TelePresence Collaboration:

Evolving a New Paradigm for Conducting Research

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How would your Life be different if travel was free and instantaneous ?

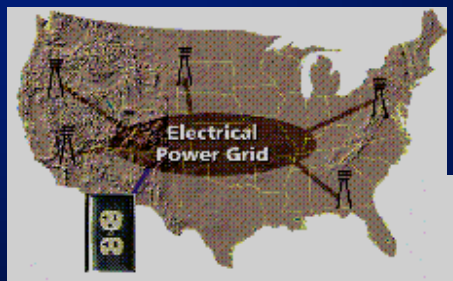
You would have a Star Trekkian Life Style

- **You Would Live Where You Want to**
- **You and Your Colleagues Would Meet in Interesting Places**
- **You Would Leave Your Things Where You Need or Use Them**
- **You Would Need to "Arrange" to Meet People in Certain Places at Certain Times**
- **You Would Need Mechanisms to "Locate" People and Things**
- **Security Might Be Problematic**

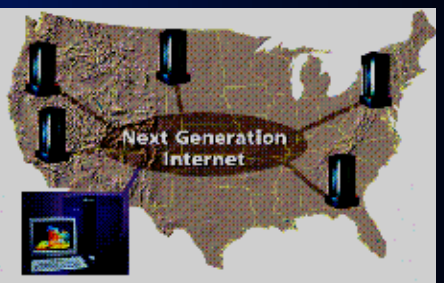
Telecommunications Trends

- Data traffic will exceed voice traffic in 3-5 years
- Voice traffic will become an small fraction within 10 years
- Bandwidth prices will eventually begin to follow Moore's law
  - 2X capability every 18 months
- Tele Co's need to become distributed services companies
  - collaboration
  - management and control of infrastructure, factories etc.
  - grid services (distributed information and computing services)
- Digital ecosystem within the global digital nervous system

The Emerging Concept of a National Scale Information Power Grid



Your Electrical Power
Available Here



Your Information Power
Available Here

From Supercomputer Centers to Today's Internet

1987 - ISDN
56 Kb/s
1992 - T1
1.5 Mb/s
1994 - T3
45 Mb/s
1996 - ATM OC3
150 Mb/s
1998 - ATM OC12
600 Mb/s
2000 - ATM OC48
2.4 Gb/s
2002 - ATM OC192
10 Gb/s
2010 > 1 Tb/s

How Big is The Data

TELEPRESENCE COLLABORATORIES: THE NEXT GENERATION OF EDUCATIONAL AND RESEARCH RESOURCES.

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Over the last five years the use of computers and remote control protocols for the operation of scientific instrumentation has been growing at an ever increasing rate. This has been fueled by the exponential growth of the Internet and its use for the entire spectrum of communication. Network-based remote control has been implemented by a number of protocols mainly to facilitate local operation and/or remote observation of a variety of instruments including the full range of electron microscopes as well as their ancillary equipment.[1] There are now an entire range of commercial and shareware products which enable access of resources via the Internet. Each of these fills an appropriate niche in the grand scheme of collaboration and no single solution is correct for every situation. The key to the optimal implementation of TelePresence Operation, at a given location, is to understand the problems, instrumentation, relative importance and the costs (both in terms of $$ and man-hours) of the various technologies involved. Furthermore, the very nature of what one means by collaboration must be defined and each of it's various components considered. Equally important are the sociological issues revolving around on-line resources be they instruments, data and/or people.

For distributed collaboration to be successful in a microscopy/microanalysis application, all of the aspects of the research/education environment must be explored. To achieve the goal of unencumbered collaboration a number of globally relevant issues, in the sense that they apply to all scientific investigations, must be addressed. These include: Persistance Electronic Space, Sharable Resources, Sharing Techniques/Protocols, Security/Access Control, Discovery Mechanisms, Transport Protocols, Resource Management and Real World User Interfaces. To effectively implement a collaboratory each of these factors must be understood and an environment created which allows both local and remote individuals or groups to interact in a seamless manner, one in which the visual and audio queues are real time, and in which the "collaboration" is not limited by the physical distance between the participants.

8 bits = 1 byte = 1 character

1 page ~50 - 250 kbytes

1 byte ~ 1 pixel (256)
1 Image ~ 300 kbytes (640x480)
1 HR Image 2 M bytes (1k x 1k x 16 bits)

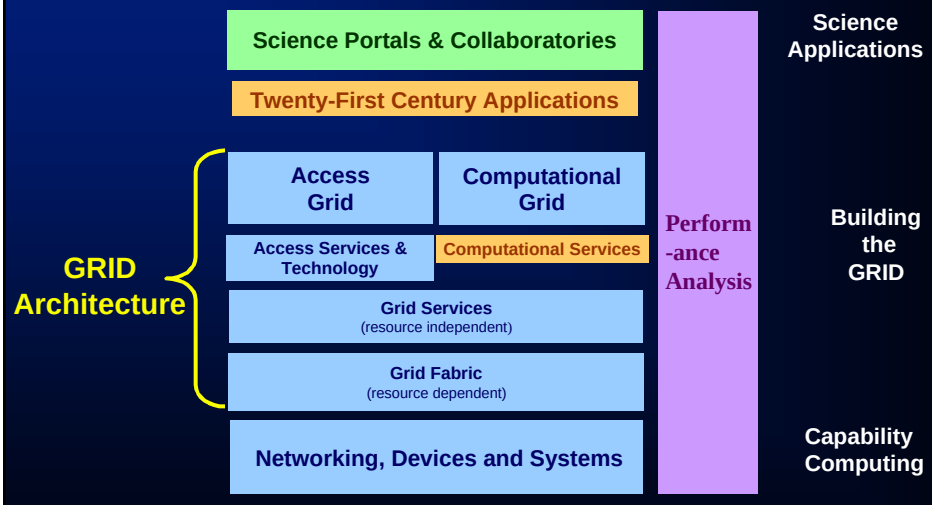
Journal Issue ~ 500 Mbytes

56 Kbit/sec -> 24 hours

1 Mbit/sec -> 90 Minutes

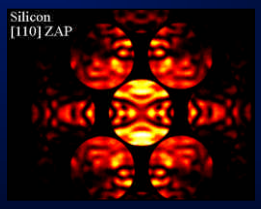
1 Tbit/sec -> 4 msec

Layered Approach to the Information Access



Key to All Scientific Experiments is the Interaction of Investigators with:

Instrumentation

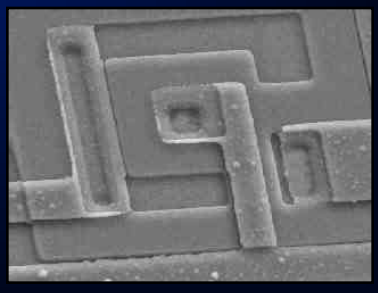


Data

Collaborators

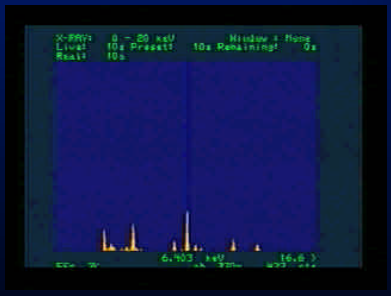
Working with Instruments the Experimentalist Needs:

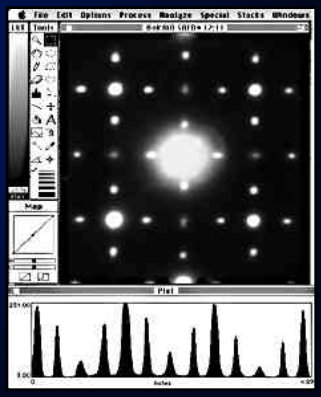
- **Monitor the Progress of the Experiment**
  - **Dials, Knobs, Gauges, Conditions, Images, Spectra.....**
- **Real-Time Control of the Experiment**
  - **Ability to Interact with the Instrumentation**



Working with Data

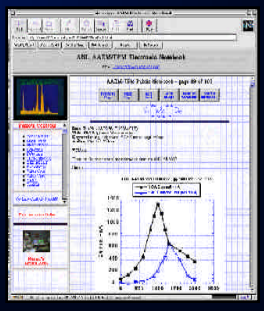
- Real-Time Access to Current Results
- Analysis Tools
- High Performance Data Engines





Working with Collaborators , Investigators Need to:

- **Discuss the Experimental Progress**
- **View Data While It is Being Acquired**
- **Sketch Out Trends**
- **Access Supporting Documentation**



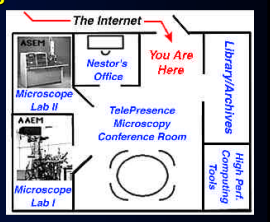
The Collaboratory

Goals

- To Integrate these three key elements (**Instruments, Data, and Investigators**) into a collaboratorative framework by creating an Interactive Multi-Disciplinary Persistent Electronic Space focussed around Areas of Scientific Excellence/Expertise
  - **Physical Sciences**: Physics , Materials , Mechanical, Electrical & BioEngineering,.....
  - **Life Sciences**: Biological Sciences, Pathology, Medicine , ...
- Establish the **Enabling Factors** which govern operation & control of scientific instruments over Networks using the Current and Next Generation Internet as the transport backbone, while using the Collaboratory as focus/tool of the interaction.
- Incorporate Collaboratory into the **Research Environment** as well as in **Distance Learning**

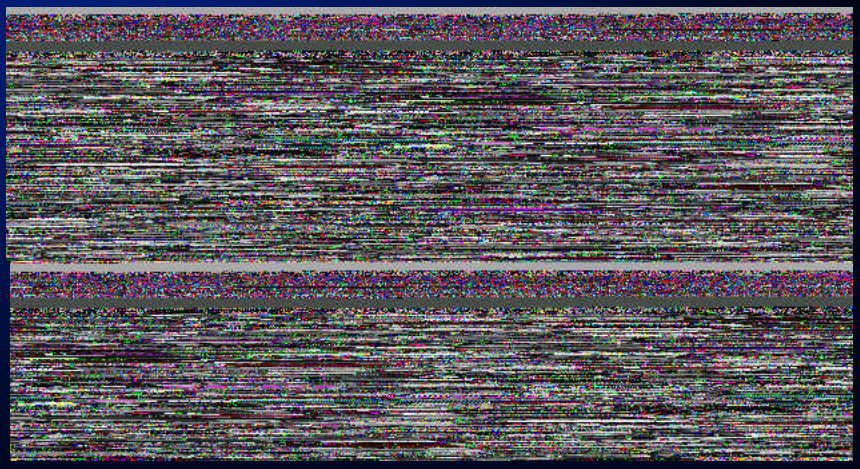
The TelePresence Collaboratory

- **Create a Persistent Virtual Location around Centers of Scientific Interest**
- **Integrate Operation & Control of Scientific Experiments**
  - Allow ***Remote Users*** to have either ***passive*** or ***active*** participation to experimentation with access to both **Expertise and Instrumentation**
    - via a platform independant GUI
      - Experimental Windows, Electronic Notebooks
      - Meeting Rooms/Offices/ TeleConference Links
      - Libraries/Data Archives
      - Access to High Performance Data Engines for data processing



- **Provide Opportunities for Distance Learning and Remote Collaboration at all levels**
  - Research and Industrial Collaborations
  - Middle / High / and Univeristy Levels
- **Provides a set of requirements which taxes the limits of the Internet**
  - Imaging, Spectroscopy, Real-Time Control, Conferencing, ...

TelePresence Collaboration Enables Access to Resources via the Internet



TelePresence Collaboration

The Challenge

Controls

Instrumentation, Data, Standards, Legacy Platforms, Human Factors, Time, Budget

Input

Users

Enablers

New Paradigm for Interactive R&D and Education

Output

Networks, Servers, Browsers, Tools

Mechanisms

TelePresence Microscopy Collaboratory

Benefits

- **Access to Unique Research Tools**
  - On-Line Shared Resources and Expertise
  - Permanent and Natural GUI Interface to Instruments and Data
  - Service & Diagnosis of Instrumental Problems
- **Persistent Electronic Laboratories**
  - Setup and Continue Experiments within a Collaboratory
  - Maintain Contact with Colleagues Regardless of Location
- **Education, Teaching, Training to/from Remote Sites**
  - Interfaces for Novice, Operator & Expert Users
    - Government / Industry/ University/ K-12

Functional Requirements for Collaboration

- ***Persistence***
- ***Sharable Entities***
- ***Sharing Techniques, Methods, Protocols***
- ***Session/Access Control***
- ***Discovery Mechanisms***
- ***Transport Mechanisms***
- ***Resource Management***
- ***Real World Interfaces***

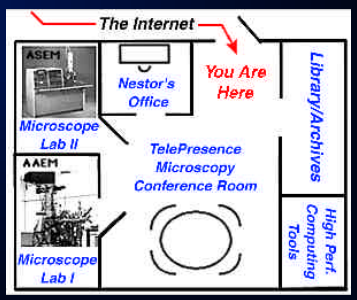
Persistent Electronic Space

WWW Site is an Ideal Proto-type Model of a Persistent Electronic Space

- **Observational Modes**
- **Capabilities for both Dynamic and Static Data**
- **Can Host both Private and Public Areas**
- **Completely Digital Media**
- **A/V Compliant**
- **Enables Data Sharing with minimal work**
- **Extensible to Application Sharing**

Characteristics of a Persistent Electronic "Lab"

