Cover Page

Contract No.: N01-LM-3-3508
Title: Advanced Biomedical Tele-Collaboration Testbed in Surgery, Anesthesia, and Emergency Medicine (ABC Testbed)

Report: Quarterly Report (Final Technical Progress Report)
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Note that Contract No. and Title (ABC Testbed) should appear prominently.

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(a) 200 word summary, invention statement and links to source code

The Advanced Biomedical Collaboration Testbed (ABC Testbed) project focuses on collaboration in biomedicine over advanced networks and technologies. Collaboration in biomedicine is distinct from tele-medicine in that collaboration involves professionals working together from multiple geographic locations and typically involves a substantial degree of presence or immersion. Tele-medicine typically involves a limited set of data sources transmitted from patient to professional, point-to-point, and may not necessarily be synchronous. The ABC Testbed prototyped and deployed technology to support a number of education and clinical scenarios based upon Access Grid (www.accessgrid.org) using multicast and wireless networks including: multi-site biomedical research collaboration; medical simulation center communications; pre-hospital emergency medical systems communications; and distributed medical visualization for anatomic education and surgical treatment planning. Operational successes included contributing to establishing the Chicago Biomedical Consortium, HealthGrid.US, the University of Chicago Medical Simulation Center, and to the city-wide commercial deployment of wireless video and data communications among ambulances in Tuscon, Arizona. Technical successes included the development of a distributed medical visualization shared application system based on Access Grid which interactively renders high resolution radiological images among arbitrary locations. This system enables realistic stereoscopic volume rendering and has been used for anatomy teaching and surgical treatment planning.

The automatic perceptual color map generation invention was submitted to the Federal government via interagency Edison.

VL3 complete source and updates: http://www.ci.uchicago.edu/trac/vl3
Access Grid downloads, complete source, and updates: http://www.accessgrid.org

Complete source on contract close (only for official documentation):
https://webshare.uchicago.edu/users/jcs/Public/abcsource/

(b) Work completed in final reporting period

The final reporting period included continued work along the operationally deployed projects but focused development and publishing exclusively on the distributed medical visualization system including a novel discovery regarding automated color maps.

Hardware assembly and Development

1. The visualization cluster system has been rebuilt upon a common Linux environment, Red Hat Enterprise
2. Re-build of the GUI on new architecture and full AG integration on new architecture is ongoing
3. All source code has been made available for free download
4. Performance improvements have been completed (MPICH 2, binary swap)
5. Multiple clip to allow the Transplant project to continue/restart is being built
6. Addition of pointer and measuring tools is planned
7. New perceptual color map generation algorithm is being integrated with the new architecture
8. More interesting clipping objects than planes are being explored

Specifically, these improvements included making the vl3/vlRadio visualizations easier to setup and use from an infrastructure standpoint with only the re-attachment of the GUI pending. Most notably, this has included faster, lower latency interaction including a round trip event rate maintained above 20 frames per second; integrated Access Grid capabilities including: compatibility with the Access Grid EventService protocol; quick-publishing which allows the visualization to be inserted directly on start-up into an Access Grid venue as a shared application; and simple installation of the remote client (double-clicking on the MedVolViz shared application package installs it - not ported to OSX yet).

Publishing/Presentations and Technical Demonstrations

Three new papers were written for peer-reviewed journal submission

1. Automatic Perceptual Color Map Generation for Realistic Volume Visualization (included as Appendix B)
2. Distributed Immersive Virtual Anatomy year two course results (submission pending)
3. Living-related-liver-transplantation treatment planning (submission pending)

(c) Qualitative description of overall progress

Progress on the contract is discussed here in two ways (in some cases necessarily repeating key developments). First, the significant software and hardware development, operational deployments and major research outcomes (excluding technical findings) are noted. Second, these are put in context of the major sub-projects in the testbed.

Development

We were the first to successfully adapt the Access Grid platform for use in routine medical team training as we implemented our simulation center with this technology. Via demonstrations, collaboration and advice to a number of other centers this technology is now more widely in use across such centers and related biomedical collaboratives (and the technology itself – of which we partially supported the development – has recently won a prestigious R&D 100 award). This is open source code (provided).

