A Cost Effective Approach to C&I AMR and Power Quality, Power Reliability Reporting

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Introduction and Background

Electric utilities and their technology partners, consultants, and vendors have diligently sought cost effective methods of addressing automated (remote) meter reading and power quality / power reliability reporting for over 20 years. In spite of $100's millions invested by many reputable companies (large and small), today, less than 5% of the installed base of electricity meters resides on fixed network AMR!

However, the winds of change are blowing. Electric utility regulatory pressures are forcing economic and technological movement, similar to the telecommunications and natural gas industries. Today, electric utility plans to compete in the deregulated and re-regulated environments require higher performance automated meter reading (AMR) and power quality and power reliability (PQ/R) reporting solutions at even lower costs. This is a huge challenge for the industry and represents an enormous prize for AMR and PQ/R vendors who can deliver these types of products.

The barrier to broadly accessible AMR and PQ/R has been price/performance of available technology options. Many technology solutions can deliver reliable AMR and PQ/R at a high cost. The determining factors for cost effectiveness relate to the efficient use of the transport layer/s or additional value achieved through proficient management of data transactions.

Under these conditions, the best solution uses public wide area networks for data transmission. This provides a cost-effective solution for high value data such as C&I metering, power quality/power reliability, and utility automation.

The Wide Area Network (WAN)

The difficulty of creating cost effective AMR has always related to distribution of devices and relative data density and value per device. Broad meter distribution requires a transport layer capable of accessing, concentrating and delivering data to the final storage location. This requires the use of a Wide Area Network (WAN).

The original WAN used for this purpose was the Telephone WAN (TWAN). The TWAN continues to be used for C&I applications, where telephone modems move data through dedicated connections. At the inception of AMR, there were no viable alternatives to public telephone networks which were moderately accessible for meter connection. The TWAN represented a relatively high cost transport layer with acceptable accessibility to the meter location. However, the combination of device costs, installation costs, and monthly line expense has limited its commercial usefulness to high revenue C&I AMR applications.

This high cost relates to the low utilization of bandwidth availability plus other disadvantages of "circuit switched" technologies. Now, there are many WAN alternatives, all with sufficient capacity and connectivity for AMR.

All WAN solutions are either wired or wireless including cellular telephone, public and private RF, Internet, satellite, etc. Cost of devices, cost of connection, and bandwidth utilization continue to make most WAN solutions problematic in relation to the density and value of AMR data.

This is why most AMR vendors continue promoting either an increase in data volume, i.e. addition of value added data services or an increase in data value due to deregulation and accompanying competition. Since neither is giving the appearance of coming to any tangible resolution in the short term, it is risky to employ a strategy that requires these assumptions to be successful.

WAN decisions fall into two main categories. Either build a WAN or utilize an existing public WAN infrastructure; and coverage, cost of connection, and bandwidth requirements are key determining factors. Cost of connection consists of device cost and implementation cost. For example, the WAN with the broadest coverage is satellite based. Until recently, device costs were in the range of thousands of dollars. With a cost displacement threshold of $20.00 per month, capital recovery would take at least 10 years. Satellite based devices are now available at lower prices, but bandwidth costs remain prohibitive.

2-Way paging, a recent development, has become the most economical WAN technology from a recurring and non-recurring cost perspective. With many thousands of units deployed, the SkyTel/Motorola 2-Way paging modules have long-since paid back the development cost and are approaching commodity-pricing levels. Also, 2-Way messaging services offered by SkyTel must be very economical to be viable in the highly competitive personal messaging market.

<u>Packet Switched vs. Circuit Switched</u>

Data, Transaction and Network Efficiency

In a circuit switched environment, efficient bandwidth utilization is a difficult technical challenge. A simple way to describe this problem is to consider the voice phone paradigm. When a call is placed, a real time connection is made. During the call, a great deal of circuit time is unoccupied since people are not talking continuously.

Sending data in a circuit switched analog environment is even more inefficient due to the modem connection and session delays. For example, utility AMR per point data quantities are relatively low, i.e. less than 200 bytes for a 24-hour load profile and register read. Daily AMR reads over a circuit switched telephone or cell phone network retrieving 200 bytes include the following session steps and <u>approx</u> times:

1. Speed dial and ring – 12 seconds
2. Negotiate and connect – 30 seconds (42)
3. Password – 10 seconds (52)
4. Launch application – 60 seconds (112)
5. Send/receive data – 10 seconds (122)
6. Disconnect – 10 seconds (132 seconds)

This small 200 byte transaction example incurred a cycle time of over two minutes plus possible long distance charges. That's assuming the call was not dropped requiring another dial-up sequence! Within a packet switched (IP) environment, this message would have been trapped by the network and sent on its way back to the server and database without consuming valuable airtime. In this example, this 200 byte transaction would have taken less than one second of air time!

