Between support of increasing video traffic, growing data center interconnect requirements, and upcoming 5G wireless evolution, metro networks face more pressure than ever before. New technologies and deployment strategies promise to ease this pressure, as the articles in this Editorial Guide describe.

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The Smallest Cables Available

AFL’s Wrapping Tube Cable (WTC) and OSP MicroCore® LM200-series—both powered by SpiderWeb Ribbon® (SWR®)—do more than save space. Their unique constructions allow for quicker installation and splicing, lowering the overall cost of fiber deployment without sacrificing the quality of traditional high fiber density products.

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Why Waiting for 5G is the Wrong Metro Network Strategy

By JIMMY MIZRAHI, ECI Telecom

Today’s metro networks are rapidly evolving and have carriers in a conundrum. Pressured by exploding mobility, major initiatives to move to the cloud, and skyrocketing consumption of high-bandwidth services on one end and the promise of 5G right around the corner, most are deciding between spending now to meet today’s demand or waiting to put the investment towards 5G when the time is right. Is there a right answer? In short, there is – if implemented intelligently.

Tier 1 service providers are making plenty of noise around the build towards 5G, with AT&T and Verizon aiming to light up 5G in some U.S. markets in 2018. Currently, it appears we’ll see 5G networks arrive for major markets around the world in late 2019 or 2020.

But can we wait until then to upgrade? The demands on the metro network are out of control. Metro infrastructure is tasked with constantly consolidating a massive amount of traffic from mobile, residential, and business services, acting as the critical bridge between the service provider core and end-user access. As a result, when demand for connectivity expands due to bandwidth-hungry services such as video streaming, gaming, cloud-based business services, and virtual and augmented reality, it is the metro network that primarily meets the need.

Adding to the metro network pressure cooker is the fact that users today expect consistently high quality of service (QoS). And customer attrition is as easy as picking up the phone. The advent of 5G mobile and explosion of Internet of Things (IoT) will undoubtedly contribute to the strain (Figure 1).
Why Waiting for 5G is the Wrong Metro Network Strategy

A metro-sized conundrum

When deciding on how to best manage the metro network to efficiently maximize network agility ahead of 5G, there are two options: Do nothing rather than potentially having to rip and replace when upgrading to 5G, or gear up now and start adding value to current service offerings. Neither is an inexpensive option, thanks to the perfect storm of market trends and increasing traffic in the metro.

Let’s explore these options in more detail:

1. **Do nothing — there’s already enough chaos to focus on!** Why invest in metro upgrades today if we’ll have to rip and replace when 5G comes along? Side effects to waiting may include minimal growth in the near-term as competitors thrive – perhaps even losses if the network fails to keep pace with incremental increases in demand for high-bandwidth services, which will also be multiplying. Standing pat sadly may also find network services going down the metaphorical tubes of commoditization. Not investing in current infrastructure is likely to affect the end-customer’s quality of experience well before 5G comes along.

2. **Gear up and start adding value to current service offerings.** This route enables service providers to use their metro evolution to diversify portfolios,
Why Waiting for 5G is the Wrong Metro Network Strategy

create new revenue streams, and compete on more than just price. At the same time, they can leverage strategic upgrades to increase capacity with minimal investment, knowing that it will deliver ROI through and past the advent of 5G.

It's clear service providers should take a proactive stance and gear up. This is easier said than done, however, especially when you consider the potential challenges:

:: Increasing capacity to cope with bandwidth-hungry new services
:: Rethinking business models to be able to offer assorted services for customers and new revenue streams
:: Maintaining flexibility while meeting customers' needs for different types of connectivity, upgradability, and virtualization services
:: Scaling to manage issues that arise from the exploding number of connection points caused from increasing devices in the business, home, and (eventually) on the road
:: Meeting the inevitable challenges of securing this flood of new end-points.

Despite these challenges, service providers will benefit in the long run from upgrading and adapting their metro networks today, ahead of 5G. They can grow alongside the bandwidth explosion, without worrying that their equipment and solutions will become obsolete or require the old rip and replace.

