INTRODUCTION TO MEDIA CONVERSION
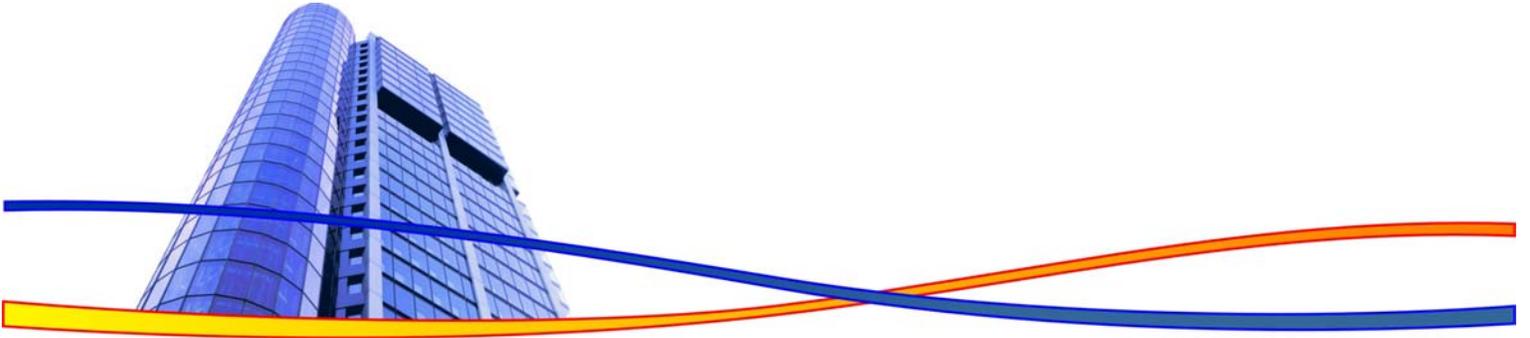
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Introduction

Media converters are flexible and cost-effective devices for implementing and optimizing fiber links in all types of networks.

Media converters have become the "Swiss army knife" of networking hardware, and this white paper will review the different types of media converters and explain their benefits. It will also provide information on the wide variety of applications for media converters.

What is a Media Converter?

The most common type of media converter is a device that functions as a transceiver; converting the electrical signal used in copper Unshielded Twisted Pair (UTP) network cabling into light waves used in fiber optic cabling. Fiber optic connectivity is necessary when the distance between two network devices exceeds the transmission distance of copper cabling. Copper-to-fiber conversion using media converters enables two network devices with copper ports to be connected over extended distances via fiber optic cabling.

Media converters also provide copper-to-copper conversion for short distance connections or connecting to a copper switch or converting to Power over Ethernet solutions.

Media converters also provide fiber-to-fiber conversion from multi-mode fiber to single-mode fiber, and convert a dual fiber link to single fiber using Bi-directional (BIDI) data flow. Media converters can also convert between wavelengths for Wavelength Division Multiplexing (WDM) applications.

Media converters are typically protocol specific and are available to support a wide variety of network types and data rates. They are available as physical layer or Layer 2 switching devices, and can provide rate-switching and other advanced features.

The Advantages of Media Conversion Technology

Network complexity, demanding applications, and the growing number of devices on the network are driving network speeds and bandwidth requirements higher and forcing longer distance requirements within the Local Area Network (LAN). Media converters present solutions to these problems, by allowing the use of fiber when it is needed, and integrating new equipment into existing cabling infrastructure. Media converters provide seamless integration of copper and fiber, and different fiber types in Enterprise LAN networks. They support a wide variety of protocols, data rates and media types to create a more reliable and cost-effective network.

Demands on the Network are Increasing:
- LANs and WANs are converging, and networks are growing in physical area
- Budget constraints are pushing preservation of capital investment in legacy switches and routers
- New network services are driving up bandwidth demand

Solutions Provided by Media Converters:
- Increase network distances by converting UTP to fiber and extending fiber links
- Maintain investments in existing equipment
- Increase the capacity of existing fiber with WDM wavelengths (when used with multiplexers)

New Applications for Media Converters:
- Remotely managed converter and multi-port switch configurations
- Convert WDM wavelengths for bandwidth capacity enhancement
- Enable Fiber-to-the-Desktop

Media converters do more than convert copper-to-fiber and convert between different fiber types. Media converters for Ethernet networks can support integrated switch technology, and provide the ability to perform 10/100 and 10/100/1000 rate switching. Additionally, media converters can support advanced features including VLAN, Quality of Service (QoS) prioritization, Port Access Control and Bandwidth Control. These features facilitate the deployment of new data, voice and video to end users. Media converters can provide all these sophisticated switch capabilities in a small, cost-effective device.

Media converters save capital equipment expenditures (CAPEX) by enabling interconnection between existing switches, servers, routers and hubs; preserving the investment in legacy equipment. They also reduce CAPEX by avoiding the need to install new fiber links by enabling WDM technology through wavelength conversion.

Media converters also reduce network operating costs (OPEX) by helping to troubleshoot and remotely configure network equipment that is at distant locations, saving time and money when there is not a network administrator at the distant location.

Benefits of Fiber Optic Cabling

Fiber can transport more data over longer distances than copper cabling, and increased distances provide the ability to reach more users and equipment. Fiber has complete immunity to electrical interference, and provides higher security than copper cabling because it has no electro-magnetic emission. These characteristics have made fiber an ideal medium for commercial, utility, government and financial networks.

