POWERLINE CARRIER – THE BASIS FOR ADVANCED METERING

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ABSTRACT

Powerline Carrier communication forms the basis of the majority of Smart Meters and Advanced Metering (AM) systems world wide. Besides many proprietary solutions, several manufacturers offer standardised PLC systems based on the IEC 61334 standards.

EUROPE ON THE VERGE OF ADVANCED METERING (AM)

Triggered by the activities in Italy and Sweden Advanced Metering has become a major topic for most of the European utilities. In the different countries the economical and the legal environment varies a lot. Nevertheless, in most of the cases the drivers behind AM can be narrowed down to two scenarios:

The "monthly billing scenario": where a law requires monthly meter reading. In this case the installation of an AM system can be economically justified by the "classical" Automatic meter reading (AMR) application alone. However, advanced metering applications offer the potential for additional business opportunities.

The "complex contracts and bad payers scenario": where the residential customers are used to demand based contracts that may even include the possibility of a complete disconnection of the power supply. Where further, substantial savings can be realised by reducing technical and non-technical losses. Or, where load management is part of the customer contracts.

Figure 1 illustrates the contribution of the different applications to the total value of an AM system. The applications are grouped into three segments:

Utility services:
Supporting the commercial and the operational processes of the distribution network operator.

- *Automatic Meter Reading* supports the billing data collection and validation process, from the meter to the billing system. At least monthly values are collected. However, more and more utilities shorten the reading cycle to "daily values". With a resolution of one day all of today's billing requirements can be satisfied: monthly bill, tenancy change, supplier change.
- *Network Mgt Support* supervises the MV/LV transformer stations and the endpoints in the distribution network to detect power outages and to support the power restoration process. Further, comprehensive event logging of power outages, and of over/under voltages provide the basis for "power quality" based contracts.
- *Tariff management* may be performed locally with downloadable tariff switching tables or, centrally by means of the load curves (e.g. hourly values). With the availability of a "real time" channel between the utility and the customer, "peak pricing" schemes can be introduced.

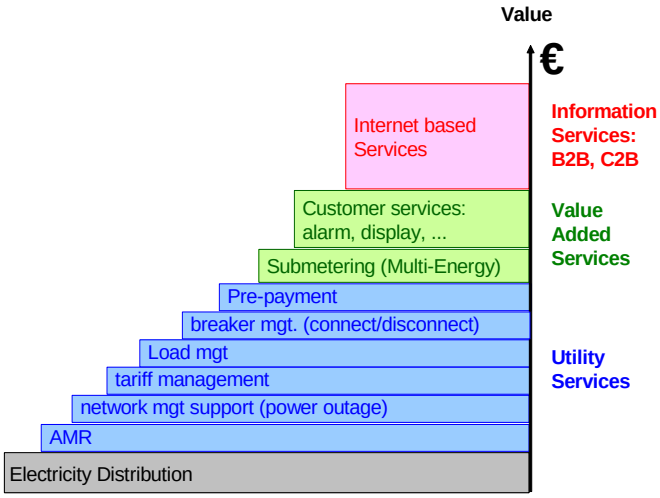

Figure 1: The Advanced Metering value staircase

- *Load Management* is typically performed with big loads (e.g. hot water/storage heaters or air conditioners). The loads are disconnected and reconnected depending on the network conditions and on contractual conditions. In cases of power shortages "emergency load shedding" is foreseen.
- *Breaker Management* is used to disconnect (or put on limited load) "bad payers" and to support the tenant change process. For that purpose the "smart meters" are equipped with a "breaker" to connect

and disconnect the customer's premises. The breaker can be operated remotely and locally (by the customer and/or by considering a maximum load). The local intelligence of the smart meter supervises the breaker operation in order to meet the safety requirements.

- *Prepayment.* With the installation of an AM system the technical foundation (breaker and two way communication between the utility and the point of delivery) for pre-payment applications is available.
  With the introduction of the breaker for all customers, the utility has different options to treat "difficult customers": from simply disconnecting them to putting them on a proper pre-payment scheme.

Value Added Services:
opening new business fields trough new service offerings. based on existing utility competences.

- *Sub-metering* (i.e. using the smart electricity meter as a gateway to read heat, gas and water meters) is particularly attractive in environments where the electricity distributor is also responsible for the distribution of the other media.
- *Extended customer services*: e.g. energy conservation; supervision and alarm handling at the customers premises.

Information Services:
Smart meters create a comprehensive set of data. The advanced metering system collects the data and processes information about the customer's energy consumption and about the electricity distribution quality. This information can be made available to the end customers and to other participants of the energy market.

HOW DOES EUROPE GO FOR ADVANCED METERING ?

