Annual Report

YR 2

Control, Measurement, and Resource Management Framework for Heterogeneous and Mobile Wireless Testbeds

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Major Accomplishments

We have met the following milestones and deliverables:

a) Work with GPO and WiMAX and cognitive radio projects in cluster to complete a plan for the setup of VLANs between testbeds, to be carried by Internet 2 (or NLR) backbone network between the testbeds.

Status: Plan completed for GEC6. Further execution of plan dependent on I2 ION.

b) Extend OMF interfaces and software to support experiments which concurrently use resources from more than one testbed. Include integration with experiment control and measurement, and provide for multiple concurrent slices. Introduce a ticket-based resource authentication mechanism, compatible with evolving GENI control framework structures.

Status: Integration of OMF experiment control tools and measurement framework (OML) with PlanetLab Europe. Demoed at GEC 7. Implemented first stage of an assertion-based resource authentication mechanism that promises to be much more appropriate for a federated environment than a simple ticket-based approach.

c) Extend OMF in mobile environments to support experimentation driven by context, particularly location information, such as passing a specific location or detecting a new neighbor.

Status: We have extended OEDL with a generic event mechanism and a relational algebra to simplify the formulation of standing queries against the measurement framework. Tying the two together addresses the above objective. This capability was demonstrated at GEC 7 where an experiment action was triggered when a mobile node crossed a specified geographic boundary.

e) Work with WiMAX and cognitive radio projects, to integrate their testbeds (utilizing OMF interfaces and software), into your OMF operating environment, as federated testbeds.

Status: Support is being provided on a continuing basis. For instance, the recently released OMF 5.3 provides support for node virtualization and with it virtualization of the WiMax basestation infrastructure. The recently demonstrated support for motes with OML integration provides the blueprint for supporting cognitive radios in a more integrated fashion.

d) Demonstrate control of VLAN connections from your testbed to backbone network, contingent upon availability of a managed end-to-end VLAN transport service (e.g., Internet2 DCN) by backbone network. (17.5mo, GEC7)

Status: Demoed with BBN.

f) Support integration of latest OMF code into WiMAX and cognitive radio projects. (starting 18mo)

Status: Support is being provided on a continuing basis.

g) Develop experiments that demonstrate federation and mobility functions, including experiments that utilize multiple testbeds, do end-to-end validation testing, and demo at a GEC. (21.5mo, GEC8)

Status: Demoed federation experiments using Planetlab. Developed ParkNet experiments for extensive testing and demonstration of mobility functions. Recently demonstrated a measurement centric experiment across Planetlab, ProtoGeni, and OMF using their respective SFA interfaces.

h) Provide OMF support for experimentation on federated testbeds by GENI users outside of related projects. (starting 21.5mo, GEC8)

Status: Prelim support in OMF 5.2 released in Jan. Full support in OMF 5.3, released 8/27

i) Collaborate with GMOC operations group on providing access to OMF operating data. (13-24mo)

Status: Data provided in 2009, no further requests received.

j) Provide POC to GENI Prototype Response and Escalation team. (13mo)

Status: No request received.

k) Provide POC to Security team and provide input for security review in Spiral 2. (13-17mo)

Status: No request received.

l) Specific contribution to GENI outreach plan:

Release of IREEL education platform, involvement of students from underrepresented groups, press coverage.

Activities and Findings

Work at NICTA has been primarily focused on setting up L2 connectivity, generalizing the experiment control tools to allow use over multiple testbeds, and to complete a new OMF release (v5.3). Rutgers has focused on supporting WIMAX integration as described in the WIMAX project report, and developing and validation location-based experiment control functions. The validation experiment not only allowed refining requirements and extensive testing of the

experiment control functions, but itself has been highly successful and showcases how GENI resources can enable significant mobile application research contributions.

Connecting and Controlling Experiments over Multiple Testbeds

In March 2010, NICTA set up the first Internet2 ION connection between Rutgers and NICTA, in collaboration with WINLAB, MAGPI (Mid-Atlantic Gigapop in Philadelphia for Internet2), and AARNET (Australia's Academic and Research Network). In an initial test, a 200 Mbps circuit was established for a period of 9 days 8 hours and 15 minutes, and has been recently tested at the full Gigabit capacity. This capability was demonstrated in March 2010 (http://www.magpi.net/News/MAGPI-Key-Partner-ION-Dynamic-Network-Deployment).

