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Standards: From Ideology to Reality

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Abstract: **Standards are a crucial factor for the acceptance of a new technology. The paper reports on the standardisation activities concerning distribution line carrier communication (DLC) between the utility and the energy consumer. Standardisation is always a compromise between the openness for future expansions and the complexity of today's implementations. This conflict is analysed considering the standardisation activities of IEC TC57, WG09.**

1. INTRODUCTION

Distribution Automation and Demand Side Management depend on efficient communication channels between the utility and the consumer. Recent developments in Distribution Line Carrier (DLC) technology and in radio technology open a wide field of new applications. The technical feasibility of the new technologies was proven in several pilot installations during the last few years .

The large scale introduction of data communication between the utility and the consumer represents a substantial investment which has to be secured for the future. There are two conditions which have to be fulfilled by such a communication system:

- The communication system must be independent of the applications, future expansions must be possible.
- The communication system must be standardised such that it (or parts of it) can be produced by several manufacturers.

The well-known OSI (Open System Interconnection) approach considers the conditions stated above. It does that by mapping the communication process to a seven layer model. The basic idea behind the layering is to use the "delegate and forget" principle as illustrated in Figure 1:

Assuming that a Dutch lawyer and a German lawyer want to exchange some information, each sitting in his office in Denmark and in Germany. The lawyer writes the text in his native language and delegates the translation to the interpreter. The interpreter translates the text into a "neutral" (abstract syntax, ASN.1) language (English) and delegates the transportation to his secretary. The secretary looks up the fax number and delegates the actual data transmission to the local telecom company.

In the following we will focus on DLC communication, a technology which uses the electricity distribution network for communication purposes. This technology is particularly attractive for the electricity utility because the network is under the utility's own control. However, most of the statements in this paper are also valid for other communication channels.

2. THE ARCHITECTURE

The OSI model was originally developed for data exchange between computers. For the "low cost" applications envisaged in Demand Side Management the complexity of the model must be reduced. The international standardisation committee IEC TC57, WG09 proposes a communication protocol which considers 3 layers. The three layer model is displayed in Figure 2. It consists of a *Physical Layer* which defines the modulation method, a *Data Link Layer* defining the channel access method, error control mechanisms and the addressing schemes, and the *Application Layer* which defines the presentation and the access of the data. Different applications can run on the same lower layers (Physical and Data Link). The applications are addressed individually or in groups via their connections to the Data Link Layer. These connections are called *Link Service Access Points (L-SAP).*

The addressing capabilities of this model can be compared with a private telephone branch exchange where the telephone number of the branch exchange corresponds to the address of the MAC sublayer and the telephone number of the extension corresponds to the address of the L-SAP.

The definition of the applications is not part of the standardisation. They are defined according to the actual needs (e.g. application 1: meter reading, application 2: gateway to home system). The communication standard must only guarantee that the services provided by the application layer can cover the communication needs of the applications. The application "System Management" is always present. It contains all necessary processes and data to perform the management of the communication system (e.g. group address tables, enciphering keys, station discovering algorithm).

2. THE LOWER LAYERS

In order to keep the doors open for future developments in technology, different modulation schemes are foreseen at the physical layer. At the moment two principles are proposed in the corresponding IEC TC57 technical reports:

- Frequency Shift Keying, a classical narrow band modulation scheme.
- Spread Frequency Shift Keying, a new modulation scheme which is a combination between narrow band and spread-spectrum technology.

The Medium Access (MAC) part of the data link layer is normally strongly related to the underlying physical layer. Therefore the MAC sublayer is also part of the report describing the physical layer. The corresponding model is shown in Figure 3.

The Logical Link Control (LLC) sublayer is general and simple enough to allow low-cost implementations. In addition it offers enough addressing possibilities to cover also the future needs of DSM. The LLC sublayer is going to become an international standard.

3. THE APPLICATION LAYER

The most controversial layer is the "application layer". It is at the application layer where the fights between the "ideologists" and the "realists" are fought.

