CHAPTER 7

Non-Ethernet Networks

The Network+ Certification exam expects you to know how to

- 1.2 Specify the main features of 802.5 (Token Ring) and FDDI (Fiber Distributed Data Interface), including speed, access method, topology, and media
- 1.4 Recognize the following media connectors and describe their uses: RJ-45, ST, SC

To achieve these goals, you must be able to

- Define the characteristics, cabling, and connectors used in Token Ring
- Describe the characteristics, cabling, and connectors used in ARCnet and LocalTalk
- Explain the characteristics, cabling, and connectors used in FDDI and ATM

No one denies Ethernet's virtual monopoly as the network technology of choice in today's world. Depending on your choice of source, something like 80 to 90 percent of all network cables in the world run some derivation of Ethernet. Still, in the immortal words of Master Yoda in *The Empire Strikes Back*, "There is another." More precisely, "There are many others," and Network+ expects you to know them as well as you know Ethernet. Some of these network technologies, in particular IBM's famous Token Ring, still enjoy strong followings, especially in organizations that have invested heavily in installing these technologies. Despite their substantial installed bases, though, the chances of you seeing any of these technologies during the course of your networking career are pretty slim. So, look at this chapter as fulfilling two goals: introducing you to the final days of rapidly fading technologies, and getting you past the Network+ questions that address them. Read this chapter carefully—after the test, you may never hear of these technologies again!

Historical/Conceptual

Token Ring

Token Ring, also known as *IEEE 802.5*, competed directly—and in the long run, unsuccessfully—with Ethernet as an option for connecting desktop computers to a LAN. Although Token Ring possesses a much smaller share of the market than Ethernet, Token Ring's installed base has remained extremely loyal. The most common Token Ring networks offer greater speed (16 Mbps) and efficiency than 10BaseT Ethernet, and the Token Ring folks have even established 100- and 1000-Mbps Token Ring standards.

EXAM TIP Expect questions on the Network+ exam about 16-Mbps Token Ring, but not about the 100-Mbps or 1000-Mbps versions.

Token Ring networks may look much like 10BaseT Ethernet networks, even using identical UTP cabling in some cases. Although these network types share the same physical star topology, Token Ring uses a logical ring topology, rather than a logical bus topology.

NOTE Although Token Ring began as a proprietary IBM technology, today the IEEE 802.5 committee defines the standards for this technology. Just as there are minor differences between the original Xerox Ethernet standard and IEEE 802.3, the original IBM standard for Token Ring and the IEEE 802.5 standard also differ slightly from one another. These differences have little impact on the average network tech, so for all intents and purposes, Token Ring and IEEE 802.5 should be considered synonyms.

Test Specific

Logical Ring Topology

Token Ring networks use a logical ring topology (see Figure 7-1). Unlike an Ethernet node, which broadcasts its frames across a shared cable to every other computer on the segment, a Token Ring node communicates directly with only two other machines: its *upstream and downstream neighbors* (see Figure 7-2). To control access to the ring, Token Ring employs a system of *token passing*.

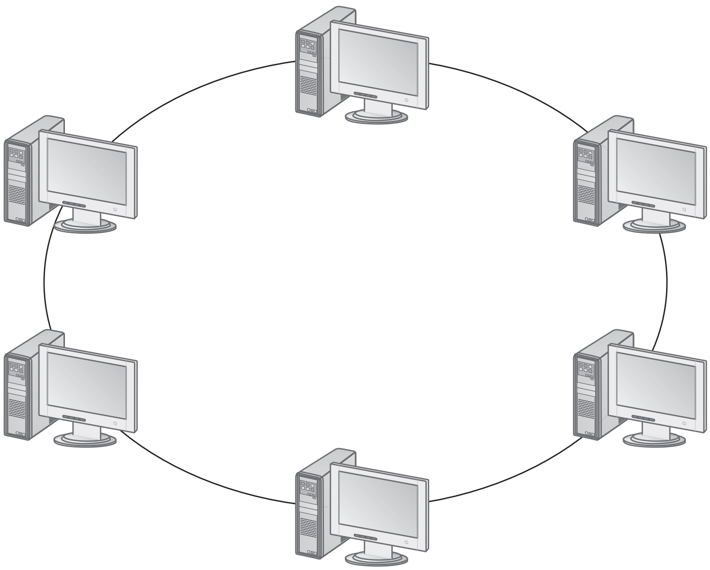


Figure 7-1 Token Ring networks use a logical ring topology.

