An Overview of High-Speed Networking for Workstations

Kerry Hake
Energy Division

Oak Ridge National Laboratory†
P.O. Box 2008
Building 4500N, MS-6207
Oak Ridge, Tennessee
USA 37831-6207
Ph: 615 574-5195
Fax: 615 576-3499
Email: hakeka@ornl.gov

† Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

An Overview of High-Speed Networking for Workstations

Kerry Hake

Oak Ridge National Laboratory
P.O. Box 2008
Building 4500N, MS-6207
Oak Ridge, Tennessee
USA 37831-6207
Ph: 615 574-5195
Fax: 615 576-3499
Email: hakeka@ornl.gov

Abstract

Future-proofing computing investments in the GIS world no longer just means procuring fast iron and vast storage. Planning the next workstation environment upgrade means considering quick transfer of computed and stored information. The telecommunications industry provides an increasing number of new technologies towards this end. High-speed networking has moved from the domain of long distance telephone companies right down to the Local Area Network (LAN). Couple this with a faster generation of Ethernet just now reaching the market and the choices become difficult. This paper briefly examines three new networking technologies, Fast Ethernet, 100VG-AnyLAN, and Asynchronous Transfer Mode (ATM).

These network technologies base themselves on approved national and/or international standards. They have industry backing in the form of forums is the case of 100VG-AnyLAN and ATM, and an alliance for Fast Ethernet. They compete in the high-speed LAN market, roughly defined here as 100 Megabits per second (Mbps). Even so, the three networking technologies have somewhat different attributes worth considering. Fast Ethernet serves as a logical extension to its predecessor 10 Mbps Ethernet providing a ten-fold increase in transmission rate. 100VG-AnyLAN offers extensions to Ethernet but embraces the world of Token Ring technology. This allows for internetworking and better performance for networked video. ATM takes a radial approach by simplifying the information quantum to a 53-byte cell. This results in rapid data handling for telecommunications equipment and allows efficient transport of data, video, and voice communications.

Other technologies compete for this market. Some hybrid approaches such as switched Ethernet or Full Duplexing may prove useful for some situations. The ultimate test of usefulness for any of these technologies lies in how they handle the GIS environment requirements. Working demonstration systems will help clarify marketing rhetoric and determine which vendor best implemented the standard.

Introduction

Rapid growth of networking and inter-networking spurred the networking industry to form three important strategic coalitions in recent years. The Fast Ethernet Alliance, the 100VG-anyLAN Forum, and The ATM Forum stake claims on the lucrative high-speed network market. They base themselves on competing standards offering hardware and software solutions. This paper provides a quick overview of these emerging high-speed technologies for the Geographic Information System (GIS) workstation.

The obvious first question is, "What is high-speed networking?" Simply put, it is characterized as anything faster than the conventional products available in the late 1980s. No strict definition exists. However, a rule-of-thumb would be a transmission rate equal to or better than 100 million bits per second (Mbps). By way of comparison, conventional Ethernet runs at 10 Mbps over copper wire while Asynchronous Transfer Mode (ATM) over fiber optic cable starts at 155 Mbps.

A recitation of transmission rates, however, does not provide an appreciation for the practical implications of these technologies. High-speed networking allows you to read large data files from a networked workstation with the ease at which you now access word processing files. The contents of a CD-ROM can be transfered over the network in a matter of minutes. Full-motion video appears smooth during peak network demand. Video conferencing looses its jerky appearance and does not require a separate network. Client/server applications support more clients and large-format data types. A mid-afternoon disk backup from a workstation to a server has no adverse affect on network responsiveness. Graphically-based network browsing software will respond within user expectations. Local Area Networks (LANs) extend over a Wide Area Network (WAN) without noticable performance degradation.

Workstations constitute an important driving force for high-speed throughput. As an output device to high-performance computers, they must keep up with a steady stream of graphical visualization computations. As clients, they demand huge data streams from servers. As peers, they claim a large percentage of overall network throughput for shared resources. Add to these the growing network demands for decentralized Internet data serving, multimedia data streams, and telephony functionality and you have good idea of the demands originating from a single network node, the workstation.

