GENI Project Quarterly Progress Report, 2Q09

Project Title: Open Virtualized WiMAX Base Station Node for GENI Wide-Area Wireless Deployments

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1. Major accomplishments: (cumulative including 4Q08 and 1Q09)

Milestones achieved:

Task 1: WiMAX BS performance evaluation		
1.1 NEC WiMAX profile A base station product delivered to NEC Lab		- done 10/08
- delivered to WINLAB Tech Center facility		- done 2/08
1.2 WiMAX BS system setup	- indoor (at NEC)	- done 11/08
	- indoor (at WINLAB)	- done 2/08
	- outdoor (at WINLAB)	- done 3/08
1.3 NEC WiMAX indoor performance evaluation		- done 12/08
1.4 Testing NEC BS interfaces	- BS/MS R1	- done 12/08
	- BS/ASN-GW R6	- done 1/09
1.5 NEC WiMAX outdoor performance evaluation		- 80% complete as of 6/09
1.6 Experimental license for WiMax obtained at Rutgers University		- approved 12/08
Task 2. Custom ASN-GW (GENI controller) implementation and testing		
2.1 Understanding NEC WiMAX BS interfaces		- done 4/09
2.2 Understanding NEC ASN-GW functions		- done 4/09
2.3 Implementing WiMAX virtualization (using KVM)		- 80% complete as of 6/09
2.4 Implementation of GENI slice scheduler		- 50% complete as of 6/09
2.5 Performance testing of WiMAX with virtualization		- 30% complete as of 6/09
Task 3. Base Station API software		
3.1 Initial open API requirements document		- done 12/08
3.2 Design & implementation of the open API		- done 2/09
3.3 SNMP control interface		- done 3/09
Task 4. System-level integration with OMF/GENI control		
4.1 Initial WiMAX integration demo with OMF experimental control		- done 3/09
4.2 System-level OMF demo with WiMAX/WiFi vehicular experiment		- done 4/09

Deliverables made:

D1. Demonstration of WiMAX base station accessed via ORBIT control interface – March 31, 2009 (features shown at GEC-4 demo in Miami include: experimenter script to set up WiMAX experiment, use of WiMAX as control channel for V2V application, high bandwidth video streaming, mobile devices with both WiFi & WiMAX, GUI)

2. Description of work performed during last quarter

Activities and findings: This project is aimed at the development of an open virtualized WiMax base station for wide-area wireless deployments in GENI. The technical approach leverages a commercial "profile A" WiMax base station product from NEC Corp as the starting point, with an open API being added for the purpose of interfacing an external GENI controller that provides L2/L3 flexibility. Software for the external GENI controller is being developed to support virtualization, experimental programmability and control features.

Installation of the WiMAX base station for outdoor use around the WINLAB Tech Center building in North Brunswick, NJ was done at the end of the previous reporting period (1Q09). During this reporting period (2Q09), we have made significant progress on the following topics:

(1) Completion of the experimental WiMAX deployment at WINLAB, and full integration with the ORBIT testbed infrastructure (i.e. GENI Cluster E).
(2) Baseline performance measurements for the WiMAX base station installed at WINLAB
(3) Design and software development for the open API base station and virtualized GENI controller.

Further details of 2Q09 progress for each of these topics are given in the following section.

In terms of key findings, we now have a complete WiMAX experimental setup operating with an FCC experimental license, and have been able to fully integrate this equipment (initially without virtualization) with the ORBIT testbed (i.e. the GENI cluster E framework). This makes it possible for a remote experimenter to use OMF services to run a WiMAX experiment within the ORBIT framework. Further, our initial implementation of the open WiMAX API permits experimenters to access certain L2 parameters of the base station radio including PHY mode settings, RSSI, service class mappings, etc. The example system-level demo using vehicles equipped with dual-mode WiMAX/WiFi radios and GPS shows the feasibility of conducting outdoor experiments with mobility. Ongoing work during 3Q09 will extend this capability to multiple virtual slices operating on the same hardware, and when completed would achieve all the major goals for year 1 of this project. An open design issue to be worked on further is that of fine-grained slice resource management for a WiMAX base station with varying user demands and mobile user signal quality.

2.1 Experimental WiMAX deployment: As shown in Fig. 1, the prototype base station has been deployed as part of the ORBIT campus network at the WINLAB Tech Center facility. This setup required integration of the WiMAX base station setup as a part of the ORBIT control framework, setting up baseline configurations and installing an outdoor antenna.