Distances supported by fiber network infrastructure are limited mostly by the optical power, or brightness, supplied by the active interface hardware. Fiber distances can range from 300 meters to 160 kilometers, depending on the type of media converter, cable, wavelength and data rate.
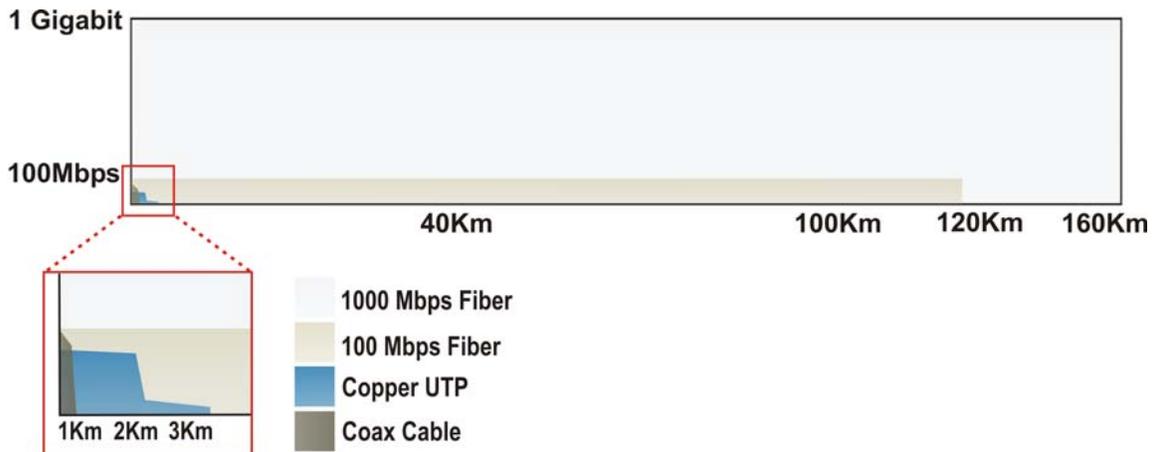
Types of Media Converters

There are a wide variety of copper-to-fiber and fiber-to-fiber media converters available that support different network protocols, data rates, cabling and connector types.

Network Protocols Supported:
- Single Pair Ethernet – 10BASE-T1L
- 10, 100, 10/100, Gigabit, 10/100/1000, 2.5G, 5G and 10 Gigabit Ethernet
- 10G OTN
- Serial RS-232, RS-422, RS-485, RS-530 and X.21
- T1/E1 and T3/E3 TDM Protocols
- OC-3/STM-1, OC-12/STM-4, OC-48/STM-16 and OC-192/STM-64 SONET/SDH
- Fibre Channel
- Protocol Transparent

Fiber Cable and Connector Types Supported:
- Multimode, single-mode, dual fiber and single-fiber
- SC, ST, LC, MT-RJ and FC connectors
- SFP, SFP+ and XFP transceivers

Copper Cable Types Supported:
- Coax
- UTP Category 4, 5 and 6
- Single Pair Ethernet cable

Unmanaged vs. Managed

An unmanaged media converter simply allows devices to communicate, and does not provide the same level of monitoring, fault detection and configuration as equivalent managed media converters. Connect the devices to the unmanaged media converter and they usually communicate automatically. Unmanaged media converters are simple to use and install. For most unmanaged converters, minimal configuration is required.

A managed media converter is typically more costly than an unmanaged media converter; however, a managed converter provides additional network monitoring, fault detection and remote configuration functionality not available with an unmanaged media converter.

Ethernet Copper-to-Fiber Media Converters

Supporting the IEEE 802.3 standard, Ethernet copper-to-fiber and copper-to-copper media converters provide connectivity for Single-Pair Ethernet (SPE), Multi-Gigabit/Multi-Rate Ethernet, 10Mbps Ethernet, 100Mbps Fast Ethernet, 1000Mbps Gigabit and 10Gbps Gigabit Ethernet devices.
- Media converters support 10/100 or 10/100/1000 rate switching, enabling the integration of equipment of different data rates and interface types into one seamless network.
- Media converters support 10/100/1000/2.5G/5G/10G rate switching enabling connection to highspeed Wi-Fi 6/6E access points and advanced 4K PTZ security cameras.
- Media converters support 10, 10/100, 10/100/1000 and 10/100/1000/2.5G/5G/10G PoE/PoE+/PoEBT for powering of external powered devices.

Point-to-Point Applications

A pair of 10G media converters can be used in point-to-point application that connect the Security Control Room via fiber to high speed Wi-Fi access point and IP cameras.
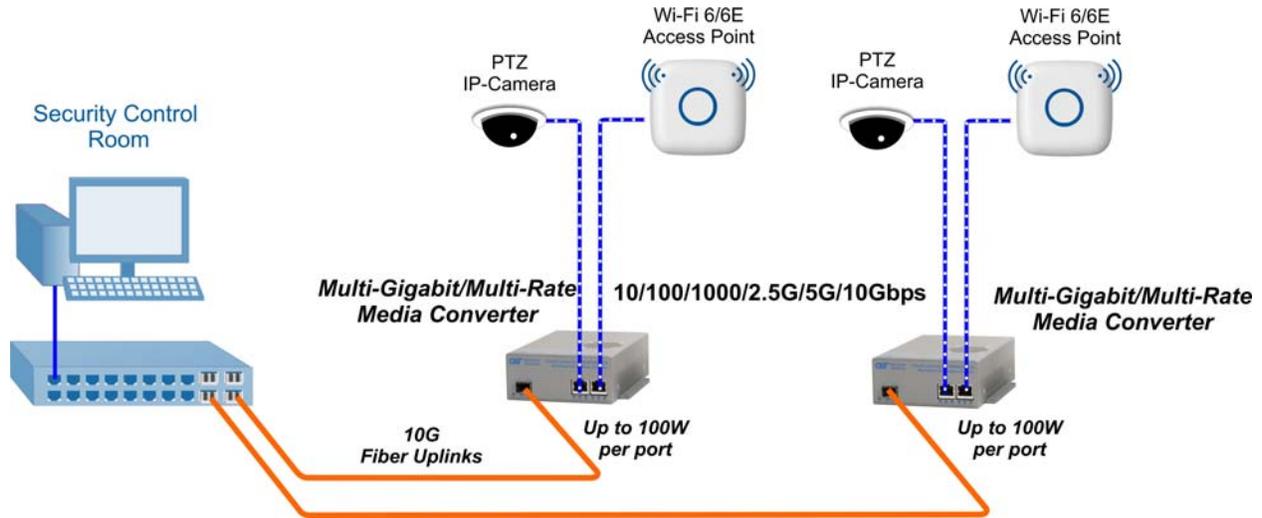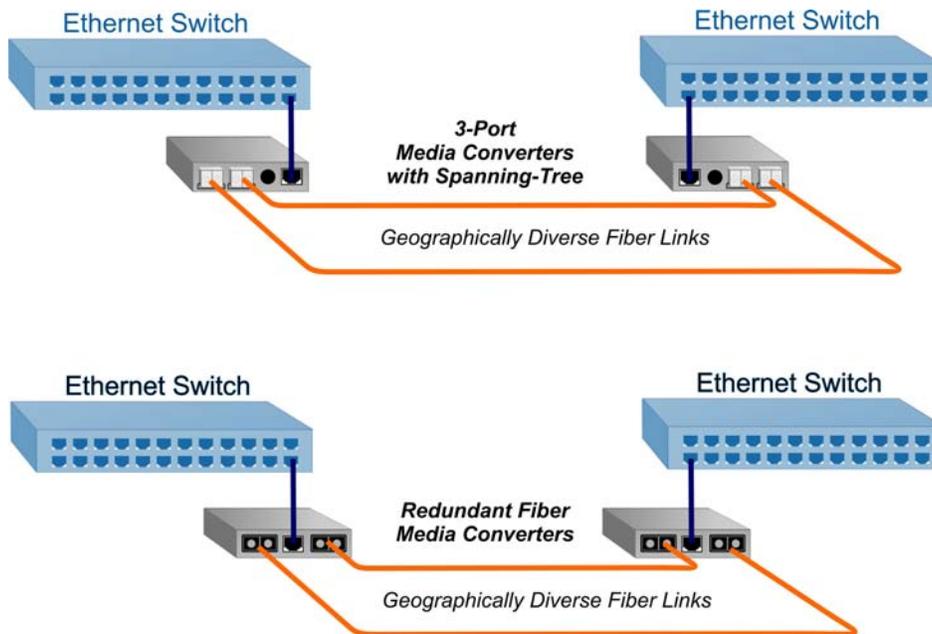

