

E-Center: A Collaborative Platform for Wide Area Network Users

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Abstract: The E-Center is a social collaborative web-based platform for assisting network users in understanding network conditions across network paths of interest to them. It is designed to give a user the necessary tools to isolate, identify, and resolve network performance-related problems. E-Center provides network path information on a link-by-link level, as well as from an end-to-end perspective. In addition to providing current and recent network path data, E-Center is intended to provide a social media environment for them to share issues, ideas, concerns, and problems. The product has a modular design that accommodates integration of other network services that make use of the same network path and performance data.

1. Introduction

Frequently, user expectations for performance of data movement across wide-area networks exceed the actual results achieved, often by a wide margin. The user is typically left wondering what the problem is, or even how to investigate it. The user's general instinct is to suspect that his sub-optimal performance is tied to problems or limitations across the network path he is using. Unfortunately, his network path is likely to cross multiple, administratively-independent network domains, with network equipment and technology varying by domain. The emerging perfSONAR[3] network monitoring framework offers opportunities to gather network monitoring and measurement data within each network domain along his network path. However, data collected within one domain is disjoint from data being collected in other domains. The user is likely to have difficulty finding where the data is

located, and then encounter access issues to get at it. What the user really desires is a central location where he can retrieve wide-area network monitoring and performance data on his network path. That central location would optimally present his network path data in a coherent manner that's understandable him, and provide levels of detail adjustable to his interests. Preferably, he would also like to be able to get help or advice at that same location.

The E-Center project, funded by Department of Energy's Office of Science, is designed to become a centralized collaborative platform for wide area network users. E-Center is intended to collect and display network monitoring and performance measurement data on the user's wide-area network path. E-Center has been designed to make that data easily accessible, and presented in a manner that the user will readily comprehend. Functionally, E-Center can be considered a network path weather map service, with user-friendly tools to help isolate path problems and set appropriate network performance expectations. It is also a place where the user may find answers, identify and isolate any network-related problem, or exchange information with other users or network experts. E-Center is built on top of web services architecture and the open source Drupal Content Management System. Services available at E-Center include advanced network performance visualization utilities, anomalous network events detection, and forecasting services.

E-Center's targeted user communities are the projects, experiments, and collaborations supported by DOE Office of Science funding. As such, the focus of our initial effort and instrumentation has been on network paths crossing the ESnet infrastructure. Project collaborators include Fermilab (lead institution), ESnet (perfSONAR infrastructure & development, Bucknell University (forecasting service), and Ohio Supercomputing Center (anomaly detection).

The E-Center is deployed at <https://ecenter.fnal.gov>.

2. Design

Conceptually, E-Center has two core components, a back end component that functions as the data collection engine for the E-Center service, and a front end component that provides the user interface into that data. The back-end component collects network interface counter data and active performance measurement data available from perfSONAR services tied to network domains, caches the data, and provides rationalization of the data for the front end. The front end provides user AA services, visualization tools for the data of interest to the user, and social media services to support interaction with others. The design is modular, with each component distinct. The REST[4] interface is used for communication and data exchange between the front and back ends.

In addition to the front end and back end components, the E-Center framework accommodates additional services in a modular manner. Currently, there are additional services for network path forecasting, path anomaly detection, and a site-centric network status indication. Each of these services interact with the front end and back end using the same REST interfaces. The design is flexible enough to support other new services as needs develop. Figure 1 depicts the E-Center design.

