OVERVIEW OF AUTOMATIC METER READING FOR THE WATER INDUSTRY

Paper Presented by :

Allan Readdy

Author:

Allan Readdy, *National Accounts Manager – Electricity,*

Elster Metering

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Allan Readdy, *National Accounts Manager – Electricity,* Elster Metering Pty Ltd

ABSTRACT

Many water meters can be read visually with little difficulty. However, there are situations, both urban and rural, where it is very difficult to access meters, which makes meter reading time consuming and on occasions down right dangerous. For such locations, some form of remote automatic meter reading (AMR) system is both convenient and cost effective.

The paper defines AMR and outlines the strengths and weaknesses of the various communication methods that are currently available.

Significant properties of radio waves are considered. A brief explanation of the popular low power wireless systems is also presented.

One of the criteria of a successful AMR system is seamless integration into an existing meter reading system. Hence implementation is addressed in the final stage of the presentation.

1.0 DEFINITION OF AMR

While there are a variety of methods for reading meters without actually sighting the meter register, not all of these are regarded as AMR.

So-called 'touch read' systems, where a sensing head (attached to some form of hand held computer) is brought into contact with a data collector located either on the meter or at a short distance from the meter, are in common usage. Such meter reading methods are not considered as AMR because the meter reader still needs to get close to the meter or out-reader.

It is generally agreed that any system that enables meters to be read at a distance of 100 meters or greater (from the meter position) is true AMR.

2.0 THE JUSTIFICATION FOR AMR

The majority of water meters can be read for a few dollars a year without risk of injury to meter readers. However there are a number of meters in a meter fleet where this is certainly not the situation.

Site related personnel injury risk and the associated liabilities are a concern where savage animals, hidden hazards, barbed wire fences and meters in dangerous locations exist.

At another level, not all meters are readily accessed by meter readers. Meters installed behind locked gates or in difficult terrain take longer to read and as such increase reading costs. Restricted access imposed by hostile property owners also add to costs.

While often not a significant problem, inaccurate manual meter reads can lead to customer disputes, which take time and money to resolve.

In light of the above, there are few utilities that would not benefit from installation of some form of AMR.

3.0 AMR COMMUNICATION METHODS

3.1 Phone Line

Readings are collected remotely via the public switched telephone network (PSTN). Obviously this entails fitting a data collector and 'phone modem to each meter. A mains supply (or battery and solar panel) is needed to power the modem. Connection to a telephone line is also required. Whether or not a dedicated or shared phone line is used is a matter for negation with the property owner. The recurring costs associated with this system are not insignificant.

In circumstances where there is a very high population density e.g. vertical high rise apartments or low rise horizontal apartment complexes, 'hardwired' AMR systems are still common. These utilise a central data collector and generally a modem connected to a 'phone line. By having a large number of consumers effectively sharing line rental and other charges, operating costs are not such an issue. However, 'point to point wiring' communication systems, have other disadvantages, of which not all are apparent initially. Some of these are detailed:

- An extensive dedicated communication wiring system has to be installed.
- If this hard wiring is installed during the course of construction of a new building the costs are reasonable. However to carry out such installations in existing buildings is cost prohibitive.
- Commissioning of these systems often costs more than budget, because of the need to correct wiring errors during installation.
- Inevitably there are numerous interconnections in hardwired systems.
- Experience has proved, that over time, faults appear in the hard wired network as a result of high electrical resistance developing at interconnections and other cable termination points. Tracing and rectification of such faults is costly and time consuming.
- Attack by rodents is also responsible for malfunction of hard wired systems.
- To make subsequent changes to an existing hard wired system is very costly.

3.2 Power Line Carrier (PLC)

While power lines are ubiquitous, communication via PLC is not common in Australia. Special power line carrier modems are needed and clearly these require connection to the power line. Agreement with the power utility to access their network is also required. Currently PLC hardware is expensive.

3.3 Wide Area RF Network

Meter readings are stored and sent by way of a long range radio network. Such a network can be a public network (GSM, GPRS, CDMA) or a private radio network. As with the two communication methods already mentioned, this one also requires modems and a source of power. A service and usage contract has to be established with the network operator.

For this method to operate, there needs to be effective and reliable network coverage at the meter location.

3.4 Local RF

Meters are fitted with small data collectors and low power radio transmitters (or radio transceivers). Batteries with 10+ year's service life are routinely fitted to these units. Read data is collected remotely either by 'Walk-by' or 'Drive-by' (i.e. vehicle mounted) receivers and computers.

When applied to a fixed AMR network in an apartment complex, Local RF frequently utilises one or more radio repeaters to overcome 'transmission' obstacles. A central receiver and data concentrator completes the hardware complement. Connection to the 'outside world' is by way of PSTN or GSM modem.

Low power wireless AMR systems suffer none of the problems of hardwired 'point to point' systems. They can be quickly and easily installed in both new and existing apartment buildings. The performance of a correctly installed wireless AMR system does not deteriorate with the passage of time. Subsequent building refurbishment is of no consequence to a wireless AMR system.

4.0 WIRELESS COMMUNICATION

To help understand what affects the reliability and performance of wireless communication it is worthwhile to consider some of the significant phenomena of radio waves.

4.1 Reflection

The law of reflection is the angle of incidence equals the angle of reflection. Good conductors (e.g. metals) are good reflectors of radio waves.

4.2 Absorption

Different materials absorb radio waves to differing extents. Absorption causes a reduction in the strength (attenuation) of the wave as it passes through the material. Good absorbers of radio waves include water, earth (soil, rock, etc), concrete and wood.