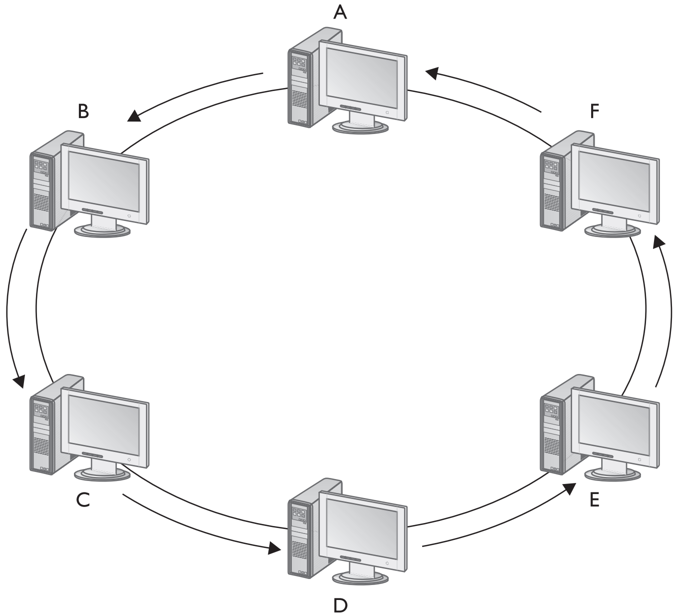


Figure 7-2 Node *A*'s downstream neighbor is node *B* and its upstream neighbor is node *F*.

Token Passing

The cornerstone of token passing is a special frame called the *token*. This frame enables the systems on a Token Ring network to effectively "take turns" sending data. The rule is that no device can transmit data unless it's currently holding the token. Because collisions simply cannot occur under this system, Token Ring nodes can make full use of the network's bandwidth, and thus operate more efficiently than Ethernet networks using CSMA/CD.

A Token Ring frame begins with the token itself, but otherwise contains much the same information as an Ethernet frame: the source MAC address, the destination MAC address, the data to be transmitted, and a *frame check sequence (FCS)* used to check the data for errors (see Figure 7-3). When receiving a frame, a Token Ring node checks the destination MAC address to determine whether to process the data it contains or send the frame to its downstream neighbor. When the intended recipient processes the data, it creates a new frame that includes a special code indicating that the frame was received in good order. The receiving node then sends this frame around to the sending node. When the sending node gets the frame with the "received in good order" code, it removes the frame from the wire and sends out a new free token—that is, a new frame consisting of only a token.

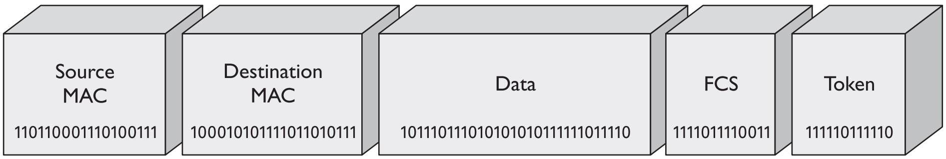


Figure 7-3 A Token Ring frame

The free token tells any node that receives it that the ring is available. A node with data to send must wait until it receives a free token; it then creates a data frame, which includes a token, and sends the new frame on to its downstream neighbor (see Figure 7-4). Again, when the sending node receives confirmation that the intended recipient received the frame, it generates a new free token, giving the next machine inline access to the ring.

A token-passing network sends data frames more efficiently than one using CSMA/CD because no collisions occur. A station may have to wait for a free token before it can send, but if it has the token, it knows no other station will try to send at the same time. In contrast, a CSMA/CD-based network, such as Ethernet, can waste significant bandwidth resolving collisions. Token passing is a deterministic method to resolve which machine should have access to the wire at a given moment. *Deterministic* means that access to the wire is granted in a predictable way, rather than through a random process like CSMA/CD. No virtual dice rolling here!

Token Ring Speed

Token Ring networks can run at either 4 or 16 Mbps, speeds that sound slow compared to the 10- and 100-Mbps Ethernet standards (again, newer versions of Token Ring improve on these speeds, but the Network+ exam has little interest, so for the moment at least, neither do we). The raw numbers, however, do not tell the full story. Token Ring networks use every bit of their bandwidth to send data. Ethernet networks, in contrast, waste significant amounts of bandwidth resolving collisions. Because of the wasted bandwidth inherent in Ethernet networks, many well-informed techs argue that 4-Mbps Token Ring's performance almost as fast as 10-Mbps Ethernet, and that 16-Mbps Token Ring's performance significantly faster. The speed at which the ring operates, however, depends on the slowest device on the ring. A Token Ring network consisting of five 4/16-Mbps Token Ring nodes and one 4-Mbps Token Ring node will run at 4 Mbps (see Figure 7-5).

Token Ring networks can be configured to give some systems higher-priority access to the token. Conceivably, a network architect could set a high priority for a particular PC, ensuring that it would get access to the token more often than other nodes on the network. Real-life Token Ring networks rarely take advantage of the capability to prioritize traffic, making the feature less useful than it might seem.

Figure 7-4 After receiving a free token, node *A* can send new data to its downstream neighbor.

