GENI Project Review - WiMAX
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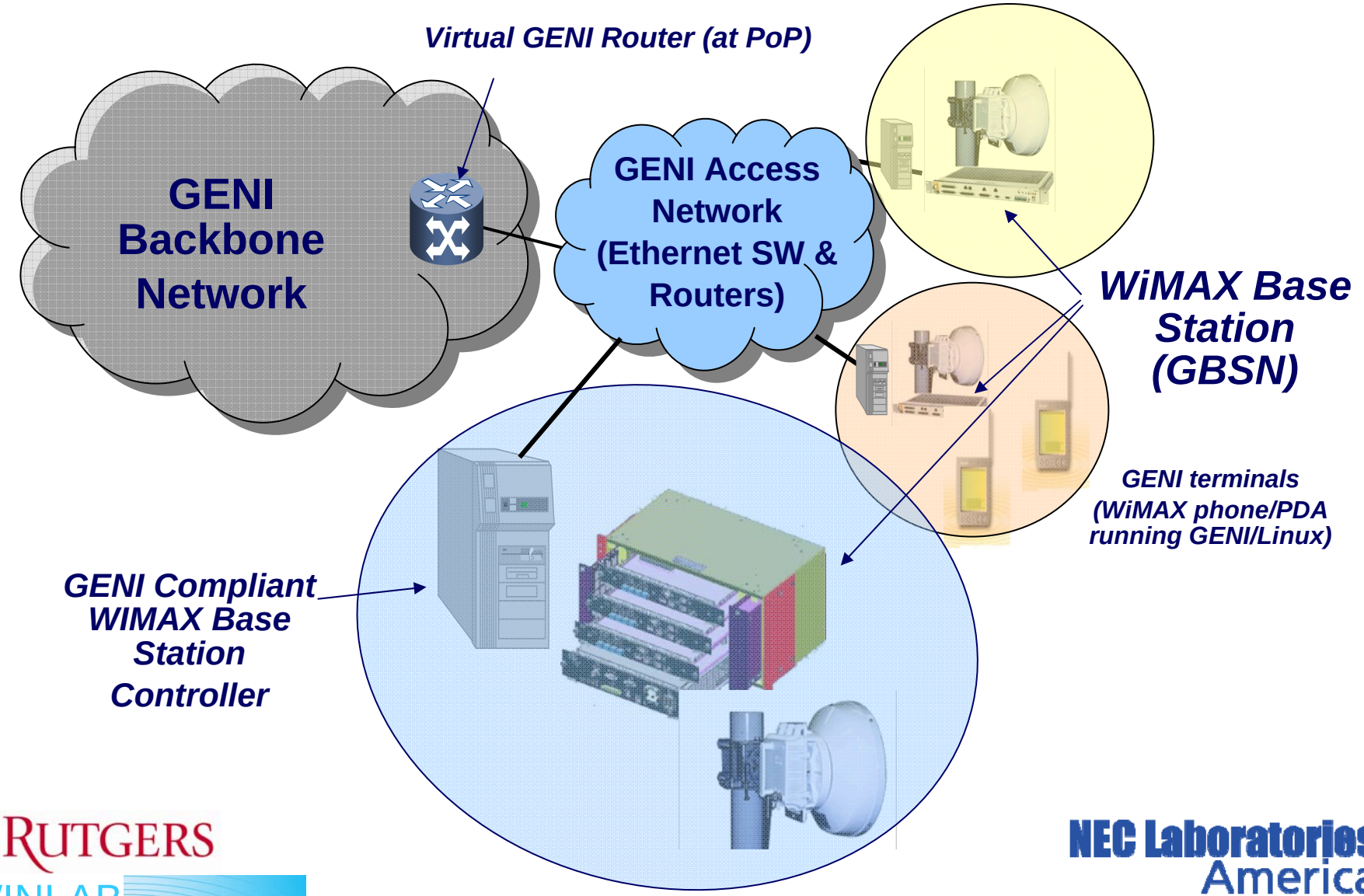
GENI WiMAX: System Overview



