Traffic Management Centers for the Extreme Do-It-Yourselfer

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Abstract: As congestion increases in urban/suburban areas, so does the need for relief. Technological advances have made Traffic Management Centers (TMCs) into powerful solutions. However a common perception is that they are complex, expensive and large undertakings best suited for major metropolitan areas. This is not necessarily true. Given the availability of advanced, off-the-shelf components, a respectable, reasonably priced TMC capable of communicating with dozens of traffic signals can be created for the cost of one or two standard traffic signal installations. The key is performing as much work as possible utilizing in-house staff.

The City of Orange, a medium-sized California city with 148 traffic signals, has implemented a very capable and low cost TMC, through liberal staff effort, taking advantage of the latest technological breakthroughs in fiber optics, spread spectrum radio links, cellular modems, CCTV and other advanced communications technology. In many cases, existing copper wire interconnects or their conduits were reused for much more robust and advanced communication technologies. This required additional training of traffic signal staff to deal with areas such as fiber optic maintenance, and Ethernet systems, but the response has been enthusiastic. Based upon Orange's experience, costs are presented for implementation of a basic low-cost TMC and associated field communications links, as well as "lessons learned" during the "do-it-yourself" process.

Introduction

The City of Orange, located in Southern California, is a typical mid-sized city with a population of about 140,000. Orange has 148, 820A model traffic signals, of which about a hundred were run under the control of an older Multisonics VMS-330 traffic signal control system. This system, while quite advanced for its time, clearly was showing signs of age, and lacked the capabilities available with modern software-based traffic control systems.

Several years ago the decision was made to upgrade the system to something more contemporary and create a Traffic Management Center (TMC). In order to get the most mileage from the limited funds available, it was decided that City staff would attempt to take on as much of the system design work and installation as possible. For a group with no experience in this area other than VMS-330 operation, this was a formidable task, or so it appeared at the time. However that staff was already doing much of the signal maintenance for the city, so the "hands on" capabilities were already in place.

Fundamental to any city considering a TMC, the first issue is what sort of software is to be used in the TMC. Traffic management software can run from a few thousand dollars to as much as $100,000 for a TMC installation. The software selection should not only be driven by cost, but also consider what sort of existing signal controllers are in place and which controllers might be used in the future. Each city will be different in this regard. Orange selected the "iVMS" (now known as "i2") package by Siemens Information Systems. This software had the ability to not only interface with the City's existing 820A controllers (in a

read-only mode), it also supported a variety of other signal controllers as well as providing CCTV camera control. This offered the City a great deal of flexibility and avoided locking the system into one specific brand of signal controller.

That said, Orange decided to standardize new controllers to Econolite ASC/2 units. These had some similarities in operation to the existing 820A units, so staff adaptation and training would be minimal. Also the Econolite headquarters is located only a few miles north of Orange, so service issues or technical questions could be dealt with quickly and in-person, if desired.

Communications System Selection

The next consideration Orange had involved the type of communications system that would be implemented between the TMC and the field signal controllers. This is another very fundamental question and typically comprises the bulk of the cost of any traffic management system. It can be divided into two sub-areas, the type of communications and method of delivery.

The City considered two types of communications methodologies, serial and Internet Protocol (IP). The latter is also known as "Ethernet". For many years the standard communication mode for field traffic signals has been serial. While serial has proven to be reliable, IP communications has shown much more flexibility as well as scalability. That is, it works well for larger number of traffic signals.

Many people are familiar with serial communications as "Com ports" on personal computers. For a serial system with 10 signals, the computer would assign a specific Com port to that signal, say Com 1 through 10. However things start to get unwieldy when the number of signals, and thus Com ports, increase to large numbers. The computer sees each Com port as a dedicated path to a specific signal and must keep track of them.

IP communications works differently. Each signal controller, when first set up, is assigned a specific IP address. These are unique 12 digit numbers that identify the signal controller to the system. For example, 192.123.123.123 might be an IP address assigned to a specific controller. The communications system doesn't care where the signal controller is physically located, as long as it has the IP address, the TMC computer can communicate with a specific field controller.

In the past, Ethernet hardware suitably hardened for use in environments such as signal cabinets was quite expensive. However that has now changed, and very robust Ethernet switches and hardware may be purchased at reasonable prices. Further, basic Ethernet networks are quite easy to set up and maintain. Many people have already done so in their homes by setting up wireless WiFi networks. The same principles scale up to larger systems involving traffic signals. The ubiquitousness of Ethernet systems is also a bonus in that an agency's computer support staff can provide advice and assistance, as it is a system they are quite familiar with. Since the pricing for the two different types of communications was comparable, Orange chose to proceed with an IP communications system because of its flexibility.

There are several ways to create a communications link between a TMC and signals in the field. In a somewhat subjective ranking in terms of cost and reliability they are fiber optic, direct copper, radio links, leased T1 lines and cellular data modems.