Other technologies developed with support from the ABC Testbed have enabled commercial application of tele-presence to pre-hospital emergency medical services. Specifically, the core system enabling ambulance to hospital communication over wireless networks from the field, deployed commercially now in the city of Tuscon, AZ, by General Devices Corp. was developed on a collaborative sub-contract from our laboratory. This is a commercial product.

We successfully developed the distributed medical visualization shared application system which renders high resolution radiological images as realistic stereoscopic volumes simultaneously enabling manipulation among multiple locations. This infrastructure leverages the Access Grid collaboration software platform, commodity Linux cluster computers, and video gaming boards to create robust multi-parallel multi-site collaborative immersive virtual environments. This work required several years of effort of software engineers in collaboration with experts from Argonne's Futures Laboratory. We conceived, designed and built a custom 9-node Linux cluster optimized for volume rendering, an open source volume rendering system written in openGL shader language that scales across clusters of arbitrary size, and a distribution system of the rendering via multicast networking in concert with Access Grid shared application context. In all, this enables rendering volumes in real time that cannot be handled by single gaming boards, breaking the combined rendering into multiple video streams that can be efficiently shared over the Internet and re-assembled on commodity desktop computers, and displaying them in interactive stereo visualization environments. This software stack has been ported to run on other larger clusters to enable scripting for massive (non-real-time) renderings, and has begun to been used for visualization of astrophysics data by other Argonne and University scientists. This system has been used for anatomy teaching and surgical treatment planning. The code is now available to meet several requests from other universities to deploy it and is open source (provided).

Most recently, in order to bring additional realism to volumetric visualization environments (e.g. important for surgeons in virtual-reality based treatment planning), we have invented a unique color adjustment algorithm that automatically re-colors each voxel based on the perceptual theory of luminance. In short, this algorithm leverages the superior discrimination capability of grayscale for the human eye while simultaneously allowing arbitrary colorization of individual pixels (or volumetric voxels). Most color algorithms sacrifice the available perceptual discrimination in the linear dynamic range of field data because arbitrary colorization creates hues with variant luminance (e.g. yellow is inherently bright and blue is inherently dark) distracting from the eye's heavy dependence upon luminance for discrimination (disrupting the monotonically increasing luminance characteristic of gray scale). Due to this, in radiology, color is minimally used, particularly in computed tomography. Our algorithm allows any arbitrary colorization table (e.g. in CT, bone is white, tissue is red, fat is yellow, lung is pink) to be adjusted with every voxel in the visualization according to the luminance it would have had were it to have been grayscale. This real-time adjustment in volume visualization enables realism in the display of volumetric radiological data never before seen and, as a fundamental visualization method, should be applicable to many other domains. This is important in high throughput visualization (such as in radiology) because, while radiologists are currently familiar and comfortable analyzing thousands of images in gray scale, the massive explosion of volumetric radiological data in clinical medicine makes diagnostic evaluation of CT in volumetric and stereo visualization inevitable due to its superior efficiency over review of multiple slice images. However, in such environments, the lack of realism of grayscale is problematic in that it limits the set of shades that can be simultaneously displayed, whereas color has several orders of magnitude more dynamic range, of which much can be used with our method without losing the perceptual characteristics of gray. This algorithm has been fully implemented for real-time use in our distributed volumetric visualization system. A manuscript describing it is under peer-review and the invention has been disclosed.

