G E N I

Global Environment for Network Innovations

Milestone S2.k
List of Measurement Handlers for GENI

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"Programmable Measurements over Texas-based Research Network: LEARN"

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1 Document Scope

This section describes this document's purpose, its context within the overall GENI project, the set of related documents, and this document's revision history.

1.1 Executive Summary

This technical note presents the results obtained in work package "Milestone LEARN: S2.k List of measurement handlers for GENI" of Project Nr. 1733, "Programmable Measurements over Texas-based Research Network: LEARN" [LEARN_1]. The purpose of this milestone is to establish a list of measurement handlers that are needed for commercial transport and measurement equipment that will be used in GENI. The document is based on the result of the Data Plane Measurements project (Project Nr. 1653).

Measurement handler software (MHS) delivers the access mechanisms and the middleware to retrieve physical layer measurements from network elements. In this respect, the MHS contains the low level mechanisms and logic necessary to interface with substrate measurement functions and in GENI-Integrated Measurement Framework (IMF) [IMF_1] plays the role equivalent to device driver in an OS. The access mechanisms can be command line interface, TL1, telnet login, SNMP, and RS-232 serial communication. The middleware functionality delivers the data types and parameters of physical layer measurements from the network element.

A MHS has been delivered for the Infinera DTN during milestone S2.j [LEARN_2] by the LEARN project in collaboration with Columbia University and BEN.

A proposed list of measurement handlers that would enable access to physical layer measurements on various GENI infrastructure networks is presented based on the results of the substrate physical layer measurements analysis during the Data Plane Measurements project [D_MEAS_1]. This report is based on information gathered by the GPO on available substrate on each cluster.

1.2 Related Documents

The following documents are related to this document, and provide background information, requirements, etc., that are important for this document.

1.2.1 GENI Documents

Document ID	Document Title and Issue Date
GENI_QSR_D_MEAS-v5	4Q08 Status Report
GENI-INF-PRO-S1-CAT-01.5	GENI Spiral 1 Substrate Catalog
GENI_MS2_DMEAS_February09	DMEAS: Document Embedded Measurement Capabilities
GENI_MS3_DMEAS	DMEAS: Identify External Measurement Equipment

1.3 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	13 Jul 10	D. Majumder	Initial draft
2.0	18 Jul 10	D. Gurkan	Revision

2 Embedded Measurements Accessible via a Measurement Handler Software

As documented in Spiral-1 projects Data Plane Measurements [D_MEAS_1] and Embedded Real-time Measurements [ERM_1], embedded measurements refer to available measurements from substrate network elements such as ROADMs, routers, and switched. The documented capabilities are briefly outlined here to indicate how a Measurement Handler Software (MHS) can be used to access these measurements.

Ciena CN 4200[ciena09_1], Fujitsu 7500 [fujitsu09_1] and Infinera DTN [inf09_1] are some of the instruments that are used in some of the substrate technologies. Table 1 gives the embedded measurement capabilities that are available on these instruments, the remote connectivity and programming tools that are available on these instruments. The remote connectivity can be leveraged using Ethernet based craft interface, RS-232, SNMP and TL1. Several remote programming tools are available with these instruments for local and remote node access.

Cluster-based substrate technologies are listed to indicate where a MHS can be written to access the physical layer measurements.

Cluster B

i) Mid Atlantic Network

Refer to Section 3.5 – Mid Atlantic Network: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

- Layer 1 equipment (AdvaOptical Networking) provides access to optical performance monitoring data, FEC counters (only for 10 G transponders), and SNMP traps for alarm monitoring

➔ MHS – ADVA Optical Networking boxes

- The DRAGON network also has a perfSONAR active measurement point deployed at https://perfsonar.dragon.maxgigapop.net.

ii) GpENI

Ciena CN 4200 is a box available on this network. The measurement capabilities of Ciena CN 4200 are listed in Table 1.