Fiber optic cabling provides the highest bandwidth. This is the "gold standard" of communications links and is priced accordingly. It's not so much the cost of the fiber optic cable (it's only a dollar or two per foot, comparable to copper cable), it's the price of placing the conduit in the ground. Orange was able to have an initial 3.1 miles of single mode fiber installed at a cost of $38 per foot. Costs in the range of $50+ per foot are now more typical. Orange is using fiber as a "backbone" for its system, to be supplemented by other communications means. Currently another 12 miles of fiber optic line is under installation, with perhaps a final 6 miles at some future date.

Obviously, due to the technical complexities of installing fiber optic, this generally isn't for the do-it-yourselfer. However if field signal interconnect conduit is available, it is possible to obtain suitable fiber optic cable, and use staff or the signal maintenance contractor to pull the fiber though the existing conduit. The joining of connectors to the ends of the raw cable can be hired out to a contractor, or staff can be taught the techniques, if feeling adventuresome. An Ethernet modem is required at each end (or at intervals, if signals are daisy chained), and they typically cost between $700 and $1,600, depending upon performance.

The next communications technology to consider is use of existing copper cabling. Since many cities already have copper signal interconnect in place, this is an attractive alternative. At first this appears dubious, as Cat 5 cable, the basis for Ethernet communications, is only rated to reliability communicate over cable lengths of less than 100 meters. So how can one communicate with traffic signals several miles away?

The answer is via the use of what are generically called "Ethernet extenders". These are devices placed at each end of a length of twisted pair copper cable (up to several miles long), which convert an Ethernet data to a format which may be sent over long distances, then re-converts the data back to Ethernet at the far end. There is a reduction in bandwidth, but most traffic signal controllers do not require large amounts of bandwidth.

Pricing is reasonable, ranging from $600 to $900 per end, depending upon capabilities. Patton Electronics, Inc., has been a leading manufacturer of these types of devices. While Orange is not presently utilizing these devices, we are exploring them. They are nicely suited for do-it-yourself work as the necessary copper cable infrastructure is usually already in place, and the devices require little, if any, setup.

Radio links are a newer technology, very much suited for do-it-yourselfers. The technical term for these devices are "Ethernet bridge radios", and they typically utilize a spread spectrum signal in the 900 MHz, 2.4 GHz or 5.8 GHz frequency bands. They do not require FCC licensing and can attain ranges of 10 miles or more, as long as a clear line-of-sight is available. One base radio, presumably at the TMC, can service a number of "slaves" simultaneously. They are potentially subject to radio interference, and since they operate at microwave frequencies, are susceptible to signal blockage by vegetation. Also their bandwidth is limited perhaps 100 Kbps to 200 Kbps. While acceptable for most signal controller communication, their low bandwidth makes them less than desirable for video applications.

Their chief advantage is cost. The radios themselves vary between $1,500 and $2,000, so an installed base unit (with antenna and cabling) could be less than $3,000. Once a base unit is operational, traffic signals can be added to the system as slaves for $2,000 or less, each, especially if the relatively simple work is performed by staff.

Leased T1 lines can be a useful solution for the right situation. The local telephone company can provide these as links between the TMC and a field location. Leased T1 lines may be most economical when used to connect a remote local network of traffic signals back to the TMC. Since a T1 line provides a bandwidth of 1.5 Mbps, it has enough capacity for a number of signals or for limited video too. Orange is able to obtain T1 lines from the local provider for about $160 per month. If one T1 line is spread over several signals, the cost per signal is reasonable. Although the T1 line is setup by the local provider, they are most certainly do-it-yourselfer items, as one merely has to plug in a standard Cat 5 Ethernet cable at each end and things are up and running. Orange is presently in the process of implementing several leased T1 lines.

The last communication technology to consider is cellular modems. This is a new technology which utilizes an area's cellular phone system to transmit data point to point. For a field installation, the signal controller is plugged into cellular modem (costing between $500 and $1,000), and a similar modem placed in the TMC. Monthly cellular charges can range from $15 to $60, depending upon the cell provider, the cellular plan and/or data throughput. The bandwidth will not be as great as with a T1 line, but adequate for a single signal controller. These have potential for use in areas with isolated signals, not suitable for line-of-sight radio links. They have a unique advantage in that they can easily be relocated by staff to other signals, if desired. Orange has not yet utilized this communications method.

TMC hardware and displays:

The next item to consider is the TMC itself, including the computer hardware needed to run the system. Most traffic management center software these days runs under the Windows operating system, so any brand of quality workstation and server should be adequate. For the computer hardware and backup systems, costs could easily be kept below $10,000 for a small to medium city. The City of Orange TMC hardware rack is shown in Figure 1, to the right of the City's existing VMS-330 system. The racks and components were installed by City staff.

A potential budget-breaker is the TMC itself. Many people have images of large screens, multiple monitors and control consoles as their idea of a TMC. A "Mission Control" room is ingrained in many of us. Also, some cities use a modern TMC as a display of their commitment towards traffic management. Unfortunately, this can be a very expensive proposition and can easily get out of hand, resulting in your elected officials not only questioning the project, but perhaps your sanity as well.

