CHAPTER 1

Catalyst 3000 Theory of Operation and Specifications

This Chapter covers the following topics:

- Catalyst 3000 Overview and Theory of Operation
- Catalyst 3000 Features and Specifications

Catalyst 3000 Overview

The Catalyst 3000 is an IEEE 802.3-compliant device designed to boost throughput on Ethernet networks. It operates as Media Access Control (MAC)-layer device that is protocol independent. The Catalyst 3000 is fully compatible with TCP/IP, DECnet, LAT, XNS, AppleTalk, and NetWare.

The Catalyst 3000 increases Ethernet throughput by supporting simultaneous, parallel conversations. Full-duplex communication mode is an option for each segment connected to a Catalyst 3000 port.

Rather than storing a whole packet before it is forwarded, the Catalyst 3000 uses error-free cut-through switching so that new connections can be made for the next packet almost immediately.

The Catalyst 3000 can solve congestion problems by dedicating a 10 Mbps or Fast Ethernet segment to each high-bandwidth device and each powerful application, as well as each user.

There are two ways of configuring Catalyst 3000s, either as a single stand alone unit or as a logical combination of up to eight units. This logical combination of units is called a Catalyst Stack.

This chapter describes how the Catalyst 3000 operates as a single stand alone unit. See Chapter 2, “Catalyst 3000 Stack Theory of Operation,” for an explanation of how to logically combine Catalyst 3000 units into a Stack.

How the Catalyst 3000 Works

The Catalyst 3000 contains four main elements as listed below:

- Cross-point switch matrix—establishes switched connections between two segments. Each connection lasts only for the duration of the packet transmission.
- 10BaseT Ports—with the 10BaseT ports, multiple conversations are allowed. Now users running basic applications are able to share bandwidth, and users running bandwidth-intensive applications can receive their own dedicated 10 Mbps port. With the optional Enhanced version of the Catalyst 3000, each 10BaseT port can be set up in full-duplex communication mode so that each 10 Mbps port doubles to 20 Mbps.
- AUI connector—the AUI connector can be attached to an external transceiver for connection to another media type such as 10BaseFL.
- Expansion Modules—each Catalyst 3000 unit supports two expansion modules. These modules include 10Mbps ports to provide up to eight additional 10Mbps ports, or high-speed connections such as 100Mbps, to provide two fast Ethernet connections for servers or backbone connectivity.
- Stack Ports—the Catalyst 3000 unit's Stack port is used to connect up to eight Catalyst 3000 units together. By connecting these units together through the Stack port, the units virtually combine to form a single unit. See Chapter 3, "EtherSwitch Stack Theory of Operation," for detailed explanation of EtherSwitch Stacks.

The following sections describe the operation and features of the Catalyst 3000.

Multiple Simultaneous Conversations

A limitation of Ethernet is that it supports only one conversation at a time. The Catalyst 3000 improves data throughput by supporting multiple, simultaneous, full-duplex conversations. Combining fast-packet, circuit-switching technology, and Fast Ethernet technology, the Catalyst 3000 creates multiple data paths. These switched connections between Ethernet segments last only for the duration of the packet transmission. New connections are made "on-the-fly" between different segments for the next packet.

The increase in throughput is directly proportional to the number of LAN segments that are interconnected through the switch. For example, a Catalyst 3000 with 16 10BaseT ports interconnected provides eight concurrent paths. With eight simultaneous conversations, the Catalyst 3000 creates 80 Mbps throughput in half-duplex mode, or 160 Mbps throughput in full-duplex mode.

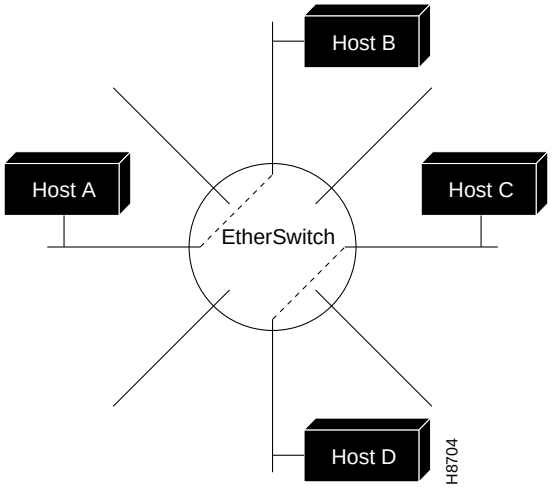
A single segment can be dedicated to a single host or shared by several. To optimize throughput, high-speed servers can be given dedicated Catalyst 3000 ports.

