BUILDING FUTURE-PROOF NETWORKS FOR INTELLIGENT TRANSPORTATION SYSTEMS

APPLICATION NOTE

Alcatel·Lucent
Enterprise

Departments of roads and highways around the world have begun to implement technology solutions to improve the safety of their highways, lessen congestion and manage traffic more efficiently. Intelligent Transport Systems (ITS), as these systems are known, require reliable, secure and scalable networks to link cameras, sensors, signage, signaling and vehicles to remote data centers and operation centers. These networks will be deployed in harsh environments and will pose their own unique challenges to operate, maintain and manage. In this application note, we will present the unique requirements of ITS networks and discuss how Alcatel-Lucent Enterprise products and technologies not only meet today's ITS requirements, but are designed to grow and scale to meet tomorrow's as well.

INTRODUCTION

Road transportation has been behind the digital technology curve, but it is quickly catching up. Concerns for safety, congestion and more efficient traffic management led to the development of Intelligent Transportation Systems (ITS) in the 1990s. Since then, the requirements and capabilities of ITS have expanded rapidly. From early implementations of variable speed limit (VSL) signs, dynamic message signs (DMS) and e-Tolls, to tomorrow's mesh of sensors, connected vehicles and, eventually, self-driving cars, the list of ITS applications is growing daily as vehicular-based transportation systems become the next promising field in the advance of digital technologies.

Wired and wireless networks handle the communications for all ITS systems and sub-systems. They link cameras, sensors, signage, signaling and vehicles to remote traffic operations centers where the vast amounts of data that will be produced by these systems are monitored and acted upon to reduce vehicle congestion, monitor and respond to incidents and otherwise ensure the smooth running of our highways.

Although traditionally serial-based, ITS communications networks are moving (along with the rest of the world) to IP and, in wired networks specifically, to IP/Ethernet. IP/Ethernet supports a wider range of applications, scales to support heavy bandwidth applications, such as video, and works with the communications already in use by drivers, passengers and vehicular systems. Thus, an ITS network based on IP/Ethernet is by definition open to new applications and services in the future, as ITS applications increasingly interact with vehicles and consumers.

Alcatel-Lucent Enterprise has a range of IP/Ethernet products for building out a hardened, scalable and secure IP/Ethernet infrastructure with the capacity and features to handle the most demanding ITS applications. Critically, our network systems are designed to simplify operational complexity, reduce configuration time, and ensure a long lifespan for products deployed in the field – an environment where the labor costs involved in replacing networking gear is many times the cost of the gear itself. In this application note, we look at the role Alcatel-Lucent Enterprise networking can play in your advanced ITS deployment.

The Alcatel-Lucent Enterprise ITS Solution at a Glance

Our high-capacity IP/Ethernet networks support the most demanding ITS applications today (e.g., video monitoring) with an expandable range of configurations ready for tomorrow's roadside devices and innovative applications.

- Our hardened OmniSwitch® 6865 Ethernet Access Switch is designed for the kinds of conditions experienced in roadside cabinets:
- Temperatures from (-40 to +167°F or -40 to 75°C)
- Variable power conditions (90 – 260 VAC and 20 – 60 VDC)
- Electromagnetic fields, high vibrations, dust/dirt and high humidity

It supports:

- Power over Ethernet (POE) and High Power over Ethernet (HPoE) for reduced cabling requirements
- Optical uplinks for 10 Gbs backhaul of sensor and video data
- Support for SPB-M, which eliminates spanning tree at the edge of the network
- Plug-n-play support for ease of installation and deployment

We have a range of aggregation and core switching products, as well as data center solutions that, with our network management software, can provide an end-to-end ITS solution, which is cost-effective and operationally efficient.

INTELLIGENT TRANSPORTATION SYSTEMS

Although initially engineered to help control congestion with technologies such as VSL and DMS signs, ITS systems will play an increasingly critical role as they are integrated with other systems, especially driver assistance systems, vehicle-to-vehicle (V2V) communications and, eventually, self-driving cars. They will require very high levels of reliability, as well as the ability to expand and scale as new applications are deployed.

