

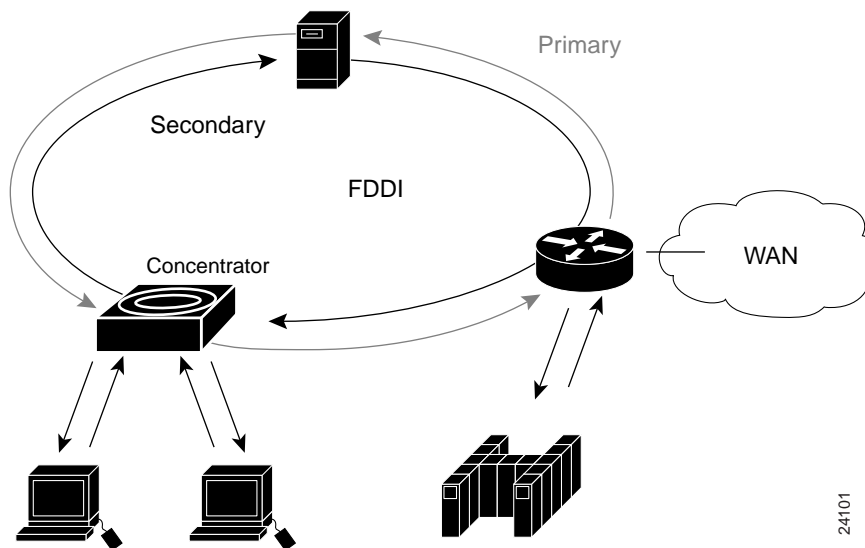
Fiber Distributed Data Interface (FDDI)

Background

The Fiber Distributed Data Interface (FDDI) specifies a 100-Mbps token-passing, dual-ring LAN using fiber-optic cable. FDDI is frequently used as high-speed backbone technology because of its support for high bandwidth and greater distances than copper. It should be noted that relatively recently, a related copper specification, called Copper Distributed Data Interface (CDDI) has emerged to provide 100-Mbps service over copper. CDDI is the implementation of FDDI protocols over twisted-pair copper wire. This chapter focuses mainly on FDDI specifications and operations, but it also provides a high-level overview of CDDI.

FDDI uses a dual-ring architecture with traffic on each ring flowing in opposite directions (called *counter-rotating*). The dual-rings consist of a primary and a secondary ring. During normal operation, the primary ring is used for data transmission, and the secondary ring remains idle. The primary purpose of the dual rings, as will be discussed in detail later in this chapter, is to provide superior reliability and robustness. Figure 8-1 shows the counter-rotating primary and secondary FDDI rings.

Figure 8-1 FDDI uses counter-rotating primary and secondary rings.



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Standards

FDDI was developed by the American National Standards Institute (ANSI) X3T9.5 standards committee in the mid-1980s. At the time, high-speed engineering workstations were beginning to tax the bandwidth of existing local area networks (LANs) based on Ethernet and Token Ring). A new LAN media was needed that could easily support these workstations and their new distributed applications. At the same time, network reliability had become an increasingly important issue as system managers migrated mission-critical applications from large computers to networks. FDDI was developed to fill these needs. After completing the FDDI specification, ANSI submitted FDDI to the International Organization for Standardization (ISO), which created an international version of FDDI that is completely compatible with the ANSI standard version.

FDDI Transmission Media

FDDI uses optical fiber as the primary transmission medium, but it also can run over copper cabling. As mentioned earlier, FDDI over copper is referred to as *Copper-Distributed Data Interface* (CDDI). Optical fiber has several advantages over copper media. In particular, security, reliability, and performance all are enhanced with optical fiber media because fiber does not emit electrical signals. A physical medium that does emit electrical signals (copper) can be tapped and therefore would permit unauthorized access to the data that is transiting the medium. In addition, fiber is immune to electrical interference from radio frequency interference (RFI) and electromagnetic interference (EMI). Fiber historically has supported much higher bandwidth (throughput potential) than copper, although recent technological advances have made copper capable of transmitting at 100 Mbps. Finally, FDDI allows two kilometers between stations using multi-mode fiber, and even longer distances using a single mode.