➔ MHS – Ciena CN 4200 boxes

Model	Measurement Parameters	Network management and Remote Connectivity	Remote Programming Tools
Ciena - CN 4200	▪ Bit error rate. ▪ Optical power. ▪ Protocol specific performance monitoring like Remote Monitoring (RMON) for Ethernet connections. ▪ Performance monitoring on all client and network services.	Remote programmability of both ports and connections. Two (2) 10/100BaseT ***Ethernet*** ports for remote connectivity, access to node level HTTP interface and access to SNMP agent SNMP v1 (RFCs 1155-1157), SNMP v2c, SNMP v3, CLI, Telnet, HTTP, FTP, ***RS-232*** serial port for local craft access Web-Based GUI, CLI, TL1, and Trilingual SNMP (v1, v2c, and v3). Transaction Language 1 (TL1) through a TCP/IP telnet connection using the MGMT (Management) interface port or by way of a Neighbor Discovery Protocol (NDP) optical connection to the NE. Command Line Interface (CLI) using the CONSOLE interface port, or by way of a telnet session using the MGMT (Management) interface port, or by way of an NDP-enabled optical connection to the NE. Simple Network Management Protocol (SNMP) using the MGMT interface port or by way of an NDP-enabled optical connection to the NE. Hypertext Transfer Protocol (HTTP) using the MGMT interface port or by way of an NDPenabled optical connection to the NE. Following HTTP browser versions are supported: FireFox 1.5.0, Mozilla 2.0.0.3, Internet Explorer 6.0, Netscape 4.7	*ON-Center Network Control System* ▪ Manages services ▪ Network management capabilities such as monitoring performance and health of the network ▪ Automation
Fujitsu - F7500	Optical performance monitoring, wavelength management, lightpath circuit tracking, topology discovery and display SONET PM Gigabit Ethernet PM	TL1 over TCP/IP, TL1 over OSI Simple Network Management Protocol (SNMP) Ethernet Local Area Network (LAN) cable or RS-232 serial cable	NETSMART 500 craft user interface NETSMART 1500 EMS NETSMART 2000 network design and planning tool *GUI via NETSMART 1500 EMS and NETSMART 500 craft system for local and remote node access*
Infinera DTN	Full digital access to the optical layer. Full digital performance monitoring. Fault management.	SNMP TL1 interface Ethernet- based craft interface Remote connection via Data Communications Network (DCN) Remote connection via the in-band management channel carried by the Optical Supervisory Channel (OSC)	Graphical Node Manager

Table 1: Measurement capabilities and remote connectivity of CN 4200, F 7500 and Infinera DTN.

iii) Enterprise GENI

Refer to Section 8.5 – Enterprise GENI: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

OpenFlow is used to gather statistics at a per flow entry granularity on the routers/switches directly. Users will need to operate an OpenFlow controller to control forwarding decisions in the network. This allows for complete control over L2/L3 forwarding decisions, including experimental protocols which are not IP based.

➔ No MHS recommendation.

iv) SPP Overlay

Refer to Section 9.5 – SPP Overlay: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

- SPP Overlay will implement the standard PlanetLab mechanisms for auditing outgoing traffic. In addition, the core components provide a large number of low level traffic counters that will be accessible to users and can be used to generate real-time charts of traffic associated with a slice
- NetFPGA is a programmable hardware. Various measurements should be possible using NetFPGA. However, SPP Overlay group did not specify any specific measurements in their documentation.

➔ No MHS recommendation.

v) Planet Lab

There is no information on physical layer measurements available from substrate network elements.

➔ No MHS recommendation.

<u>Cluster C</u>

i) CMU Testbeds

Refer to Section 6.5 – CMU Testbeds: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

CMU testbeds have standard machine monitoring like interface monitoring, tcpdump/pcap, nagios-style monitoring of machine availability, etc.

➔ No MHS recommendation.

ii) Proto-GENI

Refer to Section 10.5 – Proto-GENI: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

- Ethernet switches have basic packet counters, and can be configured to "mirror" traffic between ports for collection purposes. The PCs will be able to use standard measurement and capture tools, such as tcpdump.
- NetFPGA is a programmable hardware. Various measurements should be possible using NetFPGA. However, Proto-GENI group did not specify any specific measurements in their documentation.

➔ No MHS recommendation.

iii) Programmable Edge Node

Refer to Section 11.5 – Programmable Edge Node: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

The measurement in PEN can be done on either x86 or network processor (NP). Measurement metrics that can be obtained on network processor are primarily flow statistics, including start-of-flow timestamp, current timestamp, packet count for each direction (host to NP and NP to host), byte count for each direction and the flow tuples. In addition physical NP ports statistics including number of octets, the number of unicast/multicast/broadcast packets, and the numbers of packets of different size intervals that have been sent and received by each physical port can also be measured.

➔ No MHS recommendation.

iv) Measurement System

Refer to Section 12.5 – Measurement System: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

Measurement system enables the users to capture packets associated with their experiments. The measurement systems will also generate a set of system utilization measurements that will be available via SNMP and activity logs that will be available via syslog.

