BUILDING BLOCKS

Although ITS systems receive the praise for making highways more efficient and safer, **Leanne Keeble** investigates the foundations of this success – industrial communications networks

Illustration by Magictorch

Unreliable and lengthy journeys take valuable time out of every day, with implications of cost to businesses and individuals. Worldwide, billions of liters of fuel are burned by drivers just sitting in traffic jams. ITS networks provide one of the primary enablers for reducing congestion, not only speeding up average journey times but also making travel more reliable generally. But a primary consideration is that any network solutions should be cost-effective and offer the flexibility to evolve as traffic management requirements develop.

DISTRIBUTING DATA

According to David Moss, business development manager at GarrettCom, effective ITS networks depend upon the edge portion of the network, which links the specific data-gathering equipment (telephones, video cameras, etc) with the backbone of the network, which subsequently links the equipment back to the traffic operations center. "The bandwidth and capacity requirements of modern ITS deployments mean that the traditionally used network technologies are no longer up to the job," he explains. "So in terms of the cost of new technologies, not only must the cost of equipment such as video cameras be considered, but also the cost of the networks that will distribute the video data."

As far as Moss is concerned, industrial Ethernet ticks all of the boxes – a cost-effective network technology that is compatible with the latest breeds of traffic management equipment, which benefits from high bandwidth and capacity, flexible deployment, and is able to grow in line with the requirements of the application.

"It [Ethernet] provides the ideal protocol for networking VoIP (Voice over Internet Protocol) telephones, video cameras and other bandwidth-intensive devices, and for transmitting the data back to the TOC," Moss insists. "The scalable Ethernet standard encompasses a variety of bandwidths and with the unlimited bandwidth capacity of fiber-optic media promises inexpensive and relatively painless upgrade paths for systems as traffic control technology evolves."

Any effective and flexible Ethernet infrastructure depends on high-quality infrastructure products, such as switches and routers. So, the latest hardened Ethernet switch products from companies including GarrettCom provide connectivity for cameras, telephones and other Ethernet-enabled control devices, and combine this with fiber-optic connectivity to the control network. Moss adds, "Redundant network technologies such as rings and meshes are also supported to give the network the highest degree of resilience."

For intersection monitoring, a number of cameras can be simply connected into the network via a single switch, with ample Ethernet ports left over to daisy-chain with other intersections, or to provide the flexibility for ongoing development as requirements change over time. "The latest development," Moss reveals, "is the wider availability of Power over Ethernet (PoE), with the switch supplying power to the

connected devices and so eliminating the need for costly cabling of the device back to a central power source."

Modern Ethernet infrastructure devices need to step up to the mark in traffic monitoring and control applications by being specially hardened for challenging outdoor environments. Here, Moss has no concerns. "Our switches are rated for wide-ranging ambient temperatures, are NEBS-compliant for vibration, shock and altitude, and can be conformally coated on request for added protection against moisture, humidity and even chemical attack."

SMART THINKING

But the ability to upgrade systems easily is an especially important point, and something the City of Sacramento, California was recently thankful for. "Many cities in the USA and around the world are installing a new generation of IP-based traffic cameras and controllers to improve road safety," explains Charles Clawson from Actelis Networks. "They are waking up to the fact that they can easily and economically deploy new IP services over their existing copper-based networks, which is making their cities safer, more efficient, and greener."

Often, as in Sacramento, systems installed during the 1990s needed upgrading to provide more sophisticated monitoring and control capabilities, but this has placed much more of a burden on the voice-grade, time division multiplexing (TDM)-based network than it could handle. "In many cases," Clawson continues, "relatively slow legacy communications links are now being replaced with Carrier Ethernet solutions that are running over the same copper networks deployed decades ago."

