Backhaul 2.0:
Not Just For Mobile Anymore

shaping tomorrow with you

FUJITSU

Mention the term "backhaul" to a Telecommunications engineer or planner and they usually think in terms of cellular traffic, which is undoubtedly a large and growing component of backhaul. While cellular backhaul may be the service that grabs the most attention, telecommunications is highly diverse; other revenue-generating services also require a transport/backhaul network. Therefore, it is essential to consider these other traffic and service types when planning a future-resilient network that will serve the needs of both backhaul and transport.

Business/enterprise, residential broadband, and private-line traffic are also critical services requiring backhaul. Developing a backhaul strategy that overlooks these traffic types carries the risk of missed revenue opportunities and unnecessary future expenses. The ability to economically backhaul multiple types of revenue-generating traffic without adding complexity is vitally important.

In this article, we outline the opportunity for a multi-traffic transport/backhaul network and propose a strategy to realize the revenue potential of this type of network. We also consider a design approach that aggregates multiple traffic types within a relatively small area, transports or backhauls the traffic over an OTN network to the core, and then tunnels the various traffic types to their destinations over an OTN/ROADM network.

Cellular Services

As LTE rolls out, demand for cellular bandwidth, and therefore demand for cellular backhaul, will continue to grow. Cellular video services will exacerbate this demand, as video consumes large quantities of bandwidth. Cisco's 2011 Visual Network Index (VNI), for example, projects a 92 percent Compound Annual Growth Rate (CAGR) for cellular traffic between 2010 (0.24 Exabytes (EB) per month) and 2015 (6.3 EB per month).

Since a cell tower often houses multiple mobile carriers, each with different bandwidth and network requirements, the transport/backhaul network needs to be versatile enough to support these. Not all cellular traffic can be treated the same over a backhaul network, and a comprehensive backhaul strategy that can address all aspects of cellular traffic is needed.

Residential Broadband Services

Residential broadband access is also projected to continue its upward trend, with the average bit rate per subscriber projected to reach 100 Gbps in 2025, according to projections issued in 2011 by the FTTH council in Europe. As residential Internet access continues to grow, subscribers are demanding higher and higher bit rates. The actual physical link between the residence and the carrier can take various forms, such as DSL, PON, and direct fiber, but regardless of the type of link, the demand for higher bit rates places more demands on the backhaul network.

Business and Enterprise Services

A comprehensive backhaul strategy must consider business and enterprise services from several standpoints. For example, one type of service might employ a general Carrier Ethernet transport backhaul. Another might require transparency and utilize an Ethernet Private Line. There are also non-Ethernet-based private-line services that need consideration.

Carrier Ethernet-Based Services

The revenue potential from enterprise and business subscribers is growing with the availability of enhanced applications that enable businesses to operate more efficiently. Industry analysts, such as Infonetics have issued projections for worldwide enterprise network ports that forecast significant growth for the next three years in both Gigabit Ethernet (GbE) and 10 GbE ports.

Applications requiring enhanced communication services include videoconferencing, E-learning, E-medicine, and cloud services, among many other new applications that require enhanced packet transport. These all add to the demands on the transport network. However, they increase the efficiency of individual employees while also breaking the tether to their office desk. They allow employees to work from remote locations or while traveling and still offer them the same experience as if they were at the office. These applications usually require a Layer 3 VPN and may require low latency and high security.

All these enhanced methods of digital communication and information exchange create escalating bandwidth demands from businesses and enterprises, consequently imposing stricter requirements on backhaul and transport networks. They also increase the bandwidth demands in popular locations that businesspeople visit, such as airports, restaurants, and coffee shops, resulting in even higher enterprise bandwidth requirements.

The new-generation communications services are packet-based with an Ethernet layer that allows for aggregation with other Layer 2 traffic, as long as SLAs are followed. SLAs are appropriately addressed with a Carrier Ethernet approach that conforms to strict traffic controls, but that also allows for the other benefits of Ethernet, such as efficient aggregation, oversubscription, support of "bursty" traffic, and prioritization of services.