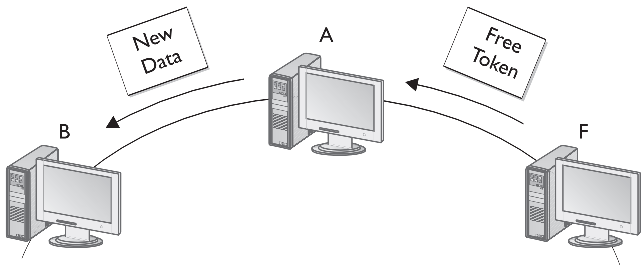
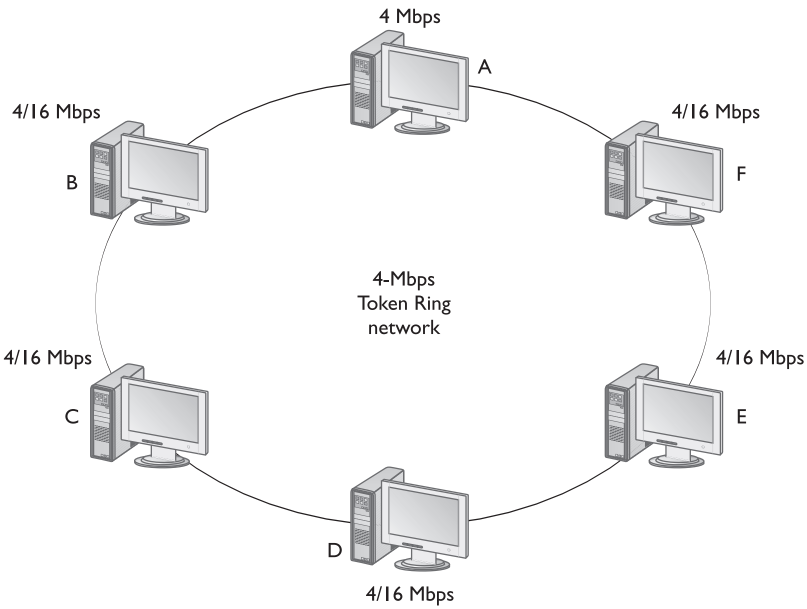


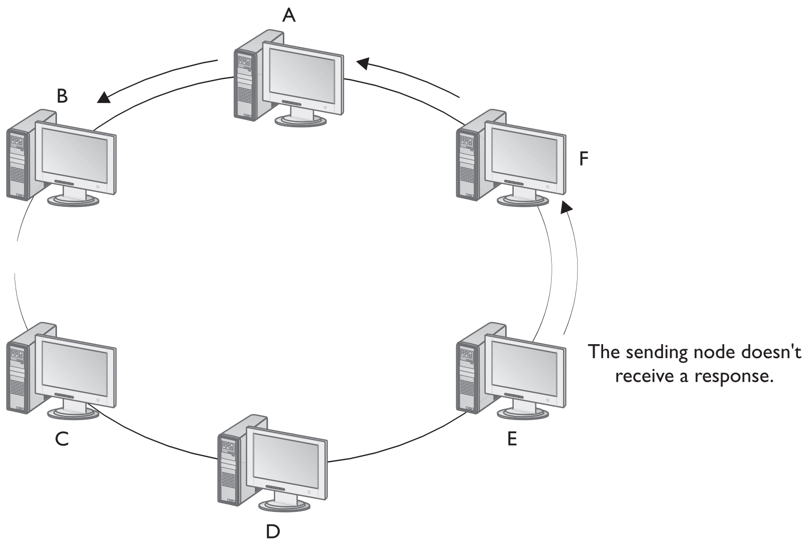
Figure 7-5 The slowest device on the ring determines the speed of the ring.



Physical Star

Physical ring topology shares the same vulnerability to cable breaks as physical bus topology. When the cable used by a physical bus topology such as 10Base2 breaks, the entire network shuts down due to electrical reflections. A physical ring topology would also fail completely from a cable break, but for a different reason. In a ring topology, all traffic travels in one direction. If the ring breaks, traffic can never complete the round trip around the network, so no node will generate a free token (see Figure 7-6). To avoid the problems inherent in a physical ring topology, Token Ring uses a physical star topology.

Figure 7-6 A physical ring topology cannot function if the ring breaks.



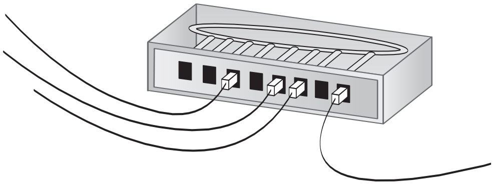


Figure 7-7 The MAU contains the logical ring.

Token Ring hides the logical ring inside a hub, technically referred to as a *Multistation Access Unit (MAU)* (see Figure 7-7). You will also see the abbreviation *MSAU*, which is less common but means the same thing. Individual nodes connect to the hub via either unshielded twisted-pair (UTP) or shielded twisted-pair (STP) cabling (Figure 7-8).