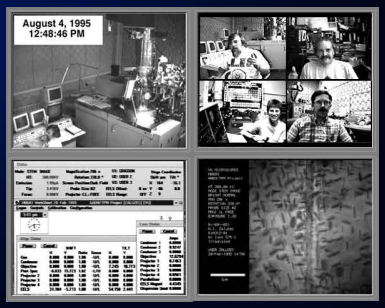
- **Always There**
- **Collaboratory Interaction Zone**
  - Offices, Work Areas, Labs, Mailboxes
- **Access Control**
  - **Active**
    - Public/Private/Restricted
    - Real Time Interactions
    - Editable
  - **Passive**
    - Public/Private/Restricted
    - Viewable not Editable
- **Scalability**



Sharable Enties

Items in the Collaboratory which may be "Sharable"

- **People / Expertise**
  - On-Line Expertise & Knowledge -> Non-Linear Interaction
- **Data**
  - Text/Graphics Documents
  - Images, Spectra
- **Instrumentation**
- **Application Programs**
- **Sessions**



Security

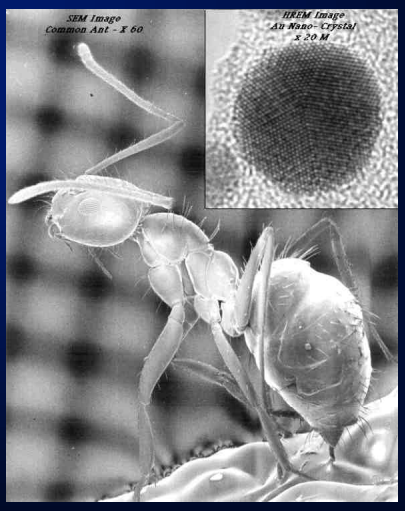
- **We are putting valuable and complicated facilities or data online to the whole world**
- **The data generated using these facilities may be proprietary**
- **If security "gets in the way" it will not be used.**
- **If security is too weak, valuable assets are at risk.**

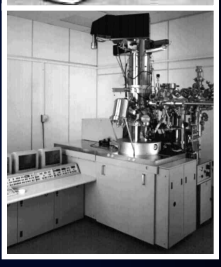
TelePresense Microscopy

Microscopy is one of the few methodologies applied to nearly every field of science and technology in use today.

A microscope can be as simple as a hand held optical device or as complex as a multi-million dollar research tool.

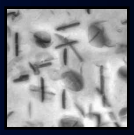
Using these instruments, both scientists and students can explore the synergistic relationships of structure and properties of a wide variety materials in both the Physical and the Life Sciences.

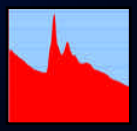




Microscopy & Microanalysis

Experimental methodologies which employs electron-optical instrumentation to spatially characterize matter on scales which range from tenths of a millimeter to tenths of a nanometer. The principle modalities employed are:





Imaging

- Transmission Electron Microscopy
- Scanning Transmission Electron Microscopy
- Scanning Electron Microscopy

Diffraction

- Convergent Beam Electron Diffraction
- Selected Area Electron Diffraction
- Reflection High Energy Electron Diffraction

Spectroscopy

- X-ray Energy Dispersive
- Electron Energy Loss
- Auger Electron

MicroCharacterization via Electron Microscopy

SEM

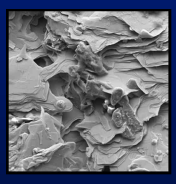
Scanning Electron Microscopy

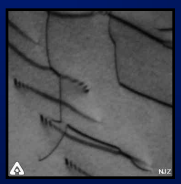
TEM - STEM - HREM

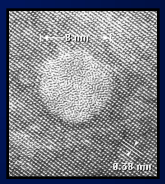
Transmission - Scanning Transmission - High Resolution Electron Microscopy

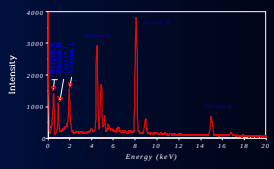
AEM

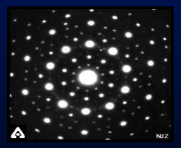
Analytical Electron Microscopy

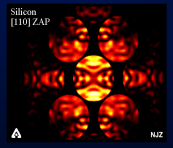


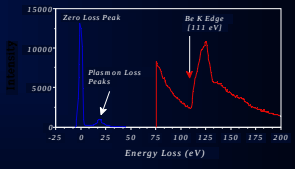












Morphology, Crystallography, Elemental , Chemical , Electronic Structure

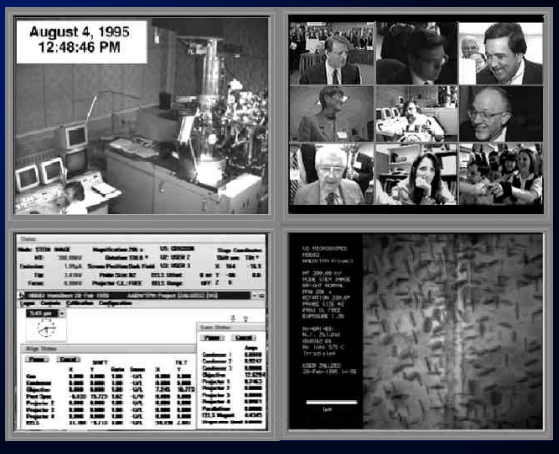
ANL - Advanced Analytical Electron Microscope

- *Cold Field Emission Electron Source*
  - Vo: 50 - 300 kV
- *Ultrahigh vacuum (UHV) environment*
  - ~ 1 x 10^{-11} torr - Gun, < 2 x 10^{-10} torr - Column
  - < 5 x 10^{-10} torr - Specimen Preparation Chamber
- *Electron Optics capable of :*
  - STEM / SEM:
  - TEM:
  - CBED/SAED:
  - Other Modes: TSEM, TSED, RHEED
- *Side Entry Goniometer Stages*
  - RT Double Tilt Beryllium:
  - LN2 Cooled Double Tilt Be Stage:
  - Single Tilt Heating Stage:
- *Analytical SubSystems on the E/O Column*
  - XEDS , EELS, AES
- *Specimen Preparation Chamber*
  - High Pressure/Temperature Gas Reaction Cell
  - Thin Film Evaporation Chamber
  - Mini-SIMS system - Gallium LMIS, Quad Mass Analyzer
  - RV LEED & Vacuum Transfer Vessel
  - ANL MultiPort Station for development work.
- *Computer Control*
- *Special Objective Lens Port Configuration*
  - 7 Experimental Ports on Objective Lens for Analytical Equipment
  - 3 Additional Ports for Electrical Feedthrus etc...