While Italy seems to have decided for PLC (power line carrier), in Scandinavia several communication technologies are competing against each other. An overview on the major communication technologies used in Europe is presented in figure 2.

PLC systems

use carrier frequencies between 9 kHz and 95 KHz in the Cenelec A band (Low frequency PLC systems with signals crossing the MV/LV transformers are successfully used in rural areas of Scandinavia, where the installation of a concentrator cannot be economically justified. However, due to limited bandwidths also the applications are limited.). Typically the frequencies are chosen well above 30 kHz. Due to the high carrier frequencies communication is restricted to the low voltage (LV) network; i.e. the signals do not cross the MV/LV transformer. These PLC systems typically provide a cannel capacity of 1000-5000 bits/sec. Besides many proprietary solutions, there exists standardised PLC systems (IEC 61334) offered by several manufacturers.

A Concentrator acts not only as a gateway between the LV-PLC network and the public telecom network. The concentrator manages the PLC communication, performs scheduled or spontaneous data acquisition tasks and stores the results. Communication in the LV network is free of charge. The PLC communication network is available 24 hours a day just for advanced metering applications. Mission critical communication tasks can be dispersed over time in order to achieve maximum reliability.

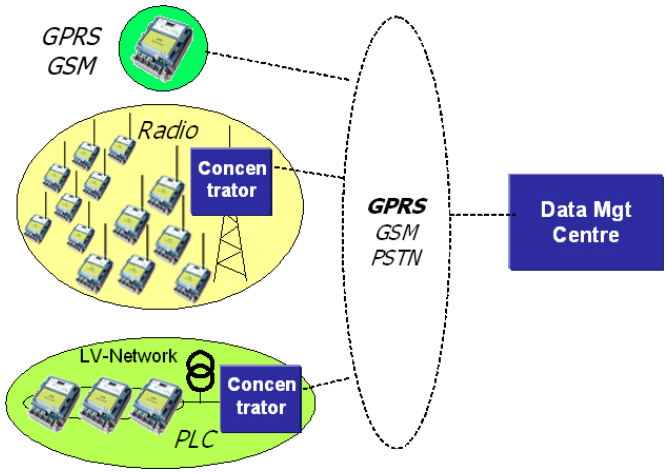

Figure 2: Communication technologies used for Advanced Metering

Engineering and Installation:
PLC systems which are designed for plug and play installation (e.g. according to IEC 61334-4-512) do not need any engineering effort. The concentrator and the metering units are installed without any pre-configuration; in particular, no topology information needs to be programmed into any device. No pushbuttons must be pressed after installation. The system automatically detects new metering points, configures the network and optimised the message routing paths. Installation is normally performed by just one person.

Maintenance:
In case of modifications in the distribution network topology (e.g. repair work) the metering points are automatically handed over from one concentrator to the other concentrator (new transformer feeding the corresponding network part).

Operating costs:
All data which is collected at the metering points and stored in the concentrator must be transported to the central data management system. If no wire based medium is available at the concentrator, GPRS is the most cost efficient communication channel to be used. The concentrator provides enough processing power to efficiently encode the metering data for transportation to the Data Management system. Through the use of the concentrator the GPRS costs can be substantially reduced compared to point-to-point GPRS communication.

Radio systems

Use frequencies in license free bands or in bands which are reserved for utility applications. Some systems are hierarchically organised, some systems use meshed technologies. Radio systems are typically used in rural locations. Concentrators – similar to PLC – serve as gateways to the public telecom network. The radio systems are based on proprietary technologies, there is no IEC standard available.

Engineering and Installation:
Prior to installation, radio systems need intensive engineering. Topology maps, considering radio coverage must be computed and locations for the repeaters and concentrators must be identified. The radio devices are typically equipped with external antennas. If the meter is installed in a metallic box, a hole must be drilled and the antenna is attached at the outside of the box. The antenna must be directed for optimal transmission and reception. Normally the installation of a radio device needs two persons.

Maintenance:
Communication quality in a radio network must be supervised. Topology changes (growing trees, new buildings) can substantially influence the communication performance. With the help of GIS systems (Geographical Information Systems) and with the communication statistics provided by the concentrators, critical points are identified and countermeasures are planned.

Operating costs:
Are similar to the PLC operating costs.

GPRS/GSM systems

offer direct wireless access to existing telecom networks and to the Internet. There is no need to establish and maintain a new communication infrastructure. The channel capacity required for advanced metering applications is neglectable compared to typical GPRS business applications.

Some GPRS providers assign only temporary Internet addresses to the meters. This could make additional GPRS routing functions in the central data management system necessary. Additional security measures must be considered for communication over the Internet. Finally, the system should not rely on GPRS only; the classical GSM data service must be kept available as backup medium.

Today the cost of a GPRS modem still exceeds the cost of a PLC modem by a factor of two or more.