NOTE Terminology alert! To make our lives more difficult, Token Ring documentation can refer to Multistation Access Units by two different acronyms: MAU and MSAU. The terms Token Ring hub, MAU, and MSAU are synonymous.

Token Ring over STP

Originally, Token Ring networks used a heavily shielded version of twisted-pair cabling referred to as *shielded twisted pair (STP)*. STP consists of two pairs of copper wires surrounded by a metal shield (refer to Chapter 4, Figure 4-14). STP's metal shield serves the same function as the shield used in coaxial cables: preventing electrical interference from affecting the wires used to send signals. When using STP, a single Token Ring MAU can support up to 260 computers. The STP cable connecting a computer to the hub may not be longer than 100 meters. While the heavy shielding of STP cabling makes it an ideal choice for environments with high levels of electrical interference, the high cost of that shielding makes it too expensive for most installations.

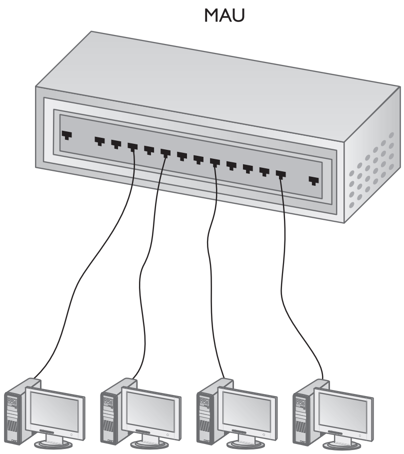


Figure 7-8 Token Ring nodes connect to the MAU.

NOTE In one of the few variances between IBM Token Ring and the IEEE 802.5 standard, the latter states that a Token Ring network can support only up to 250 nodes per segment. The IEEE 802.5 standard does not, however, distinguish between STP and UTP. In real-world applications, the 260-node limit found in implementations of IBM Token Ring networks over STP has proven accurate. (The Network+ exam reflects the real world too!)

Token Ring uses a special *Type 1 connector* for STP (see Figure 7-9). Type 1 Token Ring connectors are not RJ-45. Instead, IBM designed a unique *hermaphroditic* connector called either an *IBM-type Data Connector (IDC)* or a *Universal Data Connector (UDC)*. These connectors are neither male nor female; they are designed to plug into each other. Token Ring network cards use a nine-pin female connector, and a standard Token Ring cable has a hermaphroditic connector on one end and a nine-pin connector on the other.

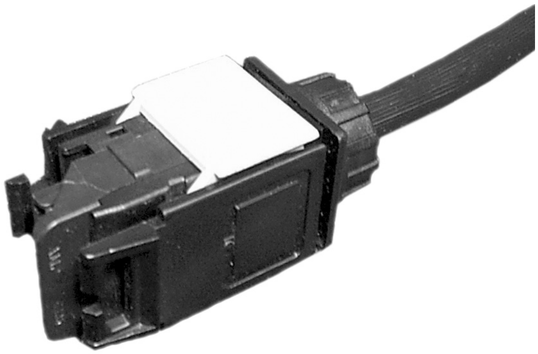
TIP Token Ring STP connectors are referred to as *Type 1* or *IDC/UDC*. Be prepared to use either term on the Network+ exam, although you'll most likely see them called Type 1.

Token Ring over UTP

UTP cabling offers a cost-effective alternative to STP for normal business environments. Because it lacks the heavy shielding of STP and is manufactured for use in a variety of applications, UTP cabling is relatively inexpensive.

Token Ring can run over UTP using the same cable and RJ-45 connectors as Ethernet. Like 10BaseT, Token Ring uses only two of the four wire pairs in the typical UTP cable: the 3/6 pair and the 4/5 pair, as shown in Figure 7-10. Provided the cable installer uses a proper wiring color code (such as the EIA/TIA 568A standard discussed in Chapter 6), the UTP cable and connectors used for Token Ring are identical to those used for Ethernet. Token Ring MAUs using UTP can support up to 72 nodes, each of which must be within 45 meters of the MAU. UTP is so common for Token Ring that you can purchase special media converters to connect UTP to MSAUs using the older style Type 1 connectors (see Figure 7-11).

Figure 7-9
An IBM Type 1 connector



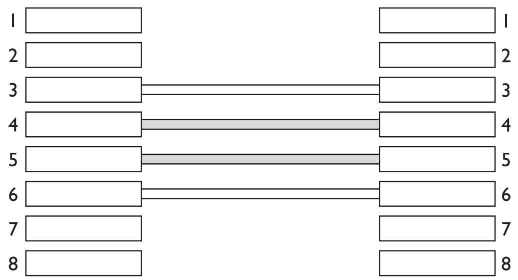


Figure 7-10 Token Ring uses two of the four pairs of available wires.