TelePresence Microscopy

Require Access to:

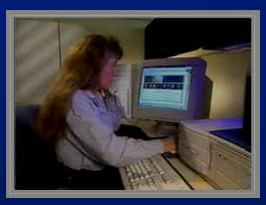
- Instrument Room
- Instrument Status
- Experimental Data
- Video Conferencing
- Electronic Notebooks
- On-Line Control



Functionality

- Platform Independent
- Intuitive GUI
- Responsive to the User
- Adaptable to Wide Range of Instruments
- Provides What the User Needs to Do the Experiment

TelePresence Microscopy Collaboratory Architecture



User Workstation

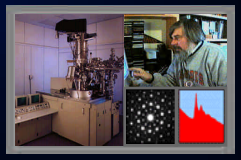
Collaboratory Server

Inter- System Communications

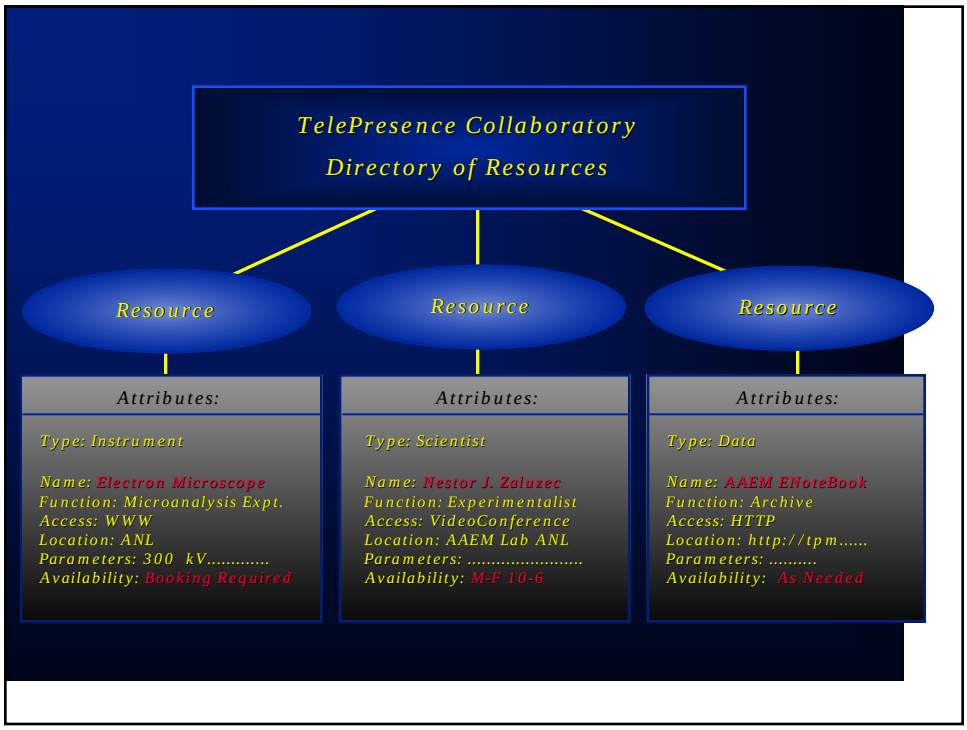
Resource: Instrumentation, Data, Expertise

Control Systems

Interface Electronics

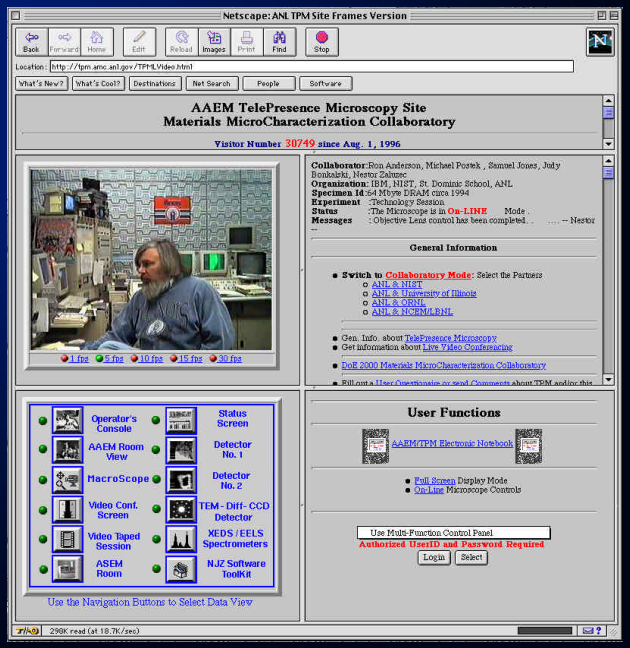


Current TelePresence Operations Architecture
WWW Model Provides Seemless Integration