Campus Fiber Application

In this application example, 10/100/1000 media converters are installed in a Redundant Power chassis for high-density fiber distribution from copper switch at the network core in Building A. A fiber switch in Building B is directly connected to a copper-to-fiber media converter at Building A. A copper workgroup switch in Building C and D is connected via fiber to the network core using standalone 10/100/1000 media converters.
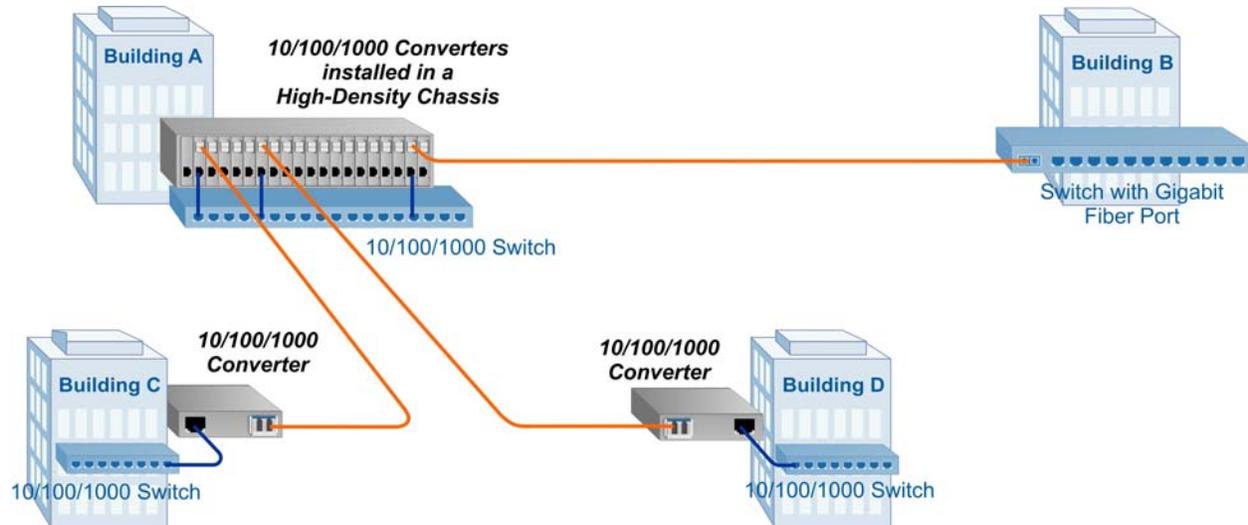
This network application example can support 10/100, 10/100/1000 and 10G data rates
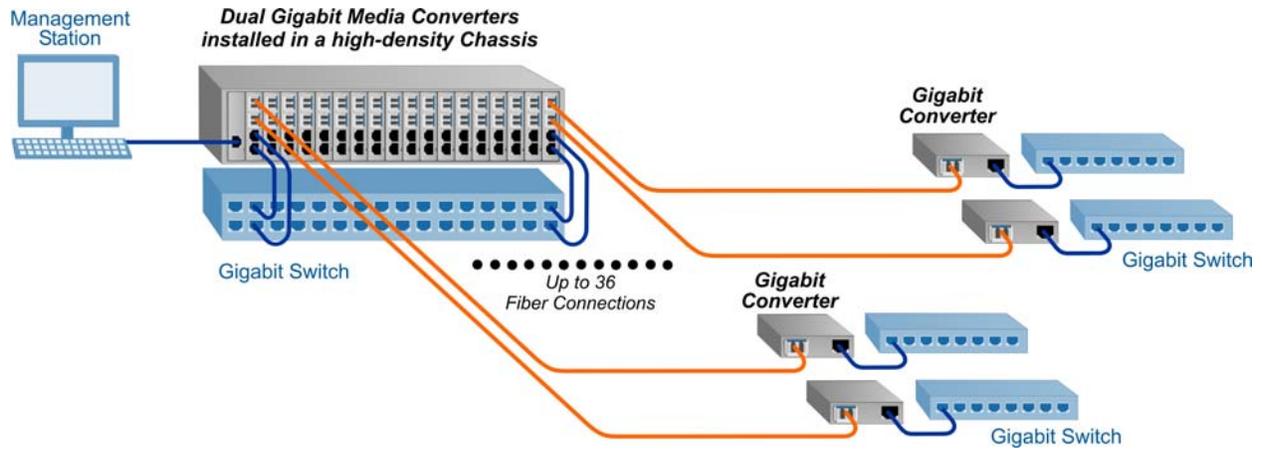
Redundant Fiber-to-Copper Application