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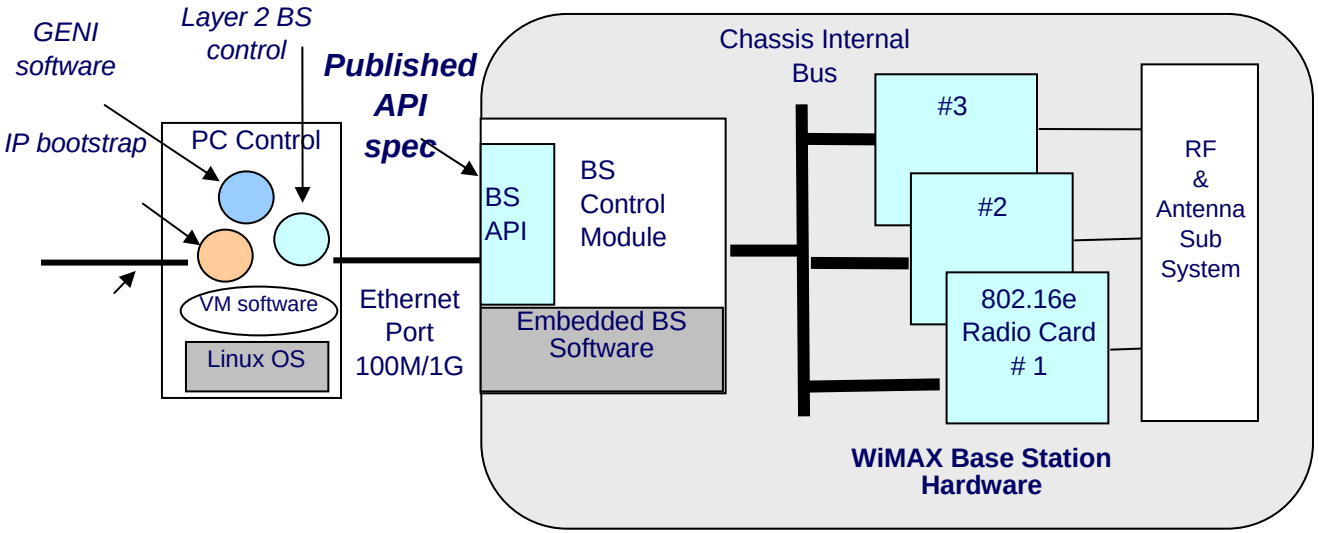
GENI WiMAX: Project Scope & Goals



NEC Release 1 802.16e BTS

- Spiral 1 GENI proof-of-concept project with NEC Labs, Princeton
- Open API for control of 802.16e BTS parameters
- Support for L2/L3 programming and resource virtualization
- Integration with ORBIT Control & release to GENI experimenters

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GENI WiMAX: BS Technical Specs

PHY	**Access mode**	**SOFDMA/TDD**
	Frequency	**2535 ~ 2605 MHz**
	DL:UL ratio	**35:12, 26:21, 29:18**
	Channel BW	**10 MHz , 8.75 MHz**
	FFT size	**1024, 512**
	Frame duration	**5ms**
	TX output Power	**35dBm (max)**
	# of sectors	**3**
MAC	**Head compression**	**PHS**
	ARQ	**HARQ/CC, ARQ**
	MBS support	**Single BS, multiple BS-MBS**
	Resource management	**Power control, mode control (idle, sleep etc.)**
Networking	**IP protocols**	**IPv4, IPv6**
	Bridging/Routing	**Transparent L2 switch, Bridging**
	Packet handling	**802.1Q VLAN, PHS**)**

Base Station Features

rtPS	real-time polling service
ertPS	enhanced real-time polling service
nrtPS	non real-time polling service
UGS	unsolicited grant service
BE	best effort

Supported Service Classes

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GENI WiMAX: Base Station Deployment at WINLAB Tech Center Building

- Rt.1 campus deployment Q1/09
- Performance evaluation in progress

RF Module
(sector)

Base
Module

Outdoor Unit (ODU)

Omni-directional antenna
(elev. < 6ft above roof!)

