STCI: OptIPlanet Cyber-Mashup

Persistent Visualization and Collaboration Services for Global Cyber Infrastructure

NSF Award OCI-0943559

www.sagecommons.org

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1. Participants

1.A. Primary Personnel

Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Jason Leigh	Principal Investigator	Yes
Maxine Brown	Co-Principal Investigator	Yes
Andy Johnson	Co-Principal Investigator	Yes
Luc Renambot	Co-Principal Investigator	Yes
Lance Long	Senior Personnel	Yes
Ratko Jagodic	Graduate Student	Yes
Hyejung Hur	Graduate Student	Yes
HeeJoo Kim	Graduate Student	Yes
Viktor Mateevitsi	Graduate Student	Yes
Sungwon Nam	Graduate Student	Yes
JD Pirtle	Graduate Student	Yes
Sangyoon Lee	Graduate Student	Yes
Jon Chambers	Graduate Student	Yes
Arthur Nishimoto	Graduate Student	Yes

1.B. Other Organizations That Have Been Involved as Partners

King Abdullah University of Science and Technology (KAUST)
King Abdullah University of Science and Technology (KAUST) <www.kaust.edu.sa/> is an international graduate-level research university located in Thuwal, on the Red Sea in the Kingdom of Saudi Arabia. KAUST was inaugurated in September 2009 by King Abdullah, whose dream for more than 30 years has been to build a university dedicated to inspiring a new age of scientific achievement that will impact Saudi Arabia, the region and the world. To foster its growth, KAUST Global Collaborative Research (GCR) established Special Academic Partnerships (SP) with select institutions across the world to rapidly develop key laboratories and facilities on campus and initiate world-class research and programs in coordination with KAUST faculty. Calit2 at UCSD receives Special Partnership funding for the period 2008-2012, and UIC/EVL receives a subaward.

Sharp Laboratories of America
Sharp Laboratories of America (SLA) <www.sharplabs.com> is Sharp Corporation's first and only US-based research and development laboratory, focusing on the trends, technology issues, and product demands of North American markets in order to develop technologies to match. SLA sees a market for high-resolution interactive display systems in research laboratories and homes in the foreseeable future, and partnered with the UIC Electronic Visualization Laboratory to learn how today's early adopters are using this technology.

Texas Advanced Computing Center
Texas Advanced Computing Center (TACC), University of Texas at Austin <www.tacc.utexas.edu>, enables discoveries that advance science and society through the application of advanced computing technologies. To fulfill this mission, TACC staff members assist research teams in properly employing the systems, software, and expertise necessary to foster educational innovation and to provide a greater societal impact. To support the world-class research, TACC provides advanced visualization resources and consulting services, including Stallion, one of the highest resolution tiled display walls in the world, and Longhorn, a very large, hardware accelerated, remote, interactive visualization cluster. EVL graduate Byungil Jeong, who received his PhD for SAGE and SAGE Visualcasting development, worked at TACC from 2008-2011. TACC had encouraged Jeong to work with EVL on SAGE development.

University of California, San Diego (UCSD), California Institute for Telecommunications and Information Technology (Calit2)
Calit2 <www.calit2.net>, founded by Larry Smarr, is a distributed institute and conducts research at both the UCSD and UC-Irvine (UCI) campuses in core technologies needed to expand the reach and capacity of the global wireless Internet and its emerging all-optical core. UCSD/Calit2 promotes SAGE in conjunction with its portable tiled display wall, called the OptIPortable, and has deployed, trained and demonstrated SAGE.

1.C. Other Collaborators or Contacts

The SAGE User Community currently consists of ~93 major research, education and corporate research sites worldwide that use SAGE and contribute to its development. Those institutions are:

AUSTRALIA
AARNet www.aarnet.edu.au
Australian National University http://information.anu.edu.au/daisy/infoservices/2085.html
CSIRO Discovery Centre http://research.ict.csiro.au/research/labs/information-engineering/ie-lab-projects/optiportal
CSIRO Information and Communication Technologies, Marsfield www.csiro.au/resources/CSIROvision.html
Monash University – Caulfield http://messagelab.monash.edu.au/Infrastructure/OptiPortal
Monash University – Clayton http://messagelab.monash.edu.au/Infrastructure/OptiPortal
University of Melbourne www.unimelb.edu.au/
University of Queensland www.vislab.uq.edu.au/research/optiputer

BELGIUM
Katholieke Universiteit Leuven, Institute for Broadband Technology (IBBT) http://www.ibbt.be/en

BRAZIL
RNP (Brazilian R&E Network) www.rnp.br
University of Sao Paulo, Laboratory of Computer Architecture and Networks www.larc.usp.br

CANADA
Ciena Networks, Canada www.ciena.org
Communications Research Centre, Broadband Applications and Demonstrations Laboratory www.crc.gc.ca
Simon Fraser University www.sfu.ca

CHINA
Beihang University, State Key Lab of Software Environment Development http://www.nlsde.buaa.edu.cn
Chinese Academy of Sciences, Computer Network Information Center http://english.cnic.cn

CZECH REPUBLIC
Masaryk University, Laboratory of Advanced Networking Technologies (2 systems) www.sitola.cz/sitola/index.en.html

GERMANY
Braunschweig University of Technology, Institute of Computer and Network Engineering, Germany www.ida.ing.tu-bs.de

INDIA
Monsanto Research Centre (Bangalore) www.monsantoindia.com/monsanto/layout/researchcentre

JAPAN

Cybernet Systems Co. www.cybernet.co.jp/english
Kyoto University www.kyoto-u.ac.jp/en
National Institute of Advanced Industrial Science and Technology (AIST) www.aist.go.jp/index_en.html
NICT (National Institute of Information and Communications Technology), Koganei, Japan
www.nict.go.jp/index.html
NICT, 5th and 6th Buildings, Koganei www.nict.go.jp/index.html
NICT, Keihanna Research Center, Kyoto http://kccc.nict.go.jp/keihanna-lab/en/
NTT Network Innovation Laboratory, Yokosuka www.ntt.co.jp/sclab/index_e.html
Osaka University, CyberMedia Center www.osaka-u.ac.jp/eng

KOREA
Gwangju Institute of Science and Technology (GIST) http://netmedia.gist.ac.kr
Korea Institute of Science and Technology Information (KISTI) www.ksc.re.kr/eng/index.htm

MEXICO
Ensenada Center for Scientific Research and Higher Education (CICESE) www.cicese.edu.mx

NETHERLANDS
SARA Computing & Networking Services www.sara.nl/index_eng.html
SARA Collaboratorium www.sara.nl/project/collaboratorium-visualization-and-presentation-facility
University of Amsterdam, System and Network Engineering Research Group
www.science.uva.nl/research/sne
University of Amsterdam, e-BioScience Laboratory www.micro-array.nl/ibu.html

NEW ZEALAND
Victoria University of Wellington http://ecs.victoria.ac.nz/EResearch/OptIPortal

POLAND
Poznan Supercomputing and Networking Center http://apps.man.poznan.pl/

RUSSIA
Russian Academy of Sciences, Science and Innovation Center
www.chernogolovka.org/eng_content/show_index.php
Russian Academy of Sciences, Space Research Institute http://arc.iki.rssi.ru/eng

SAUDI ARABIA
King Abdullah University for Science and Technology (KAUST) www.kaust.edu.sa

TAIWAN
National Center for High-performance Computing (NCHC) www.nchc.org.tw/en

UNITED STATES
Adler Planetarium & Astronomy Museum www.adlerplanetarium.org
Argonne National Laboratory, Center for Nanoscale Materials http://nano.anl.gov
Argonne National Laboratory, Math & Computer Science www.mcs.anl.gov
Argonne National Laboratory, Transportation Research and Analysis Computing Center
www.anl.gov/TRACC
Calit2/University of California, Irvine, www.calit2.net/about/info/uci
Calit2/University of California, San Diego, www.calit2.net
Casa Familiar www.casafamiliar.org
Case Western Reserve University, Kelvin Smith Library http://library.case.edu/ksl/
Extreme Networks www.extremenetworks.com
Florida International University, Center for Internet Augmented Research & Assessment www.fiu.edu
Lakota Technical Solutions Inc (TSI) www.lakota-tsi.com
Louisiana State University, Center for Computation and Technology www.cct.lsu.edu

Monsanto www.monsanto.com
NASA Ames Research Center, Lunar Science Institute http://lunarscience.arc.nasa.gov/
NASA Goddard Space Flight Center, Space Visualization Studio http://svs.gsfc.nasa.gov
Naval Postgraduate School, CED3 www.nps.edu/Academics/DL/CED3/
Naval Postgraduate School, MOVES www.movesinstitute.org/
Northwestern University, International Center for Advanced Internet Research www.it.northwestern.edu/about/departments/icair/index.html
Purdue University, Envision Center for Data Perceptualization www.envision.purdue.edu
Rincon Research Corporation www.rincon.com
Sharp Laboratories of America www.sharplabs.com
South Metro Career Center www.metrocareercenters.org
Texas A&M University, Computer Science www.cs.tamu.edu
United States Geological Survey (USGS) National Center for Earth Resources Observation and Science http://edc.usgs.gov
University of California Davis, Institute for Ultra-Scale Visualization www.cs.ucdavis.edu/~ma
University of California San Diego (UCSD), National Center for Microscopy and Imaging Research www.ncmir.ucsd.edu
UCSD, Scripps Institution of Oceanography www.sio.ucsd.edu
University of Hawaii at Manoa, Center for Microbial Oceanography: Research and Education (2 systems) http://cmore.soest.hawaii.edu
University of Illinois at Chicago, ACM Student Chapter (College of Engineering) http://acm.cs.uic.edu/sigbuild
University of Illinois at Chicago, Electronic Visualization Laboratory, Cyber-Commons and Cyber-Commons 3D www.evl.uic.edu/core.php?mod=4&type=1&indi=379
University of Illinois at Chicago, Graham Clinical Performance Center http://www.chicago.medicine.uic.edu/grahamcpc/
University of Illinois at Chicago, Innovation Center http://innovationcenter.uic.edu
University of Illinois at Urbana-Champaign, National Center for Supercomputing Applications www.ncsa.uiuc.edu
University of Michigan, Department of Atmospheric, Oceanic & Space Sciences http://aoss.engin.umich.edu
University of Michigan, Digital Media Commons www.dc.umich.edu/dmc/
University of Michigan, School of Information www.si.umich.edu
University of Texas at Austin, Texas Advanced Computing Center www.tacc.utexas.edu/resources/visualization/
University of Washington www.washington.edu
Zoom Digital Signage http://zoomdigitalsignage.com/

2. Activities and Findings

2.A. Research Activities

2.A.1. Overview

SAGE and tiled display walls are creating a global collaborative visualization environment that enables virtual teams of researchers to manage the scale and complexity of their data and work with one another. Presently, SAGE is transitioning from a research prototype to a hardened technology and creating new open services for visualization and collaboration utilizing shared cyberinfrastructure, as witnessed by the growth of the nascent SAGE User Community, with over 93 major sites worldwide.

SAGE is cross-platform, open-source middleware that enables users worldwide to have a common operating environment, or framework, to access, display and share a variety of data-intensive information – whether digital cinema animations, high-resolution images, high-definition video-teleconferencing, presentation slides, documents, spreadsheets or laptop screens – in a variety of resolutions and formats, from multiple sources, to one or more tiled display walls, with the same ease that the Web affords for accessing lower-resolution objects today. To make tiled display walls easier to use, SAGE also provides automated assistance to users to organize information, especially as the quantity of content grows.

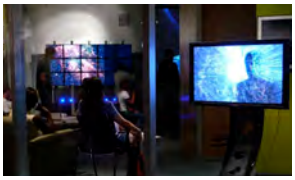
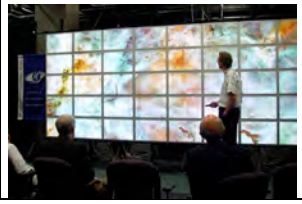
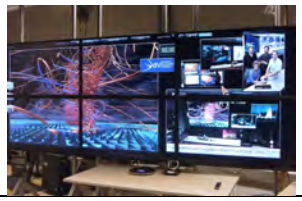
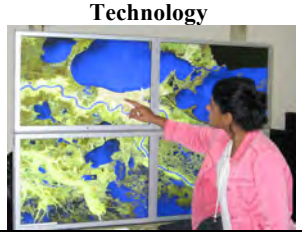
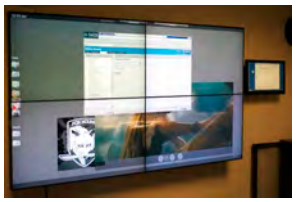
SAGE enables multi-user interaction and supports a variety of input devices; notably, laptop keyboards, the Gyromouse, joysticks, trackballs, 6 degree-of-freedom magnetic trackers, touch screens, the Nintendo Wiimote and the Microsoft Kinect.

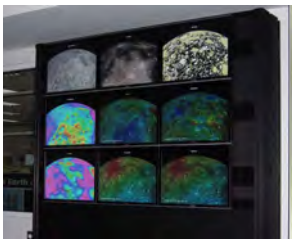
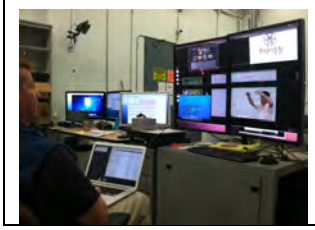
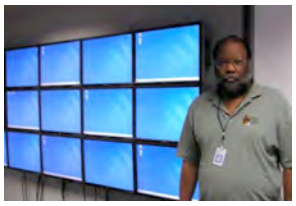
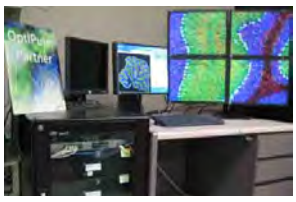
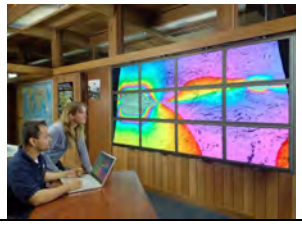
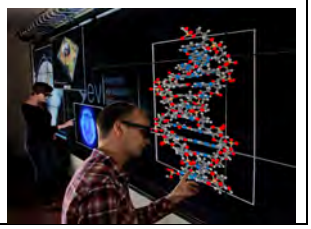
2.A.2. SAGE User Community

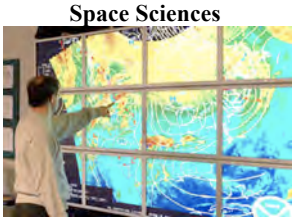
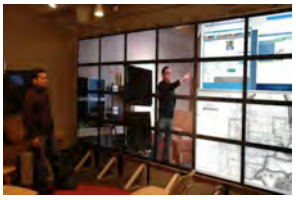
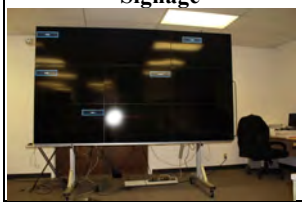
The number of international SAGE sites has been growing steadily since this STCI was awarded in 2009. While the following list is as up-to-date as we have, our users continue to build and deploy tiled display walls at their institutions, so the number of SAGE sites continues to grow.

SAGE adoption is growing, as are the types of users. In its early years, the primary users of SAGE were scientists at academic and government research institutions. There are now more corporate users and there is a growth in the education market (universities, museums, community centers). We believe that this growth is because (1) EVL is working to make tiled display walls more affordable and easier to use, and (2) students and teachers can easily push their laptop screens to tiled display walls and access documents and web pages via wireless and 1Gbps interfaces.

