INTEROPERABILITY IN IRAN'S SMART METERING PROJECT

In the second part of a three-part series, we examine the Iranian smart metering programme and the challenges of ensuring interoperability across a variety of legacy systems.

Based on the importance of interoperability in the implementation of AMI, it is essential to introduce a detailed solution, protocols, and international standards, in both meter and control centre levels, in order to consider different implementation challenges.

The Iran smart grid road map objectives and Iran AMI use cases identify that smart meters and smart grids are mostly likely to include the following technology options:

Smart grid portfolio:
- **HV networks:** automation, transmission line sensors, FACTS devices such as SVC and STATCOMs, short current circuit limiters for lines and HV substations with related communication and IT infrastructure, cybersecurity and management systems.
- **MV networks:** automation, identification and recovery of network faults, voltage and/or current sensors for voltage control, smart inverters, intelligent reclosers and switches, SCADA and DMS systems, with related communication and IT infrastructure, cybersecurity and management systems.
- **Generation:** new generators' adaptation to technical developments (such as synthetic inertia, low voltage ride through, four-quadrants inverters, frequency response) as required by technical standards or grid codes.

Smart meter technologies:
- Remote meter reading, two-way communication for software upgrades, customer account management, multiple tariffs and other key functions as covered by the functional requirements detailed.

With respect to the communication architecture for smart meters, there are a number of options and combinations of technologies that could be implemented. This choice will be a key element for the success of the overall programme and at the same time must take a prudent view of likely advances in the telecommunications field. Possible solutions could consist of a mix of data concentrator models or a direct communication model, both using a variety of mediums such as power line carrier, meshed wireless networks (Wi-Fi, RF), private or public fibre optic networks, public mobile networks (GPRS) and others.

As regards to communication standards and protocols, the IEC 62056 (DLMS/COSEM 3)

and IEC 61968-9 are being widely used by worldwide suppliers of smart meters and would give a good chance of achieving full interoperability (and exchangeability) of metering components from different manufacturers. Interoperability in Iran's AMI system means that meters from different manufacturers should be able to work with all various types of concentrators made by other manufactures. Every O&M device should connect to different types of meters and concentrators and the central access system (CAS) manage all AMI devices regardless of their manufacturers. All these items shall be fulfilled without any additional devices or protocol convertors and without interfering with the system on line operation.

Figure 1 describes the smart metering project's information exchange architecture (conceptual architecture of FAHAM interoperability between smart meters, AHEs, MDM, and application systems). This system is made up of various elements as illustrated, namely:

- FID 1: describes the data exchange between the meter data management (MDM) and the advance head end system (AHE) along the interfaces DI1 – SI3;
- FID 2: describes the data exchange between the advance head end system (AHE) and the meters. This package is divided into 3 parts:
- FID 2-1: describes the data exchange between the advance head end system (AHE) and the high consumption meters (electricity, water and gas) along the interfaces SI2 – MI2;
- FID 2-2: describes the data exchange between the DC and the PLC meters (electricity) and gas/water meters via M-Bus along the interfaces CI1 – MI1
- FID 2-3: describes the data exchange between the advance head end system (AHE) and the data concentrator (DC) along the interfaces SI2 – CI2;
- FID 3: describes the data exchange between the MDM and legacy (application) systems (billing, OMS, CIS, etc.) along the interface DI2.

Iran smart metering information exchange architecture

In general terms, the interoperability architecture of the smart metering project is presented in Figure 2. As it can be seen, interoperability can be classified between application systems and MDM (based on IEC 61968-9), MDM and AHE (based on IEC 61968-9), AHE and data concentrator (for high-consumption costumer, based on IEC 62056-9), AHE and smart meters (for low-consumption costumer, based on DLMS/COSEM), and finally between data concentrator and smart meter (based on DLMS/COSEM).

It is worth mentioning that the FID 2-1 package actually refers to the direct communication between AHE and meters through GPRS regardless of the meter type.