Operational Deployments

The ABC Testbed prototyped and deployed technology to support a number of education and clinical scenarios based upon Access Grid (www.accessgrid.org) using multicast and wireless networks. Deployed hardware include (described in prior reports):

- Venue server
- Bridge server
- Development workstations
- Cluster visualization system (9 node high-performance GPU cluster)
- Visualization node (for parallel local visualization system interaction)
- Conference room node with visualization system
- 4 Tablet PC (handheld-wireless) nodes - also used in pairs for mobile stereoscopy

- Simulation center three-room two-node construct with playback and backup
- Brown University/Rhode Island Simulation Center node (funded by collaborators)
- Chicago Biomedical Consortium Mobile room AG node (funded by CBC)
- CBC conference room nodes at Northwestern and UIC (funded by CBC)
- G-217 node (funded by Department of Surgery)
- HealthGrid Globus-MEDICUS node (pending deployment)

Upon these deployments we have conducted in the ABC Testbed: multi-site biomedical research collaboration; medical simulation center communications; pre-hospital emergency medical systems communications; and distributed medical visualization for anatomic education and surgical treatment planning. Operational successes beyond the ABC Testbed included contributing to establishing the Chicago Biomedical Consortium, HealthGrid.US, the University of Chicago Medical Simulation Center, and to the city-wide commercial deployment of wireless video and data communications among ambulances in Tuscon, Arizona.

Major Research Outcomes (excluding technical descriptions)
Major finding for Immersive Virtual Anatomy: This is the first complete anatomy course we are aware of which directly substitutes immersive virtual reality via stereo volume visualization of clinical radiological datasets for cadaver dissection. The students valued highly the new approach and the overall course was very well received. Students performed well on examinations. The course efficiently added human anatomy to the University of Chicago undergraduate biology electives. The technology was deemed equally or more valuable than the standard materials such as textbook and atlas in enjoyment and in the framework of learning.

Major finding for surgical pre-treatment planning: Preliminary work (peer-reviewed CARS abstract) shows superior performance and efficiency of combining the analysis of the dynamic range of radiological data and virtual reality tools in pre-operatively calculating the volume of liver resections for living-related transplantations. Essentially, transplant surgeons need to know fairly precisely the volume of the resection they intend to do to balance the liver insufficiency they will temporarily induce in donor and recipient. Traditionally, volumes are determined by manual segmentation (drawing on the images) of pre-operative CT data. Using our distributed medical visualization system, we compared correlations of the volumes calculated in the traditional method with resection weight (density is reasonably constant) and the virtual method. The virtual method involves surgeons mimicking operative resections in the virtual environment and the system then automatically calculates the resection volume, using the three-dimensional resection planes to limit the area of interest, and statistical methods to find the liver density. In the first five patients, the virtual method correlated highly (0.95 R^2) with the traditional method and its correlation with the weight (0.93 R^2) exceeded that of the traditional method (0.91 R^2). The method is instantaneous (e.g. 15 seconds) for the surgeon in the planning environment rather than technician dependent (and labor intensive).

Major finding for Automatic Color Map Generation for Realistic Volume Rendering: We discovered a method for combining generic field data and an arbitrary map of the data to a set of colors (e.g. red=very hot, orange=hot, yellow=warm, green=comfortable, blue=cold, purple=very cold - or in our case Air, Lung, Fat, Tissue, Bone from CT scans, each a particular color) and applying perceptual contrast theory to adjust the colors for display of the data to be perceptually correct across a continuous spectrum, and in so doing gain the contrast-enhancement typical of grayscale images without losing the color. This is likely applicable across many fields as a fundamental discovery in rendering/ visualization. Mixing perceptual and base color in arbitrary ratios and a generic realistic color algorithm for CT is also described in the included paper (under peer review).

Major finding for Globus-MEDICUS: A paper presented at HealthGrid Association International Conference in 2007 discusses an approach to federate DICOM and PACS devices for large-scale medical image workflows within a global healthcare enterprise. This Grid image workflow paradigm has been designed to provide not only solutions for global image communication, but fault-tolerance and disaster recovery using Grid data replication technology. Actual use-case of 40 MEDICUS Grid connected international hospitals of the Childerns Oncology Group and the Neuroblastoma Cancer Foundation and further clinical applications are discussed. The opensource Globus MEDICUS project is available at http://dev.globus.org/wiki/Incubator/MEDICUS

Summary Final Report by sub-project (scenario)