The Link Service Access Point (L-SAP) offers the communication services of the link layer to the application layer. The basic link services are:

- *DL-DataRequest*, the service which sends a packet of bits to the destination L-SAP;
- *DL-DataIndication* , the service which announces the reception of a packet of data from a source L-SAP.

The purpose of the application layer is to offer the "glue" between the application and the L-SAP services. The approaches to the application layer can be divided into two groups: The "command approach" and the "object-service approach". The differences between these approaches seem to be irreconcilable. The first approach claims to be the only efficient approach whereas the second one claims to be the only systematic approach.

Both approaches offer some sort of "command language" which is interpreted at the destination application layer. In both cases the "commands" are defined with a certain model of the application in mind. It is the model which makes the difference between the two approaches.

In the following the two approaches are explained with the help of the electricity meter shown in Figure 4. The meter consists of two tariff registers A and B, a switch which can toggle between tariff A and tariff B and the serial number.

3.1. The Command approach:

Today there is a well accepted standard which represents the command approach. It is known as IEC1107 or FLAG or ZVEI. In its basic version it consists of one command which says "give me your data". The meter then delivers all its data (serial nr., tariff A, tariff B and status of the switch) in an ASCII string. The IEC1107 standard is widely used for meter reading with hand held terminals.

The next step of sophistication is achieved when the command language offers access to specific data. The commands may then look as follows:

command	meaning	answer from meter
01	give me the contents of the tariff A register	contents of tariff A register
02	give me the contents of the tariff B register	contents of tariff B register
03	give me your serial number	serial number
04	switch to tariff A	acknowledgement
05	switch to tariff B	acknowledgement

As long as we are only dealing with such a simple meter which is produced by just one manufacturer the command approach fits our needs perfectly. But what do we do when we want to get data from different kind of meters or, if we want to exchange data between completely different types of equipment, e.g. tariff devices, load-controllers, domestic energy managers? Equipment which is produced by different manufacturers? Do we have to extend our set of commands (and therefore the application layer) with each new device? Who defines the format of the data received ? How is the interoperability between the equipment of different manufacturers tested ?

3.2 The Object-Service Approach:

Solutions for the problems stated above exist since about ten years. They are known as: MMS (Manufacturing Messaging Service) , FTAM (File Tranfer, Access and Management), ... These standards are based on models of "virtual equipment", "objects", "domains", "services" etc. A systems which is designed according to these standards is "future-proof", i.e. can cover all kind of applications, also the ones which are not known today.

The only disadvantage of these standards is that they were developed for computer networks. For equipment with a price level of about two orders of magnitude higher that the ones envisaged for DSM. If we would apply them to our DSM equipment we would create future-proof systems for which there is no future because they are too complex to be sold.

IEC TC57 proposes a "tamed" version of MMS which fits the needs of low cost equipment.

3.3 Distribution Line Messaging Specification (DLMS): "The poor man's MMS":

DLMS assumes that the behaviour of every DSM equipment can be modelled with 2 types of objects:

variable	with the main access services:	*read, write*
tasks	with the main access services:	*start, stop, resume* .

The strict separation between the objects and the access services allows the manufacturer to design its equipment freely by using the building stones (objects) of DLMS. Although he does not need to consider the aspects of communication, data can always be accessed through the standardised services of DLMS.

For most of the DSM equipment envisaged today the object *variable* offers by far enough features. Therefore the treatment of *tasks* is optional. A *variable* is always defined by its *name* and by its *type.* The electricity meter shown in Figure 4 can be modelled in DLMS as follows:

variable name	variable type	name in Fig. 4
1	octet string	tariff A
2	octet string	tariff B
3	octet string	serial number
4	boolean	tariff switch (true: A, false: B)

Besides the simple variable, DLMS offers also the possibility to structure the variables as arrays or records and to access elements or subsets of the structures. The definitions of the variables and of the access protocols are described in ASN.1, a widely used standard for defining upper layer protocols.