Two solutions are shown for a redundant fiber application. The top application is using two managed 3-Post media converters supporting a Spanning-Tree protocol. In the event of a fiber fault, the Spanning-Tree protocol will detect the fault and switch over to the backup fiber. The speed of the switch over and recovery will depend on the configuration of the Spanning-Tree protocol. In the bottom application, Redundant Fast Ethernet media converters provide fiber link redundancy. In the event of a fiber fault, the redundant link is enabled to ensure 100% uptime. Redundant converter modules can provide link fault detection and switch over in 100 microseconds or less to provide rapid response time required for mission-critical network applications. Redundant links can run in parallel paths or geographically diverse paths.
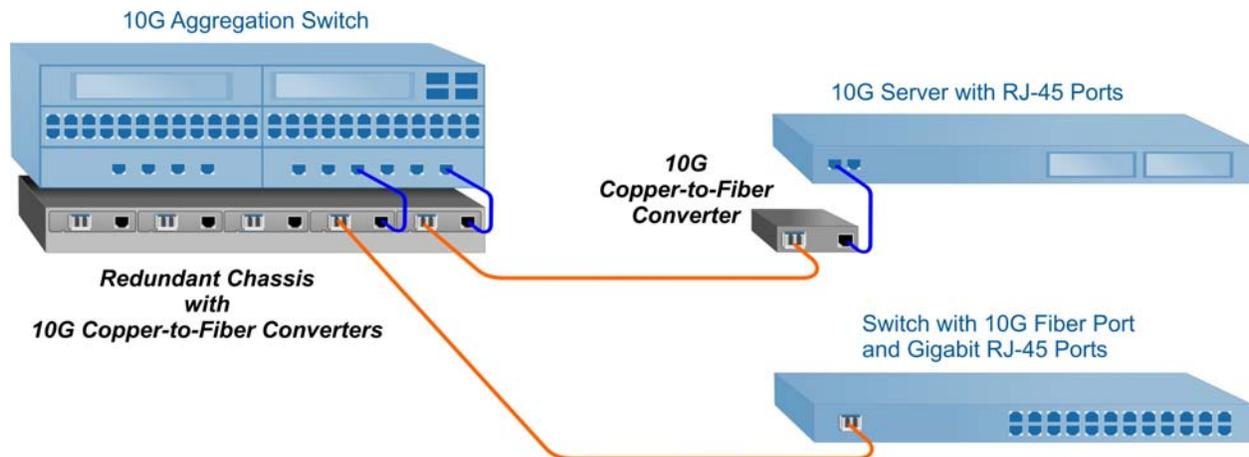
High-Density Gigabit Application

In this application diagram, eighteen dual Gigabit plug-in modules are installed in a Redundant Power chassis for high-density fiber distribution from a Gigabit copper switch. The plug-in module functions as a dual-channel media converter, providing connectivity between two fiber links and two RJ-45 ports. The conversion from copper to fiber are on separate and independent channels, so there is no cross-connection between channels. Thirty-six fiber runs are distributed from a 2-U chassis. A Network Management Module is also installed in the chassis, and connected to a Network Management Station for fault notification and remote configuration. At the end each fiber run, a standalone Gigabit media converter provides copper to fiber conversion and bridging for connectivity to Fast Ethernet or Gigabit switches at remote locations.

Management Station

Dual Gigabit Media Converters installed in a high-density Chassis

Gigabit Converter

Gigabit Switch

Up to 36 Fiber Connections

Gigabit Converter

Gigabit Switch

Gigabit Switch

Gigabit Switch

10G Application

10G media converters provide a variety of 10G data center connectivity solutions, including resolving interface disparities between equipment with 10GBASE-T RJ-45 ports and existing rack servers or switches with fiber optic ports. Architecture changes such as migrating from Top of Rack to End of Row can present cabling challenges when extending network distances from racks of servers.

In this application, fiber cabling is used to extend distances between 10G switches and servers. A Redundant Power Chassis with 10G Copper-to-Fiber plug-in media converters is used to convert the CAT-6A cabling from the RJ-45 ports on the aggregation switch to fiber.

10G Aggregation Switch

10G Server with RJ-45 Ports

10G Copper-to-Fiber Converter

Redundant Chassis with 10G Copper-to-Fiber Converters

Switch with 10G Fiber Port and Gigabit RJ-45 Ports

At the other end of the first fiber run, a standalone 10G Copper-to-Fiber converter is used to convert the fiber back to copper for connectivity to a 10G server with RJ-45 ports. The second fiber run connects directly to a fiber port on a 10G switch.

The 10G Copper-to-Fiber converter supports CAT-6A cabling (up to 100 meters) to extend distances to servers, switches and patch panels. For CAT-6A cabling links less than 30 meters, 10GBASE-T Short Reach mode can be used to conserve energy by reducing power and cooling requirements.

TDM Copper-to-Fiber Media Converters

T1/E1 and T3/E3

T1/E1 and T3/E3 copper-to-fiber converters provide a reliable and cost-effective method to extend traditional TDM (Time Division Multiplexing) telecom protocols copper connections using fiber optic cabling. T3/E3 and T1/E1 converters operate in pairs extending distances of TDM circuits over fiber, improving noise immunity, quality of service, intrusion protection and network security. This application is often useful within a building or as a connection between buildings in the building complex or a campus.

T1/E1 copper-to-fiber converters can support standard T1 (1.544Mbps), E1 (2.048Mbps) and can be compatible with AMI, B8ZS and HDB3 line codes. These converters often provide diagnostic features to aid in the installation and maintenance of the T1 or E1 connections. Some of the diagnostic features include local loopback, remote loopback and test-modes that insert data or alarm notification patterns such as all 1's insertion (AIS). These features enable the testing and troubleshooting of individual segments as well as the entire T1/E1 connection.

T3/E3 copper-to-fiber converters provide standard T3 (44.736Mbps) or E3 (34.368Mbps) coax-to-fiber conversion and can be used to connect to devices such as PBXs, multiplexers, routers and video servers via fiber. T3/E3 converters can be framing independent to operate with framed or unframed, channelized or fractional unchannelized data streams, and support B3ZS line coding for T3 (DS3) and HDB3 for E3.

