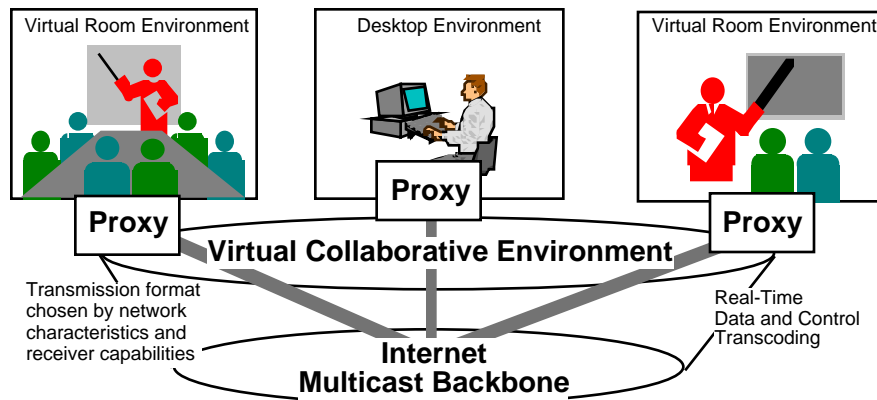


MASH: Multimedia Architecture that Scales across Heterogeneous Environments



R. H. Katz, S. McCanne, E. A. Brewer
University of California, Berkeley

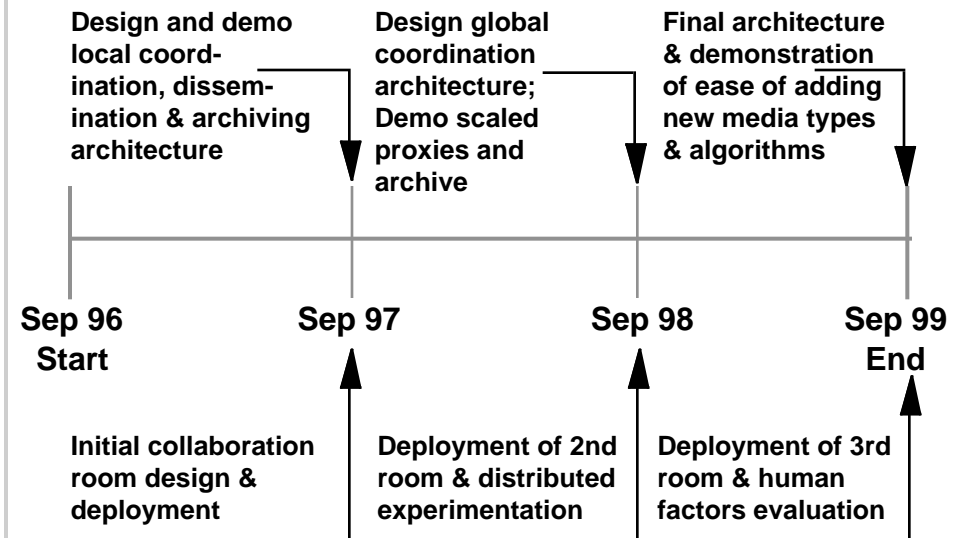
New Ideas

- **Comprehensive collaboration architecture**
 - Enhanced MBone applications
 - Media data types, coordination, resource allocation, annotation and archiving
 - Scalable reliable multicast for active object dissemination
- **Proxies to mitigate heterogeneity**
 - Image, video, audio transcoding in R/T
- **Experimental architecture for room-sized collaboration environments**
 - Multi-room, distributed testbed

Impact

- **Fundamental technology for 21st Century collaborative environments: support for wide diversity of image/video/audio data and active object types & coordination protocols**
- **Demonstrate comprehensive architecture with scalable media performance, ease of adding new media types, integrated active object dissemination and extended session archiving**
- **Demonstrate extension of desktop collaboration technology to room-sized environments, with richly extended set of input & display devices**

Schedule



MASH Mini-Retreat

- **Thursday, January 9**

1300 - 1350 MASH Project Overview, Randy Katz

**1350 - 1420 MASH Project Infrastructure & Directions,
Steve McCanne**

1420 - 1430 SRM Introduction & Status, Steve McCanne

1430 - 1500 Break

1500 - 1520 MediaBoard, Suchitra Raman & Teck-Lee Tung

**1520 - 1530 Layered Video Introduction & Status,
Steve McCanne**

**1530 - 1550 Scalable Consensus-based Bandwidth Allocation
(SCUBA), Elan Amir**

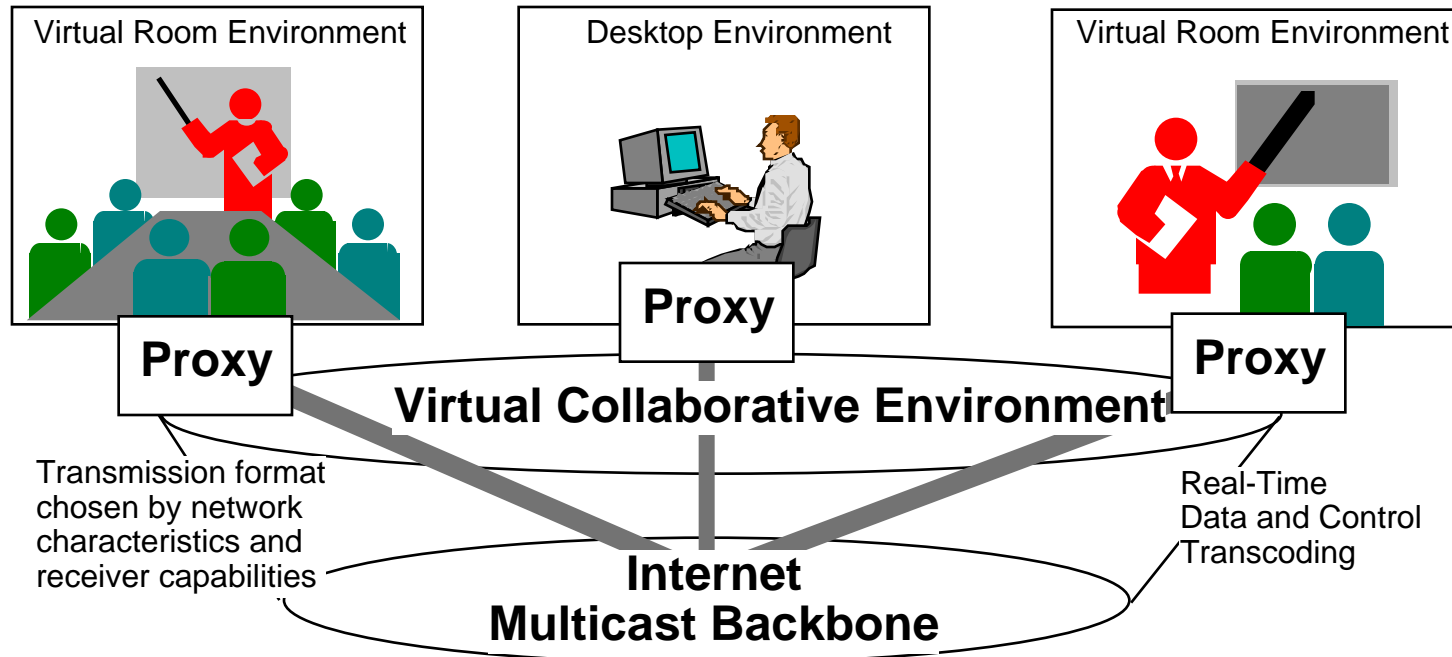
1550 - 1610 Video Archiving, Angela Schuett

