MAX Quarterly Report
April 1, 2010 - June 30, 2010

Overview

The MAX project is building a GENI facility known as the "Mid-Atlantic Crossroads GENI (MAX GENI) Facility". This is an experimental fiber-based regional network in the Washington DC metro area. MAX GENI will provide the GENI community with access to a regional optical network consisting of wavelength-selectable switches, 10 Gbps Ethernet switches, and virtual machines.   The network infrastructure is building upon the NSF-funded DRAGON network which provides end-to-end dynamic circuit provisioning via a standardized Web Services interface through the use of a distributed GMPLS control plane - ensuring deterministic, high-speed performance over dedicated network resources. DRAGON technologies and software are also deployed on multiple research and education networks throughout the world. This wide deployment will be utilized to facilitate access to the MAX GENI capabilities by remotely located researchers.

MAX GENI has leveraged the DRAGON network infrastructure (and related technologies) by adding server virtualization capabilities (PlanetLab nodes) at the edges of the network and programmable network hardware (NetFPGA hosts) at two core switching nodes. MAX GENI also has the capability to connect researchers in the Mid-Atlantic region to the rest of the GENI community via its connection to the private, high-speed Layer 2 backbone provided by Internet2 and the ProtoGENI project. The project web site is located here: http://geni.maxgigapop.net

A detailed listing and description of the MAX Spiral 2 project tasks and milestones is provided in Appendix A. The task and milestones identified for this reporting period are as follows:

Quarter 3 (6/30/2010):
MAX.S2.o: DRAGON Aggregate Manager Enhancement Updated Implementation.
MAX.S2.p: DRAGON Aggregate Manager Common Control Framework Integration Plan
MAX.S2.q: DRAGON Aggregate Manager Common Control Framework Integration Implementation
MAX.S2.r: DRAGON Aggregate Manager Common Control Framework Integration Testing
MAX.S2.s: User Tool DRAGON Framework Implementation
MAX.S2.t: User Support
MAX.S2.u: DRAGON Aggregate Manager Documentation

This document provides a summary of the activities accomplished during this reporting period, and also summarizes the focus area and work plan moving forward.

Milestones Status Report for Spiral 2, Quarter 3

MAX.S2.o: DRAGON Aggregate Manager Enhancement Updated Implementation (Completed on time 06/30/2010)
Complete updated implementation of enhanced DRAGON Aggregate Manager based on design work in milestone Task MAX.S2.c. This updated implementation will extend the work completed in MAX.S2.h to include features for more robust user authorization and resource verification (topology computation) techniques.

Status:
During this time period we have completed the implementation of all the core features and capabilities of the MAX Aggregate Manager. The MAX GENI Aggregate Manager has two key functional areas:

-Client Facing Service Interface: In this context the "client" is a clearinghouse, a slice manager, another aggregate manager, an experimenter/user or any entity which is requesting services directly from the MAX GENI Aggregate Manager. The main implementation task for this functional area was to build the service

interface to handle client service requests and interact with the backend processing on behalf of these requests.

-Backend Resource Manager Controller: This is the implementation of the backend processing and interfaces to interact, maintain states, and control other resource managers like PlanetLab MyPLC, DRAGON Network Provisioning system controllers, and ProtoGENI Aggregate Manager.

The two key features we added to the MAX Aggregate Manager during this reporting period are as follows:

- User Authentication and Authorization based on Web Service Security standards
  This new capability utilizes WS-Security standards and x509 certificates for user authentication for access to the MAX GENI facility resources via the Aggregate Manager. In addition, the MAX Aggregate Manager integrates this user authentication and authorization with the existing PlanetLab, DRAGON, and ProtoGeni user authentication and authorization methods to allow for Slice Creation which includes capabilities from multiple resources.