Private-Line Services

Private-line services define a group of business services that are typically point-to-point and may traverse multiple carriers. These services perform a wide variety of functions. They might be secure links between hospitals; they might be links required for database backup in server farms; they might be OC-n links from one carrier through another carrier; they might be PRIs for voice services, or Ethernet links between routers of private networks. Private-line services are usually high-revenue and may have stringent performance requirements, such as low latency, high security, and transparency.

Although some types of private line, such as the PRIs and OC-n, may diminish in prevalence over time , others, such as transparent GbE, are likely to increase, particularly with growing concerns over security and cyber attacks.

Currently private-line services produce approximately $36B in global revenue per year. Even if this were to show a slight decline, this large market should be part of a comprehensive transport/backhaul strategy.

Transparent Ethernet Services

Transparent Ethernet services, as the name implies, should be completely transparent to the transport/backhaul network. The carrier/enterprise is expecting every bit that enters this network to come out of the network unaltered, including the Ethernet frame. This requirement may be due to security issues or privacy concern with the packets needing to arrive at their destination with very low data loss. This transparency requirement may place a heavy cost burden on a packet network and may be better suited to another transport type.

Non-Ethernet-Based Private-Line Services

Some types of private-line service do not have an underlying Layer 2 Ethernet structure. These could be OC-n/STM-m services, Fiber Channel, EsCon, FiCon, CPRI, and others. These services require a different transport mechanism from Carrier Ethernet, unless they undergo some type of circuit emulation before being transported. However, circuit emulation has other issues, such as timing and synchronization that add additional costs.

Backhauling and Transporting Services

The backhauling of these various services from the network edge to a hub site or PoP requires a comprehensive strategy. However, these services have a variety of specifications that the network should address. Some require redundancy, low latency, high security and transparency. Not all services have the same requirements and the transport network's behavior may change depending on the service. For example, trying to transport a service that requires low latency, low delay variation, transparency, and redundancy over a packet network may overstress the network resulting in higher costs. Conversely, transporting a single 10 Mbps service over an OTN network may leave the network underutilized and therefore not economically viable.

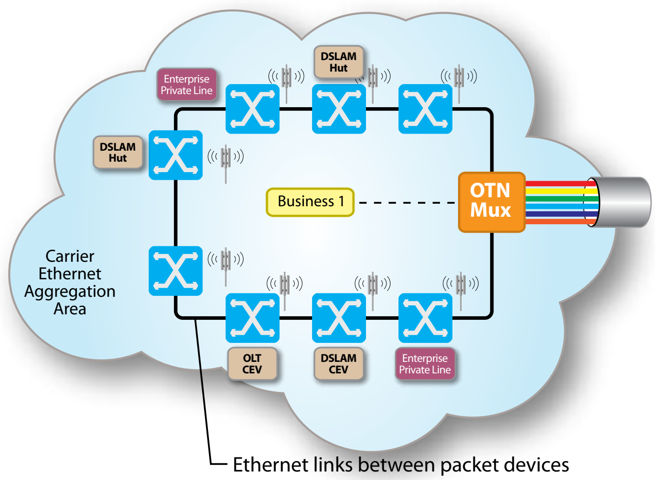
Aggregating Traffic According to Destination

Another reality of having many different service types is that data from these various services are likely to be destined for different locations. For example, wireless traffic goes to the MSC, and broadband traffic goes to an Internet PoP. Therefore, a transport/backhaul strategy needs to steer this traffic to the various destinations as inexpensively as possible while still meeting SLA requirements.

An efficient network strategy could be to aggregate traffic that is destined for the same location within a relatively small area, a "Carrier Ethernet Aggregation Area" (CAA), such that packet based impairments like jitter and latency are bounded. Backhauling to the core network would then be accomplished using an OTN network, which has deterministic jitter and latency. Cellular traffic from a single mobile carrier that originates from multiple towers within this area (or CAA) could be grouped together and ride on one tunnel, while cellular traffic within the same CAA but destined for a second carrier's MSC could be grouped together and ride on another tunnel.