1610 - 1800 Break

1800 - 1930 Dinner

1930 - Demos and Posters

MASH: A Multimedia Architecture that Scales Across Heterogeneous Environments

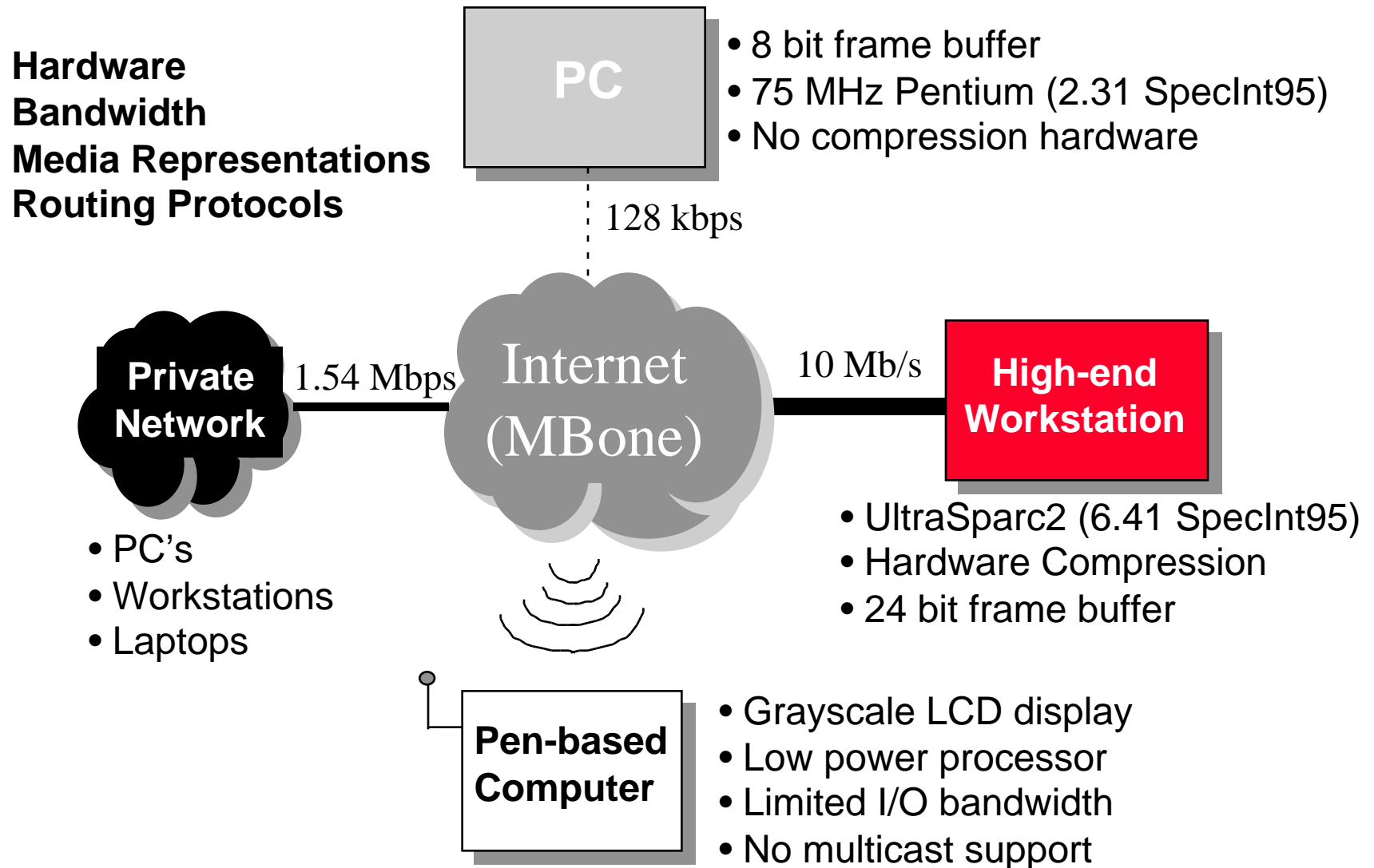


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The Challenge: Heterogeneous Collaboration Environments



New Enabling Technologies

- **Multicast-based networking protocols**
 - Multicast backbone (MBone) represents inexpensive, ubiquitous method for multipoint communications
 - Real Time Protocol (RTP): vic and vat MBone tools; Scalable Reliable Multicast (SRM): wb MBone tool
 - MBone tools in wide spread use
- **Proxy architecture**
 - Mediators for real-time, scalable adaptation of widely-used media representations (image, video, audio)
 - Appropriate transformations of RTP control protocols
 - Unicast-to-multicast routing translation

New Challenges

- **Beyond desktop collaboration**
 - New display and capture technologies
 - E.g., large-scale displays, gestures
- **Beyond images/continuous media**
 - Integrated control protocols like floor control
 - Distributed platform-independent computation
 - E.g., active objects and distributed simulation
- **Beyond ephemeral interaction**
 - Integrated archiving and retrospective playback
 - Session indexing over independent media types

