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A Japan-U.S. Educational Collaboration: Using the Telescopes in Education (TIE) Program via Intelsat

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Abstract. In 1993, a proposal at the Japan-U.S. Science, Technology, and Space Applications Program (JUSTSAP) workshop lead to a series of satellite communications experiments and demonstrations, under the title of the Trans-Pacific High Data Rate Satellite Communications Experiments. These experiments were designed to explore and develop satellite communications techniques, standards, and protocols in order to determine how best to incorporate satellite links with fiber optic cables to form high performance global telecommunications networks. This paper describes a remote astronomy experiment executed during the second phase of this program, which established a ground- and space-based network between Japan and several sites in the U.S. This network was used by students, scientists, and educators to provide real-time interaction and collaboration with an automated 14-inch telescope and associated data archive. We find that such networking can provide educators and students with a unique collaborative environment which greatly enhances the educational experience.

1. The Network Layer

The Remote Astronomy experiment made use of a network encompassing geostationary satellites and an extensive ground-based fiber optic network across three countries, connecting seven endpoints. This connectivity was achieved using the NASA Research and Education Network (NREN) in the U.S., the CA∗net3 network in Canada, Intelsat #702 between Canada and Japan, and bits of optical fiber connections for the "last mile" at several endpoints. A range of bandwidths were used, from standard T-1 (1.44 Mb/s) to ATM-based OC-3 (155 Mb/s). The Intelsat bandwidth was kindly donated and, as such, set our overall network performance limit at DS-3 speeds (45 Mb/s). The network infrastructure is illustrated in more detail in Figure 1. (See also Kadowaki et al. 2001.)

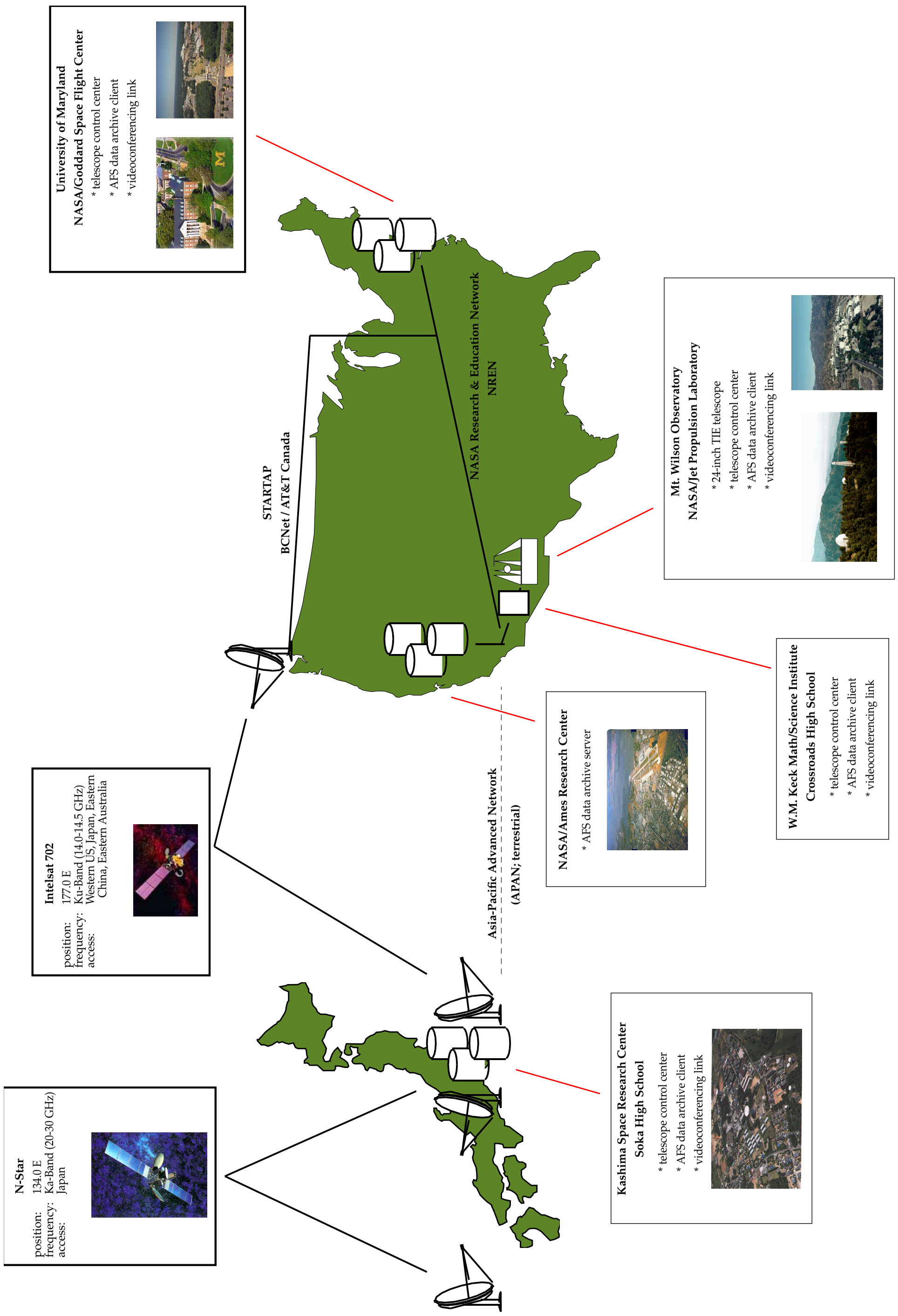

Figure 1. An overview of the U.S.-Japan network used for the Remote Astronomy experiment.

