METHODS OF GATHERING EGM DATA

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INTRODUCTION

As competition, deregulation and economic health among utilities becomes more intense, capital expenditures and cost reductions become high priorities — yet operational control and system reliability are more important today than ever before. Coupled with rapidly changing technology, this paradox presents a unique challenge for the efficient design and operation of a remote Electronic Gas Measurement (EGM) system.

Capturing remote data and the method of transporting the data back to a central host essentially falls into two basic categories, or a combination of these two categories:

- wireline — such as telephone facilities, copper based facilities, or fiber optic cable
- wireless — such as satellite, cellular, PCS, or a utility owned radio networks such as MAS or SCADA.

In this paper, we will discuss some of the advantages, efficiencies, costs and risks associated with these technologies, and how each can be utilized in Electronic Gas Measurement applications.

WIRELINE TECHNOLOGIES

Copper Plant

Copper infrastructure is widespread, readily available, and easy to commission. It has been estimated that in the United States alone, over $100 billion has been invested in the existing copper infrastructure. Even with aggressive alternative access deployment, most areas will be copper-served for years to come. In urban installations with minimal data requirements, the initial installation costs associated with copper can be far less than other technologies. However, for rural installations, special construction charges such as trenching can be cost prohibitive.

POTS (Plain Old Telephone Service) dial up technology is readily understood and has been used for EGM applications for many years. Little, if any, capital expense is required. Recurring monthly fees are typically charged against operational costs and one time installation costs can be minimal. In urban areas, a simple facility order to the incumbent Local Exchange Carrier (LEC) or Competitive Local Exchange Carrier (CLEC) schedules both installation and service.

But even though copper is "everywhere," it is rapidly running out of both capacity and bandwidth. Copper can competently handle bandwidth speeds up to 56 kb/s and Digital Loop Carrier (DLC) technology can provide temporary relief from congestion. Yet the demand for higher connectivity is dramatically increasing, with the imbedded copper cable plant becoming the bottleneck. Coupled with old and aging cables, copper may be rapidly reaching capacity, bandwidth limitations and reliability.

Often times, remote gas measurement locations are in inaccessible environments. As such, facility costs, installation costs, reliability and mean time to repair become significantly more critical. Rural installations may involve multiple LECs, CLECs and Inter-Exchange Carriers (IXCs), and may include significant special construction installation charges. In rural applications, where multiple LECs are often involved, the "Mom and Pop" telephone companies can become your worst maintenance nightmare.

Copper facilities typically represent the area where the utility has the least amount of control, highest recurring costs, and least reliability. The most frequent cause of service disruption in a facility based network is not equipment failures — it is leased line facility outages! While cable cuts are arguably the most disruptive, other factors, such as wet cables, human error, equipment problems, or dribbling data errors can all be equally troublesome and difficult to correct. Resolving such impairments can be time consuming, even in major metropolitan areas where facility maintenance is best.

xDSL Vegetable Soup

From the general consumer perspective, xDSL technology is certainly the most widely recognized, with Asynchronous Digital Subscriber Line (ADSL) being the most popular. ADSL technology can typically offer data rates up to 512 kb/s, with subscription costs of $50-$100 per month. Higher bandwidths can be attained, but with significant distance limitations.

Execution and deployment, however, has not been easy. While some market projections indicate that over 70% of existing worldwide telephone lines are ADSL capable, the reality is that older copper infrastructure, bridge taps, incomplete cable records, impedance mismatches, excessive cable distances from the central office, and maintenance issues have all contributed to both customer and carrier frustrations.

For Gas Measurement applications, xDSL may be a viable option in major metropolitan that are close to the serving telephone offices, where high data rates may be desired, or for locations where multiple EGM sites hub together. In rural applications, where remote gas locations are often located, xDSL is not feasible because of distance limitations from the central office.

