

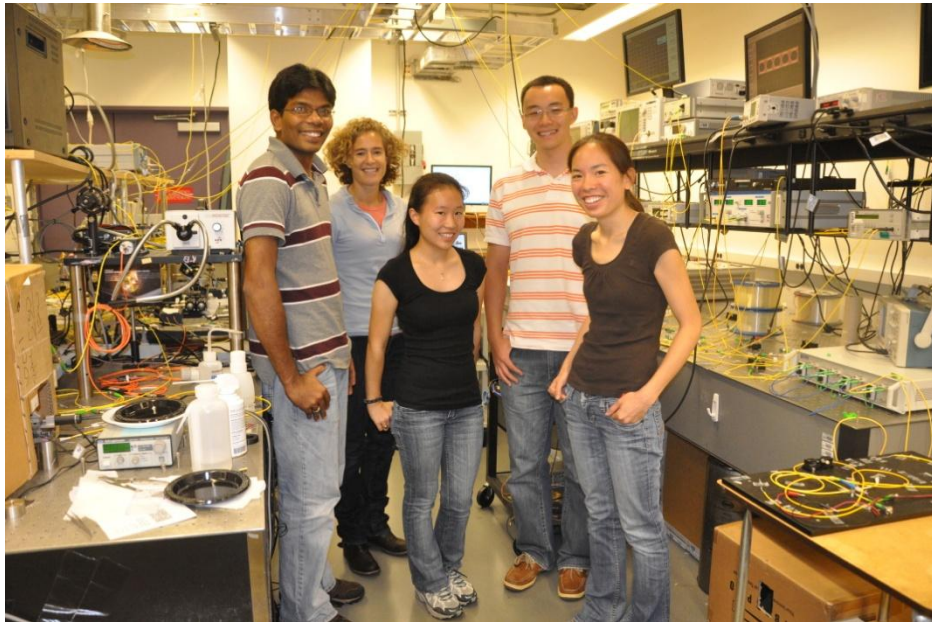
GENI

Global Environment for Network Innovations

GEC 9 ERM Status Report

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“Embedding real-time measurements for cross-layer communications”

Document Revision History

The following table provides the revision history for this document, summarizing the date at which it was revised, who revised it, and a brief summary of the changes. This list is maintained in chronological order so the earliest version comes first in the list.

Revision	Date	Revised By	Summary of Changes
1.0	18 Nov 10	M.S. Wang	Initial draft

Embedding real-time substrate measurements for cross-layer communications

GENI Quarterly Status Report

Project Nr.: 1631

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1. Major accomplishments

During this past quarter, our main accomplishments involved the completion of milestones S2.d, S2.e, S2.f, the submission of the corresponding technical notes, and the demonstration of the main results at GEC8 in July. In addition, we presented our overall spiral 2 achievements [erm_2] in the end-of-the-year review to the GPO over a teleconference. We also defined the Spiral 3 milestones.

The goal of milestone S2.d [erm_6] involved integrating the developed hardware and software resources of UMF to the BEN infrastructure at the RENCi Point-Of-Presence (PoP). Then, as part of milestone S2.e [erm_7], we developed an XML-RPC-based software module within the UMF, which enabled SILO [imf_1] to communicate with UMF through a set of predefined API functions, thereby enabling cross-layer communication. Combining the results of milestones S2.d and S2.e, as well as the efforts of the IMF [imf_1] project, we demonstrated the interoperability of SILO and UMF by demoing a cross-layer optimized digital media streaming application across the BEN network.

Furthermore, as part of milestone S2.f [erm_8], we began plans to expand the UMF into multiple GENI infrastructures. We proposed as a next step to design and develop a more universally deployable version of UMF, called the ERM box, consisting of (a) a suite of software and a NetFPGA to expand optical-layer measurement capabilities; (b) a set of active optical components (SOAs, VOAs, etc) to enable cross-layer control. We then aim to deploy multiple ERM boxes within suitable infrastructure in GENI. Potential GENI infrastructures include the BEN network [ben_1] located in North Carolina and the DRAGON/MAX network located in the greater Washington D.C. area [max_1]. Further, we aligned ourselves with several solicitation 3 proposals that seemed to require the real-time measurement and cross-layer control capabilities offered by ERM.