However there are low-cost options to a Mission Control-style TMC. I'll use the City of Orange as an example. Figure 2 depicts the City of Orange TMC. The TMC is located at the City's Public Works yard about 3 miles from City Hall. Note the 90" rear projection center screen, and the 6 LCD monitors. Toward the left is an Evans brand control console. The room was designed by a local architect and constructed by a local contractor. A systems integrator was hired to install the console and all the video display components. Considerable staff time was involved in coordinating the various efforts. The total cost for the room and equipment shown was approximately $126,000.

Figure 1. Orange TMC hardware rack.

Figure 2. Welcome to Mission Control - $126,000 for TMC room.

Because the TMC was not physically at City Hall, a remote workstation was necessary there so that City Hall staff could access the system. This dual-screen remote workstation is shown in Figure 3. The monitor on the left displays selected CCTV video feeds, while the monitor on the right displays the system map and data on individual signals. The CPU is hidden in the credenza. Despite its modest appearance, it is the functional equivalent of the much more elaborate TMC. Everything the TMC can do, so can the remote workstation. However the cost of the remote workstation was only about $2,200. The addition of a $2,000 LCD projector would give it the capability of projecting a large-scale image of the signal system status on an adjacent wall, thus rivaling that in the main TMC.

Figure 3. $2,200 for TMC Equivalent Workstation.

One topic not yet mentioned is closed circuit TV (CCTV) cameras. Most traffic management centers rely on at least a few CCTV cameras to provide real-time displays of field conditions. CCTV cameras are harder to accommodate than traffic signals as their video feeds typically require considerable bandwidth. While there are some solutions which can use existing copper wiring to route CCTV signals to a TMC, the preferred method is fiber optic lines. In the case of Orange, the bulk of the City's planned 28 cameras will be on a fiber optic line. However Orange also utilizes a fairly low-cost alternative means, quite suitable for the do-it-yourselfer.

Where an adequate line of sight exists between a desired camera location and the Orange TMC, wireless CCTV cameras have been installed. The units used by Orange consist of a Cohu iDome PTZ camera, coupled to a Verint (formally called "SmartSight") transmitter/receiver pair. This wireless link operates at 5.8 GHz and has a range of many miles. Orange has several links in excess of four miles. The video and pan/tilt/zoom commands are sent over the same radio link. Each radio, one at each end of the link, is about the size of a brick. The video feed, while not as clear as a fiber optic link, is more than adequate to monitor traffic conditions. In display quality it appears as about the equivalent to a VHS tape played on super long play. The last time the City acquired any of these units, pricing was less than $4,000 for the pair needed for one video link. Coupled with a $3,000 CCTV camera, an operational wireless video link can be achieved for less than $8,000 using staff to do the relatively easy installation.

In use, staff has been quickly able to install the units, and relocate if necessary. An interesting opportunity has presented itself several times as developments comprised of tall buildings have come in for development approval by the City. As part of their traffic mitigations, the building owners agree to allow the placement of a wireless CCTV

installation at their rooftop, which feeds video back to the TMC. The building owners also agree to provide and pay for the electricity needed by the camera (although this is less than $5 per month). Staff fabricates these wireless CCTV platforms, bolts them to the parapet wall on the building's roof, and connects the power. This provides a valuable location from which to monitor multiple intersections. Figure 4 shows one of the City's wireless rooftop installations on top an 18 story structure. The dome camera is visible on the right and the flat plate atop the vertical pole is the 5.8 GHz antenna pointing back to the TMC four miles away. Including the receiving unit back at the TMC, the total cost to fabricate and install this unit was approximately $7,000.

Figure 4. Wireless CCTV installation.

As a summarizing point of reference, the City of Orange spent approximately $262,000 to get the initial implementation of our TMC operating. The "hardware" part of the TMC totaled approximately $161,000. This included:

- TMC room remodel (design and construction) $7k + $29k
- TMC control console $10k
- Two computer workstations, a laptop and system server $10k
- Video display wall with 90" central screen and six 20" monitors $80k
- Two CCTV cameras with wireless video links $13k
- One CCTV camera with fiber link $6k
- Communications racks, video switch and support hardware $6k

Software and technical support was provided by Siemens Information Systems, which consisted of advising the City as to what hardware to acquire and installation of their software. This added an additional $101,000 to the cost. Thus the total price for the initial implementation of the Orange TMC was the aforementioned $262,000. If the City had

chosen not to create a dedicated TMC room with video wall, and implemented only a more modest workstation approach, a functional TMC could have been created for only $140,000.

Since initial implementation of the TMC, the software has been upgraded to a much higher level of capability, as well a new server added. This has added another $60,000 to the cost, still very reasonable.

Conclusions

While construction and implementation of a TMC may seem a daunting task, it is not as difficult as might be imagined. Part of the process of doing so provides valuable training for the staff, which pays back in the day to day maintenance of the TMC. Understanding the system helps immensely in keeping it running. It also has the added advantage of saving considerable money, perhaps enough to make the difference between having or not having a TMC.

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