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ADVANCED LOCAL AREA NETWORK CONCEPTS

This technology development program for onboard Local Area Network (LAN) Concepts is based on a balance of academic studies of new protocol and topology through university grants together with in-house analysis and development of simulation tools. In-house simulation of LAN concepts is being backed up by analytic performance models. Another major element of this program is the constant review of the current outside literature on LAN analysis and the review of the Space Station Data System Architecture Study reports.

Development of a good model of the data traffic requirements for LANs onboard the Space Station is a driving problem in this work. A parameterized workload model is under development with its structure to be circulated for comments to other NASA researchers, the potential user community, and the system development contractors. An analysis contract has been started specifically to capture the distributed processing requirements for the Space Station and then to develop a top level model to simulate how various processing scenarios can handle the workload and what data communication patterns result.

Most of the studies are ongoing and the material presented here should be taken as only a sampling of the work. Attached are three distinct items: (1) a summary of the "Local Area Network Extensible Simulator II Requirements Specification", (2) excerpts from a recent Stanford University grant report by M. M. Nassehi, F. A. Tobagi, and M. E. Marhic, "Topological Design of Fiber Optic Local Area Networks with Application to Expressnet", and (3) as an appendix, from a Santa Clara University grant, Prof. T. J. Healy, "Coding and Decoding for Code Division Multiple User Systems," IEEE Transactions on Communications, April 1985.

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**ADVANCED
LOCAL AREA NETWORK
CONCEPTS**

**TERRY GRANT
NASA-AMES RESEARCH CENTER
APRIL 1985**

LOCAL AREA NETWORK EXTENSIBLE SIMULATOR
(LANES)

OBJECTIVE: TO PROVIDE A SIMULATION MODELING CAPABILITY OF ONBOARD LOCAL AREA NETWORK (LAN) CONCEPTS WITH APPLICATION TO THE SPACE STATION DATA SYSTEM

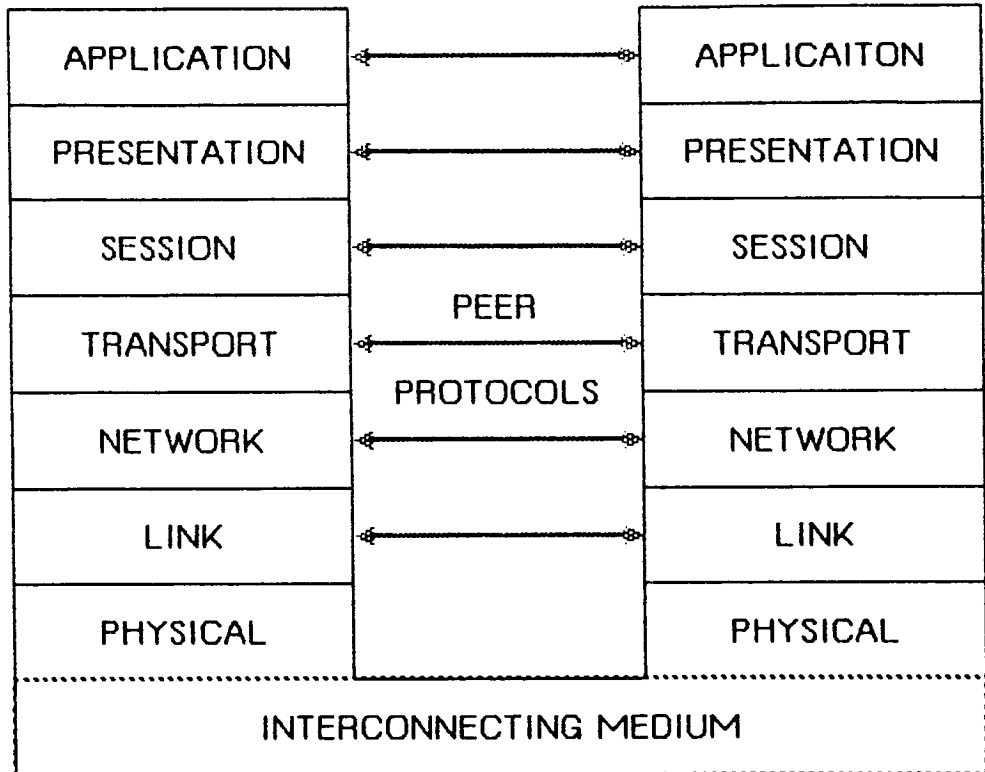
JUSTIFICATION: TO PROVIDE FOR DEVELOPMENT AND TECHNICAL INTERCHANGE OF VIABLE SPACE STATION LAN DATA SYSTEM CONCEPTS THROUGH SIMULATION MODELING