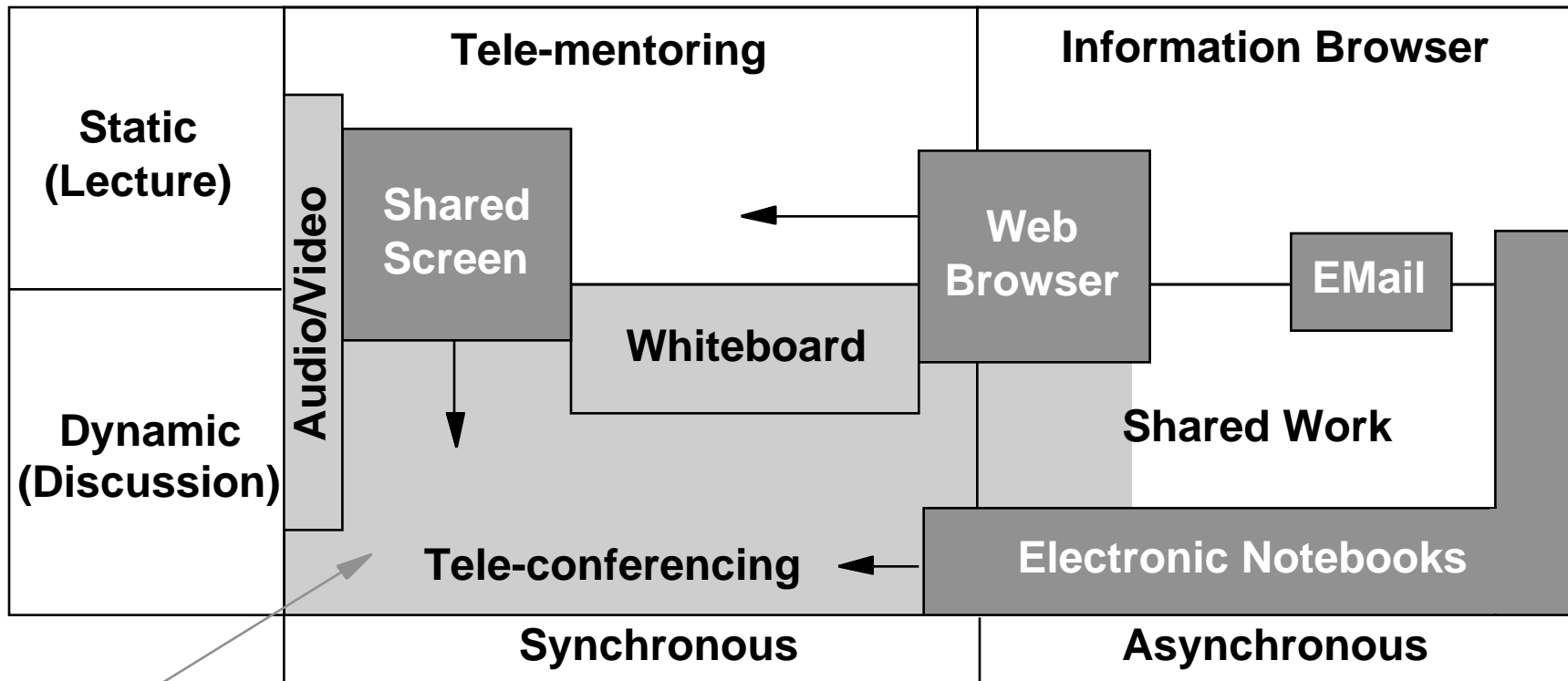
A Comprehensive Architecture

- **Distributed Coordination and Control**
 - Local management: coordinates local interactions among tools to form session on the behalf of a single user
 - Global management: distributed floor control and global conference bandwidth management
- **Integration of Heterogeneous Formats and Protocols**
 - R/T transcoding of media representations subject to manage local and global b/w demands
- **Dissemination of Executable Objects**
 - Reliable object dissemination, based on SRM
 - Active objects based on Java and Tcl/Tk

A Comprehensive Architecture

- **Archive and Annotation**
 - Capture, index, store, and retrieve collaboration sessions
 - Integration with tertiary storage for “infinite” capacity
- **Development and Testing with a Real Testbed Environment**
 - Virtual Rooms
 - » 2-3 experimental room-sized collaboration environments
 - » “Use what we build”: collaborative design sessions using DartNet II
 - » New tools and interfaces beyond the desktop, e.g., gesture recognition, wireless/roaming access

Collaboration Functionality & Tools

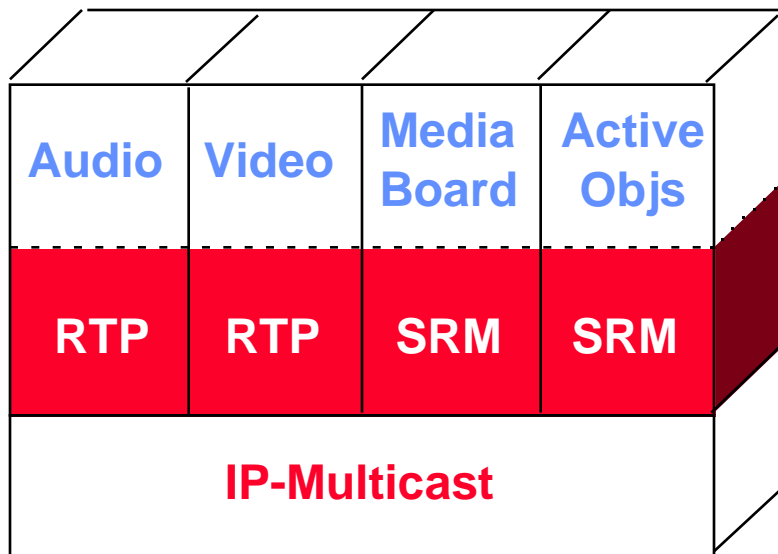


- + Active Objects
- + Archive/Replay

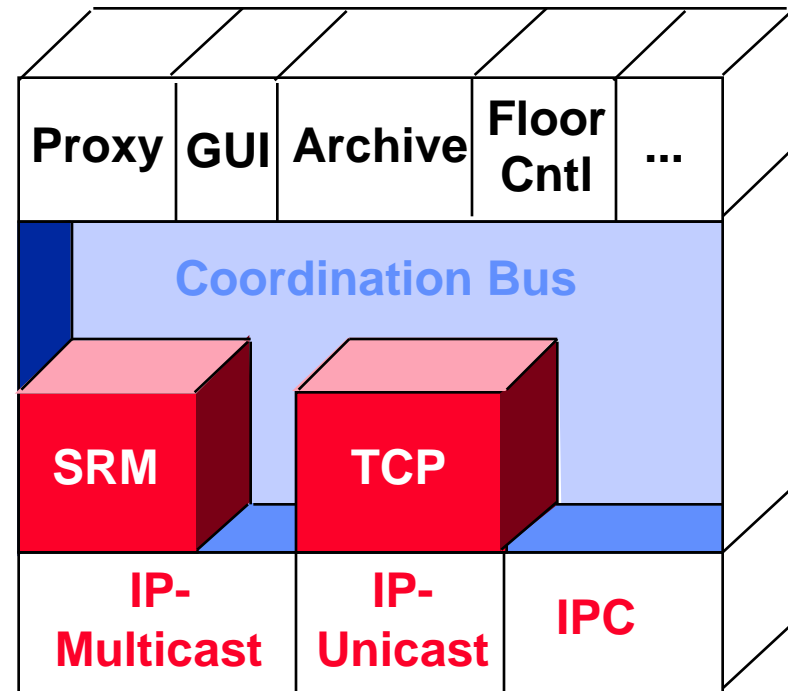
From Kouzes, Myers, Wulf, "Collaboratories Doing Science on the Internet," Computer Magazine, August 1996, pp. 40-46.