Using OTN as a Tunnel

With the advent of the ability to switch traffic, OTN is becoming a promising tool for tunneling. OTN is a Layer 1 technology and thus lower on the OSI stack, offering lower costs while still providing switching capabilities. The tunnels can vary in size with OTUflex. OTN can be path or link protected. Egress packets from OTN tunnels are not going to be out of place from their ingress position. They produce virtually no delay except the propagation delay due to the speed of light in a fiber. They produce minimal delay variation. They isolate traffic so there is no interaction of traffic between tunnels. The tunnels can traverse multiple carrier domains and provide end-to-end bearer channel transparency and end-to-end management transparency, while still maintaining segment-based monitoring capabilities and segment-based management by the traversed carriers. They utilize simple OAM and loopback mechanisms for troubleshooting and network segmentation, and they are as close as you can get to a separate fiber tunnel while still sharing the fiber for multiple service types.



Note: OTN multiplexer can be dual-homed to avoid a single point of failure.

Figure 1: Local aggregation with OTN transport

Another benefit of utilizing OTN technology for transport is that it can easily accommodate private line services. OTN has direct mapping mechanisms, such as OC-N and Fiber Channel, for transparently encapsulating private line services directly into OTN payloads with minimum jitter and latency. This provides the carriers with an easy and inexpensive means to backhaul these high revenue-generating services along with high capacity Ethernet based services, as shown in Figure 1. In this illustration, the network would transport several virtual pipes/tunnels, as follows:

- OTN pipes 1, 2 and 3 – Aggregation of cellular traffic for three different mobile carriers
- OTN pipe 4 – Aggregation of broadband Internet traffic
- OTN pipe 5 – Ethernet-based private line traffic
- OTN pipe 6 – Non-Ethernet-based private line traffic

Since OTN can be switched, it can steer the aggregated data or tunnels to different destinations. This provides a method for economically transporting the aggregated tunnels from the access area (CAA) to their respective core destinations, without having large and expensive routers at many locations in the network (Figure 2).

Many Small Streams versus Fewer Massive Rivers of Packet Information

An important question is whether it is more economical to have many smaller streams or fewer large "rivers" of packet information in the backhaul. The answer depends on what is being backhauled. If the services are uniform in nature with regard to traffic flows, protection, etc., then large flows are likely more efficient. However, if the services are disparate in nature, which is usually the case when backhauling many service types, then a larger number of smaller flows may be the best solution.

Private-Line services

In the scenario where the private-line services are non-Ethernet-based or transparent Ethernet-based, aggregating these into large packet flows does not work, as the services will not allow for it. In the scenario where the private-line service is CIR/EIR SLA -based Ethernet, there is value in large aggregated pipes assuming that the SLAs can be followed.

The Large Aggregated Packet Pipe Phenomenon

In a network consisting of many switches/routers that home back to hub sites, aggregated network pipes become progressively larger. As the traffic traverses each switch/router, it gets further aggregated with other traffic coming into that switch/router. This results in the egress pipes growing larger with each node traversed. This causes the switch/routers to need higher capacity the closer they are to the hub site, which means higher costs. This type of network is shown in Figure 2

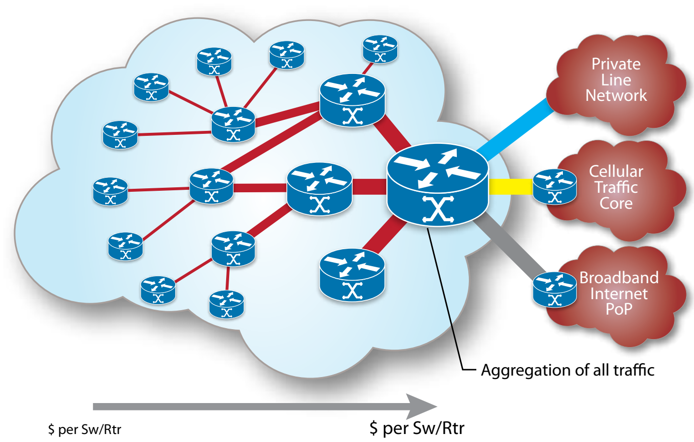


Figure 2 - Packet Aggregation Model

Conversely, in a COE/OTN network, aggregation is performed only at the edge or CAA, and then mapped into OTN containers and backhauled to the hub sites. This allows for the needed aggregation while keeping costs low. This type of network is shown in Figure 3.