- Enhanced RSpec based topology specification
  The MAX Aggregate Manager now includes enhanced features for RSpec based specification and description of GENI slices. During this reporting period we have added the ability for users to include ProtoGENI RSpecs as part of a request to the MAX Aggregate Manager. As a result, a user can request a Slice topology which includes RSpec definitions for MAX DRAGON, PlanetLab, and ProtoGeni resources. For ProtoGeni resources our current focus is on their wide area infrastructure. The ProtoGeni infrastructure includes connections in Washington DC, Kansas City, and Salt Lake City. The MAX and ProtoGENI network are interconnected in Washington DC. As a result, the intention of including ProtoGeni style RSpecs in MAX Aggregate Manager requests is to allow MAX users to interconnect to other facilities (such as GpENI) via ProtoGENI.

Additional information regarding the MAX Aggregate Manager is available on the project web site: https://geni.maxgigapop.net.

The currently deployed capabilities are available via the following mechanisms.
- MAX Aggregate Manager Service Interface
  -Human Readable Service Definition via Web Browser (FireFox)
  https://geni.dragon.maxgigapop.net:8443/axis2/services/AggregateGENI?wsdl
  -SOAP API Interface
  https://geni.dragon.maxgigapop.net:8443/axis2/services/AggregateGENI

- MAX MyPLC Service Interface
  -Human Web Browser Interface
  https://max-myplc.dragon.maxgigapop.net/
  -XML-RPC/SOAP Interface
  https://max-myplc.dragon.maxgigapop.net/PLCAPI/

- DRAGON Network Provisioning Interface
  -Web Browser Provisioning Interface:
  https://idc.dragon.maxgigapop.net:8443/OSCARS/
  -Human Readable Service Definition via Web Browser (FireFox)
  https://idc.dragon.maxgigapop.net:8443/axis2/services/OSCARS?wsdl
  -SOAP API Interface
  https://idc.dragon.maxgigapop.net:8443/axis2/services/OSCARS

MAX.S2.p: DRAGON Aggregate Manager Common Control Framework Integration Plan (Completed on time 06/30/2010)
Develop a design and implementation plan for the DRAGON Aggregate Manager to incorporate the results of the common/interoperable control framework approach developed in MAX.S2.j.

Status:
We have completed our design and integration plan for the MAX Aggregate Manager and the associated control framework. The design of the common control framework is as described in milestone MAX.S2.j and MAX.S2.i status. This includes a set of web service based capabilities that users (experimenters, clearinghouse, slice manager, etc) can utilize to build GENI experiment topologies. The MAX Aggregate Manager set of services have slightly different names and also expands on those defined in the GENI Common Control Framework described here: http://groups.geni.net/geni/wiki/GAPI_AM_API.

A key enhanced feature is a web service call which enables resource topology discovery and experiment topology requests which allow RSpec formats from multiple systems to be included (such as PlanetLab, MAX DRAGON network resources, ProtoGENI). Our design and integration approach is to utilize our common control framework and integrate other resources as available and needed for specific experiment topology creation.

Additionally it would be straight forward to modify the PlanetLab or ProtoGENI Control Framework APIs to make calls to the MAX Aggregate Manager. This would require some changes to those APIs which are not currently in place. However, the MAX Substrate has a set of resources which are not common with these other systems. For instance, the PlanetLab control framework does not include the notion of dynamically provisioned network topologies, which may extend globally via the InterDomain Controller based systems such as ION. As a result, the MAX Aggregate Manager provisioned integrated topologies (PlanetLab slices and dynamic network topologies) would not fit neatly into the resource management model of the current PlanetLab control framework.

For these reasons our design and integration plan is based on the MAX Aggregate Manager open web service based interface. This will allows for both of the following:

1. Integration of the MAX Aggregate Manager calls into the other control frameworks (PlanetLab, ProtoGENI, ORCA)
    Note: Modifying the other control framework APIs to interact with the MAX Aggregate Manager Interface will be easy. Modifying the backend resource management capabilities of these control frameworks to understand the MAX substrate unique resources will be harder.

2. Development of a higher level Slice Manager which has: i) the intelligence to understand the capabilities of multiple aggregates, ii) how to make the appropriate request to multiple aggregate managers, iii) and how to stitch them together.

We are currently planning on the approach of doing both of these as driven by specific experiment/user requests. As described in MAX.S2.r status, we have begun some work based on approach 2 above with the integration of dynamic ProtoGENI provisioning as part of experiment slice set up.