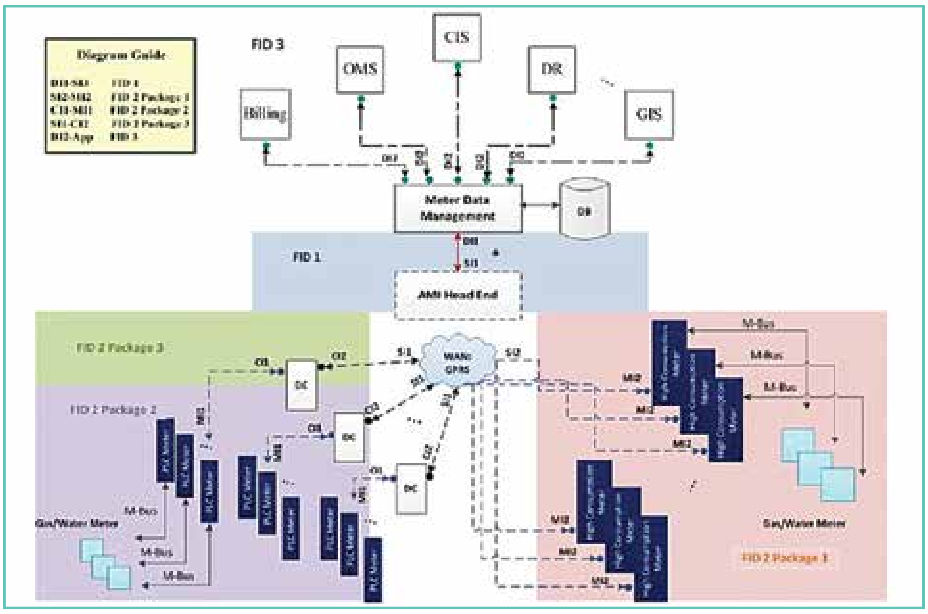

Figure 1. The smart metering project's information exchange architecture (conceptual architecture of FAHAM interoperability between smart meters, AHEs, MDM, and application systems).

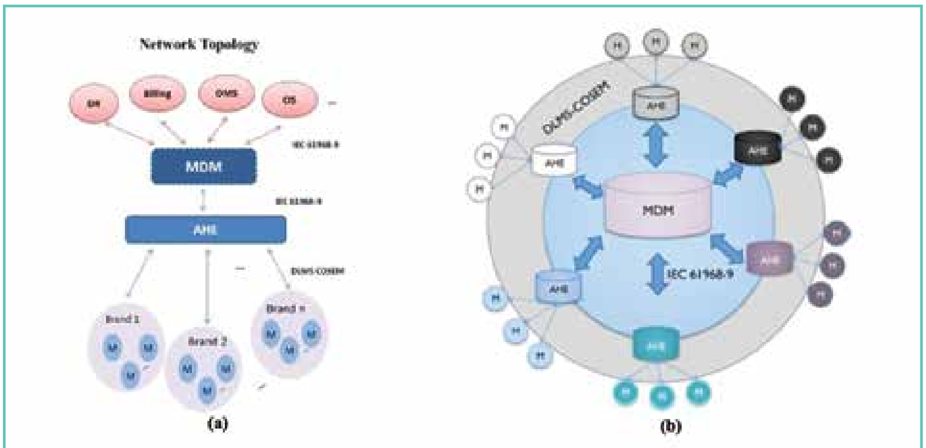

Figure 2. Interoperability concept in IRAN smart metering project (high-consumption costumer).

The DLMS/COSEM protocol specifies the data model and communication protocols for data exchange with the metering equipment. However, the protocol has a lot of open issues which cannot implement interoperability completely. According to the DLMS/COSEM specification to obtain interoperability, there is a three-step approach which must be implemented as follows:

- Step 1 (modelling): The aim of this step is to obtain a unique data model for the metering equipment as well as rules for data identification.
- Step 2 (messaging): In this step, the required protocols and methods to access attributes and methods of the defined objects in the previous step will be presented.
- Step 3 (transporting): This step covers services and protocols for the transportation of the messages through the communication channel. In order to perform interoperably at the DLMS/COSEM level, the first step is to define the data model.