T1/E1 Application

T1/E1 copper-to-fiber media converters provide a cost-effective solution for extending telecom demarcation points across a business complex or up a high-rise building. In this application, a pair of T1/E1 media converters is used to extend the demarcation point (hand-off from the Service Provider) to another tenant building with fiber. A variety of fiber types can be deployed, and fiber links can be extended up to 120km using single-mode fiber.
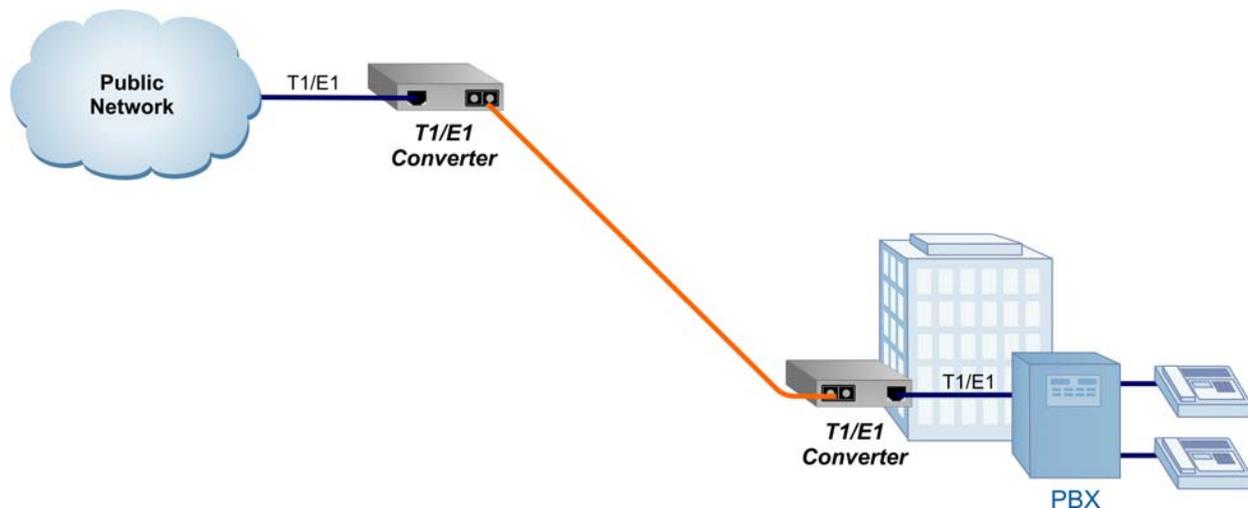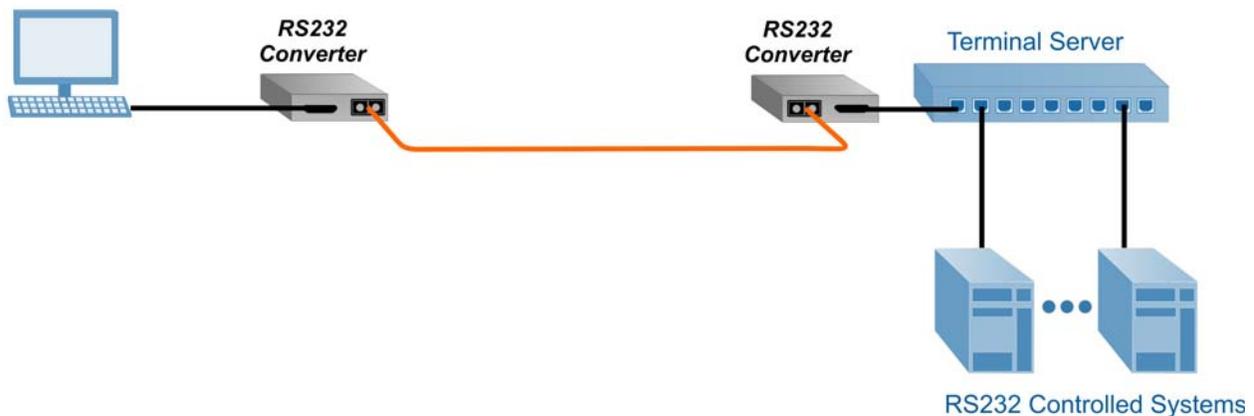
Serial-to-Fiber Media Converters

Serial-to-fiber converters provide fiber extension for serial protocol copper connections. They can automatically detect the signal baud rate of the connected Full-Duplex serial device, and support point-to-point and multi-point configurations.

RS-232 Application

RS-232 fiber converters can operate as asynchronous devices, support speeds up to 921,600 baud, and support a wide variety of hardware flow control signals to enable seamless connectivity with most serial devices. In this example, a pair of RS-232 converters provides the serial connection between a PC and Terminal Server allowing access to multiple data devices via fiber.

RS-485 Application

In this example application a pair of RS-485 converters provides the multi-drop connection between the Host equipment and the connected multi-drop devices via fiber.
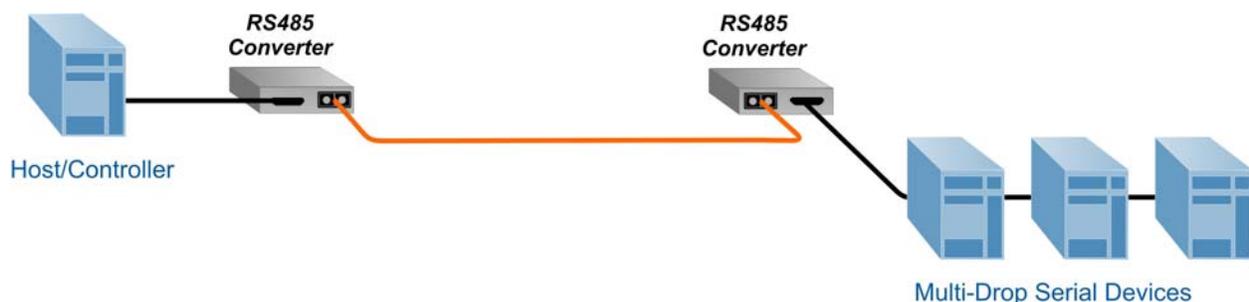

Fiber-to-Fiber Media Converters

Fiber-to-fiber media converters can provide connectivity between multimode (MM) and single-mode (SM) fiber, between different "power" fiber sources and between dual fiber and single-fiber. In addition, they support conversion from one wavelength to another. Fiber-to-fiber media converters are normally protocol independent and available for Ethernet, and TDM applications.

Multimode to Single-mode Fiber Conversion

Enterprise networks often require conversion from MM to SM fiber, which supports longer distances than MM fiber. Mode conversion is typically required when: 1) lower cost legacy equipment uses MM ports, and connectivity is required to SM equipment, 2) a building has MM equipment, while the connection to the service provider is SM, 3) MM equipment is in a campus building and SM fiber is used between buildings.