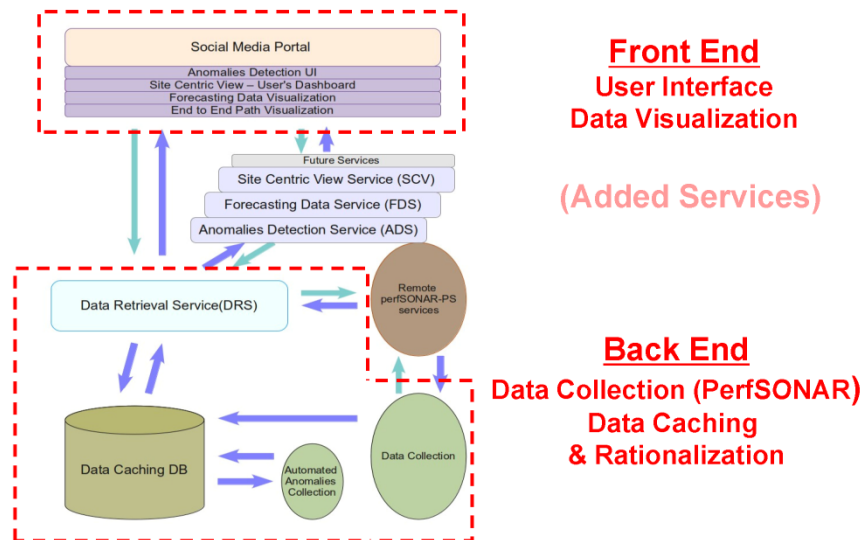


Figure 1: E-Center Design

3. The Data Retrieval Service (DRS)

3.1. DRS design:

The Data Retrieval Service (DRS) is the central control element of the back end service. It directs collection of perfSONAR monitoring and measurement data, caches the data in a MySQL database, and provides a scalable, extendable data retrieval web service for the front end. It is implemented in Modern Perl[5], providing a mature web development framework, and a high degree of compatibility with perfSONAR-PS API. The Gearman distributed Job submission manager is employed for all backend tasks, in order to provide desired level of scalability. Caching of collected network data is based on data sharding, slicing each data set in pieces for fast retrieval. Figure 2 shows the design of the DRS:

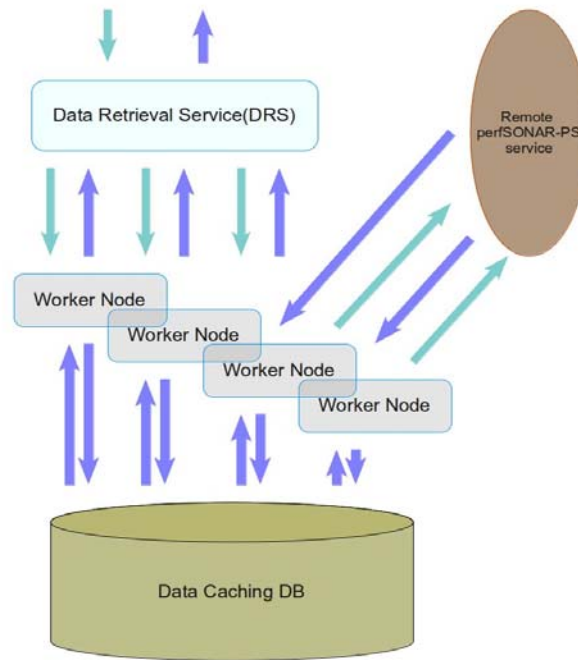


Figure 2: Data Retrieval Service Design

The DRS web service currently supports the following parameters:

- Time period
- Source/Destination IPs
- Source/Destination HUBs
- Data type
- User's provided Traceroute
- Resolution - number of aggregated data points

3.2. *perfSONAR* data collection

There are two classes of *perfSONAR* data, passive monitoring data and active measurement data. The passive monitoring data is essentially SNMP interface data that is regularly collected from the network devices (routers) within a domain by its *perfSONAR* servers. Interface utilization, discards, and errors are routinely collected by the DRS. This passive monitoring data is used to provide the user with a router-by-router and link-by-link perspective of his end-to-end path. Active measurement data involves configured performance measurements, typically from an end-to-end user perspective. The classic active measurement tools are OWAMP[11] (one way delay; packet loss), PingER[10] (round trip delay; packet loss), and BWCTL[9] (Iperf throughput). For E-Center, it was necessary to add

Traceroute[] to the perfSONAR suite of active measurements, in order to determine the network path at any given time.