2. Milestones

The following section discusses the progress made on the milestones for the ERM project.

Milestone S2.a: Prototype UMF Software (completed 12/3/2009)

Design and develop software for prototype implementation of the UMF by means of a NetFPGA, according to the evaluated GENI requirements for real-time measurements from year-1.

We decided to implement the UMF using a NetFPGA Cube. The UMF consists of a UMF SW component (implemented on the general purpose processor) and a UMF HW component (implemented on NetFPGA card). Each component has a defined role in facilitating the UMF to access the networking elements and its measurement data. Additional information, as well as a technical note, on milestone S2.a is available online [erm_1], [erm_3].

Milestone S2.b: Demo software interface from UMF to embedded measurement subsystem (completed 3/4/2010)

We implemented and demonstrated a working software interface between UMF and at least one subsystem that is capable of embedded physical layer measurements, such as bit-error rate measurement or optical power monitoring. The specific subsystem we chose to use is a set of four Polatis [polatis_1] switches from the ORCA-BEN [orca_1] network, from which we retrieved the optical power. In doing so, we have merged our UMF design with the IMF project implementation. By realizing the MH for the Polatis switch and testing the functionality of the XMPP server and PSM, we demonstrated the ability of IMF to obtain real-time optical power measurements from any of the four Polatis switches in the ORCA-BEN network. Additional information, as well as a technical note, on milestone S2.b is available online [erm_1], [erm_4].

Milestone S2.c: Demo UMF in an experimental use-case (completed 6/3/2010)

We demonstrated a working UMF prototype by implementing an experimental use-case at the Lightwave Research Laboratory at Columbia University. We set up a protected lightpath that switches the input signal into a path containing an SOA if the input optical power is below a predefined threshold, and bypasses the SOA otherwise. We compare the eye diagrams and BER curves for the unprotected and protected paths while changing the attenuation of the input signal. We find that when the power of the input signal is above -12 dBm, the SOA introduces a positive power penalty on the lightpath, and it is not useful to use the SOA to compensate for the attenuated power. However, when the input signal falls under -12 dBm, the SOA starts to have an advantage, and we examine a negative power penalty by introducing an SOA into the lightpath.

Milestone S2.d: Integrate UMF with BEN (completed 8/31/2010)

We contributed to the cluster D effort by integrating the UMF subsystem with the Cluster D network substrate. More specifically, we integrated the developed hardware and software resources of UMF to the BEN infrastructure at the RENCi Point-Of-Presence (PoP).

Milestone S2.e: Design and demo XML data exchange software modules (completed 8/31/2010)

We developed a XML-RPC-based software module within the UMF. This module enables SILO to communicate with UMF through a set of predefined API functions, thereby enabling cross-layer communication. We demonstrated the interoperability of SILO and UMF by demoing a cross-layer optimized digital media streaming application across the BEN network.

Milestone S2.f: Plan to integrate UMF within another infrastructure (completed 8/31/2010)

We began plans to expand the UMF into multiple GENI infrastructures. We proposed as a next step to design and develop a more universally deployable version of UMF, called the ERM box. We then aim to deploy multiple ERM boxes within suitable infrastructure in GENI. Potential GENI infrastructures include the BEN network located in North Carolina and the DRAGON/MAX network located in the greater Washington D.C. area. Further, we aligned ourselves with several solicitation 3 proposals that seemed to require the real-time measurement and cross-layer control capabilities offered by ERM.

3. Deliverables made

- ERM Milestone S2.d (August 2010)
- ERM Milestone S2.e (August 2010)
- ERM Milestone S2.f (August 2010)

4. Description of work performed during last quarter

- Organizational work

Working with the GPO (specifically Harry Mussman), details regarding our ongoing work and our contributions to GENI Spiral 2 were released on the GENI ERM Wikipage; this includes quarterly reports and the Milestone S2.d, S2.e, and S2.f technical notes. We have also participated in several Cluster D and GENI IMF meetings through teleconference.