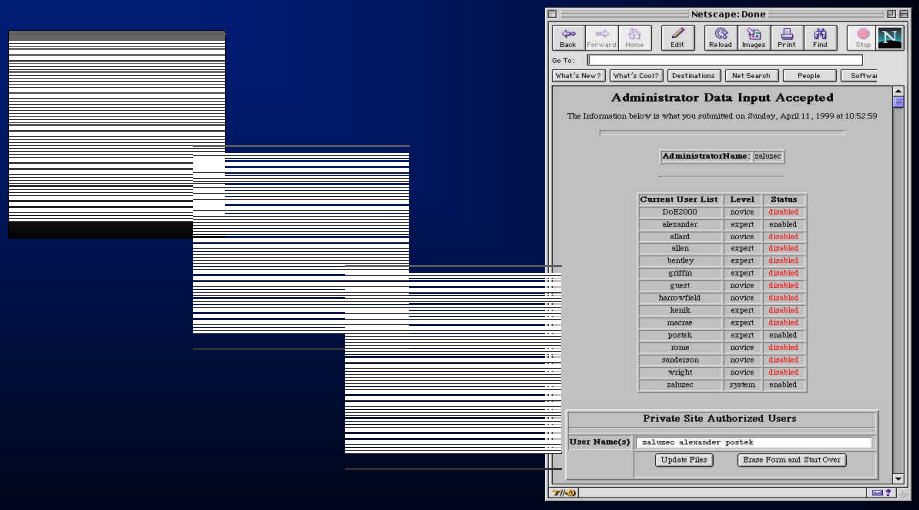


ANL - WWW TPM Server

Provides Platform Independent Access

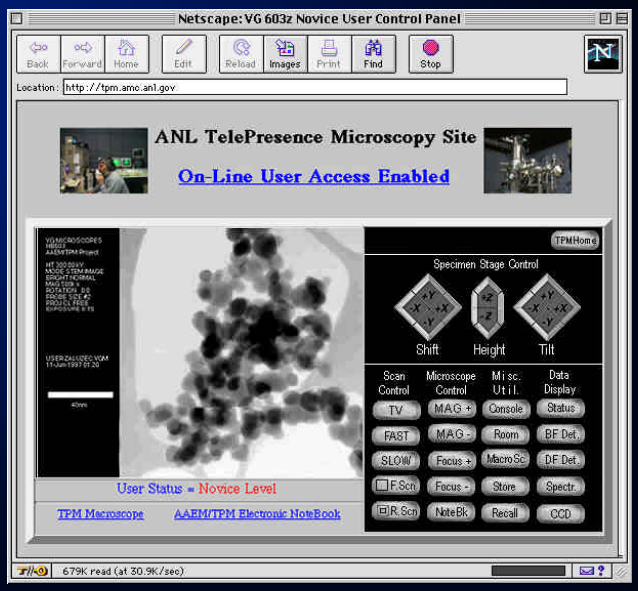


Access Control / Security



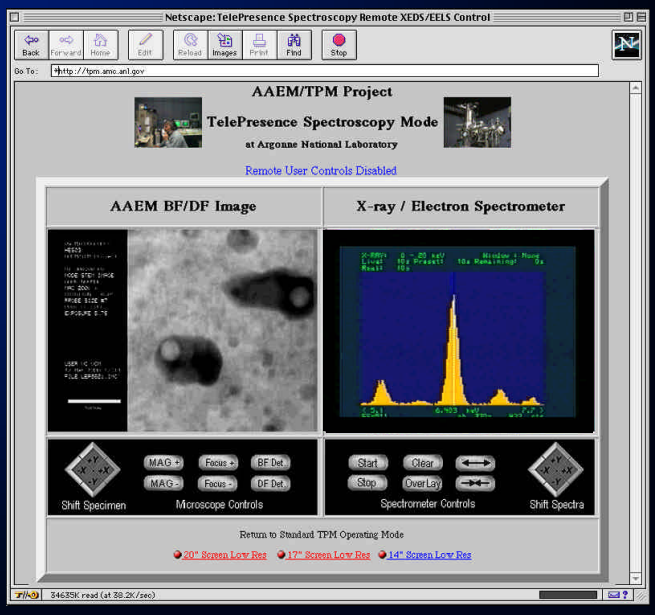
On-Line Instrument Control

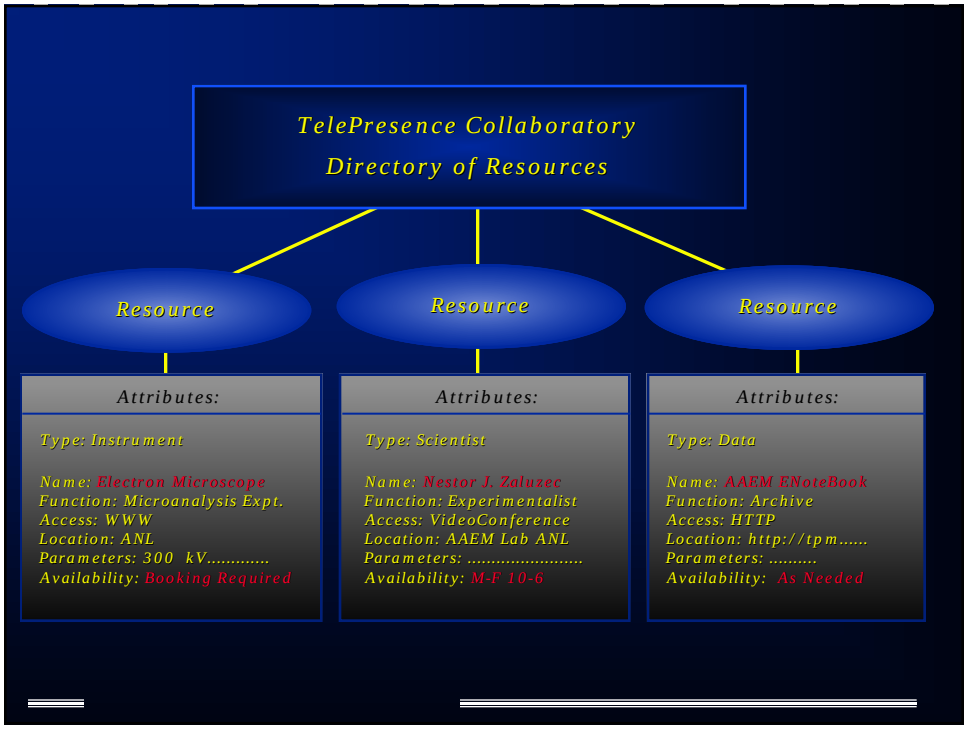
Platform Independent WWW Interface



On-Line Instrument Control

Platform Independent WWW Interface





Persistent Electronic Space Tools

- Data Archiving
- Session Archiving
- Data Mining
  - ➪Electronic Notebooks

Persistent Electronic Space Tools

An Electronic Notebook is a repository for objects that document scientific research.

Input Data

Query Data

Retrieve Data

Basic objects are: text, numerical data, images , drawings

Persistent Electronic Space Tools

Why an Electronic Notebook?

- **Virtual Laboratories encourage shared remote access to expensive, one-of-a-kind / state-of-the-art resources.**
- **Remote control of scientific instruments logically requires on-line documentation of capabilities and data.**
- **Collaboration of distributed researchers is enhanced by a common record keeping device.**