Multimode to Single-mode Fiber Application

A fiber-to-fiber media converter can extend a MM network across SM fiber with distances up to 140km. In this application, two Gigabit Ethernet switches equipped with MM fiber ports are connected utilizing a pair of Gigabit fiber-to-fiber converters, which convert the MM fiber to SM and enable the long distance connection between the switches.
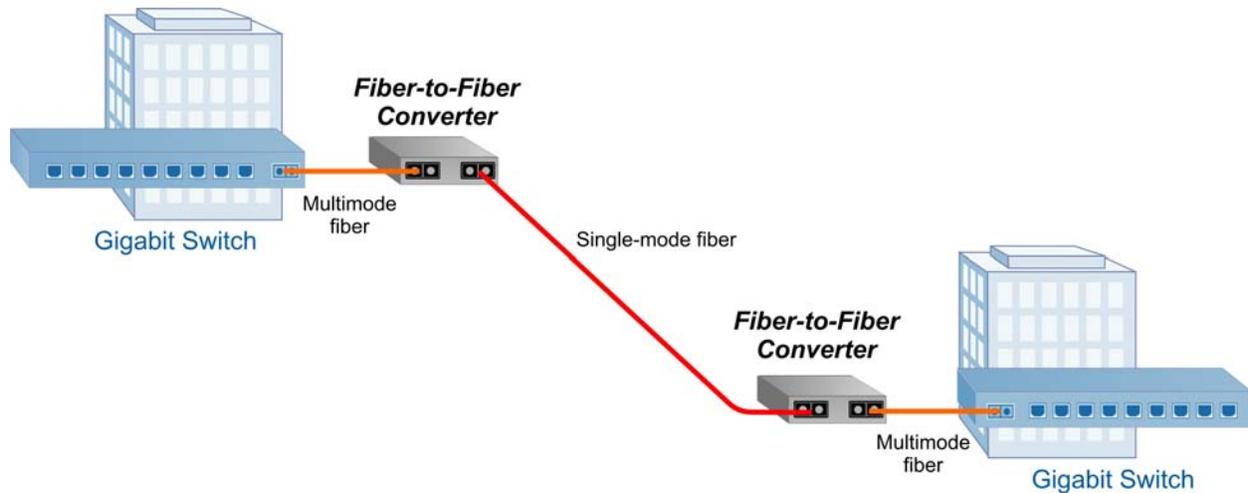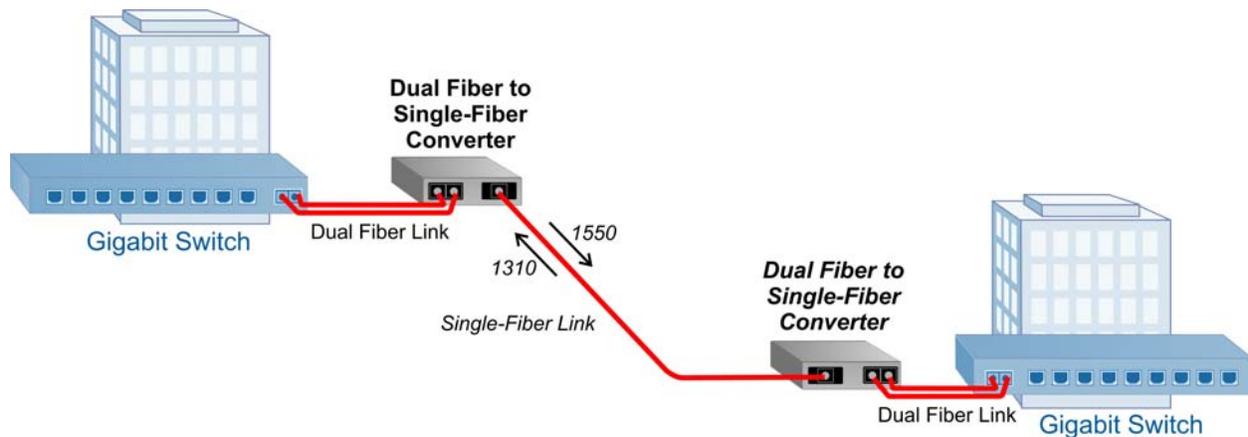

Dual Fiber to Single-Fiber Conversion

Enterprise networks may also require conversion between dual and single-fiber, depending on the type of equipment and the fiber installed in the facility. Single-fiber is single-mode and operates with bi-directional wavelengths, often referred to as BIDI. Typically, BIDI single-fiber uses 1310nm and 1550nm wavelengths over the same fiber strand in opposite directions. The development of bi-directional wavelengths over the same fiber strand was the precursor to Wavelength Division Multiplexing.

Dual Fiber to Single-Fiber Conversion Application

In this application, two dual fiber switches are connected via single-fiber. Since BIDI single-fiber uses two separate wavelengths over the same fiber strand, the transmit (Tx) at one end of the fiber link matches the receive (Rx) from the other end, and vice versa.

Double Fiber Capacity with Dual Fiber to Single-Fiber Conversion

In example **A**, a dual fiber link connects two switches in different buildings.

In example **B**, new switches are added to each location, and fiber-to-fiber media converters double the capacity of the dual fiber link by converting each strand of the dual fiber to a BIDI single-fiber link.