APPROACH: DEVELOP A VERSATILE MODEL OF LAN TECHNOLOGY THROUGH IMPLEMENTATION OF THE ISO-OSI NETWORK PARADIGM USING STATE-OF-THE-ART MEDIA ACCESS RULES AND PHYSICAL LAYER TOPOLOGIES.

TECH TRANSFER: DELIVER SIMULATION CAPABILITY FOR EXPERIMENTATION THROUGH REMOTE ACCESS OF LANES VIA TELENET AS INDIVIDUAL MODELS ARE DEVELOPED:

- 0 NASA CENTERS
- 0 INDUSTRY
- 0 UNIVERSITIES

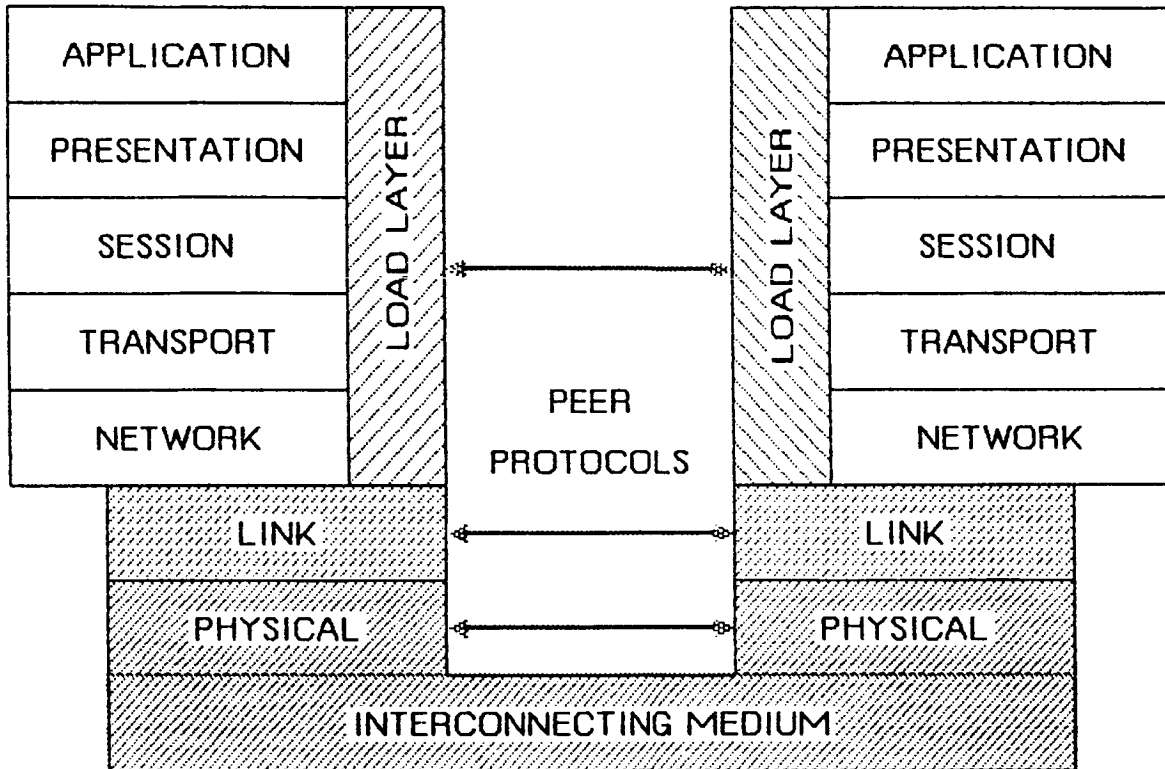
INTERNATIONAL STANDARDS ORGANIZATION—
OPEN SYSTEMS INTERCONNECT
(ISO—OSI)
REFERENCE MODEL



