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WIMAX

Evaluating VoIP using Network Simulator-2

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RoadMap

- ▣ *About WiMax*
- ▣ Technological Background
- ▣ Business Opportunities
- ▣ Our Work

What is WiMax



WiMax (Worldwide Interoperability for microwave access:

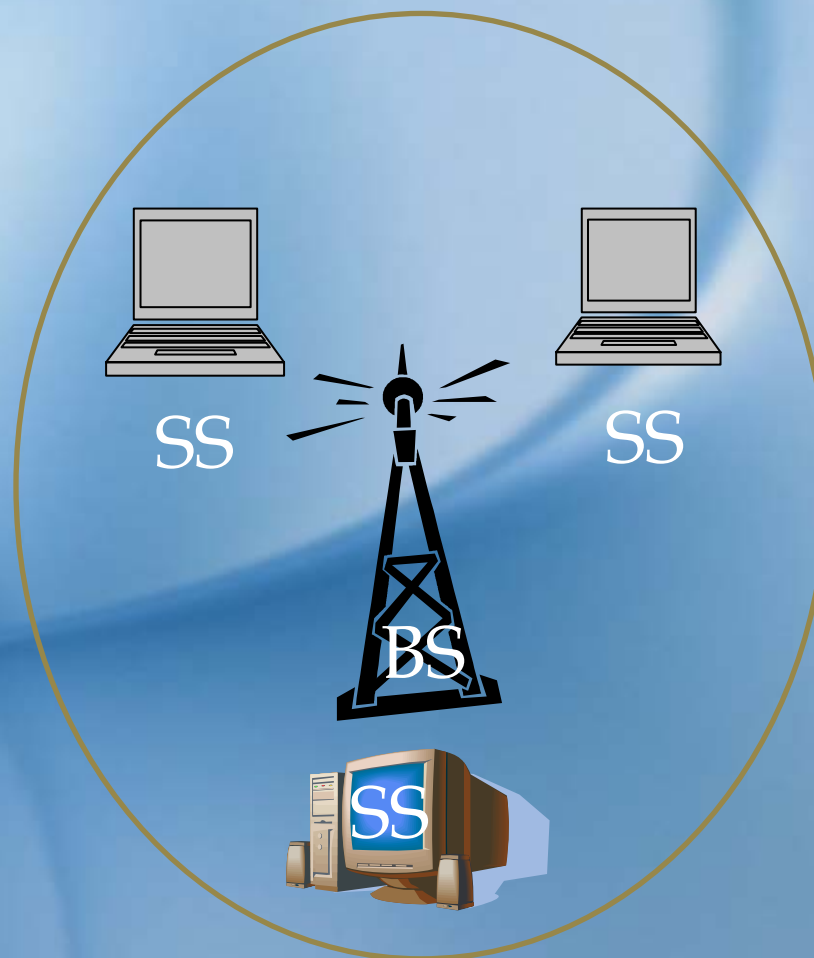
- ❑ Provides broadband wireless access over long distances
- ❑ A technology based on a standard for point-to-multipoint wireless networking
- ❑ Based on IEEE 802.16 standard
- ❑ Solution for Wireless Metropolitan Area Network
- ❑ Also solution for the last mile problem

IEEE 802.16

- ▣ Specifies:
 - The air interface, MAC (Medium Access Control) and physical layer
- ▣ Purpose:
 - To enable the deployment of cost-effective broadband wireless access products
 - Providing alternatives to wireline broadband access
- ▣ Advantages:
 - Low cost, dynamic sharing of radio resources

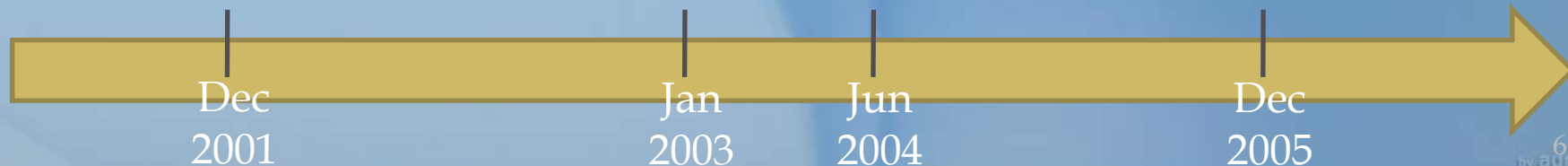
Architecture

- ▣ IEEE 802.16 consists of the access point, BS (Base Station) and SSs (Subscriber Stations)
- ▣ All data goes through the BS and BS performs the allocation of bandwidth



