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TECHNICAL SPECIFICATION

colour inside

Smart grid user interface –
Part 2: An architecture and requirements

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INTERNATIONAL
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FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62939-2, which is a Technical Specification, has been prepared by IEC project committee 118: Smart grid user interface.

The text of this Technical Specification is based on the following documents:

Enquiry draft	Report on voting
118/93/DTS	118/97A/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62939 series, published under the general title *Smart grid user interface*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Over the years, several ecosystems (especially telecommunications, sustainable energy, home automation) have been growing in parallel but separately in the customer premises. The perspective of energy applications is triggering a high level of interest in new markets such as smart home, smart community, smart building, smart industrial park, distributed energy resources, and electric vehicles. It is a growing trend that the traditional energy consumer may eventually turn out to be the prosumer, who not only consumes power from but also feeds power back to the grid, which raises the challenge for grid management.

Considering the relevance and common interests while connecting various demand-side objects with the power grid, it is urgent and important to ensure effective, economical and secure operation of the power grid from the point of view of a user as well as enhance the energy efficiency of the demand-side system and equipment. Under the circumstances, information exchange may play a more critical role in this field. Currently, various communication standards have been developed by organizations and manufacturers for customer facility management and control. However, the industry has become impatient with the lack of standard interfacing methods and solutions to exchange information with the grid.

This document focuses on standardization in the field of interfacing for information exchange between smart equipment and/or systems and the grid from the point of view of the user to the grid for customer facility management and control applications.

IEC 62939 consists of the following parts under the general title *Smart grid user interface*:

Part 1: Interface overview and country perspectives

Part 2: An architecture and requirements

In addition to the above parts, two documents in the IEC 62746 series cover the SGUI bridge standard for demand response application. The first is IEC PAS 62746-10-1 and the other is IEC 62746-10-3.

SMART GRID USER INTERFACE –

Part 2: An architecture and requirements

1 Scope

This part of IEC 62939 provides an architecture to define interfaces for the information exchange between smart equipment/systems from the demand side and the power grid. It facilitates the interoperability between the IEC common information model (CIM) and customer facility standards for smart grid applications.

This document presents one possible architecture to connect non-CIM/IEC 61850-based demand-side standards to the CIM, to support demand response type applications. It presents an immediately available architecture approach for home and building grid users for demand response applications to cope with the fragmented market and lack of harmonized standard solutions.

It proposes that a three-layer application be implemented but this does not preclude the ongoing long-term efforts of IEC ideally to promote from a semantic perspective only two-layer implementations.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
adapter
layer of software that connects one component to another component to exchange information

Note 1 to entry: An adapter can consist of multiple functions, for example, model mapping, data transformation, service matching and communication protocol mapping.

3.1.2
application
simple function, such as sending an 'open/close' command, or complicated one, consisting of a group of logically connected function units, such as demand response

Note 1 to entry: Apart from the 'physical' application, there can also be a 'virtual' one, for example, data transformation, power efficiency assessment, etc.

Note 2 to entry: In this document, "application" stands for "smart grid application".

3.1.3
demand response
action resulting from management of the electricity demand in response to supply conditions

[SOURCE: IEC 60050-617:2011, 617-04-16]

3.1.4
profile
defines a subset of an entity (e.g. standard, specification or a suit of standards/ specifications). Profiles enable interoperability and therefore can be used to reduce the complexity of a given integration task by:

- selecting or restricting standards to the essentially required content, e.g. removing options that are not used in the context of the profile
- setting specific values to defined parameters (frequency bands, metrics, etc.)

Note 1 to entry: The 'CIM profile' is simply some formal subset of the CIM, in terms of classes, attributes and relationships that can have additional restrictions imposed.

[SOURCE: IEC TR 62357-1:2016, 3.1.11, modified – the second paragraph of the definition has been deleted and a note has been added.]

3.1.5
smart grid user interface
SGUI
bi-directional, logical, abstract interface that supports appropriately secure communication of information between an entity within the customer domain (e.g., home or building energy management system, electrical load, and energy storage system or generation source) and an external energy service provider

Note 1 to entry: Devices and applications will implement the SGUI between service providers and customers to facilitate machine-to-machine communications. The SGUI has to meet the needs of today's grid interactions (e.g., demand response, grid-aware energy management, EV charging equipment interactions) and those of the future (e.g., retail market transactions).