Advanced transportation management systems (ATMS) are one of the key applications within ITS. In a manner very similar to air traffic control, ATMS systems regulate the flow of vehicles with the goal of lessening or eliminating congestion and, in this way, improving the safety and efficiency of our roads. Sensors are embedded in the surface of the road or mounted on equipment (e.g., poles, signs). Cameras are mounted on overpasses and other vantage points. They feed data and video back to a traffic operations center where it is processed and monitored and the resulting decisions are used to manage traffic. In the past decade, digital signage and FM radio were the primary ways to communicate with drivers, and ramp meters and electronic tolls were also used to manage traffic flow and volumes. In the near future, traffic management decisions will be communicated through in-vehicle advanced traveler information systems (ATIS) working with ATMS.

ATIS and ATMS applications are only part of the many ways in which vehicles and highways are becoming increasingly smart and connected. As both drivers and transport departments come to depend more and more on these systems, the demands for network-based communications reliability will become more stringent. The following examples illustrate some of the mission-critical roles that they will play, as well as some of the conveniences they will enable:

- *Green wave* — the synchronization of traffic signals to create a continuous traffic flow, thus reducing stopping and starting, lowering fuel use and reducing emissions. In some existing systems, VSL signage helps to regulate the traffic flow to the optimum speed, in the future this will be done through ATIS.
- *Cooperative Adaptive Cruise Control (Platooning)* — An application that uses V2V communications to coordinate vehicles using cruise control with the goal of having them move as a coordinated group and thus avoid the inefficiencies of some behavior, such as accordioning.
- *R.E.S.C.U.M.E. (Response, Emergency Staging and Communications, Uniform Management and Evacuation)*: First responder services can leverage the ITS system to more quickly detect and react to emergency incidents, including communications with those involved in the incident, field personnel and operations management. Video monitoring also plays an important role in assessing the situation.
- *Dynamic ridesharing* — Similar to the current Uber-type of application, this would leverage the ATIS in-vehicle system and personal smartphones to match drivers and riders.
- *Smart parking* — This application uses sensors and smartphone-enabled payment systems to predict where parking is likely to be available and even allow drivers to reserve and pay for spaces.

While ITS systems were not designed with semi-autonomous and autonomous vehicles in mind, there is no doubt that many of the applications being considered in this innovative and exciting area will make interactions between the ITS systems and autonomous vehicles possible. Adaptive cruise control, for example, envisions the driver turning over throttle control to the vehicle, as opposed to just setting a fixed speed.

It is not hard to imagine adaptive cruise control working interactively with Platooning or Green Wave ITS applications.

These applications all depend in one way or another on the underlying network, whether wired or wireless. And while some are merely nice to have, others will be considered mission-critical for safety reasons. The larger point is that these new applications will put increasing pressure on the underlying network for capacity, security and reliability.

ITS NETWORK REQUIREMENTS

As we have seen from a quick sampling of ITS applications, one of the realities facing ITS administrators is that the requirements being placed on their systems will evolve rapidly in the coming decades. Managing this evolution could potentially impose costs far in excess of the original equipment purchases. These highly distributed, outdoor network installations are expensive to service relative to the cost of the network gear itself. Thus, it is critical, as far as possible, to invest today in equipment with the capacity and features to meet tomorrow's needs.

HIGH-CAPACITY AND SCALABLE IP/ETHERNET

The traditional serial-based networks built for signaling and signage are unsuited to most of the applications we have described. Advanced ITS systems need higher bandwidth capacity in the 1–10 Gbps range to be able to handle video applications. They must be very scalable and application-aware to be able to respond dynamically to rapidly shifting user demands during road incidents, congestion and other high usage periods. Both consumer and in-vehicle applications, although using wireless[1] for the last 100–1,000 meters, will require IP/Ethernet with the ability to support Quality of Service (QoS) for voice and video, and virtual private networks (VPNs) to handle secure applications.

POWER OVER ETHERNET

With the large number of sensors, cameras and other connected devices, Power over Ethernet (PoE) will be compulsory on many access switches in order to reduce cabling requirements and simplify installation and maintenance. Also important are emerging standards to provide higher power over Ethernet that will support applications such as heated, pan-tilt-zoom (PTZ) cameras that require up to 60W or digital signage that requires up to 100W.

ROADSIDE READY

Roadside Ethernet switching will be outdoors and exposed to both extremes of weather, vibrations, and power sags and spikes. It will need to be both ruggedized and have in-built capacity to expand as new applications, sensors and devices are developed and installed. Spanning thousands of miles of highways and roads, access switches will also need to be linked by low-latency optical backbones to span the potentially long distances between nodes.

