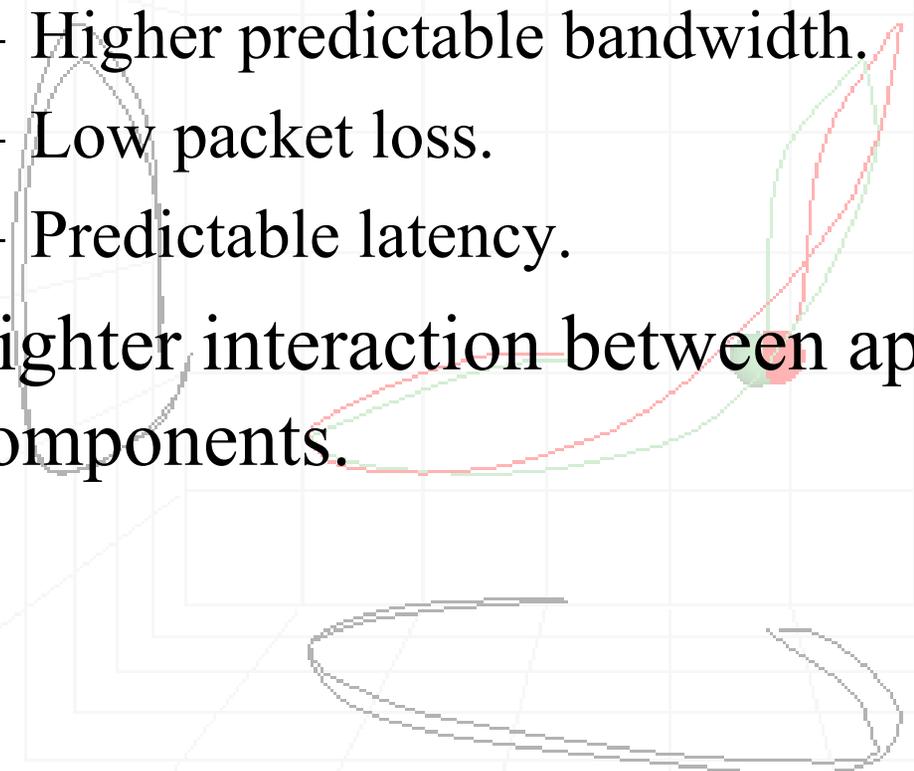


Networks

- Provide
 - Access to remote data sources.
 - Access to remote computation/simulations.
 - Exchange of information between peers.
- App design constrained by transport quality
 - Store/forward mail delivery.
 - Shared video environments.

NGI Quality of Service

- Shift the spectrum of feasible applications.
 - Higher predictable bandwidth.
 - Low packet loss.
 - Predictable latency.
 - Tighter interaction between application components.
- 

Applications

RSV

Remote Stereo Viewer

ImmSeg

Immersive Segmentation

NAV

Nomadic Anatomy Viewer

RHT

Remote Haptics Trainer

SurgSim

Surgical Simulation

RSV: Motivation

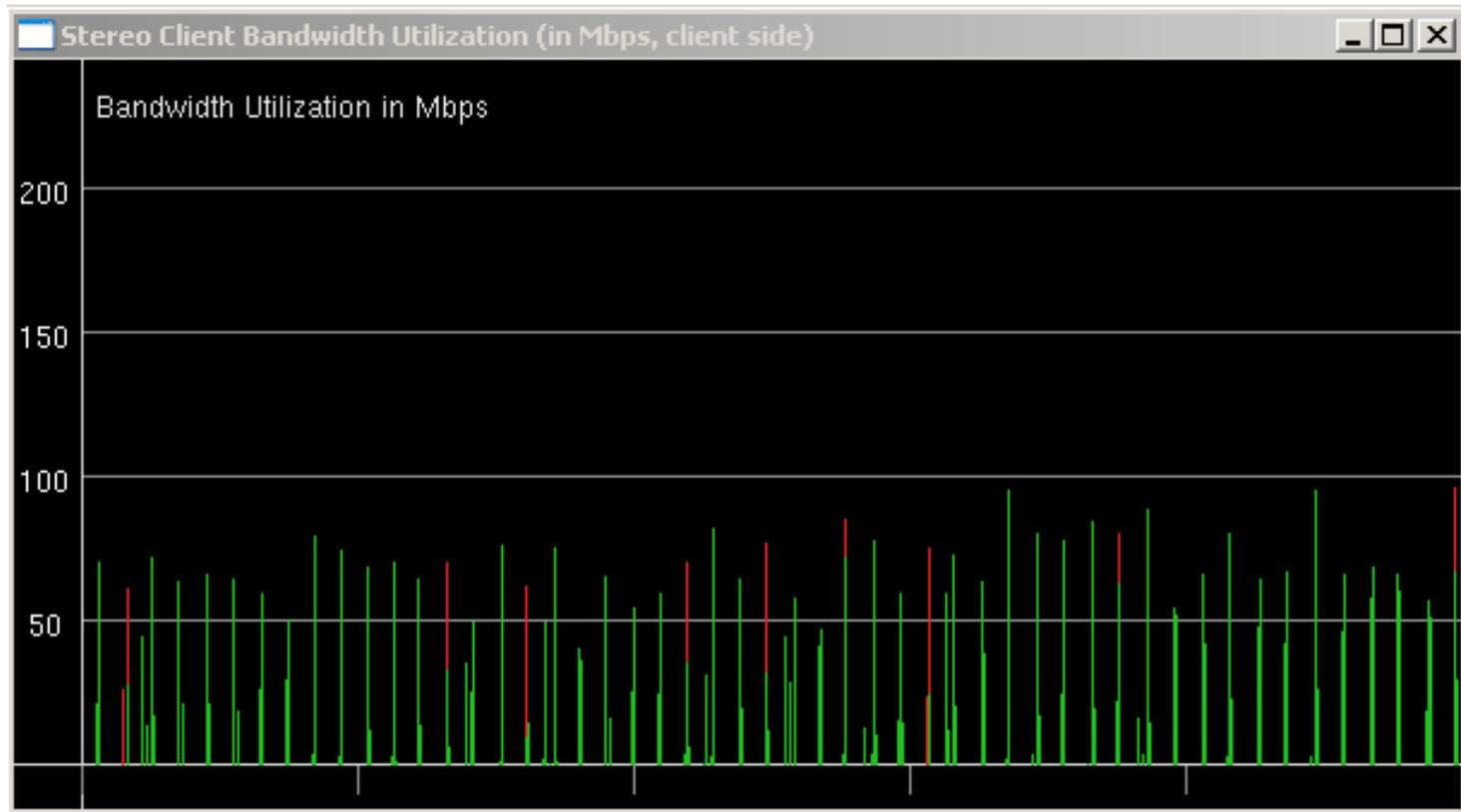
- Provide remote access to multi-dimensional, high-resolution image sets.
- Assume:
 - User views small subset of images.
 - User takes unpredictable path through image set.
- No download or pre-fetch.
- QTVR style user interface.

QuickTime™ and a MPEG-4 Video decompressor are needed to see this picture.

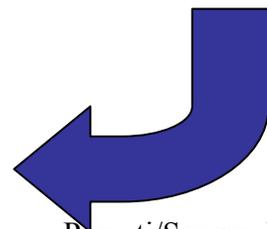
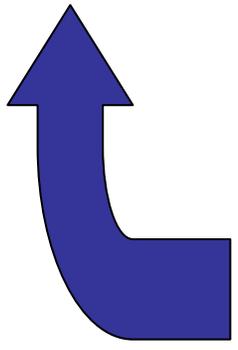
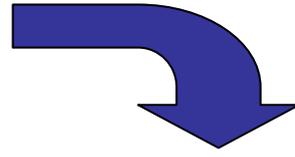
RSV: Network Characteristics

- Request/Response design using TCP control connection.
- UDP stream for image transport.
- Stanford - La Crosse:
 - 150ms to transport and display 200KB image.
 - Transport occurs in 70Mbps bursts.