In a packet switched environment, packets from multiple sources can be inserted wherever and whenever there is space available. A packet switched environment allows a lot more data to be efficiently moved over the same connection, providing better WAN economics. Packet switched economics account for the dramatic reduction in costs in digital cellular telephone systems.

Bandwidth cost has always been a function of available competitive bandwidth. The economics of other data volumes and data values support the cost and expense of construction and operation of a public network. The public network accepts the risk of bandwidth utilization. In the case of private infrastructure, a technology must be selected that will handle projected bandwidth requirements.

Most bandwidth, whether wired or wireless, is subject to regulatory influence. Only in certain public domain frequency ranges, such as unlicensed spread spectrum bands, is this not the case. Due to the proliferation of bandwidth requirements, in the instance of a wireless WAN, acquiring a frequency has become very costly in the US. In every case, public or private, bandwidth utilization and overall data transport efficiency have become the defining economic considerations for making the bandwidth ownership or outsource decision.

The dilemma is the density and value of AMR data relative to the cost of building and owning a WAN is difficult to justify. Today only C&I AMR has achieved cost displacement economics. The cost of building infrastructure to support C&I AMR alone is prohibitive. Relative C&I AMR data densities and values are extremely low, in relationship to the cost of building WAN coverage.

The very low density and current value of residential AMR data does not allow it to contribute significantly enough to alter the economics of WAN ownership. A lack of cost displacement forces WAN ownership to consider the creation of additional revenue from other value added services. This makes a WAN ownership decision prohibitive based on the economics of AMR data alone.

There are many WAN infrastructures that meet the bandwidth requirements of AMR. However, the WAN solutions must fit comfortably within the context of the optimal value equation to make the business case economically valid.

Packet Data Security

Wireless packet data networks "cocoon" the packet of information with a protective forward error correction (FEC). This error correction is the primary advantage of packet protocols over landline protocols like MNP10 and ETC for data transmission via wireless. Within a packet environment, FEC code allows the receiver to actually fix, not just identify, some errors in the packet. Landline oriented protocols like ETC and MNP10 require the sender to resend the entire packet again, increasing airtime and decreasing data efficiency.

Another advantage of packet systems is they are interlocked. When a message is received and verified as correct, and automatic acknowledgement is sent. If no "ack" is heard, the modem times out and automatically sends again. With an interlocked packet system, it's virtually impossible to get an error in transmission.

Packet Data Connectivity

Within a packet data environment, using the standard Internet Protocol (TCP/IP) ensures smooth connectivity requiring less comprehensive and complex middleware to connect other wireless IP applications. This also allows the wireless packet data network to be a seamless "extension of the Internet" and all network field devices and meters are empowered as nodes on the Internet.

Latency Requirements

The value of all data relates to the timeliness of its availability, whether scheduled or unscheduled. The time delay between the need and request for data and receipt of data is referred to as latency. In a standard telephone modem or cellular telephone modem AMR system, the degree of latency is determined by the time required for each meter transaction. This is determined by the time required for the connection and transaction (see above 2+ minute example) times the number of transactions divided by the number of polling modems at the host. If the same strategy were used to manage all meters, including residential in the distribution system, it quickly becomes cost prohibitive to maintain low latency.

In the case of billing data, the timing of the billing cycle establishes a maximum latency threshold that is relatively long. The other extreme is the SCADA example, which requires very low latency, beyond which it has no commercial value, other than for system analysis. Every data transaction has a maximum data-value / latency threshold that must be met to achieve the required data transaction economics.

WAN Conclusion

Today, the most cost effective WAN is the 2-Way paging network and accessed by the cost effective 2-way pager. Soon, it might be a combination of multiple wireless and/or wired networks. The wireless revolution will certainly provide a plethora of network choices in the future. A flexible architecture plus downloadable protocol and built-in upgradability is the best guarantee for a smooth transition to new networks.

SkyTel (ReFlex 50) Advanced Messaging Network

The FCC awarded SkyTel the first and only pioneer's preference license for a national narrow-band personal communications system (nPCS) July 1993. SkyTel launched its 2-Way paging and fixed wireless data services on its nationwide Advanced Messaging Network (AMN) September 1995. Since then, the SkyTel network has been the fastest growing wireless data network in history, currently providing service to over 500,000 advanced 2-Way messaging units.

The SkyTel Advanced Messaging Network consists of three basic components: the network operations center (NOC), the radio frequency (RF) infrastructure, and the Advanced Messaging Units. The purpose of this document is to describe these elements as they apply to a fixed wireless system deployment.

Currently, the SkyTel Advanced Messaging Network is providing such services for the following applications:

- Electric, gas, and water automated meter reading
- Vending machine management and control
- Wireless backup for security systems
- Copy machine monitoring and control
- Automotive tracking and control
- A myriad of other wireless telemetry systems.

