Final report of ITS Center project: I-81 Video Systems

A Research Project Report

For the Center for ITS Implementation Research

A U.S. DOT University Transportation Center

I-81 VIDEO SYSTEM DESIGN AND IMPLEMENTATION

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Summary of Project

The goal of this project was to install several Internet-based traffic monitoring cameras along the Interstate corridor in the Northern Shenandoah Valley to provide video images to the Virginia Department of Transportation (VDOT) and to the traveling public via the 511 web page. One objective was to develop partnerships with public institutions along the I-81 Corridor in order to utilize existing Network Virginia Internet Connections. Cameras would be located as closely to the Interstate as possible, and wireless Internet communications would be used to transmit the camera image from the roadside to the Network Virginia Internet backdrop. Another objective of the project was to develop partnerships with Shentel Telecommunications in order to locate cameras on its infrastructure; however the project funding ended before these locations could be pursued.

Summary of Accomplishments

Two cameras were completely installed and are currently in operation providing VDOT with live streaming video and the public with still pictures updated to the 511 web page. A third camera was installed; however, the networking required to access the camera image has not been completed due to conflict with the networking subcontractor at the site location. VDOT is currently finalizing the networking of this camera to bring it online.

Figure 1. 511virginia.org web page.

Design Process

Analysis of existing infrastructure. There were no existing cameras in place along I-81. The infrastructure we were looking for included State owned facilities alongside I-81. The previously discussed sights were chosen to be the most viable locations in terms of network availability, proximity to I-81, and willingness of the owners to participate.

Afton Mountain had an existing analog camera on the mountain. The analog signal was transmitted over a proprieatary link to the school where the signal was input into a digital video server connected to the Internet. The analog transmission of video was suceptible to weather fading and our fully digital system replaced the analog transmission that was in place.

Designing a new system. Network Virginia is one of the largest fiber optic Internet networks in Virginia. It is composed of public agencies of state and local governments. Our initial site surveys focused on locating camera sites in close vicinity to Network Virginia locations. By sharing a Network Virginia Internet connection, VDOT would save the cost of an Internet subscription.

Finalizing locations for the cameras proved to be a difficult task. Many factors had to be considered for each location, and, unfortunately, significant time was lost pursuing sites the turned out not to be viable.

VTTI provided Rob Slocum, the ITS project manager at the VDOT Staunton District, with suggested sights for the five network cameras. Those sights included JMU, the Museum of Frontier Culture, Lord Fairfax Community College, Winchester Welcome Center, and Shenandoah University.

VTTI began efforts to secure installations at these sites after they were approved by the Staunton ITS. The view of I-81 from Lord Fairfax Community College showed the entire southbound lane but only a portion of the northbound lane. Nevertheless, it was decided that this was an appropriate trade-off for getting a free Internet connection from the college. After a few months, however, Mr. Slocum felt that the view of I-81 from the college would not provide useful information to VDOT and wanted to move the camera from the college to the DMV Weigh station located a few miles north of the college on I-81. It was decided that attempts would still be made to use the college for the Internet connection but that a wireless network would be used to get from the camera to the college. There was no easy line of sight from the college to the weigh station, and at least one wireless hop would be required to get a signal from the college to the weigh station.

VTTI investigated using existing highmast lighting as a possible camera location or as a wireless relay location, while VDOT requested permission from the DMV to use the weigh station for a proposed camera location. The technical issues involved with using a highmast light pole halo for installing a camera or relay antenna were too complicated to make it worthwhile pursuing. Based on the difficulty of getting a signal from the weigh station to Lord Fairfax, VTTI dropped the location as a potential camera sight.

Similarly, the Winchester Welcome Center was approved as a proposed camera location. A high speed Internet connection was required at the welcome center to feed the camera. Verizon, the local telephone provider, said that an affordable DSL could be placed at the site. VTTI provided VDOT with the pricing rates from Verizon. Mr. Slocum arranged an agreement with Ms. Cindy Ward in VDOT tourism regarding how the monthly Internet fee would be paid. VTTI awaited a decision from VDOT for some time on whether an Internet connection could be obtained at the welcome center. When a decision was made to pursue a DSL connection, VTTI contacted Verizon to set it up. At that time, Verizon indicated that a DSL connection would not work at that location after all because the Welcome Center was too far from a central switch. The only option was a partial T-1 connection from Verizon. However, VDOT decided that the monthly cost of this option was prohibitve, so this location was dropped as a possible camera site.

VDOT also entered into discussions with Shentel Communications concerning two camera sights; however, the project funding ended before this option could be finalized. VDOT is still in discussion with Shentel to pursue these sites further.

At each potential location, VTTI designed a wireless architecture to transmit the camera signal from the roadside to the Network Virginia Connection.