The DRS data collection process involves collection of perfSONAR metadata on a nightly basis, from the ESnet perfSONAR lookup service, as well as any DOE Labs that offer that service for their site. Current data collection levels amount to ~300 service endpoints, about 25000 unique measurements (metadata entries). The passive monitoring and active measurement data is collected on a continuous basis. The amount of data cached monthly is show below:

OWAMP	60-100M+
SNMP	35-50M
PingER	10-20M
Traceroute	0.6-1.2M
BWCTL	60K-120K

3.3. Hubs

PerfSONAR servers run their active measurements from specific locations on the network. Frequently, a site will have multiple perfSONAR servers, each running its own configured set of active measurements. Within the DOE community, it is common for ESnet to have a perfSONAR server located at a National Laboratory, and conducting full-matrix active measurements to other ESnet perfSONAR servers located at the other National Laboratory. The Lab typically has its own perfSONAR servers located on its perimeter, and conducting active measurements with select other sites of interest. Lab projects may also have their own internal perfSONAR servers as well, running active measurements to other collaboration sites. A user of E-Center services simply wants the best active measurement data available that matches his network path. To accommodate this, the DRS supports the concept of a hub. Figure 3 displays the concept. The user need only select a specific hub (FNAL or BNL, in the figure). The DRS, based on the user's site selection, will determine which perfSONAR servers have the "best" active measurement data for the user's path, and return that data to him. The user is freed from needing any knowledge about which perfSONAR server will provide the best measurement data for him.

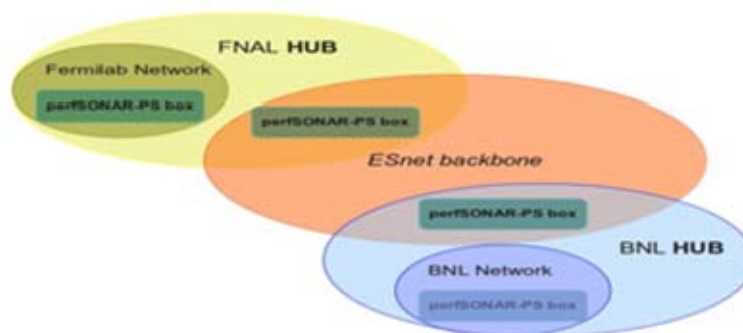


Figure 3: E-Center Hubs

4. User Interface

4.1. Front End Basics

The E-Center front end module is based on the open source Drupal Content Management System (CMS). Drupal is a popular and proven CMS, with wide deployment in the Federal Government, including whitehouse.gov, energy.gov, and recovery.gov. E-Center makes use of key social features to enhance the user experience:

- Data conversations: Issue & data notification system allows conversation & collaboration across DOE networking community.
- Knowledge base: A powerful WIKI with an easy editor for generating and sharing documentation.
- Groups: Lightweight system for sharing conversations & documentations with a task force or working group
- Activity stream: A birds' eye view of important conversations, anomalies, and knowledge base articles customized for each user

User accounts support common OpenID authentication providers such as Google, Facebook, etc. DOE Lab single sign-on systems, based on OpenID or Shibboleth are also supported.

4.2. User-Customizable Dashboard

Users log into a customizable dashboard. By default, the user is provided a site-centric view of the most recent (24 hr) network conditions to other sites. A Site Activity window, using a familiar

activity stream interface, provides information on recent user activities within his account, as well as recent general activities for groups that the user belongs. Tool buttons enable the user to utilize the network path service (weather map), as well as create wiki pages on topics or issues of interest. Figure 4 shows the login dashboard presented to the user.

