



Implementing Fast Ethernet

The Next Generation of Ethernet

Fast Ethernet (also known as IEEE 802.3u or 100BASE-T) is quickly becoming the successor to Ethernet as the network topology of choice. Fast Ethernet can operate at ten times the speed of Ethernet, and in many cases, the existing twisted pair cable (10BASE-T, or Token Ring) can be used in the migration to Fast Ethernet.

The importance of Fast Ethernet is becoming clearer each day. So too are its benefits. Fast Ethernet can deliver next generation performance and compatibility for traditional Ethernet networks with reasonable installation and implementation costs.

While Fast Ethernet's momentum and benefits may be clear, there are still many networking professionals who have questions about implementing Fast Ethernet—particularly about what type of cables to use.

The 100BASE-T Standard

Fast Ethernet is now a fully ratified IEEE (Institute of Electrical and Electronic Engineers) standard, having passed a full review in June 1995. The standard has been assigned the name 802.3u, or 100BASE-T as it is more commonly called.

The term "100BASE-T" refers not to the type of cable itself, but rather to the way the cable is used. Like 10BASE-T, 100BASE-T uses the CSMA/CD (Carrier Sense Multiple Access/Collision Detection) method to arbitrate access to the cable. The terms "100BASE-TX", "100BASE-T4", and "100BASE-FX" refer specifically to the method of implementing 100BASE-T.

In this paper, each of these cable methods are explored in depth, as are migration strategies from 10 Mbps coax and 10BASE-T Ethernet networks.

100BASE-TX and 100BASE-T4 Twisted Pair Cabling

The Fast Ethernet standard provides for three distinct cabling systems. Each system has merit, and is appropriate in different situations. For twisted pair copper cabling, the standards are 100BASE-TX and 100BASE-T4. For fiber optic cabling, the standard is 100BASE-FX. These cable systems can be intermixed within an organization, and in combination, they address virtually all cabling needs.

The 100BASE-TX method requires two pairs of high-quality twisted pair wiring (one for transmission and one for reception). This cable type can be either unshielded twisted pair (UTP) or shielded twisted pair (STP) cabling, providing it meets the required performance specifications. The most common examples of cable that meet these requirements are Category 5 UTP and IBM Type 1 STP. (These cable types are explained in more detail later.)

The 100BASE-T4 method requires four pairs of "ordinary" quality twisted pair wiring. In this method, one pair is dedicated to transmission, one pair is dedicated to reception, and two pairs are "bi-directional." By dividing the same 100 Mbps data signal over three pairs of cable, (in each direction), the effective data rate remains the same, but the cable frequency is much lower. This means that a less sophisticated cable can be used. This type of cable is sometimes referred to as "voice grade" cable. Most commonly, this will mean Category 3 UTP. It is very important to note however, that 100BASE-T4 is not limited to voice grade cable. It can be used equally well on better quality cable including Category 4 UTP, Category 5 UTP, and Type 1 STP.

There is no clear right or wrong in choosing between 100BASE-TX and 100BASE-T4. Which system is right for any given network will depend on several factors.

TIA/EIA Cable Specifications

Category (CAT)	Description
CAT 1	Telephone service and low speed data
CAT 2	ISDN and T1/E1
CAT 3	Data at up to 16 MHz (including 10BASE-T at 10 Mbps and 100BASE-T4 at 100 Mbps)
CAT 4	Data at up to 20 MHz (including Token Ring at 16 Mbps and 100BASE-T4)
CAT 5	Data at up to 100 MHz (including 100BASE-TX and 100BASE-T4 at 100 Mbps)

Twisted Pair Cable Standards Demystified

There are two general sources of specifications for twisted pair cabling. These are the Telecommunications Industry Association (TIA) branch of the Electronic Industries Association, (EIA), referred to as the EIA/TIA (or simply the EIA), and IBM.

The EIA is responsible for the "CAT" or Category cable standards (see Table 1). (The terms "Category" and "Level" are sometimes used interchangeably.) IBM is responsible for the "Type" cable standards, such as IBM Type 1, Type 2, etc.

Strictly speaking, the cable specification does not include the connector used to terminate the cable, however, both the EIA and IBM define

specific connectors for use with twisted pair cable. For CAT 3, CAT 4, and CAT 5, this standard is EIA-568, and specifies an RJ-45 connector. For Type 1 cable, this is a DB9 connector.

