White Paper

Build versus rent
Why municipal and industrial organizations should consider owning an outdoor broadband infrastructure

Municipal and industrial organizations that want to realize the significant benefits of large-scale broadband infrastructure face the option of whether to build, own and operate their own infrastructure or "rent" services from incumbent cellular providers. This paper lays out the substantial business and technical benefits associated with organizations owning the latest generation of outdoor wireless networks.

This paper discusses how a wireless infrastructure can benefit public safety, fire and EMS, and city departments such as water and building inspections. Wireless utility applications such as Advanced Metering Infrastructure (AMI) or Automated Meter Reading (AMR) are also presented. This paper also examines wireless applications for mobile workforces engaged in industrial applications, such as port operations, construction and mining.

The "own" versus "rent" or debate has a long history in computing and telecommunications. In the early days of computing (1960s and 1970s), most small and medium businesses could not afford a mainframe or minicomputer, and opted instead to purchase computing power and enterprise applications through time-share services. This model allowed smaller firms with limited resources to instead take advantage of these capabilities as services. As computing costs fell dramatically and personal computers became available, a new model emerged that allowed much smaller firms to own and operate their computing environment, and the time-share model of computing is now largely a thing of the past. A similar trajectory played out in enterprise telephony, with the centralized hosted Centrex model being supplanted in the 1980s by the PBX. Today, with capital expenditures replacing subscription fees, the IP PBX offers greater control, faster delivery of new features, cost savings, and richer feature sets.

In the context of municipal and industrial wireless networks, there are two primary technological choices: the organization can build, own and operate its own wireless network, typically utilizing unlicensed wireless frequencies at 2.4 GHz and/or 5 GHz or it can rent connectivity for its mobile workers and

applications from a cellular carrier for a monthly fee. As performance and feature-richness of "owned" broadband wireless technologies increases, and cost and complexity come down, the case for ownership versus rental becomes stronger and stronger, just as it did with telephony and computing.

Mobile application characteristics and requirements

The mobile application space has unique characteristics and requirements that benefit significantly from ownership of dedicated broadband wireless infrastructure:

- **Application diversity:** There is a broad diversity of applications that municipal and industrial operations can leverage, including AMR/AMI (Automated Meter Reading/Advanced Metering Infrastructure), automated reading of parking meters, video surveillance cameras in urban high-crime areas to deter violent crime, municipal mobile workforce automation, reduction of unscheduled outages and lost production in mining operations and mobile video including in-car video for police cars. Some of these applications such as video (mobile and fixed) present particular challenges for bandwidth-limited cellular data networks such as EV-DO. For example, currently-deployed EV-DO and HSDPA networks are incapable of supporting sustained upload speeds greater than a few hundred kbps.

- **Device diversity:** Extending applications and workflows from indoors to outdoors can present some unique challenges. Employees are accustomed to using their Wi-Fi-enabled devices in the workplace and the sheer diversity and range of these devices (including laptops, PDAs and smartphones) can present a systems integration challenge. Wi-Fi is a common denominator and open-standard for wireless technology. Wi-Fi is increasingly being embedded into all kinds of consumer electronic devices and any outdoor solution needs to accommodate this large class of devices.

- **Emerging applications and their bandwidth needs:** Emerging applications like in-car video, fixed video surveillance and rich content downloads are likely to overwhelm lower-speed cellular data networks, which were designed and optimized around delivering reliable voice communications. The existing cellular network topologies and their planned upgrade paths will have difficulty supporting the high-bandwidth uploads required by mobile video or the high capacity transport needed for surveillance applications.

- **Mobility:** Applications aimed at mobile workforce automation revolve around the concept of mobility. Traditional cellular data networks have generally performed well when delivering mobile voice capabilities. The mobile use-case for Wi-Fi has been well established since day one, necessitated by the short ranges and smaller cell sizes of Wi-Fi networks, and next-generation standards are expanding the level of support for Wi-Fi mobility.

- **Multi-use networks:** Enterprises such as municipalities increasingly want to leverage their network capital expenditures by incorporating new and varied applications across multiple user groups. For example, the police department will want to use the same network

to perform video surveillance that the public works department users utilize to monitor and report on their own systems.

— **Security and resiliency:** Data security is especially important for mission-critical applications. For example, public safety agencies that access state and federal criminal databases and local video feeds require high levels of security. These applications require strong authentication methods, access control and solid encryption protocols. Furthermore, the ability to leverage locally-licensed frequencies, such as 4.9 GHz spectrum for public safety and critical infrastructure systems, where appropriate, is important to public safety agencies. In addition, wireless systems used for mission-critical purposes need to be resilient to failures due to various causes. As an example, the wireless mesh network in New Orleans was the first to recover from the communications outages in the aftermath of Katrina and served as the lifeline for the city workers and residents while the cellular network towers stayed down[1].