RSV: Image Transport



A Collaborative Anatomy Lesson

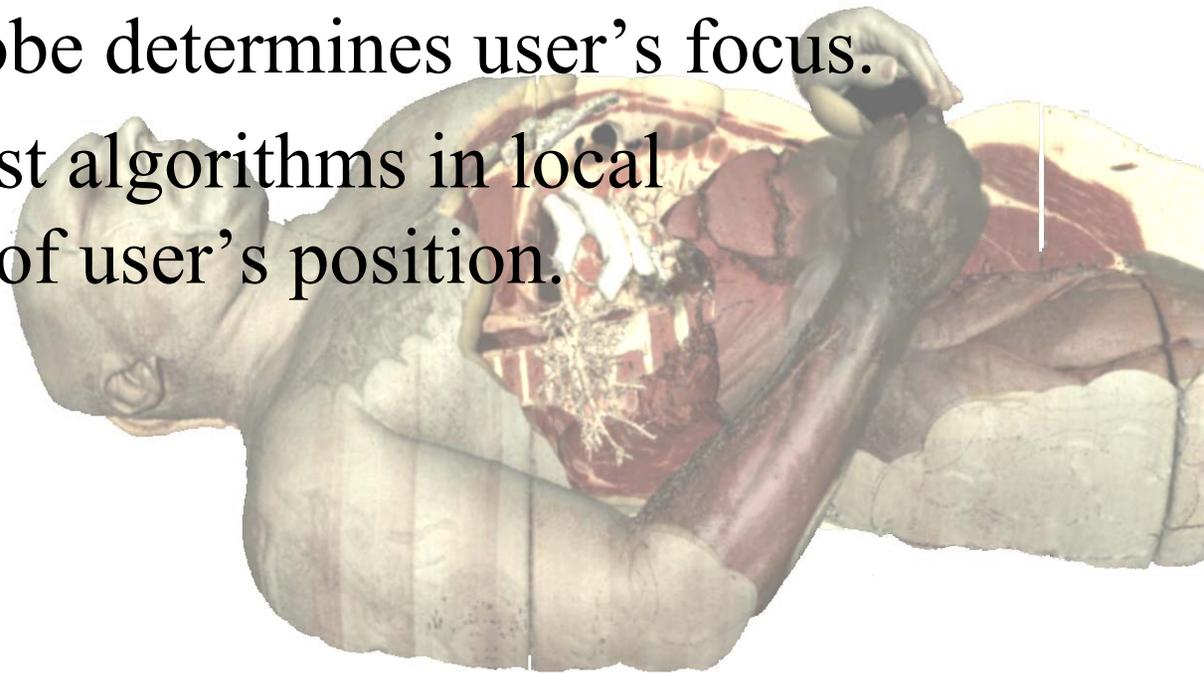


RSV: Additional Components

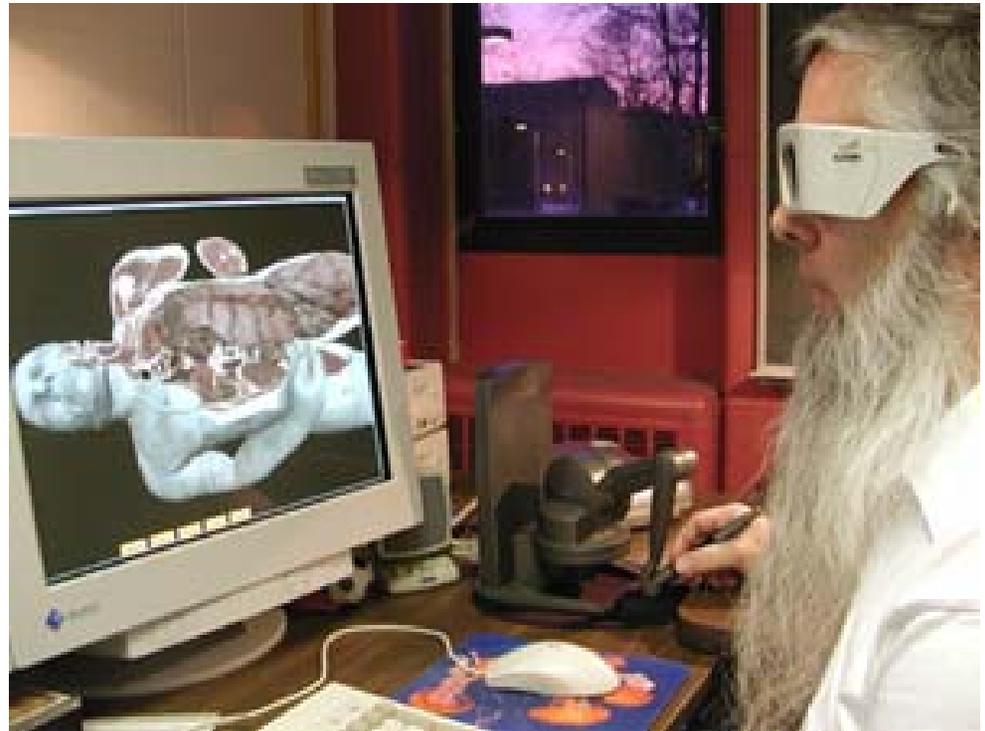
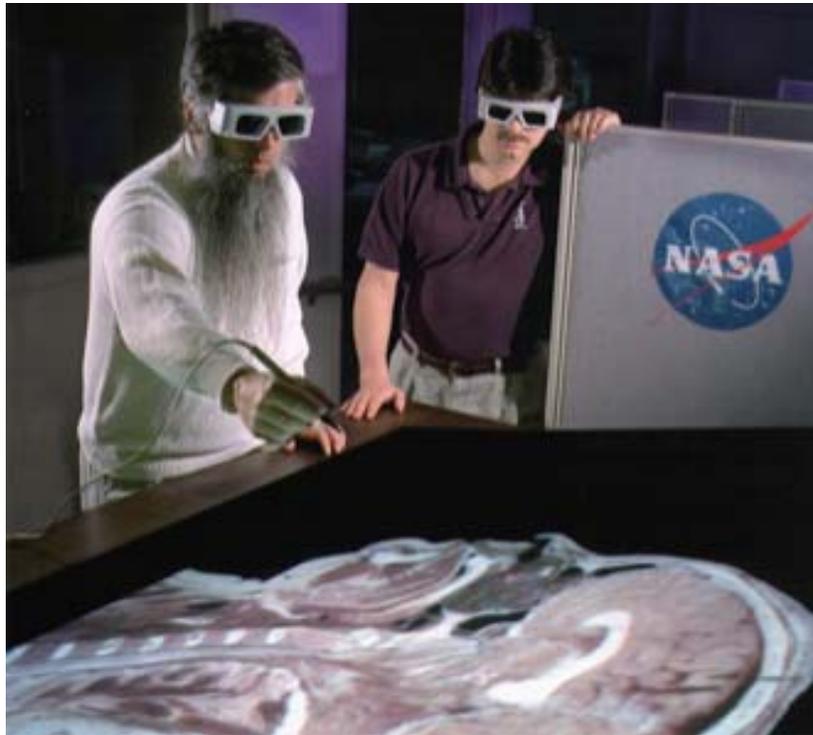
- Collaboration between clients:
 - Clients can exchange leader role within a collaborating group.
 - Shared 3D pointer.
- Structure label server:
 - Supplies identifying labels for visible structures.
 - Track 3D point on image through rotation.
 - Author/View label sets.

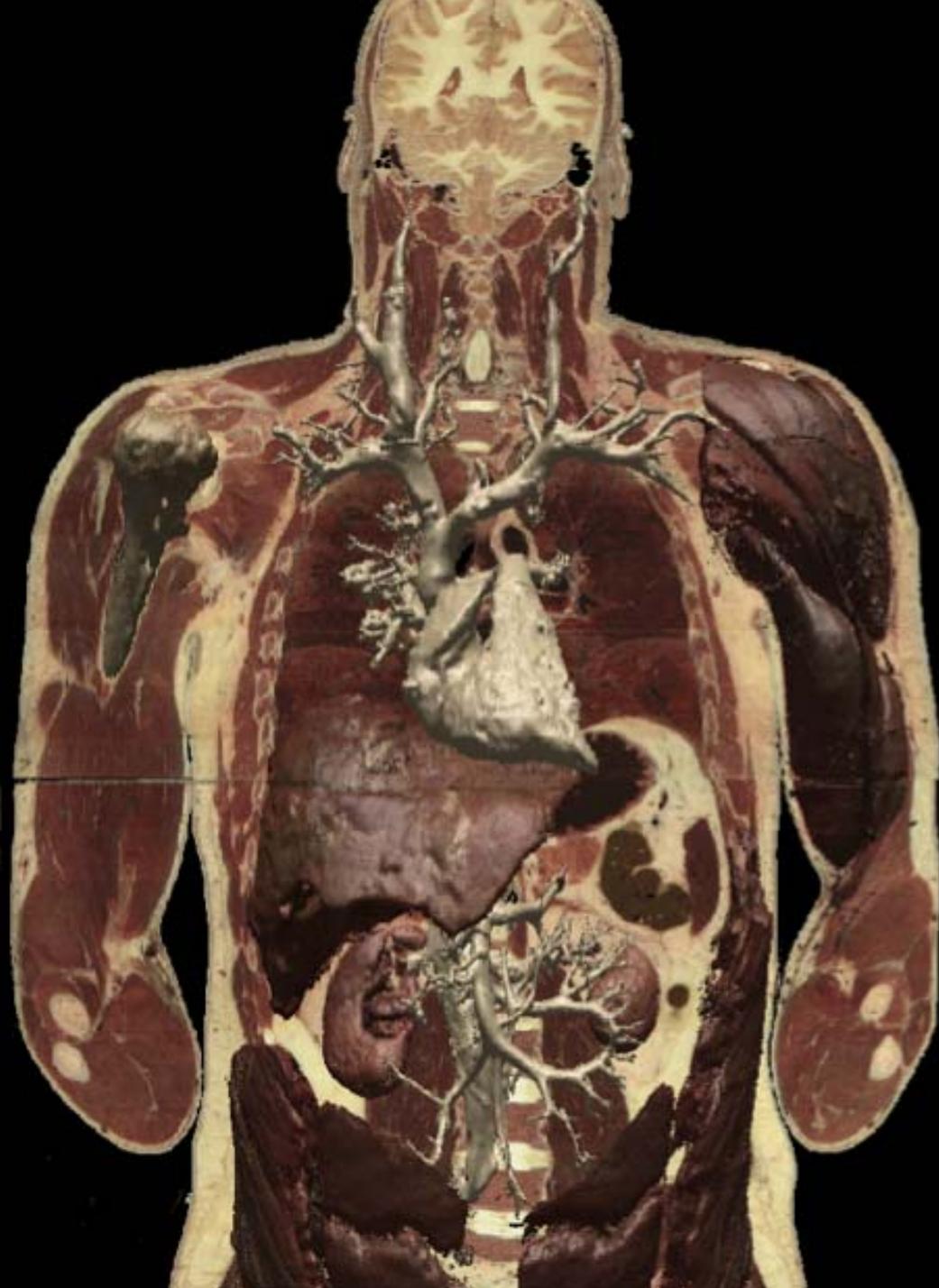
ImmSeg: Motivation

- Visualize & Segment volumetric data sets.
- Stereoscopic, visually immersive.
- 3D tracked probe determines user's focus.
- Apply high-cost algorithms in local neighborhood of user's position.