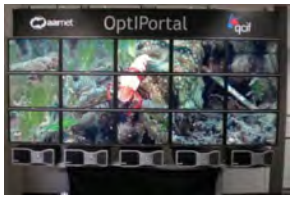
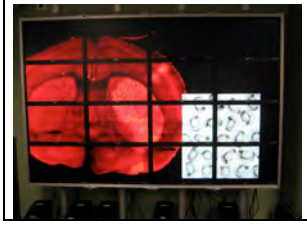
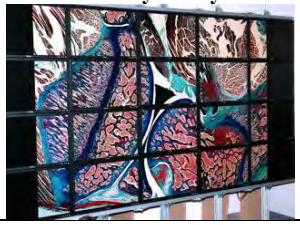
US SAGE Sites

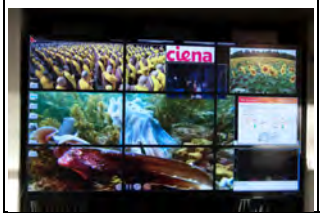
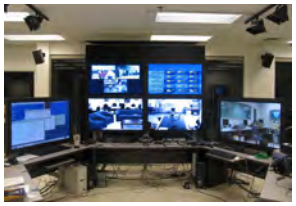
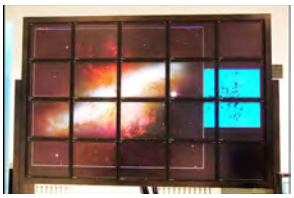
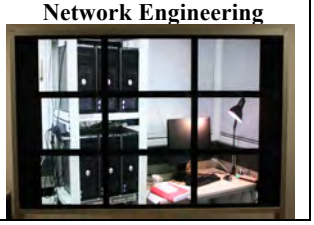
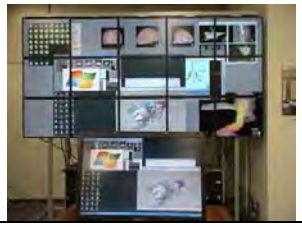
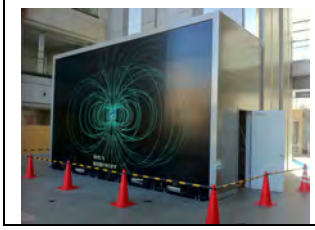
Adler Planetarium & Astronomy Museum 	**Argonne National Laboratory, Center for Nanoscale Materials (1)** 	**Argonne National Laboratory, Center for Nanoscale Materials (2)** 	**Argonne National Laboratory, Math and Computer Science Division** **NOT AVAILABLE**
Argonne National Laboratory, Transportation Research and Analysis Computing Center 	**Calit2, University of California, Irvine – HIPerWall** 	**Calit2, University of California, San Diego – HIPerSpace Laboratory** 	**Calit2, University of California, San Diego – OptIPortable** 
Calit2, University of California, San Diego – OptIPortable2 (2) 	**Calit2, University of California, San Diego – Rocks/CAMERA** 	**Calit2, University of California, San Diego – SAGE Wall** 	**Calit2, University of California, San Diego – Vroom** 
Casa Familiar, San Ysidro 	**Case Western Reserve University, Kelvin Smith Library** 	**Extreme Networks** 	**Florida International University, Center for Internet Augmented Research & Assessment** 
Lakota Technical Solutions Inc (TSI) **NOT AVAILABLE**	**Louisiana State University, Center for Computation and Technology** 	**Monsanto (Cambridge, MA)** 	**Monsanto (Research Triangle Park, NC)** **TO BE INSTALLED**

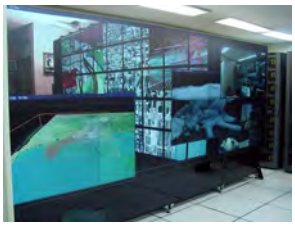
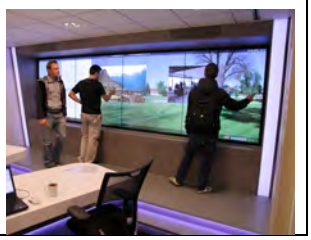
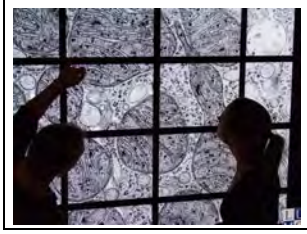
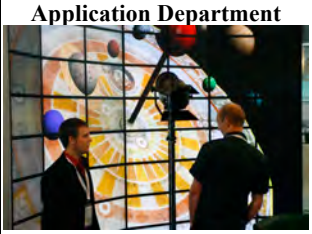
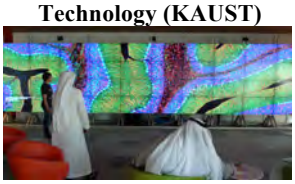
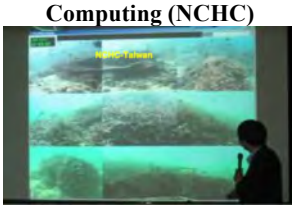
Monsanto (St. Louis, MO)	**NASA Ames Research Center, NASA Lunar Science Institute**	**NASA Goddard Space Flight Center, Space Visualization Studio**	**Naval Postgraduate School, CED3**
			
Naval Postgraduate School, MOVES	**Northwestern University, International Center for Advanced Internet Research**	**Purdue University, Envision Center for Data Perceptualization**	**Rincon Research Corporation**
			
Sharp Laboratories of America	**South Metro Career Center, San Diego**	**Texas A&M University, Dept of Computer Science and Engineering**	**U.S. Geological Survey (USGS), National Center for Earth Resources Observation & Science**
			
University of California, Davis, Institute for Ultra-Scale Visualization	**University of California, San Diego, National Center for Microscopy & Imaging Research**	**University of California, San Diego, Scripps Institution of Oceanography**	**University of Hawaii at Manoa, Center for Microbial Oceanography: Research and Education (Ampitheater)**
NOT AVAILABLE			
University of Hawaii at Manoa, Center for Microbial Oceanography: Research and Education (Meeting Room)	**University of Illinois at Chicago, ACM Student Chapter (College of Engineering)**	**University of Illinois at Chicago, EVL – Cyber-Commons**	**University of Illinois at Chicago, EVL – Cyber-Commons 3D**
			

University of Illinois at Chicago, Graham Clinical Performance Center **NOT AVAILABLE**	**University of Illinois at Chicago, Innovation Center** **NOT AVAILABLE**	**University of Illinois at Urbana-Champaign, NCSA** 	**University of Michigan, Department of Atmospheric, Oceanic & Space Sciences** 
University of Michigan, Digital Media Commons 	**University of Michigan, School of Information/ Provost's Virtual Space Interaction Testbed** 	**University of Texas at Austin, Texas Advanced Computing Center** 	**University of Washington** 
Zoom Digital Signage 			

International SAGE Sites

Australia, AARNet 	**Australia, Australian National University** 	**Australia, CSIRO Discovery Center** 	**Australia, CSIRO Information and Communication Technologies, Marsfield** 
Australia, Monash University - Caulfield 	**Australia, Monash University - Clayton** 	**Australia, University of Melbourne ("OzIPortal")** 	**Australia, University of Queensland** 

Belgium, Katholieke Universiteit Leuven, Institute for Broadband Technology (IBBT) **PICTURE NOT AVAILABLE**	**Brazil, RNP (Brazilian National Research & Education Network)** 	**Brazil, University of Sao Paulo, Laboratory of Computer Architecture and Networks** 	**Canada, Ciena Demo Room** 
Canada, Ciena Main Corridor 	**Canada, Communications Research Centre** 	**Canada, Simon Fraser University** 	**China, Beihang University, State Key Lab of Software Environment Development** 
China, Chinese Academy of Sciences, Computer Network Information Center 	**Czech Republic, Masaryk University, Laboratory of Advanced Networking Technologies (1)** 	**Czech Republic, Masaryk University, Laboratory of Advanced Networking Technologies (2)** 	**Germany, Braunschweig University of Technology, Institute of Computer and Network Engineering** 
India, Monsanto Research Centre Bangalore 	**Japan, Cybernet Systems Co., Ltd.** 	**Japan, Kyoto University** 	**Japan, National Institute of Advanced Industrial Science & Technology (AIST)** 
Japan, National Institute of Info and Comm Technology (NICT) – Exterior, Koganei 	**Japan, National Institute of Info and Comm Technology (NICT) – 5th Bldg, Koganei** 	**Japan, National Institute of Info and Comm Technology (NICT) – 6th Bldg, Koganei** 	**Japan, National Institute of Info and Comm Technology (NICT) – Keihanna Research Center, Kyoto** 

Japan, NTT Advanced Technology Corporation, Yokohama 	**Japan, NTT Network Innovation Laboratories, Yokosuka** 	**Japan, Osaka University, CyberMedia Center** 	**Korea, Gwangju Institute of Science & Technology** 
Korea, Korea Institute of Science and Technology Information (KISTI) 	**Mexico, Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE)** 	**Netherlands, SARA Computing & Networking Services** 	**Netherlands, SARA Collaboratorium** 
Netherlands, University of Amsterdam, e-BioScience Laboratory 	**Netherlands, University of Amsterdam, System and Network Engineering Research Group** 	**New Zealand, Victoria University of Wellington** 	**Poland, Poznan Supercomputing and Networking Center, Application Department** 
Russia, Russian Academy of Sciences, Space Research Institute 	**Russia, Russian Academy of Sciences, Science & Innovation Center** 	**Saudi Arabia, King Abdullah University of Science and Technology (KAUST)** 	**Taiwan, National Center for High Performance Computing (NCHC)** 

2.A.3. SAGE Website Statistics

The SAGE website <www.sagecommons.org> has general information, user locations, new versions of SAGE open-source software and a Forum on which users can post announcements or technical questions for discussion. *Google Analytics* graphs for the period August 1, 2011 – September 1, 2012 are available upon request.

2.A.4. SAGE Enhancements for the Past Year

2.A.4.1. SAGE Queries

EVL responds to email queries and SAGE Forum user questions and helps users with installations. Notably, this past year EVL consulted with Monsanto, NCSA, Communications Research Centre Canada, Harpervision Associates, Universidad Francisco MarroquÃn in Guatamala and Case Western Reserve University in Ohio.

2.A.4.2. SAGE Code Releases

Two versions of SAGE are available for download from the website: SAGE "classic" (the open-source version) and SAGE "advanced" (with the new Graphical User Interface available as Linux binaries).

Most recently EVL released new SAGE rpm distribution files containing the latest fixes and enhancements, now version 3.3.7, openSuse 12.1 and 11.4 live DVD installation discs, and CentOS 6.3 version 3.3.8.

2.A.4.3. SAGE Refined Interface Widgets

Users can now easily change various user interface items, such as background image, corner icons and buttons, but a few more enhancements are still needed, such as widget position and size. A few applications (*mplayer, pdfviewer*) were updated with less obtrusive interface widgets. Here is a screenshot of the current design.

2.A.4.4. SAGE Multi-Site File Sharing

EVL designed and implemented a simpler SAGE API to support automatic sharing of files among users. Users can now easily stream an application to multiple walls.

2.A.4.5. SAGE High-Speed Desktop Sharing

SAGE enables users to push laptop screens onto tiled display walls. While the MacOS version is used daily at EVL (in EVL's Cyber-Commons classroom), the Linux and Windows versions of SAGE still require some work (user interface, testing, packaging). SAGE users requested the ability to interact using the SAGE Pointer application and the touch screen with remote applications being displayed on the screen (e.g., basic keyboard or mouse interaction with the application on the remote machine). For this, mouse and keyboard events are passed to applications using qshare. This work is still ongoing.

For applications that cannot be modified to include the SAGE API (application programming interface), the best way to display them on walls is for the user to run the applications on his computer and push his desktop to the wall. While VNC desktop sharing allows wireless connections using the RFP protocol and compression, high-speed desktop sharing uses all available bandwidth to achieve higher frame rates – a full 1Gbps connection allows a 1080p resolution animation to be displayed at 15-20 frames per second (fps). One must trade off bandwidth for interactivity. Hopefully, the next-generation wireless standard at 1Gbps speed will allow similar untethered performance. This allows native applications (Mac, Windows, Linux) and applications using special resources (licenses, special hardware, etc) to be displayed without modification. Currently, a low-end Mac Mini using a 1Gbps wired connection achieves around 17fps, which enables applications such as video-editing software (*Final Cut Pro, Media Composer, After Effects*, etc), 3D modeling packages (*Autodesk Maya, 3DS MAX*, etc) and creative or scientific applications (*ParaView*, etc) to be displayed interactively. A modern workstation with 10Gbps can achieve much higher performances.

2.A.4.6. SAGE Support for 3D Media

In the past year, EVL built its Cyber-Commons 3D classroom using passive-stereo near-seamless LCD panels. This year, EVL is building the CAVE2 virtual-reality system. With SAGE, both Cyber-Commons and CAVE2 can support 2D and 3D content simultaneously. Support for 3D image formats has been added to the SAGE media library and a stereo image viewer has been developed. Users can display MPO files (a 3D file format supported by many consumer electronics manufacturers). MPO files contain two (or more) JPEG files, one for the left eye and one for the right eye. Many 3D video and photo cameras support this format. JPS and PNS (JPEG and PNG stereo side-by-side stereo formats) will be added.

EVL's Cyber-Commons 3D (Photo: Lance Long)

SAGE running in CAVE2. (Photo: Lance Long)

EVL Tech Meeting is held in CAVE2 using SAGE. (Photo: Lance Long)

CAVE2 panorama photo showing NASA photos of Mars Curiosity. (Photo: Luc Renambot)

2.A.4.7. SAGE Improved Session Manager and File Library

For secure sessions, users should be authenticated, access should be secured and encrypted, multiple projects should be managed, and multiple users should be able to access the assets. To access restricted files, users can acquire permission by authenticating; i.e., logging into a session. EVL tested the Apache webserver's WebDAV (Web-based Distributed Authoring and Versioning), which is a set of extensions to the HTTP protocol and allows users to collaboratively edit and manage files on remote web servers. A variety of file transfer tools support the DAV protocol natively (commonly in FTP tools); for example, *Cyberduck* on MacOS and *BitKinex* on Windows. Moreover, Finder (on Mac) and Explorer (on Windows) allow users to mount DAV endpoints as local drives (web drive). This allows for a transparent access to SAGE files. Authentication and encryption are handled directly by the web server (https access, and login/password to access the library directory).

2.A.4.8. SAGE Synchronized Playback in Support of Distributed Collaboration

Users requested that SAGE support distributed collaborative synchronized media viewing (for video clips or image sequences) among multiple locations. EVL evaluated the SAGE movie player application (*mplayer*), which supports synchronized playback, and found it works well on a local-area network but is hard to support over a wide-area network. EVL is investigating the notion of "synchronized walls" – a mirrored (or shared) region on each wall of a collaborative session – such that any content inside a given region would be replicated, using the same layout and then synchronized among multiple sites. This would fit well within the concept of "private vs. public workspace" described in the CSCW literature.

Another form of synchronized playback is achieved using NTT J2K and iVisto/XMS technologies, which

support this modality. NTT-AT provided EVL with a J2K loaner device to evaluate such integration. This would support media playback (4K and HD) and video-conferencing. This J2K unit was used successfully for the CineGrid workshop demonstration in December 2011 and again for the ON*VECTOR demonstration in February 2012. The availability of the J2K server at EVL also facilitates the development of interfaces to control a high-quality SDI-based infrastructure in collaborative spaces.

2.A.4.9. SAGE Cloud Storage Access

EVL is evaluating and prototyping SAGE cloud storage access, and is looking at Amazon S3, Google storage for developers, Dropbox, etc.

2.A.4.10. SAGE Integration of 4K Video Capture/Display and Audio De-Embedding

This year EVL began integrating 4K video streaming into SAGE. While Blackmagic advertises a 4K card, it is not yet available on the market. Instead, EVL is evaluating the Blackmagic Quad HD capture card. The capture PC with Blackmagic had very good video-streaming performance; 4.7Gbps bandwidth (over a 10Gbps link) was used. Another approach is to use NTT iVisto, and NTT is working on integrating iVisto, which has 4K streaming software, with SAGE. Regarding audio streaming, work is underway to capture full, uncompressed audio data from the capture cards. Currently, it is possible to capture two channels of audio through HDMI and eight channels through SDI at 48 kHz. Data can be captured in 16-bit or 32-bit formats.

2.A.4.11. SAGE Integration with UltraGrid

UltraGrid[1] version 1.1 RC4 video and audio streaming software, developed by the Laboratory of Advanced Networking Technologies at Masaryk University and CESNET in the Czech Republic, is now supported by SAGE. UltraGrid software enables low-latency high-definition and ultra-high-definition video transmissions over IP networks. The UltraGrid receiver displays video using various hardware devices and software APIs, one of them being SAGE.

2.A.4.12. CAVE2 Web Controller

EVL is working on a cross-platform, browser-based, *web interface*, which works on any device connected to the internet (e.g., tablet, phones, laptops), enabling users to interactively control all aspects of CAVE2: OmegaLib, CalVR, SAGE, audio, computer cluster, tracker, etc. Once the CAVE2 Audio Library is completed, it will also be integrated into the web interface.

2.A.4.13. Omicron – The User Interaction Library

Omicron was initially written to support OmegaDesk, an instrument funded by NSF MRI CNS-0821121, with software development funded by the UIC Vice Chancellor for Research Areas of Excellence Award

[1] http://ultragrid.sitola.cz

for "Development of Railroad Research and Education at UIC." We have since made Omicron general purpose and extensible, and it supports SAGE as well as EVL's OmegaLib (OmegaDesk/CAVE2 virtual-reality framework) and Calit2's CalVR virtual-reality framework.

In the past year, EVL began developing the Omicron[2] software development kit (SDK), a C++ library that handles input from a number of novel input devices – such as multi-touch, 3D hand/body gesturing, head tracking, and mobile and tablet devices – that is designed for use on multiple visualization and virtual-reality displays**.**

Omicron can be integrated into C++ applications as a static library, or can be run as a standalone input server, streaming input data to multiple applications. Omicron comes with client-side interfaces for programs written in Unity, Processing and C++.

Omicron abstracts input using modular event services, each providing access to a specific input device. Input events can be easily streamed over the network using the *Omicron Connector* API. Also, input event services can be chained together to provide advanced functionality.

