A Mobile WiMAX Module for ns-3

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Presentation Outline

1. Overview of WiMAX technology
2. Similar Works
3. WiMAX Module for ns-3
   - Key challenges
   - Software design
   - MAC Layer
   - PHY Layer
4. Limitations and future work
5. Conclusion

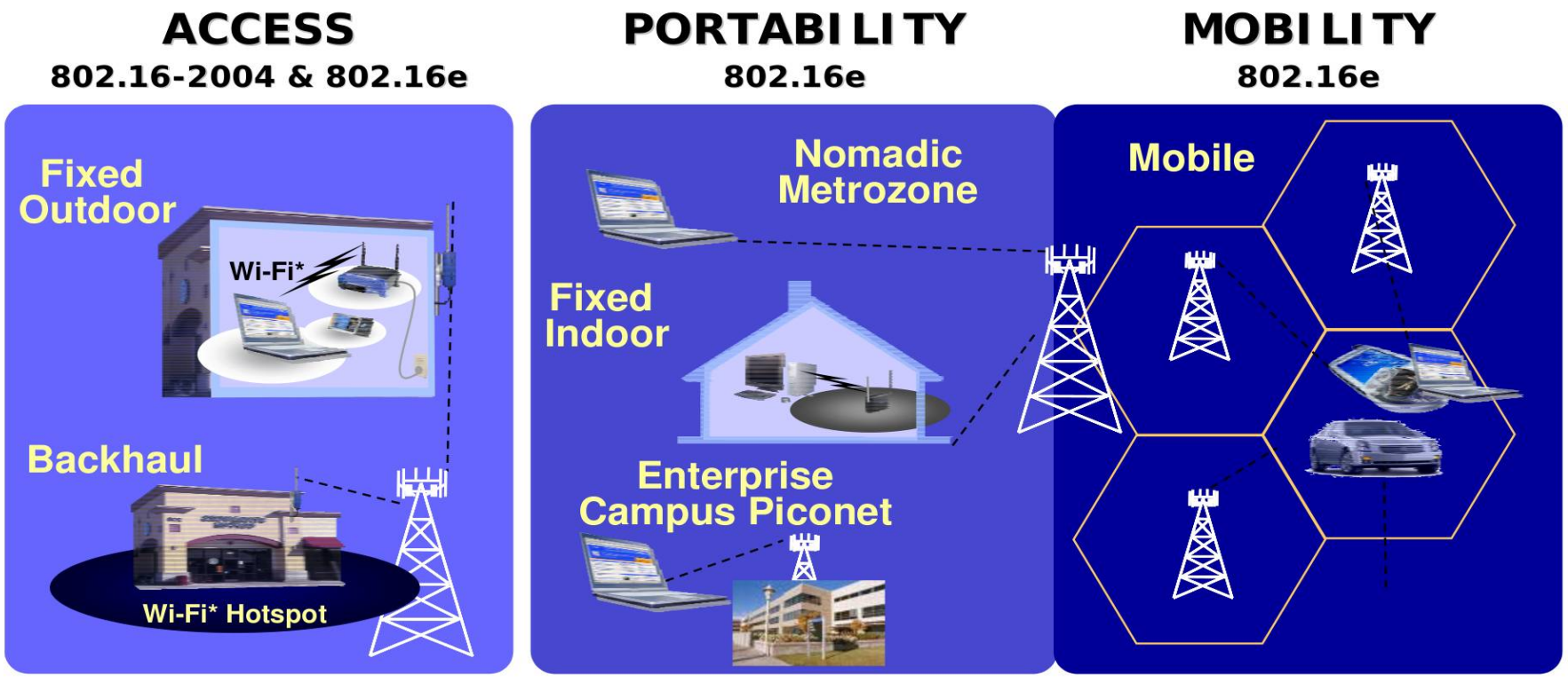
Overview of WiMAX Technology

Overview of IEEE 802.16

WiMAX (Worldwide Interoperability for Microwave Access) is:

- A radio interface technology standardized by IEEE 802.16-2004/2005 *[1] [2]*
  - IEEE defines layer 1 (PHY) and layer 2(MAC) details. The scope is limited to the interface between terminal and Base Station (BS)
  - Layer 1 is based on OFDM/OFDMA
  - 802.16-2004 (802.16d) for fixed deployment
  - 802.16-2005 (802.16e) for mobile deployment
- An end-to-end architecture defined by WiMAX Forum (WMF) *[3]*
  - The architecture details how to deploy 802.16
- A label for Compliance/Interoperability, delivered by WMF
  - A WiMAX labeled product is certified to be compliant to the standard
  - WMF takes in charge the definition and realization of certification