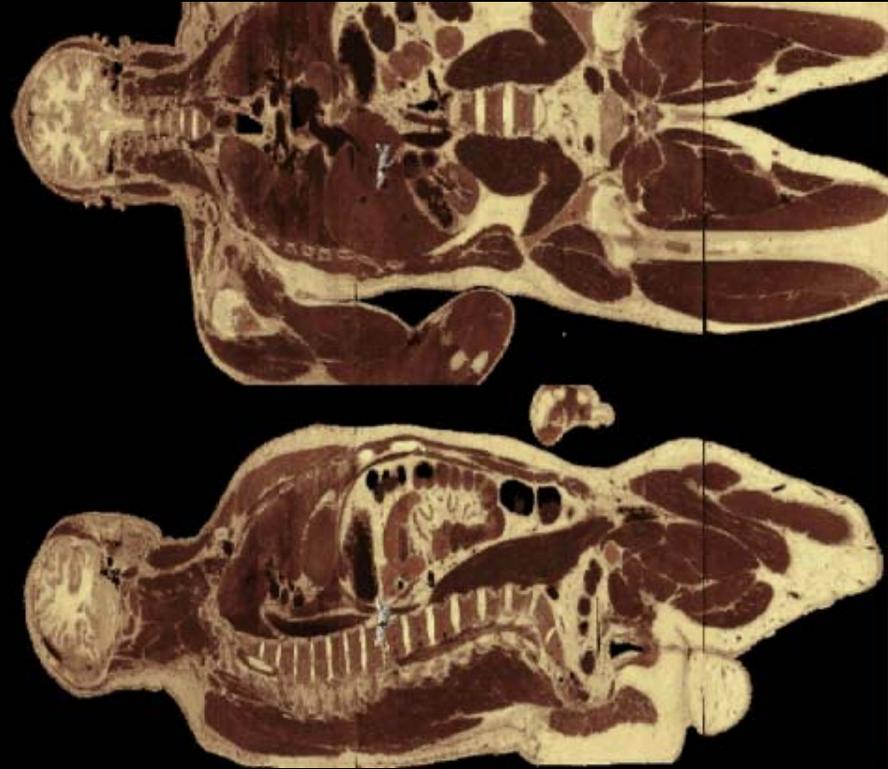


ImmSeg: Client



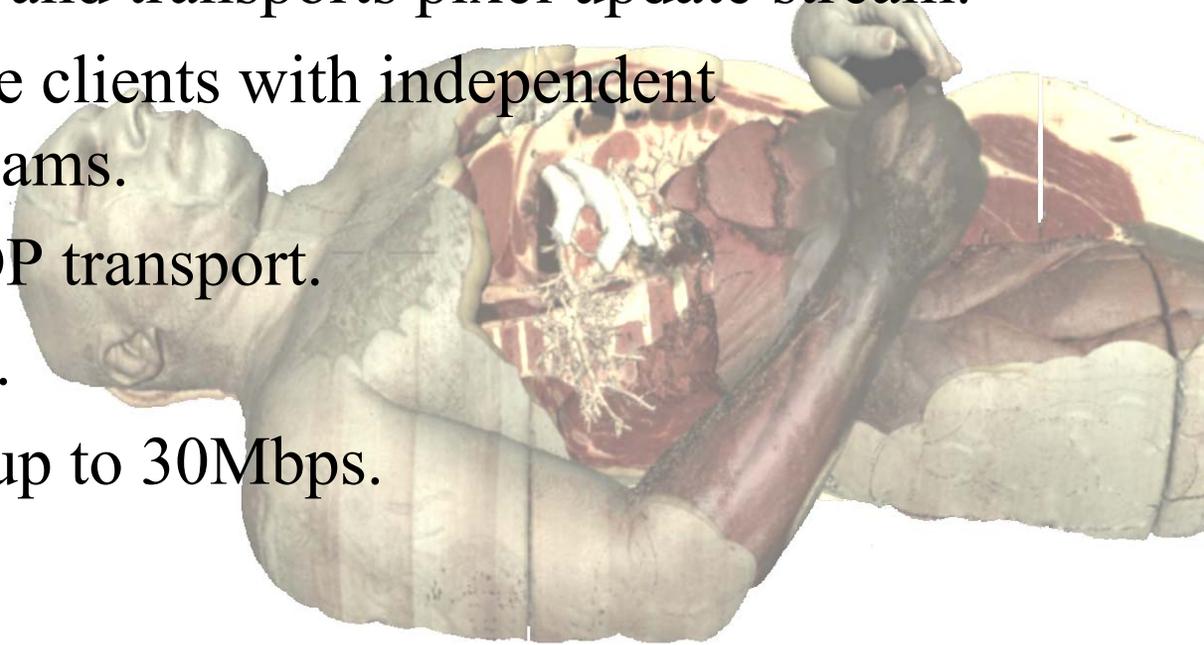


ImmSeg: Operation



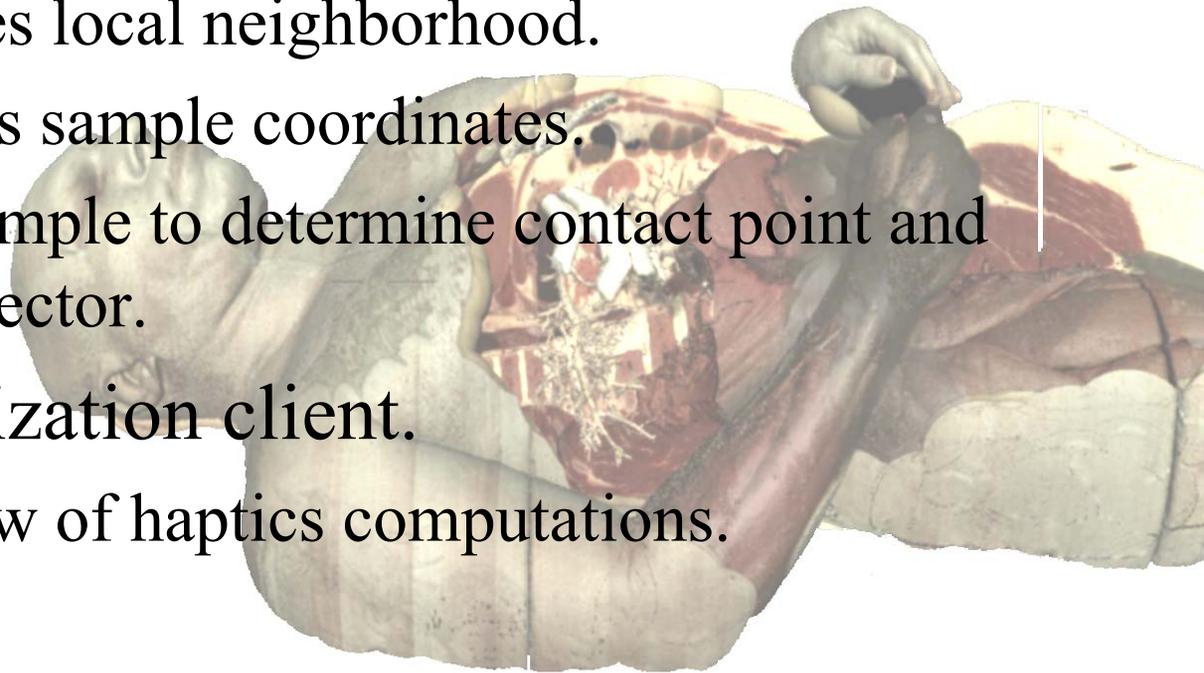
ImmSeg: Network Characteristics

- Decoupled client/server design.
- Client reports position and mode information.
- Server computes and transports pixel update stream.
- Supports multiple clients with independent visualization streams.
- Loss tolerant UDP transport.
- Can be multicast.
- Stream requires up to 30Mbps.



ImmSeg: Additional Components

- Haptics client.
 - Controls Phantom, provides 3D position.
 - Server samples local neighborhood.
 - Server streams sample coordinates.
 - Client uses sample to determine contact point and haptic force vector.
- Haptics visualization client.
 - Real-time view of haptics computations.



ImmSeg: Haptics

ImmSeg: Haptics

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

NAV: Motivation

- Explore interactive capabilities of wireless handheld computers and remote servers.
- Provide on-demand access to arbitrary cross-sectional images of anatomical data set.
- Server performs memory intensive work.

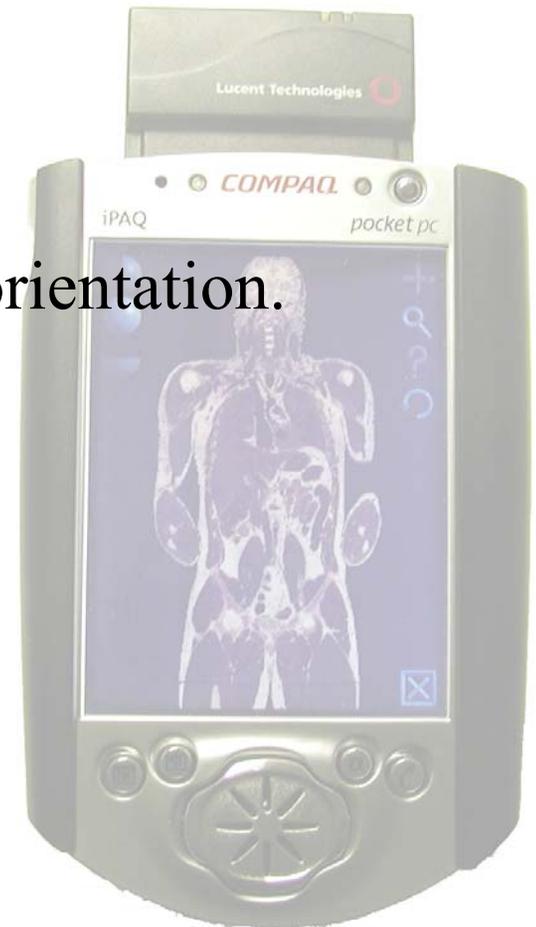


NAV: Movie

QuickTime™ and a MPEG-4 Video decompressor are needed to see this picture.

