WiMAX System-Level Simulation for Application Performance Analysis

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WiMAX AATG Interim Meeting, San Jose, December 14-15, 2006

Overview

- Goal
- System-Level Simulation Methodology
- Physical Layer Model Library
- Link-Level vs. System-Level Models
- 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

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

System-Level Simulation Methodology

- Agreed upon by WiMAX Forum members
- Can be used by anyone to develop there 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

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

Link-Level vs. System-Level Models

Link-Level:

Goal: Study different signal transmission and reception schemes

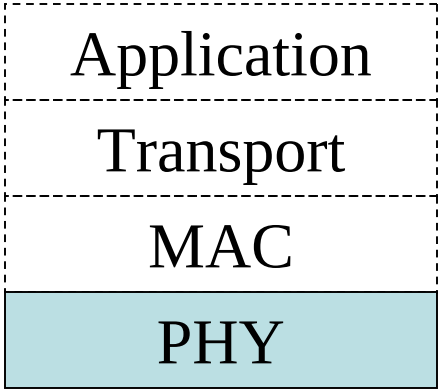
Single Link

Single Cell

Single Base Station

Emphasis on PHY

Some MAC



System-Level:

Goals: Application Level Performance

Multiple users

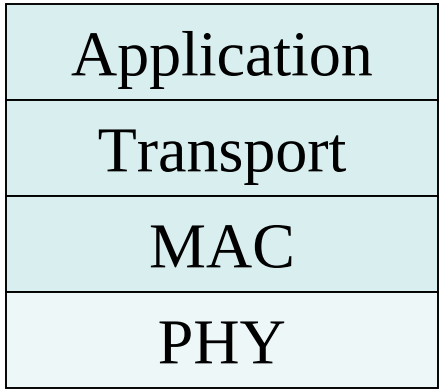
Multi-Cells

Multiple Base Stations

Large # of subscribers

Emphasis on All Layers

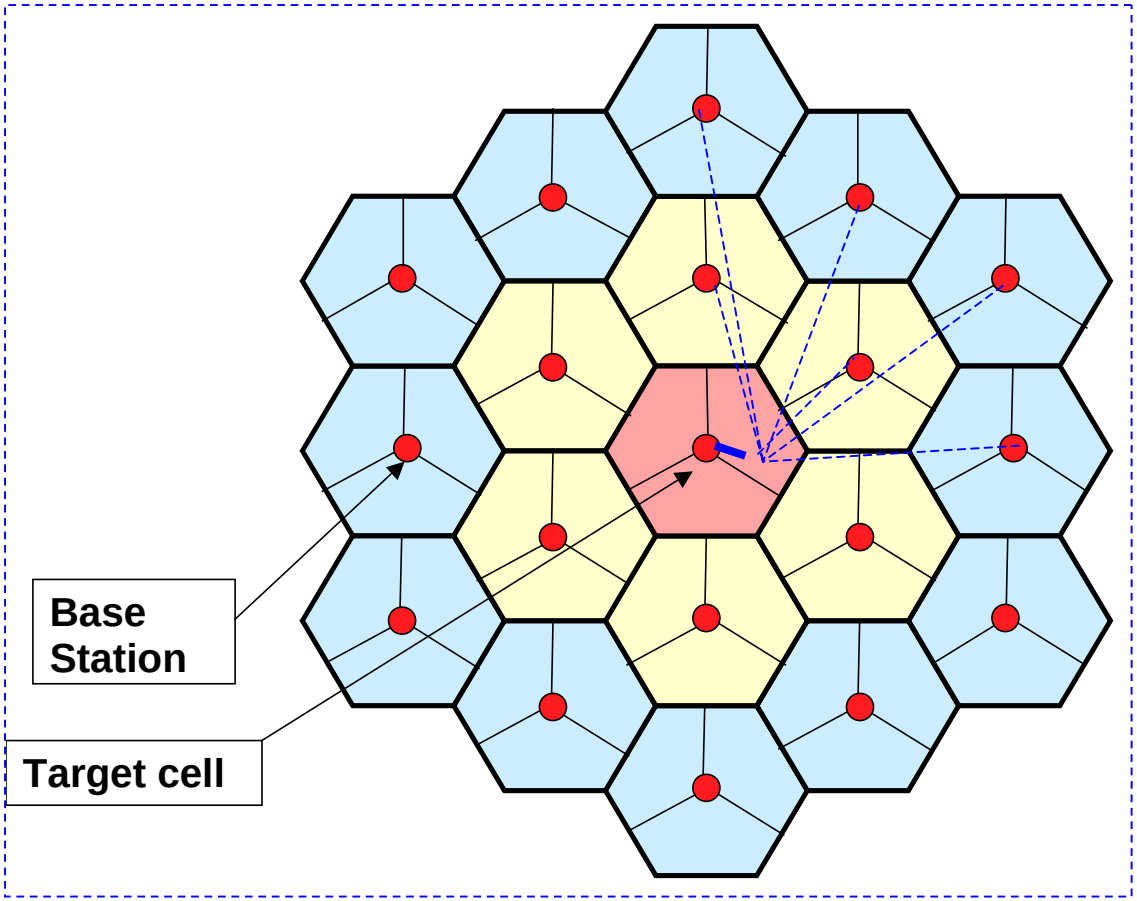
=> PHY abstraction



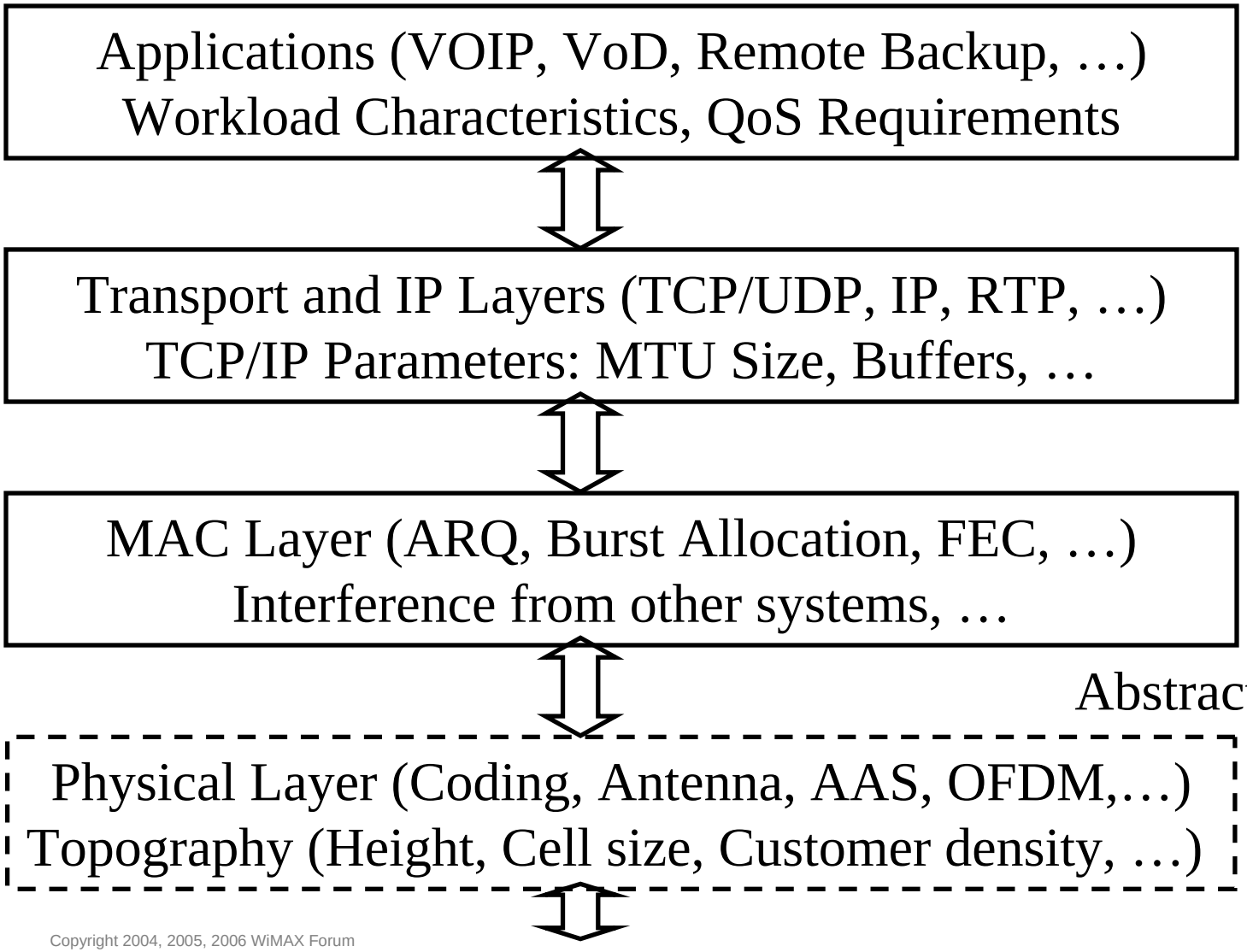
System Simulation Approach

- 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)

Topology for System Simulation



WiMAX System-Level Model Components



SLS Methodology: Table of Contents

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

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

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

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

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)

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)

Cross-Team Relationship