LOCAL AREA NETWORK EXTENSIBLE SIMULATOR

VERSION I

ISO-OSI MODEL



PHYSICAL LAYER - PASSIVE STAR

LINK LAYER - CSMA/CD/TS (FODS) PROTOCOL

LOAD LAYER - SINGLE MESSAGE SIZE,

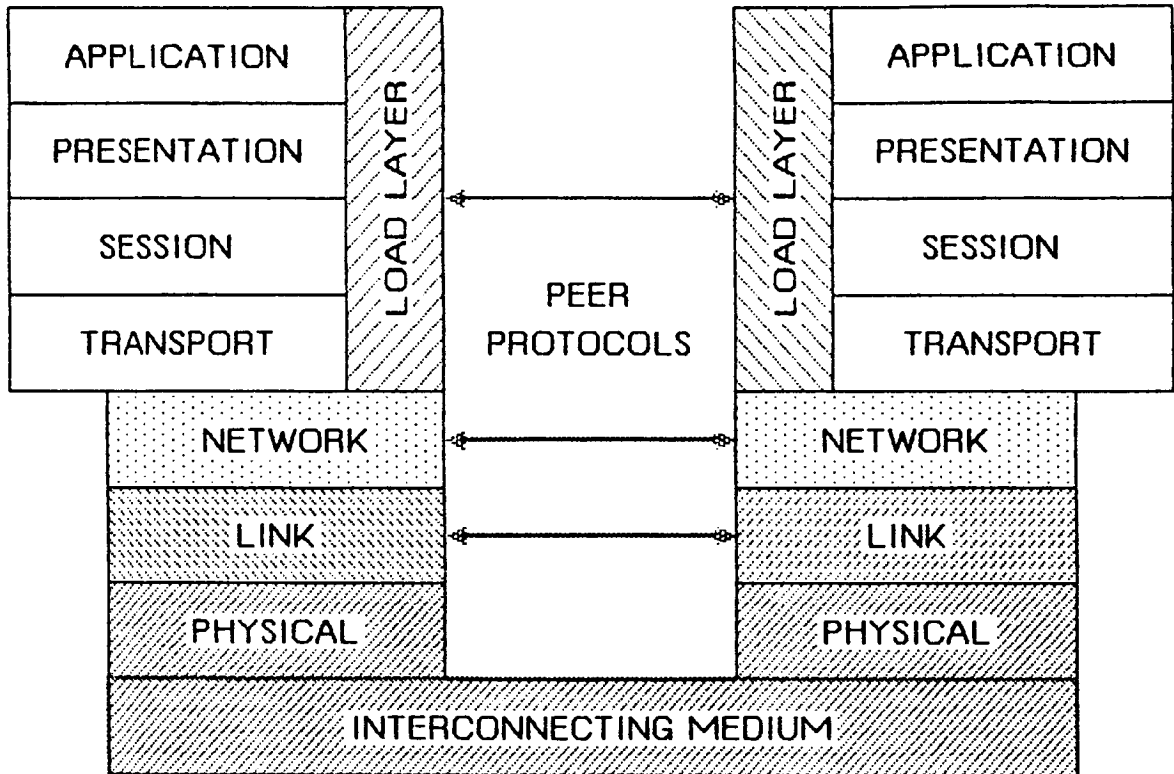
USER DEFINED MESSAGE INTERARRIVAL TIME

USER DEFINED MESSAGE ABSORPTION TIME

LOCAL AREA NETWORK EXTENSIBLE SIMULATOR

VERSION II

ISO-OSI MODEL



PHYSICAL LAYER

- STAR OR TOKEN PASSING RING

LINK LAYER

- FDS OR FDDI TOKEN RING MEDIA ACCESS CONTROL
(ANSI X3T9/84-X3T9.5/883-16 Rev. 7.2)

