GENI Project Quarterly Progress Report, 1Q09

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
1.2 WiMAX BS system setup	- indoor (at NEC)	- done 11/08
	- indoor (at WINLAB)	- done 2/~~08~~ 1
	- outdoor (at WINLAB)	- done 3/~~08~~ 1
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		- 30% complete as of 3/09
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	- 90% complete as of 3/09
2.2 Understanding NEC ASN-GW functions	- 70% complete as of 3/09
2.3 Implementing WiMAX virtualization	- 20% complete as of 3/09

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 system demo with OMF experimental control	- done 3/09

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.

During this reporting period (1Q09), a second WiMAX base station was installed at the WINLAB Tech Center facility in North Brunswick, NJ. The base station setup at WINLAB supports both indoor and outdoor testing, and includes a roof-mounted RF antenna for ~2-3 Km coverage around the building. The setup was tested with mobile end-user WiMAX devices mounted in cars, and sample location-aware applications have been built for demo purposes. In addition, the WiMAX device has been integrated into the ORBIT control framework so as to allow remote experimenters to access the network and set up available radio link parameters. The initial system setup was demonstrated at the GEC-4 in Miami as indicated in item D1 above.

In terms of key findings, 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 that we expect to be able to implement an open API with a reasonable amount of experimental flexibility. Further details on each of the tasks listed above are given below:

1.1 Testing NEC BS interfaces - BS/ASN-GW R6
During this period, the R6 interface between NEC WiMAX base station and ASN-Gateway has been thoroughly tested. Service flow creation, QoS management, multiple clients support and rate adaptation were validated for the subsequent custom ASN-GW development.

1.2 NEC WiMAX outdoor performance evaluation
We have started evaluating the performance of the NEC WiMAX BS both indoors and outdoors. We have a fully functional outdoor set-up at WINLAB with a roof-mounted antenna. The evaluation results when completed will provide benchmarks for performance of the BS under different traffic loads and channel conditions. These results will help to determine practical limits on BS virtualization in terms of total network capacity, variations due to signal quality, etc. During this reporting period, we have also integrated the WiMAX base station under the ORBIT control and management framework, thus enabling remote access by an experimenter, code downloading and automated data collection. The initial outdoor BS setup has been validated using a simple vehicular experiment in which the WiMAX channel is used for control purposes, while a second WiFi radio interface is used for opportunistic high-speed downloads. This experiment also included video uplink from the mobile device in order to evaluate high bandwidth streaming performance over the WiMAX channel.

2.1 In-depth understanding NEC WiMAX BS interfaces
NEC WiMAX BS interfaces and messages (R1 and R6) were thoroughly studied, which include: the BS Initialization, the network entry precedure, the pre-provisioned service flow, MS Network Exit, Radio Resource Management and Idle Mode Entry and Exit.

2.2 In-depth understanding NEC ASN-GW functions
The process service flow creation and deletion have been studied for different traffic classes and priorities. We now have in-depth knowledge of the implementation of the routing of packets between the BS and the ASN. We are in the process of extending the functionality of the ASN-GW to include routing of custom layer-3 protocols including support for VLANs. This will help to support slices with non-IPv4 or IPv6 flows.

2.3 Initial design of WiMAX virtualization capability and implementation.
Throughput virtualization capability was partially tested and implemented by manipulating the service flow creation and QoS parameters setting. Currently, we are looking at how to map slice flows to actual WiMAX service flows. We are also working towards the design of a scheduler and traffic shaper at the ASN-GW that will synchronize with the BS scheduler to provide the appropriate slice guarantees.

3.1 Initial design document for the open API
A baseline open API document was created with functionalities to support access control, QoS control, service flow management and radio resource utilization visibility.

3.2 Revised design of open API: functional definition and implementation
A refined API document is being defined with higher flexibility to support the BS virtualization of ASN-GW functionality, wireless link throughput and radio resource utilization.

3.3 SNMP Control Interface
We now have a good understanding of the SNMP control interface that BS provides to the ASN-GW and are in the process of modifying it to work in the virtualized environment.

4.1 System level integration with GENI control

As mentioned earlier, the WiMAX BS installed at WINLAB was used to demonstrate system-level capabilities including experimental control via ORBIT interfaces, use of WiMAX clients on mobile devices, high-speed streaming, flow setup and resource allocation, service bit-rate monitoring, etc. The demo showed a realistic experimental scenario where WiMAX is used as a control channel for location aware/opportunistic vehicular communications. This was intended as a first demo for GEC-4, and further work on more extensive control of radio API features, virtualization and performance monitoring is planned for 2Q09.

Project participants:
Rutgers: Manasi Jagganathan, 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. Open API specification document, 12/08 (v1.0), 2/09 (v2.0)

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