EXPERIMENT CONCEPTS IN THE TRANS-PACIFIC HDR SATCOM EXPERIMENT - PHASE 2

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ABSTRACT

This paper describes experiment concepts for the Phase-2 of the *Trans-Pacific HDR Satcom Experiment* (Astronomy). Broadband satellites serve as a key link in establishing a worldwide network of networks, while imposing upon us the particular characteristics of propagation delay, bandwidth, and error rates which differ from those of terrestrial networks. The Trans-Pacific **series of experiments help explore and develop** satellite transmission 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, The Trans-pacific Astronomy experiment focuses on establishing a system for remote astronomical observations. This involves the use of a computer-controlled telescope at Mt. Wilson, California, U.S.A and a number of astronomical archives in Japan and the United States. The transport protocol portion of the experiment intends to utilize prior work in the area and to make experimental changes to existing TCP variants to study the effects of the modifications. The multicast protocol portion of the experiment intends to establish an efficient framework for large-scale collaboration and protocol research, The use of high-availability file systems and high performance file systems help address the issues of link outages, network partitioning, and demands for large-capacity, high-speed data transfers.

1. INTRODUCTION

Government and industry teams in Japan and the United States have begun a series of trans-pacific experiments to develop and demonstrate the role of satellites in the Global Information Infrastructure (GII). These experiments will explore and develop satellite transmission 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. The Trans-pacific High Data Rate (HDR) Satellite Communications Experiments is a result of a 1994 proposal by the Japan-U. S. Science, Technology and Space Application Project. They are now incorporated into the G7 Global Interoperability for Broadband Networks (GIBN) project.

The first of the joint experiments between government and industry teams in the United States and Japan is the Trans-Pacific High Definition Video Experiment The purpose of the experiment was to demonstrate broadband satellites' capabilities in delivering digital image traffic at rates up to OC-3 (155 Mbps), which was normally transmitted by terrestrial fiber optic networks, and to test the ability of satellites to carry very high definition video

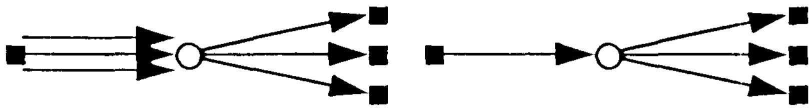

Figure 1. (left) multiple unicast connections and (right) one multicast connection.

signals for post-production processing between Sony studios in Tokyo and Los Angeles[2]. The successful results encouraged the team to construct a global HDR network utilizing satellite communications systems in conjunction with terrestrial networks, and at the same time they brought additional questions on the use of protocols and systems developed for terrestrial networks in a global infrastructure involving the use of broadband satellites.

2. TRANSPORT LAYER PROTOCOL (TCP)

In addition to assembling technologies commonly seen in the terrestrial environment, the introduction of broadband satellites in a global environment revisits the existing protocols of adaptability, scalability, efficiency, interoperability, and robustness. As a result of this, much work have been performed in developing variants of TCP that can work efficiently over a satellite link[3,4]. Recent results show promising progress in this area. The Trans-Pacific Astronomy experiment will incorporate the enhancements suggested by prior work in providing an efficient, reliable point-to-point transmission path, while examining performance for small-tile transfers.

3. MULTICAST PROTOCOL RESEARCH

In addition to the use of TCP, which is a point-to-point protocol, the use of multicast protocols permits efficient collaboration between people and organizations located over wide geographical regions. In the case of point-to-point protocols such as TCP, one needs to transmit multiple copies of the same data to all recipients; however, in the case of multicast, one transmits only one copy, and routers replicate the data only at branches of the path (Figure 1). The emergence of a global information infrastructure and cutting-edge research in issues such as local error recovery, reliability mechanism, receiver heterogeneity, and scalability present multicast as an important topic to include in the Global Interoperability for Broadband Networks (GIBN) experiments.