If you think of a standard Ethernet network as a “party-line” telephone system, a network using Catalyst 3000 units is like a PBX that supports multiple telephone conversations. By transporting multiple Ethernet packets simultaneously, it boosts overall network throughput.

Except for the port of entry, the Catalyst 3000 transmits broadcast and multicast packets on all Catalyst 3000 segments simultaneously.

For example, as shown in Figure 1-1, while host A is transmitting a packet to host B, the Catalyst 3000 connects only the lines from A to B since there is no need to send packets to all other ports. At the same time, a second switching circuit can connect host C to host D. The result: two conversations occur simultaneously.

Figure 1-1 Multiple Conversations Through a Catalyst 3000



Low Latency

The Catalyst 3000 minimizes latency—the time it takes to forward a packet from one Ethernet segment to another—by beginning switching immediately after looking at the first six bytes of the destination address in the packet. If the packet needs to be switched to another LAN segment, its data begins flowing through the destination port before the entire packet has been received.

Packets appear at the output port in only 40 microseconds after entering the input port. Network devices that use store-and-forward technology introduce much longer delays because they wait to receive the entire packet before forwarding it. For example, routers and bridges that use conventional, software-based store-and-forward technology impose a latency of 1,200 and 800 microseconds per packet, respectively.

Address Management

At power up, the system address tables do not contain any information. Whenever a Catalyst 3000 receives a packet with an unknown source or destination address, before it sends the packet, it learns the new source address by putting its location into memory. Once the Catalyst 3000 has learned the new source address, it then sends the packet out to its destination address. If the destination address is unknown it sends the packet to all of its output ports. When the response packet comes back, the Catalyst 3000 learns its location and adds it to the address table. Once the address table entry is created, the Catalyst 3000 uses all of these learned address to switch all subsequently addressed packets with less processing, and therefore, faster transmissions.

The system address table maintains up to 10,000 entries with 8 MB of DRAM. The port address tables maintain 1,700 active Ethernet addresses. On-demand aging allows users to set a threshold based on a specific time interval or a percentage of address table capacity. This ensures that the port's address table is populated only by the most frequently used address. You can adjust the aging interval to keep the address tables under the limit. Nodes that have not transmitted after the aging interval you specify on the network management console are removed. When new nodes become active, configuration is re-established with only one packet.

This capability allows users to transparently connect to high-volume backbone networks.

Address Filtering

The Catalyst 3000 supports the configuration of MAC layer filters on a per-port basis. This flexibility allows network managers to specify client access only to designated resources for security purposes. Filters can be for source or destination addresses. This allows the network manager to restrict access to certain servers or MAC addresses or to specify that an end user can communicate with only one server.

On-board Buffering

If the destination port is receiving a packet from another Catalyst 3000 port or if the output segment is busy, the Catalyst 3000 stores the packet in one of its internal buffers. Each Catalyst 3000 buffer can hold up to 384 packets in each direction (incoming and outgoing). This helps balance throughput when networks are operating near peak load and more than one packet may be directed to the same port at the same time.

Full-Duplex Communication

You can select half-duplex or full-duplex communication. The advantage of using full-duplex is that communication packets can flow in both directions simultaneously, which results in doubling the throughput capacity on the segment.

Full-duplex communication eliminates the performance degradation resulting from packet collisions. Packets cannot collide because they each travel on their own path—like cars going in opposite directions on a two-lane highway. So while the effective bandwidth to a 10BaseT port configured for half-duplex Ethernet is a maximum of 10 Mbps, with full-duplex Ethernet it is doubled to 20 Mbps.

Virtual LAN (VLAN)

Using the Catalyst VLAN feature, you can partition a single Catalyst 3000 into VLANs, each containing its own set of ports. Packets are forwarded only between ports belonging to the same VLAN. The benefit of a VLAN is to restrict access from one segment to another, either for security purposes or to reduce intersegment traffic.

EtherChannel

A high-bandwidth connection between two Catalyst units. Each EtherChannel comprises from two to seven ports, for up to 140 Mbps bandwidth in Full-Duplex mode. By connecting three cables between two Catalyst 3000 devices, for example, you would increase throughput to 30 Mbps in Half-Duplex mode, or 60 Mbps in Full-Duplex mode. Network managers can connect multiple 10 Mbps ports to create a single “fat pipe.” Existing Catalyst units can gain access to high-speed servers, routers, and backbones connected to the Fast Ethernet ports through the EtherChannel connections to an Catalyst 3000.