While this document is focused on fixed wireless systems, the network is also being utilized for 2-Way paging applications amortizing network costs accordingly.

SkyTel's Advanced Messaging Network (AMN) - Overview

The network operations center (NOC) is the central location of all the facilities, components, and services of the SkyTel Advanced Messaging Network (AMN). The NOC manages all processes required to send and receive data, manages advanced messaging units, and monitors all system components.

There are dual redundant NOCs. The primary NOC is located in Jackson, MS (headquarters location) and the backup NOC near Dallas TX. The operation of the Network can be dynamically routed to the backup NOC in a procedure known as switchover. This level of redundancy and diversity is a hallmark of SkyTel's Advanced Messaging Network.

SkyTel's Network Operations team continuously monitors the Network functions in order to prevent any downtime. Due to their efforts and the redundant architecture of the Network, SkyTel's level of service in Network uptime currently exceeds 99.99%.

The Network Operations team provides 7 X 24 X 365 customer support and continuously monitors the computer systems that comprise the NOC, all communications subsystems, and all field RF equipment.

The RF infrastructure consists of a nationwide network of high-powered base transmitters (BTs) and base receivers (BRs). The BTs and BRs are strategically located in large metropolitan and suburban areas to maximize geographic coverage with an approximate ratio of four (4) BRs for each BT. A Wide Area Network (WAN), links the BRs and BTs to the NOC (see diagram below) and consists of a satellite distribution network, Frame Relay lines, and network and software.

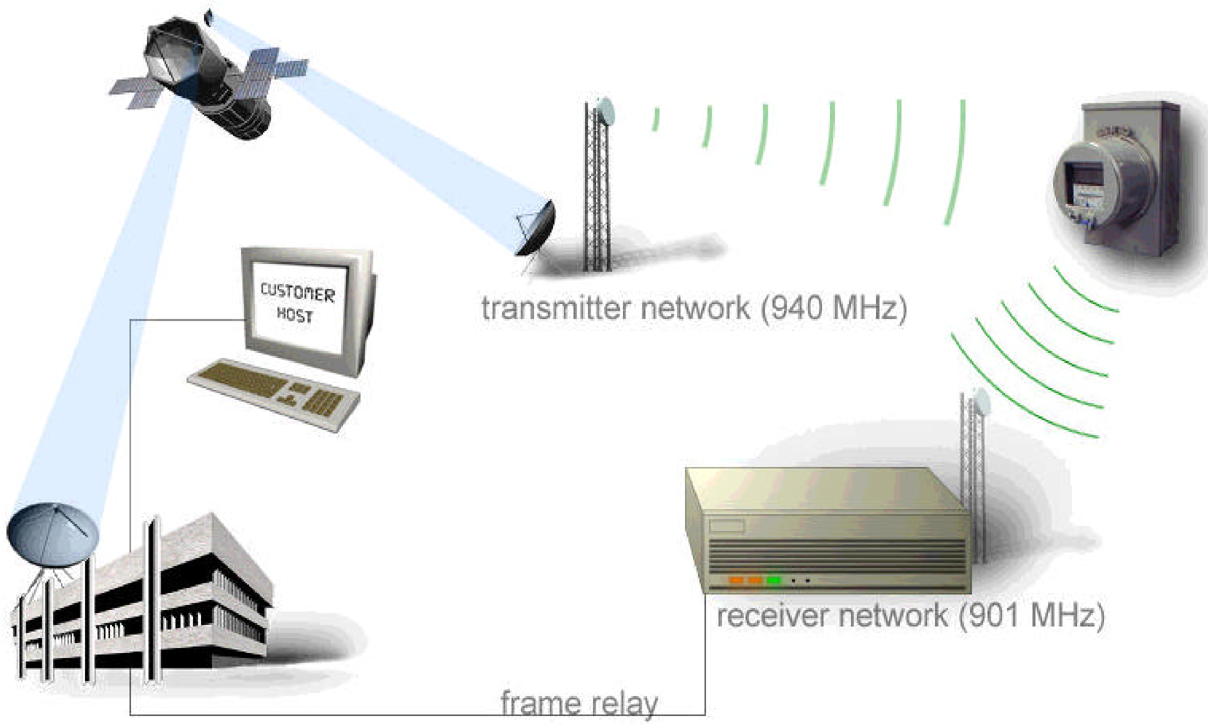
Advanced Messaging Units (AMUs) are the generic name for the portable and fixed wireless transceivers used with the SkyTel 2-Way Network and are factory installed "under the meter glass." A certification process requires protocol compliance, RF characterization, and overall consistency with Network standards. Currently two fixed wireless transceivers are certified for use on the SkyTel Network, the CreataLink 2 and the CreataLink2 XT devices from Motorola.