Fiber Optics

When compared to other technologies, fiber offers distinct advantages, such as high bandwidth, insignificant distance limitations, low monthly recurring costs for existing terminations, and no blind spots in coverage. Additionally, with an excess of available fiber in many cities around the country, the monthly leasing costs for existing fiber terminations will continue to erode.

While fiber offers extremely high bandwidth and potentially low monthly leasing costs, it is estimated that less than 5% of commercial sites are actually touched by fiber. Fiber may run down the middle of the right-of-way, but the actual entrance link into a specific commercial location may not exist. Fiber is more suitable for large industrial sites or dense campus locations requiring significant data throughput, such as hub locations used for backhaul. Though the cost of fiber termination equipment has gone down, the construction, trenching, civil engineering, right-of-way, and labor costs have all increased with inflation — making the cost of extending fiber for most gas measurement applications prohibitive.

Hybrid Fiber Coax (Cable Modems)

With widely deployed cable systems already in place and high penetration into the urban marketplace, cable TV systems offer the potential for high bandwidth at an affordable price. Data rates of 1.544 Mb/s can be readily accommodated, with monthly fees in the $50 range. However, in the US, most cable television systems are analog one-way systems serving the residential market, not businesses applications. Upgrading the analog infrastructure to digital represents a major capital investment to cable operators who are already facing stiff competition from the home satellite industry.

Security and privacy issues are also concerns, as cable systems are essentially a "party line". Residential and business subscribers are on the same cable, having potential access to all traffic, regardless of the owner. Individual connections are maintained by using different time slots on the cable, but it would not be technically difficult to break into this rudimentary encoding. Privacy issues, such as credit card numbers and eavesdropping, require more powerful encryption methods.

Equally daunting, the cable industry is typically working in a regulated monopoly environment. Competing technologies, particularly wireless technologies, are most often not burdened by local, municipal, or state regulatory agencies. The cable industry must change from a regulated to an entrepreneurial technology, and operators will be challenged to overcome the public's general perception of poor customer service, as well as an existing employee base somewhat inexperienced in telephony and data applications.

As with fiber and xDSL, Hybrid Fiber Coax solutions are technically and economically feasible only within major metropolitan areas, and generally not suitable for most gas measurement applications.

WIRELESS TECHNOLOGIES

Rising wireline facility costs coupled with the ever increasing desire for higher data speeds has necessitated that many utilities investigate ways to reduce existing monthly operating costs, improve network reliability, accommodate higher data rates, and better manage installation schedules

Management and control of facilities in a wireless network must address the real-time operational elements in providing reliable service. The principal objectives in deploying a wireless network is to provide maximum up-time, proactive restoration of network impairments and failures, self-control of the network, and elimination of monthly recurring costs.

Wireless networks for gas measurement essentially fall into two categories:

- public networks — such as Sprint PCS, AT&T Wireless, Verizon Wireless, etc.
- private networks — such as utility owned microwave systems, Multiple Address Systems, or SCADA.

Public Networks (Wireless Alphabet Soup)

When considering the use of PCS or Cellular systems for gas measurement applications, monthly subscription rates, footprint coverage, modem costs, and the cost of air time all become distinguishing factors. Equally important, as parity among service providers levels out, somewhat less intangible factors include: customer service, billing accuracy, network reliability, and migration paths towards next generation technology.

Analog cellular technology, such as Cellular Digital Packet Data (CDPD), has been used in gas measurement applications for many years. CDPD can be economical and somewhat easy to deploy. In many cases, a modem board mounted in a weatherproof box with a small "button" antenna is all that is needed. While CDPD is a packetsized data technology, it resides on an analog overlay and is therefore indelibly tied to the analog cellular network.

Despite the sales and marketing pitch a local carrier may present, all analog technology (which includes CDPD) is being rapidly phased out. Wireless carriers are in the process of implementing the next generation digital networks towards an ultimate goal, which is 3G (Third Generation) technology. Market data shows that 3G, which offers high speed data throughput, has substantially more profit margin than the voice and data offerings available today. Thus, regardless of technology platform, all carriers will eventually migrate to a 3G network.