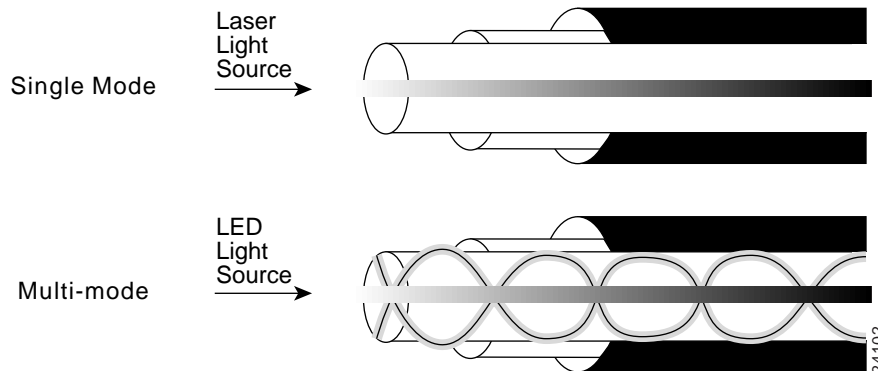
FDDI defines two types of optical fiber: single-mode and multi-mode. A *mode* is a ray of light that enters the fiber at a particular angle. Multi-mode fiber uses LED as the light-generating devices, while single-mode fiber generally uses lasers.

Multi-mode fiber allows multiple modes of light to propagate through the fiber. Because these modes of light enter the fiber at different angles, they will arrive at the end of the fiber at different times. This characteristic is known as *modal dispersion*. Modal dispersion limits the bandwidth and distances that can be accomplished using multi-mode fibers. For this reason, multi-mode fiber is generally used for connectivity within a building or within a relatively geographically contained environment.

Single-mode fiber allows only one mode of light to propagate through the fiber. Because only a single mode of light is used, modal dispersion is not present with single-mode fiber. Therefore, single-mode is capable of delivering considerably higher performance connectivity and over much larger distances, which is why it generally is used for connectivity between buildings and within environments that are more geographically dispersed.

Figure 8-2 depicts single-mode fiber using a laser light source and multi-mode fiber using a light-emitting diode (LED) light source.

Figure 8-2 Light sources differ for single-mode and multi-mode fibers.



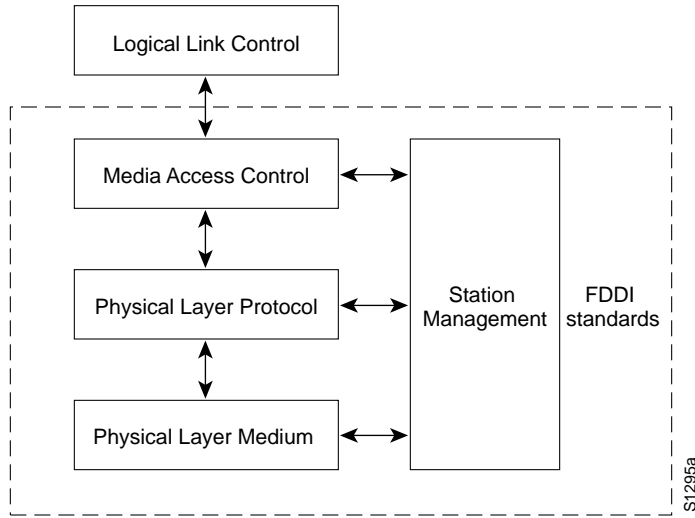
FDDI Specifications

FDDI specifies the physical and media-access portions of the OSI reference model. FDDI is not actually a single specification, but it is a collection of four separate specifications each with a specific function. Combined, these specifications have the capability to provide high-speed connectivity between upper-layer protocols such as TCP/IP and IPX, and media such as fiber-optic cabling.