Figure 7-11 A Token Ring converter

Connecting MAUs

To connect multiple Token Ring hubs to form a larger network requires the extension of the ring. Token Ring MAUs, whether using UTP or STP, have two special ports, labeled *Ring In* and *Ring Out*. These special connections can link multiple MAUs together to form a single ring. The Ring In port on the first MAU must connect to the Ring Out port on the second MAU, and vice versa, to form a single logical ring. Figure 7-12 shows two

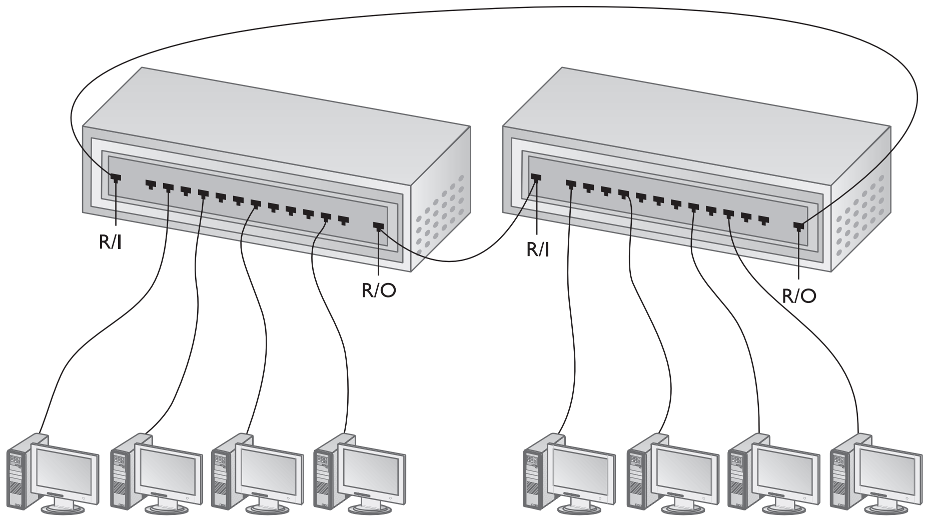


Figure 7-12 Two MAUs connected via Ring In and Ring Out ports

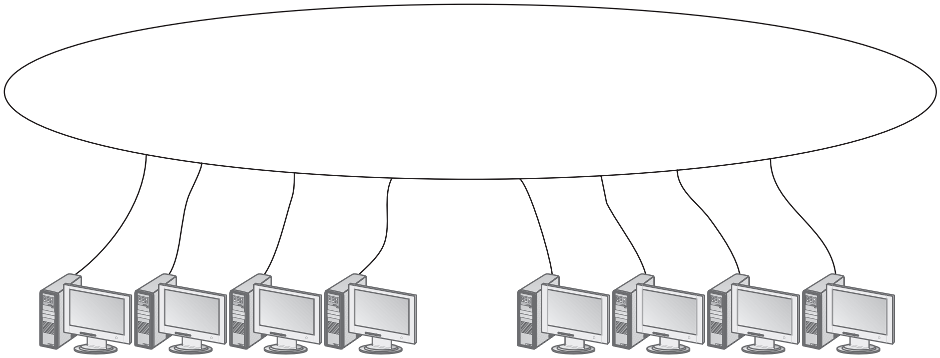


Figure 7-13 When linked together properly, the two MAUs form a single logical ring.

MAUs connected using the Ring In and Ring Out ports. Logically, the two MAUs look like a single ring to the devices attached to them (see Figure 7-13). Up to 33 MAUs can combine to form a single logical ring. Building a network with more than 33 MAUs requires the use of bridges or routers. Routers can also connect Token Ring LANs to other types of LANs, such as Ethernet.

Token Ring vs. Ethernet

The Token Ring vs. Ethernet debate was a fixture in computer networking journals for many years. Token Ring advocates argued that Token Ring's token-passing system used available bandwidth more efficiently than Ethernet's random CSMA/CD process. In addition, the token-passing system guaranteed that every node got some amount of bandwidth.

Ethernet advocates argued that even if Token Ring had technical advantages, it was too expensive to implement. Ethernet technology has always been cheaper than Token Ring for two reasons. First, Ethernet devices are simpler than Token Ring devices. CSMA/CD is a simple algorithm to program into a device, whereas Token Ring devices must deal with more complex issues, such as differing priority levels among the nodes on the ring. Second, economies of scale make Ethernet even less expensive. Because the market for Ethernet devices dwarfs the market for Token Ring devices, Ethernet manufacturers can make a smaller profit on each piece sold and still make money.

