WHITE PAPER

Take Today, Add Tomorrow

Turning existing infrastructure into a conduit of Intelligent Transportation Systems

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Abstract

Combining Intelligent Transportation Systems (ITS) with the Internet of Things (IoT) offers a solution to the challenges of modern traffic management, promising greater safety, better efficiency, reduced emissions, and happier road users. Simply put, future transport requires smarter roads—not more or bigger roads. In the face of tightening budgets, however, how can transportation administrators achieve these goals? The answer is literally under their feet: by making clever use of their existing infrastructure resources, such as legacy copper wiring, huge improvements are possible at a relatively low cost, while saving time, avoiding wastage, and winning support from road users.

Transforming roads with technology

With the world undergoing the largest wave of urbanization in history, traffic is one of the major challenges cities and municipalities across the globe have to tackle to ensure productive and healthy environments. Obstacles in their road map to smarter traffic management are traffic jams, coupled with increased air pollution and the huge economic costs of lost hours and fuel consumption, road accidents, road rage, etc. Consequently, authorities are continuously turning to new technologies as investments in smart traffic management.

The promise of better information: the IoT in ITS

For traffic authorities, providing accurate and timely information to motorists and mass transit agencies via network-based technologies is the step in the right direction to address the aforementioned problems. The benefits of this approach are legion. Information concerning traffic, road, and weather conditions can enable easy, efficient, and comprehensive remote management and adjustment, helping control center staff to see the big picture and keep traffic running smoothly across their entire network.

If these goals can be achieved, safer road travel and faster incident response are additional and most welcome outcomes. These are not farfetched outcomes, as the IoT in ITS holds such promise that eradicating serious accidents is now a plausible target.

The expected payoff for investment in new technology, for example, to make intersections safer, comes in the form of lives saved, injuries and stress avoided, as well as lower fuel expenditure and a reduction in wasted time—alleviating the common symptoms of inefficient traffic systems.

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Informed navigation not only enables drivers to avoid congestion, but also to steer clear of specified routes in case of emergencies, such as road accidents or chemical spills. Better access to information also allows more proactive road maintenance, which saves money for local governments and helps keep all transportation running smoothly (1).

By developing and implementing intelligent traffic signal control systems, we can also help control air pollution by reducing idling and harmful emissions caused by all types of transportation (2).

IP-based networks are the foundation of a smarter road system

To achieve greater safety, efficiency, and environmental protection, transport authorities need to construct a system that encourages a cooperative approach to road usage and features a reliable, real-time response system, with many subsystems, including traffic signal control. Still, before intelligent communication, signaling, and CCTV systems can be added to road intersections, a suitable basic network infrastructure needs to be in place.

Most legacy traffic data networks rely on proprietary serial-based communications technology, which is slow, inflexible, and completely inadequate for the demands of high-bandwidth real-time systems, such as digital video. The trend is to upgrade networks (or replace them) with open IP-based technology. IP-based networks use widely-accepted standards and promise a future-proof upgrade path.

In summary, the IoT makes it possible to add intelligent communication, signaling, and CCTV systems to intersections, which can benefit motorists in many ways. These benefits include reduced delays, safer travel, more efficient use of fossil fuels, and reduced air pollution.

Maximizing the benefits of IoT to upgrade road intersections requires an authority or its agency to “modify its network connectivity models and prepare for a massive increase in real-time information,” in the words of Lopez Research (3). In many cases, however, traffic authorities or their agencies have a limited budget and face time constraints.

Hence, this paper’s focus is to offer a solution that helps customers to capitalize on IoT technology and reliable IP-based networks to build smarter road intersections within sensible cost limits, while delivering high quality—doing this all within a restricted timeframe. It’s a challenging proposition, but as we’ve already discussed, the benefits are substantial: fewer traffic delays, improved safety, more efficient use of fossil fuels, and reduced air pollution.

ITS intersection systems: an overview

ITS intersection systems generally include traffic lights, roadside radars and sensors, video surveillance digital signage, and information subsystems.

