Network Working Group
Request for Comments: 829

V. Cerf
DARPA

November 1982

PACKET SATELLITE TECHNOLOGY REFERENCE SOURCES

Vinton G. Cerf
Defense Advanced Research Projects Agency

ABSTRACT

This paper describes briefly the packet satellite technology developed by the Defense Advanced Research Projects Agency and several other participating organizations in the U.K. and Norway and provides a biblography of relevant papers for researchers interested in experimental and operational experience with this dynamic satellite-sharing technique.

INTRODUCTION

Packet Satellite technology was an outgrowth of early work in packet switching on multiaccess radio channels carried out at the University of Hawaii with the support of the Defense Advanced Research Projects Agency (DARPA). The primary difference between the earlier packet-switched ARPANET [1, 2] and the ALOHA system developed at the University of Hawaii [3] was the concept of multiple transmitters dynamically sharing a common and directly-accessible radio channel. In the ARPANET, sources of traffic inserted packets of data into the network through packet switches called Interface Message Processors (IMPs). The IMPs used high speed point-to-point full-duplex telephone circuits [4] on a store-and-forward basis. All packet traffic for a given telephone circuit was queued, if necessary, in the IMP and transmitted as soon as the packet reached the head of the queue. On such full duplex circuits there is exactly one transmitter and one receiver in each direction.

The ALOHA system, on the other hand, assigned a common transmit channel frequency to ALL radio terminals. A computer at the University of Hawaii received packet bursts from the remote terminals which shared the "multi-access" channel. Under the control of a small processor, each terminal would transmit whenever it had traffic, and would await an acknowledgement, on another frequency, dedicated to the service host. If no acknowledgement was received, the terminal processor would transmit again at a randomly chosen time. The system operated on the assumption that no store-and-forward or radio relay was needed. The University of Hawaii researchers later demonstrated that the ALOHA concept worked on a satellite channel linking Hawaii and Nasa-Ames via NASA's ATS-1 satellite [5, 6]. A variety of more elaborate satellite channel assignment strategies were developed and analyzed in the early 1970's [7-13, 31].

THE ATLANTIC PACKET SATELLITE EXPERIMENT (SATNET)

In 1973, DARPA began the development of a packet satellite system which would support the sharing of a common, high speed channel among many ground stations. Using an INTELSAT-IV satellite, the Atlantic Packet Satellite experiment was carried out with the cooperation and support of the British Post Office, COMSAT Corporation, Linkabit Corporation, and Bolt Beranek and Newman Corporation, later joined by the Norwegian Telecommunication Administration and the Norwegian Defense Research Establishment (NDRE). Along with University College London and COMSAT Laboratories, NDRE became one of the major users of the SATNET system.

During 1975-1978, SATNET underwent a broad range of performance evaluations and tests. Since 1979, it has served as a stable support for international experiments and demonstrations of command and control technology of interest to DARPA, NDRE and the U.K. Royal Signals and Radar Establishment (RSRE). Late in 1982, a ground station was added to connect the German Aeronautics and Space Research Establishment (DFVLR) into the system.

The early development of SATNET is outlined in [14]. The system design is documented in [15-22]. Experience with the operation of the SATNET is reported in [23-24] and experimental results in [25-26]. Potential services which might be supported by this technology are discussed in [27].

The integration of the packet satellite technology into a larger, multiple packet network context is discussed in [28-29]. The system is expected to continue in use to support joint research by DARPA, RSRE, NDRE, DFVLR and UCL. DARPA and the U.S. Defense Communications Agency are experimenting with a 3 megabit/second domestic packet satellite system to determine whether packetized voice and data services can be integrated economically using this technology. DARPA and the U.S. Naval Electronic Systems Command recently demonstrated a Mobile Access Terminal Network (MATNET) which uses packet satellite techniques to support ship-ship and ship-shore communication over a shared FLTSATCOM satellite channel [30].

ACKNOWLEDGEMENTS

The development of Packet Satellite technology has involved many institutions and individuals, but special credit for the successful realization of the SATNET and its successor systems must be given to Dr. Robert E. Kahn, Director, Information Processing Techniques Office, DARPA, for his continuous support and technical contributions throughout the development and maturation of this technology.

REFERENCES

1. L.G. Roberts and B.D. Wessler, "Computer Network Development to Achieve Resource Sharing," Spring Joint Computer Conference, AFIPS Proceedings, Vol. 36, 1970, pp. 543-549.

2. R.E. Kahn, "Resource Sharing Computer Networks," Proceedings of the IEEE, Vol. 60, No. 11, November 1972, pp. 1397-1407.

3. N. Abramson, "The Aloha System - Another Alternative for Computer Communications," AFIPS Conference Proceedings, Vol. 36, 1970, pp. 295-298.