Why rent when you can own?

Owning the wireless network offers many benefits, such as the following.

Flexibility and control

Ease of adding coverage where it is needed: A municipality or industrial operation is typically best positioned to understand its coverage requirements within its service area, whether it is to serve PDA-equipped mobile workers in the downtown core, utility workers in residential neighborhoods or police squad cars in the community. By owning and operating the wireless network, municipalities can ensure that good coverage exists in the areas that are important to the community and that it has the flexibility to extend coverage and bandwidth into other areas as development proceeds and new applications emerge. By contrast, cellular carriers have little direct incentive to ensure that sufficient high-quality coverage exists in areas that are important to the effective functioning of an organization's applications. Municipal ownership of the metro wireless network, for example, allows it to optimize for the public interest versus the interests of the wireless carrier's shareholders. In many areas, for example, it is unprofitable for a profit-maximizing carrier to justify a broadband rollout or upgrade, even if the municipality's need is acute.

Ease of adding capacity where it is needed: Capacity needs differ across areas of any deployment. The downtown core needs more capacity, as do high-crime areas covered by video surveillance systems. By contrast, AMI infrastructure in residential neighborhoods doesn't require as much capacity. With the ability to provision additional capacity where it is needed, the organizations can make efficient investment decisions and ensure that their applications have the needed bandwidth and performance.

Ease of adding capacity when it is needed: Capacity needs also vary over time, especially as new applications are provisioned onto the network. By controlling the network infrastructure, municipalities and industrial operations can exercise control over the infrastructure decisions related to adding new applications to the network. For example, a network can start out as a meter-reading infrastructure that requires low network capacity. As video is added in to the network as an application, it becomes necessary to provision in more

capacity to accommodate the additional bandwidth needs. Having control over when and where to make these infrastructure and capacity expansion investments can be critical to the success of bringing these new applications online.

Ease of adding new devices, applications and users: An open-standard Wi-Fi network makes it easy to bring new applications, devices and users online. Wi-Fi is embedded into most of the consumer electronic devices appearing today, making it straightforward to admit many new classes of devices onto the network. These devices enable and support a host of applications including AMI, automated parking meters, video cameras, laptops, PDAs and handsets. With cellular offerings, the organizations are limited to using devices provided and/or approved by the provider.

Control over upgrading to newer technologies: Wireless technology continues to evolve over time. Since 1997, Wi-Fi technology has improved at a rapid clip: speeds have increased from 10 Mbps to over 100 Mbps (802.11b -> 802.11g -> 802.11n), quality of service has been improved (802.11e), mobility enhancements have been made to the standard (802.11r), and the manageability (802.11k) and security have been significantly improved (802.11i, 802.11r). By owning and operating the wireless network infrastructure, cities and industrial operations are able to exercise control over the technology upgrade path, determining when and what upgrades to make to the network over time, as their needs and the underlying technology evolves and improves. By contrast, upgrades to cellular networks are controlled by cellular carriers whose investment decisions tend to be driven by market economics as opposed to being tied directly to municipal needs. Conversely, cellular carriers have also been known to unpredictably obsolete technologies that municipalities have invested heavily in — remember when CDPD and GPRS went away?

Ability to set pricing, bandwidth and other access policies for consumer access: Local ownership offers municipalities the ability to use wireless broadband as a resource for economic development. By owning the network, municipalities may add in paid or free consumer access, with the flexibility to set pricing plans and simultaneously to control how much bandwidth to allocate for these consumer services versus their own application requirements.
Greater control over bandwidth, website access and security policies for city workers: Network ownership gives cities the control and flexibility to set bandwidth and access policies for their workers. Wi-Fi networks act like extensions of the LAN and the network administrator can implement and extend LAN usage and security policies to the outdoor wireless network. For example, the city IT department is able to exercise control over which web sites employees can access. The operator can also ensure that security policies such as authentication and encryption requirements are seamless extensions of the same security policies that govern how employees connect to the Internet through the LAN.