The SkyTel Network Operations Center

The Network Operations Center (NOC) is the heart of the SkyTel 2-Way Network. The NOC consists of the computer systems and the RF and telecommunications infrastructure that makes 2-Way data transmissions possible. SkyTel developed the NOCs at an expense of over $60 million. SkyTel owns and controls the architecture and can quickly implement new, value added services for its customers.

Each NOC is comprised of redundant Digital Equipment Corporation (DEC) Alpha and/or VAX servers operating in tandem. Each specific server is fully redundant within cabinet and as a node on the computer system wide-area network. Each NOC is configured for sufficient capacity to singularly operate the Network.

A fundamental capability of the NOC is the management of the Motorola ReFlex 50 protocol through the RF infrastructure and the Advanced Messaging Units. The ReFlex protocol from Motorola is a robust wireless data protocol jointly developed by SkyTel and Motorola. More info on this protocol is available at www.motorola.com.



The RF Interface

The NOC formats all messages sent out to Advanced Messaging Units (AMU) via the RF infrastructure. This is called the Forward Path. Unit profiles contain information regarding the last known location of the AMU. The system sends the message to multiple transmitters for "simulcast" in that area first. By utilizing location information, the NOC makes maximum use of the allocated frequencies by sending the message only to the area in which the meter point is located, allowing other messages to be sent to other areas at the same time.

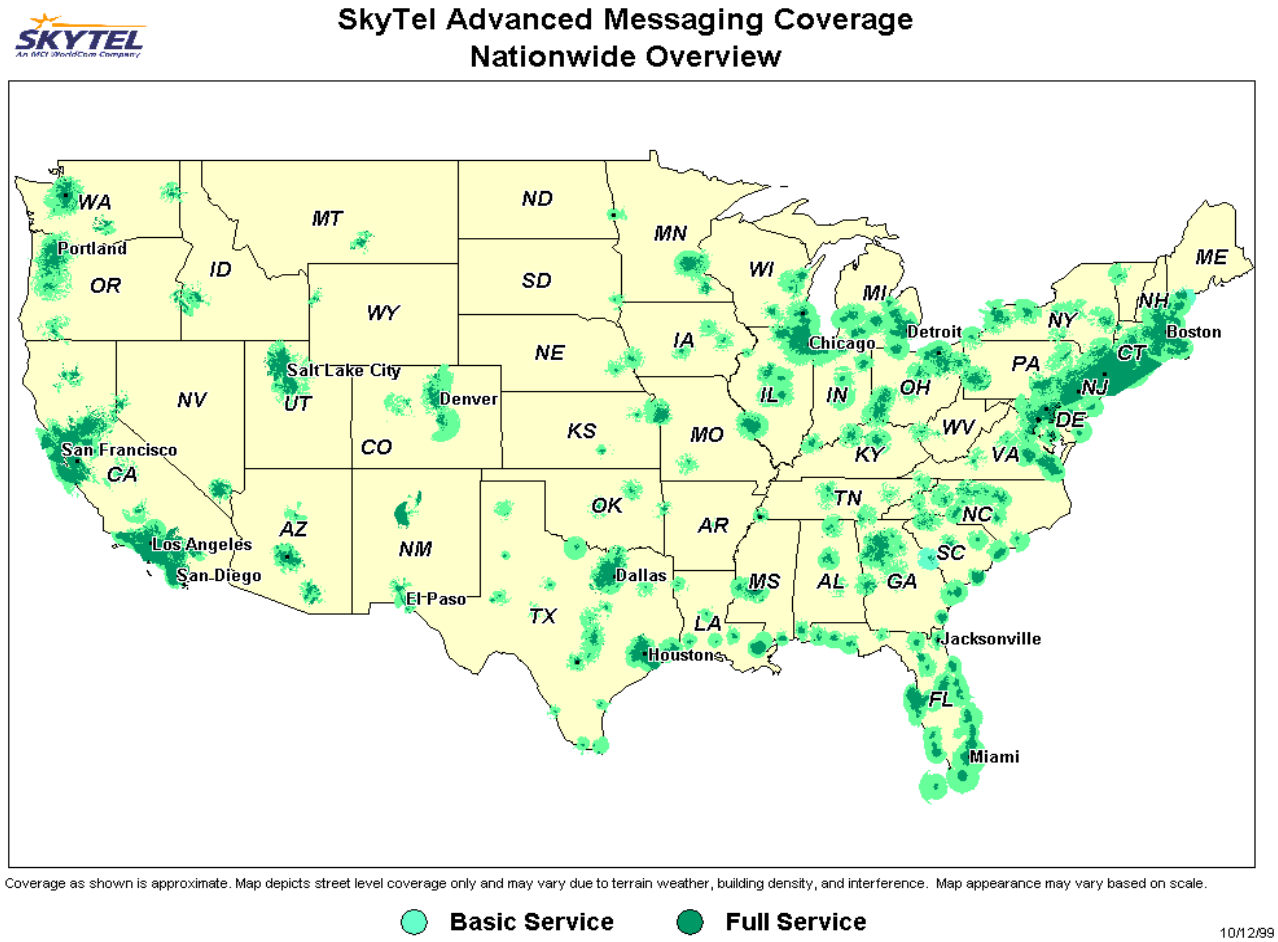
Should a message delivery fail, the NOC will employ a retry algorithm. This consists of sending out a short message, known as a location query, to all allowable areas and then waiting for the AMU to respond. Once the new location of the AMU is known, the message is sent to multiple transmitters in that geographic area.