Interoperability protocol layers in DLMS/COSEM

There are different interoperability protocol layers for upstream (central access system) and downstream (smart meters) based on the IEC standards and DLMS/COSEM protocols that are presented in Figures 3 and 4.

One-to-one comparison between the interoperability concept in upstream and downstream is presented in Figure 4 (between IEC 61968-9 and DLMS/COSEM).

Interoperability documents for the Iran smart metering project

Similar to other AMI projects in the world, the most important challenge for the massive deployment of smart meters

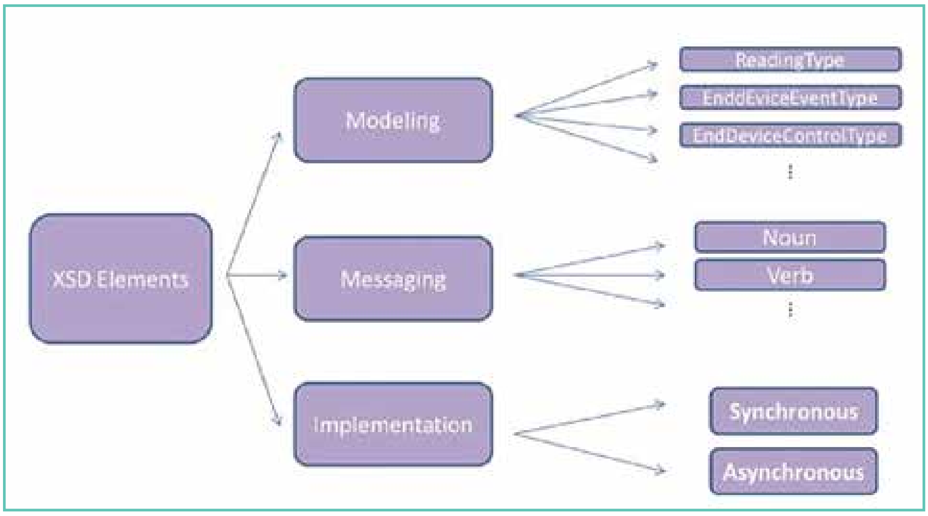

Figure 3. Interoperability in IEC 61968-9.

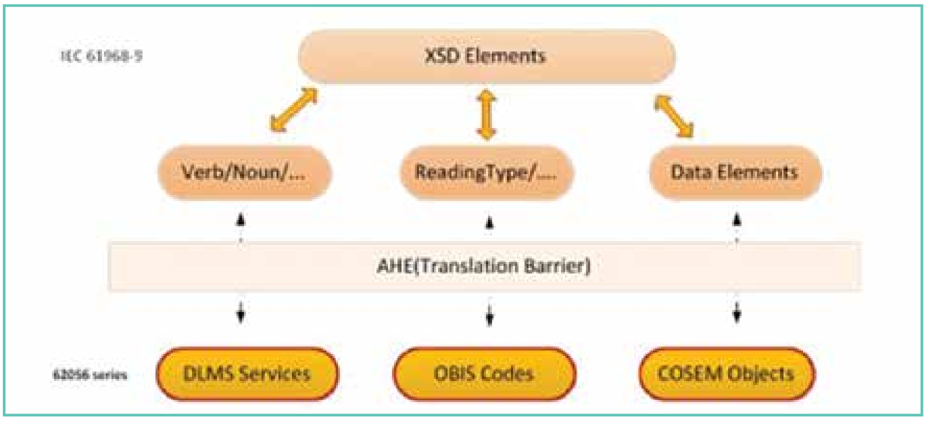

Figure 4. One-to-one correspondences between IEC 61968-9 (upstream) and DLMS/COSEM (downstream).

is the interoperability between all the components of the system by providing unique data models in each communication layer.

Monenco Iran as consultants for the AMI project decided to develop specifications for the manufacture of interoperable devices by using international standards and global successful experiences in these years. These specifications are developed by cooperation of all stakeholders as an expert working group during intensive meetings. These specifications are prepared in three colour-books that include interoperability specifications (White book), object lists (Green book) and event lists (Orange book).

