A Mobile WiMAX Module for ns-3

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Workshop on ns-3
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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
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
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 classes 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 phase
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

Subscriber Station (SS)

Upper Layer

- Classification
- Burst Profile Management
- Bandwidth Management
- Link Management

Connection/Service Flow Management

Core MAC

- Connection queues
- Scheduling

Burst Blocks

PHY Layer

Base Station (BS)

Upper Layer

- Classification
- Burst Profile Management
- Bandwidth Management
- Link Management

Connection/Service Flow Management

Core MAC

- Connection queues
- Scheduling

Uplink Scheduling

DL/UL channel descriptors

DL/UL bandwidth allocation maps

Burst Blocks

PHY Layer
The 802.16 MAC layer is divided into 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 versions of PHY layer
  - The first 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 OfdmWiMAXPhy 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


Thank you