Fiber Saver (2029) Implementation Guide

The desired MAN solution for dispersed data centers

Designing, planning, and migration considerations

Architecture, features, and applications

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Fiber Saver (2029)
Implementation Guide

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Take Note!

Before using this information and the product it supports, be sure to read the general information in Appendix D, "Special notices" on page 219.

Third Edition (August 2001)

This edition applies to Release 3.1 of the IBM Fiber Saver (2029).

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Contents

Preface

IBM offers a Dense Wavelength Division Multiplexing (DWDM) solution with the IBM Fiber Saver (2029). The IBM 2029 provides data transport capabilities for data center applications such as:

- Data center backup and recovery
- DASD mirroring
- Tape vaulting and remote printing
- Geographically Dispersed Parallel Sysplex (GDPS)
- LAN interconnectivity
- Channel extension
- Peer-to-Peer Remote Copy (PPRC)
- Storage Area Network (SAN)

This IBM Redbook is for technical professionals who are interested in a metropolitan area network (MAN) solution for their data center, using DWDM technology.

This document gives a broad understanding of the IBM 2029 architecture and application, and provides information to help plan, implement, configure, and manage an IBM 2029 network. It also contains a discussion on how to design/create a solution to migrate from an IBM 9729 to an IBM 2029.

A walkthrough of the commissioning and provisioning process, as well as practical examples for problem determination, are also included.

The team that wrote this redbook

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Comments welcome

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Chapter 1. Overview

The IBM 2029 is a high-speed, high-capacity, scalable fiber-optic data transport system that uses Dense Wavelength Division Multiplexing (DWDM) technology. It is designed for metropolitan area data communication networks.

It has per-wavelength management and passive optical passthrough, which deliver true optical networking and reduce the need for back-to-back electro-optic conversions.

Designed to meet the economic and technical requirements of metropolitan applications, it can achieve the distances encountered in most of these networks without using optical amplifiers.

The traffic-carrying modules in IBM 2029 are protocol and bit-rate independent, enabling it to carry different types of traffic over an optical channel regardless of the protocol, and to support native data interfaces.

The IBM 2029 architecture ensures data survivability regardless of the protocol of the traffic being carried. Path switching, fiber switching, and equipment switching provide protection in the IBM 2029 network to ensure that fiber cuts or equipment failures do not affect payload traffic.

This chapter provides an overview of the IBM 2029 network and its components. It also discusses the range of configuration and availability options that the IBM 2029 Fiber Saver supports.

1.1 Multiplexing on fiber optic connections

Multiplexing is the process of simultaneously transmitting multiple signals over the same physical connection. There are three common types of multiplexing used for fiber optic connections:

1. Time Division Multiplexing (TDM)
2. Wavelength Division Multiplexing (WDM)
3. Dense Wavelength Division Multiplexing (DWDM)

1.1.1 Time Division Multiplexing (TDM)

TDM is a method of combining several slower speed data streams into a single high speed data stream. Data from multiple sources is broken into portions (bits or bit groups) and these portions are transmitted in a defined sequence. Each of the input data streams then becomes a “time slice” in the output stream. The transmission order must be maintained so that the input streams can be reassembled at the destination.

Figure 1 on page 2 shows a simple example of TDM where three input data streams are combined into a single output data stream.

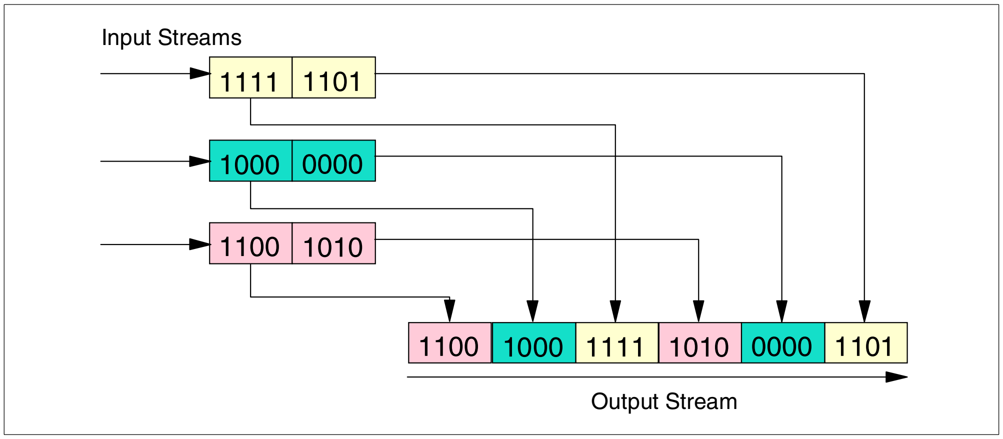


Figure 1. Time Division Multiplexing

The IBM 2029 uses TDM within a channel (wavelength) for some low data rate protocols. This allows more efficient use of the available bandwidth.

1.1.2 Wavelength Division Multiplexing (WDM)

WDM allows the simultaneous transmission of a small number of data streams over the same physical fiber, each using a different optical wavelength. WDM technology is used by the IBM 9729. The advantages of WDM over TDM are that transmission order does not need to be maintained and that the information streams can use different protocols and bit rates.

1.1.3 Dense Wavelength Division Multiplexing (DWDM)

DWDM is an approach to opening up the conventional optical fiber bandwidth by breaking it up into many channels, each at a different optical wavelength (a different color of light). Each wavelength can carry a signal at any bit rate less than an upper limit defined by the electronics, typically up to several gigabits per second. DWDM has all the advantages of WDM but with the added benefit of supporting far more independent transmissions over the same fiber.

The IBM 2029 uses DWDM to simultaneously transmit up to 32 channels over the same fiber connection. The channels are independent of protocol and bit rate, so a wide variety of protocols are supported.

Figure 2 on page 3 shows an example of four independent signals transmitted over a single fiber using DWDM. The signals are multiplexed into a single fiber using a passive grating multiplexer. Because the signal bandwidth that the electronics can handle over one wavelength is such a small fraction of the inter-channel spacing, the signals do not interfere with each other.

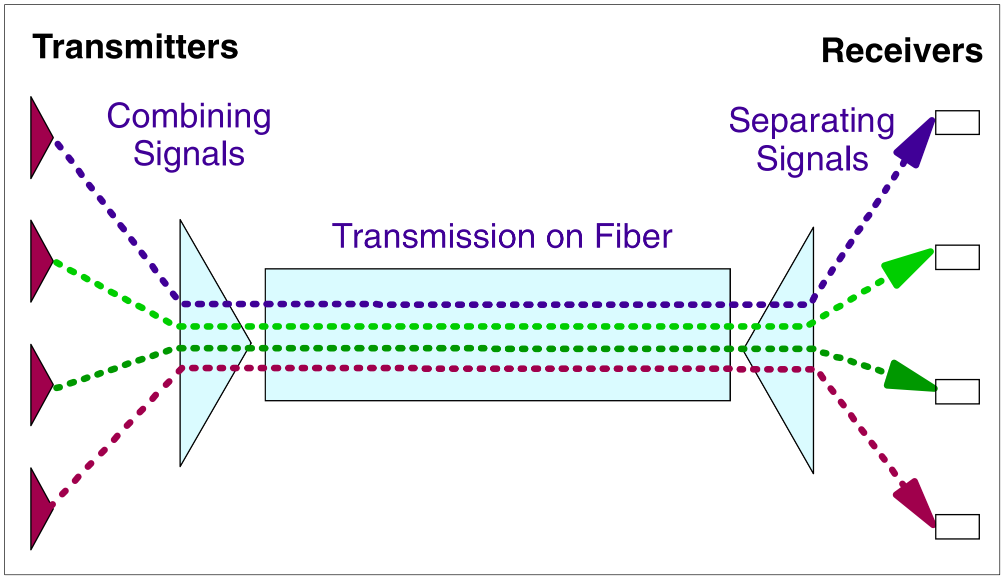


Figure 2. Dense Wavelength Division Multiplexing (DWDM) principle

An Add-Drop Multiplexer (ADM) is used at intermediate stations (see Figure 3). It removes (drops) a channel from a combined DWDM signal or adds a channel to a combined DWDM signal without interfering with the other channels on the fiber. After a channel has been dropped, the wavelength then becomes available to be reused by a different signal.

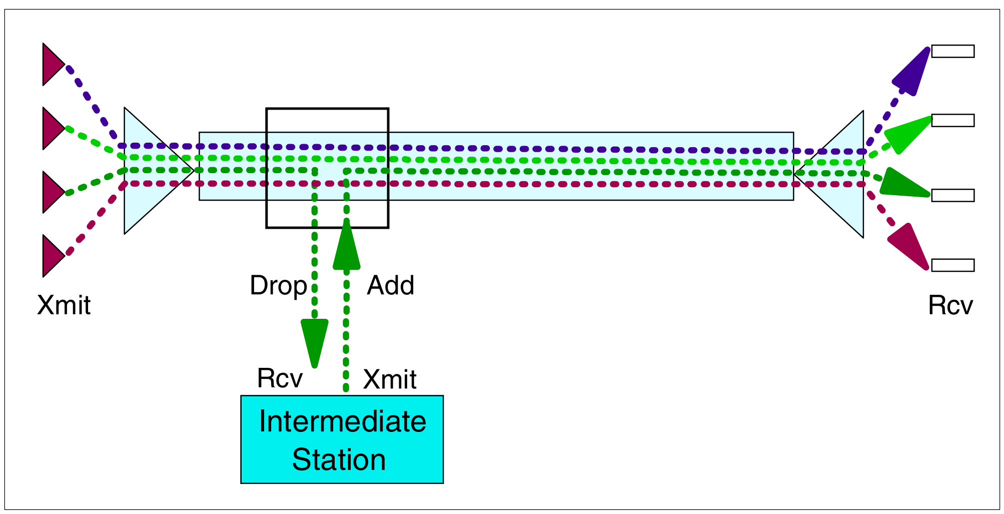


Figure 3. Add/Drop Multiplexing (ADM) principle

Figure 4 on page 4 shows a DWDM Multiplexer/Demultiplexer device. It has a crystal of transparent material, with parallel sides, on which a dielectric filter is deposited. The filter allows a single wavelength to be transmitted, reflecting all others. Thus, a ray of light entering the device through a Graded Index (GRIN) lens will have one wavelength separated or demultiplexed from it. The device will operate in reverse as a DWDM multiplexer.

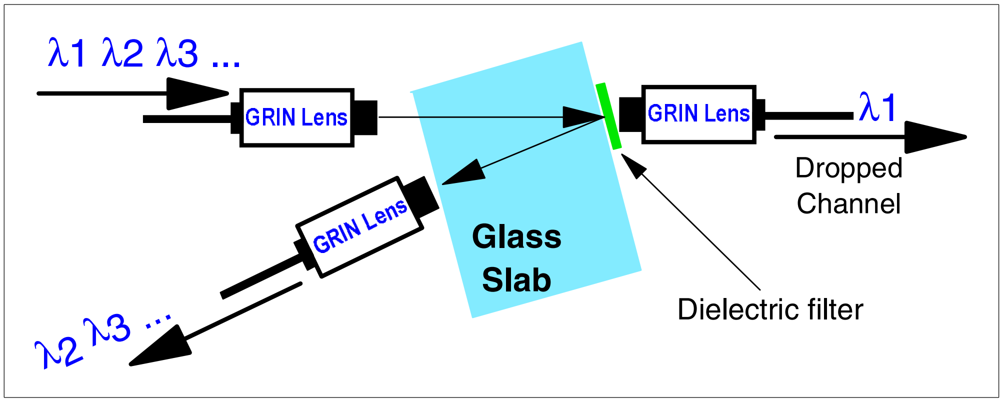


Figure 4. DWDM Multiplexer/Demultiplexer with dielectric filter

1.2 The IBM 2029 shelf

The IBM 2029 shelf is the basic unit used to build an IBM 2029 network. A shelf consists of various types of cards and components that convert optical signals into electrical signals and electrical signals into optical signals, to add, drop, multiplex and pass signals through the network.

The optical signals from the IBM 2029 network are converted into electrical signals only on the shelf that drops them. All other optical signals pass through the shelf's optical filters unchanged. The use of passive optical filters and multiplexers allows traffic continuity through a shelf even in the event of a power failure.

Each shelf operates in a specified wavelength band, which is determined by the wavelength band of the optical modules installed in the shelf. There are eight wavelength bands, Band 1 through to Band 8, that can be used in an IBM 2029 network.

Because the shelves in an IBM 2029 network operate in pairs (see Figure 5 on page 5), there must be two shelves with the same wavelength band in two locations of the network (hub site and remote site). Therefore, the maximum number of shelves in an IBM 2029 network is 16 (eight pairs).

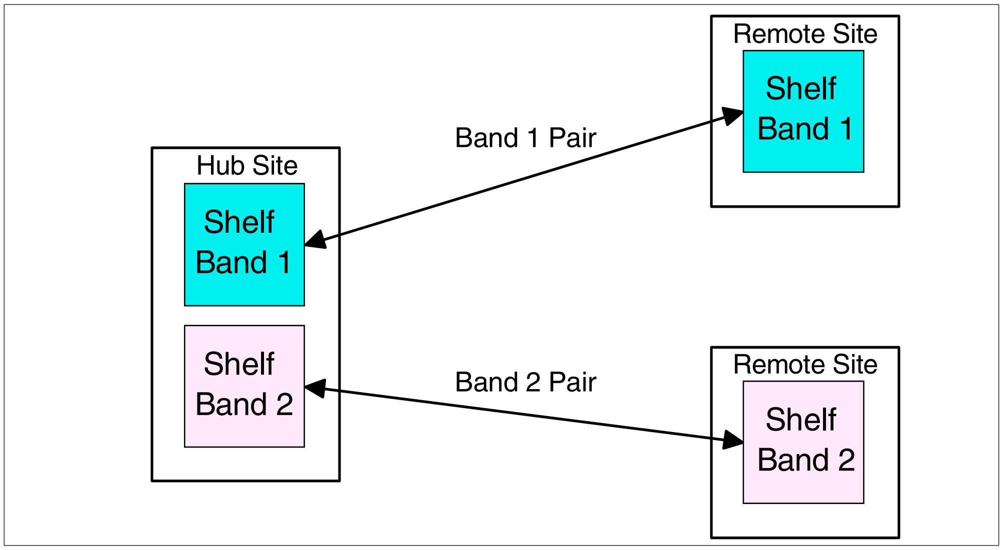


Figure 5. The IBM 2029 shelf pairs

Each shelf is divided into two parts, the West side and the East side (see Figure 6). The two sides must have the same wavelength band. A side can have up to four channels, Channel 1 (CH1) through Channel 4 (CH4), each operating on a different wavelength within the shelf's wavelength band. Each West side channel has the same wavelength as the corresponding East side channel: CH1W and CH1E have the same wavelength, and so on.

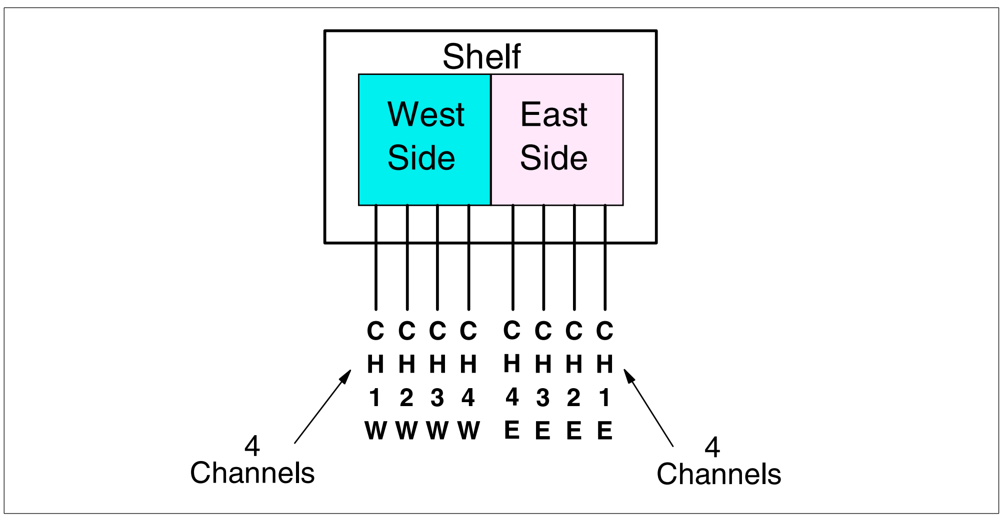


Figure 6. The IBM 2029 shelf's West and East sides

Because each shelf side can operate independently, up to eight channels (CH1W to CH4W and CH1E to CH4E) can be used in an IBM 2029 shelf.

Each channel is full-duplex and is used to carry any supported link signal from any device interface that is connected to it.

Using all eight wavelength band shelf pairs and eight channels on each shelf, the maximum number of channels in an IBM 2029 network is 64.

1.3 The IBM 2029 network

An IBM 2029 network consists of multiple IBM 2029 shelves that are interconnected by pairs of optical fibers. The optical signals from the devices that are connected to the IBM 2029 channels are transported across the IBM 2029 network.

An IBM 2029 network can have one to eight pairs of IBM 2029 shelves at multiple sites configured in a hubbed-ring or point-to-point configuration. Each site can have one or more IBM 2029 shelves.

In both configuration types, per-wavelength optical service channels provide communications between sites, over the same optical fiber pairs. These service channels are used to manage and monitor the operation of the optical channels in the network. Any shelf at any site can be used to manage any channel in the IBM 2029 network.

A fully-loaded IBM 2029 network has 16 shelves and can transport up to 32 high availability or 64 base channels over both optical fiber pairs. Each channel can operate up to 1.25 Gbps, allowing for a total transport capacity of 80 Gbps.

1.3.1 Point-to-point configuration

A point-to-point configuration has only two sites, the hub site and the remote site, connected by up to four pairs of optical fibers, as shown in Figure 7.

Both sites must have the same number of shelves. A shelf at the hub site must have the same wavelength band as a shelf at the remote site. A wavelength band can be used only by one shelf pair in an IBM 2029 network.

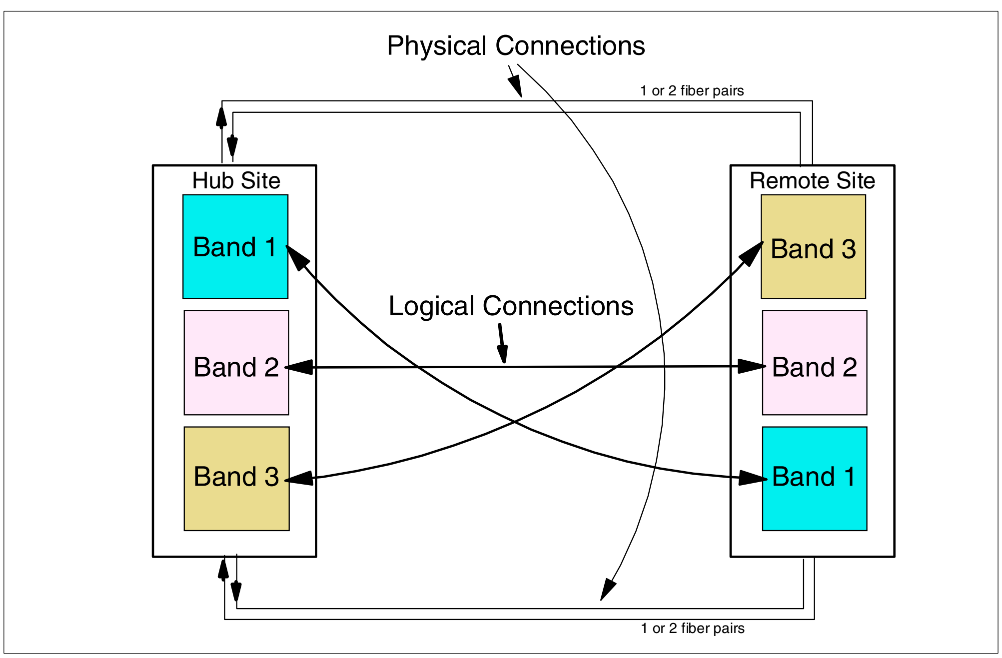


Figure 7. Point-to-point configuration

The number of shelves between the same wavelength shelf pair must be the same in both fiber path directions. This means that the shelf sequence at the remote site must be the reverse order of the shelf sequence at the hub site, as shown in Figure 7. The Band 1 signal from the hub site passes through Band 2 and 3 shelves at the remote site before reaching the Band 1 shelf. If the other path is taken, the Band 1 signal passes through the Band 2 and 3 shelves at the hub site before reaching the Band 1 shelf at the remote site.

There is some signal strength loss (attenuation) as the signal passes through each shelf. The correct shelf sequence ensures that attenuation between any two paired shelves does not exceed the maximum allowed.

The maximum point-to-point configuration consists of eight shelves at each site.

For management and monitoring purposes, an Ethernet hub must be installed at one of the two sites to provide intershelf communications if two or more shelves are present.

1.3.2 Hubbed-ring configuration

A hubbed-ring configuration (see Figure 8) can have more than two sites. Up to eight remote sites can be connected to the hub site through pairs of optical fibers in the IBM 2029 ring network.

Multiple shelves are installed at the hub site, one shelf for each remote shelf at a remote site. Remote sites can also have multiple shelves. A shelf in a remote site must have the same wavelength band as a shelf at the hub site. A wavelength band can be used only by one shelf pair in an IBM 2029 network.

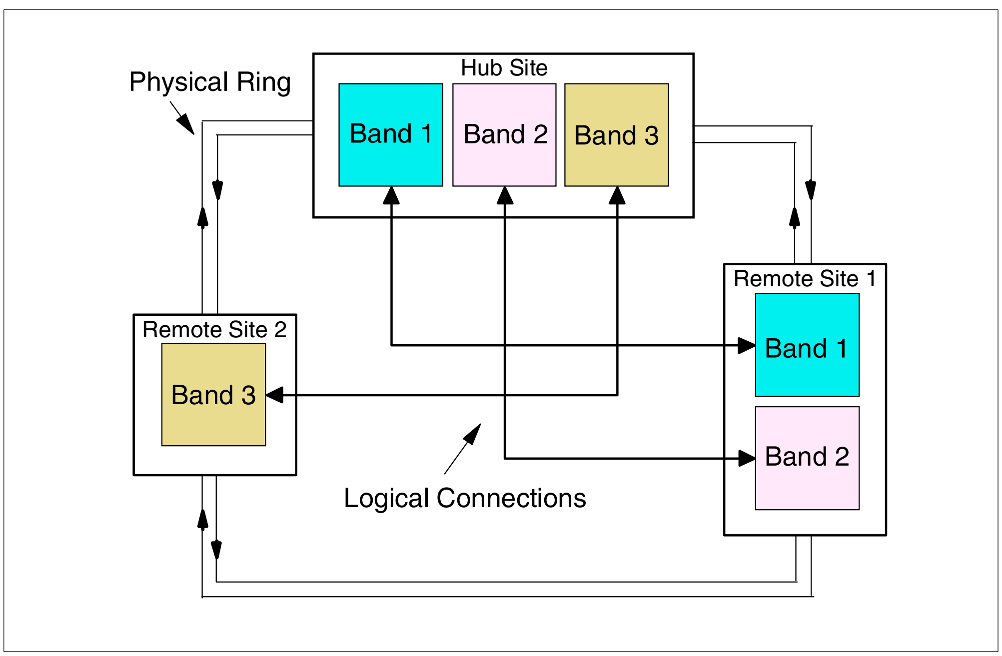


Figure 8. Hubbed-ring configuration

Communications are always between a hub site shelf and the corresponding remote site shelf with the same wavelength, passing through other wavelength band shelves. A remote site shelf cannot send or receive signals to or from another remote site shelf.

As with the point-to-point configuration, the number of shelves between the same wavelength shelf pair must be the same in both path directions. Using Figure 8 as an example, the Band 1 signal at the hub site passes through two shelves (Band 2 and Band 3 at the hub site) to reach the Band 1 shelf at remote site 1, and also passes through two shelves in the other direction (Band 3 at remote site 2 and Band 2 at remote site 1).

A maximum hubbed-ring configuration consists of eight shelves at the hub site and eight remote shelves, at eight single-shelf remote sites or fewer multishelf remote sites.

For management and monitoring purposes, an Ethernet hub must be installed at the hub site to provide intershelf communications.

1.4 Base, switched base and high availability channels

The IBM 2029 channels can be configured as *base, switched base* or *high availability* channels. The configuration should be designed to meet your availability and performance requirements.

1.4.1 Base channels

Base channels use either a West or East channel at the hub site to send signals to the remote sites. A signal flows over only one fiber pair (point-to-point) or one direction of the ring (hubbed-ring) to reach the target remote shelf. The path taken depends on whether the signal originates on the West or the East side of the shelf, as shown in Figure 9, and Figure 10 on page 9.

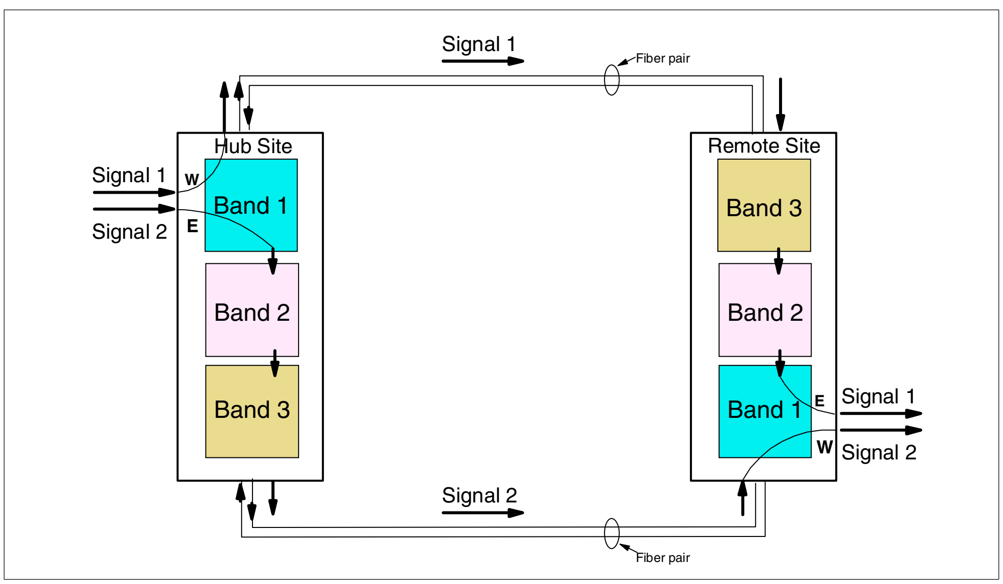


Figure 9. Point-to-point base channels

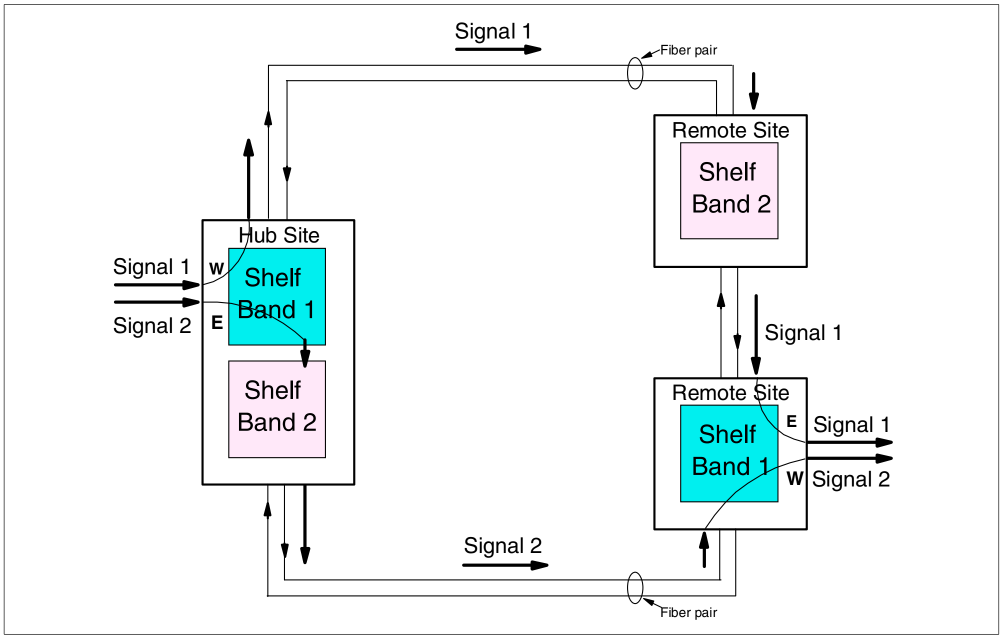


Figure 10. Hubbed-ring base channels

Both path directions can be used, each carrying up to 32 channels. If a fiber pair is cut, all base channels using that fiber pair will be impacted. This means that all signals originating from or destined for one side of the IBM 2029 (West or East) will be stopped.

A balanced distribution of the signals across both path directions can avoid this single point of failure when multipath connections are used between sites.

The maximum number of base channels in an IBM 2029 network is 64, as all eight channels on each shelf can be used.

It is also possible to implement base channels in a point-to-point configuration using only one fiber pair connection between sites. Figure 11 on page 10 shows a single-path point-to-point configuration.

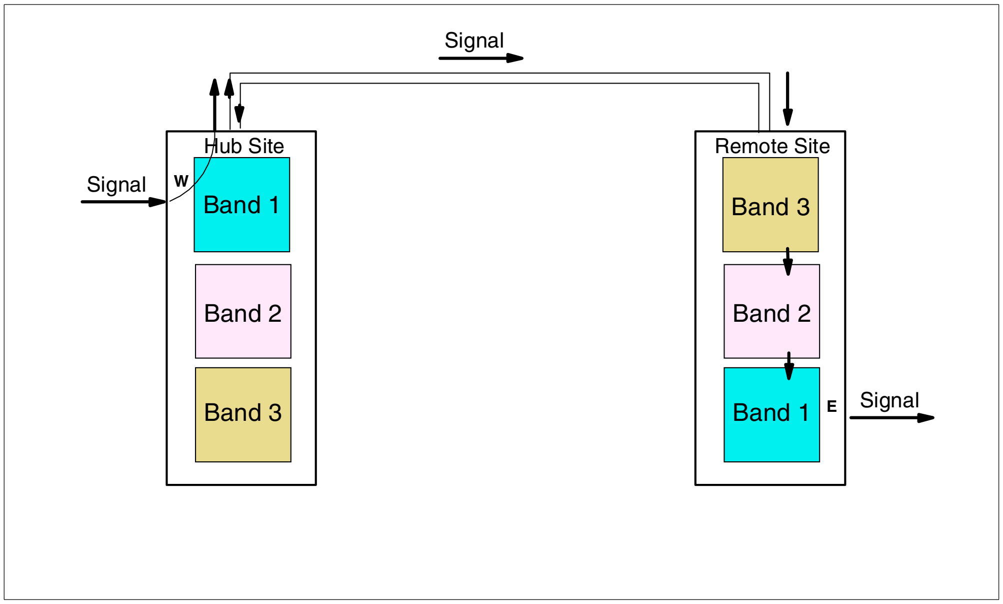


Figure 11. Single-path point-to-point configuration

The maximum number of channels available in this configuration is 32 and all must be defined as base channels. There is a significant availability exposure in such a configuration -- the fiber is a single point of failure for all signal traffic in the IBM 2029 network.

1.4.2 Switched base channels

The IBM 2029 Dual Fiber Switch (DFS) feature is the optional feature that enables switched base channels. The DFS is used to provide redundant connectivity for the cross-site fiber pairs in a point-to-point configuration. One DFS pair for each of the IBM 2029 network sides (East and West) is needed in a four fiber pair configuration, as shown in Figure 12.

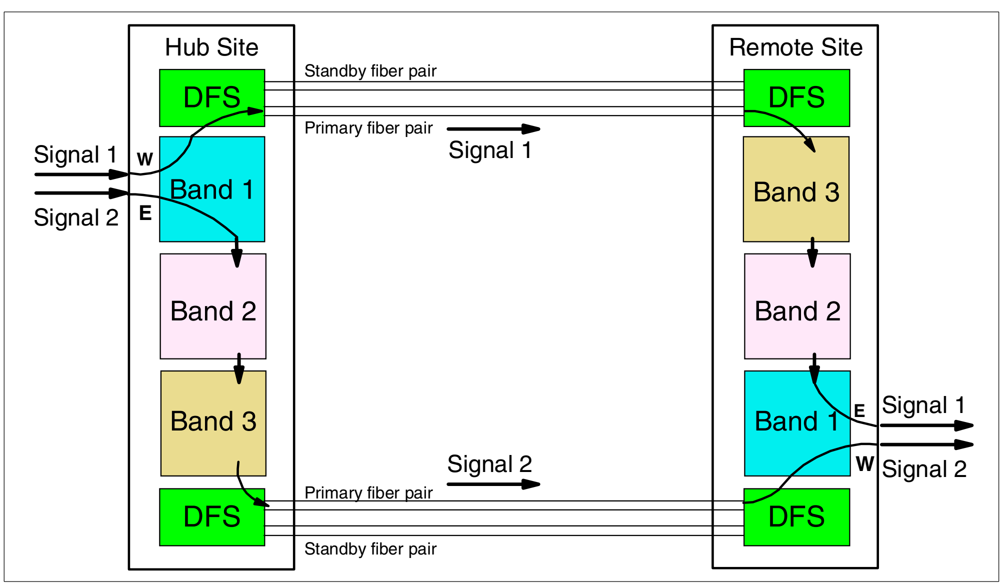


Figure 12. Switched base channels (two DFS pairs)

A single pair of DFSs is needed for a two-fiber pair configuration, as shown in Figure 13.

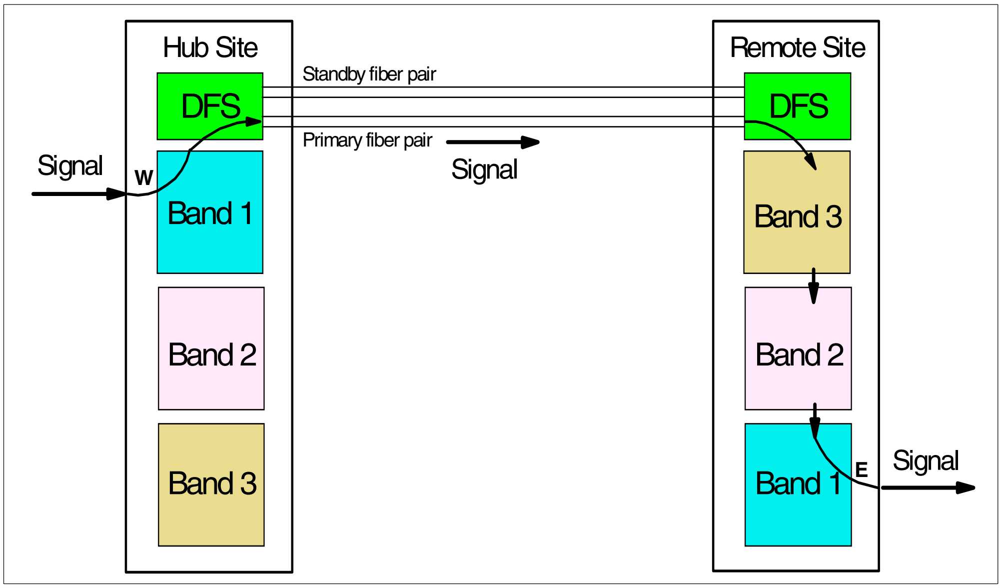


Figure 13. Switched base channels (one DFS pair)

All channels that flow through a DFS are referred to as switched base channels. Therefore, when the DFS feature is installed, all channels in the IBM 2029 network become switched base channels. DFS is not supported in a hubbed-ring configuration and the use of DFS precludes the use of high availability channels in the same IBM 2029 network.

The DFS feature provides protection against extended outages due to fiber cuts. All traffic flows over the primary path while the standby path is constantly monitored for continuity. In the event of disruption to the primary path, all traffic is switched to the standby path within 100ms. This cutover is likely to be transparent or recoverable for some protocols. Detection and recovery are entirely dependent on the recoverability of the hardware and applications that use the IBM 2029 channels.

1.4.3 High availability channels

High availability channels use both West and East channels with the same wavelength at the hub site to send signals to the remote sites. The same signal flows over the two fiber pairs (point-to-point) or over both directions of the ring (hubbed-ring) to reach the target remote shelf. The remote shelf receives both signals, but uses only one of them, as shown in Figure 14 and Figure 15 on page 12.

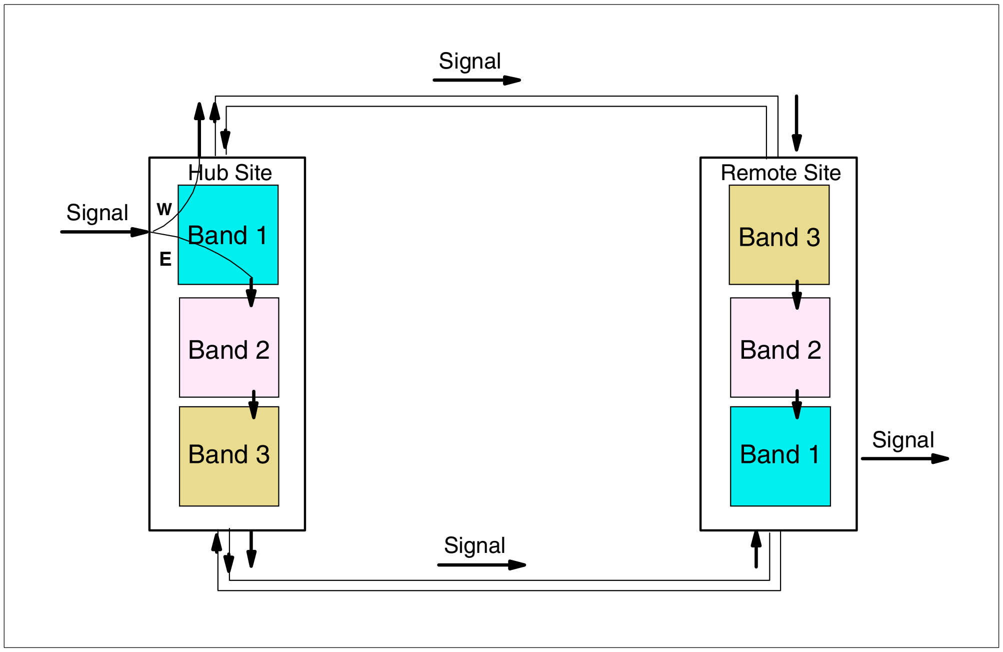


Figure 14. Point-to-point high availability channels

The signal path choice is static, based on the strongest signal received when the channel is provisioned. It can be switched manually or automatically if the active path fails. The path switching time is 50 milliseconds.

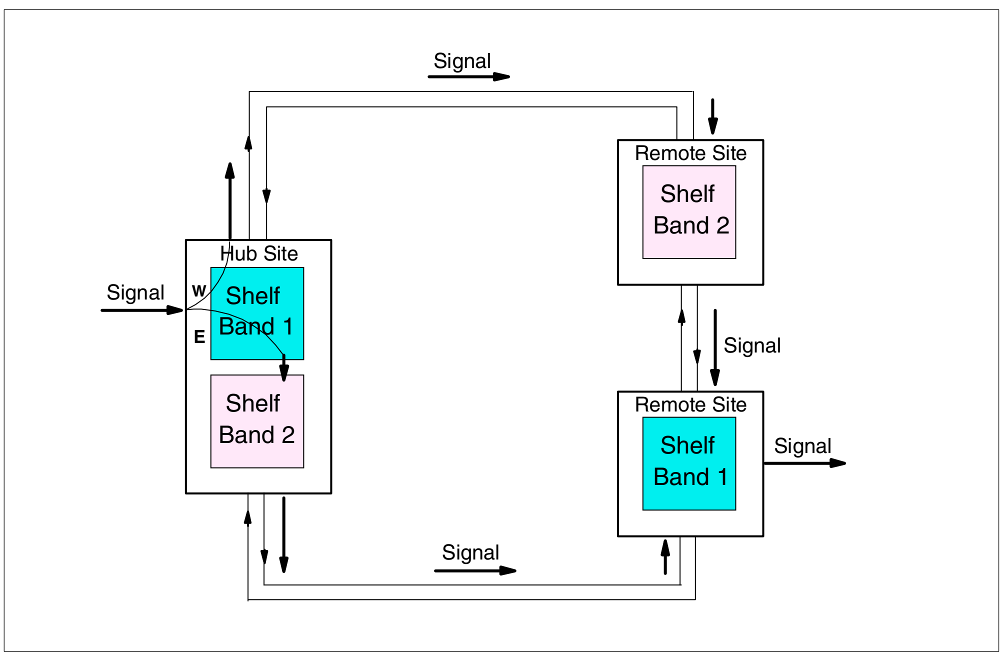


Figure 15. Hubbed-ring high availability channels

The benefit of a high availability channel is path and logic card redundancy. If a fiber pair is cut or a redundant component fails, a high availability channel will automatically be switched to the alternate path or hardware. Detection of packet loss and recovery are handled by the attached hardware, operating system or application. For many applications the switch is likely to be transparent.

The maximum number of high availability channels in an IBM 2029 network is 32, as only four channels in each shelf can be used. High availability channels are configured at an individual channel level so a mix of high availability and base channels is supported. High availability and switched base channels are mutually exclusive in a IBM 2029 network.

The advantages of high availability over switched base channels are additional redundancy for components in the IBM 2029 shelf and shorter switch time in event of a failure.

1.5 Supported protocols

The DWDM technology used by the IBM 2029 provides protocol independence. Any mixture of the following fiber-optic data link types is supported:

- Enterprise Systems Connection (ESCON)

  ESCON multimode and ESCON Extended Distance Feature (XDF) single-mode links
- Fiber Connection (FICON)

  FICON Native (FC) and FICON Bridge (FCV) single-mode Long Wavelength (LX) or multimode Short Wavelength (SX)
- 9037 Sysplex Timer

  Both External Time Reference (ETR) and Control Link Oscillator (CLO) multimode links (9037 Model 002 only) supported only as base or switched base channels in a point-to-point configuration
- Parallel Sysplex Coupling Links

  Single-mode Coupling Facility (CF) links - HiPerLinks or InterSystem Channels (ISCs)
- Asynchronous Transfer Mode (ATM) 155

  ATM, Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) OC-3, single-mode and multimode links
- Asynchronous Transfer Mode (ATM) 622

  ATM, Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) OC-12, single-mode and multimode links
- Fiber Distributed Data Interface (FDDI)

  ANSI X3T9.5 and IEEE 802.2 LAN MAC protocols, multimode links
- Fast Ethernet

  100BASE-FX Ethernet, IEEE 802.3u CSMA/CD protocols, single-mode and multimode links
- Gigabit Ethernet (GbE)

  IEEE 802.3z, Long Wavelength (LX) single-mode or multimode (through mode conditioning patch cables) and Short Wavelength (SX) multimode links

- Fiber Channel

  Fiber Channel Physical and Signaling Interface (FC-PH) ANSI X3.230-1994 and Fiber Channel Fabric Generic Requirements (FC-FG) ANSI X3.289-1996, single-mode and multimode

The IBM 2029 has the capability to mix protocols on a single platform to meet business requirements.

Note

All protocols with the exception of Sysplex Timer can be configured as either base, switched base, or high availability channels.

For more details on the supported protocols and types of connections, see Chapter 3, “Data center environment” on page 45.

1.6 Distances

The supported distance or fiber length in a IBM 2029 network is determined by a number of factors including:

- The configuration type (hubbed-ring or point-to-point)
- Dual Fiber Switch capability
- The number of shelves in the configuration
- Attenuation (dB loss) on fibers, splices and connectors throughout the IBM 2029 network

The maximum supported fiber pair length for all channel types in a point-to-point configuration is 50 km (up to 70 km with RPQ) between the two sites (15 dB maximum loss). In a point-to-point configuration with DFS, the maximum supported fiber length is 40km (12 dB maximum loss). In hubbed-ring configurations, which can have up to nine locations, the maximum distance from the hub site to the farthest remote site is 35 km (10 dB maximum loss).

The maximum end-to-end distance may be limited by individual device specifications and restrictions. Using the Sysplex Timer as an example, the maximum fiber length supported by an ETR (or CLO) link is 40 km.

Table 1 shows the cable length limitations for the protocols supported by the IBM 2029. It also shows the distance increase that can be achieved by extending the connections through an IBM 2029 network.

Table 1. Distance increases that can be achieved using the IBM 2029

Protocol	Maximum distance (km)	Distance with IBM 2029 (km)	Distance Increase (km)
ESCON/SBCON MM	3	50	47
ESCON/SBCON SM	20	50	30
FICON/Fiber Channel SM	10*	50	40
FICON/Fiber Channel MM	0.55	50	49.45
Sysplex Timer ETR/CLO	3*	40	37

Protocol	Maximum distance (km)	Distance with IBM 2029 (km)	Distance Increase (km)
HiPerLinks/ISC links SM	10*	40	30
FDDI MM	2	50	48
Fast Ethernet MM	3	50	47
Gigabit Ethernet LX SM	5	50	45
ATM 155/OC-3 SM	10	50	40
ATM 622/OC-12 SM	10	50	40
* RPQs are available to extend these distances up to 20 km			

1.6.1 Cascading IBM 2029 networks

It is possible to cascade up to four IBM 2029 networks, by connecting shelf channels from one IBM 2029 network to shelf channels on another IBM 2029 network. These networks can have different configuration types (point-to-point or hubbed-ring). Figure 16 shows some cascading possibilities.

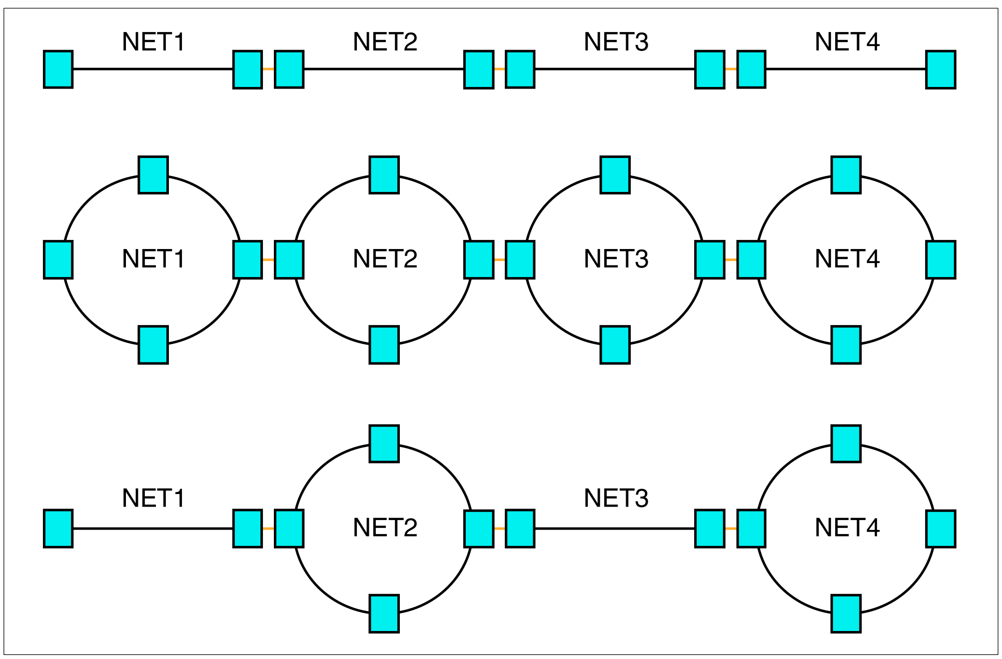


Figure 16. Cascaded IBM 2029 networks

The main reason for cascading is to extend the distance beyond the fiber length supported in an IBM 2029 network. A channel that has already been extended through an IBM 2029 network can be directly connected to another IBM 2029 network and extended again. By cascading four point-to-point configurations, the maximum end-to-end fiber pair length is 200 km. Even in a cascaded configuration the maximum fiber length for a channel is still governed by the specifications of the attached device.

Cascading may also be used to provide flexibility in a more complex configuration with multiple IBM 2029 networks. For example, cascading could be used to provide direct connectivity between two remote sites on separate IBM 2029 networks but with a common hub site, as shown in Figure 17 on page 16.

The signal enters IBM 2029 Network #1 Band 2 at remote Site #1 and exits as expected at the hub site, Network #1 Band 2. This interface is directly cabled to IBM 2029 Network #2 Band 1 so the signal enters Network #2 and exits at remote Site #2. This has effectively created a direct connection between the two remote sites.

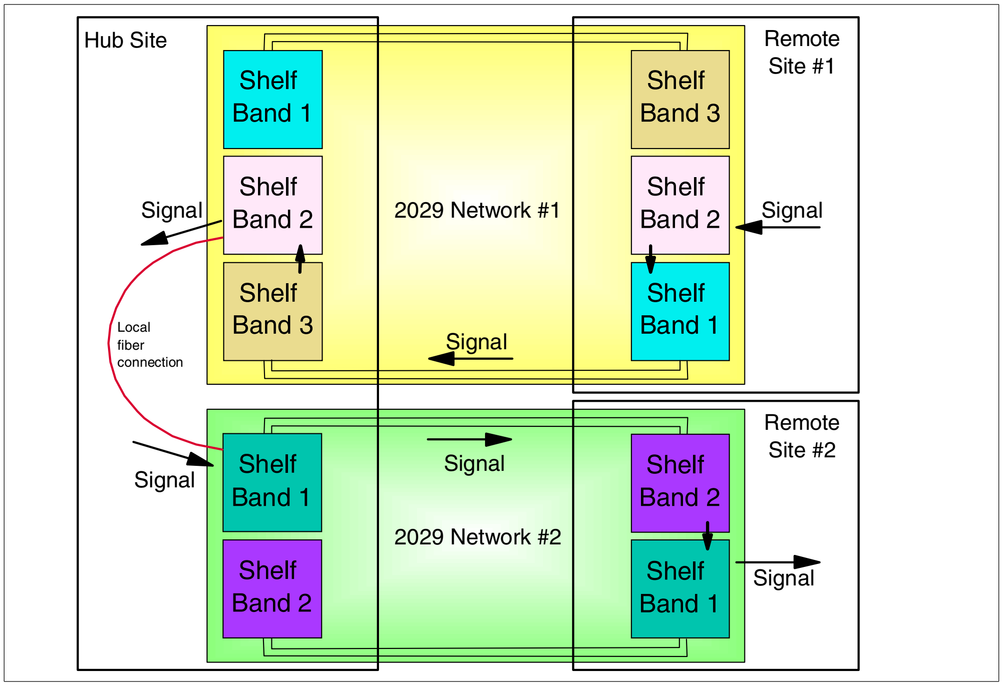


Figure 17. Cascading IBM 2029 networks to provide connectivity between remote sites

For more information on cascading refer to 4.3, "Cascading recommendations" on page 76.

1.7 IBM 2029 models

There are nine IBM 2029 models. All modes support up to 2 shelves in a frame except for the model RS0.

The IBM 2029 models 001 to 004 are to be used at the hub site (hubbed-ring or point-to-point configuration).

The IBM 2029 models RS1 to RS4 are to be used at a remote site (hubbed-ring or point-to-point configuration).

The IBM 2029 model RS0 is to be used at a remote site (hubbed-ring configuration) only.

- Models 001 and RS1

  These have one Band 1 shelf and optionally one Band 2 shelf.

- Models 002 and RS2

  These have one Band 3 shelf and optionally one Band 4 shelf.

- Models 003 and RS3

  These have one Band 5 shelf and optionally one Band 6 shelf.
- Models 004 and RS4

  Have one Band 7 shelf and optionally one Band 8 shelf.
- Model RS0

  This model has one Band 2, Band 4, Band 6, or Band 8 shelf.

An IBM 2029 network must consist of a minimum of one pair of frames (models 001 and RS1). If two or more shelf pairs are ordered, an Ethernet hub will be included. A PC for system management will be provided for each site (hub and remote).

Figure 18 shows a hubbed-ring configuration and the IBM 2029 models used at each site:

- Hub Site: IBM 2029 Model 001 (Band 1 and Band 2) and Model 002 (Band 3 and Band 4)
- Remote Site 1: IBM 2029 Model RS1 (Band 1)
- Remote Site 2: IBM 2029 Model RS0 (Band 2)
- Remote Site 3: IBM 2029 Model RS2 (Band 3 and Band 4)

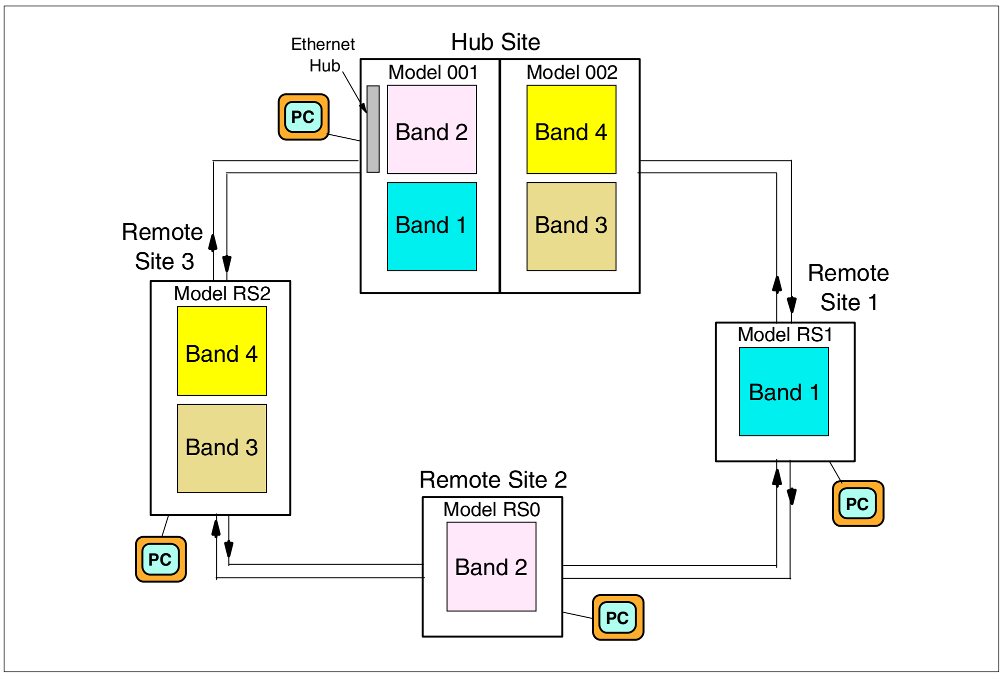


Figure 18. IBM 2029 models

1.8 The frame

Each IBM 2029 model consists of one frame with:

- One or two shelves
- Two power supplies

- One patch panel
- Optionally two Dual Fiber Switches

The patch panel has the required connector types to plug in the cables that are being connected to the IBM 2029, and also to plug in the internal cables that route the signals to and from the cards. The customer does not need to provide hybrid fiber optic cables or attenuators in order to attach different protocols to the IBM 2029.

1.9 The shelf

Each IBM 2029 shelf consists of the following:

- A maintenance panel

  The maintenance panel is located at the top of the shelf and has Bellcore-compliant fault indicators, electrical breakers for redundant power feeds, alarm indicator lamps, alarm cut-off control, and connectors for Ethernet and RS-232 interfaces.

- A card cage

  The cage card is the largest area of the shelf and supports up to 20 individual circuit cards.

- A fiber management trough

  The fiber management trough holds patchcords and fiber-optic cables that are routed to and from the cards installed in the card cage.

- A cooling unit

  The cooling unit has two fans to draw air through the front of the shelf to cool the circuit cards. The cooling fans have two speeds and the system automatically switches to the high speed if the operating temperature of the shelf exceeds the defined threshold, or if one of the fans fails.

- An Optical Multiplexer (OMX) tray

  The OMX tray is located at the bottom of the shelf and contains two OMX modules with matched wavelength bands.

1.10 The Optical Multiplexer (OMX) module

There are two OMX modules with matched wavelength bands, one for the West side and one for the East side of the shelf. Each module contains passive optical filters that add and drop the four channels in the wavelength band assigned to the shelf. Other channels pass through the OMX unchanged.

The optical drop section consists of a band filter (ADF) and a channel demultiplexer (DEMUX). The ADF drops specific wavelengths to the demultiplexer while allowing other wavelengths to pass through the filter. The demultiplexer separates the signal into the 4 channels associated with the wavelength band.

The optical add section consists of a channel multiplexer (MUX) and a band filter (ADF). The multiplexer combines the signals from the 4 channels associated with the wavelength band and passes to the ADF. The ADF multiplexes the signal with the wavelengths from upstream nodes in the IBM 2029 network.

OMX modules are identified by wavelength band (Band 1 through to Band 8).

1.11 The circuit cards

There are five types of circuit cards that plug into the shelf's card cage.

1.11.1 The Optical Channel Interface (OCI)

The OCI card provides the interface between a device and the IBM 2029. OCI cards convert incoming optical signals into electrical signals, and outgoing electrical signals into optical signals. The OCI connectors are connected to the patch panel via internal cables.

Up to eight OCI cards can be installed in a shelf.

There are five types of OCI cards. For details of card specifications and supported protocols refer to Section 2.1.1, “Optical Channel Interface (OCI) card” on page 26.

1.11.2 The Optical Channel Laser and Detector (OCLD)

The OCLD card passes electrical signals to and receives electrical signals from the OCI card through the Optical Channel Manager (OCM) card. The OCLD converts the signal to a DWDM wavelength, which is then passed to the OMX module to be multiplexed with the wavelengths generated by the other OCLD cards.

OCLD cards are identified by wavelength band (BAND 1 to BAND 8) and by channel within the wavelength band (CH1 to CH4). Channels of the OCLD cards correspond to the wavelength band of the OMX modules in the shelf.

Specific channels of the OCLD cards have fixed positions in the shelf's card cage. Up to eight OCLD cards can be installed in a shelf, and they operate from 40 Mbps to 1250 Mbps.

1.11.3 The Optical Channel Manager (OCM)

The OCM cards manage the connections between the OCI and OCLD cards. They also store shelf configuration and provisioning data.

The OCM cards manage path protection switching as the result of fiber cuts or performance degradation. The path protection switches are at the channel level and other channels in the wavelength band are not disrupted when the switch occurs.

Two OCM cards are required on each shelf for redundancy, and they have fixed positions into the shelf's card cage.There are no external connectors on the OCM card. Connectivity to the OCI, OCLD and OCM cards is accomplished through the shelf backplane.

1.11.4 The Shelf Processor (SP)

The SP card manages communication functions for the IBM 2029. It monitors all the circuit cards in the shelf to determine the state of the system. Each circuit card determines its state from feedback at various system monitoring points, then communicates its state to the SP card.

There is one SP card in a shelf on a fixed position in the card cage. There are no external connectors on the SP card. It is connected to the system through the shelf backplane.

1.11.5 Filler cards

Filler cards are installed in the slots of the shelf's card cage that do not have active cards. They can have connectors on the faceplate, used to park unused fiber optic OMX pigtails in inactive OCLD slots. Filler cards with no connectors are used to fill all other unused slots.

1.11.6 Card interaction

Figure 19 shows the signal sequence and the methods of interconnection of the circuit cards installed in an IBM 2029 shelf.

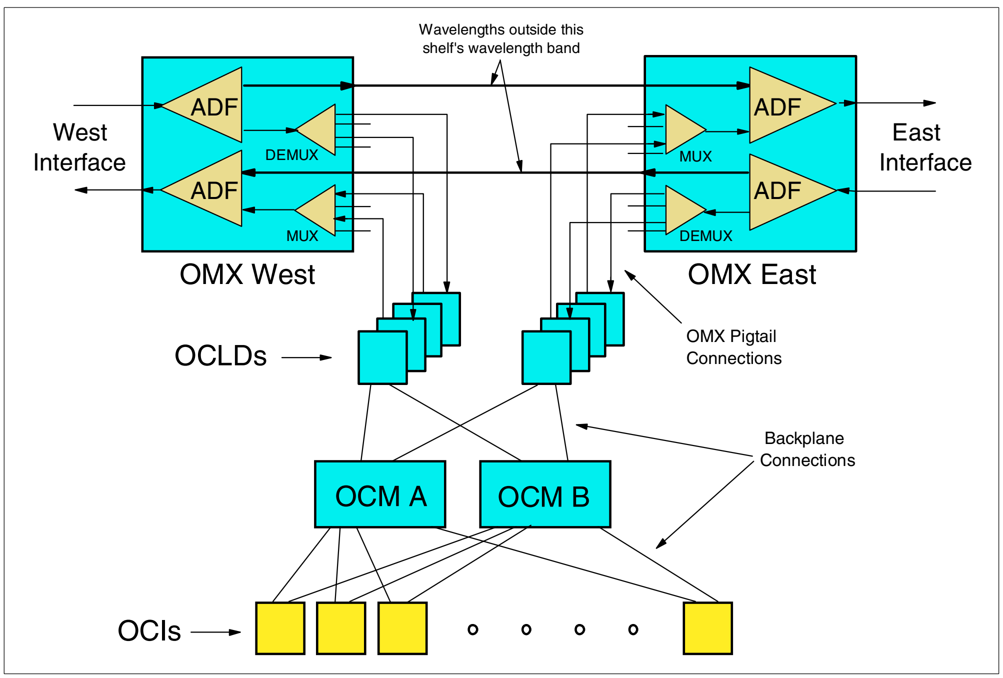


Figure 19. IBM 2029 card interaction

The OCI cards connect to device interfaces. The OCI cards connect to both OCM cards through the shelf backplane. The signal travels across the backplane through the OCM to the OCLD cards. The signal then travels over pigtail connections to the OMX module, where it is multiplexed to the network. High availability channels send signals to both OMX modules (West and East) through their two OCLD cards.

For more details on the components that make up the IBM 2029, see Chapter 2, "Technical description" on page 25.

1.12 Systems management

The IBM 2029 contains Java-based code that is used for commissioning, provisioning, monitoring and maintaining the IBM 2029 network.

The System Manager is a Web-based application that enables you to access any shelf from any shelf, locally or from a remote site, in the IBM 2029 network. The System Manager communicates with the Shelf Processor (SP) of each shelf through the in-band service channels. The Ethernet hub installed at a multishelf hub site allows communication between all in-band service channels from any band shelf pair (cross-band connectivity).

A System Manager applet is stored on the SP of each shelf. The SP card monitors all other cards in the shelf to determine the state of the IBM 2029.

The following functions are available through the System Manager:

- Alarm management
- Event history
- Equipment and facility configuration
- Connection management
- Protection management
- Software download and upgrade
- Performance monitoring
- Logging, security and user administration

For more details on connectivity for system management, see Chapter 5, “System management connectivity” on page 89.

1.13 Performance

The IBM 2029 does not cause any performance impact itself. It is completely transparent to the subsystems that are using it, acting as a single fiber-optic channel. There are no internal queues or busy conditions.

The IBM 2029 network and each network component are designed and sized to deliver the full throughput that the native protocol can achieve. However, performance may be affected by the inherent delay caused by signals travelling over long distances, which is a characteristic of the protocol architecture, rather than an IBM 2029 side effect.

1.14 Availability

The IBM 2029 is designed for high availability, having redundant components and internal cross-connections. When using high availability channels, OCIs send signals to both shelf sides through cross-connected OCMs and OCLDs, reaching both OMXs to be multiplexed and sent down both fiber pairs.

The Dual Fiber Switch feature offers an intermediate, lower-cost availability option. It provides redundancy in the event of a fiber break but it does not provide the same level of hardware component redundancy as high availability channels.

The use of passive OMXs ensures traffic continuity through a shelf even in the event of a shelf or frame power failure: the other shelves can still send and receive their channel signals through the IBM 2029 network.

Each channel on the IBM 2029 is equipped with in-band monitoring, which continually reports channel status. Whether the implementation is a point-to-point or hubbed-ring configuration, it can be managed from a single location with a PC.

The IBM 2029 provides concurrent maintenance because all cards and service elements are hot-pluggable. No regular maintenance is required except for periodically cleaning the air filter on the fan tray.

1.15 Data security

The IBM 2029 is protocol independent and does not view the data being transported. It does no error checking or correction on the data.

Access to the System Manager software is controlled by user-supplied passwords for different access levels. Access may be as administrator (can view and change the IBM 2029 configuration), operator (can view the IBM 2029 configuration and status), or observer (can view the IBM 2029 status only). A maximum of four users can be logged on to an IBM 2029 shelf at the same time.

1.16 Comparing the IBM 2029 to the IBM 9729

The IBM 9729 is the previous optical Wavelength Division Multiplexer (WDM) product, basically with the same purpose as the IBM 2029: fiber consolidation and extension.

There are some capability differences between the IBM 9729 and the IBM 2029, as shown in Table 2.

Table 2. IBM 9729 to IBM 2029 comparison

	IBM 9729	IBM 2029 Base	IBM 2029 Switched Base	IBM 2029 High Availability
Max number of channels	10	64*	64*	32*
Max number of sites	2	9	2	9
Max channel data rate	1.0 Gb/s	1.25 Gb/s	1.25 Gb/s	1.25 Gb/s
FICON links	No	Yes	Yes	Yes
Gb Ethernet links	No	Yes	Yes	Yes
Fiber channel links	No	Yes	Yes	Yes
Max distance	50 km	50km point to point 35km hubbed-ring	40 km	50km point to point 35km hubbed-ring
Number of fibers	1 or 2	2 or 4	4 or 8	4

	IBM 9729	IBM 2029 Base	IBM 2029 Switched Base	IBM 2029 High Availability
Additional backup fiber required	Yes	No	Yes	No
Switching time	< 2 s	N/A	100ms	50ms
*Use of 4TDM OCI cards increases number of channels supported by a factor of 4				

Aside from the capacity differences between the two models, it is interesting to note the differences in their switching mechanisms.

The IBM 9729 always transmits all the signals over only one fiber. A second fiber is available for backup purposes and used only when a fiber switch occurs. If the working fiber is cut, all signals are switched. Switching time is less than 2 seconds.

The IBM 2029 uses both fiber pairs simultaneously for high availability channels. If a fiber pair is cut, some high availability channels are switched but only those using that fiber as the active connection. The switching time is 50 milliseconds.

Base or switched base channels use either East or West fiber pairs. In the event of a fiber break, only the channels using the damaged fiber pair will be affected. In most configurations this is likely to be half of the channels in the IBM 2029 network. In the case of switched base channels the connectivity for affected channels will be restored within 100ms. Base channels using the affected fiber will lose connectivity and will remain unavailable until the fiber is restored.

The IBM 9729 cannot be upgraded to the IBM 2029.

For details about migrating an IBM 9729 to an IBM 2029, see “Migrating from the IBM 9729 to the IBM 2029” on page 81.

Chapter 2. Technical description

This chapter describes the physical components of the IBM 2029 and the types of network configurations in which they can be implemented.

The IBM 2029 networking platform is a scalable, high-speed, high capacity, fiber-optic data transport system. It consists of multiple IBM 2029 shelf pairs that are interconnected by pairs of optical fibers to form a photonic network. This fiber connection network uses dense wavelength division multiplexing (DWDM) to multiplex customer data over 32 (maximum) individual wavelengths, called optical channels, at up to 1.25 Gbps per channel.

An IBM 2029 network can have from one to eight pairs of IBM 2029 shelves at multiple sites configured in a point-to-point or hubbed-ring topology. Each IBM 2029 site can have one or more IBM 2029 shelves. A fully configured IBM 2029 system (16 shelves) can transport up to 32 high availability or 64 base channels.

2.1 Shelf layout

The IBM 2029 frame can contain one or two IBM 2029 shelves. Each shelf has a maintenance panel, card cage, fiber management trough, cooling unit, and optical multiplexer tray (see Figure 20).

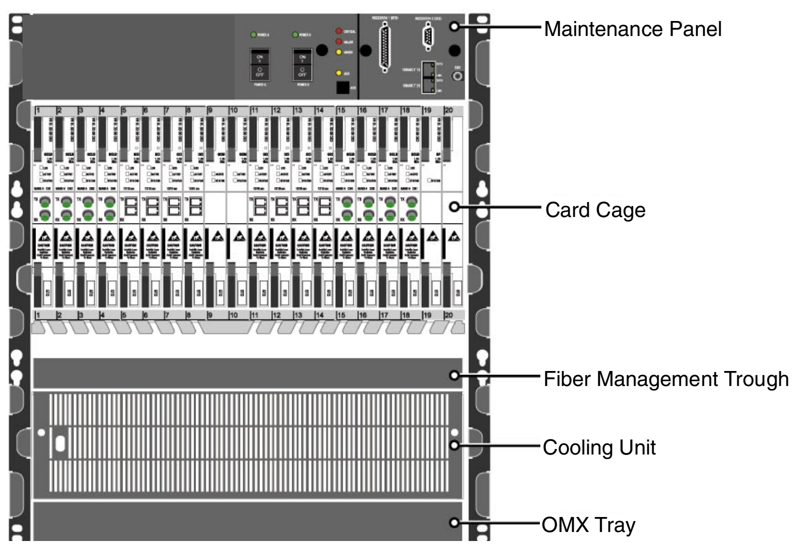


Figure 20. IBM 2029 shelf

The card cage is the largest area of an IBM 2029 shelf. It has twenty slots that hold circuit cards. The circuit cards have the following names:

- Optical Channel Interface (OCI) card
- Optical Channel Laser and Detector (OCLD) card
- Optical Channel Manager (OCM) card
- Shelf Processor (SP) card

Figure 21 shows the logical path flow of signals through the cards and how the cards are arranged in the IBM 2029 shelf, based on their dedicated slot numbers.

Each OCI card provides a fiber-optic interface for connecting a device signal into the IBM 2029 shelf. The OCI cards perform optical to electrical conversion of the signals, which are then placed onto the shelf backplane. The OCM cards map these device signals via the shelf backplane to the appropriate OCLD cards for electrical to wavelength-specific optical conversion. OCLD 1E refers to OCLD card channel number 1 (East). OCLD 1W refers to OCLD card channel number 1 (West).

The two OMX modules are located in the OMX tray at the bottom of the shelf. Each OCLD card connects to its OMX module via fiber-optic pigtails that are a part of the OMX module. The OMX modules use add/drop optical filters (ADF) to multiplex each OCLD optical wavelength-specific signal onto the IBM 2029 network.

The process is reversed to demultiplex signals being received from the IBM 2029 network and to direct those signals to their respective OCI card interfaces.

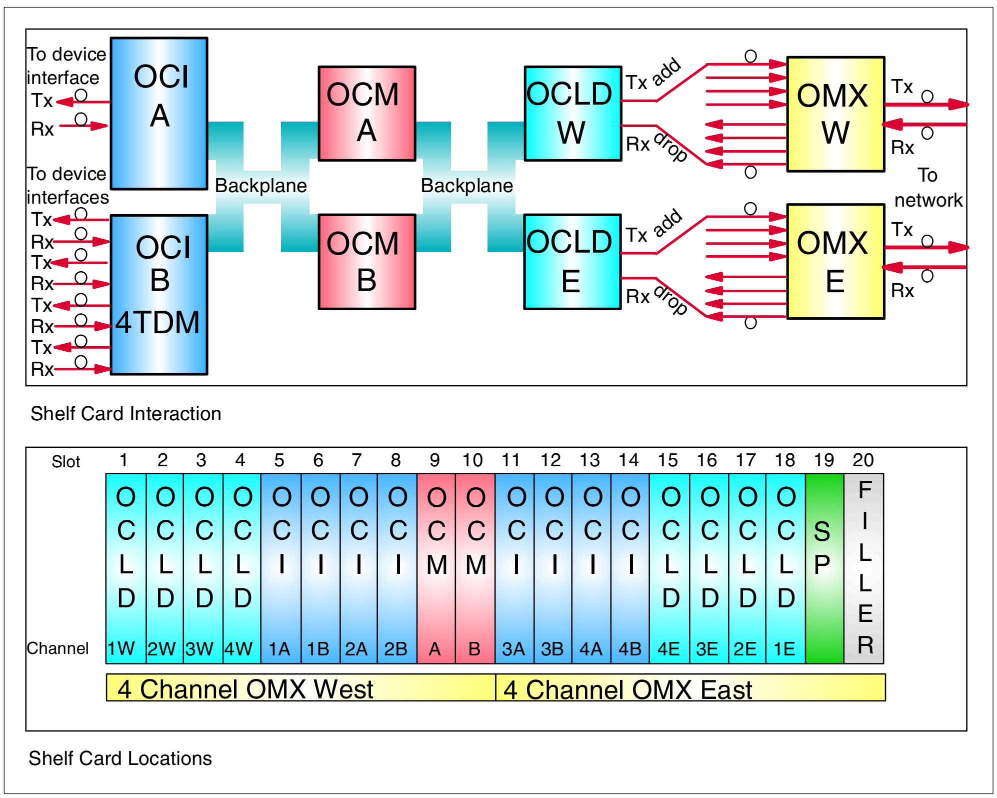


Figure 21. IBM 2029 shelf card interaction and locations

2.1.1 Optical Channel Interface (OCI) card

The OCI card provides the connection between the device interface and the IBM 2029 network. Up to eight OCI cards can be installed in an IBM 2029 shelf.