The switching to tariff B can be initiated by writing the value "false" to the boolean variable "4" of the meter. With the corresponding protocol data unit (pdu) described in ASN.1:

```
[6]WriteRequest:=   {VariableAccessSpecification::=   ObjectName,
                                            Data::=   [3]BOOLEAN }
```

Obviously, the ASN.1 expression stated above cannot be transmitted directly via the channel (using the LLC service *DL-DataRequest)*. We have to define a rule how ASN.1 is coded into bits and bytes. For DLMS there exists a proposal of a simple and efficient (avoiding protocol overhead) encoding rule - the "Adapted External Encoding Rule" (A-XDR). Applying A-XDR to the protocol data unit above leads to the following sequence of bytes:

6	1	0	0	4	3	0
WriteReqest	nr. of variables	direct access, no structure	object name high byte	object name low byte	type: boolean	data: false

The number of bytes which have to be transported by using DLMS is certainly larger than by using the "command" approach of section 3.1. But, considering the advantages the few extra bytes are a good investment.

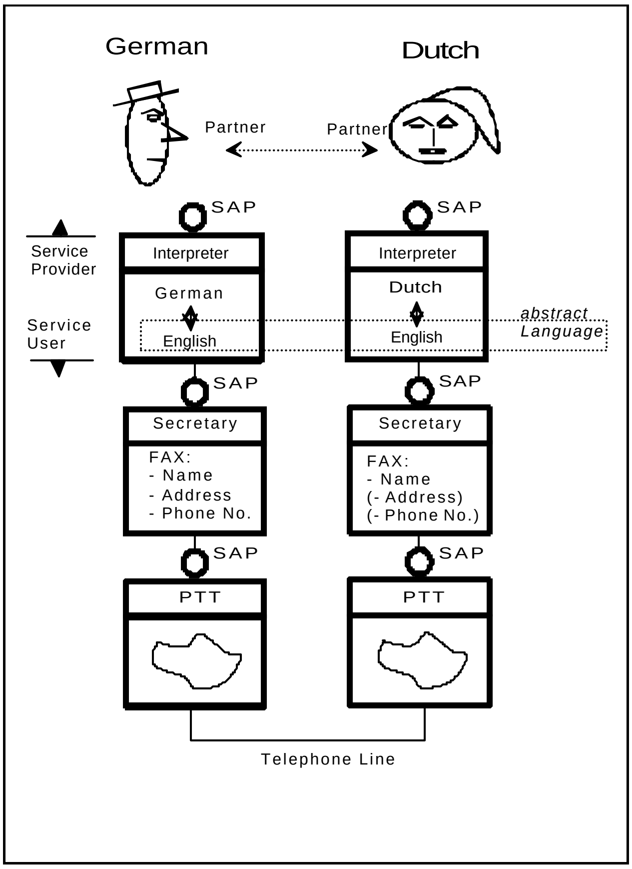

Figure 1: The OSI principle "delegate and forget"

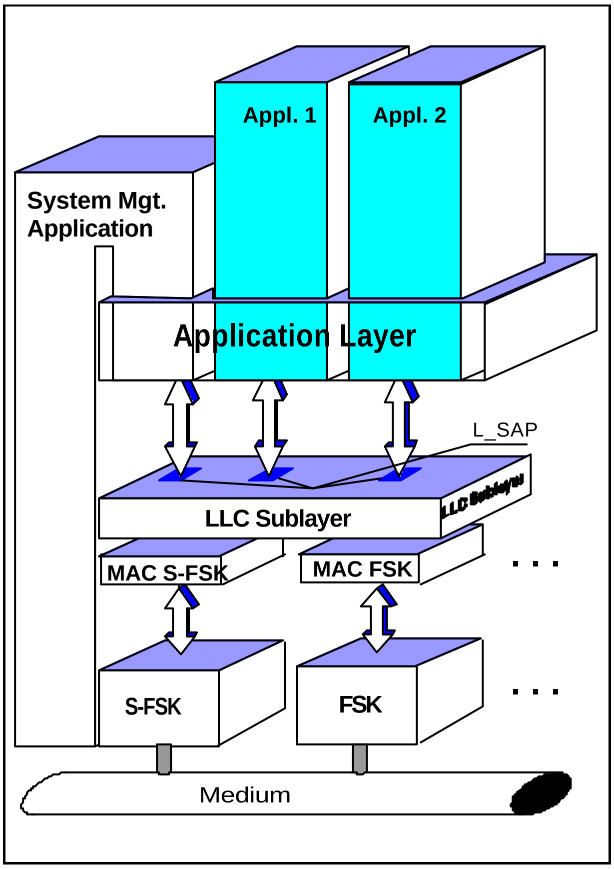

Figure 3: The IEC TC57 approach:
one Standard for the Appl. and LCC, several Reports for MAC-Phys.