FDDI's four specifications are the Media Access Control (MAC), Physical Layer Protocol (PHY), Physical-Medium Dependent (PMD), and Station Management (SMT). The MAC specification defines how the medium is accessed, including frame format, token handling, addressing, algorithms for calculating cyclic redundancy check (CRC) value, and error-recovery mechanisms. The PHY specification defines data encoding/decoding procedures, clocking requirements, and framing, among other functions. The PMD specification defines the characteristics of the transmission medium, including fiber-optic links, power levels, bit-error rates, optical components, and connectors. The SMT specification defines FDDI station configuration, ring configuration, and ring control features, including station insertion and removal, initialization, fault isolation and recovery, scheduling, and statistics collection.

FDDI is similar to IEEE 802.3 Ethernet and IEEE 802.5 Token Ring in its relationship with the OSI model. Its primary purpose is to provide connectivity between upper OSI layers of common protocols and the media used to connect network devices. Figure 8-3 illustrates the four FDDI specifications and their relationship to each other and to the IEEE-defined Logical-Link Control (LLC) sublayer. The LLC sublayer is a component of Layer 2, the MAC layer, of the OSI reference model.

Figure 8-3 FDDI specifications map to the OSI hierarchical model.



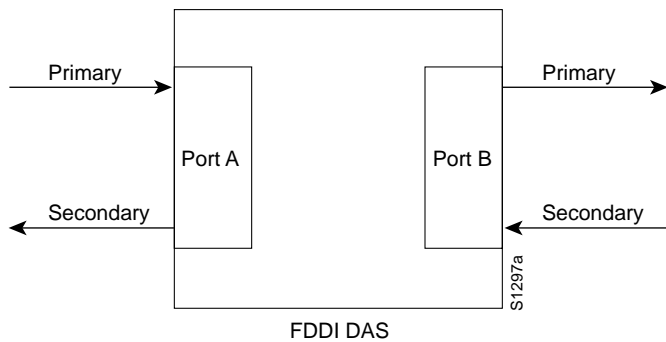
FDDI Station-Attachment Types

One of the unique characteristics of FDDI is that multiple ways actually exist by which to connect FDDI devices. FDDI defines three types of devices: single-attachment station (SAS), dual-attachment station (DAS), and a concentrator.

An SAS attaches to only one ring (the primary) through a concentrator. One of the primary advantages of connecting devices with SAS attachments is that the devices will not have any effect on the FDDI ring if they are disconnected or powered off. Concentrators will be discussed in more detail in the following discussion.

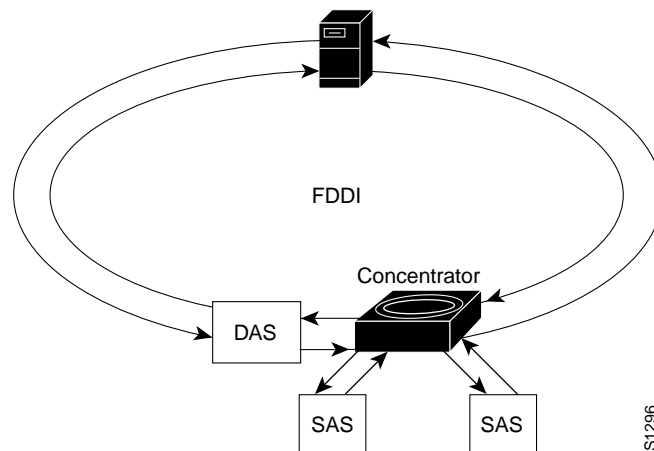
Each FDDI DAS has two ports, designated A and B. These ports connect the DAS to the dual FDDI ring. Therefore, each port provides a connection for both the primary and the secondary ring. As you will see in the next section, devices using DAS connections will affect the ring if they are disconnected or powered off. Figure 8-4 shows FDDI DAS A and B ports with attachments to the primary and secondary rings.