Ability to set terms of use: By owning the network, organizations can set their own terms of use and control which applications are allowed to run over the network. By contrast, in cellular networks the carrier imposes its own terms of use that the organization does not have influence over. Carriers typically impose limits on how much data can be transferred per user per month, even on “unlimited” data plans, and may apply rate-limiting policies on applications or users that exceed those limits, thereby adversely affecting the performance

of applications. As another example, cellular networks may explicitly disallow certain classes of applications, such as VoIP, Skype, or other peer-to-peer applications that municipalities may want to use. By providing an alternative communications infrastructure, the organization has full control and flexibility over the use of the network and can, if they choose to do so, include protections that ensure network neutrality.

Greater resiliency

Prioritized access for mission-critical applications: Municipal and industrial operations need to ensure that their mission-critical applications receive the highest priority relative to all the other applications running over the wireless network. For example, on a municipal multi-use network accommodating both consumer access and public safety access, the municipality would want to be able to ensure that public safety traffic is prioritized higher than public access traffic. The ability to maintain prioritized access for critical applications becomes especially important in emergency situations. In the event of a disaster, the public safety agency would want to be able to temporarily disable public access traffic in the interest of reserving all the available bandwidth for first responders and relief workers. If the organization doesn't actually own and control the network, this kind of prioritized access is impossible.

Resilient and fault-tolerant network architecture: Casual applications and users, such as consumer Internet users, tend to be more tolerant of network failures and outages. For mission-critical applications, the overall network architecture needs to be highly fault-tolerant and resilient to failures at every level. Cities and industrial enterprises have the ability to engineer redundancy into their networks by deploying ring topologies at the backhaul layer and deploying mesh architectures at the access layer. These topologies are highly resistant to failures and capable of re-routing in real time in response to localized outages. This level of control over the engineering of resiliency into the network can only be achieved when an operation owns and controls the network. Furthermore, mesh architectures provide a much greater degree of resiliency than traditional cellular approaches due to their avoidance of single points of failure and their ability to route around failures. For example, when Hurricane Katrina hit New Orleans, it knocked out most of the communications infrastructure including cell towers as well as power lines. When power was resumed, the first system to come back up was the wireless mesh network that was being used by the city for video surveillance. When the I-35W Minneapolis bridge collapsed in 2007, clogging the cellular communication networks, the mesh network stood up and provided disaster recovery functions including camera coverage[2].

Higher capacity

Wi-Fi offers much higher capacity than cellular data systems offer. Even the most advanced cellular data network available today provides an order of magnitude less bandwidth than a Wi-Fi-based system. The disparity is even more pronounced when one considers the uplink data rates – Wi-Fi offers more symmetrical data rates on the uplink and downlink, a physical consequence of the fact that transmit power on both downlink and uplink transmissions over unlicensed band links are constrained by FCC Part 15 rules[3]. The disparities apply to peak data rates as well as to actual speeds (see Figure 1 below).

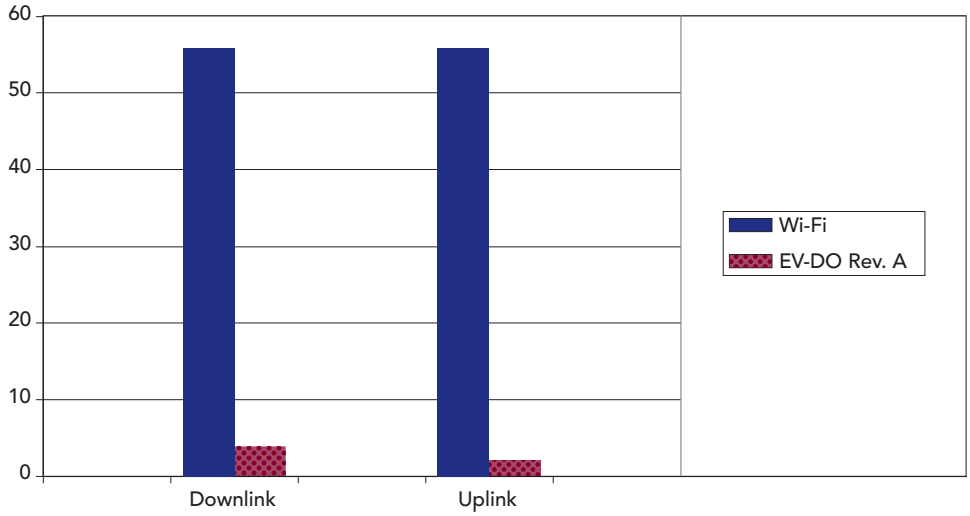

Figure 1: peak data rates: Wi-Fi vs EV-DO Rev. A

Furthermore, municipal network ownership allows cities to upgrade capacity by optimizing for the public interest, whereas, in many areas, it is unprofitable for a profit-maximizing telco to do a broadband upgrade, even if the municipality's need is acute. For example, as of March 2007, as much as 33% of the US population did not have availability to EV-DO Rev A speeds through an upgrade[4].

