# OTN for MSOs

shaping tomorrow with you

FUJITSU

The emphasis that MSOs place on delivering video-oriented services dictates a significantly different type of network architecture than that favored by traditional telecommunications carriers. MSO networks generally consist of HFC networks for access; packet networks for the metro; and video transport networks for sourcing video content.

With the advent of IPTV, video networks generally consist of redundant SHEs, VHOs, and VSOs, as shown in Figure 1. The last leg is the access network, which traditionally is an HFC network, although other networks such as FTTN/FTTH networks are also being used.

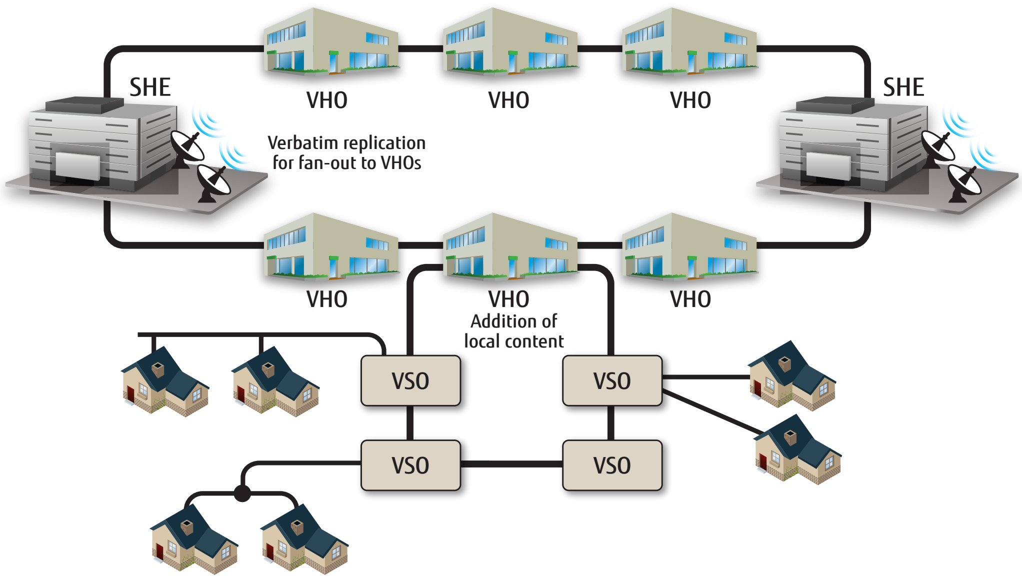


**Figure 1: Video distribution network**

The question at hand is whether or not OTN switching makes sense for the MSO network and if so, what benefits it might bring to an MSO that the existing network does not provide. Additionally, there is the question of where an OTN switched network might fit within the MSO network. If one looks carefully at this type of network, there are several places where OTN can bring additional value to the network.

OTN is a Layer 1 switching technology. It sits above the photonics layer but below the packet layers (Layer 2 or Layer 3). OTN is a multiplexing and switching technology, designed to extend the the optical network to bring more flexibility. With this in mind, if an MSO network consists of ROADM elements that can be upgraded to support OTN switching, such as the FLASHWAVE 9500 Packet Optical Networking Platform (Packet ONP), then upgrading to an OTN architecture is simple. With the installation of PIUs in the FLASHWAVE 9500 systems and proper provisioning, an MSO can support an OTN switched network that offers several important business benefits:

- **Improved wavelength efficiency** – With OTN switching and multiplexing, fewer wavelengths can usually carry the same content because, in general, most ROADM wavelengths are underutilized.
- **Greater flexibility in managing high-speed wavelengths to carry a mixture of services** – With higher wavelengths coming into the market such as OTU4s or OTU5s, the ability to pack these wavelengths with a mixture of services enables these expensive high-speed wavelengths to be used more efficiently.
- **Consolidation or reduction of router usage** – With OTN switching, wavelengths can bypass a router if no content is being dropped there. This saves on the expense of router ports and capacity.
- **Minimal latency and jitter** – With Layer 1 switching, there is no queuing of information, so the latency and jitter should be at a minimum.
- **Maximum throughput via reduced congestion** – Along with no queuing of information and bypassing routers comes maximum throughput.
- **Simplified operations and minimal packet network complexity** – An OTN switched network has very simple and efficient operations. It is set up as a connection. Protection paths can be designated if necessary. Loopbacks, PRBS, and other troubleshooting capabilities are built in.
- **Ability to provide transparent services** – The OTN switching layer allows private-line services such as transparent Ethernet to be supported without special measures such as circuit emulation.

## OTN versus Packet

OTN does not outright replace IP or MPLS, but it can replace IP or MPLS as a transport mechanism for the MSO network. This allows routers to be consolidated, providing significant cost savings and greatly simplifying the network. If traffic is not being dropped at a particular node, the traffic shouldn't have to climb up to Layer 2.5 or even Layer 3 for this forwarding decision. The routers at the edge of the network can route traffic into the OTN containers that are set up based on their routing protocols, thus taking advantage of the ability to bypass intermediate routers to provide an expeditious path.

## Private-Line Networks versus Pure Packet Networks

Some enterprise customers or even retail Telco carriers want and need transparency of their service flows. For example, instead of requesting an Ethernet-based SLA, a particular customer may want a fully transparent gigabit Ethernet service. A switched packet network may not be able to provide such a service efficiently. However, OTN is designed for transparent services. Providing transparent gigabit or even 10G service is a snap with an OTN network; it is a simple matter of mapping the client traffic into the appropriate OTN container.

## An Embedded SONET Network

If an MSO has a legacy SONET network and wants to move to a single transport network, how might this happen? One method is to "cap and grow." This means not installing any new SONET networks, but continuing to maintain what is already in the field. The issue with this is that the MSO may end up with parallel transport networks: a legacy SONET network and a packet network. This can be inefficient and expensive to maintain.

Another upgrade method is to use OTN as a universal transport mechanism for the legacy and the packet networks, so that only a single transport network is required and maintained. In an OTN network, the SONET and packet networks can easily share the same facilities. With the grooming and SONET/SDH mapping capabilities of OTN, putting these two seemingly disparate technologies onto the same facilities and even onto the same wavelength is simple. With a SONET network and OTN transport, the SONET NEs can remain in place and keep their protection mechanisms while sharing facilities with other services. This allows carriers to migrate away from the old technologies at their own pace (without a forklift upgrade) and still maintain a single metrocore transport network during migration.

## Video Networks

In an IPTV network, as shown in Figure 1,there are generally three types of offices where different functions occur. The SHE is at the satellite feed location, providing most of the national video content. The second level is the VHO where the national video is combined with local content. And finally, there is the VSO, where the HFC network or access network is homed to. The content from the SHE to the VSO is replicated multiple times in order to provide sufficient fan-out of the video to subscribers. One of the items that OTN does quite well is to "drop and continue" traffic. This is a Layer 1 replication function.

From the SHE to the VHO, the national content is generally a "verbatim" copy to all of the VHOs as any local content is provided at the VHO or VSO and not the SHE. This is a perfect application for OTN. An OTN stream can be generated at the SHE and exactly replicated to each VHO at the OTN layer. This reduces the need to use Layer 3 multicasting.

Once the local content is added at the VHO, OTN can be used as a low-latency, highly reliable transport network between the VHO and the VSO. "Verbatim" replication can again be performed for additional fan-out as needed between the VHO and the VSOs using the OTN layer. At the VSO, the video traffic is extracted from the OTN container and sent to the access network (an HFC network).

Additional replication with IGMP is likely needed for customer "joins and leaves," but the OTN replication can provide a very fast and easy replication process at Layer 1. This effectively offloads some of the higher layer replication and reduces the complexity and horsepower needed at these higher layers, while still providing the needed functionality.