Sacramento had been managing well with dial-up modem links operating at speeds as low as 1,200 baud for managing traffic signals. New traffic cameras, though, require more bandwidth and reliability. "They had deployed a limited number of fiber-optic networks in the ground that were capable of providing high-bandwidth connections straight away, but only to cameras and other devices that lie close to the network's core." IP cameras near the fiber ring were initially connected, although only at the start, as Sacramento needed the capability to deploy more cameras throughout the entire city.

Ryan Bellici is a telecommunications engineer for Sacramento. "Copper cabling was already widely deployed and provided far more extensive coverage than fiber," he says. "We have 50-80 miles of fiber in the ground, but many hundreds of miles of copper." The challenge was turning this copper asset into a medium capable of supporting high-bandwidth telecommunications. "Keeping operating expenditure to a minimum, we needed a solution capable of complementing our fiber network while upgrading the existing copper infrastructure into a next-generation network that could support existing and emerging applications, which we could also deploy over the new fiber network."

Various options were evaluated before selecting a field-proven Ethernet access solution for copper infrastructures, based on the IEEE's EFM (Ethernet in the First Mile) standard 2BASE-TL, and which uses G.HDSL DSL modem technology. Unlike residential DSL products, the Actelis ML portfolio of Ethernet Access Devices (EAD) offers symmetrical DSL bandwidth at bit rates up to 100Mbps, exploiting the company's EFM*plus* technology. In doing so, this mitigates the effects of crosstalk interference between wires.

But what does this all mean for the average Joe on the streets of Sacramento? "The city's new IP-based cameras are already making a big difference to citizens in the area," Clawson suggests. "If a signal fails, technicians at the city's TOC are now notified much faster, making repairs quicker and more cost-effective."

> "They are waking up to the fact that they can easily and economically deploy new IP services over their existing copper-based networks"

Demand for high bandwidth along with fiber cabling has resulted in the emergence of Ethernet as the protocol of choice for traffic control

Ethernet in practice

GarrettCom Europe had a hand in the congestion-busting M42 motorway pilot scheme, in which hard shoulders were opened in peak hours and VSLs implemented to reduce jams. It was also intended to increase safety by using video data, and to offer enhanced driver information about traffic flow, journey times and accidents.

GarrettCom's industrial Ethernet switches were used to network the cameras, while S-Ring redundancy software provided high standards in fault-tolerance. The result of the trial was an improvement in journey times by 27%, fuel consumption reduced by 4%, and vehicle emissions down by up to 10%. The trial also saw the personal injury accident rate fall from 5.2 to 1.5 a month on that particular stretch of motorway.

Ethernet networks as part of an ITS strategy can also play a key role in boosting safety and speeding up arrival times for emergency services. This can be critical in tunnel accidents, and a European campaign over the past five years has forced tunnel safety to the top of the agendum as a key motoring issue, impacting not only personal safety (where tunnel fires across Europe have killed more than 90 people in the past 10 years), but also the transport infrastructure of whole countries.

Recent years have seen a host of companies and universities active in ITS research and development projects associated with tunnel safety focusing on innovative components and integrated systems. Much of this work is already coming to fruition in both new tunnel projects and in reconstruction projects on existing tunnels. One example is the installation of a new VoIP (voice over

internet protocol) emergency telephone network, installed by Italian system integrator, Fort Fibre Ottiche, using VoIP phones from Teleindustria in conjunction with hardened Ethernet switches from GarrettCom Europe.

The hardened switches selected ensure the highest degree of operational reliability, while the ruggedness of the network itself is further enhanced through the use of GarrettCom's S-Ring technology, which delivers high-speed fault detection and correction.

"The systems are going to be invisible to the public," admits Shad Bennett, head of Engineering and Operations in Sacramento. "It's all about efficiency and detection. Technicians can now tune the timing of the signals in response to changing conditions to optimize flow and minimize traffic congestion. These monitoring and control capabilities are also attracting interest from other agencies within the district."