Figure 8-4 FDDI DAS ports attach to the primary and secondary rings.



An FDDI concentrator (also called a *dual-attachment concentrator* [DAC]) is the building block of an FDDI network. It attaches directly to both the primary and secondary rings and ensures that the failure or power-down of any SAS does not bring down the ring. This is particularly useful when PCs, or similar devices that are frequently powered on and off, connect to the ring. Figure 8-5 shows the ring attachments of an FDDI SAS, DAS, and concentrator.

Figure 8-5 A concentrator attaches to both the primary and secondary rings.



FDDI Fault Tolerance

FDDI provides a number of fault-tolerant features. In particular, FDDI's dual-ring environment, the implementation of the optical bypass switch, and dual-homing support make FDDI a resilient media technology.

Dual Ring

FDDI's primary fault-tolerant feature is the dual ring. If a station on the dual ring fails or is powered down, or if the cable is damaged, the dual ring is automatically *wrapped* (doubled back onto itself) into a single ring. When the ring is wrapped, the dual-ring topology becomes a single-ring topology. Data continues to be transmitted on the FDDI ring without performance impact during the wrap condition. Figure 8-6 and Figure 8-7 illustrate the effect of a ring wrapping in FDDI.

Figure 8-6 A ring recovers from a station failure by wrapping.

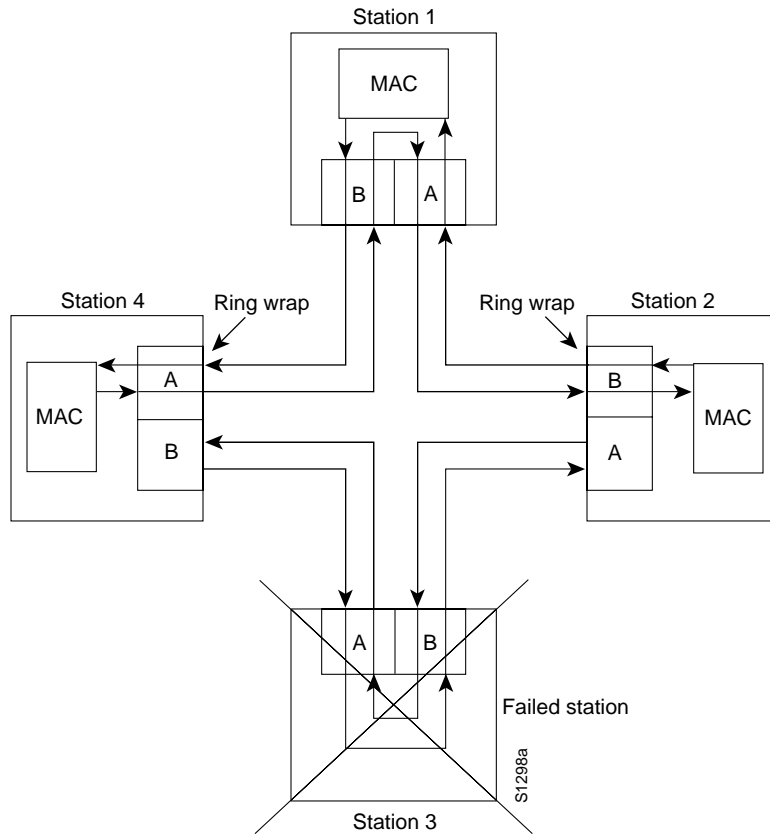
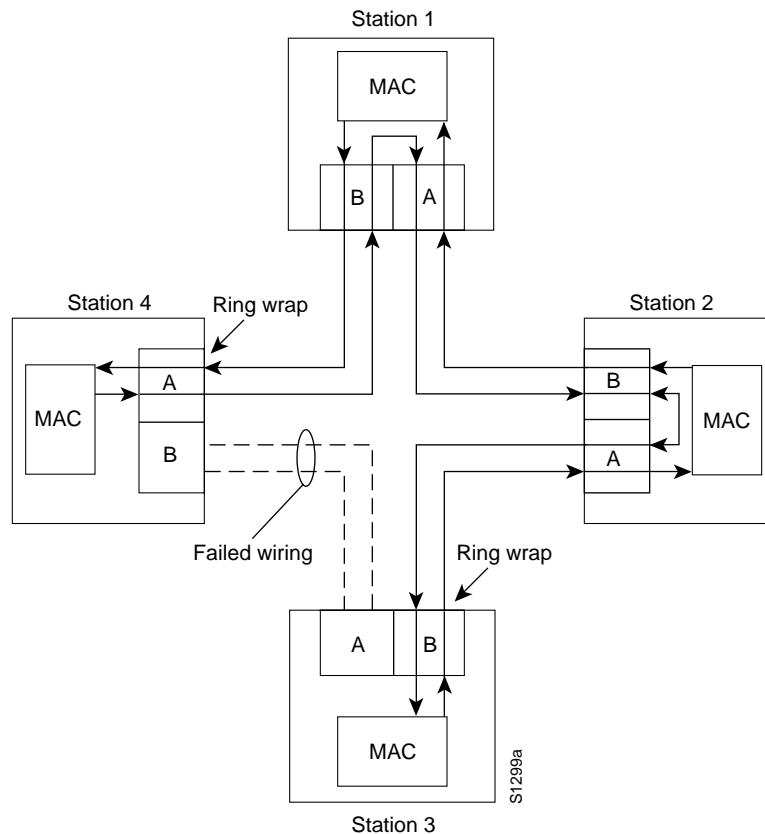


