Developing a Scalable SNMP Monitor

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***Abstract*—We present the design of a scalable visual tool for the analysis of high-throughput network traffic, power consumption and cluster-based system resource allocation. The tool explores the possibility of visualizing remote and distributed resources over large distances by using SAGE2, a collaborative framework for large scale display systems. Programmable networks and distributed cloud resources allow accessibility to large amounts of infrastructure data. The tool needs to present the information in an easy-to-understand format for users who do not have any prior systems or network administration experience, but still have an interest in power consumption and network traffic — such as university and city officials. We evaluate the effectiveness of the application through user testing and feedback.**

***Keywords*-network traffic, power consumption, cluster-based system resource allocation, analysis, large displays.**

I. Introduction

Private clouds, GPU clusters, and small scale supercomputers continue to increase the rate of data generation and processing. Science perimeter networks are becoming a necessity as campuses strive to support sharing data between collaborators. The challenge of moving large amounts of data over high bandwidth networks looms over the growing storage concerns that are forcing data transfer nodes to campus borders. Real-time access to scientific data and collaborative workflows on programmable networks are in demand. Advancements in display hardware technology further allow researchers to utilize ultra-high resolution display walls for the analysis of such data. This drives the need for visual analysis tools that are functional for the research and scientific community, and for methods of controlling the flow of data and monitoring the health of a large distributed infrastructure. The goal of this project is to develop an easy to understand visualization of infrastructure data for ultra-high resolution interactive display walls.

II. Related Work and Background

Isaacs et al [1] review the state of the art in performance visualization, and note that much of the system-wide monitoring is low level. They further note that network topologies are constantly changing and increasing in dimensionality to improve parallelism and efficiency, and as a result “existing visualization techniques may quickly become obsolete”. The work closest to ours suffers from scalability issues: Gloriad [2] uses a global view of earth and dynamic flow lines showing the protocol, activity, and application type of international network data flows.

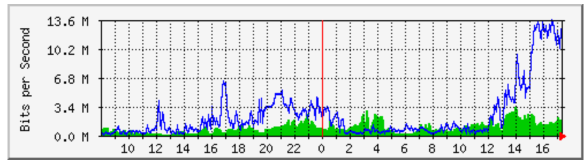

Figure 1. Existing SNMP visualizations.

Our system uses the “Simple Network Management Protocol” (SNMP) , which is a popular protocol for network management. It is used for collecting information from, and configuring, network devices, such as servers, printers, hubs, switches, and routers on an Internet Protocol network. This protocol has been used to develop simple visualizations that focus on tracking the traffic that passes through a router. Current visualizations are limited and only display the average bits in (green) and the average bits out (blue) (Fig. 1).

III. Methods

Our application provides visualizations of data pertaining to logistics (such as inflow rate of a node on a cluster, memory utilization of a process in the system, and so on) of network elements, system application, and framework-specific applications.

A. Design

Our application provides the user with a hierarchical view of the various elements which can be monitored. When the user selects an element, data about that element is visualized in the form of plots, charts and additional visual encodings. Given the variety and vast amounts of data, the user also has the ability to apply filters on the data being displayed. There are 4 main sections in our tool: Applications, Network, System, and Energy. Users can focus their attention on the performance and traffic patterns of a specific machine connected to a particular port.

Applications displays the historical breakdown of server load due to user interaction for each framework application currently running and user interaction methods with respect to that application. Each type of interaction is given its own color so that the user can easily distinguish which action is most often used(Fig. 2).

Network retrieves data from network switches, allowing the user to see information about the current and past network traffic. This application makes it possible to visualize the traffic and interact with high throughput international networks, local network switches and their attached devices from within a single application. The organization of this information in the application is generated programmatically, allowing the system to scale automatically as more data is accessible (Fig. 3).

System displays the overall system load and a list of processes that are currently running on the system. As with the Network section, the dynamic organization of system and cluster information should allow this to be scalable to cloud resources (Fig. 4).