MASH Architecture

Data



Control



- Agents and Applications
- Middleware
- Communications

Outline

- **Coordination and Control**
- Heterogeneous Formats and Protocols
- Dissemination of Executable Objects
- Archive and Annotation
- Virtual Room Testbed

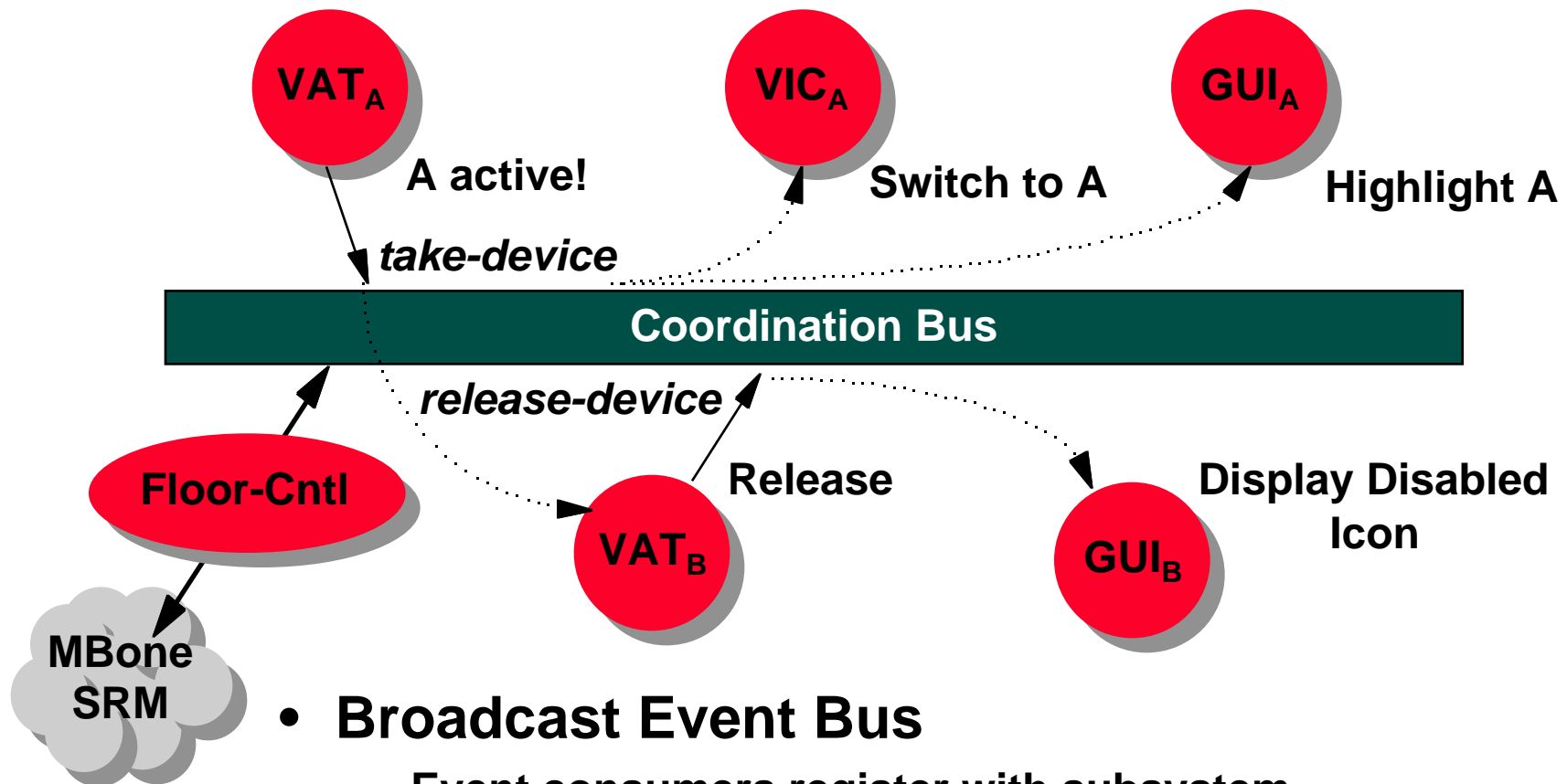
Coordination Architecture

- **Existing Media Tools**
 - Monolithic and unintegrated
 - No building blocks exist for composing new tools
- **Distributed Communications**
 - Data transport based on real-time protocol (RTP) mature and well understand
 - Reliable control signaling, via scalable reliable multicast, needs development
- **Framework for control, management, coordination of media components**
 - Little work within the context of IP multicast

Coordination Architecture

- **Composable Tools**
 - vic, vat, wb abstracted into media processors
 - shared user interface
- **Coordination Bus**
 - distributed, reliable communications medium based on IP multicast
- **Construct new applications from communicating, composed building blocks**
 - e.g., Internet phone, seminar broadcast, distributed simulation, proxy-end node communications

Coordination Architecture



- **Broadcast Event Bus**

- Event consumers register with subsystem
- Multiple buses and partitioned flows for performance
- Extend over network using SRM

Coordination Architecture

- **Local coordination bus API**
- **Global coordination framework**
- **Coordination bus optimization**
- **Suite of coordination bus-based widgets:**
 - Floor control
 - Session bandwidth manager
 - “Secure sessions” prototypes

Outline

- Coordination and Control
- **Heterogeneous Formats and Protocols**
- Dissemination of Executable Objects
- Archive and Annotation
- Virtual Room Testbed

Proxy Architecture

- **Requirements**
 - **Bandwidth variation:**
 - » **Transcode data to appropriate bandwidth level**
 - **Format conversion**
 - » **Handle client variation by transcoding to known formats (and protocols)**
 - **Quality of Service optimization:**
 - » **Tune audio/video quality based on client hardware (e.g. resolution, color depth)**
 - **Wide-area control protocols:**
 - » **Hierarchy of proxies must work together**
 - » **Both clients and effective bandwidth affect proxy**
 - **Scalability: both to wide area, and to many clients per proxy (exploit NOW)**

Proxy Architecture

- **Proxy Control**
 - Scalable Proxy Transcoder Manager and its protocols
 - User “focus” detection to drive allocation decisions
 - Distributed consensus-based bandwidth allocation
 - Common control abstraction for web proxy and real-time gateways via coordination bus mechanism
- **Applications**
 - Session Management: transcoders, filters, forwarding agents
 - Wide-area cache coherence with conflict resolution