Standards

	802.16	802.16a/d	802.16e
Completion date	Dec 2001	Jan 2003/Jun 2004	Dec 2005
Spectrum	10-66 GHz	2-11 GHz	< 6 GHz
Type of spectrum	Unlicensed	Un & Licensed	Licensed
Bit Rate	32-134 Mbps / 28 MHz channel	Up to 75 Mbps / 20 MHz channel	Up to 5 Mbps / 5 MHz channel
Mobility	Fixed	Fixed	Pedestrian mobility
Modulation	SC / QPSK, 16QAM, 64QAM	256 OFDM / QPSK, 16QAM, 64QAM	Same as 802.16a/d
Channel bandwidth	20, 25, 28 MHz	Selectable 1.25 - 20 MHz	Same as 802.16a/d
Cell Radius	1-3 miles	3-5 miles Max range: 30 miles	1-3 miles

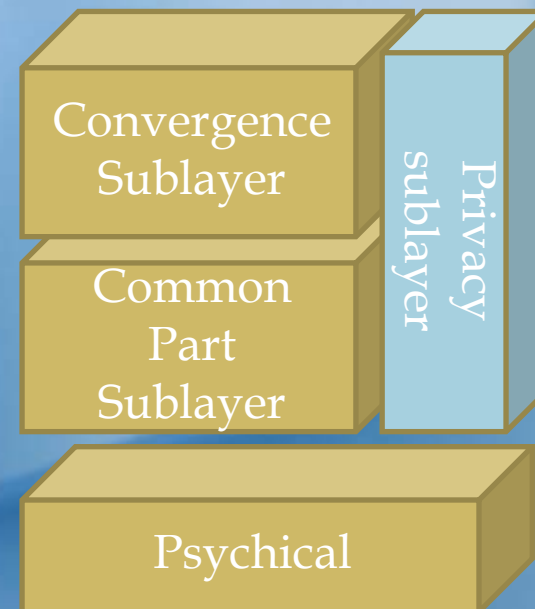
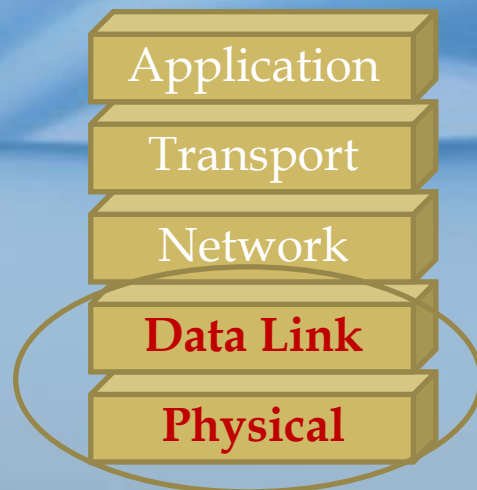


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Protocol Architecture

- ❑ CS supports heterogenous networks like ATM and IP
- ❑ CPS main functions of IEEE 802.16
- ❑ PS provides mechanisms for privacy and authentication



RoadMap

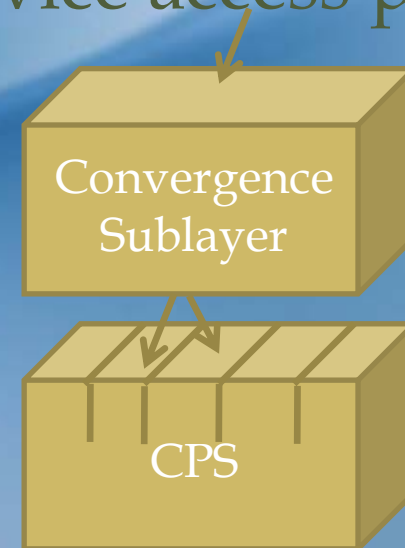
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 - Physical Layer
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Convergence Sublayer

- ❑ Sits on top of the 802.16 MAC CPS
- ❑ Act as an interface for different networks
- ❑ Accepts data from network layer, classifies them according to performance criteria and delivers them to the correct service access point
- ❑ Also may perform header suppression/compression



MAC Common Part

- ▣ Create and handle management messages:
 - Link description: UL/DL-MAP, UCD, DCD
 - Ranging: RNG-REQ/RESP. Determines power and burst profile changes
 - Bandwidth requests: BW-REQ
- ▣ Create the MAC 802.16 data frame
- ▣ Handle the flows to ensure QoS
 - The 802.16 MAC is connection-oriented. Connections identified by 16-bit CID
 - ▣ Used to distinguish the flows sharing the same channel
 - ▣ Many higher-layer session may share the same CID