In collaboration with INRIA Sophia-Antipolis, NICTA has generalized the OMF experiment control tools to allow them to describe, instrument and execute experiments which use resources on the NICTA and PlanetLab testbeds. This capability was demonstrated at GEC7, where an experiment involving a P2P problem resolution application was deployed and executed on resources from both testbeds.

NICTA has recently released a new version of OMF, which includes many new features such as traffic shaping with netem, disconnected experiment with publish/subscribe communication, Event-driven mechanism. In addition, this new release will also fix several 5.2 issues, and has gone through several code refactoring to allow easy addition of future capabilities.

Location-based Experiment Scripting

In contrast to static experiments, a mobile outdoor experiment quite often requires spatial triggers to start or stop an action when a mobile node enters or leaves a specific geographical region. For this purpose, this new tool, Trip-Polygon, has been integrated with the disconnected operation mode of ORBIT's Control and Measurement Framework (OMF). The Trip-polygon tool facilitates experiment control using the ORBIT OMF interface and can trigger actions when a node enters the region described by the polygon or when a node leaves the region. For example, the experimenter may use such geographical boundaries to assign trigger *start the experiment* and *stop the experiment* procedures. The tool lets users define Trip-polygons in Google Earth by drawing polygons around regions of interest using a map utility that could export these definitions into Google Earth's markup language (.kml). Figure-1 presents the Trip-polygon architecture where the experimenter remotely defines the event boundaries using polygons on Google Earth. Figure-2 shows an example Trip-polygon definition on Google Earth, which covers a stretch of road. The resulting .kml file exported from Google-Earth is fed into the Trip-polygon utility, which provides functionalities to establish if a given GPS co-ordinate is within the defined Trip-polygon. The Experiment Description contains the mapping between the Trip-polygon and the corresponding trigger. The Master Experiment Controller constantly queries the underlying GPS device that is attached to the Mobile ORBIT node and issues event triggers based on the location of the car. In the disconnected operation mode (i.e when the mobile node is disconnected from the ORBIT infrastructure), the proxy Experiment Controller residing on the ORBIT node takes over the task of the Master Experiment Controller.