In addition, Ethernet overcomes the efficiency advantages of Token Ring by throwing bandwidth at the problem. While 16-Mbps Token Ring may be faster than 10BaseT, it runs significantly more slowly than 100BaseT. Plus, although high-speed Token Ring standards exist, Fast Ethernet and Gigabit Ethernet have achieved a far greater penetration of the market. Most industry pundits agree that Token Ring is a dying technology. While it will continue to exist in niche markets and in organizations with a large installed base of Token Ring equipment, Ethernet will retain and expand its dominance in the marketplace for the foreseeable future.

NOTE Token Ring manufacturers have not rolled over and given in to the pressure of Ethernet standards; instead, they have continued to adapt and innovate. Modern IEEE 802.5t Token Ring networks run at 100 Mbps or faster, which is certainly a respectable speed. In fact, because Token Ring technology doesn't suffer from the overhead of CSMA/CD, High-Speed Token Ring (HSTR) networks offer phenomenally faster performance than comparably speedy Ethernet. You can check out www.madge.com for information on these speedy Token Ring solutions.

Gone But Not Forgotten—ARCnet and LocalTalk

Oh, the 1980s were an interesting time to be in the networking business. Not only were Ethernet and Token Ring slugging it out for market share, a large number of other competitors were also on the market. Two in particular—ARCnet and LocalTalk—deserve mention for two reasons. While ARCnet has disappeared from the PC networking world, it is popular in a number of niche markets, such as robotics and industrial controls. LocalTalk is definitely gone, but its relation to AppleTalk, a popular piece of networking software found on every Apple brand computer, motivates us to mention it. The terms LocalTalk and AppleTalk are often confused, so it's important to get them straight in your mind.

ARCnet

During the late '70s and early '80s, a company called Datapoint Corporation invented a networking technology called *Attached Resource Computer Network (ARCnet)*. For many years, ARCnet enjoyed some degree of popularity in smaller networks, and it still has enough of an installed base to make it interesting for the Network+ exam.

The original ARCnet standard defines a true star topology—both the physical and logical topologies work as stars. ARCnet uses token passing to get frames from one system to another. Originally, ARCnet used a type of coaxial cable called *RG-62*; later versions, however, used good old two-pair UTP cable. ARCnet runs at a whopping 2.5 Mbps—acceptable in the early 1980s, but far too slow to be of any interest for a modern network application. Faster ARCnet standards, called ARCnet Plus, ran at speeds up to 20 Mbps, but were not successful in making ARCnet a serious competitor to either Ethernet or Token Ring in mainstream networking.

ARCnet uses hubs to propagate data between nodes (see Figure 7-14). These hubs provide either 8 or 16 ports, and like 10BaseT hubs, they can be *daisy-chained*—strung together—to handle more nodes. ARCnet networks can use more basic hubs, called passive hubs. These do not repeat the signal like regular (active) hubs; they just pass the signal along without re-creating the data. Because of this, passive hubs are much less common. Using RG-62 and regular hubs, ARCnet supports segment lengths up to 600 meters. Many folks found this substantial segment distance highly attractive; in fact, the majority of ARCnet implementations still in place today involve networking scenarios that needed to span longer distances.

Figure 7-14
An ARCnet hub

Like most other network technologies, ARCnet now supports UTP and fiber-optic cabling, and has increased its speed and maximum cable length dramatically. Like Token Ring, ARCnet has bowed to Ethernet's dominance in the PC networking industry, but lives on, hidden away in a myriad of other industries that enjoy its cheap price and simple function.

LocalTalk

When the folks at Apple decided to add networking to their computers, they created a unique networking technology called *LocalTalk* (see Figure 7-15). LocalTalk used a bus topology with each device daisy-chained to the next device on the segment, and proprietary cabling with small round DIN-style connectors. (*DIN connectors* look like modern keyboard connectors.) A later version called *PhoneTalk*, produced by a company called Farallon, used regular telephone cable and RJ-11 connectors and saw widespread popularity. The rise of Ethernet, along with LocalTalk's slow speed, led to the demise of LocalTalk.

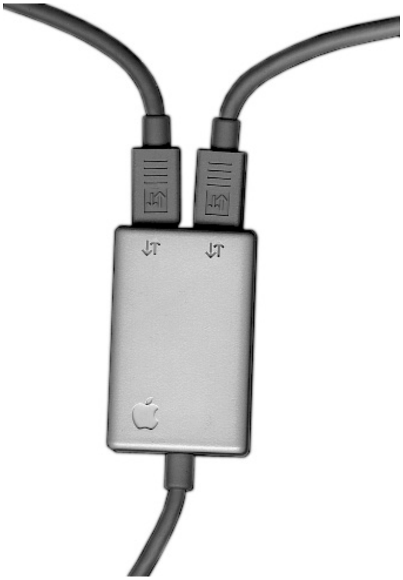


Figure 7-15
LocalTalk connectors

PART II

NOTE Many people confuse the terms AppleTalk and LocalTalk. *LocalTalk* is a networking technology, whereas *AppleTalk* is a network protocol. The networking technology defines the physical issues: what kind of cabling to use, the characteristics of the data frame, the signaling methods for sending frames through the cable, and so forth. A network protocol works at higher layers of the OSI seven-layer model, enabling the operating system to communicate effectively with the NIC, for example. You'll see a lot more on network protocols in Chapter 10, "Protocols."

