

# **ETHERNET-BASED COMMUNICATIONS FOR THE TRANSPORTATION INDUSTRY**

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Telecommunications networks are ubiquitous in today's world, connecting computers, MP3 players, Personal Digital Assistants (PDAs), phones and televisions. Almost every person depends on networks in some way for data, video and voice telecommunications. Networking has become so commonplace in our everyday lives that we hardly ever contemplate the behind-the-scenes technology involved when we open our Outlook e-mail or access [www.cowyite.org](http://www.cowyite.org) to download the monthly newsletter. The use of networks has become an important element of transportation systems with the interconnection of field devices and the active management provided by traffic management centers. This paper gives a brief look at Ethernet communications and its application to the transportation industry.

## **What is Ethernet?**

Ethernet is a family of technology and software standards used to communicate over local area networks (LAN) and wide area networks (WAN). Ethernet is an electrical connection between devices that makes use of rapidly changing voltages (between 0 and 5 volts) to indicate 1's and 0's that are commonly used in the binary system. Using these fluctuating voltages, a stream of data passes along information between devices. For example, the transmission of traffic signal timing information between the signal and the central signal system. Ethernet can travel over copper, fiber, or through the air as radio waves.

## **How does Ethernet Work?**

Devices connected via Ethernet communicate in short messages called packets, which are variably-sized chunks of information (formatted as frames defined by Ethernet standards). Data is transmitted in between a source and its destination and then reassembled upon arrival. Each source and destination device within the network has an Internet Protocol (IP) address. The term "protocol" refers to a set of rules that govern communications. Think of it as a language. The devices must "speak" the same language in order to communicate. The purpose of the IP address is similar to your home address; it is unique for each device within the network to ensure data gets to where it is going. Note that the data packets contain both the source and destination IP addresses to ensure data is passed to and from the intended devices.

IP addresses are organized in the form AAA.BBB.CCC.DDD. For example, to visit the ITE website you can either type in [www.ite.org](http://www.ite.org) or type in the IP address 216.12.138.80, the address of the computer that serves the website. Of course, the name of the website is easier to remember than the IP address, so names

have become the popular method. The “AAA” and “BBB” denotes the “Class A” and “Class B” portions of the IP address that indicate the network and subnetwork, respectively. The second half of the IP address, the “CCC” and “DDD” portions of the IP address, denote the “Class C” portion of the IP address and identifies the node and device addresses, respectively.

Packets are broadcast on the local area network and all connected devices will “hear” the transmission, but devices will only accept packets that contain their IP address as the destination. The destination device (which could be a traffic signal) acknowledges the receipt of the data from the source (which could be the traffic signal system) by sending a packet back to the source IP address.

A simple analogy to help understand this process is the US Postal Service. Let’s say you were working on a large traffic study and were mailing out sections of the report as they are completed. The recipient would receive the report sections and combine them into the whole report based on the sequence of the section numbers. The report sections arrive only to the intended recipient because you used the correct mailing address, and the recipient knew you sent them because you included your return address. The recipient would use your return address to send you a postcard to let you know that he received the document.

### **How did Ethernet evolve in the transportation industry?**

The Ethernet standard has grown to include many new technologies as computer networking evolved. In the past, the transmission of data between devices was limited by the length of the cable (because the electrical signal attenuates over distance) and the speed in which the data can be transmitted. The advent of fiber optic cabling, coupled with new high-powered, high-speed routers and switches along with better optical transmission systems, allows data to be transmitted at greater speeds over much longer distances. Now distances are measured in miles instead of feet. Also, wireless technologies allow for high-speed Ethernet-based data transmission without the need for expensive underground infrastructure. These advancements in technology lend themselves to our profession where traffic networks span across a region or the state and are often considerable distances from the local “traffic shop”. Furthermore, today’s transportation systems are nothing more than computers (much like that sitting on your desk at work), which can all be interconnected with an Ethernet-based LAN.

This situation has forged new relationships between the transportation and information technology (IT) departments. Computers are already integrated into our daily work and we rely upon IT personnel to handle our computer problems. Plus, since Ethernet-based devices use IP addresses, which are regulated by your agency’s IT personnel, transportation and IT departments need to coordinate to maintain the LAN and other system functions.

## Why Ethernet?

There are several reasons transportation professionals are looking to Ethernet-based local area networks to connect to traffic field devices such as:

- Bandwidth efficiency;
- Standardization and resource sharing; and,
- Reduce reliance on telecommunications service providers.

Note that the driving factor in each case is to seek cost efficiencies over existing communications.

**Bandwidth Efficiency** Many agencies have been installing fiber optic cabling, which is an expensive, finite resource. Fiber strands can quickly be used up with transceivers dedicated to each individual device type. For example, each analog CCTV camera typically requires a single, dedicated strand of fiber while traffic signals and other field devices require additional fibers. By using an Ethernet LAN, all communications becomes digital allowing each field device to use less bandwidth and allows all device types to utilize the same transport thus freeing up fiber capacity, delaying the need to install more fiber.

**Standardization and Resource Sharing** Standardization is another advantage of using Ethernet-based local area networks and internet protocol. Other departments within agencies, such as school districts and police, may already have infrastructure in place that may support the requirements of the transportation department (and vice versa). The cost savings of “piggybacking” onto an existing network can be tremendous. Resource sharing opportunities are not limited to single agencies. The Metrowide Fiber Network is an example of multiple agency resource sharing.

Use of internet protocol opens the existing internet infrastructure as another potential communications path especially for remote traffic devices. For example, IP-based equipment can allow for the remote configuration of devices through your web browser. Remote access can also include Ethernet-based intersection detection. Intersection “snap shots” can also be viewed over through your web browser and even over the internet.

**Reduce Reliance on Telecommunications Service Providers** Many agencies find that leased-lines and phone drops are convenient methods to connect remote devices and, in some cases, agencies have all communications provided by a third-party. The cost for this service can sometimes represent a significant portion of the annual budget of some agencies. Of course, there is a trade off to consider between the cost of the service and the cost to support in-house talent and materials to maintain an agency-owned communications infrastructure. As mentioned above existing infrastructure already owned by the agency or use of

wireless LAN may present opportunities to reduce an agencies reliance on telecommunications service providers.

### **What is the future of Ethernet?**

There are several agencies in Colorado that are already deploying Ethernet-based communication solutions and many more are planning deployments in the near future. Agencies such as Aurora, Boulder, Englewood, Littleton, and Loveland are already using Ethernet technology to connect with traffic devices.

As for the future of the technology, there are two major advances being made.

First, a new IEEE standard, 802.3af, provides for the standardization of electrical power over Ethernet. Power over Ethernet (PoE) allows you to power devices using Ethernet cabling either at end-span (Ethernet switch with embedded PoE technology) or mid-span (specialized patch panel devices). Sometimes this eliminates the need for a specific power drop for devices connect by the LAN.

The other major technological innovation is the increased speed. Current reports indicate that the industry is migrating towards 100 Gigabits per second (Gbps) instead of 40 Gbps. The fastest current speed is 10 Gbps. To give you a perspective, the first Ethernet application moved data at 2.94 Megabits per second (Mbps).

Applications in our industry are growing rapidly as more and more products are being hardened for use in outdoor environments that can withstand the temperature ranges in Colorado. Also, other communications companies are seeing the shift and making their equipment Ethernet-compatible. For example, Spread Spectrum radio manufacturers are making hybrid Ethernet-to-wireless solutions.

As more and more Ethernet-based products become available in the traffic industry and our comfort level with the new technology increases, the future for this form of communication looks promising.