For gas measurement, this creates an enormous challenge in developing a long term strategy and budget As each carrier migrates towards 3G, many questions are left unanswered. Should a utility deploy a TDMA solution or would a CDMA solution be more prudent ? As public carriers drive towards 3G, will the cost of each migration step be passed on to the end users? Will the equipment purchase today be obsolete after the transition process? Will the coverage the carrier offers today be the same footprint after 3G is deployed? A long term, carefully thought out business plan should be made before utilizing a public wireless carrier for EGM applications.

Utilities should be cautious of the long term viability of TDMA (Time Division Multiple Access). An increasing number of equipment manufacturers and cellular carriers have already announced their intentions to eventually migrate away from TDMA as they plan for 3G. The migration path for TDMA based carriers might be: CDPD (still offered today); Global System for Mobile Communications (GSM); General Packet Radios Service (GPRS); then Enhanced Data Rates for Global Evolution (EDGE); and finally Wideband CDMA (W-CDMA). Not all of these technologies are backwards compatible - meaning that with each migration step the customer (ie: the utility) will have to retrofit or replace existing modems. Even if carriers offer some form of negotiated concessions (such as modem trade-in plans), the utility will still experience equipment and installation expenses.

While existing CDMA based carriers have a less disruptive 3G migration path, it will not be totally pain free. CDMA migration will typically consist of IS-95, 1XRTT (already available in most locations today) and then directly to CDMA2000. The good news is that all devices are expected to be backward compatible. As such, CDMA migration is expected to be significantly less disruptive than TDMA, and should be less costly for the end user.

EGM applications deployed today typically require low data rates. In a dial up or CDPD application, it only takes a few minutes to capture and transport metered data back to the central processing point. When using CDPD, the utility usually pays a flat monthly fee for sufficient air time to meet metering requirements. However, the high data rates proposed by 3G represent a two-edged sword. While everyone likes the idea of high data throughput, there is a definitive cost associated with this new technology. The days of “all you can eat” air time for a flat monthly rate are quickly disappearing from major carrier rate plans. As carriers implement 3G, rate plans will evolve with much higher minimum data requirements as well as costs. Are significantly higher data rates really necessary for gas measurement applications? Are utilities willing to pay substantially higher monthly fees just to have the ability to send data at 384 kb/s or 2 mb/s, when the actual requirement is much lower?

Unfortunately, unless a utility negotiates a strategic partnership with a carrier, the cost of 3G service may be overly prohibitive. The minimum data usage for 3G services may start far above what gas measurement typically requires. Below are two examples of air time rates recently quoted by a major carrier (not including the cost of the modem):

- CDPD $8 per month, plus $0.05 per kb of data
- GPRS $20 per month for 3 mb of data

With these prices, CDPD (which is going away) may be cost effective, but GPRS (the replacement technology) is substantially more expensive, and a utility would pay for 3 mb of data that it would never need or use for an individual meter. Possibly by bundling all measurement requirements in one “bucket”, the aggregate amount of all metering devises together may justify the cost of service. Carriers will undoubtedly segregate voice and data usage separately in an attempt to increase revenue. By bundling all wireless needs under one Corporate contract, the utility may be able to lower costs to an acceptable level. Or, perhaps as an incentive, a utility could negotiate for the carrier to subsidize the cost of data modems, such as they do today with cell phones.

Without question, when it comes to using public carriers, every utility will be faced with tough economic decisions. Prudent cost management will be critical for gas measurement systems in this environment.