The NOC receives data from the AMU via the Reverse Path. Whenever an AMU transmits data, the data is picked up by base receivers and forwarded to the NOC by a subcontroller. The NOC correlates the data and takes the appropriate action. Examples of data an AMU may transmit are acknowledgments, replies, or new messages. The NOC associates the replies and acknowledgments with the original message and provides the originator of the message with the information.

AMU transmissions are often received by multiple BRs. Four or more BRs may receive each transmission. This is to ensure penetration inside buildings as well as provide redundancy to overcome potential RF interference. These transmissions are sent from the BRs to a subcontroller (message concentrator) and processed.

Duplicate copies are compared and used to clean up and correct other copies of the same transmission. One corrected copy is then sent on to the NOC. This process yields two advantages. First, the data stream to the NOC (over frame relay) is reduced. Second, messages received in error are corrected by the subcontroller using other copies of the same message.

In addition to lowering communication costs, subcontrollers satisfy other 2-Way Network needs. Subcontrollers are connected to all BRs and BTs and used to communicate Command and Alarm information between these devices and the NOC. Also, subcontrollers may act as backup distribution points for messages sent to the RF network.

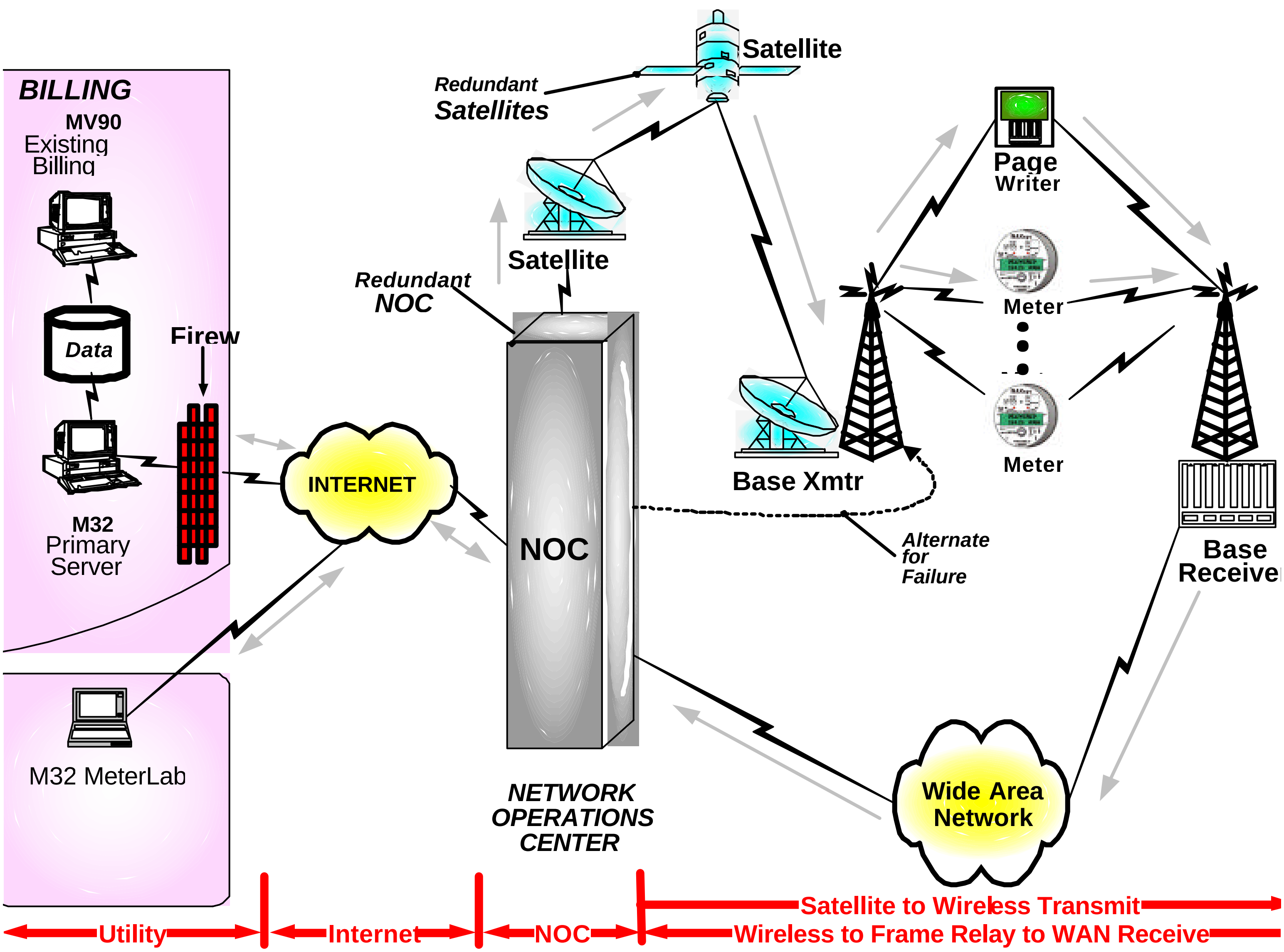


SkyTel Summary

The SkyTel Advanced Messaging System utilizes a robust wireless data protocol operating through the NOC, the RF network, and to certified Advanced Messaging Units. The utilization of redundant elements in each layer of the architecture, coupled with a 24 X 7 X 365 Network Operations team ensures maximum uptime.

Because SkyTel's PCS licenses from the FCC are all national, network coverage can be addressed in any location. SkyTel's Network currently covers approximately 70% of the U.S. population. Through the normal case of business, SkyTel expects to increase this coverage over the next several years to 90% of the U.S. population. In the meantime, if a customer requires incremental RF system buildout, SkyTel has a well-defined economic model that can assess the impact of the incremental coverage and will add new RF infrastructure where the value equation can be maintained.

SkyTel has an open business model that places the emphasis on the customer's requirements. SkyTel's pledge is to provide the most secure, reliable, and economic wide area network services available.



C&I Wireless AMR – Applications and Possible Specification

1.1. C&I Wireless Automated Meter Reading System

1.1.1. Standard Meter Reading Functions

The System should provide remote meter reading of specific commercial and industrial meters. The System should be capable of providing meter reading and reporting of that information on at least a daily basis.

1.1.1.1. Load Profile Read

As a minimum, the System should support the following load profile meter reading capabilities:

- Electric load profile recording of kWh and kVARh (15-minute interval data, read on a daily basis)
- Flexible data delivery options supporting sub-hourly, hourly, daily or monthly delivery.

1.1.1.2. Register Reads

- Consumption metering (kWh)
- Maximum 15 minute demand for the month (kVAR & kW, reset on cycle read date)