MAX.S2.q: DRAGON Aggregate Manager Common Control Framework Integration Implementation (Completed on time 06/30/2010)
Incorporate aggregate manager interoperability and common control framework features needed into the DRAGON Aggregate Manager, based on milestone MAX.S2.p.

Status:
The common control framework has been incorporated into the MAX Aggregate Manager. This includes the following web services/capabilities:

ListCapabilities
ListNodes
ListSlices
CreateSlice
DeleteSlice
UpdateSlice

StartSlice
StopSlice
QuerySlice
CreateSliceVlan
DeleteSliceVlan
QuerySliceVlan
CreateSliceNetwork
DeleteSliceNetwork
QuerySliceNetwork
GetResourceTopology

From a common control framework perspective, the following features are of special note:

-The CreateSliceNetwork allows users to request Slice/Sliver instantiation via use of PlanetLab MAX RSpecs. In addition, a ProtoGENI style RSpec can be utilized to request that the MAX Substrate resources be stitched to ProtoGENI wide area network resources. This combination allows users to request experiment specific topologies which include resources from the MAX Substrate (PlanetLab Host Slices, MAX DRAGON Network resources) and wide area connections to other facilities/substrates across wide area infrastructures such as ProtoGeni and Internet2 ION.

-The GetResourceTopology can be utilized to return a description of the entire MAX Substrate. From this information users can formulate specific experiment Slice requests in the form of RSpec descriptions.

MAX.S2.r: DRAGON Aggregate Manager Common Control Framework Integration Testing (Completed on time 06/30/2010)
Conduct testing with updated DRAGON Aggregate Manager and common control framework. Document results and changes needed.

Status:
We have tested and demonstrated setting up of GENI Experiment Topologies which utilize the MAX Aggregate Manager control framework.   These experiment topologies can currently include resources from any of the following facilities:

- MAX Substrate PlanetLab Host Resources
  The MAX Aggregate Manger interacts with the MyPLC controller via the standard MyPLC interface.

- MAX Substrate DRAGON dynamic network resources
  MAX DRAGON dynamic network resources are based on the InterDomain Controller (IDC) system. As a result other IDC based dynamic networks will also be interoperable with the MAX GENI Aggregate Manager. This includes ESnet Science Data Network (SDN), Internet ION, USLHCNet, JGN2, GEANT AutoBahn, and several other regional networks.

- ProtoGENI Wide Area Network Resources
  For this capability we have integrated the ProtoGENI API (python based) into the MAX Aggregate Manager. As a result a user may request an experiment topology which includes a ProtoGENI style RSpec to include ProtoGENI resources into the dynamic experiment topology.

At the time of this report we have completed initial testing using the ProtoGENI control framework to requests connections across the ProtoGENI wide area infrastructure to the GpENI substrate. We are planning to show this at the GEC8 demonstration session. The below link points to a web page which details the MAX Aggregate Manger GetResourceTopology and CreateSliceNetwork calls which includes MAX DRAGON and PlanetLab resources. This is from MAX Aggregate Manager provisioning tests and includes a drawing of the dynamically provisioned experiment topology.

- http://geni.maxgigapop.net/twiki/bin/view/GENI/ExperimentTopology

Based on this implementation and testing experience, we have identified several areas which we believe will require more work by the community to facilitate experiment topology instantiation across multiple aggregates. These include the following:

- Mechanisms are needed for aggregates to share topology information which provide for identification of substrate interconnect points and associated capabilities. This is needed to allow for the automated calculation and provisioning of stitching points.

- Aggregates Manager features sets should include an ability to accept constraints on provisioning requests in order to facilitate the stitching process and probability of success. An ability to accept VLAN ranges or specific VLAN suggestions is the main constraint needed to facilitate stitching. This has been an issue for us in terms of integration of ProtoGENI provisioning into our Slice creation.

- For multi-substrate GENI Slice creation, there is a need for intelligent slice managers. The intelligent agents need to know how to make decisions about the provisioning actions needed across multiple substrates, and how to make the appropriate request to multiple aggregate managers.

- Further work is needed on the federated integration of host based resources to allow creation of topologies which may include PlanetLab, EmuLab, and other host based resources which may be distributed across multiple substrates.

