Regional Collaborative Cancer Care Using the Next Generation Internet

National Library of Medicine
NGI Phase 2 final briefing
August 27, 2003
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Dave Chou, MD
University of Washington
Outline

• Collaborative Cancer Care
  – Why?
• What we did & what we found
  – Technical
  – Clinical Practice
• What it means
Outline

• Collaborative Cancer Care
  – Why?
• What we did & what we found
  – Technical
  – Clinical Practice
• What it means
WWAMI Region
University of Washington

- IAIMS
- Bench to Bedside: Research and Testing of Internet Resources and Connections in Community Hospital Libraries
- WWAMI - Rural Telemedicine Network
- Advanced Telecommunications Technology Satellite
- Ultrasound Telemedicine Projects
- Bench to Bedside and Beyond
- Digital Anatomist
- Biomedical Applications of the NGI – Phase 1
Broad Objectives

• Facilitate regional collaboration around cancer care of individual patients

• Continue exploring telemedicine
  – new IP capabilities
  – privacy and security
Generalizable Opportunity

• Seattle Cancer Care Alliance (SCCA)
  – University of Washington Medical Center
  – Childrens Hospital and Regional Medical Center
  – Fred Hutchinson Cancer Research Center
  – Southeast Lake Union (SELU) Outpatient Center

• March, 2001: all outpatient adult oncology services move 3 miles away – inpatient and outpatient providers are divided
Oncology Practice

• Tumor conferences important in oncology
  – Requires a gathering of multidisciplinary experts
  – Relative tradeoffs of treatment alternatives
  – Collegial atmosphere – a place for networking and learning

• Hematology-Oncology Tumor Board
  – “Typical” case conference
  – Synchronous communication
  – Local & Regional value
Specific Aims

• Develop infrastructure for collaborative, regional practice of oncology

• Develop specific tools for collaborative diagnosis and treatment
  – Case conferences
  – Physician consultations

• Facilitate
  – Increased participation by experts
  – Remote provider participation
  – Increased resident/mid-level participation
Seattle Cancer Care Alliance Network

Fred Hutchinson Cancer Research Center

Seattle Cancer Care Alliance (SCCA/SELU)

University of Washington Medical Center

Childrens Hospital and Regional Medical Center
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PNW Gigapop

OC-192, 10 Gbps

OC-48, 2.4 Gbps

Internet
UW and Internet2

- ’96 founding member Internet2
- Computing & Communications
- PNW Gigapop
- Pacific LightRail
- Several Internet2 Firsts
  - First live HDTV over Internet Newscast
  - Previous Internet Speed Record Set (2.4 Gbps – UW/Microsoft)
Abilene Network
Technical Environment

• Equipment mimics Internet
  – Heterogeneous
  – Includes: Cisco, Foundry, Juniper, HP
• Fiber everywhere, (last 30 feet)
• “Local control” to and of Gigapop
• Testbed emulates/is the real world
Outline

• Collaborative Cancer Care
• \textbf{What we did & what we found}
  – Technical
  – Professional Practice
• What it means
Methods

- Basic Principle: Participants, Information Artifacts, and Pathways (contextual inquiry)
- Applied to professional practice, video conferencing, and information systems design
- Three Teams
  - Contextual Inquiry
  - Tumor Board Information System
  - Folie á Deux/Telepresence
What Did We Do?

- Studied clinical/professional practice of Heme-Onc and other tumor boards
- Group to group video conferencing over IP using H.323
- Web based information system to support preparation for and discussion during clinical case conferences
- Explored augmented reality and other telepresence visualizations
Heme Onc Tumor Board Intervention

• Pre
  – Bi-monthly
  – 4-8 patients
  – Analog artifacts
  – One site
  – 30+ people
  – Hemepath, Oncology experts, students all together
  – Lunch provided

• Post
  – Bi-monthly
  – 4-8 patients
  – Digital artifacts
  – Two sites, symmetric
  – 60+ people
  – Hemepath at UW site
  – Experts, students at either site
  – Lunch at both sites!
Heme-Onc Information

Artifacts

Sue Smith

- 34 year old female
- Cervical node noted by chiropractor
- 7/99 - Dx: Hodgkin's Disease
- 7/99 - small node (5cm maximum) in axillary area
Outline

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Methods - Technical

• Video conferencing
• Information system
• Application sharing
• Enhanced Telepresence
Video conferencing

- Polycomm
  - H.323 (IP)
  - TCP/UDP
  - 384K -> 2Mbps
  - Multipoint x 4
  - Integrated, good audio, separate mics
Tumor Board Information system

• Web based
  – Standard protocols
  – Enterprise security architecture

• Linux, Apache, MySQL, Perl, PHP, Python (open source platform)