3.2 Abbreviated terms

ACSI	Abstract communication service interface
CFMC	Customer facility management and control
CIM	Common information model
CIS	Component interface specification
DER	Distributed energy resource
DMS	Distribution management system
DR	Demand response
EMS	Energy management system
ESB	Enterprise service bus
EV	Electrical vehicle
FSGIM	Facility smart grid information model
ICT	Information and communications technology
IEM	Information exchange model
OLTC	On load tap changer
PAB	Profile, adapter and bridge
RDF	Resource description framework
SCADA	Supervisory control and data acquisition

SGAM	Smart grid architecture model
SGUI	Smart grid user interface
XML	eXtensible Markup Language
XSD	XML schema definition

4 Objectives

A smart grid is a very large and complex system of systems covering bulk generation, transmission, distribution, DER and customer premises. Those systems, used for grid operations, apply the common information model (CIM) or IEC 61850 data model. Within the customer premises, smart equipment and systems usually use different information models and communication protocols for facility management and control, for example, EEBus, KNX, ECHONET Lite, LonMark, BACnet[1], etc.

The market experiences have revealed that the factors that can affect the interoperability between the customer facility and grid are as follows:

- the technologies used can be incompatible with each other,
- the legacy systems may not have a strong motivation to be upgraded or even substituted,
- the capital investment and time cost for a system upgrade may not be acceptable to both stakeholders and operator, and
- the current standards may not closely keep pace with the requirements of emerging smart grid applications.

In these circumstances, the objective of this document is to describe an interfacing reference architecture for DR applications that need to exchange information between the CIM and customer facility standards. This will enable the smart grid to:

– bridge the grid operations and the customer facility management and control,

NOTE See IEC TR 62939-1.

– boost the customer involvement in the smart grid,

– offer a fast response to the market requirements and fill the gaps in this cross-cutting field,

– reduce the cost and time for the development and maintenance of cross-domain applications,

– protect the investment in legacy systems and make the existing resources reusable,

– improve smart grid interoperability, compatibility and flexibility.

5 Reference architecture

5.1 General

Clause 5 presents the SGUI reference architecture, which provides a common practice for how to build interfaces for information exchange between the CIM and customer facility standards. IEC 62939 (all parts), shown in Figure 1, facilitates the applications in customer facility management and control (CFMC) to connect the IEC TC57 reference architecture.

[1] EEBus, KNX, ECHONET Lite, LonMark, BACnet are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of these products.

