



WiMAX System-Level Simulation for Application Performance Analysis

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- SLS Methodology: Table of Contents
- University Collaborations
- Cross-Team Relationship
- System-Level NS-2 Simulator
- NS-2 Software Architecture Document
- Features by NS-2 Releases

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Goal

- Provide Quantitative Proof of WiMAX Superiority
- Carriers Need:
 - Capacity Planning
 - Performance Optimization
 - Operational Guidelines
- Users Need:
 - Operational Guidelines
- Vendors need:
 - Performance impact of various features
- ⇒ Develop a system level simulation methodology and simulation package for application performance analysis
- Consists of three related projects
 - System Level Simulation Methodology
 - Physical Layer Model Library
 - System-Level NS-2 Simulator

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System-Level Simulation Methodology

- Agreed upon by WiMAX Forum members
- Can be used by anyone to develop their own simulation
- Can be used with any modeling language: NS-2, OPNET, ...
- Specifies default parameter values, features, and methods
- Allows comparing performance results from different vendors
- Will be used in the WiMAX Forum's NS-2 Model
- Similar documents exist for 3GPP/3GPP2

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Physical Layer Model Library

- Detailed analysis of wireless channel
- Summary tables that can be used to accurately abstract PHY layer in system level models.
- Will be used in WiMAX Forum NS-2 Model
- Can be used by others

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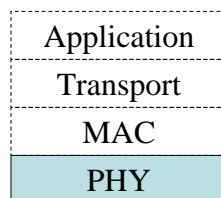


Link-Level vs. System-Level Models

Link-Level:

Goal: Study different signal transmission and reception schemes

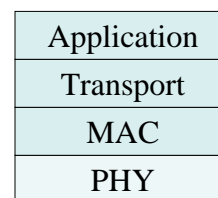
Single Link
Single Cell
Single Base Station
Emphasis on PHY
Some MAC



System-Level:

Goals: Application Level Performance

Multiple users
Multi-Cells
Multiple Base Stations
Large # of subscribers
Emphasis on All Layers
=> PHY abstraction



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System Simulation Approach

- Simulate multiple WiMAX cells
- Model different applications with different levels of penetration
- Simulate application traffic streams; use realistic traffic models
- Distribute user session randomly among the cells
- Utilize neighboring cell traffic to create interference in the center cell
- Abstract PHY to a table/graph mapping physical condition to Block Error Rate (BLER)

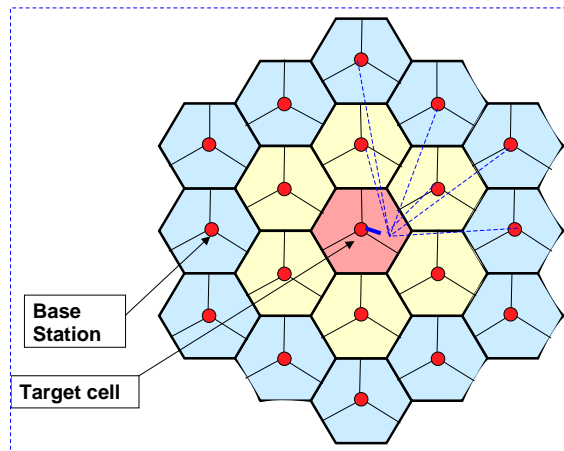
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Topology for System Simulation



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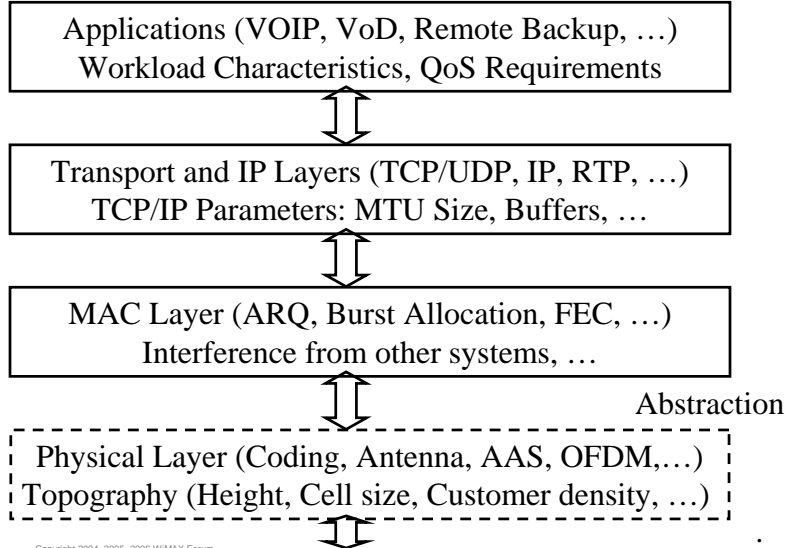
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[3GPP]

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WiMAX System-Level Model Components



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SLS Methodology: Table of Contents

1. INTRODUCTION
 2. SYSTEM SIMULATION MODELLING
 3. APPLICATION TRAFFIC MODELS
 4. MAC LAYER MODELLING
 5. PHY LAYER MODELLING
- ANNEX A: CHANNEL MODELS FOR SLS
ANNEX B: EESM PHY ABSTRACTION
ANNEX C: MIC PHY ABSTRACTION
ANNEX D: MIM PHY ABSTRACTION
ANNEX E: EESM GRAPHS
ANNEX F: MODELING PUSC IN SLS
ANNEX G: NS2 PROTOCOL LAYER MODULES