The opportunity to optimize traffic flow is crucial, as congestion in the Californian city – the home of Governor Arnold Schwarzenegger – has grown enormously over the course of the past decade. But the Actelis Traffic/ITS solution is resulting in decreased time on the road and reduced jams, which is subsequently helping to reduce the city's carbon footprint, as cars and buses are not idling for so long. In fact, the concept is catching on, and plans such as this are being implemented in cities including New York and London, where cameras originally installed to enforce toll roads, speed limits, and lane restrictions may soon be available to police real-time traffic monitoring with ALPR for use in tracking suspect vehicles.

NEW KID ON THE BLOCK

Although a new name in ITS, many of the people behind ComNet are old faces with years of experience in the ITS networks market, having previously been with the GE-owned International Fiber Systems (IFS). "What we provide is the unseen aspect of devices such as traffic lights, surveillance, video detection, ETC and VMS – the medium that connects them," explains Rob Gallagher, vice president, Engineering, at the Connecticut-based ComNet. Gallagher and his colleagues – one of whom is ›

United lines

Tyco Electronics Wireless Systems' Barry Einsig suggests to *Traffic Technology International* that the continued unification of communications systems is essential

You don't have to delve too far into the history books to appreciate the need for a unified approach to communications: Hurricane Katrina, August 29, 2005. Of the failings noted following the devastation, a lack of real-time and accurate traffic information was highlighted, with poor communication in particular singled out for criticism.

Those people involved in evacuation management often cite the need for better communication and coordination between emergency management, transportation, law enforcement agencies and the general public. Since Katrina, several US states have been working to combine emergency management personnel into single facilities and to establish coordinated evacuation policies. Barry Einsig from Tyco Electronics Wireless Systems believes this is a trend that it is set to continue in the USA. "A handful of states have already integrated traffic management and emergency response operations," he says. "But we are definitely moving toward common operational theaters and communications protocols. Just being in the same facility, able to talk face-to-face, able to respond to incidents quickly – as opposed to being in disparate facilities – will have a major impact."

Tyco Electronics Wireless Systems has a great deal of experience in the field. Among the contracts most fresh for Einsig to recall is the Pennsylvania Turnpike Commission (PTC), which recently opted for the company's VIDA (Voice, Interoperability, Data, Access) Broadband communication network. This allows the transmission of real-time video to the PTC's TOC in Harrisburg, and monitors roadway conditions, construction projects, as well as weather conditions that might adversely affect the 185 million vehicles that travel the 545-mile Turnpike every year.

The remote wireless video system is housed in a standalone, self-contained unit. When traffic reduces to 20mph, it alerts the Harrisburg TOC, at which the appropriate response is adjudged. Each unit is also connected to an adjacent traffic alert sign that notifies drivers of road and traffic conditions.

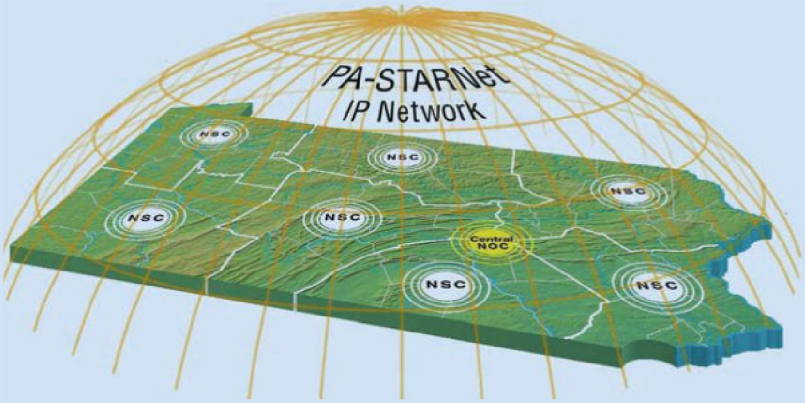
In addition to VIDA, the company provides the Commonwealth of Pennsylvania with its statewide public safety radio network, PA-STARnet. The PA-STARnet network is designed for 95% mobile coverage over Pennsylvania's 45,000 square miles and 67 counties, and employs Tyco Electronics' OpenSky system to