1 There will be a wide range of wireless technologies adopted. Some ITS functions will be able to be handled directly by cellular networks, especially as we move from LTE to the emerging 5G standard (2020-25), which will seamlessly integrate cellular and WiFi (IEEE 802.11) and have improved handling of bearer-less devices, such as sensors. However, most other wireless technologies will rely on IP/Ethernet transport networks including sensor networks, wireless Mesh/Ad hoc networks, mobile IP, smart antenna and cognitive radio.

DEPLOYMENT AND MAINTENANCE

ITS implementations are often deployed as part of larger construction projects and the personnel assigned to install a critical unit, such as a network switch, often have not undergone extensive technical training — thus the need for plug-n-play installation and automated deployment. For ongoing maintenance of such highly distributed networks, it will be important to avoid mobilizing resources, whether contractors or internal resources, and to simplify as much as possible any interactions that roadside maintenance crews need to have with the network when adding, repairing and replacing sensors, signage and cameras. Any network-specific maintenance, such as node configuration, loading of software updates and other operational tasks need to be handled remotely. Given their mission-critical characteristics, many of these applications will as well require self-healing networks with fast recovery.

DATA CENTER AGILITY

Modern data center architectures employ server virtualization, which enables the speedy creation of separate processing pools that can be dedicated to individual ITS and other applications as needed. What this means practically is that if one application becomes overloaded, it doesn't have to degrade the whole data processing capability. For instance, some resources could be dedicated to processing the information from meshes of sensors and monitoring devices and be unaffected by ATIS and first responder communications that need to be spun up quickly to deal with sudden traffic congestion or emergency incidents. It is important that the networks that serve ITS data centers be flexible and agile in responding to the quickly shifting application loads on the network — what we refer to as "application fluent" — while providing the automation, security and intelligence required to deliver high-quality services and reduce operation costs.

THE ALCATEL-LUCENT ENTERPRISE ITS SOLUTION

As we have seen, Intelligent Transport Systems require reliable, secure and scalable networks to link cameras, sensors, signage, signaling and vehicles to remote data centers and traffic operations centers. These networks will be deployed in harsh environments and will pose their own unique challenges to operate, maintain and administer. In this section we will discuss how Alcatel-Lucent Enterprise products and technologies not only meet today's ITS requirements, but are designed to grow and scale to meet tomorrow's as well.

PERSISTENT NETWORK ACCESS

ITS network access includes the need for both wireline and wireless equipment. Alcatel-Lucent Enterprise Stackable Gigabit LAN switches provide wireline access, with wireless access provided by a variety of high-performance 802.11ac Wi-Fi access points (APs).

The workhorse of the Alcatel-Lucent Enterprise ITS solution is the OmniSwitch 6865 Ethernet Access Switch. This industrial grade, layer 3, Gigabit Ethernet switch is designed to operate reliably in the kind of harsh environments experienced in roadside cabinets. It can operate at wider operating temperatures (-40 to +167°F or -40 to 75°C), variable power conditions (90 – 260 VAC and 20 – 60 VDC), and can withstand electromagnetic fields, high vibrations, dust/dirt and high humidity. It has an optimized feature set for high security, reliability, performance and easy management. Its stackable half-rack form factor (also available as a 19" half-rack model), enables it to easily squeeze into roadside cabinets where space is at premium. With support for SPB-M, the OS6865 can deliver VPN services and eliminate spanning tree from the network.

Cost-Effective VPNs with Shortest Path Bridging

Shortest Path Bridging (SPB) is an IEEE standard that eliminates the need for Spanning Tree Protocol and enables multiple shortest paths on the network. SPB natively provides MPLS-like VPN services but is comparatively cheaper and simpler to deploy and maintain. SPB requires just a single protocol (IS-IS) to build a shortest path topology, distribute service information and carry routes through the backbone. Alcatel-Lucent Enterprise's Intelligent Fabric technology brings further simplification with plug-n-play and auto-attachment capabilities. Because of this simplicity and automation, an Alcatel-Lucent Enterprise powered SPB-M solution offers very low total cost of ownership (TCO).

