Executive Summary

Introduction

The business of being a utility is rapidly evolving. Utilities need to upgrade systems to become more efficient and prepare for advanced "next-generation" applications such as Automated Metering and Supply Automation. However, utilities face greater internal scrutiny when examining major capital projects, such as the replacement of a communications system or investment in new wireless technologies. At the same time, utilities are pressured to improve their delivery of service while doing more to protect the nation's critical infrastructure; not only must communications systems do more cost-effectively, they must also utilize their limited spectrum more efficiently[1].

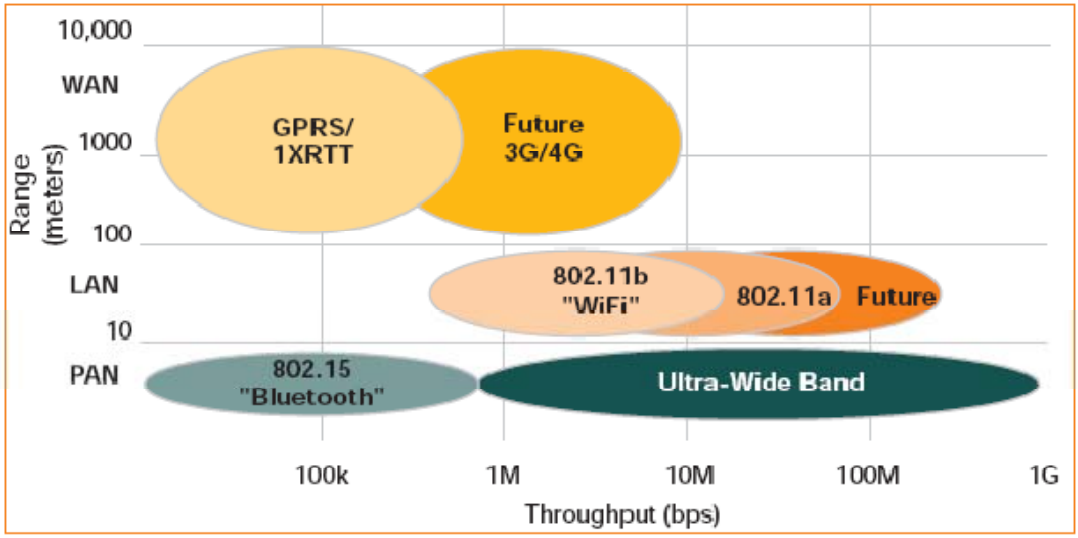
The factors mentioned above represent only some that have contributed to utility reexamination of wireless solution options; some utilities have even considered abandoning private wireless systems in favor of offerings from commercial service providers. This paper builds on prior UTC wireless research by revisiting the utility implications of new broadband access technologies, with a focus on the WiMax standard. The paper also takes a closer look at other key wireless technologies that utilities are evaluating, Radio-over-IP (RoIP) and mesh networking, as utility communications evolve to meet the significant challenges facing them.

Chapter I: Going Mobile

Like most industries where a significant amount of work is done in the field, utilities want to make mobile workers more efficient by equipping them with reliable access to high-speed communications anywhere, anytime. Demand for mobile data is fueling technology "convergence" and the adoption of new a range of multi-function handsets, and broadband wireless technologies and standards. Each wireless access technology is ideally suited for different applications because of differences in range and throughput, as illustrated in the chart below:

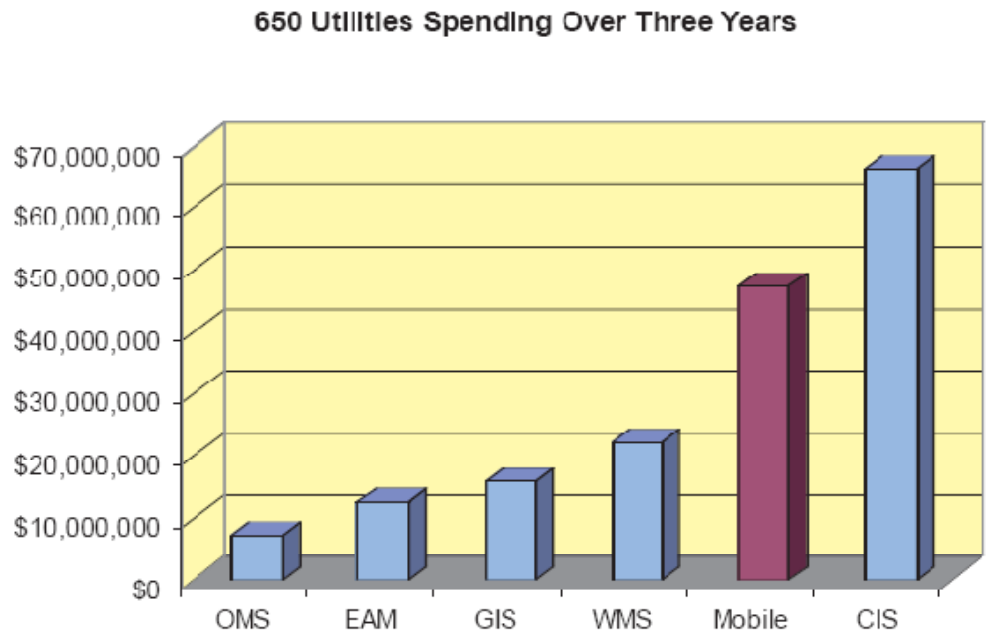
[1] Joint UTC and Booz, Allen, Hamilton Report, *Decision Factors in Wireless Communications Systems for Utilities and Critical Infrastructure,* February, 2005.

Range versus throughput, wireless data communications



Source: Mobiletrax, LLC

Utilities worldwide continue to build-out mobile capabilities as electric, natural gas and water companies integrate computing capabilities across their organizations and into the field. According to a Sierra Energy Group's (SEG), starting in 2005 and by the end of 2008, 650 of the largest utilities in the U.S. and Canada (in terms of total end-use customers), will have a minimum of$47.43 million worth of mobile projects under way:

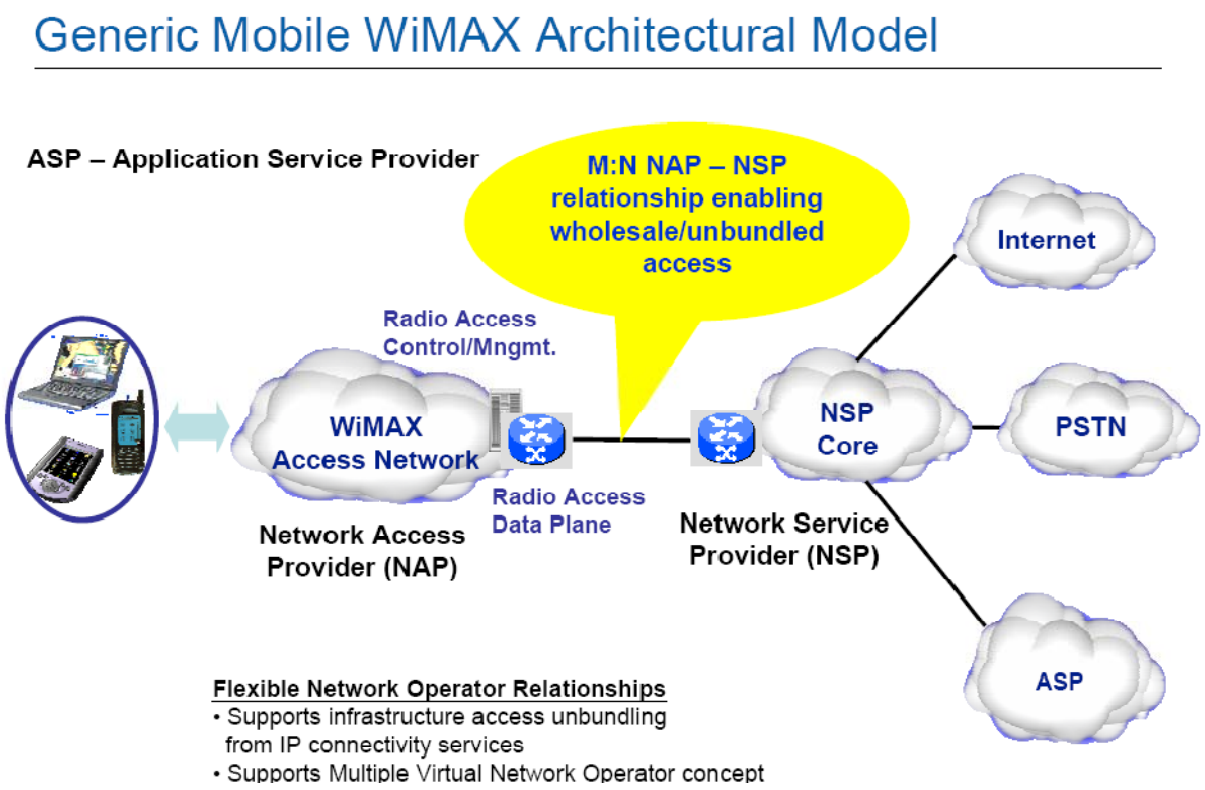


Source: Sierra Energy Group

WiMax for Utilities

The Worldwide Interoperability for Microwave Access (WiMAX) standard is a wireless industry solution for extending broadband access over longer distances, and to more locations, than Wi-Fi. In its early form, WiMAX enables the delivery of last mile wireless broadband access as an alternative to wired broadband like cable and DSL. As the WiMax standard evolves, however, it will provide mobile wireless broadband connectivity without the need for direct line-of-sight with a base station, in a typical cell radius deployment of three to ten kilometers

With a distributed WiMAX network architecture, the WiMAX system becomes an extension of the IP network to the mobile user. Leveraging simple IP-based backhaul connections, service providers can very readily service a myriad of WiMAX base sites (e.g. large, medium, sectorized, omni, micro, pico) for varying coverage and capacity profiles addressing outside environments, inside buildings, and fixed and, eventually, mobile connections:



Source: Intel WiMax Solutions Division

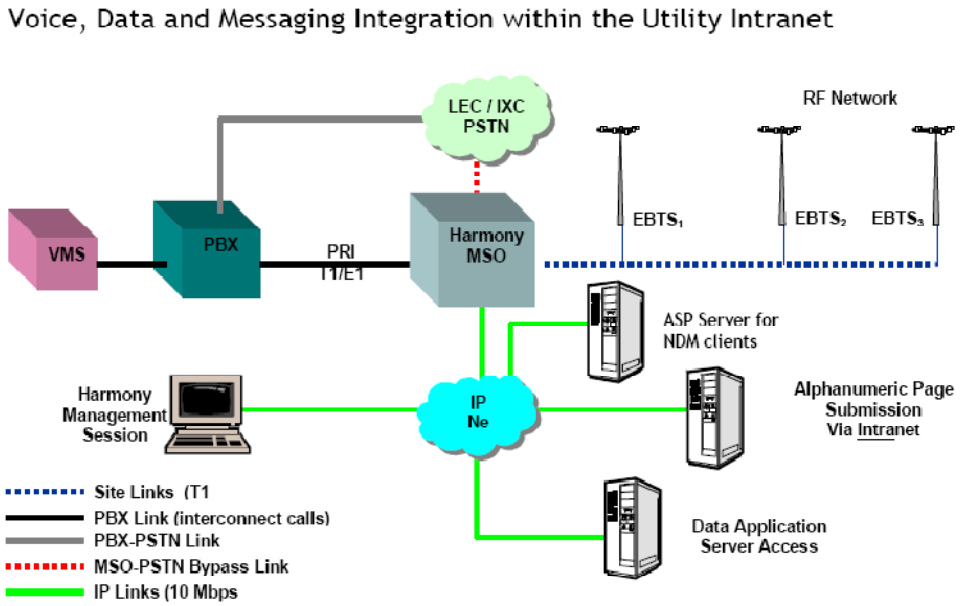
WiMAX could be useful to utilities in a number of ways: WiMAX can be used for wireless backhaul for Wi-Fi or other systems such as 3G wireless, and WiMax can perhaps combine with mesh architecture (see Chapter III) to create an AMI network deployment. WiMax is a standard, not a product, and is very specific to the 2.5 Ghz frequency in the U.S., where only two companies -- Clearwire and Sprint-Nextel -- hold frequency licenses. However, WiMax base stations and equipment can be modified to work with a variety of frequencies, and some utilities have become interested in WiMax-like technology for use in proprietary, core communications systems.