The “metro” difference

Customer demands for bandwidth and capacity are causing service providers to look eerily similar. Differentiation is difficult in the age of “more, more, more” and only getting more extreme as whitespace between competitor service offerings shrinks. The result is the unfortunate commoditization of services and connections.

Growth and profits are always affected when an industry faces this situation, wherein competition is based on price rather than service innovation. Now, connectivity itself is undergoing this commoditization – and service providers are simply joining Dot A to Dot B at the smallest possible cost to the customer. Sadly, it’s another race to the bottom, occurring throughout the industry.
Why Waiting for 5G is the Wrong Metro Network Strategy

An ideal solution here centers on the metro network and sparking innovation with new, differentiating products and services now before 5G becomes the standard. Catching up will be nearly impossible when 5G hits.

Embracing the metro evolution

Service providers have cost-effective approaches at their disposal that will enable them to overcome today’s challenges and put them in position for tomorrow’s 5G disruption. The first major initiative is to select a multifunction metro aggregation platform that facilitates key activities in the metro evolution ahead of — and through — 5G (Figure 2).

Here, then, are a few important platform qualifications service providers should look for as they consider the current state of the market and the inevitable revolution 5G will bring.

:: Easy upgrades: Most network platforms today operate at 10 or 40 Gbps. But service providers will require the ability to easily upgrade to 100 Gbps without ripping and replacing existing components. They’ll want to simply swap cards rather than replace the whole kit.

:: Flexible first: Operator should seek a flexible platform that supports IP-MPLS as well as easy evolution into segment routing. The system also should help

**RESULTING IN METRO NETWORK CHALLENGES**

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**FIGURE 2.** The right metro aggregation platform must prepare the network for the evolution to 5G, while also supporting services innovation in the meantime.
streamline day-to-day business and solve today’s most difficult operational challenges.

:: **Highly secure**: It’s vital that the platform come fully equipped with security embedded at the design level, rather than added on with various unrelated products and services. The “endpoint explosion” ushers in a new generation of vulnerabilities, which must be dealt with via Internet Protocol Security (IPSec), Media Access Control Security (MACSec), and/or Layer 1 encryption.

:: **Intelligent**: In today’s age of networking, intelligent management and traffic engineering are integral elements of a metro aggregation strategy. With deterministic network traffic control and visibility, along with local caching to reduce backhauling traffic to the core, service providers can reduce investments in capacity while ensuring QoS.

:: **Support XaaS, SDN, and NFV**: Operators should consider adding an NFVi blade for multi-access edge computing (MEC) to run different network functions such as security, caching, and routing. Or having an inherent evolution plan to software-defined networking (SDN), by either enabling SDN functionality today, or at the very least supporting open connectivity with NETCONF/YANG. This way, operators ensure a successful transition to SDN whenever they are ready.

**Coming Together**

5G backhaul will require complex multipoint networks to accommodate new services such as the resulting explosion of IoT, industrial IoT, autonomous cars, and transport networks as a whole. Yet, before then, the network still needs to address today’s point-to-point private connections. Migration and/or investments to a better-fitting metro network, therefore, have to be both simple and practical, and ensure that investments today continue generating ROI into the 5G era.

A network that enables this migration smoothly, rather than requiring tearing out previous network infrastructure and components, allows the proper innovation of services necessary to avoid commoditization today without concern for such investments becoming redundant tomorrow. The most successful metro approach will also be easily scalable for “pay as you grow” expansion. To meet the evolving service needs and huge capacity growth, the platform will need to enable seamless interworking between IP and optical transport.
Service providers are thinking ahead, but the road is unclear. Investments in some approaches aren’t likely won’t realize full product lifecycle and concurrent long-term ROI because they will need to be replaced to realize 5G’s full potential. In embracing platforms that enable rapid service innovations today that carry onward through 5G and beyond, service providers can thrive in the metro evolution driven by mobility trends, high-bandwidth services of the future, and the digital transformation in general.