➔ No MHS recommendation.

v) On-time measure

- Provide GENI community with a shared measurement service for provisioning on-going and on-demand measurement requests
- To be deployed on testbeds aimed at “clean-slate” re-design of the Internet to overcome limitations of current Internet
  - E.g., ProtoGENI testbed for Internet-scale research experiments, GENI Meta Operations (GMOC) that monitors GENI facility status

- OnTimeMeasure-GENI Software to perform centralized and distributed measurement orchestration and provisioning of active measurements
- Measurement service that uses OnTimeMeasure-GENI software in GENI experiments to enable:
  - Network paths monitoring
  - Network weather forecasting
  - Network performance anomaly detection
  - Network-bottleneck fault-location diagnosis

➔ MHS for substrate equipment towards creation of a deeper monitoring capability when researchers need all-layer measurements; e.g., during a troubleshooting session.

vi) LAMP (Leveraging and Abstracting Measurements with perfSONAR)

The project will create an instrumentation and measurement system, based on perfSONAR, for use by experimenters on ProtoGENI. The project will collaborate on a plan to develop a common GENI instrumentation and measurement architecture with an emphasis on providing a common but extensible format for data storage and exchange. The project will work to develop a representation of GENI topology to be used to describe measurements and experiment configuration, also based on perfSONAR. The project will collaborate with related GENI measurement and security projects (e.g. University of Wisconsin's Instrumentation and Measurement for GENI) on a common GENI instrumentation and measurement architecture.

➔ No MHS recommendation: However, we are collaborating with perfSONAR group to create the interface between MHS and the perfSONAR architecture for visualization, analysis, and a more integrated access to the physical layer measurements.

vii) S3MONITOR (Scalable Monitoring)

Provide monitoring information (especially network state information) to ProtoGENI system administrators and experimenters. It supports deployment of sensor pods on multiple ProtoGENI nodes and provide ProtoGENI system state in real-time.

➔ No MHS recommendation.

viii) LAMP (Leveraging and Abstracting Measurements with perfSONAR)

No substrate network elements.

➔ No MHS recommendation.

Cluster D

i) BEN

- *Polatis 32 fiber Reconfigurable Optical Switch:*

Refer to Section 5.5 – BEN: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

It supports optical power measurement. A MHS [IMF_1, LEARN_2] extracts the optical powers from specific ports. ERM implemented and demonstrated a working software interface between UMF and at least one subsystem that is capable of embedded physical layer measurements, such as optical power monitoring [ERM_2]. The specific subsystem used is a set of four Polatis switches [polatis_1] from the ORCA-BEN [orca_1] network, from which optical power was measured. Real-time optical power measurements was obtained from any of the four Polatis switches in the ORCABEN network by the MHS for the Polatis switch and testing the functionality of the XMPP server and Publish-Subscribe Module (PSM).

Polatis - 20 directional optical power monitors (OPM) as specified in the table 2.

Fiber #	Input OPM?	Output OPM?	Fiber #	Input OPM?	Output OPM?
1	Yes	Yes	17	Yes	Yes
2	Yes	Yes	18	Yes	Yes
3	Yes		19		Yes
4	Yes		20		Yes
5	Yes		21		Yes
6	Yes		22		Yes
7	Yes		23		Yes
8	Yes		24		Yes
9			25		
10			26		
11			27		
12			28		
13			29		
14			30		
15			31		
16			32		

Table 2: Polatis 20 directional optical power monitors (OPM)

- Input optical power monitors measure light entering the switch
- Output optical power monitors measure light exiting the switch

- No optical power monitors on fibers 9-16 and 25-32
- Support for Ethernet interface, serial RS-232 interface, SNMP and TL1

- *Infinera Digital Transport Node (DTN) :*

  The measurement capabilities of Infinera DTN are listed below:

  - Full digital access to the optical layer.
  - Full digital performance monitoring.
  - Fault management.