New auctions of 700 Mhz frequency formerly allocated to television usage may expand the landscape for utility access to broadband technologies such as WiMax. Although the FCC has sided against allocating 700 Mhz spectrum for the use of critical infrastructure entities, it is likely that spectrum licensees will seek to partner with infrastructure-rich utilities to help meet aggressive FCC build-out requirements. Critical Infrastructure (CI) entities like utilities could also benefit from mandated wholesale access to nationwide networks that will be built by the eventual spectrum licensees.

Chapter II: Radio-IP for Utilities

Internet Protocol (IP) based architecture represents the next generation in Land Mobile Radio systems. Radio-over-IP (RoIP) refers to a suite of technologies that allows two-way radio traffic to be transmitted over an internet protocol (IP) network.

Motorola "Harmony" System Integration



Source: Motorola

The benefits to utilities of upgrading to IP-based radio systems include:

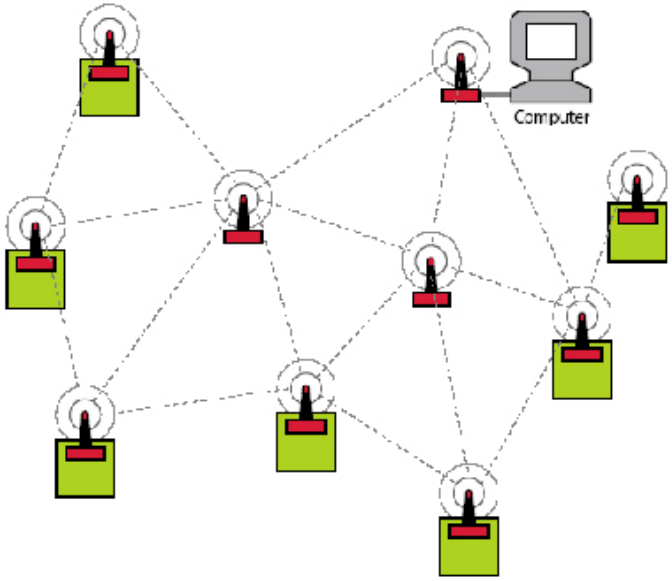
- Cost savings through reduction or elimination of leased line costs, and reduction or elimination of channel equipment and external interfaces;
- Redundancy through the routing capability incorporated in the IP packet structure
- Enables interoperability between radio, telephone and data communication systems
- Enables efficient collaboration between staff and across organizations
- Operate more efficiently and cost effectively, reduce long distance and mobile call costs
- Reduces geographical limitation of two way radios
- Leverages investment in existing radio and network infrastructure.
- Simplification through standardization and commonality of equipment, augmented by the use of off-the-shelf networking equipment.

These benefits are difficult to quantify, making the business case for Radio-IP upgrades difficult to sell to senior utility management. Utility decisions to upgrade to Radio-IP usually are made either because the utility wants to do more with its system – combine voice and data traffic, for instance -- or an old, conventional system reaches the end of its practical life. Utilities implementing applications such as Automated Meter Reading (AMR), or a similar investment, must implement an IP-based platform that can support the needed applications.