Short Message Service (SMS)

Short message text service is packetized data sent over the public carrier network. It is the text messaging that you see on your PCS cell phone, and can have 1-way or 2-way capability. SMS uses only short bursts of data (typically from 160 characters to about 255 characters, depending upon the carrier). SMS text messages are not sent on the same channels as voice or even data, but ride the control channel, which limits the available capacity. Typical latency delay is about 4 seconds from the time a message is sent to the time it is received, but this is dependant upon available capacity on the control channel at the time the message is sent. Some carriers offer “store and forward” capability, which means that the system will hold an undelivered message for several days until retrieved. SMS service can be more expensive that CDPD, and most carriers only offer SMS as an additional feature on top of other rate plans. As such, a utility may not be able to negotiate a favorable rate plan for stand alone SMS service. As carriers migrate from one technology to the next in an effort to reach 3G, customers will face many of the same upgrade issues noted earlier.

Satellites — (LEOs, MEOs and GEOs)

Satellite technology has the ability to offer large footprints, but with trade offs in high operating cost and latency. Geostationary Earth Orbiting Satellites (GEOS) are parked at a specific point along the Equator and are synchronized to track the Earth's rotation. While GEOS offer large coverage zones, by their very nature they must maintain a high altitude stationary orbit (about 25,000 miles above the earth) which causes an inherent delay in the signal and is intolerable for high-speed data. This inherent delay, called latency, is approximately 250 milliseconds roundtrip. For voice applications, using echo cancellers can compensate for this delay. Data applications, however, suffer dramatically. For example, Transmission Control Protocol (TCP), which is widely used for Internet data transfers such as Web files and email, does not respond well to high latency links and variable round trip times. When utilized over links exhibiting these characteristics, the result is generally low throughput and inefficient use of bandwidth.

Low Earth Orbiting Satellites (LEOS) are only a few hundred miles above the earth. While LEOS have minimal delay characteristics because they are not in a synchronous orbit (about 110 milliseconds roundtrip), there must be a fleet of satellites in simultaneous orbit to ensure connectivity. This fleet of satellites increases the overall operational costs of the satellite system, which in turn is passed on to the individual users (ie: the utility).

Medium Earth Orbiting Satellites(MEOS) are located between 6,000 miles and 10,000 miles above the earth, and exhibit characteristics intermediate between GEOS and LEOS — that is, modest latency but higher operational costs.

Some data oriented satellite systems provide only 1-way data transmission; others provide bidirectional communications with either symmetric or asymmetrical bandwidth. For extremely remote EGM locations, satellite technology can provide a viable means of retrieving metered data, but not without a price. The cost of terminal equipment can approach $2,000, with minimum monthly air time charges starting at $20 per month, making it cost prohibitive for many metering applications.

Multiple Address Systems (MAS)

MAS has been widely used by utilities for many years, is a field proven technology, and is readily understood. MAS is often deployed in a hierarchical topology - that is, a remote station sends data back to a nearby Sub-Master, who in turn sends the data to a Master Station, who in turn sends the data back to the main host or central collection point. A typical system might include:

- Remote Terminal Units (RTUs) — located at the metered point, the remote terminal collects data information from the metered device, which is then transported back to a Sub-Master or Master Station
- Sub-Master — The Sub-Master polls and collects data from surrounding RTUs. It will then pass this data back to the Master Station. Because the Sub-Master talks to many surrounding RTUs, it requires an omni-directional antenna and a directional antenna (yagi) to communicate with the Master Station.
- Master — The Master station communicates with surrounding Sub-Master stations. It may also poll RTUs in close vicinity to the Master. When a Master polls both Sub-Master stations and local RTUs, it will typically do so with the same omni-directional antenna. Thus, a Master station may have only one omni-directional antenna for multi-purpose applications. The collected data is sent back to the centralized data host via telco land lines, microwave radio, Internet, Satellite or other means.

Each MAS radio has a unique address, which allows data to be polled for each individual RTU /meter. Polling data for one individual device takes only a few milliseconds, but a dozen or so RTUs may take up to one minute. The entire system polling time (sometimes referred to as polling latency or delay) depends upon how many unique address are assigned throughout the entire system. Theoretically, the number of remote stations communicating with one Master station is unlimited. However, in real life applications, the amount of acceptable delay to poll an entire system is often the limiting factor.