4. F.E. Heart, et al, "The Interface Message Processor of the ARPA Computer Network, Spring Joint Computer Conference, AFIPS Proceedings, 1970, pp. 551-567.

5. R. Binder, et al, "Aloha Packet Broadcasting--a retrospect," AFIPS Conference Proceedings, National Computer Conference, 1975, pp. 203-215.

6. N. Abramson and F. Kuo, Editors, Computer Communication Networks, Prentice Hall, Englewood Cliffs, N.J., 1973.

7. L. Kleinrock and S. Lam, "Packet Switching in a Slotted Satellite Channel," AFIPS Conference Proceedings, NCC, 1973, pp. 703-710.

8. L. Kleinrock and F. Tobagi, "Random Access Techniques for Data Transmission over Packet Switched Radio Channels," AFIPS Conference Proceedings, NCC, 1975, pp. 187-201.

9. L. Kleinrock and S.S. Lam, "Packet Switching in a Multiaccess Broadcast Channel: Performance Evaluation," IEEE Transactions on Communication, Vol. COM-23, 1975, pp. 410-423.

10. L.G. Roberts, "Aloha Packet System with and without Slots and Capture," ACM SIGCOMM, Computer Communication Review, Vol 5, No. 2, April 1975.

11. S.S. Lam and L. Kleinrock, "Packet Switching in a Multi-access Broadcast Channel: Dynamic Control Procedures," IEEE Transactions on Communication, Vol Com-23, September, 1975.

12. L.G. Roberts, "Dynamic Allocation of Satellite Capacity through Packet Reservation," AFIPS Conference Proceedings, NCC, 1973, pp. 711-716.

13. N. Abramson, "Packet Switching with Satellites," AFIPS Conference Proceedings, NCC, 1973, pp. 695-702.

14. R.E. Kahn, "The Introduction of Packet Satellite Communications," National Telecommunications Conference, Nov. 1979, p. 45.1.1-45.1.8.

15. I.M. Jacobs, et al, "CPODA - A Demand Assignment Protocol for SATNET," Fifth Data Communications Symposium, Snowbird, Utah, 1977.

16. I.M. Jacobs, et.al, "General Purpose Satellite Networks," Proceedings IEEE, Vol 66, No. 11, November 1978, pp. 1448-1467.

17. I.M. Jacobs, et al, "Packet Satellite Network Design Issues," Proceedings, NTC, November 1979.

18. L. Palmer, J. Kaiser, S. Rothschild and D. Mills, "SATNET Packet Data Transmission," COMSAT Technical Review, Volume 12, No. 1, Spring 1982, pp. 181-212.

19. Weissler, et al, "Synchronization and Multiple Access Protocol in the Initial Satellite IMP," COMPCON, September 1978.

20. Hsu and Lee, "Channel Scheduling Snychronization for the PODA Protocol," ICC, June 1978.

21. E. Killian and R. Binder, "Control Issues in a PODA Voice/Data Satellite Network," ICC, June 1980.

22. C. Heegaard, J. Heller and A. Viterbi, "A Microprocessor-based PSK Modem for Packet Transmission over Satellite Channels," IEEE Transactions on Communications, COM-26, No. 5, May 1978, pp. 552-564.

23. P. Cudhea, D. McNeill, D. Mills, "SATNET Operations," AIAA 9th Communications Satellite Systems Conference, Collection of Technical Papers, 1982, pp. 100-105.

24. D.A. McNeill, et al, "SATNET Monitoring and Control," Proceedings of the NTC, November 1979.

25. P.T. Kirstein, et al, "SATNET Applications Activities," Proceedings of the NTC, November 1979.

26. W.W. Chu, et al, "Experimental Results on the Packet Satellite Network," Proceedings of the NTC, November 1979.

27. E.V. Hoversten and H. L. Van Trees, "International Broadcast Packet Satellite Services," ICCC Conference Proceedings, Kyoto, Japan, September 1978.

28. V.G. Cerf and R.E. Kahn, "A Protocol for Packet Network Intercommunication," IEEE Trans. on Comm., Vol. COM-23, May 1974, pp. 637-648.

29. V.G. Cerf and P.T. Kirstein, "Issues in Packet Network Interconnection," IEEE Proceedings, Vol. 66, No. 11, Nov 1978, pp. 1386-1408.

30. L. Evenchik, D. McNeill, R.P. Rice, F. Deckelman, et al, "MATNET, an Experimental Navy Shipboard Satellite Communications Network, "IEEE INFOCOM 82 Proceedings, March, 1982.

31. M.L. Molle and L. Kleinrock, "Analysis of Concentrated ALOHA Satellite Links," Sixth Data Communications Symposium, Nov 27-29, 1979, pp. 87-95.