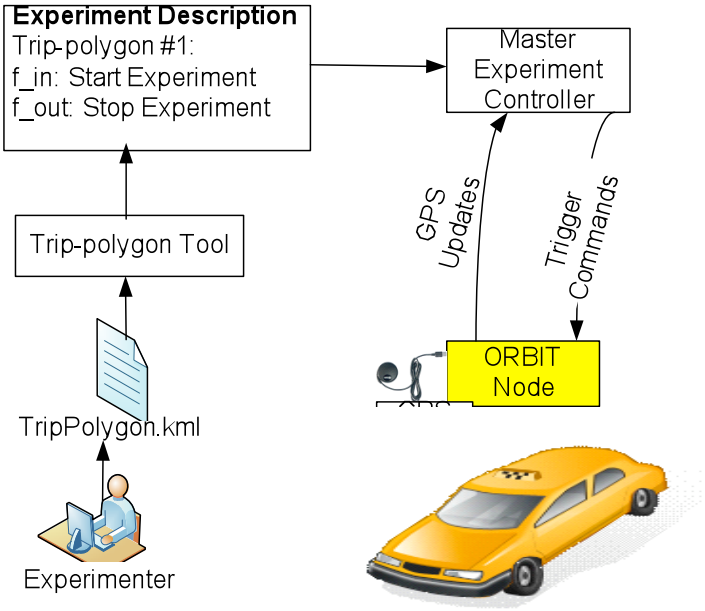

Figure 1: Trip-polygon Architecture

Figure 2: Trip-polygon on Google Earth

Validation Experiments: ParkNet

To validate and design our disconnected experiment control and in particular the location-based control primitives, we used them in our ParkNet mobile application research project. ParkNet was motivated by the fact that urban street-parking availability statistics are challenging to obtain in real-time but they would greatly benefit society by reducing traffic congestion To address this need we have designed and experimentally evaluated a mobile system comprising vehicles that collect parking space occupancy information while driving by. ParkNet vehicle is equipped with a GPS receiver and a passenger-side-facing ultrasonic rangefinder to determine parking spot occupancy. The data is aggregated at a central server, which builds a real-time map of parking availability and could provide this information to clients that query the system in search of parking. Creating a spot-accurate map of parking availability challenges GPS location accuracy limits. To address this need, we have devised an environmental fingerprinting approach to achieve improved location accuracy. Based on 500 miles of road-side parking data collected over 2 months, we found that parking spot counts are 95% accurate and occupancy maps can achieve over 90% accuracy.

This work was published at the ACM MobiSys 2010 conference and won a best paper award. It also received significant international media attention, including articles in MIT Technology Review, Canadian Broadcasting Corporation Online News, Popular Science Magazine Website, and many other online news sources.

This project benefitted immensely from a deployed testbed of vehicular nodes. We also found the location-based experiment control functions very helpful, because part the experiments involved collecting video data. For example, using the location-based triggers we were able to focus data collection on those parts of a vehicle trip where road-side parking is available and thereby significantly reduce the volume of data collected. This validation experiment, however, also

allowed us to refine the requirements for location-based experiment control tools. For example, we discovered that using polygons instead of simple triplines, reduces the complexity of the experiment definition. This led us to add polygon support to the location-based experiment control tool as described earlier.

Support and Collaboration

We continue to maintain an external website dedicated to OMF, its user community and its installation, utilization, and ongoing development.. This website is located at: http://www.mytestbed.net/

NICTA has been providing significant design and technical support to the WIMAX and cognitive radio teams at WINLAB, to integrate their specific testbed resources into the OMF framework. This is an ongoing task for deliverable 4e, Year 2.

Project Participants

Marco Gruteser

Max Ott

Thierry Rakotoarivelo

Ivan Seskar

Janani Chandrasekharan

Tong Jin

Bin Zan

Publications

[1] "Measurement Architectures for Network Experiments with Disconnected Mobile Nodes", Jolyon White, Guillaume Jourjon, Thierry Rakotoarivelo, Max Ott, International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities (TRIDENTCOM 2010), Berlin, Germany, May 2010

[2] "From Learning to Researching - Ease the shift through testbeds", Guillaume Jourjon, Thierry Rakotoarivelo, Max Ott, International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities (TRIDENTCOM 2010), Berlin, Germany, May 2010.

[3] ParkNet: Drive-by Sensing of Road-side Parking Statistics, Suhas Mathur, Tong Jin, Nikhil asturirangan, Janani Chandrasekaran, Wenzhi Xue, Marco Gruteser and Wade Trappe, The 8th Annual International Conference on Mobile Systems, Applications and Services **[ACM Mobisys 2010] Best Paper Award**

[4] TAG - Trip-Boxes for Automatic event Generation, Janani Chandrasekaran, M.S. Thesis, Rutgers University, 2010

Collaborations

NICTA has been actively participating to the GENI Instrumentation and Measurement Working Group, and has contributed many key ideas to the current I&M Architecture Draft document.

Outreach

- Janani Chandrasekharan, a Rutgers graduate student from an under-represented group developed core functions of the location-based experiment control mechanisms. This project allowed her to complete an MS Thesis and she has since found employment at Network Appliance.
- Release of IREEL v2.0 (http://ireel.npc.nicta.com.au). NICTA modified its IREEL educational platform to make it use OMF as its backend for deploying and running experiment. This new IREEL provides students with a web interface to design laboratory experiments, and utilises OMF control tools to deploy and execute these experiments. In addition, NICTA co-developed with the University of New South Wales (UNSW) a set of IREEL laboratory experiments, which will be taught to under/post-graduate students at the 2nd semester of 2010.
- International press coverage of ParkNet experiments conducted on GENI resources, including articles in MIT Technology Review, Canadian Broadcasting Corporation Online News, Popular Science Magazine Website, and many other online news sources.

Other Contributions

None to report.