Here are some of the devices currently supported, as well as their development status:

- **SAGE Pointer…**SAGE pointer is supported as an input device. Single-user mode is currently working; multiple users interacting inside the same application through multiple SAGE and tablet pointers is under development.
- **Motion Capture Systems Supporting VRPN Protocol…**The Vicon Bonita camera system is used as a rigid body tracker. Omicron supports head and input-controller tracking. This is used to track the controller (EVL uses a Playstation) and the position of the primary user's head.
- **NaturalPoint Optitrack Tracker…**This rigid body tracker predates the Vicon system, and consists of an Optitrack camera and TrackIR software. While still supported in Omicron, EVL uses the Vicon.
- **Playstation, Wii, Xbox 360 and iPhone Controllers…**These input controllers, which provide button and joystick input, are used to navigate in 3D space. Vicon trackers are attached to these controllers.
- **Microsoft Kinect…**Omicron supports hand/arm tracking by multiple Kinects, and provides functions for multi-Kinect transform calibration. EVL continues to explore the use of the Kinect's voice recognition combined with directed microphone functions and/or gesture recognition.
- **PQLabs Multi-Touch Overlay…**Currently under development, Omicron's multi-user touch/gesture solution replaces the current SAGE touch software, which was specially written and not general purpose. The PQLabs-provided touch/gesture API is also not adequate, as it cannot distinguish gestures from multiple users; e.g., when one user does a zoom gesture and a second user does a zoom gesture, PQLabs' software interprets this as one multiple touch gesture instead of two zoom gestures. The Omicron solution will enable SAGE to work with multiple users as reliably as a single user.
- **iPad Touch and Dynamic GUIs Through the Custom Porthole Protocol…**Porthole[3] is middleware that enables users to use one or multiple tablet devices (e.g., iPads) to share files between the tablets and 2D visualization or 3D virtual-reality displays. Porthole will ultimately enable two-way communication between a tablet and a display; i.e., a tablet can be both an interaction device and a storage device for current states of visualizations. Porthole enables applications to map supported GUI elements (e.g., buttons, sliders or switches) to manipulation functions. These GUI elements, in conjunction with multi-touch information generated by the tablet (e.g., translation, rotation, pinch and swipe), signal an application to manipulate the data in the 2D or 3D visualization. A stream of rendered images provides users with visual feedback on the tablet as they further manipulate the data with the GUI elements.

[2] https://code.google.com/p/omicron-sdk/
[3] http://code.google.com/p/omegalib/wiki/PortholeMarkOne?ts=1323377357&updated=PortholeMarkOne

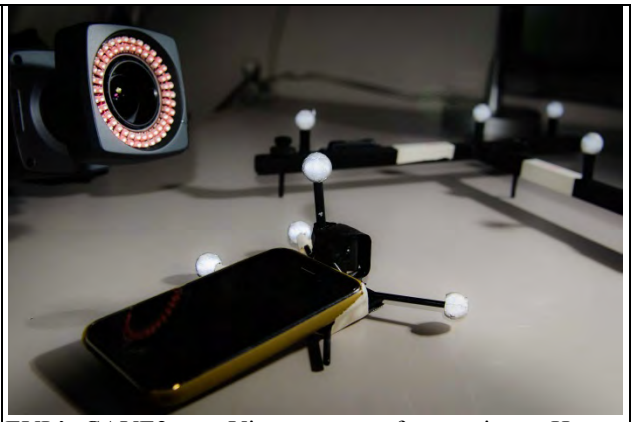
- **Thinkgear Brainwave Interfaces…** The NeuroSky Mindwave system, which reads EEG brain waves, is supported.

The following photographs show some of Omicron's interaction modalities.

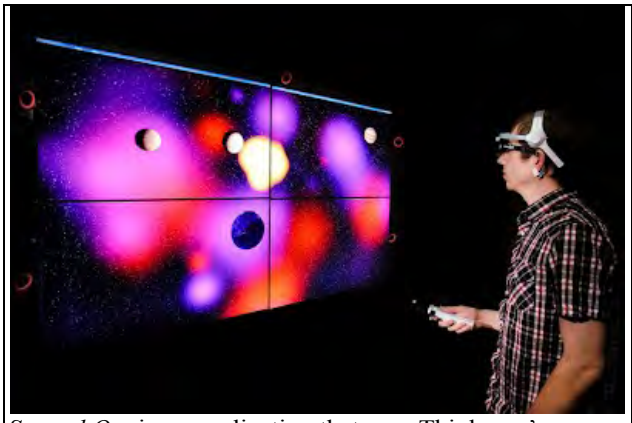
The Processing language is used to prototype Kinect-based gesture input. Mounted above EVL's Cyber-Commons tiled display wall, the Kinect receives joint data from two skeletons. Omicron gets the data from the Kinect and sends to the Processing program to interpret (i.e., to draw circles on the screen). The Processing code currently uses half the data points the Kinect recognizes for simplicity during development. (Photo: Lance Long)

Omicron handles multi-modal gesture input. The person on the right inputs via the Kinect interface, while the person on the left uses Omicron's new touch-gesture interface (which grabs data from PQLabs' touch overlay). This interface recognizes five fingers, and given their proximity to one another, groups the fingers into a hand (the large circle around the five smaller finger circles). Application programs that use Omicron will be able to define different input gestures for fingers versus hands. (Photo: Lance Long)

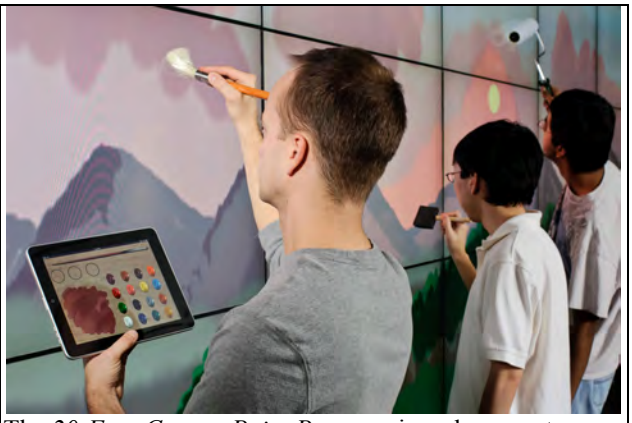
The person on the right inputs uses the Omicron Kinect interface, while the person on the left uses Omicron's touch-gesture interface (which grabs data from the PQLabs' touch overlay). Moreover, the person on the left is multi-tracked, inputting information with both hands. The program that processes the input identifies individual finger gestures, identifies a hand (a circle is drawn around the hand) and also identifies that the two gestures are close enough that they might be related (large circle enclosing the two smaller hand circles). (Photo: L. Long)



EVL's CAVE2 uses Vicon cameras for user input. Here, an iPhone is used as a positional tracker. The iPhone will ultimately have button input. It is currently being used as a calibration device. (Photo: Lance Long)



Spaced Out is an application that uses Thinkgear's NeuroSky Mindwave and Unity3D to create a model of the Solar System affected by attention, meditation, alpha, delta, and theta brain waves. Solar flares are triggered by high attention; time slows down with high meditation; alpha waves change the size of Saturn's rings; delta waves set the cloud density of Venus; and, theta wave spikes send comets toward the sun. (Photo: Lance Long) <https://sites.google.com/site/arthurnishimoto/ad-456---embedded-media-physical-computing/spaced-out>



The *20-Foot Canvas Paint Program* is an homage to traditional painting – except that instead of mixing real paints and painting with real paint, one mixes and paints with digital paint while using traditional implements (physical paint palette and paint brushes). The PQLabs touch-screen recognizes the brushes and their thickness. An iPad is the artist's palette where colors are selected and mixed; data is transmitted wireless to the Paint application. (Photo: Lance Long) <www.evl.uic.edu/core.php?mod=4&type=4&indi=750>

2.A.4.14. SAGE Audio Manager (SAM)

Last year, EVL began working with the Calit2/UCSD Sonic Arts Group to develop a robust audio system for SAGE, referred to as SAM (SAGE Audio Manager), which runs on Linux and the Mac. SAM will ultimately support the sonification of SAGE window activity and applications. *Sonification,* as defined by Wikipedia[4], is a form of auditory display; i.e., it is the use of non-speech audio to convey information or perceptualize data. Auditory perception has high temporal and pressure resolution, which opens up possibilities for it as an alternative or complement to visualization techniques.

The goal is to have SAGE treat audio as sample buffers the same way it treats video as pixel buffers. There are four use cases for SAGE audio:

- *Audio streamed from a laptop or other device to the SAGE wall*…Must use WIFI; must operate on Macs, Windows, Linux laptops; must accommodate several streams to the wall simultaneously; and, must deal with buffering issues.
- *Audio playback from within SAGE*…Audio can come from applications within SAGE or from media pushed to the wall.
- *External device connected to SAGE wall*…Microphone, LifeSize, JPEG2000 codec (via disembedder), etc.; might require echo cancellation.
- *Connecting two SAGE walls via network*…For simultaneous playback of audio; does not need WiFi.

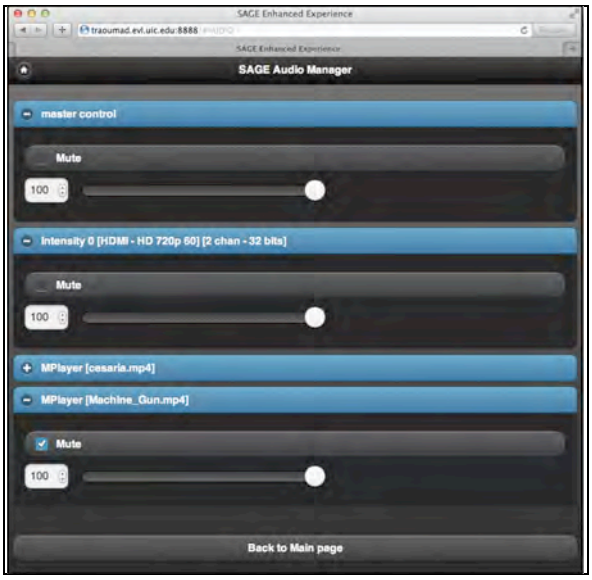
SAM allows multiple stereo sources to be streamed over the network to a sound-rendering server. It streams uncompressed audio channels between audio sources (applications, capture card, etc.) and an audio rendering engine (i.e., SAM itself). The system is based on existing software packages *Jack* (audio interface) and *JackTrip* (the network streaming component linking Jack instances).

SAGE's movie player *(mplayer)* and HD-video capture *(decklinkcapture)* applications have been updated to stream audio to SAM. EVL and Calit2 investigated audio-video synchronization issues so that SAM can adjust delays to adapt to various network and hardware latencies.

[4] http://en.wikipedia.org/wiki/Sonification

Work on localization of mono sources is underway. Currently, EVL is making SAM work on an array of 9 channels (7 speakers and 2 subwoofers) in Cyber-Commons, and will ultimately port to the CAVE2. On a related note, EVL recently acquired two SoundBender speaker arrays, which enables us to participate in additional collaborative research with Calit2 and KAUST. (Eventually one is planned for Cyber-Commons and one for CAVE2.) The SoundBender enables Wave-Field Synthesis; e.g., for an individual standing directly in its path, a beam of sound can be discretely focused in one direction but not heard in other directions. Another function of the SoundBender speaker array is the ability to play back binaural audio files, which gives the illusion of spatialized right and left channels, which is traditionally only possible with headphones.

Across-platform, browser-based, *web interface,* which can be used by any device connected to the internet (e.g., tablet, phones, laptops), is being designed to enable users to interactively control SAM sound parameters. To date, basic functionality has been implemented (e.g., sound on, off, master volume, volume for each application, mute). This web interface is a subset of the CAVE2 Web Controller, defined above (Section 2.A.4.l).



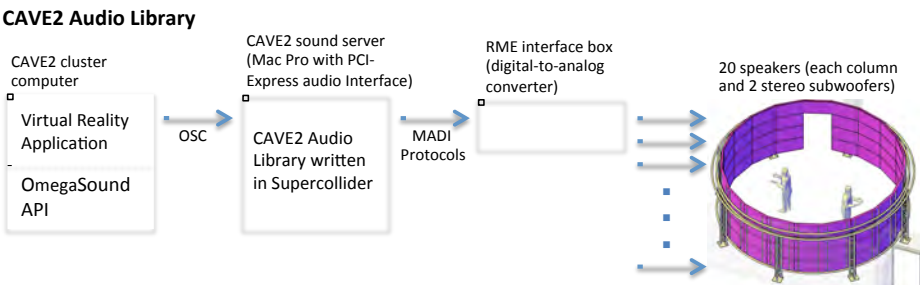
Note: While SAM implementation is underway, basic video/audio streams (video conferencing, video capture, etc.) can be handled with VNC and/or qshare applications.

2.A.4.15. OmegaSound Audio Library

EVL is developing OmegaSound[5], a CAVE2 audio library that will interface with virtual-reality middleware OmegaLib and CalVR. However, given OmegaLib and CalVR run in CAVE2, as does SAGE, this audio library could conceivably work with SAGE in the future and provide an alternative to SAM. Initially it will have basic functionality, such as the following. Ultimately, it will be capable of real-time audio synthesis.

- Trigger sample sounds for playback
- Placing samples in space
- Scale volume by distance
- Apply reverberation

The components of the audio library, hardware and software, are shown in the following diagram and explained in more detail below.



[5] https://docs.google.com/document/d/1DHKHlHZoXKkgnG1hAGNgZvb8HnGk3vC3HNXc5ZmZPqs/edit

OmegaSound is a C++ audio API. OmegaSound enables virtual-reality programmers to embed sound commands (e.g., play, stop) in their code, which it formats and translates into OSC (Open Sound Control) messages that are sent to the sound server.

The CAVE2 sound server, a Mac Pro computer, runs the CAVE2 Audio Library.

The CAVE2 Audio Library is written in Supercollider, an existing programming environment[6] for real-time audio synthesis and algorithmic composition. Notably, it supports spatialized (i.e., localized) audio through a technique known as 2D Ambisonics.

Via a PCI-Express audio interface card, the sound server sends MADI protocols to an **RME digital-to-analog converter box**, which are output to CAVE2's 22-channel speaker array. The 22 channels consist of 20 speakers, one on top of each column of the CAVE2, plus two stereo subwoofers.

The Audio Library supports the CAVE2's 22-channel speaker array as well as any source that wants only 6 or 8 channels. (Note: A 6-channel system consists of 5 speakers and 1 subwoofer, and is also referred to as a 5.1 speaker array. An 8-channel system consists of 7 speakers and 1 subwoofer, and is also referred to as a 7.1 speaker array.) For programs that produce 5.1 and 7.1 audio, the Audio Library spreads the information across all 22 channels of CAVE2, taking the listener's orientation (tracked by the Vicon system) into consideration.

OSC is a popular communications protocol in audio programming languages and between audio devices, which is quickly expanding into other areas. By using OSC, OmegaSound is not limited to interfacing with Supercollider and can interface with other audio libraries and tools as well. For example, the game engine Unity3D, another popular programming environment for virtual reality, doesn't talk to Supercollider. Unity3D has its own robust FMOD C++ audio programming environment instead[7].

For the past several months, EVL has been prototyping CAVE2 Audio Library on a 4x4 virtual-reality system with 4 speaker channels as the CAVE2 was designed and built.

2.A.5. Articulate: Voice Commands

EVL developed *Articulate,* a voice command system that attempts to interpret natural language queries to automatically produce appropriate visualizations of data, and is seeking funding to continue development. Though not embedded into SAGE, *Articulate* is compelling for controlling tiled display walls because it can provide a rapid means of creating data plots and other more advanced visualizations without requiring the user to struggle with yet another user-interaction device. The use of a natural language interpreter enables the user to issue commands without conforming to a rigid grammatical structure, and a graph reasoner enables the system to make an educated guess as to the type of visualization that best answers the user's query.

2.A.6. SAGE-Next

EVL is developing next-generation SAGE, a framework that runs on a single computer and takes advantage of the latest architectures and cloud computing. SAGE-Next will be backward compatible with SAGE. One PhD student is working on a multi-user-centric resource scheduler for SAGE-Next.

SAGE's uniqueness is that it supports distance collaboration among multiple endpoints equipped with tiled display walls connected via high-speed networks. It enables users to simultaneously share ultra-high-resolution scientific visualizations with remote collaborators while communicating with them via multi-point high-definition video and audio streamed to the displays.

Historically, computer clusters are used to drive tiled display walls. With the advent of "multi-headed" graphics cards, such as AMD's Eyefinity, Nvidia's Scalable Visualization Solutions, and Matrox's

[6] http://en.wikipedia.org/wiki/SuperCollider
[7] http://unity3d.com/unity/engine/audio

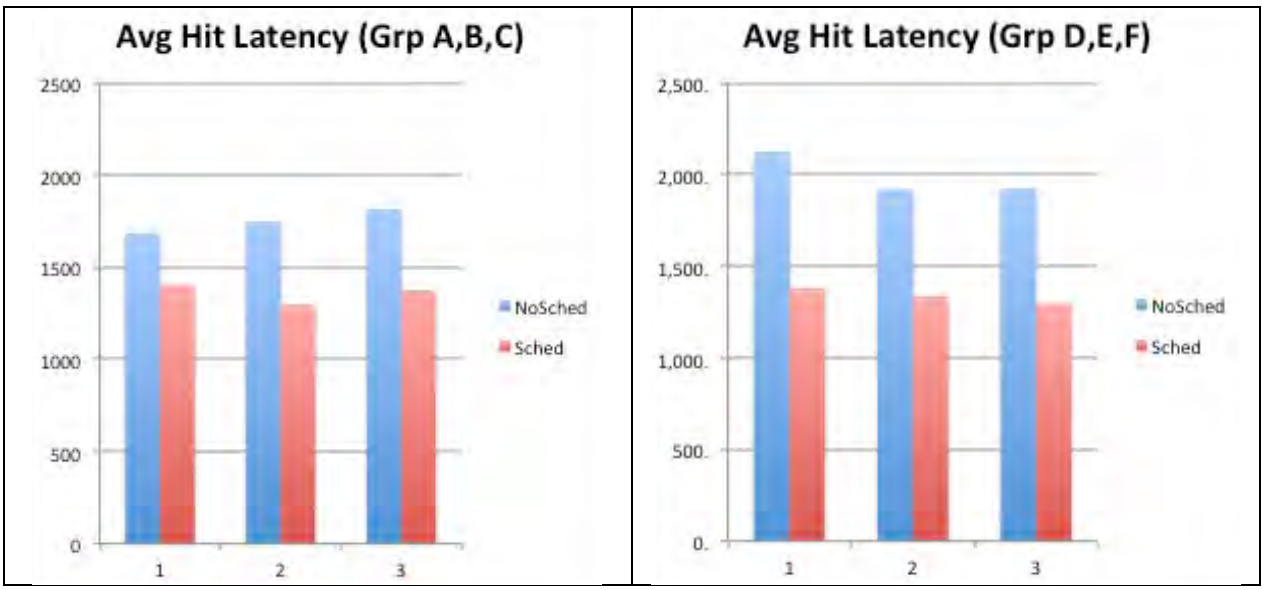
Display Wall Controller, it is possible to support over a dozen displays from a single PC. Driving a tiled display with a single computer greatly reduces the cost of ownership and maintenance of a tiled display wall. Furthermore it enables applications to run natively thereby eliminating the need to parallelize them. On the other hand, driving a high-resolution wall with a single computer introduces significant challenges in resource management. In particular, the operating system must be able to intelligently align the cores of a CPU, the available network capacity, bus bandwidth, and GPU resources to respond to the real-time interactions of multiple users attempting to manipulate content on the wall at the same time.