FUJITSU NETWORK COMMUNICATIONS INC.
2801 Telecom Parkway, Richardson, Texas 75082-3515
Telephone: 888.362.7763
us.fujitsu.com/telecom

## Selecting the Right Transport Architecture

There are four viable options for the transport architecture:

- Packet and private-line services directly over fiber
- Packet and private-line services over a wavelength
- Packet and private-line services over OTN over fiber
- Packet and private-line services over OTN over a wavelength

Networks that can provide packet and private-line over fiber (Figure 2) consist basically of routers connected to each other by fiber. These routers provide all traffic switching, congestion control, and also handle any faults that might be encountered. Private-line services would be handled with CES mapped into a pseudo-wire circuit. In this type of network, the router cost is high because the routers have to be sized to support any traversing traffic, including the private-line services. However, there is no optical network in place, so the transport cost is low. A network such as this may provide high flexibility in that the routers switch or route to direct traffic to their destination. However, this type of network may have reach issues, may not be able to provide as fast a switch over time as other architectures, and may need special engineering to support the private-line services.

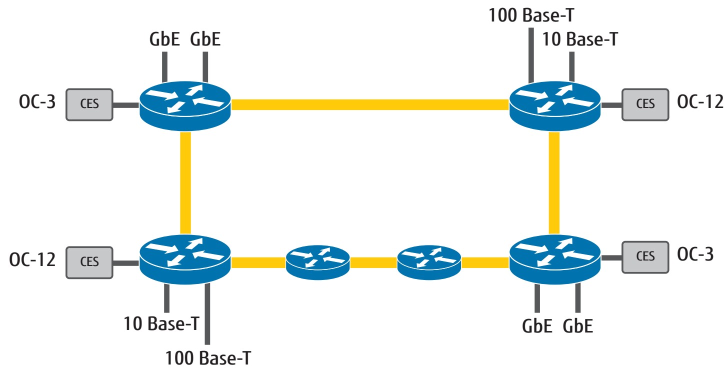


**Figure 2: Packet and private-line services over fiber**

A packet and private-line services over wavelength network (Figure 3) is basically the same as the packet over fiber network but with ROADMs as the transport layer to provide additional capacity and reach. This network can bypass routers, provide expedited paths, and reduce some of the router expenses. This network has the added advantage of being able to support private-line services over a wavelength, thus eliminating the need for circuit emulation. However, this type of network may not be as flexible as a purely switched network as the wavelengths are fairly static and might be difficult to rearrange on the fly; additionally, all services put on a wavelength are point-to-point, with no dropping of clients in between.

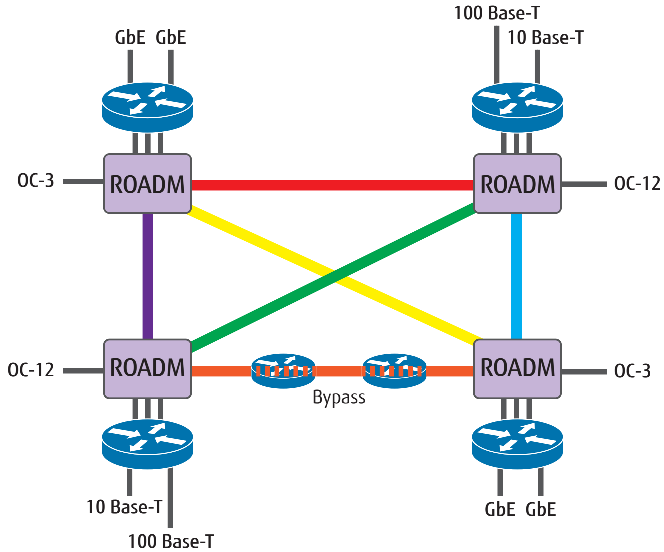


**Figure 3: Packet and private-line services over wavelength**

A packet and private-line services over OTN over fiber network (Figure 4) uses OTN switching as part of optical transport. This network provides the ability to bypass routers with OTN switching, which can provide an expedited path. It can also be used as a very fast protection layer if a fault occurs. It can also be used to easily drop private-line services to any node, not just end nodes of a wavelength. However, it also incurs the expense of the OTN switching layer, which increases the cost of the transport network because all signals need to be terminated at each terminal, even if the flow is only traversing the node.