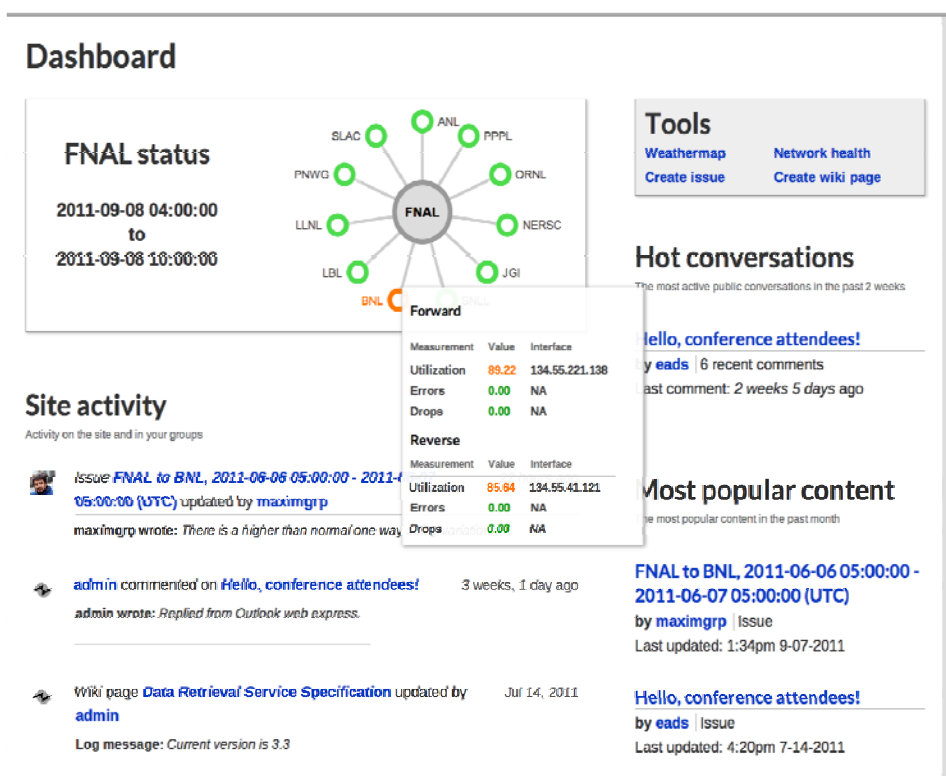


Figure 4: User Login Dashboard

4.3. Network Path Weather Map

The network weather map provides the user with the “conditions” of his network path. The user has the option of either selecting the end sites of interest, or providing a traceroute feed of his network path. If the site selection option is chosen, the user may either click on available sites on a map, or use an adjacent pull down menu. Regardless of method chosen, the front end will query the back end for network conditions along the path that is currently being utilized. Figure 5 shows the path information provided back to the user.