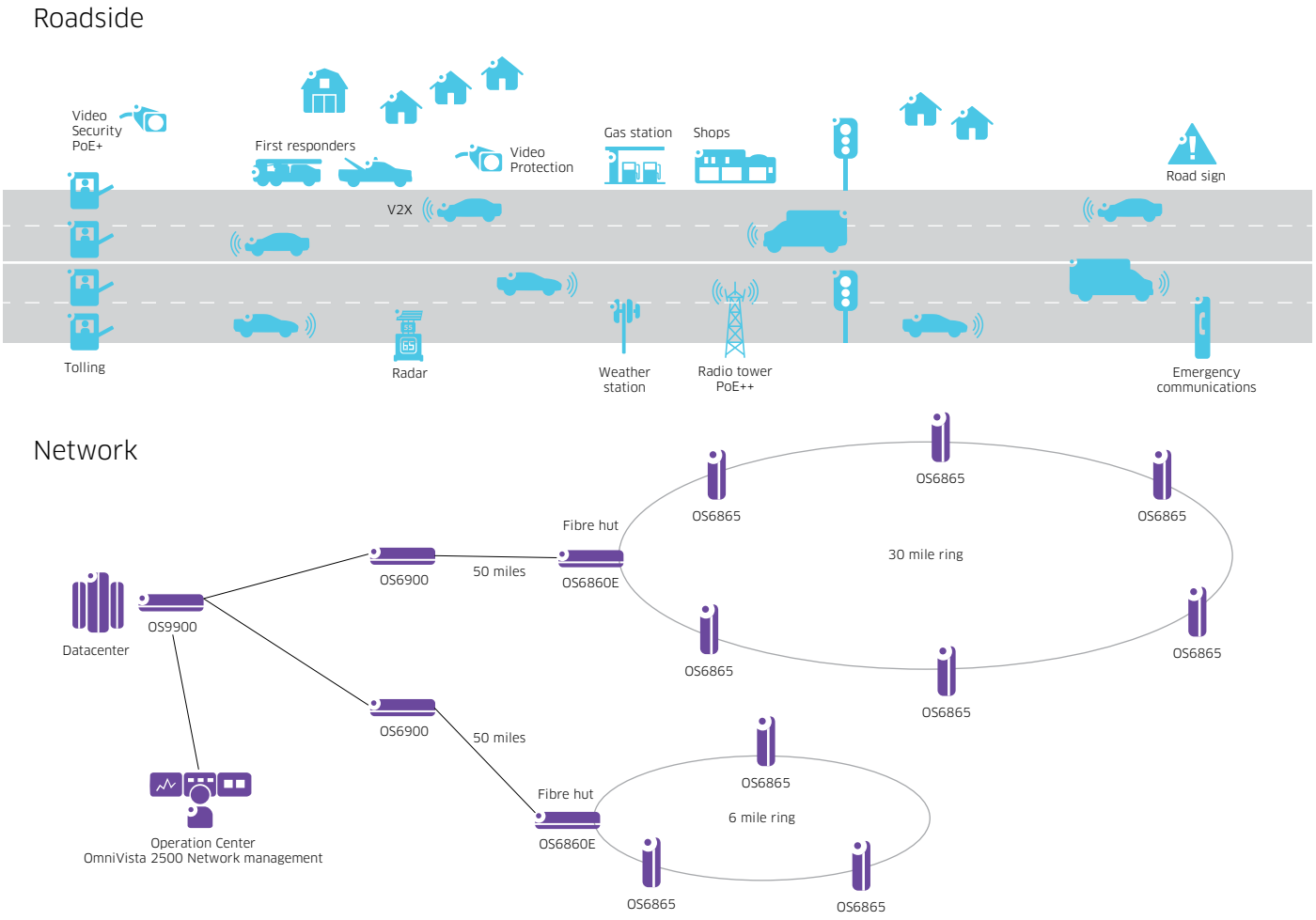
This allows, for instance, for expansion of services to a given sector by simply enabling those services at the edge, without requiring configuration changes at the core of the network (see sidebar).

The OS6865 has Gigabit optical backbone connectivity, allowing up to 10 Gigabit uplinks and support for a variety of optical fiber types including single-mode, multi-mode, short and long haul optics allowing distances of up to 50 miles.

It has PoE support for connecting security cameras, wireless access points and sensors, and High Power over Ethernet (HPoE) for up to 75W support for applications such as heated, pan-tilt-zoom (PTZ) cameras. It supports advanced quality of service (QoS) to support the special demands of video and voice applications, as well as integrated security features for controlling access to the network, policy enforcement and network security attack containment. Operationally, the OS6865's intelligent fabric technology (iFab) supports cost-effective installation and deployment using automated switch setup and configuration.