In the past—and even today—most of these intersection subsystems have been implemented and operated somewhat independently and with less cooperation between them than is desirable. In the worst case, different subsystems may sometimes offer distracting or conflicting information that confuses road users. A truly intelligent intersection traffic control system includes similar subsystems to those used in the past, but the difference is that they are organized to work together in a much more efficient manner. The subsystems cooperate with each other instead of working independently.

The ideal intersection ITS controls the right-of-way for all vehicles arriving at the intersection, regulating when and how vehicles or pedestrians move through the intersection, with signaling and timely information (4). This reduces traffic delays and conflicts that tend to cause accidents—in short, smart traffic management makes intersections safer.

The most common application is signal coordination (or signal timing). In order to achieve optimum traffic flow, traffic signals must be monitored and adjusted to handle changing traffic patterns. Traffic engineers collect detailed information about traffic patterns, traffic volume, speeds, and other factors. Once this data is analyzed, new timing plans can be developed, and field adjustments are implemented as required (5).

Implementation challenges

In most cases, intersection infrastructure falls under the remit of a city-level administration. This infrastructure is mainly designed, managed, and budgeted by local transportation departments and similar divisions. Inevitably, they must deal with tight budgetary constraints. Yet, at the same time, they are compelled to upgrade their systems to meet the requirements of increasingly tough traffic conditions. Today's transportation departments are expected to control and manage the whole system more efficiently. For example, they will need to fully utilize modern technologies such as IP CCTV for real-time monitoring of traffic conditions in order to have a better understanding of their entire road network.

For example, more than 75% of US traffic signal control systems are in need of retiming or upgrading, according to the Institute of Transportation Engineers. This is a mammoth task, as there are more than 300,000 traffic signals in the country. Upgrading, though, is not an easy job. Apart from tight budgets, challenges (from legal and geographic constraints) and the uncertain outcomes of the upgrades make this a complex task (6).

Engineers in the field need to handle a wide variety of devices for different subsystems, considering the complexity of the systems and the need to coordinate them all. They have limited time to install and integrate—or even replace—these devices. Therefore, reducing the complexity of the installation will make work significantly easier, and it is a worthy goal. One promising approach is finding ways to reduce the amount of construction required, with the aim of saving money and reducing the complexity of the task for engineers.

Solution: fiber, wireless, or DSL?

As we discussed earlier, tried-and-tested IP-based networks are the best solution for such applications. Still, decisions need to be made. Basic communications infrastructures for IP-based networks can take many forms, for instance, copper wire (RJ45 Ethernet), fiber, or even wireless transmission. Considering the special challenges of road applications that we have already considered, we can see that copper wire (RJ45) is not a cost-effective solution due to its maximum range of only 100 meters between devices. Fiber has a much better range, but it is not very cost-effective because implementation and maintenance are expensive. Wireless can be useful in some situations, but it may not be a good choice overall due to the inevitable presence of unpredictable signal-blocking obstacles, both moving and stationary, within intersections.

	Transmission Distance	Total Cost of Ownership	Construction Time
Fiber	Up to several kilometers	High	Long
RJ45 Copper (Ethernet)	Up to 100 meters	Medium	Medium
Wireless LAN (802.11/WiFi)	Up to 500 meters	Medium	Medium
Wireless WAN (Cellular)	More than 1 kilometer	High	Medium
2-Wire Copper (Ethernet over Copper via DSL)	Up to 8 kilometers	Low	Short

Table: Solution Comparison (Note: applicable only to 2-wire copper cabling)

No need to pay for a new infrastructure

Fortunately, in most cases, the decision is much simpler because a basic infrastructure already exists. Miles of telephone-grade copper wire are already installed underground for telegram or telecom communication systems as well as for old-fashioned serial-based traffic signal control systems. Although the wires' extents and capabilities vary, the fact that they are already there is a huge advantage.

It's always easier to repurpose these existing wires instead of installing new ones, particularly as few transportation budgets are healthy enough to support the cost of overhauling the entire communication system and installing new copper wire or fiber.