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Coherent modulation in next-generation optical networks

By PAUL MORKEL and SORIN TIBULEAC, ADVA Optical Networking

Operators have rapidly adopted coherent transmission since the first deployments of DSP-based coherent technologies to long-haul and submarine networks in the early part of this decade. Coherent technology is now being extended throughout the metro and soon will be deployed in access networks to meet the inexorable demand for bandwidth. Where 10-Gbps wavelengths were deployed in 50-GHz grid WDM systems, 100-Gbps wavelengths implemented with around 32-Gbaud symbol rates have been deployed on the same multiplexers and amplifiers with greater reach and enhanced impairment tolerance, thereby simplifying capacity migration. More recently, second-generation flex-coherent modulation enabling 200-Gbps wavelengths with 16QAM or 8QAM modulation, and now the first 400-Gbps wavelength deployments at higher baud rates, are being deployed.

Investments in DSP technologies with ever higher CMOS integration will shortly enable a new generation of up to 600-Gbps wavelengths with highly configurable baud rates and modulation up to 64QAM with a large degree of modulation control. Beyond this we can expect to see 800-Gbps or even 1.2-Tbps wavelengths in the future, with higher baud rates to enable 400-Gbps quantization of the wavelength capacity.

The new modulation formats, with their advanced coding and forward error correction (FEC), are bringing networks closer to the Shannon limit, defined as the maximum achievable capacity. Skirting this limit to extract the maximum utilization for real networks with complex topologies and traffic requirements requires additional consideration of network planning and management.
Optimizing parameters

Such modulation flexibility is new to optical network design. For many years fixed parameters, including bit rate and channel spacing, simplified network planning, but also led to unused margin and thus capacity on the network. Providing highly flexible coherent modulation with wavelength-based optimization for multi-point networks is the key to extracting the maximum capacity at the lowest dollar per bit. Naturally, this goal is now the focus of a number of optical network operators.

We can consider the fundamental parameters at the channel level to be the baud rate (or symbol rate), the equivalent QAM that affects spectral efficiency (SE), and the information coding with FEC. At the network level, metrics of fiber capacity and bandwidth quantization (number of managed channel entities) are relevant, which then determine overall cost per bit for incremental service additions and for the aggregate network.

While it is tempting to think maximum SE is always desired, if this comes at the expense of optical reach with additional regeneration requirements, network costs may increase. Both reach and SE are thus parameters to be jointly optimized for specific network objectives. Firstly then, it is important to understand the flexibility of the new generation of coherent DSP and optical interfaces.

How much control of SE and baud rates per channel is available and which combinations best suit specific network objectives? Varying approaches to modulation exist between vendors. Figure 1 is an example representation of the latest flex-coherent DSP capabilities showing SE versus channel information rate supporting up to 600 Gbps per wavelength. For simplicity, the figure shows a 100-Gbps granularity modulation combination; intermediate points at sub-100-Gbps granularity in the shaded area will also be possible, with various formats in different DSP implementations providing high flexibility.

What we see in the figure is a range of combinations of baud rate and QAM order leading to different channel capacities. So, which combinations should you choose? Well, that depends on your network objectives. Typically, a given application will only use a small subset of the options available. Short, high-
Coherent modulation in next-generation optical networks

capacity networks will favor high QAM. Highest baud rates will be favored except in cases where granularity is too coarse for specific network traffic patterns.

Not shown in the chart but also highly relevant is the reach characteristics for different modulation configurations. To first order, this is determined by the modulation format or equivalent QAM. For example, 16QAM signals will have comparable reach independent of the baud rate when limited by typical transmission impairments. What changes is the channel capacity and thus cost per bit and overall spectrum use, which then determines quantization of bandwidth on the fiber. Network planning and optimization tools can assist operators in determining the optimum configurations.

**Which networks benefit from highly flex-coherent modulation?**

Let us look at the requirements of a few network operator types to explore how they may use this new generation of flex-coherent technology and how it may be implemented in typical network deployments.

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**FIGURE 1. Example spectral efficiency versus channel rate.**
When discussing very high-capacity modulation, one of the first applications that comes to mind is hyperscale metro data center interconnect (DCI), which requires very high capacity over relatively short distances. This is a natural application for the highest QAM constellations – packing the largest number of bits into a symbol as possible for lowest cost. This approach may come at the expense of coarse bandwidth quantization, but deployments are generally in terabit-per-second bandwidth chunks or greater.