Overview


ACCESS
802.16-2004 & 802.16e
PORTABILITY
802.16e
MOBILITY
802.16e
Fixed Outdoor
Wi-Fi*
Backhaul
Wi-Fi* Hotspot
Nomadic Metrozone
Fixed Indoor
Enterprise Campus Piconet
Mobile

Similar Works

Similar Works

Several WiMAX modules are available for ns-2

- Networks and Distributed System Laboratory (NDSL) *[4]*
  - Scheduling services, bandwidth management and other features
  - Highly simplified as it ignores several implementation details.
- National Institute of Standards and Technology (NIST) *[5]*
  - OFDM PHY, fragmentation, ...
  - Lacks in the implementation of QoS scheduling services
  - Collaboration between WMF, Resselaer Polytechnic Institute (RPI) and Washington university adds support for QoS, ARQ and OFDMA. Available for WMF members.
- Computer Networks Laboratory (CNL) *[6]*
  - Scheduling services, bandwidth management, ...
  - Lacks implementation of compliant PHY layer

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WiMAX Module for ns-3

WiMAX Module for ns-3

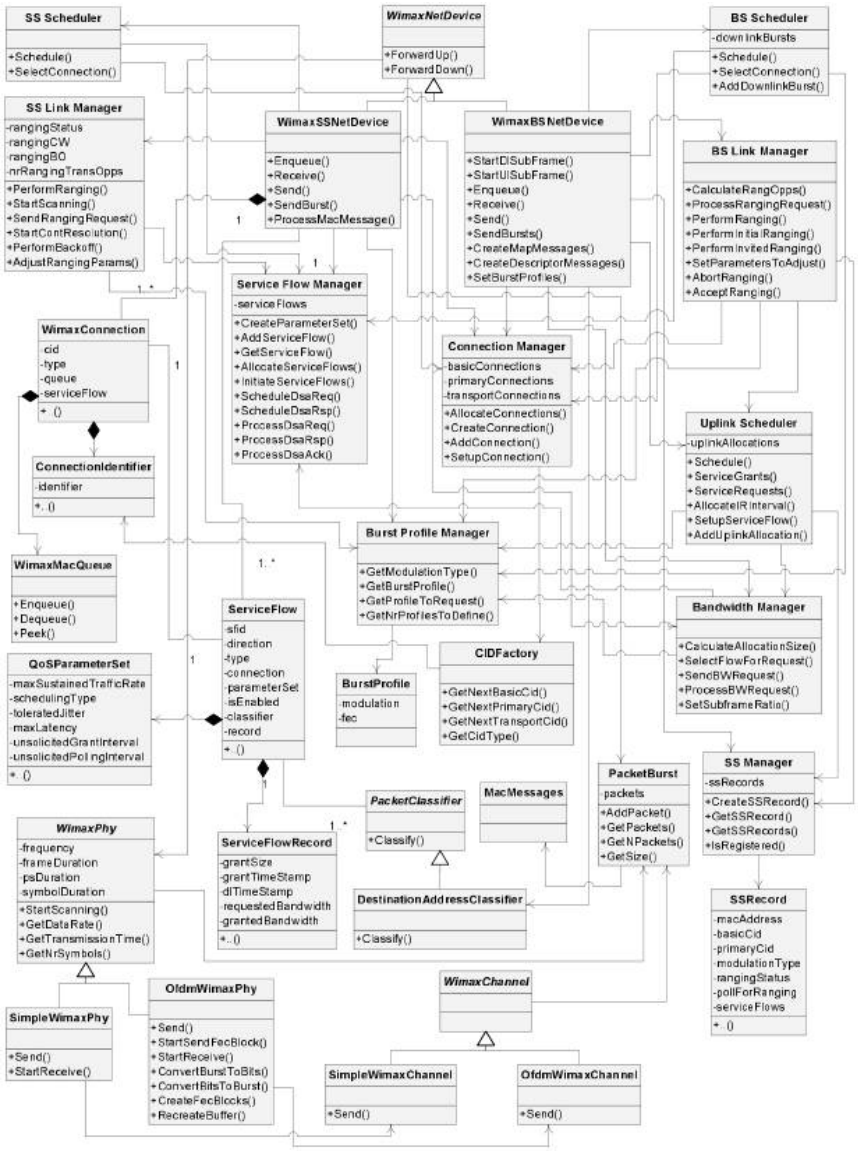
- First WiMAX module for ns-3
- Based on 802.16e standard and ns-3 version 3.2
- The code is available at the following URL: http://code.nsnam.org/iamine/ns-3-wimax under the GNU License
- Implements the Point-to-Multipoint (PMP) topology with TDD mode
- Supporting important features including QoS scheduling service, bandwidth management, uplink request/grant scheduling and the OFDM PHY layer.
- Built completely in C++ with more than 36 calsses and approximately 17000 lines of code
- Design fully object oriented, facilitating modularity, reusability, scalability and maintenance of the software
- UML has been used for the design and analysis pahse