Downsizing applications from mainframe to workstation has significantly contributed to workstation demands for high-speed networking at The Center for Transportation Analysis (CTA), Oak Ridge National Laboratory (ORNL). Spatial databases and transportation analysis tools, once the domain of mass storage devices in a central processing environment, have moved to workstations. CD-ROMs now hold the same information once stored on dedicated disk packs. During the course of the day client/server window managers use the network, constantly displaying and refreshing these multi-megabyte datasets. CTA project demands necessitate a private or segmented fast LAN both to match existing internal demand and to build in capacity for future external access.

Three Competing Standards

Choosing the right network no longer means solving the dilemma of Ethernet versus Token Ring. Whether migrating to a faster system or starting fresh, you must ponder the conflicting claims of outwardly similar offerings. Of the three chosen for examination, two grow out of existing IEEE (Institute of Electrical and Electronic Engineers) standards and one, ATM, from a collection of standards. The IEEE offerings, Fast Ethernet and 100VG-anyLAN, strive to enhance existing LAN standards. Fast Ethernet enhances the10 Mbps standard to 100 Mbps. 100VG-anyLAN couples 10 Mbps Ethernet with the 4 and 16 Mbps Token Ring standard to produce a 100 Mbps standard. (See Table 1 for standards designations). ATM, which runs over a WAN at speeds from 155 Mbps to 622, Mbps will also run at 100 Mbps based on soon-to-be approved standards.

Table 1. Comparison of Network Standards and Speeds

Fast Ethernet

Ethernet evolved into a workstation and desktop networking standard in the early '80s. This technology uses cabling for a backbone between network controllers or hubs. Workstations then attach to the hub (Figure 1). Two important aspects of networking are defined in the standards, how to handle network traffic, and the cable necessary to carry the signal. Ethernet uses a Carrier-Sense Multiple Access with Collision Detection (CSMA/CD) scheme. Simply put, workstations wait to send a frame of information until they detect no electrical signals (just the presence of the carrier). If two workstations transmit at the same time, a collision occurs and they each re-transmit at an independent, random time interval. Since this scheme heavily relies on the chances of collisions remaining low, it is termed a probabilistic approach. The physical characteristics of cabling allow signals to travel at certain reliable speeds and distances. Types of cabling include a thick cable with multiple copper wires, telephone type cabling with twisted copper wire pairs, and optical fiber cable (Table 2).

Figure 1. Generalized Ethernet Network Topology

Table 2. Cable Types

LAN-attached workstations often experience traffic congestion. A high-performance GIS workstation can literally monopolize the network since Ethernet only allows access to one end node at a time. Fast Ethernet readily addresses these types of problems. It provides a solution permiting workstations to transact its business 10 times faster. Raising the network speed limit presumably frees the network more quickly, thus allowing more workstations to enter more frequently. The Fast Ethernet Alliance (see end notes) was formed to promote a faster Ethernet standard.

The Fast Ethernet comes from IEEE 802.3 standards committee. It is sometimes referred to as 100 Base-X because the cabling standards for Fast Ethernet all begin with the term "100 Base". The basic standard specifies two-pair Category 5 Unshielded Twisted Pair (UTP) cabling, 100 Base-TX (Figure 1). For longer distances, the 100 Base-FX specifies multimode fiber optic cable. A third cabling standard broadens the range of cabling to Category 3, 4, or 5 UTP with four-pair wiring. The IEEE finalized 100 Base-T the end of 1994, for all practical purposes, and hopes to officially release the 100 Base-TX and 100 Base-FX standards in 1995.

This standard also requires a new Network Interface Card (NIC) for each workstation. Since the Fast Ethernet complies with the 802.3, the NIC may be designed to work at both 10 and 100 Mbps. Such a card could replace an existing Ethernet NIC allowing a staged LAN upgrade. Prices range 2 to 5 times higher than Ethernet adapters with parity expected by mid 1996.