Today’s networks are deployed with 100-Gbps or 200-Gbps coherent interfaces or 100-Gbps PAM4, and in the near future with 400-Gbps to 600-Gbps wavelengths. In the medium term 400-Gbps wavelengths with 16QAM modulation provided by 400G ZR coherent pluggables for use directly on packet switches will be favored by some; although others no doubt will seek maximum SE with 64QAM for highest fiber capacity. Still, for the metro DCI application, a high degree of flexibility is not required; rather, the goal is lowest dollar per bit with a sufficient level of SE to meet the optimal capacity per fiber according to the available fiber plant.

Carrier networks, on the other hand, are typically multi-point ring or mesh topologies that in general support a mix of circuit types with a range of paths, including pass-through at multiple intermediate ROADM locations. This can be metro, regional, or long haul in scale. OTN provides effective sub-wavelength aggregation for individual connectivity services in the 10-Gbps to 100-Gbps range in the near term. Packet aggregation from core switches is also used for MPLS backbone transport.

Bandwidth quantization becomes more of an issue here, as 400-Gbps and 600-Gbps waves may be too coarse for individual path connectivity; 200-Gbps or 100-Gbps channels may be preferred with higher connectivity. We may thus expect to see a range of modulation types with combinations of baud rate and QAM for optimization of reach and to enable a larger number of end-to-end circuits on the network. Backbone DCI will show less dependency on quantization and service types, but still will require path optimization through multiple ROADM nodes and to avoid regeneration – so it will share some of the same optimization criteria as carrier networks.
Modulation optimization

Primary modulation optimization metrics are baud rate, modulation format (QAM), and channel spacing or channel passband. Secondly we may consider coding and FEC overheads. Figure 2 is a schematic representation of the three primary modulation adjustment “knobs” that will be used for network optimization. We see that baud rate and equivalent QAM specify the channel rate, which directly correlates with cost per bit at the incremental channel level. Equivalent QAM and channel spacing or passband specifies the overall fiber capacity, which determines aggregate cost per bit. Baud rate and channel spacing/passband specify bandwidth quantization or the number of distinct routable channels available for connectivity.

Referring to the applications above, metro DCI will be optimized with maximum fiber and channel capacity. This implies the use of the highest QAM and baud rate, with the resultant passband typically 75 GHz for ~66-Gbaud channels. Carrier and other longer-reach multi-point applications with varying quantization requirements are optimized with combinations of baud rates and QAM. Flexible passbands on intermediate ROADMs tailored to the baud rates and also accommodating bandpass narrowing through multiple ROADM cascading will enable multiple channel rates. Aggregating multiple wavelengths into densely packed superchannels is another option to limit the impact of bandpass narrowing. Use of superchannels may further improve SE, although again at the expense of granularity and bandwidth quantization.

In practice we might expect a stepwise approach to spectrum management in more complex networks. It is easy to see that optimizing individual passbands in a multi-baud-rate network gives the most control over

**FIGURE 2.** Flex-coherent parameters.
bandwidth quantization and spectral narrowing. However, lack of coordination across a multi-point network can result in spectrum fragmentation and blocking. To avoid these headaches and simplify spectrum management, a network operator may initially choose a small number of passbands to manage, such as 50 GHz, 75 GHz, and 100 GHz. With evolved planning and control methods the operator may choose to extend to more passband options to optimize quantization and ROADM passband narrowing on a per-path basis to use spectrum to the fullest extent.

**Performance metrics**

Traditionally, optical signal-to-noise ratio (OSNR) has provided a convenient metric for characterization of amplified transport systems, with 0.1-nm optical bandwidth for noise power measurement. With flexible baud rates, however, OSNR becomes less universal; changes in baud rate lead to different optimized transmit powers, and thus OSNR, over a given line system. We then need to examine the OSNR requirement of differing baud-rate signals. Broadly, nonlinear power limits for coherent, non-dispersion-compensated systems scale with optical power spectral density (PSD). A signal with 2X baud rate may thus be used with 3-dB higher transmit power to arrive at the same signal PSD.