LAN to WAN—FDDI and ATM

The increase in demand for bandwidth in the '80s motivated the creation of more powerful network technologies. Two different types of technologies, called FDDI and ATM, appeared in the early '90s. These were the *de facto* high-speed networking standards—at least for a few years, until the emergence of high-speed Ethernet. Like so many other network technologies, FDDI and ATM continue to lose market share to Ethernet, but both have found new life with the telephony and cable industries as methods for transferring data across long distances between networks, creating wide-area networks (WANs).

FDDI

Fiber Distributed Data Interface (FDDI) stands as one of the few network technologies that did not spring directly from private industry (although private industry had a lot of impact on its development). Instead, FDDI came directly from the American National Standards Institute (ANSI) as a high-speed, highly redundant technology, specifically designed to work as a high-speed backbone to support larger networks.

The best single word to describe FDDI is "unique." FDDI uses a unique dual token-passing ring topology. Each ring runs at 100 Mbps, making an aggregate speed of 200 Mbps. If one ring breaks, the other ring continues to operate. FDDI runs on either a true physical ring or a physical star topology. Figure 7-16 shows a typical FDDI installation. Note that the server is on the FDDI ring, while other machines connect to the ring via FDDI to Ethernet hubs.

NOTE FDDI does not have to run dual rings. Single-ring FDDI is also commonly used.

FDDI connectors are also unique. Figure 7-17 shows a classic FDDI connector. To support two rings, every classic FDDI device needed two connectors, as shown in Figure 7-18. Using fiber-optic cabling, FDDI segments could reach up to two kilometers between systems, with a maximum ring size of 100 kilometers. A later version of FDDI moved to—you guessed it—CAT 5 UTP. Called Copper Distributed Data Interface or *CDDI*, this version uses the same frame types as FDDI, but it runs over copper cabling instead of fiber.

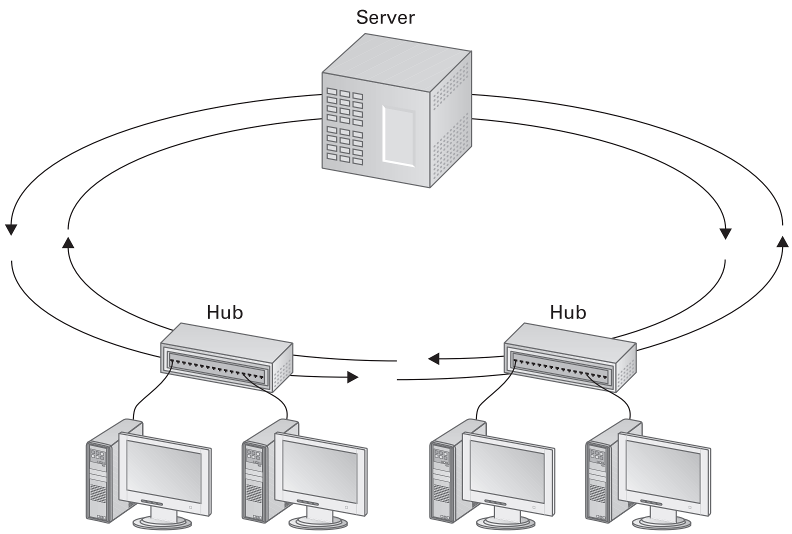
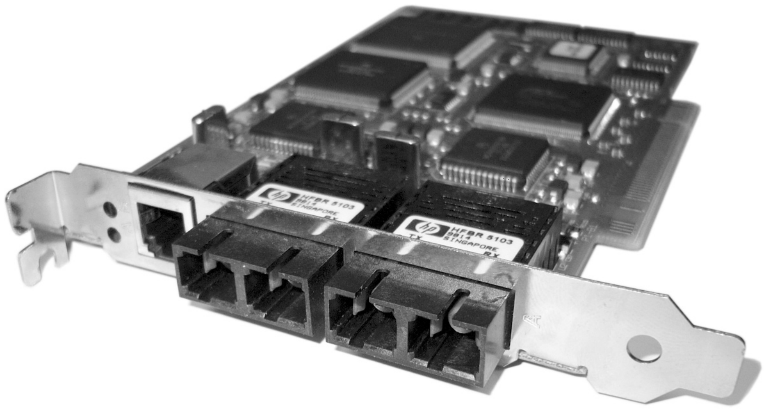


Figure 7-16 FDDI topology: two rings are better than one!