The OCI card receives its incoming optical signal from its attached device interface through an SC Duplex connector (labeled Rx) on the card faceplate.

The card converts the device optical signal to an electrical signal, which is then placed onto the shelf backplane to the OCM card. The OCM card passes the signal to the appropriate OCLD card for electrical to wavelength specific optical conversion, and then multiplexing via the OMX module onto the IBM 2029 network.

The process is reversed to demultiplex signals being received from the IBM 2029 network and to direct those signals to their respective OCI cards. The OCI card receives the electrical signal via the shelf backplane, converts it to an optical signal, and sends the signal to its attached device interface through an SC Duplex connector (labeled Tx) on the card faceplate.

The OCI cards in each shelf of an IBM 2029 frame are attached via fiber-optic pigtails to an OCI patch panel at the top of the frame. This provides a convenient point of access in the IBM 2029 frame for device interface attachment.

The 4TDM OCI card functions the same as the standard OCI, however, each 4TDM OCI allows up to four device interfaces to be connected to this single circuit card. It multiplexes four optical inputs into a single wavelength, using Time Division Multiplexing. Up to eight 4TDM OCI cards in each shelf are supported, increasing the maximum number of base or switched base channels from 64 to 256, and from 32 to 128 high availability channels. All four channels on the 4TDM OCI card will switch together when in high availability mode or switched base mode.

The 4TDM OCI cards receive incoming signals through MT-RJ connectors on the card faceplate.

There are five types of OCI cards currently available:

- OCI 1310 nm 622 Mbps single-mode (SM) fiber attachment
- OCI 1310 nm 1.25 Gbps single-mode (SM) and multimode (MM) fiber attachment
- OCI ISC (InterSystem Channel) 1300 nm 1.0625 Gbps single-mode (SM) fiber attachment
- OCI 4TDM (Time Division Multiplexer) 1310 nm 1.25 Gbps single-mode (SM) and multimode (MM) fiber attachment
- OCI short wavelength (SX) 850 nm 1.25 Gbps multimode (MM) fiber attachment

Note

1.25 Gbps 1310 nm OCI cards also support the protocols offered on 622 Mbps OCI cards on an RPQ basis only; different combinations of attenuators may be required to support the same protocols on these different types of OCI cards.

Table 3 shows the protocols and fiber types supported on the OCI cards. The 4TDM OCI card only allows one given protocol across all four ports; intermixing of protocols is not supported.

Table 3. OCI card protocol and fiber type support

Protocol / fiber type	OCI 622 Mbps 1310 nm 622 Mbps max. 50 Mbps min.	OCI 1.25 Gbps 1310 nm 1.25 Gbps max. 50 Mbps min.	OCI ISC 1310 nm 1.0625 Gbps	OCI 4TDM 1310 nm 270 Mbps max. 32 Mbps min.	OCI SX 850 nm 1.25 Gbps max. 50 Mbps min.
ESCON/SBCON MM		Yes		Yes	
ESCON/SBCON SM	Yes	Yes *RPQ			
ETR/CLO MM		Yes *Note			
FICON/FCS SM		Yes			
FICON MM					Yes
Fiber Channel MM					Yes
FICON MM via MCP		Yes			
FDDI MM 62.5 micron		Yes			
ATM 155 / OC-3 MM		Yes		Yes	
ATM 155 / OC-3 SM	Yes	Yes *RPQ		Yes	
ATM 622 / OC-12 MM		Yes			
ATM 622 / OC-12 SM	Yes	Yes *RPQ			
Fast ENET MM		Yes		Yes	
Fast ENET SM	Yes			Yes	
Gigabit ENET SX MM					Yes
Gigabit ENET LX SM		Yes			
Gigabit ENET LX MM via MCP		Yes **RPQ			
ISC / HiPerLink SM			Yes		

ENET = Ethernet
SM = single-mode fiber (9/125 micron)
MM = multimode fiber (either 50/125 or 62.5/125 micron unless otherwise noted)
MCP = mode conditioning patch cable, provided as an IBM feature code on selected channel types
SX= short wavelength (SC Duplex or LC connector types can be used)
LX = long wavelength (Gigabit Ethernet)
ISC = InterSystem Channel
TDM= Time Division Multiplexer
*RPQ = supported on a Request for Price Quotation basis only. Different combinations of attenuators may be required to support the same protocols on the different types of OCI cards.
**RPQ = Gigabit Ethernet LX is supported by RPQ request on MM 50/62.5 fiber with MCP cable installed on both ends of the device interface link. The RPQ request allows for an MCP cable to be installed between the OCI card and the patch panel.
*Note: ETR/CLO links for IBM 9037 model 2 Sysplex Timer are only supported in a point-to-point network at a data rate of 16 Mbps on the 1.25 Gbps 1310 nm OCI card.

For OCI card dB specifications, see B.2, “Optical Channel Interface (OCI) specifications” on page 209.

2.1.2 Optical Channel Laser and Detector (OCLD) card

The OCLD card performs electrical to optical conversion for one of the 32 wavelength channels used in the IBM 2029 network. Up to eight OCLD cards can be installed in an IBM 2029 shelf. Each OCLD is identified by shelf wavelength band (Band 1 to Band 8) and by channel within the shelf wavelength band (CH1 to CH4).

A shelf's wavelength band consists of four wavelengths or channels. Each wavelength within the band is assigned to one or two (East and West) OCLD cards in the shelf. For example, OCLD-1E and OCLD-1W both use the same wavelength (CH1) within the shelf band, OCLD-2E and OCLD-2W both use a second wavelength (CH2) within the shelf band, and so on.

The four channels of the OCLD cards have fixed slot locations within the shelf and correspond to the wavelength band of the two OMX modules in the shelf.

Each OCLD passes electrical signals to, and receives electrical signals from, its respective OCI card via the OCM cards and shelf backplane. Optical signals are transferred to and from each OCLD card via fiber-optic pigtails connected to the card's respective OMX module.

Each OCLD card injects a per-wavelength optical service channel (PWOSC) that provides supervisory and performance management for the IBM 2029 network. This overhead information is received and transmitted on the same optical path as the main channel but at a much lower bit rate. The PWOSC is a communication path that is carried along each channel of the optically multiplexed signal connecting the IBM 2029 network.

For OCLD card dB specifications, see B.3, "Optical Channel Laser and Detector (OCLD) specifications" on page 209.

2.1.3 Optical Channel Manager (OCM) card

The two OCM cards in an IBM 2029 shelf manage the connections between the OCI and OCLD cards. They also perform path protection switching (for high availability channels), on a per-channel basis as a result of fiber cuts or performance degradation. See 2.5 "IBM 2029 protection schemes" on page 49 for details on path protection.

The two OCM cards are fully redundant. In the event of an OCM card failure, the other OCM card will continue to manage the channel connections in the IBM 2029 shelf with no disruption to network traffic. System management of the shelf can continue via the redundant communications buses (backplane).

The OMX cards also store shelf configuration and provisioning data.

2.1.4 Optical Multiplexer (OMX) module

The OMX Tray in each IBM 2029 shelf contains two identical OMX modules with wavelength bands matched to the shelf's assigned band and OCLD cards. Each OMX module contains passive add/drop optical filters (ADF) that add (multiplex) and drop (demultiplex) the four channels (wavelengths) in the wavelength band assigned to the IBM 2029 shelf.

Figure 22 shows the functional areas and logical path flow of an OMX module.

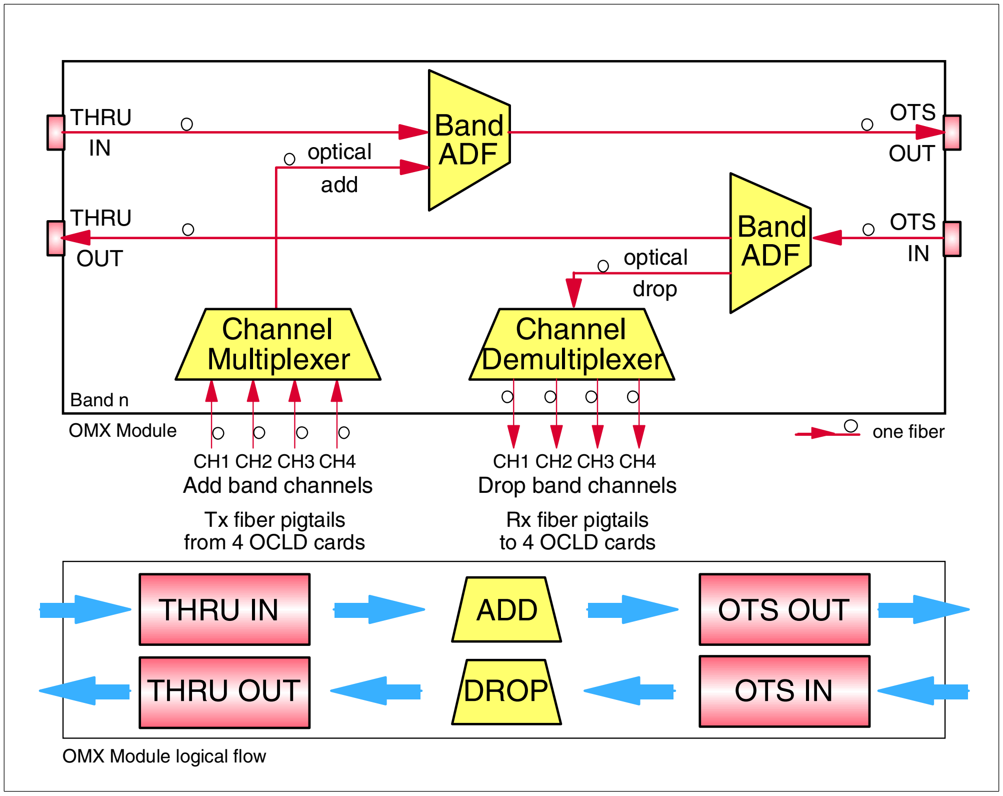


Figure 22. OMX module optical path flow

In the figure, OTS designates the optical transmission section of the OMX module. The OMX module uses passive optical technology to add and drop the shelf's wavelength band (four channels) to and from the IBM 2029 network.

The optical add section consists of an ADF and a channel multiplexer. The optical multiplexer combines the four optical channels from the attached OCLD cards into the shelf's wavelength band. The ADF adds the shelf's wavelength band from the multiplexer to the rest of the optical traffic flowing through the IBM 2029 network.

The optical drop section consists of an ADF and a channel demultiplexer. The band filter drops its wavelength band to the demultiplexer and allows the bands from other shelves to pass through the filter. The optical demultiplexer separates the four optical channels of the shelf's wavelength band and passes them to the attached OCLD cards.

An OMX module is a completely passive device. It cannot add or drop optical channels that have wavelengths outside its designated spectral band. Nor can it bypass optical channels that have wavelengths within its designated spectral band.

For OMX module dB specifications, see B.4, “Optical Multiplexer (OMX) module specifications” on page 210.

2.1.5 Shelf Processor (SP) card

The SP card contains the system manager microcode and provides local shelf systems management, inter-shelf systems management communications, alarm consolidation, shelf software and configuration management, and performance monitoring.

It monitors all the circuit cards in the IBM 2029 shelf and can diagnose a failure to a specific card. The SP card triggers alarms in the IBM 2029 shelf based on data it receives from various monitoring points on the shelf circuit cards, OMX modules, maintenance panel, shelf power, and cooling unit.

2.1.6 Device interface patch panel

The OCI cards in each shelf of an IBM 2029 frame are attached via fiber-optic pigtails to an OCI patch panel at the top of the frame. This provides a convenient point of access to the IBM 2029 frame for device interface attachment.

The IBM 2029 base patch panel is 2U high and has 16 single port connectors.

Base patch panel pigtails:

- Multimode protocols require 12 dB TX (transmitter) attenuated cables
- Single-mode protocols are not attenuated; except when using the 622 Mbps OCI for Fast Ethernet (SM), a 7 dB TX attenuated cable is needed

The new patch panel is 4U high and can have single port or quad port facias. The single port facia supports MT-RJ, LC, ESCON, and SC Duplex connector types. For 4TDM OCI cards, the quad port facia supports ESCON, MT-RJ, and SC Duplex (for ATM 155 and Fast Ethernet) connector types.

New patch panel pigtails:

- Multimode protocols require 12 dB TX (transmitter) attenuated cables, while the protocols using the 4TDM OCI require 7 dB TX attenuated cables
- Single-mode protocols are not attenuated; except when using the 622 Mbps OCI for Fast Ethernet (SM), a 7 dB TX attenuated cable is needed

The appropriate patch cables and couplers between the OCI cards and the integrated patch panel are provided as part of the IBM 2029 frame.

Note

Fiber-optic cables to connect device interfaces to the IBM 2029 patch panel must be provided by the customer.

Figure 23 shows the OCI interface mapping of the base patch panel.

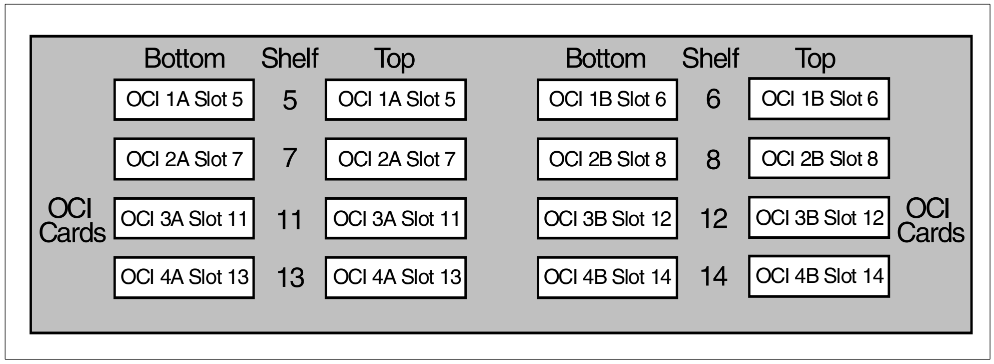


Figure 23. IBM 2029 frame base patch panel

Figure 24 shows an example of the physical layout of the new IBM 2029 frame patch panel to support the 4TDM feature (quad port facia). This patch panel is standard for configurations that contain Dual Fiber Switches or the 4TDM feature, or both.

The 4TDM cards have 4 ports that are identified in the System Manager as port 1, port 2, port 3, and port 4, from top to bottom. These correspond with the 4 connectors on the IBM 2029 patch panel facia, from left to right. In other words, the leftmost connector is for port 1on the 4TDM card, the next connector to the right is for port 2 on the 4TDM card, and so on.

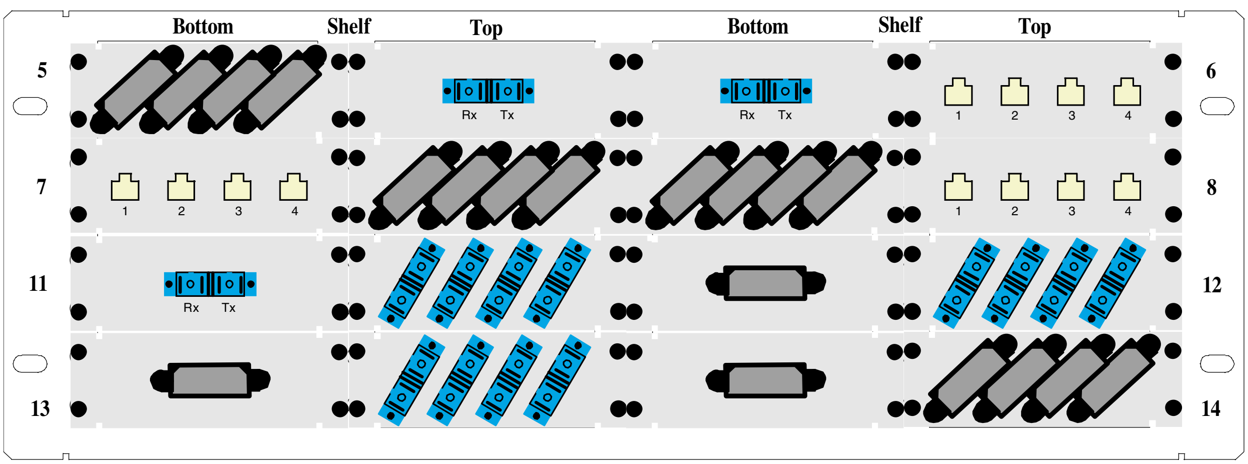


Figure 24. IBM 2029 frame new patch panel (example)

2.1.7 Maintenance panel

The maintenance panel is located at the top of the IBM 2029 shelf. It has fault indicators, electrical breakers for redundant power feeds, alarm indicator lamps, alarm cut-off (ACO) control, and connectors for 10 Mbps Ethernet and RS-232 interfaces. A 32-pin connector (24-AWG wiring interface) is located under the left side of the maintenance panel cover for alarm management connectivity to the Dual Fiber Switch.

Figure 25 on page 33 shows the maintenance panel of the IBM 2029 shelf.

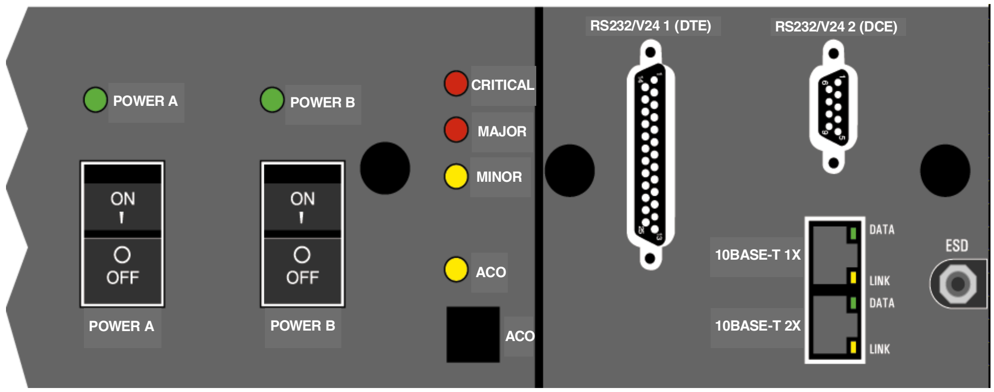


Figure 25. IBM 2029 shelf maintenance panel

2.1.8 Ethernet hub

The Ethernet hub (see Figure 26) is installed at the hub site in the IBM 2029 frame, if two or more shelves are present. It enables intershelf (cross-band) messaging in the IBM 2029 network. At the remote site an additional hub can be installed to omit a single point of failure for intershelf messaging. The customer must supply the second 2029 Ethernet hub at the remote site.

Intershelf messaging at the hub site is achieved by connecting the 10Base-T 2X 10 Mbps Ethernet port on the maintenance panel of each hub site shelf to the Ethernet hub (the same at the remote site if an Ethernet hub is installed). Intershelf messaging to the remote shelves is achieved via the per-wavelength optical service channel (PWOSC). The PWOSC is a communication path that is carried along each channel of each shelf pair in the optically multiplexed signal connecting the IBM 2029 network.

For more information, see Chapter 5, “System management connectivity” on page 89.

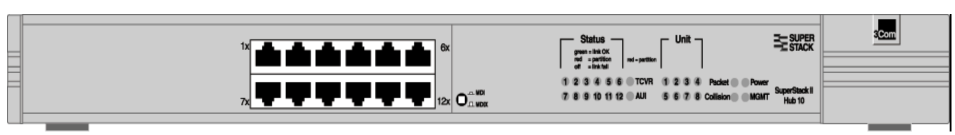


Figure 26. IBM 2029 Ethernet hub

2.1.9 Dual Fiber Switch

The Dual Fiber Switch (DFS) is an optional feature, offering protection against fiber trunk failures for base channels. DFSs are installed in pairs, one DFS at the end of each fiber trunk in a point-to-point configuration. Thus an extra pair of optical fibers must be available as a backup for each working pair of fibers. This means, a two fiber installation will then require four fibers and a four fiber installation will require eight fibers. The DFSs attach to the first and last OMX at each site, via fiber cables. If your configuration has only one pair of fibers, then the two DFSs will be connected to either the first or last OMX at each site.

Each DFS is 1U high, and is installed in place of the base 2U high patch panel in the IBM 2029 Models 001and RS1. This will also require the installation of the new 4U high patch panel.

Figure 27 shows the front of the DFS. The OTS IN and OTS OUT of the OMX are connected via the OTS OUT and OTS IN of the DFS, respectively. The fiber pairs (Tx and Rx) for both the primary path and standby path are also connected to the front panel.

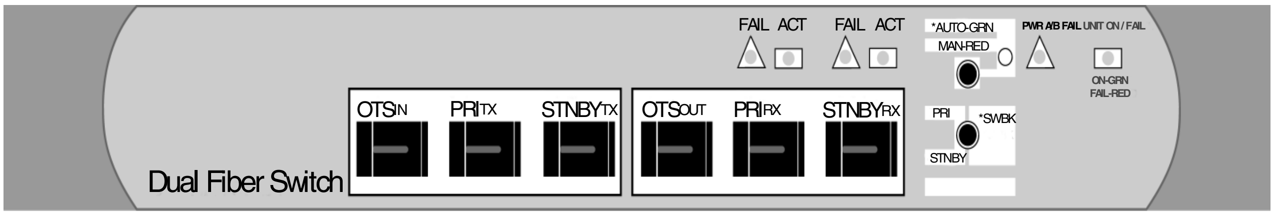


Figure 27. Dual Fiber Switch (front)

During normal operation all data traffic is routed through the primary path of the DFS. In case of a fiber trunk failure at the primary path, all traffic is switched to the standby path within 100ms. The standby path is continually monitored to ensure availability in the event a fiber trunk switch is required. Both fibers (Tx and Rx) switch to the standby path, even if only one primary fiber fails. Once a switch has occurred the traffic will not revert to the primary path unless the standby path is interrupted or a user command to switch back to the primary path is issued.

The maximum distance supported by the DFS between sites is 40 km.

Figure 28 shows the back of the DFS. The Ethernet port (RJ-45) provides a LAN access point for configuring and operating the DFS. Telemetry connectors can be used to forward alarms to the IBM 2029 shelf via cables that connect to telemetry connectors under the maintenance panel of any shelf of the site. The redundant power connectors are coupled to the IBM 2029 frame power supply.

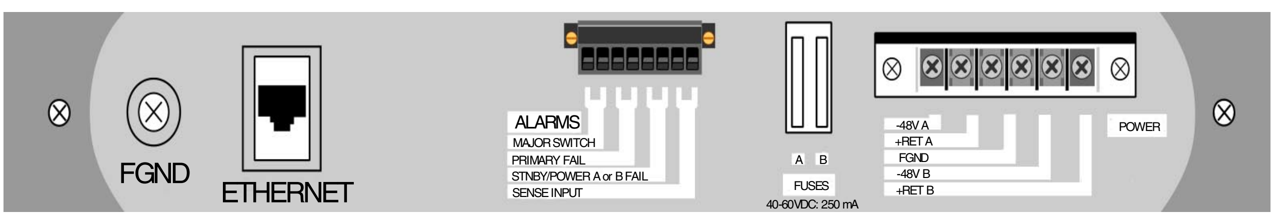


Figure 28. Dual Fiber Switch (back)

The appropriate cables and couplers between the OMX cards and the DFS, as well as the power cables for the DFS, are provided as part of the IBM 2029 frame.

For more information concerning the installation and usage of the DFS see Chapter 7, “Dual Fiber Switch (DFS)” on page 149.

2.2 Physical specifications

For the IBM 2029 physical specifications, see Appendix C, “Physical specifications” on page 215.

2.3 Point-to-point network configuration

The 32 optical channel wavelengths in the IBM 2029 network are divided into eight shelf bands of four channels, all of which are transmitted over a single fiber pair and each of which can be managed separately. In the point-to-point configuration, shelves in the remote site have a one-to-one correspondence with shelves in the hub site, according to their allocated shelf band pairs.

An IBM 2029 point-to-point network consists of a minimum of two IBM 2029 shelves (a hub shelf and a remote shelf) connected via two fiber pairs. The pair of shelves are allocated to the same band wavelength (Band 1 through Band 8). The shelf band wavelengths can be arbitrary, but must be unique within the network.

Figure 29 on page 36 shows a point-to-point network with four shelves in each site. These are interconnected using single-mode fiber-optic jumper cables (also known as pigtails), which connect the OMX West modules in a site to each other, and the OMX East modules in a site to each other.

The two fiber pairs running between the hub site and the remote site are connected to an OMX module in the first and last shelves in each site. The first fiber pair (transmit and receive) connects the OMX East module in the Band 1 hub shelf with the OMX West module in the Band 4 remote shelf. The second fiber pair (transmit and receive) connects the OMX West module in the Band 4 hub shelf with the OMX East module in the Band 1 remote shelf.

Note that the sequence in which the shelves are interconnected in each site is balanced so that a given high availability channel of a shelf pair passes through the same number of OMX modules in either direction through the network. See 2.5, “Protection schemes” on page 39 for more information on high availability channels.

The network traffic flow for Figure 29 on page 36 (using ADF, shown in Figure 22 on page 30), is as follows:

We called all signals originating or destined for the East side of all shelves in the hub site E-Bx, and for the West side W-Bx (x being the respective band number).

1. Starting from the Band 1 East side at the hub site, the E-B1 signal gets added. All signals (E-B1, B2, B3, B4) are then sent out (OTS OUT) to the remote site.
2. At the remote site the signals are received on the West side of Band 4 through OTS IN. At Band 4, the E-B4 signal gets dropped and all other signals (E-B1, B2, B3) are passed (THRU OUT) to Band 3 West side.
3. Band 3 receives the signals through OTS IN, the E-B3 signal gets dropped and all other signals (E-B1, B2) are passed (THRU OUT) to Band 2 West side.
4. Band 2 receives the signals through OTS IN, the E-B2 signal gets dropped and the E-B1 signal is passed (THRU OUT) to Band 1 West side.
5. Band 1 receives the signal through OTS IN, and the E-B1 signal gets dropped.

In the opposite direction:

1. Starting from the West side of Band 1 in the remote site, an E-B1 signal gets added, then sent out (OTS OUT) to Band 2 West side.

2. Band 2 receives the E-B1 signal through THRU IN and adds an E-B2 signal, then sends both (E-B1, B2) through OTS OUT to Band 3 West side.
3. Band 3 receives the E-B1, B2 signals through THRU IN and adds an E-B3 signal, then sends all (E-B1, B2, B3) through OTS OUT to Band 4 West side.
4. Band 4 receives the E-B1, B2, B3 signals through THRU IN and adds an E-B4 signal, then sends all (E-B1, B2, B3, B4) through OTS OUT to Band 1 East side at the hub site.
5. Band 1 receives the E-B1, B2, B3, B4 signals through OTS IN, drops the E-B1 signal, then passes (THRU OUT) all other signals to Band 2 West side, and so on, until each signal gets dropped by its respective band.

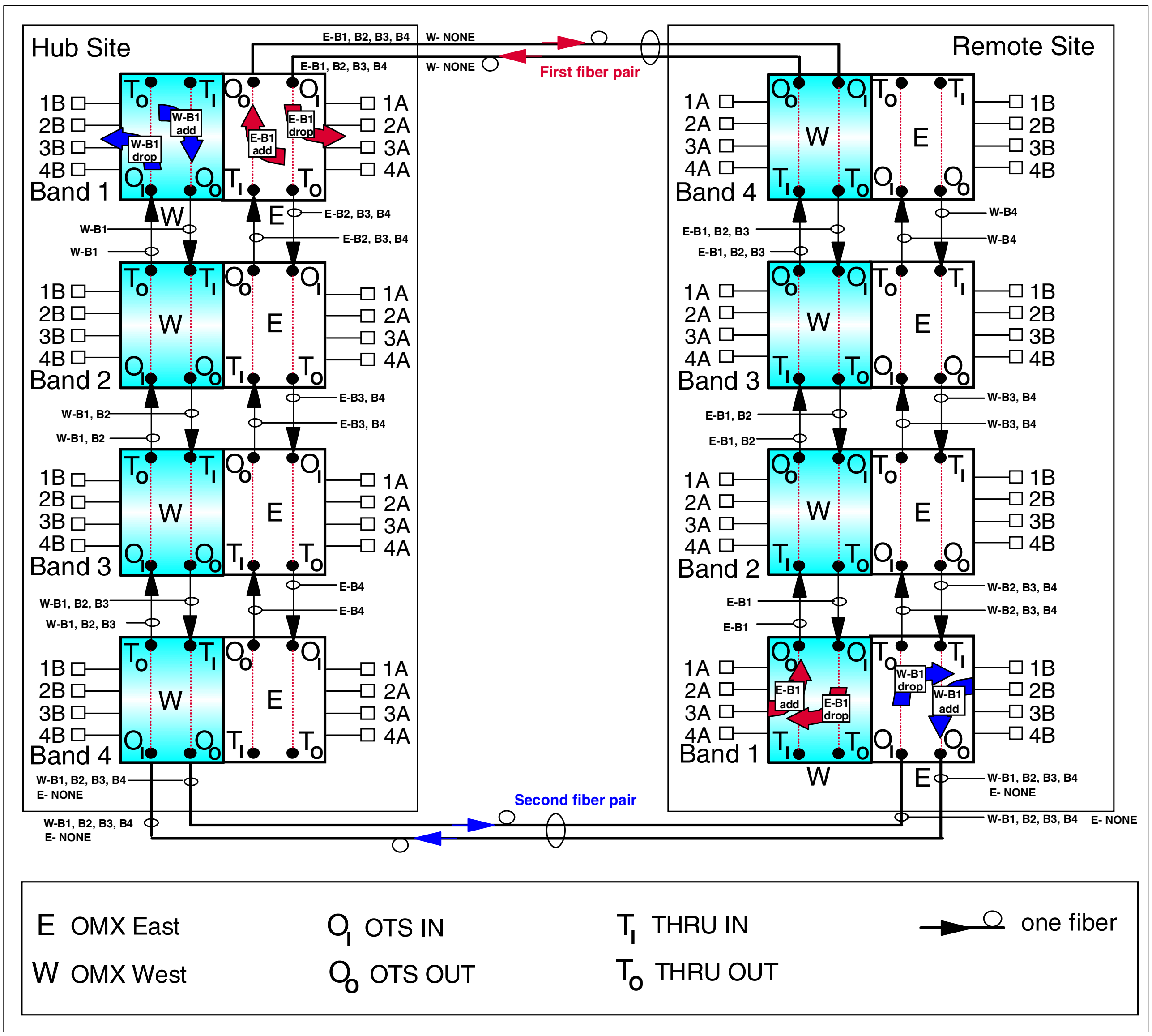


Figure 29. IBM 2029 point-to-point network - four shelf pairs

A point-to-point network may have up to eight shelves in each location. The maximum fiber distance supported between the two sites is 50 km, or up to 70 km via RPQ with a link budget of 15 dB.

2.4 Hubbed-ring network configuration

In the hubbed-ring configuration, shelves in the remote sites have a one-to-one correspondence with shelves in the hub site, according to their allocated shelf band pairs. The pair of shelves are allocated to the same band wavelength (Band 1 through Band 8). The shelf band wavelengths can be arbitrary, but must be unique within the network.

Figure 30 on page 38 shows an example of an IBM 2029 network in the hubbed-ring configuration. It consists of a hub site with four IBM 2029 shelves connected through a fiber pair ring to four remote shelves.

The shelves in each site are interconnected using single-mode fiber-optic jumper cables (also known as pigtails). These jumper cables connect the OMX West modules in the hub site to each other, and the OMX East modules in the hub site to each other.

The two fiber pairs running between the hub site and the remote sites are connected to an OMX module in the first and last shelves at the hub site. The first fiber pair (transmit and receive) connects the OMX East module in the Band 1 hub shelf with the OMX West module in the Band 4 remote shelf. The second fiber pair (transmit and receive) connects the OMX West module in the Band 4 hub shelf with the OMX East module in the Band 1 remote shelf.

The OMX West and OMX East modules of each remote site shelf are interconnected using fiber-optic pigtails.

The network traffic flow for Figure 30 (using ADF, shown in Figure 22 on page 30), is as follows:

We called all signals originating or destined for the East side of all shelves in the hub site E-Bx, and for the West side W-Bx (x being the respective band number).

1. Starting from Band 1 East side at the hub site, the E-B1 signal gets added. All signals (E-B1, B2, B3, B4) are sent out (OTS OUT) to remote site Band 4 West side.
2. Band 4 receives the signals through OTS IN, the E-B4 signal gets dropped, then all other signals (E-B1, B2, B3) are passed (THRU OUT) to Band 4 East side (THRU IN), W-B4 signal gets added and E-B1, B2, B3, and W-B4 get sent out (OTS OUT) to remote site Band 3 West side.
3. Band 3 receives the signals through OTS IN, the E-B3 signal gets dropped, then other all signals (E-B1, B2, and W-B4) are passed (THRU OUT) to Band 3 East side (THRU IN), W-B3 signal gets added and E-B1, B2, and W-B3, B4 get sent out (OTS OUT) to remote site Band 2 West side.
4. Band 2 receives the signals through OTS IN, the E-B2 signal gets dropped, then all other signals (E-B1 and W-B4, B3) are passed (THRU OUT) to Band 2 East side (THRU IN), W-B2 signal gets added and E-B1 and W-B2, B3, B4 get sent out (OTS OUT) to remote site Band 1 West side.
5. Band 1 receives the signals through OTS IN, the E-B1 signal gets dropped, then other all signals (W-B2, B3, B4) are passed (THRU OUT) to Band 1 East side (THRU IN), W-B1 signal gets added and W-B1, B2, B3, B4 get sent out (OTS OUT) to the hub site Band 4 West side.

6. Band 4 at the hub site receives W-B1, B2, B3, B4 signals through OTS IN, drops the W-B4 signal and passes (THRU OUT) all other signals to Band 3 West side, and so on, until each signal gets dropped by its respective band.

In the opposite direction the flow is the same, only in reverse order.

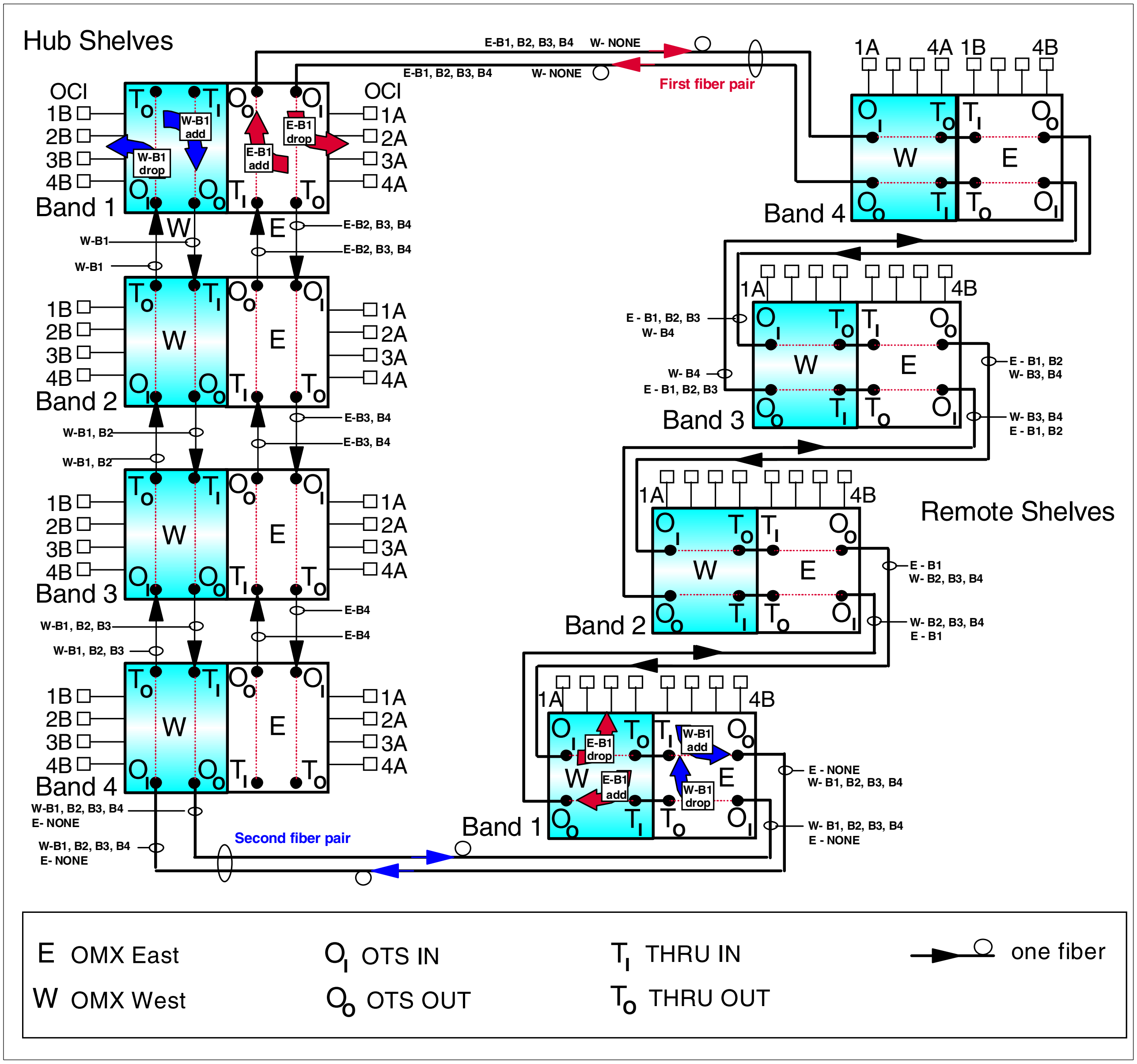


Figure 30. IBM 2029 hubbed-ring network

A hubbed-ring network may have up to eight shelves in the hub site and eight remote shelves. The remote shelves' site locations may be one shelf each in eight remote sites, or fewer multishelf remote sites, or all shelves in one remote site. The maximum fiber distance supported between the hub site and the furthest remote site shelf is 35 km.

2.5 Protection schemes

IBM 2029 channels are configured on a per-channel basis, in either base mode or high availability mode. Base channels are design to meet high reliability requirements. They are typically used when multipath devices (for example, ESCON control units) are implemented, and performance and through-put are not the predominating requirement. However, redundancy for base channels can be attained with the Dual Fiber Switch (DFS); these channels are called switched base channels. Switched base channels are protected against a fiber trunk failure and can only be implemented in a point-to-point configuration. Fiber switching time is 100ms.

In high availability mode the OCM cards manage the path connections between the OCI card and the corresponding two OCLD cards within the shelf. By provisioning a channel in this mode, the configuration provides end-to-end signal protection from one OCI card in a hub site shelf to the corresponding OCI card in the remote site shelf. High availability channels are protected against an IBM 2029 shelf component failure and a fiber trunk failure. Path switching time is 50ms. These channels can be provisioned in a point-to-point configuration as well as a hubbed-ring configuration.

Each shelf in the IBM 2029 frame can consist of one of the following combinations:

- 8 base channels
- 8 switched base channels
- 4 high availability channels
- 6 base channels and 1high availability channel
- 4 base channels and 2 high availability channels
- 2 base channels and 3 high availability channels

Channels provisioned with the 4TDM OCI card can be multiplied by a factor of four. For example, 8 base channels, each with a 4TDM OCI card, equates to 32 base channels. The IBM 2029 uses TDM within a channel for some low data rate protocols, making more efficient use of the available bandwidth.

Note

Switched base channels and high availability channels are mutually exclusive.

Figure 31 depicts the three protection schemes available with the IBM 2029.

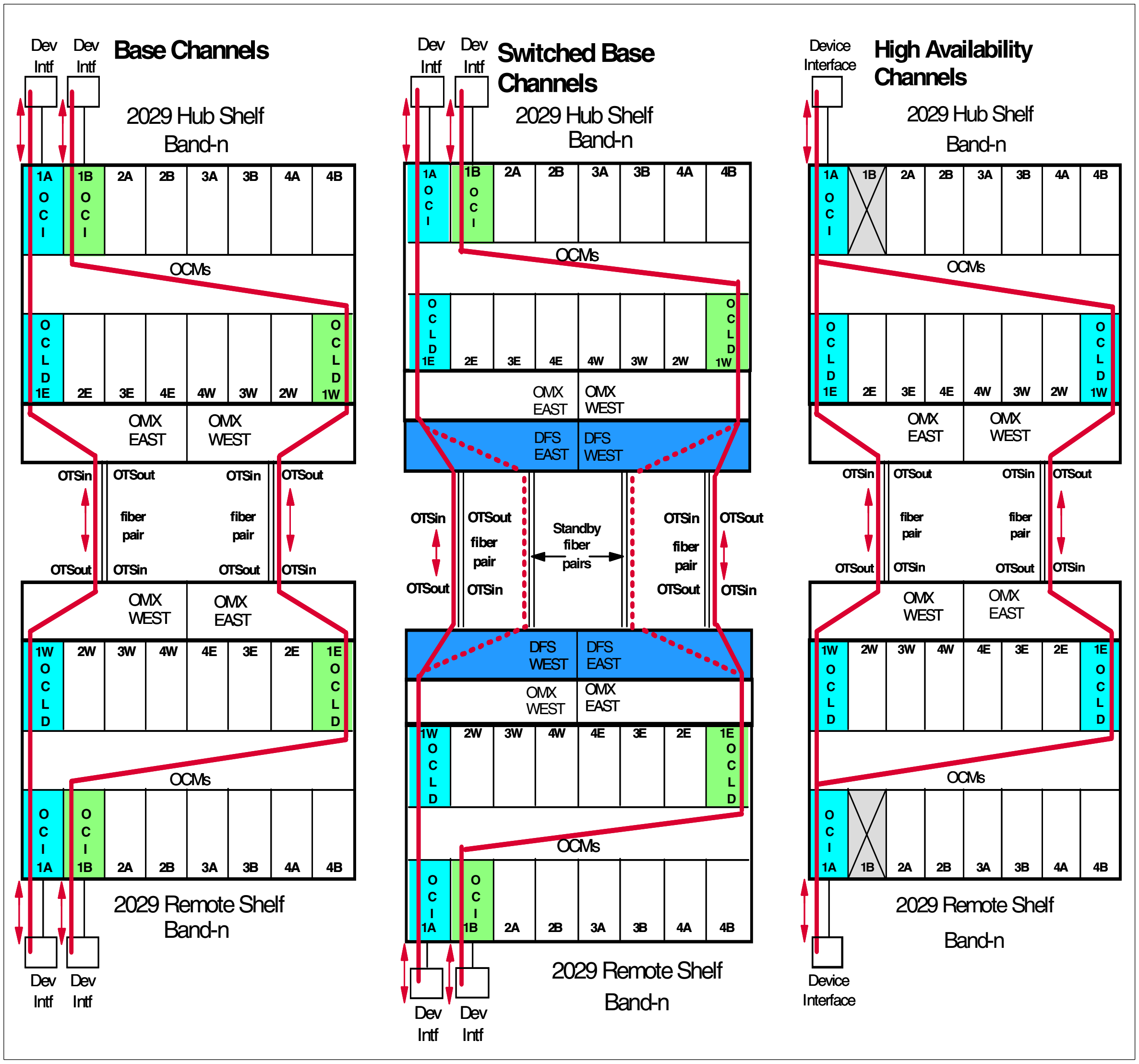


Figure 31. Logical channel connectivity

Terminology

The IBM 2029 base and high availability channels correspond to SONET-based industry standard 1+1 protection switching configurations, in which the base channel is an *unprotected* SONET channel and the high availability channel is a *protected* SONET channel.

The IBM 2029 also supports the Dual Fiber Switch (DFS) with base channels, known as switched base channels. DFSs protect against a fiber trunk failure; however, they do not protect against circuit card failures, hence a switched base channel is an unprotected channel.

Throughout this section the terms unprotected channel and protected channel are synonymous with the terms base channel and high availability channel, respectively.

2.5.1 Unprotected channels

An unprotected channel connects an attaching device interface via a single OCI card; and an OCLD card in one shelf of the shelf pair to corresponding OCLD and OCI cards in the second shelf of the shelf pair. The data path flow between the OCI and OCLD cards within each shelf is managed by the two Optical Channel Manager (OCM) cards in each shelf.

The unprotected channels are mapped as shown in Figure 32.

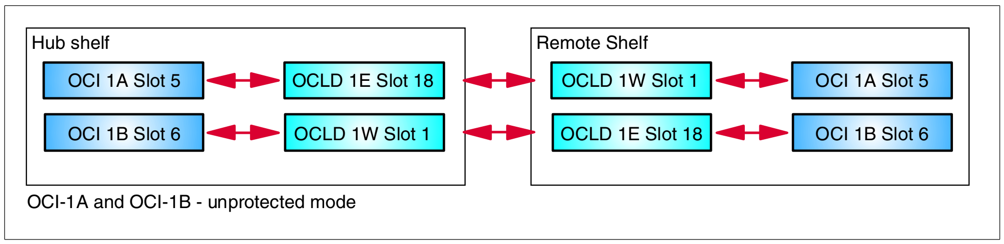


Figure 32. OCI to OCLD channel mapping - unprotected mode

Due to the flexibility of mapping OCLD cards to OCI cards within a shelf, there are other possible mapping combinations that can be selected when provisioning an unprotected channel.

Note

This flexibility also means that channel provisioning must be carefully planned. The OCLD to OCI card mapping for each unprotected channel in each shelf of the shelf pair must allow end-to-end connectivity between the two OCI cards (one in the hub shelf and one in the remote shelf) of the channel.

These examples represent the recommended OCLD to OCI card mapping when provisioning unprotected (base or switched base) channels. For more information on channel provisioning, see 4.2.3, “Provisioning recommendations” on page 73.

2.5.2 Protected channels

A protected channel connects an attaching device interface via a single OCI card and *two* OCLD cards (each having the same wavelength) in one shelf of the shelf pair, to *two* corresponding OCLD cards (each having the same wavelength) and a single OCI card in the second shelf of the shelf pair. The data flow between the OCI card and two OCLD cards within each shelf is managed by the two Optical Channel Manager (OCM) cards in each shelf.

The protected channel is mapped in one of two ways, as shown in Figure 33 on page 42.

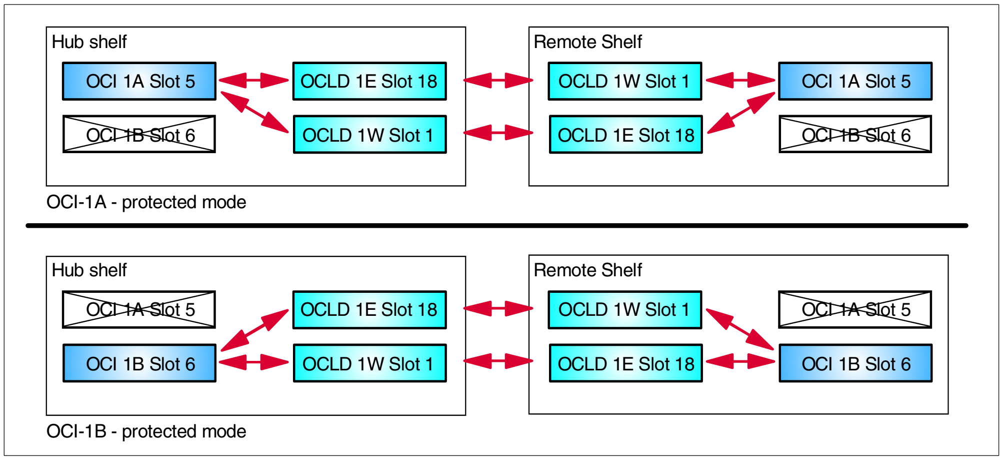


Figure 33. OCI to OCLD channel mapping - protected mode options

In this example, OCI-1A is provisioned in each shelf in protected (high availability) mode. This places the respective OCI-1B cards in an unavailable state because their normally mapped OCLD cards are in use by the OCI-1A protected channel.

Equally, OCI-1B can be provisioned in each shelf in protected mode. This would place the respective OCI-1A cards in an unavailable state because their normally mapped OCLD cards are in use by the OCI-1B protected channel.

2.5.3 Path protection switching

For channels provisioned in protected mode, the OCM cards perform path switching in case of a network fiber cut, OCLD card failure, path performance degradation, or system manager user request.

Path protection switching is performed on a per-channel basis; other channels in the shelf wavelength band are not affected when a protection switch occurs.

2.5.4 Fiber switching

The Dual Fiber Switch feature of an IBM 2029 provides protection for unprotected channels against fiber trunk failures between the two sites of a point-to-point configuration. In case of a primary fiber pair failure, the DFSs at both sites will switch to the standby fiber pair. The standby fiber pair is monitored continually to ensure availability in case of a fiber switch. For this protection type an additional pair of fibers is needed for each existing fiber pair. For example, a one fiber pair configuration will need two fiber pairs, and a two fiber pair configuration will need four fiber pairs.

2.5.5 Equipment switching

Equipment switching ensures that a failure in a circuit card does not cause a traffic outage in the IBM 2029 network.

For protected paths, the OCM cards switch the channel path to the other OCLD card of the protected channel in the event of an OCLD card failure.

The two OCM cards are fully redundant. In the event of an OCM card failure, the other OCM card will continue to manage the channel connections of the IBM 2029 shelf with no disruption to network traffic. System management of the shelf can continue using the redundant communications buses.

Chapter 3. Data center environment

This chapter describes the benefits of using the IBM 2029 in a data center environment. It shows the types of connections that are supported for all generations of 9672 Servers as well as for the IBM @server zSeries 900. It also includes examples of how the IBM 2029 can be used in support of solutions such as Geographically Dispersed Parallel Sysplex (GDPS) and IBM Enterprise Storage Area Network (SAN).

For planning details, see Chapter 4, “Network planning and design” on page 65.

3.1 ESCON channels

The Enterprise Systems Connection (ESCON) I/O interface consists of a set of media specifications, physical and logical protocols, and elements of the ESA/390 architecture that allow the transfer of information between an ESA/390 channel subsystem and a control unit or ESCON Director (ESCD).

ESCON is a circuit-switched protocol and ESCON links use a synchronous bit stream to send user data and control information between the channel and a control unit.

ESCON channels provide 160 Mbps point-to-point links using light-emitting diode (LED) transmitters over multimode (MM) fiber. An ESCON interface uses two fibers to provide a duplex connection for control information, but only half duplex for data.

The ESCON architecture allows for a maximum transmission distance of 3 km for a single link. IBM offers a feature called the ESCON Extended Distance Feature (XDF), which uses laser transmitters and single-mode (SM) fiber to extend the maximum transmission distance to 20 km. This feature has been withdrawn from marketing for use with processors since May 1995. It is still available for ESCON Directors and some control units.

The ESCON Director (ESCD) is a dynamic switch for ESCON channels and can also be used as a repeater to extend the maximum distance between a processor and control unit. Up to two ESCDs can be chained, resulting in a configuration with three links: Central Processor Complex (CPC) to ESCD, ESCD to ESCD, and ESCD to Control Unit (CU). Each of these links can be up to 3 km, or 20 km if using XDF features.

If the CPC, ESCON Director and control unit all have XDF channels, the maximum distance (channel length) between CPC and control unit is 60 km (20 + 20 + 20). If the processor does not have ESCON XDF channels, the total maximum distance can be up to 43 km (3+20+20). If the control unit also does not have ESCON XDF channels, the maximum distance can be up to 26 km (3+20+3). And if the ESCDs do not have XDF ports, the maximum distance is 9 km (3+3+3). Each of the possibilities supported by current hardware is shown in Figure 34. Note that in the majority of cases these distances are not achievable because the ESCDs must be located somewhere between the two sites.

ESCON channel lengths can also be extended using the 9036-001 and 9036-002. The 9036-001 acts as an XDF/LED converter; one interface is LED and the other is XDF. The 9036-002 has 2 XDF interfaces. 9036s work in pairs. A pair of 9036s can be installed in any link where there is at least one XDF interface, such as CPC to ESCD XDF port or ESCD XDF port to control unit. The maximum cable length between the 9036s in the pair is 20 km. As with ESCDs, maximum supported distances are often not achievable due to the requirement to position hardware between sites.

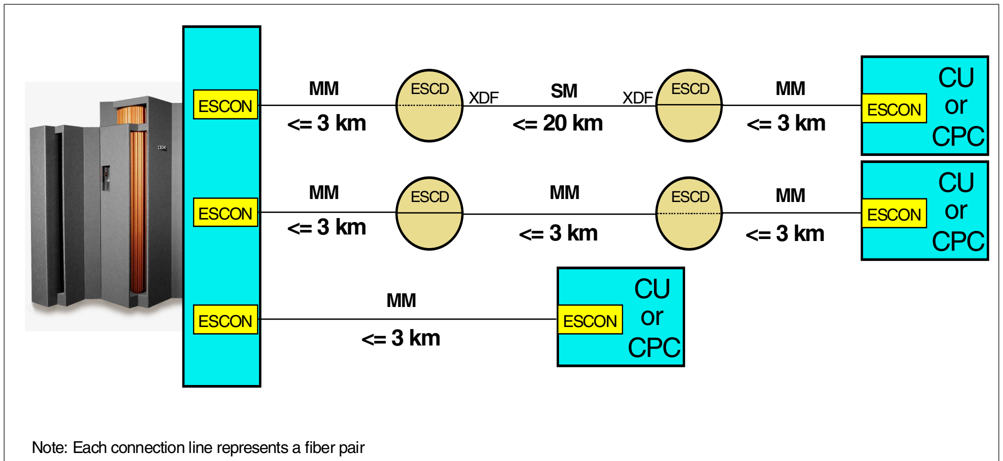


Figure 34. ESCON channels

The IBM 2029 can also be used to extend ESCON distances. The maximum distance between an IBM 2029 pair is 50 km.

The actual maximum end-to-end distance may be limited by specific characteristics of the attached control units and devices. The maximum distances supported by some IBM control units are shown in Table 4.

Table 4. Maximum distances of control units

Control Unit Model	Maximum ESCON Distance	Control Unit Model	Maximum ESCON Distance
3172 1,3	43 km	3174 12L/22L	43 km
2216 400	43 km	3490 All models	23 km
3590 A00/A50/A60	43 km	3494 B18	75km
3990 002/003	15 km	3745	43 km
3990 006	43 km	3746 900/950	43 km
9343 Dxx	43 km	RAMAC Array	43 km
9393 All models	43 km	2105 All models	103 km
3995 133	9 km	ESCON CTC	60 km
RS/6000 /SP2	43 km	3900	43 km

It is important to remember that the throughput of an ESCON channel is a function of distance. As the distance between an ESCON channel and control unit increases, the performance decreases. A local ESCON connection can perform at up to 17 MB/s, while at a distance of 43 km the throughput can drop down to about 3 MB/s.

The IBM 2029 supports both single-mode and multimode ESCON links, however, only multimode ESCON links are supported by the 4TDM OCI card. This allows you to configure 4 ESCON links on a single IBM 2029 channel using Time Division Multiplexing. This makes the use of multimode ESCON channels in a IBM 2029 network far more cost-effective than single-mode.

3.2 Fiber Connection (FICON) channels

Fiber Connection (FICON) is a high-bandwidth channel type that uses a new mapping protocol (Layer FC-4) to take full advantage of the unique characteristics of the ANSI Fiber Channel Standard:

- Layer FC-0 Interface/Media
- Layer FC-1 Transmission Protocol
- Layer FC-2 Signaling Protocol
- Layer FC-3 Link Services
- Layer FC-4 Mapping (IPI, SCSI, IP, HIPPI, SERIAL BYTE CONN.)

FICON channels offer a more efficient and faster data transfer. There are two types of FICON channel cards available on both the IBM 9672 G5/G6 processors and the IBM @server zSeries 900:

- Long Wavelength (LX)
- Short Wavelength (SX)

FICON LX channels without repeaters support link distances up to 10 km (20 km with RPQ 8P1984) using 9-micron single-mode fiber, and 550 meters using 50 micron or 62.5-micron multimode fiber. Note that multimode fiber can only be used for the LX FICON channel via mode conditioning cables.

FICON SX without repeaters supports link distances up to 550 meters using 50 micron fiber and 250 meters using 62.5 micron fiber.

Each FICON channel is capable of supporting up to 4000 I/O operations per second. This allows each FICON channel to provide the same I/O concurrency as up to 8 ESCON channels. This capability allows customers the option of channel to control unit consolidation.

FICON implementation has taken place in three separate phases:

- The first phase is the FICON Bridge (FCV, also known as FICON conversion), in which a FICON channel in a CPC connects to a 9032 Model 5 ESCON Director with a Bridge Card. This enables existing ESCON control units, without any changes, to exploit the FICON channel.

  The 9032 Model 005 Director was the first device to support FICON, and is intended to provide investment protection for currently installed ESCON control units. Up to 16 Bridge Cards are supported on a single 9032 Model 005, with each card capable of supporting up to eight concurrent ESCON control unit connections. Control units can be connected to the system using a combination of FICON (through the Bridge Card) and ESCON paths, preserving the customer's investment in ESCON Directors, as well as the investment in the existing fiber infrastructure.

- The second phase of implementation is native FICON Direct Attachment (FC). The FICON channel plugs directly into a native FICON control unit. Some IBM control units that support native FICON attachment are 3590-A60, 2105-F10/F20 Enterprise Storage Server and 3170-005 (Infoprint).
- The third phase of implementation is FICON Director connectivity. The FICON Directors (IBM 2032 and 2042) enable full dynamic switching of a FICON control unit between multiple channels, as well as multiple FICON control units on a single FICON channel. The FICON Directors support both LX and SX ports. Note that the distance limitation for SX ports using multimode 62.5 micron fiber is reduced to 175 m.

Figure 35 shows the physical connections and distance limitation associated with each of the 3 phases of FICON implementation for both LX and SX FICON channels.

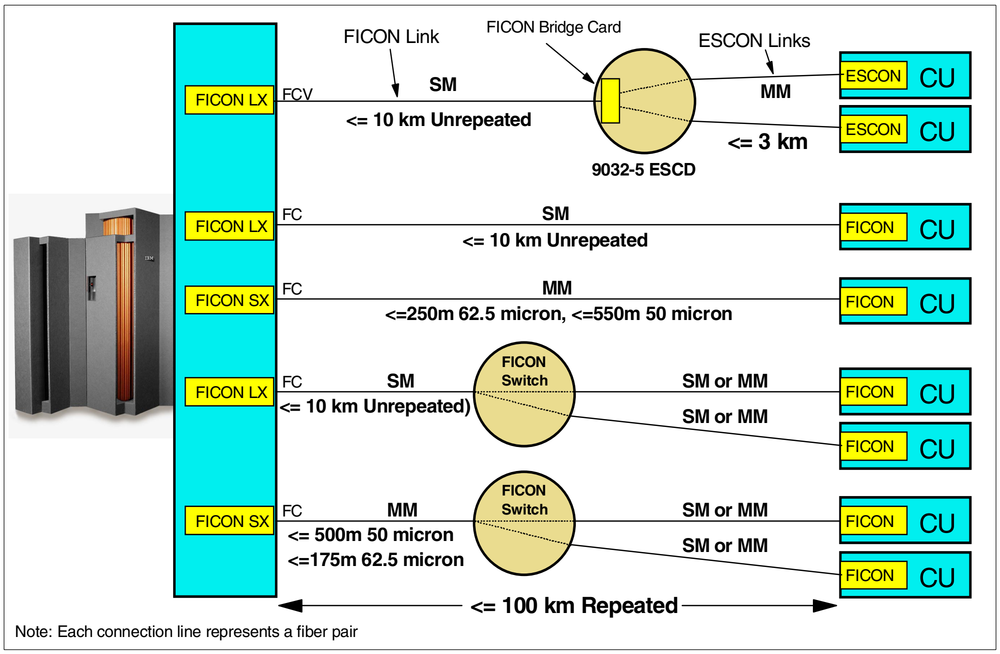


Figure 35. FICON connections

FICON channels have data rates of up to 100 MB/s, using full-duplex data transfer. It is possible to send data in both directions simultaneously—unlike ESCON, which is a half-duplex protocol. FICON channels can also execute multiple concurrent I/Os on a single channel.

The data rate droop which impacts ESCON channels at distances of around 9km does not occur with FICON channels. The data rate droop point for FICON channels is 100 km. Therefore, there is negligible performance degradation at distances up to 100 km.

Both long wavelength (LX) and short wavelength (SX) FICON channels can be connected directly to an IBM 2029 shelf. The maximum end-to-end distance supported for FICON channels is 100 km. This can be achieved by cascading two IBM 2029 point-to-point networks.

3.3 Sysplex Timer - External Time Reference (ETR)

The External Time Reference (ETR) or Sysplex Timer is a mandatory requirement for any multi-CPC sysplex (base or parallel) environment. It is used to synchronize the time across all systems. The Sysplex Timer is one of the most critical components in a sysplex because any system that loses access to the timer will load a non-restartable, disabled wait state. The only way to recover is to restore access to the timer and then re-IPL the system.

The ETR function is provided by the IBM 9037 Sysplex Timer. There are two 9037 models, 9037-001 (withdrawn from marketing in 1997) and 9037-002. Both models are available in both basic and expanded availability configurations. The base configuration is a single timer unit (which is a single point of failure); the expanded availability configuration is two synchronized timer units. The expanded availability configuration is the recommended configuration for a production sysplex environment.

The maximum distance between the timer units in a 9037-001 expanded availability configuration is limited to 3 meters. This restriction makes the 9037-001 less suitable for multi-site applications, so only the 9037-002 will be considered in the following examples.

There are 2 types of fiber links associated with the 9037-002 Sysplex Timer:

- Control Link Oscillator (CLO) links are connections between the two timer units in an expanded availability configuration. Two links are provided for redundancy.
- External Time Reference (ETR) links are the connections between the CPC and the timer units. Each CPC should have at least one connection to each timer unit in an expanded availability configuration.

A typical 9037-002 expanded availability configuration is shown in Figure 36. The 9037 Model 002 links use multimode fibers for both ETR and CLO links. The maximum distance (cable length) for both types of links is 3 km. Each of the fiber links shown in Figure 36 is a jumper cable with 2 fibers, one for data transmission in each direction.

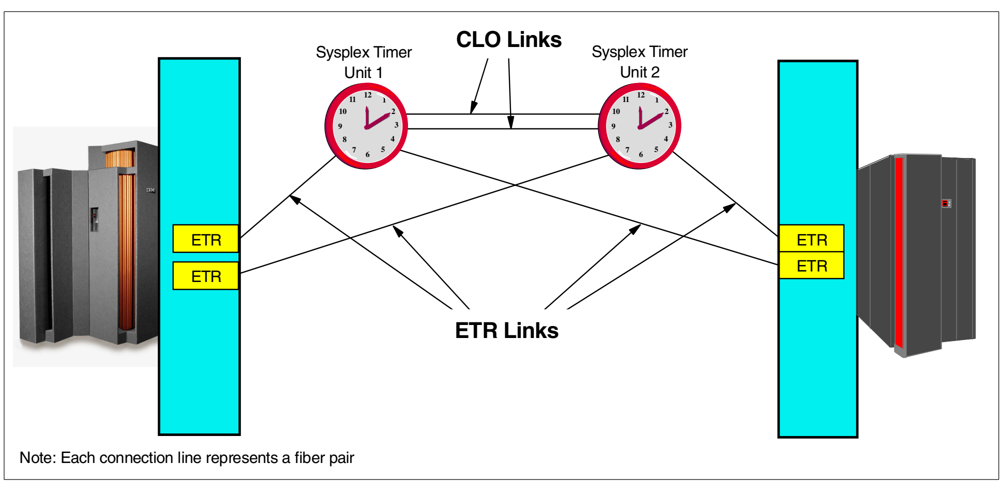


Figure 36. Sysplex Timer Expanded Availability configuration connections

The TOD clocks in the two 9037s units are synchronized using the hardware on the CLO card and the CLO links between the 9037s. Both 9037 units are simultaneously transmitting the same time synchronization information to all attached CPCs via the ETR links. Critical information is exchanged between the two 9037s every 1.048576 second, so that if one of the 9037 units fails, the other will continue transmitting clock signals to the attached CPCs.

The 9036 Model 003 with 9037 RPQ 8P1919 can be used to extend ETR/CLO links up to 26 km. These models work in pairs, one pair for each connection, using single-mode fibers up to 20 km long between them. The maximum end-to-end cable length for ETR and CLO links is therefore 26 km: 3 km from a CPC (or 9037) to a 9036-003, 20 km between 9036-003s and 3 km from a 9036-003 to a 9037. In the example shown in Figure 36, four 9036-003 pairs are necessary to extend all connections between Sysplex Timers and CPCs. Note that to achieve these distances the 9036-003 units must be located somewhere between the two sites.

The IBM 2029 can be used to extend 9037-002 Sysplex Timer connections to up to 40 km with RPQ 8P1955.

When extending Sysplex Timer links through an IBM 2029 network, the same availability recommendations that apply within a site should be applied across sites. One Sysplex Timer unit should be installed in each site and all CPCs should have one connection to each Sysplex Timer unit.

Figure 37 shows the previous Sysplex Timer configuration example, except that the processors and timer units are now in separate sites and cross-site connections are extended via an IBM 2029 network. This configuration requires four channels in the IBM 2029 network. With appropriate channel selection in the IBM 2029 shelves, this configuration has no single points of failure.

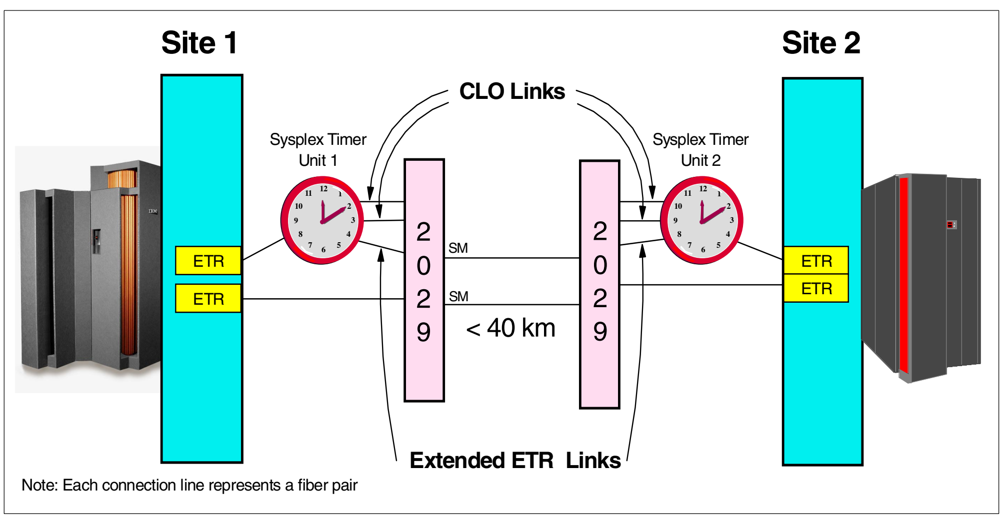


Figure 37. Cross-site Sysplex Timer expanded availability configuration

Because the links between CPCs and the Sysplex Timer can be of varying lengths, the Sysplex Timer must compensate for propagation delay in order for all CPCs to see the same TOD clock.

The Sysplex Timer transmits an ETR on-time signal, referred to as the On Time Event (OTE). It occurs every 1.048576 seconds and corresponds to the carry-out of bit 32 of the Sysplex Timer TOD. It is initially used as the starting signal for CPC TOD clocks in the clock-setting process, and later to monitor continued synchronization.

The propagation delay compensation is calculated by measuring the OTE signal round trip delay. The Sysplex Timer assumes that the CPC is positioned exactly half way along the round trip. In order for the propagation delay to be calculated accurately it is necessary for the send and receive fibers in the ETR link to be the same length (within 10 meters). If the fibers in the link are different lengths, the calculated propagation delay will be wrong. The attached CPC will not see the same time signals as other CPCs and, in a Parallel Sysplex environment, this is a data integrity exposure.

Maintaining a fiber length difference of less than 10 meters is not a problem within duplex-to-duplex jumper cables, where the fibers are the same length. This is an important consideration, however, when laying trunk cables and using distribution panels.

Fiber length considerations

If you intend to use an IBM 2029 network to extend Sysplex Timer links, you must ensure that the end-to-end fiber lengths of the two fibers in a fiber pair or trunk are equal (to within 10 meters). The end-to-end fiber length includes cross-site trunks, patch cables within the site and cables between IBM 2029 shelves and components. When dark fiber services are purchased from a supplier it is important that you clearly specify the acceptable tolerances.

Sysplex Timer links (CLO and ETR) are not supported as high availability channels in a IBM 2029 network. The reason for this is related to the critical timing requirements for signals on the ETR and CLO links.

In a IBM 2029 high availability channel there are 2 pairs of fibers used to transmit signals between hub and remote bands. The signal that will be used at the receiving site is determined during provisioning, based on signal strength. It is quite feasible for communication to be established using one fiber from each of the fiber pairs. Since the fiber pairs should be diversely routed they are extremely unlikely to be equal lengths. Even if communication is established using two fibers in the same pair, it is possible that one fiber could switch to the other pair if a problem occurs since high availability switching occurs at the individual fiber level. This high risk of creating a data integrity exposure is the reason why ETR and CLO links are not supported on high availability channels.

Hubbed-ring configurations are also not supported for Sysplex Timer links, because there is no guarantee that in this configuration the transmit and receive paths will have lengths within the 10 meter limit, as required for processor TOD clock synchronization.

3.4 Coupling Facility (CF) links

Coupling Facilities are a critical resource in a Parallel Sysplex environment. Connectivity between an operating system and a Coupling Facility (LPAR running

Coupling Facility Control Code (CFCC)) is provided by coupling links known as InterSystem Coupling (ISC) links or High Performance Links (HiPerLinks).

The recommendation for availability is to have at least two coupling facilities in a production Parallel Sysplex environment, each one having at least two CF links to each system. Figure 38 shows a simple Parallel Sysplex configuration with two CPCs, two coupling facilities and two links between each CPC and coupling facility. More links may be necessary for capacity and performance reasons.

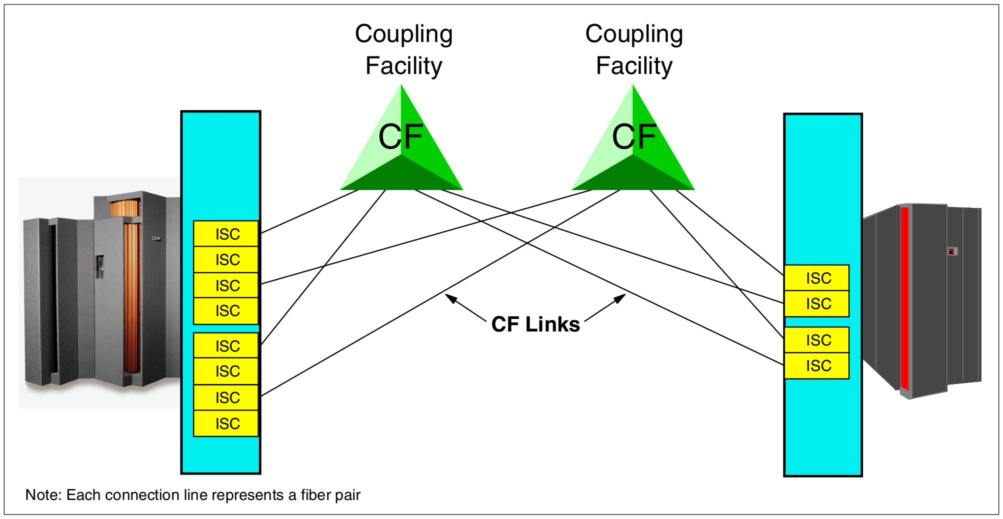


Figure 38. CF link connections

There are several different types of coupling links. Table 5 shows the types of coupling links that use fiber cables along with the maximum unrepeated cable length and data rate. The table also shows which links can be extended using the IBM 2029.

Note that there is some overlap in the features supported by different CPC generations. This happens because, in several cases, the older features can be transferred to newer models as part of an upgrade.

Table 5. Fiber coupling links

Coupling link type	Fiber type	Maximum distance	Speed	Supporting CPCs	IBM 2029 support
Intersystem channels, ISC	MM	1km	50Mb/s	9672 G1 - G3	No
	SM	3km	100Mb/s	9672 G1 - G3	Yes
HiPerLink, ISC-2*	MM	1km	50Mb/s	9672 G3 - G6	No
	SM	3km (FC0016)	100Mb/s	9672 G3 - G6	Yes
	SM	10km (FC0216) 20km with RPQ)	100Mb/s	9672 G5 - G6	Yes
Intersystem channel, ISC-3, compatibility mode	SM	10km 20km with RPQ	100Mb/s	IBM @server zSeries 900	Yes
Intersystem channel, ISC-3, peer mode	SM	10km 20km with RPQ	200Mb/s	IBM @server zSeries 900	No
* HiPerLink is an enhanced version of ISC with link capacity improvement of up to 20%.					