100VG-AnyLAN

Under the oversight of the 100VG-AnyLAN Forum (see end notes) 100VG-AnyLAN implements the IEEE 802.12 standard for transmitting Ethernet (802.3) and Token Ring (802.5) over the same 100 Mbps cabling. 100VG-AnyLAN, like Fast Ethernet, runs over existing 10 Base-T topologies without alteration. (See Table 2 for the full range of cabling options). Unlike Fast Ethernet, it allows for interoperation with Token Ring networks. Token Ring, sometimes referred to as IBM Network or IBM Ring, determines ahead of time who passes a frame of information onto the network. This deterministic approach, as compared to Ethernet's probabilistic scheme, prevents collisions by passing a "token" around a connected ring of workstations (Figure 2). Each workstation waits to receive the token before it transmits data to the network. 100VG-AnyLAN employs Demand Priority Protocol (DPP) for eliminating collisions and minimizing token rotation time. DPP accommodates time-critical applications like real-time video by assigning one level of priority for data and another for multimedia. This assures non-stop transmission for video conferencing and video on-demand based on standards like MPEG (Motion Picture Experts Group). Every workstation NIC must be replaced to conform with the standard. Integrating an exisiting Ethernet and Token Ring LAN requires a separate hub (Figure 3). Unlike Fast Ethernet, however, the NIC will probably not be backwardly compatible with 10 Mbps Ethernet. Thus, upgrading to 100VG-AnyLAN requires an immediate, system-wide transition.

Figure 2. Generalized Token Ring Network Topology

Figure 3. Generalized 100VG-AnyLAN Network Topology

100VG-AnyLAN design allows it to integrate with existing LAN cabling provided it meets the 10 Base-T or Token Ring cable specifications (Table 2). The VG portion of 100VG-AnyLAN stands for Voice Grade. This means it operates over less expensive 4 twisted pair, category 3, voice grade cable.

Asynchronous Transfer Mode

The ATM standard appears to many as the final solution to networking. It scales down or up to WAN and LAN networks. ATM Networks currently run at 155 Mbps and soon will branch to 100 Mbps and 622 Mbps. The technology provides network carrying capacity as needed, sometimes called bandwidth on demand. It handles numerous protocols, interoperaateing with Internet Protocol (IP), X.25 (packet switching), and Frame Relay (high-speed packet switching). It carries multiple traffic types such as data, video, and voice. In fact, ATM has become the standard of choice for the US telecommunications long haul carriers in WAN applications. LAN offering entered the market in earnest with numerous vendor announcements the second half of 1994

The elegance of simplicity forms the attraction of this standard. Unlike the variable frame size of Ethernet and Token Ring, the basic information quantum is a fixed-length 53 byte cell. Switches operate at high speeds because there is no overhead associated with processing variable length frames with preceding and following information bits (headers and trailers). Each cell does, however, have a 5-byte information field. This field pertains to the ATM network addressing to set up virtual connections. The fixed cell size facilitates high-speed transfer of multi-megabyte files, fast transfer of screen updates to workstations from high-performance computers, and flicker-free display of real-time video and video playback. Oddly enough this simple, elegant solution introduces a bewildering number of network configurations because of it multi-level applicability (Figure 4). It also produces a vast amout of terminology (see end notes).

Figure 4. Generalized ATM Network Topology

The ATM Forum claims 290 principle members as of November 22, 1994. The list includes major computer manufacturers, telecommunications carriers, telecommunications equipment manufacturers, and major networking software firms. They maintain a current listing on their World Wide Web server (see end notes).

The ATM Forum ostensibly functions as its own standards organization because of its diverse technical membership and international presence. Even so, they coordinate with numerous standards organizations including the IEEE, the International Telecommunications Union (ITU), and Internet Engineering Task Force (IETF). The ATM Forum Technical Committee has produced three documents: The User-Network Interface (UNI) specification for interoperability between ATM products, the Data Exchange Interface (DXI) specification for how existing network equipment should act as front-end processors to ATM, and the Broadband Inter-Carrier Interface (B-ICI) to define inter-carrier services. These specifications plus others covering LAN emulation, network management (M3 and M4), physical interfaces (100 Mbps, DS3, OC-3), and Private Network-to-Network Interface (PNNI) for internetworking exist in various stages of approval. Many hardware and software vendors have announced LAN products in 1994 with significant delivery dates in 1995. ATM appears as the workstation networking flagship with the shake-down cruise beginning this year.

Conclusion

All three technologies, Fast Ethernet, 100VG-AnyLAN, and ATM, appear to compete in the same 100 Mbps LAN market. Even so, each exhibits different strengths for high-speed LAN applications. Fast Ethernet offers a step-wise upgrade path to 100 Mbps and performs well for routine data transfers within a workstation LAN. Many view it as the logical successor to Ethernet. 100VG-AnyLAN requires immediate wholesale network changes but offers an advantage for video data transfer. It looks to improve Ethernet not only with speed but by including its rival Token Ring. ATM handles data, video, and voice for an integrated mixed-media environment with seamless integration to a WAN. An important difference between technologies lies in the way the hardware vendor implement each standard.