- Integrated UMF with BEN

The UMF, whose architecture is shown in Figure 1, is integrated into the BEN network.

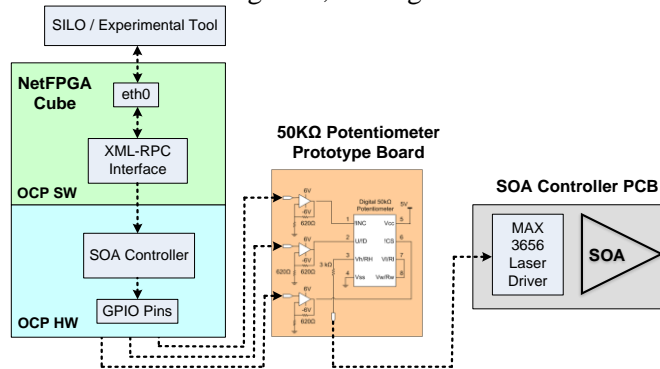


Figure 1. UMF Architecture

Figure 2 shows the physical connections made in the integration process. BEN consists of four PoPs located in North Carolina. The UMF is integrated into the link connecting the UNC PoP and the RENCi PoP. Note that we also connected a variable optical attenuator (VOA) into the path. The VOA is programmable and is used to alter power on the lightpath. This VOA is not controlled by the UMF, but is instead controlled by an external MatLab script. The UMF is then used to adjust for the power fluctuation through cross-layer control.