- Cumulative demand for the month (kW & kVAR). Every month the peak demand for the month is totaled into an accumulated peak demand at the same time the maximum 15-minute demand is reset on cycle read day. This value needs to be read before and validated after the 15-minute demand reset.

1.1.2. Wireless Public WAN Communication

The System should use a public wireless network for communications with most of the meters. The master station should use an Internet connection to retrieve the data from the Network Operations Center (NOC).

1.1.2.1. Communication Activity Report

A communications activity report should provide performance information. Your utility can produce this report daily. Each record (line) should contain, as a minimum, the site name, the number of times of successful and unsuccessful meter communication.

1.1.2.2. Communications Statistics

The System should produce the following communication statistics upon operator request:

- Minimum, maximum, average meter communication time.
- Meter communication times by location.

1.1.2.3. Retries

The System should use flexible retry schemes for points that fail to respond.

1.1.3. Phone Modem Communication

The System should also support the use of dial-in modem connections for meters equipped with such devices.

1.1.3.1. Communication Activity Report

A communications activity report should provide performance information. The Buyer can produce this report daily. Each record (line) should contain the site name and the number of times of successful meter communication.

1.1.3.2. Communications Statistics

The System should produce the following communication statistics upon operator request, e.g. successful meter communication times by location.

1.1.3.3. Retries

The System should use flexible retry schemes for points that fail to respond.

1.1.4. Meter Data Processing

The System should have the ability to support meter data processing functions to include data verification, estimation, editing and posting of data:

1.1.4.1. Data Verification and Editing Requirements

The System should compare register readings with totals for profile data. Profile data should be verified by summing all the intervals in the period and comparing to the total energy metered since the previous reading.

The System should determine if expected intervals of data are missing from each set of interval profile data. If intervals are missing, exception reports should inform the operators who should have the ability to continue the processing of the data, automate data insertion into the missing intervals, manually insert data or discard the data and initiate a reread.

The System should retrieve flags from the meter's interval data and stores them in the database. Each interval should be marked with the appropriate flag. Certain selected flags should initiate (1) an exception report from the

System for the operators to investigate or (2) other action by the System as specified in this document. These flags include:

- Power outage
- Meter errors and/or diagnostics
- Gap Data
- Overlap Data condition (see below)
- Test Mode - All data marked with the Test Flag is Gap Data. This data should not be used for any billing data or calculations.

The System should compare the start time of the current data file with the stop time of the previous file. Any overlap should be reported.

