Case Study
Phoenix, Arizona
Improving traffic flow with ITS

Background
Phoenix ranks as one of the fastest-growing cities in the nation with a population of more than 1.4 million which ranks it as the sixth largest city in the country. From 1990 through 2000 population in the Phoenix metropolitan area increased an impressive 45.3% compared to the U.S. average rate of 15%. It is the state capital of Arizona and the greater Phoenix area includes about 23 cities and towns and covers 519 square miles.

The major portion of the economic base is the service industry (43%); trade (18%); government (14%); construction (5%); financial services (8%); and manufacturing (6%). Major employers in the Phoenix metropolitan area include the State of Arizona, Wal-Mart Stores, Inc., Banner Health Systems, City of Phoenix, Wells Fargo and Company, Apollo Group, Inc., Maricopa County, Arizona State University, Bank of America, Intel Corporation, JP Morgan Chase and US Airways Group, Inc.

Phoenix’s Street Transportation Department is comprised of five divisions. Traffic Services is the division that carries responsibility for ensuring the safe movement of all types of traffic, both vehicles and pedestrians, and includes planning, implementing and managing the 1,093 traffic signals on 4,818 miles of streets located throughout the >500 square mile Phoenix area.

Customer Highlights
Challenges
– Cost effective communications network to replace costly, low bandwidth T-1 lines used for traffic signal management across 500 square miles
– Multi-use network with adequate bandwidth for traffic management, >50 traffic cameras, and additional applications
– High reliability network to enable dynamic adjustments to traffic signals as traffic conditions change

Solution
– Highly reliable broadband wireless mesh network with link-level redundancy, minimizing downtime
– Fast, easy wireless router installation and seamless association with network

Results
– Enabled complete replacement of leased lines used for traffic management saving $400K annually
– Tropos network has achieved 99.999% reliability since installation in 2010
– A highly scalable infrastructure that seamlessly supports integration of different Tropos mesh router models into a single cohesive network

Systems and Services
– Tropos mesh routers
  – 902 Tropos 7320, 6320, 5320 and 5310 outdoor wireless mesh routers
– Tropos Control wireless network management system
– Traffic management system
  – TransCore TransSuite® Advanced Traffic Management System (ATMS)
– Local system integrator
  – L4 Technologies provided Tropos products; consulting and training services during initial rollout phase

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transportation infrastructure rather than on building in order to meet public demand for a safe and efficient transportation system. As part of this effort, the FHWA requested states develop an Operations Vision and Action Plan. In response, AZTech™ began as an FHWA Intelligent Transportation Systems (ITS) Model Deployment Initiative (MDI) for the Phoenix metropolitan area in 1996. AZTech’s mission is to serve as a regional body that champions the integration of ITS and communication systems across the regional to reduce travel, time, reduce travel costs, and improve the safety of the traveling public. This body includes participants from the transportation departments in cities and towns in the Phoenix area. While each of these traffic departments operates and makes decisions autonomously on the products and technologies they use, AZtech is working towards facilitating the communication between the multiple ITS systems to improve traffic flow and safety. For example, enabling signal timing coordination and timing; development of plans for signal timing during planned and unplanned closures; and adaptive signal control coordination in specific areas.

Challenges

In 2010, the city of Phoenix's Street Transportation Department embarked on a project to reduce travel times for commuters as well as operational expenses. The project received partial funding from the Federal Highway Administration (FHWA) which included $3.6M for fiber and $4.1M for wireless communications, with the remainder coming from a bond. A key part of the project included building a private wireless IP-based communications foundation that could be used for multiple Intelligent Transportation System (ITS) applications. While the city had approximately 100 miles of fiber and used it where possible, it was not accessible at most of the locations the transportation department needed access. At the time, the transportation department utilized T-1 lines for communication to most traffic signals. Currently, approximately half of these connect to the Tropos network and are hands-off. Installers require no network knowledge or special training.

During the testing phase of our selection process, we ensured that the network was subjected to the most strenuous conditions, and the Tropos equipment passed with flying colors.*

Joel Havris
Signal Systems Specialist
Street Transportation Department
City of Phoenix

Results

The Tropos wireless mesh network was deployed in phases with initial launch in August 2010. In this first phase the network covered over 250 square miles and included 420 Tropos radios that provided communications to 412 traffic signals in the Phoenix area. The Tropos routers are mounted primarily on traffic signals with power from photocells. A small number of routers are also installed on streetlights where needed to augment signal strength. The Tropos network in Phoenix was architected by George Frangos, IT systems specialist for the City of Phoenix’s Street Transportation Department, who now oversees network support for the system. Centralized management of the network takes place in downtown Phoenix at the traffic center where ITS application are also monitored and managed.

The TransCore TranSuite ATMS, which had been in use since 1998, was the first application deployed on the mesh network as part of the initial rollout phase. This application enables traffic operators in the traffic management center located in downtown Phoenix to manage traffic signals from a centralized location. Secondly, more than 80 video cameras were installed at key intersections on traffic signals for use by the traffic department, approximately half of these connect to the Tropos Network. The video cameras provide traffic operators with the ability to see critical intersections in real time and to adjust signal timing as needed, to improve traffic flow, reducing commute times and vehicle exhaust emissions.

L4 Technologies delivered Tropos product for the project and also provided related consulting and training services to traffic department IT staff.