FAHAM Interoperability document 1 (FID-1)
In accordance with Iran's smart metering use cases, to establish interoperability between the MDM and AHEs of local manufacturers, the message structure should comply with IEC 61968-9. As this is an open standard, there should be some kind of consensus between manufacturers. After reaching consensus regarding message structures, AHEs should be tested to verify the accuracy of the implementation.

Manufacturers should consider the following points:

- Messages should be completely based on IEC 61968-9 and there should be no innovation in messages;
- All elements used in the messages should be based on the FIDs.

According to IEC 61968-9, the general structure of messages is defined in Table 1 below.

According to IEC 61968-9, three kinds of messages are defined:

- **Request message:** Request messages are used for sending queries or commands. For example, a request message might be sent from a MDM to an AHE to obtain a set of meter readings.
- **Response message:** Response messages are used for returning the corresponding data or status information to a request message. Response messages are also used to indicate whether a given request succeeded or whether there were any failures in performing the command. Response messages may also be used for sending simple acknowledgements in the context of web services.
- **Event message:** Event messages are used for sending unsolicited data such as asynchronous data or status information. For instance, such messages may be sent to notify a MDM such as installing a meter or other entity of an asynchronous event such as a power outage to a meter. Event messages may also be used to send meter readings according to a pre-configured schedule. For example, an AHE might maintain its own schedule of meter interrogations and push these data to a MDM at regular intervals as required.

Message	Header
	Request
	Reply
	Payload

Table 1. IEC 61968-9 general structure of messages.

Any IEC 61968-9 message, whether it is a request message, response message or event message, is composed as an XML document. These different message types are distinguished by the top-level element in the XML document.

FAHAM Interoperability document 2 (FID-2)
The FID-2 is divided into three main packages as follows:

- **FID2-Package 1:** MI2-SI2 Interface;
- **FID2-Package 2:** MI1-CI1 Interface;
- **FID2-Package 3:** CI2-SI1 Interface.

System Architecture and DLMS Structure

The system architecture of FID-2 Package 1 is presented in Figure 5. The data exchange between the electricity meter and HES (Head-end System) is based on an IP backbone, SMS services and DLMS protocol. The AHE acts as a DLMS client and the electricity meter takes the role of DLMS server.

Multi-utility meters (gas and water) and IHD (In-home Display) are connected to the system via electricity meter. For multi-utility meters/IHD interfaces (MI4 and MI5), the required functions (and data model) are defined in this specification. The default physical interface for communication with multi-utility meters is wired M-Bus, but the provisions shall be provided to convert it to wireless (by using convertor/transceiver) in wireless M-Bus applications.

Interface specifications

Interface specifications are explained in the following.

MI2-SI2 (Meters-HES)
This interface is based on an IP network and SMS service. The DLMS protocol is used for

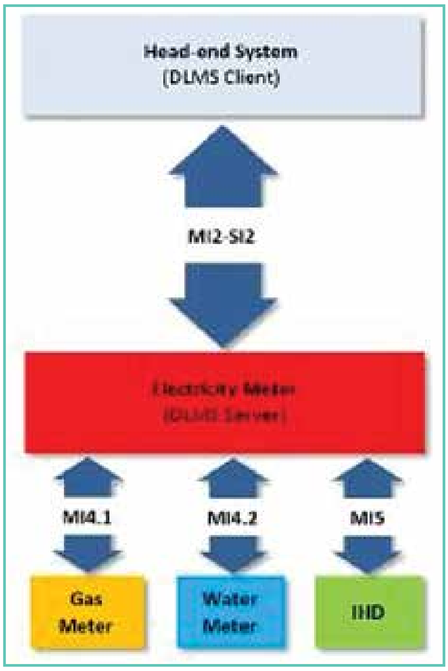

Figure 5. FID-2 package 1 system architecture

data exchange between electricity meters and HES. The HES acts as the DLMS client and the electricity meter as the DLMS server. The following communication services shall be provided in this interface:

GPRS CSD/SMS (Wake-up)

Two operating modes are used in this interface as follows:

Pull/Push: The "Pull" mode is initiated by HES. It is used for collecting data from meters or sending commands/information to meters and consumer's interface. The "Pull" is realized by using the following DLMS services:

OPEN RELEASE GET SET ACTION: The "Push" mode is initiated by electricity meter to send some critical information such as Alarms and so on to Head-end system/IHD. The DATA-NOTIFICATION service of DLMS is used in this mode. Table 2 shows the DLMS services in Pull and Push modes according to the type of communication (IP-based or SMS).

MI4 (electricity/gas/water meter)

The M-Bus is used in this interface. The data of M-bus devices is mapped to COSEM objects in electricity meter (According to EN 13757-3). The M-bus devices are accessed via COSEM objects in the electricity meter (not transparent access through electricity meter). The required functions and data mapping model are defined in this specification. The default physical interface for communication with gas/water meters is wired M-Bus, but the provisions shall be provided to convert it to wireless (by using convertor/transceiver) in wireless MBus applications.

Wired M-BUS

- The format class FT1.2 of EN 60870-5-1 and the telegram structure according to EN 60870-5-2 is used.
- The wired M-Bus is based on the EN 13757-2 physical and link layer.

FAHAM interoperability document 3 (FID-3) (Interoperability at legacy systems)

Application systems (or conventional legacy systems) use load profiles (available through the smart electricity meters) to control and manage the power system and guarantee the effective operation of the whole system. The most important parts of the application systems are billing, outage management system, customer information system, demand response management, management and engineering, power quality, energy management system, GIS, asset management etc.

The Iranian smart metering system must provide and process the information related to metering equipment in an information infrastructure and this information is then shared in order for application layer usage. Billing is the first and the most important application system that already is used for processing of captured metering information in order to process customer payments. Different billing periods, on-demand and accurate billing are the most interesting features of the billing application system. Other application systems such as an interface between the network operator and customer are in pilot phase and offline test procedure. The complete implementation of application systems in FAHAM needs software and hardware upgrading and other consideration.

These documents (FID3-40 and 41) aim to present the steps toward collecting periodic meter readings for the billing process. Periodic meter readings are typically daily and monthly readings. Monenco Iran Consulting Engineers designed and developed software to test the WebService process and the receipt and transmission of data between MDM and billing in order to solve technical problems and enable a successful billing process. (Implementation of interoperability among billing system and MDMs, based on FID3-40 and 41).

In Iran, the most successful experience of the billing system is in Semnan province where all the features of the billing system are now fully implemented. Other provinces such as Tehran and Mashad are in the final implementation stages. MI

In March 2009 implementation of the Iranian national advanced metering infrastructure plan (FAHAM) was placed on the agenda of the Iranian government and Power Ministry of Iran. The target was to decrease electricity losses by at least 1% per year and a 14% decrease in overall network losses by 2015. Afterwards preparation of a seven-year roadmap to exchange electricity meters for all customers was started.

The FAHAM project is funded by the Power Ministry of Iran and under the supervision of the Iran Power Generation, Transmission and Distribution Management Company (TAVANIR).

FAHAM transforms the meter from a simple measuring and counting device, to one element of an integrated system of hardware, software and people that can be used to better manage the electricity service which customers find essential to their lives.

FAHAM is not simply a tool to capture customer consumption of energy, but hardware and software architecture capable of capturing real-time consumption, demand, voltage, current and other information.

In the next edition of Metering & Smart Energy International, we will conclude our examination of the implementation in Iran with a comparison of Idis, Faham, and International standards and future trends for the application system.

Operating Mode	DLMS Services	
	IP Communication	SMS Communication
Pull	GET, SET, ACTION (Confirmed)	SET, ACTION (Unconfirmed)
Push	DATA-NOTIFICATION (Unconfirmed)	DATA-NOTIFICATION (Unconfirmed)

Table 2. DLMS Services in Pull/Push modes