Notebook Architecture

WWW - User Interface

Submit / Retrieve Requests

NoteBook Engine

CGI
Java, Perl

Input Modules

Text
Forms
HTML Editors
Java Applets
Live Data

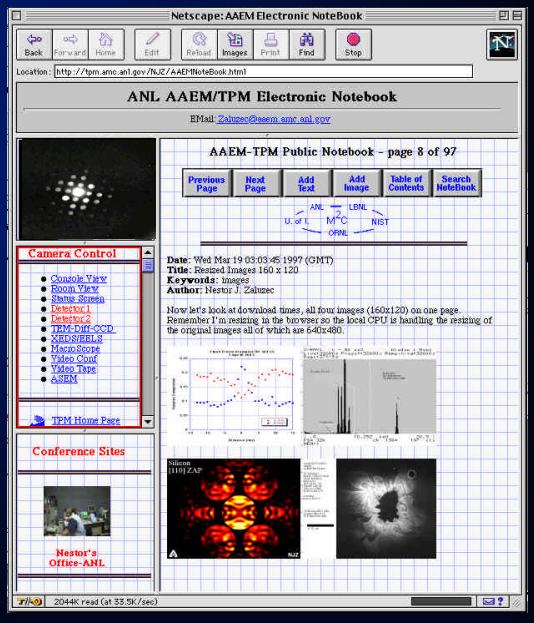
Storage

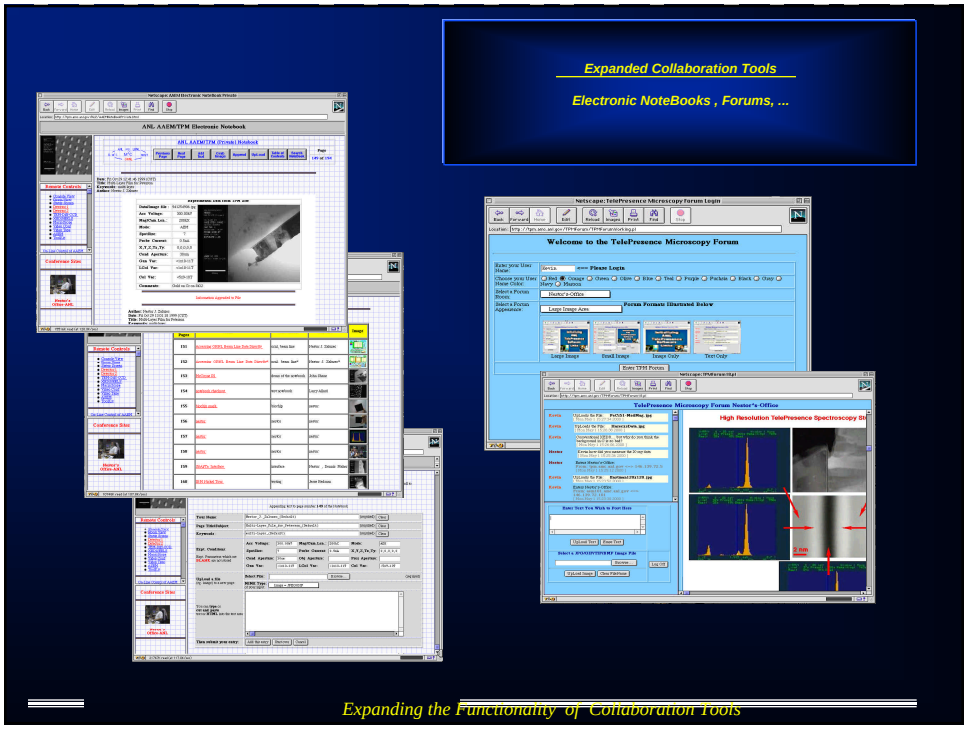
Flat File Storage
Store
Retrieve
Time Stamped

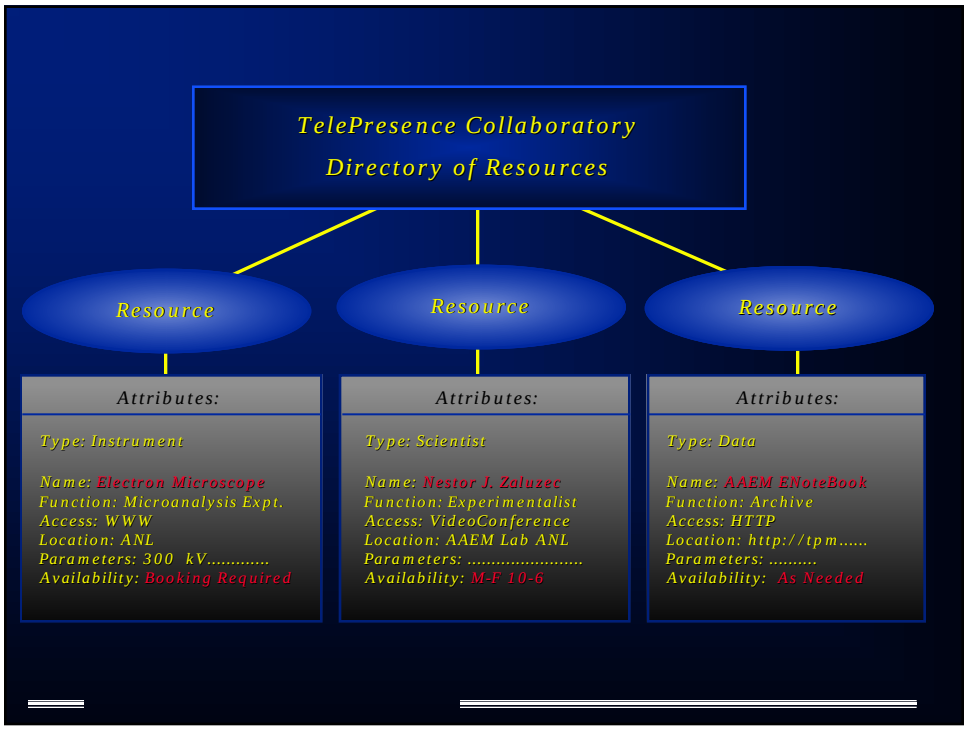
TelePresence Microscopy

Electronic NoteBooks

On-Line Data Sharing and Collaboration



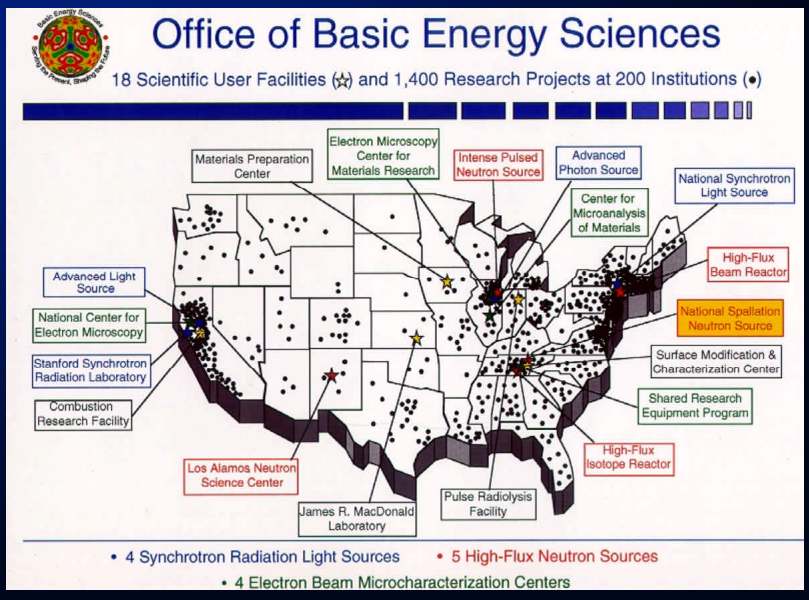

Expanded Collaboration Tools
Electronic NoteBooks , Forums, ...
Welcome to the TelePresence Microscopy Forum
TelePresence Microscopy Forum Nestor's Office
Expanding the Functionality of Collaboration Tools


TelePresence Collaboratory
Directory of Resources
Resource
Resource
Resource
Attributes:
Type: Instrument
Name: Electron Microscope
Function: Microanalysis Expt.
Access: WWW
Location: ANL
Parameters: 300 kV.....
Availability: Booking Required
Attributes:
Type: Scientist
Name: Nestor J. Zaluzec
Function: Experimentalist
Access: VideoConference
Location: AAEM Lab ANL
Parameters: .....
Availability: M-F 10-6
Attributes:
Type: Data
Name: AAEM ENoteBook
Function: Archive
Access: HTTP
Location: http://tpm.....
Parameters: .....
Availability: As Needed

TelePresence Microscopy

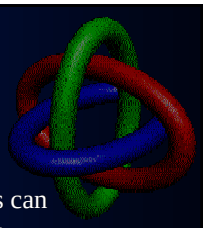
Benefits

- **Access to Unique Research Tools**
  - On-Line Shared Resources and Expertise
  - Permanent and Natural GUI Interface to Instruments and Data
  - Service & Diagnosis of Instrumental Problems
- **Persistent Electronic Laboratories**
  - Setup and Continue Experiments within an ***eLab***
  - Maintain Contact with Colleagues Regardless of Location
- **R&D, Education, Teaching, Training to/from Remote Sites**