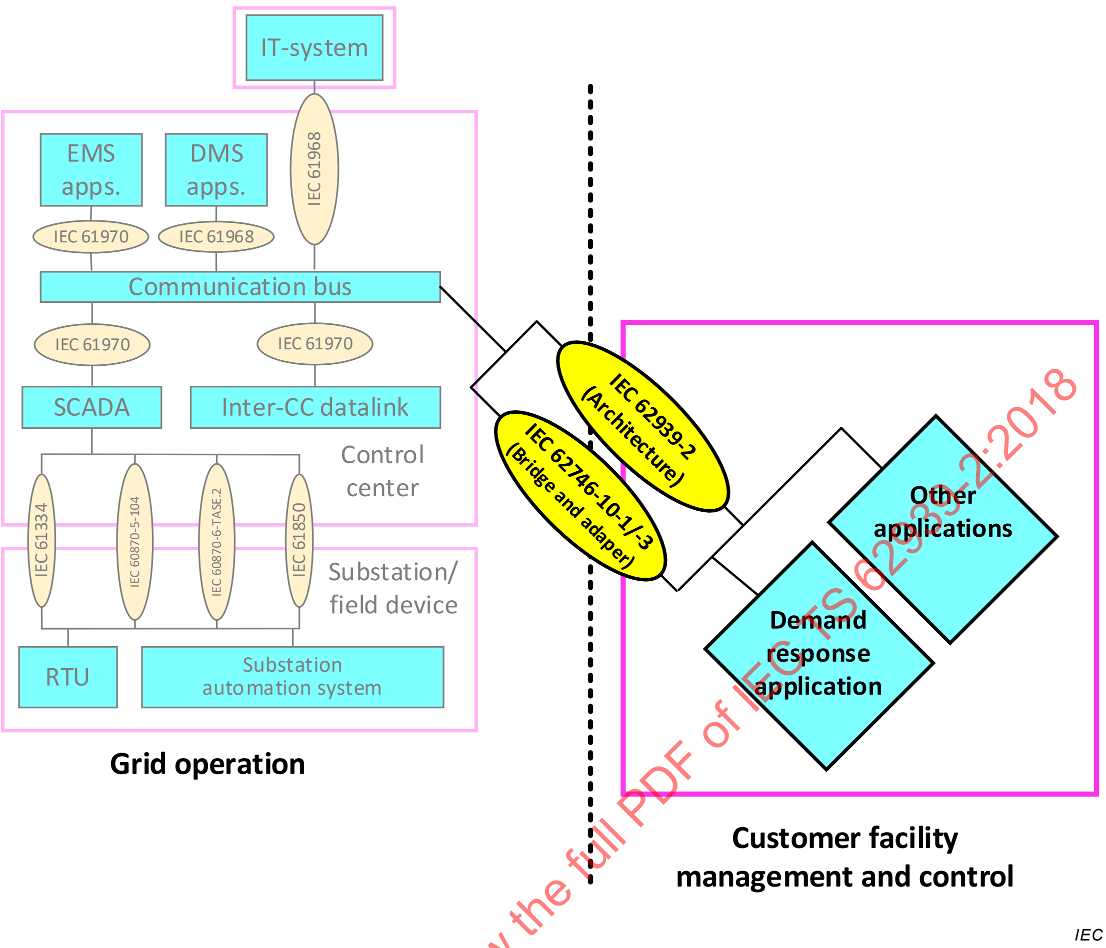

Figure 1 – Relationship with other IEC standards in parts of TC57 reference architecture

The idea of bridge is the key concept of the SGUI architecture. A demand response (DR) application from the point of view of the customer is embedded within the CFMC block. By using IEC 62939-2 (architecture) and IEC PAS 62746-10-1 and IEC 62746-10-3 (specific bridge and adapter for DR), the DR application can build the connection to the communication bus in the grid at the enterprise level. In the grid operation, on the left side of Figure 1, the communication bus can integrate EMS/SCADA, DMS and other utility business systems by using IEC 61970-1 and IEC 61968-1 respectively. So, through the SGUI, the DR application in CFMC has the ability to exchange information with relevant applications in EMS or DMS according to the use cases.

The SGUI reference architecture may be applicable to other applications that need the cooperation of equipment and systems from both the power system and the customer premises, for example, power efficiency assessment, black-out prevention, etc. Therefore, a block called 'other applications' is added in the CFMC block in Figure 1. By using the SGUI architecture and proper application-specific bridges and adapters, those applications can connect to the utility systems as the DR application mentioned above does.

Common to most of the smart grid technologies is an increased use of communications and IT technologies, including an increased interaction and integration of formerly separate systems (see IEC TR 63097). With this in mind, the SGUI architecture may not be limited to the state-of-the-art information and communications technology (ICT) and may be independent from the specific underlying technology. For example, the communication bus in Figure 1 can be a middleware, enterprise service bus (ESB) or cloud platform depending on the application requirements and deployment and operation environments. Therefore, the SGUI should have the ability for extensions to match the fast-changing environment both from the perspective of the power system and the customer facility.

5.2 Conceptual model

The SGUI conceptual model, shown in Figure 2, provides a high-level, overarching perspective. It is not only a representation for clarifying the idea of SGUI architecture, but also a useful way for identifying potential information interaction between the grid operations and CFMC. It is a tendency that applications, usually limited in customer premises, have now been driven to connect with the power system because of the development of smart grids.

In Figure 2, the dashed line is the logical boundary of the SGUI, which lies between the grid operations and CFMC. The bi-directional arrows represent the needed information flows for each application. Conceptually, the SGUI is a system of interfacing for applications.

In some cases, the application can be a simple function. For example, the 'disconnect' command, generated by the owner of a photovoltaic array on the roof of a building to operate the switch device, is sent to the local distribution control center to inform of the changed status of the equipment for load forecasting or energy supply estimation. In this use case, the message sent from the customer to the power system can be very short and direct.

In other cases, the application can be sophisticated. For example, secondary voltage regulation, which needs the combination of and cooperation among different equipment and systems, both from the grid and customer facility, can involve the coordination control of OLTCs, compensators, switches, and appliances. Therefore, the complicated application can be broken down into several simpler sub-applications. On the other hand, simple applications can also flexibly work together to implement the complex applications according to the use cases.

An application, from another perspective, can also consist of several services in support of an application function. For example, connect/disconnect, request/reply, and subscribe/unsubscribe are pairs of communication services for normal conditions, and alarm/error processing is a pair of event-handling services for emergencies.