4.3 Diffraction

Waves tend to spread out as they travel. They can bend around obstacles in their path or spread out past openings. Diffraction has the greatest effect when the openings/obstacles are about the dimensions of a wavelength. This phenomenon is significant (particularly indoors). However it is difficult to calculate.

4.4 Interference

When two waves pass through the same point, they interact with each other. This leads to constructive and destructive interference.

Because of diffraction and reflection, radio waves from a single point source can take different routes to a given point.

These various wave trains interfere at this point. If strong destructive interference takes place, a dead point is created – a point where the radio signal from the source cannot be detected.

4.5 Polarisation

A radio wave is made up of an electric field and a magnetic field. (The electric field must be perpendicular to the direction of propagation). If a wave is travelling horizontally, the electric field can point vertically, horizontally, or somewhere in between.

The orientation of the electric field is called the polarisation. For optimum reception, the transmitter and receiver antennas need to have the same polarisation i.e. the antennas need to be oriented in the same way.

4.6 Radiation

A radio wave stores energy in it's electric and magnetic fields. Radio waves transfer energy from one place to another. This is called radiation. The rate at which a source radiates energy is called its power, measured in W, mW or dBm. The intensity of radiation is the power flow per unit area, measured in W/m^2.

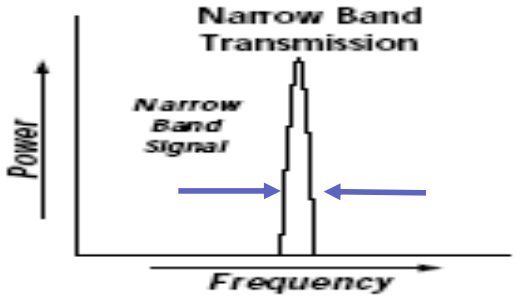
In empty space, the intensity from a radiation source follows an "inverse square law" drop off.

In real life, there are always reflections from the ground causing interference. This leads to weak spots near to the transmitter and a faster drop off further away (proportional to $1/r^4$. This makes predictions of signal strength very difficult.

5.0 POPULAR LOW POWER AMR WIRELESS SYSTEMS

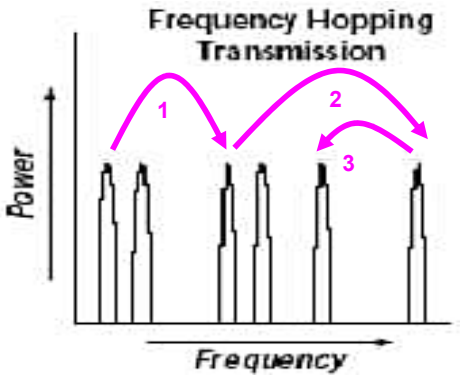
5.1 Narrow Band

Data is transmitted on carrier waves. In narrow band communication, the carrier wave has a single frequency. When this is modulated with data, there is a small range of frequencies present. This is called the bandwidth.



5.2 Frequency Hopping Spread Spectrum (FHSS)

The carrier wave hops between frequencies in a pseudo-random fashion. The receiver knows the hopping sequence so it can keep track of what frequency the transmitter is operating on.



5.3 Comparison of Narrow band and FHSS

Narrow band equipment is usually easier and cheaper to produce. However FHSS does have a number of advantages that are very worthwhile in fixed network systems. These are

- Reduced interference from other systems;
- Resistant to jamming and eavesdropping;
- Reduced multi-path interference (dead spots);
- Redundant message transmission is possible.

6.0 AMR IMPLEMENTATION

Depending on the operating frequency and transmission power of the AMR equipment used, various licence fees and network usage charges apply.

In Australia, most low power local RF systems utilise the so-called Class Licence bands at 433MHz and 915 – 928 MHz. Equipment operating in these bands does not require individual user licences. Such hardware must meet satisfy performance parameters such as frequency of operation, spurious radiated emission, and maximum radiated power. These requirements are detailed in AS/NZS 4268:2003 and ACMA (previously ACA) publications 'Radiocommunications (Spread Spectrum Devices) Class Licence 2002' and 'Radiocommunications (Low Interference Potential Devices) Class Licence Variation 2005'

As AMR equipment for field use is frequently called upon to operate reliably in harsh environments, its important that such equipment be robust and have at least an IP68 rating. Gear, which performs adequately in a workshop or office setting, can have an alarmingly short life in the field.

Power consumption of battery operated AMR transmitters (attached to water meters) should be as low as possible, consistent with licence and performance requirements. For Class Licence transmitters battery life (between replacement) should be 10+ years.

Portable receivers should have a facility to conserve power (when not actually receiving signals) to ensure that the period between charging is at least one working day, for obvious reasons.

It is important that the meter read data retrieved by AMR can be 'seamlessly' transferred to existing information systems e.g. customer and billing systems. Invariably this entails some development or modification of software interfaces. Manual transfer of data to these systems simply adds unnecessary cost.

Adequate vendor support for any AMR system purchased, not only at the outset but also on an ongoing basis, is essential. Such support should also include operator training.

7.0 CONCLUSIONS

Appropriate AMR solves elegantly solves the problem of 'hard to read meters' for water utilities. Generally, such 'reads' account for between five and ten percent of the total meter population. Hence it's usually possible to justify the cost of at least a modest AMR system that can be incrementally expanded (with no further outlay on infrastructure) as demand grows.

Local RF AMR systems operating in the Class Licence bands provide a low cost solution which addresses the majority of 'difficult access' meter reads.