These measurements are embedded into the nodes, and are available to the GENI researcher's access through a Measurement Handler Software (MHS) as defined in the milestone documents of LEARN [LEARN_2]. MHS is a set of Perl scripts that enables one to obtain real-time optical measurements (bit-error rate (BER) and optical power) from performance monitoring devices like the Infinera Digital Transport Node (DTN). These measurements in turn would be used by the IMF project to further enable cross-layer experiments in optical networks.

ii) DOME

Refer to Section 7.5 – DOME: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

When the computers come up they do a self-check of their health and log the results to UMass server. Once running, the computers on the buses continuously attempt to report their GPS coordinates so that we can determine a computer is running and track the bus's location. The measurement metrics includes SSIDs discovered, whether a bus could communicate with the mesh or other buses, throughput information, etc. The control of the devices has now been added to the GENI experiments, and the GENI researchers are free to measure whatever they find useful. The information for 802.11 includes available SSIDs and BSSIDs, signal strength, noise level, and type of security that may be enabled. Since both the raw PCI device and root access is available, all traffic, including beacons, can be recorded using standard tools such as tcpdump. With respect to the GPS device, both interpreted data and access to the raw sentences will be available.

➔ MHS can be written for the embedded measurements available in mobile nodes in the forms of signal strength and noise levels as well as access points.

iii) Vise

Refer to Section 13.5 – Vise: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5. Each sensor measures attributes of its physical surroundings. The raw reflectivity and voltage data gathered by the radar is stored in NetCDF files.

➔ No MHS recommendation.

iv) Kansei Sensor Networks

Refer to Section 17.5 – Vise: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

The Kansei health management service, called 'Kansei Doctor', is an autonomous health service, periodically measures the number of available nodes, their health, radio link quality and other networking metrics relevant for sensor networks. Kansei also provides storage space for users to log their custom experimental data, and it has user interaction services such as data/command injection.

➔ MHS can be written for the embedded measurements available in mobile nodes in the forms of signal strength and noise levels as well as access points.

Cluster E

i) WiMax

Refer to Section 14.5 – WiMax: Measurement and Instrumentation of Spiral1 substrate catalog, document id GENI-INF-PRO-S1-CAT-01.5.

WiMax plan to use features of the ORBIT measurement library for collecting real-time measurements for experiments. The library will run on the GBSN controller and record per flow or per packet measurements and maintain databases for each experiment, and make it available through the ORBIT experiment control portal. The framework will handle both Layer 2 and 3 measurements. The collection library will aggregate the measurements and send them to a collection server running in the OMF management system.

NEC WiMax Base station features are listed in the table 3. The Phy, MAC and networking layer information can be retrieved and the information might be useful for researchers.

PHY	**Access mode**	SOFDMA/TDD
	Frequency	2535 ~ 2605 MHz
	DL:UL ratio	35:12, 26:21, 29:18
	Channel BW	10 MHz , 8.75 MHz
	FFT size	1024, 512
	Frame duration	5ms
	TX output Power	35dBm (max)
	# of sectors	3
MAC	**Head compression**	PHS
	ARQ	HARQ/CC, ARQ
	MBS support	Single BS, multiple BS-MBS
	Resource management	Power control, mode control (idle, sleep etc.)
Networking	**IP protocols**	IPv4, IPv6
	Bridging/Routing	Transparent L2 switch, Bridging
	Packet handling	802.1Q VLAN, PHS**)

Table 3: NEC WiMax Base station features

➔ MHS can be written for the embedded measurements available in mobile nodes in the forms of signal strength and noise levels as well as base stations.

Disclaimer: The summary of substrate technologies available in GENI's substrate infrastructure given in this section does not raise the claim of completeness. GENI working group members are invited for further discussions. Any information about additionally, current or future, available at the substrate level should be sent to the authors to be included in future revisions of this document.

3 Summary of Recommended Measurement Handler Software Development

Table 4 summarized all recommended MHS integrations for the GENI substrate:

Project name/Cluster	MHS recommendation and description
Mid Atlantic Network / B	MHS – ADVA Optical Networking boxes
GpENI / B	MHS – Ciena CN 4200 boxes
On-time Measure / C	MHS for substrate equipment towards creation of a deeper monitoring capability when researchers need all-layer measurements; e.g., during a troubleshooting session.
LAMP / C	No MHS recommendation: However, we are collaborating with perfSONAR group to create the interface between MHS and the perfSONAR architecture for visualization, analysis, and a more integrated access to the physical layer measurements
DOME / D	MHS can be written for the embedded measurements available in mobile nodes in the forms of signal strength and noise levels as well as access points.
Kansei Sensor Networks / D	MHS can be written for the embedded measurements available in mobile nodes in the forms of signal strength and noise levels as well as access points.
WiMax / E	MHS can be written for the embedded measurements available in mobile nodes in the forms of signal strength and noise levels as well as base stations.

Table 4. Summary of all MHS recommendations.

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