Key challenges

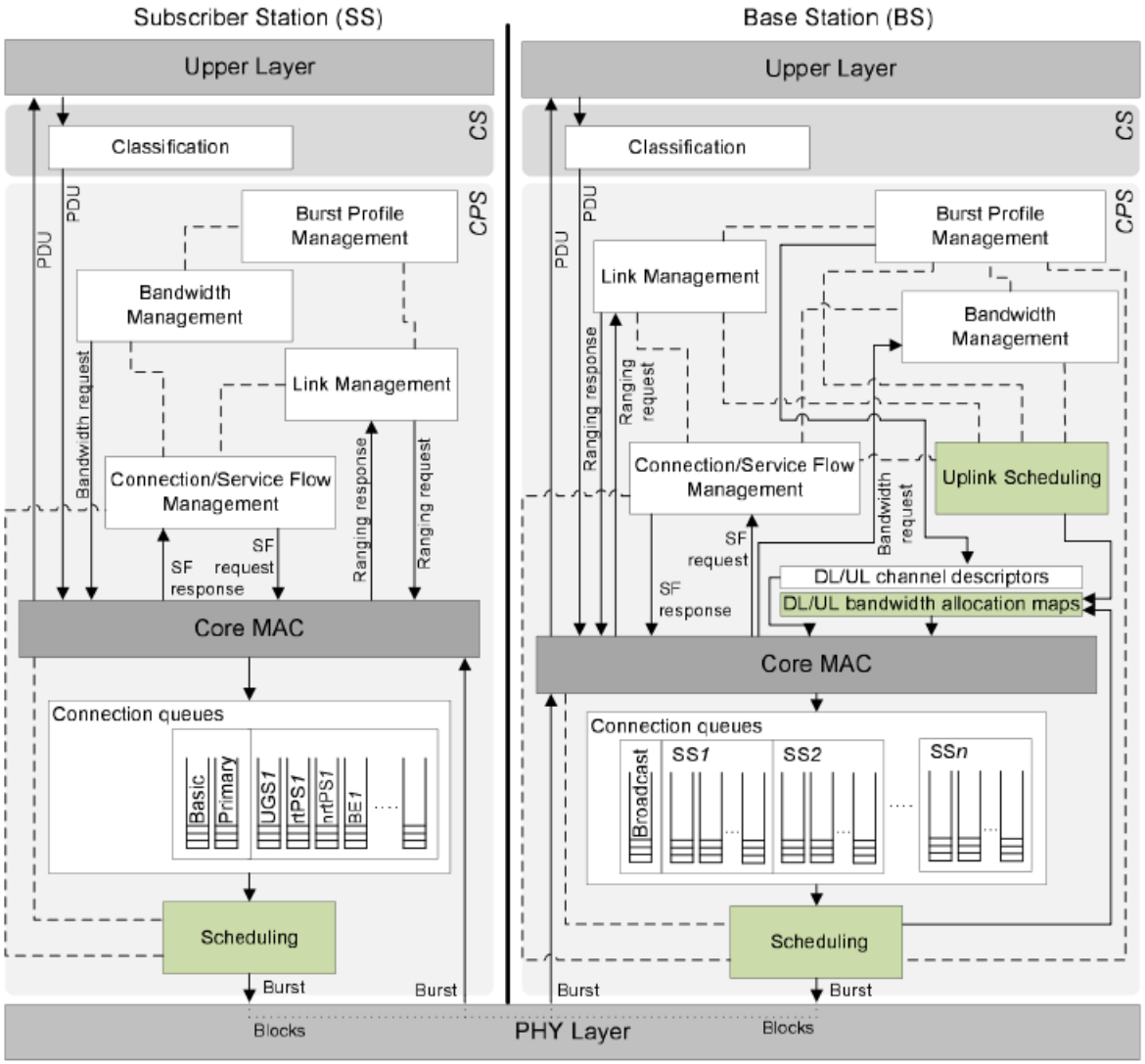
- Understanding 802.16
  - Engineering point of view
  - A complex technology, huge specification, vague description
  - Interaction between modules
  - Open Area (Scheduling, Burst adaptation)
- Search for the best design
- Robust architecture
  - Facilitates adding features
  - Flexible for enhancement
- Programming challenges
  - Compliance with ns-3 API and coding standard
  - Time and memory efficient code
- PHY layer
  - Parallel MAC and PHY development , interdependence MAC/PHY

Software Design

- Design fully object oriented
- Class *WimaxNetDevice* for the MAC layer of WiMAX it extends the *NetDevice* class of ns-3
- *WimaxNetDevice* is extended by *BaseStationNetDevice* and *SubscriberStationNetDevice* defining the MAC layers of BS and SS respectively.
- The key functions of MAC are distributed to several other classes like: *LinkManager, UplinkScheduler, Scheduler, ConnectionManager, serviceFlowManager, BurstProfileManager*, ...