Fig 1: WiMAX antenna on the WINLAB Tech Center roof (elevation <6ft) and the base station with the power amplifier in the ORBIT control room

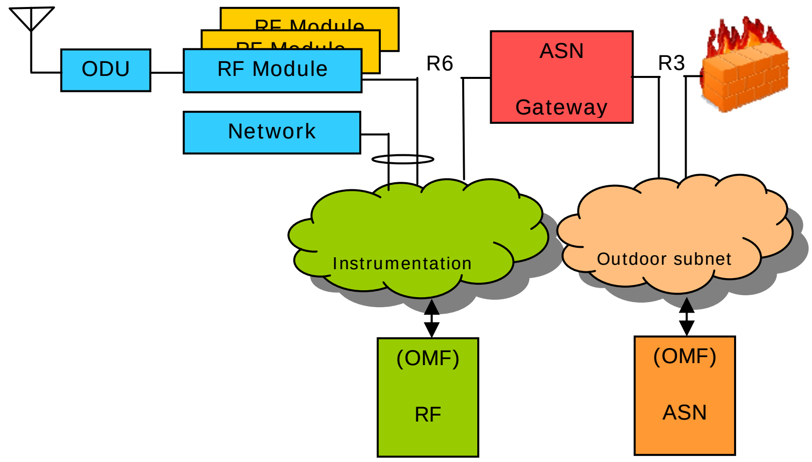
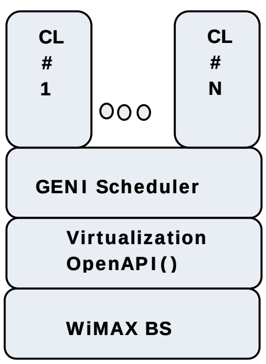


Fig 2: Integration of the WiMAX setup as a part of the ORBIT control and management framework.

Fig 2 shows the integration of this setup in the ORBIT network. This allows experimental end-users to access the ASN – GW, and the WiMAX BS device. The ASN-GW is accessible as a part of the outdoor network in the ORBIT setup. Our initial tests with the laboratory setup of the NEC WiMAX base station show that the selected equipment provides flexible service configuration, reliable transport and carrier-grade reliability. It also provides the necessary interfaces for open API design as required for GENI programmability and measurements. The base station features control and monitoring capabilities for key link layer parameters (such as bandwidth, rate, modulation and coding scheme, link quality, scheduling priority, traffic class, etc.), so as to allow open API with a high degree of experimental flexibility.

2.2 OpenAPI() and the GENI scheduler design: As shown in the adjacent figure, the virtualized base station architecture includes an OpenAPI for control and management of the BS. This OpenAPI is defined with the intention of exposing L2 hooks to the GENI scheduler while placing a protective wrapper around manufacturer-specific software and design. The OpenAPI will provide the GENI scheduler with control features needed for slice resource allocation, control and revocation. The current draft of the mutually agreed OpenAPI document has been publicly released [2].



The GENI scheduler is responsible for controlling the access of the virtual machines (VMs) to the WiMAX BS and providing some SLAs to every slice. The GENI scheduler will work off the built-in WiMAX scheduler by exploiting its tight scheduling mechanisms to enforce slice fairness. It will create service flows, allocate and control access to each of them based on GENI defined slice policies. For the initial GENI scheduler design we are following a two pronged approach –

1. A Click modular router based design for quick prototyping.
2. Building an open driver as a part of the GENI scheduler.

The Click based design will allow us to quickly determine what design strategies could work with the BS and correct things that would not. We are also in the process of designing a device driver that will be made available as an installable module to work with a GENI policy manager. The advantage of having this device driver would be independence from any version change to the Click software, and ease of deployment across a wide range of platforms.

2.3 Baseline WiMAX Performance Evaluation: During this reporting period, we have carried out a significant number of performance measurements for the base station deployed at the WINLAB Tech Center building. The purpose was to conduct basic validations of the experimental deployment and to understand the achievable performance and features of the WiMAX hardware used in the setup.