Error Handling

A major source of errors in Ethernet networks is packet collisions that are due to low network throughput. The Catalyst 3000 uses cut-through switching to reduce latency, thus increasing throughput. The network interface cards of the destination servers or workstations check for any packet errors that the Catalyst 3000 forwards to them, so to maintain low latency, the Catalyst 3000 can be set to not duplicate this function. In contrast,

routers and bridges that perform redundant store-and-forward error checking on all packets impose delays of between 51.2 and 1,214 microseconds. The reason for the delay is because they must receive the entire packet before forwarding it to its destination port, since the Frame Check Sequence (FCS) comprises the final 32 bits of an IEEE 802.3 packet.

Individual ports on the Catalyst 3000 can be set to run in a dedicated low latency, low error cut-through switching mode, or they can be set to run only in the store-and-forward mode, or they can be set to a mode of automatic switching from cut-through to store-and-forward. The automatic mode measures the amount of CRC errors in cut-through mode and if the level rises above a configurable setting, error handling switches to store-and-forward. Error handling will automatically switch back to cut-through when the error level falls below the set amount. The error handling will be in the store-and-forward mode only for different port speed connections (10Base to 100Base for example).

The Catalyst 3000 can also be set to check for incomplete packets and discard them. See Chapter 7, “Console Configuration,” for a detailed explanation and configuration of the error handling modes for the Catalyst 3000.

Catalyst 3000 Features and Specifications

The following sections list the features and specifications of the Catalyst 3000.

Catalyst 3000 Features

- Immediate plug and play capability
- Low error cut-through switching
- Error-free cut-through switching
- Address filtering on source and destination addresses
- Automatic on-demand address aging on a per-port basis
- 10,000 system addresses
- 1700 addresses per port
- 192 KB buffering per 10 Mbps port (384 packets)
- 40 microseconds latency time
- IEEE 802.1d spanning tree compliant
- SwitchProbe SPAN (Switch Port ANalyzer) monitoring port
- RMON
- Console port
- Telnet support
- Bridge MIB, Ethernet MIB, SNMP MIB II and Catalyst extensions
- Flash PROM for software updates
- Full-duplex support
- EtherChannel for connectivity to existing Catalyst (Kalpana) products
- Virtual LAN (VLAN) capability
- Expansion Components
- Redundant power supplies (Non-Removable) with 2 AC inputs

Catalyst 3000 Specifications

The following table details the Catalyst 3000 system specifications.

Table 1-1 Catalyst 3000 Specifications

Catalyst 3000 Specification	Description
Rack mount	19 in. rack mount (hardware included)
Dimensions	Width: 17 in. (43 cm) Depth: 13.38 in. (34 cm) Height 5.5 in. (14 cm) (3.2 Rack Units)
Weight	Chassis only: 27 lbs. Chassis fully loaded with modules: 32 lbs.
Power	90 to 264 VAC auto-sensing
Frequency	47 to 63 Hz
AC current rating	4A @ 120V; 2A @ 220V
Thermal dissipation	100 Watts 340 BTUs/hr
Temperature:	
Operating	0 to 50 C
Not operating	-25 to 70 C
Humidity:	
Operating	8 to 80% (non-condensing)
Not operating	90% @ 45 C
Electromagnetic Emissions	FCC Class A (47CFR, Part 15)
Certification	EN 55022 Class B, VCCI Class 2 ICES-003 (Industry Canada) Class A CE marking with UTP
Safety	UL1950, CSA-C22.2 No.950-33 EN60950

Catalyst 3000 Specification	Description
Microprocessor	i960 RISC processor
Memory	8MB
Flash EPROM	1024KB standard
LAN compatibility	Ethernet/IEEE 802.3
Expansion Modules (LAN port)	See Chapter 5, Expansion Components Installation and Configuration
Console (monitoring port)	EIA(RS)232, DB9 connector
SwitchProbe SPAN port (monitoring *only* port)	AUI, DB15 connector
Address support	1,700 addresses per port 10,000 addresses per system
Address Filter Rate	357 K packets/second
Address Forward Rate	714 K packets/second
Address Table Setup	Transparent and automatic
Latency	10 to 10: 40 microsec. 10 to 100: 64 microsec.
Software updates	Flash PROM, bootp/TFTP
Protocol compatibility	Transparent to higher layer protocols
Spanning Tree support	IEEE 802.1d compliant
RFC MIB's supported	Ethernet Statistics (RFC1643) Bridging (RFC1493) System, TCP/IP, SNMP MIB II (RFC1213) Interface Extensions (RFC1573) RMON (RFC1757)

Catalyst 3000 Specification	Description
Network Management	**Applications**: • CiscoView • SNMP Management Platform Console: • Console sessions • Telnet sessions