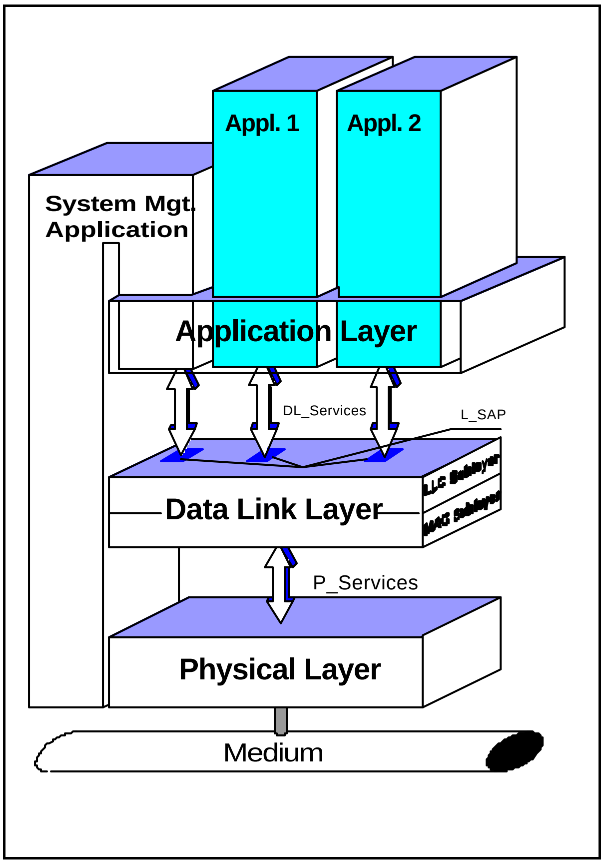

Figure 2: Collapsed 3 layer model

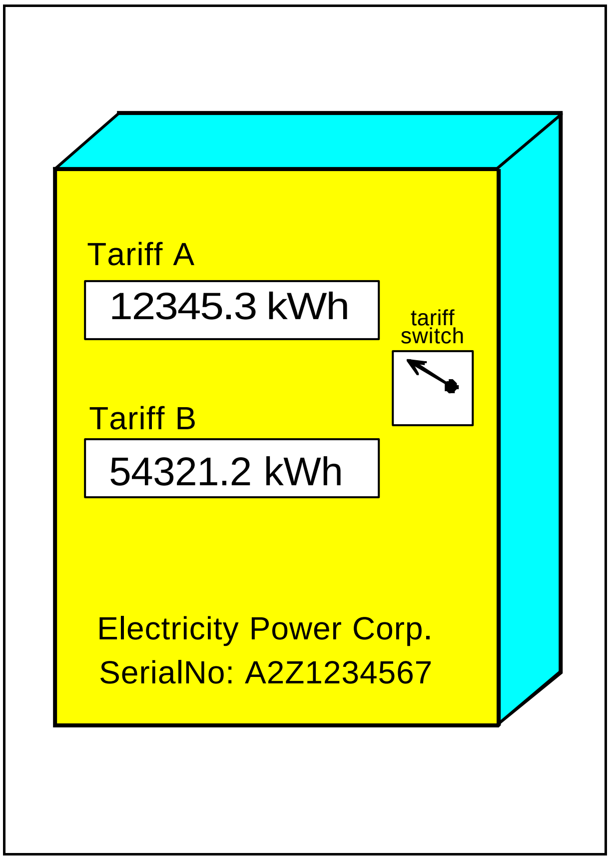

Figure 4: A Electricity Meter