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Application Traffic Models

- 3.1 INTERNET GAME TRAFFIC MODEL (CLASS 1)
- 3.2 VOIP TRAFFIC MODEL (CLASS 2)
- 3.2 VIDEO CONFERENCE TRAFFIC MODEL (CLASS 2)
- 3.3 PTT TRAFFIC MODEL (CLASS 2)
- 3.4 MUSIC/SPEECH TRAFFIC MODEL (CLASS 3)
- 3.5 VIDEO CLIP TRAFFIC MODEL (CLASS 3)
- 3.6 MOVIE STREAMING TRAFFIC MODEL (CLASS 3)
- 3.7 MBS TRAFFIC MODEL (CLASS 3)
- 3.8 IM TRAFFIC MODEL (CLASS 4)
- 3.9 WEB BROWSING (HTTP) TRAFFIC MODEL
- 3.10 EMAIL TRAFFIC MODEL (CLASS 4)
- 3.11 TELEMETRY TRAFFIC MODEL (CLASS 5)
- 3.12 FTP TRAFFIC MODEL (CLASS 5)
- 3.13 P2P TRAFFIC MODEL (CLASS 5)
- 3.14 VPN SERVICE
- 3.15 HTTP TRAFFIC MODEL [3GPP]
- 3.16 FTP TRAFFIC MODEL [3GPP]
- 3.17 NRTV (NEAR REAL TIME VIDEO) TRAFFIC MODEL [3GPP]
- 3.18 REFERENCES

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University Collaborations

- **Rensselaer Polytechnic Institute (RPI):**
Developing the base NS2 simulation model
- **Washington University in Saint Louis (WUSTL):** Methodology, Scheduler, HARQ
- **Beijing University of Posts and Telecommunications (BUPT):** PHY abstractions, Link simulation outputs for system simulation
- **Information and Communications University (ICU), Korea:** Analyze WiBro/WiMAX for VoIP and selected TCP applications

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NS-2 Software Architecture Document

- This document is intended to promote modularity of the simulator and to encourage collaborative development
 - Defines building blocks for BS and SS/MS models
 - Identifies important packet flows in the model, e.g., for data packets, BW requests, UL/DL ARQ/H-ARQ, and CQICH
 - Defines key APIs (e.g., for scheduler and PHY abstraction model) to enable easy substitution

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System-Level NS-2 Simulator

- **Goal:** Develop the NS-2 modules required for simulating different applications over a WiMAX network, and make them freely available to the public at large
- **Purpose:** Enable vendors, service providers and researchers to conduct extensive system level studies of WiMAX networks through simulations to promote mass deployment of such networks
- **Approach:** AATG is driving this effort by
 - Consulting with universities (RPI, WUSTL, BUPT, ICU)
 - Collaborating with WiMAX Forum members
- **Why NS-2?**
 - NS-2 is extensively used by the networking research community
 - NS-2 is open-source and is available for free download
 - Many of the standard networking components and protocols are already available with NS-2
- **Timeline:** Release 1 by 4Q, 2006, Release 2 by 2Q, 2007

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Features for NS-2 Simulator Release 1

- Software Architecture Compliant
- Support for Multiple Cells (up to 19)
- Configuration Management Support
- Applications: VoIP, Web Browsing, FTP
- MAC:
 - IP Convergence Sublayer (with PHS)
 - Common Part Sublayer (Fragmentation & Packaging)
 - Automatic Repeat Request (ARQ) – Basic Version
 - Scheduler API, Reference Scheduler, Request/Grant Mechanism, Bandwidth Request
 - Services: Best Effort, UGS, rtPS, nrtPS, ertPS
- Single Carrier (SC) PHY
- Validation (Release 1)

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Features for NS-2 Simulator Release 2

- Applications: Streaming Video, Online Games
- MAC:
 - ARQ – Enhanced Version
 - Connection Establishment & Termination
 - Idle Mode, Sleep Mode
 - Multicasting & Broadcasting Service (MBS)
 - Mobility (Handoff and Mobile IP)
- PHY
 - OFDMA PHY
 - PHY Abstraction API
 - Exponential Effective SIR Mapping (EESM)
 - Channel Quality Indicator Channel (CQICH)
 - Power Control and Hybrid ARQ (HARQ)
 - MIMO
- Validation (Release 2)

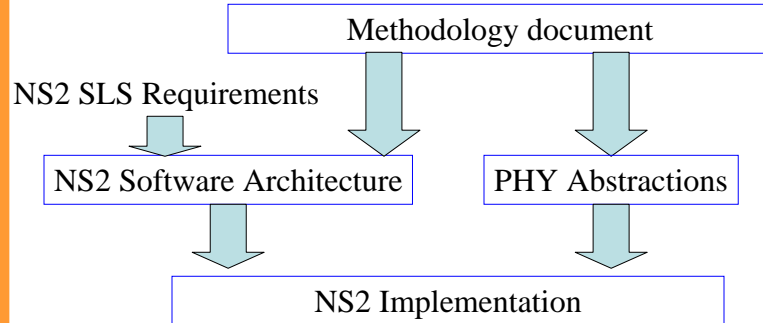
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