Materials MicroCharacterization Collaboratory

The Collaboratory Concept



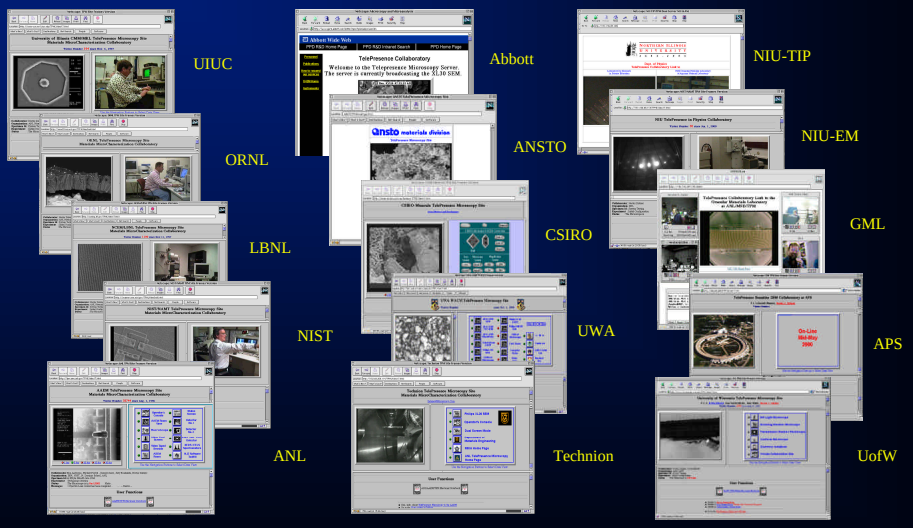
A "... 'center without walls,' in which the nation's researchers can perform their research without regard to geographical location

- interacting with colleagues,
- accessing instrumentation,
- sharing data and computational resources, [and]
- accessing information in digital libraries." *Bill Wulf (1989)*

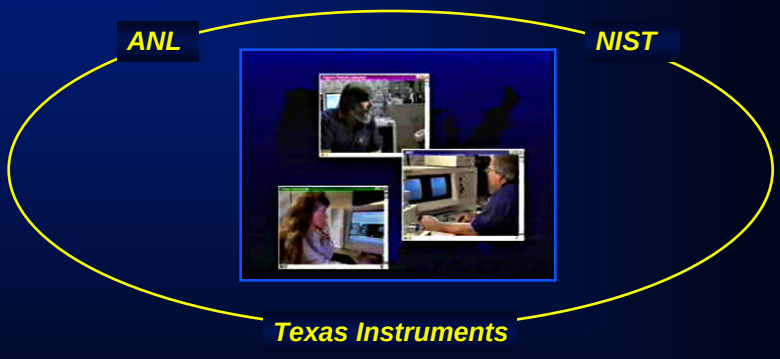
Adding value to Scientific User Facilities through

- accessibility, utilization, and integration of unique facilities;
- enhanced ability to assemble multidisciplinary teams
- new science by supporting collaboration and sharing across a gamut of tasks

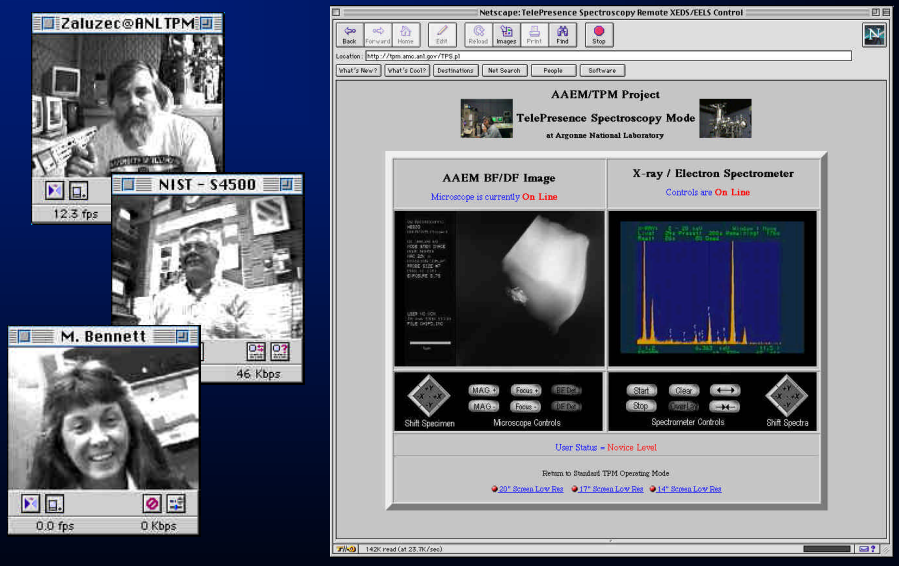
TelePresence Collaboratory Deployment is Growing



TelePresence Collaboration



MultiSite Collaboration



Remote Collaboration Example
ANL - NIST - TI

Complete copies available on

VideoTape or CD

Contact:

postek@nist.gov

zaluzec@anl.gov

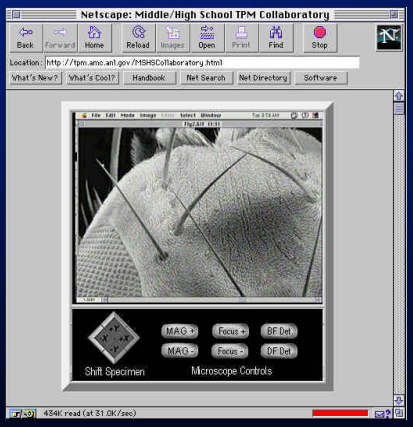
Educational Outreach / Distance Learning

- Electronic collaboratories are a natural and accessible educational resource
- Web-based, schools should not require specialized software / hardware
- Teaching should be interactive
- Learn to “collaborate” remotely

Middle/High School Collaboratories

TelePresence Microscopy

Middle/High School Collaboratories

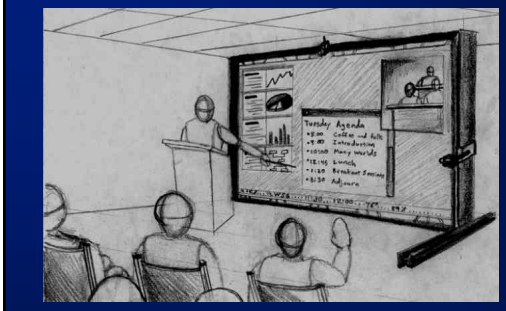


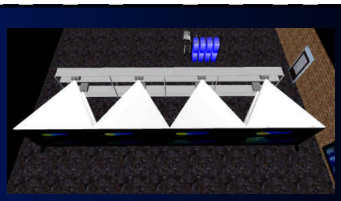
Netscape Client on Mac's & PC's in Classroom provides simple and inexpensive interface where students and remote instructors can interact with Microscopes.