Multi-site biomedical research collaboration

In the Chicago region, after several years of deliberation and negotiation among scientists to identify areas of inter-institutional interest and programs to support the expansion of collaborative “big” science, we were successful in establishing the Chicago Biomedical Consortium among the University of Chicago, Northwestern, and University of Illinois at Chicago. As one of the scientific directors (founding leaders), we have increased funding and visibility for large-scale science collaborations in the Chicago region, particularly in Systems Biology, proteomics, informatics, and imaging, and establishing a regional proteomics facility. Key to the development of the Consortium was developing a plan to “virtualize” the consortium among the six campuses via deployment of AG nodes modeled after the ABC Testbed conference room. CBC has spawned a number of new collaborative research programs and scientific infrastructures among some of our most esteemed faculty members. National panels have taken an interest in this program as a model for new ways of supporting research. Also, via collaborations and recruitment among the University and Argonne via the Computation Institute, we are expanding the capacity of computation and informatics and visibility of related research in the region.

Nationally, our work collaborating with (but not funded by) the Army's Telemedicine and Advanced Technology Research Center (TATRC) has led to an integrated research team roadmap for HealthGrid, increasing the visibility of grid computing and Access Grid applied to biomedicine. This has led to the HealthGrid.US Alliance, a professional society intended to build communities of practice, a sister organization collaborating with the international HealthGrid.org, and to prominence of approaches to global data sharing in biomedicine such as Globus-MEDICUS. Thus our newest collaboration, interactions among the Globus-MEDICUS team and the HealthGrid.US Alliance, has moved us from the prototypical usage of advanced networks and visualization for surgical/anatomic teaching and surgical planning applications, to investigating and enabling the infrastructure for global radiological data sharing and use of clinical data.

Medical simulation center communications

The University of Chicago's Medical Simulation Center was implemented with Access Grid for all communications among the control room, simulation room and debriefing room. In coordination with this a custom hardware setup using commodity components enabled splitting of the audio and video streams to enable synchronized playback as a backup system. Also, in tandem with AG VCR software, playback was enabled directly over AG. Similarly the collaborating center in Rhode Island was set up. The simulation center setup is now used on a regular basis for training for the University of Chicago Hospitals staff which we consider a successful outcome of the technology.

Also, handheld design points operating of wireless were created, however, limitations of the deployed hospital wireless network and the handheld devices available during the contract (a combination of bandwidth and security limitation in the precise configuration - as the devices work just adequately on other networks) did not allow wider deployment of these among the medical center. The Department of Surgery, though, has taken on the Access Grid as a key communication means for activities involving collaboration among the operating rooms, the G-217 conference room, simulation areas and remote teaching hospitals. Thus, while the surgical scenarios planned did not occur over wireless handhelds during the period of the contract, other wired methods to achieve similar scenarios are now progressing as production deployments now that the contract has ended (rather the research deployments during the contract were sufficiently compelling as to warrant investment by the department). We anticipate, then, that we will continue to work toward the original surgical collaboration scenarios as further work.

Distributed medical visualization for anatomic education

We used the technology to create a unique course to teach anatomy to undergraduate students in multiple simultaneous locations. In short, we assemble small groups of students in rooms implemented with Access Grid for multi-site video and audio sharing in combination with our distributed medical visualization platform (in immersive stereo). We substitute for cadaver dissection with demonstrated segmentation and rendering of individual structures via volumetric techniques such as cutting, transparency, adjustment of data dynamic ranges for display, and color algorithms. In the course, we walk through the same textbook, in one quarter, used for medical school anatomy and test the students with identifications from photographic atlases and other exam questions. Brief survey after the course each of the last two years has demonstrated that the students value the technology highly in terms of enjoyment and learning. The Pritzker Medical School anatomy curriculum is under reconsideration at this time and serious consideration is being given to using this technology for medical student education (and as noted in the prior section also for resident education) thus it appears to be a viable program for undergraduate, medical, and graduate medical education - we consider this a major success.