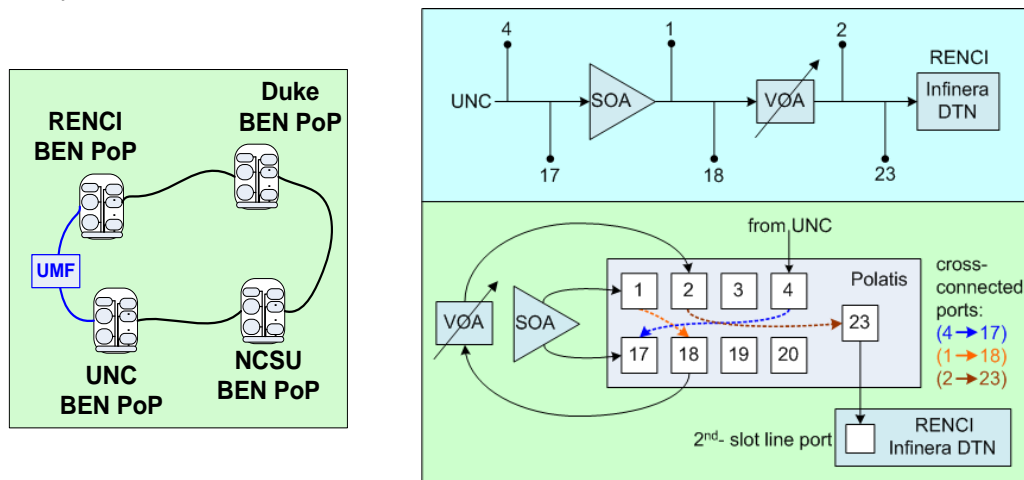
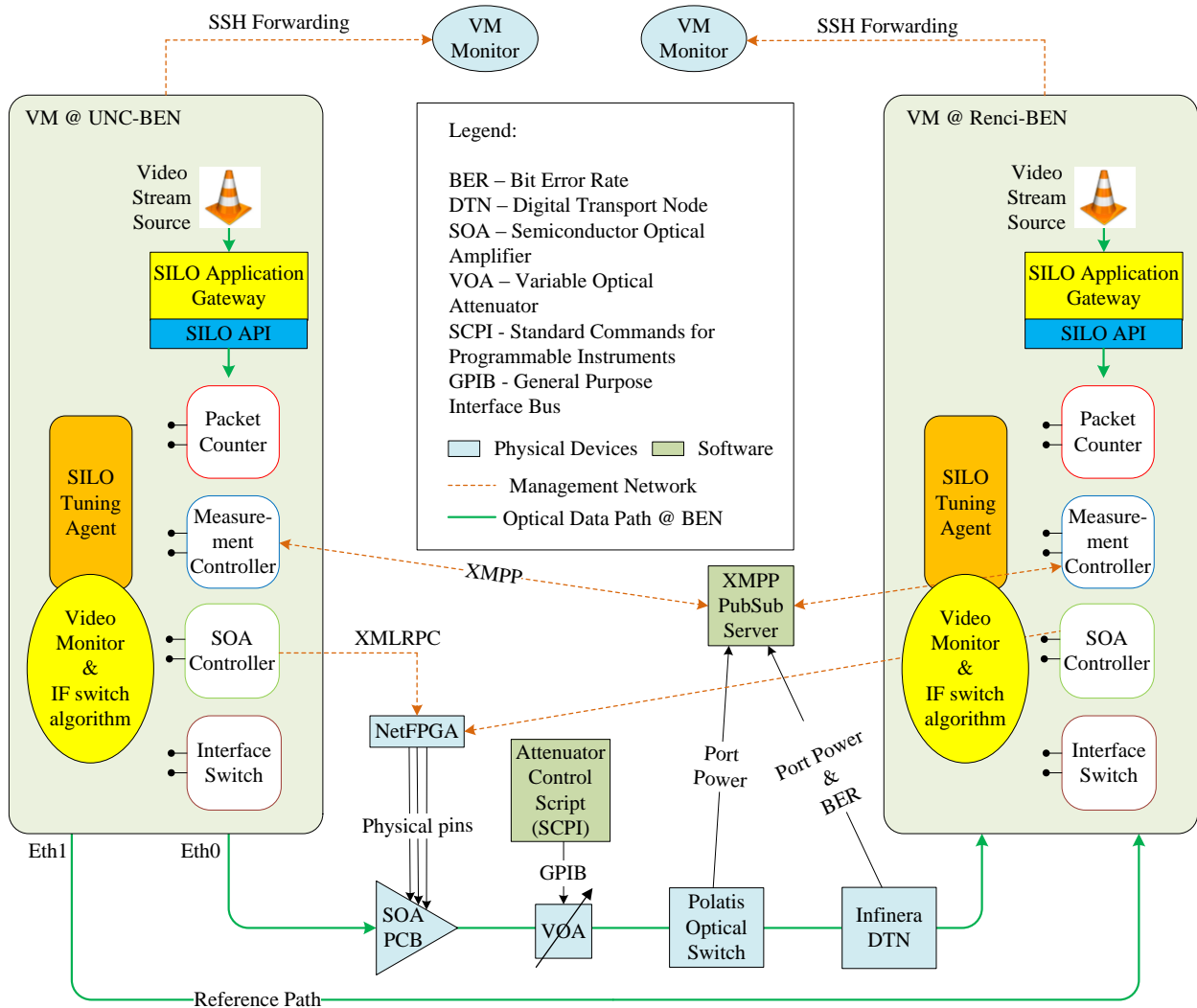


Figure 2. Connecting UMF with BEN

- Demonstration of cross-layer optimized digital media streaming
Figure 3 shows the experimental setup used to demonstrate the interoperability of SILO and UMF.



Note: Reference Path does not exist in the current experiment, SILO switches traffic to the management network.

Figure 3. Cross-Layer Optimized Video Streaming Experiment

The goal of this demonstration is to showcase the ability to run a streaming digital media application across BEN. Combining the results of milestones S2.d and S2.e, as well as the efforts of the IMF project, we aim to demonstrate cross-layer communication among various layers of the Internet protocol stack, from the application layer to the optical physical layer. GENI provides the unique ability to run a real application on a network that supports cross-layer communication at various layers. More specifically, we streamed a video across BEN while adjusting the physical layer. By introducing a controlled error into the network, we have shown the benefits of cross-layer communication.