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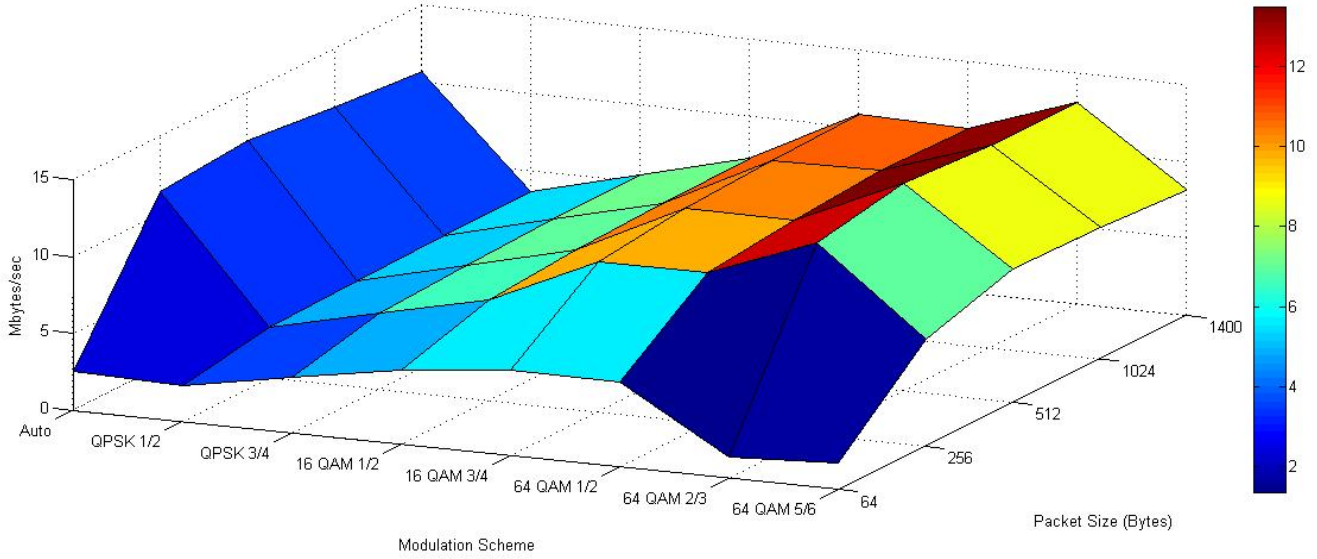
GENI WiMAX: Baseline Coverage and Throughput Measurements

- Max DL/UL Throughput

  Max DL throughput (DL:UL ratio = 29:18) = 12Mbps (UDP AND TCP) Max UL Throughout (DL:UL ratio = 29:18) = 5Mbps (UDP AND TCP)

- Coverage: 5~10 Km



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GENI WiMAX: ASN Functional Modules

1. NEC R6 CONTROLLER: This entity consists of the R6 control messages that are exchanged with the NEC BS. It will be a binary as it consists of proprietary NEC R6 messages. It will use “GENI-R6 messages” to talk to the GENI controller.

2. GENI CONTROLLER: This component will be developed to exchange messages with the GMC and the NEC R6 Controller. It is responsible for slice maintenance, datapath creation, configuring the GENI TUN Device and the GENI scheduler.

3. GENI TUN DEVICE: This is a virtual device that will handle all packets between the Slices and the Mobile Stations. The GENI controller will configure this device on the fly with information about the MSs, the Slices and the corresponding GRE interfaces. This device is responsible for routing traffic to the correct GRE interface in the Downlink and the correct Slice in the Uplink. This device is responsible for providing complete isolation between the slices.

4. GENI SCHEDULER/SHAPER: This is the most significant part of the architecture. It schedules the Downlink traffic across the various flows of the different Slices. It will be configured on the fly by the GENI Controller. There will be some feedback information from the BS that it will use for efficient scheduling.

