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TECHNICAL Brief

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Flow Control

The flow control mechanism for Ethernet networks is different for full-duplex and half-duplex transmission types. The next section discusses these two transmission schemes, and the flow control mechanisms for each.

Full-Duplex Transmission

Using full-duplex transmission, signals travel in both directions on the same connection, at the same time. Simultaneous bi-directional transmission allows the aggregate data rate of an Ethernet network to be doubled. For example, a 10Mbps Ethernet network can achieve an aggregate 20Mbps data rate, a 100Mbps Fast Ethernet network can achieve an aggregate 200Mbps, and a 1000Mbps Gigabit Ethernet network can achieve and aggregate 2Gbps data rate.

Full-duplex transmission is available for point-to-point connections only. Using full-duplex transmission, the issue of collisions on the network is completely eliminated and the CSMA/CD access control mechanism does not need to be invoked. Full-duplex can be used between a single workstation and a switch port, between two switch ports, or between two workstations. Full-duplex cannot be used for shared port connections, such as a repeater or hub port connecting to multiple workstations. Figure 10 shows a full-duplex, point-to-point network.

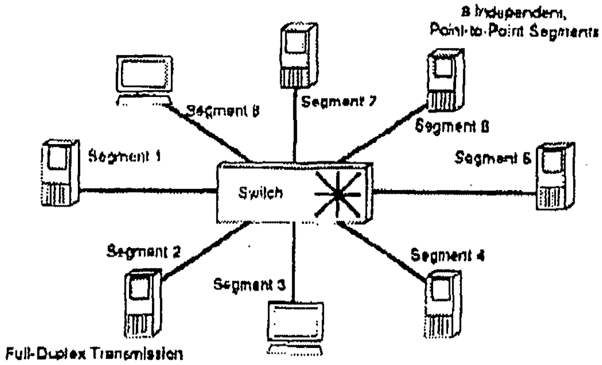

Figure 10. Full-duplex, point-to-point Ethernet segments

An optional flow control mechanism being defined by IEEE 802.3x, is available for full-duplex transmission and works in a way similar to XON/XOFF flow control. A receiving station at one end of the point-to-point connection can send a packet to the sending station at the opposite end of the connection instructing the sending station to stop sending packets for a specified period of time. The sending station ceases to transmit packets until the period of time has passed, or until it receives a new packet from the receiving station with a time of zero, indicating that it is okay to resume transmission.

Full-duplex Ethernet is being standardized by the IEEE 802.3x committee. The full-duplex standard is not specific to any particular speed for Ethernet. It can be used for Ethernet, Fast Ethernet, and Gigabit Ethernet.

Half-duplex Transmission
Using half-duplex transmission, signals travel in both directions on the wire, but not simultaneously. The original 802.3 standard specifies half-duplex transmission.

To gain access to the network in a half-duplex environment, Ethernet has traditionally employed Carrier Sense Multiple Access with Collision Detection (CSMA/CD) as the standard access method. Using CSMA/CD, a station waits for a clear channel. When it detects clear channel, it begins to send frames onto the wire. If two stations start sending data at the same time, a collision occurs. Each station must detect the collision, abort the transmission, and wait for a random interval of time before attempting to transmit data on the network again.

Half-duplex transmission is most commonly used on shared Ethernet segments. Unlike point-to-point connections, shared segments have two or more stations sharing a single port. Figure 11 shows a half-duplex, shared segment.

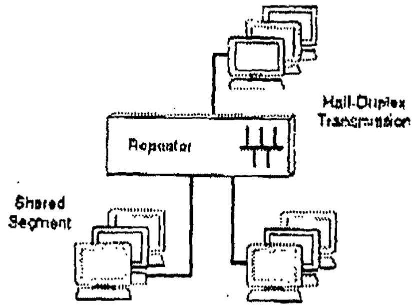

Figure 11. Half-duplex, shared Ethernet segment

Most switches manufactured today allow the user to select half-duplex or full-duplex on a port by port basis. This allows you to migrate your network from shared segments to point-to-point full-duplex segments over time. A switch port can be shared by front-ending the port with a repeater or hub. Figure 12 shows a network with both shared and dedicated switch ports.

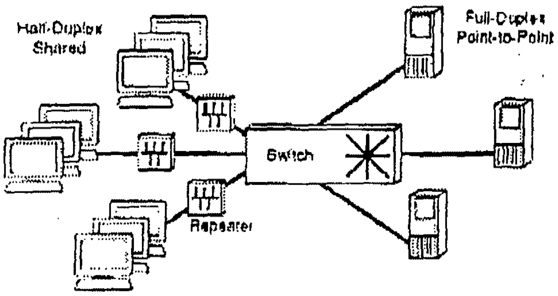

Figure 12. Ethernet network with full-duplex and half-duplex ports

Carrier Extension

In order to abide by the rules of the CSMA/CD access method, all stations sharing an Ethernet segment must be able to hear and detect a collision that has occurred on the network. More specifically, a station must hear the collision for the frame it is sending before it has completed transmitting the entire frame. The amount of time it takes for a station to send the frame the full length of the wire and have the jam signal resulting from a collision travel back to the station is known as the slot-time.

With very small (64 byte) frames travelling at speeds of 1,000 Mbps, the standard slot time used in the original IEEE 802.3 Ethernet specification is not long enough to accommodate a 100 meter cable run. The small frames are transmitted too quickly, and the sending station is finished transmitting the frame before it is aware of any collision that might have occurred at the other end of the segment.

In order to account for the problems of simply scaling CSMA/CD, and allow for minimum 64-byte frame sizes for compatibility across Ethernet devices, half-duplex Gigabit Ethernet implements a longer slot time using a technique called carrier extension. The frame size is not changed, but the time consumed on the wire is extended. Figure 13 shows a standard Ethernet frame and how extension is used, when necessary, to guarantee at least a 512-byte slot time.

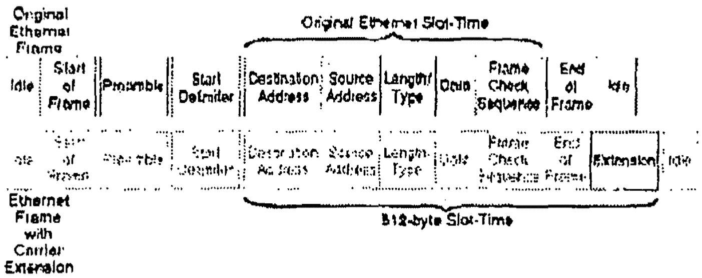

Figure 13. Ethernet Frame using Carrier Extension

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Technology Advances

We have seen that workstations using the PCI bus have more than enough power to accommodate gigabit-speed network interface cards (NICs). Although the PCI bus is ready for Gigabit Ethernet NICs, traditional NIC technology is not suitable for Gigabit Ethernet speeds. The problem is that as network speeds accelerate past the speed of the CPU, utilization of the CPU can reach 100%.

Technology innovators are faced with two compelling questions:

- Which processes require the bulk of the CPU time?
- How can we reduce or even eliminate the CPU-intensive processes, thereby enabling the host to concentrate on application processing?

In terms of network interaction, there are two processes that use a great deal of host CPU time:

- Interacting with protocol layers-adding protocol headers, removing protocol headers, generating checksums, and so on
- Moving data within the memory system

Minimizing the involvement of the host CPU in both of these categories is a requirement for scaling Ethernet NICs to gigabit speeds. While it is not possible to completely eliminate protocol interaction and the need to move data within the

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