Distributed medical visualization for surgical treatment planning

We used the technology to conduct pilot studies in surgical treatment planning as described in the major findings section above. In short, we demonstrated feasibility of use of the system directly by attending surgeons for the purposes of a retrospective clinical trial. After the system is re-deployed on the faster, more functional, software architecture (using the same hardware) we anticipate direct clinical usage. We consider it a major success to take a software idea all the way to clinical usage in a short time period. We will further update the Program office as developments in this area proceed.

EMS Telemedicine - Final Progress Report: Completed April 8, 2007

In the past year the concept of EMS (Emergency Medical Services) Telemedicine has moved considerable forward.

1) e-Bridge: General Devices has completed its development of e-Bridge, a comprehensive, multi-purpose EMS Telemedicine system. Consisting of a set of configurable "building-blocks", e-Bridge can take on many forms dictated by the needs of the user. The core purpose of the e-Bridge System is to provide advanced means of communications between fixed and mobile locations to serve both day-to-day as well as emergency EMS needs. The system includes handheld, vehicular and portable field devices supported by a powerful multi-purpose hospital/command-post EMS Telemedicine workstation. The e-Bridge System will be used by the City of Tucson's ER-Link project

(see below).

2) Access to Physiologic Data: General Devices now has formal relationships with all three EMS field monitor device providers that allow the sending of physiologic information from the field to the hospital by a variety of means. Up to now, such data was sent only by proprietary means with limited user access to this data. These relationships represent a milestone in the progress of availability of data and open architecture approaches to instrumentation used in EMS.

3) Tucson ER-Link: The City of Tucson is expected to inaugurate its ER-Link EMS Telemedicine project in May of 2007. ER-Link is the first fully implemented, municipally owned and operated EMS telemedicine system in the United States. The system will provide 2-way video, voice and data over a 200+ sq mile region. ER-Link uses a commercially available mobile telemedicine system (e-Bridge) and a fully digital high speed wireless communications system (Tropos mesh). The system will be phased in with trauma and treat-and-release as initial applications. Other applications will follow.

4) NAEMSP (National Association of EMS Physicians) Annual Meeting: The General Devices booth at the annual NAEMSP Meeting this past February featured our e-Bridge EMS Telemedicine System. Unlike previous years, where the concept of EMS Telemedicine was greeted with considerable skepticism, this year saw a marked change in user attitude. The booth had a large amount of traffic with virtually all EMS Physicians displaying great interest and asking series questions. The only explanation for this as that the concept of using data and images has finally taken hold within this EMS.

5) Amazon Swim: As a demonstration of the utility of mobile telemedicine, a portable system (General Devices Rosetta-GO (the Go-Box) was provided to a project in which an athlete, Martin Strel, was to swim the entire length of the Amazon River. The Go-Box is a portable version of the e-Bridge ambulance (vehicular) system, and provides moving images, voice and physiologic and other data from the boat in the Amazon to the University of Arizona's EMS Telemedicine center. The 70lb Go-Box is the first commercially available implementation of a portable system specifically intended for medical application.

6) NYC-Fire/EMS: General Devices has been invited by NYC FD/EMS to present a range of "next generation" EMS applications utilizing advanced communications and information management. This invitation is in response to NYC's acquisition of a highly advanced broadband wireless system that will cover the entire city and be used for public safety and municipal use. The acceptance of the concept of EMS Telemedicine by NYC FD/EMS is

remarkable.

7) Other Interested parties: General Devices has been invited to discuss EMS telemedicine in Baton Rouge, Louisiana and Atlanta, Georgia. These invitations are a demonstration of the increased level of awareness and acceptance of advanced application of communications and information management technologies in EMS.

8) News Media/Professional Journals: ER-Link has been shown on Tucson's Channel 12 News as well as CNN. Both JEMS and EMS, the two leading journals in EMS are publishing articles on EMS Telemedicine. Both Michael Smith and Jonathan Silverstein were recently interviewed by HealthTech, a leading subscriber-based industry news organization. This service is used by large health care organizations, such as Partners, Banner Health, Blue Shield, Veteran's Health Administration and many others. This report will alert major heath care provider organizations to this new technology.