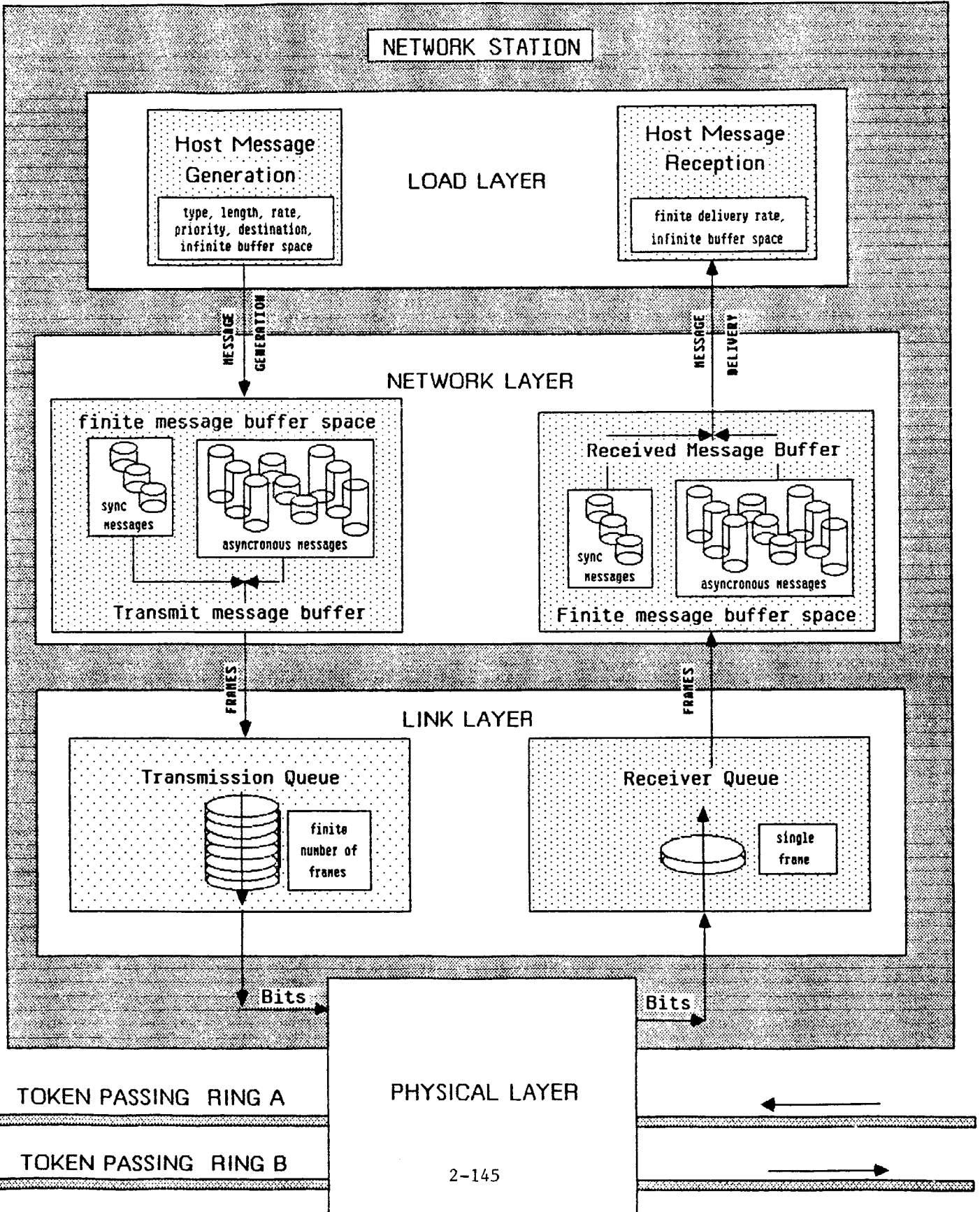
NETWORK LAYER

- USER DEFINED MESSAGE BUFFERING

LOAD LAYER

- USER DEFINED MESSAGE DESCRIPTORS

NETWORK STATION
DATA TRANSMISSION, RECEPTION, AND STORAGE



LANES

USER INTERFACE

THE USER INTERFACE ALLOWS THE EXPERIMENTER TO:

- 0 CONSTRUCT ALTERNATIVE NETWORKCONFIGURATIONS
- 0 SELECTIVELY COLLECT AND ANALYSE DATA
- 0 CONSTRUCT AND RUN MULTIPLE SEQUENTIAL EXPERIMENTS

THE USER INTERFACE PROVIDES:

- 0 USE OF "MENU" SYSTEM TO MANIPULATE LANES PARAMETERS
- 0 AN ON-LINE "HELP" UTILITY
- 0 A HARDCOPY USER'S GUIDE

LANES
DATA COLLECTION AND ANALYSIS SERVICE

COLLECTION SERVICES: STATION LEVEL

- 0 NUMBER OF OCCURRANCES OF ELEVEN PARAMETERS
- 0 MAXIMUM, MINIMUM, AND MEAN VALUE OF ELEVEN PARAMETERS
- 0 INTERVAL BASED COLLECTION OF TWENTY-ONE PARAMETERS
- 0 EVENT TIME TRACES OF ALL STATION ACTIVITY

COLLECTION SERVICES: NETWORK LEVEL

- 0 NUMBER OF OCCURRANCES OF ELEVEN PARAMETERS
- 0 MINIMUM, MAXIMUM AND MEAN VALUES OF TEN PARAMETERS
- 0 INTERVAL BASED COLLECTION OF TWENTY-ONE PARAMETERS

ANALYSIS SERVICES:

- 0 NETWORK THROUGHPUT EFFICIENCY
- 0 TOTAL BUS UTILIZATION

Topological Design of Fiber Optics Local Area Networks With Application to Expressnet*

by

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Abstract

The use of fiber optics technology as a transmission medium in Local Area Networks (LAN's) brings about primarily three benefits: high bandwidth, immunity to electromagnetic interference, and light weight. But in (multi-tapped) passive broadcast bus configurations, the characteristics of certain fiber optics components that are needed, (such as reciprocity and excess loss in optical taps,) place severe constraints which must be taken into account in the topological design of such networks. These constraints manifest themselves in the form of a limitation on the maximum number of stations that a particular network configuration can support, given the components' characteristics and special requirements introduced by the access scheme. In this paper we provide a general and unified approach to the power budget analysis and optimization problem, and apply the technique to the study of a number of interesting high-performance LAN's, among others, Expressnet.

*This work was supported by the National Aeronautics and Space Administration under Contracts NASA-NAG-2-292 and NASA-NAGW-419. M. Mehdi Nassehi is on an IBM Graduate Fellowship.

†On leave from Northwestern University, Dept. of Electrical Engineering and Computer Science, Evanston, IL, 60201.

VI. Conclusion

A number of configurations for fiber-optics implementation of Expressnet, and other related networks, were presented. Based on a unified approach, the maximum number of stations N_{\max} that each of these configurations can support was computed.

For local area networks such as Expressnet, it proved useful to make a distinction between the *connectivity* requirement needed for broadcast communication and the *linear ordering* requirement needed for access control. Such a distinction allowed us to consider configurations consisting of two separate subnetworks: one called the *data subnetwork* satisfying the connectivity requirement, and the other called the *control subnetwork* satisfying the linear ordering requirement. The topology of the control subnetwork is inherently *linear*. When the topology of the data (collection) subnetwork is linear, then the latter automatically satisfies the linear ordering requirement and a separate control subnetwork becomes unnecessary.

The numerical results have shown that, with multimode fibers, high-cost components, and uniform optimization of couplers, all fiber-optics configurations implementing Expressnet can support more than 50 stations, with the exception of the all-linear configuration (i.e., linear collection and linear distribution) which can support 30 stations. For configurations in which the *data (collection) subnetworks* do not have a linear topology (i.e., tree, star, or compound), the number of stations that these data subnetworks can support (discarding the control subnetwork) far exceed 50, reaching several hundreds. The limitation of 50 to 70 stations, depending on the data rate (50 Mbps to 200 Mbps,) is then imposed by the linear control subnetwork. For components with mid-range parameters, only data subnetworks with the star topology and compound topologies (with large funneling width) can support large numbers (also in the hundreds). All others including the linear control subnetwork can hardly reach 10. Low cost components in all cases are totally inappropriate.

The numerical results have also shown that individual optimization substantially improves the number of stations, doubling it in many cases (obviously, with the exception of the star network where no 2×2 coupler is used.) It was observed that the singlemode fiber technology does not outperform the multimode case, despite the lower excess-loss of couplers in the former. This is due to the fact that the amount of optical power that can be injected into a singlemode fiber is significantly smaller than what can be injected into a multimode fiber.