Multicast is well suited for applications that are distributed in nature[5-7]. Example of such applications include tele-education, tele-conferencing, digital libraries, wide-area distribution, etc. The need for participants over a wide geographical region to work together can benefit greatly from the use of multicast capability.

The types of data being transferred in a typical multicast network can be classified into two general categories. The first of which is file data, which must be reliably transferred from a sender to all receivers; and the second of which is real-time/interactive data, whose timeliness requirement needs to take precedence over reliable delivery. Commonly available applications today for each of these categories are collaborative White Board (wb) software using Scalable Reliable Multicast (SRM) transport protocol and WC, VAT, NV, IVS and FreePhone video and audio conferencing tools based on transport protocols such as Receiver-driven

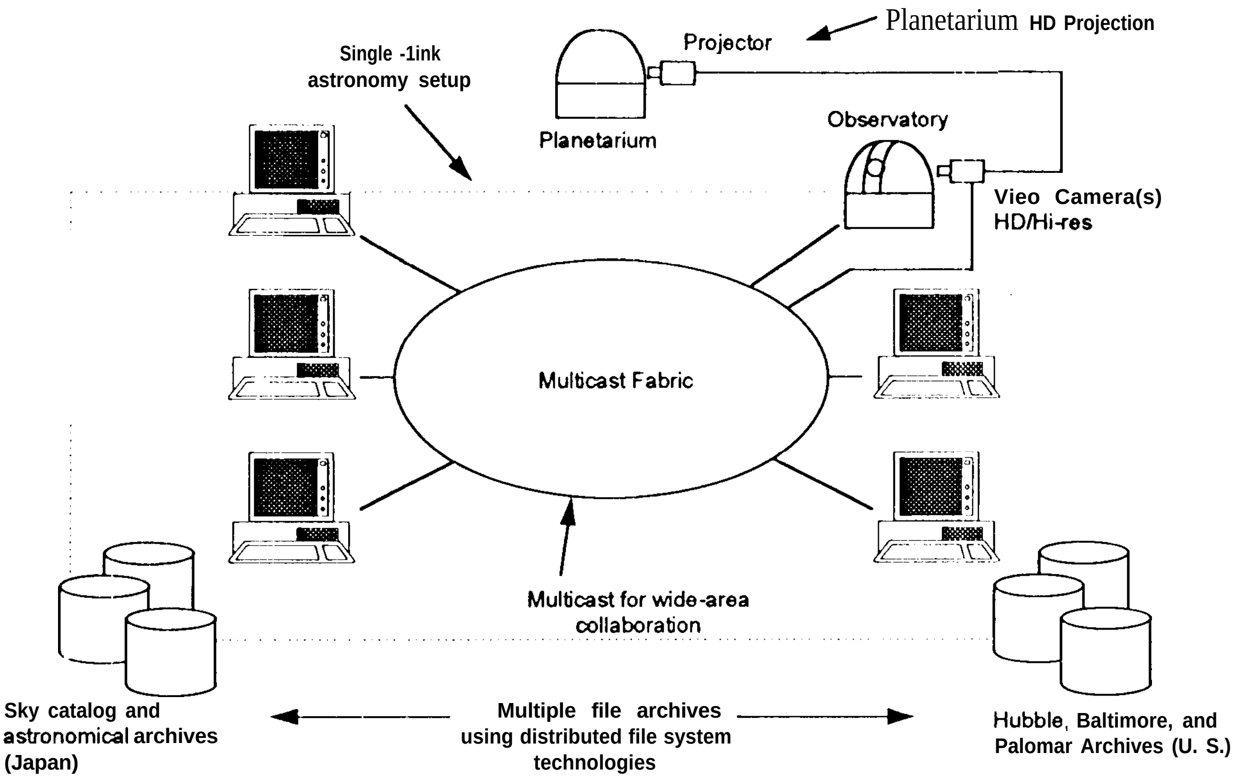

Figure 2. Experiment concepts in Phase-2 of the Trans-Pacific HDR Satcom Experiment.