THE CABLE GUYS

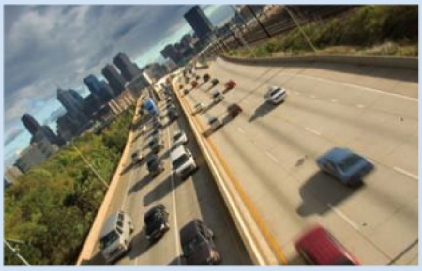
Ethernet has become a firm favorite in roadside communications over the past few years as a result of its interconnectivity. In fact, virtually every equipment supplier makes products with an Ethernet port as the preferred choice of connection. "The real benefit of using an Ethernet infrastructure is not that it can transport IP traffic, as many people believe, but that it can transport IP traffic as well as any other protocol that pops out of the generic RJ-45 port," explains Westermo UK's Alan Bollard, managing director – referring to its capability to allow many protocols to run simultaneously over the same cable. "This means a single network can handle CCTV, roadside VoIP phones, information displays, traffic management systems, and any other piece of equipment that may need to be temporarily mounted on the roadside."

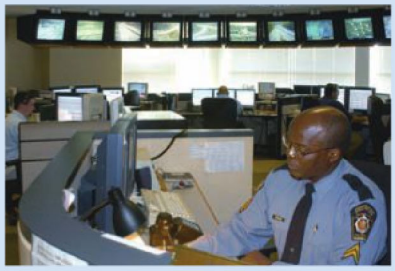
New ITS cameras can now send high-quality pictures using Ethernet as the medium

But several questions arise due to the fact that all of these technologies are running on the same network. For instance, will there be enough bandwidth? How resilient is this now critical network? And how can you tell if it is in danger of overloading? Having been used in many diverse industries for a number of years, such questions have fortunately already been answered. "Bandwidth management is handled by



Pennsylvania's statewide public safety radio network, PA-STARNet, uses Tyco Electronics' OpenSky system to provide state agencies with clear, reliable speech transmission





provide state agencies with clear and reliable speech transmission. "OpenSky data networks are based on Cellular Digital Packet Data (CDPD) protocols and packet-switching technology, which offer CDPD-like services on private radio channels." Mobile applications are provided with end-to-end TCP/IP connectivity, in doing so simplifying application-to-network integration.

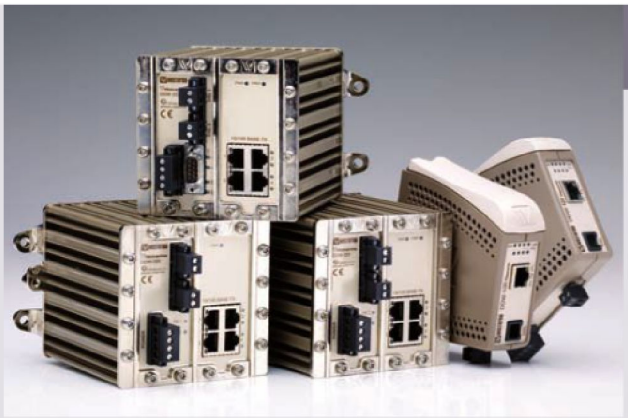
"Our goal is always to create shared networks to be more cost-effective," Einsig explains. "In Pennsylvania there's fiber, there's microwave backhaul, OpenSky technology and now our Beta Broadband technology deployed within the state to create a shared-use network for public safety, transportation and turnpike entities. That's a real value because you have a common operational procedure, a common network, and a common communications protocol back at the core, so it's much easier to share data between the systems. Such systems are definitely part of the route forward."