Chapter III: Making it Mesh

Mesh networking is a design topology where nodes pass information from node to node to eventually get information out of the network or into a point in the network; every node in the network essentially serves as a repeater. Mesh networking topology looks like a web, as opposed to a traditional “star” topology where peripheral nodes connect to a central node. This architecture offers the advantage being simple to set up, thus decreasing costs, and it is very resilient and reliable, in some cases achieving 100% reliability, because the nodes automatically re-route if data traffic is interrupted.

Mesh Architecture



Source: TechOnline

Utilities are studying meshing architecture primarily for use in AMR metering applications where cost of installation and maintenance is an important factor. The meters at each person's house communicate with one another, forming a network that eventually brings the meter data to a gateway that routes the information to the correct area of the utility.

Conclusion

Despite the challenges that come with upgrading a wireless system, substantial cost and business enhancement can be achieved by improving the capabilities of a utility's wireless system. Advanced wireless access technologies such as WiMax , mesh networking and Radio-IP can support the delivery of new products, services and applications such as AMR / AMI, while simplify network and application integration across the utility.

The extent to which utilities implement new wireless technologies will vary, but continued utility investment in private, wide area, mission-critical voice and data networks appears unavoidable for the foreseeable future; reliance on commercial services does not appear to be a long term solution to utility needs for ubiquitous coverage and reliabiltiy. Utilities will have to invest in integrated voice and data

backbone capabilities across the entirety of their service areas to enable next-generation, mission-critical communications. Utility backbone wireless networks will likely emphasize capacity, and reliability at lower speeds.

Utilities will likely, however, make use of high-speed data public networks when and where there is acceptable coverage, and where greater speed and flexibility is useful and available at reasonable cost. Utilities will likely make increased use of new, converged, handheld multi-carrier radios that perform nearly seamlessly on public and private networks, and take advantage of the most efficient access technologies for given applications, distances and unique circumstances of each utility.

Introduction

No one paper could do justice to the entire realm of technologies and all of the relevant issues facing even wireless technology decisions. But there are a few things that we can say nearly for certain: wireless technologies will fill an expanding role in the make-up of utility communications infrastructure; every utility will be different in terms of the mix of emerging wireless technologies it employs; and nearly all utility telecom managers are faced with trying to determine what the right mix of technologies will be in the evolving wireless landscape. This paper builds on prior UTC wireless research by revisiting the much-anticipated WiMax broadband standard, and by looking closely at the utility implications for other key wireless technologies: Radio over IP (RoIP) and mesh networking.

Wireless communications systems play an integral role in the efficient operations of modern electric, gas, and water utilities. These systems provide access to remote locations, mobile communication throughout utility service territories, and service under a variety of circumstances. The chart below summarizes the major wireless systems used today by utilities and the primary functions these systems perform.

Utility Wireless Systems

System	Functions
Radio/Console Dispatch	▪ Voice communications among managers, dispatchers and field personnel for standard maintenance and service restoration ▪ Emergency calls in case of injury or imminent danger ▪ Communications with adjacent utilities as part of mutual aid operations ▪ Interoperability including real-time communications with law enforcement, fire and emergency services during emergency situations ▪ Interconnection to public switched networks ▪ In certain cases, mobile communications backbone for data applications
Control Systems (e.g., SCADA)	▪ Computer controlled radio communications links used to monitor and control power generation, storage and distribution systems, water system pressure, natural gas distribution ▪ Opening and closing circuit breakers ▪ Monitoring alarms for overload conditions
Automated Meter Reading (AMR)	▪ Periodic collection of usage data from residential customers using wireless devices
Cellular	▪ Non-critical voice communications with customers, suppliers, contractors and staff
Paging	▪ Broadcast messaging ▪ Staff notification
Mobile Data	▪ Work order dissemination ▪ Job status

Source: Booz, Allen, Hamilton