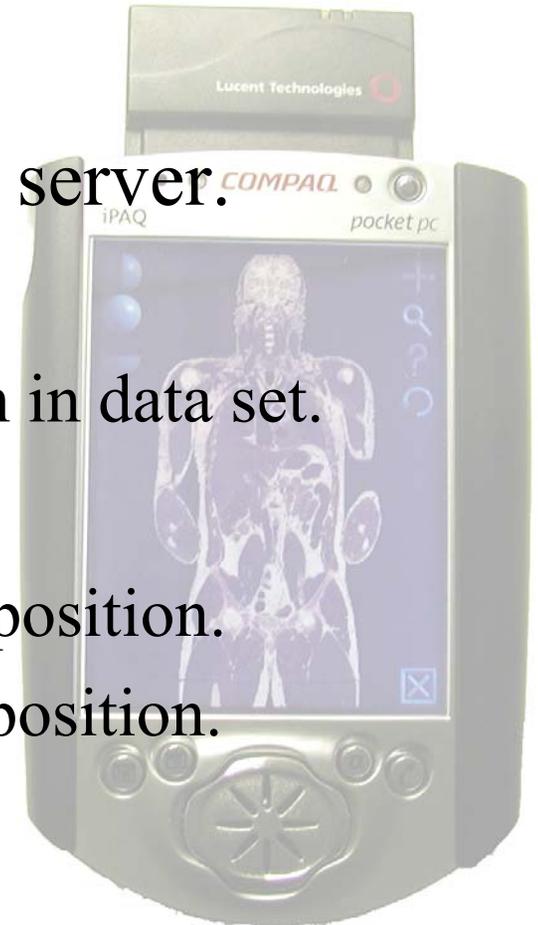
NAV: Network Characteristics

- Client: WinCE, 802.11b wireless.
- Decoupled client/server design:
 - Client interface navigates position/orientation.
 - Server computes cross-section.
- TCP transport - approx. 3Mbps



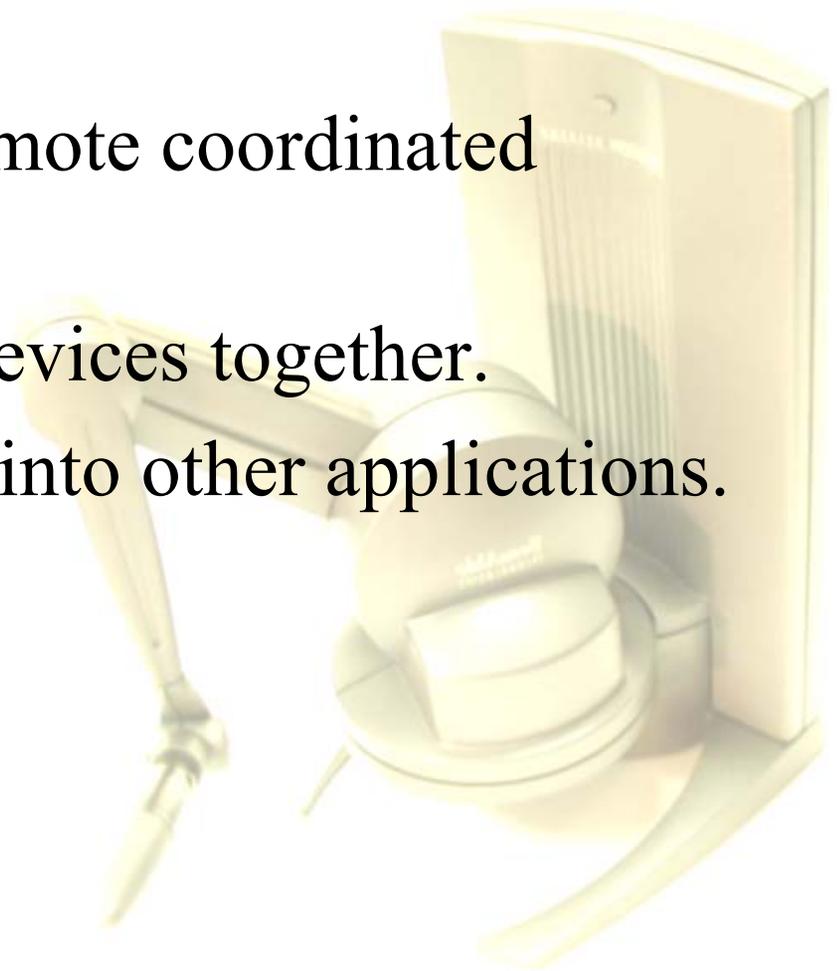
NAV: Additional Components

- Collaboration between clients.
- Collaboration recording/playback server.
- Structure label server:
 - Provides structure name for position in data set.
- Auto-Pilot:
 - Monitors collaboration channel for position.
 - Examines neighborhood of current position.
 - Offers to navigate structure.



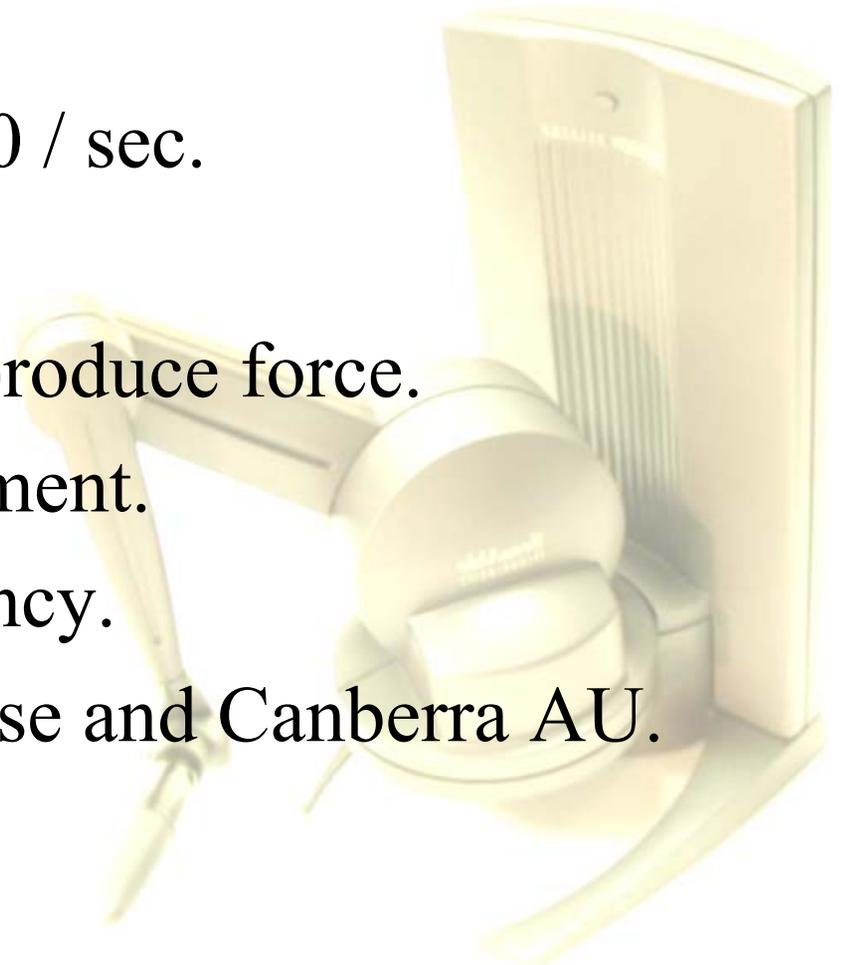
RHT: Motivation

- Explore feasibility of remote coordinated physical action.
- Slave multiple haptics devices together.
- Capability incorporated into other applications.



RHT: Network Characteristics

- Peer reports position 100 / sec.
- UDP layer transport.
- Receiving peer uses to produce force.
- Low bandwidth requirement.
- Requires consistent latency.
- Tested between La Crosse and Canberra AU.