Camera 1: I-64 at Afton Mountain

VDOT had an existing weather station located at the top of Afton Mountain adjacent to I-64. This location had an existing tower, power, and cabinetry. The top of the mountain is in direct line-of-sight to a water tower owned by the City of Waynesboro four miles away. Approximately 200 yards away from the water tower is a school building owned by the City of Waynesboro Community College. VTTI made arrangement with the city and the school district to use their facilities to install a wireless network from the mountaintop to the water tower and to then relay the signal down to the school building. The school has a Network Virginia Connection that the camera signal would tap into.

Unfortunately, the community college whose Internet connection VTTI was using was scheduled to be closed in May due to budget cuts. VDOT began searching for other potential public partners who could receive a wireless signal from the water tower. Luckily, another Internet connection was secured in the same building as the Waynesboro Public School District.

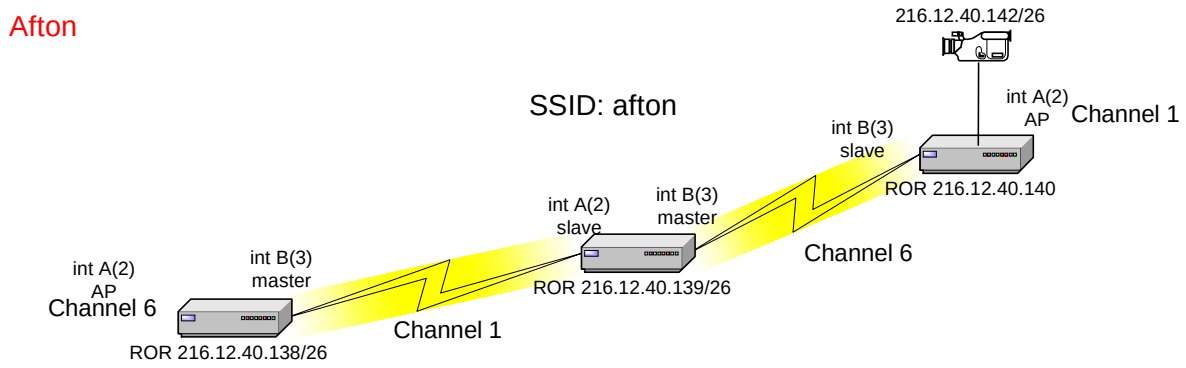

Figure 2. Afton Mountain Wireless Network.

The wireless design consisted of three wireless outdoor routers, creating a wireless backbone between the school and the mountaintop. Two user-enabled wireless access points are available at each end.

A fully digital web-based camera recently released by JVC was integrated into a domed environmental housing. It was capable of color and PTZ operation and contained an onboard web server that allowed the image to be viewed from anywhere on the Internet. The camera was mounted to the existing weather station tower and was connected into the backbone wireless network.

Figure 3. Camera at Afton Mountain.

Figure 4. 150' Water Tower owned by the City of Waynesboro.

The actual camera feed is not made available to the general public. Rather, a still picture is taken from the camera and is placed on the 511 webpage, which is located on a separate public server. In this manner, the camera is secure and the public can view a still picture of the highway.

Figure 5. Camera image from Afton Mountain.

Camera 2: Shenandoah University at Winchester, Virginia

Shenandoah University (SU) is a State institution located adjacent to I-81 in Winchester, Virginia. VTTI arranged to meet with SU's Director of Information Systems to locate a camera at their location. The camera was installed on a sign just off the right-of-way of I-81. The camera signal is transmitted wirelessly from the sign to a nearby dorm. This building houses access to SU's Network Virginia Internet connection. As with the Afton camera, the public does not have direct access to the camera. Rather, a still picture is uploaded to the public server that houses the 511 web page.

Winchester

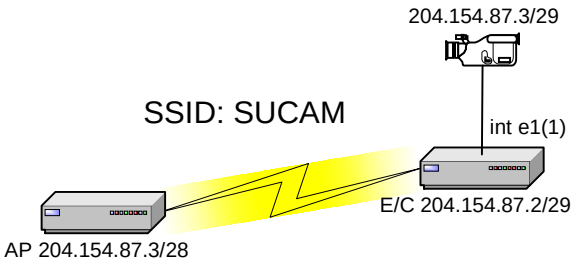

Figure 6. Winchester Wireless Architecture.

The wireless architecture for this camera is a little different from the camera on Afton Mountain. Because there is only one "hop" from the camera to the Internet Backdrop, a more economical selection of an Access point and a wireless/Ethernet client was selected. An access point is located in the dorm, and the wireless client is located at the camera.

Figure 7. Camera at SU (bottom right of sign).

Figure 8. Cabinet at SU camera.

Figure 9. Still image from SU camera.

Camera 3: Frontier Museum

The Museum of Frontier Culture in Staunton, Virginia is a state-owned facility with ties into Network Virginia. Several of the museum's buildings have views of I-81. The potential camera locations were not in as close proximity as in Winchester; however, the museum was the only viable Network Virginia facility in the area.