There are other types of coupling links, not shown in Table 5, which do not use fiber connections; therefore, they cannot be extended using the IBM 2029. These are Internal Coupling (IC) channels, which are microcode-emulated; and Integrated Cluster Bus (ICB) channels, which use copper cable connections.

The IBM 2029 can be used to extend supported single-mode CF links to up to 40 km.

There are some performance considerations when extending CF link distances. Longer links may increase the CPU overhead (higher CPU busy time for the same workload) and may also increase application response times and throughput. Capacity planning is required to ensure that performance requirements are met when coupling links are extended.

3.5 Open Systems Adapter (OSA)

OSA-2 and OSA-Express are fully integrated processor hardware features that provide SNA/APPN and TCP/IP host applications with direct access to ATM, FDDI, Ethernet and Token-Ring local area network clients. The OSA-2 was introduced with IBM S/390 Enterprise Servers Generation 2 and the OSA Express was introduced with Generation 5. The OSA-Express is the latest technology but some OSA-2 features are still supported in IBM @server zSeries 900 processors. OSA offers integrated, industry standard LAN connectivity with the availability and security of S/390 architecture.

3.5.1 Asynchronous Transfer Mode (ATM) 155 and 622

Asynchronous Transfer Mode (ATM) is a communication technology radically different from others, designed to be a low-cost way of building high-speed networks. ATM can handle any form of digital information (voice, data, video, image) in an integrated way.

ATM is an electronic technology, designed to run on optical communications links to take advantage of the speed and error rate characteristics of those links.

In Wide Area Trunk environments two link speeds are standardized: 155 Mbps and 622 Mbps. On LAN connections, the maximum data rate is 155 Mbps on single-mode fibers of up to 20 km, or up to 2 km on multimode fibers.

The S/390 Open System Adapter 2 (OSA-2) features available on the IBM 9672 Servers support either ATM 155 Mbps single-mode or multimode links. The OSA-2 ATM feature has one 155 Mbps physical port and two logical ports that provide access to Ethernet and Token-Ring LANs, and Wide Area Networks (WANs), attached to a high-speed ATM network.

The 9672 G5/G6 OSA-Express 155 ATM cards have one physical port. There are two features available to support single-mode (9 micron) and multimode (62.5 micron) attachment to a 155 Mbps ATM network.

The IBM @server zSeries 900 OSA-Express 155 ATM cards have two independent physical ports. Like other ATM OSAs, they are available for either single-mode or multimode attachment.

The IBM 2029 can be used to extend the supported distance for multimode and single-mode OSA 155 ATM links. The maximum distance supported is governed by the specifications of the attached devices. ATM 155 links (multimode and single-mode) can be connected via the 4TDM OCI card. This allows four connections to be multiplexed on a single IBM 2029 channel.

3.5.2 Fiber Distributed Data Interface (FDDI)

Fiber Distributed Data Interface (FDDI) was developed by the American National Standards Institute (ANSI). It was originally proposed as a standard for fiber-optic computer I/O channels, but has become a generalized standard for operation of a LAN at 100 Mbps. FDDI specifies that either single-mode or multimode fibers be used.

The IBM 9672 OSA-2 FDDI feature has one 100 Mbps port that supports single ring or dual ring attachment, as well as attachment to an optical bypass switch. It supports multimode fiber attachment and distances up to 2 km.

The IBM 2029 can be used to extend OSA FDDI distances. Maximum distances are governed by the limitations of the protocol and specifications of the attached devices.

3.5.3 Fast Ethernet

Fast Ethernet is a high-speed Ethernet that operates at 100 Mbps. It is a growth path upward from the 10BASE-T (10 Mbps) and preserves the existing 802.3 Medium Access Control (MAC) logic, to allow most existing software to use the system.

The Fast Ethernet (100BASE-FX) uses identical physical layer optical specifications to those of FDDI. This applies to the optical signal specifications, data encoding, and also the interface connectors.

The IBM 9672 OSA-2 Fast Ethernet (FENET) feature requires an unshielded twisted pair (UTP) connected to an RJ-45 port, which can be attached to either a 100 Mbps or 10 Mbps Ethernet LAN, in either full duplex or half duplex mode. It uses auto negotiation to set the LAN speed and duplex mode of the port, or can also be set explicitly. Fiber-optic attachment is not supported by the OSA-2 FENET.

The OSA-Express FENET feature for both the IBM @server zSeries 900 and 9672 G5/G6 processors also supports only UTP cable connections.

The IBM 2029 cannot be used to extend distances for FENET OSAs.

3.5.4 Gigabit Ethernet (GbE)

The Gigabit Ethernet (GbE) is designed to scale Ethernet speed up by another order of magnitude. The data transfer rate is 1 Gbps of real data, which means 1.25 Gbaud after encoding.

GbE employs the same Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol, the same frame format and the same frame size as its predecessors, Ethernet (10 Mbps) and Fast Ethernet (100 Mbps). There are some changes to the MAC layer protocol, and physical layers are completely new. It can use either single-mode or multimode fiber.

The S/390 Open System Adapter Express (OSA-E) features, available on the IBM 9672 G5 and G6 Servers and IBM @server zSeries 900, support either Short Wavelength (SX) or Long Wavelength (LX).

The 9672 G5/G6 SX feature has one physical port supporting attachment to a 1 Gbps Ethernet LAN, using a short wavelength optical transceiver for multimode fibers (50 or 62.5 micron) up to 550 m. The LX feature has one physical port supporting attachment to a 1 Gbps Ethernet LAN, using a long wavelength optical transceiver via multimode (50 or 62.5 micron) up to 550 m or single-mode fibers (9 micron) up to 5 km. Note that attachment to the LX feature using multimode fibres is only supported via mode conditioning patch cables.

The IBM @server zSeries 900 OSA-Express GbE features have the same specifications as the 9672 G5/G6 features except that there are two independent ports instead of a single port.

The IBM 2029 can be used to extend distance for both SX and LX OSA-Express GbE connections. Both SX and LX GbE OSAs can be directly connected to the IBM 2029 without the need for mode conditioning patch cables.

3.6 Data center applications

This section discusses various multisite scenarios, including their distance limitations and the number of intersite fibers that are required.

For planning details, see Chapter 4, “Network planning and design” on page 65.

3.6.1 Remote control units and LANs

Some installations have a second site to implement remote backups to tapes, remote DASD access, remote printers, and/or remote LANs.

ESCON channels (without ESCDs) are limited to 3 km and FICON Bridge (FCV) or FICON native channels to 10 km (20 km with RPQ). Even with ESCON Directors or 9036 remote channel extenders the distance is limited to 20 km unless there is an intermediate site.

Figure 39 on page 56 shows a two-site example. The remote site has some multipath ESCON control units, some ESCON control units using FICON (FCV) channels through ESCDs with Bridge Cards, FICON native control units, an ATM and a Gigabit Ethernet network. This configuration, with no fiber extender, is limited to 3 km and requires 23 fiber pairs between sites.

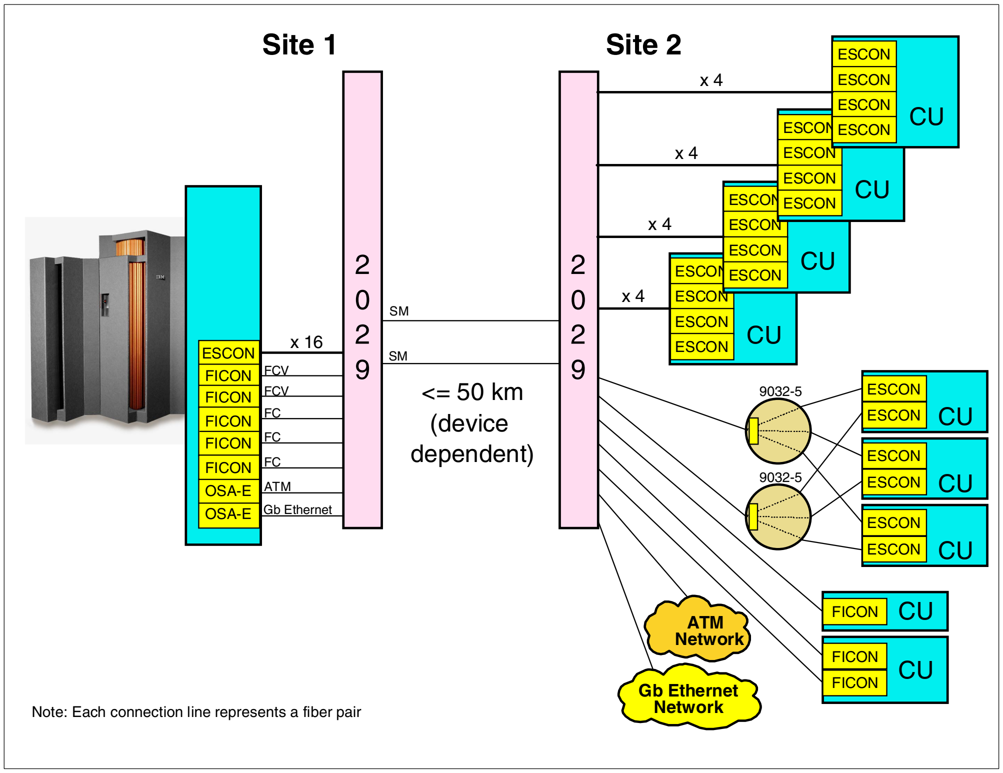


Figure 39. IBM 2029 in a remote control unit and LAN point-to-point configuration

Using the IBM 2029 point-to-point configuration, the distance can be extended up to 50 km (device dependent) and only two single-mode fiber pairs are required between the sites. The extended configuration could be implemented as follows:

> We have decided that the four ESCON-attached, multipath control units can use IBM 2029 base channels, with half of each control unit's paths going through each of the two fiber pairs (East or West). We will take the same approach for the FICON native multipath control unit. This decision was made only after evaluating the impact of losing half of the paths and concluding that performance would be acceptable. As four ESCON channels can be supported on each 4TDM OCI card, this configuration requires a total of six IBM 2029 base channels: four for ESCON (enough for 16 channels) and two for FICON.
>
> The control units attached to the 9032-5 ESCDs are particularly critical to this installation and the loss of one of the paths cannot be tolerated. For this reason, both of the FCV channels will be implemented as high availability channels. The remaining single path connections will also be implemented as high availability channels.
>
> In order to support this configuration with six base and five high availability channels, we will need to install two IBM 2029 shelves at each site. Fiber pairs should take diverse physical routes to avoid a double path failure.

Had we chosen to implement this configuration using switched base channels, we would still need two shelves at each site, although the number of hardware features required would be less. The maximum distance between the two sites would be reduced to 40 km. We would also need to increase the number of fiber pairs between the sites from two to four.

Figure 40 shows a three-site scenario, having the same remote devices spread across two remote sites.

The IBM 2029 network is implemented using a hubbed-ring configuration with two remote sites (Site 2 and Site 3). Only one single-mode fiber pair is required between each site and its neighboring site to complete the ring. This still provides redundancy for high availability channels because the signal travels in both directions around the ring.

The maximum distance from the hub site to the farthest remote site is 35 km (device dependent). Remember that in a hubbed-ring configuration communications are always between the hub site and a remote site.

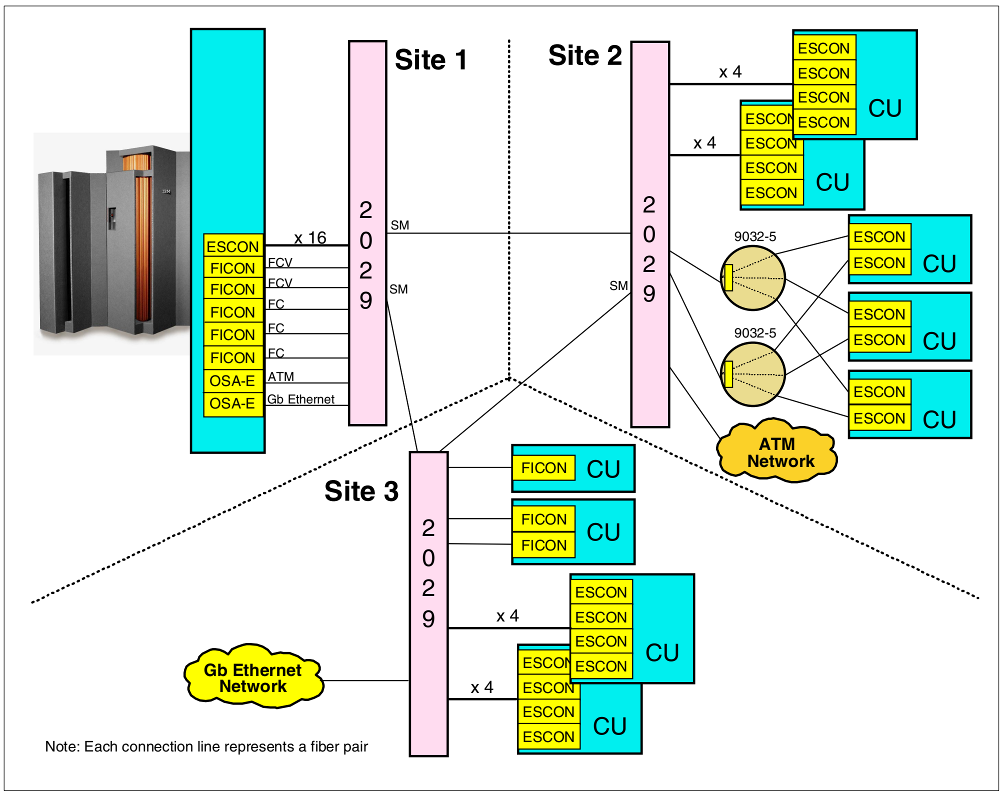


Figure 40. IBM 2029 in a remote control unit and LAN hubbed-ring configuration

Using the same approach as in the previous example, Site 2 (remote site) needs two IBM 2029 base channels to support eight ESCON connections to multipath control units, and three high availability channels to support the FICON bridge and ATM connections. This combination of two base and three high availability channels requires one shelf. Site 3 (remote site) needs four base and two high availability channels, also requiring only one shelf. The hub site (Site 1), which is the sum of the remote sites, requires two shelves.

3.6.2 Multi-site Parallel Sysplex

Multi-site Parallel Sysplex is a very attractive way to share resources and distribute workload across CPCs at multiple sites.

Usually, two sites are involved, as shown in Figure 41, each having its own CPC (one or more), 9037-002 Sysplex Timer unit, and Coupling Facility (CF). Some DASD sharing is also required. To avoid one of the sites becoming a single point of failure for all systems, we assume that there is some shared DASD at each site. ESCON channel-to-channel (CTC) connections between sites are also common.

This implementation requires several connection types between sites:

- Each CPC must have access to at least one Sysplex Timer unit and, for availability reasons, should have a connection to both units.
- The two Sysplex Timer units must be connected to each other by two CLO links.
- Each CPC should have at least two connections to each coupling facility.
- Each CPC should have at least two CTC links to any other CPC.
- Shared DASD subsystems should have multipath connections to both the local and remote CPCs. The local connections to DASD have been excluded from the diagram for clarity.

In this scenario, with no fiber extender, the maximum distance between two sites is 3 km, and 30 fiber pairs are required.

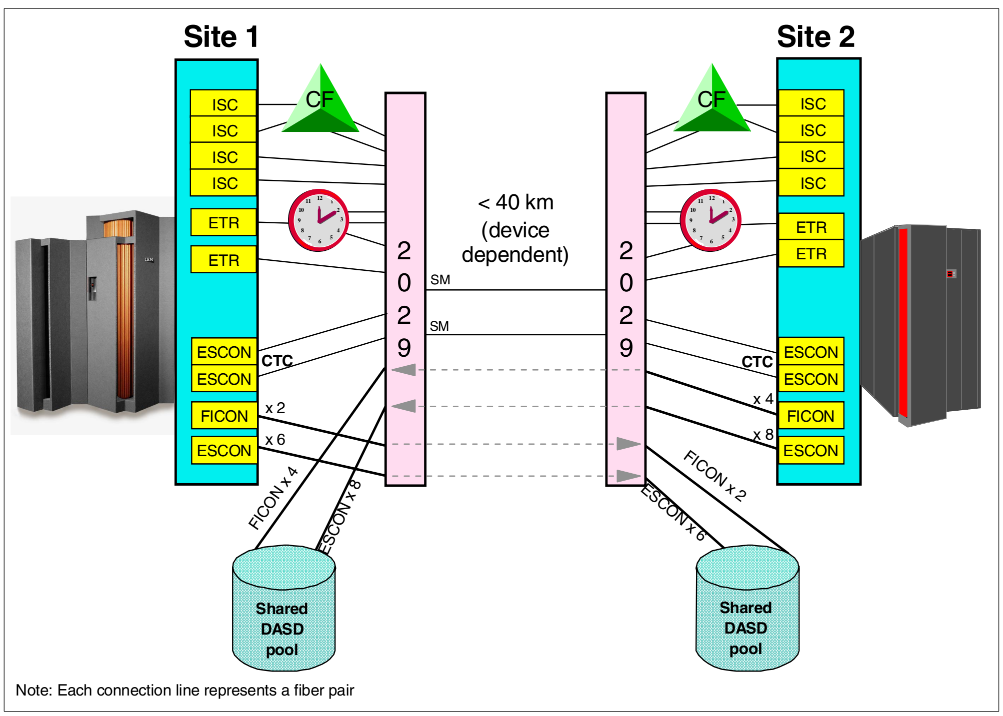


Figure 41. IBM 2029 in a multi-site Parallel Sysplex configuration

Using the IBM 2029 point-to-point configuration, the distance can be up to 40 km (device dependent), and only two single-mode fiber pairs are required between sites.

In this case all connections can use IBM 2029 base channels, as the whole system is already redundant by design, having multiple Sysplex Timer links, CF links, CTCs, and DASD connections. Each fiber pair should carry half of the paths for each connection type to maintain the redundant design. However, performance impacts must be evaluated if only half of the CF links, CTCs, and DASD connections are available.

This configuration has 14 links that are not supported by 4TDM OCI cards, and 16 ESCON links that will be supported using 4TDM cards. The total number of IBM 2029 base channels required is 18. This configuration requires three shelves at each site. Three shelves can support up to 24 base channels, so there is capacity available for growth if required.

This configuration can be protected against an extended outage due to fiber breaks by installing the Dual Fiber Switch (DFS) feature. This effectively converts all of the base channels into switched base channels. This would require additional fiber connections between the sites and it prevents the use of high availability channels.

To avoid potential performance impact in the event of a fiber pair failure, some links could be defined as high availability channels. Assuming all CF links and all FICON DASD links are defined as high availability channels, the result will be 10 high availability and eight base channels. This configuration requires four shelves at each site.

Each fiber pair should have a different physical route to avoid double path failure.

3.6.3 Peer-to-Peer Remote Copy (PPRC)

DASD Peer-to-Peer Remote Copy is a storage subsystem mirroring technique in which updates at the primary DASD subsystem are synchronously copied to a secondary DASD subsystem, usually located at a remote site. This results in mirrored volume pairs between the sites. The copy process is independent of the host systems.

PPRC is very useful for backup site implementations. If a disaster occurs at the primary site, no data is lost and full data integrity is expected at the backup site.

PPRC is implemented by connections between primary and secondary DASD subsystems. The total number of connections between sites depends on the number of DASD subsystems and their update data rates.

The maximum distance between the DASD subsystems for PPRC ESCON links, with no fiber extender, is 3 km. Using the IBM 2029 point-to-point configuration, as shown in Figure 42, the distance can be up to 50 km (device dependent) and only two single-mode fiber pairs are required between sites.

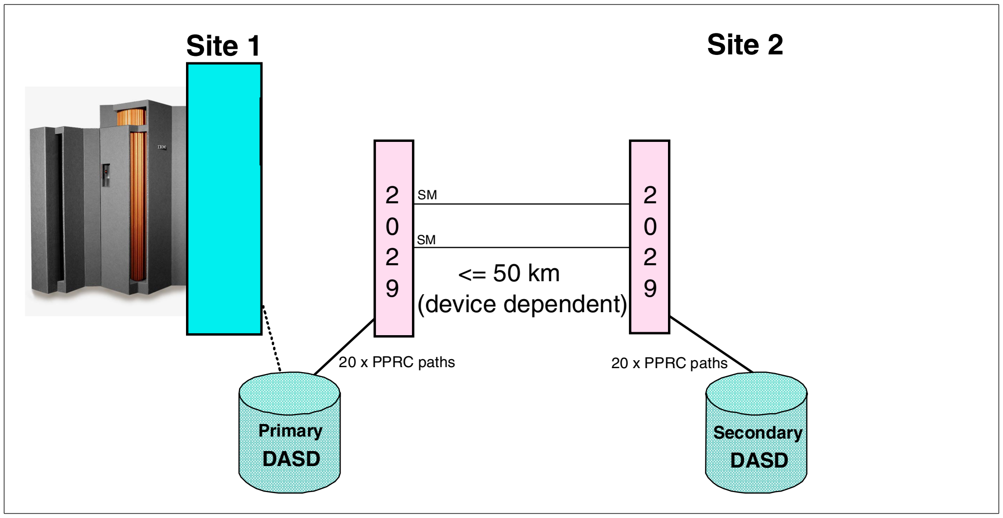


Figure 42. IBM 2029 in a DASD peer-to-peer Remote Copy configuration

PPRC links can be connected to the 4TDM OCI card, which allows four links to be multiplexed on a single IBM 2029 channel. If, for example, we need 20 PPRC links between sites and all of them are configured using base channels, the number of IBM 2029 channels used will be five. Paths should be balanced as evenly as possible across the fiber pairs. Each fiber pair should have a different physical route to avoid double path failure.

In this situation we are using an odd number of base channels so it is not possible to distribute the PPRC channels evenly across the fiber pairs. A fiber break could result in the loss of more than half of the PPRC links.

To avoid potential performance impact in the event of a fiber pair failure, at least some of the PPRC links should be defined as high availability channels. In this example we could use three high availability channels and two base channels. This configuration can still be accommodated with a single shelf at each site.

If all five channels are configured as high availability channels, two shelves are required at each site. Besides the path redundancy in this case, single-shelf sites are also avoided and the second shelf introduces shelf redundancy. Spreading signals across both shelves means that the traffic can be sustained even if a shelf pair goes offline.

In reality, it is unlikely that an IBM 2029 network would be used to support only PPRC links. PPRC links are likely to be used in conjunction with other types of cross-site connections. Intermixing with other protocols in the same network can make management of placement for availability more complex, but it may also provide diversity at the shelf level. In the case of PPRC links there may also be the opportunity to intermix with ESCON links on the same 4TDM OCI card. Mixing with other protocols on the 4TDM card is not supported.

3.6.4 Geographically Dispersed Parallel Sysplex

Geographically Dispersed Parallel Sysplex (GDPS) is an IBM service offering to implement a multisite management facility designed to minimize and potentially eliminate the impact of a disaster or planned site outage.

GDPS is a combination of system code and automation that utilizes the capabilities of Parallel Sysplex technology, storage subsystem mirroring, and databases to manage processors, storage, and network resources to perform a controlled site switch.

This multisite application availability solution provides the capability to manage the remote copy configuration and storage subsystems, and automates Parallel Sysplex operational tasks and failure recovery from a single point of control, hence improving application availability.

By utilizing Parallel Sysplex and PPRC, GDPS requires all the connection types shown in their respective scenarios:

- Sysplex Timer links
- CF links
- ESCON and/or FICON channels for CTCs, DASD and other control unit sharing links
- PPRC links
- OSA-Express Gigabit Ethernet, enabling the high performance network

The maximum supported distance between two sites, with no fiber extender, is 3 km.

The total number of links depends on the number of ESCON, FICON, PPRC, OSA and CF links required.

As with previous examples in this chapter, a two-site scenario with one CPC and one CF at each site is used. Maintaining the same number of links, this scenario requires:

- For Sysplex Timers: four links
- For CF links: at least four links (workload dependent)
- For ESCON connections: two for CTCs and 14 for shared DASD subsystems, total of 16 links (workload dependent)
- For FICON connections: six links (workload dependent)
- For PPRC: 20 links (dependent on DASD subsystem design and workload)
- For OSA-E: at least one link (dependent on network design and workload)

In this example, 51 fiber pair links between sites are required.

The IBM 2029 can extend this distance and drastically reduce the number of required inter-site-connection fibers, as shown in Figure 43 on page 62.

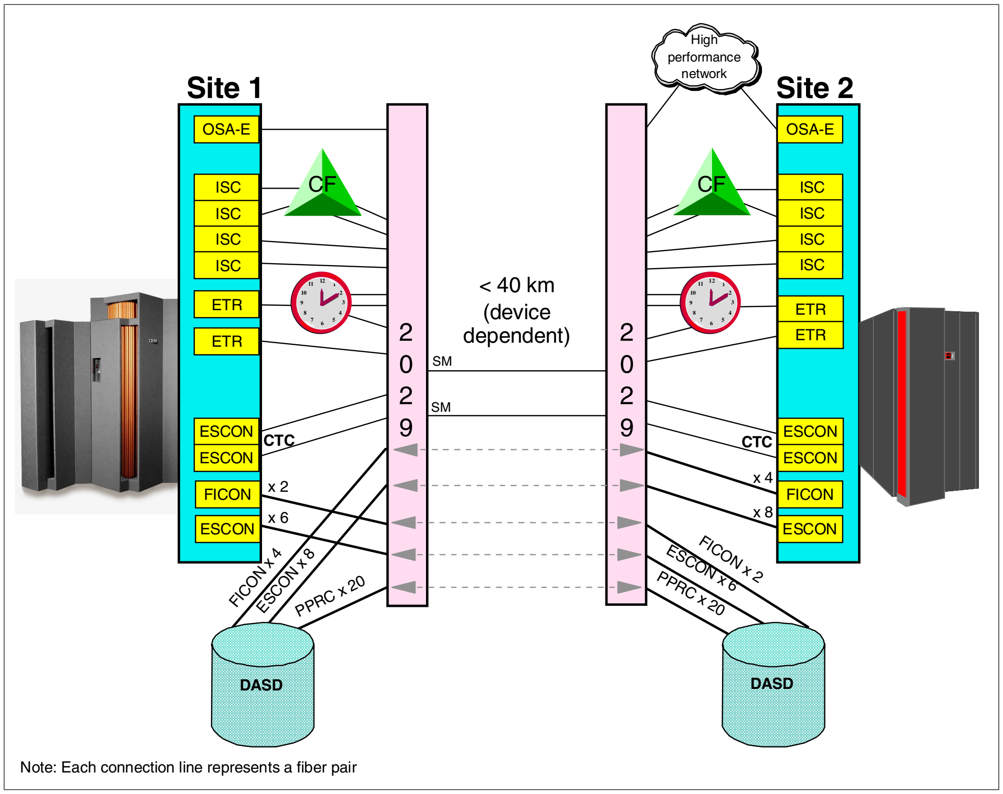


Figure 43. IBM 2029 in a GDPS configuration

Using the IBM 2029 point-to-point configuration, the distance can be up to 40 km (device dependent) and only two single-mode fiber pairs are required between sites.

The ESCON channels and PPRC links can be supported by the 4TDM OCI card. The total number of IBM 2029 channels required to support the ESCON and PPRC links is nine. This is one quarter of the total number of ESCON and PPRC links (36). The ESCON and PPRC links can be intermixed within a 4TDM card because they use the same protocol.

The remaining 15 links require one IBM 2029 channel each. The total number of IBM 2029 channels required is therefore 24.

Implementing all 24 channels as base channels requires three shelves at each site. Base channels may be an acceptable option in this scenario because the system design already provides significant redundancy, having multiple Sysplex Timer units, CF links, CTCs, DASD, and PPRC connections. The only exception is the single Gigabit Ethernet OSA-Express, but it is likely that the network design would incorporate other connectivity to provide backup or redundancy.

Each fiber pair should carry half of the paths for each connection type to maintain the redundant design. Performance impacts must be evaluated because a failure such as a fiber break will impact half of the connections in the IBM 2029 network.

The dual fiber switch (DFS) may be an acceptable availability option for a GDPS scenario. The DFS feature provides protection against an extended outage due to a fiber break. The number of fiber pairs between sites is doubled, but no additional shelves are required. The DFS only protects the cross-site connections. There are other failure scenarios that can still impact half of the paths through the IBM 2029 network.

To avoid the potential performance impact in the event of a fiber pair failure or hardware problem, some links could be defined as high availability channels. Assuming all links other than ETR links are defined as high availability channels, we need 20 high availability and four base channels. This configuration requires six shelves at each site.

Each fiber pair should take a different physical route to avoid double path failure.

3.6.5 Storage Area Network (SAN)

A Storage Area Network (SAN) is a dedicated, centrally managed, secure information infrastructure enabling any-to-any interconnection of servers and storage systems. Consolidation of storage hardware and management offers significant business benefits, including more efficient hardware utilization along with reduced management and administration costs.

FICON and Fiber Channel (FC) switches and directors are central to the SAN fabric. The IBM 2029 can be used to extend distance for both FICON and FC. Figure 44 shows an example of how the IBM 2029 could be used to extend the distance between FICON and FC servers and the shared storage hardware.

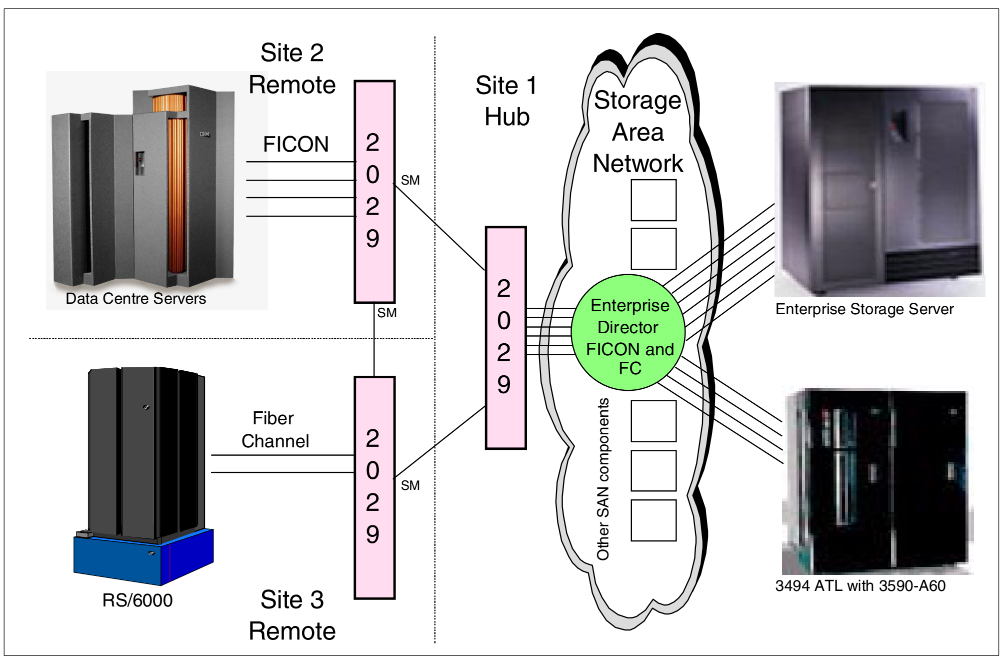


Figure 44. FICON and FC channels extended via IBM 2029 in a SAN environment

This example shows a hubbed-ring configuration. The storage devices (DASD and tape) are physically located at the hub site. The IBM 2029 is used to provide connectivity to the shared storage devices via FICON and FC through an Enterprise Director. The FICON and fiber channel servers are located at different remote sites. Other servers may also access the shared storage devices via other connections and protocols through the SAN.

Since FICON supports distances up to 100 km, the distances between sites can be extended further by cascading IBM 2029 networks.

Chapter 4. Network planning and design

This chapter describes the planning and design considerations, as well as the various tasks required to implement an IBM 2029 network in a data center environment.

First, to assist in the planning process, a flowchart is introduced. This raises a number of network planning and design questions.

To help answer these questions and guide you through your network design, subsequent sections provide:

- Network planning suggestions
- Channel provisioning recommendations
- Cascading recommendations
- Link loss budget calculations

This chapter also includes a discussion on migrating from an IBM 9729 network to an IBM 2029 network.

4.1 Planning and design considerations

When planning an IBM 2029 network, certain criteria must be considered. Figure 45 on page 66 shows a flowchart with the most important items that need to be evaluated, and their respective sequence. Each step and/or decision is explained immediately following the flowchart. Before embarking on the planning process we will review the IBM 2029 configuration rules.

Configuration rules

There are a number of configuration design points and rules to consider when planning your IBM 2029 network configuration. For example, your design must have:

- A minimum of one shelf pair in a point-to-point or hubbed-ring configuration.
- A maximum of eight shelves per terminal (site) in a point-to-point configuration.
- A maximum of eight remote shelves and eight hub shelves in a hubbed-ring configuration.
- In a point-to-point or hubbed-ring configuration, each remote and hub shelf pair uses a unique wavelength band (Band 1 through Band 8) of four wavelengths.
- In a point-to-point or hubbed-ring configuration, the same wavelength band cannot be used for more than one remote and hub shelf pair.
- The maximum end-to-end distance is 50 km (31 miles) in a point-to-point configuration.
- The maximum end-to-end distance is reduced to 40km (25 miles) if Dual Fiber Switches are used.
- In a hubbed-ring configuration the maximum distance is 35 km (22 miles) to the furthest remote shelf

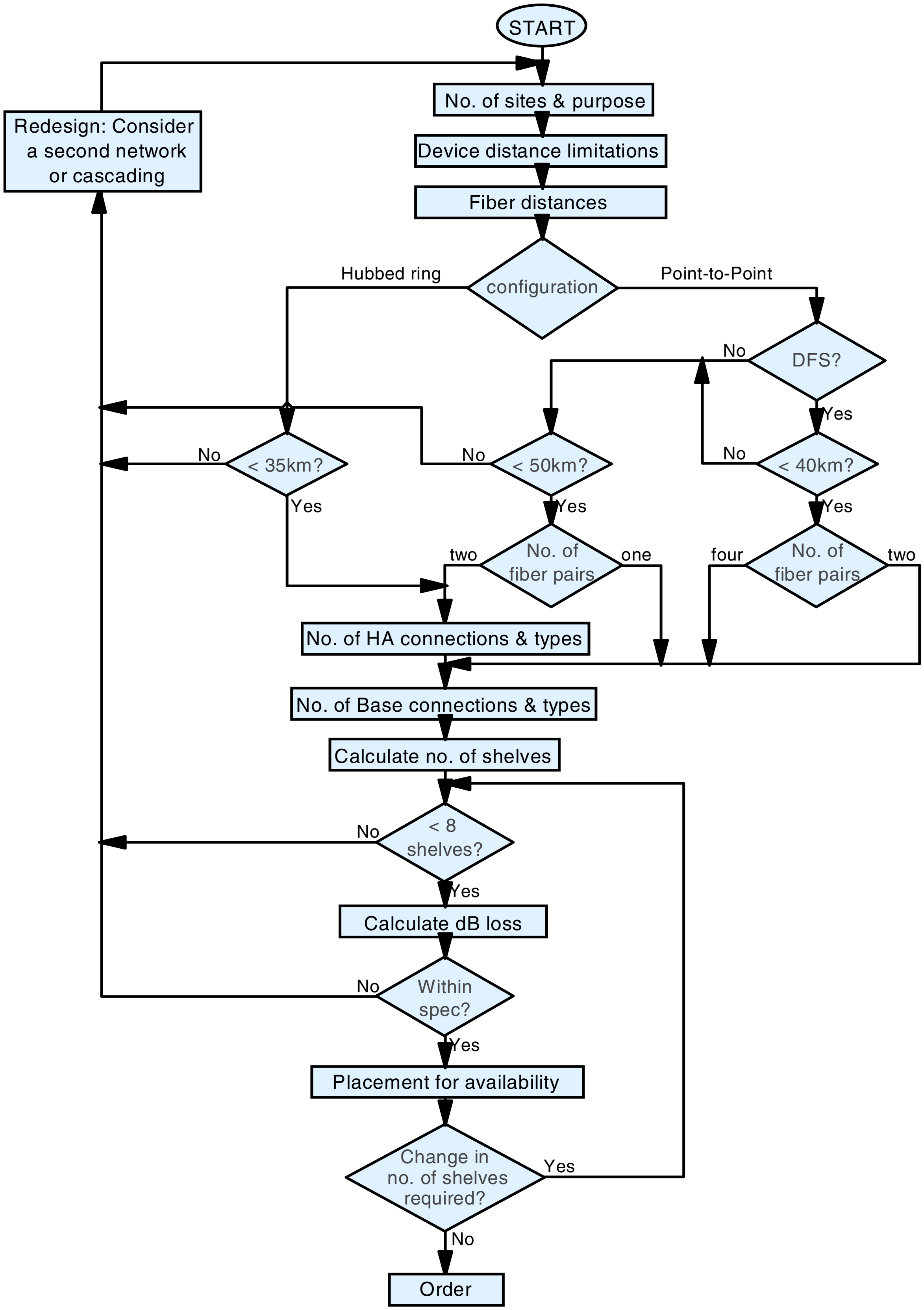


Figure 45. Design and Planning

Number of sites and purpose

Before you can start planning your IBM 2029 network, you need to have a clear picture of what you are trying to achieve. Your requirement could be as simple as providing connectivity to a remote tape library for offsite backups, or as complex as Geographically Dispersed Parallel Sysplex.

You need to know which device types will be used at each site, the protocols that they use and the number of links required.

Device distance limitations

Now that you know which devices you plan to connect, you need to know if there are any distance limitations imposed by those devices. There are a number of examples of ESCON distance limitations shown in Table 4 on page 46. There is also a restriction of 40km for ETR links and coupling facility channels. You may need to ask your hardware vendor to provide you with the specifications for the devices you want to support.

Fiber distances

You need to know the length of the fiber cables that will be connected between the IBM 2029 shelves. You will probably need to go to your service provider to find this information for the intersite fibers. You then need to add the lengths of any patch cabling within your sites.

Ensure that the contractual requirements associated with obtaining “dark fiber” between connecting sites is understood and agreed to by all parties. If you plan to support ETR links there is an additional requirement for the fibers in a fiber pair to be the same length (within 10 meters).

Configuration

The decision on whether to implement a hubbed-ring or point-to-point configuration will depend on the number of sites and distances between sites that were determined in the previous steps.

- Hubbed-ring: Up to eight remote sites are supported. The maximum distance from the hub site to the farthest remote site is 35 km. One of the benefits of using a hubbed-ring configuration is that additional remote sites can be added later with minimal disruption to the existing network.
- Point-to-point: This configuration is only valid for a single remote site. The maximum distance between sites is 50 km.

Dual Fiber Switch?

This feature is valid only in a point-to-point configuration. It reduces the allowable distance between sites to 40 km. Additional fibers are required between sites if the DFS feature is used.

Keep in mind that the installation of the dual fiber switch feature results in all IBM 2029 channels becoming switched base channels. In this configuration, the use of high availability channels is not allowed.

Your decision on whether to implement the DFS should be based on your availability and performance requirements. If your installation can tolerate an extended outage due to a fiber break, then you may not need the DFS feature. If your installation requires high availability channels, then you cannot use the DFS feature.

Number of fiber pairs

An IBM 2029 network may be implemented with just one fiber pair connecting two sites (see Figure 11 on page 10). In this configuration a maximum of four channel slots is supported in each shelf. These channels can only operate as base channels. The corresponding DFS configuration requires an additional fiber pair between sites. There are single points of failure in these configurations so they do not meet the availability requirements for most installations.

Your decision on the number of fibers to use between sites will probably be dependent on costs and possibly the number of connections already available. You must ensure that the decision you make at this point allows a configuration that will support your availability requirements.

Number of high availability connections and types

Now it is time to decide how many of your connections will be provisioned as high availability channels at each remote site. This decision should be based on your availability and performance requirements. Refer to 4.2.2, “Candidates for protected channels” on page 72, for guidance and recommendations.

You may want to consider configuring additional high availability channels to meet future growth requirements.

Number of base connections and types

In several configurations, base channels are the only option, so all links will be configured as base channels. For other configurations, the number of high availability channels was determined in the previous step. The remaining links will be base channels. For more information and recommendations refer to 4.2.1, “Candidates for unprotected channels” on page 72.

Once again, you may want to consider configuring additional channels to meet future growth requirements.

Calculate number of shelves

Having decided on the number of base and/or high availability channels required, you can now determine the number of shelves required at each site. The calculation will vary, depending on how you arrived at this task in the flowchart. Results of each calculation must be rounded up.

There is an example of shelf calculation for a GDPS configuration shown after step 5. You may find it useful to refer to the example as you step through the procedure.

If you are using a hubbed-ring configuration, you need to go through this process for each remote site.

1. Determine how many 4TDM OCI cards will be required for base channels.

   The number of cards for each protocol must be calculated separately as intermixing of protocols within the 4TDM card is not allowed. Count the number of links for each 4TDM supported protocol and divide by four. Add the number of cards for each protocol.

2. Determine the total number of OCI slots required for base channels.

   Add the number of 4TDM OCI cards calculated in step 1 to the number of base channels not supported by the 4TDM OCI card.

3. Determine how many 4TDM OCI cards will be required for high availability channels.

   Use the same procedure as in step 1.

4. Determine the total number of OCI slots required for high availability channels.

   Add the number of 4TDM OCI cards calculated in step 3 to the number of high availability channels not supported by the 4TDM OCI card. This determines the number of OCI cards required. Multiply the result by two to determine the number of channel slots required.

5. Calculate the number of shelves required.

   - For hubbed-ring and point-to-point with 2 fiber pairs, add the results from steps 2 and 4 and then divide by eight.
   - For point-to-point with DFS and 4 fiber pairs, take the result from step 2 and divide by eight.
   - For point-to-point with 1 fiber pair or DFS and 2 fiber pairs, take the result from step 2 and divide by four.

Here is an example showing how to calculate the shelves required for a GDPS configuration similar to Figure 43 on page 62. We have decided on a mixture of base and high availability channels as shown in Table 6.

Table 6. Number of base and high availability channels for GDPS example

Protocol	No of base channels	No. of HA channels
ESCON (including PPRC)	16	20
ETR	4	0
ISC	0	4
OSA-Express	0	1
FICON	3	3

The steps required to calculate the number of shelves are:

1. 4TDM cards for base channels: $16 \div 4 = 4$
2. Total OCI slots for base channels: $4 + 4 + 3 = 11$
3. 4TDM cards for HA channels: $20 \div 4 = 5$
4. Total OCI slots for HA channels: $(5 + 4 + 1 + 3) \times 2 = 26$
5. No. of shelves: $(11 + 26) \div 8 = 4.625$

For this GDPS example configuration, **5** shelves are required. Remember, all calculations must be rounded up. This also applies to the calculation for the number of 4TDM cards for each protocol.

Calculate dB loss

The optical link budget calculation is required to determined whether attenuation (dB loss) in the network is within the acceptable range. You will probably need assistance from your dark fiber service provider to determine dB loss on the intersite fibers. The loss calculation must also include losses on patch cables and connections within your sites. Refer to 4.4, “Link loss budgets” on page 77 for details of the allowable loss for your configuration.

Placement for availability

Now that you know how many shelves will be installed at each site, you can decide how your channels will be provisioned within the shelves. Your first priority for base channels should be to ensure that links which provide redundancy for each other use different fiber pairs (East or West). Second priority is to spread links which provide redundancy for each other across different shelves.

You will find that the band and channel allocation charts in Appendix A, "Network installation worksheets" on page 201 are very useful when planning channel placement.

Change in number of shelves?

When you decide on your channel placement you may find that you cannot configure the shelves to provide the diversity that you need. Configuring additional links or converting some base channels to high availability channels could resolve this, but may also increase the number of shelves required.

If additional shelves are required (for hub and remote sites), this will modify the link loss budget so another budget check will be required.

Redesign: Consider a second network or cascading

If you have reached this point in the flowchart, it means that your IBM 2029 network design will not satisfy all configuration requirements. The options to consider at this point depend on the reason for needing to redesign your configuration.

- Point-to-point configuration exceeding 50km:
  - Consider cascading IBM 2029 networks. Refer to 4.3, "Cascading recommendations" on page 76 for more information.
  - There is an RPQ available to extend the supported distance in a point-to-point configuration to 70km. If the link budget can be met, this may be a suitable option.
- Hubbed-ring configuration exceeding 35km:
  - Implementing a second network may overcome this problem. For example, if you have two remote sites, you could implement two point-to-point networks (with a common hub site) as an alternative to a hubbed-ring configuration.
- More than 8 shelf pairs in the network:
  - Create a second network and spread the channels across the two networks. Aside from resolving the capacity issue, this also has availability advantages.
  - Look at options for reducing the number of shelves, such as reducing the number of high availability channels. Take care not to compromise availability.
  - If you are using a single fiber pair configuration (or 2 pairs with DFS), upgrade with an additional fiber pair (or 2 pairs for DFS). This will enable all channels in the shelf.
- Attenuation not within link budget:
  - Can the attenuation be reduced? Determine whether your dark fiber service provider can improve the dB loss on the intersite connections. You may be able to reduce the dB loss within your sites by reducing the number of connections and patch cables.

- Consider creating a second network so that you can reduce the number of shelves in each network. Reducing the number of shelves increases the link budget.
- If you are planning a hubbed-ring configuration, consider multiple point-to-point configurations. Point-to-point configurations have a less stringent link budget than hubbed-ring configurations.

Order

The final design has now been decided and you are ready for the hardware to be ordered. It is important to go through this planning exercise *before* the hardware is ordered. Detailed planning will ensure that there are no surprises with device restrictions or link budget requirements. Planning also ensures that the hardware will be customized to support your requirements without the need for reconfiguration in the field.

Other issues to consider at time of ordering

- What type, length, and quantity of device interface cables are required?

  Various device interface cables will be required to attach devices at each site to the IBM 2029 network. These cables must be provided by the customer.

- From which site is system management of the network done?

  A system management console is provided with each IBM 2029 model 1 and model RS1. For more information, see Chapter 5, “System management connectivity” on page 89.

- How will the System Manager console be connected to the network?

  See 5.3, “Network connectivity options for system management” on page 97.

4.2 Network planning suggestions

A major decision in planning and designing an IBM 2029 network is which device interface connections to provision as unprotected channels and which to provision as protected channels.

Terminology

The IBM 2029 base and high availability channels correspond to SONET-based industry standard 1+1 protection switching configurations, in which the base channel is an *unprotected* SONET channel and the high availability channel is a *protected* SONET channel.

The IBM 2029 also supports the Dual Fiber Switch (DFS) with base channels, known as switched base channels. DFSs protect against a fiber trunk failure; however, they do not protect against circuit card failures, hence a switched base channel is an unprotected channel.

Throughout this section the terms unprotected channel and protected channel are synonymous with the terms base channel and high availability channel, respectively.

The decision will be influenced by a number of factors, including:

- Subsystem performance and throughput requirements

- Subsystem availability requirements
- Subsystem redundancy already present in the system design
- Availability of spare IBM 2029 channel slots
- Cost

In some cases, one factor will override all others in determining which channel mode to provision. In other cases, each factor will need to be weighed against the others and the decision will not be as clear-cut.

This section discusses some suggestions for arriving at the determination of whether “to protect or not to protect.” These can only be generalizations, as there are as many ways to design a system as there are systems.

4.2.1 Candidates for unprotected channels

The following are suggestions for candidates for unprotected channels where subsystem performance and through-put are not the overriding requirement.

Wherever possible, route unprotected channels that provide backup for each other via different shelf fiber pairs (East or West) and via different shelves.

- Use unprotected channels for multipath ESCON control units, for example DASD subsystems. End-to-end protection is provided by multiple channel path support in the operating system. Place ESCON Director static switch connections at the host end to allow ESCON Director dynamic switching at the device end.
- Use unprotected channels for FICON bridge (9032 model 5) channel (FCV) interfaces supporting multipath ESCON control units attached to the ESCON Director. End-to-end protection is provided by multiple channel path support in the operating system.
- Use unprotected channels for multipath FICON control units.
- If redundancy is provided for a single-interface control unit via a second control unit, then use an unprotected channel for each control unit routed via a different shelf fiber pair. As an example, you may have two 2074 control units providing console support (alternate and master) for multiple OS/390 operating systems. The connections to these control units should be routed via different fiber pairs (East and West) to maintain the redundant design.
- Use unprotected channels for Sysplex Timer External Time Reference (ETR) and Control Link Oscillator (CLO) links routed via different shelf fiber pairs. These protocols are only supported in unprotected mode. See 3.3, “Sysplex Timer - External Time Reference (ETR)” on page 49 for more details.

4.2.2 Candidates for protected channels

The following are suggestions for candidates for protected channels. Protected channels are primarily used for device subsystems where performance, throughput, and availability are critical.

- Use protected channels for single interface control units.
- Use protected channels for the following if there are no other redundant links:
  - Fast Ethernet (100BASE-FX)
  - Gigabit Ethernet (GbE)
  - Fiber Distributed Data Interface (FDDI)

  - Asynchronous Transfer Mode (ATM-OC3 155 Mbps and ATM-OC12 622 Mbps)
  - Fiber Channel Standard
- Use protected channels for FICON Bridge (9032 model 5) channel (FCV) interfaces supporting single interface ESCON control units attached to the ESCON Director.
- Use protected channels for Coupling Facility ISC and HiPerLink.
- Use protected channels for FICON (FC) for single port control units
- Use protected channels for Peer-to-Peer Remote Copy (PPRC) links.

4.2.3 Provisioning recommendations

At channel provisioning time, an OCLD card, for example OCLD-1W, provisioned for use in an unprotected channel connection, can be mapped to either the OCI-1A or OCI-1B card within the shelf. This flexibility in mapping is on a per-channel, per-shelf basis.

Note

This flexibility also means that channel provisioning must be carefully planned.

The OCLD to OCI card mapping for each unprotected channel in each shelf of the shelf pair (hub and remote) must allow end-to-end connectivity between the two OCI cards and consequently, their attached devices.

Figure 46 on page 74 shows the four possible OCLD to OCI card mapping combinations for an unprotected channel. The OCI-1A channel is used as the example for clarity.

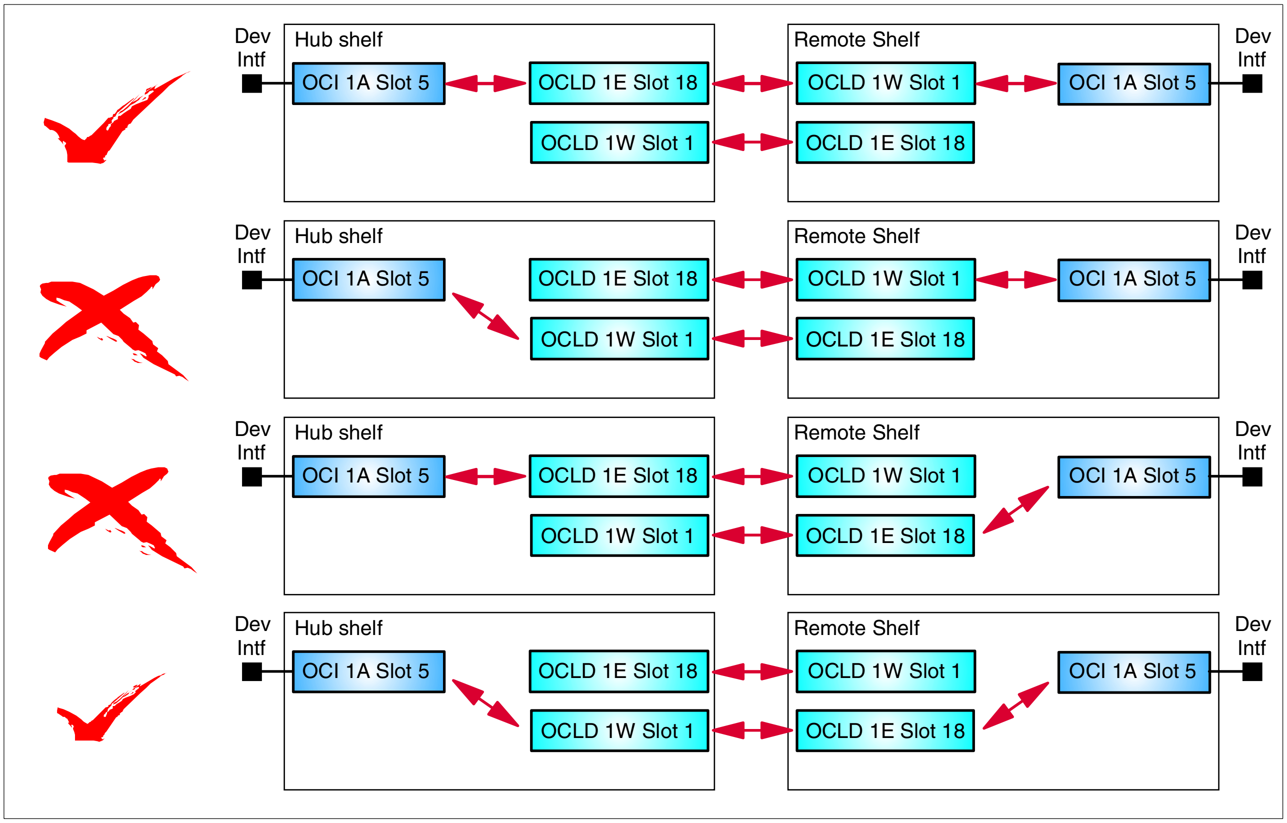


Figure 46. Provisioning unprotected channels

The connectivity between the OCLD cards in the hub shelf and the OCLD cards in the remote shelf reflect the inter-shelf fiber network design of an IBM 2029 network. That is, the OMX East modules of the hub site shelves are connected to the OMX West modules of the remote site shelves. And the OMX West modules of the hub site shelves are connected to the OMX East modules of the remote site shelves. See Figure 29 on page 36.

In Figure 46, the first provisioning combination shows end-to-end connectivity through the network. This is the recommended way of provisioning an unprotected channel.

The second and third provisioning combinations show that there is no end-to-end connectivity through the network.

The fourth provisioning combination shows end-to-end connectivity through the network. However, for network design consistency and ease in maintaining your network configuration, we recommend that the first provisioning combination be used.

At channel provisioning time, map the OCLD and OCI path connections within a shelf as follows (see Table 7 on page 75):

At the hub site end of an unprotected channel, provision the hub shelf as:

- East OCLDs (1E through 4E) and East OMX mapped to the "A" OCI cards (1A through 4A).

- West OCLDs (1W through 4W) and West OMX mapped to the "B" OCI cards (1B through 4B).

At the remote site end of an unprotected channel, provision the remote shelf as:

- West OCLDs (1W through 4W) and West OMX mapped to the "A" OCI cards (1A through 4A).
- East OCLDs (1E through 4E) and East OMX mapped to the "B" OCI cards (1B through 4B).

Table 7. OCLD and OCI recommended channel assignments

Recommended Channel Assignments				
Unprotected Channels			Protected Channels	
HUB shelf OCLD Slot/Channel	REMOTE Shelf OCLD Slot/Channel	OCI Slot/Channel	HUB and REMOTE OCLD Slot/Channel	* OCI Slot/Channel
1 1W	18 1E	6 1B	1/1W and 18/1E	5/1A or 6/1B
2 2W	17 2E	8 2B	2/2W and 17/2E	7/2A or 8/2B
3 3W	16 3E	12 3B	3/3W and 16/3E	11/3A or 12/3B
4 4W	15 4E	14 4B	4/4W and 15/4E	13/4A or 14/4B
15 4E	4 4W	13 4A	* Note: In protected mode, each channel's A slot and B slot OCIs are mutually exclusive.	
16 3E	3 3W	11 3A		
17 2E	2 2W	7 2A		
18 1E	1 1W	5 1A		

Use A.3, “Site band and channel allocation chart” on page 203 to assist in planning for OCI channel provisioning.

Since the release of the new 4TDM OCI card, you may now provision up to four links on a single OCI card. Only ESCON, ATM (single mode and multimode) and Fast Ethernet are allowed with 4TDM card and protocol mixing is not supported. The recommended OCLD to OCI mapping does not change with the 4TDM OCI card. The recommended mapping for the Channel 1 4TDM OCI cards is shown in Table 8 on page 76.

Table 8. OCLD and OCI recommended channel assignments with 4TDM OCI cards

Recommended Channel Assignments				
Unprotected Channels			Protected Channels	
HUB shelf OCLD Slot/Channel	REMOTE Shelf OCLD Slot/Channel	4TDM OCI Slot-Port /Channel	HUB and REMOTE OCLD Slot/Channel	4TDM * OCI Slot-Port/ Channel
1 1W	18 1E	6-1 1B	18/1E and 1/1W	5-1/1A or 6-1/1B
1 1W	18 1E	6-2 1B	18/1E and 1/1W	5-2/1A or 6-2/1B
1 1W	18 1E	6-3 1B	18/1E and 1/1W	5-3/1A or 6-3/1B
1 1W	18 1E	6-4 1B	18/1E and 1/1W	5-4/1A or 6-4/1B
18 1E	1 1W	5-1 1A	* Note: In protected mode, each channel's A slot and B slot OCIs are mutually exclusive.	
18 1E	1 1W	5-2 1A		
18 1E	1 1W	5-3 1A		
18 1E	1 1W	5-4 1A		

The System Manager provisioning process prevents mapping ports on the same 4TDM OCI card to different OCLD cards.

4.3 Cascading recommendations

Cascaded IBM 2029 configurations can involve any combination of hubbed-ring and point-to-point networks. A single link can be cascaded through up to four IBM 2029 networks. Cascading offers more flexibility in the network design and extends the maximum distance that can be achieved between devices attached to IBM 2029 networks. With this flexibility, however, managing and tracking end-to-end connectivity can become very complex. Therefore, it is extremely important to have current and accurate IBM 2029 network configuration documentation.

Cascading is achieved by connecting the shelves' channels across different IBM 2029 networks. That is, the transmit (Tx) and receive (Rx) connectors of an OCI card on one network are connected to the Rx and Tx connectors of an OCI card on another network, respectively.

Consider the following points when you are designing a cascaded network:

- There is no requirement for a cascaded connection to use the same band or channel in each IBM 2029 network.
- A link that has been extended through an IBM 2029 network via a 4TDM OCI card can be cascaded to another network using single port OCI cards. Intermixing of single port and 4TDM OCI cards is not supported for a link within a network, but it is supported for cascading connections between networks.
- A link that has been provisioned as a base (unprotected) channel in one network can be cascaded to a high availability (protected) channel in another network.
- Cascading IBM 2029 networks does not affect the link budgets of individual networks.

- Cascading does not affect device-specific distance limitations.
- Interconnecting point-to-point and hubbed-ring configurations is supported when cascading.
- Only OCI cards without Open Fiber Control (OFC) capability can be used to connect IBM 2029 networks together. For this reason, cascading is not supported for ISC or HiPerLink connections.

Figure 47 shows an example of cascaded IBM 2029 networks.

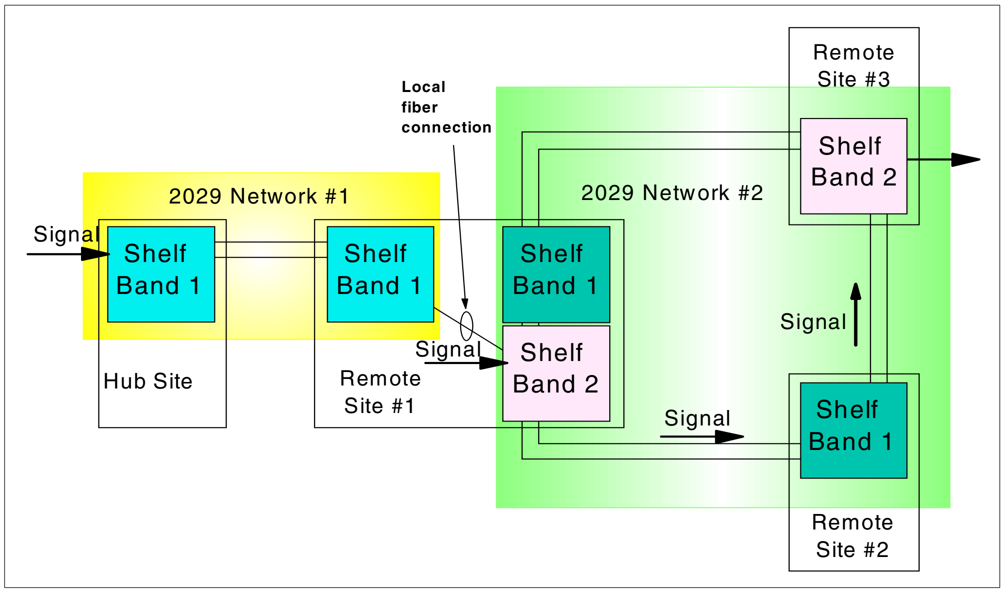


Figure 47. Cascaded IBM 2029 networks

In this example, let us assume that we have one channel attached to an OCI card in Network #1, Hub Site. This channel is to be connected to a device at Remote site #3.

The outputs of Network #1 at Remote site #1 can be connected to a port on a 4TDM OCI card in Network #2 at Remote site #1 (which is in fact the hub site for Network #2). The local fiber connections between Network #1 and Network #2 comply with the distance limitation rules of 500 meters for multimode and 1 kilometer for single mode fiber.

In our example, the signal enters Network #1 at the Hub site. The output signal from Network #1 goes to an OCI port of Shelf band 2 in Network #2. The corresponding remote shelf is in Remote site #3 so that is where the signal emerges from the cascaded networks.

4.4 Link loss budgets

The term *link loss budget* is used to specify how much loss (attenuation) in signal strength can be tolerated and still allow the receiver to interpret an accurate signal. Many factors can reduce (attenuate) the signal strength on its journey through a network, such as:

- Fiber distance
- Fiber patch panel connections

- Dirty or damaged fiber connectors
- Broken, bent, or crimped fiber cables
- Fiber splices
- Dual Fiber Switch

The IBM 2029 network will not function properly if too many of these combined factors attenuate the signal. It is important that none of the fibers have a link loss that exceeds the link budget of the IBM 2029 network. The signal strength loss is measured in decibels (dB).

4.4.1 dB or dBm - a terminology primer

It is important to understand the link budget terminology. The *decibel (dB)* is a convenient way of expressing an amount of signal loss or gain within a system or the amount of loss or gain caused by some component of a system.

When signal power is lost, you never lose a fixed amount of power. Instead you lose a portion of power—one half, one quarter, and so on. This makes it difficult to add up the lost power along a signal's path through the network if measuring signal loss in watts. For example, a signal loses half its power through a bad connection, then it loses another quarter of its power later on through a bent cable. You cannot add 1/2 plus 1/4 to find the total loss. You must *multiply* 1/2 by 1/4. This makes calculating large network dB loss time-consuming and difficult.

Decibels, though, are logarithmic. This allows us to easily calculate the total loss/gain characteristics of a system just by adding them up!

Keep in mind that they scale logarithmically. If your signal gains 3dB, the signal *doubles* in power. If your signal loses 3dB, the signal *halves* in power.

It is important to remember that the decibel is a *ratio* of signal powers. You must have a reference point. For example, you can say, “there is a 5dB drop over that connection.” But you cannot say, “the signal is 5dB at the connection.” A decibel is not a measure of signal strength, but a measure of signal power loss or gain.

A *decibel milliwatt (dBm)* is a measure of signal strength. People often confuse dBm with dB. Do not fall into this trap! A dBm is the signal power in relation to one milliwatt. A signal power of 0 dBm is one milliwatt, a signal power of 3 dBm is 2 milliwatts, 6 dBm is 4 milliwatts, and so on.

Also, do not be misled by minus signs. It has nothing to do with signal direction. The more negative the dBm goes, the closer the power level gets to zero. For example, -3 dBm is 0.5 milliwatts, -6 dBm is 0.25 milliwatts, and -9 dBm is 0.125 milliwatts. So a signal of -30 dBm is very weak.

4.4.2 Point-to-point networks

The link loss budget in an IBM 2029 network depends in part on the number of shelves in the network. Since each shelf causes an inherent dB loss (due to the optical components and connections in the OMX modules), the more shelves installed in a network, the higher the dB loss through the network. To compensate for this added network attenuation within the shelves, more stringent link loss budgets are assigned to the fiber links as the number of shelves in the network increases.

Table 9 shows the maximum dB loss allowed through one fiber connecting a hub site and a single remote site, depending on the number of shelves and presence of the Dual Fiber Switch feature.

Table 9. Link loss budget - single remote site (all fiber types, up to 1.25 Gbps

Number of Remote IBM 2029 Shelves	Maximum Loss (dB)	Maximum Loss (dB) with Dual Fiber Switch
1	21.7	18.7
2	20.6	17.6
3	19.6	16.6
4	18.7	15.7
5	17.8	14.8
6	16.9	13.9
7	15.9	12.9
8	15.0	12.0

4.4.3 Hubbed ring networks

With multiple remote sites, the link loss budgets decrease further. The worst case path to a remote shelf can cross up to twice the number of OMXs as in a single remote site network because of internal OMX cross connections. To compensate for this added attenuation due to additional remote sites, more stringent link budgets are assigned. As with a single remote site network, a higher number of shelves means a lower link budget. Table 10 shows the link loss budgets for a network with multiple remote sites. Link loss budgets are based on the distance from the hub site to the furthest remote site.

Calculate the loss from the hub to the remote site furthest from it in both directions around the ring. The loss calculated in each direction must be less than the link budget listed in Table 10.

Table 10. Link loss budget - multiple remote sites

Number of Remote IBM 2029 Shelves	Maximum Loss (dB) (all fiber types, up to 1.25 Gbps)
1	21.7
2	19.9
3	18.3
4	16.8
5	15.2
6	13.7
7	12.1
8	10.6

4.4.4 Estimating the maximum distance of your IBM 2029 network

The maximum end-to-end distance in an IBM 2029 network is 50 km (31 miles) in a point-to-point configuration, 40 km (35 miles) in a point-to-point configuration with Dual Fiber Switch, or 35 km (22 miles) to the furthest remote shelf in a hubbed-ring configuration.

However, the dB loss characteristics of your network design may prevent these distances from being reached. To verify the feasibility of your planned IBM 2029 network, it is important that you estimate the network dB losses.

In calculating the network dB losses, three general rules are applied:

- 9 micrometer single-mode fiber at 1550nm has an average loss of 0.3 dB per km.
- Patch panels have a loss of approximately 0.5 dB per fiber connection.
- Add a 10% margin to total dB loss for fiber/connector "end-of-life" and repair.

For example, a point-to-point network with sites 43 km apart, and two patch panel fiber connections at each site, and all the fiber types up to 1.25 Gbps, may be limited to six remote shelves (see Figure 48 on page 81). The network dB loss calculations are:

Network dB loss example

dB loss due to fiber length: 0.3 dB/km x 43 km = 12.9 dB

dB loss due to patch panel fiber connections: 0.5 dB x 4 = 2.0 dB

10% margin = 1.5 dB

Total estimated network dB loss = 16.4 dB

Looking at Table 9 on page 79, the maximum dB loss for a fiber of a seven remote shelf network is 15.9 dB. Therefore, our network example is theoretically limited to six remote shelves. Actual dB loss measurements of the installed network may allow a seventh remote shelf to be installed (if the actual loss measured is less than 15.9 dB).

After installing the IBM 2029 network, measuring and understanding the actual dB loss characteristics of the network is important, especially as a troubleshooting aid if connectivity problems arise in the network at a later date.

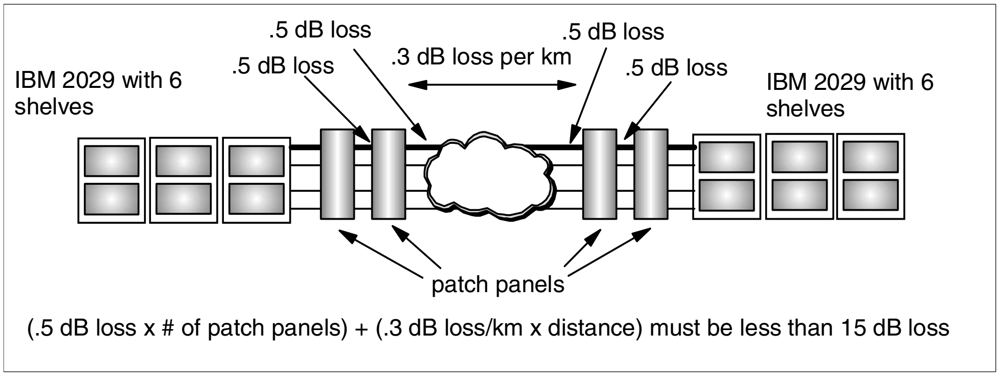


Figure 48. Link budget example for a six remote shelf network

4.4.5 Device interface cable and dB loss

Just as there is a link loss budget for the fibers between the IBM 2029 network sites, there is a link loss budget between the attaching device interfaces and the shelf OCI cards.

Currently, the maximum distance supported by the IBM 2029 for multimode device interface cables is 500 m or 2.0 dB loss, and for single mode device interface cables, 1 km or 3dB loss. See Table 41 on page 211 for more information.

4.5 Migrating from the IBM 9729 to the IBM 2029

The migration from the IBM 9729 to the IBM 2029 is a straightforward process; however, thorough planning is important. This section discusses the planning considerations for such a migration.

4.5.1 Dual fiber switch and high availability channel

It is important to distinguish between the IBM 9729 *dual fiber switch feature,* the IBM 2029 *dual fiber switch feature* and the IBM 2029 *high availability channel* when choosing the number of fiber pairs needed for your installation. The 9729 uses single fibers to carry data in both directions between the multiplexers. The IBM 2029 always uses fiber pairs rather than single fibers. Each fiber pair consists of one transmit and one receive fiber.

In all cases, the user may choose to utilize two independent physical paths between the multiplexers. This provides a backup path in the event the main path is cut.

The IBM 9729 has static protection while the IBM 2029 may have dynamic or static protection:

- In an IBM 9729 network, the extra path is used purely as a backup to the main path. It cannot be used to carry additional channels. A maximum of ten channels may be used with one *or* two fibers between the two IBM 9729s.

  The unused fiber has no signal traveling on it. A hardware monitor within the IBM 9729 polls the receiving cards for light every second. If the monitor sees no light on any cards, a fiber switchover occurs and all channels are routed through the second fiber. The fiber switching takes an average of 2 seconds.

- In an IBM 2029 network with the dual fiber switch feature installed, there are either four of eight fibers between sites, depending on whether both East and West connections are used. The DFS feature acts similarly to the DFS feature in the IBM 9729, but the switching time is significantly reduced. The switching time for the IBM 2029 DFS is 100 milliseconds.

  It is important to note that in an IBM 2029 network, the DFS and high availability channels are mutually exclusive, and DFSs are only supported in a point-to-point configuration.

- In an IBM 2029 network supporting high availability channels, two physical fiber pairs are used between the IBM 2029 sites.

  The IBM 2029 utilizes the second fiber pair to provide a redundant path for channels configured as high availability or to carry additional channels configured as base or a mixture of both. An IBM 2029 network can multiplex up to 32 channels (128 base channels with 4TDM card) on each fiber pair, giving a maximum of 64 base channels (256 base channels with 4TDM card), or it may be provisioned to provide a redundant path on the second fiber pair for up to 32 channels. This protection is implemented on a per-channel basis.

  Every high availability channel travels down both paths and is individually monitored. The IBM 2029 transmits all channels down both paths but receives from only one of the paths. If the hardware monitor within the IBM 2029 detects a loss of signal on one of the channels, the IBM 2029 starts receiving just that channel’s signal from the other path. The channel path switching takes 50 milliseconds.

4.5.2 Mapping the device interface cables

When planning to migrate from an IBM 9729 network to an IBM 2029 network, the existing channels attached to the IBM 9729 need to be mapped to shelves and channels in the IBM 2029. This will determine the number of IBM 2029 shelves and channels required to support the existing network.

See Figure 49 for an example of how to map from an IBM 9729 to an IBM 2029. The hub site of the network is shown.

