The Tenet Real-time Protocol Suite: A Demonstration

Edward Knightly, Fred Templin, Anindo Banerjea,
Bruce Mah, Hui Zhang and Domenico Ferrari

The Tenet Group
University of California at Berkeley
and International Computer Science Institute

A recent trend in computer networks is their use for the transmission of various forms of multimedia data, such as video, audio, and still images. When these data streams are transmitted for immediate consumption at the destination, the frames in these streams must be delivered regularly for reception quality to be high. For example, frames that arrive too late to be played in the proper order are to be considered lost [2]. Packet-switching networks occasionally suffer from traffic congestion and cannot guarantee such regular delivery. The Tenet real-time protocol suite, shown in Figure 1 along with the Internet protocol suite, transforms a congestion-prone network or internetwork into one able to offer the required performance guarantees to the real-time portion of its traffic. In the Tenet suite's connection-oriented, resource-reservation based paradigm, clients can specify what their distributed multimedia applications want, and obtain from the network explicit and binding guarantees that their needs will be met. Since the Tenet real-time protocols have been designed to coexist with the Internet protocols in the same network, they will transform a conventional network into an integrated-services one, which can transport several different kinds of traffic while satisfying the requirements of each kind. Further details about the Tenet protocols may be found in [3].

This videotape documents a live demonstration presented by the Tenet Group at UC Berkeley's 1994 Industrial Liaison Program. Since many of the anomalies common for live television broadcasts may appear in the videotape, we ask viewers to recognize that the immediacy of the live demonstration precluded stringent audio/video editing. The demonstration involves the transmission of live and pre-recorded video streams from San Diego to Berkeley over the Sequoia 2000 network (S2Knet) testbed [4] using the application `vic`, a video conferencing tool developed by Steve

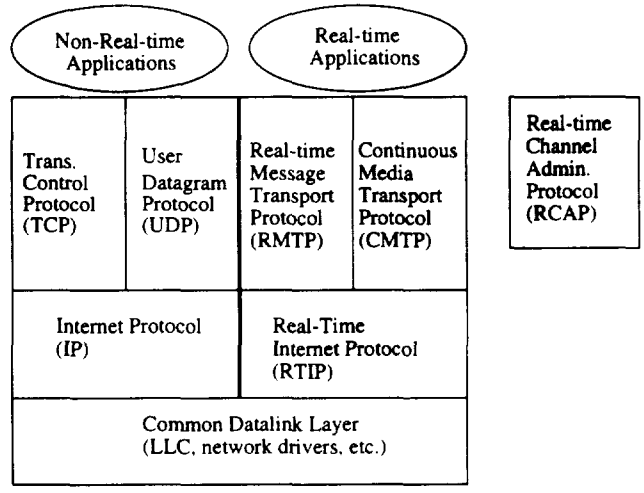

Figure 1: Tenet Real-Time Protocol Suite

McCanne of the Tenet Group. The testbed, shown in Figure 2, concurrently runs both the Tenet real-time protocol suite as well as the Internet protocol suite. Under various network loads, the demonstration qualitatively compares the service received by the application when using the Tenet protocols with the service received by the application when using the Internet protocols.

As shown in Figure 3, The same video stream is JPEG-compressed in hardware at a workstation in San Diego, and transmitted with both the UDP/IP Internet protocols and the RMTP/RTIP Tenet protocols under different network loading conditions. At Berkeley, the two streams are decompressed in hardware and displayed. During the experiment, the S2Knet is also transferring files from Los Angeles to Berkeley; this traffic interferes with the video traffic in the Santa Barbara and Berkeley routers and FDDI rings as well as on the Santa Barbara - Berkeley link. When the

file transfer load is light, the qualities of the two video streams at the receiving end are equally good. At medium loads, the quality of the stream transmitted over UDP/IP becomes visibly worse than the quality of the RMTP/RTIP stream. With heavy network loads, the UDP/IP stream deteriorates profoundly, while the quality of the stream transported by the Tenet protocols still remains unaffected.