Energy shows the overall power consumption of the devices attached to the power distribution unit, making it easier to establish a schedule or monitor large scale computing with more accurate understanding of cost per visualization from a perspective of electricity usage.

B. Multi-Monitor Wall Display

Advancements in display hardware technology coupled with affordability has led to more and more data intensive problems seeking scalable resolution display systems as potential targets for their solutions. We chose to develop our application using the SAGE2 (Scalable Amplified Group Environment) framework [3] because the framework is geared towards use on large-scale displays, especially multi-monitor wall displays in ultra-high definition. Utilizing SAGE2 as the framework for our application allows us to further leverage the concept of collaborative workflows.

As resource related to network, computation (CPU and GPU), storage and visualization become more distributed, SAGE2 uses web browser technologies to integrate these resources into an environment that supports the utilization of data intensive resources and provides access to non-expert users. SAGE2 also leverages emerging technologies, allowing our application to utilize emerging interaction and visualization trends.

As a SAGE2 application, the tool allows users to navigate through the data by interacting directly using pointers from laptops or mobile devices, in addition to touch screens. Unsurprisingly, we found that pointer movement was the most common interaction on ultra high resolution, large scale display systems.

The knowledge of actual traffic and bandwidth utilization can help the user determine the required transfer speeds in order to keep the system from being bottle-necked by the transfer rate of the selected network. As we transition to Software Defined Networks (SDN) and seek to understand and control connectivity over high-throughput and high-capacity networks, our tool can quickly scale and visualize the topology and connectivity. Utilizing the SAGE2 framework allows us to leverage large scale high resolution visualization systems, cloud solutions and other emerging technologies.

Table I
EXAMPLE RESULTS FROM USER STUDY

Task	User 1		User 3		User 3	
	Success	Time	Success	Time	Success	Time
1	no	35 s	yes	50 s	yes	20 s
2	yes	56 s	yes	33 s	yes	40 s
3	yes	40 s	yes	52 s	yes	1m 37s
4	yes	28 s	yes	24 s	yes	17 s
5	yes	10 s	yes	30 s	yes	31 s
6	yes	16 s	yes	14 s	yes	51 s

IV. EVALUATION

The application was tested on a small group of three non-expert users (first and second year Computer Science Masters students), unfamiliar with the lab infrastructure or with the visual tool. The application was run on a display of size of 1.29m $\times$ 1.09m and a resolution of 1500 pixels $\times$ 1300 pixels. The users were seated directly in front of the display. They interacted with the application through a web interface on a laptop in front of them. The users were given a brief tutorial about how to interact with SAGE2 in general and with the application in particular.

The users were asked to use our tool to perform analysis tasks about the Electronic Visualization Lab (EVL) infrastructure, as follows:

- Find out how many clusters/computers are connected on the EVL network through Switch1.
- Find the summary of network usage for all Orion nodes.
- The virtual reality CAVE2 [4] of EVL is driven by a cluster of computer nodes named lyra-xx, where xx is a two digit number. Find out how many lyra-xx nodes there are and report if any of these do not have any traffic on them.
- Find out how many EVL nodes are offline.
- Find the program that is consuming the highest memory on the host computer.
- What is the most commonly occurring event in SAGE applications?

The task success (whether a task was completed) and time-on-task are presented in Table I, while Table II summarizes these results.

We have further asked the participants to complete a brief questionnaire using a Likert five-scale, to assess the menu flow and visual layout, the color scheme and ease of navigation. For each category, the application was rated between 4.33/5 and 4.66/5.

Figure 2. Historical breakdown of server load due to user interaction.

Figure 3. Network switch data.