Traditional resource scheduling in modern operating systems that focus on fair sharing of resources and system-wide job completion throughput can fail to provide perceived good performance, expected by users, when the system is overloaded. Also, hierarchical memory architecture in modern multi-core processors is not efficiently utilized by operating systems. For SAGE, the prioritization of system resources is not necessarily based on fastest job completion time, such as in traditional approaches, but rather, which windows are the largest on the wall, which ones are least occluded by other windows, and which ones are interacting with a user. Work to develop a multi-user interaction-based resource manager is currently underway in the design of the next generation of SAGE, called *SAGE-Next*. To adequately control system resources, SAGE-Next uses the concept of Rails, which enables the alignment of specific cores and memory caches of a CPU, system interrupts, and network interfaces, on an application basis – in essence providing applications with the notion of "Quality of Service".

SAGE-Next supports multi-user collaborations of multiple content, and provides a plugin interface for application developers to develop cloud applications. SAGE-Next maintains compatibility with SAGE, so that it will support streaming of images from SAGE applications as well as allowing tiled walls to be the visualization endpoint of cloud technology.

In August 2012, PhD candidate Sungwon Nam conducted SAGE-Next user tests. He ran ANOVA (Analysis Of Variance) statistical tests on the data, to determine the effect of multiple users interacting with SAGE. The two main effects were:

- Sched versus NoSched
- Number of users interacting simultaneously



About the number of interacting users:

- For the first 3 groups (A, B and C), the subjects' interaction performance decreased as the number of users increased under NoSched condition.

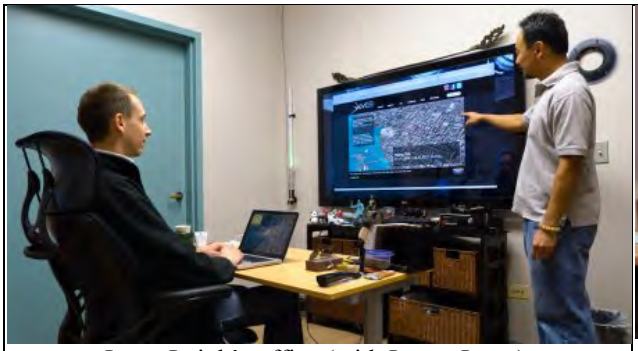
- For the last 3 groups (D, E and F), the subjects' interaction performance increased as the number of users increased under NoSched condition.

This contradicting result was because of different test conditions. For group A,B,C, the NoSched was the last condition whereas NoSched was the first condition for the group D,E,F. As the user study progressed, subjects became familiar with the application's interaction scheme and performed better. Nam is writing up his findings for a paper as well as his dissertation, so more information will be reported in the future.

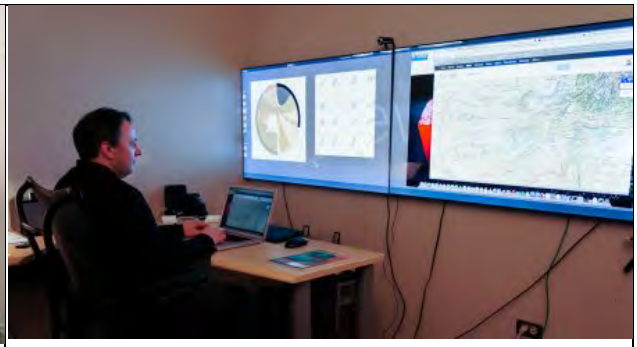
2.A.7. Education, Outreach and Broader Participation

2.A.7.1. SAGE in EVL Offices

Starting in January 2012, EVL offices began converting to SAGE-enabled wall-mounted displays (55″ LCDs) and people got rid of their desktop monitors. Using SAGE's file-sharing capability, users can drop relevant files onto other people's displays for subsequent follow-up. Renambot, SAGE's chief architect, enjoys having his own personal system, particularly since EVL's other SAGE walls are often in use.



Jason Leigh's office (with Lance Long).



Luc Renambot's office.

2.A.7.2. SAGE in the Classroom: Cyber-Commons

Cyber-Commons is a technology-enhanced meeting room on the UIC campus that supports local and distance collaboration and promotes group-oriented problem solving in formal and informal situations. More specifically, Cyber-Commons is a large-scale tiled display wall with 20Gbps of networking that runs SAGE, though SAGE is not required for its use.

EVL supports and uses Cyber-Commons for classroom instruction for undergraduate, Masters and PhD students. Cyber-Commons' goal is to help students learn how to collaborate within a university and among universities – to solve problems within a discipline and among multiple disciplines.

Since the summer of 2009, when the Cyber-Commons wall was installed, 13 different UIC courses have been taught by six different instructors in the new Cyber-Commons: CS 340 Software Design; CS 376 Practicum in Computer Science Presentations; CS 426 Video Game Design and Programming, with half of the class *virtually* attending from Louisiana State; CS 424 Visualization and Visual Analytics; CS 522 Programming Language Semantics; CS 524 Visualization and Visual Analytics II; CS 525 GPU Programming; CS 527 Computer Animation; CS 528 Virtual Reality; CS 594 Computational Biology, with a live link to Princeton; Physics 594 Parts 1 and 2 – Hunt for the Quark Gluon Plasma, with remote lectures from Los Alamos and CERN; and Art and Design 508 Advanced Electronic Visualization and Critique. There are also regularly scheduled research meetings, seminars, and videoconference calls that take place in Cyber-Commons several times a week.

We have also seen and encouraged ad-hoc use of the Cyber-Commons outside of regularly scheduled classes and meetings. Groups of students in the Visual Analytics course and the Video Game Design course use the space to brainstorm different ideas using the Wacom tablet on the wall as a whiteboard. Groups of graduate students discuss ideas for their research and upload related journal papers onto the wall from their laptops. Groups of PhD students studying for the qualifying exam display multiple exams

and their answers along with related web pages on the wall for discussion.

2.A.7.3. SAGE Press Releases and Videos

SAGE and the Cyber-Commons tiled display wall have appeared in the news and on YouTube.

Profile: Computer scientist Jillian Aurisano bridges the gender gap, UIC NEWS, September 2, 2012, http://www.uic.edu/htbin/cgiwrap/bin/uicnews/articledetail.cgi?id=16590

Serendipity: How a Student from University of Southern Mississippi Found Research Opportunities at UIC, August 16, 2012, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=819

UIC/EVL Student Jillian Aurisano Receives Scholarship to Grace Hopper Conference, EVL NEWS, July 11, 2012, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=817

Spark Student Mentored in Video Game Development at the UIC Electronic Visualization Laboratory, EVL NEWS, June 11, 2012, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=814

New Mobile Game from UIC Markets University and Showcases Engineering Courses, EVL NEWS, June 7, 2012, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=813

70 young women recognized as Google Anita Borg Memorial scholars, Googleblog, May 27, 2012, http://googleblog.blogspot.com/2012/05/70-young-women-recognized-as-google.html

Grad Engineering Programs Probe Intersection of Science, Art, U.S. News & World Report, May 9, 2012, http://www.usnews.com/education/best-graduate-schools/articles/2012/05/09/grad-engineering-programs-probe-intersection-of-science-art, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=808

Innovative virtual reality technology revolutionizes stroke therapy, Medill Reports Chicago, Northwestern University, March 1, 2012, http://news.medill.northwestern.edu/chicago/news.aspx?id=201800, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=797, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=803

Chicago computer scientists develop tools to help ecologists in Kenya, Medill Reports Chicago, Northwestern University, February 15, 2012, http://news.medill.northwestern.edu/chicago/news.aspx?id=200403&terms=kenya, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=793

Chicago virtual reality lab home to futuristic health class, Medill Reports Chicago, Northwestern University, February 14, 2012, http://news.medill.northwestern.edu/chicago/news.aspx?id=200322, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=794

Technology Transfer: UIC/EVL Partners with Industry to Advance 3D Visualization Display Technology, EVL NEWS, February 3, 2012, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=791

Jason Leigh Interview, WISE9 (Japan), November 24, 2011, http://wise9.jp/archives/5623

Future World, UIC Alumni Magazine, Winter 2011, http://www.uiaa.org/uic/news/uicalumni/1111a.html

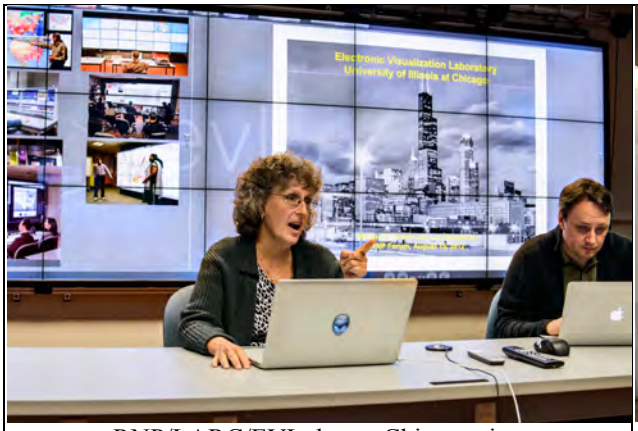
Learning in 3D, UIC NEWS, November 18, 2011, http://www.uic.edu/htbin/cgiwrap/bin/uicnews/articledetail.cgi?id=15876

Diaspora Diaries: King George V Alumnus Jason Leigh is Making Waves…, South China Morning Post, April 2011, http://www.evl.uic.edu/core.php?mod=4&type=4&indi=820

2.A.7.4. SAGE Technical Demonstrations and Presentations

August 29, 2012. EVL did demonstrations for Timothy S. Kroecker, Corporate Development Officer of the Air Force Research Laboratory, Information Directorate, located in Rome, NY. He visited UIC to recruit and promote collaboration with members of the UIC College of Engineering.

August 16, 2012. Maxine Brown and Luc Renambot did a remote SAGE demo for Brazil's RNP Forum in Brasilia, Brazil. RNP is Brazil's National Research & Education Network. The goal of the demo was to promote the benefits of tiled displays for research and education activities and its uses to campuses in Brazil. EVL worked with Tereza Cristina Carvalho and Fernando Redigolo of the University of *Sao Paulo's Laboratory* of Computer Networks and Architecture (LARC – a SAGE user). The live demo between the two campuses was transmitted via video camera to an audience at the site of the Forum. One outcome of this demo is that RNP will loan out its 2x2 SAGE system to educators who want to use it <http://translate.google.com/translate?hl=en&sl=pt&u=http://www.rnp.br/&prev=/search%3Fq%3Drnp%2Bforum%2B2012%2Bbrasilia%26hl%3Den%26biw%3D1041%26bih%3D687%26prmd%3Dimvns&sa=X&ei=EXpHUNnEHoLSqgGctoGADQ&ved=0CCMQ7gEwAA>.



RNP/LARC/EVL demo: Chicago site.

RNP/LARC/EVL demo: RNP Forum site.

July 25, 2012. EVL did a SAGE demo with UCSD/Calit2 to showcase collaborative technologies to Joe Papa and Ken Fulton, technical staff people from the National Academies of Science.

July 18-19, 2012. EVL and its partner Calit2/UCSD recently used SAGE to work on Omicron enhancements with collaborators from KAUST. KAUST provides EVL with partial funding for the development and deployment of (1) SAGE and (2) Omicron's multi-user tracking and interaction capabilities. The partners (Calit2, EVL and KAUST) met in the Calit2 VROOM room with the intent of integrating Kinect gesture-recognition capabilities with CalVR. The group integrated not only the Kinect, but also SAGE pointer and the iPad with Omicron so that they also work with CalVR.

The following panoramic photo shows project members having a marathon coding session in Calit2's VROOM room. So everyone could see what others in the room were doing, all the workstations (Kinect, CalVR) and all the laptops (Windows, Mac) were pushed to VROOM's large wall (64-Megapixel) driven by SAGE (using a combination of 'qshare' and VNC, where appropriate). Two main zones were defined on the wall: the left side was for Kinect and Omicron integration (Kinect workstation, Omicron server, iOS development) using VNC sharing, whereas the right side displayed the CalVR workstation using 'qshare' (needed for high-speed 3D capture). After the coding marathon, Jason Leigh commented, "The feeling of excitement as EVL and Calit2's merged codes first began to work was palpable; it felt like something out of an old NASA rocket launch."

EVL, Calit2 and KAUST have a marathon coding session in Calit2's VROOM room. (Photo: Luc Renambot)

July 16-17, 2012. EVL, Calit2, NTT Network Innovation Laboratories, NTT Advanced Technologies and Pacific Interface met at UCSD to discuss remote collaboration (OptIPortables and SAGE) technologies. From EVL, Jason Leigh, Luc Renambot, Sungwon Nam, Huy Bui and Dana Plepys attended.

July 12, 2012. Maxeler representatives (an FPGA company) visited EVL for a tour/demos.

July 12, 2012. EVL did a SAGE demo with Calit2 to showcase collaborative technologies to a Northrup Grumman Vice President in charge of training, who was visiting Calit2. He has major Defense Department contracts to create realistic training environments for troops going to Afghanistan.

June 25, 2012. EVL was visited by Anwar Osseyran, Director of SARA Supercomputing Services in the Netherlands and Sander Ruiter from Vancis BV (a SARA subsidiary that handles commercial ICT services). They were on their way to an NCSA conference on industrial applications of HPC in Champaign-Urbana, but Osseyran first wanted to see what new technologies we were developing at EVL. (SARA has adopted many of EVL's technologies, from the CAVE in the '90s to today's SAGE).

June 21, 2012. The UCSD Institute of the Americas organized a tour of Calit2 for journalists from El Universal, Mexico's largest newspaper. They were very impressed with OptIPortables and SAGE <http://www.ultra.com.mx/noticias/michoacan/Internacional/15779-calit2--una-mirada-al-futuro-del-video.html>.

June 19, 2012. Martin Reed and Paul Farrow of University of Essex (UK) and Joe Mambretti, Jim Chen and Fei Yeh of Northwestern University visited EVL to see its latest technologies and discuss SAGE.

June 14, 2012. EVL did a SAGE demo with Calit2 to showcase collaborative technologies to senior managers of Price Waterhouse Coopers and some of their select clientele.

June 8, 2012. Representatives from the Chicago office of advertising company Draftfcb visited EVL to see its technologies and brainstorm potential collaborations.

June 6, 2012. EVL did a SAGE demo with Calit2 to showcase collaborative technologies to Dr. M.R.C. Greenwood, president of University of Hawaii, who was visiting.

June 1, 2012. Calit2 collaborator Greg Hidley visited EVL to see and learn more about its technologies.

May 25, 2012. Representatives from Chicago's Field Museum of Natural History visited EVL to learn more about high-resolution, immersive displays for use in the museum's research and exhibitions.

May 25, 2012. Greg Hidley of Calit2, on behalf of Larry Smarr, attended the CUDI (Mexico R&E Network) Annual Meeting in Ensenada, Baja California, Mexico, where Calit2 received an award for facilitating the 10Gbps connection from CICESE to CENIC. Real-time demonstrations used SAGE and the CICESE OptIPortal connected via the new 10Gbps network to a display wall at Calit2. Plans to extend this network to other UNAM institutions in Mexico will only further opportunities for international collaboration.


El Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California

CICESE

Otorga el presente

RECONOCIMIENTO

A

Calit2

Por su valiosa aportación al "Impulso de la conectividad nacional e internacional del enlace de 10 Gbps para el uso académico y científico en México".

Ensenada, Baja California, México, a 25 de mayo del 2012

Dr. Federico Graef Ziehl
DIRECTOR GENERAL

Dr. Raúl Rivera Rodríguez
DIRECTOR DE TELEMÁTICA

May 15, 2012. EVL has funding from the Air Force Office of the Surgeon General to work on a visualization project. Program Managers visited UIC for a site visit and came to EVL for a tour/demos.

May 8, 2012. EVL alumna Dr. Maria Roussou, founding director of *makebelieve design & consulting,* as well as a researcher and Adjunct Lecturer at the University of Athens, Greece, toured EVL.