Most Ethernet installations use cable based on EIA standards, and most installations of IBM and/or Token Ring equipment tend to use cable that meets the IBM cable standards. The notable exception is many Token Ring installations which are installed using CAT 4 UTP cable.

Advantages of 100BASE-TX and 100BASE-T4

Both 100BASE-TX and 100BASE-T4 have their place in Fast Ethernet networks. In fact, many networks will have a mixture of the two methods. In order to understand where each option should best be used, it makes sense to first examine the relative advantages and disadvantages of each:

Advantages of 100BASE-T4

- Operates on virtually any preexisting twisted pair cabling
- Adapters are about 10% less expensive
- Less expensive CAT 3 cabling can be used

Advantages of 100BASE-TX

- Uses only two pairs of twisted pair
- Supports Full Duplex mode for up to 200 Mbps in servers

Disadvantages of 100BASE-T4

- Cannot support Full Duplex mode (unnecessary in workstations)
- Requires four pairs of wiring

Disadvantages of 100BASE-TX

- All patch panels and jumper blocks must be CAT 5
- Adjacent cable pairs cannot be used for other applications
- Full Duplex mode requires Full Duplex switches

Choosing between 100BASE-TX and 100BASE-T4

There is no clear right or wrong in choosing between 100BASE-TX and 100BASE-T4. Which system is right for any given network, will depend on several factors:

Installed cable type

If properly installed CAT 5 or Type 1 is not available, then 100BASE-T4 must be chosen, or new twisted pair wiring installed.

Budget

Substantial amounts of money may be saved if 100BASE-T4 adapters and CAT 3 cabling can be used. (A quick survey of cable costs shows four-pair CAT 3 plenum cable priced at \$.09-.25/ft., and four-pair CAT 5 plenum cable at \$.23-.37/ft.)

Future needs

If Full Duplex mode is required, or desired in the future, 100BASE-TX provides the flexibility required. If the quality of the cable installation(s) is unknown or questionable, then 100BASE-T4 provides the flexibility needed to run on more cable types.

One conclusion that can be drawn from this analysis is that 100BASE-T4 is best suited for use in workstations, where cost is an important issue. 100BASE-TX is more desirable in network servers that can take advantage of Full Duplex Fast Ethernet (FDFE) mode, and where the quality of the cabling can be easily controlled.

The 100BASE-FX Fiber Optic Option

Until now, we have not considered the role of fiber optic cabling in the Fast Ethernet network. Fiber has the same advantages in FDFE as it does in traditional Ethernet (10BASE-FL), and FDDI networks: extended distances,

electromagnetic immunity, and increased security. It also uses the same type of fiber optic cable as 10BASE-FL and FDDI.

Like 10BASE-T, 100BASE-T allows a maximum distance between a repeater (hub) and a node of 100 meters. Using fiber optic cable, 100BASE-FX increases this distance to a maximum of 185 meters. Between a server and workstation (with no repeater), the maximum distance is increased to 400 meters, or even 2 kilometers when using Full Duplex mode.

The standard cable type for 100BASE-FX is multimode fiber with a 62.5 micron core and 125 micron cladding. Only one pair of fibers is required, one for transmission and one for reception. This is the cable that is commonly used in 10BASE-FL Ethernet networks with "ST" bayonet-style connectors. The new EIA-preferred connector is the "SC" plug-style. The SC connector has the advantage of being a push-on/pull-off connector (no twisting), and since it is keyed, there is no possibility of incorrectly connecting the transmit and receive cables. If the fiber optic cable is already terminated with FDDI compatible "MIC" connectors, then an inexpensive MIC to ST converter can be used.

The 100BASE-FX standard will best apply in the interconnection of repeaters to form a fiber optic backbone. In a typical company, there will be Fast Ethernet repeaters on each floor or in each department that support 100BASE-TX or 100BASE-T4 workstations. The repeaters are then interconnected using 100BASE-FX links. When connecting repeaters on different floors, the fiber optic cabling will provide protection from electromagnetic noise that is often associated with elevators, and will also enable longer cable runs between buildings.