From these results, it is clear that there are configurations in which one can support a significant number of stations, and that the main limitation comes from the linear ordering requirement imposed by the scheme. This suggests that the use of repeaters on the (fiber-optics) linear control subnetwork may be necessary to increase the maximum number of stations. This also suggests that, if one uses a medium other than fiber-optics (such as twisted-pair and coaxial cable) to implement the control subnetwork, then one could support a much larger number of stations than indicated.

The numerical results obtained for the data subnetworks, (excluding the control subnetwork,) are useful as they pertain to networks based on demand assignment access schemes that do not have the linear ordering requirement. Examples are PODA [34] and IIAM [35] both of which achieve a high utilization of bandwidth by employing a reservation technique. Unfortunately these schemes tend to be more complex than the Expressnet access algorithm, and thus more costly to implement.

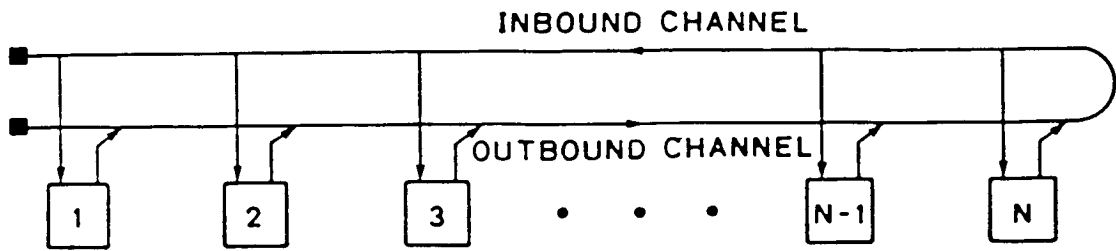


Fig. 2 The folded bus structure.

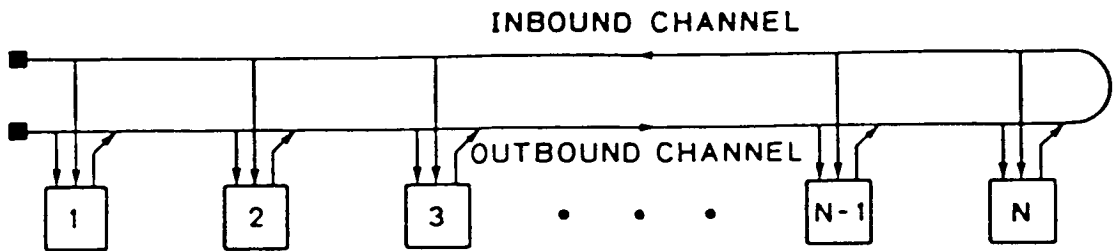


Fig. 3 The folded bus structure with sense taps on the outbound channel.

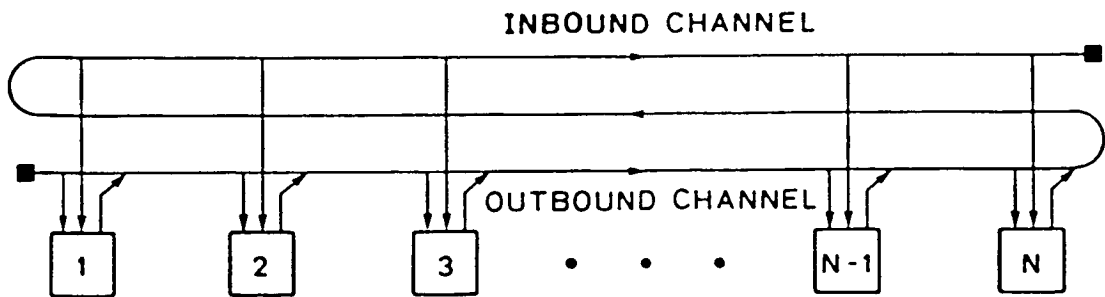


Fig. 4 UBS configuration used with Expressnet.



