GENI Project Progress Report

Project Title: GENI Spiral 3: GENI WiMAX at Clemson

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1. Major accomplishments (period 7/2013 through 6/2014)

Milestones achieved:

The following tasks and goals were identified in the statement of work:

1. Complete installation of access facilities and switches, to provide connectivity from your WiMAX base stations, through campus OpenFlow switches, where available, to the GENI Internet 2 backbone. (by GEC18)
2. Complete plan for local research experiments at your WiMAX site during Year 3, e.g., handover, multi-homing or content delivery. (GEC18)
3. Complete extended deployment plan for your WiMAX site during Year 2. Install 4 custom PC yellow nodes, Login Service plus OMF/OML services operating on custom PC node, multiple base-station management service operating on custom PC node, handover service utilizing multiple base-station management service, GIMI I&M services, connection to I2, data-path gateway service operating on custom PC node, multi-homing service utilizing data-path gateway service, WiFi access point for dual-homing operating on custom PC node, vehicular mobile station operating on custom PC node, fixed “mobile station” for remote experimenters operating on custom PC node, and/or unlocked Android WiMAX/WiFi handsets. (GEC18)
4. Complete deployment of necessary extended capabilities at your WiMAX site, utilizing hardware and software provided by Rutgers WINLAB, the Univ of Wisconsin, and/or UMass Amherst. (Complete by GEC19)
5. Demonstrate and document planned local research experiments at your WiMAX site. (GEC18)
6. When your base station is on-the-air, forward monitoring information to the central collection site at Rutgers WINLAB, and cooperate with Rutgers WINLAB and Clearwire to avoid interference with Clearwire’s services; when necessary, do an “emergency stop” of your transmissions. (starting GEC18, and continuing)
7. Make your WiMAX site accessible to remote experimenters, with access via Login Service to OMF and OML services, a connection to the I2 backbone, and an accessible fixed “mobile station”. (starting GEC18, and continuing)
8. Develop v1 handover service utilizing multiple base-station management service and vehicular mobile station operating on custom PC node, then document and demonstrate at your WiMAX site. (GEC17)

Deliverables made:
D1: At GEC 17 (July 2013):
• Tasks 1,2 complete.
• Demo #1 (described below) contributed at the GEC.
D2: At GEC 18 (October 2013):
• Task 3 partially complete (yellow nodes not fully operational due to ASN GW issue)
• Demo #2 contributed at the GEC
D3: At GEC 19 (March 2014):
• Task 4, 5 complete.
• Demo #3 contributed at the GEC
D4: At GEC 20 (June 2014):
• Tasks 6 completed
• Plenary Demo contributed at the GEC
2. Description of work performed

Activities and findings:

Initially, the thought was to use a form of Mobile IP to implement the vertical handover testbed. Because the scope of this project was limited to IPv4, there were limited mobile IPv4 implementations to choose from. The most appealing choice was a software collection called TMIP – Transparent Mobile IP. It was found to be rather outdated and very buggy. As such, and due to the lack of other mobile IPv4 projects out there, we abandoned the search for an existing solution and built our own based on OpenFlow (Figure 1). Leveraging DHCP, our OpenFlow network, and a custom OpenFlow controller based on Floodlight, we can track clients as they roam between APs/BSs and assign the same IP address. Using the controller and the OpenFlow switches, we can also reroute client packets in the testbed network to send them to wherever the client is currently located/connected. To allow the client to switch network interfaces without bringing down the application’s socket, we have installed a virtual OpenFlow network onboard the client (Figure 2). The purpose is to mask the state of the network interfaces from any applications on the client, which preserves the application’s socket. The application sees an “always-up” network interface. This is also controlled by an onboard custom Floodlight OpenFlow controller. Details of our campus WiMAX/WiFi vertical handover deployment can be found in Figure 3.

- Vertical handover network software architecture (Figure 1)

![Network Architecture Diagram](image1)

- Vertical handover client software architecture (Figure 2)

![Client Architecture Diagram](image2)
• Detailed Clemson GENI WiMAX/WiFi network topology (Figure 3)

**Project participants:**
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**Publications:**
- K. Xu, R. Izard, F. Yang, KC Wang, J. Martin, "Cloud-Based Handoff as a Service for Heterogeneous Vehicular Networks with OpenFlow", GENI GREE 2013

**Internal project documents:**
N/A
External publications:
See above.

Outreach activities:
REU student involvement:
  • Sean Stemm (Junior, University of North Carolina, Ashville, sstamm@unca.edu)
  • Benton Kribbs (Sophomore, Clemson University, bkrhibs@g.clemson.edu)
  • Joseph Porter (Sophomore, Clemson University, jporter@g.clemson.edu)
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  • David Reynolds (Junior, Clemson University, dreydon@g.clemson.edu)

Collaborations:
  • GENI research community: Our project requires collaboration across a broad set of researchers. In particular, we have interacted with faculty at Rutgers, University of Wisconsin, and Wayne State University.
  • SciWiNet: Our project is synergistic with SciWiNet (an NSF Exploratory project conducted at Clemson and Rutgers). The two projects share device, infrastructure, software, and faculty/student resources.

Other Contributions:
We contributed the following GEC demos:
  • GEC 17: Vertical handover demonstration; WiFi-Ethernet local demo
  • GEC 18: Vertical handover demonstration; WiFi-WiFi local demo; DHCP addition
  • GEC 19: Sample vertical handover topology; updates to the project
  • GEC 20: SciWiNet at plenary; no vertical handover demo/updates