SNR defined in unitary bandwidth on the receiver therefore provides an additional performance metric useful for characterization of networks with multiple baud rates. As to first order, it shows achieving a specific SNR will enable similar reach independent of the baud rate for a given modulation format or QAM. Although it may sound counterintuitive to maintain the same reach when we double the channel capacity, it is similar to two channels being supported over the same distance with double the spectrum usage.

The following is the simple conversion to SNR on the receiver from a given OSNR, which is still the metric for optical link amplifier noise characterization:

\[
\text{SNR}_{\text{dB}} \approx \text{OSNR}_{\text{dB}} + 11.0 - 10.\log(\text{BR}) - \text{Rx}_{\text{dB}}
\]

Where the constant is derived from 0.1-nm bandwidth used for OSNR, BR = signal Gbaud per second, and the Rx dB is an electrical receiver impairment.
The SNR increases with OSNR, as expected, but decreases with baud rate. However, increasing the channel power in proportion to the baud rate (constant PSD) enables OSNR to increase approximately in proportion and maintains the same SNR and reach.

**Dynamic optimization**

We have seen above how multiple controls now available on flex-grid ROADMs and coherent interfaces enable a much higher degree of optimization capability for networks than was available in the past. What this advance means in practice is that operators can maximize spectrum resources for lowest cost per bit and maximum scalability on the network.

Operators can do this with consideration of the bandwidth quantization needs of their network. This is easy to see for static optimization, but the prospect of elastic networks with dynamic optimization looks even more tantalizing. Static optimization trades excess start-of-life margin for capacity and lower cost per bit. Dynamic optimization could enable compensation for impairments that would otherwise be assigned aging margin on the network, including fiber repairs, component aging, etc. Such compensation could be applied either with user intervention or via automated network processes – hence using SNR as the primary resource to maximize bandwidth utilization and lower network costs. For DSP-based adjustments, such dynamic control would typically affect service and would generally require reconfiguration of user services. Still, as control methods evolve we may expect to see such techniques used in the future.

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Multipath traffic distribution in the era of SDN

By GUNTER VAN DE VELDE, Nokia

Our love affair with all things digital continues. We are, as a result, experiencing a disruptive scaling in network services. Simply put, we need to connect an ever-increasing number of things at higher and higher speeds. At the same time, we are seeing massive uptake of cloud-based services. Some of these services are pushing the current cloud paradigm — the centralization of information and compute resources — towards a more distributed cloud architecture. This move will require an evolution to new wide-area network (WAN) architectures and technologies, such as 5G and software-defined networking (SDN), to support edge-cloud deployments. But how will these changes affect the ways in which we distribute traffic in this more chaotic and dynamic environment?

Where we’re heading

In the land of classic multipath traffic distribution our goals are simple: survive failures, keep the network stable, and spread the load as evenly as possible across the whole network. This was never simple but, traditionally, access and subscriber networks did grow steadily and usage patterns were predictable. However, today’s and tomorrow’s applications and services, such as 5G mobile, SD-WAN, video, augmented and virtual reality, and internet of things (IoT), impose different usage patterns that can only be met by a more agile and dynamic architecture based on network functions virtualization (NFV) and SDN. Traditional networks have long deployed Layer 2 link aggregation and/or bundling and equal-cost multipath (ECMP) mechanisms to increase the available bandwidth capacity between the ingress and egress of a link or network demarcation points. However, this way of handling multipath traffic distribution is no longer good enough, especially with the dominance of cloud services today and the way that they are evolving beyond the traditional data center. Hyperscale data centers initially had little interaction with the network outside of them. They accepted the network much as it had been originally
designed and supplemented it, in the case of video, with content distribution networks. Within the data center, however, there was a need to deploy a different approach to network routing. Here the focus was on the benefits of centralizing both information and compute resources — increased reliability, security, and operational excellence — and bandwidth resources inside the data center were relatively inexpensive. SDN and virtualization gave data center operators the agility and scale they needed, but the optimization of traffic distribution was low on the list.

However, under localized legislation, or driven by operator and enterprise network architectures, workloads that normally run within hyperscale cloud services are moving towards smaller, workload-tailored, more distributed data centers or edge clouds. These workloads might run at premises owned by the service provider, enterprise, or even at the subscriber level. These distributed cloud services empower ultra-performing, ultra-resilient, and ultra-reliable workloads and it all needs to be seamlessly connected (Figure 1).