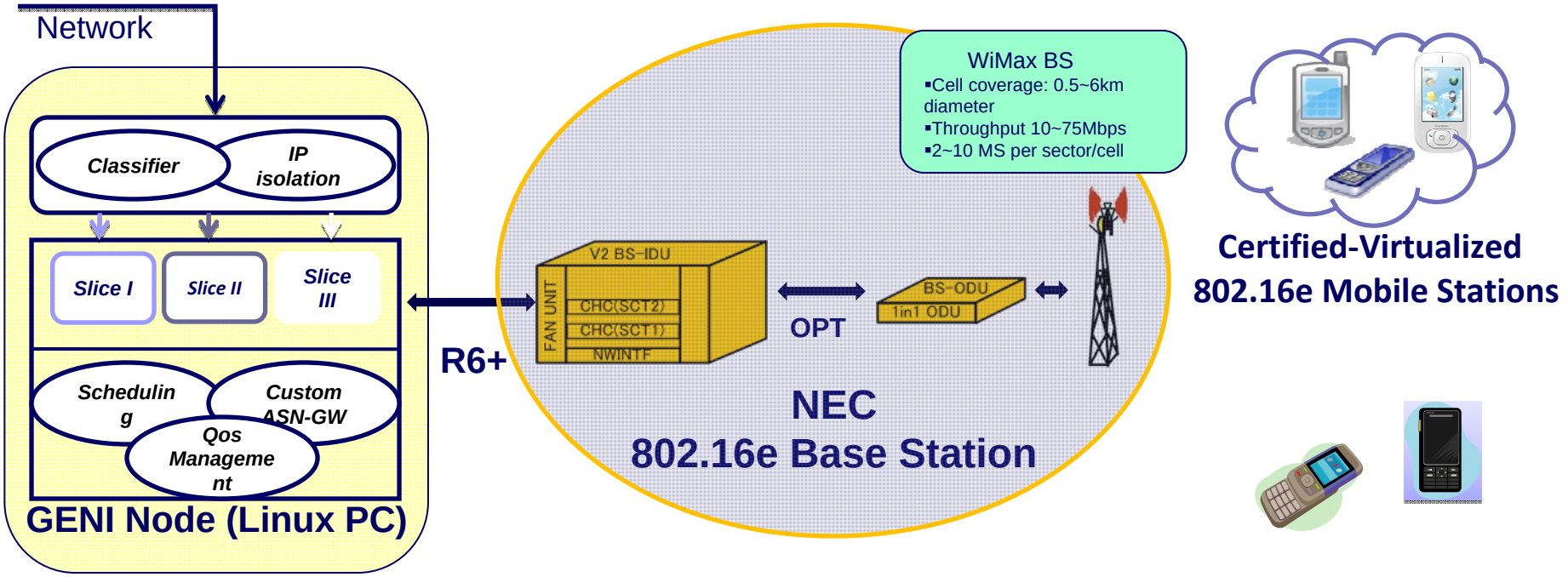
GENI WiMAX: R6 Messages

1. MS_REG(MAC_Address,Status) : This message is sent from the NEC R6 Controller to the GENI controller indicating that a MS has registered successfully or unsuccessfully.

2. SF_CREATION(MAC_Address,SFIDs) : This message is sent from the NEC R6 Controller to the GENI controller specifying the Service Flows(SFIDs) created for that MS.

3. MS_POLICY(MAC_Address,Policy) : This message is sent from the GENI controller to the NEC R6 Controller for configuring the Service Flow policies for the specified MS.

GENI WiMAX: Open API Control Parameters



GENI Open API

- Maximum Bit-Rate, Burst-Rate
- Minimum Tolerable Sending Bit-Rate
- Maximum Tolerable jitter
- Minimum Delay
- Scheduling Type (e.g., UGS, rtPs ,nrtPs)
- Frequency of Operation
- Rate / Power requirements

Base Station State

- Radio resources (UL and DL)
- Time slots (UL and DL)
- Downlink burst profile
- Uplink burst profile
- Frequency
- Power
- Rate

Legend

BS-IDU: Base Station indoor unit
BS-ODU: Base Station outdoor unit
R6+: Extension of standard ASN-GW-BS R6 interface
OPT: Optical Link

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GENI WiMAX: Open API Functions -1

- **Network Entry Control**

1. append_mac_acl (MS_MAC_Addr, IPaddress/mask)

- Add the given MAC address to the ACL (access control list)
- IP address for the corresponding MAC address is specified along with the mask.
- Done before a connection / flow can be setup.

2. remove_mac_acl(MS_MAC_Addr, IPaddress/mask)

- Remove the given MAC address from the ACL
- IP address for the corresponding MAC address is specified along with the mask.

GENI WiMAX: Open API Functions -2

- **Flow Level Service Differentiation**

3. create_service flow(DL/UL, CID, MSID, Class TLV)

- Used to create a service flow in the uplink/downlink direction for a particular connection ID based on a specified service class classifier.

4. delete_serviceflow (SFID)

- Terminates the service flow allocated to a particular user.

Success returns true.

5. create_service_class(direction, priority, classifier-ips, classifier-ports, service_type)

- Service_type - One of the five types – BE/UGS/rtPS/nrtPS/ertPS

6. delete_serviceclass(direction, priority, classifier-ips, classifier-ports, service_type)

7. set_minimal_mcs(Service class tlv, mcs) and set_fixed_mcs(Service class tlv, mcs)

- Used to set the minimal or fixed modulation and coding scheme (MCS) to be used for that service class according to channel condition

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GENI WiMAX: Open API Functions -3

- **Radio Level Service Differentiation**

8. set_radio_resource(MSID, RR)

- Information provided by this function should be consulted during initial ranging and connection setup.