MAX.S2.s: User Tool DRAGON Framework Implementation (Completed on time 06/30/2010)
Incorporate user tools identified in milestone MAX.S2.l into the DRAGON facility and control framework.

Status:
During this reporting period we have completed implementation of JAVA based reference API. This is a fully functional API that users can use from the command line or incorporate into their experiment specific application to request GENI Slices from the MAX Aggregate Manager. This API is available at the below link:

- https://geni.maxgigapop.net/twiki/bin/view/GENI/AggMgrApiClient

This API includes use of standard WS-Security and x509 certificates for authentication and resource control. The README file in the API software distribution provides instructions on how to generate key and certificate signing request, and then submit to MAX for approval.

The below document provides an overview of how to utilize this API in the context of an experiment topology instantiation:

- https://geni.maxgigapop.net/twiki/pub/GENI/AggMgrApiClient/MAXGENIAggregateManager.pdf

The intention of this API is to provide a simple mechanism for users to access MAX GENI Substrate resources.

MAX.S2.t: User Support (Completed on time 06/30/2010)
Work with and support interested users on use of the DRAGON GENI Facility.

Status:
This task includes outreach and support of external researchers who would like to use the MAX GENI facilities. Our primary efforts thru this reporting period have been focused on development of the MAX Aggregate Manager capabilities, interconnects to other network/substrate resources, and user APIs. We

feel this was necessary in order for users to have a set of tools of sufficient simplicity and robustness for their work. With the release of the MAX Aggregate Manger client API during this reporting period, this work is now complete. As a result, direct outreach to existing and potential new users will be a key focus for the next Quarter reporting period. We currently have MAX users who are focused on the network resources but not the other GENI resources available on MAX or connected substrates. We are planning to discuss with them their needs and make sure they are aware of GENI resources available. In addition, we are planning to reach out to other university and government researchers in the MAX region in an attempt to identify others that may benefit thru use of the MAX GENI substrate.

<u>MAX.S2.u: DRAGON Aggregate Manager Documentation (Completed on time 06/30/2010)</u>
Update the design and installation documents for the MAX Aggregate Manager. Provide updated open source software distribution of MAX Aggregate Manager and other related software.

Status:
The MAX GENI Aggregate Manager documentation has been updated to reflect the latest feature and implementation details. The below web site contains the Aggregate manager documentation:

- http://geni.maxgigapop.net/twiki/bin/view/GENI/Software

The documentation located here provides instructions on how to install the MAX Aggregate Manager for those interested in deploying the system to control their own set of substrate resources. In addition, this site includes documentation for those who desire to utilize the MAX Aggregate Manager Web Service interface to request instantiation of MAX GENI resources. Documentation is also provided for installation and use for of the reference MAX Aggregate Manager API. This API provides a set of tools to greatly facilitate access to all the available MAX GENI capabilities.

We will continue to update the main project web site (geni.maxgigapop.net) with the latest software distributions and configuration documents. Below is a listing of the locations of some of the most critical components:

MAX-DRAGON-GENI Aggregate Manager Repository:
svn://svn.maxgigapop.net/geni-aggregate

MAX Aggregate API Reference Implementation
https://geni.maxgigapop.net/twiki/bin/view/GENI/AggMgrApiClient
https://geni.maxgigapop.net/twiki/pub/GENI/AggMgrApiClient/MAXGENIAggregateManager.pdf

PlanetLab Control Framework MAX RSPEC:
http://svn.planet-lab.org/svn/sfa/trunk/sfa/rspecs/aggregates/max.xml

PlanetLab Control Framework SFA:
http://svn.planet-lab.org/svn/sfa/trunk/

DRAGON Software Repositories:
svn://cvs.maxgigapop.net/dragon-sw
http://sands225.east.isi.edu/narb-sw

DRAGON/OSCARS/IDC Software Package:
https://wiki.internet2.edu/confluence/display/DCNSS

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Focus For Next Quarter:
The focus for next quarter is to continue with the Quarter 4 tasks and milestones as identified. This includes the following: i) continue with MAX Aggregate Manager testing, ii) continue with development of features to facilitate multi-substrate stitching and resource provisioning, iii) increased outreach and work with potential GENI researchers in the MAX region and beyond, iv) evaluate the possibility of incorporating National Lambda Rail (NLR) dynamic network paths provisioned via the SHERPA into our Slice creation resources.