Figure 8-7 A ring also wraps to withstand a cable failure.



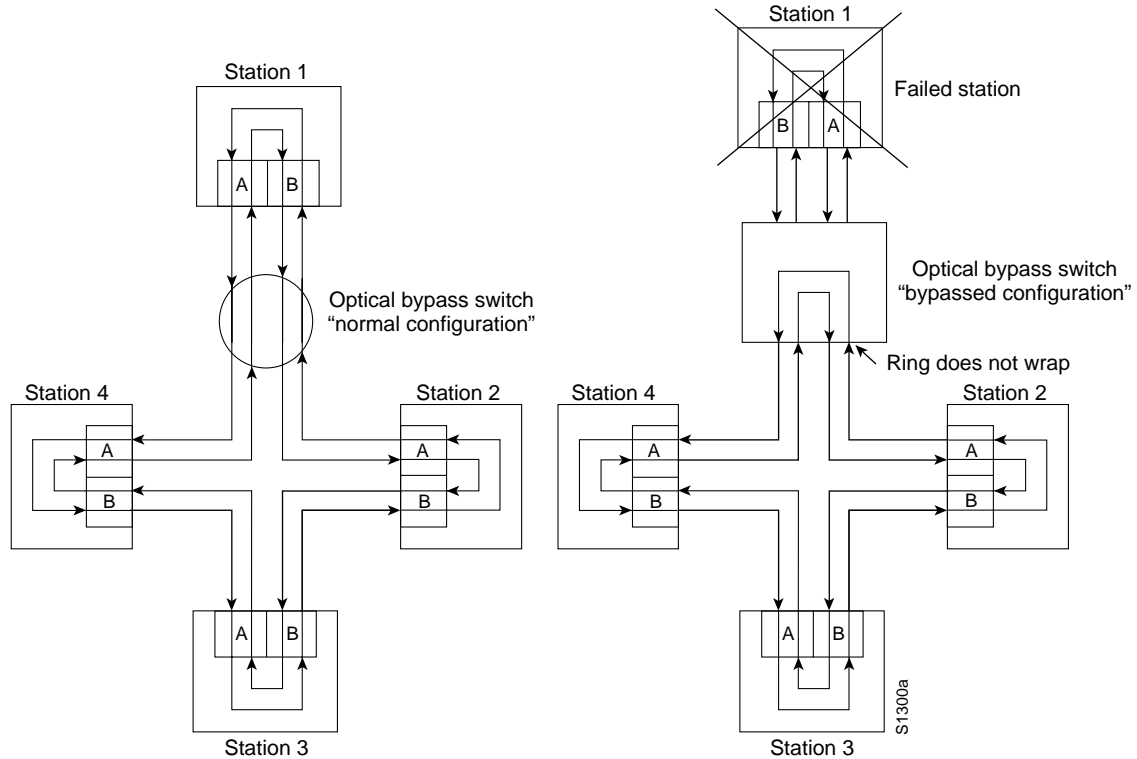
When a single station fails, as shown in Figure 8-6, devices on either side of the failed (or powered down) station wrap, forming a single ring. Network operation continues for the remaining stations on the ring. When a cable failure occurs, as shown in Figure 8-7, devices on either side of the cable fault wrap. Network operation continues for all stations.