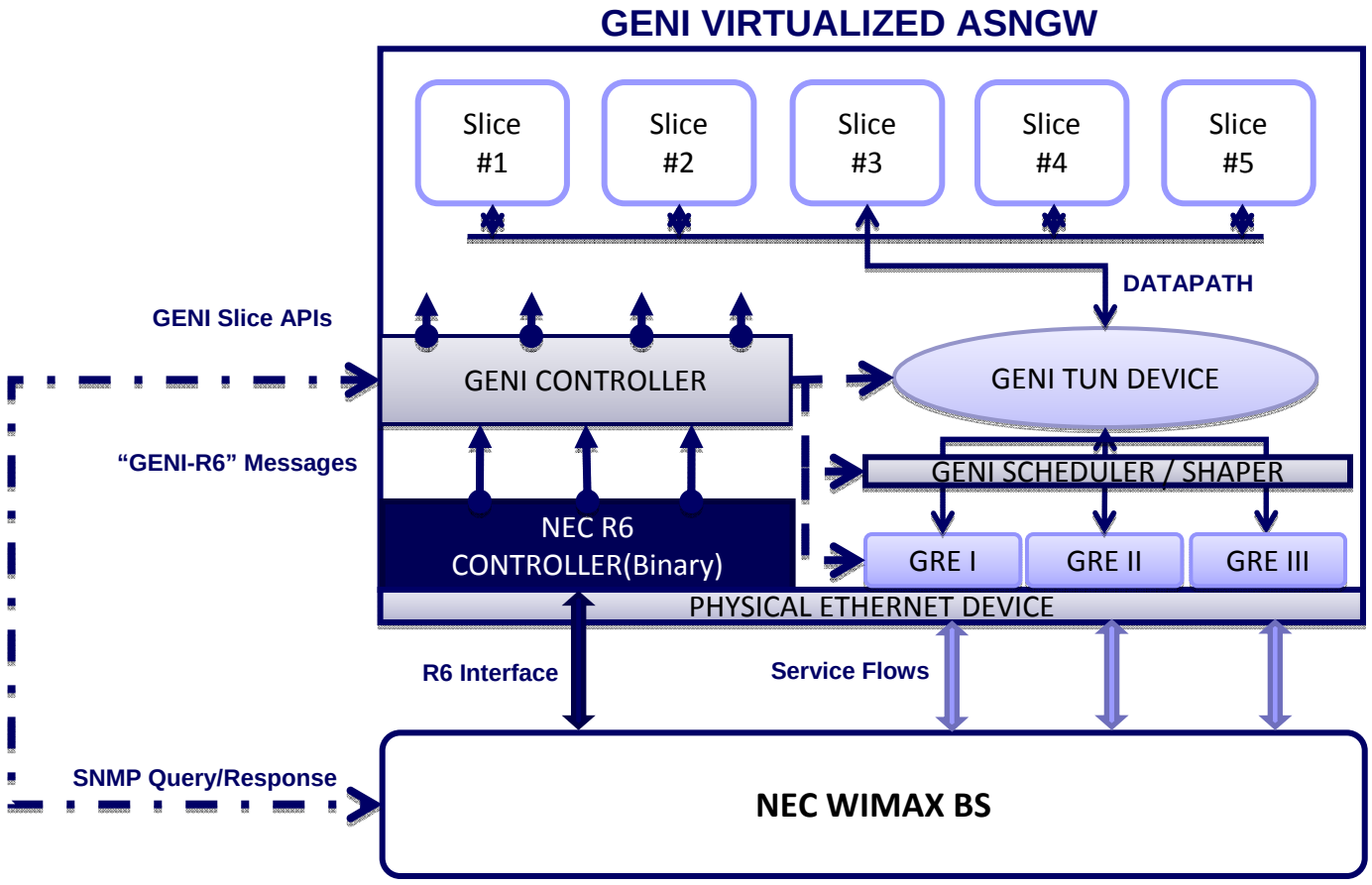
9. set_ul_dl_ratio(BSID, UL_DL_ratio)

- Based on RR allocation in set_radio_resource(), this routine allows the user to set the uplink-downlink ratio as a fraction of the RR.