As Fig 3 shows, a video is streamed from UNC and RENC. When the cross-layer signaling is turned on, it ensures that the video is sent above a guaranteed optical power threshold, even when there is power fluctuation in the physical channel. When the cross-layer signaling is turned off, we see a dramatic degradation in video quality. By comparing the video qualities at the receiving end, we showcase the advantages of our cross-layer communication design.

- Composed letters of support for several solicitation 3 proposals

As part of Milestone S2.f, we began work to extend the unified measurement framework (UMF) to different networking infrastructures within GENI. In order to facilitate this, we participated in the following proposals:

1. GENI Measurement and Instrumentation Infrastructure (GEMINI)

The proposal to develop the GENI Measurement and Instrumentation Infrastructure (GEMINI) offers exciting collaboration opportunities for our ERM project. Our ERM efforts involve providing an abstraction of physical layer measurements (i.e. optical power and BER) through a unified interface, and utilizing these measurement capabilities to allow for cross-layer control and optimization. We understand that GEMINI aims to serve the dual roles of support for managing and monitoring the substrate for infrastructure providers and operations centers, but will also provide experimenters with the tools they need to analyze their experimental results or to adapt system behavior at runtime. The work being done in ERM to provide physical-layer measurement and cross-layer control can potentially extend the range of performance metrics supported by GEMINI and offers a nice counterpart to its existing goals.

2. RENCI's GENI Racks

These GENI racks would be connected via multiple static VLANs to NLR (and potentially Internet2) to allow the creation of various topologies. The racks will be deployed over a period of 3 years as the solicitation requires. Each rack will be linked to other campuses through the ORCA control framework and national-footprint dynamic circuit networks (e.g., NLR and/or I2). Columbia University is directly connected to NLR via a gateway at 32 Avenue of the Americas. If a GENI Rack is deployed at Columbia, it provides another potential node to expand the reach of UMF.

- Defined Spiral 3 goals

1. Design and develop a robust, universally deployable version of the UMF (called the 'ERM Box') consisting of:
 - a. A suite of software and NetFPGA code to expand the optical layer measurement capabilities
 - b. A set of active optical components (SOAs, VOAs, etc) to enable cross-layer control

The design of this box will integrate the needs and requirements of current GENI infrastructures, instrumentation/measurement platforms, our primary plan is to integrate with PerfSONAR.

[Target date: 6 months.]

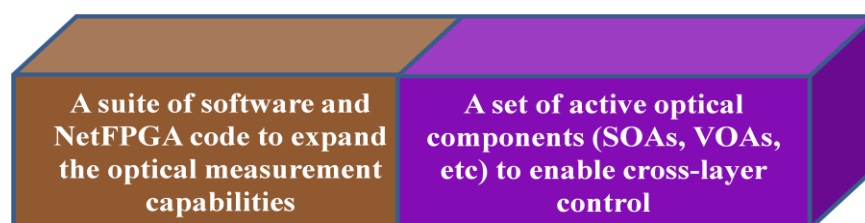


Fig 4. ERM Box

2. Develop simulation environment with networking model incorporating the ERM Box and cross-layer measurement capabilities enabling experimental modeling in large scale networks.
[Target date: 6 months.]

3. Deploy multiple ERM boxes (between 2 to 4) within suitable GENI infrastructures that can most take advantage of real-time optical layer measurement and cross-layer control. Potential GENI infrastructures include the BEN network located in North Carolina (where we have already been working during spiral 2) and the DRAGON/MAX network located in the greater Washington D.C. area.
[Target date: 12 months.]