Other technological solutions compete in the high-speed LAN arena. These include FDDI (Fiber Distributed Data Interface), CDDI (Copper Distributed Data Interface), Fibre Channel, High Performance Parallel Interface HIPPI, and isoENET (ISOETHERNET or Isochronous Ethernet). Two hybrid technologies based on switching and doubling connectivity (full-duplexing) stand out as popular migration strategies.

The first hybrid solution, switching, works on networks from 1 Mpbs to 100Mbps for Ethernet and up through 622Mbps for ATM. Proponents point out this technology extends the life of legacy systems by keeping the same NIC and most cabling. A likely implementation of a switching solution would include high-speed switches with Fast Ethernet to connect servers. In this case, a Fast Ethernet backbone linking a series of 10/100 Mbps switches would provide a dedicated 10 Mbps of bandwidth to each workstation. Only the servers receive a new NIC. Likewise only the backbone connecting the servers requires new cabling. Thus the hybrid network minimizes the conversion cost. (The network design or topology would apprear like Figure 1 except with a 100 Mpbs link between the hubs). This type of upgrade works fine if the network merely wants to transmit routine data types. However, transmission speed demands of new data types such as voice and video would quickly obsolesce a switched system.

The second hybrid solution, Full Duplexing, takes an extra pair of wires to accomplish its function. In this situation, Ethernet may simultaneously receive and send without a collision. An overriding limitation stems from the performance burden placed on each workstation by increasing CPU utilization. The increase in network throughput does not come close to doubling the base speed as implied by the name.

The emphasis of Fast Ethernet and 100VG-AnyLAN rhetoric centers on what they can deliver to the LAN market today and what ATM only promises for tomorrow. Not all cabling choices are approved standards much less the concomitant switches, hubs, routers, and bridges. A wise GIS systems manager should learn the difference between an announced product name and a shipping part number. Ask to see a working demo, preferably at a customer site. Be aware that several vendors belong to more than one networking camp, which may work to a customer's advantage. Finally, remember standards are only as good as their implementation.

Selected Readings

Bryan, John, 1994. "LANS Make the Switch," Byte, September, pp. 113-114.

Bryan, John, 1994. "Fast Ethernet Becomes Focused," Networking, October, p. 96.

Communications Week, "Special Report: ATM," Communications Week, No. 539, January 16, 1995, p. S3-S30.

Costa, Jania Furtek, 1994. Planning and Designing High-Speed Networks Using 100VG-AnyLAN, PTR Prentice Hall: Englewood Cliffs, NJ.

Creager, Ken and Delcamps, David, 1994. "Moving to Faster LANs, The Computer Conference Analysis Newsletter, March 17, No. 338, p. 5.

Krause, Reinhardt, 1994. "100VG-AnyLAN Group Eyes Redundant Links, MPEG," Electronic News (1991), Vol. 40, No. 2005, March 14, p. 36-37.

http://www.atmforum.com/atmforum/atm_basics/notes1.html

Lippis, Nick, 1994. "Love Misguided: The Truth About ATM," PC Magazine, June 14.

Loudermilk, Stephen, 1994. "Full-duplex Technology Pays Off; Token-ring, Fast Ethernet Devices Get a Bandwidth Boost," LAN Times, Vol. 11, No. 20, October 3, pp. 21-22.

McLean, Michelle R., 1994, "Fast Ethernet is Standard, But Deployment in Doubt," LAN Times, Vol. 11, No. 15, August 8, p. 1-2.

Melatti, Lee, 1994. "Fast Ethernet: 100 Mbit/s Made Easy: Thanks to 100Base-T, Breaking the Bandwidth Barrier Doesn't Have to Mean Breaking the Bank," Data Communications, Vol. 23, No. 16, November, pp. 111-114.

Rauch, Peter, 1994. "10-Mbit/s Switched Ethernet doesn't Add Up," Data Communications, Vol. 23, No. 17, November 21, p. 134.

Restivo, Ken, 1994. "The Boring Facts About FDDI," Data Communications, Vol. 23, No. 18, December, pp. 85-89.