Software Design



MAC Layer

- The 802.16 MAC layer is divided in to two sublayers: The Convergence sublayer (CS) and the Common-part sublayer (CPS)
- CS is responsible for:
  - Receiving packets from the higher layer and from peer stations
  - Classifying packets to appropriate connections
  - Keeps a mapping between connection ID and service flows
  - Packet Header Suppression (not implemented yet)
- CPS is responsible for
  - Framing and management messages (DL and UL MAP, packet burst, ...)
  - Downlink and Uplink scheduling
  - Network Entry and Initialization
  - Connection and addressing
  - Service flow creation
  - Bandwidth request and Grant Mechanism

PHY layer

- The module provides two different version of PHY layer
- The first one is a basic implementation
  - Simply forwards bursts received by the MAC layer ignoring any underlying PHY layer details
  - Implemented by the *SimpleWiMAXPhy* Class
- The second is an implementation of the OFDM PHY layer
  - Based on WirelessMAN-OFDM specification
  - Implemented by the Ofdm*WiMAXPhy* Class
  - Block encoding : packet burst are converted to bit stream and then splitted into smaller FEC blocks
  - 20MHz channel BW and 10ms frame duration
  - Uses an external OFDM module *[7]* and IT++ library *[8]*: encoding, randomization, interleaving and modulation

Implementation: Things already done...

- Basic architecture, framing, base station, subscriber station, ...
- Mac low: Creation, transmission and processing of control messages
    - Key MAC management
- Scanning synchronization and network entry
- Link manager: Initial ranging, transmission of ranging messages
- Creation of connections and transmission of data messages
- Simple scheduler
- A basic PHY layer
- A more complete OFDM PHY layer
    - ns-3 to OFDM PHY interface
    - Burst to FEC block conversion and the reverse

Future Works

Implementation: Things to be done...

- Full implementation of a classifier
- Support of fragmentation and defragmentation of PDUs
- More sophisticated scheduler
- Propagation/error model at the PHY layer
- Dynamic update burst profile information according to the channel quality
- Implementation of the IPCS as defined by the IETF
- Packet tracing

Conclusion

Conclusion

- We have proposed an IEEE 802.16 WiMAX module for the recently released ns-3 simulator
- Implementing the PMP mode and 2 different PHY layers
- Module's design fully follows the object-oriented software development and utilizes UML
- High attention has been put to come up with a standard compliant implementation
- The module implements the key components of WiMAX MAC and PHY
- We hope this module contributes to the scientific society and facilitates in evaluating and designing WiMAX systems.

References

- **[1]** IEEE std. 802.16-2004, IEEE Standard for Local and Metropolitan Area Networks- Part 16: Air Interface for fixed Broadband Wireless Access Systems. October 2004.
- **[2]** IEEE std. 802.16e-2005, IEEE Standard for Local and Metropolitan Area Networks- Part 16: Air Interface for fixed Broadband Wireless Access Systems- Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands. February 2006.
- **[3]** www.wimaxforum.org
- **[4]** J.Chen, C.-C Wnag, F.C.-D. Tsai, C.-W. Chang, S.-S. Liu, J. Guo, W.-j. Lien, I.-H Sum and C.-H Hung. Desing and Implementation of WiMAX Module for ns-2 Simulator. In 1st International Conference on Performance Evaluation Methodologies and Tool, October 2006
- **[5]** The Network Simulator ns-2 NIST add-on – IEEE 802.16 model (MAC+PHY). Technical report, National Institute of Standards and Technology, June 2007
- **[6]** J.F. Borina and N.L. Da Fonseca. WiMAX Module for ns-2 Simulator. In 18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communication (PIMRC'07). IEEE, September 2007
- **[7]** F. Cristiani. Simulation of WiMAX Physical Layer. Technical report, Universita degli Studi di Napoli. Federico II, Italy, December 2007
- **[8]** IT++ Library of mathematical, signal processing and communication routines, http://itpp.sourceforge.net/, july 2008.

Thank you