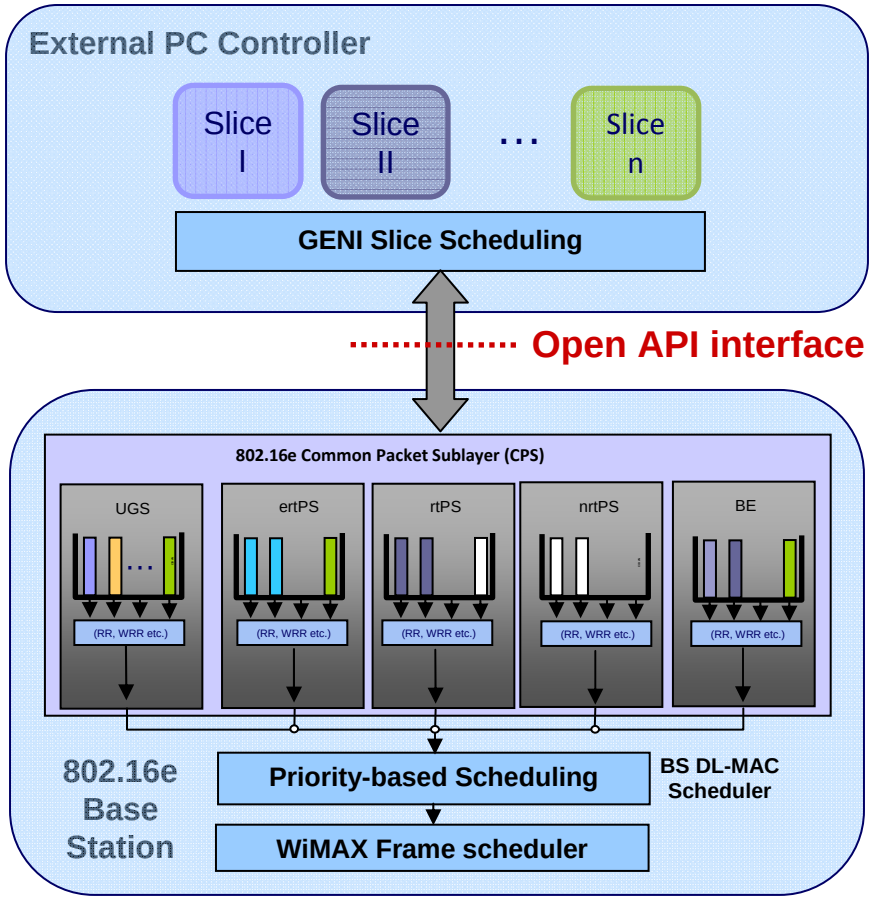
10. set_qos_priority(BSID, QOS_priority)

- Information provided by this function should be consulted during initial ranging and connection setup.

GENI WiMAX: BS Virtualization Architecture



GENI WiMAX: Open API & Interface to Base Station Queues



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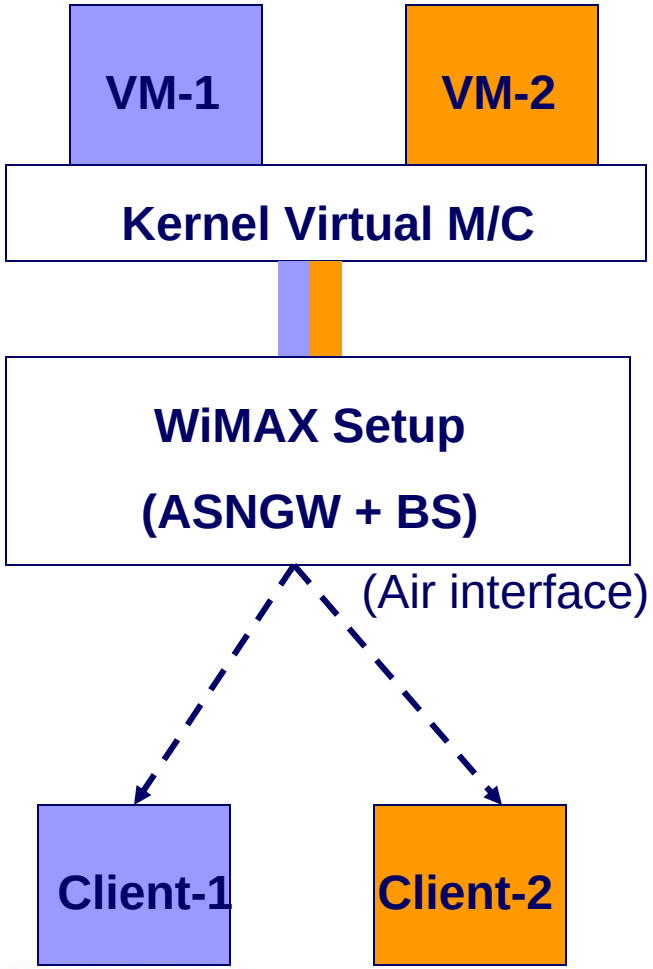
GENI WiMAX: Current Work on Virtualization