Slawter, Barry, 1995. "ATM Spec Gets Mixed Reviews," Internetwork, Vol. 6, No. 1, January, p. 1,46.

Sullivan, Kristina B., 1994. "Fast Ethernet Technology Offers Solutions for Overtaxed LANs," PC Week Netweek, Vol.11, No. 38, September 26, p. 16.

Tolly, Kevin, 1994. "100VG Nowhere LAN," Data Communications, Vol. 23, No. 16, November, pp. 37-38.

Notes

Fast Ethernet Alliance: Forest City, CA, voice: 408.486.6832.

100VG-anyLAN Forum: Founded in March 1994. Chairman - Kenneth Hurst, Valley Communications of Fremont, CA. P.O. Box 1378, North Highland, CA, 95660, voice 916.348.0212, Fax: 916.344.0835.

The ATM Forum: Founded in October 1991. Chairman - Fred Sammartino, Sun Microsystems, 303 Vintage Park Drive, Foster City, CA, 94404-1138, voice 415.578.6860, Fax: 415.525.0182, Fax-on-Demand: 415.688.4318, World Wide Web Server: http://www.atmforum.com, Email: info@atmforum.com.

Sample terminology

The terms included here represent a small fragment of the the telecommunications industry. Most of these were used in this paper and will hopefully aid your understanding of the material covered.

Standards

10 Base-F - 10 Mps Ethernet over fiber optic cable
10 Base-T -10 Mps Ethernet over twisted pair cable
10 Base-2 - 10 Mps Ethernet over coaxial cable
10 Base-5 - 10 Mps Ehternet over "Thick" or AUI cable
10 Net - 1 Mps Ethernet over one twisted pair cable
100 Base-FX - 100 Mps Ethernet for multimode optical fiber
100 Base-T - 100 Mps Ethernet, general term for Fast Ethernet
100 Base-TX - Category 5 UTP with two-pair cable
100 Base-T4 - 100 Mps Ethernet for Category 3, 4, or 5 UTP with foru-pair cable
100 Base-VG - old name for 100VG-AnyLAN (VG stands for Voice Grade)
100 Base-X - Fast Ethernet standard at 100 Mps using CSMA/CD
100VG-AnyLAN - standard for 100 Mps Ethernet using DPA
802.12 - IEEE standard for 100VG-AnyLAN at 100 Mps
802.3 - IEEE standard for "standard" Ethernet at 10 Mps
802.5 - IEEE standard for Token Ring at 4 or 16 Mps
ATM - Asynchronous Transfer Mode
BISDN - Broadband Integrated Services Digital Network
CDDI - Copper Distributed Data Interface networking standard
DSN - Digital Signal level N where N is 1, 2, 3, or 4 with transmission speeds of 1.544, 3.152, 6,312, 44.736, and 274.176 Mbps respectively
FDDI - Fiber Distributed Data Interface networking standard
Fibre Channel - ANSI networking standard
HIPPI - High Performance Parallel Interface ANSI networking standard
ISDN - Integrated Services Digital Network
isoENET - Isochronous Ethernet
OC-N - Optical Carrier level N where N is 1,3,9,12,24,36, or 48 with transmission speeds of 52, 155, 466, 622, 933, 1200, 1900, and 2500 Mbps respectively
OSI - Open Systems Interconnect, a standard network model
SONET - Sychronous Optical NETwork
X3T11 - ANSI standard for Fibre Channel

Standards organizations

ANSI - American National Standards Institute
CCITT - Consultatif Internationale de Telegraphique et Telephonique or Consultative Committee on International Telegraphy and Telephone. It is now called the ITU-T.
ECSA - Exchange Carriers Standards Association
IEEE - Institute of Electrical and Electronic Engineers
ITU - International Telecommunications Union
ITU-T - International Telecommunications Union - Telephony
MPEG - Motion Picture Experts Group

IETF - Internet Engineering Task Force

Nomenclature
AUI - Attachment Unit Interface (thicknet connector)
CAN - Campus Area Network
CSMA/CD - Carrier-Sense Multiple Access with Collision Detection
DPA - Demand Priority Access
DPP - Demand Priority Protocol
Fibre Channel -
LAN - Local Area Network
MAN - Metropolitan Area Network
NIC - Network Interface Card
NOC - Network Operations Center
STP - Shielded Twisted Pair
UTP - Unshielded Twisted Pair
WAN - Wide Area Network

Table 1. Comparison of Network Standards and Speeds.