In example **C**, fiber-to-fiber media converters double the capacity of the dual fiber link by converting each strand of the dual fiber to a BIDI single-fiber link, providing redundancy protection between the two switches.
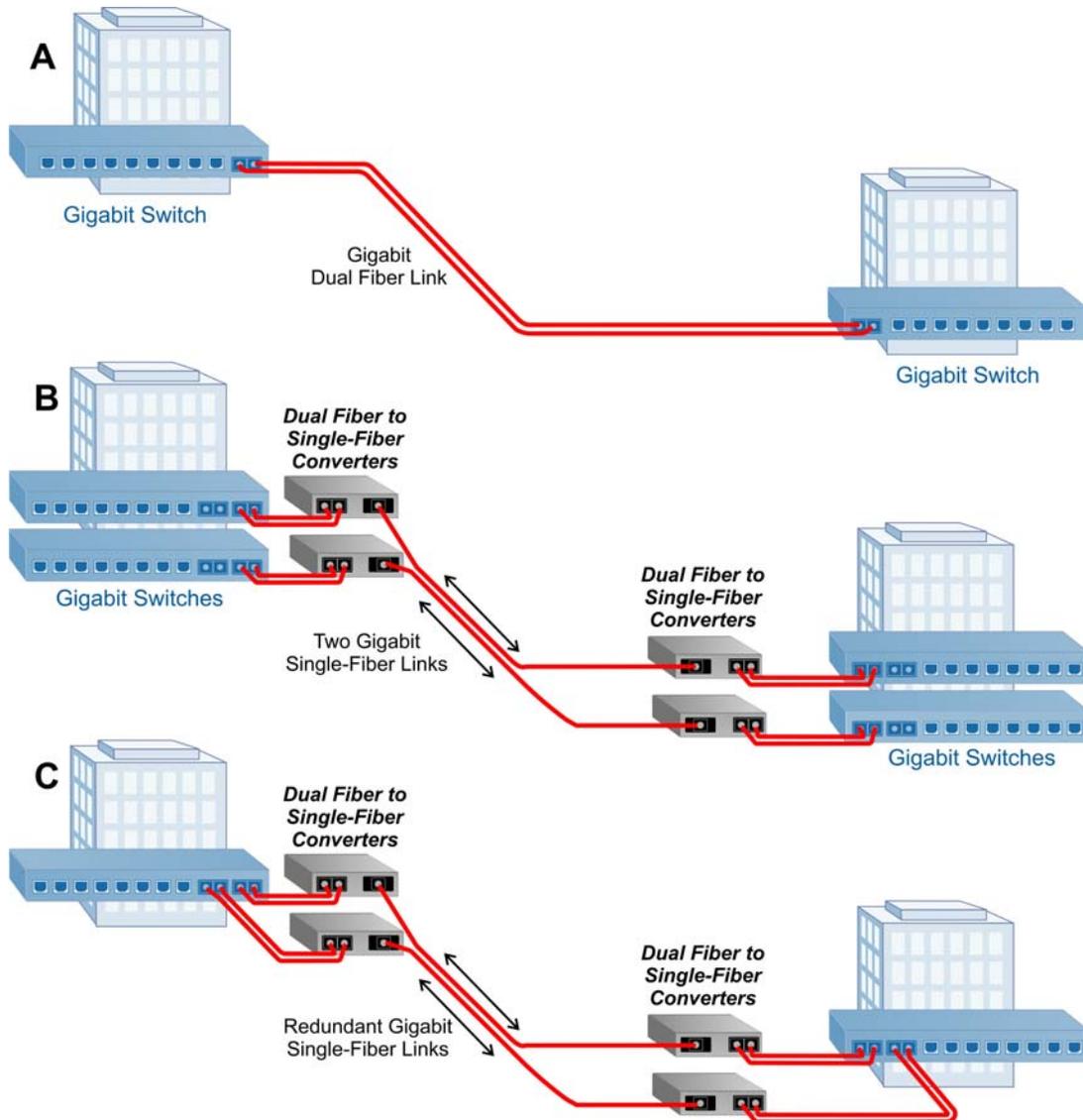
Wavelength Conversion

Copper-to-fiber and fiber-to-fiber media converters are capable of wavelength conversion by using Small Form Pluggable (SFP) transceivers that transmit different wavelengths. SFP transceivers provide a convenient and flexible method of adapting to different equipment requirements.

For applications involving Wavelength Division Multiplexing (WDM), copper-to-fiber converters can convert a copper interface to a specific WDM wavelength. Fiber-to-fiber converters provide a cost-effective solution to convert from standard optical wavelengths (850nm, 1310nm and 1550nm) of legacy equipment to optical wavelengths specified for WDM networks. Fiber-to-fiber wavelength converters are also known as transponders. Transponders are protocol transparent and can support Common Public Radio Interface (CPRI), Fibre Channel and Ethernet data rates.

WDM technology provides the flexibility to increase the capacity of existing fiber infrastructure, eliminating the need to lay new fiber at full capacity locations. Bandwidth is increased because each wavelength carries data independently from the others, allowing network designers to mix and match speeds (100Mbs or 1000Mbps) and protocols (T1, T3, OC-3, OC-12, Ethernet, etc) over the same fiber link.

In this application example, an Enterprise network requires multiple devices and network protocols to be connected across a campus to another building. The challenge is that only one fiber link is available between the buildings. Utilizing media converters with SFPs and two WDM multiplexers (MUX), three wavelengths are sent over the same fiber link.

There is an Ethernet Gigabit fiber switch, a 10/100 UTP Ethernet Switch and a DS3 Multiplexer at the network core. The fiber switch link is converted from 1310nm to 1570nm fiber, the Ethernet UTP switch link is converted from copper to 1590nm fiber, and the DS3 Multiplexer link is converted from DS3 copper to 1610nm fiber. All three wavelengths are combined (multiplexed) into the WDM common fiber link.

At the other end of the WDM fiber link, the MUX filters out each of the wavelengths to a fiber link. At each link, a media converter with the appropriate wavelength SFP converts the fiber to back to copper. The two Ethernet links are connected to workgroup switches, and the DS3 link is connected to a PBX.