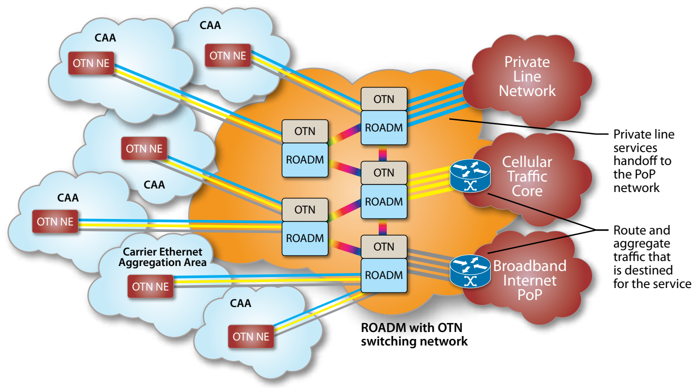


Figure 3- Transport with OTN/Photonics Layer

Pure Packet Aggregation

In a pure packet network, if the pipes from the edge are already filled, further aggregation is not necessary because it provides no additional value.

Carrier Ethernet Aggregation with OTN Backhaul

The case of Carrier Ethernet aggregation with OTN backhaul assumes that some Carrier Ethernet aggregation is necessary to fill the OTN-based pipes within the CAAs. Once filled, the OTN network performs steering and transport from the CAAs to the core. At the core or PoP, further packet aggregation can be performed if necessary to condition the many pipes to their aggregated handoffs.

Scalability

One of the most critical aspects of a backhaul/transport strategy is scalability. The worst thing that could happen is to have a network that cannot meet customer demand or causes a customer-affecting degradation of quality when services are added. Scaling also needs to be economically incremental. The concept of contained aggregation areas, as presented here, can easily scale. Since the CAAs are contained and have arbitrary boundaries, it might be advantageous to split them into smaller areas if they start growing too large, to enable easier management or to control jitter and latency. This allows the individual CAAs to stay small and manageable. The ROADM/OTN network can scale to terabit rates, so it should not be a short-term concern.

An All-Encompassing Backhaul Strategy

Although LTE is the fastest growing service requiring backhaul and transport, many other service types also need backhauling. A comprehensive backhaul strategy encompasses all of these.

Each service has a different set of requirements that they impose on the network. Some require transport-based redundancy, some require low latency, some require transparency, and some do not support an Ethernet link layer. Trying to fit all of these services onto a single type of packet network may not be the most economical solution.

A hybrid Carrier Ethernet/OTN network has many benefits for the metro network. The COE network can aggregate traffic within a contained aggregation area so that its management and the jitter/latency within this network are bounded and easily scaled. Once the data pipes are sufficiently aggregated, they are then mapped to OTN containers and steered to their destinations with OTN switching. Once at the destination, they are unwrapped from OTN and distributed to customers. This type of network has all of the qualities of a packet network and an OTN/ROADM network in terms of minimizing jitter/latency and cost, while maximizing flexibility and making the best use of the metro fibers.

© Copyright 2012 Fujitsu Network Communications Inc.
FUJITSU (and design)® and “shaping tomorrow with you” are trademarks of Fujitsu Limited.
All Rights Reserved. All other trademarks are the property of their respective owners.
Configuration requirements for certain uses are described in the product documentation.

FUJITSU NETWORK COMMUNICATIONS INC.
2801 Telecom Parkway, Richardson, Texas 75082-3515
Telephone: (972) 690-6000
(800) 777-FAST (U.S.)
us.fujitsu.com/telecom