Multiple Address Systems are fairly inexpensive to deploy It is not uncommon for the remote, sub-master and master radios to all be the same type and model of radios. This allows for common spares and easy maintenance. MAS radios can be purchased in the $500 to $1,000 price range, and come in numerous flavors and options to enhance reliability, performance, maintenance and costs.

MAS radios are available in several frequencies, both licensed and unlicensed, but all require near line of sight. In the Untied States, the frequency bands typically used are:

- 450 MHz — because this band requires a FCC license, operation is protected from interference. This band is the most "forgiving", in that true line-of-sight is not always mandatory. Slight path obstructions and blockage can occur while still maintaining good signal continuity.

- 2.4 GHz Spread Spectrum — this band is “license free” and does not require an FCC license. However, this band is subject to interference from other communications devices and should be used with great caution. In rural locations, interference issues may be minimal. For metropolitan areas the potential for interference significantly increases. Other devices operating in this same band include microwave ovens, cordless telephones, garage door openers, wireless LANs, laptop modems, etc. If interference should be encountered, there are limited options available to mitigate the interference and continue operating as normal. In most cases, the presence of strong interference will mean that the site cannot continue to be serviced by unlicensed radios.

- 900 MHz — this band is available in licensed and unlicensed frequencies. True line of sight is almost always required for stable operation. The potential for interference noted for 2.4 GHz as well as the protection from interference noted at 450 MHz also apply.

Many utilities already have existing Multiple Address Systems in place. When deploying EGM applications, careful consideration should be given to utilizing these systems. MAS typically offer robust response times, easy installation, easy expansion, and in the case of licensed systems, protection from interference. MAS has little or no costs beyond the initial equipment deployment. Once in operation, there is no further expense beyond periodic maintenance. Other solutions, both wireline and wireless, often involve equipment and /or installation costs PLUS monthly recurring costs. A Net Present Value projection can demonstrate that MAS can easily have a payback of 12 -18 months.

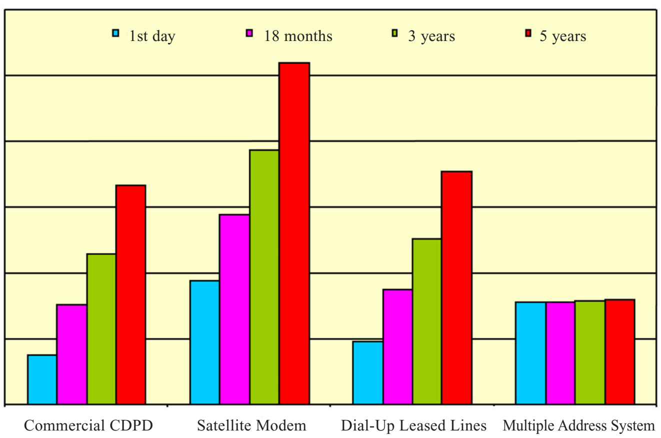

FIGURE 1. Cost Per Monitor Point

SUMMARY

An investigation of these different technologies shows that each has opportunities, challenges, advantages, and disadvantages. Figure 1 compares a real-life example for cost per monitored point verses technology and time. Solutions considered for this application were: CDPD; Satellite; Telco leased lines; and MAS. In this example, installation costs were assumed to be similar for all solutions. As shown. the cost and payback of a Multiple Address System is 18 months.

Deployment decisions for EGM applications will include many drivers, such as: initial equipment costs, monthly recurring charges, capital constraints, life expectancy, reliability, and availability. This is particularly true in the Wireless Public Carrier domain, where technology decisions made today will have significant implications for the future. Utilities need to avoid locking themselves into a wireless platform that has a limited life expectancy or that will require painful and costly upgrades.

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