4. Conduct an experiment using this ERM-enabled network involving non-GENI researchers. We have already initiated these projects with collaborators at AT&T Research and Lucent/Alcatel. Potential issues that ERM could address are:
 - a. Restoration and Protection: IP-layer restoration is becoming an important issue for the networking community. We can utilize the ERM box to monitor the IP traffic on the WDM network. ERM box can be enabled with functionalities to restore and protect IP router failures, by intelligently rerouting the traffic on the optical layer.
 - b. Energy Efficiency: The increasing number of networking devices in the present day Internet is causing a significant rise in the energy consumption. The ERM box can be used to enable traffic engineering (TE) based on energy-efficient routing. For example, the routing algorithm could minimize the number of IP ports used by enabling optical bypass.
 [Target date: 12 months.]

5. Activities and findings

5.1 Digital Media Streaming Experimental Results

Figure 5(a) shows the received power level of a low QoS video, which does not have the cross-compensation activated. The range of power fluctuation is 11 dB (between -11 to -22 dBm). This is the attenuation that is set by the VOA. Figure 5(b) shows the received power level of a high QoS video, which has cross-layer compensation turned on. In this case, the power level is ensured to always fall within a smaller range of fluctuation. The full range of power fluctuation is around 3 dB (b/w -10 to -13 dBm) for the majority of the time.

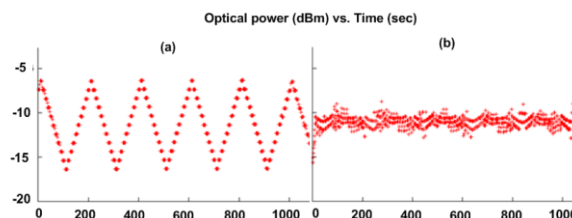


Fig. 5. Received power of (a) low QoS and (b) high QoS video

6. Project participants

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7. Publications (individual and organizational)

- M.S.Wang, B. G.Bathula, C.P.Lai, C. Chen, and K. Bergman, “Integrate UMF with BEN (Project Nr. 1631, Milestone S2.d),” August 2010.
- M.S.Wang, B. G.Bathula, C.P.Lai, C. Chen, and K. Bergman, “Design and Demo XML Data Exchange Software Modules (Project Nr. 1631, Milestone S2.e),” August 2010.
- M.S.Wang, B. G.Bathula, C.P.Lai, C. Chen, and K. Bergman, “Plan to Integrate UMF within Another Infrastructures (Project Nr. 1631, Milestone S2.f),” August 2010.

8. Outreach activities

We participated in the First Workshop on the perfSONAR Network Measurement Infrastructure (July 7-9, 2010 in Arlington, VA). At this workshop, we reached out to the community and highlighted our embedded real-time measurements and cross-layer efforts at the breakout sessions. Further, we discussed potential to use physical layer measurements to deal with disaster management of L1 infrastructure.

9. Collaborations

- **Cluster D IMF Project:** Renaissance Computing Institute (RENCI), North Carolina State University (NCSSU), and University of Houston, Ilia Baldine, Shu Huang, Rudra Dutta, Deniz Gurkan Anjing Wang, and Debjyoti Majumder

We work closely with Ilia Baldine of RENCI, Rudra Dutta and Anjing Wang of NCSSU, and Deniz Gurkan and Debjyoti Majumder of the University of Houston in the scope of the IMF project. More specifically, we worked with Anjing to integrate SILO with UMF and setup at the cross-layer optimized video streaming demonstration for GEC8. Further, we worked with Ilia and Shu to physically integrate UMF into the RENCI PoP of BEN. We hold a phone meeting once every 1-2 weeks, and we communicate with email using an IMF mailing list.

- **GENI LEARN Project:** University of Houston, Deniz Gurkan, Debjyoti Majumder
We collaborated with Deniz and Debjyoti of the LEARN Project [learn_1] in learning more about how perfSONAR can be integrated into our work in ERM and IMF. Both ERM and LEARN sent representatives to participate in perfSONAR conference from July 8-9.

- **GPO:** Harry Mussman

We closely cooperated with Harry Mussman to create an updated version of the GENI Wikipage and submitting milestone reports and quarterly status reports.

10. Other Contributions

none

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