May 8, 2012. University of Birmingham (UK) professors Richard Clay and Henry Chapman toured EVL.

May 1, 2012. Maxine Brown served on an NSF MRI panel, and was specifically selected for her knowledge of visualization display systems.

April 24, 2012. Roger Shiffman, co-founder of Tiger Electronics and Zizzle iZ Toy company, toured EVL.

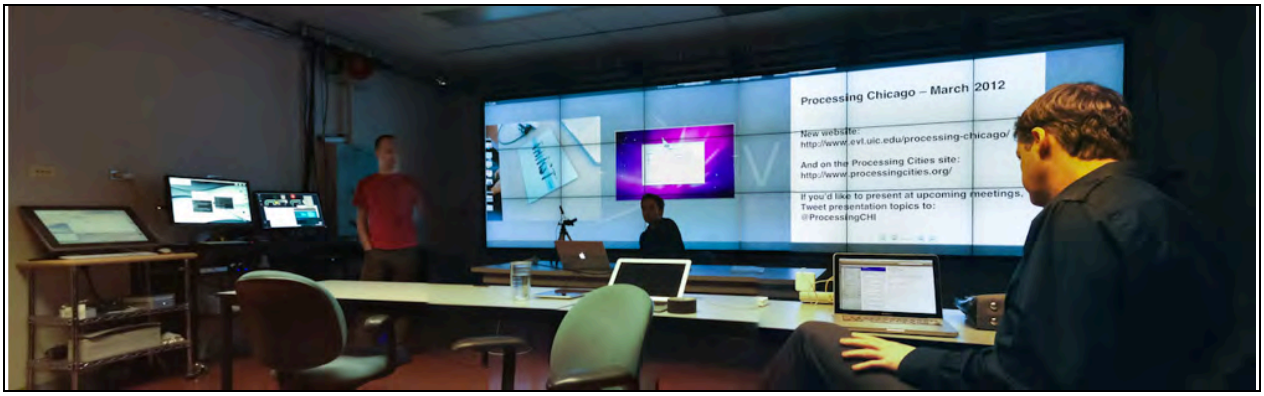
April 19, 2012. Cheryl Easter, wife of University of Illinois President Robert Easter, toured EVL.

April 18, 2012. EVL hosted Scott Rettberg, Associate Professor and the Director of the Digital Culture Research Group from the University of Bergen, Norway.

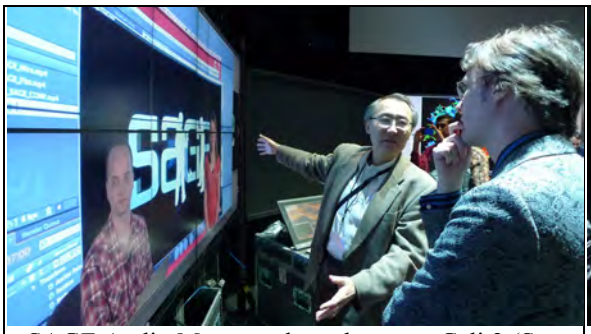
March 30, 2012. EVL did a 10Gbps SAGE demonstration and Jason Leigh gave the remote keynote presentation from Chicago for the opening of the SARA Collaboratorium in The Netherlands. The audience consisted of scientists with needs to share research within various disciplines and who normally have large amounts of complex data. Visualization and collaboration is essential for them. SARA is a major SAGE user, so felt it was important to have EVL talk about collaboration environments like those provided by SAGE and how they could be of great value to SARA's audience.

March 12, 2012. EVL did a tour and demos for Paula Golden, Executive Director of Broadcom Foundation and Director, Community Affairs, who was visiting the UIC College of Engineering.

March 6, 2012. EVL hosts *Processing Chicago,* a monthly meeting that consists of workshops and presentations given by artists, designers and scientists exploring creative research using a variety of media and toolsets, including (but not limited to) Processing, Arduino, openFrameworks, Cinder, Max/MSP and Supercollider. The presenters use SAGE on EVL's Cyber-Commons wall for their presentations, as shown in the photo below. For information, see <http://www.evl.uic.edu/processing-chicago/>.



February 29-March 1, 2012. Maxine Brown and Luc Renambot attended and participated in the 11th annual ON*VECTOR International Photonics Workshop, held at Calit2. (ON*VECTOR is the Optical Networked Virtual Environments for Collaborative Trans-Oceanic Research project, a joint project of NTT Network Innovation Laboratories, Keio University's Institute for Digital Media and Content (DMC), the University of Tokyo's Morikawa Laboratory, UIC/EVL, Calit2/UCSD and Pacific Interface Inc.). Brown chaired a session on "Collaborative Networking Technologies." Renambot and Nathan Brock from Calit2/Sonic Arts talked about "SAM (SAGE Audio Manager)" and how they are incorporating better audio, and synchronized audio and video, into SAGE for distance collaboration. Renambot and Brock also demonstrated SAM between San Diego and EVL in Chicago. In addition, the audience was treated to a presentation on the process of making a collaborative film using SAGE on large tiled display systems. Student teams from Calit2/Sonic Arts and Keio University's School of Media Design are using SAGE to make the movie "Growing Documentary," which is about displaced people, inspired by the aftermath of the Japanese earthquake and tsunami, March 11, 2011.



SAGE Audio Manager demo between Calit2 (San Diego) and EVL (Chicago).

"Growing Documentary" SAGE collaboration demo between Calit2 (San Diego) and Keio (Tokyo).

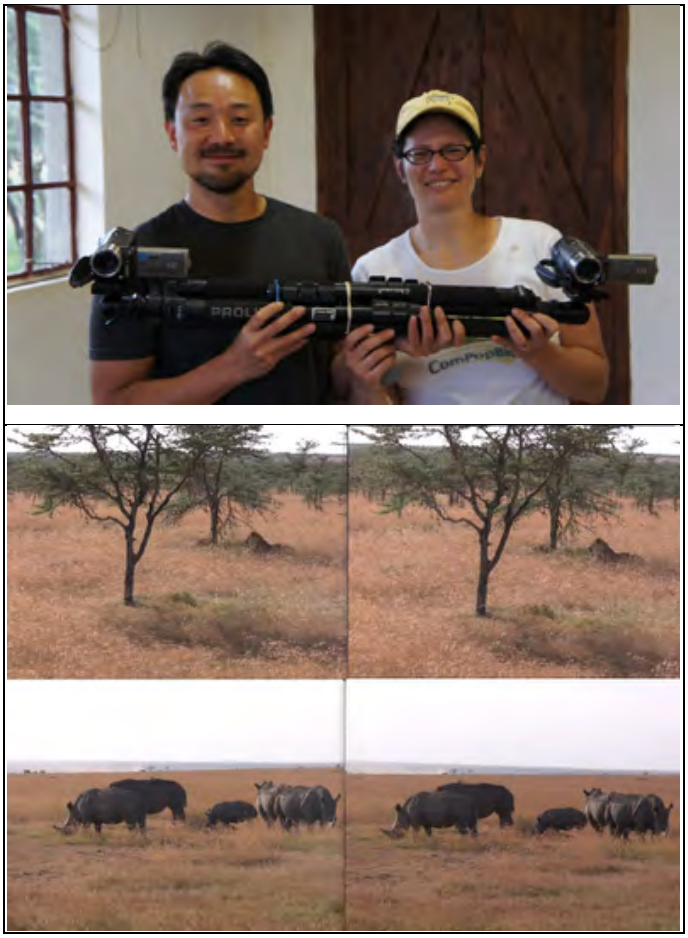
February 28, 2012. Maxine Brown and Luc Renambot attended the NTT-sponsored Digital Media Analysis, Search and Management (DMASM 2012) Workshop, held at Calit2. EVL did a SAGE demonstration with PIX System, a tablet-based application that uses wireless to interact with video clips displayed with SAGE on a tiled wall. Here is a photo of the SAGE/PIX demo, and a panorama of the Calit2 VROOM room running three different SAGE sessions.

DMASM 2012 SAGE/PIX demo

DMASM 2012 VROOM panorama

January 19, 2012. EVL gave a tour and demos to a staff member of Illinois Senator Mark Kirk's office.

January 18-20, 2012. Maxine Brown, with support from her NSF IRNC TransLight/StarLight award, helped organize two small, invitational Workshops at the University of Hong Kong (HKU), to bring together network infrastructure leaders, both in Hong Kong and in southeast Asia, to discuss the overall design, development and operation of global, open, communications exchange points for data-intensive science. Brown gave a presentation on applications that could take advantage of high-speed networks, and showed SAGE photos and videos. For more information, see <www.startap.net/starlight/PUBLICATIONS/GLORIAD_HongKong.html>.



January 4-25, 2012. EVL and the UIC Laboratory for Computational Population Biology (LCPB), together with ecology scientists from Princeton University, spent almost a month on a field trip to Kenya. This is a joint course that brought together PhD students from ecology and computer science in an effort to foster interdisciplinary research in computational ecology. LCPB director Tanya Berger-Wolf combined her background in data mining, which focuses on finding patterns in information, with EVL professor Jason Leigh's expertise in data visualization, but it was the ecology course students who drove the projects – projects that included the study of ants in acacia trees, ant navigation and "Virtual Mpala" (Mpala was the field site location, which students documented with 2D and 3D photos and videos for ultimate viewing on the EVL Cyber-Commons 3D display using SAGE.) In addition to bringing a consumer 3D video camera, Leigh and Berger-Wolf built a hyper stereo rig that consisted of two inverted tripods with HD video cameras on each end (shown in photo). Shown here are two cross-eye stereo snapshots of videos. The subjects in the photos were over 50 feet away so the hyper stereo helped place them in depth. Partial zoom was used to bring the subjects close enough to see. The course blog can be found at <http://kenyacourse.blogspot.com/>. An article written by a Northwestern University Medill School of Journalism graduate student appears at: <http://news.medill.northwestern.edu/chicago/news.aspx?id=200403&terms=kenya>.

December 4-7, 2011. Calit2 hosted the 6th Annual CineGrid International Workshop 2011. The media and entertainment industries are actively involved in CineGrid to better understand the role of robust large-bandwidth networks in applications from content creation and remote collaboration, and are beginning to adopt high-end distributed telepresence technologies for their companies and their global suppliers. Jason Leigh, Luc Renambot and Dana Plepys from EVL participated. There were several SAGE demos, including one between San Diego and Chicago.

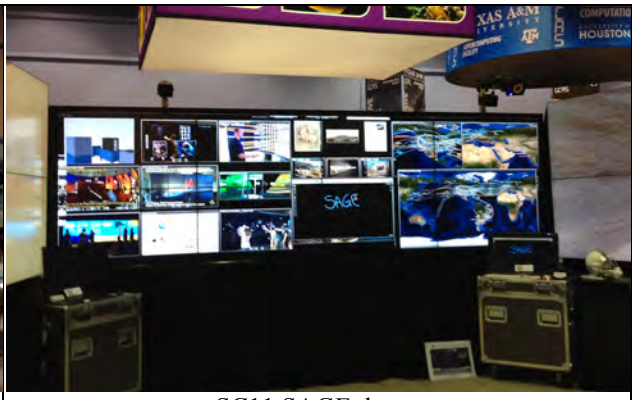
CineGrid 2011 attendees

CineGrid 2011 "Growing Documentary" SAGE collaboration between Calit2 (San Diego) and Keio (Tokyo).

November 29-December 3, 2011. Andy Johnson from EVL participated in the 2011 Southeast Asia International Program (SEAIP) "Southeast Asia International Joint Research and Training Program in High-Performance Computing Applications and Networking Technology," an effort supported by Taiwan's National Science Council (NSC) to share and to disseminate current IT developments in High-Performance Computing and Networking within the region. Johnson gave a presentation on SAGE and distance collaboration.

November 15-17, 2011. At SC11, EVL organized a very successful SAGE Birds-of-a-Feather (BOF) session, attracting ~50 people; the BOF agenda and presentations are posted on the SAGE website <www.sagecommons.org/index.php?option=com_content&view=article&id=114>. EVL also participated, with Calit2, in the KAUST booth, doing SAGE/OptIPortable demonstrations. Participants included Jason Leigh, Luc Renambot, Maxine Brown, Sungwon Nam and Arthur Nishimoto. In addition to typical SAGE demos, EVL worked with Masaryk University and CESNET (Czech Republic) to demo their UltraGrid high-quality, low-latency video transmission system <http://ultragrid.sitola.cz>, which they integrated with SAGE and streamed animations from Brno, Czech Republic to the KAUST OptIPortable.

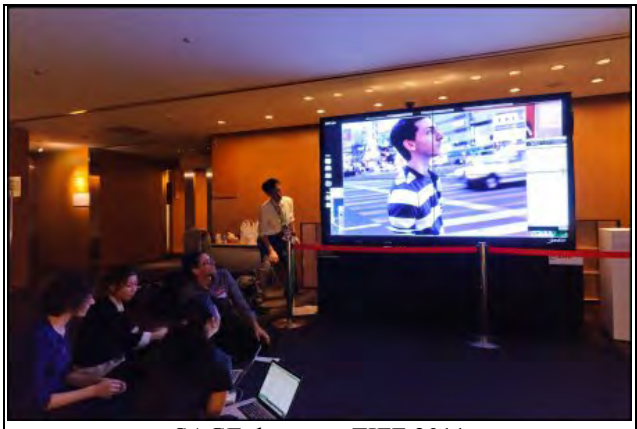
SC11 SAGE BOF



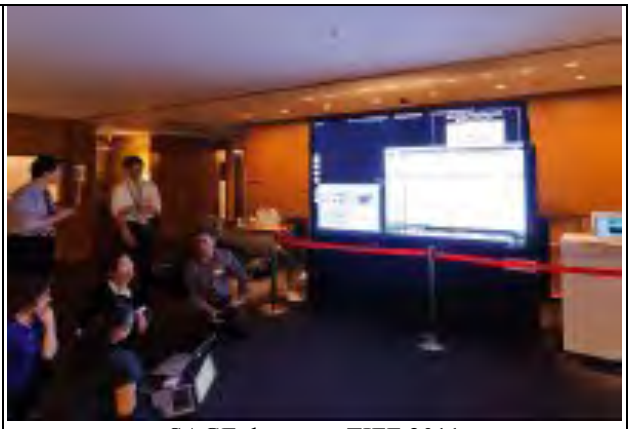
SC11 SAGE demo

November 11, 2011. Northwestern Memorial Hospital facilities people and architectural design firm Navigant visited EVL to see SAGE and Cyber-Commons. They are interested in using large-scale visualization to showcase renovation/construction designs and plans to hospital users and focus groups.

October 25, 2011. Luc Renambot, in collaboration with CineGrid partners NTT, Keio University, Calit2 and Pacific Interface, participated in the Tokyo International Film Festival (TIFF), where SAGE was demonstrated. NTT set up an OptIPortable with four 55" HD screens and a touch screen.

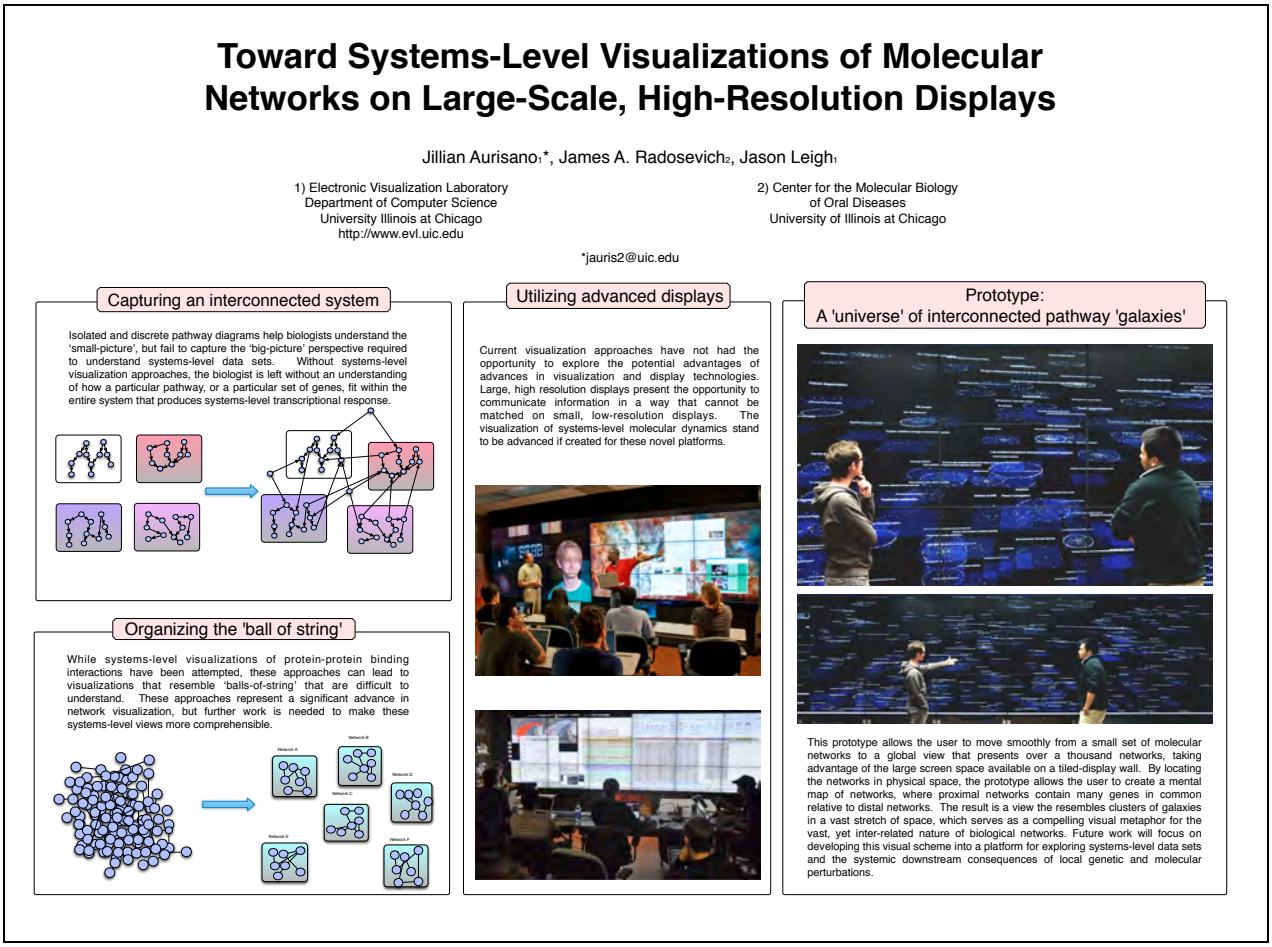


SAGE demos at TIFF 2011



SAGE demos at TIFF 2011

October 23-24, 2011. EVL graduate student Jillian Aurisano presented a poster at the 1st IEEE Symposium on Biological Data Visualization (BioVis). SAGE and tiled display walls were some of the topics covered on her poster (see below).