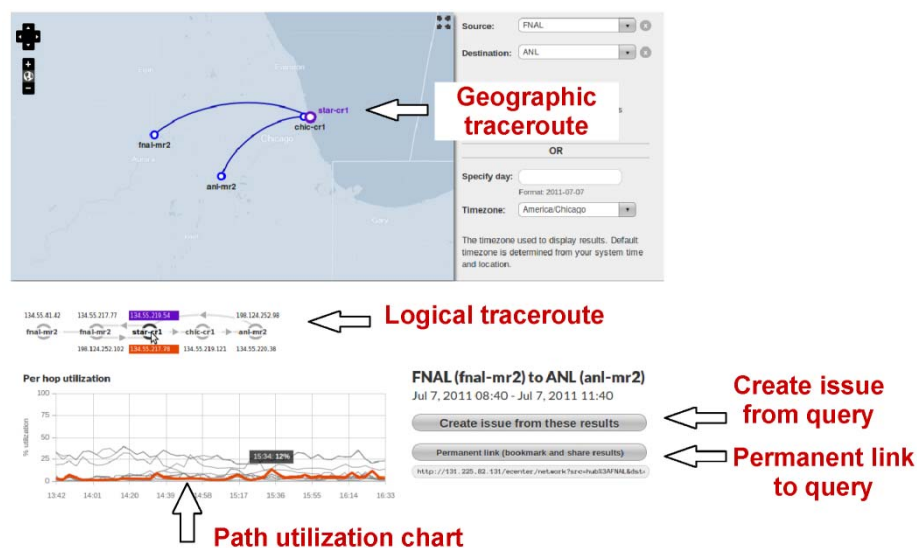


Figure 5: Network Path Conditions

The user is presented with a geographical depiction of his forward (source-to-destination) network path. Directly under the geographical map is what is referred to as the “subway map”, a logical traceroute of both his forward and reverse network paths. Finally, the user is presented with the set of link utilization graphs for all links in both forward and reverse paths. The geographic map, subway map, and utilization graphs are all linked. The user may hover with his cursor over any point on any map or graph and observe the corresponding information highlighted on the other maps or graphs. For example, if a user observes a high utilization spike on one link in the graph, by hovering over that point, the forward and reverse graphs are highlighted, as are the corresponding router hops on the subway and geographical maps. The user is presented with a complete picture of that particular segment of his network path.

Users may want to capture the network conditions that have been provided to them for later analysis or debugging. The Create Issue capability captures the provided network data, and makes it available as a web service.

The network path conditions displayed in Figure 5 reveal the network conditions on the individual links that compromise the user's end-to-end network path. The user is also provided with any active performance measurement data that is being conducted between source and destination. This gives the user an end-to-end network performance perspective as well. Figure 6 shows active measurement data.

End to end results

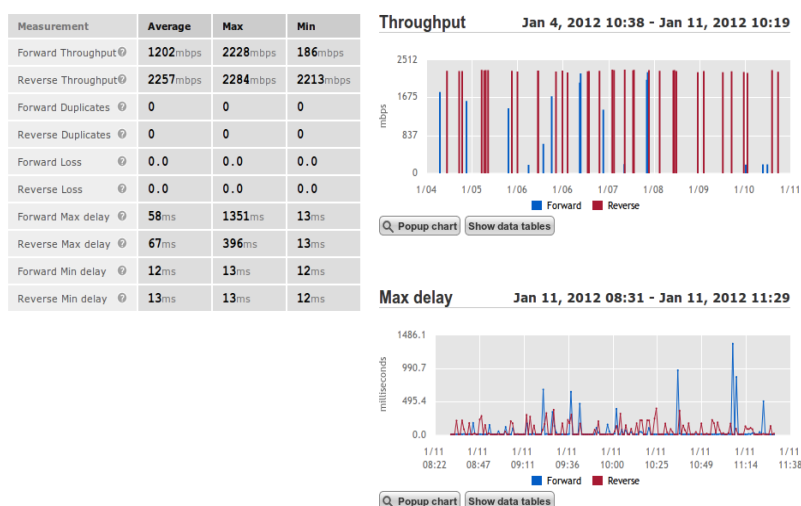


Figure 6: End-to-end Performance Measurement Data

The table on the left shows maximum, minimum, and average measurements for throughput, duplicate packets, packet loss, and latency measurements. The graphs on the right provide forward and reverse throughput and latency information over time. The Create Issue capability captures this information as well.

4.4. Advanced Network Path Services

Two additional advanced network services have been developed to work with E-Center, Anomaly Detection Service (ADS) and Forecasting Data Service (FDS). Each service has been developed as a standalone web service, based on REST, and integrated into E-Center. The E-Center front end will call upon these services, via REST, whenever a user requests them. In turn, these services will retrieve the needed data from the DRS, again via REST, perform their analysis, and then return the results to the front end. The modular design of E-Center makes addition of new services like ADS and FDS straightforward and relatively simple.