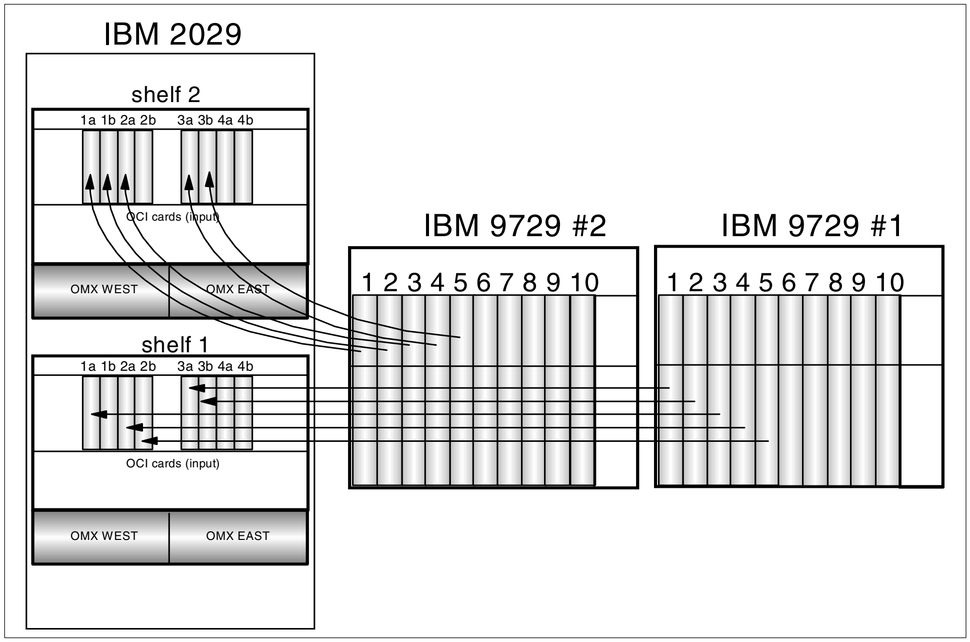


Figure 49. Sample I/O interface cable mapping from an IBM 9729 to an IBM 2029

The channel mapping is more clearly represented by a port-to-port table (see Table 11).

Table 11. Port-to-port migration plan - hub site

Channel type	IBM 9729 Unit / Port	Maps to	IBM 2029 Shelf / Channel	IBM 2029 Channel OMX Path	Channel mode
ISC	# 1 Port 1	===>	Shelf 1 Channel 3A	East OMX	Base
ETR	# 1 Port 2	===>	Shelf 1 Channel 3B	West OMX	Base
ESCON	# 1 Port 3	===>	Shelf 1 Channel 1A	East & West OMX	High availability
ESCON	# 1 Port 4	===>	Shelf 1 Channel 2A	East OMX	Base
ESCON	# 1 Port 5	===>	Shelf 1 Channel 2B	West OMX	Base
ETR	# 2 Port 1	===>	Shelf 2 Channel 1A	East OMX	Base
ISC	# 2 Port 2	===>	Shelf 2 Channel 1B	West OMX	Base
ESCON	# 2 Port 3	===>	Shelf 2 Channel 2A	East & West OMX	High availability
ESCON	# 2 Port 4	===>	Shelf 2 Channel 3A	East OMX	Base
FDDI	# 2 Port 5	===>	Shelf 2 Channel 3B	West OMX	Base

In the sample migration plan in Figure 49 and Table 11, there are two ISC channels and two ETR channels connected to separate IBM 9729s to provide redundancy.

Both pairs of channels have been mapped to different IBM 2029 shelves and OMX module paths. For example, the ISC channel attached to Port 1 on IBM 9729 #1 is mapped to Shelf 1 Channel 3A, which is provisioned to use Shelf 1

East OMX. The ISC backup channel attached to Port 2 on IBM 9729 #2 is mapped to Shelf 2 channel 1B, which is provisioned to use Shelf 2 West OMX.

We recommend that you provision redundant channels from multipath devices through different shelves and different OMX modules within the shelves. This ensures that if either a shelf or a fiber pair lose connectivity through the network, the redundant channel will still be able to carry the channel traffic.

See Figure 50 for an example of how to map from an IBM 9729 to an IBM 2029 with 4TDM OCI cards. As a single 4TDM OCI card has 4 ports, the same IBM 9729 configuration may now be moved to a single shelf of the IBM 2029. Channel locations 1A and 2A utilize a 4TDM card. Only the hub site of the network is shown.

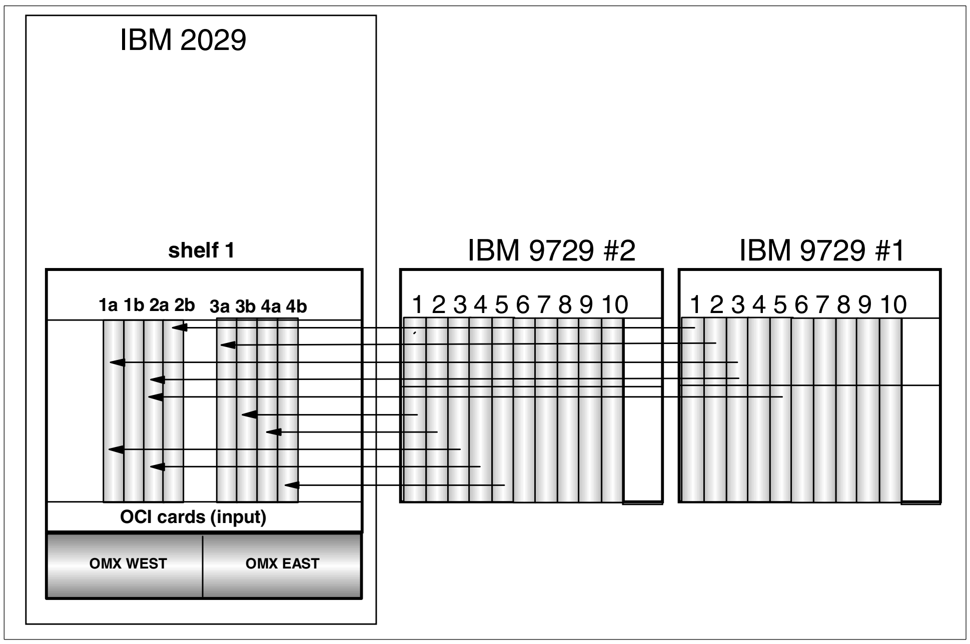


Figure 50. Same sample as figure 4 with 4TDM OCI card

Ports 1 and 2 are provisioned for Channel 1A. Channel 1B is not connected and reserved for High Availability. The second 4TDM OCI card for channel 2A has three provisioned ports for ESCON.

The channel mapping is more clearly represented by a port-to-port table (see Table 12).

Table 12. Port-to-port migration plan - hub site (4 TDM OCI card)

Channel type	IBM 9729 Unit / Port	Maps to	IBM 2029 Shelf / Channel	IBM 2029 OCI / Port	IBM 2029 Channel OMX Path	Channel mode
ISC	# 1 Port 1	===>	Shelf 1 Channel 2B	8 / NA	West OMX	Base
ETR	# 1 Port 2	===>	Shelf 1 Channel 3A	11 / NA	East OMX	Base
ESCON	# 1 Port 3	===>	Shelf 1 Channel 1A	5 / 1	East & West OMX	High availability
ESCON	# 1 Port 4	===>	Shelf 1 Channel 2A	7 / 1	East OMX	Base
ESCON	# 1 Port 5	===>	Shelf 1 Channel 2A	7 / 2	East OMX	Base

Channel type	IBM 9729 Unit / Port	Maps to	IBM 2029 Shelf / Channel	IBM 2029 OCI / Port	IBM 2029 Channel OMX Path	Channel mode
ETR	# 2 Port 1	===>	Shelf 1 Channel 3B	12 / NA	West OMX	Base
ISC	# 2 Port 2	===>	Shelf 1 Channel 4A	13 / NA	East OMX	Base
ESCON	# 2 Port 3	===>	Shelf 1 Channel 1A	5 / 2	East & West OMX	High availability
ESCON	# 2 Port 4	===>	Shelf 1 Channel 2A	7 / 3	East OMX	Base
FDDI	# 2 Port 5	===>	Shelf 1 Channel 4B	13 / NA	West OMX	Base

4.5.3 Link loss budget differences

The term link loss budget is used to specify how much loss in signal strength (attenuation) a connection can tolerate and still allow the receiver to accurately interpret a signal.

IBM 9729s are more sensitive to signal attenuation than the IBM 2029s. The IBM 9729 has a link loss budget of 15 dB while the IBM 2029 point-to-point configuration has a link loss budget of 15 to 21.7 dB, depending on the number of shelves commissioned. Therefore, if your IBM 9729 network is operating within its recommended link loss budget, the replacement IBM 2029 network should also operate correctly over the same fibers, even with the maximum number of IBM 2029 shelves commissioned. See 4.4, “Link loss budgets” on page 77 for more information on dB loss.

4.5.4 Environmental considerations

The shipment, storage, and operating temperatures of the IBM 2029 all fall within the temperature specifications of the IBM 9729. Therefore, the IBM 2029 can operate in the same physical environment as the IBM 9729.

4.5.5 Power differences

The IBM 9729 power requirements are country dependant. Commonly, an installation will have two power outlets per IBM 9729 with either of the following power ratings:

- 90-125 volts, 6 amps, 47-63 Hz (North America)
- 180-264 volts, 4 amps, 47-63 Hz (outside North America)

Each IBM 2029 frame has two 220V 20A, single-phase connections. The connector type is a Hubble 316R6W in North America (bare pigtail outside North America).

The two power sources per IBM 2029 frame are designed for redundancy, so it is recommended to provide separate power sources. For example, an IBM 2029 network with four frames requires eight outlets connected to two separate sources.

Further, each IBM 2029 model 001 and RS1 requires three standard appliance power outlets for the Ethernet hub, System Manager PC, and monitor.

See Appendix C.5, “Frame power requirements” on page 217 for more information on IBM 2029 power requirements.

4.5.6 Cabling considerations

Unless the distances differ between the device interfaces and the IBM 9729s, and the device interfaces and the IBM 2029s, all device interface cables can be swung over from the IBM 9729s to the IBM 2029s. However, to minimize downtime, you may wish to order new device interface cables and lay them prior to the scheduled migration window.

The OCI cards in each IBM 2029 shelf use standard SC duplex connectors, which are connected through patch cables to the IBM 2029 internal patch panel. OCI cards provisioned for ESCON or ETR/CLO protocols have patch cables with inline 12 dB attenuators and ESCON duplex connectors at the IBM 2029 patch panel.

The IBM 9729 network fiber connectors, however, are different from those used on the IBM 2029. The IBM 9729 uses FC connectors, while the IBM 2029 uses SC connectors. Most likely, your IBM 9729 installation currently uses a patch panel and jumper cables between the fiber trunk and the IBM 9729. These jumper cables cannot be swung over to the IBM 2029s. The appropriate jumper cables to this patch panel must be ordered and, to minimize downtime, laid prior to the scheduled migration window.

4.5.7 Floor space differences

Generally, IBM 2029 frames use more floor space than the IBM 9729s due to high availability channel configurations. For example, ten channels on an IBM 9729 translate into one IBM 2029 frame with all base channels or two IBM 2029 frames with all high availability channels.

The IBM 2029 frames are 35 mm wider and have doors that extend the service clearance an extra 635 mm to the front and rear of the frame.

See Appendix C for more information on IBM 2029 floor space requirements.

4.5.8 Floor tile cutout differences

The IBM 2029 uses floor tile cutouts at the front and rear of the frame, while the 9729 uses a cutout at the front only.

See Appendix C for more information on IBM 2029 floor tile requirements.

4.5.9 Phased migration plan

We recommend that you implement a phased migration from the IBM 9729 network to the IBM 2029 network to ensure minimal system impact.

Start with connecting the fiber pairs between the IBM 2029 frames in the different geographies. Install one fiber pair at a time and test connectivity between the two sites.

If you are using the IBM 9729 fibers for the IBM 2029 network and have the dual fiber switch feature, consider testing the connectivity of each fiber pair path (East and West) between the IBM 2029 sites using unused backup fibers from the IBM 9729 network. Removing the unused path does not affect the IBM 9729 network traffic. Lights on the IBM 9729 indicate which fiber is not in use.

After connectivity is established between the IBM 2029 shelves in each site, provision the device channels through the system manager console.

Disconnect the appropriate IBM 9729 device interface cables and connect the IBM 2029 device interface cables to the IBM 2029 patch panel one channel at a time. If possible, test data transmission through each channel before proceeding to the next channel until the migration is completed.

Chapter 5. System management connectivity

This chapter focuses on the way the IBM 2029 shelves are interconnected to provide intershelf communications for system management. It also outlines the information needed at shelf commissioning time for the IBM 2029 network.

Example configurations for connecting system management and external management workstations to the IBM 2029 network are described in:

- “Stand alone environment - connecting through a shelf” on page 98
- “Connecting to the IBM 2029 network through an IP network” on page 100
- “Dark fiber managed services” on page 110

The system management and external management functions are described in:

- “The IBM 2029 System Manager” on page 114
- “External management using SNMP” on page 115

5.1 Intershelf communications

A per-wavelength band optical service channel allows intershelf communications between shelves in an IBM 2029 network. These service channels (also known as overhead channels) are used to transport information for managing and monitoring the operation of the optical channels between shelf pairs. Figure 51 shows the one-to-one relationship between shelves of the same band.

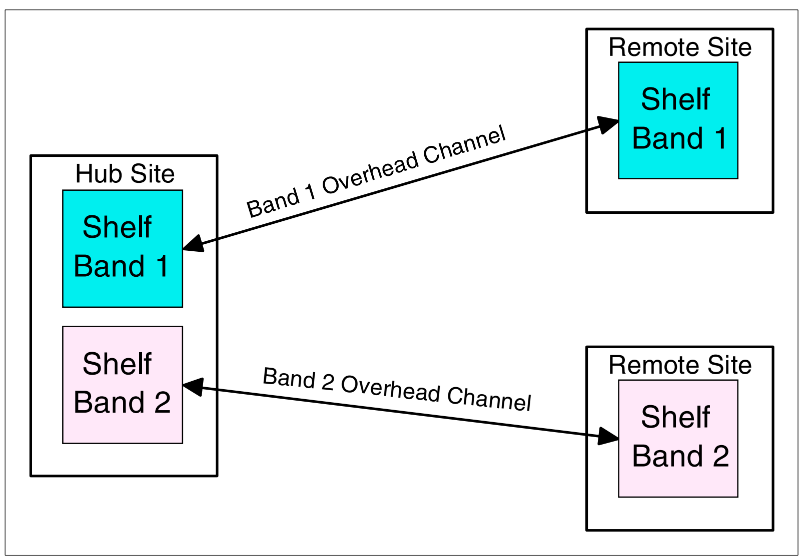


Figure 51. Overhead channels

Intershelf communications between shelves of different bands (cross-band) is achieved through a 10BASE-T crossover port (2X) on the maintenance panel of the IBM 2029 shelf and the overhead channels. An IBM 2029 Ethernet hub is used to interconnect the 2X ports of each shelf in the hub site, as shown in Figure 52 on page 90. A second IBM 2029 Ethernet hub, however, may be installed in a multishelf remote site for redundancy of the cross-band communications path. All shelves within the site are connected to the IBM 2029 Ethernet hub with 10Base-T crossover cables from each shelf's 2X port.

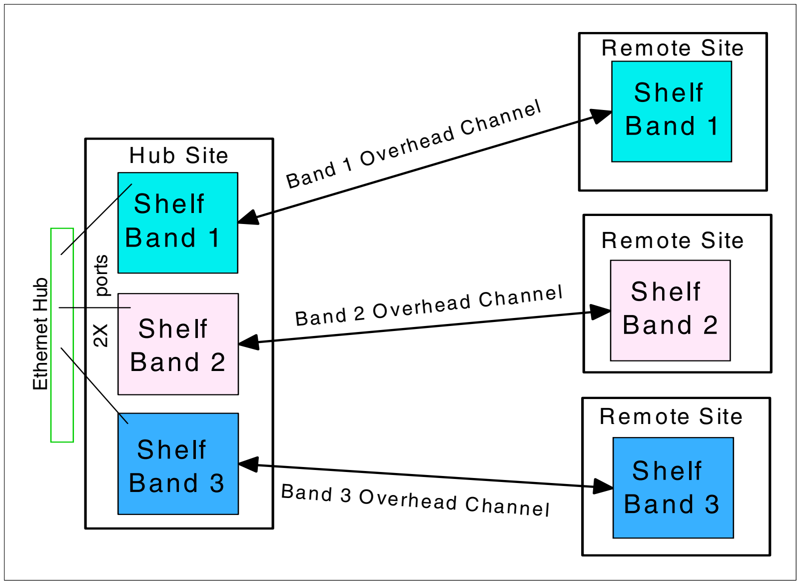


Figure 52. Interconnected shelves through an Ethernet hub

Internal IP addresses (see Table 13 on page 91) are automatically assigned to each shelf by the shelf's System Manager code at shelf commissioning time. These internal IP addresses are used in conjunction with an internal OSPF (dynamic IP routing protocol) to broadcast system management information within the IBM 2029 network, so that all shelves receive the information. An example of system management traffic flow, using Figure 52, is as follows:

1. Band 2 shelf in a remote site detects a component failure.
2. The information is broadcasted using the Band 2 overhead channel to the Band 2 shelf in the hub site.
3. Band 2 shelf in the hub site forwards the information to the other shelves in the hub site through the IBM 2029 Ethernet hub.
4. The other shelves then forward the information to their partner bands in the remote sites using their overhead channel.

The IBM 2029 network can also be connected to an IP network to do surveillance and operations tasks for all IBM 2029 shelves, from a remote location. This is done by designating a shelf as a Gateway Network Element (GNE) to act as a communications gateway between the IBM 2029 network and the IP network. The IBM 2029 environment supports two GNEs per network.

Recommendation

We strongly recommend that you do not use the IBM 2029 Ethernet hub for connectivity to a system management workstation or to your IP network. This may cause performance problems with intershelf communications, and/or internal routing problems.

5.1.1 Internal IP addresses

Some IP addresses are reserved for internal use in an IBM 2029 network (for example, to route system management traffic from shelf to shelf using the internal OSPF protocol flows). A breakdown of these IP addresses is shown in Table 13.

Table 13. Internal IP addresses

IP Address	Range	Details
10.0.0.x	1 to 19	Used for intershelf communications
10.0.shelfID.x	1 to 254	Used for intershelf communications
10.1.254.1		Uncommissioned shelf address
10.1.shelfID.1		IP address for 10BASE-T 1X port
10.1.shelfID.2		DHCP address for 10BASE-T 1X port
10.2.hubbinggroup.x	shelfID	IP address for 10BASE-T 2X port
10.2.hubbinggroup.x	shelfID + 128	DHCP address for 10BASE-T 2X port
10.2.hubbinggroup.255		Broadcast address
10.3.shelfID.1		DTE local
10.3.shelfID.2		DTE remote
10.4.shelfID.1		DCE local
10.4.shelfID.2		DCE remote

Note that hubbinggroup (Ethernet Hubbing Group) and shelfID (Shelf Identifier) are set at shelf commissioning time. For a description of these values, see “Ethernet Hubbing Group” on page 95 and “Shelf Identifier” on page 92.

Important

If you assign any of the internal IP addresses to any shelf, communications within the IBM 2029 network will fail.

5.1.2 IP addressing rules

The following rules must be applied when commissioning a shelf, to allow communications between all shelves in the IBM 2029 network and the System Manager and/or the External Manager.

- Each shelf in the network must have a unique IP address.
- The internal IP address range listed in Table 13 must not be used when allocating the shelf IP addresses.
- Only one shelf in the IBM 2029 network must be defined as the primary shelf. This shelf maintains the network management information database including the System Manager shelf list and network tree.
- Each shelf in the network must point to the primary shelf IP address.
- Each shelf must be segmented into its own subnetwork, using a subnet mask. The only exception to this is the GNE shelf connecting to an IP network using the Proxy Address Resolution Protocol (ARP) function. See 5.3.3, “Connecting via an IP Network in a single GNE environment” on page 102.

5.2 Network commissioning information

There are three basic network connectivity options for managing an IBM 2029 network:

- Connecting to a shelf in a stand alone environment with no connectivity to an external IP network
- Connecting through an external IP network to one GNE in a proxy ARP environment
- Connecting through an external IP network to two GNEs in an OSPF environment

Each of these connectivity options are discussed in detail in 5.3, "Network connectivity options for system management" on page 97.

Before discussing the various types of IBM 2029 network configurations, it is important to understand what networking information is needed at shelf commissioning time.

Note that the information you enter at shelf commissioning time is used to create a network tree (maintained by the designated primary shelf) that appears in the System Manager; see Figure 76 on page 133. Keep the System Manager network tree in mind when naming the network, sites, and shelves in your IBM 2029 network.

5.2.1 Shelf naming information

Network Name can be any combination of letters and numbers, up to 32 characters. We recommend that all shelves in the same physical network have the same network name, for example, *Andreas Network*.

Site Name can be any combination of letters and numbers, up to 32 characters. We recommend that all shelves at a site have the same site name, for example, *San Francisco*.

Shelf Name can be any combination of letters and numbers, up to 32 characters. We recommend that each shelf in the network have a unique descriptive shelf name, for example, *SF Hub Band 2*.

Shelf Description can be any combination of letters and numbers, up to 64 characters. We recommend that each shelf in the network have a unique shelf description, for example, *SF Hub Band 2 Primary*.

Site Identifier can be any number from one through nine. The site identifier logically groups shelves together. Shelves at the hub site are assigned to site number 1. The other sites in the network are assigned the next available number.

Shelf Identifier can be any number from 1 to 16. The shelf identifier number must be unique to the shelf in the network (each number can only be assigned to one shelf). We recommend that numbers 1 through 8 be assigned to shelves at the hub site, and numbers 9 through 16 to shelves at remote sites. These numbers are used by the shelf System Manager to automatically assign each shelf's internal IP addresses; see Table 13 on page 91.

Note: These internal shelf addresses must not be assigned elsewhere in the 2029 network or the external IP network, as communications within the IBM 2029 network will fail.

5.2.2 Shelf communication information

Primary Shelf Address is the IP address of a shelf designated to be the primary shelf of the IBM 2029 network. Any hub site shelf in the network may be designated the primary shelf.

There is only one primary shelf in the network. It maintains the network management information database including the system manager shelf list and network tree. All shelves in the network must point to the same primary shelf address.

The primary shelf may also perform the GNE function for the IBM 2029 network when connected to an external IP network. Then the primary shelf's IP address must be within the subnet IP address range of the IP router that connects it to the external IP network. However, the primary shelf does not have to be the GNE. We recommend, for redundancy in multiple shelf pair environments, to designate different shelves as the primary shelf and GNE.

Shelf Address is the IP address of the shelf. Each shelf in a network must have a unique IP address. The internal IP address range listed in Table 13 on page 91 must not be used. Each IBM 2029 shelf is shipped with an arbitrary IP address assigned.

A detailed IP addressing scheme must be developed before you begin commissioning each IBM 2029 shelf. For more information on addressing schemes, see 5.3, "Network connectivity options for system management" on page 97.

Subnet Mask typically segments a shelf from other shelves in the IBM 2029 network. The network is generally segmented to force system management traffic to use the IBM 2029 internal IP routing. Otherwise, the shelf will attempt to establish a connection at the 10BASE-T 1X port on the maintenance panel.

- Each IBM 2029 shelf is shipped with its subnet mask set to 255.255.255.252. This gives each shelf four IP addresses in its IP subnetwork, which are used as follows:

  - Subnetwork identification address (n)
  - Shelf address (n+1)
  - DHCP (n+2) or gateway address (n+2)
  - Subnetwork broadcast address (n+3)

  This 255.255.255.252 subnet mask scheme can be used for all shelves in a stand alone environment (see 5.3.1, "Stand alone environment - connecting through a shelf" on page 98), or for non-GNE shelves in an external IP environment where there are sufficient IP addresses available (4 per non-GNE shelf) to be allocated to each shelf's subnetwork.

- A non-GNE shelf may be assigned a network mask of 255.255.255.255. Its shelf IP address becomes the only address in its subnetwork. In this case the DHCP address and gateway address parameters of the shelf are ignored (set to 0.0.0.0) and an internal DHCP IP address (see Table 13 on page 91) is automatically assigned to the 1X port by the shelf System Manager.

This 255.255.255.255 subnet mask scheme can be used for all shelves in a stand alone environment, or for non-GNE shelves in an external IP environment to reduce the number of IP addresses allocated to one per non-GNE shelf. We recommend using this scheme for non-GNE shelves in an external IP environment. See 5.3.2, “Connecting to the IBM 2029 network through an IP network” on page 100.

- In an OSPF environment, two GNE shelves are assigned net masks which are the same as each IP router that connects each GNE shelf to the external IP network so that each GNE shelf’s IP address is within the IP address range of its router’s subnetwork. Additionally, all GNE and non-GNE shelves in the IBM 2029 network must each have unique subnetworks so that they are segmented from each other. This is to allow OSPF between the GNE shelves and the external IP network to manage connectivity with all shelves in the IBM 2029 network. Therefore the network masks of the non-GNE shelves, the GNE shelves, and their attaching routers must allow for this shelf subnetwork segmenting. See 5.3.4, “Connecting via an IP network in a dual GNE environment” on page 105.
- In a proxy ARP environment, the single GNE shelf is assigned a subnet mask which is the same as the IP router that connects it to the external IP network so that the GNE shelf’s IP address is within the IP address range of the router’s subnetwork. Additionally, only the non-GNE shelves in the IBM 2029 network must be segmented from each other. The subnet mask of the single GNE (which is also the same mask as its attached router) must include the IP addresses of all the non-GNE shelves within the IP address range of the GNE shelf’s subnetwork. This is to allow the GNE shelf to manage connectivity between all shelves in the IBM 2029 network and the external IP network by using the GNE’s proxy ARP function. See 5.3.3, “Connecting via an IP Network in a single GNE environment” on page 102.

DHCP Address is an IP address that allows you to connect a workstation to the 10BASE-T 1X port on the maintenance panel of the shelf.

- For non-GNE shelves with a subnet mask of 255.255.255.252, the DHCP address must be set to one higher (n+2) than the shelf’s IP address (n+1).
- For non-GNE shelves with a subnet mask of 255.255.255.255, the DHCP address must be set to 0.0.0.0. The shelf’s System Manager automatically allocates a DHCP address to the 1X port using Table 13 on page 91.
- For GNE shelves in an OSPF environment, the DHCP and Default Gateway addresses must both be set to 0.0.0.0. Shelf OSPF parameters must then be defined.
- For GNE shelves in a proxy ARP environment, the DHCP address must be set to 0.0.0.0 and a Default Gateway Address defined. This will disable DHCP on the 1X port of the shelf.

Note

DHCP address and default gateway address are mutually exclusive.

Default Gateway Address This is an IP address of an IP router in a proxy ARP environment that is connected to the 10BASE-T 1X port on the maintenance panel of the GNE shelf. The default gateway address activates the proxy ARP function in the GNE shelf.

For GNE shelves in an OSPF environment, the Default Gateway and DHCP addresses must both be set to 0.0.0.0. Shelf OSPF parameters must then be defined.

For non-GNE shelves, the default gateway address must be set to 0.0.0.0. This will disable the default gateway function and allow you to assign a DHCP address, if the subnet mask is set to 255.255.255.252.

Shelf Type is either terminal, OADM, or OFA.

- Terminal is used for shelves in both sites of a point-to-point configuration and in the hub site of a hubbed-ring configuration.
- OADM (optical add drop multiplexer) is used for shelves in remote sites of a hubbed-ring configuration.
- OFA (optical fiber amplifier) is not supported with this release.

Ethernet Hubbing Group is a number from 1 to 8 that usually corresponds to the Site Identifier. The hubbing group designates which shelves are connected through an IBM 2029 Ethernet hub to each other's 2X port. Ethernet hubbing group 1 is assigned to shelves at the hub. These numbers are used to assign internal IP addresses; improper use will cause internal routing problems.

The following OSPF routing control information is only required when connecting to an external IP network in an OSPF environment:

Note

The OSPF backbone parameters are only activated when the OSPF Backbone flag is selected. Password Enabled, Password, Transit Delay, Retransmit Interval, Hello Interval, and Router Dead Interval values used in the GNE must match its attached router for them to be OSPF neighbors.

Area ID defines the OSPF Area number used by the IBM 2029 internal OSPF network. It is not the Area ID the GNE shelf uses for connectivity to an external IP network in an OSPF environment.

The shelves in an IBM 2029 network form an internal OSPF router network which ensures that all shelves are aware of routes to each other. This internal OSPF network is architected in the IBM 2029 design. It is in operation whether or not there is connectivity to an external IP network. You should not confuse this internal OSPF Area ID with the Area ID used by GNE shelves for external IP network connectivity in an OSPF environment.

The internal OSPF Area ID parameter can be set on GNE and non-GNE shelves whether or not the OSPF Backbone flag is enabled. The default value is *0.0.0.0* which is automatically translated by the shelf's System Manager to a non-zero value. This value is then used by all shelves in the internal OSPF network. If you change this value, *all* shelves must be set to the new value. We recommend the Area ID value to be set to the default of *0.0.0.0.*

OSPF Backbone flag must only be enabled for GNE shelves communicating with external OSPF routers. This flag disables the proxy ARP function in the GNE and allows the GNE's other OSPF parameters to be set. The OSPF Area ID of the

GNEs and their attached routers is 0.0.0.0. This is hard coded within each GNE's external OSPF parameters and cannot be changed.

OSPF Area ID 0.0.0.0, by definition, is the OSPF backbone of the external IP network. Organizations that do not wish to attach the GNE shelves directly to the external IP network OSPF backbone may have to implement a Border Gateway Protocol (BGP) function to connect to the IBM 2029 network. You should not confuse the internal OSPF Area ID set by the Area ID parameter with the Area ID used by GNE shelves for external IP network connectivity in an OSPF environment. See "Connecting via an IP network in a dual GNE environment" on page 105.

Router Priority If you assign two routers to a network, both will try to become the Designated Router. The router with the higher priority value becomes the Designated Router. Priority values are from 0 to 255. A router with a value of 0 is never the Designated Router.

Cost refers to the cost of sending a data packet on the interface, from 0 to 200. The default value for 10BaseT Ethernet is *10*.

Password Enabled flag indicates if there is a password assigned to the OSPF backbone the GNE shelf is attached to. The password is used for simple password authentication.

Password refers to a key to allow the authentication procedure to generate and check the incoming and outgoing OSPF packets. The password can be up to eight characters, for example *IBM2029.*

If there are two GNE shelves in the IBM 2029 network, the OSPF Backbone Password must be the same for both GNE shelves.

Transit Delay refers to the number of seconds to transmit a link state update packet over the 10BaseT 1X port, from 0 to 100. The default is *1* second.

Retransmit Interval refers to the number of seconds after which a Link Request for one or more link state advertisements will be resent, from 0 to 100. The default is *5* seconds.

Hello Interval refers to the number of seconds between Hello packets that are sent on the interface, from 0 to 1800. The default is *10* seconds.

Router Dead Interval refers to the number of seconds after which a router that has not sent a Hello will be considered dead by its neighbors. This value must be greater than the Hello Interval. The default, which is four times the configured Hello Interval, is *40* seconds.

Worksheets where this information can be entered and used when commissioning the shelf for your environment are provided in Appendix A, "Network installation worksheets" on page 201.

Also, a description and walkthrough of the commissioning process can be found in 6.1, "Commissioning the IBM 2029 network" on page 121.

5.3 Network connectivity options for system management

This section describes the methods used to connect the System Manager and External (SNMP) Manager to the IBM 2029 network. Three network configurations are presented and evaluated, with recommendations on implementing each network design. Our scenarios only show point-to-point configurations, but all options described in this section equally apply to hubbed-ring configurations.

When implementing an IBM 2029 network, a detailed IP addressing scheme must be developed before you begin commissioning each IBM 2029 shelf. The network administrator should be consulted to ensure the IBM 2029 shelf fits into the organization's existing IP network design. A key consideration for the IP network design plan is the type of connection used.

When building their IP networks, many organizations do not have the requirement to route outside their own networks and across the Internet. Other organizations use firewalls to connect their internal networks to the Internet or to other organizations. Under these circumstances the internal network of the organization can be assigned any IP address space that the local network administrator chooses.

This practice is formalized in RFC 1597, "Address Allocation for Private Internets". This RFC details the three ranges of IP addresses that the Internet Assigned Number Authority (IANA) has reserved for private networks:

10.0.0.0 through 10.255.255.255 One single Class A network

172.16.0.0 through 172.31.255.255 16 contiguous Class B networks

192.168.0.0 through 192.168.255.255 256 contiguous Class C networks

These addresses may be used by any organization in their internal networks without reference to any other organization, including the Internet authorities.

The three IBM 2029 network configurations discussed in this section use these private IP addresses. For organizations that cannot route private addresses through their networks, explicit public addresses from the organization's public address space must be allocated.

If you plan to route your IBM 2029 system management traffic through a non-secure IP network (for example, through the Internet), you should consider using a Virtual Private Network (VPN). A VPN creates a secure private connection that essentially acts like a point-to-point connection.

For more detailed information concerning IP network planning, refer to *IP Network Design Guide,* SG24-2580.

There are three basic network connectivity options for managing an IBM 2029 network:

- Connecting to a shelf in a stand alone environment with no connectivity to an external IP network.
- Connecting through an external IP network to one GNE in a proxy ARP environment.

- Connecting through an external IP network to two GNEs in an OSPF environment.

Note that the shelves in an IBM 2029 network form an internal OSPF router network which ensures that all shelves are aware of routes to each other. This internal OSPF network is architected in the IBM 2029 design. It is in operation regardless of which of the three basic external connectivity options are implemented. You should not confuse this with external IP network connectivity with dual GNEs in an OSPF environment.

Note that SNMP traps generated by the SP in each shelf will be forwarded to its External Manager using the same IP definitions defined for System Manager traffic. See 5.7, "External management using SNMP" on page 115.

5.3.1 Stand alone environment - connecting through a shelf

The configuration shown in Figure 53 is the simplest way to set up connectivity for the System Manager and/or External Manager. It involves little planning for an IP addressing scheme for the IBM 2029 network. A point-to-point network is shown for clarity.

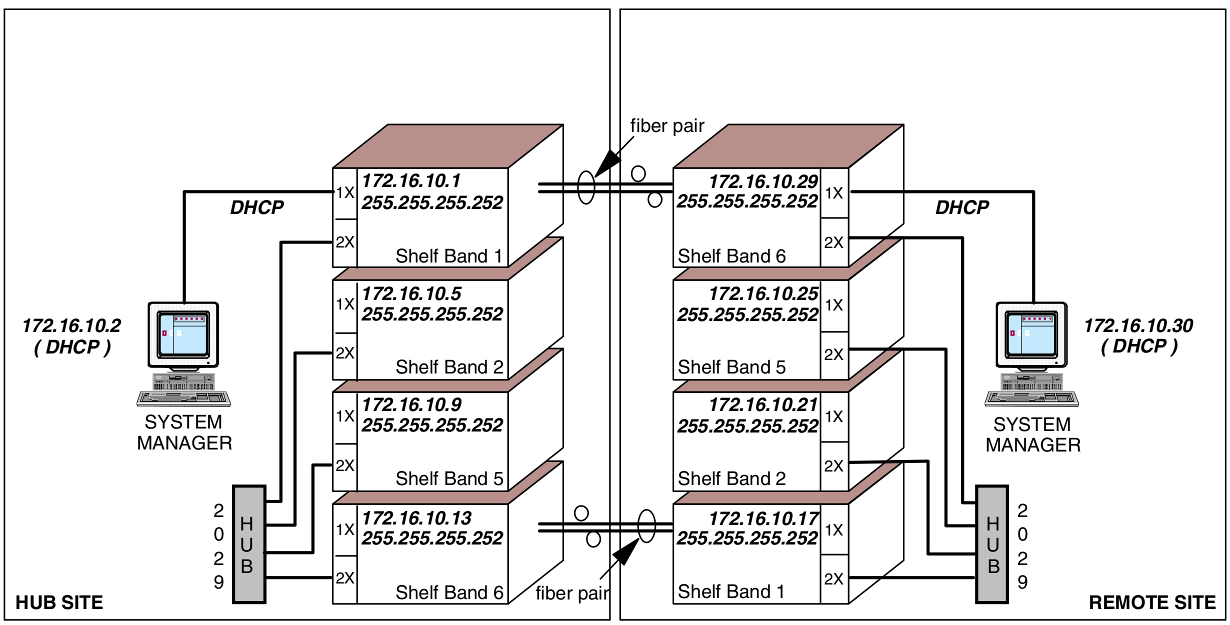


Figure 53. Connecting through the 1X port

The physical attributes of this configuration are:

- An IBM 2029 Ethernet hub is used in the hub site to interconnect the shelves, because there are multiple pairs of shelves in this configuration.
- Crossover 10Base-T cables are used to connect the IBM 2029 Ethernet hub and the 2X ports on the shelves in the hub site, for intershelf communications of the overhead channels (cross-band traffic).
- A second IBM 2029 Ethernet hub is installed in the remote site for redundancy of the cross-band communications path.
- A straight-through 10Base-T cable is used to connect the system management workstations to the 1X ports of their respective shelves.

- In the hub site, the system management workstation is connected to the designated primary shelf (Shelf Band 1); however, this is not mandatory.
- With this configuration you can connect a system management or external (SNMP) management workstation with DHCP support to any shelf (using the 1X port).

Note

Due to the distance limitation with 10Base-T cables, your system management or external management workstation must be within 100 meters of the shelf you are connecting to. You could, however, use an Ethernet hub to extend the distance between the shelf and a system management workstation to 200 meters.

The logical attributes of this configuration are:

- The primary shelf is Shelf Band 1 in the hub site. All non-primary shelves have Shelf Band 1 defined as their primary shelf.
- Private IP addresses (172.16.10.x) are used because the IBM 2029 network is not integrated in an existing IP network.
- The subnet mask (255.255.255.252) that is assigned to these shelves limits the number of IP addresses to four per shelf and segments the shelves from one another.
- The first available IP address of the subnetwork is used as the shelf address.
- The other available IP address of the subnetwork is assigned to DHCP. It is not necessary to define a default gateway address to any of the shelves in this IBM 2029 network configuration, since none will be connected to an IP network.
- Internal IP addresses (determined through the Ethernet Hubbing Group and Shelf Identifier values), in conjunction with internal OSPF protocol, provide intershelf communications.

Table 14 shows the IP addressing scheme of the hub site in Figure 53 on page 98.

Table 14. Stand alone environment - Hub site IP addressing scheme

Parameter	Shelf Band 1	Shelf Band 2	Shelf Band 5	Shelf Band 6
Primary Shelf Address	172.16.10.1	172.16.10.1	172.16.10.1	172.16.10.1
Shelf Address	172.16.10.1	172.16.10.5	172.16.10.9	172.16.10.13
Netmask	255.255.255.252	255.255.255.252	255.255.255.252	255.255.255.252
DHCP Address	172.16.10.2	172.16.10.6	172.16.10.10	172.16.10.14
Default Gateway Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Identifier	1	2	5	6
Ethernet Hubbing Group	1	1	1	1
External Mgr Address	not applicable	not applicable	not applicable	not applicable

Table 15 shows the IP addressing scheme of the remote sites in Figure 53 on page 98.

Table 15. Stand alone environment - Remote site IP addressing scheme

Parameter	Shelf Band 1	Shelf Band 2	Shelf Band 5	Shelf Band 6
Primary Shelf Address	172.16.10.1	172.16.10.1	172.16.10.1	172.16.10.1
Shelf Address	172.16.10.17	172.16.10.21	172.16.10.25	172.16.10.29
Netmask	255.255.255.252	255.255.255.252	255.255.255.252	255.255.255.252
DHCP Address	172.16.10.18	172.16.10.22	172.16.10.26	172.16.10.30
Default Gateway Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Identifier	9	10	13	14
Ethernet Hubbing Group	2	2	2	2
External Mgr Address	not applicable	not applicable	not applicable	not applicable

5.3.2 Connecting to the IBM 2029 network through an IP network

The configuration shown in Figure 54 on page 101 provides more flexibility for connecting an IBM 2029 network to a system management environment than Figure 53 on page 98. It also involves more IP network planning in the areas of IP routing and IP addressing, as well as in network hardware (for example, IP routers, LAN adapters, and hubs).

If you plan to route your IBM 2029 system management traffic through a non-secure IP network (for example, through the Internet), you should consider using a Virtual Private Network (VPN). A VPN creates a secure private connection that essentially acts like a point-to-point connection.

For more detailed information concerning IP network planning, refer to *IP Network Design Guide,* SG24-2580.

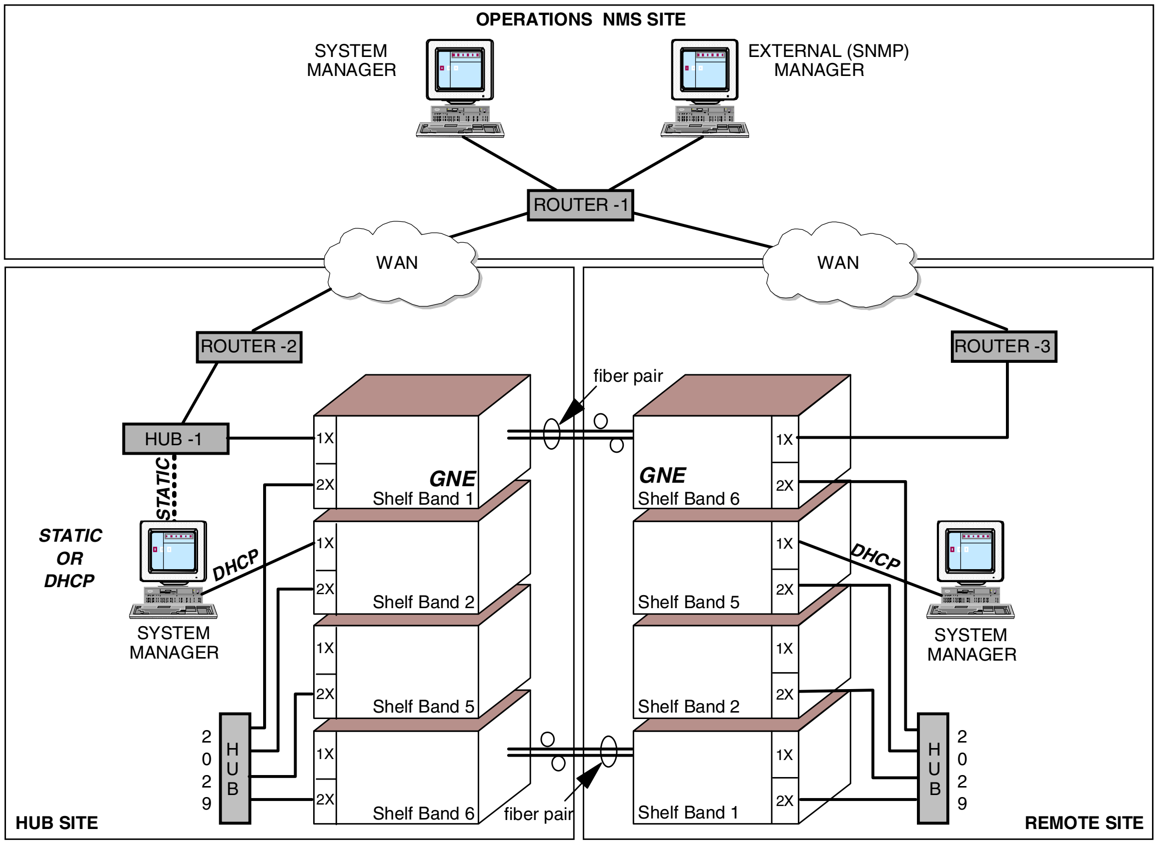


Figure 54. Connecting through an external IP network

The physical attributes of this configuration are:

- An IBM 2029 Ethernet hub is used in the hub site to interconnect the shelves, because there are multiple shelf pairs in this configuration.
- Crossover 10Base-T cables are used to connect the IBM 2029 Ethernet hub and the 2X ports on the shelves in the hub site for intershelf communications of the overhead channels (cross-band traffic).
- A second IBM 2029 Ethernet hub is installed in the remote site for redundancy of the cross-band communications path.
- Hub-1 (Ethernet hub) in the hub site connects to three device interfaces:
  - Router-2 dedicated Ethernet adapter using a straight-through 10Base-T cable.
  - GNE shelf Band 1 1X port using a crossover 10Base-T cable.
  - The System Management workstation using a straight-through 10Base-T cable.
- Additional System Management or External Management workstations may be connected, if required, to spare ports in Hub-1 using straight-through 10Base-T cables and static IP addresses.
- Alternatively, Hub-1 may be removed from the configuration and Router-2 connected directly to the GNE Shelf Band 1 1X port using a straight-through 10Base-T cable. The System Management workstation may then be

connected to any non-GNE 1X port using a straight-through 10Base-T cable and DHCP addresses.

- Router-3 in the remote site is connected directly to the GNE Shelf Band 6 1X port using a straight-through 10Base-T cable. The System Management workstation is connected to any non-GNE 1X port using a straight-through 10Base-T cable and DHCP address.

Note

The second external connectivity path provided by Router-3, and the second GNE (Shelf Band 6) in the remote site, is only supported in an external IP network in an OSPF environment.

- Router-1, Router-2, and Router-3 are interconnected in the external IP network through wide area network (WAN) links to provide connectivity from the Operations Network Management System (NMS) site to the IBM 2029 network. This provides remote System Management and External (SNMP) Management capability from the NMS site.

Note

Due to the distance limitation with 10Base-T cables, your IP router must be within 100 meters of the shelf you are connecting to. You may, however, use an Ethernet hub to extend the distance between the shelf and the IP router to 200 meters.

5.3.3 Connecting via an IP Network in a single GNE environment

The IBM 2029 supports the use of proxy ARP in a GNE as the mechanism of IP connectivity between the IBM 2029 network and external IP network. This allows the use of one GNE at the IBM 2029 hub site, connected through a single external router connection, for the external monitoring and management of the IBM 2029 network from the Operations NMS site. See Figure 55 on page 103.

The IBM 2029 also supports the use of two GNEs at different IBM 2029 sites connected through two or more external OSPF enabled routers, to provide redundancy and higher availability for the external monitoring and management of the IBM 2029 network. See Figure 56 on page 107.

If your external IP network supports OSPF and you require this redundancy and higher availability of dual GNEs, we recommend implementing the OSPF network solution described in 5.3.4, “Connecting via an IP network in a dual GNE environment” on page 105.

ARP and Proxy ARP are described in:

- RFC 925, “Multi-LAN Address Resolution”
- RFC 826, “An Ethernet Address Resolution Protocol”
- RFC 1027, “Using ARP to Implement Transparent Subnet Gateways”

In order for two IP hosts to communicate on a LAN, both devices must determine the hardware interface address (also known as a MAC address) of each other. This process is known as Address Resolution Protocol (ARP).

In normal ARP usage, the initiating host broadcasts an ARP Request carrying a target IP address. The corresponding target host, recognizing its own IP address, sends back an ARP Reply containing its own hardware interface address.

The GNE shelf can provide a function known as “proxy ARP” where the GNE shelf replies to ARP requests (from the external network) targeted to its own IP address or the IP address of any non-GNE shelf in the IBM 2029 network. The GNE sends the ARP Reply, on behalf of the non-GNE shelves, specifying its own (GNE) hardware interface address (MAC).

The GNE shelf will only proxy ARP on behalf of other shelves whose shelf IP address is within the IP address range of the GNE’s subnetwork. This IP address range is determined by the subnet mask of the GNE.

The GNE will respond to host IP devices whose addresses fall within the address range of its Ethernet subnet. For devices with source IP addresses outside this range, the GNE uses a defined Default Gateway to route datagrams back to the source network.

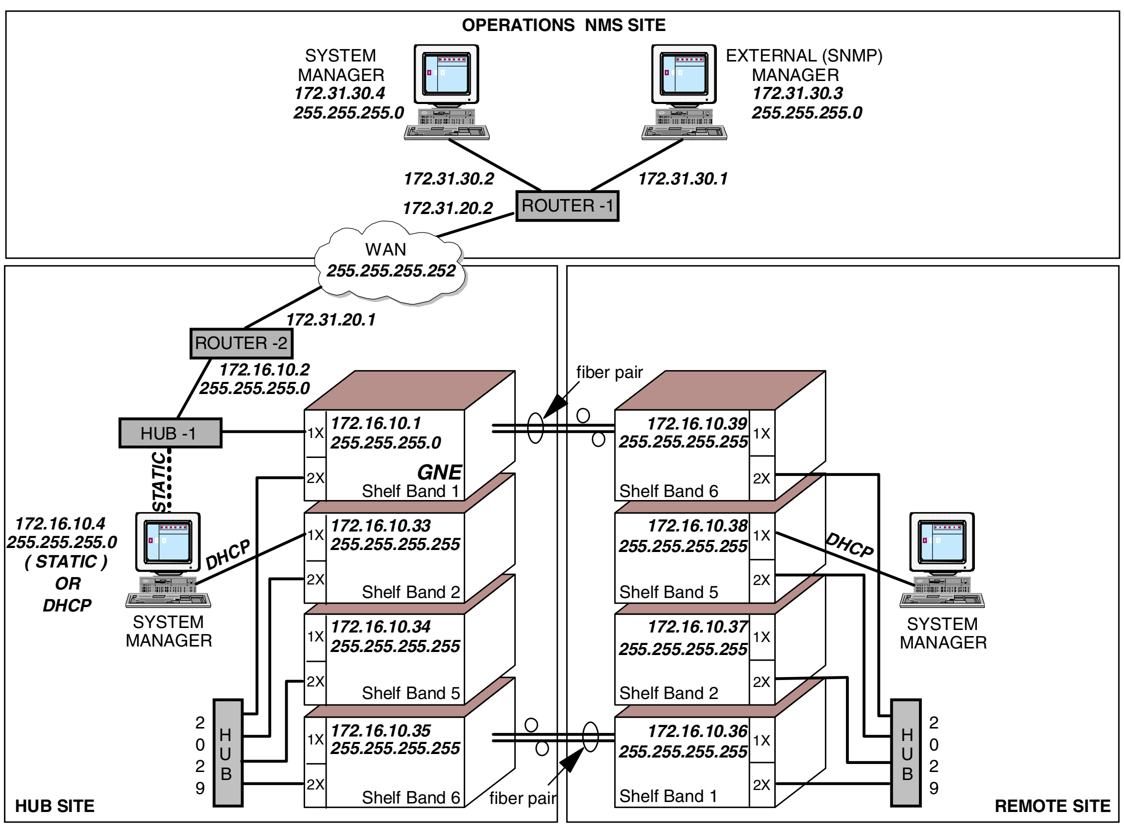


Figure 55. Connecting through an external IP network - single GNE

The physical attributes of this configuration are described in 5.3.2, “Connecting to the IBM 2029 network through an IP network” on page 100.

The logical attributes of this configuration are:

- Private IP addresses (172.16.10.x) are used for all shelves and routers as the external IP network supports routing these addresses. For organizations that cannot route private addresses through their networks, explicit public addresses from the organization's public address space must be allocated.
- The primary shelf is Shelf Band 2 in the hub site. All other shelves have Shelf Band 2 in the hub site defined as their primary shelf.
- A subnet mask of 255.255.255.255 is assigned to all non-GNE shelves. This has the following effects:
  - The number of IP addresses allocated to each non-GNE shelf is limited to one and segments these shelves from each other.
  - The one available IP address of each non-GNE shelf subnetwork is used as the shelf IP address.
  - Each non-GNE shelf has its DHCP address set to 0.0.0.0 and the shelf's System Manager automatically allocates an internal DHCP address to the 1X port using Table 13 on page 91. For example, the DHCP address allocated to the 1X port of Shelf Band 2 in the hub site is 10.1.2.2.
- The GNE Shelf Band 1 in the hub site has OSPF backbone disabled and a Default Gateway address of 172.16.10.2 pointing to Router-2.
- The GNE Shelf Band 1 has its DHCP function disabled, by setting its DHCP address to 0.0.0.0.
- The IP address and the subnet mask of the GNE shelf is determined by the addressing scheme of the IP network the GNE shelf is connecting to. This subnet mask must also include the IP addresses of all other shelves within the GNE shelf's subnetwork. This allows the GNE shelf to proxy ARP on behalf of the non-GNE shelves.

  For example, GNE Shelf Band 1 in the hub site has an address of 172.16.10.1 and a subnet mask matching its attached Router-2 of 255.255.255.0. This subnet mask gives a subnetwork address range 172.16.10.0 through 255. This address range includes the GNE Shelf Band 1 (172.16.10.1), Router-2 (172.16.10.2), and the hub site System Manager workstation (172.16.10.4, connected to Hub-1), as well as all non-GNE shelves, all within the one subnetwork.
- Static routes are not required in Router-2, since the GNE shelf and Router-2 are in the same subnetwork, and the GNE shelf will proxy ARP on behalf of the non-GNE shelves.
- The system management workstation in the hub site can be connected to the IBM 2029 network in one of two ways, as shown in Figure 55 on page 103:
  - To GNE Shelf Band 1 through a straight-through 10Base-T cable connection to Hub-1 (Ethernet hub). The workstation has set a static IP address within the subnetwork of the GNE Shelf Band 1 and Router-2, for example, 172.16.10.4 with a subnet mask of 255.255.255.0 and default gateway of Router-2 (172.16.10.2).
  - To any hub site non-GNE shelf through a straight-through 10Base-T cable connection to the shelf's 1X port. The workstation's network properties are set to obtain an IP address from a DHCP server, that is, the shelf. The shelf leases the DHCP address allocated to its 1X port to the workstation, for example 10.1.2.2 for Shelf Band 2 in the hub site.

We recommend, for redundancy in multiple shelf pair networks, that the System Manager workstation within a site be set up for DHCP so that it may connect to any shelf within the site that has DHCP enabled.

- Internal IP addresses (determined through the Ethernet Hubbing Group and Shelf Identifier values), in conjunction with the internal OSPF, provide intershelf communications.

Table 16 shows the hub site IP addressing scheme; see Figure 55 on page 103.

Table 16. Single GNE environment - Hub site IP addressing scheme

Parameter	Shelf Band 1	Shelf Band 2	Shelf Band 5	Shelf Band 6
Primary Shelf Address	172.16.10.33	172.16.10.33	172.16.10.33	172.16.10.33
Shelf Address	172.16.10.1	172.16.10.33	172.16.10.34	172.16.10.35
Netmask	255.255.255.0	255.255.255.255	255.255.255.255	255.255.255.255
DHCP Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Default Gateway Address	172.16.10.2	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Identifier	1	2	5	6
Ethernet Hubbing Group	1	1	1	1
External Mgr Address	172.31.30.3	172.31.30.3	172.31.30.3	172.31.30.3

Table 17 shows the remote site IP addressing scheme; see Figure 55 on page 103.

Table 17. Single GNE environment - Remote site IP addressing scheme

Parameter	Shelf Band 1	Shelf Band 2	Shelf Band 5	Shelf Band 6
Primary Shelf Address	172.16.10.33	172.16.10.33	172.16.10.33	172.16.10.33
Shelf Address	172.16.10.36	172.16.10.37	172.16.10.38	172.16.10.39
Netmask	255.255.255.255	255.255.255.255	255.255.255.255	255.255.255.255
DHCP Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Default Gateway Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Identifier	9	10	13	14
Ethernet Hubbing Group	2	2	2	2
External Mgr Address	172.31.30.3	172.31.30.3	172.31.30.3	172.31.30.3

If you plan to route your IBM 2029 system management traffic through a non-secure IP network (for example, through the Internet), you should consider using a Virtual Private Network (VPN). A VPN creates a secure private connection that essentially acts like a point-to-point connection.

For more detailed information concerning IP network planning, refer to *IP Network Design Guide,* SG24-2580.

5.3.4 Connecting via an IP network in a dual GNE environment

The IBM 2029 supports the use of Open Shortest Path First (OSPF) in a GNE as the mechanism of IP connectivity between the IBM 2029 network and an external

IP network. This allows the use of two GNEs at different IBM 2029 sites, connected through two or more external OSPF enabled routers, to provide redundancy and higher availability for the external monitoring and management of the IBM 2029 network. See Figure 56 on page 107.

OSPF is described in:

- RFC 2178, “OSPF Version 2”
- RFC 1131, “OSPF Specification”

Open Shortest Path First is a dynamic interior gateway protocol that uses a link state protocol and a shortest path first algorithm to create a topology database of an IP network.

OSPF routers maintain the operating status of their interfaces and the cost for sending traffic on these interfaces. This information is then exchanged with other OSPF routers allowing all routers within an OSPF area to have a common view of the network topology. Changes in the network topology are quickly updated to all routers within the OSPF area. Enabling the OSPF function in the GNEs allows the GNEs to participate in the OSPF area of their attaching routers.

Note that the IBM 2029 shelves form an internal OSPF router network which ensures that all shelves are aware of routes to each other. This internal OSPF network is architected in the IBM 2029 design. It is in operation regardless of whether the IBM 2029 network is:

1. In a stand alone environment
2. Connected to an external IP network through a single GNE in a proxy ARP environment
3. Connected to an external IP network through dual GNEs and an external OSPF router environment

This internal OSPF shelf network should not be confused with enabling the OSPF function in the GNEs to connect to an external OSPF router network.

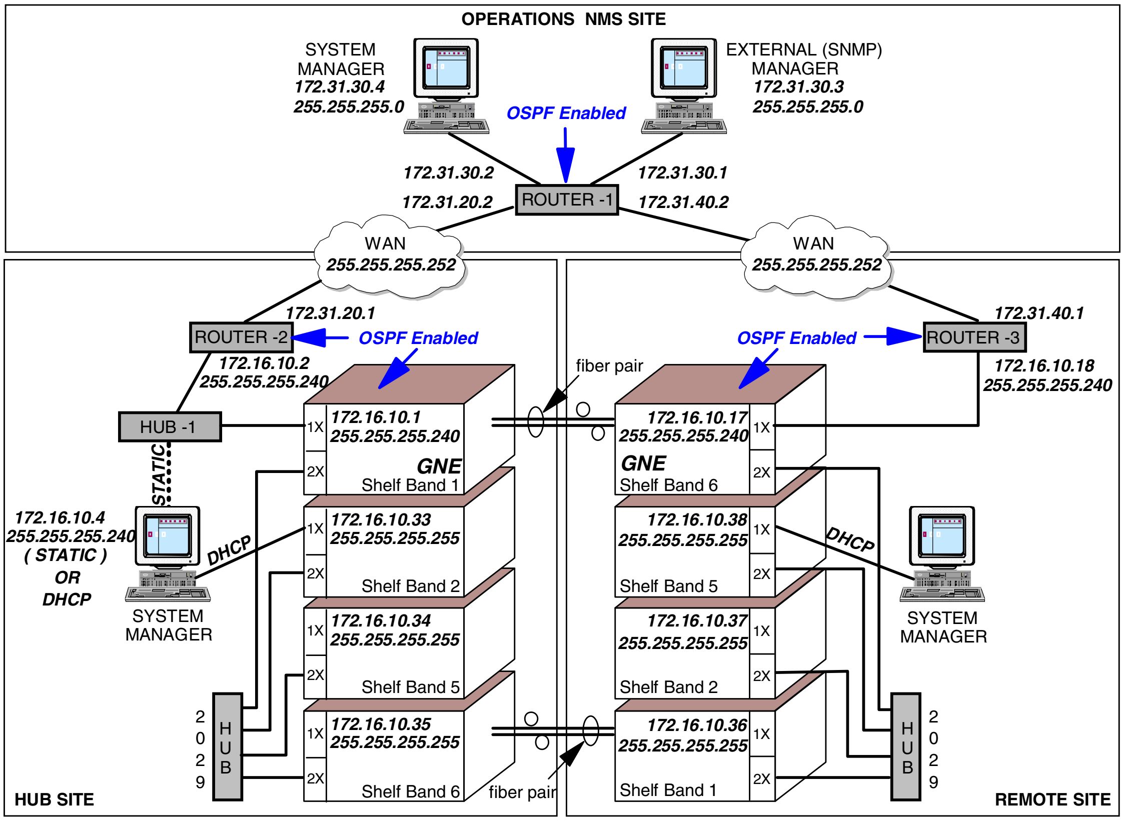


Figure 56. Connecting through an external IP network - dual GNEs

The physical attributes of this configuration are described in 5.3.2, “Connecting to the IBM 2029 network through an IP network” on page 100.

The logical attributes of this configuration are:

- Private IP addresses (172.16.10.x) are used for all shelves and routers as the external IP network supports routing these addresses. For organizations that cannot route private addresses through their networks, explicit public addresses from the organization’s public address space must be allocated.
- The primary shelf is Shelf Band 2 in the hub site. All other shelves have Shelf Band 2 in the hub site defined as their primary shelf.
- A subnet mask of 255.255.255.255 is assigned to all non-GNE shelves. This has the following effects:
  - The number of IP addresses allocated to each non-GNE shelf is limited to one and segments these shelves from each other.
  - The one available IP address of each non-GNE shelf subnetwork is used as the shelf IP address.
  - Each non-GNE shelf has its DHCP address set to 0.0.0.0 and the shelf’s System Manager automatically allocates an internal DHCP address to the 1X port using Table 13 on page 91. For example, the DHCP address allocated to the 1X port of Shelf Band 2 in the hub site is 10.1.2.2.
- The GNE shelves each have OSPF backbone enabled, which has the following effects:

- Each GNE can participate in the OSPF area of their attaching routers to provide redundancy in the connectivity to the external IP network.
- The OSPF Area ID of the GNEs and their attached routers is 0.0.0.0. This is hard coded within each GNE's OSPF parameters and cannot be changed. OSPF Area ID 0.0.0.0, by definition, is the OSPF backbone of the external IP network. Organizations that do not wish to attach the GNE shelves directly to the external IP network OSPF backbone may have to implement a Border Gateway Protocol (BGP) function to connect to the IBM 2029 network.
- Each GNE's DHCP function is disabled and their DHCP addresses are set to 0.0.0.0.
- Each GNE's default gateway and proxy ARP function is disabled and their Default Gateway addresses are set to 0.0.0.0.

- The IP address and the subnet mask of each GNE shelf is determined by the addressing scheme of the IP network each GNE shelf is connecting to. This subnet mask must also segment each GNE shelf's subnetwork from each other and all non-GNE shelves.

  For example, GNE Shelf Band 1 in the hub site has an address of 172.16.10.1 and a subnet mask matching its attached Router-2 of 255.255.255.240. This subnet mask gives a subnetwork address range 172.16.10.1 through 14. This address range includes the GNE Shelf Band 1 (172.16.10.1), Router-2 (172.16.10.2), and the hub site System Manager workstation (172.16.10.4, connected to Hub-1), all within the one subnetwork. All other shelves, including the second GNE Shelf Band 6 (172.16.10.17 with its subnetwork range of 172.16.10.17 through 30) are segmented outside this address range and are in their own individual subnetworks.

  The subnet mask of 255.255.255.240, allocated to each GNE and their attached routers, provides 14 addresses within the subnetwork of each GNE. The unused addresses within each GNE subnetwork allows additional system management and/or external management workstations to be easily connected to the IBM 2029 network (for example, through Hub-1 to GNE Shelf Band 1 in the hub site).

- The system management workstation in the hub site can be connected to the IBM 2029 network in one of two ways:
  - To GNE Shelf Band 1 through a straight-through 10Base-T cable connection to Hub-1 (Ethernet hub). The workstation has a static IP address within the subnetwork of the GNE Shelf Band 1 and Router-2, for example 172.16.10.4 with a subnet mask of 255.255.255.240 and default gateway of Router-2 (172.16.10.2).
  - To any hub site non-GNE shelf through a straight-through 10Base-T cable connection to the shelf's 1X port. The workstation's network properties are set to obtain an IP address from a DHCP server, that is, the shelf. The shelf leases the DHCP address allocated to its 1X port to the workstation, for example 10.1.2.2 for Shelf Band 2 in the hub site.

  We recommend, for redundancy in multiple shelf pair networks, that the System Manager workstation within a site be set up for DHCP so that it may connect to any shelf within the site that has DHCP enabled.

- Internal IP addresses (determined through the Ethernet Hubbing Group and Shelf Identifier values), in conjunction with the internal OSPF, provide intershelf communications.
- The OSPF Area ID parameter is used to assign a number for the Area ID of the IBM 2029 internal OSPF network. It does not set the number of the Area ID that the two GNEs use to connect to the external IP network. The external Area ID number is hard coded to 0.0.0.0 and cannot be changed.

  The default value of OSPF Area ID parameter for the IBM 2029 internal OSPF network is 0.0.0.0. If this parameter is not changed from the default, the value is automatically translated by the shelf System Manager to a non-zero value which is used by all shelves. If this parameter is changed from the default, then the same value must be set in every shelf and becomes the Area ID used in the internal IBM 2029 OSPF network.
- No static routes are required in the routers as OSPF topology updates between the routers and GNE shelves manages traffic flow through the OSPF backbone.

Table 18 shows the hub site IP addressing scheme; see Figure 56 on page 107.

Table 18. Dual GNE environment - Hub site IP addressing scheme

Parameter	Shelf Band 1	Shelf Band 2	Shelf Band 5	Shelf Band 6
Primary Shelf Address	172.16.10.33	172.16.10.33	172.16.10.33	172.16.10.33
Shelf Address	172.16.10.1	172.16.10.33	172.16.10.34	172.16.10.35
Netmask	255.255.255.240	255.255.255.255	255.255.255.255	255.255.255.255
DHCP Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Default Gateway Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Identifier	1	2	5	6
Ethernet Hubbing Group	1	1	1	1
External Mgr Address	172.31.30.3	172.31.30.3	172.31.30.3	172.31.30.3

Table 19 shows the remote site IP addressing scheme; see Figure 56 on page 107.

Table 19. Dual GNE environment - remote site IP addressing scheme

Parameter	Shelf Band 1	Shelf Band 2	Shelf Band 5	Shelf Band 6
Primary Shelf Address	172.16.10.33	172.16.10.33	172.16.10.33	172.16.10.33
Shelf Address	172.16.10.36	172.16.10.37	172.16.10.38	172.16.10.17
Netmask	255.255.255.255	255.255.255.255	255.255.255.255	255.255.255.240
DHCP Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Default Gateway Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Identifier	9	10	13	14
Ethernet Hubbing Group	2	2	2	2
External Mgr Address	172.31.30.3	172.31.30.3	172.31.30.3	172.31.30.3

Table 20 shows the OSPF parameters for the GNE and non-GNE shelves in each site; see Figure 56 on page 107.

Table 20. OSPF environment - shelf OSPF parameters

OSPF parameters	GNE shelves	Non-GNE shelves
Area ID (internal OSPF)	0.0.0.0	0.0.0.0
OSPF Backbone Enabled	Yes	No
Router Priority	3	not applicable
Cost	10	not applicable
Password Enabled	Yes	not applicable
Password	IBM2029	not applicable
Transit Delay	1 (default)	not applicable
Retransmit Interval	5 (default)	not applicable
Hello Interval	10 (default)	not applicable
Router Dead Interval	40 (default)	not applicable

The following GNE shelf OSPF parameters must match those of the router the GNE shelf is connecting through:

- Password Enabled
- Password
- Transit Delay
- Retransmit Interval
- Hello Interval
- Router Dead Interval

Note

The Area ID parameter in Table 20 determines the value of the Area ID of the IBM 2029 internal OSPF network only. The Area ID value used by the GNE shelves to connect to the external OSPF network is 0.0.0.0. This value is hard coded in each GNE shelf and cannot be changed.

If you plan to route your IBM 2029 system management traffic through a non-secure IP network (for example, through the Internet), you should consider using a Virtual Private Network (VPN). A VPN creates a secure private connection that essentially acts like a point-to-point connection.

For more detailed information concerning IP network planning, refer to *IP Network Design Guide,* SG24-2580.

5.4 Dark fiber managed services

Dark fiber trunk services are typically integrated and managed by telecommunications companies (TELCO) who usually own the fiber optic trunk cables throughout a metropolitan area. As the owner of the dark fiber, the TELCO can offer managed dark fiber services to client organizations to provide fiber optic connectivity between two or more of the organization’s sites. The client organization leases the managed dark fiber service from the TELCO, rather than owning the fiber service infrastructure.

Figure 57 is an example of this type of managed service. The dual GNE environment is shown for completeness.

IBM 2029 Fiber Savers are the network nodes of the dark fiber service infrastructure, and so the TELCO, as the fiber service integrator, requires the ability to manage the IBM 2029 network from their network management system (NMS) site. This external management is achieved through the external (SNMP) management workstation located at the NMS site. See 5.7, “External management using SNMP” on page 115.

The client organization requires system management of their device fiber optic channels attaching to, and being transported by, the IBM 2029 network. System management may include such tasks as adding new device channel connections, changing existing device channel protocols, and channel link problem determination. This is achieved through the system management workstations located at the client’s hub and remote sites, and remotely at the client operations site. See 5.6, “The IBM 2029 System Manager” on page 114.

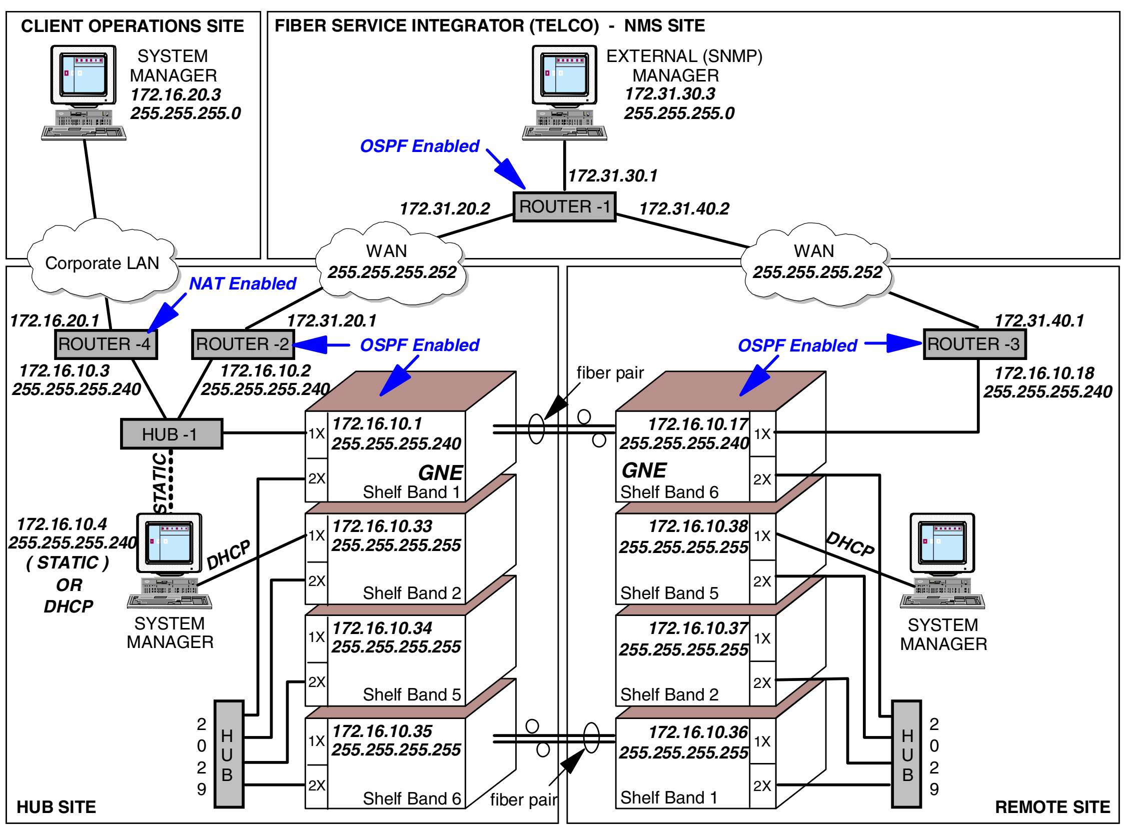


Figure 57. Connecting through an external IP network - managed service

The physical attributes of this configuration include those described in 5.3.2, “Connecting to the IBM 2029 network through an IP network” on page 100.

Additional physical attributes of this configuration are:

- Hub-1 (Ethernet hub) in the hub site connects to an additional device interface, Router-4, using a straight-through 10Base-T cable.
- Router-4 provides the connection from the IBM 2029 network to the client organization's IP network for system management.
- Router-2 and Router-3 provide the interfaces from the IBM 2029 network to the TELCO IP network for external management.

The logical attributes of this configuration include those described in 5.3.4, "Connecting via an IP network in a dual GNE environment" on page 105.

In addition to those logical attributes is the implementation of a Network Address Translator (NAT) function within the client's Router-4.

NAT is described in RFC 1631, "The IP Network Address Translator".

In Figure 57 on page 111, the client network Router-4 is not a participant in the TELCO OSPF backbone network because Router-4 does not have OSPF enabled. OSPF routing within the TELCO IP network, which also includes the IBM 2029 GNE shelves, will not include Router-4. Therefore, there is no connectivity between the client's IP network and the TELCO IP network, including the IBM 2029 network.

Note

This prevents OSPF routing topology updates from the TELCO network being propagated into the client network, ensuring network isolation and security. This is desirable as it creates an effective firewall function between the two organization's IP networks.

In order to provide connectivity from the client's network to the IBM 2029 network, a Network Address Translation (NAT) function is enabled in Router-4.