Appendix A
MAX GENI Project
Tasks and Milestones

1. Introduction
This appendix defines the tasks and deliverables for Spiral 2 phase of the MAX project which is constructing the Mid-Atlantic Network Facility for Research, Experimentation, and Development (MANFRED) GENI Facility. A listing of the deliverables and milestones organized by due date is provided below. Section 2 provides a more detailed description of the tasks and deliverables.

Quarter 1 (12/31/2009):
MAX.S2.a: NetFPGA Integration into DRAGON
MAX.S2.b: NetFPGA as a GENI Resource Plan
MAX.S2.c: DRAGON Aggregate Manager Enhancement Design
MAX.S2.d: Common Control Framework Design
MAX.S2.e: User Support
MAX.S2.f: DRAGON Aggregate Manager Documentation

Quarter 2 (3/31/2010):
MAX.S2.g: NetFPGA as a GENI Resource Implementation
MAX.S2.h: DRAGON Aggregate Manager Enhancement Initial Implementation.
MAX.S2.i: Common Control Framework Design Update
MAX.S2.j: Common Control Framework Implementation
MAX.S2.k: Common Control Framework Documentation
MAX.S2.l: User Tool Evaluation and Development Plan
MAX.S2.m: User Support
MAX.S2.n: DRAGON Aggregate Manager Documentation

Quarter 3 (6/30/2010):
MAX.S2.o: DRAGON Aggregate Manager Enhancement Updated Implementation.
MAX.S2.p: DRAGON Aggregate Manager Common Control Framework Integration Plan
MAX.S2.q: DRAGON Aggregate Manager Common Control Framework Integration Implementation
MAX.S2.r: DRAGON Aggregate Manager Common Control Framework Integration Testing
MAX.S2.s: User Tool DRAGON Framework Implementation
MAX.S2.t: User Support
MAX.S2.u: DRAGON Aggregate Manager Documentation

Quarter 4 (9/30/2010):
MAX.S2.v: DRAGON Aggregate Manager Enhancement Performance Testing and Evaluation.
MAX.S2.w: DRAGON Aggregate Manager Common Control Framework Updates
MAX.S2.x: User Support
MAX.S2.y: DRAGON Aggregate Manager Documentation

2. Tasks and Deliverables
a) Virtualization Servers Integration into MANFRED
This task will include the integration of the PC/NetFPGA systems into the DRAGON network environment. These systems will be connected to the edge of the DRAGON network and will be available as a resource for GENI researchers. These NetFPGA cards have multiple Gigabit Ethernet interfaces which will be connected to the DRAGON network to facilitate multiple topologies in support of experiment configurations. The PC/NetFPGA systems will be made available for use as a PlanetLab node or as standalone system with access to NetFPGA card and programming interface. Other organizations in the

ProtoGENI cluster are working on techniques to virtualize the NetFPGA resource. This capability will be tested and incorporated as possible into the DRAGON environment.

The Quarterly Milestones for this task are defined below.
- Quarter 1 (12/31/2009):
  i) (S2.a)<u>NetFPGA Integration into DRAGON</u>. Complete the placement and configuration of the NetFPGA systems into the DRAGON network. This will include configuration and integration to allow use of the NetFPGA systems as end-systems connected to DRAGON provisioned network paths. This will not include integration into the general GENI slice/sliver provisioning system. That functionality will be dependent on results from study in item ii below.
  ii) (S2.b) <u>NetFPGA as a GENI Resource Plan</u>. Develop a plan to enable the NetFPGA systems to be generally available as part of a GENI slice/sliver and topology provisioning. This will include a review of the work by ProtoGeni and others on the development of NetFPGA virtualization technologies.
- Quarter 2 (3/31/2010):
  i) (S2.g)<u>NetFPGA as a GENI Resource Implementation</u>. Implement the results of the plan from milestone Task a:Quarter 1:ii above. The expected result is for the NetFPGA systems to be available as MANFRED GENI slice/sliver resource.