ADS was developed by Dr. Prasad Calyam, of the Ohio SuperComputing Center (OSC). It returns all warning and critical anomalies found in end-to-end active measurement data, based on plateau detection parameters. ADS implements both Static Plateau Detection (SDP) and Adaptive Plateau

Detection (ADP) algorithms. When a user requests ADS, he has the option of selecting either algorithm, with SDP being the default. Figure 7 shows samples of SDP and ADP detected anomalies.

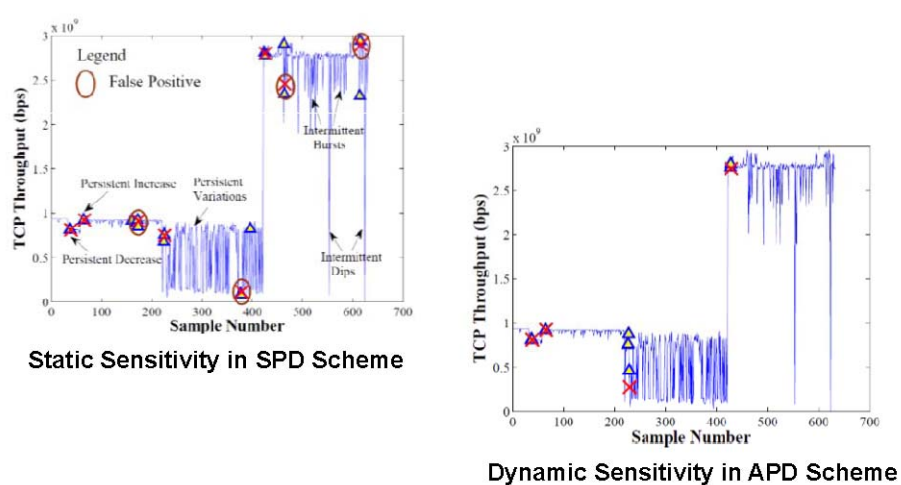


Figure 7: Anomaly Detection Service Results

FDS was developed by Dr. Michael Frey, of Bucknell University, based on forecasting algorithms that he developed. FDS is designed to forecast future values of the perfSONAR data collected by the DRS. Forecast value ranges, with error bands, are returned to E-Center. Figure 8 shows a sample FDS forecast for existing link utilization data of a particular path segment.

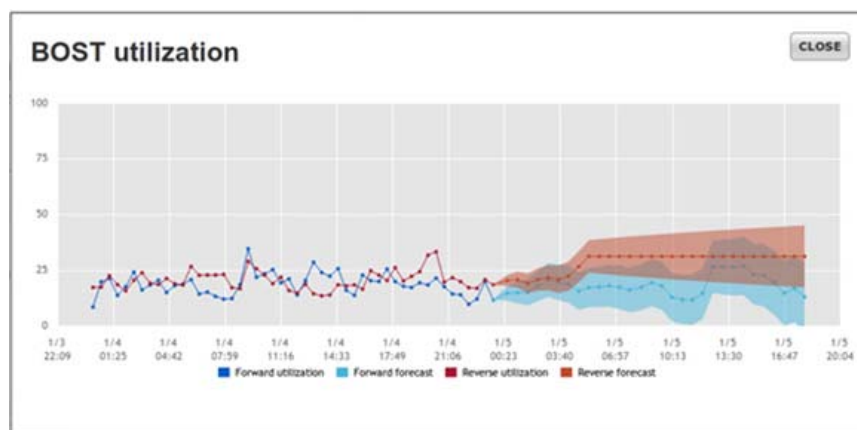


Figure 8: Forecasting Data Service results

5. Current Status & Future Directions

E-Center is in the final year of a three year development cycle. The product is functioning at a production-quality level, and is available for researchers to test and evaluate. As a DOE-funded project, the current scope of E-Center service covers the US DOE National Laboratories, and their R&E network carrier, ESnet. The long term vision for the product is a service with global scope, covering all R&E network communities. In order to accomplish that, a federation capability for E-Center will need to be developed, and other instances of E-Center services deployed within other network domains. The E-Center project team intends to work toward those goals in the coming years.

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