For agencies considering upgrading their existing communications systems, Einsig advises them to look at their entire community and ecosystem and develop shared-use networks in order to create that "common operational theater", which should also be the most cost-effective network theater. "Regardless of the size of the area to be covered, most agencies have multiple communications technologies – wired and wireless – so being able to create and administer one common network is the most efficient and cost-effective for an authority, whether it's a state, a county, or even a turnpike authority.

"We are all looking to create not only single authority-wide networks but also regional networks, so that you can have both regional networks for private use in large metropolitan areas to ease congestion, as well as the national networks that would be provided by the carriers. If you were to look at a Washington and Baltimore regional network for privatization, for instance, that covers three or four states, it covers common operational networks where there's traffic management and multiple modes of traffic, whether it's freight, transit or highway systems that all need a common operational theater. For me, that's where we need to get to: the Integrated Corridor Management-type concept in those bigger regions."

methods such as VLANs, prioritization, head-of-line blocking prevention, and IGMP snooping," Bollard explains. "VLANs effectively provide channel separation and can be used to ensure certain data is only available to certain parts of the network, thereby providing both security and the chance to optimize performance for particular devices."

Prioritization can be used to enable particular time-critical protocols to jump the queue upon arrival at an Ethernet switch to ensure that the quality of a CCTV image or voicecall, for instance, are of sufficient level. "IGMP snooping," Bollard adds, "is a special technique that can be used to control multicast data – the type often created by CCTV – in a switched Ethernet network."



Westermo's Wolverine Ethernet SHDSL extender line can provide data rates up to 5.7Mbps

The management of the network can be handled simply by using SNMP (Simple Network Management Protocol), which provides a mechanism to look at details such as new devices being added to the network, how much data traffic is present, and also when the network has to reconfigure as a result of a media failure. All of this can be handled from single or multiple management stations.

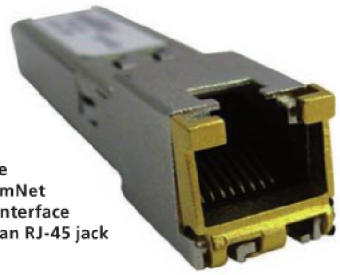
"Network resilience is also critical if all of your data traffic is relying on just one network," Bollard states. Again, Ethernet has many standard solutions. STP (Spanning Tree Protocol) and RSTP (Rapid Spanning Tree Protocol) are standards that allow networks to reconfigure automatically within 0.5 seconds. When safety dictates a faster reconfiguration, then specialist protocols such as Westermo's FRNT can be used to provide ring recovery in 20ms for networks up to 200 switches. (20ms reconfiguration means only a slight flicker on a high-resolution CCTV image.)

One obstacle that Ethernet faces is its transmission range over copper cable. "Ethernet standards dictate that 100m of UTP cable is the maximum

George Lichtblau (interviewed in the January 2009 issue of *Traffic Technology International* magazine, *p61*) – have been working with fiber-optic transmission since before ITS came into prominence. "Over the years, fiber-optic transmission has become one of the best available solutions to link field devices to the TMC in order to monitor and manage the flow of traffic," Gallagher says. "Point-to-point and other relatively simple network topologies used to be the norm, and utilized low-speed serial data and baseband analog video over optical fiber. In time, though, the use of digitally encoded video replaced the previous generation of FM video transmission products, the technical benefits and advantages of which are now well known and widely accepted."

Right now, Gallagher feels we're in the middle of a convergence of IT and ITS. Although fiber-optic transmission is still the medium of choice, he says that Ethernet is the preferred method for implementing ITS-specific communications networks – and this is reflected in ComNet's expanding portfolio. The company has recently introduced a new Ethernet line that utilizes modules known as Small Form-Factor Pluggable Devices (SFPs) as optical interfaces for its line of managed and unmanaged switches and media converters, about which Gallagher reveals more. "SFPs are devices that convert electrical signals to optical and vice versa, small modules that allow a user to select – on a port basis for an SFP-enabled Ethernet network component – the type and performance of connectivity.

