2.4 Collaboration

Our society increasingly relies on geographically distributed collaborations for human interactions in business, science, the arts, and other areas, both nationally and internationally. These collaborations improve communication among individuals with a common purpose; promote sharing, development, and dissemination of information; and foster interdisciplinary interactions.

The Internet supports distributed collaboration teams in which collaborators at multiple sites can interact visually and verbally, augmented by additional tools and services such as virtual reality and immersive environments. Distributed collaborations increasingly require realistic, "natural" interactions supported not only by high bandwidth but also by a wide array of enhancing services to provide ease of use, completeness of information, and appropriate levels of trust and assurance. Collaboration tools assist these groups in performing complex tasks, such as providing multimodal access to remote sites of scientific interest and supporting coordination to overcome problems and failures as they occur.

2.4.1 Collaboration Scenario

Current-generation network collaboration tools have not been widely used because they support limited exchange of information, provide limited "visibility" of remote collaborators, and are often difficult to set up and maintain. To be more widely accepted and used, collaboration environments (collaboratories) will need to provide automated setup and enhanced exchange of information and visualization. In addition they will need to be active, adapt to individual work patterns, and provide interoperable services over heterogeneous applications. Collaboration services, provided over a network, will need to adapt to end user personal preferences and work patterns, provide interoperable services over heterogeneous applications, and provide multimedia interactions, whiteboarding, and access to data and computational resources.

It is envisioned that future collaboration environments will make remote collaboration natural by being very easy to use, proactive, and engaging. They proactively will offload tasks from collaborators to enhance any given collaboration. For example, an automated "assistant" will retrieve information relevant to the collaboration. The system will configure the network and network services to support the particular individuals in the collaboration.

Future collaboration environments will need to deal with unpredictable and emergent changes, meet hard real-time constraints, and handle asynchronous events as they occur. Scientific collaborations will be particularly effective if scientific experiments can be conducted from local laboratories with all phases of the experiment coordinated so that it appears to be a local endeavor to each participant. The right level of coordination must be selected dynamically, depending on the task at hand and the feedback from the participants. Each participant should be able to augment the physical world with virtual worlds to consider "what-if" scenarios.

A collaborative scientific environment might include a large number of small sensors and robots with varying capabilities, capable of being embedded into the natural environment with minimum disturbance. Low-power nodes, with limited communication bandwidth, need to understand local conditions and together collaborate to identify and monitor global environmental conditions. Network traffic loads may be reduced if data and information can be aggregated and correlated at a local site to the level of granularity required by the collaborators.

2.4.2 Collaboration Scenario Networking Needs That Require Networking Research

To support collaboration environments in the future, networks will have to provide:

New middleware services

- Transparency among the collaborators, by accommodating heterogeneous technologies and interfaces and asynchronous events among end users
- User trust including security and reliability
- A virtual whiteboard
- The ability to convey body language (e.g., eye contact), visual cues, haptic, and olfactory information
- Ability to accommodate cultural differences among collaborators
- An automated “scribe” to record the collaboration including intrinsic information such as voice inflections and body language

Ubiquitous access

End users will have a wide range of technologies for accessing the network, depending on the technologies available to them (such as wireless and optical access) where they are located. The system must automatically implement the system interface for the different access technologies.

Intelligent collaborations

The collaboration system must be able to support the varying capabilities of different collaborators’ systems. This will require automated mechanisms to:

- Correctly identify every collaborator
- Retrieve collaborator preferences and permissions
- Detect each collaborator’s network speed, system protocols, and system capabilities – e.g., different modes of operation such as a Personal Digital Assistant (PDA) versus a dedicated multimedia facility
- Configure the system to support the above capabilities

This system will need to meet the needs of widely varying collaborative groups from small to large, across diverse disciplines, and operating in differing environments that could range from a laboratory supported by an array of technologies and high bandwidth connectivity to a remote field site with more limited technologies and wireless connectivity.

In addition, the system needs to be able to extract real-time data from the scientific instruments, computing and data resources, and human collaboration as it happens. It also needs to extract contextual data (e.g. voice pitch and intensity) and bring additional relevant information into the collaboration for use, reference, and/or citation. Using advanced pattern recognition techniques and artificial intelligence agents to mine this complementary information as the collaboration happens will help enhance the collaboration. These capabilities contribute to ease of use, thereby encouraging system adoption, and they provide additional information on the collaboration for establishing an historic record.

Virtual environments and coupling issues

A scientific collaboratory needs to support scientists performing both virtual simulations and physical experiments. It should provide seamless support for interaction with science discipline models, virtual reality environments, and on-line databases. It must also address issues of coupling that can take several different forms. For example, two large-scale simulations being used by different groups of collaborators may operate in the same physical space but use different physical units such as meters versus millimeters. Other collaborations may use multiple virtual environments or virtual environments interfacing with physical experiments. Multiple databases accessed by different groups of collaborators may need to present data in different physical units or differing formats are a third example.

Multiple modality expert consultation

Collaborations need to be able to include ad hoc consultation with experts wherever they are located using interaction technologies ranging from PDAs to sophisticated collaboratory environments.

Network measurement

Instrumentation for performance measurement should be provided throughout the network to measure network performance and enable isolation of system faults. It needs to be implemented for multiple link types (e.g., optical, electronic, wireless) and measure end to end performance. Network measurements should be standardized across network providers to provide this end-to-end capability. Performance measurement should also support network reconfiguration for active networking.

Automated supervisory oversight

The system must support supervisory oversight for monitoring performance and identifying problems. It must ensure that standards are adhered to when carrying out experiments that have safety and/or environmental implications and/or when performing experiment-critical functions. The system needs to be able to warn participants when requirements for critical functions are not met.

Virtual meeting maker

The system must be able to schedule, establish, and record virtual meetings. It must support schedule conflict resolution, scribing, attendance authentication, and archiving. In addition, the system must support asynchronous access and coordination for meeting absentees who access archived meeting materials.

Security and privacy

Security and privacy tools must be able to handle a wide range of requirements such as authorization, end-to-end key management, and revocation of authorization. In addition, the system must be able to support advanced security features such as allowing selective anonymous collaborators to participate and retrospectively access archived collaboration materials.

Other features

The system will also need to support a variety of additional capabilities such as shared and private workspaces, an “electronic whisper” capability that allows two collaborators to hold a private conversation during a collaboration session, and language translation.