QoS and Applications

- ❑ Packets are associated with a service flow (parameters: bandwidth, latency, jitter)
- ❑ The convergence sublayer gives a connection ID (CID)
- ❑ The service flow is mapped to this ID

	Max/Min bit rate	Latency	Jitter	Typical Applications
UGS	YES/YES	YES	YES	T1
rtPS	YES/YES	YES	NO	Video streaming
ertPS	YES/YES	YES	YES	VoIP
nrtPS	YES/YES	NO	NO	Guaranteed FTP
BE	NO	NO	NO	Web browsing, email

Bandwidth Requests

- Several kinds of req:
 - **BW-REQ messages:**
 - Uses BW header
 - Incremental or aggregate (up to 32KB)
 - **Piggybacked request:**
 - Presented in GM subheader
 - Always incremental (up to 32KB)
 - **Poll-me bit (for UGS):**
 - Used by SS for requesting BW for non-UGS services
- Two modes transmitting BW-REQ:
 - **Contention mode:** during contention period (back-off mechanisms)
 - **Contention-free mode** (piggybacked, Poll-me): suitable for real-time appl.

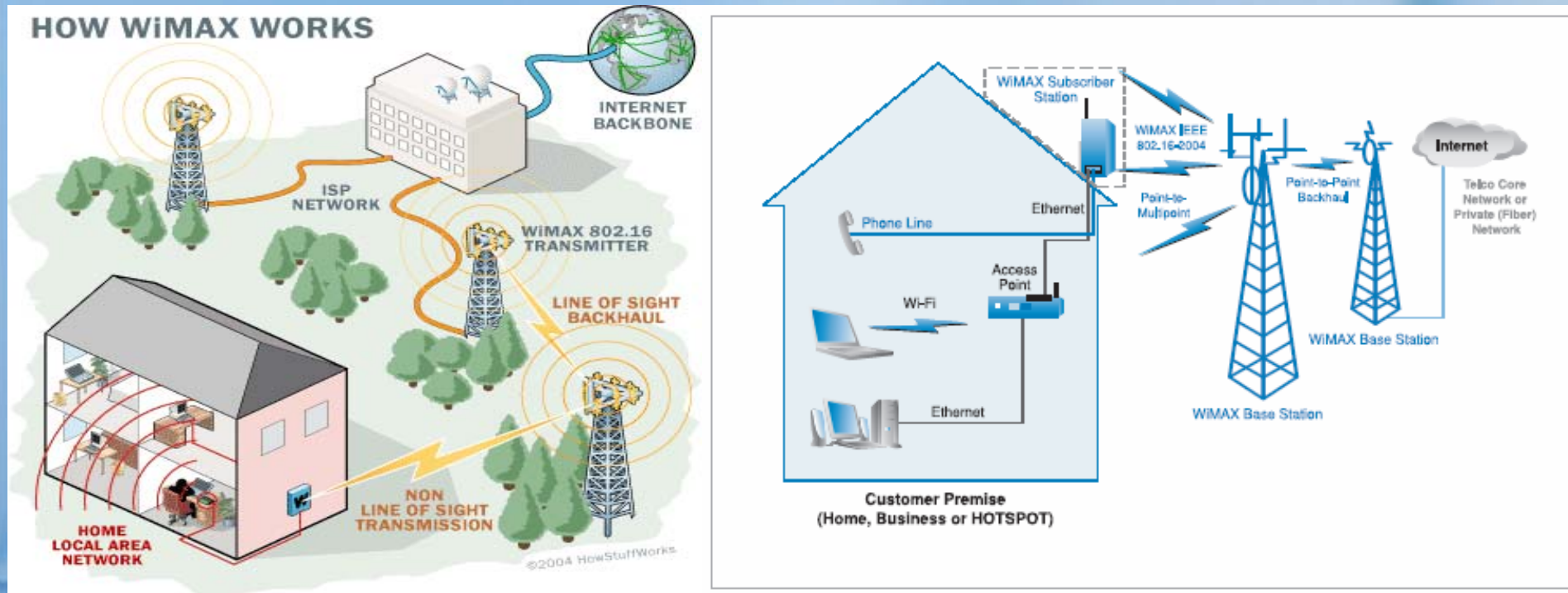
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WiMax & Business Opportunities