Toward Systems-Level Visualizations of Molecular Networks on Large-Scale, High-Resolution Displays

Jillian Aurisano[1]*, James A. Radosevich[2], Jason Leigh[1]

1) Electronic Visualization Laboratory
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Capturing an interconnected system

Isolated and discrete pathway diagrams help biologists understand the 'small-picture', but fail to capture the 'big-picture' perspective required to understand systems-level data sets. Without systems-level visualization approaches, the biologist is left without an understanding of how a particular pathway, or a particular set of genes, fit within the entire system that produces systems-level transcriptional response.

Organizing the 'ball of string'

While systems-level visualizations of protein-protein binding interactions have been attempted, these approaches can lead to visualizations that resemble 'balls-of-string' that are difficult to understand. These approaches represent a significant advance in network visualization, but further work is needed to make these systems-level views more comprehensible.

Utilizing advanced displays

Current visualization approaches have not had the opportunity to explore the potential advantages of advances in visualization and display technologies. Large, high resolution displays present the opportunity to communicate information in a way that cannot be matched on small, low-resolution displays. The visualization of systems-level molecular dynamics stand to be advanced if created for these novel platforms.

Prototype: A 'universe' of interconnected pathway 'galaxies'

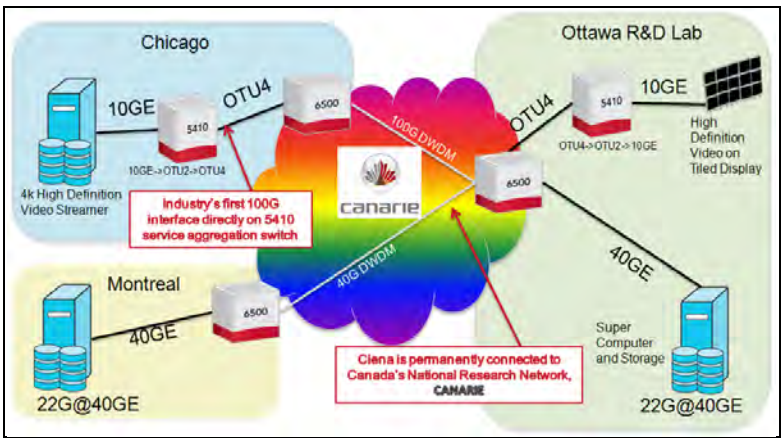
This prototype allows the user to move smoothly from a small set of molecular networks to a global view that presents over a thousand networks, taking advantage of the large screen space available on a tiled-display wall. By locating the networks in physical space, the prototype allows the user to create a mental map of networks, where proximal networks contain many genes in common relative to distal networks. The result is a view the resembles clusters of galaxies in a vast stretch of space, which serves as a compelling visual metaphor for the vast, yet inter-related nature of biological networks. Future work will focus on developing this visual scheme into a platform for exploring systems-level data sets and the systemic downstream consequences of local genetic and molecular perturbations.

October 17, 2011. Maxine Brown attended the PRAGMA Workshop in Sapporo, Japan, and gave a SAGE presentation.

October 6, 2011. Maxine Brown attended an NSF IRNC PI meeting in Washington DC and, together with co-PI Joe Mambretti, gave a presentation on the NSF-funded TransLight/StarLight project. One of the efforts focused on high-performance applications, and Brown spoke about SAGE and international

collaboration.

October 3-7, 2011. EVL provided technical support to Extreme Networks for SAGE demos at Interops, Las Vegas.



September 26 - October 28, 2011. EVL worked with Ciena Networks and Northwestern University on SAGE trials between Chicago and Ottawa as part of the company's Future Internet and emerging immersive media environments demonstrations. Visitors to Ciena's R&D facility in Ottawa watched e-science, high-definition visualization and computer and telecommunication science research applications that utilized 10/40Gbps Ethernet clients transported over a100Gbps long-haul network provided by CANARIE. Specifically, a 40Gbps lightpath connecting the Ecole de Technologie Superieur (ETS) in Montreal to Ciena's lab in Ottawa conducted computer-to-computer protocol latency experiments. And, a 10Gbps link between EVL and StarLight, and CANARIE's 100Gbps link between StarLight and Ciena's lab, were used to send multiple high-definition e-science video streams. Additional information can be found at:
http://www.ciena.com/corporate/blog/Ciena-Vectors-Summit.html
http://www.ciena.com/corporate/blog/Up-to-Ottawa-for-Vectors-Summit.html
http://www.ciena.com/corporate/blog/Vectors-Summit-Not-your-average-trade-show.html

September 26, 2011. NTT Advanced Technologies visited EVL to learn more about SAGE. Attending from NTT-AT were Hitoshi Takanashi, Takeshi Sampei, Shinji Matsuoka and Yukito Tanaka. EVL participants included Jason Leigh, Luc Renambot, Maxine Brown, Dana Plepys, Arthur Nishimoto, Sungwon Nam and JD Pirtle.

September 8-9, 2011. Rita Rodriguez and Alexander J. Schwarzkopf of the NSF were at UIC to participate in an NSF I/UCRC Security and Software Engineering Research Center Workshop. Given Rodriguez has funded, and continues to fund, many of EVL's MRIs – including tiled display walls – we invited her to EVL where we demo'ed SAGE on Cyber-Commons.

2.A.7.5. SAGE Outreach

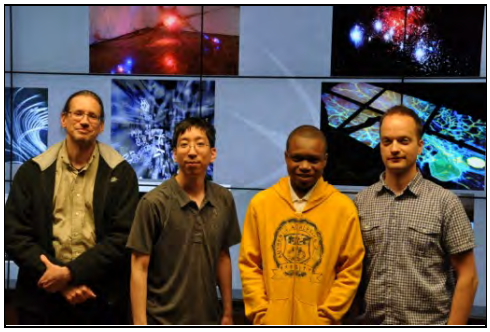
EVL does numerous education and outreach demonstrations to assist UIC with recruitment, retention, and professional development efforts. EVL faculty and students both demonstrate SAGE and use SAGE to give EVL overview presentations in the Cyber-Commons room.

September 2, 2012. UIC NEWS profiled female UIC Computer Science MS student and EVL research assistant Jillian Aurisano. Aurisano's research combines her undergraduate work in biology with her Master's degree work in computer science. In the article, she explains, "'I'm working with a series of computer monitors connected together, driven by a single computer...I hope to write programs to take biological data, questions researchers have, and translate it to interactive visual representation to permit researchers to take advantage of large high-resolution digital space.' Huge wall screens 'can show lots of data, lots of juxtaposed information, considering lots of pieces of the puzzle,' she said, and expects them to be standard equipment in labs and offices within 10 to 20 years." The article "Profile: Computer scientist Jillian Aurisano bridges the gender gap" can be found at: <http://www.uic.edu/htbin/cgiwrap/bin/uicnews/articledetail.cgi?id=16590>. Other articles about Aurisano include "UIC/EVL Student Jillian Aurisano Receives Scholarship to Grace Hopper Conference" at <http://www.evl.uic.edu/core.php?mod=4&type=4&indi=817> and "70 young women recognized as Google Anita Borg Memorial scholars," at <http://googleblog.blogspot.com/2012/05/70-young-women-recognized-as-google.html>.

August 2, 2012. Maxine Brown and Sungwon Nam did a remote SAGE demo for Calit2's Minority-Serving Institutions Cyberinfrastructure Coalition (MSI-CIEC) Workshop: Advancing the Building of Virtualization Environments Instruments for Faculty Research at MSIs.

July 31, 2012. EVL hosted a visit by ~25 teachers attending an intensive summer program. The UIC College of Engineering's Electrical and Computer Engineering Department hosted three intensive training sessions for Project Lead The Way (PLTW) middle-school and high-school teachers this summer. EVL presented an overview of its research activities, and then treated the group to a demo of EVL's new virtual-reality CAVE2 system.

June – August, 2012. Terrance Thigpen, an African-American undergraduate studying Information Technology at the University of Southern Mississippi (USM) completed a summer internship at EVL, where he worked with faculty, staff and students to build CAVE2, an advanced, panel-based, hybrid virtual-reality and visualization environment. Thigpen plans to apply to graduate school at UIC. The article "Serendipity: How a Student from University of Southern Mississippi Found Research Opportunities at UIC," describes his experiences: <http://www.evl.uic.edu/core.php?mod=4&type=4&indi=819>.



May – June 2012. EVL mentored Spark student Elonzo for one afternoon per week. Spark is a national non-profit agency that focuses on encouraging middle-school children from disadvantaged communities to excel in school and pursue their dream jobs. When Spark staff learned that 7th grader Elonzo from Dodge Renaissance Academy in Chicago was interested in learning more about creative programming, they arranged to have him attend EVL for a two-month apprenticeship. The article "Spark Student Mentored in Video Game Development at the UIC Electronic Visualization Laboratory" describing his experience is at: <http://www.evl.uic.edu/core.php?mod=4&type=4&indi=814>.

May 18, 2012. Science journalism students from Northwestern University's Medill School visited EVL for a lecture and demonstrations.

April 26, 2012. EVL hosted tours for the UIC Take Our Daughters to Work Day (ages 9-15).

March 26, 2012. EVL hosted a tour/demo for UIC Engineering's Project Lead the Way (PLTW) recruitment, hosting students from Chicago's Martin Luther King High School.

March 16, 2012. EVL hosted a tour/demo for UIC WISE (Women In Science & Engineering) Pre-College Outreach program for 25 students from Chicago's Mother McAuley High School.

February 20, 2012. EVL did demonstrations and presentations for the UIC Computer Science Open House. Also attending was Derrick Williamson, a Technology Supervisor at Wheeling High School who was interested in learning more about EVL's technologies for an innovative program for his school.

February 7-10, 2012. EVL hosted two Northwestern University Medill journalism graduate students at EVL who developed several EVL articles for their course practicum.

November 11, 2011. EVL did demos/tours for the UIC Computer Science Open House.

October 10, 2011. EVL did demos/tours for the UIC Computer Science Open House.

September 16-17, 2011. Luc Renambot did a remote SAGE demo for Calit2's Minority-Serving Institutions Cyberinfrastructure Coalition (MSI-CIEC) Workshop: Visualization Tools to Bridge Gaps for Distributed Knowledge and Distance Collaboration <http://greenlight.calit2.net/outreach/>. This workshop focused on advanced cyberinfrastructure to support data analysis and distance collaboration using high-resolution display wall environments connected by high-speed networks. Renambot participated in a SAGE/OptIPortable demonstration.

Everyone pushes his/her desktop screen to the OptIPortable using SAGE.

Calit2 VROOM (Virtual Room) with OptIPortables, some running SAGE.

2.B. Research Findings: SAGE SurveyMonkey

SAGE SurveyMonkey Tally, May 1, 2012…*In Spring 2012, EVL published a SurveyMonkey for SAGE, telling users that EVL's success in securing future funding depended on the Lab's ability to communicate to NSF program managers the importance of SAGE to enabling national and international teams to do their work. Below is a list of people who responded to the survey, followed by the questions and responses. In total, EVL received 40 responses – which, at the time, represented almost 50% of known SAGE sites. The survey was available at <https://www.surveymonkey.com/s/9Y5TT5Z>.*

Respondents (37 out of 40 names provided)

Jim Chen, Northwestern/iCAIR
Brian Corrie, WestGrid/IRMACS, Simon Fraser University, Canada
Susumu Date, Cybermedia Center, Osaka University, Japan
Brian Davis, USGS/EROS Center
Tom DeFanti, Calit2, UCSD
Kevin Kejun Dong, Computer Network Information Center, Chinese Academy of Sciences, China
Mats Erixon, KTH, Sweden
Sanjaya Gajurel, Case Western Reserve University
Gibeom Gu, KISTI Supercomputing Center, Korea
Laurin Herr, CineGrid
Erik Hofer, University of Michigan
Petr Holub, SITOLA Laboratory, Masaryk University and CESNET, Czech Republic
Kohei Ichikawa, Osaka University, Japan
Joseph Keefe, Calit2, UCSD
Chi-Woong Kim, KISTI, Korea
JongWon Kim, GIST (Gwangju Institute of Science & Technology), Korea
Joe Mambretti, iCAIR, Northwestern University
Todd Margolis, CRCA, UCSD
Jiri Matela, Masaryk University and CESNET, Czech Republic
Donald McLachlan, Communications Research Centre, Canada
Bernard Meade, The University of Melbourne, Australia
Hideo Miyachi, Cybernet Systems Co.Ltd.
Leonel Morales-Diaz, Universidad Francisco MarroquÃn, Guatemala
Bernard Pailthorpe, University of Queensland, Australia
Steve Poulos, University of Hawaii
Han Rauwerda, University of Amsterdam, MAD/IBU, The Netherlands
Brett Rosolen, AARNet, Australia
Lev Shchur, Science Center of Russian Academy of Sciences in Chernogolovka
Shinji Shimojo, NICT, Japan
Srinivas Sukumar, Calit2, UCSD
Art Vandenberg, Georgia State University
Vasily Velikhov, Kurchatov Institute and Russian Academy of Science, Russia
Jeffrey Weekley, MOVES Institute, Naval Postgraduate School
Jon Welch, NASA Ames Research Center (Lockheed Martin)
Paul Wielinga, SARA, The Netherlands
Christopher Willing, University of Queensland, Australia
Wenjun Wu, Beihang University, China

1. What is your name? (optional)

Note: 36 people out of 40 people provided their names, but one individual who did not give his name offered to write a letter of support in response to a subsequent question, so provided his name then.

SAGE Survey

What is your name? (optional)	
	Response Count
	36
answered question	36
skipped question	4

2. What is the name of your Institution / Organization? (optional)

What is the name of your Institution / Organization? (optional)	
	Response Count
	37
answered question	37
skipped question	3

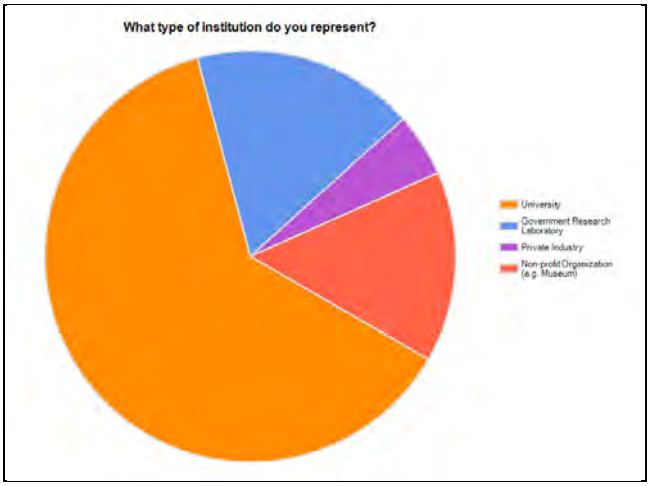
1. AARNet
2. Beihang University
3. Case Western Reserve University
4. CineGrid
5. Communications Research Centre
6. Computer Network Information Center, Chinese Academy of Sciences
7. Cybermedia Center, Osaka University
8. Cybernet Systems Co. Ltd.
9. Georgia State University
10. GIST (Gwangju Institute of Science & Technology)
11. International Center for Advanced Internet Research, Northwestern University
12. KISTI Supercomputing Center
13. KISTI, Korea
14. KTH
15. Masaryk University / CESNET
16. NASA Ames Research Center (Lockheed Martin)
17. National Research Center, "Kurchatov Institute"
18. Naval Postgraduate School, MOVES Institute
19. NICT
20. Northwestern/iCAIR
21. Osaka University

22. SARA
23. Science Center, Russian Academy of Sciences in Chernogolovka
24. SITOLA Laboratory (Masaryk University and CESNET)
25. The University of Melbourne
26. UCSD
27. UCSD/Calit2
28. UCSD/Calit2
29. UCSD/CRCA
30. Universidad Francisco MarroquÃn
31. University of Amsterdam, MAD/IBU
32. University of Hawaii
33. University of Michigan
34. University of Queensland
35. University of Queensland
36. USGS/EROS Center
37. WestGrid/IRMACS, Simon Fraser University

3. What type of institution do you represent?

What type of institution do you represent?