1.1.4.2. Demand Resets

Automatic demand resets can be performed as desired with scheduled and non-scheduled communication sessions. The System can also perform communication sessions without resetting demands.

1.1.4.3. Tamper Detection

The C&I Meter should monitor its environment for conditions that may indicate meter tampering. In such an event, the meter should set a flag that should be read by the meter interface board. This board should transmit this information to the master which should provide an operator alert.

1.1.4.4. Flexible Meter Reading

The System shall provide on-demand meter reading of individual meters.

The System should enable utility-specified bill dates and/or intervals. For instance, your utility should be able to offer to bill a customer on a specific date each month or at specific intervals such as every two weeks or 10 days, etc.

The System should enable your utility to bill a customer on any particular date, such as to handle customer moving out or a change in energy vendor.

The System should enable customized billing options like these to meet the needs of commercial, industrial, and other aggregated customer loads.

1.1.4.5. Data Security

The System should ensure that all metering data in the System is secure and that third parties cannot access, intercept or process such data unless explicitly authorized by your utility.

1.1.4.6. Monitoring of System Performance

The communication protocols used for the System should provide on line monitoring of System performance, including data packet transfer, real time configuration status, performance statistics and data collection to ensure that all performance requirements are met. Your utility should have access to all monitoring reports.

1.1.5. Special Reads

The application should perform spontaneous reads of any meter at any time. The communication technology should support this function.

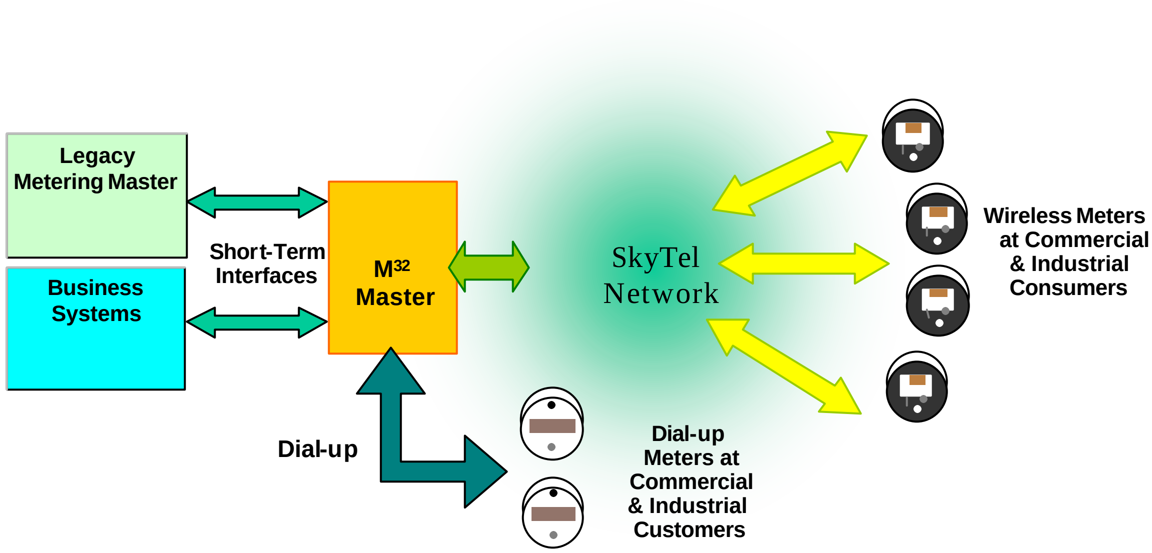
1.1.6. Load Curtailment

A Load curtailment function should be available. This function allows a utility to provide signals to C&I consumers when load curtailment is required, provides inputs for acknowledgement of those signals, and monitors for actual curtailment.

The System should provide communication support, inputs and outputs required for load curtailment. Each utility's implementation of load curtailment is different, so the actual details of implementation should be per your utility's specific requirements.

1.1.7. Submetering

The System should include a submetering function and process data via KYZ pulse inputs to the C&I Meter from submeter KYZ outputs.



Power Quality / Power Reliability – Applications and Possible Spec

The System should be equipped to monitor and report power quality and power reliability (PQ/R). The functions are described below:

System Power Quality / Reliability Monitoring should be supported in two modes:

- The first mode is spontaneous reporting of Power Quality and Power Reliability (PQ/R) events, where the meter reports these events unsolicited.

- The second mode allows querying each meter for an archived file of PQ/R events. The maximum number of events in this file depends on memory size, and how this memory is allocated.

PQ/R Functions:

1) Outage

An outage event is defined as a voltage drop below 50% on any phase for a user defined time (from 1 to 10 minutes).

2) High / Low Voltage Event

A high/low voltage event is defined as the voltage on any phase deviating from the normal voltage on any phase by a user defined percentage (from +/- 5% to 20%) for a user-defined time (from 1 to 30 minutes).