Engineering and Installation:
Prior to installation, GPRS systems need some engineering. Radio coverage of the different providers must be considered in the planning process. For rural areas, coverage problems – reducing the communication reliability - must be considered. Contracts with the suitable providers must be negotiated and the SIM cards need to be configured accordingly.

	PLC	Radio	GPRS GSM
Topology **+** cost effective 0 neutral - not cost effective			
very rural	-	0	0
rural	0	+	+
urban	+	-	+
Reliability **+** reliable - unreliable			
very rural	+	+	-
rural	+	+	-
urban	+	-	+
Applications **+** suitable - not suitable			
monthly billing data	+	+	+
Load curves	+	+	+
Tariff/Contract mgt	+	+	+
Advanced applications	+	+	+
Costs **+** low 0 medium - high			
Engineering	+	-	0
Installation	+	-	-
Operation	+	+	-
equipment	+	+	-

Table 1: AM communication technologies

Maintenance:
Maintenance of the GPRS/GSM network is done by the

network operator. As a consequence, the utility depends on the quality of service provided by the network operator. Experience in Scandinavia shows, that for large scale deployment of GPRS/GSM based systems a close cooperation with the network operator is recommended.

Operating costs:
Depend on the price policy of the network operator. Considering the fact, that AM applications only use a very small part of the available network capacity and that bulk data transport can be scheduled during "non-busy" times (e.g. 00:00 to .06:00) innovative pricing schemes for AM applications may be expected in the future.

Table 1 summarises the different communication technologies and evaluates their suitability for major advanced metering applications.

Considering the high engineering, installation and maintenance costs involved with radio systems, PLC systems are more and more getting considered even for rural areas. With the price decay of GPRS modems, GPRS may be considered as an alternative to PLC in specific environments. The economical threshold between PLC and GPRS depends very much on the operating fees charged by the operator.

Generally PLC communication offers the most cost effective solution for Advanced Metering applications. Further, PLC allows the distributing utility to use its own network as a basis for advanced metering; i.e. the utility does not depend on a third party to support its mission critical business processes.

PLC – THE STANDARD IS AT HAND

The first generations of AMR systems (radio or PLC) were based on manufacturer specific solutions. With the globalisation of the markets the utilities can no more relay on local, proprietary solutions. Only a standardised system which is completely open and where no hidden property rights and licensing issues are involved can guarantee its availability also in the future. Besides EdF in France several European utilities started the deployment of AM systems based on international PLC standards (IEC 61334).

Standardisation started on communication protocol level. However, experience from industrial and commercial metering shows that a standardised protocol does not ensure interoperability on data management level. Today major IT costs are caused by incompatibilities of the data models between different applications. The IEC 62056-62 standard provides the data models that support advanced metering applications. The models of IEC 62056-62 are supported by the application layer (IEC 61334-41, DLMS), the link layer (IEC 61334-4-32) and the MAC-Physical layer (IEC 61334-5-1). These communication protocols are optimised to cope with the specific conditions of the PLC channel. In particular, the protocols provide robust modulation and the necessary error protection to cope with the heavy disturbances encountered on the distribution network. On the other hand the protocols are lean and are avoiding any unnecessary overhead.

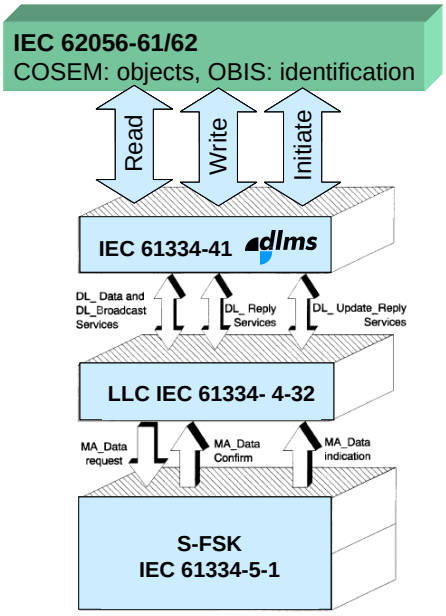

Figure 3: The standardised PLC protocol stack for advanced metering

The combination of robustness and efficiency provided by the complete IEC 61334 protocol stack (shown in figure 3) makes PLC communication capable to cope with the challenges of advanced metering - today and tomorrow.

CONCLUSIONS

Today PLC offers the most cost-efficient communication technology supporting advanced metering applications. The existing IEC standards form the basis for manufacturer independent solutions. PLC enables the utility to keep full control over the communication backbone for their crucial business processes. GPRS may be considered as alternative to PLC. However, reliable and efficient solutions are only possible in close cooperation with the GPRS network operator. To lower the risk for the utility, long term service level agreements with the network operators should be considered.