It should be noted that FDDI truly provides fault-tolerance against a single failure only. When two or more failures occur, the FDDI ring segments into two or more independent rings that are unable to communicate with each other.

Optical Bypass Switch

An optical bypass switch provides continuous dual-ring operation if a device on the dual ring fails. This is used both to prevent ring segmentation and to eliminate failed stations from the ring. The optical bypass switch performs this function through the use of optical mirrors that pass light from the ring directly to the DAS device during normal operation. In the event of a failure of the DAS device, such as a power-off, the optical bypass switch will pass the light through itself by using internal mirrors and thereby maintain the ring's integrity. The benefit of this capability is that the ring will not enter a wrapped condition in the event of a device failure. Figure 8-8 shows the functionality of an optical bypass switch in an FDDI network.

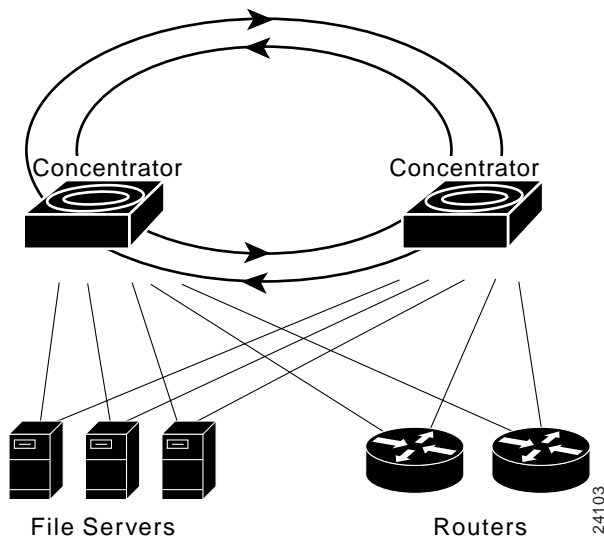
Figure 8-8 The optical bypass switch uses internal mirrors to maintain a network.



Dual Homing

Critical devices, such as routers or mainframe hosts, can use a fault-tolerant technique called *dual homing* to provide additional redundancy and to help guarantee operation. In dual-homing situations, the critical device is attached to two concentrators. Figure 8-9 shows a dual-homed configuration for devices such as file servers and routers.

Figure 8-9 A dual-homed configuration guarantees operation.