Migration Strategies

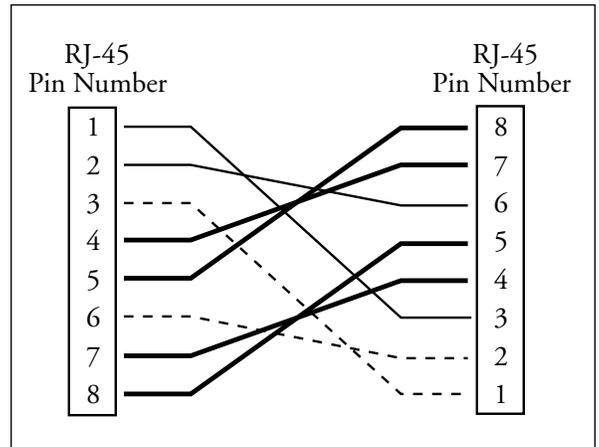
Today, many networks are based on twisted pair cabling, and on thin coax with BNC connectors. Clearly there must be a strategy that will allow today's networks to smoothly migrate to Fast Ethernet. In order to protect their investments, buyers' should consider AutoSense network adapters for their workstations.

AutoSense-capable adapters can be used today for 10 Mbps Ethernet (either coax or UTP), and can be used in the future for 100 Mbps Fast Ethernet (UTP). This will allow workstations to automatically switch to Fast Ethernet when the servers and repeaters are upgraded. Because of the ability to run on a wide variety of cable types, 100BASE-T4 adapters will be popular for such applications.

A number of options are available to those who are ready to install Fast Ethernet today, and need to do so gradually, or to keep some 10 Mbps devices. Perhaps the simplest is to install a Fast Ethernet adapter in the existing server, alongside the 10 Mbps Ethernet adapter, and use the connection to support a Fast Ethernet repeater and workstations.

Others will choose to use a multiport server adapter that can handle more than one network connection. Multiport adapters, such as Adaptec's Cogent™ Quartet™ ANA™ -6944/T4 adapter, can be either dedicated to Fast Ethernet or can be used as four 10/100 adapters, allowing a mixture of Fast Ethernet and traditional Ethernet ports.

Yet a third option, which is useful for very small networks or pilot projects, is to create a repeater-less Fast Ethernet network. Up to eight nodes can be easily installed by using two Quartet server adapters and "cross connect" cables to connect the Fast Ethernet workstations. The cross connect cables act to



Cross Connect Cable (Repeater Eliminator) for 10BASE-T, 100BASE-T, and 100BASE-T4.

connect the sending and receiving pairs of the two nodes, providing a dedicated Fast Ethernet channel between them. Construction details for a cross connect cable that can be used with 10BASE-T, 100BASE-TX or 100BASE-T4 is given in the figure above.

Adaptec's Cogent Quartet ANA-6944/T4 adapter can be either dedicated to Fast Ethernet or can be used as four 10/100 adapters, allowing a mixture of Fast Ethernet and traditional Ethernet ports.

Tips for Installing Twisted Pair Cable

When migrating to Fast Ethernet, it is possible that you will find yourself needing to pull more twisted pair cable. If so, you may find these tips useful:

- Use the best cable you can afford. The most expensive part of twisted pair cable is the labor needed to install it. If you can afford CAT 5 cable, then invest in it now, even if you plan to use 100BASE-T4.

- Pull at least four pairs of cable to each desktop, or more. Even if your plans now call for using two pairs of CAT 5, there could come a time when the extra pairs will prove useful. Any extra pairs can be terminated later to save money now.
- Plenum-rated cable, although more expensive, is designed for use in the walls and ceilings of buildings. In case of fire, it produces much less noxious gas than PVC-coated cable. Certain building codes require the use of plenum cable.
- Twisted pair premises cabling should be of the solid conductor types, because of its superior electrical qualities. Stranded cable should only be used for patch cables, where the extra flexibility is necessary.
- If cabling to CAT 5 standards, remember that patch panels and jumper blocks must also be of CAT 5 quality.

Fast Ethernet is Ready to Go

The Fast Ethernet standard is designed to provide flexible solutions for a wide variety of cabling situations. With the availability of Adaptec's Cogent Ethernet/Fast Ethernet 10/100 adapters (including versions with BNC/coax support), the migration path to Fast Ethernet is well charted. Fast Ethernet is the clear successor to Ethernet and will provide millions of users the performance they will require for many years to come.



Adaptec, Inc.
691 South Milpitas Boulevard
Milpitas, California 95035
Tel: (408) 945-8600
Fax: (408) 262-2533

Adaptec Europe-Belgium
Tel: (32) 2-352-34-11
Fax: (32) 2-352-34-00

Adaptec Japan-Tokyo
Tel: (81) 3-5276-9882
Fax: (81-3) 5276-9884

Adaptec Singapore
Tel: (65) 278-7300
Fax: (65) 273-0163

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