Figure 7-17 FDDI connector

Figure 7-18 FDDI NIC



ATM

Asynchronous Transfer Mode (ATM) came into development at roughly the same time as FDDI. ATM runs at 155 Mbps using fiber-optic cabling or CAT 5 UTP.

While FDDI may be unique, ATM—at least from a topology and physical connection standpoint—is rather boring. ATM typically uses a physical star, just as 10/100/1000BaseT does. ATM supports a number of physical connection types. The most common ATM looks like any other fiber cabling system, using two fiber connectors per node. ATM can also run over CAT 5 or better cabling with RJ-45 connectors, making an ATM NIC look identical to any Ethernet NIC.

ATM didn't make a large mark in the high-speed networking world, but ATM's signaling method, which uses fixed-length frames on a point-to-point connection, became popular as a method for WAN connections. In Chapter 15, "TCP/IP and the Internet," you'll see ATM again. Even though ATM lost in the LAN connectivity wars to Gigabit Ethernet, its frames have found new life in the world of WANs.

Don't Be an Ethernet Snob!

For all Ethernet's popularity, failing to recognize that other network technologies exist can turn you into an Ethernet snob. Although Ethernet definitely rules the vast majority of installed networks today, by keeping an open mind toward other network technologies, you'll be more likely to notice when the next great thing in networking technology presents itself. Don't follow the unfortunate path worn bare by so many other network administrators, who blindly follow only the networking technologies they know. One day, Ethernet will no longer enjoy its current predominance, and when that happens, an alert network tech like you will be prepared to use the technology that best suits you and your network.

Chapter Review

Questions

1. Which of the following standards defines Token Ring networks?
   - **A.** IEEE 802.3
   - **B.** IEEE 802.5
   - **C.** EIA/TIA 568A
   - **D.** IEEE 1284
2. Token Ring networks use a ___________ physical topology and a ___________ logical topology.
   - **A.** Mesh, ring
   - **B.** Ring, star
   - **C.** Star, ring
   - **D.** Ring, bus

3. Which of the following are true about Token Ring networks? (Select all that apply.)
   A. Collisions occur as a normal part of their operation.
   B. Only a machine with a free token can transmit a new data frame.
   C. In the event of a break in the cable connecting a machine to the MAU, the entire network shuts down.
   D. Token Ring can use either UTP or STP cabling.
4. Token Ring nodes transmit data only when they receive a special frame called a free ____________.
   A. Ring
   B. Frame
   C. MAU
   D. Token
5. Philip calls Bob, a tech support technician, for help with a networking problem. Bob asks Philip to tell him what kind of network he uses. Philip responds that he uses UTP. This tells Bob that Philip:
   A. Uses a Token Ring network.
   B. Uses a 10BaseT network.
   C. Uses a 10Base5 network.
   D. Has not provided enough information for Bob to know what kind of network Philip uses.
6. Token Ring MAUs using STP can support up to ___________ nodes.
   A. 1024
   B. 260
   C. 100
   D. 72
7. Token Ring MAUs using UTP can support up to ___________ nodes.
   A. 1024
   B. 260
   C. 100
   D. 72
8. Token Ring MAUs use special ports called _____________ to connect to other MAUs.
   A. Crossovers
   B. Uplinks

C. Ring In and Ring Out

D. Repeaters

9. A node connected to its MAU using UTP can be ___________ from the MAU.

A. 100 meters

B. 100 feet

C. 45 meters

D. 45 feet

10. Which of these technologies can run on a dual-ring topology? (Select all that apply.)

A. ARCnet

B. ATM

C. FDDI

D. Token Ring

Answers

1. **B.** IEEE 802.5 is the IEEE standard for Token Ring. IEEE 802.3 is the standard for Ethernet. EIA/TIA 568A is a cabling standard for UTP cabling. IEEE 1284 is the IEEE standard for parallel communication.
2. **C.** Token Ring networks use a star physical topology and a ring logical topology.
3. **B and D.** Token Ring nodes transmit new data frames only if they have a free token. Token Ring can use either UTP or STP cabling. Although collisions are a normal part of the operation of an Ethernet network, Token Ring's token passing system prevents collisions from occurring. Because Token Ring uses a physical star topology, a break in the cable between the MAU and a device affects only that device, not the rest of the network.
4. **D.** Token ring nodes transmit data only when they receive a special frame called a free token.
5. **D.** Both Token Ring and Ethernet networks can use unshielded twisted-pair cabling.
6. **B.** Token Ring MAUs using STP can support up to 260 nodes.
7. **D.** Token Ring MAUs using UTP can support up to 72 nodes.
8. **C.** Token Ring MAUs use special ports called Ring In and Ring Out to connect to other MAUs.
9. **C.** A Token Ring node using UTP can be up to 45 meters from the MAU.
10. **C**. An FDDI network can run on a dual-ring topology, as either a true physical ring or a physical star.