Peer-Reviewed Publications

Papers

Silverstein JC, Dech F. Precisely Exploring Medical Models and Volumes in Collaborative Virtual Reality. Presence: Teleoperators & Virtual Environments (MIT Press) 2005 Feb; 14(1):47-59.

Silverstein JC, Ehrenfeld JM, Croft D, Dech F, Small S, Cook S. Tele-Immersion: Preferred Infrastructure for Anatomy Instruction. Journal of Computing in Higher Education Fall 2005; 18(1):80-93.

Silverstein JC, Dech F, Kouchoukos PL. Enhancing Radiological Volumes with Symbolic Anatomy Using Image Fusion and Collaborative Virtual Reality. Stud Health Technol Inform. 2004; 98:347-52.

Silverstein JC, Tsirline V, Dech F, Kouchoukos P, Jurek P. Automated Renderer for Visible Human and Volumetric Scan Segmentations. Stud Health Technol Inform. 2005; 111:473-6.

Silverstein JC, Dech F, Binns J, Jones D, Papka ME, Stevens R. Distributed Collaborative Radiological Visualization using Access Grid. Stud Health Technol Inform. 2005; 111:477-81.

Binns J, Dech F, McCrory M, Papka ME, Silverstein JC, Stevens R. Developing a Distributed Collaborative Radiological Visualization Application. Stud Health Technol Inform. 2005; 112:70-9.

Silverstein JC, Walsh C, Dech F, Olsen E, Papka ME, Parsad N, Stevens R. Immersive Virtual Anatomy Course Using a Cluster of Volume Visualization Machines and Passive Stereo. Stud Health Technol Inform. 2007;125:439-44.

Erberich SG, Silverstein JC, Chervenak A, Schuler R, Nelson M, Kesselman C. Globus MEDICUS - Federation of DICOM Medical Imaging Devices into Healthcare Grids. Stud Health Technol Inform. 2007;126:269-278.

Erberich SG, Silverstein JC, Chervenak A, Schuler R, Nelson M, Kesselman C. Globus MEDICUS – Protected Health Information in Medical Imaging Grids. Int J CARS (2007) 2 (Suppl 1):S297-99

[in review and enclosed] Silverstein JC, Parsad N, Tsirline V. Automatic Perceptual Color Map Generation for Realistic Volume Rendering

Abstracts/Posters

Silverstein JC, Binns J, Papka M, Parsad N. EMS Telemedicine in the Access Grid: from ambulance to ER [Abstract/Presentation]. Proceedings of the Access Grid Retreat, San Francisco CA, April 2005.

Silverstein JC, Papka ME, Small S, Stevens R. The Access Grid: Enabling Infrastructure for Surgical Collaboration [Abstract and Oral Poster]. First Annual Academic Surgical Congress 2006, San Diego, CA. J Surg Res. 2006;130(2):286.

Silverstein JC, Papka ME, Small S, Stevens R. The Access Grid: Open Source Infrastructure for Biomedical Collaboration [Poster]. American Medical Informatics Association Spring Meeting 2006, Phoenix AZ.

JC Silverstein, N Parsad, F Dech, J Philips, S Small, E Olson, ME Papka, R Stevens. Distributed Collaborative Biomedicine Including Shared Volume Visualization [Abstract/Presentation]. Access Grid Retreat. Chicago, May 15, 2007.

N. Parsad, M. Millis, M. Vannier, F. Dech, E. Olson, M. Papka, J. Silverstein, Real-time Automated Hepatic Explant Volumetrics on a Stereoscopic Three-Dimensional Parallelized Visualization Cluster [Abstract/Presentation]. Int J CARS (2007) 2 (Suppl 1):S488

S Small, J Silverstein, K Metis. Application of the Access Grid to Immersive Medical Simulation and Visualization [Abstract/Presentation]. CompMed 2007. Montreal, Canada. May 16, 2007.

J Silverstein, N Parsad, F Dech, E Olson, M Papka, S Small. Immersive Virtual Surgical Anatomy: Real Time Manipulation of Three Dimensional Visualization via a High Performance Graphics Cluster [Abstract/Poster]. CompMed 2007. Montreal, Canada. May 16, 2007.