3) Voltage Unbalance

A voltage unbalance event is a deviation of any of the three phase-to-phase voltages from the average voltage on by a user-defined percentage (from 2% to 6%) for a user-defined time (from 15 to 30 minutes). The average voltage is the sum of the three phase-to-phase voltages divided by three. Voltage unbalance should be calculated at a minimum every 5 minutes.

4) Momentary Interruption/Voltage Sag

A momentary interruption/voltage sag (MIVS) is defined as the voltage on any phase deviating from the normal voltage on any phase by a user defined percentage (below 80%) for more than 3 cycles (50 ms). A MIVS event should have occurred when a user programmable number of MIVS events (1 to 10) have occurred within a user defined time window (from 1 to 60 minutes).

5) Power Quality Log

The system should be able to communication with any C&I meter via wireless or dial out to request a table listing all recent power quality events. Each event should be time-tagged to the nearest second, and contain a static text description of the event. Each MIVS should each be recorded as an event.

In Summary – The Best Solution

There are many choices in wireless networks today, and there will be many more choices in the future. Even a cursory evaluation can demonstrate that wireless packet data communication has a lower cost and can support more functions than PSTN. However, the optimum network solution depends on coverage, economics, and C&I app requirements. To design the best solution for C&I AMR, we must be willing to use the most economical network for each location and each application.

Currently the most economical network solution for C&I AMR (daily profile reads) is the digital 2-Way paging network. The 2-Way paging network with the best overall coverage in the US is the SkyTel Network.

The 2-Way paging network offers considerable value:

Lowest Recurring Cost

The recurring communication (service) cost per meter for daily retrieval of load profile intervals range from approximately $5 to $8 per month depending on the data load. This is much less expensive than any other communication service.

Lowest Installed Cost

All meter communication hardware should be under-glass. Additionally, a wireless meter's plug-and-play design means that the meter is actually commissioned into the wireless network during manufacture. When the wireless meter is powered up on site, it defines its new location in the network and immediately starts communicating through the network with the metering master station. No on-site setup is required.

This means that the installation process only requires verifying coverage with a standard Coverage Validation Unit (CVU)), replacing the old meter with a wireless meter, and verifying connectivity to the network. The total elapsed time for the wireless meter's installation is typically under 15 minutes.

The above features, when combined with a very reasonable initial price, and very low service cost means an exceptionally quick payback.

Most Scalable Design

It is possible to start out with a small pilot system consisting of a few hundred meters, and expand this to a system that can cover tens of thousands of C&I consumers. Utilizing public networks, there is no minimum density requirement for the system to be cost-effective. A system could read thousands of meters concentrated in a very small area, or a few hundred meters spread over the whole US. The communication cost per meter for each scenario would be the same with equal data loading.

Features and Benefits to Demand from Your AMR Supplier

- Packet switched IP addressable wireless public network - an **"extension of the Internet"**… empowering all field devices and meters as nodes on the Internet.
- As IP devices, they are **"always on"** and **"always connected"** to the network.
- **Internet connectivity** and web interfaces, direct e-mail, and pager messaging for individuals, groups, or systems… including automated fax and phone messages.
- Interlocked packet switched IP data with FEC for **data security** and efficiency.
- **Efficient message size** and structure, which are optimal for AMR data loads.
- Public network **"information efficiency"** (lowest cost) by innovative data parsing, data compression, protocol management at both the field devices and the host.
- **2-Way communication** - to support spontaneous outage reports and PQ events, load control, real time pricing, remote connect/disconnect, pre-pay metering.
- **Power Quality / Reliability** functions - outage reporting, voltage alarms, etc. Utility can be offer value added $ervice like "call waiting" in the phone industry.
- **Broadcast capabilities** - for load curtailment or real-time pricing signals which are not supported by PSTN and some wireless networks.
- Geographic area **simulcast transmission** (multiple transmitters) and multiple receiver network coordination for superior "in building" penetration.
- A **nationwide network** with economics that do not change according to distance, i.e. no long-distance toll charges for distant or national C&I accounts.
- Significant network RF coverage and a cooperative supplier/service provider strategy to expand to meet future AMR requirements**. "Footprint is King."**
- Mass-produced, **low cost WAN gateway** device such as Motorola CreataLink 2.
- Self-contained unit - **"under the meter glass"** equals lower install costs.
- Automated device registration and coordination **"plug and play"** commissioning; no coordination of modem, meter, communication circuits, and master station.
- Simple installation procedures and tools such as **RF Coverage Validation Unit**; a self-contained "go/no-go" lunch box unit designed for lower skilled workers.
- **Scalable system** architecture means one can start small with a C&I pilot and, over time, evolve and grow large to full deployment AMR… including residential.
- **Cost displacement payback (ROI) within two (2) years.**