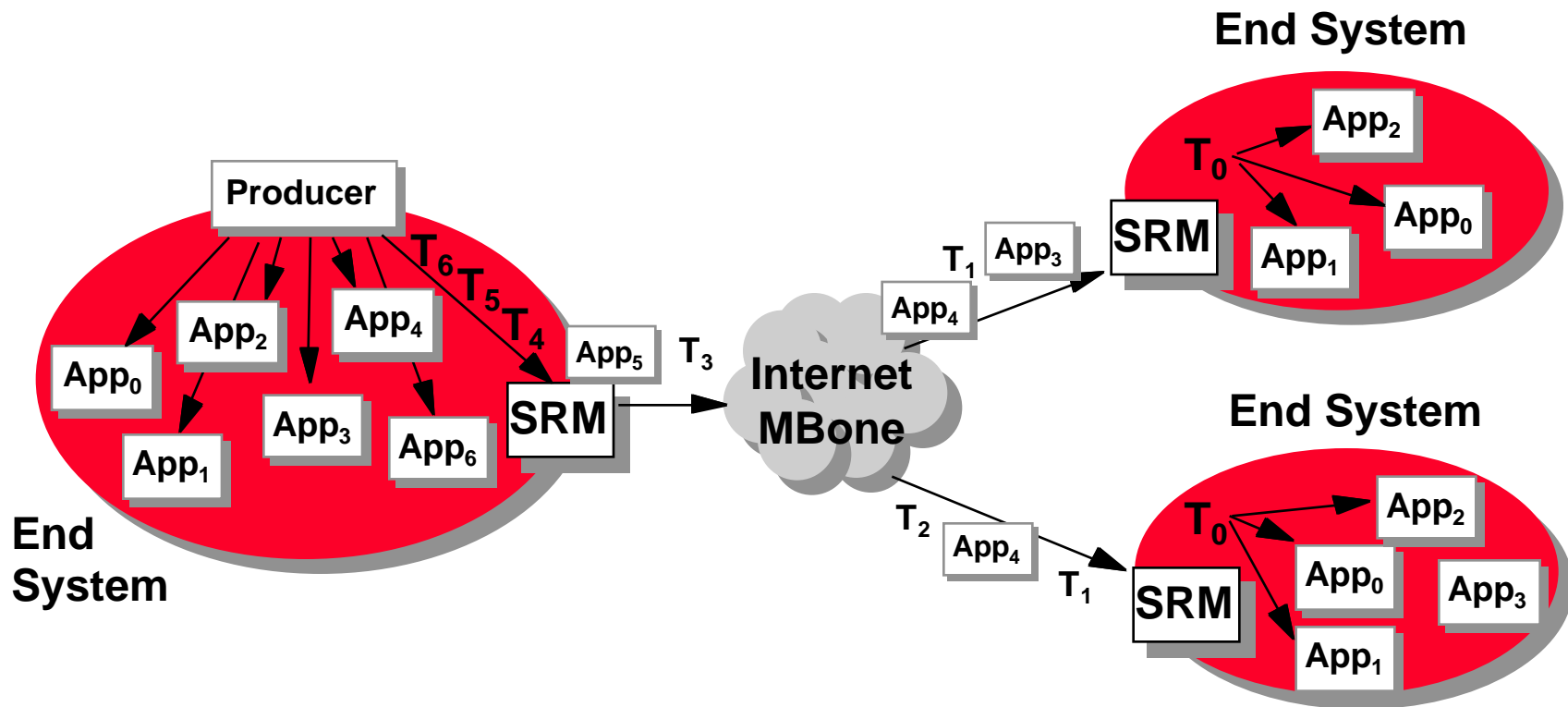
Outline

- Coordination and Control
- Heterogeneous Formats and Protocols
- **Dissemination of Executable Objects**
- Archive and Annotation
- Virtual Room Testbed

Active Object Model

- **Current wb model**
 - postscript objects
- **Active objects:**
 - **General objects that can be rendered**
 - **Rendering can be ordered in time and synchronized**
 - **Enables stateless representation for easy storage, replay, play backwards, etc**
 - **Disseminated via SRM**

Active Object Architecture



- Sample Application: Network Animator

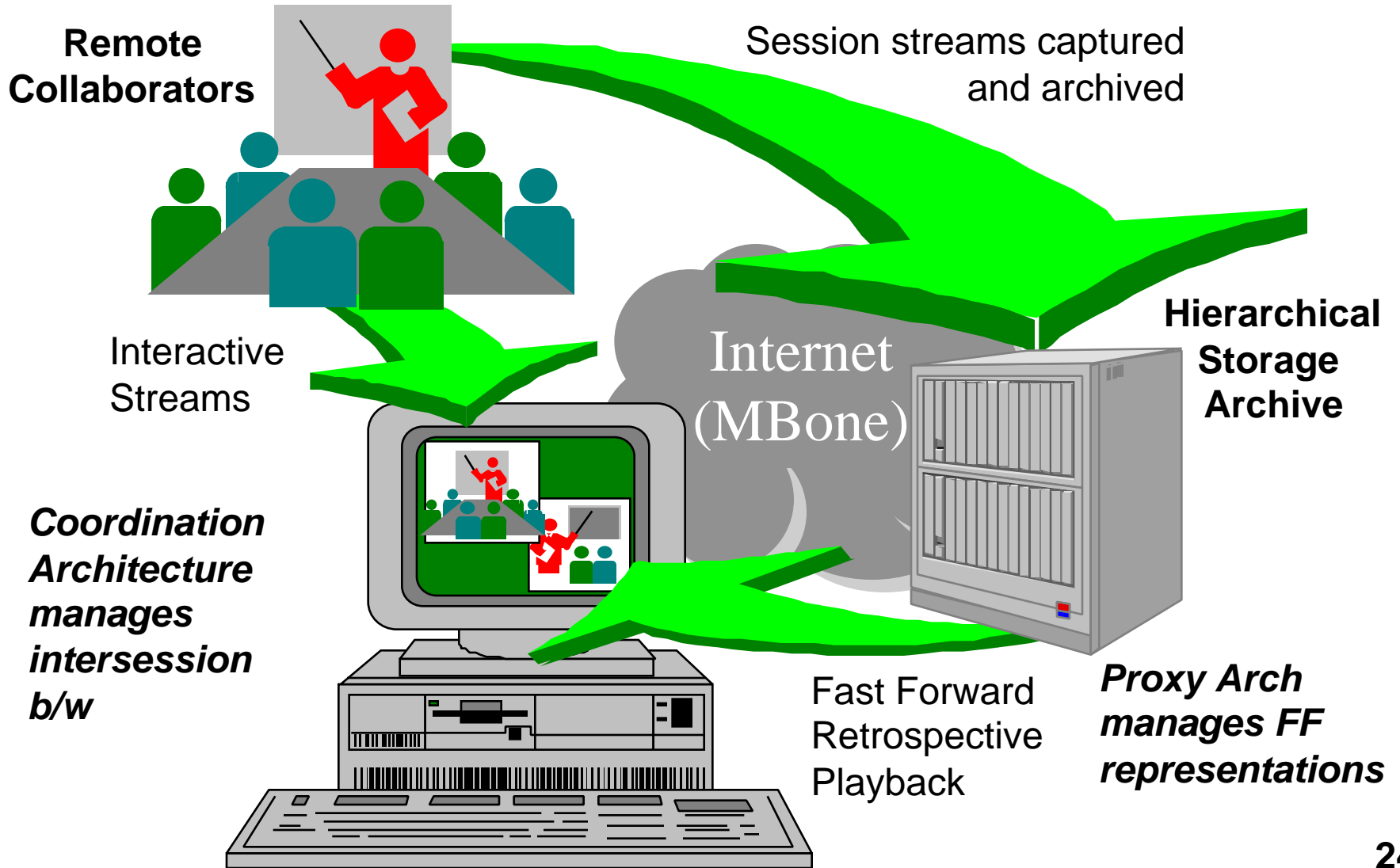
Active Object Architecture

- **SRM base protocol + profiles**
 - Active objects, coordination
- **SRM toolkit**
 - C++ class library
- **Active Object architecture and toolkit**
- **Early prototype: MediaBoard**
- **Application: interactive network animation (Collaboration with VINT)**