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*“The Tropos routers are very easy to install – I can just send someone out with a screwdriver and a node. Once installed and powered, nodes just immediately associate with the network and are hands-off. Installers require no network knowledge or special training.”

George Frangos
IT Systems Specialist
Street Transportation Department
City of Phoenix

During the pilot phase, 60 Tropos mesh routers were deployed along curved streets and under challenging conditions in order to evaluate the resiliency and reliability of the technology. L4 Technologies, a local system integrator and technology partner for the Phoenix transportation department, assisted with the pilot project deployment.

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George Frangos
IT Systems Specialist
Street Transportation Department
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Since 2010, the department has continued to extend their ITS system primarily using funds from the original bond, adding additional Tropos wireless mesh radios and video cameras with the goal of covering all metered intersections in their jurisdiction. An additional $400K in funding was obtained from an American Recovery and Reinvestment Act (ARRA) grant. As of mid-2013, the Tropos network has grown to include 902 radios (approximately 100 of these serve as gateway nodes with most of these connected to city fiber) covering more than 500
square miles. Where fiber backhaul is not accessible, the Tropos network utilizes a wireless PTP link. All T-1 leased lines have been disconnected and replaced by the Tropos network providing the Phoenix Street Transportation Department with a savings of $400K annually. In addition, the network is available for additional ITS applications in the future.

Because the network was installed over a period of years, it incorporates several models of Tropos outdoor wireless mesh routers. The Phoenix network employs Tropos 7320, 6320, 5320 and 5310 mesh routers. Interoperability between the different models is assured because all use Tropos Mesh OS as their network operating system and Tropos tests for software compatibility with each release to ensure they work together seamlessly.

Network redundancy is an integral feature of the Tropos mesh architecture and the transportation department network layout was planned accordingly to take advantage of this. If any gateway fails (typical causes include power failures, lightening, vehicles hitting and knocking over a traffic signal), wireless traffic is immediately rerouted over to an adjacent gateway in just a matter of seconds. When the failed node is repaired and rejoins the network, it automatically re-associates and traffic is routed appropriately to take advantage of the additional gateway. As a result, the Tropos network has achieved a remarkable 99.999% system uptime.

There are over 100 traffic cameras connected to the transportation department network of which half are connected wireless over the Tropos network (the remainder connect directly to fiber at traffic signals). Most of the cameras are used for traffic signal management and control; additional uses include monitoring of pedestrian signals and crosswalks and assessment of areas to determine if specific traffic department services are needed. Other City departments use the network for public safety and homeland security.

The Street Transportation Department does ongoing maintenance and support of the Tropos network.

“Tropos network has never gone down since it became operational in 2010. It’s an invaluable asset.”

George Frangos
IT Systems Specialist
Street Transportation Department
City of Phoenix

The map below shows the location of all the closed circuit cameras used by Phoenix street transportation department staff to monitor and improve traffic conditions at signalized intersections. The website can be viewed allowing live public viewing of video throughout the city. At this time, none of the video is recorded by the City.

City of Phoenix Street Transportation Department Traffic Cameras
The Phoenix Street Department continues to participate as an active member of the AZTech regional organization. Their network is connected via fiber to the Regional Community Network (RCN) to which all the regional traffic departments connect facilitating communication between the entities with the goal of improving traffic flow and safety.

AZTech published a study in 2011 that provides metrics on the improvements made within the region, some of which directly relate to improvements with use of ITS, for example:

- Bell Road travel time from 303 to 101 has decreased by 14% in east bound and 25% in west bound direction
- Club Road (city of Mesa) travel time was reduced by 3 minutes or 27% due to improved signal coordination along the corridor

**Future**

Possible future applications for the Tropos network by other facets of the City’s transportation department include:

- Digital parking meters
- Streetlight management

**Wireless Mesh as a T-1 Replacement**

Both incumbent carriers, such as AT&T and Verizon, as well as CLECs, such as EarthLink, have submitted FCC filings to discontinue their T-1 service offerings. As a result, municipalities that have relied on T-1 for connectivity with traffic signal controllers, traffic cameras and other traffic management/intelligent transportation system (ITS) devices and applications must find a replacement communication technology.

IP-based broadband wireless mesh networks are an excellent option for T-1 replacement. Wireless mesh networks are cost-effective and offer a number of benefits including:

- High reliability
- Scalability
- Performance – high throughput and low latency
- Security
- Multi-application support

For traffic management and ITS applications, wireless mesh networks are easy to deploy and eliminate the need for costly and disruptive trenching to install fiber or cables. Mesh routers can be located at intersections, with the traffic signal pole serving as the mounting asset. Traffic cameras can be co-located with the mesh routers while wired Ethernet can be used to connect to mesh routers to the nearby traffic signal controllers.

More than just a replacement, IP-based broadband wireless mesh networks offer significant advantages over T-1. Mesh networks can be engineered to deliver >10Mbps to each mesh router, a big increase over the 1.5 Mbps provided by T-1. This enables better support for video cameras (more cameras per intersection, higher resolution per camera, higher frame rate per camera) as well as support for ITS applications beyond traffic signal management. Being wireless, mesh networks also support mobile workforce and M2M applications.

The sunset of T-1 service is looming. For the next generation of ITS communication technology, municipalities should look beyond the wire.

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