• Enterprise clinical data repository linked through web protocol interface
Application Sharing

- T.120
- TCP
- Evolution:
  - VNC/SSH (-performance) ->
    NM ->
    PC Anywhere (+control, multipoint-) ->
    NM (+multipoint)...
- T.120 multipoint
Results - Technical

• Distributed Conference
  – January 2001, and every two weeks since
  – Successful transfer to turnkey system

• Technical
  – Network performance
  – Contextual Inquiry
    • Video performance
    • Application Sharing performance
SCCA Side
UW Networking

- Peak average out 450mbits/10gbits
- Peak average in 250mbits/10gbits
Network Measurement

• Excellent Capacity - iperf
  – Typical 60/100 mbps
  – Typical 9/10 mbps

• Performance:
  – Break-ups
  – Dropped video/disconnects
  – User dissatisfaction
Networking Issues

• Goal: Instrument the network & assess
• Achieved:
  – Keep system operating through a variety of challenges
    • Network/switch – configuration
    • Firewall – administrative
    • Router patch bugs, etc.
    • Cracked fiber connection
  – Close cooperation with C&C people!
Telepresence - provide a greater sense of “being there”

- Tele-Immersion
- Shared space
- Vision-based pen input
- Augmented reality/mixed reality
Shared Space

Telepresence

Mixed Reality Visualization and Vision-Based Pen Input

Augmented Surfaces

Image Annotation/Comparison
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Methods – Clinical Practice

- Visited and observed 11 tumor boards
- Four were observed in detail
- Review Contextual Inquiry
  - Tool to look at software/technology design and implementation using observations and interviews
  - NGI team lead by Judith Ramey, chair of Department of Technical Communications in the College of Engineering
- Review conference experience of clinicians, esp. hematopathologists in Lab Medicine
Contextual Inquiry and Design

- Work Modeling
  - Work models provide a concrete & ‘objective’ representation
- Consolidation
  - See common structure inherent in work people do
- Work Redesign
  - Team invents improved ways to structure work: vision; use data to see what technology can be inserted to support the new work practice
- User Environment Design
  - Ensure that structure is right for user and manage the work of the project across engineering teams
- Mock-up and Test with Users
  - Prototype system, test the structure and user interface; redesign mock-up (iterative feedback)
Contextual Inquiry/Design Team

- User-centered design (ethnographic field research methods)
  - Social roles, hierarchy, relationships, interactions, artifacts
  - Information handing/use, views/attitudes towards technology
- ‘Unobtrusive’ observations
  - Handwritten notes → Sticky notes → Affinity diagrams → Data Wall
  - Videotaping of activities
  - Timeline of activities, Accounted for roles, QDA (NUD*IST)
- Invasive inquiries
  - Interviews with users and technical teams
  - Surveys of participants
“Data Wall”
Two Survey Types

• General participant group ranking (quarterly):
  – Various data sources available in the conferences
  – Reasons and motivations for attending
  – Satisfaction and experience of hardware/software and how they impact their participation

• Studies comparing issues associated with the single and multi-site conferences including:
  – Medical complexity
  – Variety of viewpoints presented
  – Timeliness of information presented
  – Source of pedagogical information
## Conference Participant Survey

### Demographic Information

Are you (circle one):  
- attending fellow  
- resident  
- medical student  
- nurse  
- other (specify)  

What is your primary affiliation? (circle one)  
- SCCA  
- FHCRC  
- HMC  
- UWMC  
- referring/external  

What is your subspecialty? (e.g., Medical Oncology, Hematopathology)  

How many times have you attended this conference before? (circle one)  
- 0  
- 1  
- 2—5  
- 6—20  
- more  

At which site did you attend today’s conference? (circle one)  
- SCCA  
- UWMC  

### Please rank the five most important data sources (1 = most important) for this conference.

<table>
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<tr>
<th>Data Source</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Not applicable</th>
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<tbody>
<tr>
<td>Anatomic pathology photos</td>
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<tr>
<td>Chart (MINDscape)</td>
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<td>Chart (paper)</td>
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<td>Clinical pathology (flow cytometry, hematology, including hematopathology)</td>
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<td>Documentation from referring lab or clinic</td>
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<td>Documentation from referring MD</td>
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<td>Email printout of summary of case</td>
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<td>Group discussion of case</td>
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### Please complete the section below about your reasons to attend.