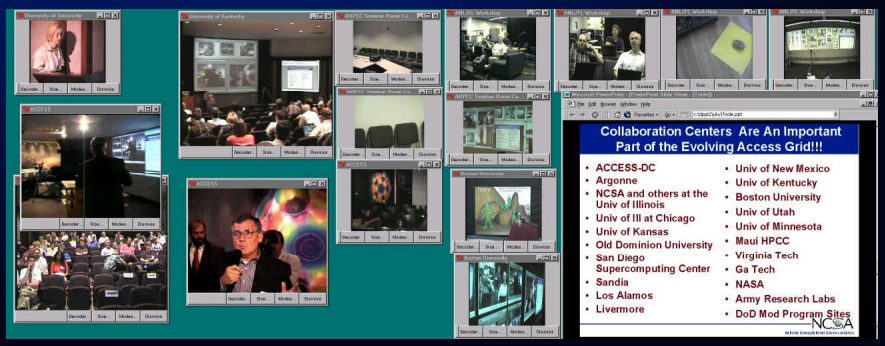
Live Video Conferencing using "CuSeeMe" provides low cost interactions between Instructor and Students

TelePresence is Beyond Desktop Teleconferencing

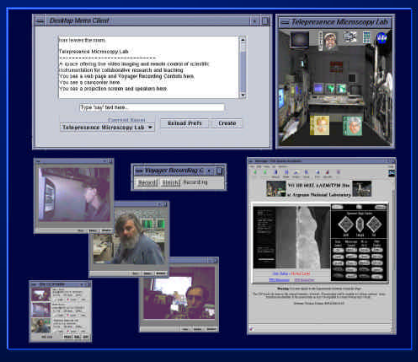
- Physical Groupwork spaces
  - lighting, audio, video, screens
- Virtual collaborative spaces
  - strong metaphors for resource organization
  - interaction scope management
- Agenda driven scenarios and work sessions
  - lectures, brainstorming, demos, meetings, planning
- Integration with GRID services
  - resource management, security, services, brokering
- Debut at Chautauqua '99 in August and Sept.
  - Boston U, U Kentucky, and UNM
  - ACCESS, Argonne, NCSA, EVL, Utah (supporting sites)





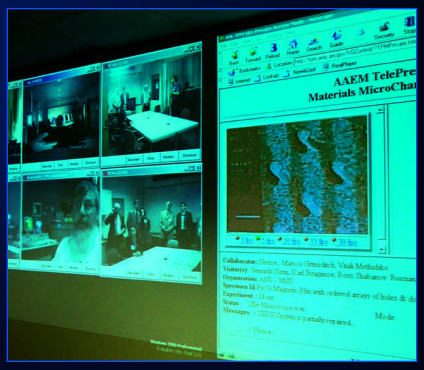


InterOperability of TPM with Other Internet Tools



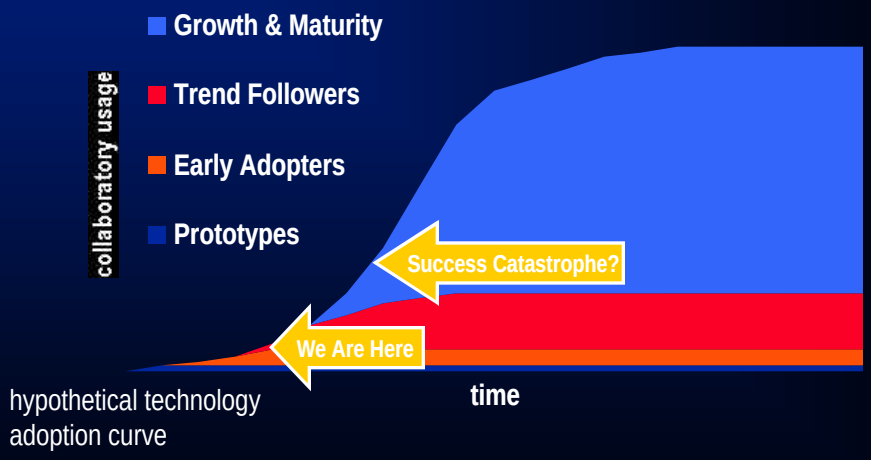
Metro

Access Grid



Scaling

Network Usage Tracks Collaboratory Use



hypothetical technology adoption curve

TelePresence Microscopy

Vision

The key to the understanding the TelePresence Microscopy Collaboratory and it's role is to remember that ultimately, it is *not simply the presence of, or access to instrumentation* that produces new ideas, better students or new science.

TelePresence Microscopy

Vision

Instead, advances results from the *work of individuals who learn from their interactions with others*. These individuals continue to interact, to formulate ideas , develop new instruments/technology or execute "experiments" to solve vexing problems, expand their knowledge and understanding , and this carried out using the tools which we have placed at their disposal.

TelePresence Microscopy

Vision

In the TPM, a *Functional Collaboratory* is the "tool" which we are developing and/or extending. The concept of an *Interactive Persistent Electronic Space* is a major component of a collaboratory that enables scientists to work together.

Demonstration
Connection to ANL
TPM Site

Accessing the TPM Collaboratory from your DeskTop Computer

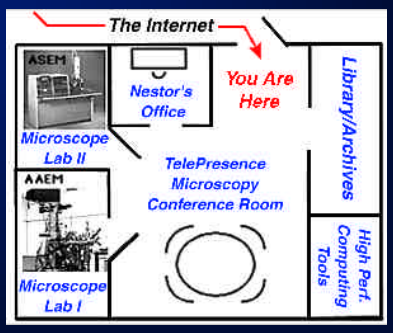
- **Install a copy of NetScape Version 2.0 or better on your Computer**
  - The TPM Server software is computer platform independent you may use any **Macintosh, Intel/PC, or Unix** computer. The faster your CPU the better the performance, a high resolution 17" (800 x 600 pixel) monitor is recommended but not required.
  - Microsoft ***Internet Explorer (IE) software*** **is *not compatible*** with the TPM server
- **Using your WWW Browser login to the TPM Public Site**
  - http://tpm.amc.anl.gov
  - Use the fastest connection to the Internet you can obtain
    - Fast Modems are usable but not recommended
    - ISDN is acceptable, T1 connections are fine
- **To Operate the Microscope over the Internet**
  - You must login to the TPM Private Site.
  - This requires authorization and is password protected.
  - Video Conferencing software is recommended but not necessary a Telephone may substitute
  - Contact Colin Macrae to discuss your experiment and/or needs

ANL TelePresence Microscopy Collaboratory

http://tpm.amc.anl.gov

Zaluzec @ AAEM. AMC.ANL.GOV

TelePresence Microscopy Collaboratory



http://tpm.amc.anl.gov

Connection to Nestor's Office