- ▣ Alternative solution for the last mile
 - More cost-effective compare to DSL, cable
 - ▣ i.e 200 square km area coverage costs: \$11M DSL, \$450K WiMax
 - Deals with infrastructure problems
 - ▣ Environmental problems, low population (rural regions)

WiMax Scenario



- ❑ Many BSs connect to each other: increase capacity, coverage
- ❑ Indoor many users and applications share the connection

Markets for WiMax

- SOHO users: cable DSL are so far the winners
 - Cost-effective solution
 - Provide QoS vs. overbooking
 - Provide Bandwidth on Demand (BoD) i.e. for video on demand
- Small & medium business: Leased lines
 - Smaller cost than leased lines
 - Double play
- Wi-Fi Hot Spots Backhaul:
 - Coverage the gap between them

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VoIP Principles

- ▣ Definition:
 - VoIP converts voice into data and sends the voice packets over the network

- ▣ Purpose:
 - We trying to evaluate the WiMax performance handling VoIP streams in a heavy traffic situation

Note: VoIP is needs delay/jitter guarantees

WiMax Modules Options

- NIST's module
 - But does not support QoS and service flow
- KAIST's module
 - Only supports BE services
- OPNET module
 - But uses shareware simulator
- NDSL (Networks & Distributed Systems Laboratory), CS Dep. Chang Gung University
 - Supports QoS

NDSL Module

- ❑ Network Simulator 2.29 (NS) add-on module
- ❑ Implements all CSs and CPSs sublayer functions
- ❑ Provides security/authentication
- ❑ Provides service flows and five class QoS: UGS, ertPS, rtPS, nrtPS, BE
- ❑ Implements the Scheduler function using: Weighted Round Robin (WRR)
- ❑ Simply Call Admission Control (CAC)

VoIP and NDSL Module

- VoIP application implemented through ertPS service:
 - ertPS:
 - On/Off traffic source
 - Each time:
 - Talking mode (sending data)
 - Silence mode (no sending data)
 - Guarantees about
 - Latency < 50ms
 - Jitter < 30ms
 - Max/Min Rate: 64Kbps/8Kbps
 - Greater priority than nrtPS, BE

Challenges Using NDSL

- ▣ NDSL module has memory leaks which limits total simulation time and/or number of SSs (uses 320MB memory for 32 SSs and 6sec S.T.)
- ▣ Performs fragmentation always at 108 bytes packet size
- ▣ BUT: It lacks the defragmentation function!
- ▣ BE is implemented like nrtPS (not right sense of BE service)
- ▣ A SS starts the transmission of data before gaining entrance
- ▣ Is the definition of the “spaghetti code” ...
 - Violates the object-oriented programming principles
 - Uses hardcoded and erroneous variables
 - Does not use the appropriate classes
 - Configuration variables in C++ instead of in tcl

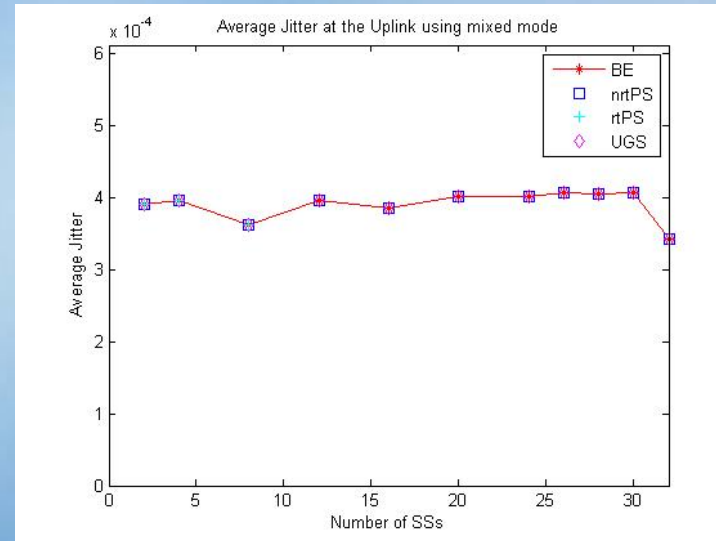
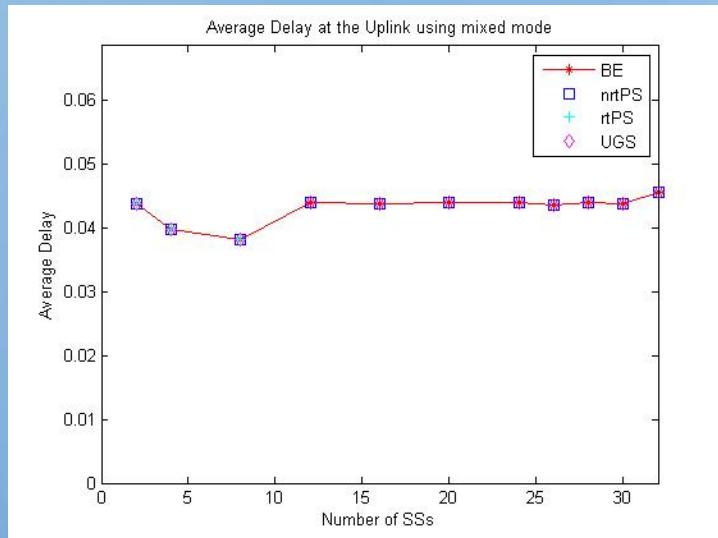
Simulation Scenario