To properly support these distributed cloud applications, the SDN-empowered network needs to connect everything together, from access to cloud services, via the most operationally optimal, scalable, reliable, and future-proof architecture. Underlying connectivity operations must match the agility and scalability of the NFV/SDN technologies to be most profitable.

**FIGURE 1.** *The implementation of SDN can provide significant benefits.*
Getting to NFV/SDN

Most current network implementations involve either the deployment of Layer 2 link aggregation/bundling or Layer 3 ECMP. However, these traditional technologies do not make use of all available bandwidth resources, which results in stranded network bandwidth. Nor do they provide sufficient mechanisms to upsell network resources by introducing flow constraints such as delay, reliability, link costs, or packet loss. These mechanisms also do not allow the network to be used as a consumable resource, which requires differentiating between the various options available and offering them as different services based upon attributes such as reliability, latency, and bandwidth.

In contrast, SDN requires traffic to be optimized in real time based upon the network state and the required service levels of a flow. SDN controllers harvest real-time topology, network state, and business rules to optimally program the distribution of traffic across the network. At its foundation, SDN provides the toolset to distribute traffic more efficiently and, potentially, even deliver multi-tiered transport services (see Figure 2).

**FIGURE 2.** Data from a variety of sources helps SDN technology optimize network performance.
To provide the contracted traffic distribution behavior when programming a path for any given flow through the network, the SDN controller must be informed about the state of the core links (e.g., bandwidth utilization, latency) and about the programmatic SDN capabilities of the individual network components.

Network state can be harvested using recent well-known streaming telemetry technologies such as gRPC (the Google-developed remote procedure call). With these kinds of technologies, it is possible for the SDN controller in real time to know latency, used bandwidth, traffic queuing, and so on.

The specific programmatic capabilities of network devices are often harvested by means of routing protocol extensions to BGP, ISIS, or OSPF. This is important information for the SDN controller because these capabilities capture the complexity of the paths that the controller can program into the operator network. The main relevant capabilities are Maximum Segment Depth (MSD), Entropy Label Capability (ELC), and Entropy capable Readable Label Depth (ERLD). MSD defines the number of segments or “hops” a network device can impose upon a flow. When a flow is tagged with an entropy label, ELC informs the SDN controller that the device can act upon this value accordingly, helping to spray

**FIGURE 3.** Algorithms such as Self-Tuned Adaptive Routing (STAR) leverage the SDN controller capabilities for network load balancing.
traffic fairly within the core network. ERLD informs the SDN controller how deep in the packet headers the network device can look to retrieve the entropy tag.

Once the network controller has harvested (in real time) the most recent network state and learned the programmatic capabilities of the network devices, it needs to program the paths through the core network accordingly. It is in the service provider’s best interest (for service and cost optimization) to spray the traffic across the network in such a manner that bandwidth, latency, and quality of service (QoS) resources are consumed most efficiently. The algorithms used to load balance traffic flows over the greatest number of paths depend upon the capabilities of the SDN controller. For example, the Bell Labs STAR (Self-Tuned Adaptive Routing) algorithm provides on average about 28% more traffic efficiency compared to classic non-SDN load balancing (Figure 3).

**Putting it all together**

Let’s look at how this kind of multipath traffic distribution might be used to offer SD-WAN services. SD-WAN services possess many of the desired capabilities for interconnecting the telco cloud: programmability, virtualization, agility, automation, and security. Because SD-WAN uses an overlay service model it is independent of the underlying transport layer and takes advantage of any IP transport option available. Underlay network transparency is a key advantage when connecting remote, out-of-region clients and small enterprise branch offices over a commodity internet service. However, the use of commodity services also makes it unable to support deterministic performance requirements such as those available to carrier-grade cloud services.