Current Name	Speed (Mps)	Standard	Other Name
100VG-AnyLAN	100	IEEE 802.12	100-BaseVG
ATM	25-622	ITU, BISDN, TETF, IEEE	none
Ethernet	10	802.3	10 Base-T
Fast Ethernet	100	802.3	100 Base-X
Token Ring	4 & 16	803.5	IBM Network

Table 2. Cable Types.

Standard	Speed (Mps)	Cable Type	Category
10 Net	1	1 twisted pair	-
10 Base-2	10	coaxial	-
10 Base-5	10	AUI (thick net)	-
10 Base-F	10	optical fiber	-
10 Base-T	10	2 twisted pairs (thin net)	3
100 Base-FX	100	multimode optical fiber	-
100 Base-TX	100	2 twisted pairs	5
100 Base-T4	100	4 twisted pairs	3,4,5
100VG-AnyLAN	100	2 twisted pairs 4 twisted pairs, voice grade 4 twisted pairs optical fiber	5 3 4,5 -
ATM	25	4 twisted pairs	5
	50	4 twisted pairs	5
	100	optical fiber	-
	148	optical fiber	-
	255	multimode optical fiber	-

Fig. 1. Generalized ethernet network topology.

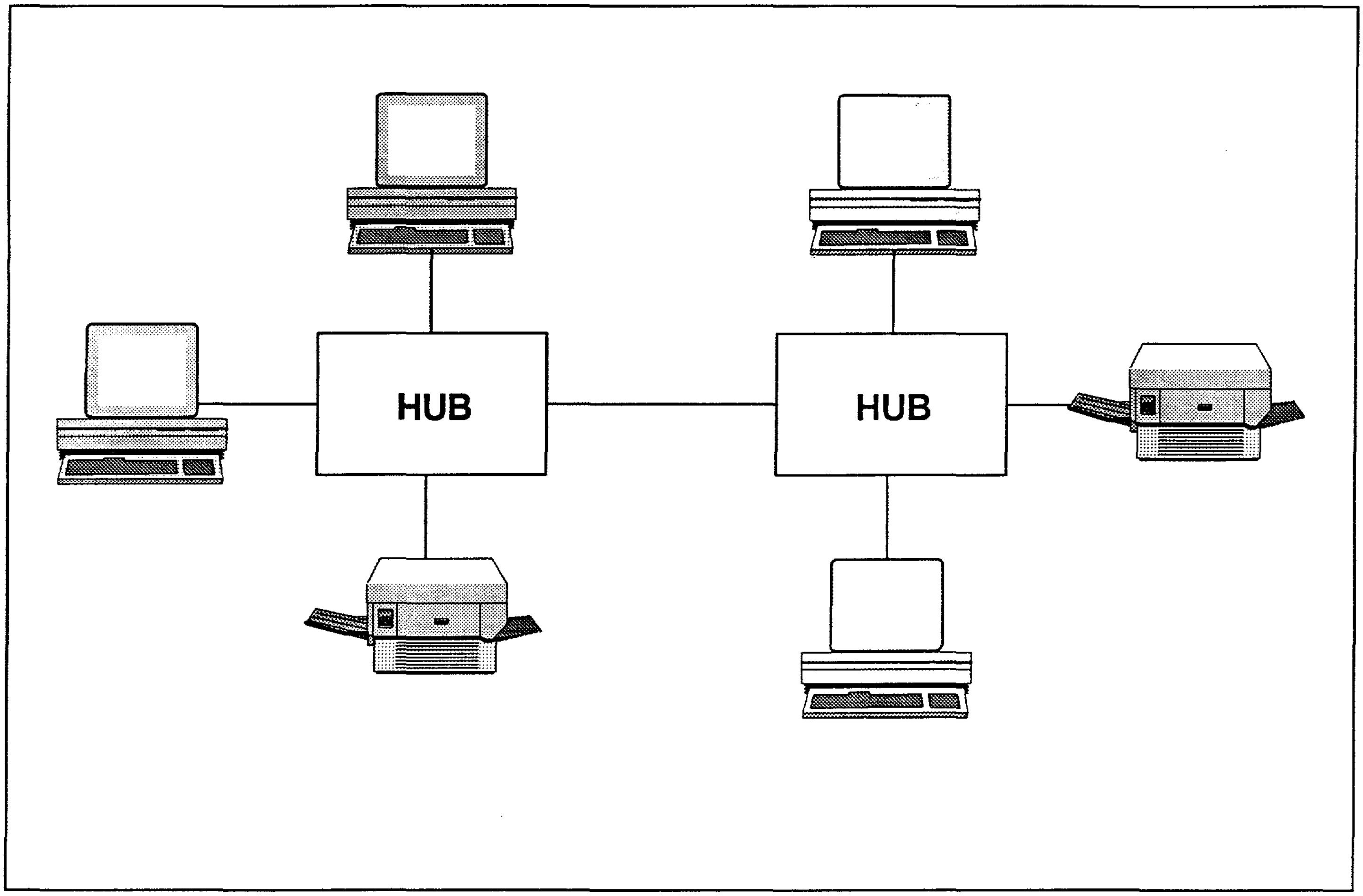

Fig. 2. Generalized token-ring network topology.

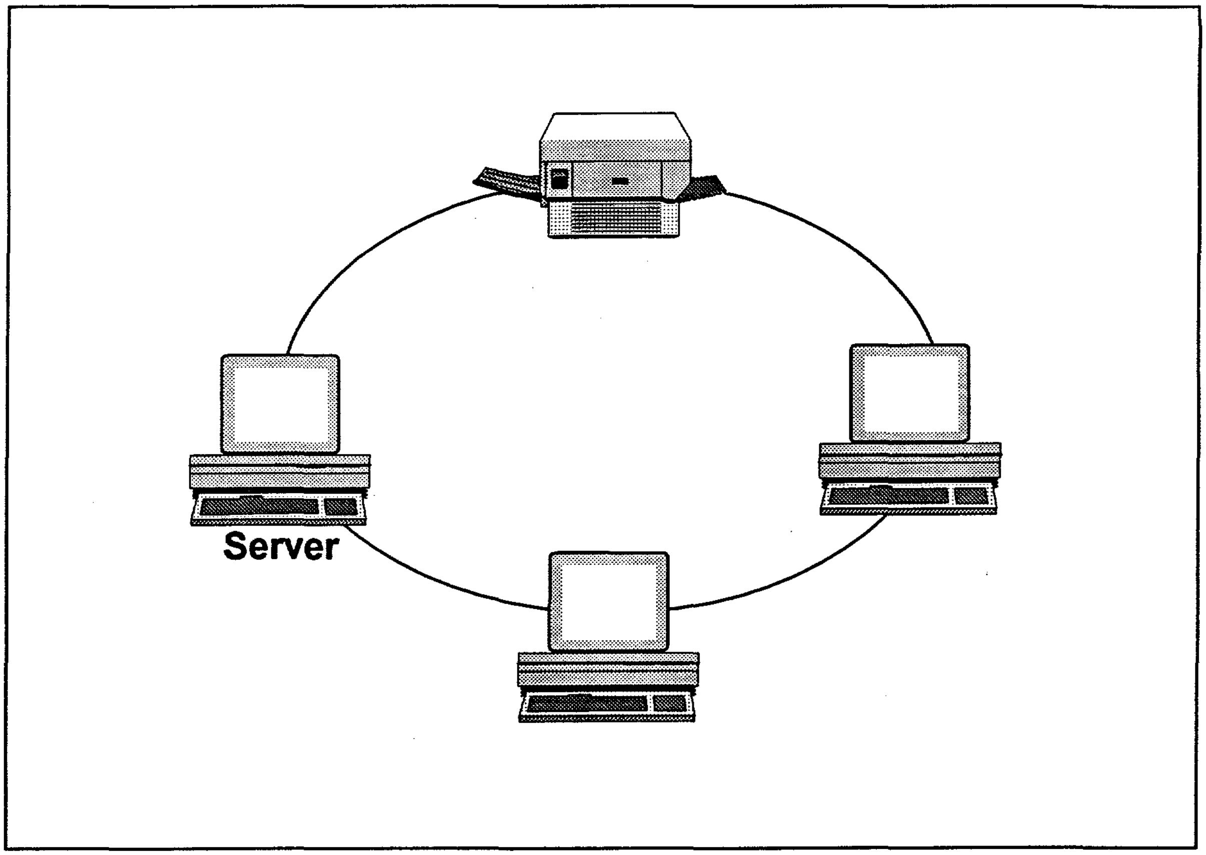

Fig. 3. Generalized 100VG-AnyLAN network topology.