The question is: How can we most effectively reuse these telephone-grade copper wires to enable IP-based networks and ensure fast and reliable data transmission? If we can achieve this, the cost and time savings can be immense, compared to the installation of an expensive new infrastructure.

This is where the concept of Ethernet over copper wire (EoC) comes to the rescue. Thanks to Digital Subscriber Line (DSL) technology, we can now leverage the telephone-grade copper wires, which are already in place and paid for, and use them to set up an IP-based network. Even old and very basic systems may be usable because only two simple wires are required for DSL. Most importantly, the maximum 100-meter point-to-point distance limitation of RJ45 Ethernet copper connections no longer applies. Instead, a range measured in kilometers is achievable between devices.

What is DSL and why should we use it for ITS?

Digital Subscriber Line (DSL) is a technology for providing high-speed data communications over multi-kilometer distances on a simple pair of wires twisted together (7). Moxa DSL whitepapers, available here on Moxa's website, provide further information.

DSL can offer tremendous cost advantages over alternative communications technologies. Laying new wires in urban streets is expensive. Costs are often measured in the millions of dollars, even for comparatively simple projects (8).

In the US, transport authorities in Alexandria, Virginia, needed a new control system to better support nineteen existing signalized intersections along approximately 5.5 kilometers of road. They found that the most cost-effective solution was to use DSL over the existing twisted copper-wire signaling infrastructure, which was in good condition. Replacing copper wire with fiber was too costly.

During the upgrade, existing cable splices were modified to remove bridge taps, which can degrade communications quality. This work further improved the capabilities of the old infrastructure to meet the needs of new technology (9).

Further advantages of adopting Ethernet over copper via DSL

The advantages of Ethernet over copper via DSL are numerous (10):

- Uses the existing infrastructure
- Much cheaper than new fiber, in most cases
- First step in a scalable ITS
- Can complement fiber and wireless
- IP-based links have wider support and are future-proof
- Ethernet promotes real-time remote management
- Ethernet reduces maintenance costs
- Can be very easy to deploy—may even be installed and operational in one day (11)

Time pressure may be a factor

When Arlington County, Virginia, wanted its local Traffic Operations Center to have control and CCTV video links to critical traffic intersections, they simply did not have time to upgrade the communications network to support the new hardware (12).

Although Arlington County does have a fiber network, and the Comcast fiber network was also considered, these were not adequate to support the whole CCTV project because of their limited coverage area as well as integration and maintenance issues. Arlington eventually chose DSL and routed the signals over the wires of its existing traffic system's communications network, but they kept their options open to integrate more of the fiber network in the future. As this example illustrates, some ITS infrastructure alternatives may have issues related to geographic coverage or other problems.

Best practices, hardware, and services

Best practices have already been established by companies experienced in the field, such as Moxa (13). For practical examples and related products, please see the brief overview and links on the web page here.

Here is a basic outline of the process to follow when determining whether Ethernet over copper wire (EoC) is an option for your roads:

1. Engage an expert ITS communication and network consultant to evaluate the existing copper wire and to define the planned future usage.
2. The consultant performs an in-depth review to analyze the city's long-term bandwidth needs and priorities.
3. The consultant provides input into planning the system and determines the hardware required.

This thorough review process ensures the network will be fast and reliable enough to handle the projected network data—taking into account not only traffic signals and other existing infrastructures, but also IP cameras and other new subsystems that may be installed now or in the future.

Moxa's wide range of products and services helps illustrate the types of solutions that make smart transport systems possible. We will briefly introduce these in the following section.

Products designed for ITS

Moxa makes a comprehensive range of products, addressing all the networking needs of ITS builders, including industrial Ethernet switches, industrial video networking products, NPort device servers, and wireless devices. Moxa's IEX-402 Managed DSL Ethernet extenders seamlessly connect to Ethernet devices and networks, extending their range from tens of meters up to several kilometers by carrying the Ethernet data over a DSL link.

Consulting services

The Moxa Professional Industrial Network Service (PiNS) consultancy offers a global team of senior engineering staff with the professional experience and passion to tailor industrial network products for your transport network. They offer precise and clear plans that optimize customers' networks and provide industry-proven reliability.