ALCATEL-LUCENT ITS SOLUTION

Figure 1. IP/Ethernet network for a typical ITS installation



A RESILIENT AND HIGH-PERFORMING CORE

Although ITS planners and architects will be primarily focused on the access network, which links all the sensors, signs, cameras and other roadside devices, these access switches will also need to have larger switches to aggregate their traffic and, at the core of the network, very large switches to ensure that data centers and operation centers provide the seamless visibility and control that ITS managers will require.

There are inherent advantages to all of these network components working closely together. It is especially important for technical staff to have end-to-end visibility and control of all the network resources. Traffic congestion and emergency incidents, for instance, can have a direct spillover effect on the operation of the network. As discussed in relation to data centers, specific ITS applications will have individual needs that require the network to be aware or 'application-fluent'. As well, data analytics can be employed to anticipate problems and issues before they occur.

The network counts on high-performance wire-rate 10 Gigabit Ethernet / 40 Gigabit Ethernet network switches that provide unparalleled port density and switching capacity to grow and scale the network inexpensively. This includes the market-leading OmniSwitch 6860E Stackable LAN Switch for roadside fiber huts, the Alcatel-Lucent OmniSwitch 6900 Stackable Ethernet LAN Switch family, for aggregating the traffic coming from the roadside switches, and the OmniSwitch 9900 and OmniSwitch 10K Modular LAN Chassis which function as the high-capacity core of the ITS network solution.

All Alcatel-Lucent Enterprise OmniSwitches have the virtual chassis (VC) feature, which enables up to six switches to be combined and behave as a single fully redundant unit. In many cases, this can replace an expensive chassis, require less space and power, and be delivered at a lower cost. It allows for rapid expansion of the core network, as new sectors of the highway system have ITS capabilities added. The VC provides fast re-convergence if equipment fails, without impacting real-time applications and user experience, such as voice and video. The core products incorporate the award-winning Intelligent Fabric (iFab) technology offering a set of capabilities, including automation techniques that simplify the design, deployment and operation of the network (see sidebar).

END-TO-END NETWORK MANAGEMENT

The management suite includes all the tools needed to provision, monitor, analyze and troubleshoot the network. The OmniVista 2500 is capable of managing the LAN, WLAN, core, WAN, and data center from a centralized single pane of glass. It is an essential component of our iFab technology.

The Alcatel-Lucent Enterprise network analytics technology enables technical staff to analyze the network information in a meaningful manner. The OmniVista® 2500 uses a customizable dashboard to summarize and display the vast information available from the network. From this dashboard, staff can expand the analysis in more detail through multiple graphs and reports. The data collected includes information for the users, devices and applications traversing the network. It also includes network device status, network traffic behavior, warnings and key statistics.

The OmniVista 2500 has the unique ability to offer predictive analysis reports. It analyzes network traffic patterns over a large period of time and uses sophisticated algorithms to predict future behavior. It provides visibility into potential future bottlenecks, enabling

Best of INTEROP 2015 Networking Winner

iFab or Intelligent Fabric makes roadside maintenance of networked devices much simpler with plug-n-play deployment.

iFab attaches itself to wireless access points, servers, sensors and cameras to automatically configure the appropriate connectivity settings. The award-winning iFab technology enables:

- Simpler network design
- Comprehensive interoperability
- Automation of moves, adds and changes
- Remote configuration loads (RCL)
- Self-healing capability, where any component failure, link or node, is detected in real time with automated re-routing of the network traffic
- Network upgrades while in service

The iFab technology includes self-configuration of the network equipment through Auto Fabric:

- Eliminates many manual tasks during the deployment process
- Shortens the time-to-production of the infrastructure
- Reduces the chances of errors in the deployment process.

proactive planning of the network capacity and expansion. The system can detect abnormal network traffic behavior and alert administrators to network security attacks.

DATA CENTER SOLUTIONS

If we think of the traffic operations center of the ITS system as the eyes and ears, then the network is the nervous system, and the data center, although rarely seen, is the brain. It must analyze the entire sensor and monitoring data of the ITS system rapidly, responding automatically to fluctuating traffic congestion and management issues, and ensuring that ITS operational staff have the latest information at their fingertips.