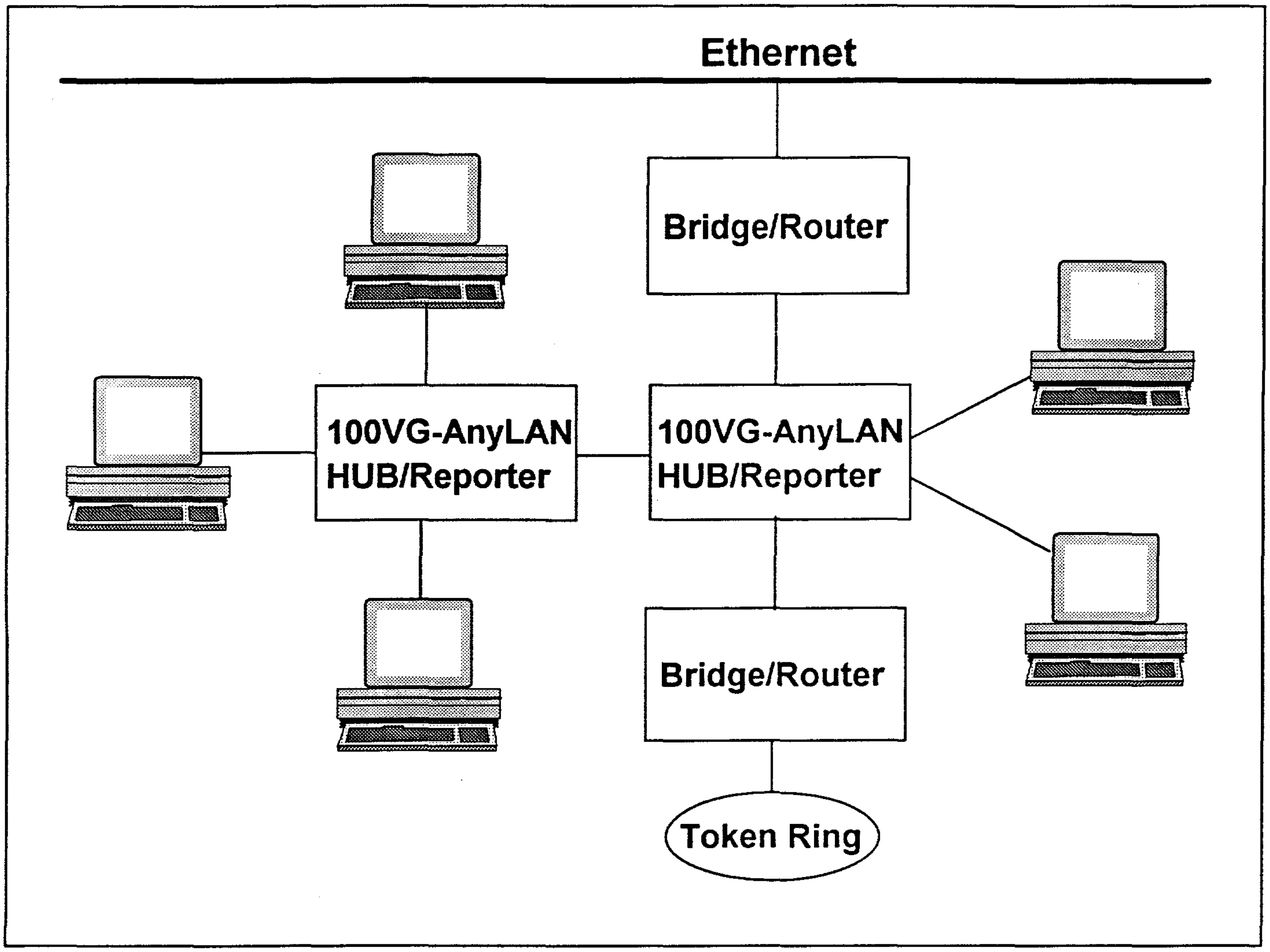

Fig. 4. Generalized ATM network topology.