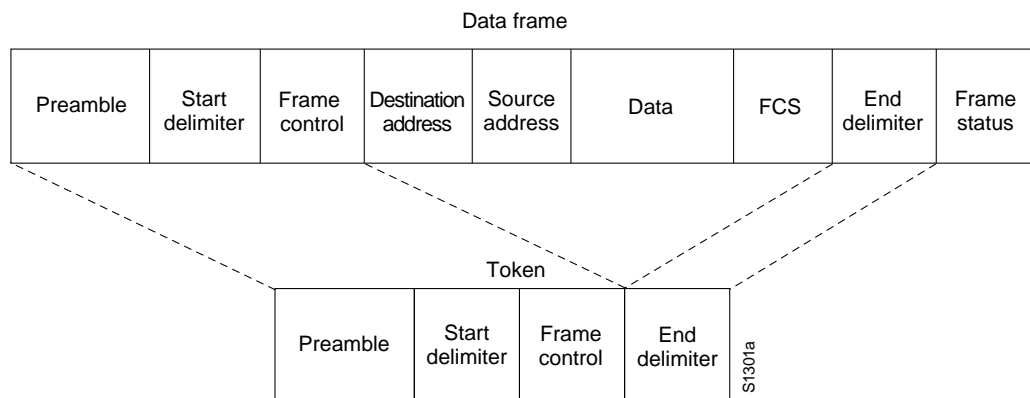


One pair of concentrator links is declared the active link; the other pair is declared passive. The passive link stays in back-up mode until the primary link (or the concentrator to which it is attached) is determined to have failed. When this occurs, the passive link automatically activates.

FDDI Frame Format

The FDDI frame format is similar to the format of a Token Ring frame. This is one of the areas where FDDI borrows heavily from earlier LAN technologies, such as Token Ring. FDDI frames can be as large as 4,500 bytes. Figure 8-10 shows the frame format of an FDDI data frame and token.

Figure 8-10 The FDDI frame is similar to that of a Token Ring frame.



FDDI Frame Fields

The following descriptions summarize the FDDI data frame and token fields illustrated in Figure 8-10.

- *Preamble*—A unique sequence that prepares each station for an upcoming frame.
- *Start Delimiter*—Indicates the beginning of a frame by employing a signaling pattern that differentiates it from the rest of the frame.
- *Frame Control*—Indicates the size of the address fields and whether the frame contains asynchronous or synchronous data, among other control information.
- *Destination Address*—Contains a unicast (singular), multicast (group), or broadcast (every station) address. As with Ethernet and Token Ring addresses, FDDI destination addresses are 6 bytes long.
- *Source Address*—Identifies the single station that sent the frame. As with Ethernet and Token Ring addresses, FDDI source addresses are 6 bytes long.
- *Data*—Contains either information destined for an upper-layer protocol or control information.
- *Frame Check Sequence (FCS)*—Filled by the source station with a calculated *cyclic redundancy check* value dependent on frame contents (as with Token Ring and Ethernet). The destination address recalculates the value to determine whether the frame was damaged in transit. If so, the frame is discarded.
- *End Delimiter*—Contains unique symbols, which cannot be data symbols, that indicate the end of the frame.

- *Frame Status*—Allows the source station to determine whether an error occurred and whether the frame was recognized and copied by a receiving station.

Copper Distributed Data Interface (CDDI)

Copper Distributed Data Interface (CDDI) is the implementation of FDDI protocols over twisted-pair copper wire. Like FDDI, CDDI provides data rates of 100 Mbps and uses a dual-ring architecture to provide redundancy. CDDI supports distances of about 100 meters from desktop to concentrator.

CDDI is defined by the ANSI X3T9.5 Committee. The CDDI standard is officially named the *Twisted-Pair Physical Medium Dependent (TP-PMD)* standard. It is also referred to as the *Twisted-Pair Distributed Data Interface (TP-DDI)*, consistent with the term *Fiber-Distributed Data Interface (FDDI)*. CDDI is consistent with the physical and media-access control layers defined by the ANSI standard.

The ANSI standard recognizes only two types of cables for CDDI: shielded twisted pair (STP) and unshielded twisted pair (UTP). STP cabling has a 150-ohm impedance and adheres to EIA/TIA 568 (IBM Type 1) specifications. UTP is data-grade cabling (Category 5) consisting of four unshielded pairs using tight-pair twists and specially developed insulating polymers in plastic jackets adhering to EIA/TIA 568B specifications.

Figure 8-11 illustrates the CDDI TP-PMD specification in relation to the remaining FDDI specifications.

Figure 8-11 CDDI TP-PMD and FDDI specifications adhere to different standards.