Data center technology is rapidly evolving. Traditionally, data centers were internally managed, but increasingly the heavy processing tasks are being outsourced to cloud-based providers. In many enterprise networks today, a hybrid private-public model is emerging, with small, private data centers handling day-to-day operations but backed up by public cloud providers to manage overflow and very large but intermittent data processing tasks. The advantage of this model is to minimize the higher costs of fixed data center infrastructure and maximize on-demand, low-cost variable infrastructure. Ideally, processing tasks can move fluidly between different physical locations, as demand requires. However, this puts new demands on the network to respond to these large shifts in the flows of data.

Alcatel-Lucent Enterprise provides a blueprint for ITS traffic operations center network evolution that offers low latency, high density and sustainable design options for the data center. Our innovative data center switching fabric can form a mesh network that enables a range of innovative data center deployment models. These include dedicated virtual data centers, multi-site private clouds or a hybrid cloud environment. In all cases, the network provides the automation, security and QoS required to deliver high quality, agility and reduced costs.

AN ITS NETWORK THAT'S READY TO ROLL

There is more excitement every day about the intersection of digital technologies and vehicles. Transportation authorities worldwide recognize the cost to their economies of inefficient road systems and traffic congestion, while the public demands greater safety and convenience. New applications are emerging, vehicles are become increasingly smart and on-board systems are re-defining the user interface. Governments are formulating new policies and standards for vehicle-to-vehicle and autonomous vehicles applications.

To those managing transportation systems, it is an exciting and challenging time. There are new skills to learn, staff to hire and suppliers to on-board. And budgets aren't getting any bigger. Technologies are changing so quickly that specifying what you need based on today's specifications means that by the time it is installed it will likely be insufficient for the job.

Alcatel-Lucent Enterprise has a range of solutions for deploying networks that will support ITS applications: from network management and data center solutions to our core and edge switches and — the key product for ITS environments — the hardened Gigabit Ethernet OmniSwitch 6865. We build our solutions on open standards and interfaces, like IP/Ethernet, so that we are interoperable with other vendors' equipment and you are ready to handle tomorrow's applications. We support both PoE and HPoE so that you can reduce your cabling requirements. Our network systems are highly automated and designed to minimize the intervention of technical staff, while achieving

high availability, sub-second recovery from failures and integrated security. Network analytics provides assurance that mission-critical applications have the network resources they require, while our comprehensive management system provides end-to-end visibility and facilitates troubleshooting.

All of this adds up to network solutions that leave more room in your capital and operating budgets for the many other important investments you will need to make in equipment, training, testing and deployment of your ITS infrastructure, with the security of knowing that it is a system you can grow on in the exciting years ahead.

ALCATEL-LUCENT ENTERPRISE ITS SOLUTION SUMMARY

Challenge	Solution
Environment-hardened Ethernet access for roadside cabinets	The OmniSwitch 6865 Gigabit Ethernet LAN Switch is environmentally hardened to withstand a broad range of temperatures (-40 to +167°F or -40 to 75°C), electrical fluctuations (90 – 260 VAC and 20 – 60 VDC), as well as vibrations, electromagnetic fields and high humidity – all in a space-efficient half-rack design. It supports Shortest Path Bridging (SPB-M) for bridging and routed services and has the port density to support multiple devices and new applications as they emerge.
Evolve existing networks to handle video and new applications supporting IoT from access to the core	Alcatel-Lucent OmniSwitch 6860E Stackable LAN Switch for the network edge (e.g., fiber huts). The OmniSwitch 6900 for aggregation and the OmniSwitch 9900 family for the core. Supports up to10 Gbps access/40 Gbps uplinks, with full, low latency, wireline performance.
Reduced cabling requirements	Power over Ethernet (PoE) and High Power over Ethernet (HPoE) is available on the OS6865 powering roadside devices up to 75W.
Plug and play installation of networked roadside devices	Award-winning Intelligent Fabric (iFab) technology
Ensure network can adapt to shifts in application use and scale to meet extraordinary demand	Application-Fluent network technology allows for network resources to be re-allocated to meet changing demands in real time.
Improve network resilience	SPB-M supports faster convergence times and improves efficiency by allowing traffic to load share across all paths of a mesh network. Redundant power supply units (PSUs). Virtual Chassis ISSU
Automate deployment	iFab, SPB-M and remote configuration download
Ensure interoperability	IP/Ethernet with iFab and compliance with industry-standards
Manage and secure the network	OmniVista 2500 and CodeGuardian

Alcatel·Lucent Enterprise