Lower cost

The economics of Wi-Fi: Wi-Fi is the most prevalent wireless broadband technology as measured by the number and the diversity of mobile devices that come with embedded Wi-Fi. By comparison, add-on PC cards for EV-DO or other 3G technologies tend to be much more expensive than using built-in Wi-Fi that comes included in end-user devices. This additionally implies that the cost of the network per device actually decreases with every new device added to the network. The scale economies of Wi-Fi also directly translate to lower network infrastructure costs in $/Mbps/square mile of capital expenditure . As a result, a city considering building and owning its own wireless network faces a dramatically more favorable cost structure than a cellular carrier. It can often be more economical for a municipality in an underserved area, for example, to economically build out its own metro Wi-Fi network versus waiting for the incumbent carriers to justify the cost of a wireless broadband rollout.

Control over key assets translates to lower deployment cost: Municipalities often own several key network assets, such as fiber or point-to-multipoint wireless backhaul systems. In addition, they often own access to mounting assets that are critical to deploying wireless broadband systems, such as streetlights, utility poles, water towers and city buildings. These advantages translate to reduced infrastructure provisioning cost for many cities deploying outdoor wireless networks. For these reasons, it is often faster and cheaper for a city to build out a wireless network that meets its needs than for a traditional carrier to do so.

Multi-use network

There is a very wide and diverse set of devices that are Wi-Fi-enabled today. The Wi-Fi Alliance has certified over 4000 Wi-Fi products to date. By contrast, only about 500 CDMA2000 1xEV-DO devices have been commercialized. Furthermore, Wi-Fi is the technology of choice for indoor wireless LANs. This

combination enables better multi-use networks. Devices don't need to be retrofitted with Wi-Fi capability since it is typically built-in. Users don't need to be educated about the technology since they use Wi-Fi at the workplace and at home. This combination makes Wi-Fi the ideal technology for a multi-use network.

Multi-use networks allow an operation to support a variety of applications and user groups with differing bandwidth, quality of service (QoS), security and other performance requirements over a single network. Leveraging the network CapEx and OpEx across a wide range of applications and constituents makes for an attractive return on investment (ROI). A municipality can simultaneously generate savings from increased mobile worker productivity, reduced crime, promotion of economic development, greater officer safety, faster building inspections and approvals, more accurate reading of utility meters, etc.

The multi-use advantages of Wi-Fi enable it to fulfill several of the goals of municipalities that are not likely to be adequately addressed by providers of cellular data:

— **Public safety:** Municipalities are motivated to improve the overall security of their communities. Wireless applications such as video surveillance are helping to reduce crime rates and deter violent crime. For example, New Orleans, Louisiana deployed a wireless video surveillance network that ended up delivering a 57% reduction in murders and a 30% reduction in auto-thefts . Broadband wireless networks are also improving the effectiveness of first-responders through applications such as computer-aided dispatch (CAD) and field access to state and federal criminal databases, enabling the creation of tactical mobile wireless communication networks on scene at a disaster or incident, etc. As one example, Tucson, Arizona deployed a wireless mesh network to allow emergency room surgeons to obtain live real-time feeds of voice, video and patient vital signs from the moment that patient is loaded into the ambulance, thereby improving their response effectiveness. Public safety also includes, as a goal, the improving of officer safety though measures such as on-board video cameras in police squad cars that allow dispatchers to view the scene in real-time as an officer steps out of his car.

— **Mobile workforce automation and productivity enhancements and E-government:** Municipalities are looking to improve efficiencies and enhance mobile workforce productivity through a range of applications targeted at municipal mobile workers. For example, building inspectors with wireless access throughout the city can speed the inspections and approvals process for new building construction by 80%. In a city with ubiquitous high-speed wireless access, police officers can download high-resolution mug shots and upload their reports while remaining in the field, thereby enhancing their overall productivity and improving their community's safety.

— **Economic development, digital inclusion, education and tourism:** In an increasingly competitive climate for jobs, development and housing growth, municipalities are in the forefront of promoting community economic development through education and digital inclusion initiatives. St. Cloud, Florida built and provides a free high-

speed wireless network to its residents and saves its residents hundreds of thousands of dollars a month in broadband access, money that can stay in the community and support local businesses. Amory, Mississippi offers a free high-speed wireless network to its residents enabling, among other things, improved education for their next generation of citizens who face the challenge of creating marketable skills in an increasingly competitive global job market. Municipalities also increasingly confront local and regional obstacles in their growth aspirations. This comprises competition between neighboring cities and regions, as well as competition in the job market as it extends to the retention of valued members of the municipal workforce. By offering high-speed wireless access at low or subsidized rates to their residents and employees, municipalities can make it more attractive for small and medium businesses to stay in the city and for its workforce to be more productive. Tourism is also a factor. Many cities have significant numbers of tourist visitors. By providing low-cost mobile high-speed wireless access, cities can make themselves more attractive tourist destinations while also creating new revenue sources.