Layered Multicast (RLM) and Real-time Transport Protocol (RTP).

4. DISTRIBUTION - THE EMERGING NATURE OF SYSTEMS

The capabilities afforded by an emerging information infrastructure of the global scale emphasizes the distributed nature of today's information systems. People, resources, and organizations are ecoming more distributed. Powerful communications networks serve to connect people from distant places, permit sharing of resources such as supercomputers and astronomical observatories. It also facilitates the expansion of organizations to meet growing consumer demands. The reach of network users are farther than ever before.

The distribution of users and systems brings with it issues of scale, heterogeneity, robustness, and interoperability:

- *Scale:* Systems are serving an increasing number of users. From several users of recent past to hundreds and thousands of users of today.

- ***Heterogeneity:*** Various types of systems are expected to work together. These systems represent a spectrum of differences in terms of speed, capacity, functionality, etc.

- *Robustness:* An ideal solution for a large scale system is one that is capable of self-configuring. It permits the system to adapt to changing conditions with minimal operator intervention. In a large-scale distributed system, link outages and network partitioning should not"be seen as a norm and not an **exception.** A robust system, therefore, needs to deal with the challenge of partial data consistency, as the cost of maintaining total consistency becomes very high with a large system. A system that can operate in light of resource failures is useful when high system availability is needed. A high-availability system is useful in disaster management.

- ***Interoperability:*** Distribution, scale, and heterogeneity mean increased system dynamics. A robust interoperable solution should permit systems to operate together efficiently.

These issues bring the following experiment concepts.

5. EXPERIMENT CONCEPTS

The following is a list of experiment concepts being studied by the participants in Japan and the United States. Several concepts in this section are shown in Figure 2.

5.1 Remote Astronomy

The remote astronomy concept intends to demonstrate the possibility of using global network technology in distance education, A remote astronomy network at Mt. Wilson, California, will be extended to Japan, This would permit the use of the Mt. Wilson facility by Japanese students during day time in Japan. Additional observatories in Japan would permit United States students to observe in the day time in the U. S.. The concept of projecting the video images in the observatory dome at a planetarium is being considered.

5.2 TCP Modification for Efficient Small File Transfers

Additional changes are planned to made to existing TCP variants to examine the transfer efficiency of small files. Issues of interoperability with existing TCP variants shall be examined, and measurements of the effectiveness of the modifications shall be made. The TCP test is expected to provide some additional insight into the use of broadband satellites as a component in the global information infrastructure.

5.3 High-availability/FUgh Performance file systems

As networks grow in size, one would expect that link-outages and network partitioning becomes a norm rather than an exception. The systems today are also gradually becoming more distributed in nature. The use of a highly available file system[8] in a global environment will ensure that data is available to certain regions even though other regions may be partitioned from the others for a duration of the time. Such a file system is of interest in the context of disaster recovery. High mobility also benefits from the study of high-availability file systems. A highly available file system also is a file system that can be highly mobile. Topics to study include the effects of link quality vs. the availability of information, speed of access, consistency of information, and unresolvable update conflicts in a global infrastructure using satellites. Concepts in utilizing network-attached peripherals are being considered for establishing a high performance file systems (HPSS) for large-capacity, high-speed data transfers.

6. CONCLUSIONS

The experiment concepts for the Phase-2 of the Trans-Pacific High Data Rate (HDR) satellite communications experiment, called the Trans-pacific Astronomy Experiment, have been described in this paper. In addition to establishing the architecture for performing remote astronomical observations, opportunities will be present for data collection and research in the areas of satellite communicant ions, network protocols, distributed systems and high-performance systems technologies.

7. ACKNOWLEDGMENT

The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration and by the Communications Research Laboratory, Ministry of Posts and Telecommunications of Japan.

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