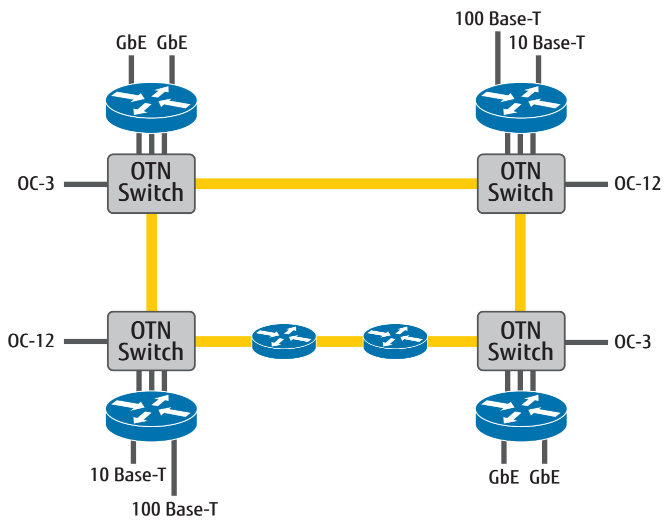


**Figure 4: Packet and private-line service over OTN**

A nice compromise is a packet and private-line service over OTN over a wavelength network (Figure 5). This network is a hybrid of the packet over wavelength and the packet over OTN over fiber network. It provides wavelength bypass capabilities, which eliminates signal termination and regeneration if the wavelength is not dropping traffic to a client, which can reduce the expense of traversing nodes. This network also provides OTN switching capabilities, enabling wavelengths to be better utilized and thus decreasing the cost of the transport network. This type of network can also use the OTN switch for fast protection switching. There is also the option to not use OTN switching in some nodes, further reducing the capital cost of the network.

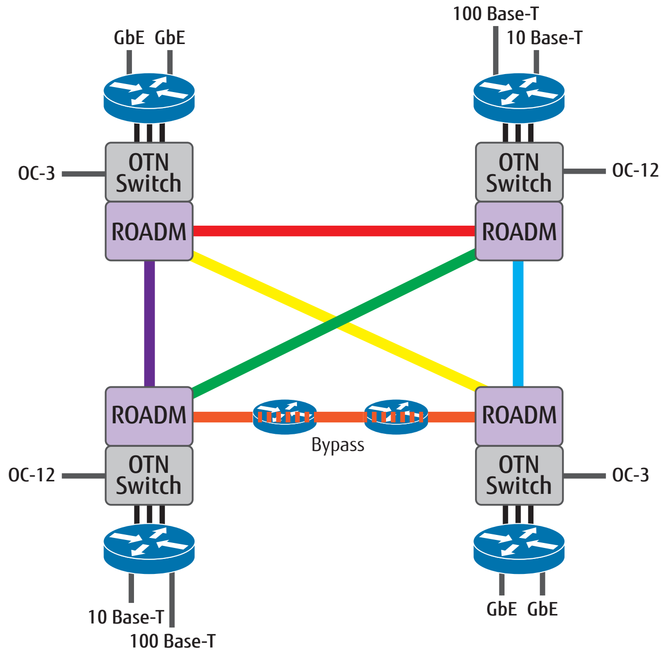


**Figure 5: Packet and private-line services over OTN over wavelength**

The table below summarizes these four different architectures:

| Network Configuration / Impact | Flexibility | Router Costs | Transport Costs | Protection Method |
|---|---|---|---|---|
| Packet and private-line over fiber – routers connected to fiber | High – all traffic is directed by IP/MPLS | High – no router bypass results in more ports and higher capacity of the routers | Low – assumes direct fiber connect, so no transport costs | FRR |
| Packet and private-line over wavelength – routers connected to ROADMs | Low – wavelengths are generally static and might be difficult to change | Medium – assumes some router bypass, however, fixed wavelengths may not provide optimal bypass | Medium – due to addition of the ROADM in the transport network | FRR, OUPSR |
| Packet and private-line over OTN over fiber – routers connected to OTN switches | High – OTN switching and packet switching provide full flexibility | Low – with OTN switching can achieve optimum router bypass | High – OTN switching with 3-R regeneration at each hop increases the cost of the transport network | FRR, OTN protection |
| Packet and private-line over OTN over wavelength – routers connected to OTN switches and ROADMs | High – OTN switching and packet switching provide full flexibility | Low – with OTN switching and direct wavelengths, optimum router bypass can be achieved | Medium – can reduce some of the cost of the transport by not populating OTN switching in nodes that do not need it | FRR, OUPSR, OTN protection |

## Summary

MSO networks have as their primary function delivery of video content to their customers. An OTN switching layer on top of the optical layer can bring considerable benefit to an MSO network, particularly the video transport network.

Consider an OTN container to be like a virtual wavelength. Since the OTN container allows full transparency of its payload, putting this payload into an OTN container is effectively putting the payload over its own independent wavelength. The payload can be of any type and size including private-line, SONET, Ethernet, and video. The containers can fit within any physical wavelength size: a 10G (OTU2), a 40G (OTU3), a 100G (OTU4), or even higher as the rates progress over time. The OTN container is a discrete element of this wavelength that can be switched at every node, or just passed through to the next node. The ROADM layer can provide additional expedite capabilities and save on transport capital expenses if OTN switching is not required at some of the intermediate nodes.

OTN can also provide a replication function to the network between the SHE, the VHO, and the VSO to offload the higher layer multicast functions. This would work in conjunction with the higher layer replication to provide the full functionality but with lower complexity and higher performance.

OTN provides a universal transport layer that can support all services. The simplicity of OTN from an OAM&P perspective makes it attractive for reducing operational costs. Simple loopbacks, PRBS, bit error detection and correction allows the network to be easily monitored and segmented for fault detection and isolation.

As the demand for video bandwidth continues to increase with uber high definition TVs, ROADMs and OTN are not just going to be "nice-to-haves," they are going to be absolutely necessary. 100G, 400G, or even 1000G wavelengths will be the norm in five to ten years and OTN makes these high-speed wavelengths manageable. Since most MSOs also offer enterprise private-line services, they need a network that delivers transparent services without huge cost or complexity. OTN over WDM wavelengths can be the universal transport layer for private lines, for video, for switched packet services, for everything.

## Acronyms

| | |
|---|---|
| CES | Circuit Emulation Services |
| FTTN/FTTH | Fiber to the Node/Fiber to the Home |
| HFC | Hybrid Fiber/Coax |
| IGMP | Internet Group Management Protocol |
| IP | Internet Protocol |
| IPTV | Internet Protocol Television |
| MPLS | Multi Protocol Label Switching |
| MSO | Multi System Operator |
| OAM&P | Operation, Administration, Maintenance and Provisioning |
| OTN | Optical Transport Network |
| PIU | Plug-In Unit (card) |
| PRBS | Pseudo Random Bit Sequence |
| ROADM | Reconfigurable Optical Add/Drop Multiplexer |
| SDH | Synchronous Digital Hierarchy |
| SHE | Super Headend |
| SLA | Service Level Agreement |
| SONET | Synchronous Optical Network |
| VHO | Video Hub Office |
| VSO | Video Serving Office |



FUJITSU NETWORK COMMUNICATIONS INC.
2801 Telecom Parkway, Richardson, Texas 75082-3515
Telephone: 888.362.7763
us.fujitsu.com/telecom