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<th>Reason to attend</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>Not applicable</th>
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<tbody>
<tr>
<td>To present my own patient</td>
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<td>To hear about a patient similar to mine</td>
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<td>To hear about an unusual case</td>
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<td>To discuss my patient informally</td>
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<td>To interact with my colleagues</td>
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<td>To meet with colleagues from other institutions</td>
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<td>To learn</td>
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<td>To teach</td>
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<tr>
<td>Other (specify)</td>
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</table>

### Please circle the most appropriate response.

1. The picture quality of the clinical images (CT, path slides, etc.) for my purpose at this conference was:  
   - Acceptable  
   - Not acceptable

2. The quality of the video met my communication needs:  
   - Acceptable  
   - Not acceptable

3. The quality of the audio met my communication needs:  
   - Acceptable  
   - Not acceptable

4. To what extent did you feel included in the conference?  
   - Acceptable  
   - Not acceptable

5. To what extent did you feel that the people in the other room were included in the conference?  
   - Acceptable  
   - Not acceptable

6. Making eye contact with participants in the other room was:  
   - Easy  
   - Impossible

7. I made eye contact with a participant in the other room:  
   - All of the time  
   - None of the time

8. I was able to understand what was going on in the conference:  
   - Comfortable  
   - Not comfortable

9A. I made a public comment in today’s conference:  
   - Yes  
   - No

9B. Adding comments to today’s discussion felt:  
   - Comfortable  
   - Not comfortable

10. How likely would you be to attend at this site in the future?  
    - Very likely  
    - Not at all likely

11. Compared with a conference with everybody in the same room, I felt it was:  
    - Easier to hear the discussion  
    - Neutral  
    - Harder to hear the discussion

12. What would improve your experience of this multi-site conference? (Please comment)

13. How could the audio-visual elements of the conference be improved? (Please comment)

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Please return the survey at the conference, or mail to Brent Stewart, 357115
Results – Clinical Practice

• Hematology Oncology conference became testbed
  – Large number of practitioners at SCCA and UW
  – Timeliness of change
  – Opportunity to use contextual inquiry tools and NGI technology
Workflow of Analog Presentation
Before Feb. 2001

• Clinicians identify cases for presentation by Wednesday
• Pathologists obtain slide material
  – Outside cases require 24 hours to get slides
  – If inside case, retrieve slides from files
• Review glass slides and photograph findings on 35mm film
• Develop film – send to photography by 1PM Thursday; film back by 5PM (~4 hours)
• Prepare slides for Friday noon presentation
WORKFLOW – Analog Conference Preparation

Owner requests cases

Invites expert

Gathers teaching materials

Clinicians volunteer cases, gather data sources when confirmed

Gathers teaching materials

Hematopathology

Photographic Slides

Photos

Radiology Films

Transparencies

Conference

Transparencies

Journal Articles

Photos

Slides
Digital Conferencing

• Tumor Board software developed to support digital presentation
• Software anticipated “divided” conference
• Early Tumor Board software was labor intensive and added 2-4 hours Thursday eve
  – 35mm slides were digitized and enhanced with Photoshop.
  – Early presentation software was buggy and awkward. Improved through contextual inquiry.
WORKFLOW – Digital Conference Preparation
Digital Microscope

- Digital camera installed May 17, 2001
- Pathology fellows and residents used camera for May 18 conference
  - Little difference in technology
  - Electronic images accepted even though slightly lower quality
  - Immediate feedback on image
- Flow cytometry scattergrams printed and scanned; display poorly otherwise
Olympus DP11 Camera + BH2 Microscope
Changes to Conference

• Negative impacts
  – Digital Tumor Board has speeded up process
  – Early path residents objected to faster pace
  – Decreased preparation time before conference
  – Images often loaded Friday AM before conference

• Positive impacts
  – Digital camera is faster overall
  – Tumor Board software allows presentation review by both presenter and faculty
  – Transition to dual site conference uneventful in March, 2001
INTERACTION MAP
August 6, 2001

REMOTE SITE

Guest MD lectures, responds

Audience member comment

Informal expert comments

Pathologist

Attending Physician

Audience member question

Owner introduces presenter
Conference Attendance

Estimated Attendance Figures

- Phase One: Natural Tumor Boards
- Phase Two: Single-Site Prototype
- Phase Three: Early Distributed Conferences
- Phase Four: Later Distributed Conferences

Number of Attendees

Project Phases

UWMC
SCCA
Total
Survey Result Analysis (1)

• Results through quarterly surveys administered over a 22 month period:
  • Access to Expertise
    – 63% attendees reported that access to transplant-related expert opinion had increased over the course of the study
  • Time Saved
    – *Physicians reported an average savings of 1.25 hours commute time per conference*
Survey Result Analysis (2)

• Comfort with technology
  – 86% of participants revealed that they were “not at all likely” to travel to the distant site for conference

• Usefulness of information
  – 68% reported that the usefulness of information had increased versus the old single-site format