$\lambda_1$1570 Ethernet
$\lambda_2$1590 Ethernet
$\lambda_3$1610 DS3 MUX

MUX

CWDM Fiber Link

MUX

λ_1
λ_2
λ_3
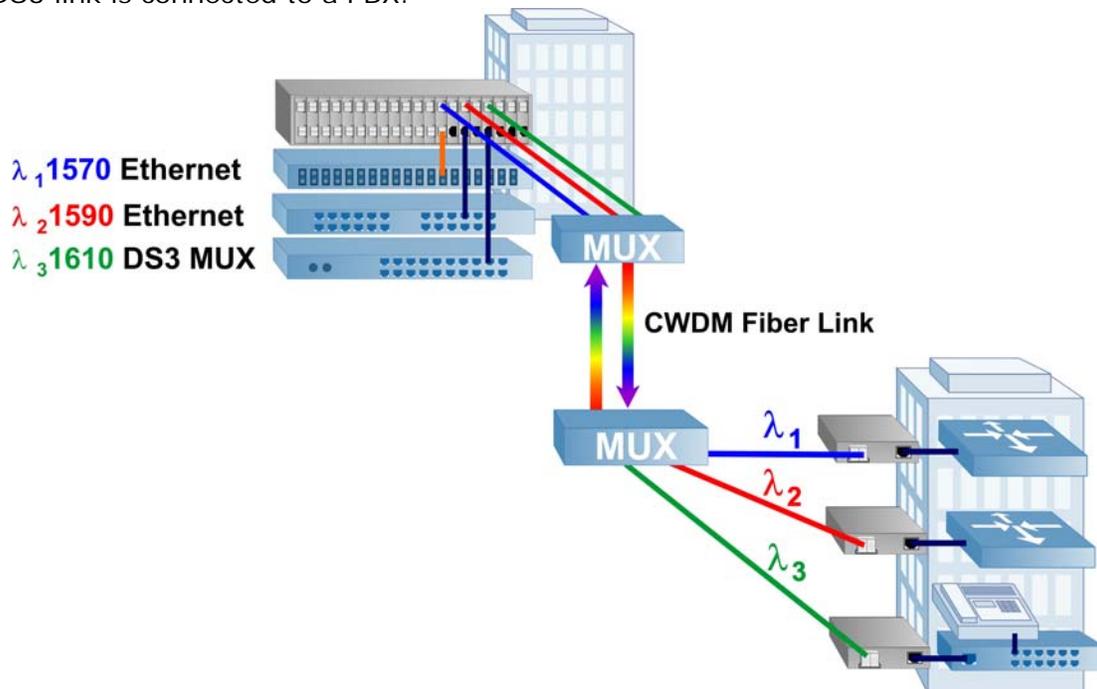
Omnitron Product Families

Omnitron's unmanaged and managed media converters provide fiber optic connectivity in First-Mile FTTx broadband networks, Metropolitan Area Networks and Enterprise LANs worldwide. Used where copper-to-fiber, dual fiber to single-fiber or multi-mode to single-mode fiber conversions are required, Omnitron media converters support a wide variety of network protocols and technologies.

Technologies Supported:

- Single-Pair Ethernet
- Power over Ethernet
- 10, 100, 10/100 Ethernet
- 10/100/1000 and Gigabit Ethernet
- 10 Gigabit Ethernet
- 10G OTN
- T1/E1and T3/DS3/E3
- OC-3 (STM-1) and OC-12 (STM-4)
- OC48 (STM-16) and OC-192 (STM-64)
- Up to 8G Fibre Channel
- CPRI Transponders
- Serial RS-232, RS-422/485 and X.21

Cabling Media and Port Interfaces

- Single-Pair Ethernet Cable
- Unshielded Twisted Pair (UTP)
- Coaxial Cable
- Multimode and Single-mode Dual Fiber
- Single-mode Single-fiber
- ST, SC, LC, FC and MT-RJ connectors
- SFP transceivers for standard and WDM wavelengths

Omnitron products are backed by free 24/7/365 technical support, and a Lifetime Warranty for the entire product, including power supplies.

FlexPoint Unmanaged Media Converters

Omnitron's FlexPoint® copper-to-fiber and fiber-to-fiber media converters provide unmanaged fiber connectivity between different cabling types. The self-contained FlexPoint media converter modules can be used as a desktop or wall-mounted standalone unit, or be rack-mounted using a 5-Module shelf or a 14-Module FlexPoint powered chassis.

FlexPoint media converter modules are AC powered, and can be DC powered (18-60VDC) by attaching an optional DC power supply. Network administrators can mix and match FlexPoint media converter modules in a chassis for fiber access in a variety of network configurations.

miConverter Miniature Unmanaged Media Converters

The *miConverter*® miniature copper UTP-to-fiber media converters provide cost-effective fiber connectivity from the network core to a desktop or a portable laptop.

The miConverter S/GXT Gigabit fiber to 10/100/1000BASE-T and the S/FXT Fast Ethernet fiber to 10/100/1000BASE-T media converters are ideal for mobile applications where light weight, compact size and low power are critical requirements. Weighing less than 2.5 oz. (72 grams), and about the length of a standard house key, the miConverter S-Series converters can conveniently slip into any pocket or laptop carrying case for easy portability.

miConverter media converters are ideal for connecting large numbers of workstations or thin client devices in unmanaged fiber-to-the-desktop Enterprise network applications. These applications can include remote edge locations where power outlets are at a premium, such as portable, temporary facilities. The miConverter is also an excellent solution for construction and military fiber-to-the-laptop applications where fiber connectivity is required and local power is not available.

The miConverter 18-Module Power Chassis is a cost-effective mounting and powering solution for miConverter miniature media converters. This compact chassis is ideal for consolidating multiple media converters into a high-density, rack mountable form factor. It can be deployed in Service Provider, Enterprise and Government applications where fiber optic links are distributed from UTP switch equipment. The miConverter chassis is suitable for Fiber-to-the-Desk, Campus LAN/WAN fiber networks and hybrid copper/fiber networks.

The chassis holds up to eighteen miConverter 10/100, 10/100 Plus, Gx and GX/T copper to fiber media converter modules with barrel-style DC connectors. It provides centralized power for all installed modules, and eliminates the need for individual power supplies. It is available with a single universal AC, 24VDC or 48VDC internal power supply.

OmniConverter Power over Ethernet Media Converters

OmniConverter® PoE Media Converters enable network distance extension over fiber optic cabling, and provide PoE, PoE+, HPoE, and IEEE 802.3bt to Powered Devices (PDs). Classified as Power Sourcing Equipment (PSE), OmniConverter compact PoE switches and PoE media converters provide full power to Powered Devices using standard UTP cables that carry the Ethernet data.

A variety of port configurations are available, including single or dual SFP and single or dual powered UTP ports. Models with dual SFP ports support critical applications that require redundancy and sub 50ms switch over in the event of a fiber failure. The product is DC powered and available with an optional external 100 - 240VAC universal power adapter.

iConverter Media Converters and Network Interface Devices

iConverter® carrier-class media converters and Network Interface Devices (NIDs) provide fiber access in Metropolitan FTTx and Enterprise LAN networks. iConverter are used to distribute high-density, managed fiber links from the network core to intelligent NIDs that provide secure service demarcation with copper and fiber ports at the network edge.

iConverter media converters can be used in managed or unmanaged networks. The iConverter system is used in unmanaged networks where redundant power options, high density, and multi-port chassis configurations are required. In managed networks, the iConverter management system reduces expenditures by keeping trips to remote locations to a minimum through extensive provisioning and instant trap notification capability. The iConverter system is managed via SNMPv3 or Omnitron's IP-less management, which is

provided by a Network Management Module, or a media converter with integrated management (also known as a Network Interface Device, or NID). The network management is accessible via Omnitron's *NetOutlook*® Management Software, Telnet or local serial port. iConverter management modules also support remote modem access.

The iConverter system provides fiber connectivity that supports advanced services at a fraction of the cost of conventional switches. Ultimately, it's not just the initial cost of a system that provides value, but the sustained cost of operating and maintaining the equipment month after month and year after year that counts.

APPENDIX: Additional Information Resources

Other Omnitron White Papers

https://www.omnitron-systems.com/white-paper

Enterprise Network Solutions

http://www.omnitron-systems.com/solutions/enterprise-and-government/