In contrast, managed IP/MPLS network services do support deterministic QoS guarantees with mission-critical reliability. The combination of MPLS, segment routing, and carrier SDN control adds scalable and efficient traffic engineering capabilities with tremendous control granularity and flexibility. The superior instrumentation of carrier transport services sets the bar on reliability and quality of service. However, the reach of typical managed services is limited and doesn’t extend beyond the WAN perimeter into the telco cloud data centers. Moreover, communication service providers also want to virtualize the WAN in logical network slices that can be optimized and shared for multiple applications.
The ideal solution for telco cloud connectivity is a hybrid WAN service that combines the qualities of software-defined overlay services and managed underlay transport services — without inheriting the shortfalls of each. It is a service that maintains the functional decoupling between IP overlay and underlay network services, but permits the coordination of routing and transport policies between layers. Management and control extend end-to-end: from connected clients in the access network, to distributed virtual network functions (VNFs) in the multi-service cloud edge, and VNFs in centralized telco cloud data centers and potentially even the public internet cloud.

**Summary**

SDN controllers bring value to existing core networks and introduce new ways to differentiate flow-handling and traffic distribution. They will help an operator to steer flows through most optimal paths and provide a competitive service offering for best-effort and premium traffic, as well as for any other type of traffic in between.

Looking ahead, platforms are in development that will harness the traffic distribution characteristics of SDN to enable telco-cloud automation or, in other words, cloud-optimized services with deterministic guarantees. They will enable agile and seamless connectivity for distributed network functions in telco edge and core data centers to support the many exciting but demanding applications and services that are coming.

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Company Description:

Founded in 1984, AFL is an international manufacturer providing end-to-end solutions to the energy, service provider, enterprise and industrial markets as well as several emerging markets. The company’s products are in use in over 130 countries and include fiber optic cable and hardware, transmission and substation accessories, outside plant equipment, connectivity, test and inspection equipment, fusion splicers and training. AFL also offers a wide variety of services supporting data center, enterprise, wireless, and outside plant applications.

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Innovation is a key component of the AFL culture and one of our core values. Our engineers continually research and develop the latest in optical fiber technology to provide the best solutions for the industry and our customers. Check out these white papers - you might find the answer you’re seeking.

LINKS:

- Cost Study: Network System Cost Study
- White Paper: Re-Enterable Plug and Play Fiber Access Terminals
- White Paper: FASTConnect® or FUSEConnect®—Which Should You Choose?
Network System Cost Study

Patrick Dobbins, Director of Solutions Engineering, AFL

OBJECTIVE
As network bandwidth demands continue to grow, AFL strives to assist each and every customer in achieving scalable growth and effectively managing network costs through innovative solutions. Included herein is a study which identifies a number of key elements where new cable technology notably impacts fiber optic network installation and maintenance costs.

These key elements below represent just a few areas of primary cost savings:

• Rights-of-Way (pathway and facilities)/Lease cost reductions
• Longer cable lengths to reduce reel end splice points
• Reduced scrap via larger master reels and less residual lengths
• Decreased time for access splicing and cable preparation
• Faster installation speed and improved handling

In a recent high profile access project currently underway in metropolitan New York City, AFL was able to tangibly substantiate the value and savings associated with the key elements noted above.

PROJECT HIGHLIGHT
In 2014, the New York City Administration issued a competitive RFP to re-purpose payphone infrastructure with free WiFi, phone calls and advertising. A large consortium group submitted a proposal for a WiFi project and was chosen for its innovative and community-first approach. They were awarded the 12-year franchise contract to provide the new infrastructure for the communication services. This large consortium group is an organization of experts in technology, media, user experience and connectivity that includes Intersection, Qualcomm and CIVIQ “Smartscape.”
ABOUT THE WIFI PROJECT

- This WiFi project will bring free, super-fast WiFi across New York City with a network of at least 7,500 Link kiosks.
- Each gigabit Link is powered by an all-new, purpose-built fiber optic network that will deliver speeds up to 100 times faster than average public WiFi.
- The consortium group is making a significant investment to build hundreds of miles of new fiber optic cable that will deliver gigabit connectivity to Links in all five boroughs.
- Each Link has the capacity to support hundreds of WiFi users simultaneously.
- In partnership with the City, the consortium group will also bring gigabit service to an indoor public center in each borough for New Yorkers to access educational opportunities and connect to their communities.

