16m standard
- Simulating the WiMAX technology
- Simulation challenges: bridging the MAC/PHY gap

Main features the IEEE 802.16 WiMAX

- LOS and NLOS operations
- Large coverage
- High performance
- Set of MCSs to adapt to link conditions
- Support for a variety of services
- Support for a variety of link-level technologies through a sophisticated convergence sublayer
- Support for the mobility (latest standards)

WiMAX PHY levels

- SC
  - The first WiMAX PHY level
  - Single-carrier PHY
  - Suitable for LOS operations, but no proper support for NLOS deployment
- OFDM
  - 256 subcarriers per an OFDM symbol
  - Works in NLOS scenarios
  - Suitable for fixed subscriber stations
  - Supports Mesh mode, i.e., ad-hoc networking
  - Optionally, supports subchannelization (simplified form of OFDMa)
- OFDMa
  - Similar to the OFDM PHY
  - The number of subcarriers depends on the configuration (up to 2048)
  - Unlike OFDM, subcarriers are grouped into the logical subchannels
  - Optimized for mobility

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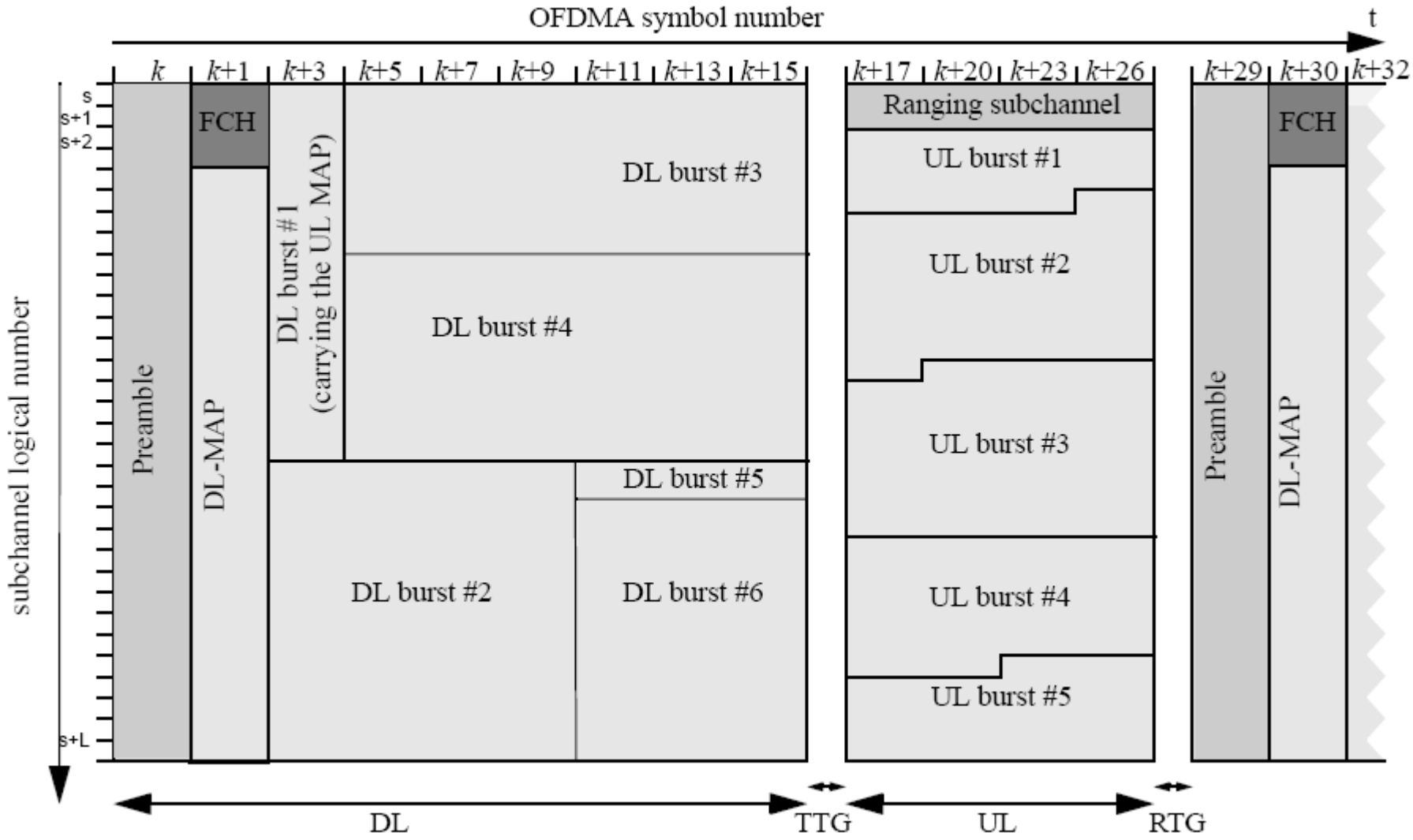
WiMAX OFDMa frame structure



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Key IEEE 802.16 specifications

- 802.16d (2004)
  - Defined OFDM and OFDMa PHYs
  - Targets the fixed deployment scenarios
  - No proper support for mobility
- 802.16e (2005)
  - Extensions to the OFDM and OFDMa PHYs
  - MAC and PHY extensions to support mobility
- 802.16m (under development)
  - Currently, there are only requirements
  - Core areas:
    - Reduced complexity
    - Support for new services, E-MBS, LBS
    - Support for advanced antenna techniques (MIMO) and beamforming
    - New performance requirements
    - New mobility and coverage requirements