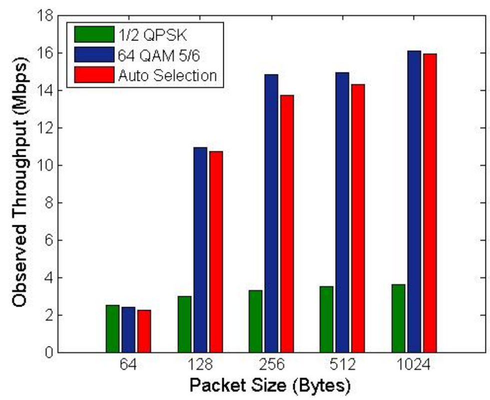


Fig. 3: Performance with varying packet size & mode

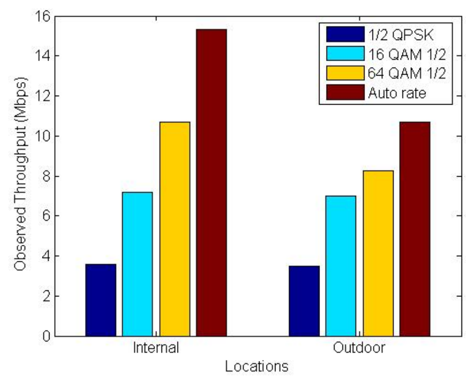


Fig. 4: Performance at different locations

As part of this effort (which is still ongoing during 3Q09), we have measured throughput, latency, RSSI and PER by varying modulation and coding schemes, service classes, receiver locations and performance under mobility. Figure 3 shows a sample measurement of packet size versus achievable downlink throughput in various modes of the base station PHY (1/2 QPSK, 64QAM with 5/6 coding and AutoRate) at a transmit power level of 35 dBm. The results show that the auto rate algorithm is able to select the near optimal modulation/coding scheme (MCS) for varying packet sizes with a fixed location. A similar measurement in Figure 4 compares the downlink throughput performance at two different locations for a fixed packet size of 1024B. These results show that as the location of the receiver is changed from indoor to outdoor; the RSSI is reduced leading to a corresponding decrease in performance as might be expected. These measurements are to be followed by mobile measurements and performance across different service classes.

A broader result from the performance evaluation is shown in the outdoor measurements characterized in Figures 5. The CINR measurement at this location was 27 and average RSSI value was -67dB. It is seen that the auto rate selection scheme on the base station is able to select near optimum MCS for best performance. For the given location (link quality) 64QAM 2/3 has the best performance. Finally, we observed that ½QPSK provides the most robust link modulation and performance is consistent through measurements at multiple locations.

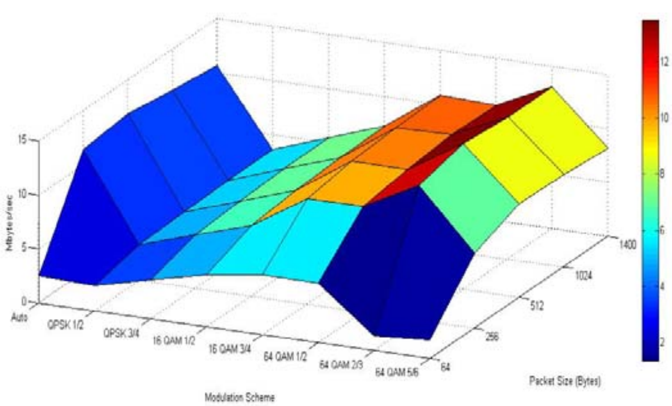


Fig 5: Measurements at *LOCATION 1* with varying modulation and coding schemes, packet sizes at an outdoor location. RSSI and CINR values measured at this location were -67dB and 27 respectively.

Additional data has been collected on coverage and signal quality and is currently being summarized as guidance for experimenters. As the next step, we also plan to extend these measurements to include virtual network performance with multiple slices sharing the same base station.

Project participants:
Rutgers: Gautam Bhanage, Ronak Daya (graduate students), Ivan Seskar, Dipankar Raychaudhuri
NEC: Meilong Jiang, Rajesh Mahindra, Sampath Rangarajan

Publications:
Internal project documents:

1. GENI WiMax system engineering document, 11/08
2. OpenAPI Specification for the GENI WiMAX Basestation, 5/09

   http://www.winlab.rutgers.edu/~gautamb/pubs/API_wimax_v1.0-3.pdf

No external publications during this reporting period

Outreach activities:
None

Collaborations:

1. Coordinating with Stanford U (Prof. Nick McKeown) to make the same NEC WiMax base station available for OpenFlow campus network deployment.
2. Collaborating with ORBIT project team to use the ORBIT Management Framework (OMF) software as the foundation for the WiMAX base station controller.

Other Contributions:
None