Table II
AVERAGE TIME AND SUCCESS RATE

Task No	Average Time on Task	Success Rate
1	35 sec	66%
2	43 sec	100%
3	1 min 3 sec	100%
4	23 sec	100%
5	23.6 sec	100%
6	27 sec	100%

V. DISCUSSION AND CONCLUSION

The results show that our application is reasonably easy to navigate and use. All users were able to complete tasks 2 through 6 in approximately 1 minute or under, and all users but one completed task 1. The exception on task 1 was due to one tester who failed to locate the Applications tab; we believe this was due to the too-high location, at the time, of the tab on the wall display relative to the user's line of sight. All users rated the application favorably.

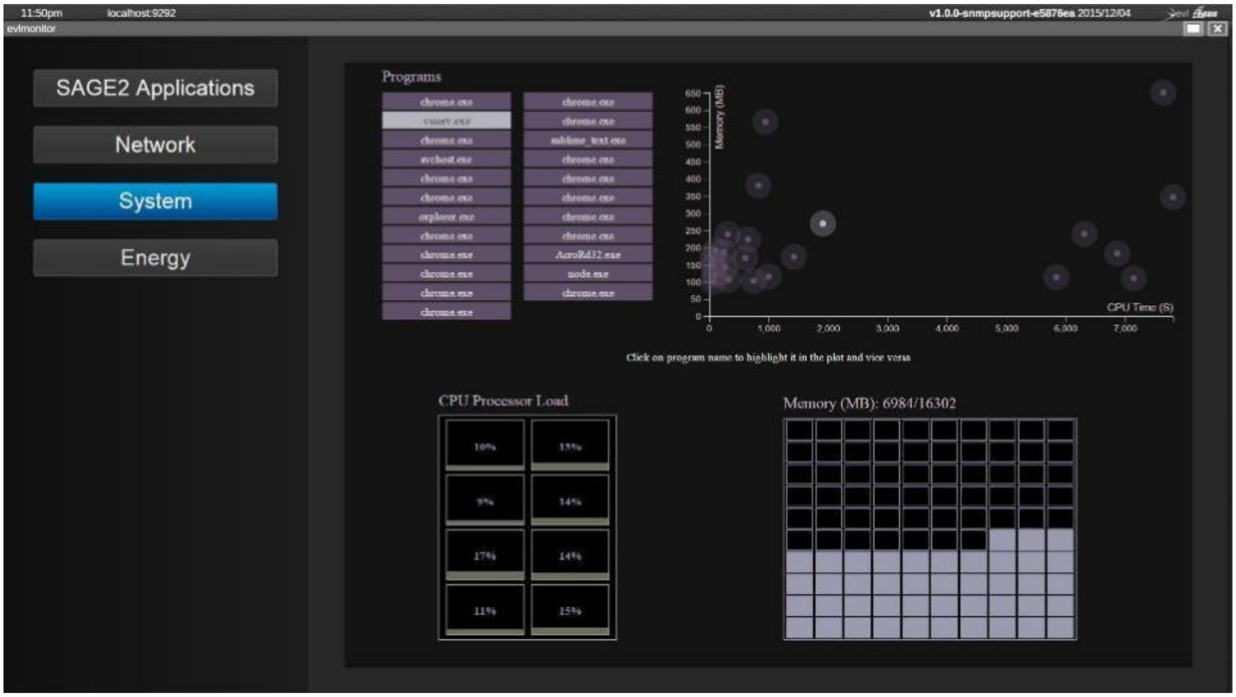

Figure 4. Overall system load and list of processes.

Currently, the application is designed to monitor lab resources and 100G connectivity. The goal is to extend this system to large scale graphics clusters connected to campus border data transfer nodes (DTNs). The DTNs would then have multiple high-throughput paths to collaborators and remote resources. As we transition to Software Defined Networks (SDNs) and seek to understand and control connectivity over these high-throughput and high-capacity networks, our tool can quickly scale and visualize the topology and connectivity. Utilizing the SAGE2 framework allows us to leverage large scale high resolution visualization systems, cloud solutions and other emerging technologies as we hope to monitor and control data flows in real time during collaborative sessions.

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