Also, because all shelves in an OSPF environment must be segmented into separate subnetworks, a static route is required in the NAT-enabled Router-4. This static route statement is used by Router-4 to route any IP traffic from the client network destined for any shelf in the IBM 2029 network through the GNE Shelf Band 1. For example, the route statement "addroute 172.16.10.0 mask 255.255.255.0 gateway 172.16.10.1" will route all 172.16.10.x traffic to the GNE shelf 172.16.10.1.

NAT is used to translate the client's network IP addresses, for example 172.16.20.3, into IP addresses that are within the GNE's IP address range, for example 172.16.10.10.

This allows the GNE to route data from the client IP network to the IBM 2029 network using the IP address of a device the GNE believes to be within its subnetwork, that is, 172.16.10.10. The NAT function translates packets received from the GNE with IP address 172.16.10.10 back to the client IP address 172.16.20.3.

GNE Shelf Band 1 in the hub site has an IP address of 172.16.10.1 and a subnet mask matching its attached Router-2 of 255.255.255.240. This subnet mask gives an IP subnetwork address range 172.16.10.1 through 14. This IP address range includes the GNE Shelf Band 1 (172.16.10.1), TELCO Router-2

(172.16.10.2), client Router-4 (172.16.10.3), and the hub site System Manager workstation (172.16.10.4), all within the one IP subnetwork.

The remaining unused IP addresses within the IP subnetwork (172.16.10.5 through 14) are available for the NAT function in Router-4 to translate to client IP addresses on a one-to-one basis for a total of ten individual address mappings. This allows up to ten individual workstations within the client's IP network to have connectivity to the IBM 2029 network. The limit of ten in this example is determined by the size of the GNE subnet mask (255.255.255.240) and the number of unallocated IP addresses within the GNE's IP subnetwork.

An alternative to implementing NAT in the client Router-4 is to implement Network Address Port Translator (NAPT) instead.

NAPT is described in RFC 2663, "IP Network Address Translator (NAT) Terminology and Considerations".

NAPT is an extension of NAT that translates multiple client IP addresses into a single IP address on the GNE subnet.

This is done by binding each client IP address and TCP or UDP port to a single IP address using multiple ports numbers. This may be necessary if the number of addresses available on the GNE subnetwork is limited and there are many client devices that require access to the IBM 2029 Network.

In this network example, NAT and NAPT offer an additional type of firewall protection. The binding of addresses can only be set up in the direction from the client IP network to the IBM 2029 network. It is not possible to initiate a connection from the GNE to the client network, unless this is specifically defined for individual client network IP addresses and ports. This effectively isolates and secures the client network from the TELCO and IBM 2029 networks.

The network example discussed in this section is based on connectivity to an external IP network through dual GNEs and an external OSPF router environment. However, the NAT function can equally be applied in a non-OSPF environment as described in 5.3.3, "Connecting via an IP Network in a single GNE environment" on page 102

5.5 Communication ports

A number of different ports are used to communicate with the IBM 2029 shelves:

- TCP ports:
  - Port 1966 - used for session management between the Shelf Processor (SP) and System Manager workstation.
  - Port 1970 - used for TCP stream-based alarms between the SP and External Manager workstation.
  - Port 10001 - used for TL1 over TCP.
  - Port 10002 - used for TL1 over Telnet.

- HTTP ports:
  - Port 80 - used for access to the Web server from the system management workstation.
- SNMP Ports:
  - Port 161 - SNMP requests.
  - Port 1062 and above - SNMP traps. The following algorithm is used. The System Manager workstation attempts to bind to port 1062. If that port is already in use by another System Manager workstation, the port number is increased by one and another bind is attempted. This continues until a free port is found.
- Telnet Ports:
  - Port 23 - used for telnet sessions to a shelf System Manager.
- FTP ports:
  - Port 21 - used for software upgrades of a shelf System Manager.

5.6 The IBM 2029 System Manager

System management for the IBM 2029 is provided through Java-based code that is used for commissioning, provisioning, monitoring, and maintaining an IBM 2029 shelf. This Java-based code is referred to as the System Manager and enables you to access one or more shelves in an IBM 2029 network, either through a local shelf connection or through an IP network that the Gateway Network Element (GNE) shelf is connected to. The System Manager code and a Java applet are stored on the Shelf Processor (SP) of each shelf in the IBM 2029.

The Java applet allows for communications between the System Manager workstation and the shelf. When the workstation Web browser is pointed to the IP address of a shelf, the shelf SP downloads the Java applet to the workstation Web browser to allow communications with the System Manager code within the shelf.

In the IBM 2029 shelf, the SP card provides the following:

- Local shelf system management
- Intershelf system management communications
- Alarm consolidation
- Shelf visibility
- Software and configuration management
- Performance monitoring
- Inventory control for the shelf

The SP card monitors all other cards in the shelf to determine their state. If a shelf component fault is detected by the SP, an SNMP trap is generated and broadcasted throughout the internal IBM 2029 network via its corresponding shelf (same band), then forwarded to all other shelves through the cross-band connection (for example, the IBM 2029 Ethernet hub). Any shelves that have a

System Manager session will pick up the SNMP trap and raise an alarm, then forward the alarm to the System Manager workstation.

Shelf visibility is a method of informing a System Manager of its connectivity status to all shelves in the IBM 2029 network. Shelf visibility is achieved through the SP when logged in to a shelf. The SP provides the IP addresses of all shelves known in the IBM 2029 network from the *shelf list* (built by the primary shelf), to the System Manager. The System Manager invokes a heartbeat (polling) to all shelves (using their IP addresses), at certain intervals to detect their connectivity status.

The system management software is preloaded in the SP of the IBM 2029 shelf, and the Web browser software is installed on the workstation that comes with the IBM 2029.

The IBM 2029 installation CD-ROM includes both the System Manager software, as well as the Web browser software. This software can run on either of the following platforms:

- Sun Workstation with the Solaris 2.6 operating system and Java-enabled Netscape Communicator 4.51
- An Intel-based desktop or laptop PC with the Windows 95 or NT operating system and either Java-enabled Internet Explorer or Java-enabled Netscape Communicator 4.51

For instructions on installing and using the System Manager, refer to *IBM Fiber Saver (2029) Planning and Operations Guide,* SC28-6808.

For using the System Manager for problem determination purposes, refer to Chapter 9, “Problem determination using the System Manager” on page 181.

5.7 External management using SNMP

Simple Network Management Protocol (SNMP) is supported by the IBM 2029 and provides a means for monitoring alarms from a single point. SNMP Version 1.0 is used to generate traps for monitoring events in an IBM 2029 network. SNMPv1 allows for architected management type actions and information, and consists of Managers and Agents. An SNMP Manager is an application that typically issues request operations, such as GET and SET to SNMP Agents. An SNMP Agent is a server at a managed host that responds to SNMP operations.

The SNMP Agent in the IBM 2029 environment resides in the SP and forwards SNMP traps to an SNMP Manager (also known as an External Manager). The External Manager in this case can be any application that supports SNMPv1, such as Tivoli system management products and HP OpenView. A Management Information Base (MIB) file is included on the IBM 2029 installation CD-ROM. The MIB file is a text file that describes the SNMP traps that are generated by the SP.

Figure 58 on page 116 shows an example of a shelf connecting to an External Manager (EM) through an IP network, using the well-known UDP ports for SNMP. If you want to receive SNMP traps from all shelves in your IBM 2029 network, you must define an EM to each shelf. All SNMP traffic generated by a shelf will be forwarded to its External Manager by using internal routing (OSPF) and the GNE connection to the external IP network.

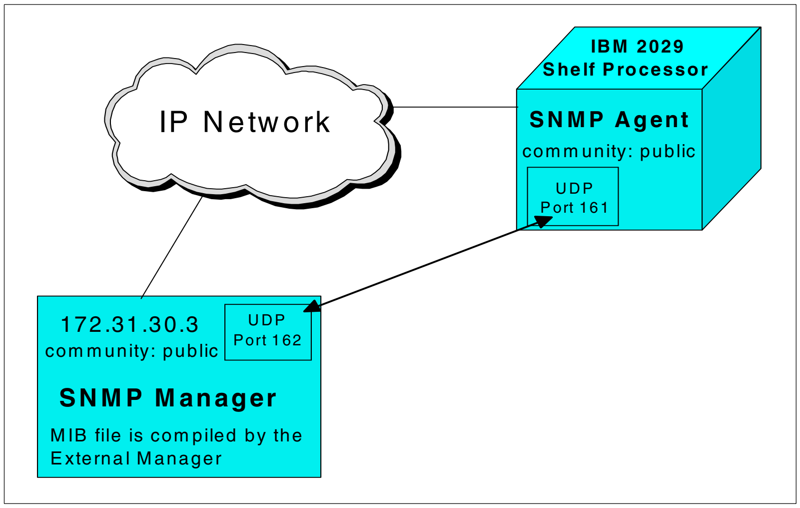


Figure 58. External Manager example

Setting up an External Manager for a shelf is done through the network administration function of the System Manager, during or after the shelf has been commissioned (see Chapter 6, "Configuring the network" on page 121).

Only one EM can be defined to each shelf in the IBM 2029 network; however, most system management products support forwarding of SNMP traps to other SMNP trap receivers. Refer to your system management product documentation for more details.

1. From the IBM 2029 System Manager window, select the appropriate network or shelf, then click **Apply**.
2. Click the **Configuration** tab, then double-click the shelf, as shown in Figure 59.

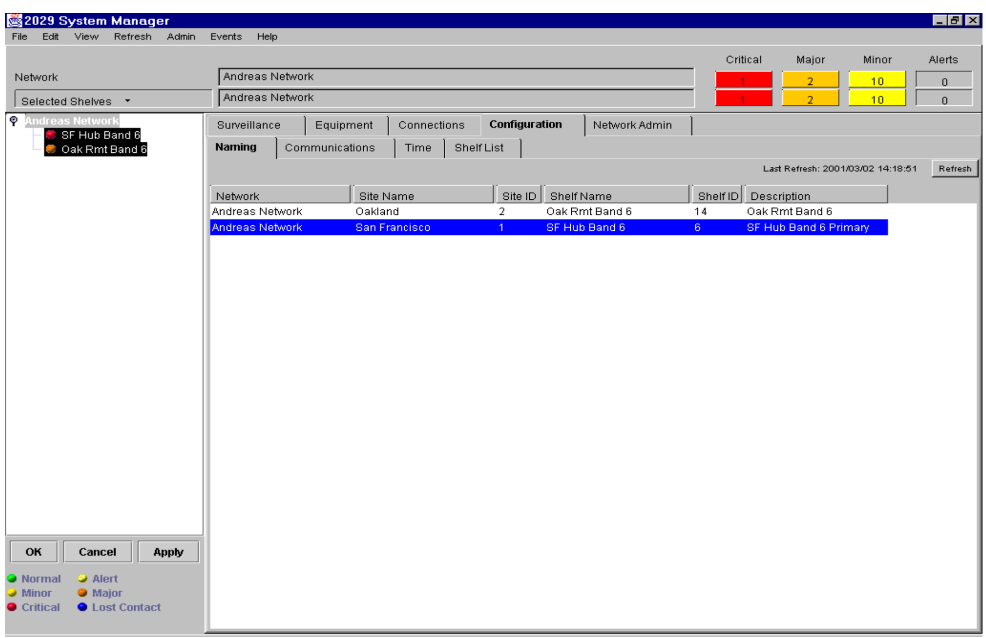


Figure 59. System Manager window

3. Click the **Surveillance** tab (see Figure 60).

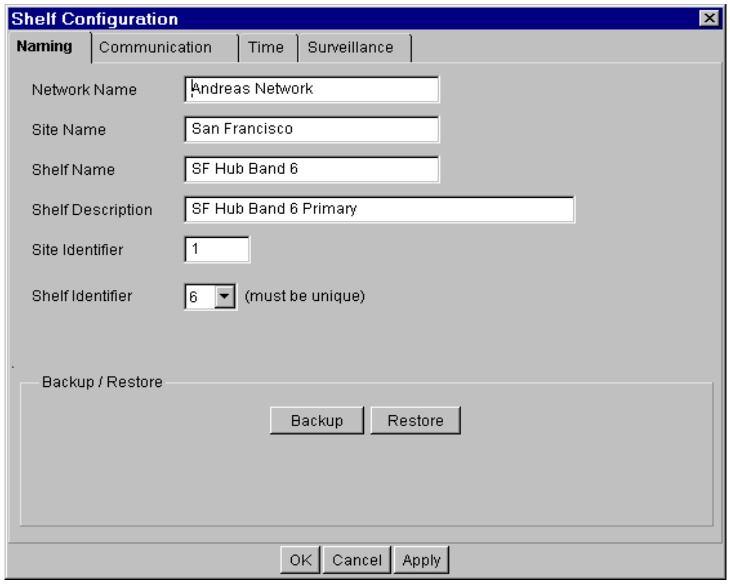


Figure 60. Shelf Configuration window

4. Double-click the shelf, as shown in Figure 61.

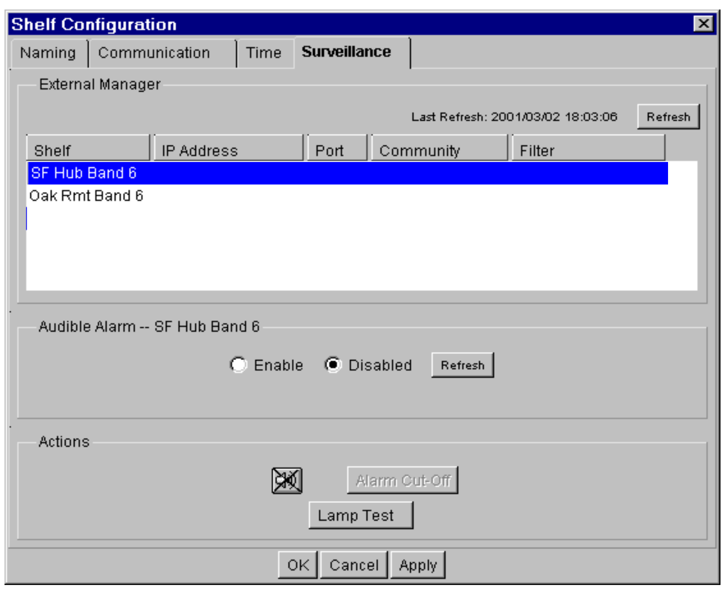


Figure 61. Shelf Configuration window

The External Manager Entry window will appear. Figure 62 on page 118 is an example of the External Manager Entry window with the values from Figure 58.

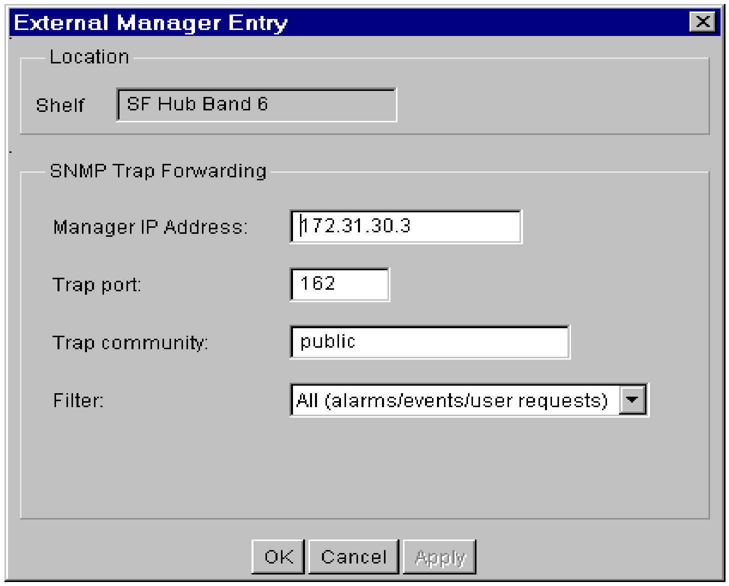


Figure 62. External Manager window

5. Enter the IP address of the EM.
6. Enter the UDP port of the EM. The Trap port must match the UDP port of the EM. The default is *162*.
7. Enter the community of the EM. The Trap community must match the community of the EM. The default is *public*.
8. Select the filter type.

   There are three filter classes determining which types of SNMP traps will be forwarded to the External Manager:

   Alarms are events which may indicate hardware or network problems affecting network traffic.

   Events report on state changes in the IBM 2029 network equipment (for example, placing a channel in and out of service).

   User requests report actions performed through the system management workstation (for example, a login request).

   Network Management Systems sites are primarily concerned with availability in the networks they are monitoring and so may only want notification of problems with the potential of affecting network traffic. For this reason, we recommend selecting **Alarms only** as the filter type.
9. Click **Apply**, then **OK.**

Figure 63 on page 119 will appear to verify the information you entered.

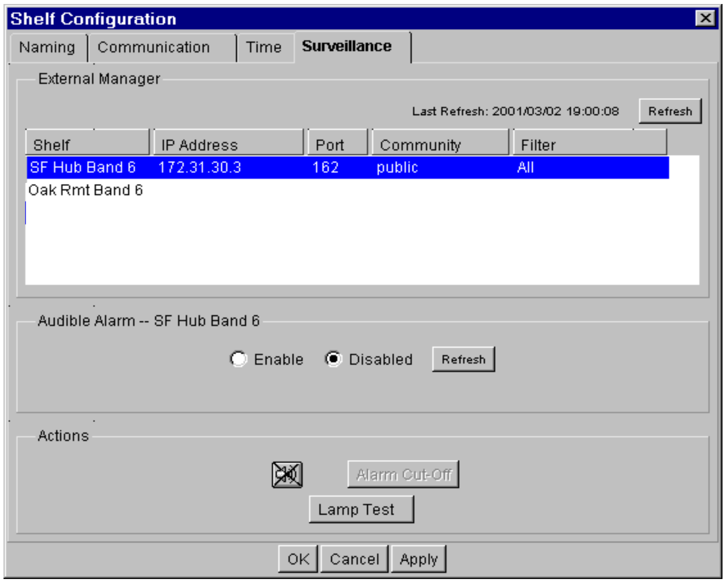


Figure 63. Verifying External Manager information

These steps must be repeated for all shelves that will forward information to an External Manager.

Chapter 6. Configuring the network

This chapter steps you through the configuration process of the IBM 2029 network, using the information given in Chapter 4, “Network planning and design” on page 65, and Chapter 5, “System management connectivity” on page 89.

The configuration process consists of two steps:

Commissioning

This is the process of supplying the required customer-specific management information to each shelf. More specifically, when you commission a shelf, you load naming information, the current date and time, and the shelf-specific IP addresses. The System Manager software arrives preinstalled on each shelf, but you supply this information for management and intershelf communications purposes. You must commission each shelf by connecting the workstation directly to it.

Provisioning

This is the process of configuring each individual channel with a name, protocol, and protection status. You may dynamically provision channels without affecting the traffic on other channels.

The terminology is somewhat confusing and people regularly interchange the two words. Just remember: you *provision* a channel, but you *commission* a shelf.

The scenario used in this chapter is a point-to-point configuration. The hub site is located in San Francisco with four shelves, while the remote site is in Oakland. The IBM 2029 network is configured to allow connectivity to an external TCP/IP network using two GNEs with OSPF enabled.

6.1 Commissioning the IBM 2029 network

Commissioning is a configuration task that occurs after the hardware has been installed and powered on. You do not need to connect the IBM 2029 fiber pairs prior to the commissioning process, but we recommend that you do so. It aids in verifying intersite connectivity.

The IBM 2029 is shipped with the following default IP addressing scheme, which will need to be altered to attach to an existing IP network:

- Default Gateway is set to the value of 0.0.0.0.
- Net Mask (64 bits) is set to the value of 255.255.255.252.

Shelves containing IP addressing 10.10.0.x, where X is provided in the following way (see Table 21 on page 122):

Table 21. Shelf IP addressing

Band	1	2	3	4	5	6	7	8	RS1	RS2	RS3	RS4	RS5	RS6	RS7	RS8
Network ID	0	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
Shelf	1	5	9	13	17	21	25	29	33	37	41	45	49	53	57	61
DHCP	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	62
Broadcast	3	7	11	15	19	23	27	31	35	39	43	47	51	55	59	63

Note: The default IP address for an uncomissioned shelf is 10.1.254.1

You must commission the shelves one by one, connecting the workstation directly to the shelf's 1x port on the maintenance panel. Do the following:

1. Physically connect the workstation to the shelf.
2. Find the shelf's IP address.
3. Use the IP address to connect to the shelf's System Manager.
4. Use the Commissioning Wizard to input:
   a. New naming information
   b. New IP addresses
   c. Current date and time
5. Reboot the shelf and System Manager.
6. Find the shelf's new IP address.
7. Use this IP address to log in to the System Manager.
8. Confirm the commissioning.
9. Disconnect the workstation and go on to the next shelf.

6.1.1 Step-by-step commissioning

This section presents steps for the commissioning process using the information supplied in Chapter 5, "System management connectivity" on page 89.

Table 22. Shelf Commissioning Wizard worksheet

Network name	Andreas Network			
Hub Site name	San Francisco		Hub Site ID 1	
Shelf Band #	Band 1	Band 2	Band 5	Band 6
Shelf Name	SF Hub Band 1	SF Hub Band 2	SF Hub Band 5	SF Hub Band 6
Shelf Description	SF Hub Band 1	SF Hub Band 2	SF Hub Band 5	SF Hub Band 6
Shelf Identifier	1	2	5	6
Shelf Address	172.16.10.1	172.16.10.33	172.16.10.34	172.16.10.35
Primary Shelf Address	172.16.10.33	172.16.10.33	172.16.10.33	172.16.10.33
Subnet Mask	255.255.255.240	255.255.255.255	255.255.255.255	255.255.255.255
DHCP Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Default Gateway Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Type	Terminal	Terminal	Terminal	Terminal
Ethernet Hubbing Group	1	1	1	1
External Mgr Address	172.31.30.3	172.31.30.3	172.31.30.3	172.31.30.3

Network name	Andreas Network			
Remote Site name	Oakland		Remote Site ID 2	
Shelf Band #	Band 1	Band 2	Band 5	Band 6
Shelf Name	Oak Rmt Band 1	Oak Rmt Band 2	Oak Rmt Band 5	Oak Rmt Band 6
Shelf Description	Oak Rmt Band 1	Oak Rmt Band 2	Oak Rmt Band 5	Oak Rmt Band 6
Shelf Identifier	9	10	13	14
Shelf Address	172.16.10.36	172.16.10.37	172.16.10.38	172.16.10.17
Primary Shelf Address	172.16.10.33	172.16.10.33	172.16.10.33	172.16.10.33
Subnet Mask	255.255.255.255	255.255.255.255	255.255.255.255	255.255.255.240
DHCP Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Default Gateway Address	0.0.0.0	0.0.0.0	0.0.0.0	0.0.0.0
Shelf Type	Terminal	Terminal	Terminal	Terminal
Ethernet Hubbing Group	2	2	2	2
External Mgr Address	172.31.30.3	172.31.30.3	172.31.30.3	172.31.30.3

Our example uses the worksheets in Table 22. The steps, though, are generic—they can be used for all shelves of all configurations. Only the user-specific information will change.

1. Power the workstation on.
2. Connect the workstation to the shelf that you would like to commission through the 1x port on the shelf's maintenance panel. Use a straight-through 10Base-T cable.
3. In the Start menu on the workstation, choose MS-DOS Prompt.
4. On the C:> prompt, type `ipconfig /release` (see Figure 64). Ipconfig is a utility that requests IP configuration information from a DHCP server in a TCP/IP network (in our case, the DHCP server is the shelf). Using `/release` clears the IP configuration of its current settings.

```
C:\>ipconfig /release

Windows NT IP Configuration

IP address 172.16.10.4 successfully released for adapter "IBMFE1"
```

Figure 64. ipconfig /release

5. Type `ipconfig /all` to view the current communications settings (see Figure 65).

```
C:\>ipconfig /all

Windows NT IP Configuration

        Host Name . . . . . . . . . : rcvywdm
        DNS Servers . . . . . . . . :
        Node Type . . . . . . . . . : Broadcast
        NetBIOS Scope ID. . . . . . :
        IP Routing Enabled. . . . . : No
        WINS Proxy Enabled. . . . . : No
        NetBIOS Resolution Uses DNS : Yes

Ethernet adapter IBMFE1:

        Description . . . . . . . . : IBM 10/100 EtherJet PCI Adapter
        Physical Address. . . . . . : 00-06-29-12-58-15
        DHCP Enabled. . . . . . . . : Yes
        IP Address. . . . . . . . . : 0.0.0.0
        Subnet Mask . . . . . . . . : 0.0.0.0
        Default Gateway . . . . . . :
        DHCP Server . . . . . . . . : 255.255.255.255
```

Figure 65. IP configuration after ipconfig /release

6. Then type `ipconfig /renew`. This requests IP addresses from the shelf, as shown in Figure 66. These are the initial IP addresses of the shelf, which you will use to communicate with the shelf through a Web browser.

```
C:\>ipconfig /renew

Windows NT IP Configuration

Ethernet adapter IBMFE1:

         IP Address. . . . . . . . . : 10.1.254.2
         Subnet Mask . . . . . . . . : 255.255.255.0
         Default Gateway . . . . . . : 10.1.254.1
```

Figure 66. IP configuration after ipconfig /renew

7. Keeping the DOS prompt open, now open your Web browser.
8. Copy the `Default Gateway` IP address into the Location field of the Web browser (the IP address in our case is 10.1.254.1), then press Enter. This step allows the Web browser to access the System Manager software in the shelf.
9. Once you see the connection screen from the System Manager software, click **Start the System Manager**. The System Manager takes a minute or more to load.
10. At the login screen, enter the User name `admin` and the default password `opterasm`. Click **OK**.

    You will now see the Shelf Commissioning Wizard window, prompting for naming information (see Figure 67).

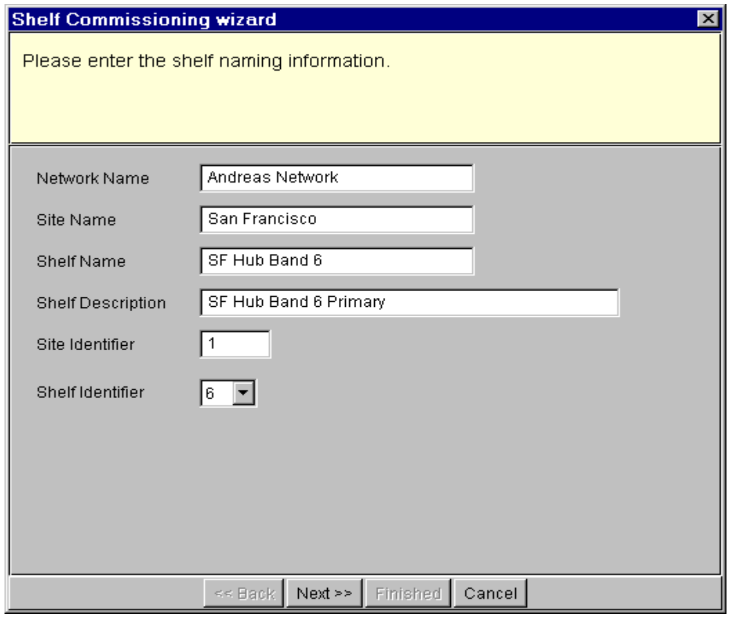


Figure 67. Shelf naming information

11.Fill in the blanks with the naming information that you compiled. Note that the information in Figure 67 comes from our sample worksheets shown in Table 22 on page 122.

The shelf naming information is as follows:

Network Name The name of the entire network. This name is the same for all shelves at all sites.

Site Name The name of the shelf's location or data center.

Shelf Name The specific name of the shelf. We recommend including the site, "hub" or "remote", the name "shelf" or "band", and the shelf number. We also recommend that you keep the shelf name under 16 characters so the entire name will appear in the tree, which you will see in later screens.

Shelf Description A description of the shelf's function. We recommend this to be the same as the shelf name. For the same reason as before, we recommend that you keep the name length under 24 characters.

Site Identifier A numerical representation of the geography.

Shelf Identifier A numerical representation of the shelf in the network. We recommend that you start with 1 at the hub site and with 9 at the remote site to allow for future growth.

Refer to 5.2.1, "Shelf naming information" on page 92 for more details about these fields.

12.When finished with the naming information, click **Next**.

13.The next screen prompts you for the shelf's IP addresses (see Figure 68 on page 126).

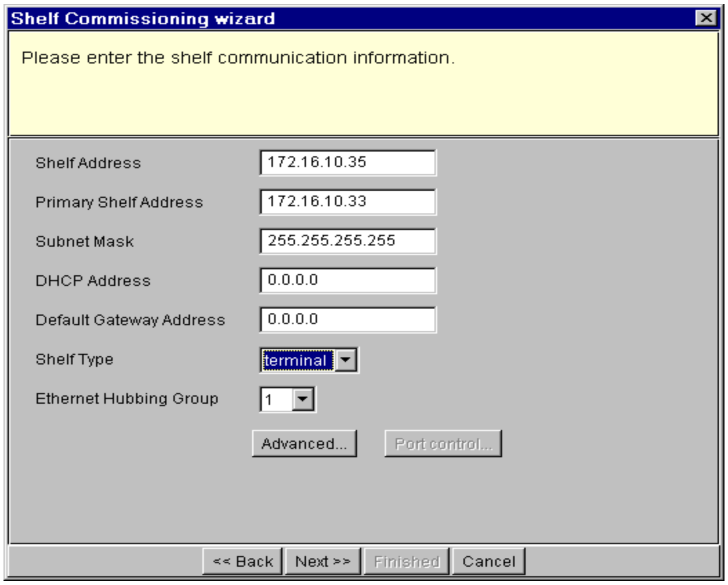


Figure 68. Primary shelf communication information

14. Fill in the fields with the IP address information you compiled. Note that the information in Figure 68 comes from our sample worksheets (Table 22 on page 122).

The shelf communication information is as follows:

Shelf Address The IP address of the shelf, unique to that shelf.

Primary Shelf Address The IP address of the primary shelf in the network.

Subnet Mask Segments the shelf from the other shelves in the network.

DHCP Address Set to 0.0.0.0 because we will be using internal IP addresses generated by the shelf. An IP address of 10.1.<Shelf-id>.1 is given to the workstation that is directly attached through the shelf's 10Base-T 1X port.

Default Gateway Address The IP address of the IP router that the shelf uses when connecting to a TCP/IP network. In our scenario it is set to 0.0.0.0 because we are using OSPF to connect to a TCP/IP network.

Shelf Type The function of the shelf can be OADM, OFA, or terminal. Since this is a point-to-point configuration, we defined our shelves as terminal.

Ethernet Hubbing Group Used for internal management within the shelves. All shelves in a site are part of the same hubbing group. Therefore, we recommend that you set this to the site identifier**.**

See "Shelf communication information" on page 93 for more details about these fields.

By clicking **Advanced**, you can enable OSPF.

Figure 69 shows the OSPF communications parameters. Initially the fields are blank; they are shown with recommended default values.

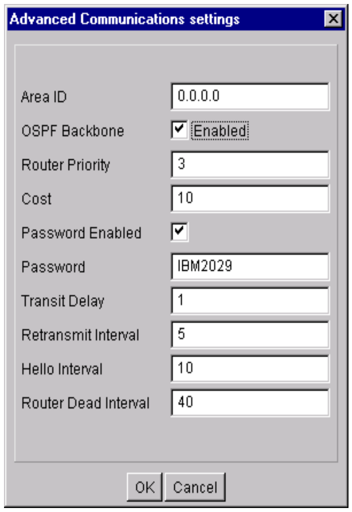


Figure 69. Advanced communications settings for OSPF

The OSPF advanced communications information is as follows:

Area ID Defines the OSPF Area number used by the IBM 2029 internal OSPF network.

OSPF Backbone This backbone flag enables GNE shelves to communicate with external OSPF routers.

Router Priority If you assign two routers to a network, both will try to become the Designated Router. The router with the higher priority value becomes the Designated Router. Priority values are from 0 to 255. A router with a value of 0 is never the Designated Router. In our environment both GNEs had this value set to *3*.

Cost The cost of sending a data packet on the interface, from 0 to 200. The default value for 10Base-T Ethernet is *10*.

Note

The following parameters must match those of the external OSPF-enabled router that the GNE shelf is connecting through.

Password Enabled This flag indicates if there is a password assigned to the OSPF backbone the GNE shelf is attached to. The password is used for simple password authentication.

Password A key to allow the authentication procedure to generate and check the incoming and outgoing OSPF packets. The password can be up to eight characters. For example, *IBM2029.*

If there are two GNE shelves in the IBM 2029 network, the OSPF Backbone Password must be the same for both GNE shelves. The password must also be defined in the external OSPF enabled routers.

Transit Delay The number of seconds to transmit a link state update packet over the 10Base-T 1X port, from 0 to 100. The default is *1* second.

Retransmit Interval The number of seconds after which a Link Request for one or more link state advertisements will be resent, from 0 to 100. The default is *5* seconds.

Hello Interval The number of seconds between Hello packets that are sent on the interface, from 0 to 1800. The default is *10* seconds.

Router Dead Interval The number of seconds after which a router that has not sent a Hello will be considered dead by its neighbors. This value must be greater than the Hello Interval. The default is *40* seconds, which is four times the configured Hello Interval.

See "Shelf communication information" on page 93 for more details about these fields.

15. When finished with the Advanced communications settings, click **OK**.
16. When finished with the Communications information, click **Next**.
17. The screen on Figure 70 allows you to enable/disable the audible alarm, or to define the SNMP Trap parameters. Select a shelf and double click on that entry.

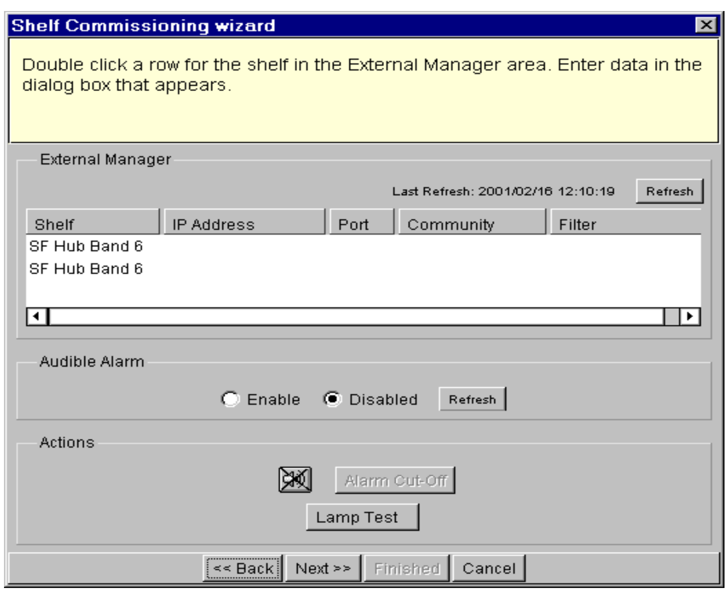


Figure 70. External Manager screen

18. Define the SNMP Trap forwarding parameters and the alarm filtering level, (Figure 71 on page 129). Remember that the External Manager IP address comes from our sample worksheets shown in Table 22 on page 122.

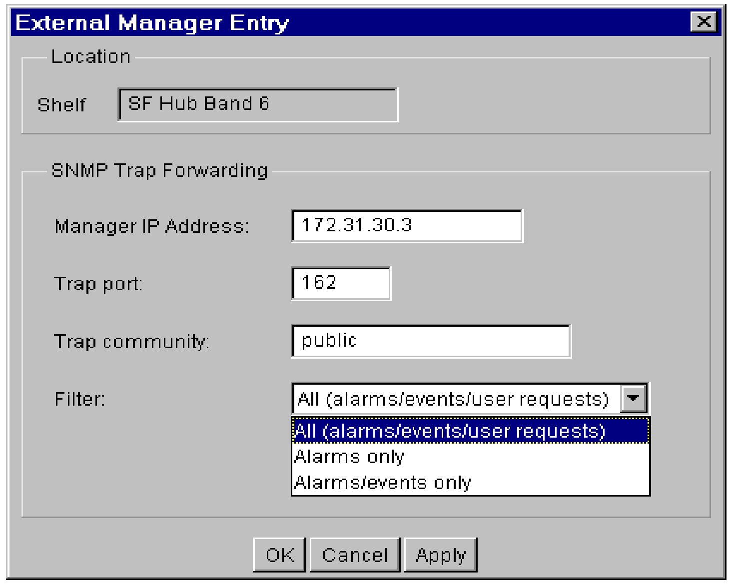


Figure 71. SNMP Trap parameters

Manager IP Address The IP address of the External Manager.

Trap port The UDP port of the External Manager. The default is *162*.

Trap community The community of the External Manager. The default is *public.*

For details on External Management refer to 5.7, “External management using SNMP” on page 115.

19.When finished, click **Apply**, then **OK**, and the screen in Figure 70 on page 128 will appear. Click **Next**.

20.The next screen (Figure 72 on page 130) prompts you for the date and time. If you select the Apply PC Date/Time box, the System Manager will take the date and time from the workstation that it is running on. Click **Next** when you have finished.

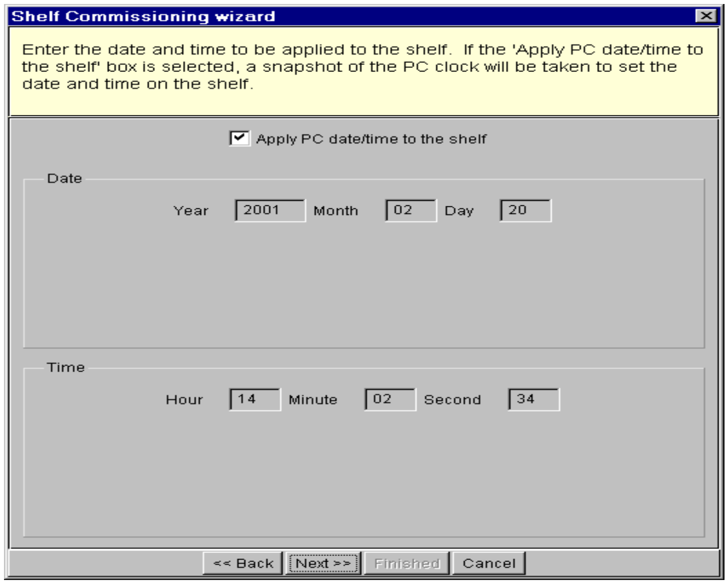


Figure 72. Shelf date and time

The final screen in the Commissioning Wizard prompts you for a saving location for a copy of the commissioning information (see Figure 73 on page 130). The information is saved on the workstation or any drive the workstation can access, but not back on the shelf. Click **Browse** to find a suitable storage place on the workstation. We saved it to a new file, C:\2029\ShelfData.dat.

If you ever need to retrieve this information, there is no "import" function to load the information back into the Commissioning Wizard. You view this file in a notepad as plain text and type it back into the Commissioning Wizard.

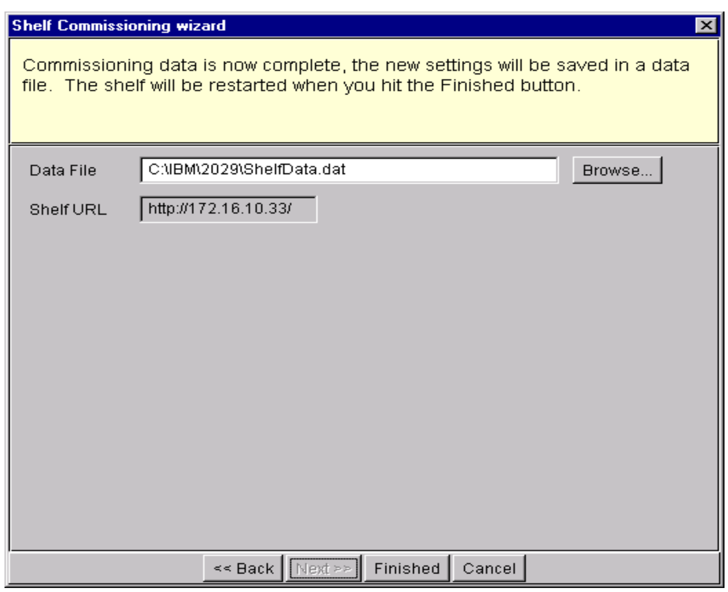


Figure 73. Shelf saving location

21. Once you have finished with date and time, click **Finished**. The shelf then reboots with its new information.

22.Click **Close** in the Shelf Commissioned window.

The shelf takes a minute or more to reboot, and the System Manager shuts down. Meanwhile, an audible alarm sounds on the shelf. Press the Alarm Cut Off (ACO) button on the shelf's maintenance panel. Also, you see an LED on the shelf's cards blinking—this is normal.

After the Reboot Complete message appears, we suggest waiting an extra minute before logging back in to the shelf. We had connection problems when logging in too quickly.

Before commissioning the other shelves, we suggest that you log back in to the shelf to verify that the shelf has been commissioned properly.

To log in to a shelf's System Manager, use the IP addresses that you supplied during the commissioning steps. The following steps take you through the System Manager login.

23.Make sure that the workstation is connected to the shelf through the 1X port on the shelf's maintenance panel. Use a straight-through 10Base-T cable.

24.In the Start menu on the workstation, choose **MS-DOS Prompt**.

25.On the C:> prompt, type `ipconfig /release`. This will clear the current IP configuration settings.

26.Type `ipconfig /renew`. This requests a DHCP IP address from the shelf (see Figure 74). Note that the DHCP address returned for the 1x port will be in the form: 10.1.<Shelf-id>.2, when using a shelf Subnet Mask of 255.255.255.255. In our case the DHCP address returned for Shelf-id 6 was 10.1.6.2.

```
C:\>ipconfig /renew

Windows NT IP Configuration

Ethernet adapter IBMFE1:

        IP Address. . . . . . . . . : 10.1.6.2
        Subnet Mask . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . : 10.1.6.1
```

Figure 74. Configuration after renew

27.To start the System Manager, type in the commissioned shelf IP address in the location field of the Web browser. Press Enter. The IP address in our case was 172.16.10.35. This step allows the Web browser to access the System Manager software within the shelf.

Note

Do not use the IP address of the Default Gateway (see Figure 74), this will appear to start System Manager, but you will not be able to log in -- you will receive a `Login failed` message.

28.Once you see the connection screen from the System Manager, click **Start the System Manager**.

29.At the login screen, enter the User name `admin` and the default password `opterasm`. Click **OK**.

The next screen you will see is the System Manager (Figure 75). It defaults to the Active Alarms screen, showing a history of error messages from the OCLD cards.

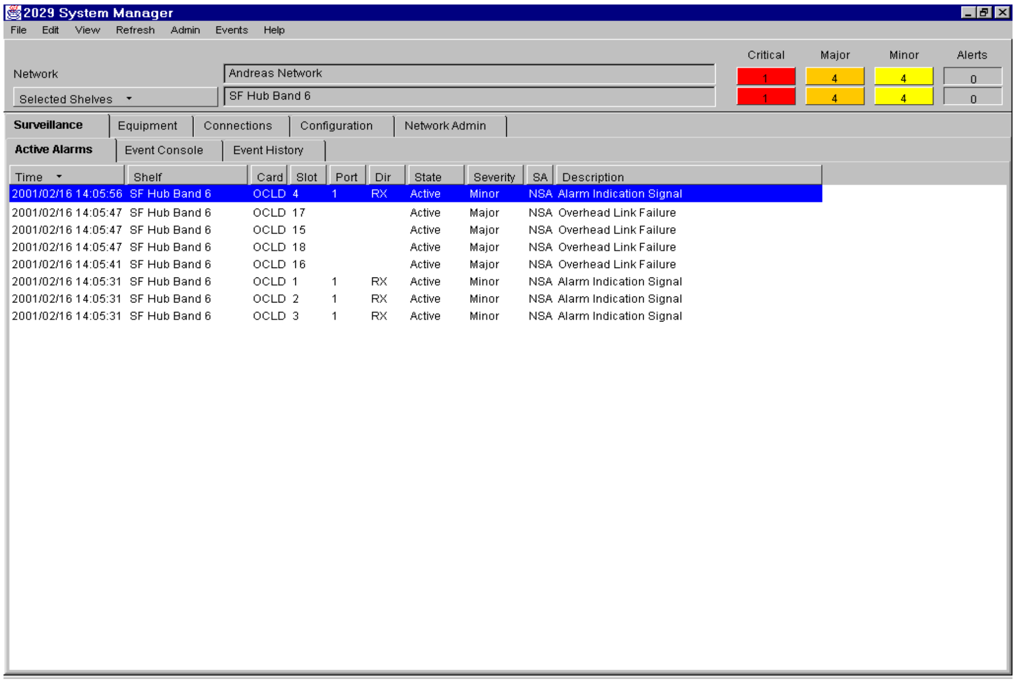


Figure 75. Opening screen of System Manager

The alarms on this screen arise during the commissioning stage. Overhead Link Failures, because the remote shelf has not been commissioned and provisioned yet. RX Alarm Indication Signals arise because there are no I/O signals received by the OCIs and OCLDs. During the commissioning stage, you can disregard these alarms.

For a further description of the alarms and card indicator lamps, refer to *IBM Fiber Saver (2029) Planning and Operations Guide,* SC28-6808.

30.To view the Network tree, click **Selected Shelves** (see Figure 76 on page 133). We recommend that you do this every time you log in to the System Manager to ensure that connectivity exists to all shelves in the network.

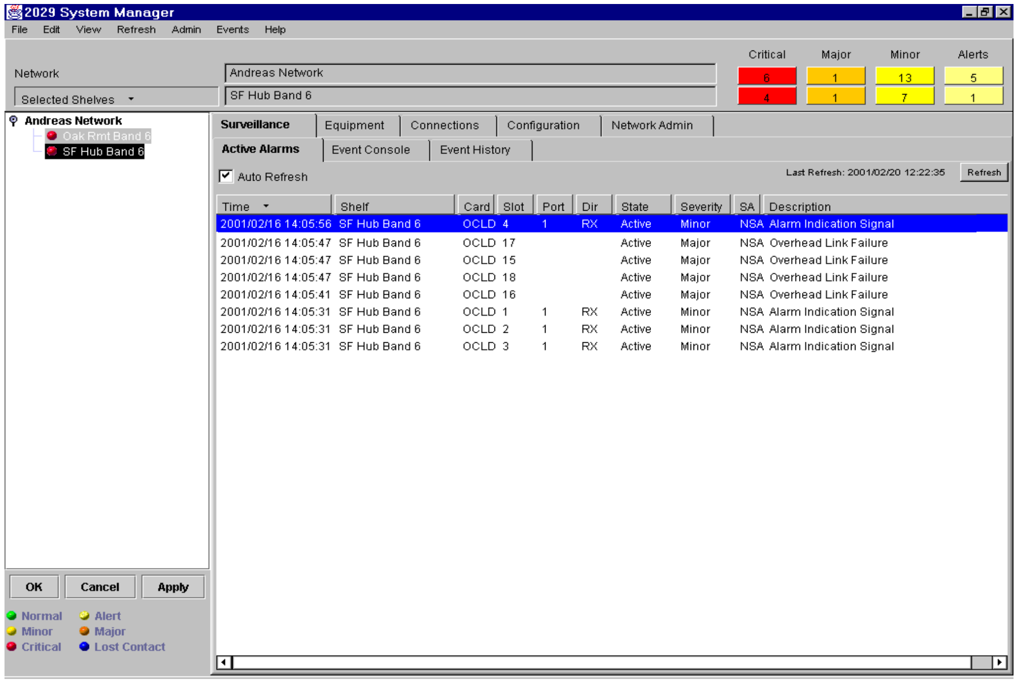


Figure 76. Network tree view of a 2029 network

31. To view the commissioning information, click **Configuration** on the menu bar (see Figure 77).

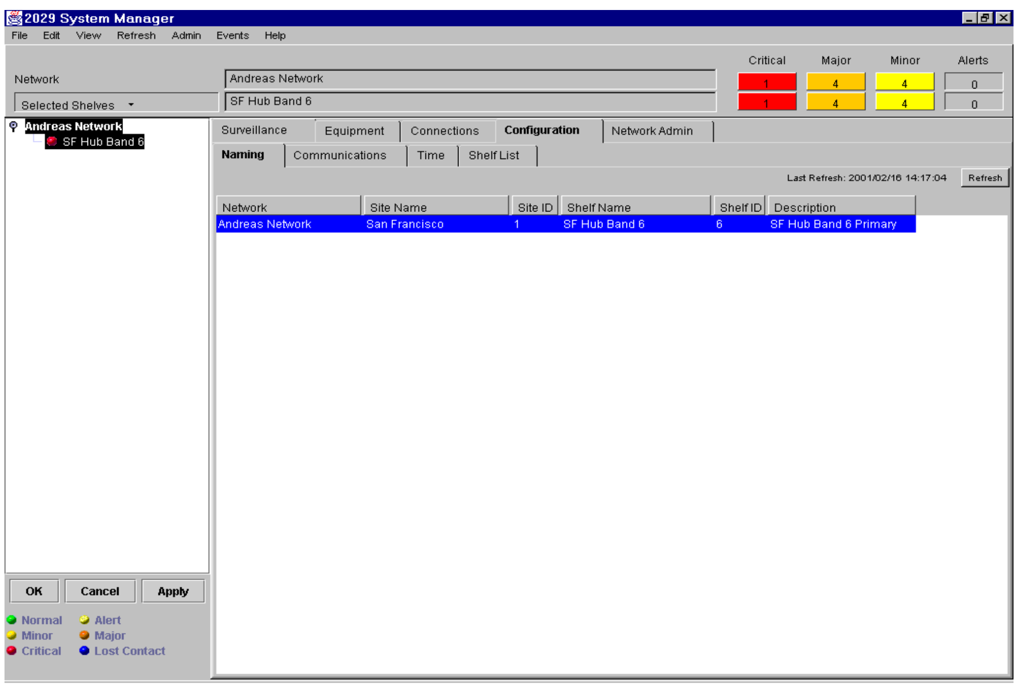


Figure 77. Configuration panel

32. Notice that the first screen is Naming, showing you the naming information you entered in the commissioning stage. This verifies that the shelf was commissioned properly.

You may step through Communications, Time, and Shelf List to view the rest of the management information that you entered in the commissioning stage. Note that you may change this information here by double-clicking on the shelf. The change reboots both the shelf and the System Manager, without interrupting traffic.

33.Close the System Manager and the Web browser, and disconnect the workstation from the shelf.

6.1.2 Commission the entire network

Commission the rest of the shelves in the network using the same procedure, and verify them by logging in to the System Manager. The following list takes you through the necessary steps:

1. Commission the second shelf following the step-by-step process in 6.1.1, "Step-by-step commissioning" on page 122.
2. After commissioning the second shelf, log in and verify that the System Manager sees not only its own shelf, but the first shelf. Remember that you may be connected to any shelf's 10Base-T 1x port to log in to the System Manager and view the entire network.

   At first, the System Manager may not see all commissioned shelves within the network.
3. Commission the next shelf, in our case the Oakland Band 6 in the remote shelf. Note the differences in commissioning a remote shelf (see Figure 78).

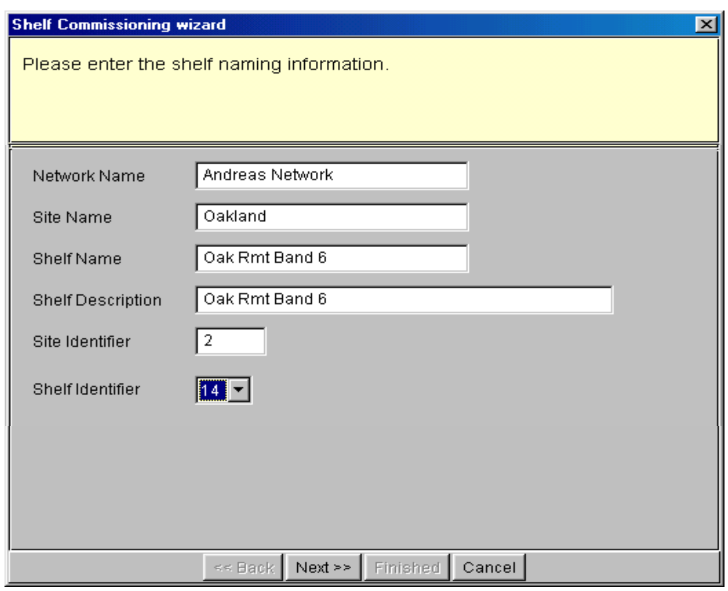


Figure 78. Remote shelf naming information

   The site name and identifier have changed to Oakland and 2, respectively. Also note that we are using 14 as the shelf ID to allow for future growth at the hub site.
4. Note that in the communications information, we had to specify Ethernet Hubbing Group as 2 for this shelf (see Figure 79 on page 135). Remember that we defined the IP addresses in the worksheets in Table 22 on page 122.

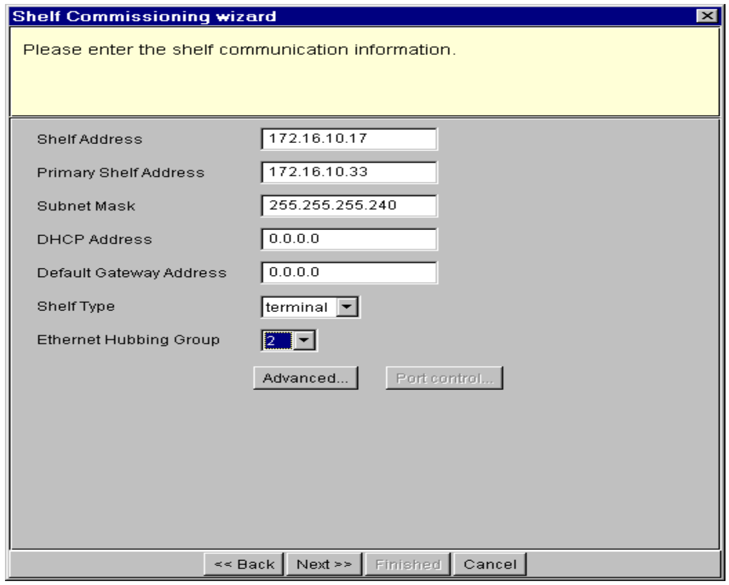


Figure 79. Remote shelf communications information

5. Click **Next**, then on the upcoming External Manager screen define the alarm reporting and filtering parameters for the remote site. For details refer to the hub site definitions (see Figure 70 on page 128 and Figure 71 on page 129).
6. When commissioned, the first remote shelf shows up in the System Manager branch tree. After you commission all shelves, they will all show up in the branch tree of the System Manager (see Figure 80). Select **Andreas Network** from the branch tree and click **Apply**.

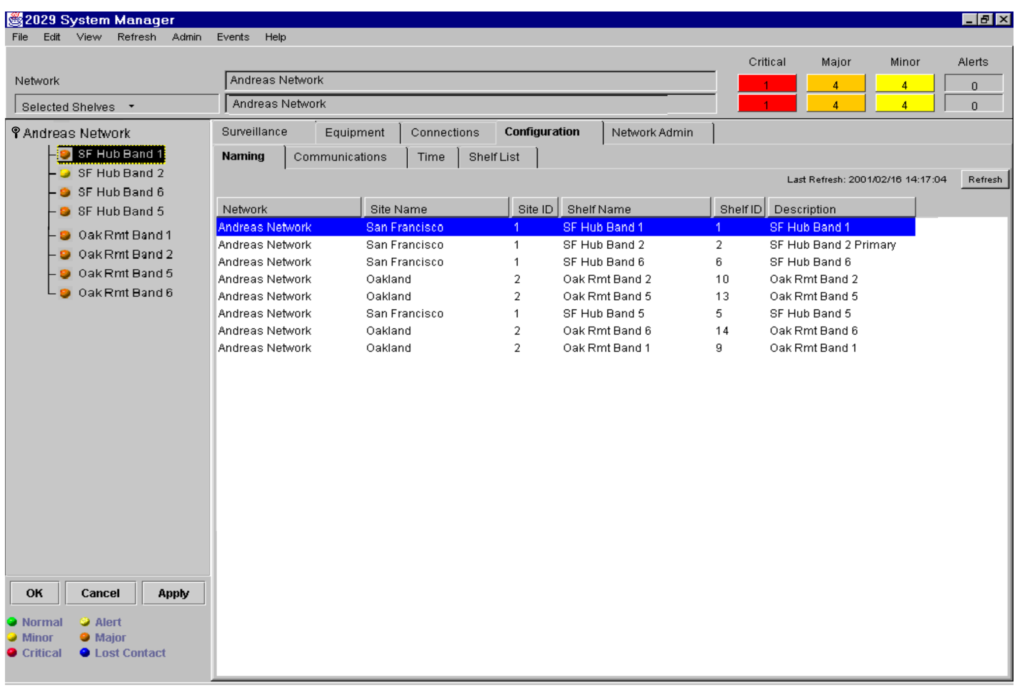


Figure 80. View of the entire Andreas Network

Once you have finished commissioning all shelves, verify that the OCLDs are "seeing" each other: on each OCLD card, the LOS LED should be off and the Active LED should be green.

Now you are ready to provision the channels.

6.2 Provisioning the IBM 2029 network

Once the shelves have been commissioned and therefore "see" each other, you are ready to provision the channels or connections. When you provision a channel, you are telling the channel its name, protocol, and protection status. Until the network is provisioned, you cannot add traffic to it.

Terminology

The IBM 2029 base and high availability channels correspond to SONET-based industry standard 1+1 protection switching configurations, in which the base channel is an *unprotected* SONET channel and the high availability channel is a *protected* SONET channel.

The IBM 2029 also supports the Dual Fiber Switch (DFS) with base channels, known as switched base channels. DFSs protect against a fiber trunk failure. However, they do not protect against circuit card failures, hence a switched base channel is an unprotected channel.

Throughout this section the terms unprotected channel and protected channel are synonymous with the terms base channel and high availability channel, respectively.

Unlike the commissioning process, you do not need to directly attach to that channel's shelf to provision a channel. You may connect to any shelf in the network and provision all channels.

Following are the steps to provision a channel. These steps use the information discussed in Chapter 4, "Network planning and design" on page 65.

Our example uses the worksheet illustrated in Table 23 on page 137. The steps, though, are generic—they can be used for any channel in any configuration; only the user-specific information will change.

Table 23. Band and channel allocation chart

Network name: *Andreas Network* Network ID: *1*			Hub Site name: *San Francisco* Hub Site ID: *1*					Remote Site name: *Oakland* Remote Site ID: *2*				
			IBM 2029 frame serial: *12345*					IBM 2029 frame serial: *67890*				
			TOP SHELF pair band number: *6*									
			Hub Shelf name: *SF Hub Band 6* Shelf ID: *6* Hubbing group: *1*					Remote Shelf name: *Oak Rmt Band 6* Shelf ID: *14* Hubbing group: *2*				
Channel Description	Protocol	Mode B / HA	P/P top	OCI Card / Slot		OCLD Card / Slot		OCLD Card / Slot		OCI Card/Slot		P/P top
~~Aggregate:~~ Port 1:*ESCON#1* ~~Port 2:~~ ~~Port 3:~~ ~~Port 4:~~	*ESCON*	*HA*	T5 1 ~~2~~ ~~3~~ ~~4~~	1A	5	1E	18	1W	1	1A	5	T5 1 ~~2~~ ~~3~~ ~~4~~
Aggregate: Port 1: Port 2: Port 3: Port 4:			T6 1 2 3 4	1B	6	1W	1	1E	18	1B	6	T6 1 2 3 4
~~Aggregate:~~ Port 1:*GBE#1* ~~Port 2:~~ ~~Port 3:~~ ~~Port 4:~~	*GbE*	*B*	T7 1 ~~2~~ ~~3~~ 4	2A	7	2E	17	2W	2	2A	7	T7 1 ~~2~~ ~~3~~ 4
~~Aggregate:~~ Port 1:*FICON#1* ~~Port 2:~~ ~~Port 3:~~ ~~Port 4:~~	*FICON*	*B*	T8 1 ~~2~~ ~~3~~ ~~4~~	2B	8	2W	2	2E	17	2B	8	T8 1 ~~2~~ ~~3~~ ~~4~~
Aggregate: Port 1: Port 2: Port 3: Port 4:			T11 1 2 3 4	3A	11	3E	16	3W	3	3A	11	T11 1 2 3 4
Aggregate: *4TDM ESCONs* Port 1: *ESCON#2* Port 2: *ESCON#3* Port 3: *ESCON#4* Port 4: *ESCON#5*	*ESCON*	*B*	T12 1 2 3 4	3B	12	3W	3	3E	16	3B	12	T12 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			T13 1 2 3 4	4A	13	4E	15	4W	4	4A	13	T13 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			T14 1 2 3 4	4B	14	4W	4	4E	15	4B	14	T14 1 2 3 4

1. Connect the workstation to any shelf's 1x port using a straight-through 10Base-T cable.
2. In the Start menu on the workstation, choose **MS-DOS Prompt**.
3. On the C:> prompt, type `ipconfig /release`. This clears the current IP configuration settings.
4. Type `ipconfig /renew`. This requests the DHCP IP addresses from the shelf.
5. Open your Web browser, then type the commissioned IP address of the shelf you are attached to into the Location field of the Web browser. Press Enter. This step allows the Web browser to access the System Manager software in the shelf.
6. Once you see the connection screen from the System Manager, click **Start the System Manager**.
7. At the login screen, enter the User name `admin` and the default password `opterasm`. Click **OK**.
8. Now you will see the opening screen of the IBM 2029 System Manager. Click the **Connections** tab (see Figure 81).

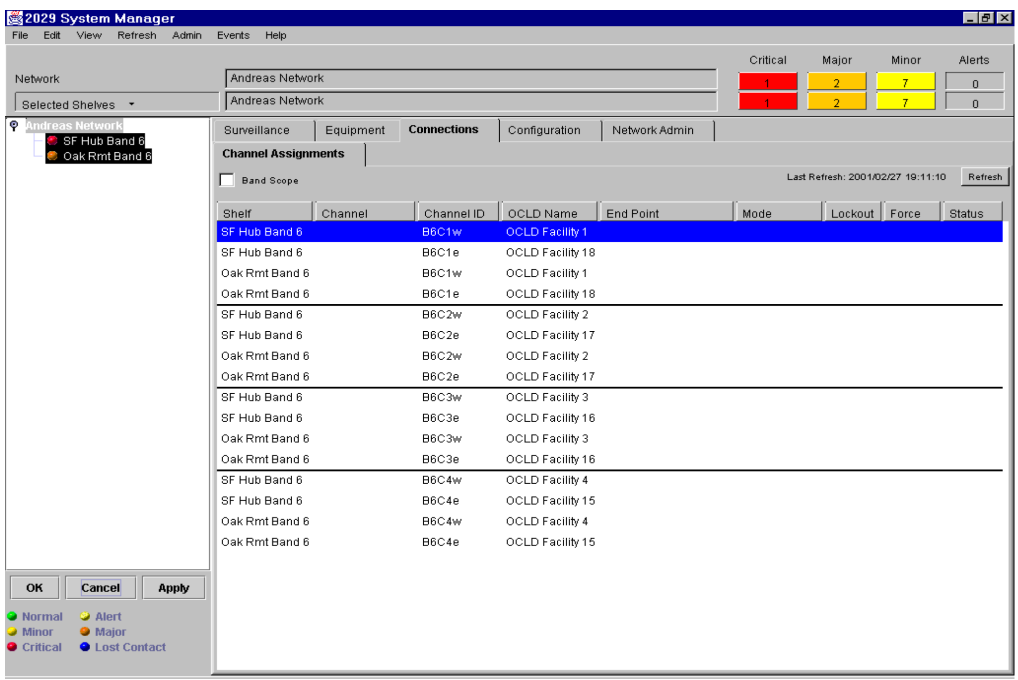


Figure 81. Channel Assignment window

The channel assignments screen shows the OCLD card assignment in each shelf. The first two, for example, are Channel 1 West and East in San Francisco Shelf 1. The second two are Channel 1 West and East in Oakland Shelf 1. Click the connection that you would like to provision. In our example we are starting with the San Francisco side of Band 6 Channel 1 West. The Channel Assignments window appears. This is where you provision the channels (see Figure 82 on page 139).

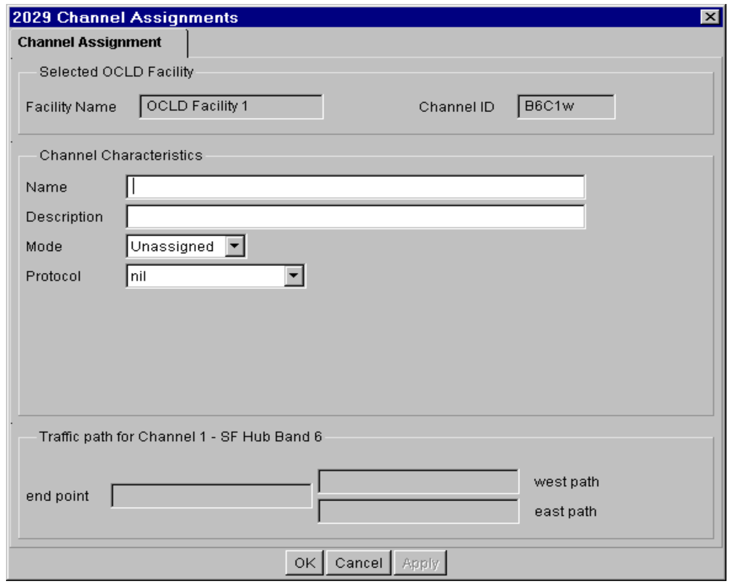


Figure 82. Channel Assignment panel

9. Name the channel. We used `ESCON #1` to indicate that it is the first ESCON channel.

10. Add a channel description. We used the channel name plus the protection status: `ESCON #1 protected`. Choose the mode: protected or unprotected (see Figure 83). Note that Passthrough is not supported with this release.

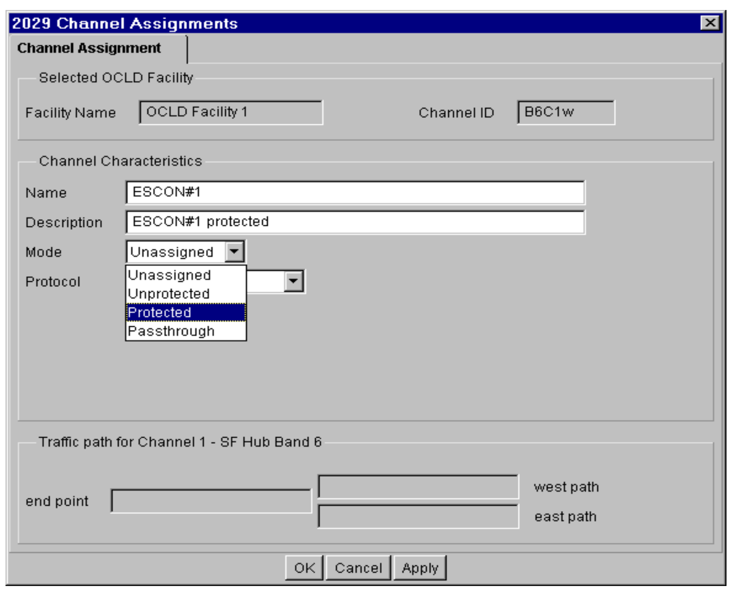


Figure 83. Choosing protection mode

11. Choose the channel's protocol from the pull-down menu (see Figure 84 on page 140).

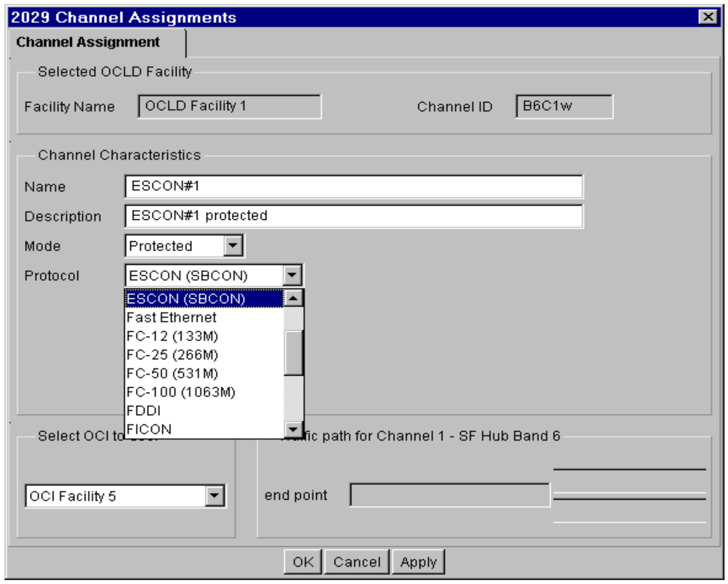


Figure 84. Choosing a protocol

12.Next, choose the OCI card that the channel will use at the site (see Figure 85). Refer to Table 23 on page 137, and 4.2, “Network planning suggestions” on page 71 for further details on which OCI card to use.

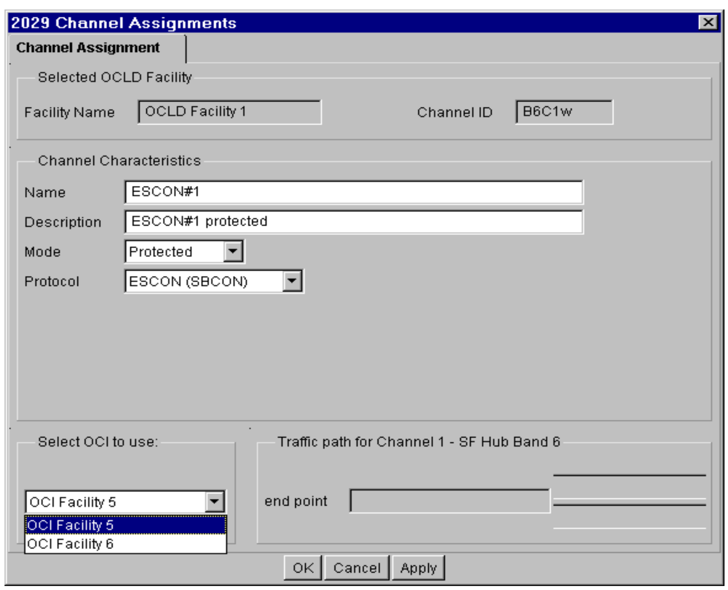


Figure 85. Selecting the OCI card

13.Click **Apply**, then **OK**.

14.Notice that in the Channel Assignments panel both East and West Channel 1 in the hub show up as provisioned (see Figure 86 on page 141). In protected mode, both OCLD paths (B6C1W and B6C1E) are used for that channel (ESCON#1).

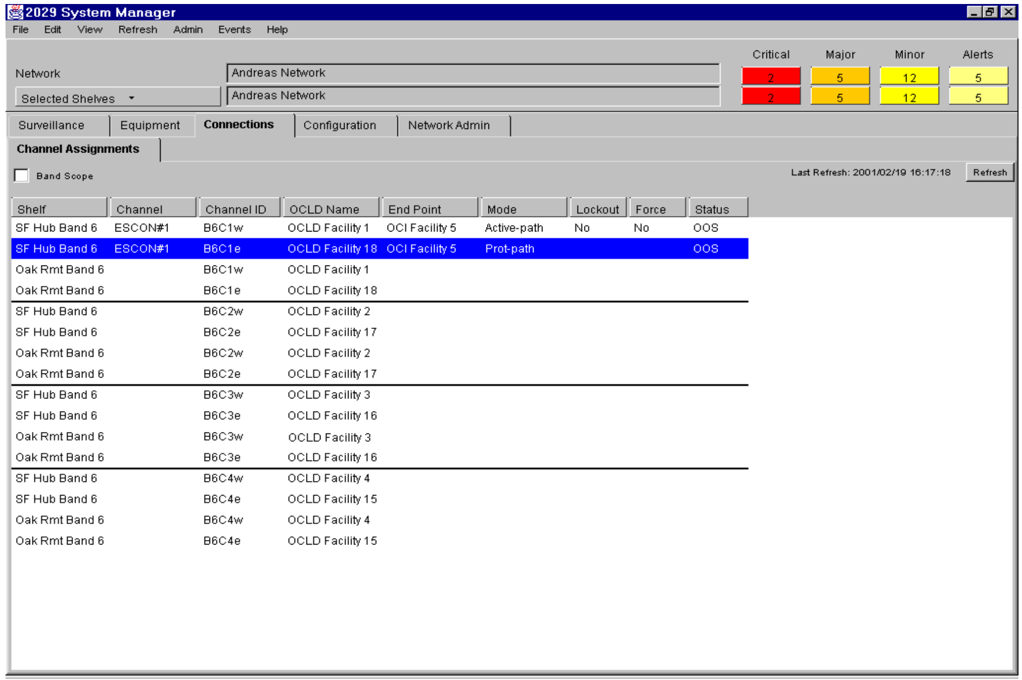


Figure 86. Channel Assignments window - with hub site provisioned

15.Next, provision the remote side of Band 6 Channel 1 West by clicking **Oak Rmt Band 6**.