Experience: successful ITS cases

Case study: Secure traffic signal control and CCTV in a major city in California

This project created an intersection-secured traffic signal control and CCTV monitoring system along a key harbor corridor in a major California city. Moxa devices were used extensively. The system uses existing copper wires to carry data over several kilometers with DSL technology, as well as fiber and wireless links. Intersection controllers and video feeds were connected to the county-wide Internet, with VPN connections and firewall protection to prevent attacks and protect data. In many situations, DSL, fiber, and wireless solutions can complement each other when used together, as this case demonstrates.

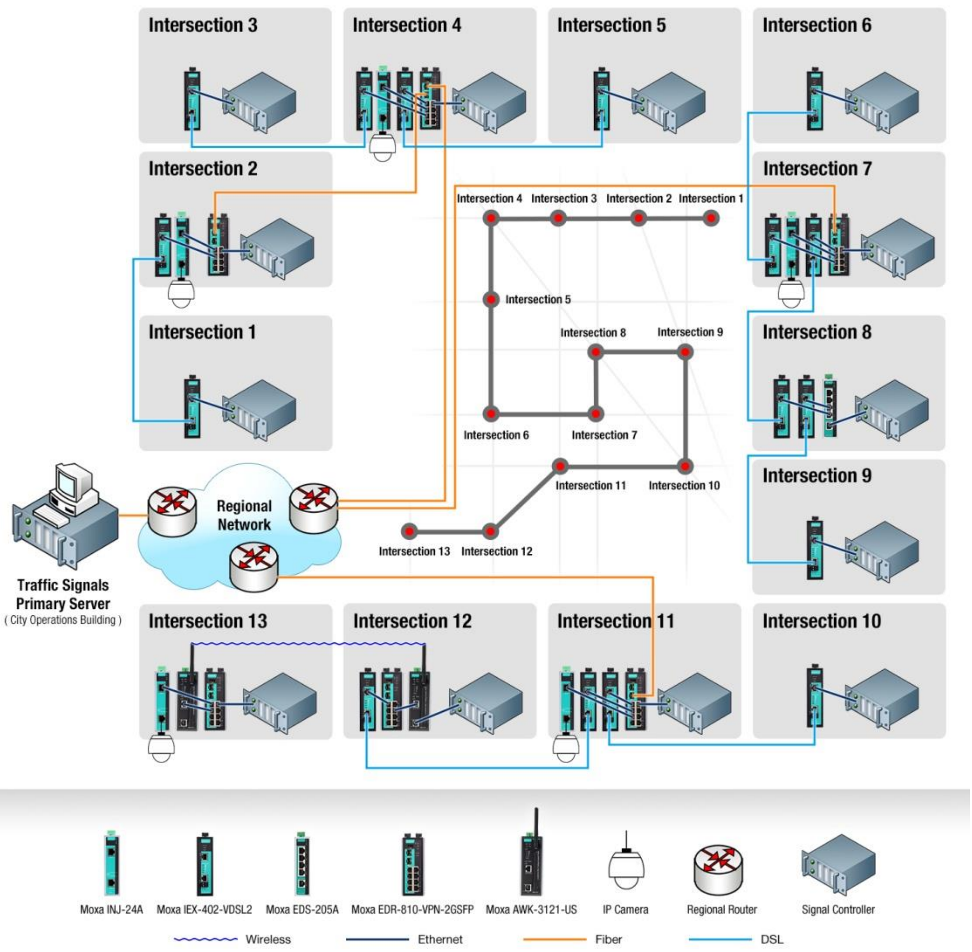

Figure - Secure traffic signal control and CCTV in a major California City

More information about the products mentioned is available on Moxa's website at:

- IEX-402-SHDSL series: http://www.moxa.com/product/IEX-402-SHDSL_Series.htm
- IEX-402-VDSL2 series: http://www.moxa.com/product/IEX-402-VDSL2_Series.htm

Read Moxa's Case Study: *Re-using existing copper wiring for intersection traffic signals and CCTV* for more information: http://www.moxa.com/application/existing_copper_US.htm

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