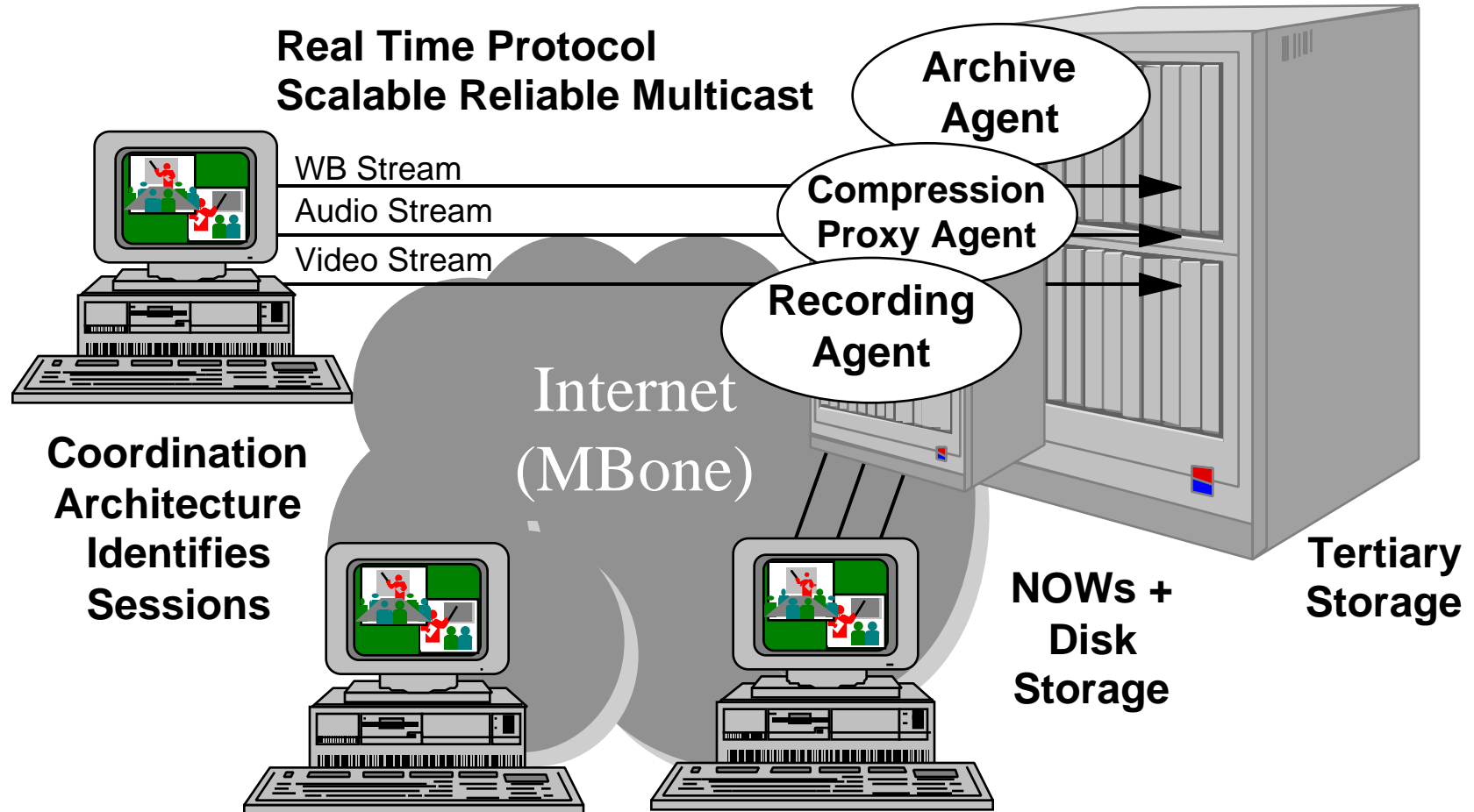
Outline

- Coordination and Control
- Heterogeneous Formats and Protocols
- Dissemination of Executable Objects
- **Archive and Annotation**
- Virtual Room Testbed