16.Follow steps 9 through 14 for the remote side to complete the provisioning of ESCON #1. Notice that in the Channel Assignments panel the channel for ESCON#1 has been fully assigned to the Band 6 Channel 1 West and East OCLDs and OCIs of the hub and remote sites (see Figure 87 on page 142).

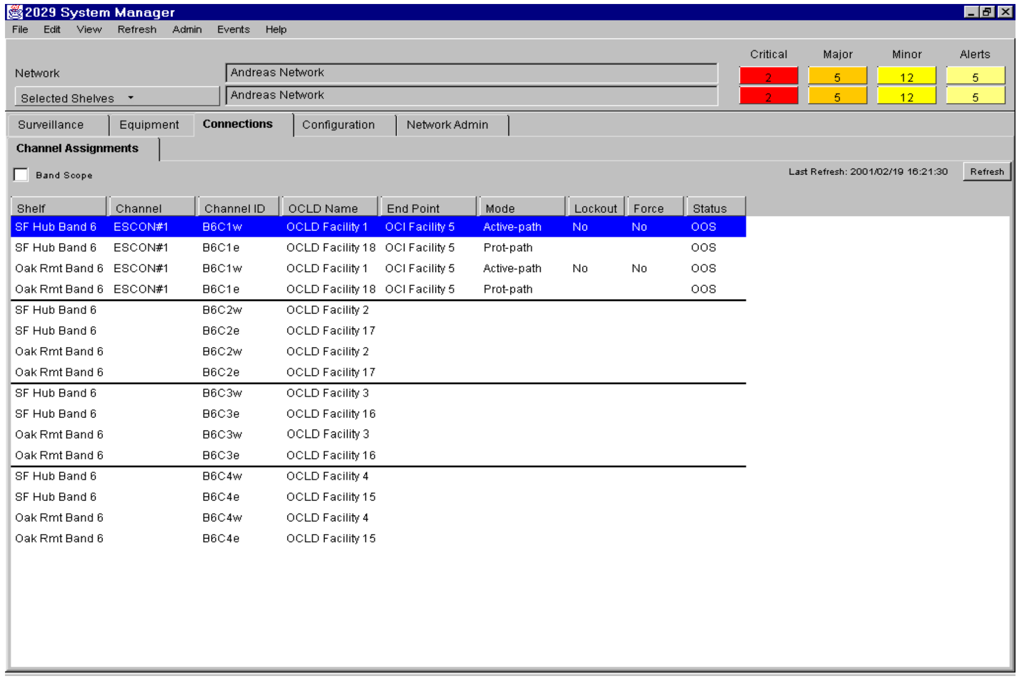


Figure 87. Channel Assignments window - after remote site provisioning

17. We now provision a FICON unprotected channel in Band 6 Channel 2. On the hub side it is West, while on the remote side it is East. Click **SF Hub Band 6 B6C2W**. Provision it as FICON unprotected. Select OCI Facility 7 as the OCI to use (see Figure 88 on page 143).

> **Note**
>
> Incorrect selection of an OCI card for an unprotected channel in the "Select OCI to use" field may prevent end-to-end connectivity through the IBM 2029 network.

For more details on the East/West relationships for an unprotected channel, see 4.2, "Network planning suggestions" on page 71.

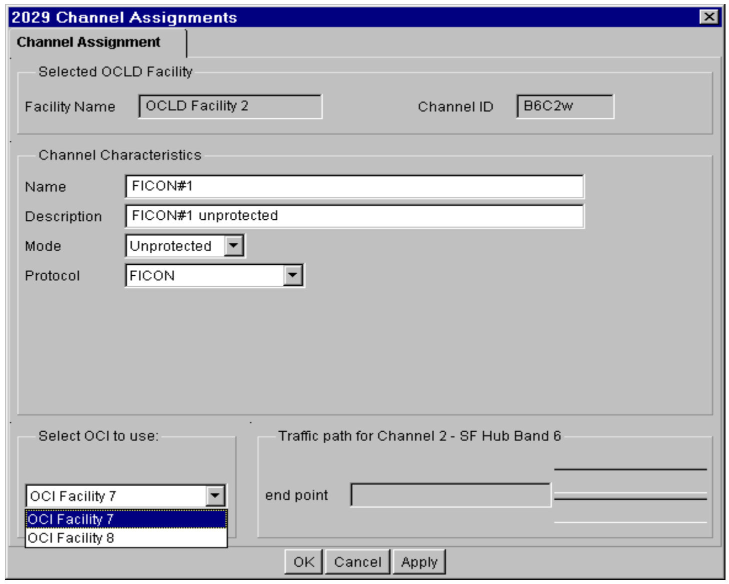
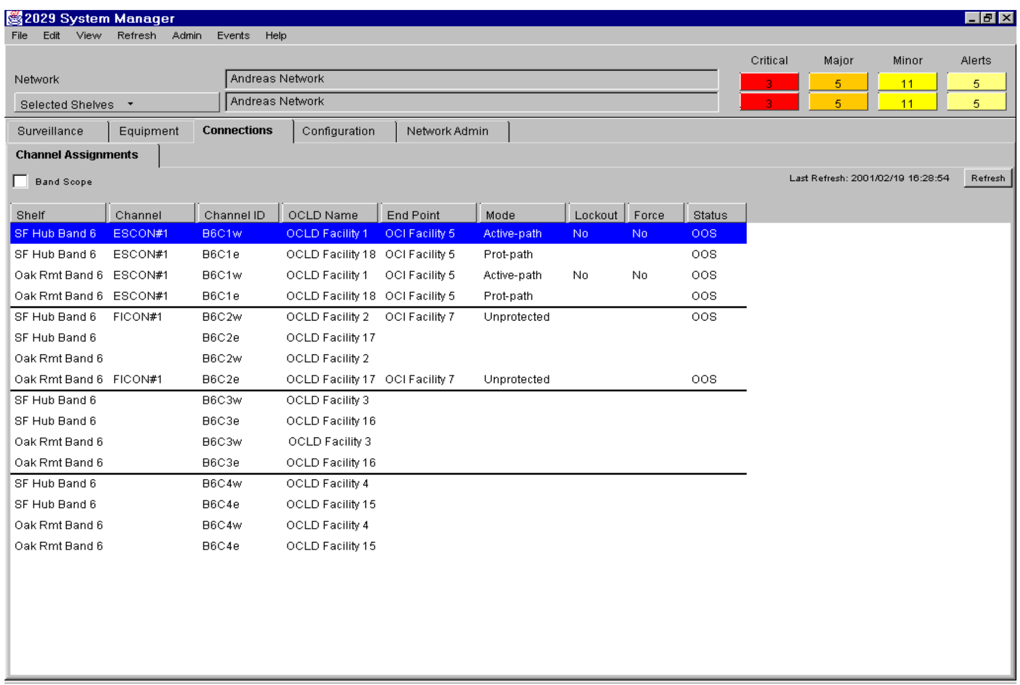


Figure 88. FICON provisioning

18. Provision the remote side of the unprotected FICON channel on the East path (see Figure 89). Select OCI Facility 7 as the OCI to use. For more details on the East/West relationships for an unprotected channel, see 4.2, "Network planning suggestions" on page 71.



Shelf	Channel	Channel ID	OCLD Name	End Point	Mode	Lockout	Force	Status
SF Hub Band 6	ESCON#1	B6C1w	OCLD Facility 1	OCI Facility 5	Active-path	No	No	OOS
SF Hub Band 6	ESCON#1	B6C1e	OCLD Facility 18	OCI Facility 5	Prot-path			OOS
Oak Rmt Band 6	ESCON#1	B6C1w	OCLD Facility 1	OCI Facility 5	Active-path	No	No	OOS
Oak Rmt Band 6	ESCON#1	B6C1e	OCLD Facility 18	OCI Facility 5	Prot-path			OOS
SF Hub Band 6	FICON#1	B6C2w	OCLD Facility 2	OCI Facility 7	Unprotected			OOS
SF Hub Band 6		B6C2e	OCLD Facility 17					
Oak Rmt Band 6		B6C2w	OCLD Facility 2					
Oak Rmt Band 6	FICON#1	B6C2e	OCLD Facility 17	OCI Facility 7	Unprotected			OOS
SF Hub Band 6		B6C3w	OCLD Facility 3					
SF Hub Band 6		B6C3e	OCLD Facility 16					
Oak Rmt Band 6		B6C3w	OCLD Facility 3					
Oak Rmt Band 6		B6C3e	OCLD Facility 16					
SF Hub Band 6		B6C4w	OCLD Facility 4					
SF Hub Band 6		B6C4e	OCLD Facility 15					
Oak Rmt Band 6		B6C4w	OCLD Facility 4					
Oak Rmt Band 6		B6C4e	OCLD Facility 15					

Figure 89. FICON unprotected channel assignment

19. Now provision a Gigabit Ethernet channel on Band 6 Channel 2 through the other path of the network. In other words, the GbE channel will use SF Hub Band 6 Channel 2 East and Oakland Rmt Band 6 Channel 2 West. You can

only select OCI Facility 8 as the OCI to use--OCI Facility 7 is already in use for FICON #1 (see Figure 90).

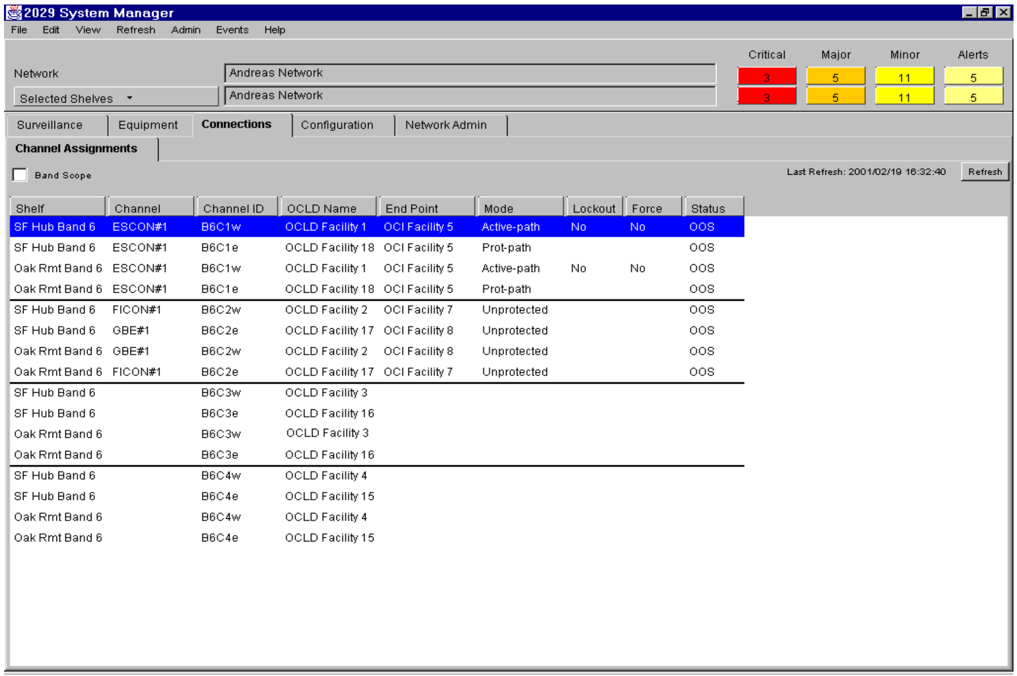


Figure 90. Gigabit Ethernet unprotected channel assignment

20. In the next sample we provision four ESCON unprotected channels going through a 4TDM OCI card. We provision Band 6 Channel 3. Double-click **SF Hub Band 6 B6C3w** and define the channel parameters. Next select the OCI card and the port. We selected SRM Facility 12, port 1. SRM (SubRate Multiplexer) denotes the 4TDM OCI. Any of the four ports can be selected, however the same port must be selected on the remote side of the 4TDM OCI card to establish the connection. Each port can be selected separately; different protocols for the ports are not supported. Click the port, in our sample **SRM Facility 12, port 1** (see Figure 91 on page 145).

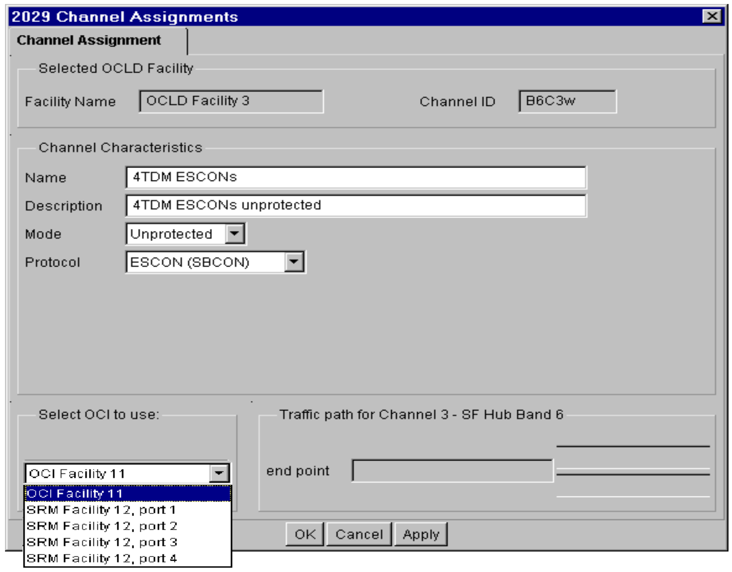


Figure 91. ESCON channel provisioning through 4TDM OCI card

21.On the next screen describe the channel and port parameters (Channel Characteristics). We used the parameters in Table 23 on page 137. When finished, click **Apply** (see Figure 92).

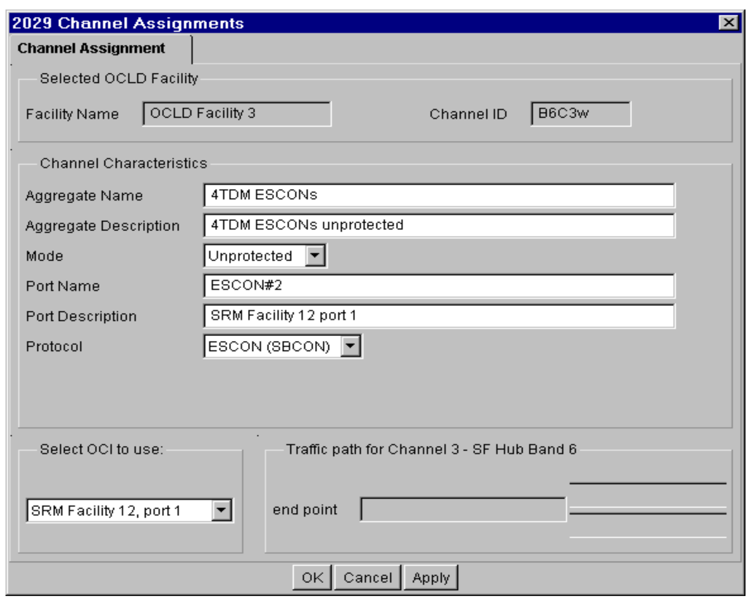


Figure 92. 4TDM channel characteristics

22.Now the hub side of the channel connected to the first port of the 4TDM OCI card is provisioned. Double-click **SF Hub Band 6 B6C3w** again to provision the second ESCON channel connected to the second port of the same 4TDM OCI card. Define the channel parameters and select the second port (SRM Facility 12,port 2). Complete the channel provisioning as shown on Figure 92. Follow the same steps for the third and fourth ports. Remember that only the same protocol is supported for the four ports of the 4TDM OCI card.

23. The remote side of the channel must be provisioned accordingly. First double-click **Oak Rmt Band 6 B6C3e** (this is Channel 3 at the remote site), then follow steps 20 through 22. Now all four ESCON channels on the 4TDM OCI card are provisioned (see Figure 93).

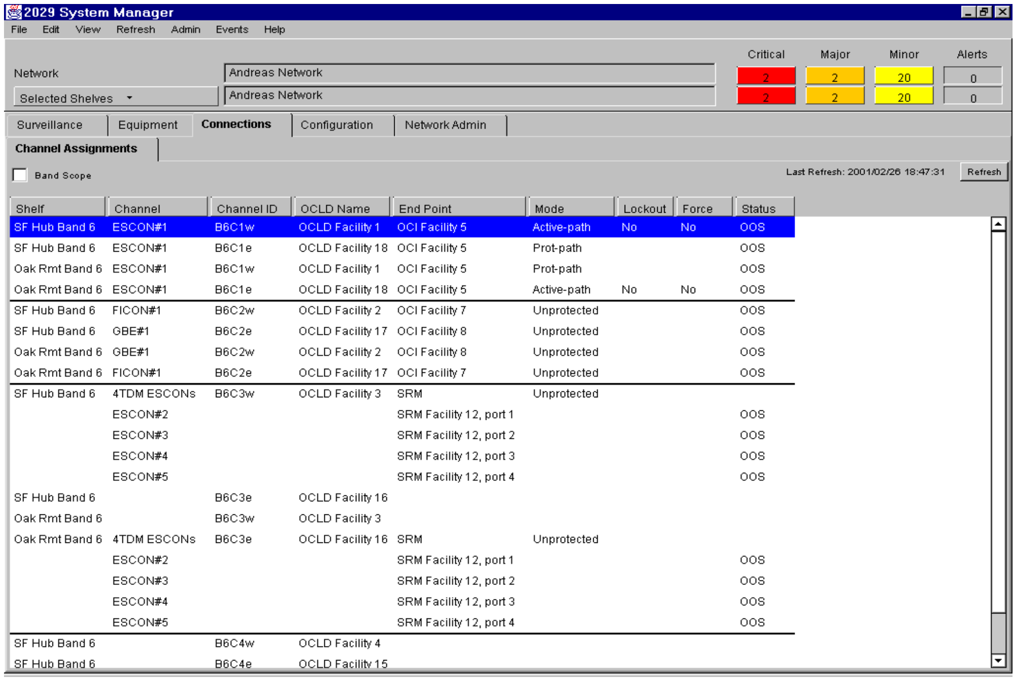


Figure 93. Channel Assignment window with 4 ESCON channels provisioned on the 4TDM OCI card

24. The provisioned channels on the Channel Assignment panel show Out-Of-Service (OOS) status, since the facilities are in the OOS state. The facility must be switched in an Administrative In-Service (IS) state, which means that the channel path through the IBM 2029 Fiber Saver is ready to transmit data. Click the **Equipment** tab, then the **Facility** tab (see Figure 93).

25. On the Facility panel select the facility to switch to IS. We selected the FICON#1 facility (**OCLD 2** and **OCI 7** at hub site and **OCLD 17** and **OCI 7** at the remote site). See Figure 94 on page 147.

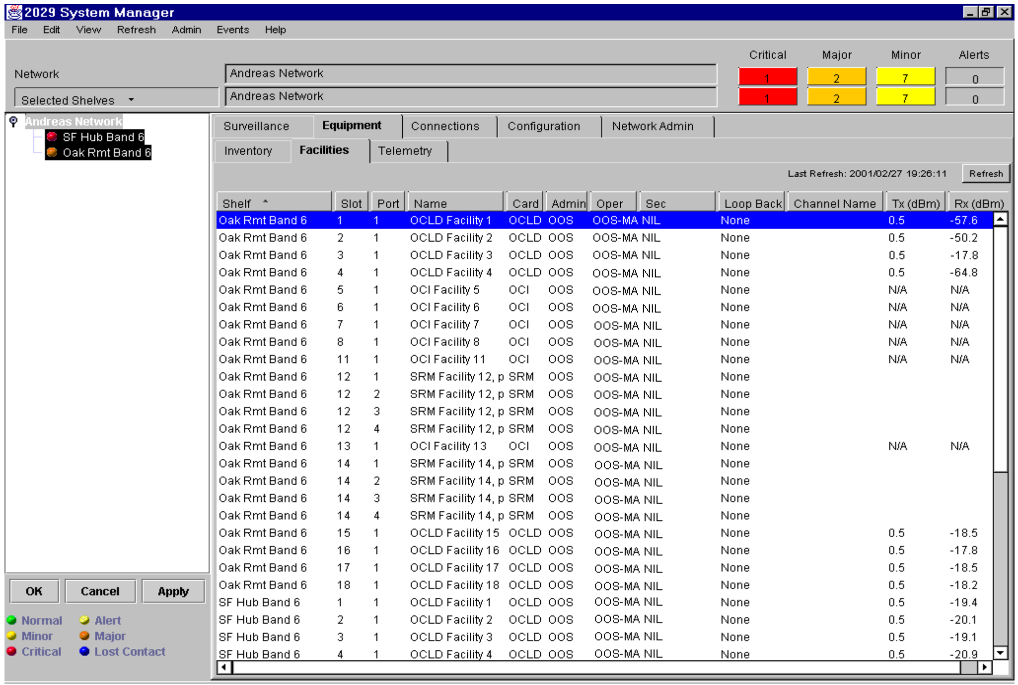


Figure 94. Facility window

26.Double-click **OCLD 2**, then on the next panel select **IS** (see Figure 95). Click **Apply** then **OK**.

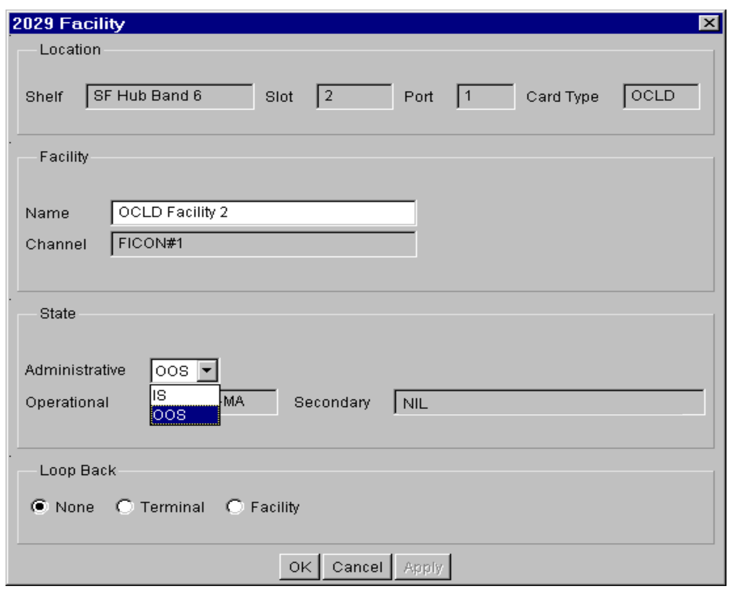


Figure 95. Facility management panel

27.Repeat steps 25 and 26 for **OCI 7** at the hub site, and for **OCLD 17** and **OCI 7** at the remote site to put all parts of the channel in the IS state. Notice that the OOS status on the Channel Assignment panel (see Figure 93 on page 146) will turn to IS only if the channel is varied ON from the host system, which will turn the facility status into Operational In-Service (IS) also. On the Facility management panel (Figure 94 on page 147) the telemetry parameters are also displayed. Since no working channels are connected, N/A (Not Applicable) appears next to the OCI cards. The 4TDM OCI cards do not provide telemetry parameters for the separate channels going through them.

Chapter 7. Dual Fiber Switch (DFS)

This chapter describes the purpose and capabilities of the Dual Fiber Switch (DFS), and how to install and customize it. Two basic connectivity alternatives and recommendations are also described:

1. Connecting through a shelf
2. Connecting through a network

Key commands used for monitoring the DFS are also provided.

7.1 Overview

As a lower-cost option to high availability channels, the DFS can provide redundant fiber trunk connectivity for base channels, called switched base channels. While high availability channels provide protection against either a fiber trunk or equipment failure in the IBM 2029 network, switched base channels only provide protection against a fiber break. Furthermore, high availability channels (protected) may be provisioned on a per-channel basis, whereas with the DFS, all channels must be provisioned as base channels (unprotected).

DFSs can only be used in a point-to-point configuration, and a separate pair of switches is needed for the east side fiber connection as well as the west side fiber connection. Thus, an extra pair of optical fibers must be provided as a backup for each working pair of fibers. The DFS supports fiber links with a maximum distance of 40 km (12 db loss). The DFSs are installed in Model 001 and Model RS1, and attach to the first and last OMXs in the system via fiber cables (these are provided with the DFS).

During normal operation, all data traffic is routed through the primary path of the DFS; in the event of a fiber break, all traffic is switched to the standby path within 100 ms. The standby path is monitored for continuity to ensure it will be available in the event of a traffic switch. Both optical fibers will switch together to the standby path, even if only one fiber of the pair is cut. Once a switch has occurred, the traffic will not revert to the primary path again unless either the secondary path is interrupted or a user command to switch back is given.

7.1.1 Switched base channels

Each shelf can contain up to 8 switched base channels (32 when provisioned with eight 4TDM OCI cards).

The switching of fiber paths is likely to be transparent for some protocols. Detection and recovery are entirely dependent on the robustness and recoverability of the hardware and applications that use the switched base channels.

Switched base channels are commonly used for:

- Multipath ESCON control units, since multiple channel paths are configured in the operating system
- FICON bridge interfaces, multipath ESCON control units attached to an ESCON Director

• Disk and tape mirroring channels

Switched base channels are not supported in a hubbed-ring configuration and the use of DFS with high availability channels is not supported.

7.2 Hardware implementation

Two DFSs (per site) are installed over the top shelf of the first frame between the maintenance panel and the new patch panel. This implementation is valid for the hub and the remote sites (Model 001 and Model RS1), regardless of the number of installed shelves per site.

On the front of the DFS, the fiber trunk pairs (Tx and Rx) and the OTSIN and OTS OUT on the OMXs will be connected to their respective optical plugs; see Figure 96.

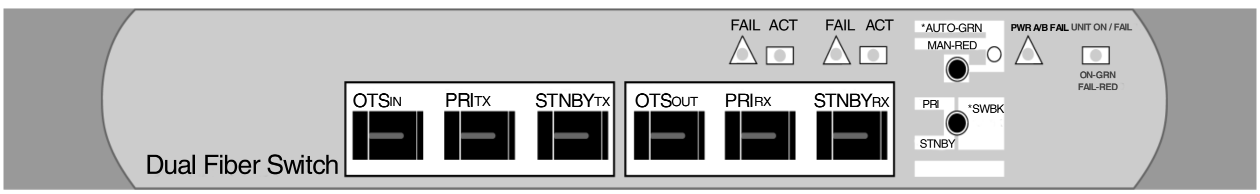


Figure 96. Dual Fiber Switch front view

On the back of the DFS, relay connections for alarm management (telemetry) are directly connected to the maintenance panel. Power connectors are coupled to the IBM 2029 frame power supply. The Ethernet port (RJ45) is used for the initial setup and to connect to a LAN for monitoring of the DFS; see Figure 97.

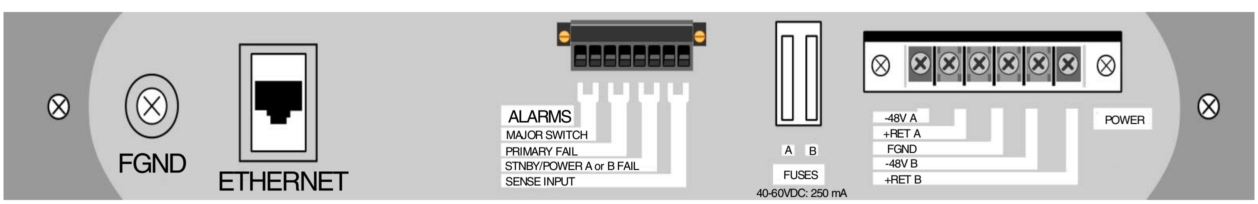


Figure 97. Dual Fiber Switch rear view

7.2.1 Power

The DFSs are powered for redundancy to the two AC rectifiers in the IBM 2029 frame. No power on/off button is available. As soon as the power is turned on, the “unit on” LED turns green. If one power input has failed (defective AC rectifier) then the “PWRA/B fail” LED comes on (red).

To make electrical connections from the DFS to the IBM 2029 frame power supply, follow the connector pin-out descriptions on the back panels of the DFS and IBM 2029 frame power supply:

1. Connect the office ground cable to FGND.
2. Connect the primary power source (Load1+ and Load1-) to +RET A and -48V A.

3. Connect the secondary power source (Load2+ and Load2-) to +RET B and -48V B.

7.2.2 Fiber trunk connections

Connect the fiber trunks to the DFSs according to Figure 98. Rx at one end of the fiber must always be connected to Tx at the other end, for both Primary and Standby fiber pairs. For example, one fiber of the primary fiber pair is connected to the PRI Rx of the hub site and to the PRI Tx of the remote site, while the other fiber of the primary fiber pair is connected to the PRI Tx of the hub site and to PRI Rx of the remote site.

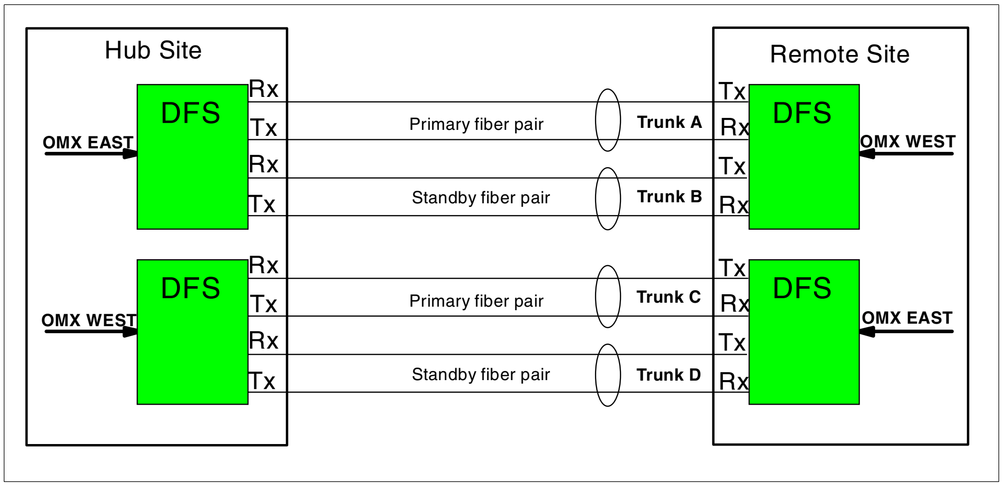


Figure 98. Fiber pair connections

Recommendation

Using separate physical fiber paths ensures that a break in a fiber path will not fully affect either side (east or west) of a point-to-point configuration. Therefore, make certain Trunk A and Trunk D take one physical fiber path, and Trunk B and Trunk C take the other physical fiber path.

7.2.3 OMX fiber installation

DFSs are installed in the top portion of the IBM 2029 frame in the hub and remote sites. The OTSIN and OTSOUT of the east and west OMX (*first* and *last* shelves) are connected to the DFS using optical jumpers, as shown in Figure 99 on page 152.

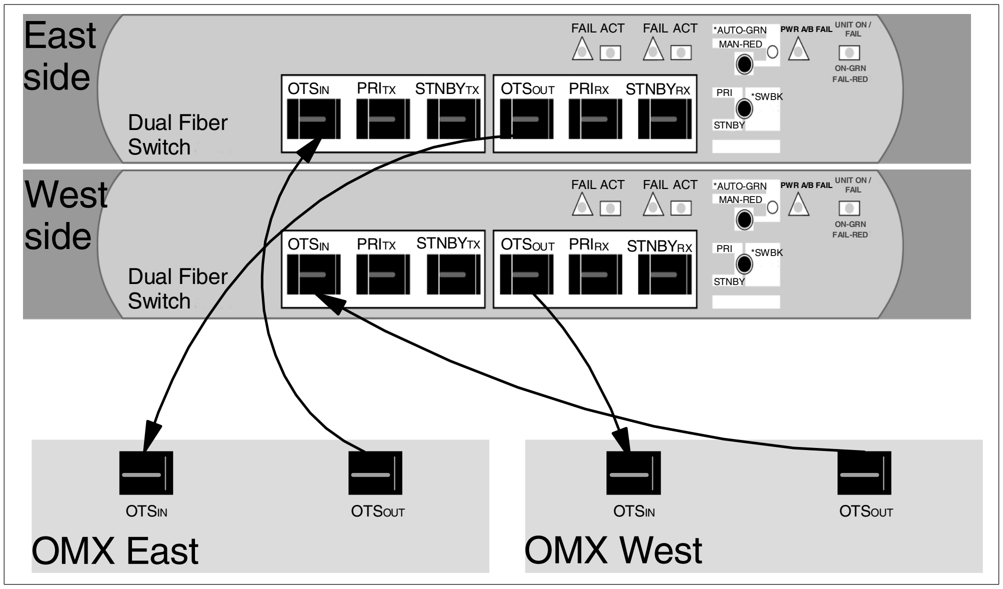


Figure 99. OMX to switches links

Using Figure 98 on page 151 and Figure 99 as a guide:

- At the hub site, ensure Trunk A and Trunk B connect to the DFS that is linked to OMX east, and Trunk C and Trunk D connect to the DFS that is linked to OMX west.
- At the remote site, ensure Trunk A and Trunk B connect to the DFS that is linked to OMX west, and Trunk C and Trunk D connect to the DFS that is linked to OMX east.

Refer to Figure 29 on page 36 for a detailed cabling diagram of a point-to-point configuration.

7.2.4 Synchronize the connections

Check for link failures (red LEDs) in both hub and remote sites. Table 24 lists the type of indicators and their meanings.

Note that the indicator lamps of one switch do not indicate the bidirectional state of the link. Check both sides before taking any action that may affect traffic flow.

Table 24. Dual Fiber Switch trunk indicator lamps

Indicator	Color	State	Description
PRI FAIL	red	on	The primary path has failed.
		off	The primary path is operating normally.
PRI ACT	green	on	Rx is being selected from the primary path.
		off	Rx is being selected from the standby path.
STNBY FAIL	red	on	The standby path has failed.
		off	The standby path is operating normally.
STNBY ACT	green	on	Rx is being selected from the standby path.
		off	Rx is being selected from the primary path.

If one fiber of a fiber pair is cut, only one DFS reports a failed link. This is because only the Rx (receive side) can detect the loss of light.

7.2.5 Using the DFS buttons

There are two buttons on the front side of the DFS, and they are used to do the following:

- Toggle between manual and automatic mode
- Switch traffic back to the primary path (automatic mode)
- Switch traffic between primary and standby Rx selection (manual mode)

  After a failure, if you try to initiate a switchback (from a standby link to the primary link) from the DFS that did not report the failure, that DFS will try to restore traffic to the primary link; however, it will not be able to do so.

  There is an unpredictable traffic disruption of more than 100 ms if you request a switch to a failed link.

Note

Under normal operations, you should not have to use these switches. DFS management is done by software using a TL1 interface or menu commands, via a telnet session.

7.2.6 Alarms via telemetry

Alarms from the switch are reported to the IBM 2029 via a telemetry cable connected to the Central Office alarms and TELemetry(COTEL) card under the maintenance panel cover of the shelf. Each DFS has its own telemetry to a separate shelf. If only one shelf is present, two DFSs can share one shelf with a special telemetry cable.

Figure 100 on page 154 shows how the alarm relay block on the back of the DFS should be connected to the COTEL card of the IBM 2029 shelf.

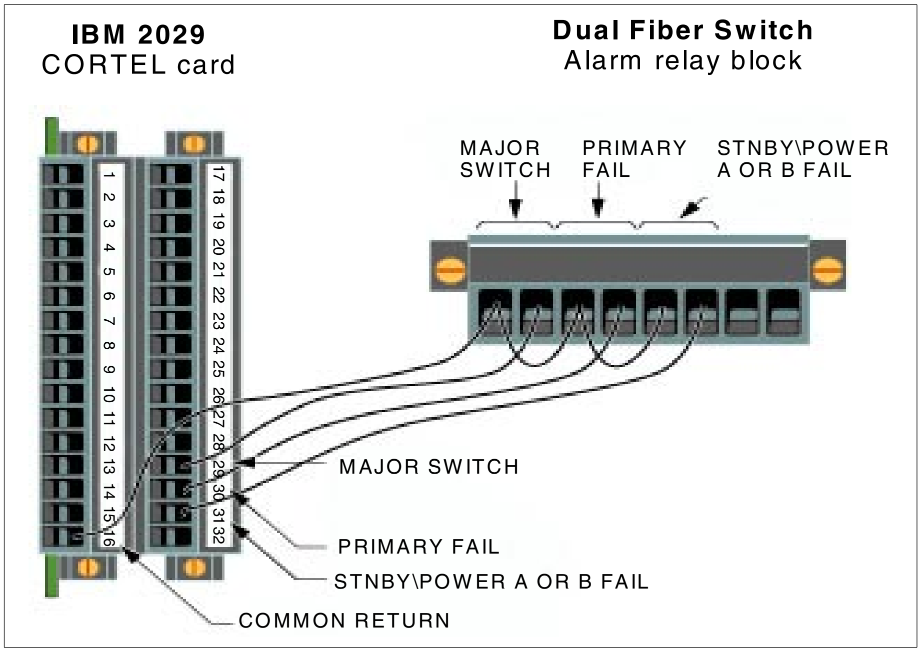


Figure 100. Telemetry connections

To make alarm connections from the DFS to the IBM 2029 COTEL card, do the following:

1. Loosen the two thumb screws on the left maintenance panel cover of the shelf and remove it to expose the CORTEL card.
2. Identify the connectors on the CORTEL card to which the DFS alarm relay block will be connected.
3. Connect the Major Switch relay on the back of the DFS to connector 29 of the COTEL card.
4. Connect the Primary Fail relay on the back of the DFS to connector 30 of the CORTEL card.
5. Connect the STNBY/Power A or B Fail relay on the back of the DFS to connector 31 of the CORTEL card.
6. Connect the second connector of each relay on the back of the DFS to the other relays as shown in Figure 100. Then connect one of the second relay connectors to connector 16 of the CORTEL card.

The DFS alarms will show up on the System Manager, but the DFS cannot be controlled via the System Manger since it has no inband channel monitoring capabilities.

The switch generates three types of alarms:

- When a fiber trunk switch from primary to standby occurs
- When the primary Rx path fails
- When the standby Rx path fails or when there is a power supply failure

The System Manager must be configured for the DFS telemetry alarms. This is done by selecting the Equipment tab of the System Manager and clicking the Telemetry tab.

Configure the input ports according to Table 25.

Table 25. Dual Fiber Switch alarms

Input Port	Description	Recommended alarm severity	Recommended alarm text	Location (on relay)
1	DFS on standby link	Major	Dual Fiber Switch operating on standby link	MAJOR SWITCH
2	DFS primary link failure	Major	Dual Fiber Switch Primary link failure	PRIMARY Fail
3	DFS standby or power fail	Major	Dual Fiber Switch link or Power A/B failure	STNBY/ POWER A or B fail

See Figure 101 for Parallel Telemetry Input. The information in the telemetry window is specific to each shelf. Double-click a cell to view information.

When entered, select **Apply,** then **OK**.

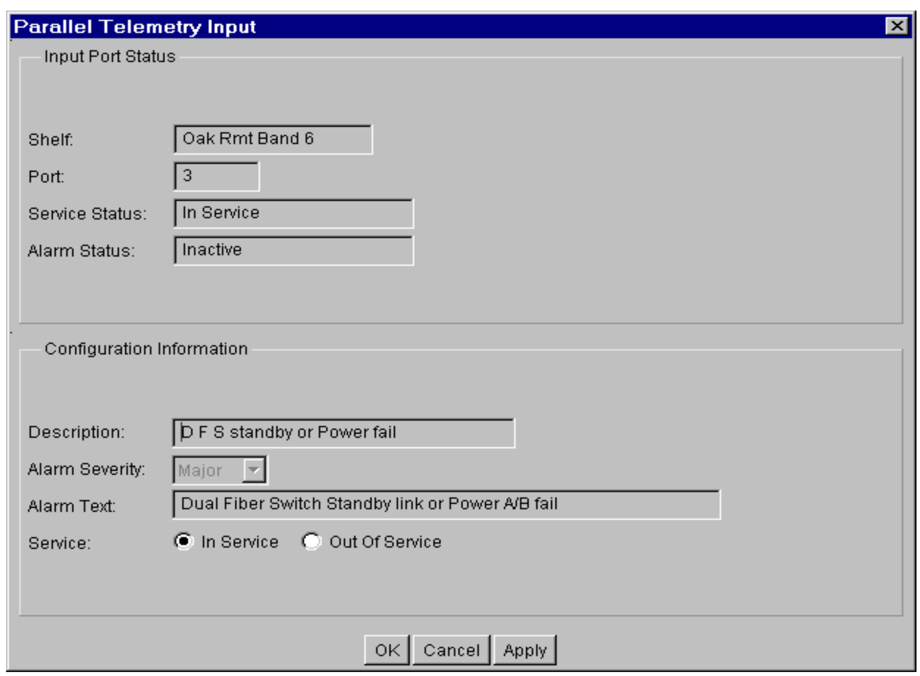


Figure 101. Input Port Status view

Figure 102 on page 156 shows a major alarm on input 3 for SF Hub Band 6. Port 3 has been configured to report either a DFS standby failure or a power failure. At this stage, there is no way to determine exactly which error surfaced. You can check the DFS lamp indicator (see Figure 96 on page 150) or use the TL1 interface menu commands as explained in, “Logs” on page 168.

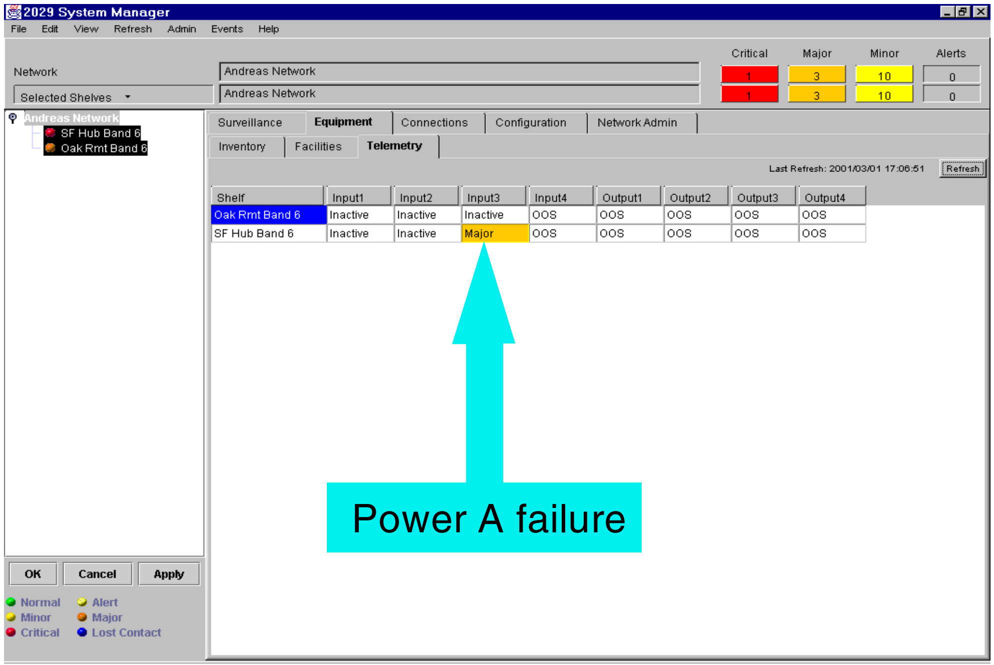


Figure 102. Telemetry Major Alarm

7.3 IP connectivity

This section describes the methods used for IP connectivity to the DFS for management purposes. FTP and telnet are supported. FTP is used when downloading a software binary image from a remote system to DFS flash memory. Telnet allows you to log into the DFS for the initial setup and to monitor its status, logs, and alarms.

The DFS supports basic IP functions. You can define an IP address and subnet mask that would typically conform to the Ethernet LAN environment it is connecting to. It also supports the use of a default gateway that allows for connectivity outside its own LAN. Two connectivity scenarios are discussed, with recommendations on implementing each configuration.

7.3.1 Connecting through a shelf

The stand-alone environment shown in Figure 103 on page 157 is for an IBM 2029 configuration that does not have connectivity to an external IP network; this means no external Ethernet hub is available.

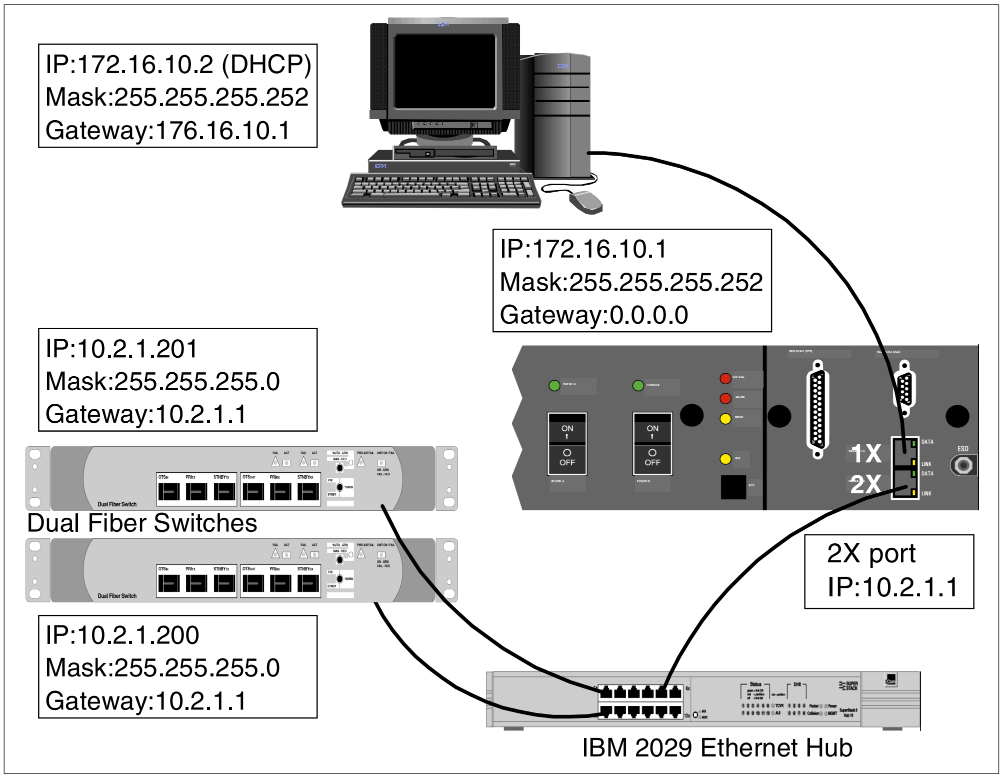


Figure 103. DFS connectivity through a shelf

The physical attributes of this configuration are:

- The IBM 2029 Ethernet hub is used in the hub site to interconnect the shelves and the DFSs.
- Crossover 10Base-T cables are used to connect the IBM 2029 Ethernet hub and the 2X ports on the shelves in the hub site.
- Straight-through 10Base-T cables are used to connect the Ethernet ports on the back of the DFSs to the IBM 2029 Ethernet hub in the hub site.
- A straight-through 10Base-T cable is used to connect the workstation to the 1X port of a shelf.

The logical attributes of this configuration are:

- Private IP addresses (172.16.10.x) are used because the IBM 2029 network is not integrated in an existing TCP/IP network.
- The subnet mask (255.255.255.252) that is assigned to the shelf allows for the use of DHCP.
- The first available IP address of the subnetwork is used as the shelf address.
- The other available IP address of the subnetwork is assigned to the DHCP of the shelf. It is not necessary to define a default gateway address in this IBM 2029 network configuration, since the shelf will be connected to a TCP/IP network.
- The workstation has DHCP enabled and receives the IP attributes from the shelf.

- The internal IP shelf addressing scheme (determined through the Ethernet Hubbing Group) is applied to the DFSs since connectivity will be provided through a shelf. Ethernet Hubbing Group is the integer assigned to the shelf at commissioning time. To omit possible IP addressing conflicts, we recommend using host addresses at the high end of the range; for example, 10.2.hubbing_group.200 and 10.2.hubbing_group.201.
- The IP address of the shelf's 2X port is used as the default gateway of the DFSs. The IP address of the 2X port is determined by the Ethernet Hubbing Group and Shelf ID (10.2.hubbing_group.shelf_ID). If you have multiple shelves in your site, any shelf's 2X port IP address can be used as the default gateway.

Note

In a stand-alone environment, an Ethernet hub for the remote site is provided when the DFSs are ordered. This will enable connectivity to the remote site DFSs. Therefore, the same setup as the hub site DFSs can be applied to the remote site DFSs (with the appropriate remote site IP settings).

Refer to 5.3.1, "Stand alone environment - connecting through a shelf" on page 98 for additional information about the IBM 2029 network configuration and IP addressing scheme.

7.3.2 Connecting through a network

The network environment shown in Figure 104 on page 159 is a configuration that provides LAN connectivity to an external IP network. This means an Ethernet hub is present to allow access to the DFSs from anywhere in the IP network.

In this scenario, because the DFSs are in close proximity to the IBM 2029 shelf (GNE), we recommend connecting them to the same Ethernet hub as the GNE. The same can be done at the remote site.

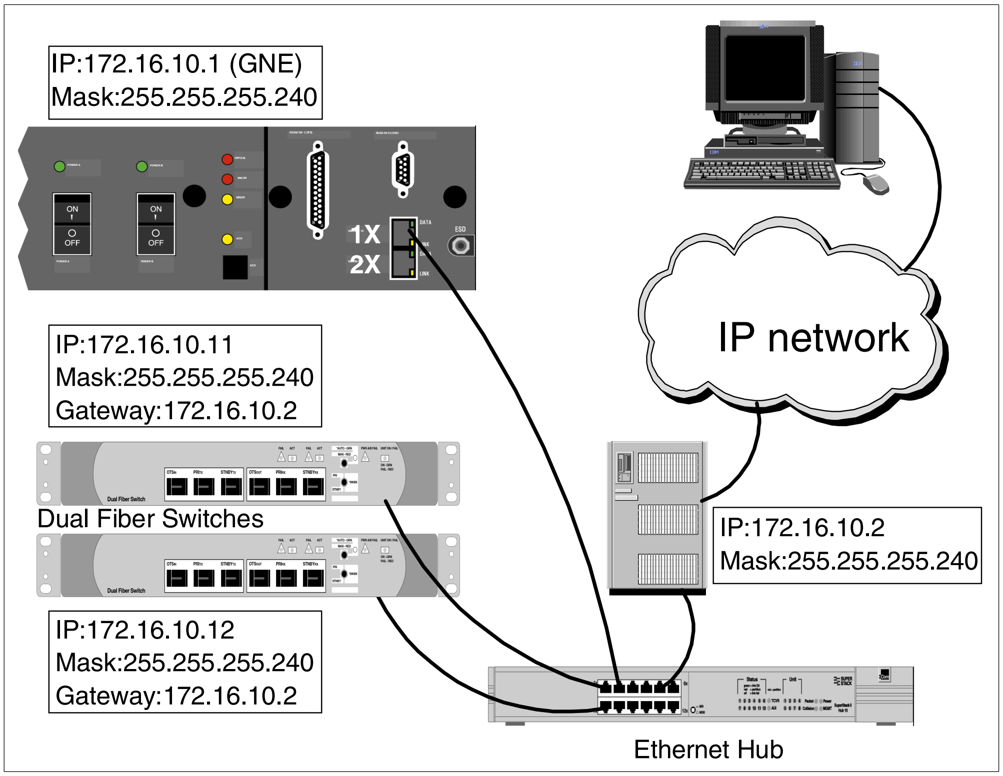


Figure 104. DFS connectivity through an IP network

The physical attributes of this configuration are:

- An IP router is present to allow connectivity to the Ethernet LAN from the IP network.
- The Ethernet hub is used to interconnect the GNE shelf, IP router, and the DFSs.
- Straight-through 10Base-T cables are used to connect the Ethernet ports on the back of the DFSs and the IP router to the Ethernet hub.
- A crossover 10Base-T cable is used to connect the 1X port of the GNE shelf to the Ethernet hub.

The logical attributes of this configuration are:

- Private IP addresses (172.16.10.x) are used; for cases where private address cannot be routed through the network, public addresses must be allocated.
- The subnet mask (255.255.255.240) is the same as the IP router.
- The IP address (172.16.10.2) of the IP router is used as the default gateway of the DFSs.

Recommendation

We recommend an Ethernet hub to be installed in the remote site to provide connectivity to the remote site DFSs.

Any faults on the remote DFSs will raise alarms via the shelves they are connected to, through the telemetry cable. You will not, however, be able to FTP or telnet into the remote site DFSs unless an Ethernet hub is provided.

If an Ethernet hub is available in the remote site, the same setup as the hub site DFSs can be applied to the remote site DFSs (with the appropriate remote site IP settings).

For more details concerning connectivity options, refer to 5.3, “Network connectivity options for system management” on page 97.

7.4 Configuring the DFS

This section describes the necessary steps for defining a DFS as in Figure 103 on page 157; however, they can be applied to any IP configuration.

The Dual Fiber Switch is provided with IP default values. Table 26 lists the terminology and default values used.

Table 26. Dual Fiber Switch IP default values

Name	TL1 name	Default value
Local IP address	IP-ADDRESS	192.170.1.1
Sub-network IP mask	SUBNETMASK	255.255.255.0
Gateway IP address	GTWY-ADDRESS	0.0.0.0

These values, once set, can be reset to the defaults by pressing and holding the AUTO/MAN button for at least nine seconds (until the UNIT ON/FAIL indicator lamp lights).

Establishing communication with the DFS

1. Set up your PC to initiate communications with the Dual Fiber Switch, using the following IP values:
   - IP address: 192.170.1.2
   - Subnet mask: 255.255.255.0
   - Default Gateway: 192.170.1.1
2. Connect the PC Ethernet card directly to the Ethernet port on the back of the DFS, using a 10Base-T crossover cable.
3. Establish a telnet session by selecting Run from the Start menu of the PC.

   In the Run dialog box, type:

   ```
   telnet 192.170.1.1
   ```

   The telnet initial screen will appear, as shown in Figure 105 on page 161.

```
 00-01-01 00:03:24
M  strtup COMPLTD
   OPTICAL TRUNK SWITCH,R1.00"
   /*Marketing P/N          = 18K3341
   Manufacturing Boot P/N = 535-505-009R100
   Manufacturing Appl. P/N = 535-505-008R100 */
;
>
```

Figure 105. Initial telnet screen

4. Log into the Dual Fiber Switch using the default TL1 login ID(OEM_User) and password (OEM_%#1) by typing the following (note that these values are case sensitive):

   `act-user: :OEM_User:x: :OEM_%#1;`

   You will then see the Login screen.

```
;
>act-user: :OEM_User:x: :OEM_%#1;

    00-01-01 00:04:42
M  x COMPLTD
   "OEM_User:,,,,,"
   /* OPTICAL TRUNK SWITCH,
   User Access Privilege:
   THIS SOFTWARE CONTAINS INFORMATION OF VENDOR
   AND IS NOT TO BE DISCLOSED OR USED EXCEPT IN ACCORDANCE
   WITH APPLICABLE AGREEMENTS.
   NOTICE:   THIS IS A PRIVATE COMPUTER SYSTEM.
   USE OF THIS SOFTWARE IS GOVERNED SOLELY AS EXPRESSLY
   AUTHORIZED IN THE RELEVANT AGREEMENT BETWEEN
   VENDOR AND CUSTOMER.
   UNAUTHORIZED ACCESS OR USE MAY LEAD TO PROSECUTION.
   COPYRIGHT 2000. */
;
>
```

Figure 106. Login screen

5. Launch the menu session by issuing the following command:

   `menu;`

   You will see the main menu screen shown in Figure 107 on page 162.

```
;
>menu;

* Optical Trunk Switch Main Menu [00-01-01 00:05:11] *

Card Type:              Optical Trunk Switch
Card ID:                HUBBOTDFS


[a] Card Information
[b] Card Operations
[c] Card Logs and Alarms

[x] Exit
```

Figure 107. Main menu

6. From the main menu, select option **b** for Card Operations.

```
* Optical Trunk Switch Card Operations [00-01-01 00:05:15] *

[a] Change Date
[b] Change Time
[c] Change Card ID
[d] Change IP Address
[e] Change IP Net Mask
[f] Change IP Gateway Address
[g] Change Mode Between Automatic and Manual
[h] Change Optical Switch Position
[i] Trigger Switch-back to PRI
[j] Enable/Disable Autonomous Messages
[k] FTP Software Download
[r] Reset Card

[p] Previous Menu
[x] Exit
```

Figure 108. Card Operations menu

7. From the Card Operations menu, select option **d** to modify the IP address setting, then press Enter.

```
You can enter the IP address and also use the backspace key.
Press ENTER to validate your entry or press ESC to cancel.

[010.002.001.200]

*** This change will take effect only after the card is reset ***


Press ENTER to continue.
```

Figure 109. DFS IP address

8. From the Card Operations menu, select option **e** to modify the subnetwork mask setting, then press Enter.

```
You can enter the IP Net Mask and also use the backspace key.
Press ENTER to validate your entry or press ESC to cancel.

[255.255.255.  0]

*** This change will take effect only after the card is reset ***


Press ENTER to continue.
```

Figure 110. DFS IP Net Mask

9. From the Card Operations menu, select option **f** to modify the default gateway setting, then press Enter.

```
You can enter the IP Gateway Address and also use the backspace key.
Press ENTER to validate your entry or press ESC to cancel.

[010.002.001.001]

*** This change will take effect only after the card is reset ***


Press ENTER to continue.
```

Figure 111. DFS IP Gateway Address

The DFS is now ready to be reset. This operation will then make all the IP setting changes effective. From the Card Operations menu, select option **r**, then press Enter. You will be requested to confirm this operation.

```
Do you really want to reset card?

[y] Yes
[n] No

>



>

*** Card is being reset! ***


Press ENTER to continue.
```

Figure 112. DFS reset

The telnet session will be disconnected from the DFS, since they are no longer in the same LAN segment (subnetwork).

Proceed in the same manner with the other DFSs by initiating communication from the PC. Prior to setting up each DFS, ensure the ARP table entry from the preceding DFS is deleted from your PC. This will avoid having a problem connecting to the next DFS due to a mismatched MAC address in the ARP table. Do so by typing the following:

```
arp -d 192.170.1.1
```

When the IP settings for all DFSs are complete, connect the DFSs to their respective Ethernet hubs using a straight-through 10Base-T cable and set the PC back to DHCP enabled or to your specific IP settings.

The DFSs are now ready to be operated from the PC. See 7.5, “Commands” for Dual Fiber Switch control and monitoring.

7.5 Commands

Commands can be passed to the DFS by using either the menu options or the command line TL1 interface.

These commands can be used to:

- Get additional information about the alarms (switch logs)
- Isolate alarms on a 2 DFS per shelf configuration
- Isolate a standby link fail from a switch power fail as both share the same telemetry link
- Provide switch controls (reset IP address, switch on demand)

We recommend to using the menu options since most of the information available from the TL1 interface is also available from the menu interface. The use of the menu options is easier and more convenient.

If your session is idle for 10 minutes, the menu session logs out and returns to the TL1 interface.

7.5.1 TL1 Interface Commands

TL1 is an industry-recognized common language protocol used to exchange messages between network elements and an operating system.

The commands to open and close a DFS TL1 session are:

- `act-user: :OEM_User:x: :OEM_%#1;` (to activate a session)
- `canc-user: :OEM_User:x;` (to close a session)

The TL1 default login ID and password are case sensitive.

You must type these TL1 commands exactly as they appear in Table 27.

Table 27. Dual Fiber Switch TL1 Interface commands

Command	Purpose
`act-user`	Activate the TL1 user administration session.
`alw-msg-all`	Allow reporting of autonomous message.
`canc-user`	Terminate the TL1 administration session.
`dwnld-sw`	Initiate an FTP software download. *This command is not Telecordia-compliant.*
`ed-dat`	Set real time clock date and time.
`ed-eqpt`	Set equipment information.
`ed-pid`	Change a user password (PID).
`ent-sys`	Change the Dual Fiber Switch IP values.
`inh-msg-all`	Inhibit reporting of autonomous messages.
`init-log`	Clear the current log.
`init-sys`	Cause a Dual Fiber Switch reset.
`menu`	Initiate menu command interface. *This command is not Telecordia-compliant.*
`rtrv-alm-eqpt`	Display current equipment alarm conditions.
`rtrv-eqpt`	Display equipment information.
`rtrv-hdr`	Display current date and time.
`rtrv-log`	Display current log.
`rtrv-netype`	Display product identification and software version number.

TL1 Interface commands are described and detailed in *Planning and Operations Guide,* SG28-6808.

7.5.2 Menu commands

After logging in to the DFS, type `menu;` (the main menu is displayed). The choices shown have the following meanings:

- [a] Card Information. Display system level information, such as card ID, card type, and card IP.
- [b] Card Operations. Allows the selection of the configurations possible on the card by the Card Operations Menu.
- [c] Card Logs and Alarms. Allows the selection of the configuration possible on the Card Logs and Alarms Menu.

```
Card Type:              Optical Trunk Switch
Card ID:                HUBBOTDFS


[a] Card Information
[b] Card Operations
[c] Card Logs and Alarms

[x] Exit
```

Figure 113. Main menu

See Figure 114 for the card details. The Optical Mode is set to AUTOMATIC and the Standby trunk is in use. The switch IP settings are also displayed.

```
Optical Trunk Switch Card Information [00-01-01 00:06:58]

Card Type:              Optical Trunk Switch
Card ID:                HUBBOTDFS
Optical Mode:           AUTOMATIC
Switch Position:        Standby
Autonomous Messages:    Disabled
IP Address:             10.2.1.200
Subnet Address Mask:    255.255.255.0
Gateway Address:        10.2.1.1
Ethernet Address:       00:01:9c:00:00:1e
Software Boot P/N:      535-505-009R100
Software P/N:           535-505-008R100
CLEI Code:              WMMMN30GRA
Marketing P/N:          18K3341
Manufacturing P/N:      535-503-017-100
Serial Number:          PC000030

Press ENTER to continue.
```

Figure 114. Card information

Controlling the Dual Fiber Switch

From the main menu (Figure 113 on page 166), select option **b** for Card Operations; you will see the screen shown in Figure 115.

```
 * Optical Trunk Switch Card Operations [00-01-01 00:44:53] *

 [a] Change Date
 [b] Change Time
 [c] Change Card ID
 [d] Change IP Address
 [e] Change IP Net Mask
 [f] Change IP Gateway Address
 [g] Change Mode Between Automatic and Manual
 [h] Change Optical Switch Position
 [i] Trigger Switch-back to PRI
 [j] Enable/Disable Autonomous Messages
 [k] FTP Software Download
 [r] Reset Card

 [p] Previous Menu
 [x] Exit
```

Figure 115. Card Operations screen

Table 28 describes the commands that are available through the Card Operations menu. Options [**d**], [**e**], and [**f**] are for the DFS IP settings; an example of their usage can be found in 7.4, "Configuring the DFS" on page 160.

Table 28. Card Operations commands

Option	Command	Description
[a]	Change Date	Use this command to enter the new current date.
[b]	Change Time	Use this command to enter the new current time.
[c]	Change Card ID	Use this command to change the DFS ID.
[d]	Change IP Address	Use this command to change the IP address of the DFS. The change takes effect after a reset card command is issued.
[e]	Change IP Net Mask	Use this command to change the IP subnetwork mask of the DFS. The change takes effect after a reset card command is issued.
[f]	Change IP Gateway Address	Use this command to change the IP gateway address of the DFS. The change takes effect after a reset card command is issued.
[g]	Change Operating Mode Between Automatic and Manual	Use this command to change the operating mode; for example, from manual to automatic.
[h]	Change Optical Switch Position	Use this command to change the position of the DFS.
[i]	Trigger switchback to PRI	Use this command to trigger the switch to the primary path.
[j]	Enable/disable autonomous messages	Use this command to toggle autonomous messages on or off.
[k]	FTP Software Download	Use this command to initiate an FTP software download to the DFS from the specified external server.
[r]	Reset Card	Use this command to reset the DFS. Note that this command terminates the menu session.

7.5.3 Logs and alarms

Card Logs and Alarms are selected from option [**c**] of the main menu. Three entries can be then selected:

- [a] Display logs

  This command is used to display the 25 most recent logs.

- [b] Delete logs
- [c] Display alarms

  Use this command to display all the alarms on the DFS.

Figure 116 shows the Logs and Alarms menu.

```
* Optical Trunk Switch Card Logs and Alarms [00-01-01 00:07:49] *

[a] Display Logs
[b] Delete Logs
[c] Display Alarms

[p] Previous Menu
[x] Exit
```

Figure 116. Logs and alarms

Logs

The most recent logs are saved (up to 25 lines). They are displayed in the following format: Date, time, Log Text.

```
Log Entries:
2000-01-01 00:04:42 LOG-IN: OEM_User
2000-01-01 00:00:00 ALM-ON-STNBY-FAIL MIN SYS
2000-01-01 00:00:00 MAJOR-SWITCH to STNBY by PRI FAIL
2000-01-01 00:00:00 ALM-ON-PRI-FAIL MAJ SYS
2000-01-01 00:00:00 ALM-ON-SW-STNBY CRIT SYS
2000-01-01 00:00:00 ALM-ON-48VB MIN SYS

Press ENTER to continue.
```

Figure 117. Logs entries

The list and the description of the Log Text can be found in Appendix C of the *Planning and Operations Guide*, SG28-6808.

Alarms

The alarm information for the DFS is accessed through the System Manager. This can also be viewed from the card Logs and Alarms Menu.

```
Alarm            Grp  Condition
-------------------------------------------------
48V_B           MN  EQPT Lost 48B volt power supply
ALM_PRI_FAIL    MJ  EQPT PRI loss of signal
ALM_STNBY_FAIL  MN  EQPT STNBY loss of signal
ALM_SW_PRI2SEC  CR  EQPT Optic switch to STNBY
```

Figure 118. Alarms

If you are making use of the telemetry feature as described in 7.2.6, “Alarms via telemetry” on page 153, then the alarms can also be viewed and managed from the System Manager.

Chapter 8. Hardware Management Console (HMC)

This chapter describes the requirements to implement the Hardware Management Console (HMC) for surveillance of the IBM 2029 network. The HMC definitions will be described and detailed.

Among the features of the HMC is its ability to receive alarms from the IBM 2029 shelves; certain classes of errors will cause the HMC to “call home” to IBM with details of the problem.

8.1 Overview

Systems management for the IBM 2029 is provided through a JAVA (1)-based application which launches a Web browser graphical user interface (GUI). Each channel can be configured and monitored from the console. Configuration and connection management, software updates, alarm management, monitoring, and administration are also performed via the System Manager.

In addition to the System Manager interface, the IBM 2029 shelves can now communicate with the HMC via SNMP. The HMC must register with the IBM 2029 shelf to receive SNMP traps. This function is supported when the HMC is operating at Driver 36E (version 1.7.0) and above.

Critical shelf alarms cause the HMC to call home with details of the problem. The alarms which generate a call home are presented in 8.4.2, “Call home function” on page 178.

8.2 IP connectivity

Each HMC is shipped with an Ethernet port; an optional Token Ring port can be added. Many customers prefer to have the HMC and the attached CPCs connected to a private “Service LAN”. This LAN can then be linked to an IP network via a LAN hub or switch, or an IP router. The connectivity scenarios depicted in this section are using the IP network configuration described in 5.3.4, “Connecting via an IP network in a dual GNE environment” on page 105.

Figure 119 on page 172 shows an example of a direct LAN connectivity option. Since the CPC is connected to the HMC via a Token Ring, the Ethernet port of the HMC is used to communicate with the IBM 2029 network via an Ethernet hub.

The gateway (IP address of the GNE shelf) and subnetworks of the IBM 2029 network have to be defined (as route statements) to the HMC to allow access to the shelves. This can be done via the routing tab of the HMC TCP/IP definition settings.

The LAN 1 adapter (Ethernet) of the HMC has to be defined to the same LAN segment (subnetwork) as the IBM 2029 GNE shelf.

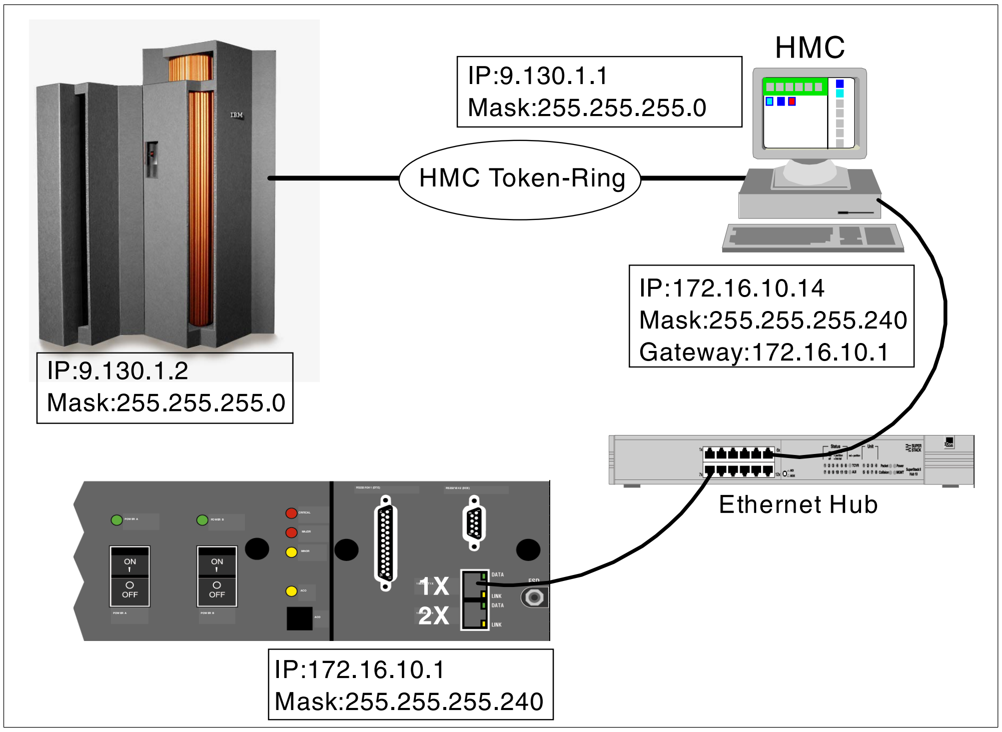


Figure 119. HMC and IBM 2029 GNE shelf on the same LAN

In the second example (see Figure 120 on page 173) the HMC and IBM 2029 GNE shelf are on two separate LANs. The HMC connects to the IBM 2029 network via an IP router.

The gateway (IP address of the router) has to be defined to the HMC to allow access to the shelves in the IBM 2029 network. This can be done via the routing tab of the HMC TCP/IP definition settings. If the IP router is using OSPF to communicate routing information with the IBM 2029 GNE shelf, then the IP router should be defined as the default router in the HMC. Otherwise, the subnetworks of the IBM 2029 shelves must be defined as route statements pointing to the IP router, in the HMC.

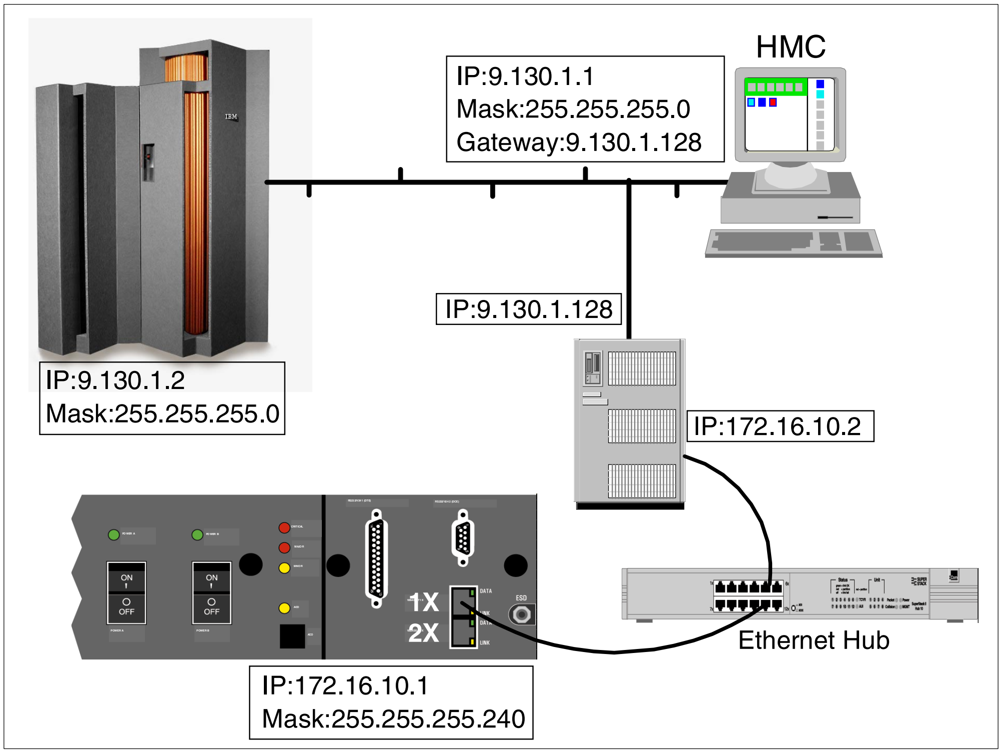


Figure 120. HMC and IBM 2029 GNE shelf in separate LANs

For more information concerning the IBM 2029 network options, refer to 5.3, "Network connectivity options for system management" on page 97.