	Response Percent	Response Count
University	**62.5%**	**25**
Government Research Laboratory	17.5%	7
Private Industry	5.0%	2
Non-profit Organization (e.g. Museum)	15.0%	6
Other (please specify)		5
answered question		**40**
skipped question		**0**



4. Why is SAGE important to you? What does SAGE enable you to do that you cannot do otherwise, or enhance what you already do?

Why is SAGE important to you? What does SAGE enable you to do that you cannot do otherwise, or enhance what you already do?	
	Response Count
	36
answered question	36
skipped question	4

1. A dynamic administration of live streams in our 4K installations.
2. Acts similar to a command center, showing various datasets and environmental conditions for coordinating at-sea activity. Also a useful tool during visitor tours for highlighting a variety of different funded science studies.
3. Collaboration in many areas, such as biomedical research, advanced cinematic production and community outreach. These are just a few examples.
4. Collaboration in research and education environments where people bring their devices of dissimilar nature is key to achieve our goals and SAGE provides tools and visualization techniques suitable for collaboration in these dissimilar settings. The case for visualization of high-detail images (with high-pixel density) is particularly important for us and SAGE allows us to access these images in a way that is not possible with any other tool or technology. Also, our research related to human-computer interaction and the future of interactive devices would not be complete without wall screens that we believe will be widely available in the years to come. SAGE provides a testbed for these innovations.
5. Enables us to show large-scale simulation and scientific observation results in a scalable manner, which is important for scientists and the general public.
6. Enables us to visualize high-resolution images/video and share high-resolution images/video over high-speed networks.
7. High-resolution (4K) representation of: 1) environment, 2) virtual museum (e.g., antique frescoes), 3) virtual medicine (e.g., field of surgery operation), 4) results of simulations (e.g., random fractals).
8. I am beginning a research Master's degree investigating the processes for processing and distributing radio astronomy data, focusing particularly on SKA precursor telescopes. I plan to utilize OptIPortals around Australia as display endpoints for a cloud-enabled processing service. SAGE provides the most effective method of synchronizing these displays, and the possibility for developing new methods of shared interaction.
9. Northwestern/iCAIR uses SAGE for a wide range of scientific visualization imaging and for research programs related to high-performance digital media and wide-area optical transport.
10. It enables us to present an immersive and collaborative environment for displaying rich visual information, such as biomedical data and GIS images.
11. It enables visualization of large imagery for pathology applications and also enables visualization of high-resolution video and multi-point videoconferences with high resolution.
12. It is a very important tool for us for (remote) collaboration, information mash-ups, and sharing of high-resolution visualizations.
13. It's the only mechanism we have for multiple, very-high-resolution applications to run simultaneously. The SAGE-Bridge is the only mechanism we have that enables real-time collaborations around these applications.

14. Local and remote collaboration with large media collections.
15. Multi-group collaboration; easy data transfer from laptop to remote locations; enhanced visualization of physical artifacts; and, community outreach and interaction.
16. Remote visualization and high-definition visualization.
17. SAGE allows us to build an interactive environment for immersive workspaces. We have the bandwidth across our entire community to capitalize on the way SAGE performs best, and we want to support our community to collaborate.
18. SAGE allows us to provide a collaboration-ready and tested tiled-display capability to our many university, community, government and industry users.
19. SAGE could be important to us to use with our Visualization Wall (http://www.gsu.edu/ist/research-computing/visualization-wall.html). Our Viz Wall is Windows 7 based, so we have been working to create a Windows version. A PhD student has made initial code changes so that our Viz Wall can become the SAGE Server, but much work remains.
20. SAGE has been our middleware platform for ultra-resolution collaborative displays since 2005. With an increasing number of ultra-resolution systems on our campus, SAGE provides both critical user-interaction and cross-display collaboration capabilities that no other framework provides.
21. SAGE helps us to display sessions with high-resolution images and videos.
22. SAGE is used by several CineGrid members as a key technology for media-centric remote collaboration over high-speed networks, such as content creation, image analysis, command and control, etc. SAGE has proven especially good for group collaborations.
23. SAGE is very important in our project. Because SAGE is used for education and training, we have been working on studies on the interface, network and architecture of SAGE. In addition, we also have several industry-university joint research programs using SAGE.
24. SAGE provides a role model for our research work for developing a multi-party, visual sharing system.
25. SAGE wall is the only device capable of displaying 4K and higher resolutions that we currently have in our lab.
26. Scalable visualization of large data, images and simulations.
27. Tiled displays are used as a large workspace.
28. Visual communication of large and complex earth science datasets.
29. Visualization of large datasets.
30. We are providing SAGE with tiled-display to our customers.
31. We can display various images or datasets without decreasing resolution and can compare it at a time.
32. We have a 2x4 tiled display (2 OptIPortables based on Calit2's design) that we use for collaboration technology research, and SAGE is our primary application on the wall: its multi-user features enable co-present groups of researchers to work out solutions together and page through many media files and datasets easily. We are also working towards a network of SAGE-enabled walls (via SAGE Bridge) at NASA that will augment our ability to work with these datasets across geographic boundaries.
33. We run SAGE on our tiled display in our e-BioLab.
34. We use SAGE for data visualization from supercomputing center.
35. We use SAGE to collaborate with Navy and non-Navy partners across a wide variety of application areas – Modeling and Simulation, Media Production and Virtual Telepresence – to reduce costs and save CO_2.
36. We use video as an application for loading/demonstrating high-speed networks. Thus, to load [utilize] high-speed networks, we are interested in playing 4K video.

5. How many SAGE-enabled tiled display walls do you currently have at your institution, either for your use or for use by other groups?

How many SAGE-enabled tiled display walls do you currently have at your institution, either for your use or for use by other groups?

	Response Percent	Response Count
None	7.5%	3
1	**37.5%**	**15**
2-4	35.0%	14
More	20.0%	8
	answered question	**40**
	skipped question	**0**

6. What is the approximate resolution of your largest SAGE wall?

What is the approximate resolution of your largest SAGE wall?

	Response Percent	Response Count
Less than 8 Megapixels	12.5%	5
18 Megapixels	20.0%	8
24 Megapixels	25.0%	10
50 Megapixels	**30.0%**	**12**
100 Megapixels	12.5%	5
	Larger (please specify)	6
	answered question	**40**
	skipped question	**0**

7. In the next 4 years, how many SAGE display walls do you or other groups you work with plan to deploy?

In the next 4 years, how many SAGE display walls do you or other groups you work with plan to deploy?		Response Percent	Response Count
Unknown		25.0%	10
0		2.5%	1
1		10.0%	4
2-4		30.0%	12
More		**32.5%**	**13**
		answered question	**40**
		skipped question	**0**

8. If you plan to deploy new SAGE walls in the next 4 years, what will be the approximate resolution of the largest wall?

If you plan to deploy new SAGE walls in the next 4 years, what will be the approximate resolution of the largest wall?		Response Percent	Response Count
Less than 8 Megapixels		0.0%	0
8 Megapixels		0.0%	0
18 Megapixels		25.0%	8
24 Megapixels		15.6%	5
50 Megapixels		21.9%	7
100 Megapixels		**37.5%**	**12**
		Larger (please specify)	3
		answered question	**32**
		skipped question	**8**

9. How many different groups use SAGE at your institution? (A group is one or more persons who collaborate on a specific project.)

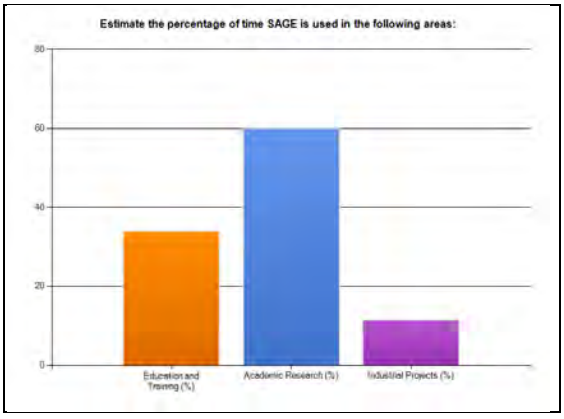
How many different groups use SAGE at your institution? (A group is one or more persons who collaborate on a specific project.)

	Response Percent	Response Count
1	30.0%	12
2-4	**47.5%**	**19**
4-6	15.0%	6
More	7.5%	3
	answered question	**40**
	skipped question	**0**

10. Estimate the percentage of time SAGE is used in the following areas

Estimate the percentage of time SAGE is used in the following areas:

	Response Average	Response Total	Response Count
Education and Training (%)	33.94	1,086	32
Academic Research (%)	**60.00**	**1,980**	33
Industrial Projects (%)	11.43	240	21
	answered question		**35**
	skipped question		**5**



11. Describe examples of SAGE use in each of these areas:

Describe examples of SAGE use in each of these areas:

	Response Percent	Response Count
Education and Training	78.8%	26
Academic Research	**90.9%**	**30**
Industrial Projects	51.5%	17
	answered question	**33**
	skipped question	**7**

Education and Training

37. "Growing Documentary" – joint effort UCSD-Keio University.
38. Various NASA outreach/education events dealing with collaboration technologies.
39. Student projects in atmospheric sciences.
40. Visitor education and outreach.
41. Workshops on specific subjects in collaborative sessions.
42. Visualization and graphics education.
43. Telemedicine lectures.
44. Teaching classes, special projects presentations, data visualization.
45. Introduction to high-performance computing course, students doing their work using SAGE.
46. We have a Communications course at UCSD that uses SAGE walls for training UCSD students in remote collaboration best practices.
47. High-performance network for high-resolution images/video.
48. Astroinformatic.
49. How to display sessions on the wall using SAGE.
50. Visual Communications of Earth Science Data at South Dakota (SD) Technology Summit; American Association of Geographers Conference; U.S. Department of Interior Operations Center
51. Community outreach centers.
52. Pushing students' displays onto the tiled display for discussing results of individual students.
53. Groups showing code and output simultaneously.
54. Remote lecture exchange (planned).
55. PhD student work to port SAGE code to support Windows 7 wall.
56. Environment, medicine, space research.
57. Not currently used.
58. We use SAGE as a type of large-scale display for students in a classroom environment to show images and applications.
59. Using the SAGE as a large display in classes.
60. Demos of large visualizations.
61. Presentations, Courses, Videos, Images, Collaboration.
62. Course Delivery.

Academic Research

63. Experimental deployments of SAGE to determine feasibility of operational use.
64. Projects in information visualization, search and collaboration.
65. Display various medical or weather images.
66. In collaborative workspaces.
67. Showing various datasets simultaneously.
68. High-definition video and image visualization.
69. Climate studies, Genomics, Astrophysics, Geology, Information visualization, Water management.
70. Live collaborative projects.
71. Remote-sensing image analysis.
72. Usability testing, visualization techniques, collaborative interaction.
73. Pathology and related image processing algorithms, new video processing algorithms, tactile interaction with distributed screens (HCI technologies).
74. Our walls are currently part of a study of visualizing the medical history of patients, searching for patterns and potentially improving diagnoses.
75. High-performance networking for high-resolution images/video.
76. Geoinformatic, bioinformatics, protein-folding, molecular visualizations.
77. Visualization and simulation of weather and spatial data.
78. Display their research work on VIz-Wall.
79. See answer to #4 above.
80. Digital cinema.
81. Display of many visualizations to get insight into a multi-facetted problem.
82. Same.
83. Visual sharing system development.
84. Simulation and data analysis.
85. Simulations in different areas of computational physics.
86. Biomedical and astronomy imagery.
87. Advanced digital cinema production and distribution; UI/UX prototyping; exhibition platform; performance medium.
88. We have been studying the interface, network and architecture of the SAGE.
89. Using Paraview for visualization of large simulations.
90. Technology mediated communication between University and Community.
91. Research experimentation.
92. Naval Engineering.

Industrial Projects

93. Vroom R&D – joint effort of UCSD-UIC-NTT Labs.
94. Fluid dynamics visualization, digital cinema (research).
95. Initiate new joint projects.
96. Data visualization for banking industry.
97. Collaboration with cinematography industry.
98. We are currently working with industrial partners in developing a production/editing collaborative environment, utilizing SAGE's ability to share content over large distances.
99. High-performance network for high-resolution images/video.
100. CAE visualization.
101. Digital cinema.
102. Testbed development.
103. Digital museum.
104. Advanced digital cinema production and distribution.
105. We have developed some software as a industry-university joint research program.
106. Satellite imaging.

12. List any citations for papers you have published as a result of using SAGE.

Note: Citations were submitted by SAGE users – not SAGE developers – although in a few cases, developers are co-authors. Not everyone responded to this question – some said they were beginner SAGE users, some said they didn't have papers currently, and some said they would respond later (but didn't) and we believe they didn't want to go through the effort to compile.

List any citations for papers you have published as a result of using SAGE.

	Response Count
	18
answered question	18
skipped question	22

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Miloš Liška, Petr Holub, "CoUniverse: Framework for Building Self-organizing Collaborative Environments Using Extreme-Bandwidth Media Applications," Lecture Notes in Computer Science, Vol. 5415, Euro-Par 2008 Workshops - Parallel Processing. Las Palmas de Gran Canaria, Spain : Springer Berlin / Heidelberg, 2008. ISBN 978-3-642-00954-9, s. 339-351. 2008.

Luděk Matyska, Eva Hladká, Petr Holub, Miloš Liška, "High Quality Large Scale Virtual Classroom," Proceedings of the 14th International Conference of European University Information Systems (EUNIS

2008). Arhus, Denmark : Aarhus University, 2008. ISBN 978-87-91234-58-3, 4 s. 25.6.2008.

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Han Rauwerda, Wim C. de Leeuw, Jorrit Adriaanse, Maurice Bouwhuis, Paul van der Vet, Timo M. Breit, "The Role of e-BioLabs in a Life Sciences Collaborative Working Environment," Proceedings of eChallenges 2007, The Hague 2007.

Vít Rusňák, Lukáš Ručka, "Towards Collaborative System Based on Tiled Multi-Touch Screens," TEI '11 Work-in-Progress Workshop Proceedings. Funchal, Portugal : Association for Computing Machinery, 2011. ISBN 978-1-4503-0478-8, s. 73-78. 23.1.2011.

Lev Shchur, "Experience with high performance environment for collaborative work" (invited talk), Conference for Computational Physics, Trondheim (Norway), 23-26 June 2010

Shinji Shimojo, Masaki Chikama, Kaori Fukunaga, Rieko Kadobayashi, "Networked Museum: Our Vision and Experience," EVA2012, Florence Italy, May 2012.

B. Stolk, P. Wielinga, "Building a 100 Mpixel graphics device for the OptIPuter," Future Generation Computer Systems Volume: 22, Issue: 8, 2006, pp. 972-975.

Taiki Tada, Kohei Ichikawa, Susumu Date, Hirotake Abe, Shinji Shimojo, "A visualization adapter for SAGE-enabled tiled display wall," Proceedings of the 2011 IEEE International Conference on Granular Computing, Nov. 2011, pp. 613-618.

Taiki Tada, Kohei Ichikawa, Susumu Date, Shinji Shimojo, Ryosuke Nakamura, Naotaka Yamamoto, Yoshio Tanaka, "Visualization of GEO Science Data on TDW using SAGE Adapter," 21st PRAGMA Workshop, October 2011.

Kenny Welshons, Patrick Dorn, Andrei Hutanu, Petr Holub, John Vollbrecht, Gabrielle Allen, "Design and Implementation of a Production Dynamically Configurable Testbed," Proceedings of the 2010 TeraGrid Conference. Pittsburgh, PA, USA : ACM New York, NY, USA, 2010. ISBN 978-1-60558-818-6, s. 1-8. 2.8.2010, Pittsburgh, PA, USA.

Comment: No papers published, but many references to SAGE in CineGrid presentations at conferences and symposia around the world

Comment: SAGE was a contributing factor for multiple publications, including the book Grid Networks, which explores programmable networks.

Comment: We use SAGE to share scientific experimental data.

13. Approximately how many hours a week is your SAGE wall in use at your institution?

Approximately how many hours a week is your SAGE wall in use at your institution?