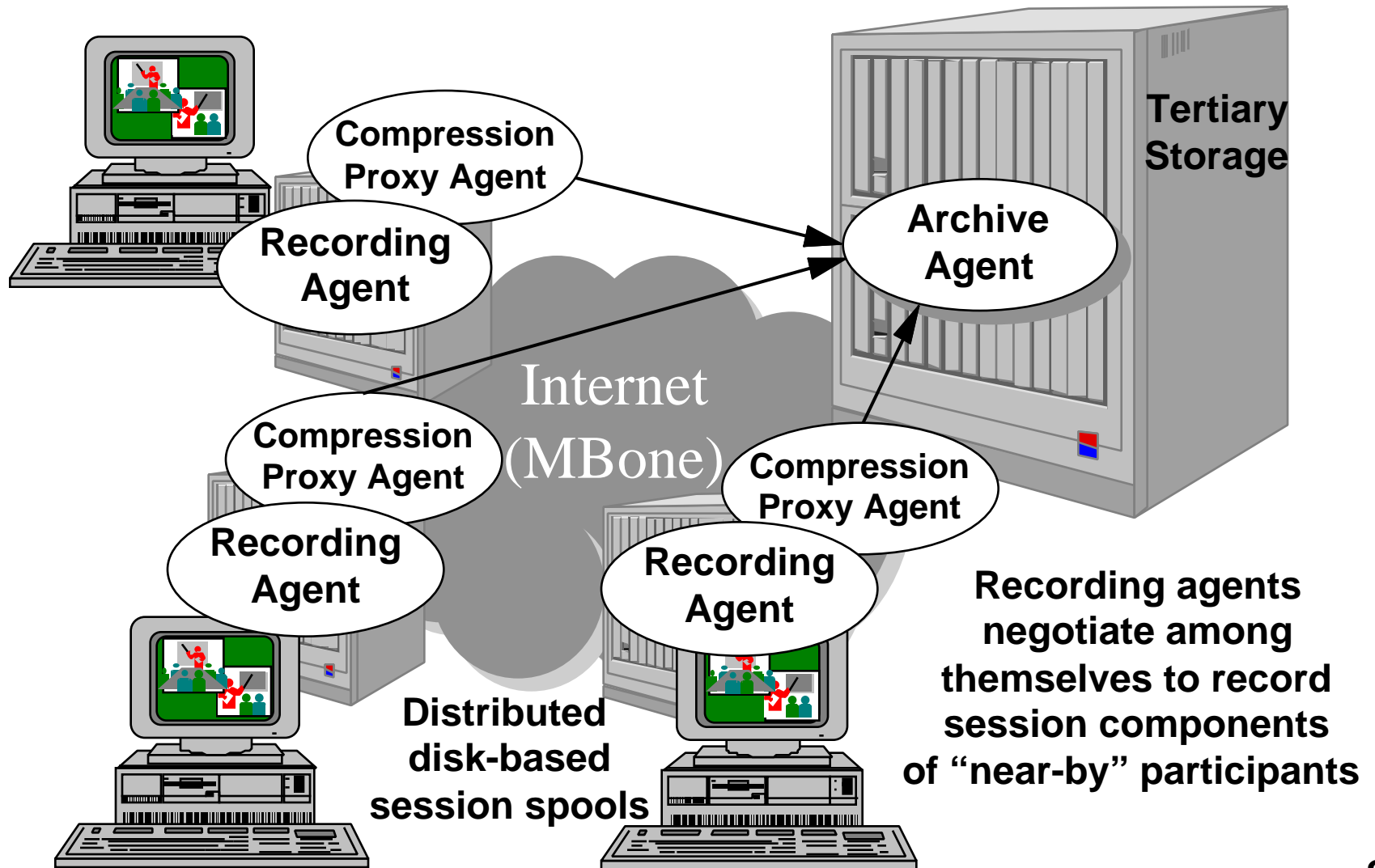
Archive System



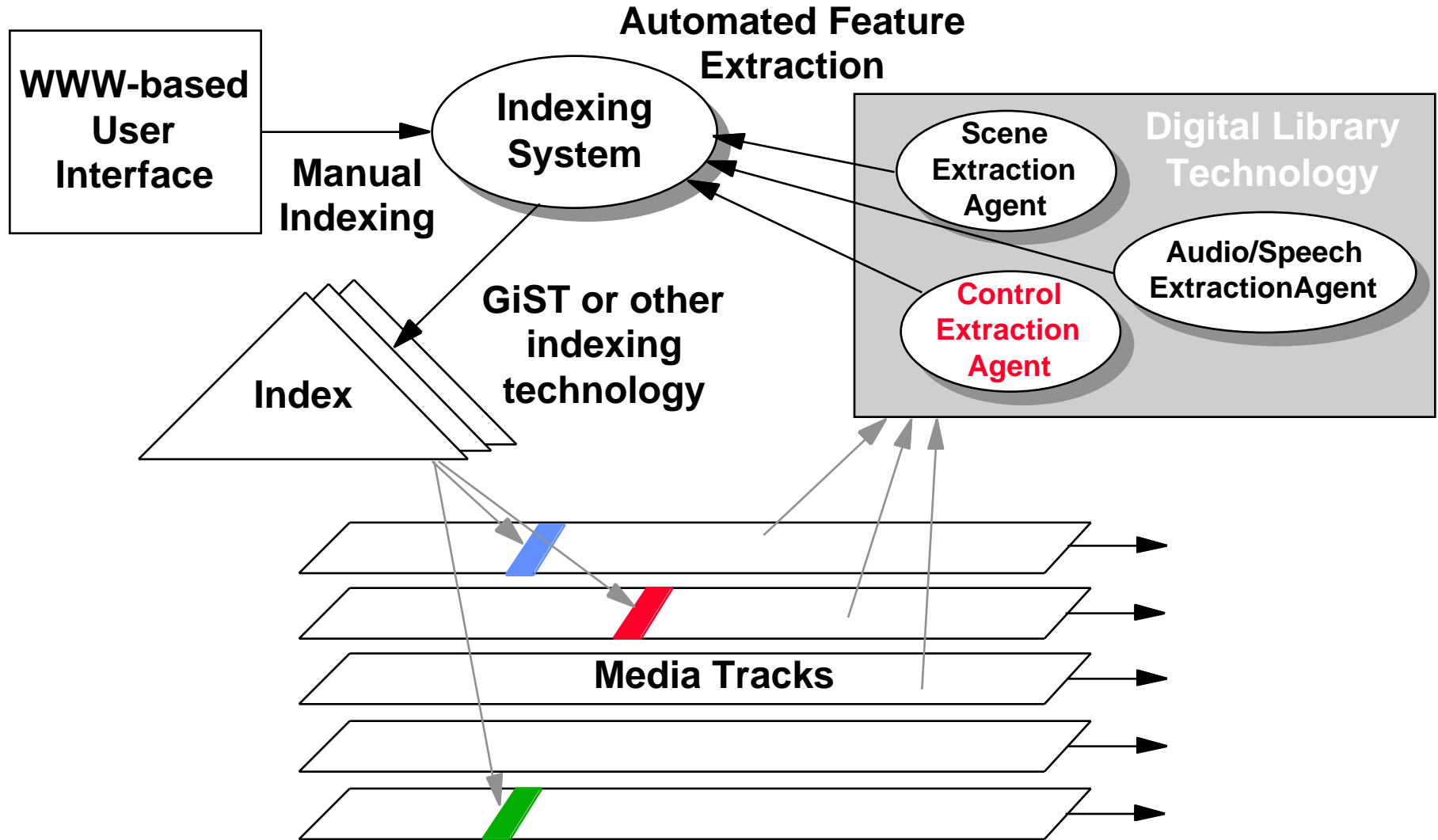
Basic Archive System



Scalable Archive System



Annotation System



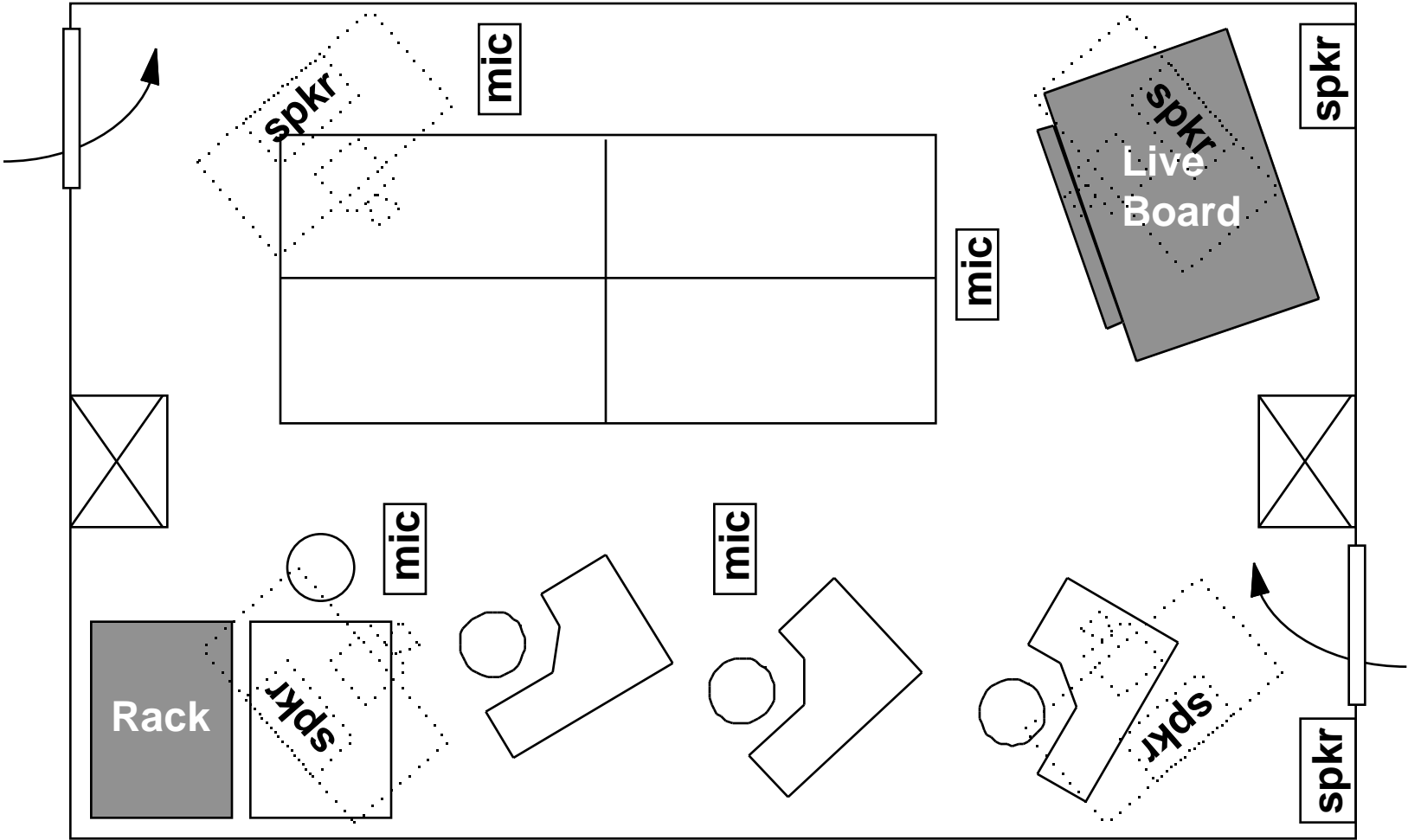
Archive & Annotation Archive

- **Standard Formats, Archiving, Playback Tools**
 - Standardize RTP Archive Format
 - Develop SRM Archiving Tool
 - Automatic Session Recorder: integration with session directory protocol for “operator-free” automated archive
 - Playback Tools: MBone tools, extended for random access, fast forward, integration with database system through forms, etc.
- **Indexing and Annotation Tools**
 - Semantically-based index structures, browsers, annotators, etc.
 - Hooks for feature extractors
- **Deployment of Public Archive Service**
 - Implementation of archive and annotation system on top of available distributed hierarchical storage systems being developed at Berkeley

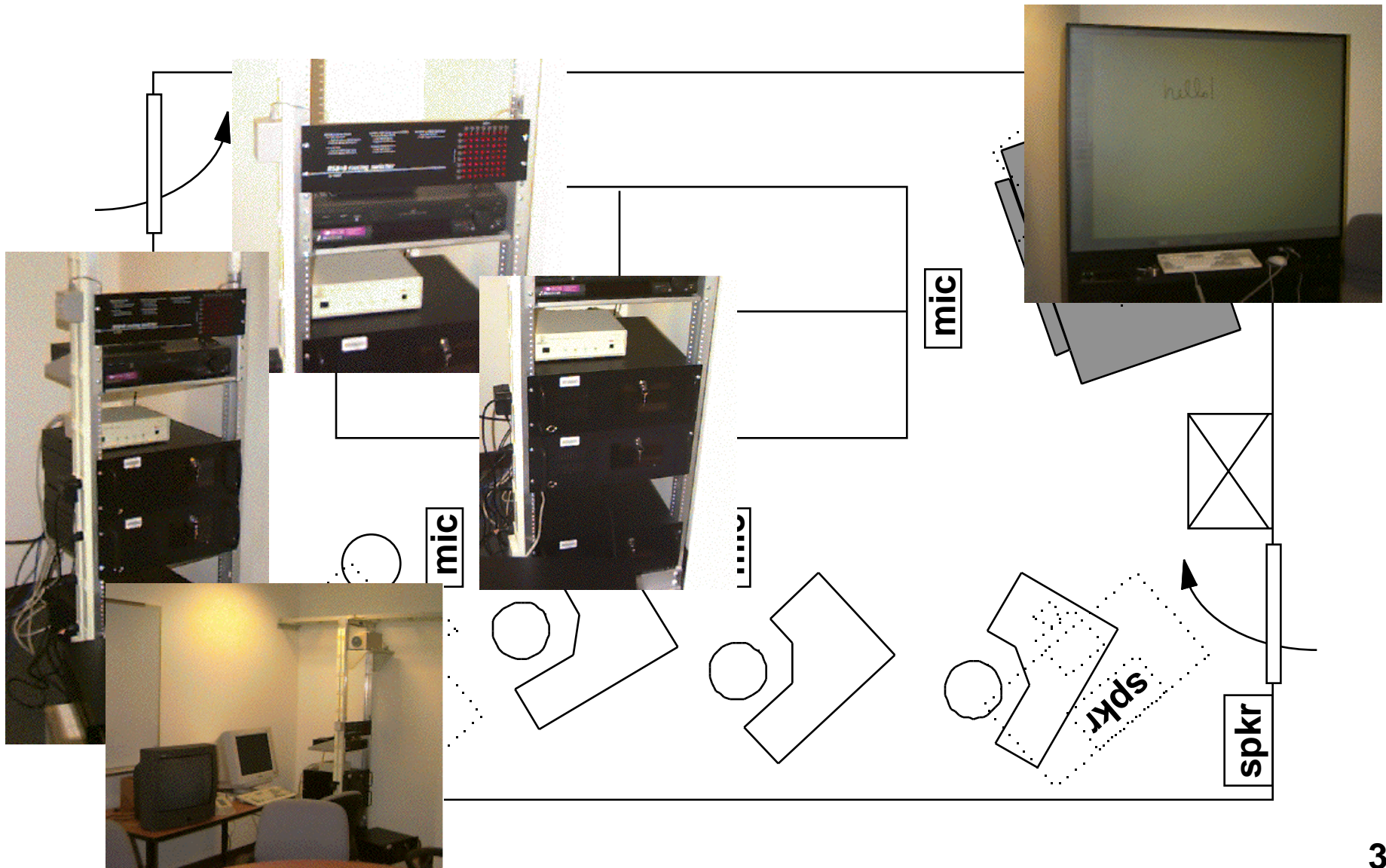
Outline

- Coordination and Control
- Heterogeneous Formats and Protocols
- Dissemination of Executable Objects
- Archive and Annotation
- **Virtual Room Testbed**

Virtual Room Testbed



Virtual Room Testbed



Project Plan

Coordination	Develop local tool coord arch, API, and GUI	Develop global coord arch publ floor cntrl spec	Experimentation and Refinement of Coordination and Proxy architectures, IETF standardization; Extensive interoperability testing; Demonstration of ease of extension thru object architecture Deploy scaled archive & annotation architecture; Integrate feature extractors Deploy 3rd room and complete evaluation	