- There is a number of SSs randomly located at the space
- Two modes:
 - **Mixed mode:**
 - Every SS runs a VoIP (ertPS) application or one of the rest services (UGS, rtPS, nrtPS, BE)
 - **Single mode:**
 - There is only a single VoIP application



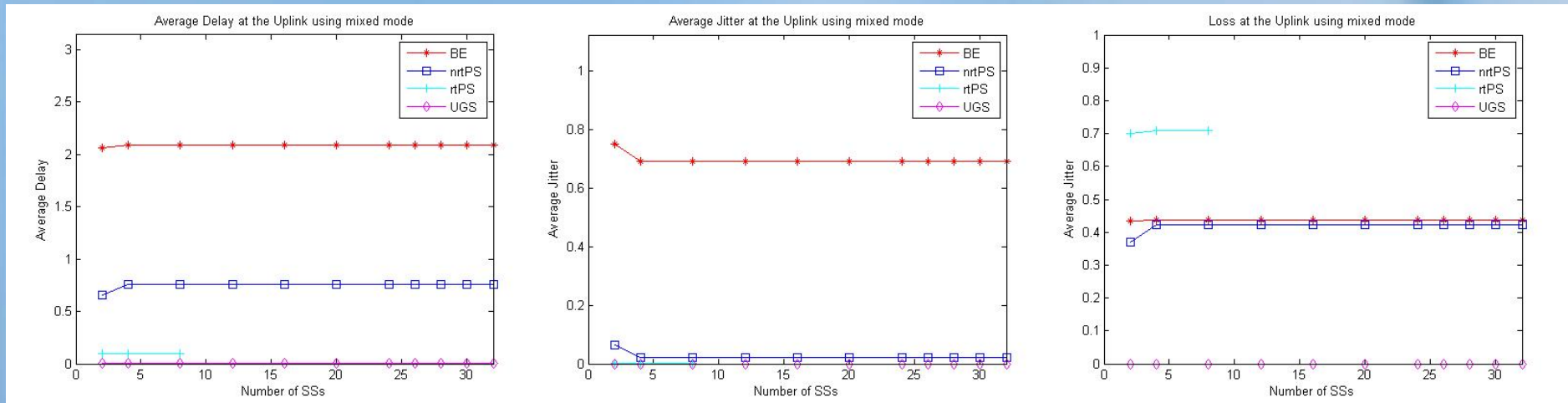
- Every application use UDP protocol
- Applications starts randomly within a period of time
- The measuring starts when all applications already started

Our Results (I): VoIP



- WiMax handles successfully VoIP streams:
 - Delay < 45 ms
 - Jitter < 0.4ms
- There is not any difference about which is the competitive service
 - Probably there is not any congestion
- Same results using single mode

Our Results (II): Rest Services



- NDSL's scheduler keeps partly the priorities:
 - Delay/Jitter: $BE > nrtPS > rtPS > UGS$
- There is unacceptable loss using only two nodes:
 - i.e. BE: 45%
- Same results using single mode

Lessons From Our Work

- ▣ We have failed producing reliable results
 - We based on a fully bugged piece of software
(NDSL module paper published on WNS2'06, Pisa, Italy)
- ▣ So...there is a lot of work to do about WiMax:
 - Create a reliable WiMax module
 - Produce reliable and useful results
 - Test the performance of several kind of schedulers
- ▣ To convince:
 - The academic community
 - Enterprises and the typical user

Thanks You!