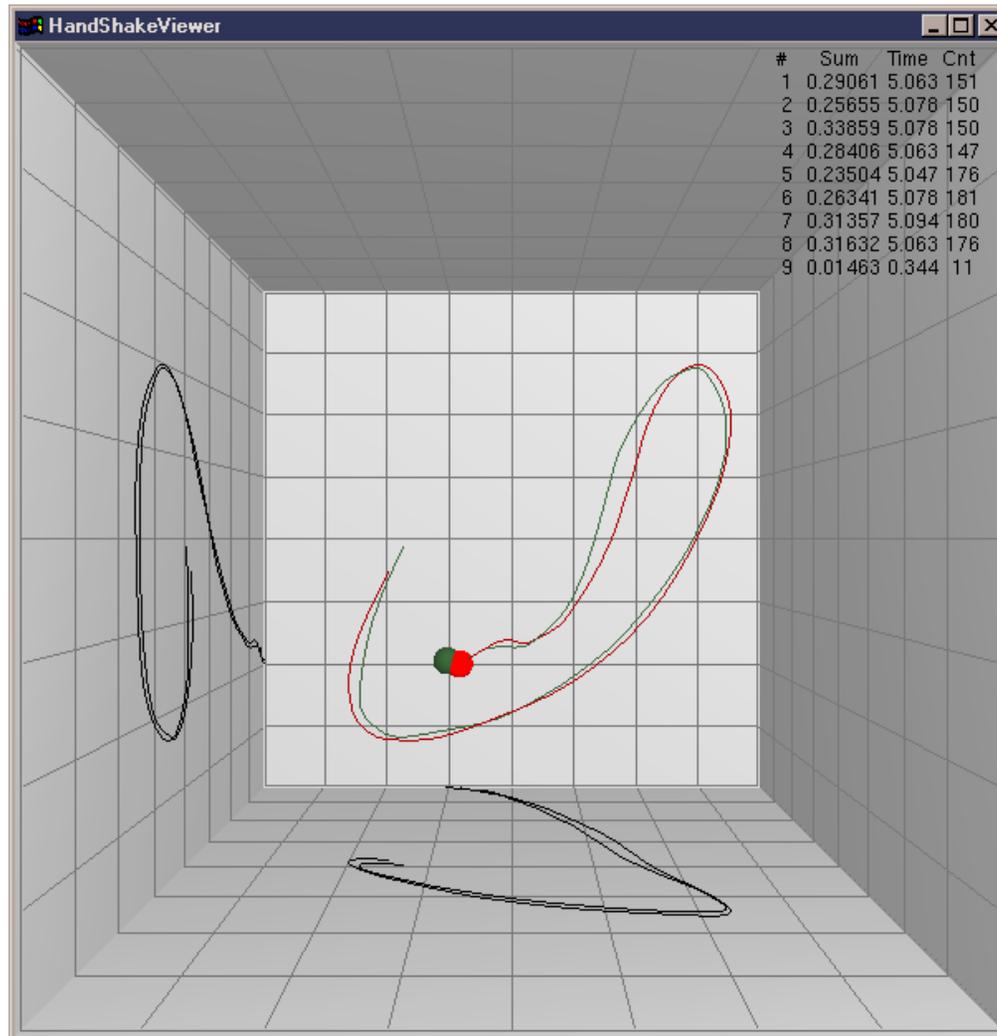


RHT: Additional Components

- Auto-Handshake Server: records and replays closed loop movements.
- Palpation Server: “tap” against simulated remote object.
- Visualization tool: real-time monitoring of peer operation.



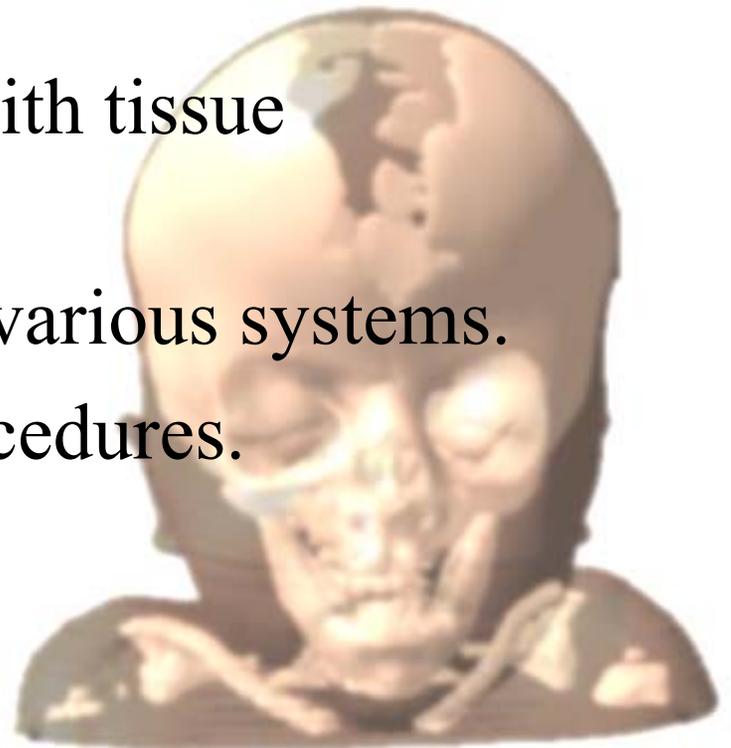
RHT: Visualization Tool



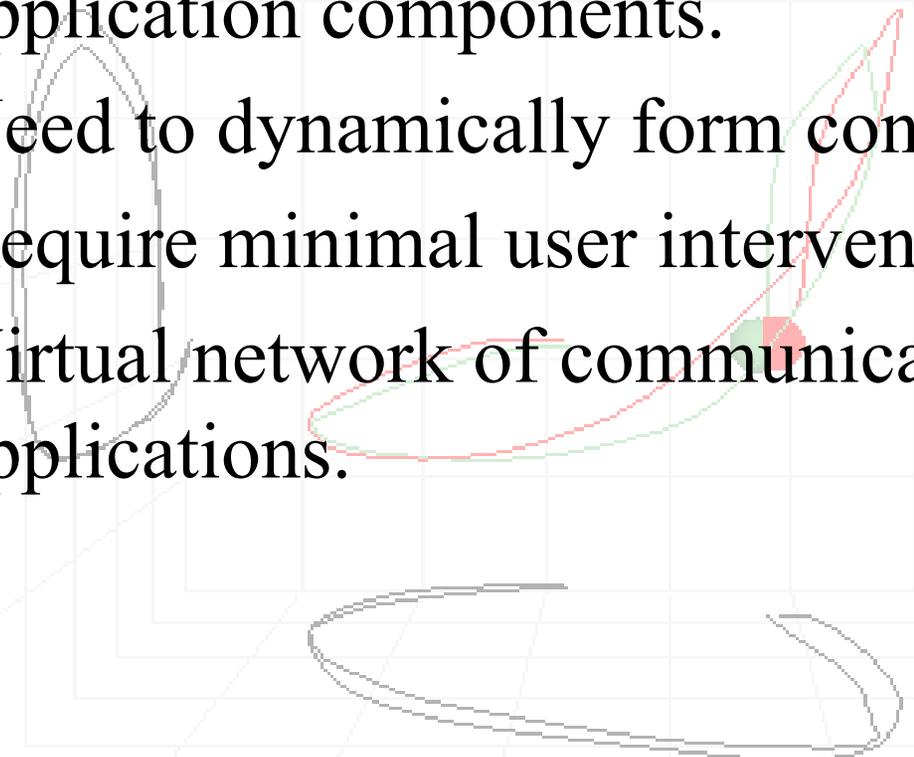
SurgSim: Motivation

(Kevin Montgomery: NASA Biocomputation Center)

- Provide access to remotely hosted surgical simulation.
- Polygonal based models with tissue deformation.
- Large scale integration of various systems.
- Simulation of surgical procedures.



Discovery & Organization

- Complex interconnection possibilities between application components.
 - Need to dynamically form connections.
 - Require minimal user intervention.
 - Virtual network of communicating applications.
- 

Information Channels

- Channel: any data stream between application components.
- Registration Server:
 - Listens for channel announcements on a multicast address.
 - Responds to queries for active channels.
- Web Page Formatter:
 - Queries for active channels of specified type.
 - Formats web page listing of channels.

peabrain - Information Channels - ImgSvr

Address: @ | > go

Live Home Page Apple Apple Support DevChannel Apple Store .Mac Mac OS X

Active ImgSvr channels.

- Stanford SUMMIT Image Server
 - [Skull-2](#)
 - [Bassett-Neck-74](#)
 - [ModelHand](#)
 - [Bassett-Neck-72-73](#)
 - [Bassett-Neck-75-76](#)
 - [Bassett-Neck-77-78](#)
 - [Leg](#)
 - [Hand](#)
 - [Bassett-Hand](#)
 - [BioMechanics](#)
 - [Skull](#)
- La Crosse Image Server
 - [ModelHand](#)
 - [Leg](#)
 - [Hand](#)
 - [Skull](#)

Search channels:

Available channels: [DiagVwr](#) - [ImgSvr](#) - [CEAnt](#) - [HndShk](#) - [WthrStn](#) - [WthrRpt](#) - [Information Channels Home](#)