[To be presented] RSNA2007 #5007317: Patient Centric Authorization for Cross Enterprise Healthcare Information Exchange in HealthGrids

Non-Peer-Reviewed

Silverstein JC, Dech F, Binns J, Jones D, Papka ME, Stevens R. Distributed Collaborative Radiological Visualization using Access Grid [Poster]. University of Chicago Department of Surgery Huggins Research Conference 2005.

Kratz M, Silverstein JC, Dev P, Dugan J, Bilofsky H, Legre Y. HealthGrid: An International Initiative for Collaborative eHealth [Poster]. National Centers for Biomedical Computing All Hands Meeting, July 17-19 2006, Bethesda MD.

Erberich SG, Silverstein JC, Daher N. Open-Source Grid Opens Nationwide Image Exchange. Imaging Technology News. March 2007:47(2).

Silverstein JC, Walsh C, Dech F, Olson E, Papka M, Parsad N, Stevens R. Immersive Virtual Anatomy Course Using Cluster of Volume Visualization Machines and Passive Stereo [Poster]. University of Chicago Department of Surgery Huggins Research Conference; May 5, 2007.

Parsad NM, Milis MJ, Vannier MW, Dech F, Olson E, Papka M, Silverstein JC. Real-time Automated Hepatic Explant Volumetrics on a Stereoscopic, Three-Dimensional Parallelized Visualization Cluster [Abstract/Presentation]. University of Chicago Department of Surgery Huggins Research Conference; May 5, 2007.

Silverstein JC, Dech F, Small S, Papka M, Stevens R. Advanced Biomedical Collaboration. [Technology Demonstration]. Radiological Society of North America, Chicago, Dec 1-4, 2003. This was an exhibit sponsored by the National Library of Medicine and Internet2. Tele-Immersive and Access Grid collaborations demonstrated the convergence of these technologies.

Dech F, Papka M, Binns J, Jones D, Stevens R, Silverstein JC. Advanced Biomedical Collaboratory. [Technology Demonstration]. Access Grid Retreat June 9, 2004. Ryerson University, Toronto, Canada. This retreat is the annual meeting of the Access Grid community. Collaborative medical volume visualization was demonstrated over the Access Grid simultaneously among Ryerson University, The University of Chicago, and Argonne National Laboratory.

Silverstein JC, Parsad N, Papka M, Binns J, Small S, Philips J, Dech F, Stevens R. Distributed Collaboration Using Access Grid [Technology Demonstration]. Radiological Society of North America, Chicago, Dec 1-4, 2005. This was an exhibit sponsored by the National Library of Medicine and Internet2. Advanced biomedical uses of Access Grid were demonstrated.

Small S, Philips J, Dech F, Silverstein J. Collaborative Technology Expands Simulation Training Center [Technology Demonstration]. Remote: Supercomputing Global 2005.

Olson E, Dech F, Papka ME, Parsad N, Silverstein J, Stevens R. Volume Rendering and the Access Grid [Technology Demonstration]. Access Grid Retreat May 2006. Ann Arbor, MI.

Small S, Philips J, Dech F, Metis K, Silverstein JC, Fennessy M. Medical Simulation Applications of Advanced Networking and Visualization [Technology Demonstration]. SC 2006, International Conference for High Performance Computing, Networking, Storage and Analysis.

Erberich SG, Silverstein JC, Chervenak A, Schuler R, Nelson M, Kesselman C. Globus MEDICUS - Federation of DICOM Medical Imaging Devices into Healthcare Grids [Technology Demonstration]. HealthGrid 2007. Geneva, Switzerland.

Invited Colloquia

April 6, 2005 – "Virtual Reality in Surgical Education" – Surgery Department Grand Rounds, The University of Chicago

April 25, 2005 – "Virtual Reality for Surgical Education" – Southern Society of Clinical Surgeons, The University of Chicago

September 27, 2005 – "Urban Lambda Grids for Advanced Biomedical Collaboration" – in panel: "Bridging the Challenges: Medicine Meets the LambdaGrid" at iGrid 2005, San Diego, CA.