2. The Application Layer

Telescope Control – The experiment employed a fully-automated 14-inch telescope and CCD camera at Mt. Wilson Observatory. This telescope is part of the Telescopes in Education (TIE) project, an award-winning program initiated and maintained by one of us (GC), which allows school children around the world to remotely operate the telescope and obtain their own pictures of astronomical objects. The telescope is controlled via a commercial digital planetarium software product, *TheSky*. This software includes tools for controlling local and remote telescopes and cameras. For the Remote Astronomy experiment, the *TheSky* software package was installed at four endpoints of the network: Kashima Space Research Center (KSRC) in Japan, JPL, Crossroads High School in California, and the University of Maryland (UMD).

Data Archiving – In order for users at each site to obtain the acquired data simultaneously, we used a shared disk protocol known as the Andrew File System (AFS). AFS provides a robust network file service, with server and client software freely available for numerous operating systems. AFS servers were installed on systems running Windows NT at both the Ames Research Center (ARC) and JPL. AFS clients were installed on each of the endpoint observing systems at KSRC, JPL, Crossroads High School, and UMD.

Videoconferencing – Numerous remote observing projects, including one executed by JPL and Caltech in the first phase of the JUSTSAP experiments (Cohen et al. 1998; Shopbell et al. 1998), have pointed to the communication requirements of the partners in shared observing sessions. We therefore installed a standard H.323 videoconferencing package, *CuSeeMe*, on each of the endpoint observing systems. Associated video cameras and microphones were installed where needed. The *CuSeeMe* package includes video and command-line interfaces; it does not include a shared whiteboard or more complex interactive tools.

3. Experiment Operation

The experiment was comprised of three two-hour observing sessions, on June 29, June 30, and July 7, 2000. At the start of each session, participants at all four observing stations contacted each other through a public *CuSeeMe* reflector. The satellite delay affected comprehension of the audio stream to a far greater degree than the video stream; a standard teleconference phone line was therefore used for the audio portion of the final session. The chat mode of *CuSeeMe* was found to be very useful for transmitting detailed information where errors could not be tolerated, such as target names and coordinates. When word was received from Mt. Wilson that the 14-inch telescope was ready for use, the four participant sites connected to the telescope using the *TheSky* software.

As the lead astronomer, one of us (PLS) developed a detailed observing plan in advance, including an overall science goal for the session, choices of target objects, and comparison images from the Internet. The scientific themes of our sessions were “The Types of Galaxies” and “The Lives of the Stars.” The former session concentrated on imaging a number of galaxies of differing types, which we then compared to HST images of nearby and very distant galaxies, in an attempt to explore the common classifications of galaxies. The latter session concentrated on imaging a number of gaseous nebulae of different types, representing both the birth and death sites of stars.

Each session began with a brief introduction to the subject, presented by an astronomer. The sessions then became heavily observational in nature, with most discussion centering around the data being obtained by the telescope. Periodically as needed, control of the telescope camera was taken by one of the participant sites, who then moved the telescope to a desired object and obtained an image of it. The acquired image was automatically placed in the shared AFS directory, giving all participants simultaneous access to the data. The process of taking an image was relatively rapid, required approximately 10 minutes per exposure. During that time period, the participants not controlling the telescope would examine the previous image, discuss its relevance to the scientific goals, and monitor the progress of the current exposure. Comparisons were made with published imagery from other telescopes and the Internet. Each session ended with a brief summary of the observations and their relevance to the scientific goals for the session, again presented by the guiding astronomer. A final question-and-answer period provided seeds for discussion and thought after the end of the collaborative session.

4. Conclusions

The widespread adoption of the Internet by research and educational institutions has created vast opportunities for collaboration and interaction on a global scale. Satellite technology can provide a crucial piece of this new model by enabling high-bandwidth networking to virtually any location in the world. As collaborative applications become more complex, and as more simultaneous streams are involved (e.g., video, audio, whiteboard, AFS data, telescope commands), the required network capacity also increases rapidly. The current bottleneck against more widespread use of satellite technology in collaborative research and education is the relative difficulty in building the network. Finally, we note that collaborative software is advancing rapidly; researchers and educators should familiarize themselves with the powerful capabilities available now and in the near future. Such tools provide a means for technical and social interaction at levels previously impossible. Modern collaborative software, together with global satellite networking, can bring together remote resources—both hardware and human—for impressive results in research and education.

References

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