NEW TECHNOLOGY NETWORK

The high-speed pathway for the WiFi project is being built by the owner/operator of dark fiber network in New York City, which provides backhaul fiber and passive wavelength connectivity to all major co-location facilities throughout the New York metro area, as well as to macro sites, small cells and WiFi nodes. The company’s backhaul solutions connect carrier and enterprise aggregation points back to their core network facilities and common carrier services collocated at carrier hotels.

The WiFi kiosks are now interconnected with a number of AFL fiber optic technologies. These products provide the high speed pathway for connectivity of the gigabit system. Each kiosk provides connection to any enabled wireless device for access to internet, voice calling, 911/411 services and other information services.
The main backbone fiber system is the AFL Wrapping Tube Cable (WTC) with SpiderWeb Ribbon® (SWR®). The backbone cable used is a 1,728 fiber Wrapping Tube Cable that was chosen due to the cost saving technology that it offered.

With the smallest diameter and lowest weight of any 1,728 fiber cable in the world, this cable eliminated the need for a second 2-inch conduit that would have been required for a different cable technology. The result was the elimination of 50% of the annual pathway expense.

WTC also offers another significant cost reduction in that it allows longer cable lengths – up to 30% longer. These longer cable lengths provided savings on reel-end splicing costs by allowing the cable runs to go further without the need for a splice. Additionally, mid-cable access splicing times were greatly improved through reduced cable preparation time and faster mass fusion splicing time.
Furthermore, WTC realized even more savings due to the installation improvements as a result of the cable handling itself. The smaller diameter and lighter weight allowed for faster installation than the pulling of traditional cables as well as accommodating the use of standard installation apparatus and methods when pulling the ultra-high fiber count cable.

During the installation process, whenever slack was required or when installation constraints forced bi-directional pulls, WTC was quickly coiled into figure-8 coils and transitioned to the next pulling stage. The smaller diameter and lower cable weight ensured that the cable could be coiled into large figure-8 storage points then quickly pulled in the opposite direction.
COST IMPACT SUMMARY

Although the project is still in the early stage, a number of specific cost savings on key elements have already been realized. Some savings are direct and easy to identify. Others are somewhat intangible and require more details to quantify into specific savings, but nevertheless are known and accepted to have a positive value proposition and cost saving impact.

The key elements that have achieved cost savings to date are as follows:

1. Cost of Right-of-Way for the project was initially identified as needing two (2) 2-inch innerducts for most of the underground network. With the use of AFL’s WTC, the network could pull a single 1,728 fiber WTC rather than two (2) 864 fiber cables and eliminate one (1) 2-inch innerduct. This resulted in a significant cost reduction per year for the first phase of this project alone.

2. By using WTC which offers a 30% smaller diameter and 55% lower weight than a traditional ribbon cable, AFL was able to provide cable reels at 4,570 meters (15,000 feet) rather than 3,500 meters or (11,500 feet). This reduced reel end splice points by 25%.

3. Consideration of scrap impact resulted in a calculation of residual scrap of an estimated average of 200 meters (656 feet) at the end of the cable pull. With the use of a larger master reel, the scrap impact equals 200 meter per 4,570 meter master, or 4.3%, versus 200 meters per 3,500 meter master, or 5.7%. This is a savings of 1.4% per reel.

4. With WTC being a dry core cable, the access splicing cable preparation and the reel-end splicing preparation is reduced by 50%. Actual mass fusion splicing time is approximately the same; however overall splicing and cable preparation combined was reduced by approximately 35%.

5. The final factor reviewed was installation time during the actual cable pulling process. While traffic control and permitting for dense city traffic was the most significant issue for pulling underground in an urban environment, the impact of the cable was not significantly apparent. Previous studies have indicated that typical savings of time is an estimated 11% decrease. Many of the savings for this project were more intangible in nature including elements such as size of work areas for figure-8 coils and amount of set up space for tandem pulling with multiple capstans.

In conclusion, the many positive attributes associated with AFL’s Wrapping Tube Cable have made a significant impact on the deployment costs of the WiFi project. As this project is still currently progressing, a more detailed analysis will be completed and may potentially be the subject of a future published paper. For further information, please contact AFL.

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