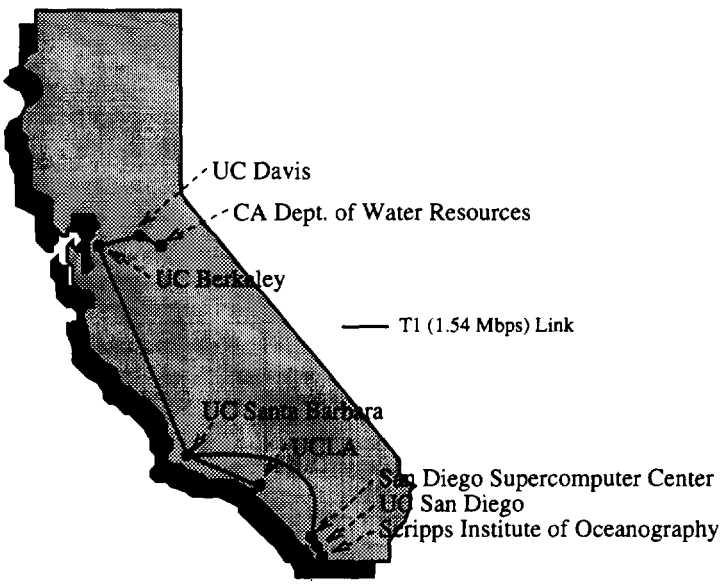

Figure 2: S2Knet Topology

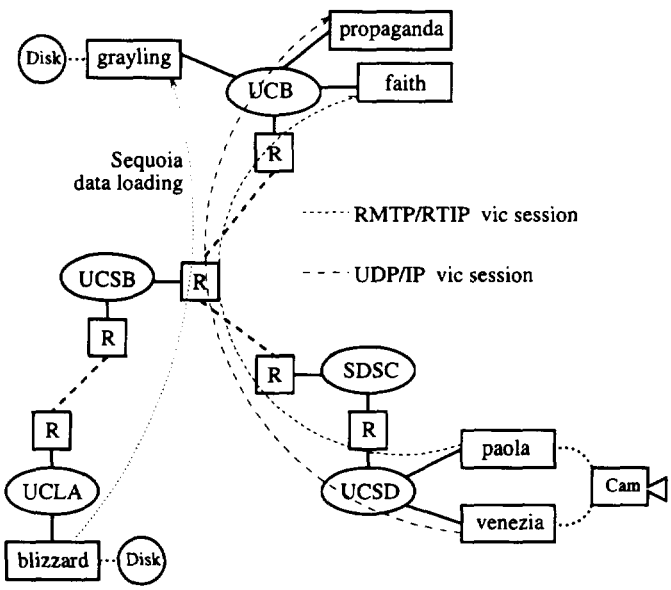

Figure 3: Demonstration Scenario

One unexpected result of the demonstration is the severe dissatisfaction expressed by the demo's observers regarding the audio drop-outs. These drop-outs are easily perceivable and nearly always provoked complaints and questions. The reason for the severe audio outages is that the audio tool we used (**vat**) uses UDP/IP rather than the Tenet protocols. This further emphasizes the need to use guaranteed performance protocols to protect audio quality from network load fluctuations. Further details of the demonstration and further experimental results may be found in [1].

The Tenet Group was established in 1989 and is jointly sponsored by the Computer Science Division (EECS Department) of the University of California at Berkeley and by the International Computer Science Institute, also located in Berkeley. Its research mission in the areas of real-time communication and multimedia networking applications is carried out in the context of three high-speed networking testbeds: BLANCA, one of the five national gigabit testbeds sponsored by the Corporation for National Research Initiatives, with support from the National Science Foundation, and the Advance Research Projects Agency of the Department of Defense, the Department of Energy, and AT&T Bell Laboratories; S2Knet, the network of Sequoia 2000, the flagship project of Digital Equipment Corporation; and the Bay Area Gigabit Network provided by Pacific Bell and supported by the CalREN Foundation.

References

[1] A. Banerjea, E. Knightly, F. Templin, and H. Zhang. Experiments with the Tenet real-time protocol suite on the Sequoia 2000 wide area network. In *Proceedings of the 2nd ACM International Conference on Multimedia*, San Francisco, CA, October 1994.

[2] D. Ferrari. Client requirements for real-time communication services. *IEEE Communications Magazine*, 28(11):65–72, November 1990.

[3] D. Ferrari, A. Banerjea, and H. Zhang. Network support for multimedia: a discussion of the Tenet approach. Technical Report TR-92-072, International Computer Science Institute, Berkeley, California, October 1992. Also to appear in *Computer networks and ISDN systems.*

[4] D. Ferrari, J. Pasquale, and G. Polyzos. Network issues for Sequoia 2000. In *Proceedings of COMPCOM 92*, pages 401–406, San Francisco, CA, February 1992.