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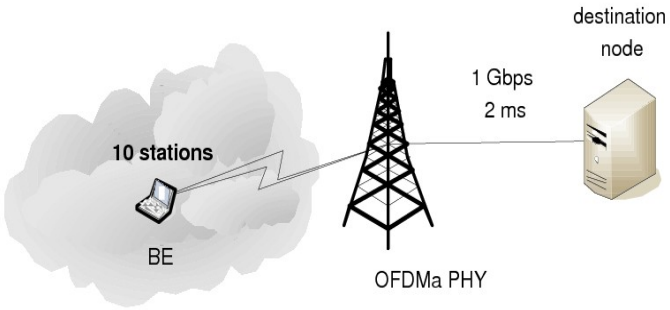
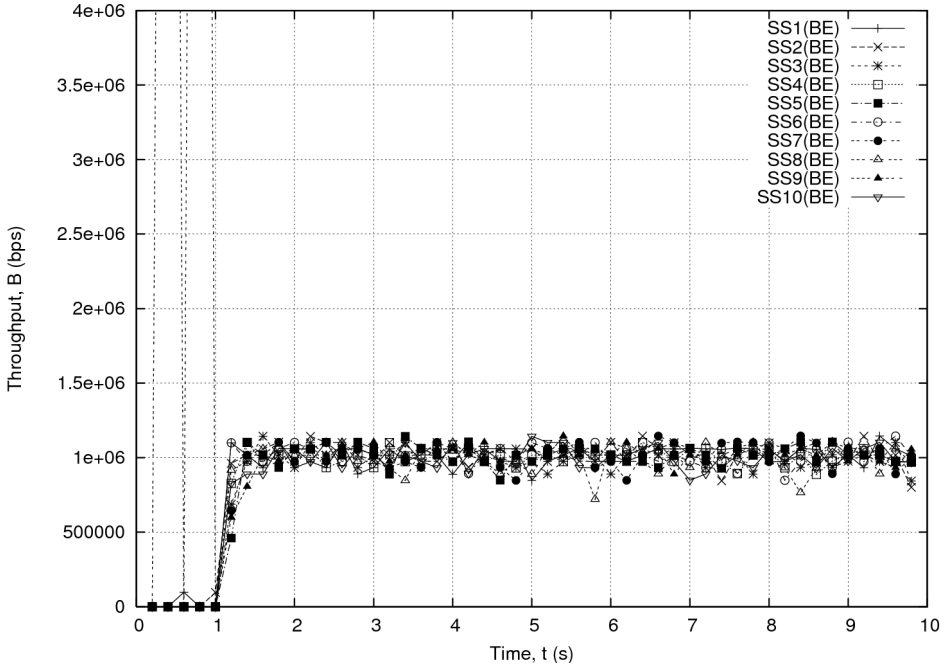
IEEE 802.16m tasks and challenges

- Must be backward compatible with IEEE 802.16e standard
- Functional requirements:
  - Peak data rate: > 6.5 bps/Hz, double the relative performance!
  - Max latency (both uplink and downlink): 10 ms
  - Handover interruption time: 50-150 ms
- Mobility functional requirements:
  - Low (0-15 km/h), high (15-120 km/h), highest (120-350 km/h)
  - Should support IEEE 802.21 Media Independent Handover
- Coverage:
  - Optimized (up to 5 km), graceful degradation (5-30 km), functional system (30-100 km)
- Multi-hop relay networks

Sample simulation scenario

PHY	OFDMa
Bandwidth	10Mhz
FFT	1024
Cyclic prefix length	1/8
TTG+RTG	232 PS
Duplexing mode	TDD
Frame duration	5 ms
OFDM symbols	47
DL/UL symbols	26/21
DL/UL subcarrier alloc.	DL FUSC/UL PUSC
DL/UL slots	416/245
MCS	64-QAM3/4 (27B/slot)
Fragmentation/packing	ON
PDU size	as large as possible
CRC/ARQ	ON
ARQ feedback	standalone
ARQ block size	16 B
ARQ window	1024
ARQ block rearrangement	ON





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PHY simulation challenges

- Low-level simulators
  - Sophisticated PHY modeling
  - Quite poor support for MAC and upper level protocols modeling
    - It is possible to implement them, but
    - ... it requires too much human work hours
  - Need a significant amount of computational resources
- High-level network simulators
  - NS-2, OpNet
  - Provide libraries with transport and high-level protocols
  - If something is missing, it can be added easily
  - Much faster when compared to the low-level simulators
  - Support for PHY modeling is quite poor
    - It is possible to model PHY accurately, but
    - ... it will be too slow

Bridging the MAC/PHY gap

- It is crucial to simulate accurately PHY in the high-level simulator
  - It does not diminish the value of the low-level simulator, but rather
  - Allows for achieving more accurate performance results
- Simulation models used in the low-level simulators:
  - They are too accurate
  - They require too much computational resources
- New PHY simulation models are need for:
  - Interference
  - MIMO
  - Subcarriers and logical subchannels
  - .....

Collaborators

- Nokia Siemens Networks

- University of Jyväskylä, Finland,
  MIT department, Telecommunication laboratory
  - Development and support of the NS-2 WiMAX simulator
  - Research activities:
    - QoS and scheduling
    - MAC performance optimizations (e.g., ARQ, MAC overhead)
    - Adaptive contention resolution

- WiMAX Forum AATG group
  - Simulation methodology
  - Performance evaluation

Thanks for your attention!

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