	Response Average	Response Total	Response Count
Hours	16.20	648	40
		answered question	40
		skipped question	0

14. Four years from now, how much do you anticipate SAGE use to increase.

Four years from now, how much do you anticipate SAGE use to increase:			
	Response Average	Response Total	Response Count
%	204.88	6,761	33
		answered question	33
		skipped question	7

15. Which US Federal agencies, if any, fund your activities that use SAGE?

Which US Federal agencies, if any, fund your activities that use SAGE?			
		Response Percent	Response Count
National Science Foundation		81.8%	9
Department of Energy		36.4%	4
NASA		36.4%	4
Department of Defense		0.0%	0
		Other (please specify)	7
		answered question	11
		skipped question	29

16. If you are not a US institution, what country/agencies support your work?

If you are not a US institution, what country/agencies support your work?	
	Response Count
	20
answered question	20
skipped question	20

Australia: ARC (a la NSF), DERM (Environment), University of Melbourne, Swinburne University, University of Western Australia, University of Queensland, Queensland University of Technology, SIRO
Canada: Foundation for Innovation
China: Ministry of Science and Technology,
Czech Republic: Government

Guatemala: Private funds and CONCYT
Japan: MIC, Ministry of Education, Culture, Sports, Science and Technology of Japan, ministry of science and education
Netherlands: NWO, NBIC, TTI-GG, NLeSC, Netherlands Ministry of Education
Russia: Russian Ministry of Economy, Russian Ministry of Science and Education, Russian Academy of Sciences, Russian Foundation of Basic Research
South Korea: Republic of Korea / Ministry of Education, Science and Technology
Sweden: Knut & Alice Wallenberg Foundation (KAW), Swedish EU money

17. List any international institutions with whom you collaborate using SAGE.

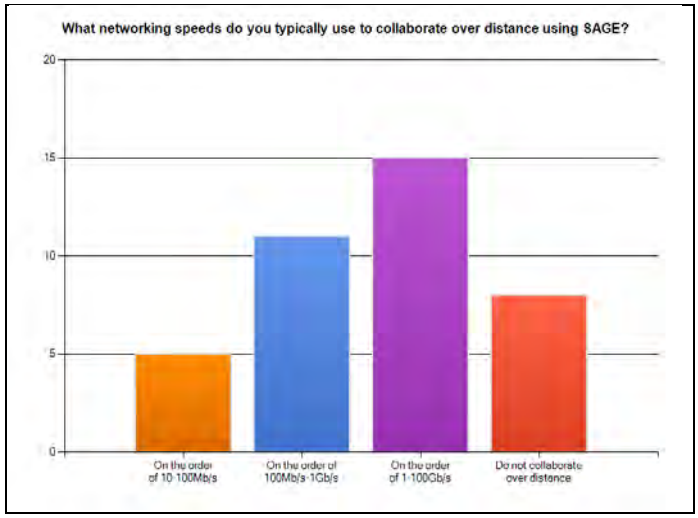
List any international institutions with whom you collaborate using SAGE.	
	Response Count
	20
answered question	20
skipped question	20

Collaborators listed:
Braunschweig University of Art
Braunschweig University of Technology, Institute of Computer and Network Engineering
Calit2 / University of California, San Diego
CANARIE
Ciena Research Lab
Communications Research Center of Canada
GARR, Italy
GIST, Korea
i2CAT
Keio University / DMC
King Abdulaziz City for Science and Technology (KACST)
King Abdullah University of Science and Technology (KAUST)
Kyoto University
KISTI
Louisiana State University / CCT
Monash University
Naval Postgraduate School
National Institute of Advanced Industrial Science and Technology
NCHC
NICT
SARA
University of Amsterdam
University of Essex
University of Illinois at Chicago / Electronic Visualization Laboratory
University of Queensland

18. What networking speeds do you use to collaborate over distance using SAGE?

What networking speeds do you typically use to collaborate over distance using SAGE?

	Response Percent	Response Count
On the order of 10-100Mb/s	13.5%	5
On the order of 100Mb/s-1Gb/s	29.7%	11
On the order of 1-100Gb/s	**40.5%**	**15**
Do not collaborate over distance	21.6%	8
	answered question	**37**
	skipped question	**3**



19. What networking speeds do you typically use with SAGE when working within your institution?

What networking speeds do you typically use with SAGE when working within your institution?

	Response Percent	Response Count
On the order of 10-100Mb/s	7.5%	3
On the order of 100Mb/s-1Gb/s	35.0%	14
On the order of 1-100Gb/s	**57.5%**	**23**
	answered question	**40**
	skipped question	**0**

20. What future SAGE improvements and enhancements will be most important to you?

What future SAGE improvements and enhancements will be most important to you?

	Response Percent	Response Count
Single-node system computer	25.0%	10
Stereoscopic 3D	45.0%	18
Cloud storage	30.0%	12
Cloud applications (e.g., Google docs, Google maps)	37.5%	15
Virtualization	30.0%	12
Standalone apps	27.5%	11
User Interaction techniques	**67.5%**	**27**
Remote collaboration	60.0%	24
Desktop conferencing (Skype, iChat, Webex, Goto Meeting, ...)	25.0%	10
High-definition video teleconferencing (Lifesize, Polycom, Telepresence, ...)	60.0%	24
Commercial product document sharing (Dropbox, Google docs, ...)	25.0%	10
SAGE document sharing	25.0%	10
SAGE streaming	57.5%	23
Other (please specify)		9
answered question		**40**
skipped question		**0**

21. What applications (commercial or open source) would you like to be compatible with SAGE? (e.g. ArcGIS, Avizo, Microsoft Office, etc)

What applications (commercial or open source) would you like to be compatible with SAGE? (e.g. ArcGIS, Avizo, Microsoft Office, etc)	
	Response Count
	26
answered question	26
skipped question	14

Recommended applications:
Acapella
Adobe Connect
ArcGis
Browser Interfaces (Chrome, etc)
CAE
ERDAS Imagine
GIS packages – any packages, commerical or open source
Google Earth
Google Maps
GRASS, GIS *geospatial* data management and analysis software
Mathematica
Matlab
Maya
Microsoft Office
Microsoft PowerPoint
ParaView
PIX System
RTT (commercial software, www.rtt.ag)
Skype
Telepresence
Video editing software
Video teleconferencing (H.323 compliant)
VisIT
VMD
X3D Viewers (Instant Reality, Xj3D)

High resolution image viewer with zoom capability

The headend often is not located to see the nodes. Some sort of node image depiction other than just a rectangle would be helpful when setting up the display. Otherwise one has to drag in a laptop to be able to see and control display arrangement. Overall, the questions about improvements above shows that the awareness is there that SAGE can be a very very powerful tool for a variety of tasks.

22. Would you be agreeable to writing EVL a SAGE letter of support for an upcoming NSF grant proposal?

Would you be agreeable to writing EVL a SAGE letter of support for an upcoming NSF grant proposal?

	Response Percent	Response Count
Yes	90.0%	36
No	10.0%	4
answered question		40
skipped question		0

23. If you are willing to provide a letter, please provide us with your name and email address.

If you are willing to provide a letter, please provide us with your name and email address.

	Response Count
	40
answered question	40
skipped question	0

2.C. Research Training and Development

NSF's many CI initiatives are amassing terabytes to petabytes of data, and will soon reach exabytes. EVL's SAGE efforts enable users to connect visualization pipelines running on supercomputers, data storage systems and/or instruments to ultra-resolution tiled display walls.

In addition to advancing Computer Science, this project is helping advance knowledge and understanding in the domain sciences, by providing faculty, staff and students with a means to manage the scale and complexity in their data with an intuitive environment for controlling cyberinfrastructure-enabled resources.

Those involved in this project extend outside the boundaries of UIC, given EVL's other collaborators -- on campus, nationally (museums, NCSA Great Lakes Consortium for Petascale Computing partners, DOE/SciDAC partners), and internationally (via StarLight, PRAGMA and GLIF). All the people working on display-related projects – computer scientists building infrastructure and the domain scientists who use it – are involved in furthering research; either by contributing to SAGE's development or by helping us better understand the limitations and future directions of our activities. It is clearly our students who benefit most, and are in high demand by the commercial sector for jobs in R&D when they graduate.

Making SAGE open-source has enabled greater participation by industry partners, including Monsanto, NTT Network Innovation Laboratories, Sharp Laboratories of America, Rincon, Ciena and Microsoft Research. They are working with EVL to prototype ideas and solutions.

2.D. Outreach Activities

For detailed information, see Section 2.A.7: Education, Outreach and Broader Participation.

EVL is committed to diversity and deems it central to its programs, projects, and activities, and provides research assistantships to graduate students, support for Research Experiences for Undergraduates (REUs), and mentoring programs for high-school students from the Illinois Math and Science Academy. Also, EVL faculty uses the technologies and tools it develops in the classroom, helping train the next-generation workforce.

In addition, EVL is very active in UIC College of Engineering and Computer Science recruitment and minority outreach activities, and does demonstrations and presentations for several Computer Science Open Houses (for local high-school kids) per year, the annual Engineering Open House, "Take Your Daughters to Work" day, the Society of Women Engineers (SWE), and the Association for Computing Machinery (ACM) student chapter, among others.

To reach out to domain scientists and other computer scientists, EVL participates in major computer science conferences (e.g., ACM/IEEE Supercomputing), workshops (e.g., PRAGMA, GLIF), and domain-science conferences (e.g., TeraGrid/XSEDE, AGU). EVL disseminates information via its website, YouTube, conference presentations, journal articles, social networks and media promotion.

EVL also actively works with museums, another outlet for broad dissemination to the public; we currently work closely with Adler Planetarium in Chicago and the Science Museum of Minnesota.

EVL attracts a disproportionately higher number of underrepresented students than other CS departments because of its joint program with the Art & Design Department, and its many collaborations with humanities, engineering, medicine and science. UIC has a higher percentage of Latino and African-American students than any Big 10 university and ranks 44th (of over 2,000 universities) in the number of BA degrees awarded to Latinos and African-Americans. At the graduate level, UIC is ranked 26th in MA degrees awarded to Latinos and African-Americans.

3. Publications and Products

3.A. Journal Publications

Jason Leigh, Andrew Johnson, Luc Renambot, Tom Peterka, Byungil Jeong, Daniel J. Sandin, Jonas Talandis, Ratko Jagodic, Sungwon Nam, Hyejung Hur, Yiwen Sun, "Scalable Resolution Display Walls," Proceedings of the IEEE, Issue 99, May 2012, pp. 1-15, <http://dx.doi.org/10.1109/JPROC.2012.219160>

3.B. Books / Publications

Yiwen Sun, Articulate: Creating Meaningful Visualizations from Natural Language, PhD Dissertation, Electronic Visualization Laboratory and Department of Computer Science, University of Illinois at Chicago, March 2012 <http://www.evl.uic.edu/core.php?mod=4&type=4&indi=798>

Yu-Chung Chen, Immersive Empathic Design for Interdisciplinary Collaborations, PhD Dissertation, Electronic Visualization Laboratory and Department of Computer Science, University of Illinois at Chicago, March 2011 <http://www.evl.uic.edu/core.php?mod=4&type=3&indi=454>

3.C. Internet Dissemination

www.sagecommons.org

3.D. Other Specific Products

Other than the information reported here, we have not developed any other specific product of significance.

4. Contributions

4.A. Contributions within Discipline

Since 2002, EVL has been conducting research in the use of high-performance remote rendering and streaming as a possible solution to the large-scale data visualization problem. This approach performs the "heavy lifting" of accessing, filtering and visualizing the data, using NSF cyberinfrastructure investments in the TeraGrid/XSEDE, high-speed national networks (such as National LambdaRail and Internet2), and relies on instruments, such as the Cyber-Commons and SAGE, to view the results.

SAGE development opens up new opportunities in computer science research at the intersection of large-scale data visualization, human-computer interaction, virtual reality, and high-speed networking. In addition, SAGE is being used to support several UIC classes and seminars taught in the Computer Science, Art and Design, and Physics departments.

4.B. Contributions to Other Disciplines

Coping with complexity and scale in data is a problem that spans all of e-science. The Nation's cyberinfrastructure initiatives are amassing terabytes to petabytes of data, which will soon reach exabytes. With NCSA Blue Waters coming online, the only way to access the data it generates will be over networks. SAGE can provide scientists with a conduit into visualizing petascale computations.

Today, ultra-resolution display environments are the "lenses" of virtual "microscopes" and "telescopes," enabling researchers to observe the data in cyberinfrastructure repositories. Using SAGE, scientists can create visualization pipelines from multiple sources -- whether supercomputers, data storage systems and/or instruments (such as high-definition cameras), as well as laptop screens and the Web -- to access and share a variety of information, in a variety of resolutions and formats, and create giant cyber-mashups. These "digital war rooms" enable users to access up-to-date, related sets of information and simultaneously display them, to quickly see context as well as details and make more informed and timely decisions. This is unprecedented and heretofore not available, and will have a profound and transformative effect on data visualization, data exploration and collaboration, making cyberinfrastructure more accessible to end systems and to end users, both in the laboratory and in the classroom.

4.C. Contributions to Human Resource Development

Tiled display walls and SAGE are transformative technologies that are changing the way today's scientists and future scientists manage large-scale and complex data -- in order to more rapidly discover the underlying causes and solve problems of national priority, such as global climate change or disaster response. We firmly believe that we need to give scientists and students better technologies in the laboratory and classroom than they currently have at home. At EVL, SAGE and tiled display walls provide a community resource openly accessible to our faculty and students, where they gather, meet, study, and work. In addition, EVL employs graduate and undergraduate students to help build the technologies, and our faculty uses it in the classroom, helping train the next-generation workforce.

4.D. Contributions to Resources for Research and Education

Our Nation already invests in network-connected, middleware-enabled cyberinfrastructure to generate and disseminate petabytes (ultimately exabytes) of data among researchers worldwide. What is missing, however, is a globally integrated collaborative work environment to facilitate data analysis and high productivity. The SAGE User Community believes SAGE and tiled display walls can fulfill that need, and are adapting these technologies to use in such diverse disciplines as: geoscience, homeland security, bioscience, cosmology, atmospheric science, chemistry, computer science, medicine and art.

A few groups already use SAGE and tiled display walls in the classroom, giving the next-generation workforce access to these advanced technologies. And, industry is starting to partner with visualization and networking researchers to better understand and use these technologies. For example, Monsanto provided an EVL student with a summer 2011 internship, both at their headquarters in St. Louis, Missouri, and at their Research Center in Bangalore, India; they continue to fund her Research Assistantship to develop SAGE tools specific to their application. And, KISTI expressed interest in supporting a graduate student to help tailor SAGE to their educational requirements. Providing a production-quality SAGE will make cyberinfrastructure more accessible to broader communities of scientists and students, and help maintain US leadership in high-performance computing.

4.E. Contributions Beyond Science and Engineering

A "cyber-mashup," or juxtapositions of information, is a transformative high-productivity tool. It is a critical component of data analysis, enabling people to gain more holistic views and insight regarding complex issues, and to make more informed observations and discoveries. SAGE leverages low-cost scalable thin-client PC clusters to enable end users to interactively access remote visualization data objects from shared cyberinfrastructure, as easily as the Web makes access to remote lower-resolution images today.

Technology costs have dropped to the point that adoption of these once-considered high-end technologies is now affordable. EVL actively works with museums; EVL currently works with Adler Planetarium in Chicago and the Science Museum of Minnesota, who employ our tools and technologies in their instructional exhibitions to educate the general public.

In addition, EVL has a number of industry research groups interested in SAGE and tiled display walls; notably, Monsanto, NTT Network Innovation Laboratories, Sharp Laboratories of America, Rincon, Ciena and Microsoft Research. EVL's prior visualization systems, including the CAVE, ImmersaDesk, and GeoWall, created new hardware and software companies and new jobs for Americans, to commercialize and/or use these systems in research institutions and companies.

5. Conference Proceedings

A. Febretti, K. Richmond, S. Gulati, C. Flesher, B.P. Hogan, A. Johnson, W.C. Stone, J. Priscu, P. Doran, "Poisson reconstruction of extreme submersed environments: The ENDURANCE exploration of an under-ice Antarctic Lake," 8th International Symposium on Visual Computing (ISVC'12), Crete, Greece, Springer-Verlag, Lecture Notes in Computer Science, 2012, Volume 7431/2012, pp. 394-403, <http://dx.doi.org/10.1007/978-3-642-33179-4_38>

Alessandro Febretti, Victor A. Mateevitsi, Dennis Chau, Arthur Nishimoto, Bradley McGinnis, Jakub Misterka, Andy Johnson, Jason Leigh, "The OmegaDesk: Towards A Hybrid 2D & 3D Work Desk" (chapter), 7th International Symposium on Visual Computing (ISVC11), Las Vegas, Nevada, September 26-28, 2011, Proceedings, Part II (editors: George Bebis, Richard Boyle, Bahram Parvin, et al.), Springer, <http://dx.doi.org/10.1007/978-3-642-24031-7_2>

K. Richmon, A. Febretti, S. Gulati, C. Flesher, B.P. Hogan, A. Murarka, G. Kuhlman, M. Sridharan, A. Johnson, W.C. Stone, J. Priscu, P. Doran, "Sub-ice Exploration of an Antarctic Lake: Results from the ENDURANCE Project," 17th International Symposium on Unmanned Untethered Submersible Technology (UUST11), Portsmouth, NH, US, 2011, <http://auvac.org/publications/view/229>.

Yu-Chung Chen, R. Jagodic, A. Johnson, J. Leigh, "Cross-Cultural Scientific Collaboration Case Studies" (position paper), Workshop on The Changing Dynamics of Scientific Collaborations, 44th Hawaii International Conference on System Sciences 2011 (HICSS11), Koloa, Hawaii, 2011, <http://www.evl.uic.edu/core.php?mod=4&type=4&indi=736>

6. Special Requirements

6.A. Objectives and Scope

A brief summary of the work to be performed during the next year of support if changed from the original proposal.
Our scope of work has not changed.

6.B. Special Reporting Requirements

Do special terms and conditions of your award require you to report any specific information that you have not yet reported?
No.

6.C. Animals, Biohazards, Human Subjects

Has there been any significant change in animal care and use, biohazards, or use of human subjects from what was originally approved (or approved later)?
No.