"These devices evolved into a standard from an earlier small outline soldered-in component to the field-installable and replaceable devices used today," Gallagher explains. A cooperative agreement or Multi-Source Agreement for Small Form Factor Pluggable Devices was created so that manufacturers and users could specify an SFP and produce or receive a product that is universally understood from an electrical and mechanical standpoint.



The ComNet copper interface SFP has an RJ-45 jack

Available in electrical or optical output, different fiber connector types (SC, LC), numbers of optical fibers required (two or one), distance (up to 120km) and speed (100Mbps FX or 1,000Mbps FX), this offers system designers an incredible amount of flexibility in designing their network. "The main advantage of using SFPs is that the devices, whether they're managed switches, unmanaged switches or media converters, can be custom-configured to the application. That is, SFPs of differing performance characteristics can be interchanged within the same device. For example, if you are using a managed switch, such as our CNGE3FE7MS as an aggregation point, it has three configurable SFP gigabit optical ports. By using different SFP modules, you can optically link to two other devices that can be located at different distances, have different optical connector types, or require the use of one or two fibers. The built-in flexibility of devices that use SFP devices can offer users large savings in the purchase of transmission equipment by not having a distance limitation common to non-SFP (fixed-optic) devices."

In layman's terms, the SFPs are small transceiver modules that slide into an Ethernet network element. Although there are other devices that utilize SFPs, they are traditionally used in Ethernet devices. A locking mechanism holds the SFP in place and they are also hot-swappable, meaning they can be installed or removed in a unit that has power applied. "The advantage here is that they are field-installable and replaceable," Gallagher says.

SFP-enabled devices provide a great cross-section of choices to meet the network interconnect requirements for an Ethernet network design. The selection process is the same as for any optical network where the optical link needs to be evaluated to determine the correct transmitter and receiver choice. However, with a greater choice of SFP solutions, the cost can be kept to a minimum by selecting a suitable device while not having to pay for additional 'dB's' that are not being used. As an added benefit, SFP devices can be installed in the field, which allows additional links to be added to an existing network as future requirements dictate and not as an upfront cost. ■

MORE ONLINE

For further exclusive detail from Rob Gallagher on ComNet's SFP devices, log on to www.traffictechnologytoday.com

distance," Bollard says. "After that, the solution is fiber-optic cable. Although data rates of 1Gbps are possible over the fiber cable, it can be prohibitively expensive to install." Bollard's solution is the company's Wolverine SHDSL extenders. "SHDSL technology can provide data rates up to 5.7Mbps along many kilometers of ordinary telecoms-grade cable, which is often already installed," he says. Westermo's Wolverine extenders are effectively transparent to the Ethernet traffic so can be installed easily and used like a normal Ethernet switch. "The SHDSL ports can be connected over great distances and the DDW-200 series products are fully manageable using SNMP." Redundant rings can also be supported to ensure network resilience.

Westermo supplied equipment for the A14 highway, which was used to control message signs

One recent application that required Ethernet to be used on the roadside was on the A14 highway, linking the Paris central business district of La Défense with Orgeval. "The highway is mainly underground and the total tunnel length is more than 13km," Bollard details. "There are eight tunnels in total, and at each tunnel entrance a message sign and road barrier system is designed to stop the traffic in the case of an emergency."

A central redundant fiber network was built with Lynx Ethernet switches to provide a backbone for a number of DDW-221 SHDSL subnetworks, responsible for controlling the message signs.

By using Westermo's DDW-221, the cost of the installation was kept down as copper cables could be used, whereas fiber would have been the only other alternative. "The use of the Westermo FRNT redundancy protocol also ensured that the network was able to maintain operation, even in the event of a cable break or power failure to part of the network.

"The engineering company, SDEL, and the end customer were delighted with the solution that we provided," Bollard says.