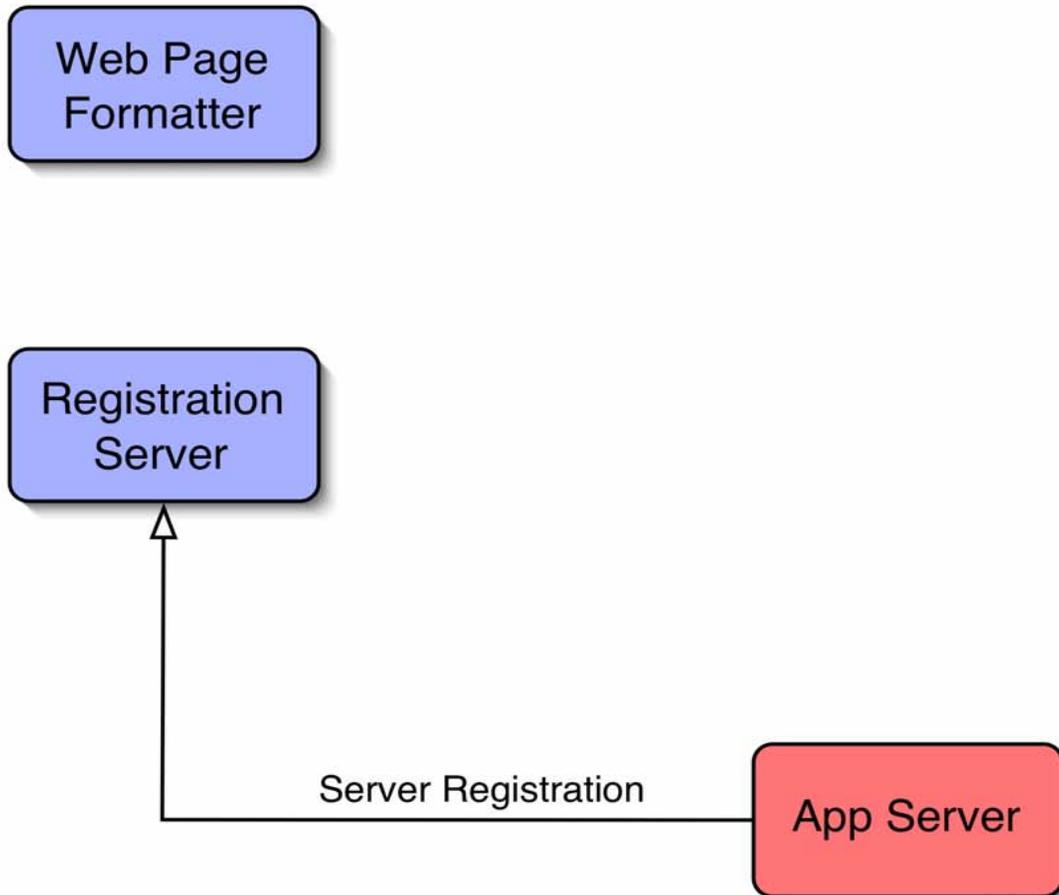
Internet zone

Core Components

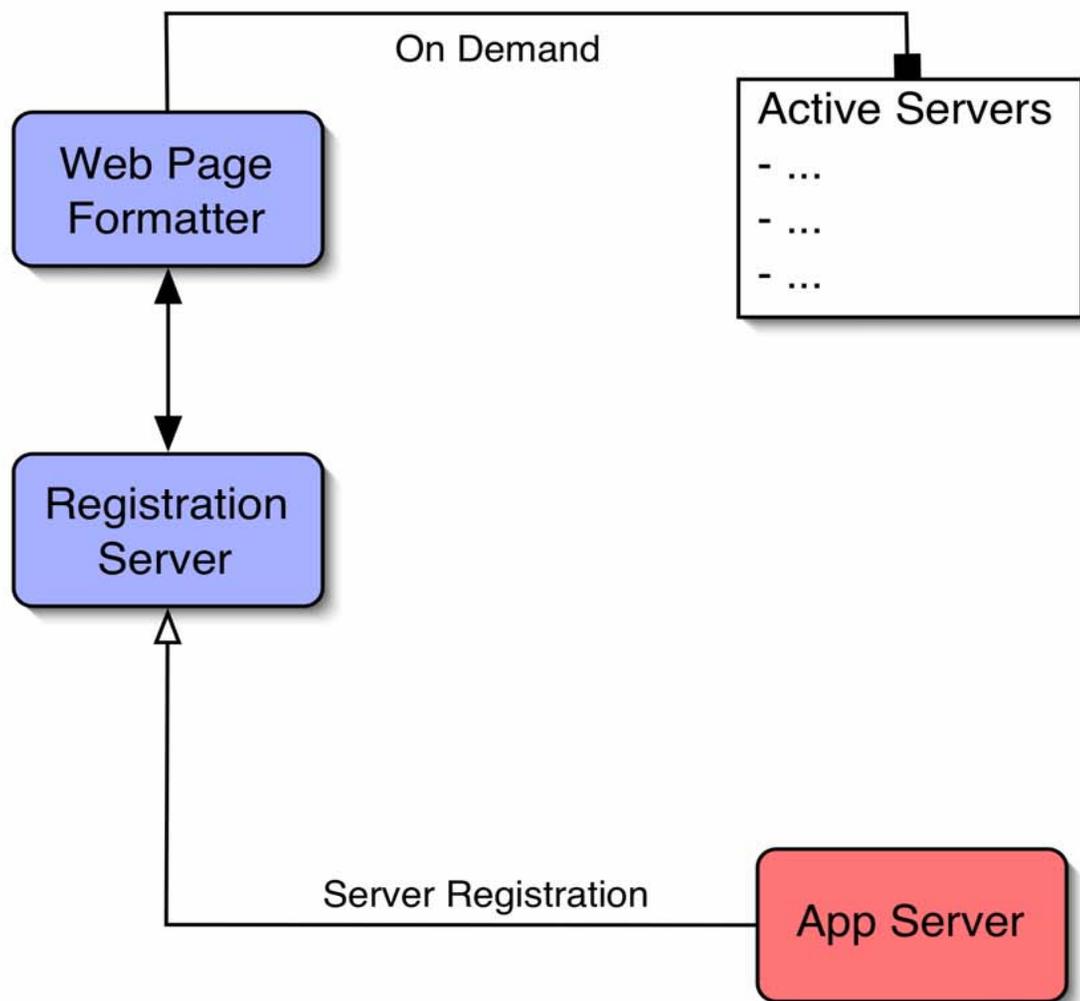
Web Page
Formatter

Registration
Server

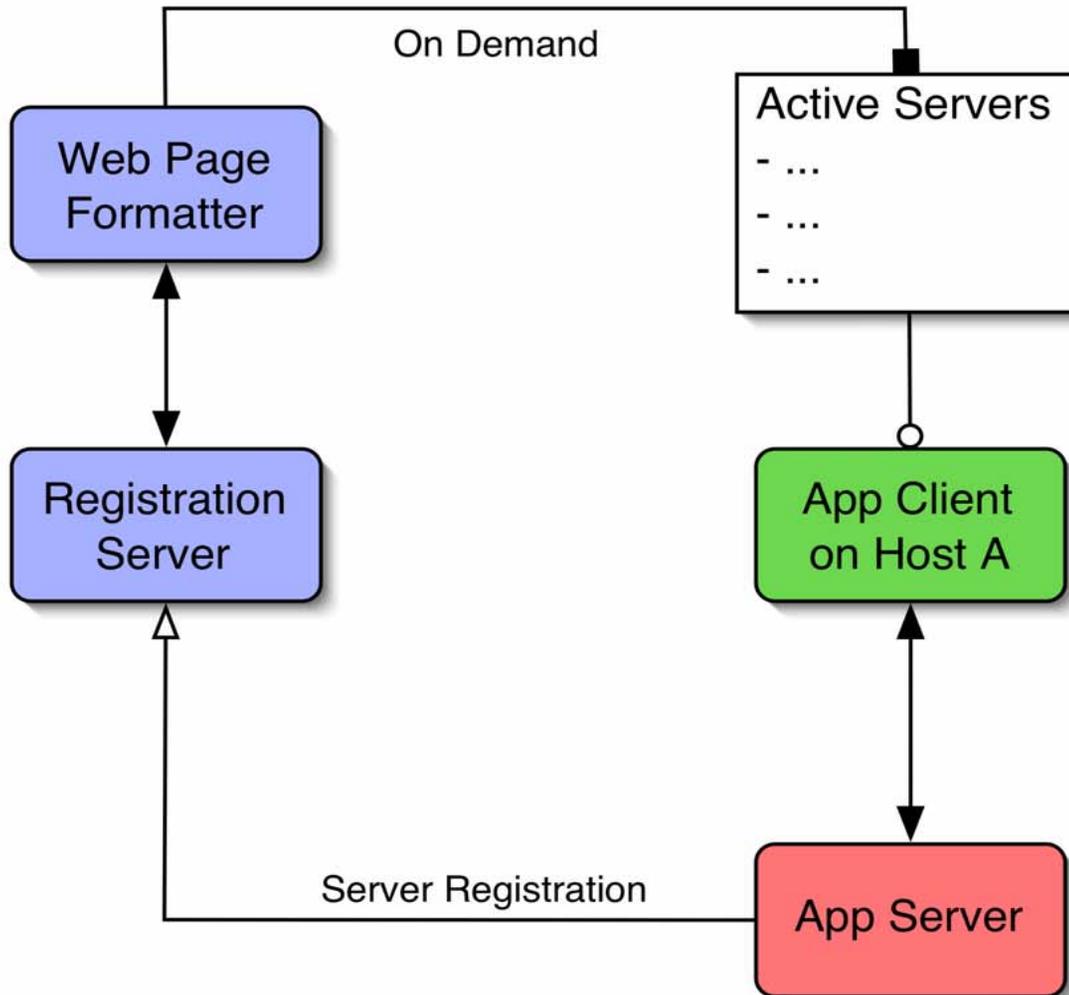
1. App Server announces channel



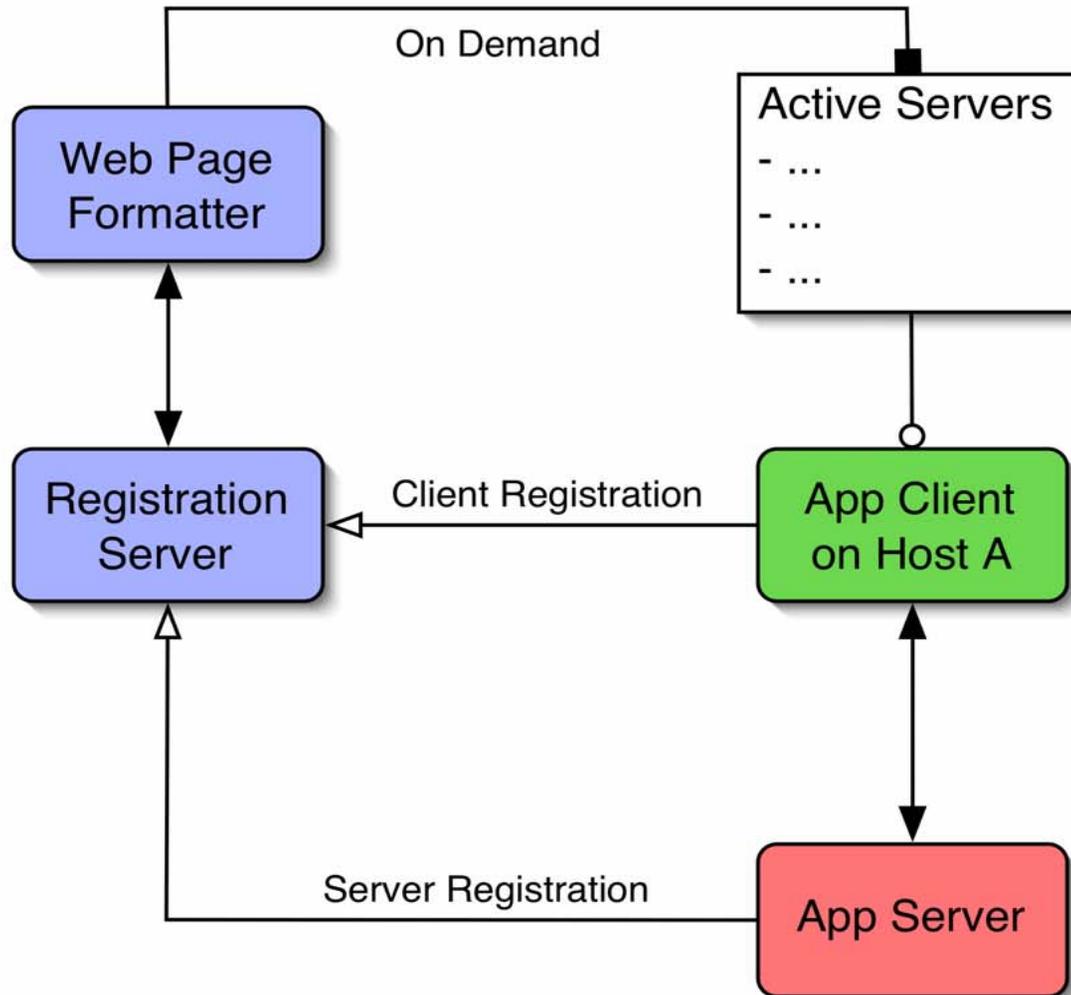
2. User views active channels



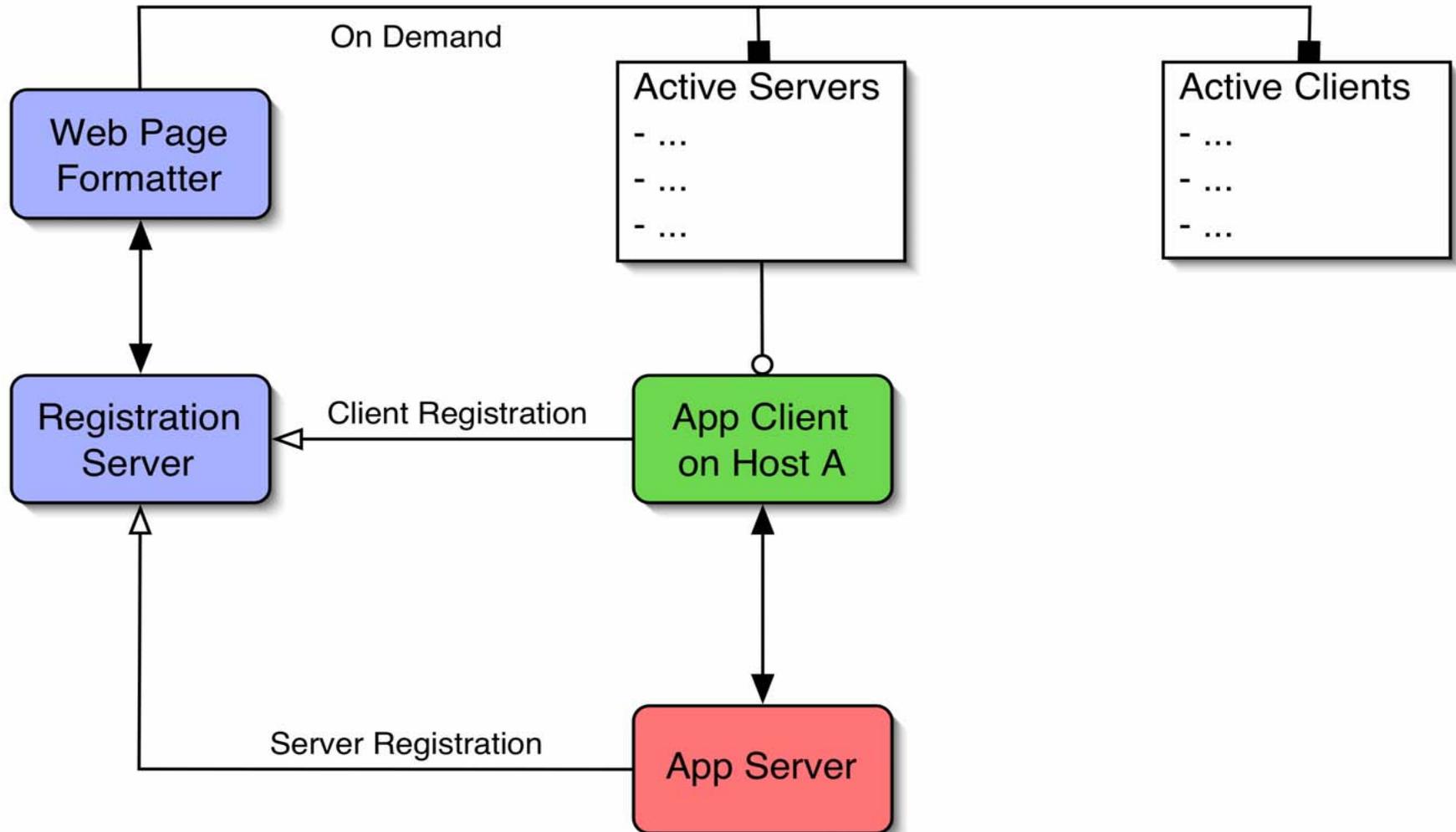
3. User selects link to launch client



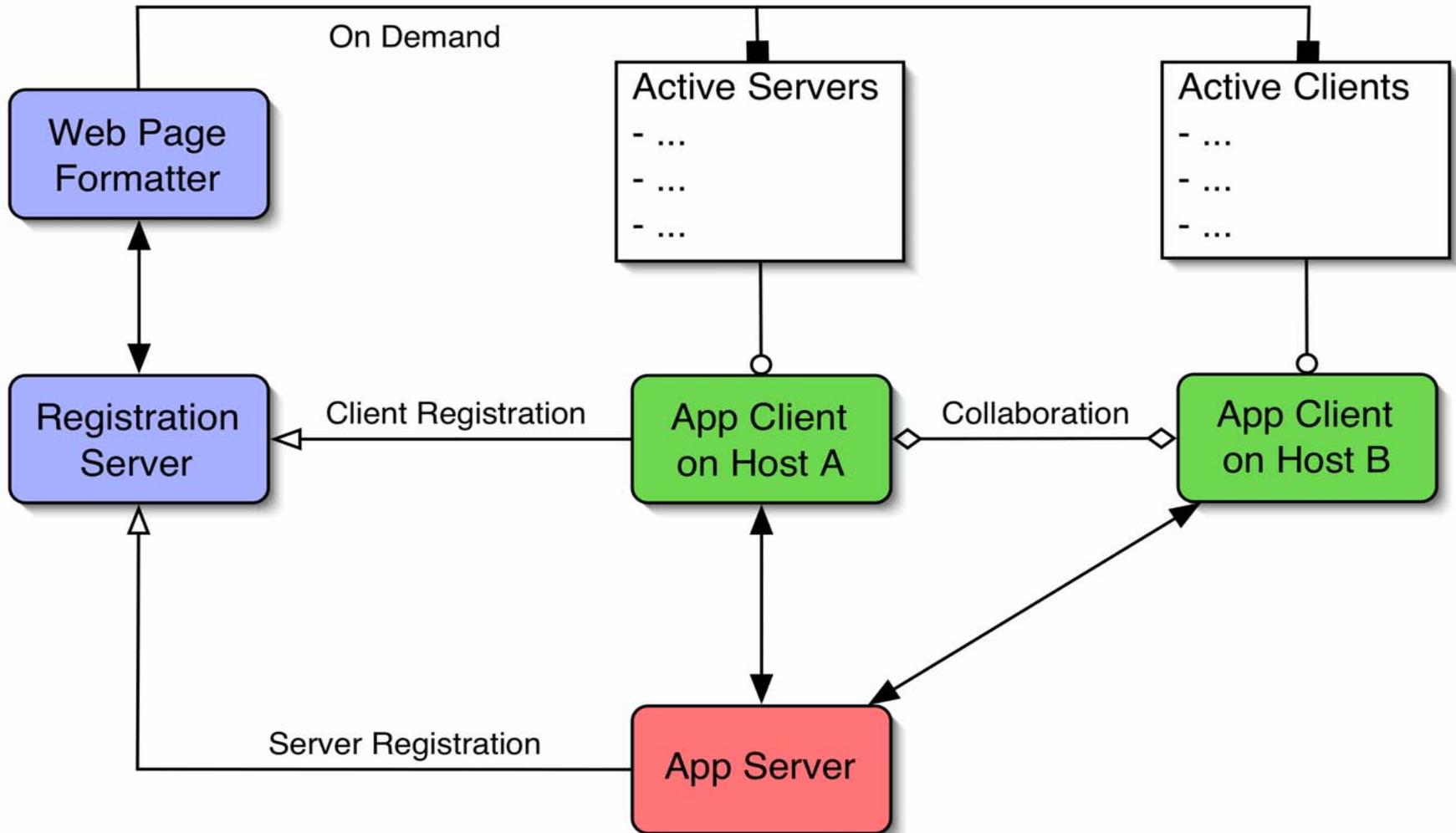
4. Client announces collaboration



5. Second user views active clients



6. Second user launches client



Applications - Lessons Learned

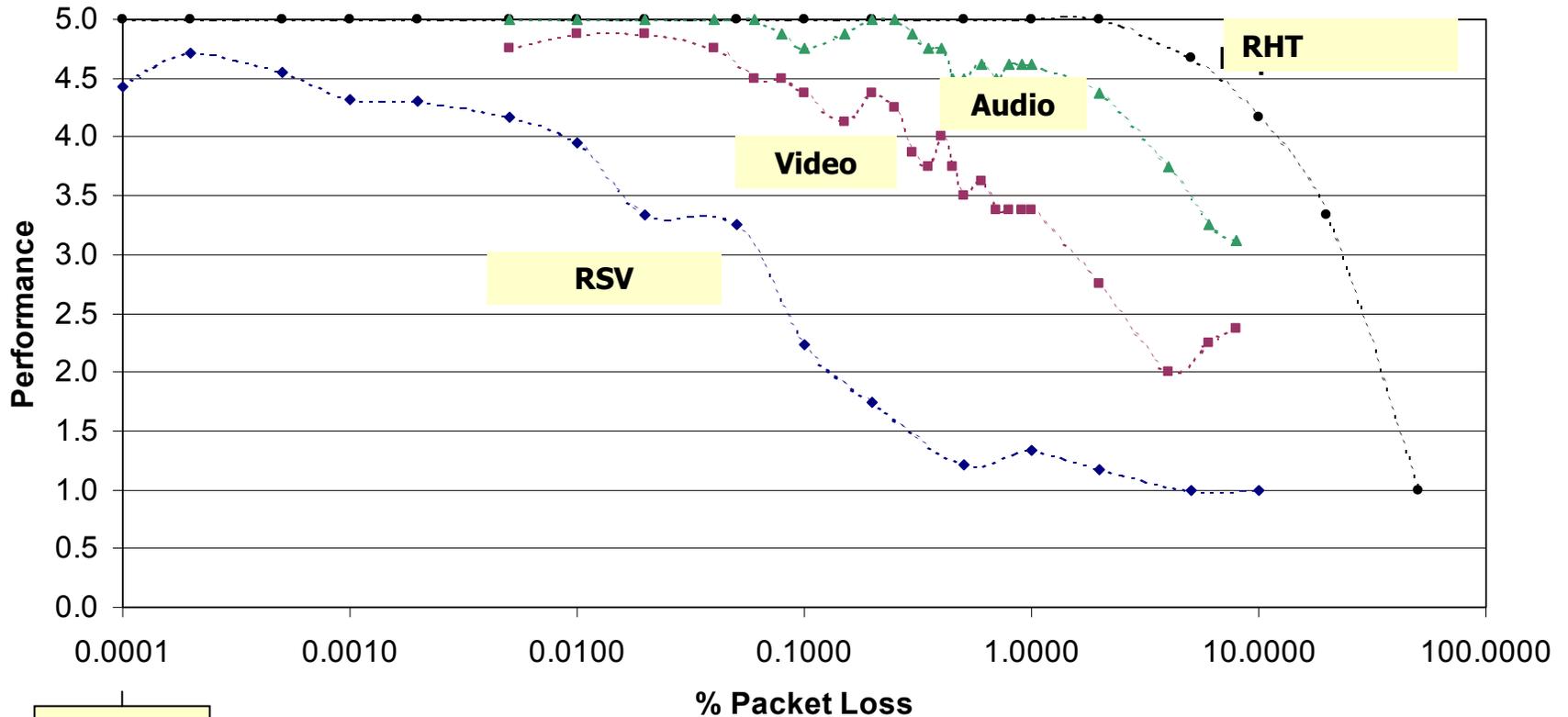
RSV	Remote Stereo Viewer
ImmSeg	Immersive Segmentation
NAV	Nomadic Anatomy Viewer
RHT	Remote Haptics Trainer
SurgSim	Surgical Simulation
&	Information Channels

Evaluation

- of the network
- of end-to-end performance
- of student acceptance of collaborative networked applications
- of the learning value of simulators
- of haptic perception and learning

Performance vs. Packet Loss

RSV, Video, Audio and RHT vs Packet Loss



100LAN

~~WLAN~~

U.Wisc.

Sweden

Performance: 5 = Excellent, 4 = Good, 3 = Fair, 2 = Poor, 1 = Bad

Evaluation Framework