- Migration to debian
- KVM tested independently
- Integration of KVM with the WiMAX setup complete
- Static slice setup is possible through external configuration
- Next steps-
  - Performance evaluation with KVM
  - API for end – to – end slice creation
  - Implement resource management algorithms

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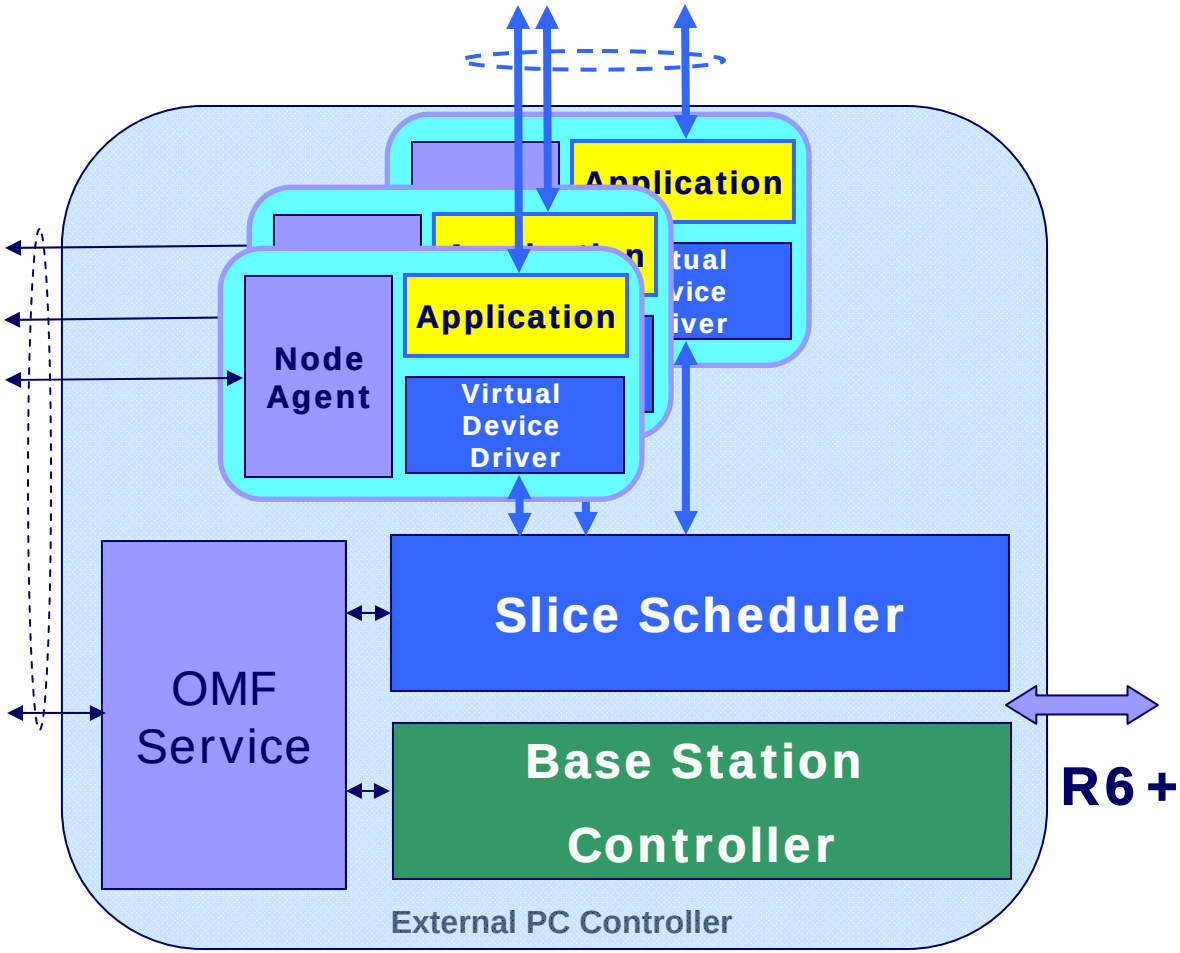
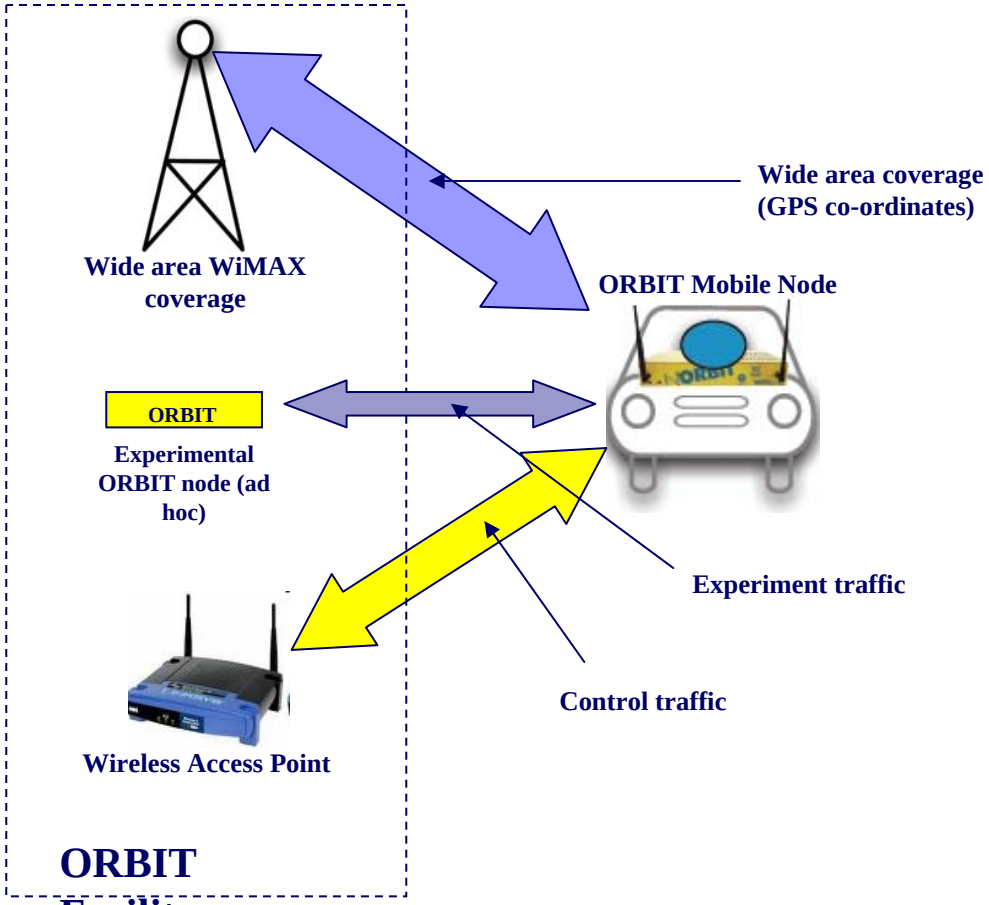
GENI WiMAX: Integration with OMF