b) Enhance DRAGON Aggregate Manager

This task is to enhance the current reference implementation of the DRAGON Aggregate Manager. The objective here is to facilitate the provision of the DRAGON network resources in support of GENI researcher and experiment use. This will include enhancement of the current Aggregate Manager to enable user specification of a topology which includes both compute and network resources. The DRAGON Aggregate Manager will be responsible for authorization and resource verification (topology computation) in advance of resource provisioning in accordance with the user specified topology descriptions. This work will extend the previous DRAGON Aggregate Manager to provide the basis for an extensible control and provisioning framework.

The Quarterly Milestones for this task are defined below.
- Quarter 1 (12/31/2009):
  i) (S2.c) <u>DRAGON Aggregate Manager Enhancement Design</u>. Complete design for the enhancements to the DRAGON Aggregate Manager to include the features described in above task description.
- Quarter 2 (3/31/2010):
  i) (S2.h)<u>DRAGON Aggregate Manager Enhancement Initial Implementation.</u> Complete initial implementation of enhanced DRAGON Aggregate Manager based on design work in milestone Task b:Quarter 1:i above. This initial implementation will focus on user interface and topology specification which combines compute and network resources into a common user request format.
- Quarter 3 (6/30/2010):
  i) (S2.o) <u>DRAGON Aggregate Manager Enhancement Updated Implementation.</u> Complete updated implementation of enhanced DRAGON Aggregate Manager based on design work in milestone Task b:Quarter 1:i above. This updated implementation will extend the work completed in Task b:Quarter 2:i above to include features for more robust user authorization and resource verification (topology computation) techniques.
- Quarter 4 (9/30/2010):
  i) (S2.v) <u>DRAGON Aggregate Manager Enhancement Performance Testing and Evaluation.</u> Conduct performance testing and evaluation of DRAGON Aggregate Manager. Solicit user feedback on use of DRAGON Aggregate Management. Summarize strengths and weakness of DRAGON Aggregate Manager and develop recommendations for future upgrades.

c) Participate in the development of a common GENI Control Framework or set of Interoperable Mechanisms

This task will include working within the larger GENI community to work on development of a common or compatible set of GENI control frameworks. This may include the normalization of the existing GENI control frameworks to a common GENI interface definition, or possibly the development of a common set of mechanisms for individual framework specification. The latter would allow mechanisms such as

translators to be developed to enable cross framework interactions. It is anticipated that the details of the technical solution will be the subject of specially focused GENI working groups consisting of PlanetLab, ProtoGENI, ORCA, ORBIT, and other control frameworks. This task will include participating in these larger discussions to work toward a common GENI control framework.

The Quarterly Milestones for this task are defined below.
- Quarter 1 (12/31/2009):

i) (S2.d) <u>Common Control Framework Design</u>. Work with GENI community to develop an approach for a common control framework and/or other mechanisms to allow interoperation between GENI facilities. Develop initial documentation of this plan in sufficient detail for the various clusters to take implementation action for their respective control frameworks.
- Quarter 2 (3/31/2010):

i)(S2.i) <u>Common Control Framework Design Update.</u> Continue work with the GENI community to develop an approach for a common control framework and/or other mechanisms to allow interoperation between GENI facilities. Update associated documentation.
ii) (S2.j) <u>Common Control Framework Implementation.</u> Develop an initial common framework implementation sufficient for interoperability testing. Conduct interoperability testing with other GENI Facilities to evaluate ability for multiple GENI facilities to interoperate.
iii) (S2.k) <u>Common Control Framework Documentation.</u> Generate a document summarizing the results of interoperability testing and general capabilities for GENI Facilities to interoperate.

d) Integrate enhanced DRAGON GENI Control Framework with DRAGON Testbed
The primary objective of this task is to apply the results of task c above, to the actual DRAGON network and facilities. The common GENI framework, or inter-framework mechanisms, that result from task c will require changes to the current DRAGON Framework and Aggregate Manager. This will include adaptation for the unique set of resources located on the DRAGON network, as well as enhancements to the experimenter facing interface.