	1. Beta testing	2. Content review	3. Usability testing	4. Validity testing	5. Learning Outcomes	6. Curriculum Integration	7. Practice
E-Pelvis	✓	✓	✓	✓	✓	✓	✓
Virtual Labs	✓	✓	✓				
CathSim	n.a.	✓	✓		✓		
Mentice A	n.a.	✓	✓	✓			
Mentice B	n.a.	✓	✓		✓		
Nutrition	✓	✓	✓		✓	✓	
PharmaPaC	✓	✓	✓		✓	✓	
Dosimetry	✓	✓	✓		✓		
NGI Hand	✓	✓	✓		✓		

Implementation in Curriculum

- 3,000 Bassett images and diagrams were placed on a media server for stereo and mono display, and organized into thematic series.
- 504 images of a dissected hand form a linked set with rotatable views.
- These are now routinely accessed for use in the Human Anatomy course.
- Student use of our other applications is being explored.



Los Angeles, CA



UCLA Visualization Portal



UCLA Operating Room

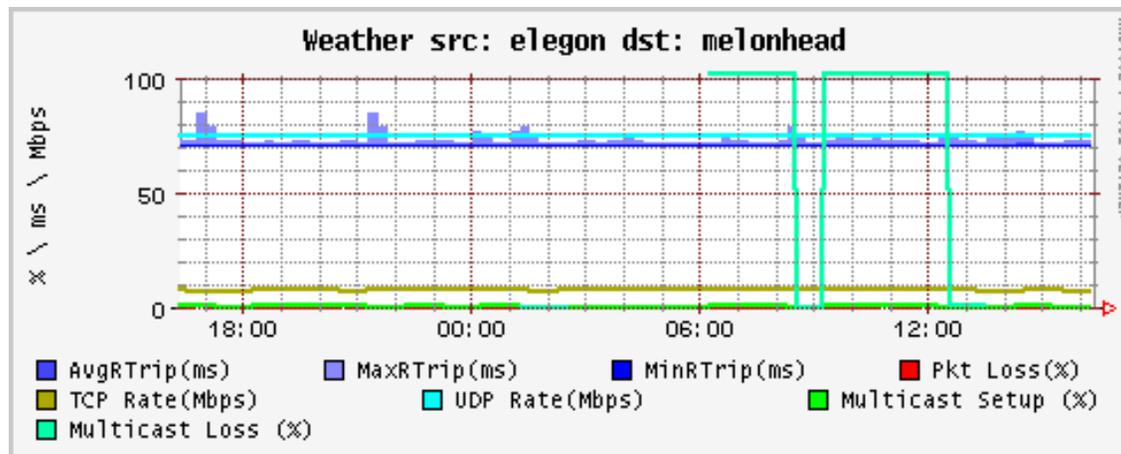
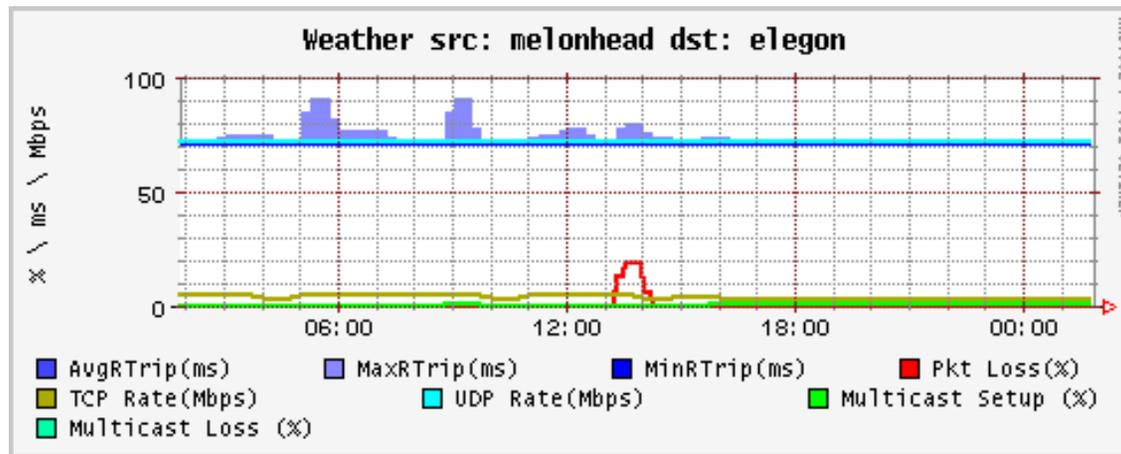


Stanford University

Network Performance Monitoring

- In absence of QoS must test end-to-end performance.
- WeatherStations: conducts periodic tests
 - Packet loss and round-trip latency
 - TCP throughput
 - UDP throughput
 - Multicast group setup time
- Integrated into InformationChannels framework.

WeatherStation Graphs: 8/15/03



Learning from Experience: Network Connectivity

- Collaboration has required daily interaction with connectivity through
 - Internet 2
 - CalRen, WiscNet
 - Campus Networks
 - Made lots of new friends.

Learning from Experience: Real-time Events

- Demos:
 - Internet2, CORN, RSNA, NLM, HP
- Logistics:
 - Time consuming preparation.
 - Verification of connectivity requirements.
 - Local configuration of equipment.

Learning from Experience: Multicast

- Multicast for video conferencing (e.g. Access Grid)
 - Groups setup and left in place for extended periods of time.
 - Main question: “Can you see the beacon now?”
- Our apps
 - Expect more dynamic setup and breakdown of groups.
 - Main question: “How long will group setup take today?”
- We have found
 - Considerable variation depending on border configurations.
 - Unexpected ttl thresholds.

Learning from Experience: Different Expectations

- Commercial Internet: significant packet loss at peering points is common.
- Acceptable
 - standard internet apps work.
- Unacceptable
 - we assume a different level of interaction.

Conclusion

- Higher levels of QoS create new application opportunities.
 - Degree of interactivity.
 - Multiple remote resources.