January 24, 2006 - "Collaborative Immersive Virtual Environments" - in panel: "Enabling Technologies for Simulation: Impact and Influence on Medical Training and Education" at Telemedicine and Advanced Technology Research Center day of Medicine Meets Virtual Reality conference, Long Beach, CA.

June 9, 2006 - "Immersive Virtual Anatomy" - Grand Rounds, Department of Obstetrics and Gynecology, University of Chicago

August 1, 2006 - "Intersections of Computation Across the Biomedical Spectrum" - Keynote speaker at fifth annual Great Lakes Bioinformatics Retreat of the Michigan Center for Biological Information.

November 12, 2006 - "From Health (Biomedical Chaos) and Grid (Decomposition and Integration) to HealthGrid" - Panel presentation in HealthGrid Workshop of American Medical Informatics Association 2006, Washington D.C.

December 5, 2006 - “From Health (Biomedical Chaos) and Grid (Decomposition and Integration) to HealthGrid” - Panel presentation in HealthGrid Workshop of Internet2 Members Meeting 2006, Chicago.

February 1, 2007 - “Immersive Virtual Anatomy” - Section of Otolaryngology, Head and Neck Surgery Small Group Research Meeting - University of Chicago Department of Surgery.

February 8, 2007 - “From Health (Biomedical Chaos) and Grid (Decomposition and Integration) to HealthGrid” - Panel presentation in HealthGrid Workshop of Medicine Meets Virtual Reality Meeting 2007, Long Beach, CA.

February 9, 2007 - “Distributed Medical Visualization” - Panel presentation: 3D Interactive Real-Time Surgical Education on the Web, at Medicine Meets Virtual Reality Meeting 2007, Long Beach, CA.

June 7, 2007 - “Globus MEDICUS - Federation of DICOM Imaging Devices into HealthGrids” - GridAsia 2007, Singapore.

July 11, 2007 - “Simulation Labs” - Chicago Academic Medicine Program (CAMP), Multicultural Affairs, Pritzker School of Medicine, University of Chicago.

September 7, 2007 - “HealthGrid: Grid Technologies for Biomedicine” - 2007 International Brain Mapping and Intraoperative Surgical Planning Society (IBMISPS) Meeting - Washington D.C.

September 26, 2007 - “Immersive Virtual Anatomy via Computational Grids” - Department of Surgery research conference - Chicago.

[to be presented] October 4, 2007 - Keynote on HealthGrid.US Alliance at Enabling Grids for E-sciencE (EGEE) meeting - Budapest, Hungary.

Publicity seen by general audiences
An article appeared in GridToday, December 2003 describing our InfoRad demonstration at Radiological Society of North America “Doctors See Potential For Grid-Enhanced 3-D Medical Training”

Newsletter for the University of Chicago Biological Sciences Division Peer Review highlighted this project in Winter 2003-2004

The Access Grid Focus Newsletter highlighted this project in Spring of 2004

The University of Chicago Magazine highlighted this project in Spring 2004

We used the ABCollaboratory AG node as a focal point to establish the first virtual meeting of the Chicago Biomedical Consortium of Northwestern University, The University of Chicago and The University of Illinois at Chicago. This is a significant development in the Chicago region.

The work on the EMS component of the ABC Testbed conducted a successful demonstration of the technology in February 2005 at the prestigious Gathering of Eagles meeting in Dallas, Texas - the surgeon general was in attendance.

Dr. Silverstein was interviewed and an article appeared regarding this and related projects in ELITE magazine of the Daily Southtown Newspaper in Chicago, October 2005 titled: "from game room to operating room".

The ABC Testbed project and related efforts were featured in an article in Medical Imaging Magazine in February 2006, titled: "Cutting the Cord".

Spring 2006 - The General Devices EMS system deployment in coordination with the city of Tuscon was featured on CNN.

October 7, 2006 - The project was highlighted in a poster and demonstration by the Computation Institute at the Argonne National Laboratory Open House