8.3 Defining a shelf to the HMC

Since the IBM 2029 shelves do not support the NetBIOS protocol, they will not be autodiscovered by the HMC. In order to collect SNMP traps, each shelf must be manually defined to the HMC. A shelf will only forward its own SNMP traps to the HMC.

The procedure to define an IBM 2029 shelf to the HMC is as follows:

1. Log on using the ACSADMIN user ID.
2. Open (double-click) **Groups** from the Views Area.

   The new icon **Undefined Fiber Savers** is now displayed in the Groups Work area as shown in Figure 121 on page 174.

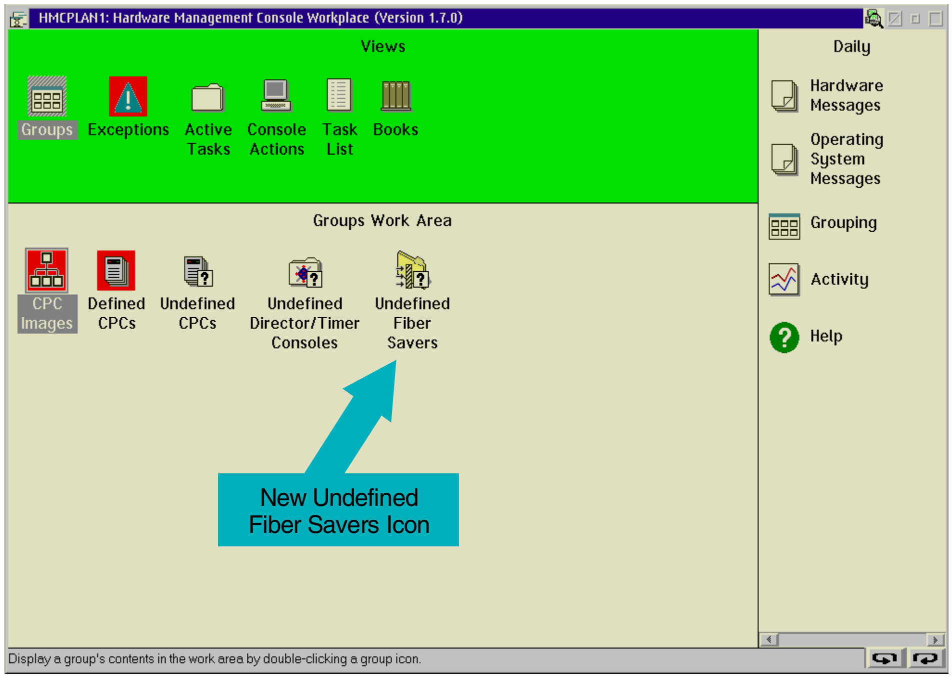


Figure 121. Group Work Area, user ACSADMIN

3. Double-click **Undefined Fiber Savers.** The Fiber Saver Definition Template icon and icons for any previously defined IBM 2029 shelves will be displayed as shown in Figure 122.
4. Scroll the Task List to **Object Definitions.**
5. In the Undefined Fiber Savers Work Area, drag and drop the Fiber Saver Definition Template icon onto the Add Object Definition icon in the Object Definitions task list.

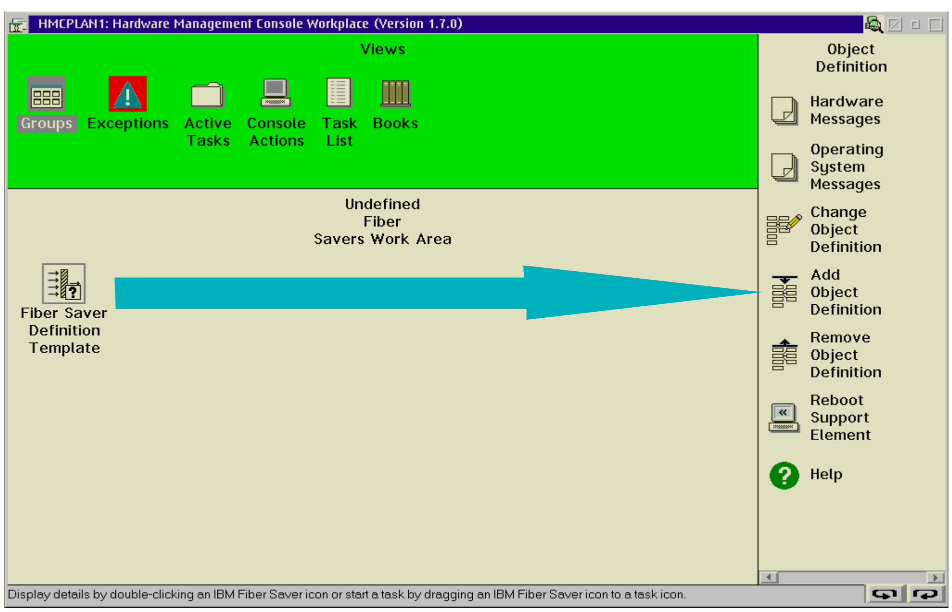


Figure 122. Undefined Fiber Savers Work Area

6. The IBM Fiber Saver (2029) Manual Add Object Definition window will appear.

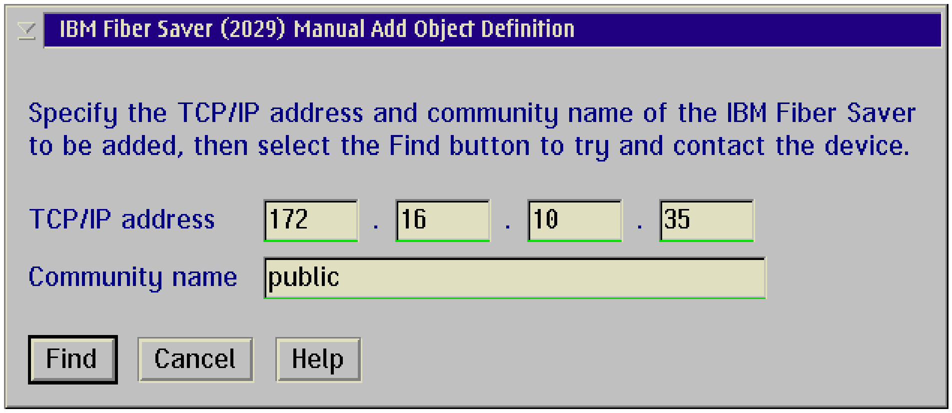


Figure 123. Manual Add Object Definition

7. Provide the TCP/IP address and Community name of the shelf to be defined.
   d. TCP/IP address: this is the IP address of the shelf you want to receive SNMP traps from.
   e. Community name: this SNMP community parameter must match that used in the shelf. The default is *public*.
8. Click **Find**. This will first check if the TCP/IP address is valid, then check if the contacted address is really an IBM 2029 shelf. When communication is established with the IBM 2029, a product information panel appears with details regarding the IBM 2029 shelf. See Figure 124 for an example.

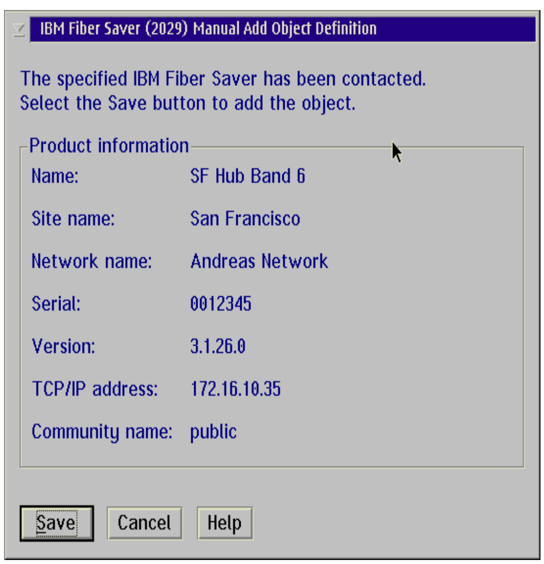


Figure 124. Product Information panel

9. Click **Save**. The specified IBM 2029 shelf will be added to the Group Work Area as Defined Fiber Savers.
10. Click **OK** in the Confirmation pop-up window.

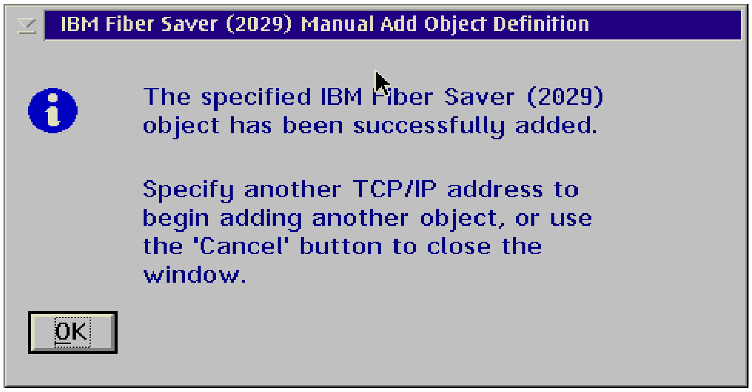


Figure 125. IBM 2029 added

11.Log off and then log on to the HMC using the SYSPROG user ID. Open (double-click) **Groups** in Views. The Defined Fiber Savers icon now appears in the work area as shown in Figure 126.

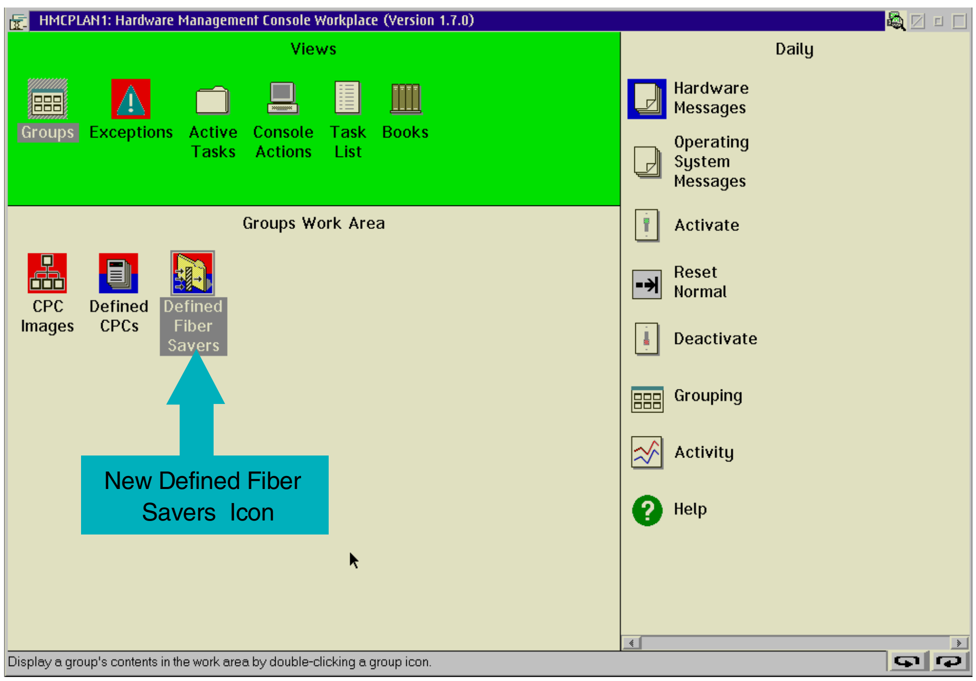


Figure 126. SYSPROG user ID Groups Work Area

12.Open **Defined Fiber Savers** (double-click). See Figure 127 on page 177.

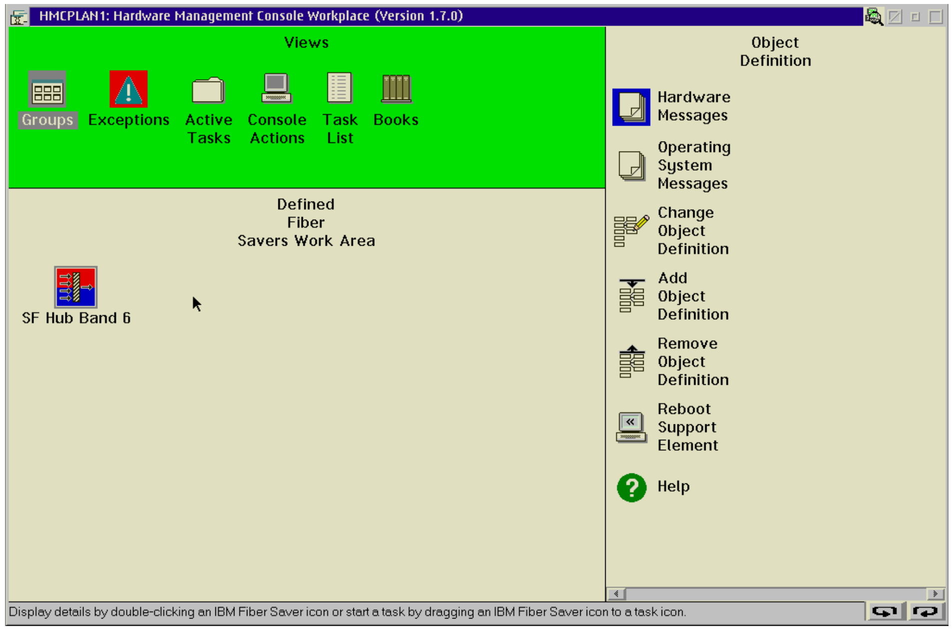


Figure 127. Defined Fiber Savers Work Area

13.Open (double-click) **SF Hub Band 6**. The Details panel, shown in Figure 128, displays the following information:

1. Instance Information, in this case, Alert Pending
2. Alarm Information, which mirrors information from the System Manager’s active alarms window
3. Product Information

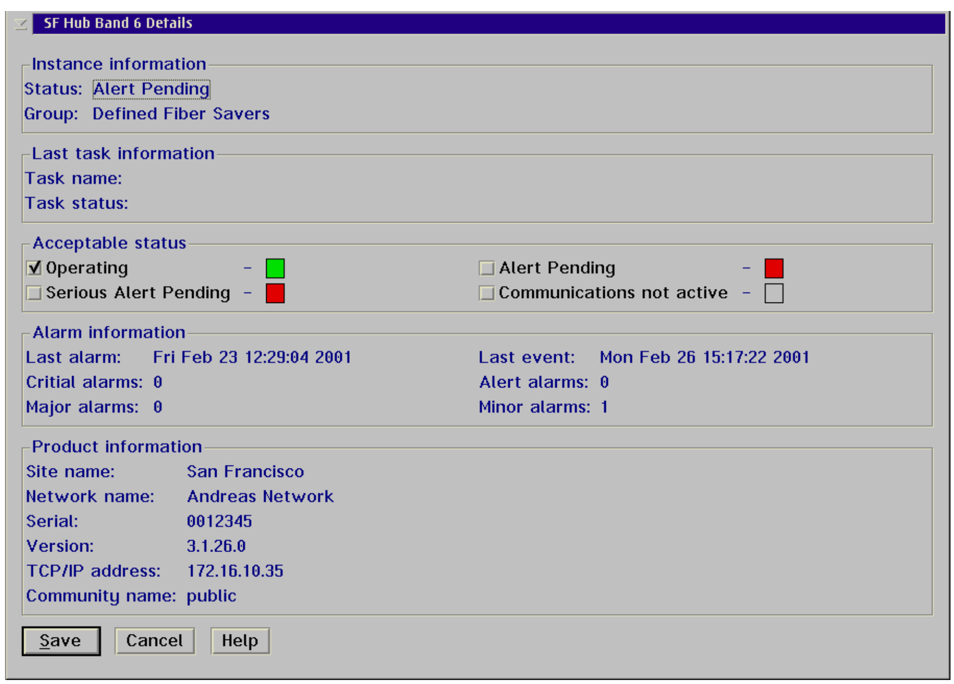


Figure 128. SF HUB 6 Details

8.4 HMC alarms and call home function

HMC support for the IBM 2029 extends IBM's proven "call home" function and level of service to your IBM 2029 shelves. This ensures that problems in your IBM 2029 network are not left undetected.

8.4.1 Alarms

All IBM 2029 alarms are displayed on the HMC via the Hardware Messages task. As shown in Figure 129, the information displayed includes:

- The text of the alert
- The name of the shelf where the alarm originated
- Date and time when the alarm originated
- Severity of the alarm
- State of the alarm
- Description

This alarm will generate a call to IBM.

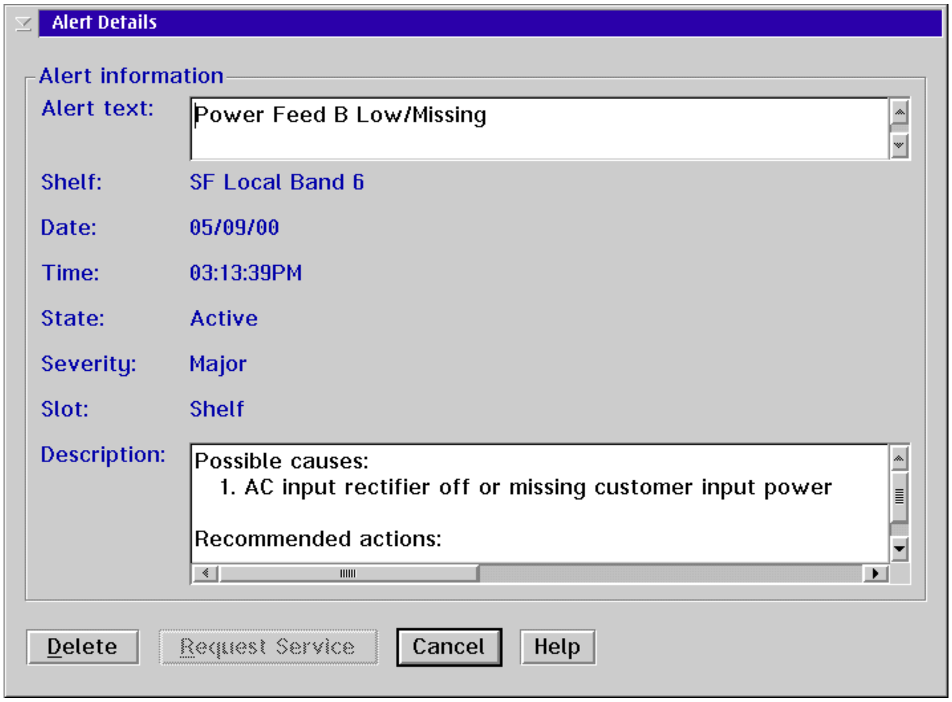


Figure 129. Alarm Details

8.4.2 Call home function

The Hardware Management Console will receive alerts from all defined IBM 2029 shelves and, for certain classes of alerts, will generate a "call home".

These alerts are:

- Circuit Card Missing
- Circuit Card Failed
- RX Optical Input Failure
- No supporting OMX
- Loss Of Activity
- Backplane Signal Failure
- Sbus Failure
- Breaker A Tripped
- Breaker B Tripped
- Brownout
- Cooling Unit Missing/Failed
- OMX Mismatch
- 10Base-T 1X Input Failure
- 10Base-T 2X Input Failure
- Loss of Overhead Synchronization
- Overhead Link Failure
- Power Feed A Low/Missing
- Power Feed B Low/Missing

Chapter 9. Problem determination using the System Manager

This chapter discusses the use of the System Manager as a problem determination aid in diagnosing error conditions that may occur in the IBM 2029 network.

A simple point-to-point network configuration example is used to highlight the information that is available via the System Manager to help diagnose the cause of link failures. The procedures described in this chapter can generally be applied to most IBM 2029 network errors.

9.1 Test environment configuration

Figure 130 shows the configuration that will be used for the problem determination examples in this chapter. We have provisioned two base (unprotected) channels.

For clarity, the IBM 2029 network has only these two channels provisioned in the shelf pair band.

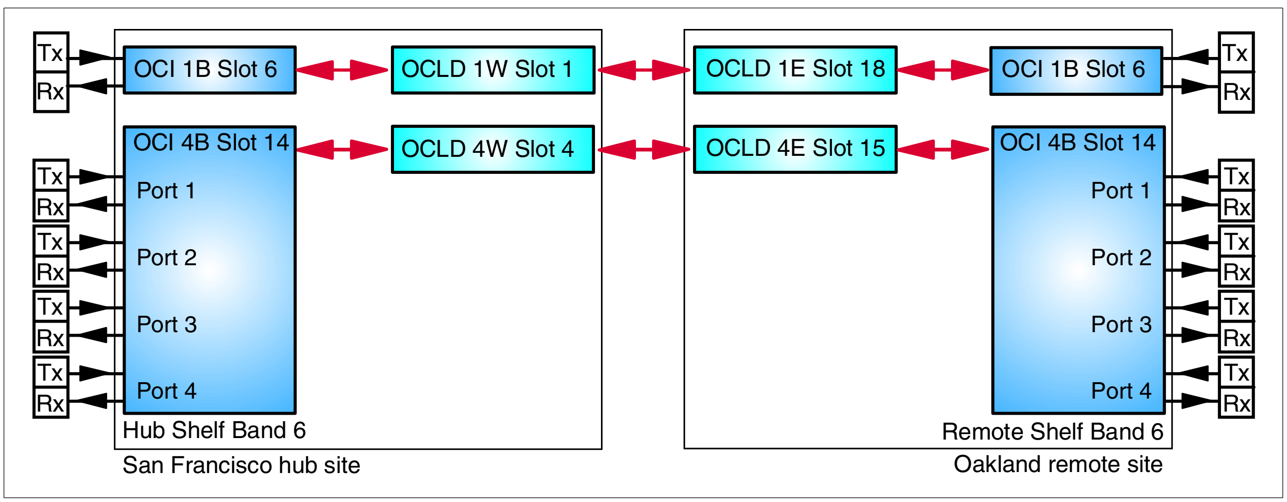


Figure 130. Configuration used for problem determination scenarios

The band and channel allocation chart that was used during the channel provisioning procedure is shown in Table 29 on page 182.

> **Note**
>
> It is important that a channel allocation chart be used and maintained for your IBM 2029 network configuration. It must contain current and accurate channel provisioning data. This chart is extremely useful as a problem determination tool in understanding the OCI-to-OCLD channel mapping through the network, and therefore reconciling which active alarms are associated with an error condition.

Table 29. Band and channel allocation chart for problem determination configuration

Network name: *Andreas Network*			Hub Site name: *San Francisco* Hub Site ID:*1*					Remote Site name:*Oakland* Remote Site ID:*2*				
			IBM 2029 frame serial:*12345*					IBM 2029 frame serial:*67890*				
			TOP SHELF pair band number:*6*									
			Hub Shelf name: *SF Hub Band 6* Shelf ID: *6* Hubbing group:*1*					Remote Shelf name: *Oak Rmt Band 6* Shelf ID: *14* Hubbing group:*2*				
Channel Description	Protocol	Mode B / HA	P/P top	OCI Card / Slot		OCLD Card / Slot		OCLD Card / Slot		OCI Card/Slot		P/P top
~~Aggregate:~~ Port 1:*P701 ETR port 1* ~~Port 2:~~ ~~Port 3:~~ ~~Port 4:~~	*ETR*	*B*	T6 1 ~~2~~ ~~3~~ ~~4~~	1B	6	1W	1	1E	18	1B	6	T6 1 ~~2~~ ~~3~~ ~~4~~
Aggregate: 4-TDM Slot 14 Port 1: *SWAE Port EC* Port 2: *SWAE Port AD* Port 3: *P701 CHPID A6* Port 4: *P601 CHPID A9*	*ESCON*	*B*	T14 1 2 3 4	4B	14	4W	4	4E	15	4B	14	T14 1 2 3 4

One of the IBM 2029 channels supports an ETR link between a server (known as P701) and a 9037-002 Sysplex Timer. The other IBM 2029 channel that has been provisioned uses a 4TDM card to support four ESCON links. Two of the links are from a server to an ESCON Director, and the other two are from an ESCON Director to control unit interfaces.

9.2 Normal operational status

It is important to understand what status is good for an IBM 2029 channel link and attached devices, as displayed on the System Manager workstation. The initial conditions for this network are:

- ETR ports on both the server and the 9037-002 are enabled.
- ESCON CHPIDs are online to the operating systems running in the servers.
- ESCON director ports are unblocked and have a status of online (that is, the ports can see light on attached ESCON interface cables).
- Attached device interfaces are enabled.
- There are no outstanding IBM 2029 equipment alarms on the System Manager workstation.

After logging in to the System Manager, the IBM 2029 System Manager window is displayed. See Figure 131 on page 183.

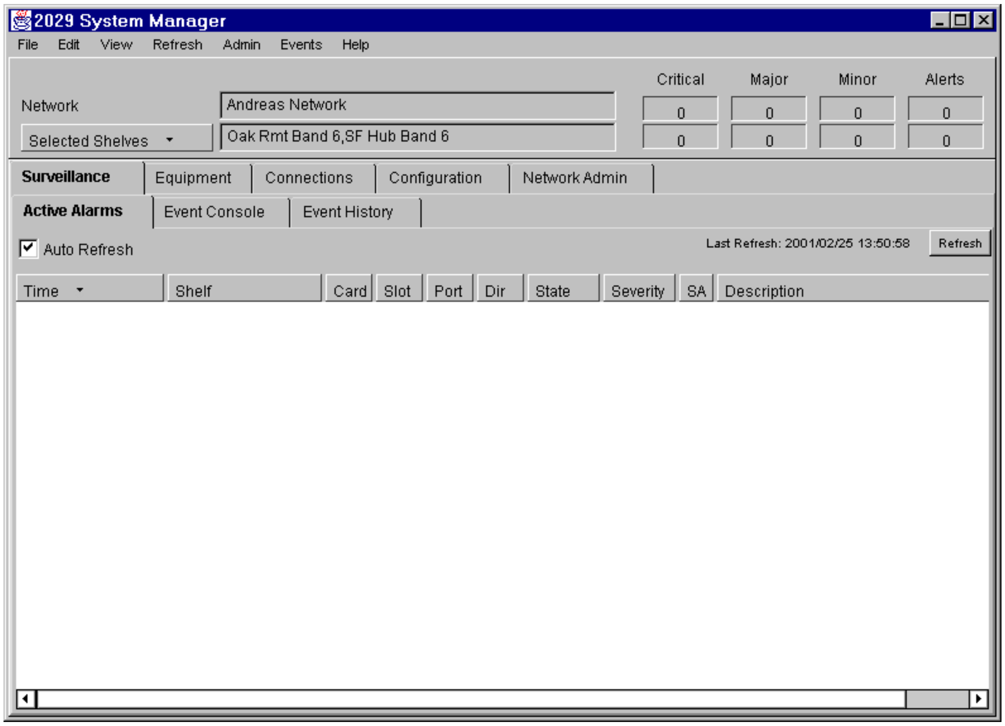


Figure 131. IBM 2029 System Manager window - no active alarms

On the IBM 2029 System Manager display, information relating to only SF Hub Band 6 and Oak Rmt Band 6 is displayed for clarity. This filtering of shelf information is done using the following procedure:

- Click the **Selected Shelves** tab; the Network tree is displayed.
- Click shelf icon **SF Hub Band 6**; the icon is highlighted.
- Press and hold the **Ctrl** key and click shelf icon **Oak Rmt Band 6**. Both shelf icons are highlighted.
- Click the **Apply** button.
- Click the **Selected Shelves** tab again to hide the Network tree.
- Click **Surveillance,** then **Active Alarms** to display the current active alarms for both Band 6 shelves.

In Figure 131:

- The upper area of the IBM 2029 System Manager window is the Alarm Banner. This shows a summary count of active alarms in the IBM 2029 network using colored fields.
- The top row of the Alarm Banner shows the number and type of alarms which are currently active for the whole Andreas Network (all shelves).
- The bottom row of the Alarm Banner shows alarms which are currently active for the shelves selected from the Network tree (SF Hub Band 6, Oak Rmt Band 6).
- The alarm banner uses red, orange, and yellow to highlight the alarm counts that have not been acknowledged.

The alarm categories are:

- Critical (Red): A traffic-affecting anomaly that requires immediate attention.
- Major (Orange): An anomaly that may affect traffic if it does not receive immediate attention.
- Minor (Yellow): A secondary indicator of another alarm or a condition that does not affect traffic.
- Alerts (Light Yellow): An anomaly that is not traffic affecting; an alert can be an early indication of equipment that is failing.

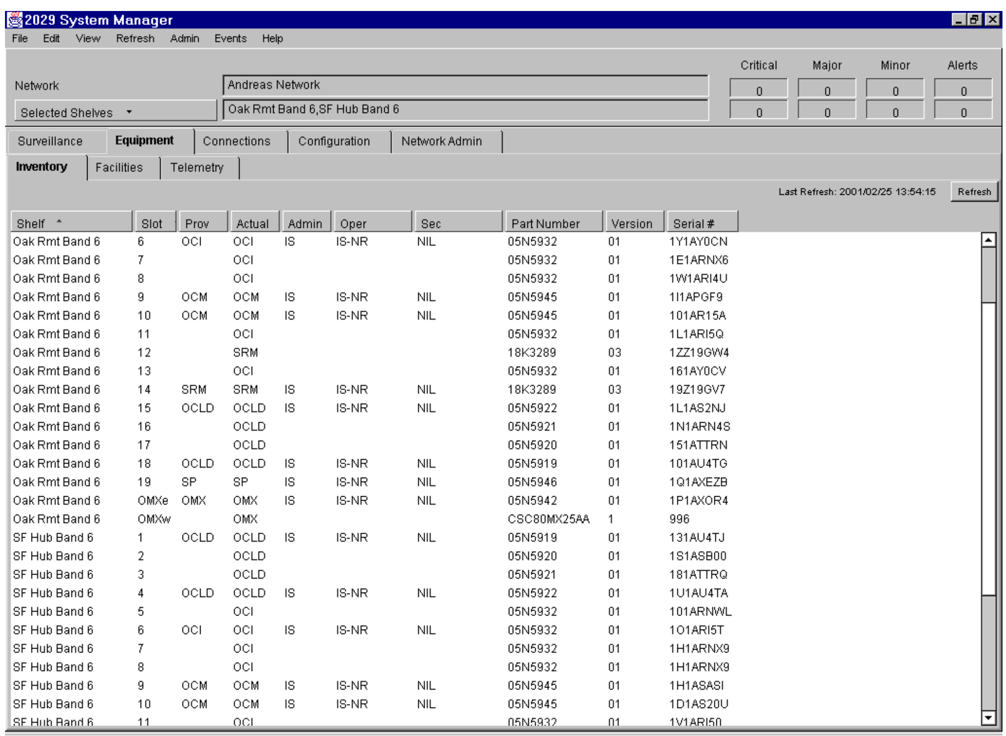
Gray indicates acknowledged alarms and alerts. Clicking a colored Alarm field acknowledges the alarm and turns the icon gray.

- There are no active alarms of any category present in the Alarm Banner. Also, there are no active alarms displayed in the **Surveillance - Active Alarms** window.
- The **Active Alarms** window updates automatically when the **Auto Refresh** option is selected.

To display the current physical operational state of the shelf hardware:

- Click **Equipment**, then **Inventory.**
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Equipment - Inventory** window is displayed in Figure 132.



Shelf	Slot	Prov	Actual	Admin	Oper	Sec	Part Number	Version	Serial #
Oak Rmt Band 6	6	OCI	OCI	IS	IS-NR	NIL	05N5932	01	1Y1AY0CN
Oak Rmt Band 6	7		OCI				05N5932	01	1E1ARNX6
Oak Rmt Band 6	8		OCI				05N5932	01	1W1ARI4U
Oak Rmt Band 6	9	OCM	OCM	IS	IS-NR	NIL	05N5945	01	1I1APGF9
Oak Rmt Band 6	10	OCM	OCM	IS	IS-NR	NIL	05N5945	01	101AR15A
Oak Rmt Band 6	11		OCI				05N5932	01	1L1ARI5Q
Oak Rmt Band 6	12		SRM				18K3289	03	1ZZ19GW4
Oak Rmt Band 6	13		OCI				05N5932	01	161AY0CV
Oak Rmt Band 6	14	SRM	SRM	IS	IS-NR	NIL	18K3289	03	19Z19GV7
Oak Rmt Band 6	15	OCLD	OCLD	IS	IS-NR	NIL	05N5922	01	1L1AS2NJ
Oak Rmt Band 6	16		OCLD				05N5921	01	1N1ARN4S
Oak Rmt Band 6	17		OCLD				05N5920	01	151ATTRN
Oak Rmt Band 6	18	OCLD	OCLD	IS	IS-NR	NIL	05N5919	01	101AU4TG
Oak Rmt Band 6	19	SP	SP	IS	IS-NR	NIL	05N5946	01	1Q1AXEZB
Oak Rmt Band 6	OMXe	OMX	OMX	IS	IS-NR	NIL	05N5942	01	1P1AXOR4
Oak Rmt Band 6	OMXw		OMX				CSC80MX25AA	1	996
SF Hub Band 6	1	OCLD	OCLD	IS	IS-NR	NIL	05N5919	01	131AU4TJ
SF Hub Band 6	2		OCLD				05N5920	01	1S1ASB00
SF Hub Band 6	3		OCLD				05N5921	01	181ATTRQ
SF Hub Band 6	4	OCLD	OCLD	IS	IS-NR	NIL	05N5922	01	1U1AU4TA
SF Hub Band 6	5		OCI				05N5932	01	101ARNWL
SF Hub Band 6	6	OCI	OCI	IS	IS-NR	NIL	05N5932	01	1O1ARI5T
SF Hub Band 6	7		OCI				05N5932	01	1H1ARNX9
SF Hub Band 6	8		OCI				05N5932	01	1H1ARNX9
SF Hub Band 6	9	OCM	OCM	IS	IS-NR	NIL	05N5945	01	1H1ASASI
SF Hub Band 6	10	OCM	OCM	IS	IS-NR	NIL	05N5945	01	1D1AS20U
SF Hub Band 6	11		OCI				05N5932	01	1V1ARI50

Figure 132. Equipment Inventory for Oak Rmt Band 6 and SF Hub Band 6

The **Equipment - Inventory** window lists the hardware circuit cards installed in the selected shelves. The current physical operational status of the cards is shown in the Oper column.

Click the scroll bar on the right of the **Equipment - Inventory** window to scroll through the list and display the hardware circuit cards for all selected shelves. In Figure 132, the status for all installed cards displayed IS-NR: In-service Normal.

The possible states are:

- IS-NR: In-service normal
- IS-ANR: In-service abnormal
- OOS-MA: Out-of-service maintenance
- OOS-AU: Out-of-service autonomous
- OOS-AUMA: Out-of-service autonomous, maintenance
- OOS-MAANR: Out-of-service maintenance abnormal

If there were observers at each shelf site, viewing the faceplate of the OCI and OCLD cards in each shelf would show:

- The LOS (Loss Of Signal) LEDs are off, indicating the cards are receiving optical signals.
- The Active LEDs (OCI only) are green, indicating the cards are provisioned with a channel assignment.
- The Status LEDs are green, indicating the cards are in service to the shelf system processor.

To display the current logical operational state of the shelf hardware:

- Click **Equipment**, then **Facilities.**
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Equipment - Facilities** window is displayed in Figure 133.

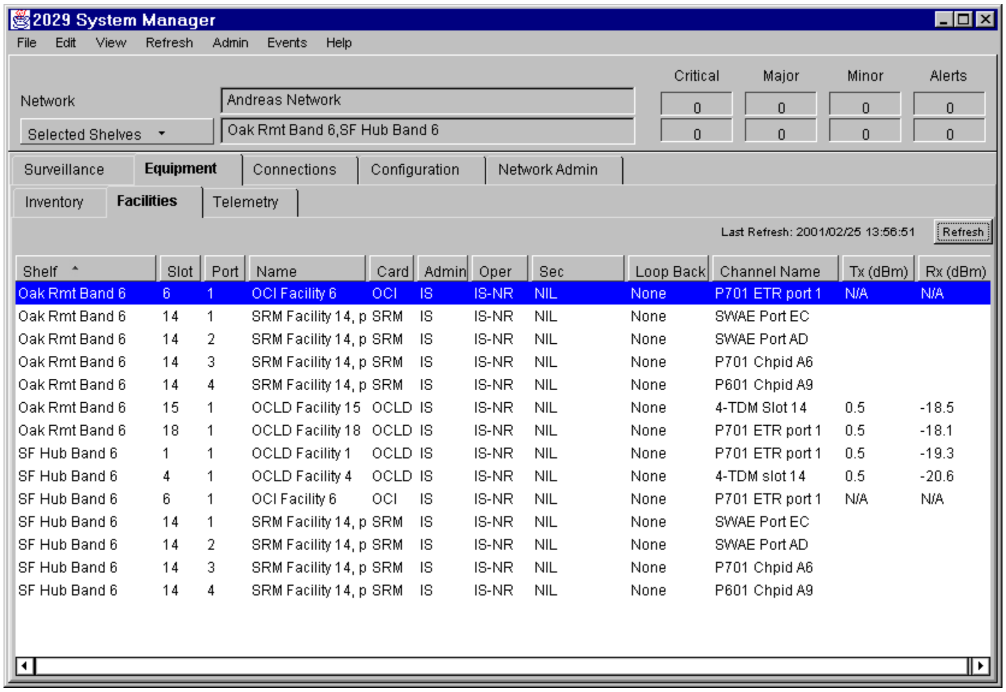


Figure 133. Equipment Facilities window - no error conditions.

The **Equipment - Facilities** window lists the OCI and OCLD hardware circuit cards installed and provisioned in the selected shelves. The current logical operational status of these cards is shown in the Oper column.

In Figure 133 (using Figure 130 on page 181 as a guide):

- The status for each OCI and OCLD card installed in the SF Hub Band 6 shelf and Oak Rmt Band 6 shelf is IS-NR: In-service Normal.
- The IS-NR status for an OCI Facility indicates that an optical signal is being received from the attached device interface.
- The **Equipment - Facilities** window also displays the optical power levels of the transmit Tx (dBm) and receive Rx (dBm) signals for each OCLD card provisioned in the selected shelves. These levels are useful in determining if an OCLD card is receiving light from the IBM 2029 network that is within the operational range of the OCLD. See B.3, “Optical Channel Laser and Detector (OCLD) specifications” on page 209.

To display the current channel provisioning information for the shelf hardware:

- Click **Connections.**
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Connections - Channel Assignments** window is displayed in Figure 134.

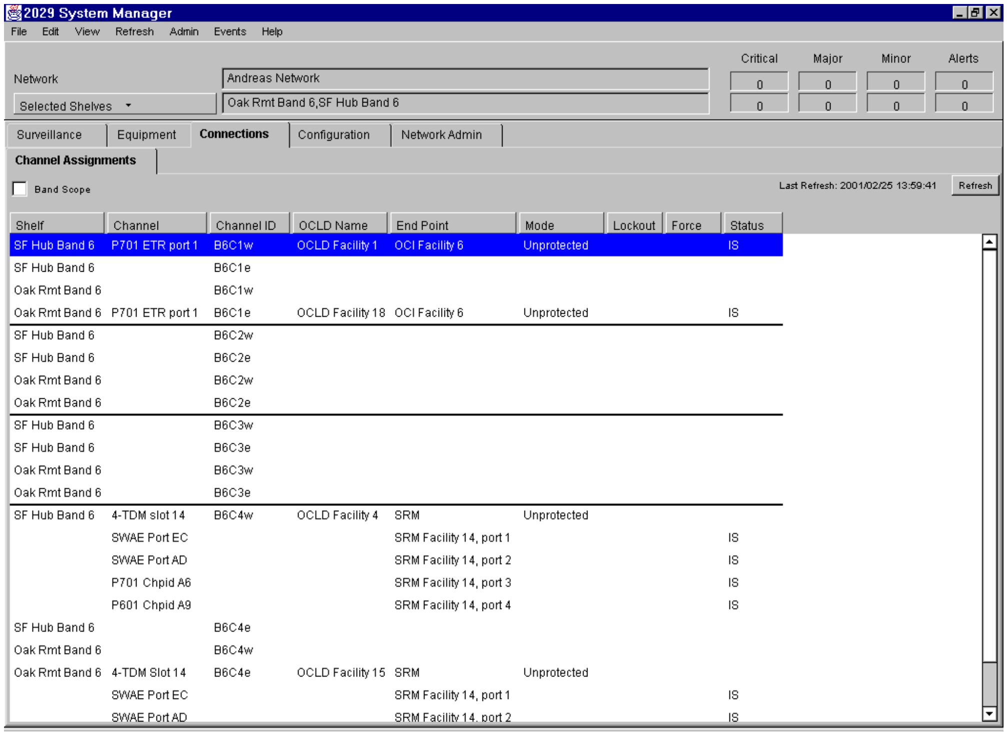


Figure 134. Connections - Channel Assignments window - no error conditions

The **Connections - Channel Assignments** window displays the channel mapping of the OCI and OCLD cards for the selected shelves.

Band Scope displays the channel assignments for shelves in the same band pair as the displayed shelves. For example, if we had selected only SF Hub Band 6 in the network tree, the **Channel Assignments** window would show only channel provisioning information for that shelf. Selecting Band Scope would cause the Oak Rmt Band 6 data to be included in the display.

In Figure 134 (using Figure 130 on page 181 as a guide):

- For the SF Hub Band 6 shelf:
  - OCLD B6C1w (Band-6 Channel-1w) in slot 1 is mapped to OCI slot 6
  - OCLD B6C4w (Band-6 Channel-4w) in slot 4 is mapped to OCI slot 14
- For the Oak Rmt Band 6 shelf:
  - OCLD B6C1e (Band-6 Channel-1e) in slot 18 is mapped to OCI slot 6
  - OCLD B6C4e (Band-6 Channel-4e) in slot 15 is mapped to OCI slot 14
- To see the port details for the 4TDM OCI cards, you need to double-click anywhere along the SRM line. The Status column shows a status for all of the channel assignments. For the 4TDM OCI card, it shows a status for each individual port. In our case, the status for all provisioned channel assignments is: IS (In Service). This indicates that each OCI card (or port) is receiving an optical signal via the IBM 2029 network from the OCI card in the distant shelf, and the provisioned base (unprotected) channel connection is carrying traffic between the attached external device interfaces.

The possible connection states are:

- IS: In Service
- OOS: Out of Service

9.3 Example 1: Loss of signal on one port of a 4TDM OCI card

At this point an event occurs which results in the ESCON CHPID (P601 CHPID A9), going to an offline state to the operating systems running in the server. Connectivity between the server and the attached ESCON Director has been lost.

The first indications of a failure are likely to be the following:

- Error messages will be displayed on the operating system consoles indicating that some system resources have become unavailable.
- If there is a critical alarm, an audible alarm will sound in the shelf where the critical alarm originated. The audible alarm can be suppressed by pressing the ACO (Alarm Cut-Off) button located on the maintenance panel of the shelf to the right of the power switches. The audible alarm will also clear after the condition that caused the alarm has been cleared.
- If the IBM 2029 shelves are defined to a Hardware Management Console (HMC), you will see an exception condition and “Hardware Messages” for any affected shelves.
- If External SNMP management is enabled, an SNMP trap is sent to the IP address of the shelf’s External Manager by each shelf where an alarm event originated. The SNMP trap may be displayed in different forms on the External Manager workstation, depending on the external manager software product installed.

The first step in our problem determination procedure is to gather as much information as possible through the various screens available on the System Manager console.

Click **Surveillance,** then **Active Alarms** to display the current active alarms for both Band 6 shelves, shown in Figure 135 on page 189.

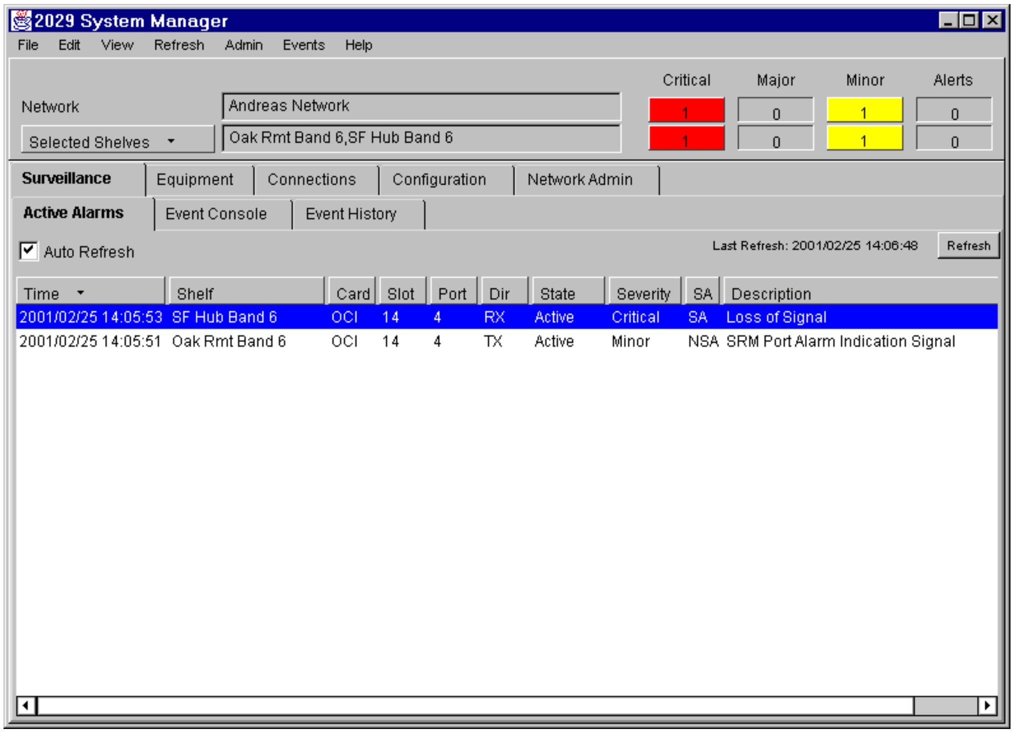


Figure 135. Active Alarms - OCI Facility 14 port 4 in error

In Figure 135:

- The top row of the Alarm Banner indicates there is now one Critical (Red) alarm and one Minor (Yellow) alarm active in the IBM 2029 network (Andreas Network).
- The bottom row of the Alarm Banner indicates each alarm originated in either one or the other of the two selected shelves, SF Hub Band 6 and Oak Rmt Band 6.

The **Surveillance - Active Alarms** window lists two alarms. Each alarm entry indicates the following:

- Time of the alarm
- Shelf name originating the alarm
- Card type of the affected card
- Card slot number of the affected card
- Port number of the affected port
- The signal direction affected (Tx or Rx)
- State of the alarm
- Severity of the alarm
- SA - indication of whether the alarm is service affecting (SA) or non-service affecting (NSA)
- Description of the alarm

The OCI slot 14 card in SF Hub Band 6 has reported “Loss of Signal” on port 4 (Rx)—a loss of input signal to the card’s optical receiver. The severity is critical because the alarm affects traffic and requires immediate attention.

The OCI slot 14 card in Oak Rmt Band 6 has reported “SRM Port Alarm Indication Signal” for port 4 —an indication that a traffic-related defect from the other shelf in the shelf band pair (SF Hub Band 6) has been detected. The severity is minor because the alarm does not affect traffic.

A detailed view of each event can be displayed by double-clicking the event entry. The detailed view may contain an additional text description of the alarm.

To display the current logical operational state of the shelf hardware:

- Click **Equipment**, then **Facilities.**
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Equipment - Facilities** window is displayed in Figure 136.

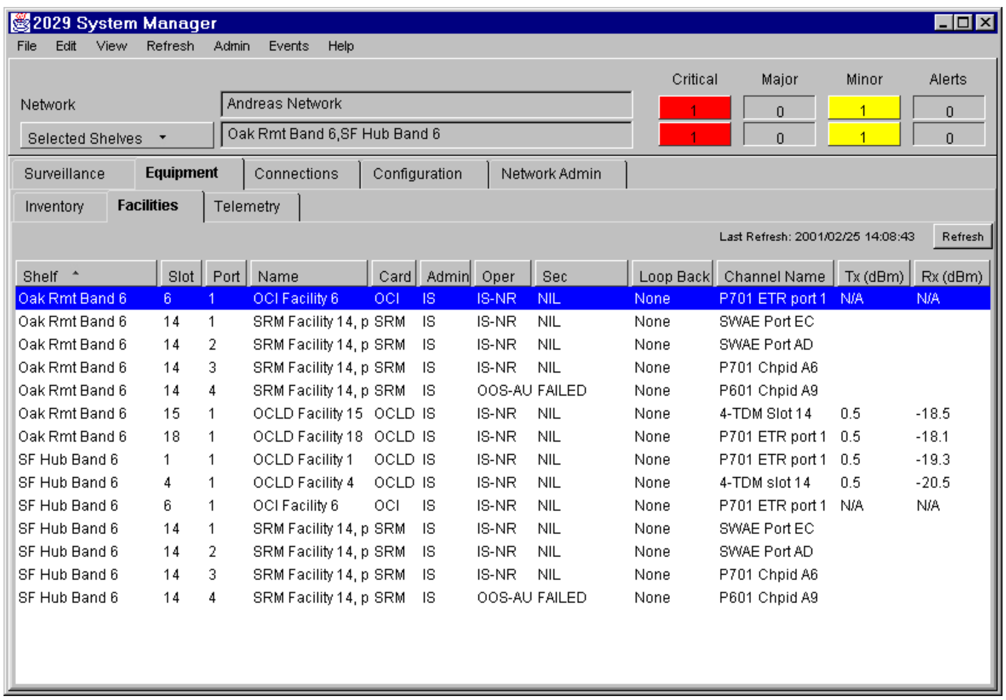


Figure 136. Equipment Facilities window - OCI Facility 14, port 4 link in error

The current logical operational status of the OCI and OCLD cards is shown in the Oper column.

In Figure 136 (using Figure 130 on page 181 as a guide):

- The status of SRM Facility 14, port 4 in SF Hub Band 6 has changed to OOS-AU: Out Of Service - Autonomous.

  Viewing the faceplate of the OCI slot 14 card shows the LOS (Loss Of Signal) LED for port 4 is yellow.

The OOS-AU status and the LOS LED for SF Hub Band 6 SRM Facility 14, port 4, indicate that no optical signal is being received from the attached device interface which, in this case, is P601 CHPID A9.

- The status of SRM Facility 14, port 4 in Oak Rmt Band 6 has also changed to OOS-AU: Out Of Service - Autonomous.

  Viewing the faceplate of the OCI slot 14 card shows the LOS (Loss Of Signal) LED for port 4 is off, indicating the OCI port is receiving an optical signal from the attached device interface which, in this case, is an ESCON Director port.

  The OOS-AU status for Oak Rmt Band 6 SRM Facility 14, port 4 is a secondary indication of the loss of an optical signal being received from the corresponding hub OCI interface. This turns off the optical transmit interface of the Oak Rmt Band 6 SRM Facility 14, port 4 which is connected to its attached device, the ESCON Director port. The ESCON Director port sees a loss of light and the port changes to offline status. See Figure 137.

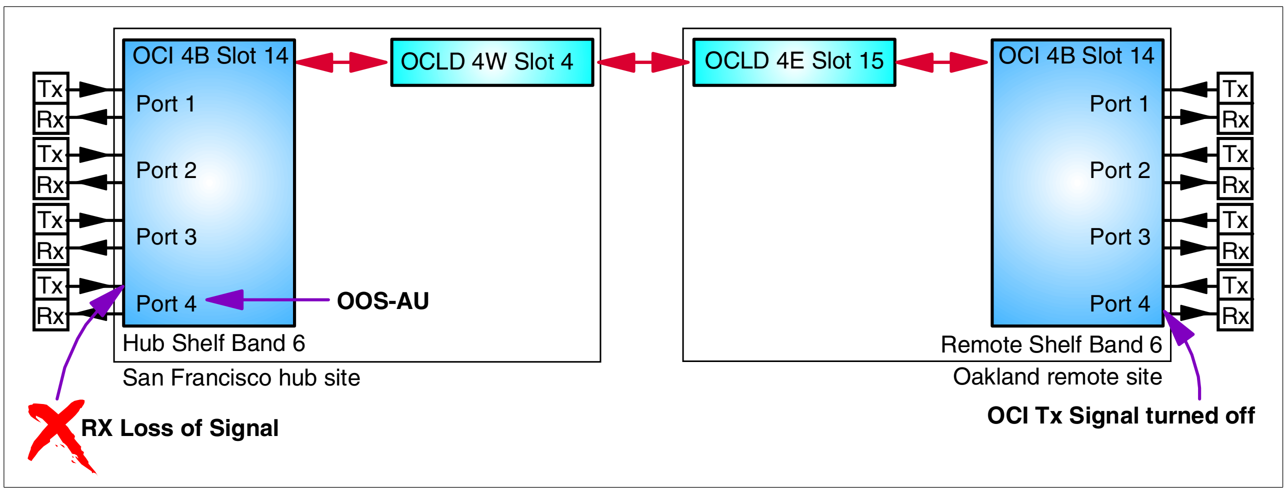


Figure 137. ESCON base channel configuration example - OCI Facility 14, port 4 link in error

Note

This architecture ensures that the IBM 2029 network appears transparent to the attaching devices. That is, when an attaching device interface's transmit optical signal state changes at one end of the IBM 2029 network, the corresponding OCI card's transmit optical signal state changes accordingly at the other end of the network.

- There are no error indications on the OCLD cards associated with OCI Facility 14 in either shelf. The OCLDs are still functioning and carrying traffic for the three remaining operational ports on the 4TDM OCI cards.
- The **Equipment - Facilities** window also displays the optical power levels of the transmit Tx (dBm) and receive Rx (dBm) signals for each OCLD card. These levels indicate the OCLD cards are receiving light from the IBM 2029 network that is within their operational range. This means the optical fiber pairs connecting the two sites of the IBM 2029 network have an acceptable link loss. See B.3, "Optical Channel Laser and Detector (OCLD) specifications" on page 209.

- A detailed view of the **Equipment - Facilities** for each card can be displayed by double-clicking the event entry. Figure 138 shows the detail view for SF Hub Band 6 Slot 14, port 4.

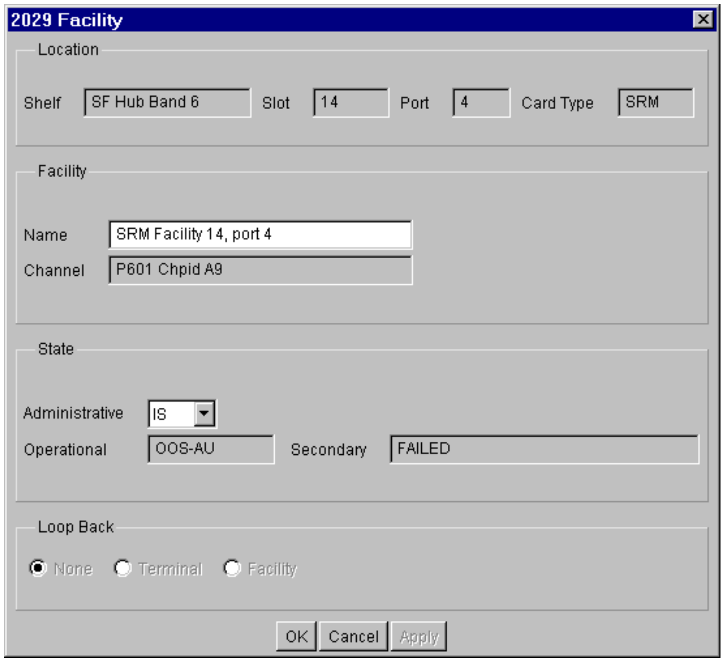


Figure 138. Detail view of facilities for SF Hub Band 6 Slot 14, port 4

To display the current channel provisioning information for the shelf hardware:

- Click **Connections**.
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Connections - Channel Assignments** window is displayed in Figure 139 on page 193.

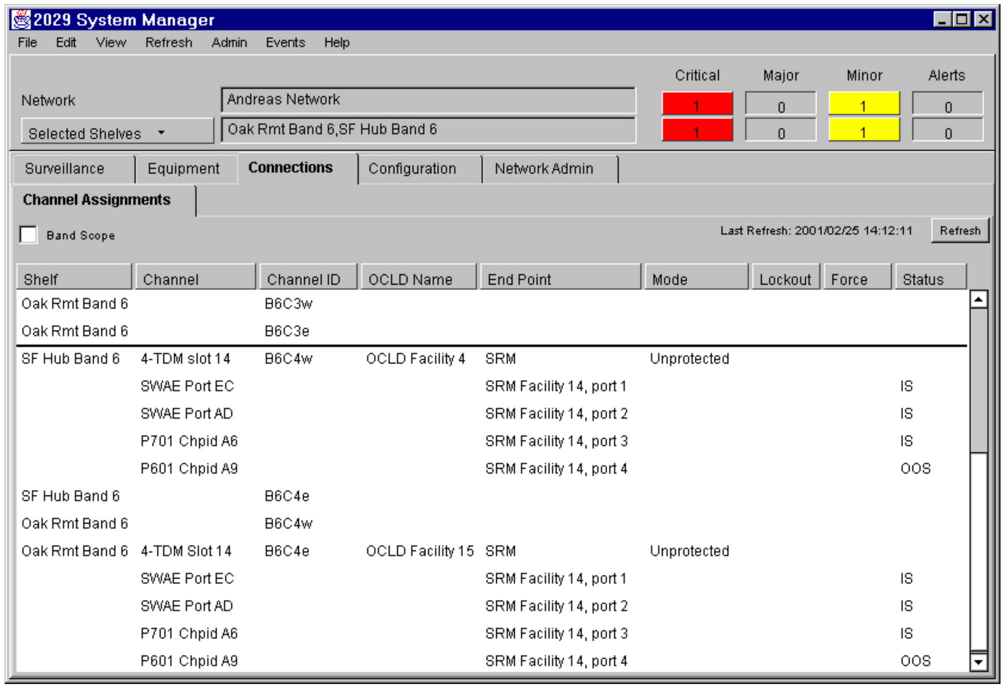


Figure 139. Channel Assignments window - OCI Facility 14, port 4 link in error

The **Connections - Channel Assignments** window displays the channel provisioning mapping of the OCI and OCLD cards for the selected shelves.

In Figure 139, the Status column shows the status for OCI Facility 14, port 4, for both shelves is OOS: Out of Service. This indicates that the provisioned base (unprotected) channel connection (P601 CHPID A9) is not carrying traffic between the attached external device interfaces.

Looking at the information gathered from the System Manager for this example, we can deduce that there is an apparent loss of optical signal from P601 CHPIDA9 at the SF Hub Band 6 OCI Facility 14, port 4 interface. The possible conditions which may cause this loss of light are discussed at the end of this chapter.

At this point the original condition, which resulted in the ESCON CHPID going to an offline state to the operating systems running in the server, is removed. Connectivity is now restored between the two attaching device interfaces and the ESCON CHPID is once again online.

The **Surveillance - Active Alarms** window shows there are no active alarms present in either of the shelves. This window returns to the state shown in Figure 131 on page 183.

The **Equipment - Inventory** window shows the status for all cards installed in both shelves is IS-NR: In-service Normal. This status has not changed throughout this link error example, as shown in Figure 132 on page 184.

The **Equipment - Facilities** window now shows the status for each OCI and OCLD card installed is IS-NR: In-service Normal. See Figure 133 on page 186.

The **Connections - Channel Assignments** window now shows the status for both OCI ports is IS: In Service. See Figure 134 on page 187.

9.4 Example 2: Loss of signal on a single port OCI card

At this point an event occurs which results in an ETR link from Server P701 going to a nonoperational state. Connectivity between the server and the attached 9037-002 has been lost.

The first indications of a failure will be similar to the previous example. Error conditions may be highlighted by any or all of the following:

- Operating system consoles
- IBM 2029 audible alarm
- HMC exception condition and "Hardware Messages"
- External Manager console

As with the previous example, the first step in our problem determination procedure is to gather as much information as possible through the various screens available on the System Manager console.

Click **Surveillance,** then **Active Alarms** to display the current active alarms for both Band 6 shelves, shown in Figure 140.

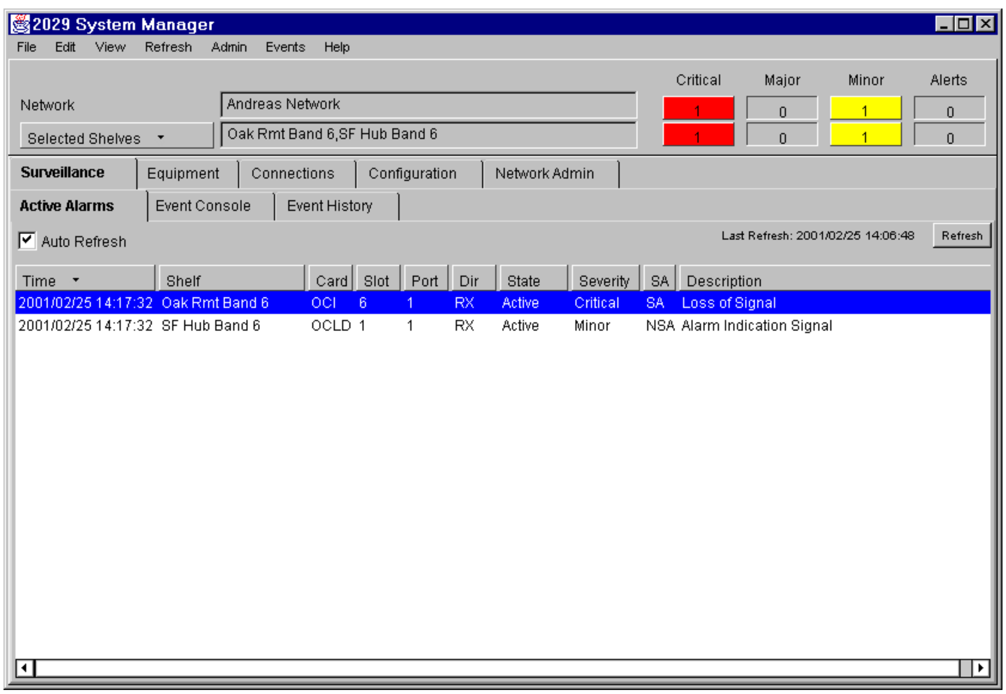


Figure 140. Active alarms - OCI Facility 6 link in error

In Figure 140:

- The top row of the Alarm Banner indicates there is now one Critical (Red) alarm and one Minor (Yellow) alarm active in the IBM 2029 network (Andreas Network).

- The bottom row of the Alarm Banner indicates each alarm originated in either one or the other of the two selected shelves, SF Hub Band 6 and Oak Rmt Band 6.

The **Surveillance - Active Alarms** window lists two alarms.

The OCI slot 6 card in Oak Rmt Band 6 has reported “Loss of Signal” on port 1 (Rx)—a loss of input signal to the card’s optical receiver. The severity is critical because the alarm affects traffic and requires immediate attention.

The OCLD slot 1 card in SF Hub Band 6 has reported “Alarm Indication Signal”—an indication that a traffic-related defect from the other shelf in the shelf band pair (Oak Rmt Band 6) has been detected. The severity is minor because the alarm does not affect traffic.

To display the current logical operational state of the shelf hardware:

- Click **Equipment**, then **Facilities.**
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Equipment - Facilities** window is displayed in Figure 141.

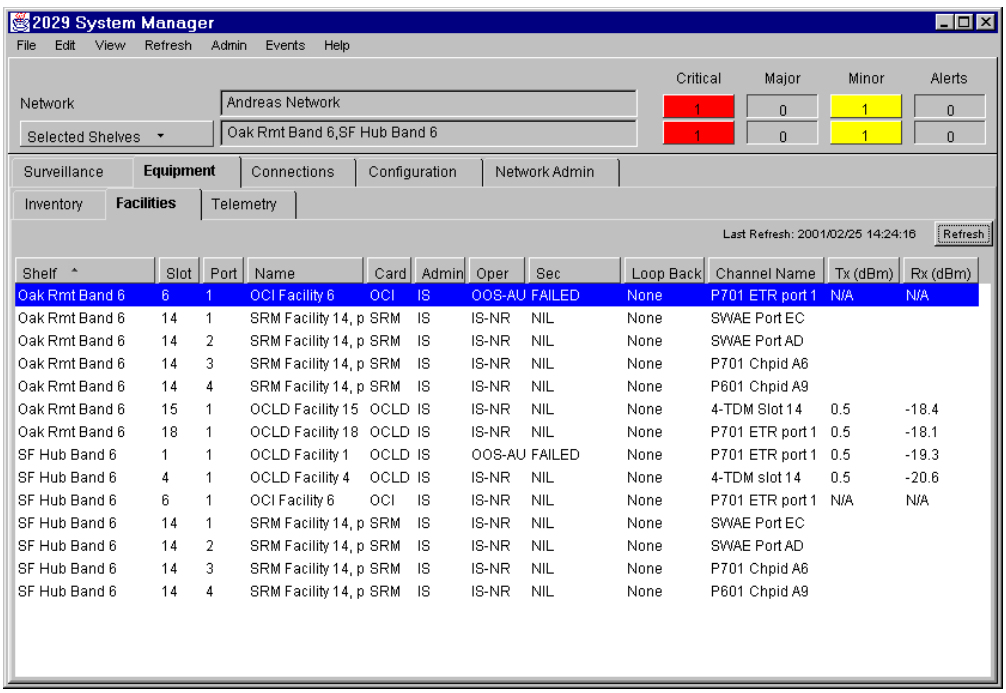


Figure 141. Equipment - Facilities window - OCI Facility 6 link in error

The current logical operational status of the OCI and OCLD cards is shown in the Oper column.

In Figure 141 (using Figure 130 on page 181 as a guide):

- The status of OCI slot 6 in Oak Rmt Band 6 has changed to OOS-AU: Out Of Service - Autonomous.

Viewing the faceplate of the OCI slot 6 card shows the LOS (Loss Of Signal) LED is yellow.

The OOS-AU status and the LOS LED for Oak Rmt Band 6 OCI Facility 6 indicate that no optical signal is being received from the attached device interface which, in this case, is a 9037-002 port.

The status of OCLD slot 1 in SF Hub Band 6 has also changed to OOS-AU: Out Of Service - Autonomous.

Note that in the case of a single port OCI card, because there is only one incoming signal, the loss of that signal is detected at the OCLD level.

Viewing the faceplate of the OCLD slot 1 card shows the LOS (Loss Of Signal) LED is off, indicating the OCLD is receiving an optical signal from the IBM 2029 network (the overhead service channel).

The OOS-AU status for SF Hub Band 6 OCLD slot 1 is a secondary indication of the loss of an optical signal being received from the corresponding remote OCI interface. This turns off the optical transmit interface of the SF Hub Band 6 OCI slot 6 which is connected to its attached device, P701 ETR port 1. The server sees a loss of light on the ETR port and the port status changes to nonoperational. See Figure 142 on page 196.

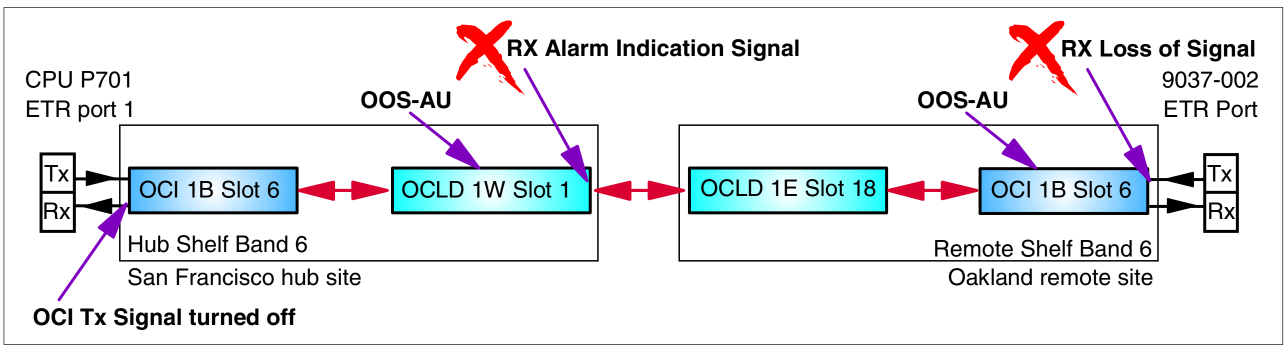


Figure 142. ETR base channel configuration

- The IS-NR (In Service - Normal) status for SF Hub Band 6 OCI Facility 6, and Oak Rmt Band 6 OCLD Facility 18, indicates an optical signal is still being received from the device interface connected to SF Hub Band 6 OCI Facility 6 (P701 ETR port 1).

  Viewing the faceplates of both cards shows the LOS (Loss Of Signal) LED is off (receiving an optical signal).

- The **Equipment - Facilities** window also displays the optical power levels of the transmit Tx (dBm) and receive Rx (dBm) signals for each OCLD card. These levels indicate that the OCLD cards are receiving light from the IBM 2029 network that is within their operational range. This means the dB loss on the optical fiber pairs connecting the two sites in the IBM 2029 network are within link loss budget.

- A detailed view of the **Equipment - Facilities** for each card can be displayed by double-clicking the event entry.

To display the current channel provisioning information for the shelf hardware:

- Click **Connections**
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Connections - Channel Assignments** window is displayed in Figure 143.

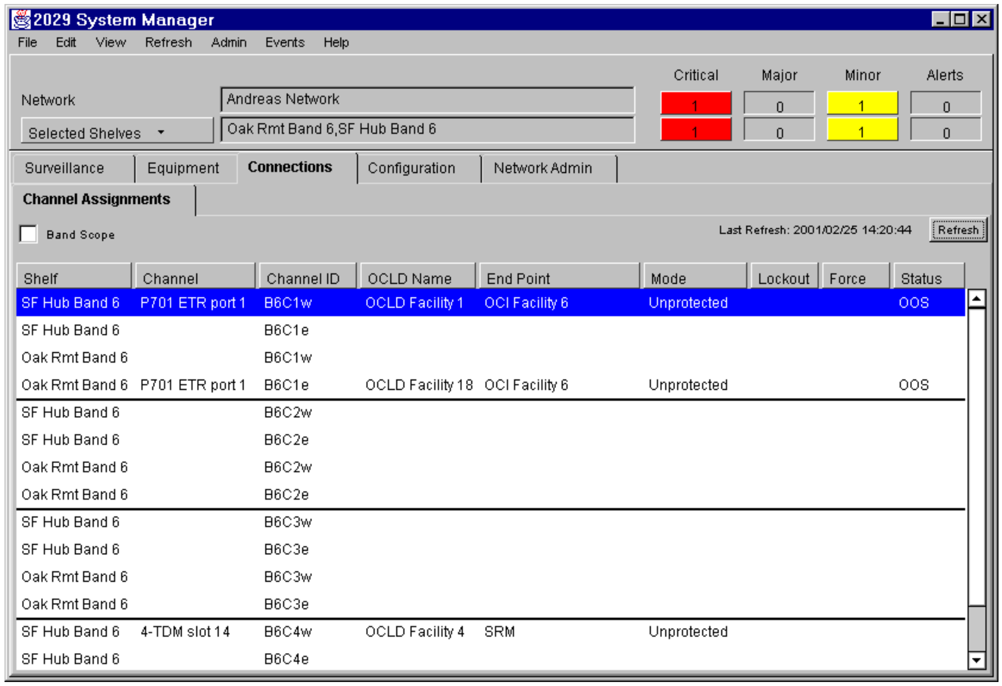


Figure 143. Channel Assignments window - OCI Facility 6 link in error.

The **Connections - Channel Assignments** window displays the channel provisioning mapping of the OCI and OCLD cards for the selected shelves.

In Figure 144, the Status column shows the status for OCI Facility slot 6 for both shelves is OOS: Out of Service. This indicates that the provisioned base (unprotected) channel connection (P701 ETR Port 1) is not carrying traffic between the attached external device interfaces.

Looking at the information gathered from the System Manager for this example, we can deduce there is an apparent loss of optical signal from the 9037-002 at the Oak Rmt Band 6 OCI Facility 6 interface. The possible conditions which may cause this loss of light are discussed at the end of this chapter.

At this point the original condition, which resulted in the ETR link failure, is removed. Connectivity is now restored and the ETR port returns to operational status.

All of the System Manager windows return to the conditions shown in 9.2, “Normal operational status” on page 182.

9.5 Event logs and history

A history of these link error events can be viewed in the event console log and event history log.

To display the event console log:

- Click **Surveillance,** then **Event Console.**
- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window**.