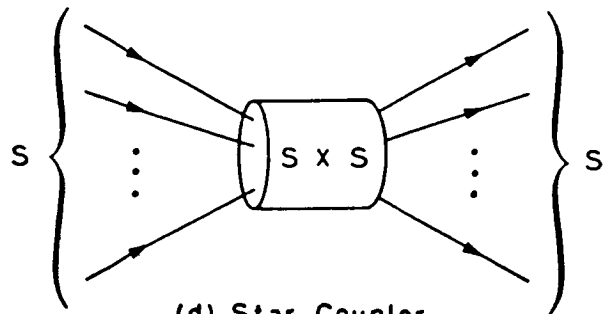
(a) Connector



(c) Coupler C

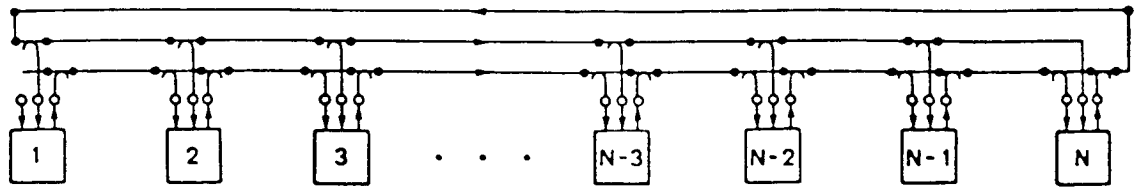


(b) Joint

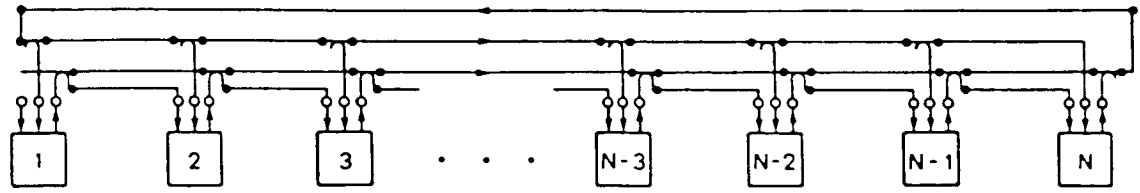


(d) Star Coupler

Fig. 5 Fiber-optics components: (a) a connector, (b) a joint, (c) a coupler, and (d) an $S \times S$ star coupler.



(a)



(b)

Fig. 6 Linear configuration (L).

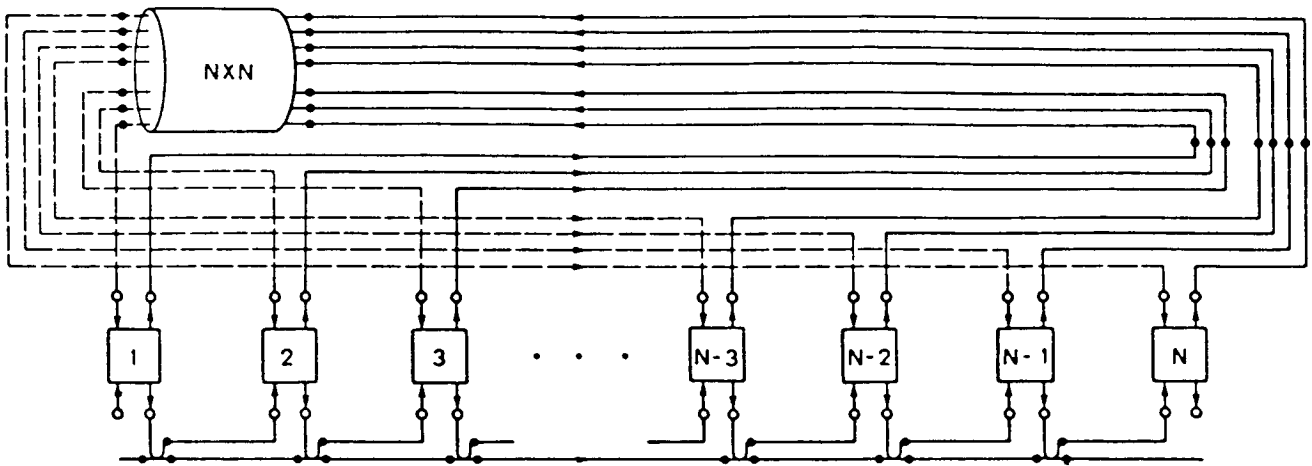


Fig. 7 Star configuration (S/C).

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