These goals are not mutually exclusive – rather, in many cases they overlap. For example, improving officer safety through mobile in-car video surveillance also promotes public safety and crime reduction. Furthermore, having a single wireless network that is capable of achieving all these objectives simultaneously can have significant implications for the cost justification of owning versus renting the wireless network.

Though we haven't discussed the "managed services" or "public-private partnership" models of network ownership in detail, these goals that accrue to municipally-owned wireless networks also apply to the managed services model, provided the service provider subscribes to some of the key municipal goals and tenets such as digital inclusion and network neutrality.

Practical considerations of owning versus renting

Although there are overwhelming benefits from owning outdoor broadband infrastructure, there are several important considerations that a deployment must plan for:

- **Mounting assets:** The city or enterprise must have access to sufficient mounting locations to provide necessary coverage and capacity. Mounting is generally provided by street and signal lights, but buildings and other assets like storm warning siren poles can be used as well.

- **Backhaul capabilities:** Outdoor broadband systems require fiber or copper networks to provide backhaul at capacity injection layer access points and/or mesh gateways.

- **Design, implementation and optimization:** Systems owned by municipalities or other industrial applications are generally installed by VARs or system integrators skilled in large-scale project management.

- **Ongoing support services:** Outdoor broadband systems generally require a network operation center and, if consumer access is to be

provided, customer support and billing operations as well. Advanced mesh systems offer comprehensive network and system management applications that simplify the task of providing ongoing support.

Summary

Historically, as the cost and complexity of technology has been reduced, organizations have migrated almost exclusively to a model of owning versus renting their IT infrastructures. Control, flexibility and cost savings associated with ownership versus rental are the overriding considerations and more than offset the additional planning and skill required to build, own and operate these systems. Telephony and computing have both migrated to organizational ownership over time. The increased performance and feature set of broadband wireless, coupled with lower cost and reduced complexity, is now driving the strong case for city and enterprise ownership of these systems. Figure 2 represents a summary comparison of the benefits of owning vs. renting a wireless broadband network.

	Own	Rent
Flexibility	●	◔
Resiliency	●	◕
Capacity	●	◑
Cost	◕	◕
Multi-Use Network	●	◕

Figure 2: Comparison of the benefits of owning versus renting a wireless broadband network

References:

[1] New Orleans' Wi-Fi Network Now a Lifeline, ComputerWorld, http://www.computerworld.com/mobiletopics/mobile/story/0,10801,109662,00.html

[2] Minneapolis Bridge Collapse Provides Early Test of Wi-Fi Network, http://w2i.com/resource_center/the_w2i_report__weekly_newsletter/news/p/newsletterId_/id_122

[3] 1xEV-DO Overview, http://www.qualcomm.com/media/pdf/QCOM_1xEV-DO.pdf

[4] VZW Nears Rev. A Rollout Completion, Telephony Online, March 2007, http://telephonyonline.com/home/news/vzw_revision_rollout_030907

[5] Price-Performance Comparison: 3G and Tropos MetroMesh™ Architecture, http://www.tropos.com/pdf/whitepapers/tropos_whitepaper_price_performance.pdf

[6] More Than 4,000 Products Wi-Fi CERTIFIED™ by the Wi-Fi Alliance®, Wi-Fi Alliance, November 2007, http://www.wi-fi.org/pressroom_overview.php?newsid=621

[7] Mobile Handset Value Chain, Clint McClellan, QUALCOMM, http://www.wca.org/event_archives/2007/MCCLELLAN_WCA_21AUG2007.pdf

[8] City's Mesh Network Nets Criminals, SearchNetworking.com, http://searchnetworking.techtarget.com/news/article/0,289142,sid7_gci1023354,00.html

1KHA - 001 279 - SEN - 1000 - 7.2013

For more information please contact:

ABB Inc.
Tropos Wireless Communication Systems
555 Del Rey Avenue
Sunnyvale, CA 94085
Phone: +1 408.331.6800
E-Mail: tropos.sales@nam.abb.com

abb.tropos.com

Power and productivity
for a better world™