• Learning something useful for the future
  – 66% reported that such learning was more likely in the multi-site setting
  – 34% reported no qualitative difference between single or multi-site formats
Quality and Telepresence

Box Plot
Split By: Site Attended

Units

Picture Quality
Video Quality
Audio Quality
Feel Included
Others felt included
Making Eye Contact
Make Eye Contact
Hear the discussion
Fuller discussion
Take part in discussion
Get distracted
Understanding on
Attend in the future

SCCA
UWMC
Transitioning to Users and Staff

• Main Goal: keep developed tools in use beyond end of contract period
• Hematopathology residents, fellows and attendings were quickly trained since July of 2001
• Oncologists run the conferences themselves as of March 2002.
  – Only a few enter their own presentations
  – Facilitated the oncologists to create PPT presentations and load their own materials, including radiographic images
• Several “how-to” Quick Guides and an extensive Users Guide were created
• AV personnel trained in setup and management of system
Transitioning to Users and Staff

• This successful hand-off of the operation and technical aspects of the conference is a prime achievement of the project. The conference has been operational for almost a year without significant changes and minimal support.
Lessons Learned

• Rolling evaluation of the usability, content and utility of the system helps prioritize future enhancements and
• Gradual introduction of new technologies allows users to master each transition towards the targeted design
Corollary A: Technology Must Be Familiar

- We experimented with telepresence objects (whiteboard, augmented reality, virtual reality, etc.). Clinicians reacted negatively.
- Digital microscope readily accepted
- Microphones readily accepted
Corollary B: Making Technology Transparent Is Challenging

• Transition to AV support personnel went well, but requires a “cart”
• Software was rewritten (Fred Brooks Mythical Man Month rule – write one to throw away)
• Nothing is simple about networking
  – 100 mb/s required a direct cable to the switch – via the closet didn’t work.
  – Network device autonegotiations don’t
  – Changes in firewalls, routers and switches
  – MSBlast traffic?
  – The politics of firewalls
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Key Results

• Leverage advanced networking to:
  – Increased conference attendance
    • Experts
    • Learners
  – Avg 1.25 hour time savings (travel)
  – 66%: distributed “learning more likely”
  – Sustainable, with help
Implications

• Methodological developments
  – Application to clinical domain of:
    • Information Artifacts and Channels
    • Iterative Contextual Inquiry

• Impact on tumor board
  – CSCW tools for clinicians
  – Group to group setting
TBIS Demos

• NLM Collaboratory Demo
  – Privacy issues -> “mock conference”

• The “mock” conference consists of two cases, a deidentified composite of multiple, representative, “real” cases
  – A pregnant Native American woman with Stage IV nodular sclerosing Hodgkin’s disease
  – An Asian-American man with chronic myelogenous leukemia

• Access to the demonstration Web server with cases: https://secure.cirg.washington.edu/tb/
Internet2 Health Sciences
Advanced Application Forum -
March 2001
Publications (Technical)

- **Tumor Conferencing Tools for Regional Collaborative Cancer Care Using the Next Generation Internet.** Stewart BK, et. al., Proc. AMIA Symp. 2001; 836.
- **An Evolutionary Approach to Implementing Augmented Reality for Clinical Case Conferences.** Lober WB, Trigg LJ, Stewart BK, Ramey JA, Chou D, Weghorst S. Presented at MMVR 2002, Newport Beach, CA.
- “Adapting to Tradition: Bringing Tumor Boards Online.” submitted
Publication (Contextual Inquiry)


- **Approaching On-line Self-representation in a Community of Practice.** CKVieira da Cunha, J Ramey, CS de Souza. Accepted for Presentation at HCI International 2003.
Conclusions

• Research Areas
• Expanded Domains
Research Areas

• Reuse of materials
  – Clinical consultation, re-admits, conference review
  – Teaching files
• Expanded Telepresence
• Multipoint
• Multibandwidth Adaptive Delivery
Expanded Domains

- Clinical
  - Case Conference Information System
- Public Health
  - Advanced Collaborative Infrastructure for Public Health Emergency Management (ACIPHER)
Next Steps

- scale NGI to ACIPHER - Advanced Collaborative Infrastructure for Public Health Emergency Response

- Extension of NGI to public health disasters
  - Aim 1 – Security infrastructure
  - Aim 2 – Network aware applications
  - Aim 3 – Knowledge model
  - Aim 4 – Tools for presentation and collaboration
  - Aim 5 – Assessment and evaluation
Acknowledgments

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  • NLM 467-MZ-802300 (Biomedical Applications of the Next Generation Internet, “Adopting the Next Generation Internet as a Tool for Healthcare Delivery and Information Access”)

8/27/2003
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Questions?

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