- OMF service for base station/slice scheduler control
- Node Agent for experiment orchestration support
- (WiMax) virtual device in each sliver



GENI WiMAX: WiMAX/OMF Demo



- Allowed wide area GPS tracking
- Simultaneous wide area video coverage
- Integrated operation with OMF framework
- Demo shown at GEC-4

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GENI WiMAX: Remaining Year 1 Tasks & Milestones

- Base Station API & L2 Controls
  - Complete API software implementation 8/09
- Virtualization Software Development
  - KVM performance evaluation 7/09
  - Click-based GENI controller 8/09
  - System integration & evaluation 9/09
- Full OMF Integration - 9/09
  - Gridservice based global BS controller
  - Slice creation & experimental OMF support
- Year 1 system-level demo – 10/09
  - Operational WiMAX BS with multiple slices
  - Experiments specified and executed via OMF
  - Includes mobile vehicular experiment
- Slice resource management algorithms – 10/09
  - Mapping of slice rspec to BS capabilities
  - Algorithms for statistical multiplexing & fairness

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GENI WiMAX: Year 2 Goals and Schedule

- L2 connectivity to GENI backbone
  - Fiber connectivity from Rutgers via PHL PoP
- Network management & measurements
  - ORBIT measurements framework
  - Improved operator management GUI
- Virtualization of handsets
  - Mobile platform (laptop/card, later “G-phone”) with virtualization software
- Software updates for NEC’s 2010 BS equipment
  - R6 standard interface
  - Other changes?
- Reference implementation & documents for campus WiMAX “kit”
  - Add WiMAX resources to ORBIT and GENI web pages
  - Documents to assist with deployment and RF planning

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