Proxy	Develop proxy mgr, wide-area “coherent” objects	Develop scalable R/T proxy Exploit user focus		
Active Objects	Active object extensions to MBone tools	Prototype network animator based on SRM toolkit		
	Scalable reliable multicast “middleware”: C++ library	tk/java rendering widget, deployment and feedback		
Archive	RTP A/V storage repr, Server control protocol, Recording tools and formats	SRM archive tool, session recorder, playback tool; Integrate with Digital Libr		
Testbed	Design and implement 1st collaboration room	Deploy second room and perform experiments		
	Sep 96	Sep 97	Sep 98	Sep 99

Progress to Date

- **Coordination Architecture**
 - Restructured of vic, vat; reimplementaion of wb as MediaBoard
 - Demonstration of composable mbone audio/video objects (Netscape vic/vat plug-in)
- **Proxy Architecture**
 - Design & evaluation of scalable consensus-based bandwidth allocation protocol for proxy control
- **Active Object Architecture**
 - MediaBoard prototype implementation
- **Archive and Annotation Architecture**
 - Initial design investigations
 - Raw capability to record RTP sessions and RTP archive format
- **Virtual Room**
 - Initial design complete, liveboard and A/V rack in place
 - Vint meetings to be held in room during Spring 1997
 - Cairn/DartNet II connectivity established