The Quarterly Milestones for this task are defined below.
- Quarter 3 (6/30/2010):

i) (S2.p) <u>DRAGON Aggregate Manager Common Control Framework Integration Plan</u>. Develop a design and implementation plan for the DRAGON Aggregate Manager to incorporate the results common/interoperable control framework approach developed in Task c above.
ii) (S2.q) <u>DRAGON Aggregate Manager Common Control Framework Integration Implementation</u>. Incorporate changes to the DRAGON Aggregate Manager based on the results of milestone Task d: Quarter 3: i above.
iv) (S2.r) <u>DRAGON Aggregate Manager Common Control Framework Integration Testing.</u> Conduct testing with updated DRAGON Aggregate Manager and common control framework. Document results and changes needed.
- Quarter 4 (9/30/2010):

i) (S2.w) <u>DRAGON Aggregate Manager Common Control Framework Updates</u>. Incorporate updates and changes to the DRAGON Aggregate Manager based on the results of milestone Task d: Quarter 3 above and user feedback.

e) Improve user access to prototype GENI via enhanced tools
This task will include development of user focused tools to facilitate and enhance the ability and ease with which users can access the GENI DRAGON environment. This will likely include working with other project and cluster developed APIs such as GUSH and RAVEN to ensure they work seamlessly with the DRAGON control frameworks.

The Quarterly Milestones for this task are defined below.
- Quarter 2 (3/31/2010):

i) (S2.l) <u>User Tool Evaluation and Development Plan</u>. Review the available user tools across the GENI facilities and clusters and identify best candidate for integration into the DRAGON facility and control framework.
- Quarter 3 (6/30/2010):

i) (S2.s) <u>User Tool DRAGON Framework Implementation</u>. Incorporate user tools identified in milestone Task e: Quarter 2: i above. into the DRAGON facility and control framework

f) Support increased use of testbed by external researchers

This task will include the outreach and support of external researchers who would like to use the GENI DRAGON facilities. The exact support will be tailored to the individual users and researchers as they are identified.

The Quarterly Milestones for this task are defined below.
- Quarter 1 (12/31/2009):
  i) (S2.e) <u>User Support</u>. Work with and support interested users on use of the DRAGON GENI Facility.
- Quarter 2 (3/31/2010):
  i) (S2.m) <u>User Support</u>. Work with and support interested users on use of the DRAGON GENI Facility.
- Quarter 3 (3/31/2010):
  i) (S2.t) <u>User Support</u>. Work with and support interested users on use of the DRAGON GENI Facility.
- Quarter 4 (9/30/2010):
  i) (S2.x) <u>User Support</u>. Work with and support interested users on use of the DRAGON GENI Facility.

g) Deliver aggregate manager design documentation to GPO

This task will be to deliver design and usage documentation to the GPO for the DRAGON Aggregate Manager. This is expected to include architecture and design documents, configuration and usage documentation, and open source software distributions.

The Quarterly Milestones for this task are defined below.
- Quarter 1 (12/31/2009):
  i) (S2.f) <u>DRAGON Aggregate Manager Documentation</u>. Update the design and installation documents for the DRAGON Aggregate Manager. Provide updated open source software distribution of GENI DRAGON Aggregate Manager and other related software.
- Quarter 2 (3/31/2010):
  i) (S2.n) <u>DRAGON Aggregate Manager Documentation</u>. Update the design and installation documents for the DRAGON Aggregate Manager. Provide updated open source software distribution of GENI DRAGON Aggregate Manager and other related software.
- Quarter 3 (6/30/2010):
  i) (S2.u) <u>DRAGON Aggregate Manager Documentation</u>. Update the design and installation documents for the DRAGON Aggregate Manager. Provide updated open source software distribution of GENI DRAGON Aggregate Manager and other related software.
- Quarter 4 (9/30/2010):
  i) (S2.y) <u>DRAGON Aggregate Manager Documentation</u>. Update the design and installation documents for the DRAGON Aggregate Manager. Provide updated open source software distribution of GENI DRAGON Aggregate Manager and other related software.