The architecture of the wireless system for the museum location is identical to that found in Winchester. A camera is connected to a wireless Ethernet converter that communicates to an access point that interfaces with Network Virginia.

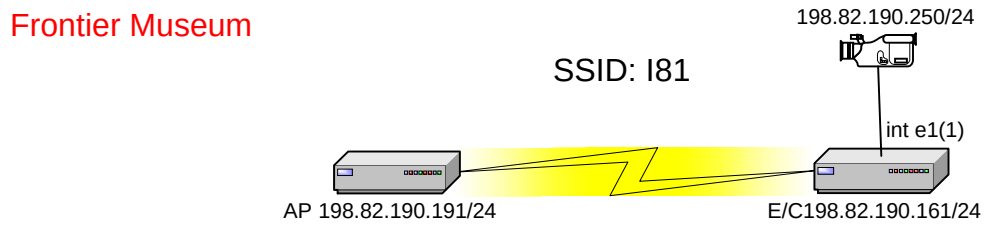

Figure 10. Frontier Museum Architecture

The camera was placed on the Interstate side of an old storage barn. The wireless equipment was placed inside the 2nd level of the barn, while the access point was placed in offices located in a renovated barn adjacent to the storage facility.

Figure 11. Camera placement at Frontier Museum.

Figure 12. Wireless equipment inside Barn.

The camera and wireless transmission equipment were successfully installed at the site; however, camera images have yet to be integrated into the museum's network to be made available on the Internet. The Museum subcontracted out the design and installation of their computer network to an outside consultant. The consultant would not allow VTTI to integrate the camera into their network without paying for their assistance. Therefore, VTTI began working with the consultant to finalize the networking of the camera. However, the project ended before VTTI was able to complete the routing of the camera image to the Internet. VDOT has been in contact with the consultant to complete the networking portion of the camera.

Equipment costs of the project

Item	QTY	Cost	Total
Cameras	5	$ 2,200	$ 11,000
wireless routers	3	$ 1,800	$ 5,400
Wireless APs	2	$ 900	$ 1,800
Wireless/Ethernet Converters	2	$ 200	$ 400
Antennas	8	$ 125	$ 1,000
Cables	8	$ 100	$ 800
Arresttors	8	$ 100	$ 800
PC cards	10	$ 75	$ 750
Misc hardware/power	1	$ 500	$ 500
Cabinets	2	$ 400	$ 800

$ 23,250

Camera specifications

Model VN-C30U
Camera Image Sensor 1/4" CCD, 3800,000 pixels
Lens Zoom Optical 15x
Focal Length (f) 4.1mm - 61.5mm
Aperture Ratio (F) F1.4
Focus Auto/Manual
Min. Object Distance 0.8m
Min. Illumination 2.5 Lux
Interface 10Base-T/100Base-TX
Alarm I/O Input x2, Output x1
Protocol UDP/IP, TCP/IP, HTTP, FTP
Picture Resolution (Pixels) 160 x 120, 320 x 240,
640 x 480
Compression MPEG1, JPEG
Frame Rate (fps)* 160 x 120 MPEG1: 30, JPEG: 15
320 x 240 MPEG1: 30, JPEG: 10
640 x 480 MPEG1: -, JPEG: 3
Position Memory 10 positions
Pan/Tilt Angle Pan +160° -160°
Tilt 0° -90°
Pan/Tilt Speed 100°/s
View Through JVC Control Software/
Web Browser**
Power Requirement DC12V 2.0A (Max.)
Dimensions (H x W x D) 166mm x 105mm x 105mm
(6-1/2" x 4-1/8" x 4-1/8")
Weight 800g (28.2 oz.)

Accessories
(optional) VN-BK20 Bracket for VN-C2U/2WU
VN-BK30 Ceiling bracket for VN-C30U
VN-BK31 Wall bracket for VN-C30U

* Frame rate varies depending on the operating environment.
** Web browser compatible with both Java-script and frame display. Netscape 4.0 or later, or Internet Explorer 4.0 or later is required.

Depending on which version of Java VM (virtual machine) is installed, it may not be possible to view moving images even with Internet Explorer version 4.0 or later

Conclusions

VTTI succesfully showed a method for using commercial off-the-shelf products to wirelessly transmit video. Sharing Network Virginia connections allowed the DOT to use existing infrastructure and to avoid recurring monthly costs. However, the tradeoffs for sharing a connection include having to settle for the camera location that may not be the most ideal and giving up control of the network connection.

The responsibility for the network connection lies with the owner and is out of the hands of the DOT. For this reason, it is probably more appropriate for the DOT to own its own Internet Backdrops in order to maintain control over the entire system rather than share an existing resource. However, for situations in which cost is a major issue, sharing available resources and using off-the-shelf products provides a fast and economical method for placing traffic monitoring cameras on the interstate.