The **Surveillance - Event Console** window is displayed in Figure 144. It shows all the events in the IBM 2029 network (all shelves) that have occurred during the current System Manager session.

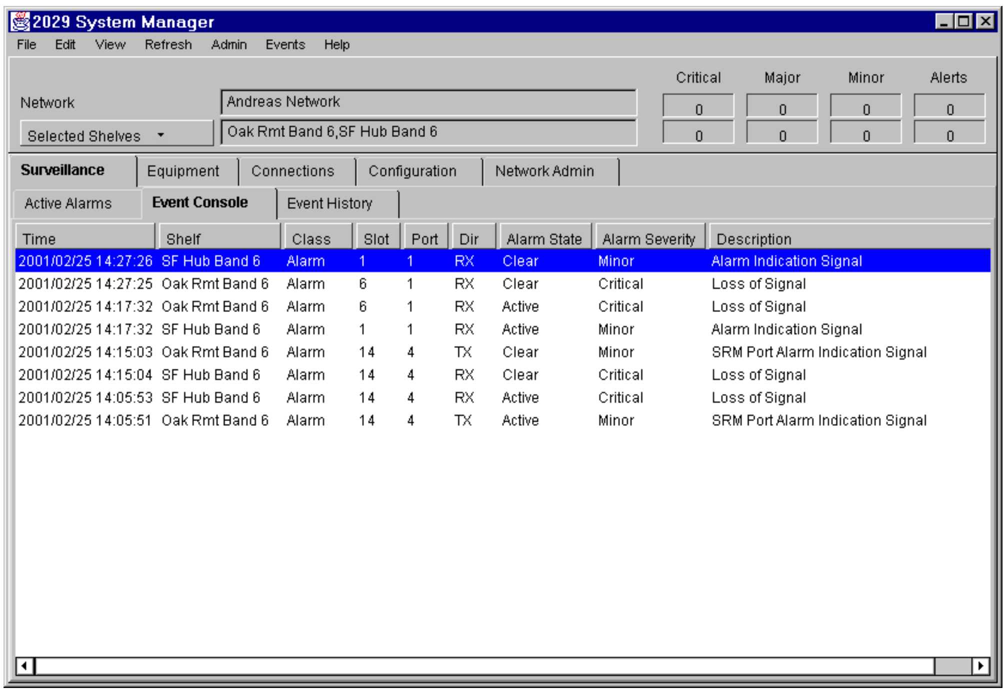


Figure 144. Surveillance Event Console - error conditions removed

In Figure 144, the **Surveillance - Event Console** window lists all of the alerts associated with the two link failures that we have just encountered and resolved. In each case there were two events (alarms) when the error condition first occurred, and two new events (alarms) when the error condition was removed. In the **Alarm State** column, the events indicating that the active alarms have been cleared have a state of: Clear.

If External SNMP management is enabled, an SNMP trap is sent to the IP address of the shelf's External Manager by each shelf where an alarm event originated indicating a "Cleared" status. The SNMP trap may be displayed in different forms on the External Manager workstation, depending on the external manager software product installed.

To display the event history log:

- Click **Surveillance,** then **Event History.**

- Either click the **Refresh** button or, on the menu bar, click the **Refresh** pulldown, then **Refresh current window.**

The event history window shows history events from the shelves selected in the network tree. The System Manager updates the Event History when **Retrieve event history** is selected. This information can be sorted by clicking the column headers in the window. For this network example, the Event History log contains the same information as the Event Console log.

9.6 Problem determination summary

The symptom observed in both examples was Loss of Signal on an OCI interface.

This error could be caused by any of the following conditions.

- Hardware defect conditions:
  - Dirty fiber cable connectors.
  - A broken fiber in the fiber cable attached to the IBM 2029 patch panel Rx (receive) connector for this OCI card.
  - Dirty IBM 2029 patch lead connectors.
  - A broken fiber in the patch lead from the IBM 2029 patch panel attached to the Rx (receive) connector for this OCI card.
  - Faulty optical transmitter in the attached device interface (P601 CHPID A9 for example 1 and 9037-002 ETR port for example 2).
  - Faulty optical receiver in the OCI card.
- Operational conditions:
  - The ESCON channel (P601 Chpid A9) has been configured offline to the operating systems running in the server.
  - A power-on reset (POR) of the server is in progress. All channel interfaces (for example, ESCON, FICON, OSA-Express, ISC, ETR) will stop transmitting light for a period during the POR.
  - An attached device has been taken offline or powered off for scheduled maintenance or changes.

In our scenarios, the conditions which caused our link errors were:

1. CHPID A9 was configured offline to all operating systems running on server P601. The condition was recovered by configuring the CHPID back online again.
2. At the 9037-002, port control was turned off for the port connected to server P701 ETR port 1. The condition was subsequently removed by turning port control on.

These examples highlight that not all alarm conditions which may appear in the IBM 2029 network are hardware defect-related. Alarms may be symptomatic of standard operating procedures in the data center environment.

With an IBM 2029 network that is externally managed, the Network Management System site needs to have operating procedures in place to allow the NMS staff to quickly identify whether or not a received SNMP trap alarm is the result of normal operating procedures. For example, an IBM 2029 network provisioned with 64 base channels generates 128 SNMP trap alerts to the Network Management System indicating “Rx Loss of Signal” on all 64 channels. This may indicate a catastrophic site disaster, or it may indicate that the attached server is performing a scheduled POR during a systems maintenance window.

This is especially important in a managed dark fiber environment. The telecommunications provider (as the fiber service integrator responsible for external management) and the client organization (as the operator of the data center environment) need to have these operating procedures defined and agreed to by both organizations to effectively manage their IBM 2029 network.

Appendix A. Network installation worksheets

This appendix contains the worksheets required for commissioning and provisioning shelves in an IBM 2029 network.

A.1 Shelf Commissioning Wizard worksheet

Table 30. Shelf Commissioning Wizard worksheet

Network name				
Hub Site name		Hub Site Identifier		
Shelf Band #	Band #	Band #	Band #	Band #
Shelf Name				
Shelf Description				
Shelf Identifier				
Shelf Address				
Primary Shelf Address				
Subnet Mask				
DHCP Address				
Default Gateway Address				
Shelf Type				
Ethernet Hubbing Group				
External Mgr Address				
Remote Site name		Remote Site Identifier		
Shelf Band #	Band #	Band #	Band #	Band #
Shelf Name				
Shelf Description				
Shelf Identifier				
Shelf Address				
Primary Shelf Address				
Subnet Mask				
DHCP Address				
Default Gateway Address				
Shelf Type				
Ethernet Hubbing Group				
External Mgr Address				

A.2 Shelf Commissioning Wizard worksheet - OSPF parameters

Table 31. Shelf Commissioning Wizard worksheet - OSPF parameters

OSPF parameters	GNE Shelf Hub Site	GNE Shelf Remote Site	All Non-GNE Shelves
Shelf name			not applicable
Shelf Identifier			not applicable
Internal Area ID (default 0.0.0.0)			
OSPF Backbone Enabled	Yes	Yes	No
Router Priority			not applicable
Cost			not applicable
Password Enabled			not applicable
Password			not applicable
Transit Delay (default 1)			not applicable
Retransmit Interval (default 5)			not applicable
Hello Interval (default 10)			not applicable
Router Dead Interval (default 40)			not applicable

A.3 Site band and channel allocation chart

Table 32. IBM 2029 band and channel allocation chart - top shelf

Network name: Network ID:	Hub Site name: Hub Site ID:	Remote Site name: Remote Site ID:
	IBM 2029 frame serial:	IBM 2029 frame serial:
	TOP SHELF pair band number:	
	Hub Shelf name: Shelf ID: Hubbing group:	Remote Shelf name: Shelf ID: Hubbing group:

Channel Description	Protocol	Mode B / HA	P/P top	OCI Card	OCI Slot	OCLD Card	OCLD Slot	OCLD Card	OCLD Slot	OCI Card	OCI Slot	P/P top
Aggregate:			T5	1A	5	1E	18	1W	1	1A	5	T5
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4
Aggregate:			T6	1B	6	1W	1	1E	18	1B	6	T6
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4
Aggregate:			T7	2A	7	2E	17	2W	2	2A	7	T7
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4
Aggregate:			T8	2B	8	2W	2	2E	17	2B	8	T8
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4
Aggregate:			T11	3A	11	3E	16	3W	3	3A	11	T11
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4
Aggregate:			T12	3B	12	3W	3	3E	16	3B	12	T12
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4
Aggregate:			T13	4A	13	4E	15	4W	4	4A	13	T13
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4
Aggregate:			T14	4B	14	4W	4	4E	15	4B	14	T14
Port 1:			1									1
Port 2:			2									2
Port 3:			3									3
Port 4:			4									4

Table 33. IBM 2029 band and channel allocation chart - bottom shelf

Network name: Network ID:			Hub Site name: Hub Site ID:					Remote Site name: Remote Site ID:				
			IBM 2029 frame serial:					IBM 2029 frame serial:				
			BOTTOM SHELF pair band number:									
			Hub Shelf name: Shelf ID: Hubbing group:					Remote Shelf name: Shelf ID: Hubbing group:				
Channel Description	Protocol	Mode B / HA	P/P top	OCI Card / Slot		OCLD Card / Slot		OCLD Card / Slot		OCI Card/Slot		P/P top
Aggregate: Port 1: Port 2: Port 3: Port 4:			B5 1 2 3 4	1A	5	1E	18	1W	1	1A	5	B5 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			B6 1 2 3 4	1B	6	1W	1	1E	18	1B	6	B6 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			B7 1 2 3 4	2A	7	2E	17	2W	2	2A	7	B7 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			B8 1 2 3 4	2B	8	2W	2	2E	17	2B	8	B8 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			B11 1 2 3 4	3A	11	3E	16	3W	3	3A	11	B11 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			B12 1 2 3 4	3B	12	3W	3	3E	16	3B	12	B12 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			B13 1 2 3 4	4A	13	4E	15	4W	4	4A	13	B13 1 2 3 4
Aggregate: Port 1: Port 2: Port 3: Port 4:			B14 1 2 3 4	4B	14	4W	4	4E	15	4B	14	B14 1 2 3 4

Appendix B. Fiber optic overview and specifications

This appendix contains an overview of fiber optic components and the IBM 2029 optical module specifications that can help you to plan, design and debug a fiber optic network.

B.1 Fiber optics

In order to understand the specification of the IBM 2029 optical modules, it is useful to have some knowledge of the fiber optic components.

Fiber cables

The fiber element within an optical cable usually consists of a core and a cladding. The *core* provides the light path, and the *cladding* surrounds the core. The optical properties of the core and cladding junction cause the light to remain within the core. Different types of fiber optic cables are often identified as core diameter/cladding diameter (in micron). The IBM 2029 supports three different types of fiber cable:

1. 9/125 micron single-mode: Widely used for high data rate and long distance applications
2. 62.5/125 micron multimode: Widely used for low to moderate speed data links
3. 50/125 micron multimode: Also used for low to moderate speed data links, but not as commonly used as 62.5 micron fiber

Larger core size fibers are generally more expensive, have higher loss (attenuation) per unit distance, and lower bandwidth. They do, however, allow the use of lower cost light sources and connectors, so they yield the lower system cost over shorter distances. Table 34 shows the typical fiber loss at four major fiber optic wavelengths.

Table 34. Optical fiber loss

Fiber		**Optical loss (dB/Km)**			
Size (micron)	**Type**	**780 nm**	**850 nm**	**1310 nm**	**1550 nm**
9/125	SM			0.5~0.8	0.2~0.3
50/125	MM	4.0~8.0	3.0~7.0	1.0~3.0	1.0~3.0
62.5/125	MM	4.0~8.0	3.0~7.0	1.0~4.0	1.0~4.0
*Fiber loss depends heavily on the fiber size and the operating wavelength.					

Tx (Transceiver) and Rx (Receiver)

A *transceiver* converts an electrical signal into an optical signal (E/O conversion). A *receiver* converts an optical signal back to an electrical signal (O/E conversion). A Tx and an Rx are incorporated in different parts of the IBM 2029, wherever E/O and O/E conversion occurs.

The optoelectric devices used in a Tx can be either a light-emitting diodes (LEDs) or laser diodes (LDs). An LED is small and quite inexpensive and is usually the light source for multimode fibers. An LD has the advantage of a coherent, high intensity, and narrow spectrum width. On the other hand, LDs are used with single-mode fibers for long distance links.

However, LDs are rather complicated devices and are therefore more expensive than LEDs. See Table 35 for a comparison of the major types of light sources.

Table 35. Comparison of LED and LD

Characters	Light-Emitting Diode (LED)	Laser Diode (LD)
Coupled power	Moderate	High
Speed	Moderate	High
Wavelength available	660 ~ 1650 nm	780 ~ 1650 nm
Emission spectrum	Broad	Narrow
Data rate-distance performance limits	Short wavelength <150 (Mbps* Km) Long wavelength <1.5(Gbps* Km)	Short wavelength <2.5 (Gbps* Km) Long wavelength <25(Gbps* Km)
Current	50 ~100 mA	5 -40 mA
Cost	Moderate	High

*In the 2029 system, the OCLD card uses DWDM LD, which complies with the ITU standard.

Fiber optic connectors

OCI cards are attached to an OCI patch panel within the IBM 2029 frame to provide a convenient point of access for device attachment. The OCI patch panel inserts include the necessary fiber optic jumper cables, connector adapters, and optical attenuation to allow the OCI to interoperate with the attached channels of different types.

For example, device interface ESCON cables with ESCON duplex connectors and ISC cables with SC duplex connectors connect to the IBM 2029 patch panels. IBM-supplied jumper cables extend from the patch panel to the OCI cards.

The OCI card connectors are dual-SC panel connectors (Tx and Rx). The appropriate patch panel connectors are supplied by IBM based on the individual configuration.

The OMX connections are found in the OMX tray below the OCI cards. They use SC/PC connectors for intershelf and fiber pair connections.

Table 36 on page 207 shows the loss for the typical connectors used in an IBM 2029 optical interconnection.

Table 36. Fiber optic connector loss

Connector	Insertion loss (dB)	Fiber type	IBM 2029 Application
SC	0.2~0.45	SM, MM	OMX
SC Duplex	0.2~0.45	SM, MM	OCI
FC*	0.5~1.0	SM, MM	OCLD
MT-RJ**	0.3~1.0	SM, MM	4TDM
ESCON	0.2~0.7	MM	ESCON
FDDI	0.2~0.7	SM, MM	FDDI

* FC connectors for OCLD are PC-type connectors incorporating a "physical contact" curved polished fiber end face that greatly reduces backreflections.
** MT-RJ is a fourth generation high-packing density connector.

Mode Conditioned Patch (MCP) cables

Because of the limitation of multimode fiber, future high speed fiber optic interconnects will be based on single-mode fiber. However, as the fiber plant is upgraded to support higher data rates on single-mode fiber, we must also provide a migration path which continues to reuse the installed multimode fiber.

Accordingly, mode-conditioned patch cables(MCP) are designed to address this concern. MCP is used to interface the single-mode optical adapter and the installed multimode fiber.

Let's discuss some examples, using Figure 145 on page 208 as a reference:

- If you use single-mode fiber for Gigabit Ethernet, you will not use MCP.
- With single-mode Gigabit adapters, you will need two MCPs to connect to both ends of the multimode fibers, as shown in Figure 145 on page 208.
- If you use multimode fiber, you will need MCP to interface with them at both ends.

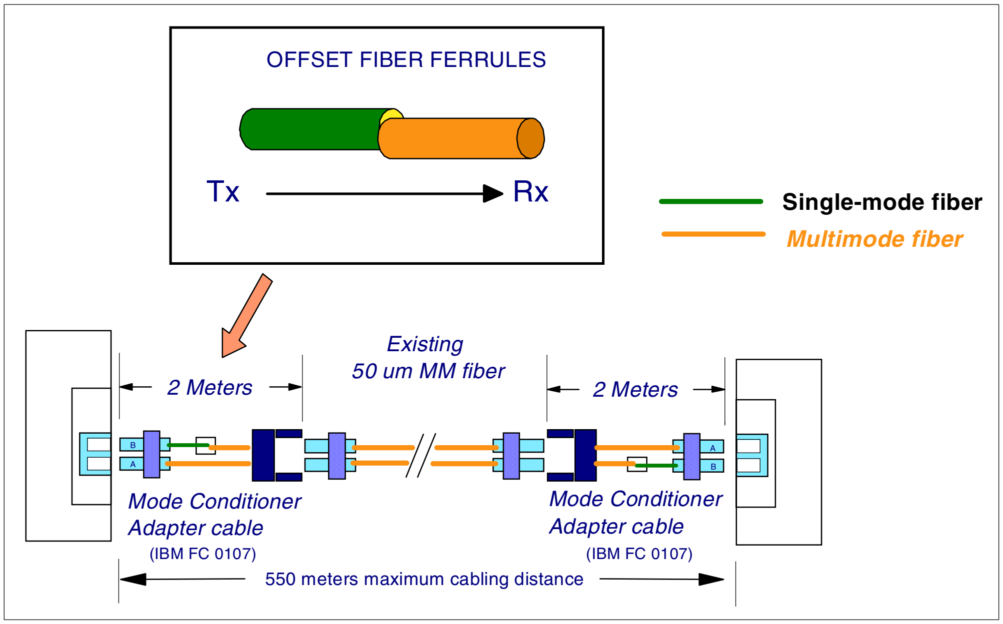


Figure 145. Mode Conditioned Patch (MCP) cables

Figure 145 also shows an MCP that is designed with offset fiber ferrules to “condition” the laser launch from single-mode fiber to a multimode fiber.

B.2 Optical Channel Interface (OCI) specifications

Table 37 lists the specifications of the OCI cards.

Table 37. Optical Channel Interface (OCI) card specifications

Specification	OCI 622 Mbps 1310 nm	OCI 1.25 Gbps 1310 nm	OCI ISC (1.0625 Gbps) 1310 nm	4TDM (per port) 1310 nm	OCI SX (1.25 Gbps) 850 nm
Max. bit rate	622 Mbps	1.25 Gbps	1.0625 Gbps	270 Mbps	1.25 Gbps
Min. bit rate	50 Mbps	50 Mbps	1.0625 Gbps	32 Mbps	50 Mbps
Max. Tx power	-8 dBm	-3 dBm	-3 dBm	-8 dBm	-4 dBm
Min. Tx power	-15 dBm	-12 dBm	-8 dBm	-15 dBm	-9.5 dBm
Min. Rx sensitivity	-28 dBm	-20 dBm	-20 dBm	-28 dBm	-17 dBm
Rx overload	-7 dBm	-3 dBm	-3 dBm	-8dBm	0 dBm
Input wavelength	1270 to 1355 nm	1270 to 1355 nm	1270 to 1605 nm	1270 to 1380 nm	770 to 860 nm
Output wavelength	1274 to 1356 nm	1285 to 1343 nm	1295 to 1320 nm	1274 to 1356 nm	830 to 860 nm
Fiber type	SM only	SM & MM 50/62.5	SM only	SM & MM 62.5	MM 50/62.5
Max. power consumption	19 W	19 W	19 W	30 W	19 W
When using a multimode connection to an long wavelength OCI card, a mode conditioning cable is generally required. For short distances, however, the SM transmitters on the OCI card can transmit over the MM fiber.					
A 4TDM card can multiplex up to four channels into a single wavelength. However, you cannot configure each of the multiplexed channels to drop at different shelves.					
Except for the 4TDM card using an MT-RJ connector, all others use Dual SC connector.					

B.3 Optical Channel Laser and Detector (OCLD) specifications

The OCLD card does E/O and O/E conversion. The OCLD receives a signal from the OCI card (through the OCM) and converts the signal to the DWDM wavelength assigned to the connection.

Table 38 shows the specifications of Tx and Rx used in OCLD.

Table 38. OCLD specifications

Specification	OCLD 1.25 Gbps
Max. bit rate	1.25 Gbps
Min. bit rate	32 Mbps
Max. Tx power	0.8 dBm
Min. Tx power	-0.3dBm
Min. Rx sensitivity	-30 dBm
Rx overload	-3 dBm
Center wavelength	Table 39 on page 210
Wavelength tolerance	± 0.25 nm
Fiber type	SM only
Max. power consumption	28 W

Table 39 shows the center wavelengths of the Tx of each IBM 2029 band.

Table 39. OCLD center wavelength for each band

Wavelength Band	**Channel 1 (nm)**	**Channel 2 (nm)**	**Channel 3 (nm)**	**Channel 4 (nm)**
Band 1	1528.77	1533.47	1530.33	1531.90
Band 2	1538.19	1542.94	1539.99	1541.35
Band 3	1547.72	1552.52	1549.32	1550.92
Band 4	1557.36	1562.23	1558.98	1560.61
Band 5	1570.42	1575.37	1572.06	1573.71
Band 6	1580.35	1585.36	1582.02	1583.69
Band 7	1590.41	1595.49	1592.10	1593.80
Band 8	1600.60	1605.73	1602.31	1604.02
1. Thirty-two wavelengths are partitioned into eight bands of four channels. 2. Wavelengths are 200 Ghz apart, based on the ITU grid. 3. Range of the center wavelengths is 1528.77 nm to 1605.73 nm				

B.4 Optical Multiplexer (OMX) module specifications

Table 40 lists the specifications of the Optical Multiplexer (OMX) module, for example, the channel multiplexer and demultiplexer.

Table 40. Optical Multiplexer (OMX) module specifications

Specification	Value or Range
Input power range per channel (demultiplexer)	-27.5 to - 2.9 dBm
Output power range per channel (multiplexer)	-4.6 to -1.5 dBm
Minimum adjacent channel isolation** for demultiplexer	22 dB

Specification	Value or Range
Minimum nonadjacent channel isolation** for demultiplexer	35 dB
Minimum channel isolation** for multiplexer	10 dB
Minimum directivity	55 dB
Insertion loss (port to port) - add path	4.2 dB max 2.1 dB min.
Insertion loss (port to port) - drop path	4.9 dB max 2.5 dB min.
Insertion loss (port to port) - pass through per band	1.9 dB max 1.0 dB min.
Minimum return loss (all ports)	45 dB
* Intershelf connections require patch cords with SC connectors. **Isolation: The ratio of the power at the output port in the transmitted wavelength band to that in the extinguished wavelength band.	

B.5 Device interface cable specifications

Table 41 lists the specifications of the device interface cable supported by the IBM 2029.

Table 41. Device interface cable specifications

Protocol/Fiber Type	Attenuator @ Tx	Distance/dB loss
1.25 Gbps SM / MM OCI Card		
ESCON/SBCON MM	12dB	500 m (1500 ft.)/2.0 dB
ESCON/SBCON SM		1000 m (3000 ft.)/3.0 dB
ETR/CLO MM	12dB	500 m (1500 ft.)/2.0 dB
FICON/Fibre Channel SM		1000 m (3000 ft.)/3.0 dB
FICON MM via MCP	12dB	500 m (1500 ft.)/2.0 dB
FDDI MM *	12dB	500 m (1500 ft.)/2.0 dB
ATM 155 (OC-3) MM	12dB	500 m (1500 ft.)/2.0 dB
ATM 622 (OC-12) MM	12dB	500 m (1500 ft.)/2.0 dB
Fast ENET MM	12dB	500 m (1500 ft.)/2.0 dB
Gigabit ENET LX SM		1000 m (3000 ft.)/3.0 dB
Gigabit ENET LX MM via MCP	12dB	500 m (1500 ft.)/2.0 dB
ISC 1.0625 Gbps SM OCI Card		
ISC / HiPerLink SM		1000 m (3000 ft.)/3.0 dB
622 Mbps SM OCI Card		
ATM 155 (OC-3) SM		1000 m (3000 ft.)/3.0 dB
ATM 622 (OC-12) SM		1000 m (3000 ft.)/3.0 dB

Protocol/Fiber Type	Attenuator @ Tx	Distance/dB loss
ESCON SBCON SM		1000 m (3000 ft.)/3.0 dB
Fast ENET SM	7dB	500 m (1500 ft.)/2.0 dB
4TDM 1.25 Gbps SM/MM OCI Card		
ESCON/SBCON MM	7dB	500 m (1500 ft.)/2.0 dB
ATM 155 (OC-3) SM		1000 m (3000 ft.)/3.0 dB
ATM 155 (OC-3) MM	7dB	500 m (1500 ft.)/2.0 dB
Fast ENET SM		1000 m (3000 ft.)/3.0 dB
Fast ENET MM	7dB	500 m (1500 ft.)/2.0 dB
1.25 Gbps MM OCI SX		
FICON MM		500 m (1500 ft.)/2.0 dB
Fibre Channel MM		500 m (1500 ft.)/2.0 dB
Gigabit ENET MM		500 m (1500 ft.)/2.0 dB
SM = single-mode fiber (9/125 micron) MM = multimode fiber (either 50/125 or 62.5/125 micron unless otherwise noted MCP = Mode Conditioning Patch Cable, provided as an IBM feature code on selected channel types LX = long wavelength (Gigabit Ethernet) SX= short wavelength (reduce the need for MCP) * = 62.5 micron MM fiber only		
Distance and dB loss values given are for IBM 2029 OCI card attachment to IBM equipment within a site. These distance/link budgets for device interface attachment to the IBM 2029 may be less than typical device interface link specifications; it is assumed that multiplexers such as the IBM 2029 will not be required to support long distances within a site to the attached device interfaces.		
In cases where the distance/link budget between an IBM 2029 OCI card and IBM equipment at a site would be larger than the distance/link budget supported for a typical device interface link, the device interface link distance will be the maximum distance supported in all cases.		
Deviations from the distance/link budgets in the above table, or requests to support protocols or IBM 2029 configurations that are different from the standard IBM announced product, will be considered as RPQ requests against the IBM 2029 on a case-by-case basis.		
The term “co-locate” in OEM specifications has been interpreted as a maximum specification of 500 m (1500 ft.)/ 2.0 dB loss in IBM 2029 specifications.		
1.25 Gbps OCI cards will also support the protocols offered on 622 Mbps OCI cards on an RPQ basis only; different combinations of attenuator may be required to support the same protocols on different types of OCI cards.		
Minimum bandwidth for all MM links is 500 MHz-km unless otherwise specified.		

B.6 Dual Fiber Switch specifications

Dual Fiber Switch is an optical switch. Table 42 lists its specifications.

Table 42. DFS specifications.

Specification	**Minimum**	**Maximum**
Optical power level at input		24 dBm
Bandwidth*	1528 nm	1607 nm
Insertion loss	1.5 dB	4.0 dB
Optical return loss**	40 dB	
Polarization depend loss***		0.4 dB
Switch time		100 ms
Operating Temperature	0 ^{o} C	55 ^{o} C

* The range of operating wavelengths
** The ratio of the power returned to the input port to the launched power
***The maximum (peak-to-peak) variation in insertion loss as the input polarization varies

Appendix C. Physical specifications

This appendix describes the physical specifications of the IBM 2029.

C.1 Operating environment

- Temperature:
  - Operating: 10° to 35°C (50° to 95°F)
  - Maximum rate of temperature change: 8.3° C per hour
  - Shipping and storage: -40° C to 66°C (-40° to 150°F)
- Relative humidity: 8% to 80%
- Wet Bulb: 27°C (80.6°F) (Class C)
- Total electrical power consumption (with 2 shelves): 1500 W
- Acoustic noise emission limit: Category 1A, LWAu (Operating) = 7.5 dB

C.2 Physical attributes (including covers and closed doors)

- Width: 648 mm (25.5 inches)
- Depth: 686 mm (27.0 inches) (requires an additional 635 mm (25 inches) for front and rear doors to open fully)
- Height: 1795 mm (70.7 inches)
- Weight: 321 kg (708 lb) - dual shelf system
278 kg (613 lb) - single shelf system

The frame rides on four lockable casters permanently attached to the base. The front and rear doors are lockable and removable when unlocked. The side and top covers are removable. Removing side covers facilitates access to the Ethernet hub for service, while removing top covers facilitates dressing fiber or Ethernet cables through an overhead cable tray if desired.

In general, frame placement follows the same rules as for other standard S/390 mainframe cabinets:

- Frames should be arranged from left to right, with additional frames added to the right (when facing the front of the frames).
- Frames with covers on can be butted together side-by-side with no space in between - the doors will still have clearance to open completely. If frames are butted together, *do not* remove side covers. This will prevent doors from opening sufficiently.
- The frames should not be butted together back-to-back. The IBM 2029s need sufficient space for airflow and easy access to power line cords from the rear door. At least 12 inches should be allowed between frames placed back-to-back. Note that with this distance, rear doors will not open fully.

C.3 IBM 2029 footprint

The fiber pairs and Ethernet cables dress out the front of the frame, and power cords dress out a circular cutout in the back of the frame as shown in Figure 146.

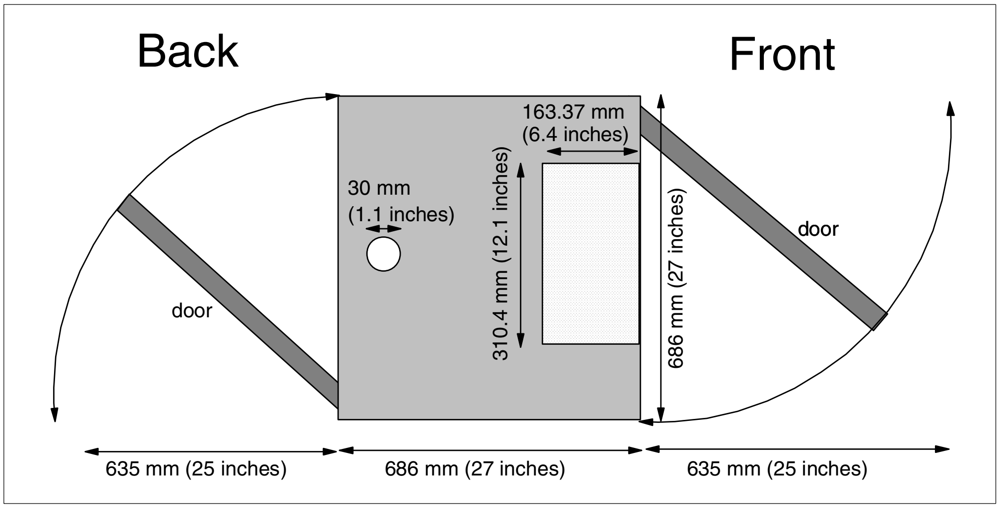


Figure 146. IBM 2029 footprint dimensions

C.4 Floor tile cutouts

It is the customer's responsibility to provide floor tile cutouts. We recommend that you create ample size tile cutouts to allow for any small frame placement changes.

There are two cutouts per frame: one at the front and one at the back, as shown in Figure 147 on page 217.

- Front cutout: centered on the frame, 6 inches deep and 6 inches wide.
- Back cutout: centered on the frame, 6 inches deep and 6 inches wide.

These dimensions are only suggestions. The sizes can be varied with little impact.

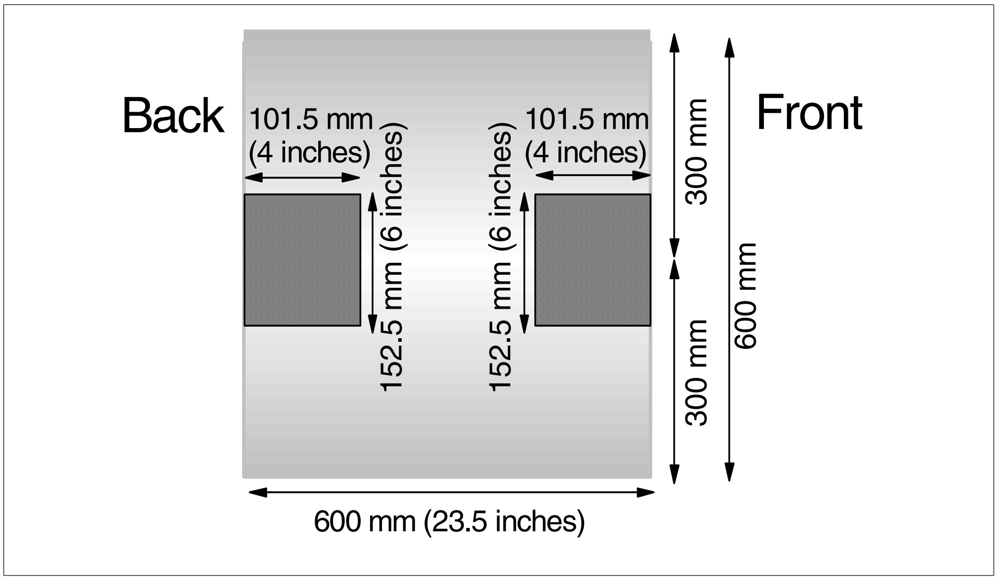


Figure 147. IBM 2029 recommended floor tile cutout dimensions per frame

C.5 Frame power requirements

Each IBM 2029 frame is equipped with dual redundant power supplies to maximize the probability that the network will function even in the event of a power failure. We strongly recommend that you provide two separate power feeds to extend this redundancy.

Frame power outlets

You must provide the following power outlet per frame:

- One 2x 220V 20A single phase outlet under a raised floor

The connector type is a Hubble 316R6W in North America, bare pigtail outside North America. The power cord is 19 ft long.

The maximum power dissipation of a fully loaded shelf: 750 watts. Remember that there are up to 2 shelves per frame and 4 frames per IBM 2029. Therefore, one fully loaded frame will dissipate 1500 watts, while four fully loaded frames will dissipate 6000 watts.

C.6 PC and Ethernet hub requirements

IBM provides one PC for each site (hub and remote), and one Ethernet hub if more than two IBM 2029 shelves are ordered for the hub site. The PC is a standard IBM desktop PC preinstalled with Windows NT and the Netscape Navigator Web browser.

IBM also provides the necessary RJ45 cables to connect the PC to the IBM 2029, and the RJ45 cables between the Ethernet hub and the shelves. No cables are supplied for any external connections to routers or the customer's systems management network.

PC and Ethernet hub power

The customer must also provide the following power outlets per IBM 2029 hub site:

- 1x 110V 15A, single phase, standard 3-prong grounded plug outlet for the PC
- 1x 110V 15A, single phase, standard 3-prong grounded plug outlet for the monitor
- 1x 110V 15A outlet under raised floor for Ethernet hub

The customer must also provide a table for the PC within reasonable working distance from the IBM 2029 to facilitate service actions that may require access to both the PC and the IBM 2029. We recommend that you place the table and PC directly to the left of the first frame so you can glance at the indicator lights while sitting at the PC.

C.7 Cable connector types

OCI cards are attached to an OCI patch panel within the IBM 2029 frame to provide a convenient point of access for equipment attachment. The OCI patch panel inserts include the necessary fiber optic jumper cables, connector adapters, and optical attenuation to allow the OCI to interoperate with the attached channels of different types.

For example, device interface ESCON cables with ESCON duplex connectors and ISC cables with SC duplex connectors connect to the IBM 2029 patch panels. IBM-supplied jumper cables extend from the patch panel to the OCI cards.

The OCI card connectors are dual-SC panel connectors (Tx and Rx).

The appropriate patch panel connectors are supplied by IBM based on the individual configuration.

The OMX connections are found in the OMX tray below the OCI cards. They use SC/PC connectors for intershelf and fiber pair connections.

Appendix D. Special notices

This publication is intended to help technical professionals understand, plan, implement, and configure an IBM 2029 network. The information in this publication is not intended as the specification of any programming interfaces that are provided by the IBM 2029. See the PUBLICATIONS section of the IBM Programming Announcement for the IBM 2029 for more information about what publications are considered to be product documentation.

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Appendix E. Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this redbook.

E.1 IBM Redbooks

For information on ordering these publications see “How to get IBM Redbooks” on page 223.

- *Understanding Optical Communications*, SG24-5230
- *S/390 I/O Connectivity Handbook*, SG24-5444
- *IP Network Design Guide*, SG24-2580
- *Introduction to IBM S/390 FICON,* SG24-5176
- *IBM S/390 FICON Implementation Guide,* SG24-5169
- *S/390 Time Management and IBM 9037 Sysplex Timer*, SG24-2070
- *IBM @server zSeries 900 Technical Guide,* SG24-5975

E.2 IBM Redbooks collections

Redbooks are also available on the following CD-ROMs. Click the CD-ROMs button at http://www.redbooks.ibm.com/ for information about all the CD-ROMs offered, updates and formats.

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IBM Enterprise Storage and Systems Management Solutions	SK3T-3694

E.3 Other resources

These publications are also relevant as further information sources:

- *2029 Fiber Saver Planning and Operations Guide*, SC28-6808
- *2029 Fiber Saver Maintenance Information*, SC28-6807
- *Planning for the Open Systems Adapter Feature*, GC23-3870
- *OSA-Express Customer’s Guide and Reference*, SA22-7476
- *Planning for Fiber Optic Channel Links,* GA23-0367
- *Hardware Management Console Operations Guide,* SC28-6805

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This section explains how both customers and IBM employees can find out about IBM Redbooks, redpieces, and CD-ROMs. A form for ordering books and CD-ROMs by fax or e-mail is also provided.

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Glossary

Numerics

1+1 protection. A hot standby protection method that is not protocol-related.

10BASE-T. Ethernet 802.3 over RG-58 twisted pair.

1U. (One "U" vertical unit) One "U" is 1.75 inches. Standard equipment racks have bolt holes spaced evenly on the mounting rails to permit equipment that is sized in multiples of this vertical unit to be mounted in the same rack.

4TDM. Four port OCI card, using Time Division Multiplexing.

A

AC. Alternating Current.

ACO. Alarm Cut-Off.

adapter. A mechanical device designed to align and join fiber-optic connectors. Also referred to as a coupler, bulkhead, or interconnect sleeve.

add/drop filter (ADF). A bandwidth-limited filter that passes only a specified wavelength or wavelength band between a device and a transmission path.

add/drop multiplexer (ADM). Digital multiplexing equipment that provides interfaces between different signals in a network.

address resolution protocol (ARP). A method for finding a host's Ethernet address from its Internet address. An ARP request is sent to the network, naming the IP address; the machine with that IP address returns its physical address so it can receive the transmission.

ADF. Add/Drop Filter.

ADM. Add/Drop Multiplexer.

administrative state. The administrative state is the *desired* state of the entity. The user configures this state to put an entity in-service or out-of-service.

agent. A component of network and desktop-management software such as SNMP, that gathers information from MIBs.

AIS. Alarm Indication Signal.

alarm. A user-visible indication derived from a fault pattern.

alarm cut-off (ACO). A switch on the maintenance panel that allows the audible alarms to be silenced without affecting the visual alarms.

alarm indication signal (AIS). A device that responds to a signal from an alarm sensor.

alternating current (AC). Electric current that periodically and regularly reverses its direction. The frequency of the change in flow is expressed in cycles per second (Hertz or Hz).

American National Standards Institute (ANSI). A U.S.-based organization that develops standards and defines interfaces for telecommunications.

ANSI. American National Standards Institute.

APD. Avalanche Photo Diode.

applet, signed/trusted. A trusted applet is an applet that has been signed with a digital certificate and has been granted extended privileges (for example, access to the client-side file system). For a signed applet to become a trusted applet, the user must grant permission upon examining the digital signature of the applet (this mechanism is specific to the Web browser implementation).

APS. Automatic Protection Switch.

architecture. The specifications of a system and how its subcomponents interconnect, interact, and cooperate.

ARP. Address Resolution Protocol.

asynchronous transfer mode (ATM). A high-speed multiplexing and switching method that uses fixed-length cells of 53 octets to support multiple types of traffic. As specified in international standards, ATM is asynchronous in the sense that cells carrying user data need not be periodic.

ATM. Asynchronous Transfer Mode.

attenuation. The decrease in signal strength in an optical fiber caused by absorption and scattering. Attenuation can be calculated to express: (1) signal loss between two points; (2) total signal loss of a telecommunications system or segment.

attenuation coefficient. The rate of optical power loss with respect to distance along an optical fiber, usually measured in decibels per kilometer (dB/km) at a specific wavelength. The lower the number, the better the attenuation of the fiber. Typical multimode wavelengths are 850 nm and 1300 nm; single-mode wavelengths are 1310 nm and 1550 nm. **Note**: When expressing attenuation, it is important to specify whether the value is average or nominal.

attenuator. A device inserted into the electrical or optical path to lessen or weaken the signal.

auto-provision. The process by which the IBM 2029 shelf processor (SP) automatically provisions a circuit card with default configuration data when the card is inserted into a slot for which no configuration data exists.

avalanche photo diode. A photo diode that exhibits internal amplification of photo current through avalanche multiplication of carriers in the junction region.

AWG. American Wire Gauge.

B

babble. The total crosstalk induced in a line by all other lines.

backbone. The network of broadband communications between switches.

band ADF. IBM 2029 band add/drop filter.

bandwidth. The range of frequencies within which a fiber-optic medium or terminal device can transmit data or information.

bend radius. The smallest radius an optical fiber or fiber cable can bend before increased attenuation or breakage occurs.

BER. Bit-Error Ratio.

bif. Band Input Failure.

bit. The smallest unit of information upon which digital communications are built. A bit has one of two values: 0 or 1 for “on” or “off”. Also an electrical or optical pulse that carries this information.

bit-error ratio (BER). The ratio of the number of bit errors in the received signal to the total number of bits transmitted.

BOM. Bill of Materials.

boot strap protocol (BOOTP). An Internet suite protocol commonly used by dataless nodes at system startup to query or receive an IP address and other startup information such as a boot load name.

BOOTP. Boot Strap Protocol.

browser. A client program that uses the Hypertext Transfer Protocol to make requests of a server for an end user.

buffer. A protective coating applied directly to optical fiber as protection from environmental hazards.

C

cable. One or more optical fibers enclosed within protective covering(s) and strength members to provide mechanical and environmental protection for the fibers.

cable assembly. An optical-fiber cable with connectors installed on one or both ends. The general purpose of the cable assembly is to interconnect the cabling system with opto-electronic equipment at either end of the system. Cable assemblies with connectors on one end only are called *pigtails*. Assemblies with connectors on both ends are typically called *jumpers* or *patch cords*.

cable plant. The cable plant consists of all the optical elements such as fiber connectors and splices between a transmitter and a receiver.

CD-ROM. Compact Disc Read-Only Memory.

central office (CO). A major equipment center designed to serve the communication traffic of a specific geographical area.

central office telemetry (COTEL). The IBM 2029 circuit card that physically interfaces with the central office alarm system to provide monitoring and alarm information about the IBM 2029 network.

channel. A communications path or the signal sent over that path. By multiplexing several channels, voice channels can be transmitted over one optical channel.

channel assignment. A channel assignment is a mapping of an OCI facility to either one (unprotected) or two (protected) OCLD facilities.

cladding. In fiber-optic cable, a colored material with a low refractive that surrounds the core and provides optical insulation and protection to the core.

CLEI. Common Language Equipment Identification.

CLO. Control Link Oscillator.

CO. Central Office.

common language equipment identification (CLEI). A standard used to identify telecommunications equipment. CLEI codes appear on barcode labels that are attached to equipment items and provide the technical base for tracking inventory and investment information.

compact disc read-only memory (CD-ROM). A compact disc with data pre-recorded, normally used in large database-type applications such as directory, reference, or data retrieval.

configuration. (noun) The relative arrangements, options, or connection pattern of a system and its subcomponent parts and objects.

(verb) The process of defining an appropriate set of collaborating hardware and software objects to solve a particular problem.

configuration management. One of five categories of network management defined by ISO for management of OSI networks. Configuration management subsystems are responsible for detecting and determining the state of a network.

conformant management entity (CME). A real open system that supports the NM/Forum-defined interoperable interface. Can manage networks made visible by agent CMEs.

connection. A connection is a collection of two endpoints. In IBM 2029, a connection spans two IBM 2029 shelves, joining a channel assignment on one shelf to a channel assignment on another shelf over the same channel and wavelength band.

connector. A mechanical device used to align and join two optical fibers. The connector provides a means for coupling and decoupling fiber to a transmitter, receiver, or another fiber. Common used connectors include ST Compatible, STII Compatible, FC/PC, SC, FDDI, ESCON, and SMA.

core. The light-conducting central portion of an optical fiber, composed of material with a higher refractive index than the cladding.

COTEL. Central Office Telemetry.

coupler. A device that connects three or more fiber ends. A coupler divides one input between two or more outputs or combines two or more inputs into one output.

CSA. Canadian Standards Association.

CSM. Customer Service Management.

cutoff wavelength. The wavelength corresponding to the cutoff frequency.

D

DAC. Digital-to-Analog Converter.

dark fiber. An inactive optical fiber; that is, a fiber without connected transmitters, receivers, amplifiers, and so on.

data communications network (DCN). The computer network to which an IBM 2029 network is connected by the operating company to do network surveillance and operations tasks for all its interconnected systems.

data rate. The maximum number of bits of information that can be transmitted per second, as in a data transmission link. Typically expressed as megabits per second (Mbps).

data terminal equipment (DTE). A connector that connects to a computer (serial port) with a straight-through cable. The link speed for this port is 120 kbps.

dB. Decibel.

dBa. Adjusted decibels.

dBm. Decibels Per Milliwatt.

DC. Direct Current.

DCE. Data Circuit-Terminating Equipment.

DCN. Data Communications Network.

decibel (dB). A unit of measure indicating relative optic power on a logarithmic scale. Often expressed to a fixed value, such as dBm (1 milliwatt) or dBµ (1 microwatt).

decibels per milliwatt (dBm). The absolute power levels that are read by a test device (optical or electrical).

defect. An anomaly that interrupts the normal operation of the system and persists for a defined period of time.

demultiplexing. The process of separating optical channels.

demux. Demultiplexer.

DHCP. Dynamic Host Configuration Protocol

digital. A discrete transmission format that uses two distinct physical values (binary) to transmit information. A binary signal has only two states: 0 and 1.

digital-to-analog converter (DAC). A device that produces an analog signal that is proportional to a digital (numeric) value.

direct current (DC). An electric current that flows in one direction only.

dispersion. The broadening of input pulses as they travel the length of an optical fiber. There are three major types of dispersion: (1) modal dispersion, which is caused by the many optical path lengths in a multimode fiber; (2) chromatic dispersion, which is caused by the differential delay at various wavelengths in the optical fiber; (3) waveguide dispersion, which is caused by light traveling through both the core and cladding materials in single-mode fibers.

dispersion shifted fiber (DSF). Standard single-mode fibers exhibit optimum attenuation performance at 1550nm and optimum bandwidth at 1310nm. Dispersion-shifted fibers are made so that both attenuation and bandwidth are optimum at 1550nm.

downstream. In the transmission path of a network, you transmit data to equipment that is downstream from you. *See also* upstream.

DS-3. A digital signaling rate of 44.7 Mbps, corresponding to the North American and Japanese T3 designator.

DSF. Dispersion Shifted Fiber.

DTE. Data Terminal Equipment.

DTR. Data Terminal Ready.

duplex. A duplex cable contains two fibers; a duplex connector links two pairs of fibers.

duplex SC. (or Dual SC) Two SC-type connectors that are physically joined so they can be plugged or unplugged at the same time. See SC.

DWDM. Dense Wavelength Division Multiplexing.

dynamic host configuration protocol (DHCP). A protocol used to centrally manage and automate the assignment of Internet Protocol (IP) addresses in a network.

E

E/O. Electrical to Optical.

EIA. Electronics Industries Association.

electrical to optical (E/O). Electrical to optical conversion.

electromagnetic interference. Any electrical or electromagnetic interference that causes undesirable response, degradation, or failure in electronic equipment. Optical fibers neither emit nor receive EMI.

Electronics Industries Association (EIA). A group that specifies electrical transmission standards. The EIA and TIA have developed numerous well-known communications standards, including EIA/TIA-232 and EIA/TIA-449.

electrostatic discharge (ESD). Discharge of stored static electricity that can damage electronic equipment and impair electrical circuitry, resulting in complete or intermittent failures.

EM. External Manager. An SNMP management product, external to the IBM 2029 network.

EMI. Electromagnetic Interference.

Enterprise Systems Connection (ESCON). A duplex optical connection used for computer-to-computer data exchange.

equipment fault. A fault that has been isolated to the failure of a specific piece of equipment.

ER or R_e. Extinction Ratio.

ESCON. Enterprise Systems Connection.

ESD. Electrostatic Discharge.

Ethernet. A local area network data link protocol based on a packet frame. Ethernet, which usually operates at 10 Mbps, allows multiple devices to share access to the link.

ETR. External Timing Reference.

ETSI. European Telecommunications Standards Institute.

European Telecommunications Standards Institute (ETSI). The organization created by the European Post, Telephone, and Telegraph and the European Community to propose telecommunications standards for Europe.

extinction ratio (ER or R_e). The ratio of two optical power levels of a digital signal generated by an optical source.

F

facia. A mounted plate for connecting cable connectors to a cabling system.

facility. Any provisional configuration.

facility. A facility is the logical representation of a transport signal.

facility fault. A fault that has occurred elsewhere than on the reporting shelf. That is, the fault has occurred on another shelf or on the fiber connecting two shelves.

failure. An end to the ability of an item to do a required function. A failure is caused by the persistence of a defect.

FC. Fiber Connector.

FCC. Federal Communications Commission.

FDDI. Fiber Distributed Data Interface.

ferrule. A mechanical fixture, generally a rigid tube, used to confine and align the stripped end of a fiber within a connector.

fiber. See optical fiber.

fiber amplifier. An all-optical amplifier using erbium or other doped fibers and pump lasers to increase signal output power without electronic conversion.

fiber channel. A technology for transmitting data between computer devices at a data rate of up to 1 Gbps.

fiber connector. A keyed, locking type of fiber-optic connector with a round barrel and threaded retaining ring.

fiber distributed data interface (FDDI). A 100 Mbps, fiber-based token ring LAN standard.

fiber loss. The attenuation of the light signal in optical-fiber transmission.

fiber-optic link. A combination of transmitter, receiver, and fiber-optic cable capable of transmitting data.

fiber-optic test procedure (FOTP). Standards developed and published by the Electronic Industries Association (EIA) under the EIA-RS-455 series of standards.

fiber optics (FO). The branch of optical technology dedicated to transmitting light through fibers made of transparent materials such as glass and plastic.

FICON. Fiber Channel Connection.

field-replaceable unit (FRU). A hardware component that can be removed and replaced on-site. Typical field-replaceable units include cards, power supplies, and chassis components.

filler card. A blank circuit card with faceplate that is installed in unused slots in an IBM 2029 shelf to ensure the flow of cooling air through the card cage. There are two types of filler card: OCLD filler cards have two connectors on the faceplate to park unused OMX pigtails; blank filler cards are used in all other unused slots.

filter. An arrangement of electronic components designed to pass signals in one or more frequency bands and to attenuate signals in other frequency bands.

FO. Fiber Optics.

forced switch. A user-initiated protection switch. A forced switch has a higher priority than automatic switches and therefore cannot be overridden.

FOTP. Fiber-optic Test Procedure.

frequency. The number of cycles per unit of time, denoted by Hertz (Hz). One Hz equals one cycle per second.

frequency shift keying (FSK). A method of encoding data with two or more tones.

FRU. Field-Replaceable Unit.

FSK. Frequency Shift Keying.

FTS. Fiber Transport Services.

fusing. The process of joining fibers together by fusion (melting).

G

gain. The ratio of output current, voltage, or power to input current, voltage, or power, respectively. The opposite of attenuation. Gain is usually expressed in dB.

gateway network element. The IBM 2029 shelf designated as the communications gateway between the IBM 2029 network and network operations center (NOC) of the operating company. IBM 2029 supports two gateway network elements per network. *See also* DCN.

Gbps. Gigabits Per Second.

GbE. Gigabit Ethernet.

GHz. Gigahertz.

gigabit ethernet (GE). A LAN transmission standard that provides a data rate of one billion bits per second (Gbps).

gigabits per second (Gbps). A measure of the bandwidth on a data transmission medium. One Gbps equals 1,000,000,000 bps.

gigahertz (GHz). Unit of frequency equal to 1 billion cycles per second.

GMT. Greenwich Mean Time.

GNE. Gateway Network Element.

graphical user interface (GUI). A graphical (rather than textual) interface to a computer.

ground. An electrical term meaning to connect to the earth or other large conducting body to serve as an earth thus making a complete electrical circuit.

GUI. Graphical User Interface.

H

head end. The end of the optical path where the optical signal originates.

hertz (Hz). A measure of frequency or bandwidth; one Hz equals one cycle per second.

HOP. High Optical Power.

host. On the Internet, any computer that has full two-way access to other computers. A host has a specific local or host number that, together with the network number, forms its unique Internet Protocol address. If you use PPP to get access to your service provider, you have a unique IP address for the duration of any connection you make to the Internet and your computer is a host for that period. In this context, a host is a node in a network.

HP-OV. HP OpenView.

HTML. Hypertext Markup Language.

HTTP. Hypertext Transfer Protocol.

hub. A group of circuits connected at one point on a network.

hypertext. An interactive online documentation technique. Hypertext requires a “tag” language (HTML) to specify branch labels with a hypertext document.

Hypertext Markup Language (HTML). An application of SGML (Standard Generalized Markup Language [ISO 8879]) implemented in conjunction with the World Wide Web to facilitate the electronic exchange and display of simple documents using the Internet.

Hypertext Transfer Protocol (HTTP). A protocol used between HTTP servers, usually called Web servers, and Web clients or browsers.

Hz. Hertz.

I

I/O. Input/Output.

ICES. Interference-Causing Equipment Requlations.

IEC. International Electrotechnical Commission.

in service (IS). An administrative state.

indicator lamp. A status indicator, usually an LED, that provides constant visual information about the state of operation of a component or device or indicates a change of status.

input/output (I/O). I/O describes any operation, program, or device that transfers data to or from a computer.

insertion loss. Additional loss in a system when a device such as a connector is inserted, equal to the difference in signal level between the input and output.

interface. A shared boundary between two functional units, defined by specific attributes, such as functional characteristics, common physical interconnection characteristics, and signal characteristics.

intermediate reach (IR). The distance specification for optical systems that operate effectively from 3 to 20 km (1.8 to 12.5 mi).

International Standards Organization (ISO). An international organization that defines communications and computing standards.

International Telecommunications Union (ITU). The specialized agency of the United Nations for telecommunications. ITU is also the organization in which governments, private companies, and scientific and industrial institutions cooperate to improve the rational use of telecommunications.

Internet. A worldwide, public, and cooperative computer network system based on TCP/IP.

Internet Protocol (IP). An IETF standard protocol used in interconnected systems of packet-switched computer communication networks.

IOCP. I/O Configuration Program.

IP. Internet Protocol.

IR. Intermediate Reach.

IS. In Service.

IS-ANR. In service abnormal.

IS-NR. In service normal.

ISO. An international organization that defines communications and computing standards.

ITU. International Telecommunications Union.

ITU grid. ITU standard wavelength designation. It is based on optical frequency with 100 GHz spacing. The anchor optical frequency is 193.1 Tera Hz, corresponding to 1552.52 nm wavelength.

J

Java. An object-oriented programming language commonly associated with machine-independent network-based applications or applets.

jumper. An optical fiber cable with connectors installed on each end. See Cable Assembly.

K

kbps. Thousands of Bits Per Second.

kg. Kilogram.

km. Kilometer.

L

LAN. Local Area Network.

laser. Light Amplification by Stimulated Emission of Radiation.

LED. Light Emitting Diode.

light. Electromagnetic radiation visible to the human eye at 400 nm to 700 nm. The term is also applied to electromagnetic radiation with properties similar to visible light, including the invisible near-infrared radiation in most fiber-optic communication systems.

light amplification by stimulated emission of radiation (LASER). One of the wide range of devices that generates light by that principle. Laser light is directional, covers a narrow range of wavelengths, and is more coherent than ordinary light. Semiconductor laser diodes are the standard light sources in fiber-optic systems.

light-emitting diode (LED). A semi-conductor device that accepts electrical signals and converts the energy to a light signal; with lasers, the main light source for optical fiber transmission; used mainly with multimode fiber.

LOA. Loss of Activity.

local area network (LAN). A data communications network that is geographically limited (typically to a 1 km radius), allowing easy interconnection of terminals, microprocessors, and computers within adjacent buildings. Most notable of LAN topologies are Ethernet, token ring, and FDDI.

lockout. A user-initiated action that freezes the protection group on which it is invoked. No further protection actions can take place until the lock has been removed.

LOL. Loss of Lock.

LOL-RX. Receiver Loss of Lock.

long reach (LR). The distance specification for optical systems that operate effectively from 20 to 100 km (12.5 to 62 mi).

LOP. Low Optical Power.

LOS. Loss of Signal.

loss. Attenuation of optical signal, normally measured in decibels.

loss of signal (LOS). A physical-layer alarm sent by the receiver to indicate a cessation in signal transmission. For example, LOS is declared if a fiber-optic cable is cut and the receiving end no longer detects any signal transmissions. The LOS alarm continues until it is manually suppressed or the problem is fixed. Detection of LOS prompts an AIS.

LR. Long Reach.

M

MAN. Metropolitan Area Network.

management information base (MIB). The data schema that defines the information available to network management systems from an SNMP-manageable device or service. The term MIB is also commonly used to refer to any subset of managed objects that comprises a MIB.

manual switch. A user-initiated protection switch which has a lower priority than automatic switches and therefore can be overridden if necessary.

margin. The additional amount of loss that can be tolerated in a link.

Mbps. Megabits Per Second.

mC. Microcontroller.

MCP. Mode Conditioning Patch cable.

mean time between failures (MTBF). The mean value of the length of time between consecutive failures under stated conditions.

megabits per second (Mbps). A measure of the bandwidth on a data transmission medium. One Mbps equals 1,000,000 bps.

megahertz (MHz). A unit of frequency equal to 1,000,000 cycles per second.

metropolitan area network (MAN). A MAN consists of LANs interconnected within a radius of approximately 80 km (50 mi). MANs typically use fiber-optic cable to connect LANs.

MFD. Mode Field Diameter.

MHz. Megahertz.

MIB. Management Information Base.

micrometer. See micron.

micron. (μ) One millionth of a meter (10^{-6} meter). Commonly used to express the geometric dimensions of optical fiber.

millisecond. One thousandth of a second.

MM fiber. Multimode Fiber.

mode. An independent light path through an optical fiber. See single-mode fiber and multimode fiber.

mode field diameter (MFD). The diameter of the one mode of light propagating in a single-mode fiber, typically slightly larger than the core diameter.

modulation. The process by which the characteristic of one wave (the carrier) is modified by another wave (the signal). Examples include amplitude modulation (AM), frequency modulation (FM), and pulse-coded modulation (PCM).

monitor point. A location within the network that is frequently checked by the system in case of traffic or functionality degradation.

ms. Millisecond.

MSDS.Material Safety Data Sheet.

MTBF. Mean Time Between Failures.

multimode fiber (MM fiber). A fiber-optic medium in which light travels in multiple modes. Typical core/cladding sizes (measured in microns) are 50/125, 62.5/125 and 100/140.

multiplexer. A device that combines two or more signals into a single composite data stream for transmission on a single channel.

MUX. Multiplexer.

mV. Millivolt.

N

nanometer (nm). One billionth of a meter (10^{-9} meter). A unit of measure commonly used to express the wavelengths of light.

NE. Network Element.

NEBS. Network Equipment Building System.

net mask. A 32-bit mask that shows how an Internet address is to be divided into network, subnet, and host parts. The netmask has ones in the bit positions in the 32-bit address which are to be used for the network and subnet parts, and zeros for the host part. The mask should contain at least the standard network portion (as determined by the class of the address) and the subnet field should be contiguous with the network portion.

network element (NE). In integrated services digital networks, a piece of telecommunications equipment that provides support or services to the user.

network equipment building system (NEBS). A Bellcore physical requirement and testing standard with which the vendor equipment used by telephone companies must comply. The requirements were created to ensure that a product installed in a central office is safe, robust, and extremely reliable.

network name. The name of the network.

network operations center (NOC). In an operating company, the designated site on the DCN that does surveillance and operations tasks for all the interconnected systems.

nm. See nanometer.

NOC. Network Operations Center.

node. For networks, a branching or exchange point.

nonvolatile random access memory (NVRAM). Random access memory that retains its contents after electrical power is removed.

non-zero dispersion shifted fiber (NZ-DSF). A type of optical fiber optimized for high bit-rate and dense wavelength-division-multiplexing applications.

NRTL. Nationally Recognized Testing Laboratories.

NTP. Network Time Protocol.

NVRAM. Nonvolatile Random Access Memory.

NZ-DSF. Non-Zero Dispersion Shifted Fiber.

O

O/E. Optical to Electrical.

OADM. Optical Add Drop Multiplexer.

OC. Optical Carrier.

OC-1. Optical Carrier - Level 1.

OC-12. Optical Carrier - Level 3.

OC-3. Optical Carrier - Level 2.

OCI. Optical Channel Interface.

OCLD. Optical Channel Laser and Detector.

OCM. Optical Channel Manager.

OEM. Original Equipment Manufacturer.

OFA. Optical Fiber Amplifier.

OFC. Open Fiber Control.

OH. Overhead.

OIF. Optical Input Failure.

OMX. Optical Multiplexer.

OMXI. Optical Multiplexer Interface card.

one plus one protection (1 + 1 protection). A hot standby protection method that is not protocol-related.

one "U" vertical unit (1U). One "U" is 1.75 inches. Standard equipment racks have bolt holes spaced evenly on the mounting rails to permit equipment that is sized in multiples of this vertical unit to be mounted in the same rack

OOS. Out of Service.

OOS-AU. Out of service autonomous

OOS-AUMA. Out of service autonomous maintenance.

OOS-MA. Out of service maintenance.

OOS-MAANR. Out of service maintenance abnormal.

open shortest path first (OSPF). A protocol that defines how routers share routing information. Unlike the older Routing Information Protocol (RIP) which transfers entire routing tables, OSPF conserves bandwidth by transferring only routing information that has changed since the previous transfer.

operating system (OS). The underlying software that schedules tasks, allocates storage, handles the interface to peripheral hardware, and presents a default interface to the user when no application program is running.

operational state. The operational state of an entity (equipment, facility, etc.) is its *actual* state. This state is derived from the underlying condition of the entity and cannot be edited.

OPM. Optical Power Meter.

OPT. Optical Power Transmitted.

optical amplifier. A device that amplifies the input optical signal without converting it to electrical form. The best developed are optical fibers doped with the rare earth element erbium. *See also* OFA.

optical carrier (OC). Series of physical protocols (OC-1, OC-2, OC-3, and so on), defined for SONET optical signal transmissions. OC signal levels put STS frames onto fiber-optic line at a variety of speeds. The base rate is 51.84 Mbps (OC-1); each signal level thereafter operates at a speed divisible by that number (thus, OC-3 runs at 155.52 Mbps).

optical carrier - level one (OC-1). An optical SONET signal at 51.84 Mbps.

optical carrier - level three (OC-12). An optical SONET signal at 622.08 Mbps.

optical carrier - level two (OC-3). An optical SONET signal at 155.52 Mbps.

optical channel. An optical wavelength band for WDM optical communications.

optical channel interface (OCI). The circuit card that interfaces with the customer equipment (subtending equipment) in an IBM 2029 network. A non-WDM card in the IBM 2029 node that provides an interface to the WDM fiber. Types of OCI cards are OC-3, OC-12, gigabit Ethernet, FDDI, etc.

optical channel laser and detector (OCLD). The optical channel transmitter and receiver circuit card that interfaces with the WDM ring through the OMX in an IBM 2029 Network.

optical channel manager (OCM). The circuit card that does protection switching for the IBM 2029 network.

optical fiber. A thin filament of glass that consists of a core and a cladding that is capable of carrying information in the form of light.

optical fiber amplifier (OFA). A device that amplifies an optical signal directly, without the need to convert it to an electrical signal, amplify it electrically, and reconvert it to an optical signal.

optical multiplexer (OMX). A module that does optical add/drop operations to the various IBM 2029 nodes.

optical power meter (OPM). An electronic device that measures optical power levels. The meter reads absolute power levels in dBm or relative units of dB. OPMs typically have a range of –80 dBm to +33 dBm.

optical to electrical (O/E). Optical to electrical conversion.

optical waveguide. See optical fiber.

original equipment manufacturer (OEM). Many computer hardware manufacturers resell their product for packaging as part of another company's product and brand name. The supplier of the product to be included is known as the OEM.

OS. Operating System.

OSHA. Occupational Safety and Health Administration.

OSPF. Open Shortest Path First.

OTS. Optical Transmission Section.

out of service (OOS). The status of a primary rate link when it is out of service.

OVP. Overvoltage Protection.

OVW. Restarts HP OpenView GUI.

P

passthrough. A signal bypass mechanism that allows the signal to pass through a device with little or no signal processing.

path. An end-to-end unidirectional connection from a source OCI to a destination OCI. There are separate paths for each direction and for working and protection.

path protection. Path protection relates to the OCM card switching from one input to another to maintain traffic.

performance management. One of five categories of network management defined by ISO for management of OSI networks. Performance management subsystems are responsible for analyzing and controlling network performance including network throughput and error rates. *See also* accounting management, configuration management, fault management, and security management.

phase. The position of a wave in its oscillation cycle.

photonic. A term created to describe devices using photons, analogous to "electronic" for devices that work with electrons.

PIC. Product Identification Code.

pigtail. Optical-fiber cable that has a connector installed on one end only. *See also* cable assembly.

point-to-point network. A network arrangement of point-to-point links.

point-to-point protocol (PPP). An Internet suite protocol used to establish IP communications between two nodes over non-Ethernet physical interfaces. (Typically used to establish IP communications over point-to-point slow-speed serial links.)

PPP. Point-to-Point Protocol.

primary IP. The address of the primary shelf in the network.

primary shelf. The IBM 2029 shelf that contains the system time and date references with which the other shelves in the network synchronize.

protocol. The procedure used to control the orderly exchange of information between stations on a data link or on a data-communications network or system. Protocols specify standards in three areas: the code set, usually ASCII or EBCDIC; the transmission mode, usually asynchronous or synchronous; and the non-data exchanges of information by which the two devices establish contact and control, detect failures or errors, and initiate corrective action.

provisioning. The process by which a requested service is designed, implemented, and tracked.

proxy ARP. The GNE shelf can provide a function known as "proxy ARP" where the GNE shelf replies to ARP requests (from the external network) targeted to its own IP address or the IP address of any non-GNE shelf in the IBM 2029 network. The GNE sends the ARP Reply, on behalf of the non-GNE shelves, specifying its own (GNE) hardware interface address (MAC).

PWOSC. Per-Wavelength Optical Service Channels.

R

RAM. Random Access Memory.

random access memory (RAM). A data storage device for which the order of access to different locations does not affect the speed of access.

real time. The rapid transmission and processing of event-oriented data and transactions as they occur in contrast to being stored and retransmitted or processed as batches.

real time clock (RTC). A microprocessor peripheral device used to track local date and time.

receiver (Rx). A terminal device that includes a detector and signal processing electronics. It functions as an optical-to-electrical converter.

reflectance. The ratio of power reflected to the incident power at a connector interface or other optical junction. Reflectance is typically stated in negative decibels (–dB). The terms return loss, back reflection, and reflectivity are used interchangeably throughout the industry, but are typically stated as positive values.

reflection. The abrupt change in direction of a light beam at an interface between two dissimilar media so the light beam returns into the media from which it originated.

ring network. A network topology in which terminals are connected serially point-to-point in an unbroken circle.

ROM. Read-Only Memory.

RS-232. A standard that describes the physical interface and protocol for relatively low-speed serial data communication between computers and related devices.

RTC. Real-Time Clock.

Rx. Receiver.

S

S/390. System 390.

S-Bus. Supervisory Bus.

SC. Subscriber Connector.

scalable. The ability to add power and capability to an existing system without significant expense or overhead.

SDH. Synchronous Digital Hierarchy.

selector. A software entity whose purpose is to pick one of two available paths, for the purpose of protection.

SELV. Safety Extra Low Voltage.

sensitivity. For a fiber-optic receiver, the minimum optical power required to achieve a specified level of performance, such as a BER.

session. A session is the length of time the user is logged on to the system at the System Manager.

shelf processor (SP). The circuit pack that provides alarm consolidation, software and configuration management, node visibility, and other features for the IBM 2029 system.

shelf URL. IP address of the shelf.

short reach (SR). The distance specification for optical systems that operate effectively up to 3 km (1.8 mi).

signal-to-noise ratio (SNR). The ratio of the amplitude of the desired signal to the amplitude of noise signals at a given point in time.

simple network management protocol (SNMP). A standard for the management of entities in a TCP/IP local area network.

single-mode fiber (SM fiber). An optical fiber that supports only one mode of light propagation above the cutoff wavelength. Core diameters are usually between 5 and 10 microns and claddings are usually ten times the core diameter. These fibers have a potential bandwidth of 50 to 100 GHz per kilometer.

SM. System Manager.

SM fiber. See single-mode fiber.

SMI. System Manager Interface.

SNMP. Simple Network Management Protocol.

SNMPv2. Simple Network Management Protocol, version 2.

SNR. Signal-to-Noise Ratio.

SONET. Synchronous Optical Network.

SP. Shelf Processor.

SP1. Service Pack 1.

span. An optical channel between two nodes terminated by OCLD cards. Spans are unique for each wavelength and direction.

SPS. Surrogate Payload Signal

SR. Short Reach.

SRM. Sub-rate Multiplexer (see 4TDM).

subscriber connector (SC). A push-pull type of fiber-optic connector with a square barrel.

supervisory bus (S-Bus). The intercard communication bus that uses IEEE 1494 (Fire Wire) to transport messages between cards in the IBM 2029 shelf.

surrogate payload signal (SPS). A clock signal placed on the data channel in the absence of other valid data. Formerly known as AIS.

Sx. Short Wavelength.

synchronous digital hierarchy (SDH). An international digital telecommunications network hierarchy that standardizes transmission around the bit rate of 51.84 megabits per second, which is also called STS-1.

synchronous optical network (SONET). An interface standard for synchronous optical fiber transmission.

system manager interface (SMI). The graphical user interface used to commission, provision, monitor, and maintain an IBM 2029 system.

T

tail end. The end of the optical path where the optical signal terminates.

TCP. Transmission Control Protocol.

TDM. Time Division Multiplexing

terminal. Any device capable of sending or receiving information over a communication channel.

thousands of bits per second (kbps). A measure of the bandwidth on a data transmission medium. One kbps equals 1000 bps.

time division multiplexing (TDM). Digital multiplexing in which two or more apparently simultaneous channels are derived from a given frequency spectrum, i.e., bit stream, by interleaving pulses representing bits from different channels.

topology. The physical layout of a network.

traffic. The activity on a network or an individual circuit.

Transmission Control Protocol (TCP). A transport protocol that offers a connection-oriented transport service in the Internet suite of protocols.

transmitter (Tx). A device that includes a LED or laser source and signal conditioning electronics that is used to inject a signal into optical fiber.

Tx. Transmitter.

U

U. (One “U” vertical unit) One “U” is 1.75 inches. Standard equipment racks have bolt holes spaced evenly on the mounting rails to permit equipment that is sized in multiples of this vertical unit to be mounted in the same rack.

UL. Underwriters Laboratories.

unidirectional channel. One-way only channel.

uniform resource locator (URL). The address of a file or other resource accessible on the Internet.

upstream. In the transmission path of a network, you receive data from equipment that is upstream from you. *See also* downstream.

URL. Uniform Resource Locator.

user ID. A unique name or number or both that is associated with a user name on a server system.

V

VAC. Volts Alternating Current.

variable optical attenuator (VOA). A device that enables adjustment of signal strength through a fiber-optic cable by means of an aperture that is controlled by a set screw.

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IBM Redbooks review

Your feedback is valued by the Redbook authors. In particular we are interested in situations where a Redbook "made the difference" in a task or problem you encountered. Using one of the following methods, **please review the Redbook, addressing value, subject matter, structure, depth and quality as appropriate.**

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Review	
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IBM Redbooks

Fiber Saver (2029) Implementation Guide

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Fiber Saver (2029) Implementation Guide

The desired MAN solution for dispersed data centers

Designing, planning, and migration considerations

Architecture, features, and applications

IBM offers a Dense Wavelength Division Multiplexing (DWDM) solution with the IBM Fiber Saver (2029). The IBM 2029 provides data transport capabilities for data center applications such as:

-Data center backup and recovery
-DASD mirroring
-Tape vaulting and remote printing
-Geographically Dispersed Parallel Sysplex (GDPS)
-LAN interconnectivity
-Channel extension
-Peer-to-Peer Remote Copy (PPRC)
-Storage Area Network (SAN)

This IBM Redbook is for technical professionals who are interested in a metropolitan area network (MAN) solution for their data center, using DWDM technology.

This document gives a broad understanding of the IBM 2029 architecture and application, and provides information to help plan, implement, configure, and manage an IBM 2029 network. It also contains a discussion on how to design/create a solution to migrate from an IBM 9729 to an IBM 2029.

A walkthrough of the commissioning and provisioning process, as well as practical examples for problem determination, are also included.

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