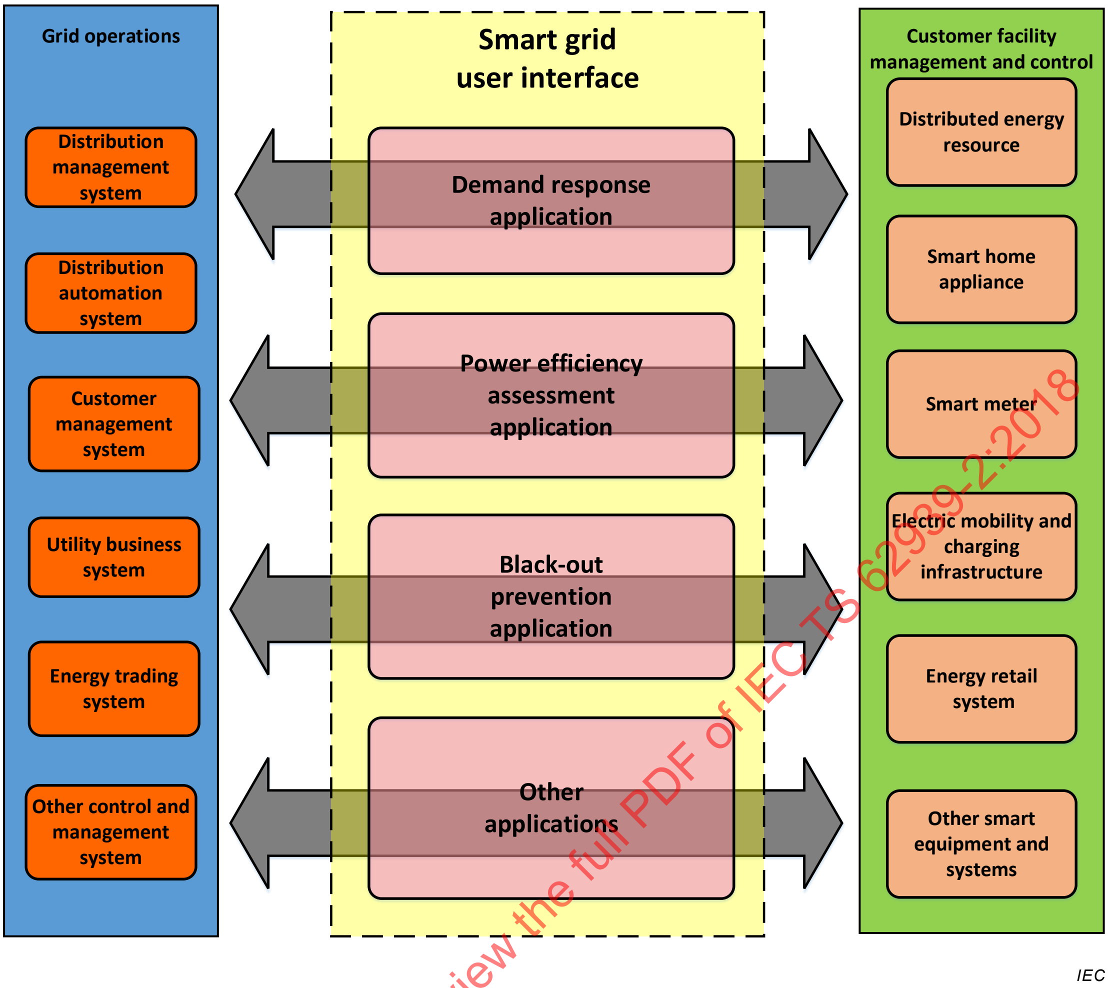

Figure 2 – Application examples for applying SGUI

The SGUI may be designed as simply as possible to enable fast response to industry requirements and for easy use and maintenance. For the sake of simplicity, it is recommended that each service in application use one profile. The profile regulates the format and meaning of data elements carried by the message, which ensures the data is recognized by both the sender and receiver.

The data can be generated from the field device, working process, system management, or even customer behavior. The data can contain the information on the application, operational status, control command, market signal, event, or business process depending on the service definition for certain application functions.

Different kinds of activities can trigger and initiate the process of information exchange, for example, a request for monitoring real-time DER power output, or a reply to acknowledge the changed price signal in the retail market. The sequence of information flows may be defined and regulated in certain use cases. The actors or entities in use cases can have different scales and granularities, from a single end device to an integrated system.

5.3 Layered structure

To build the interface between the demand-side equipment and the grid, the entire process of information exchange has to be taken into consideration. Therefore, the SGUI reference architecture may be a layered structure as shown in Figure 3. There are three kinds of components, namely, profile, adapter and bridge (PAB). In most cases, every layer is necessary.

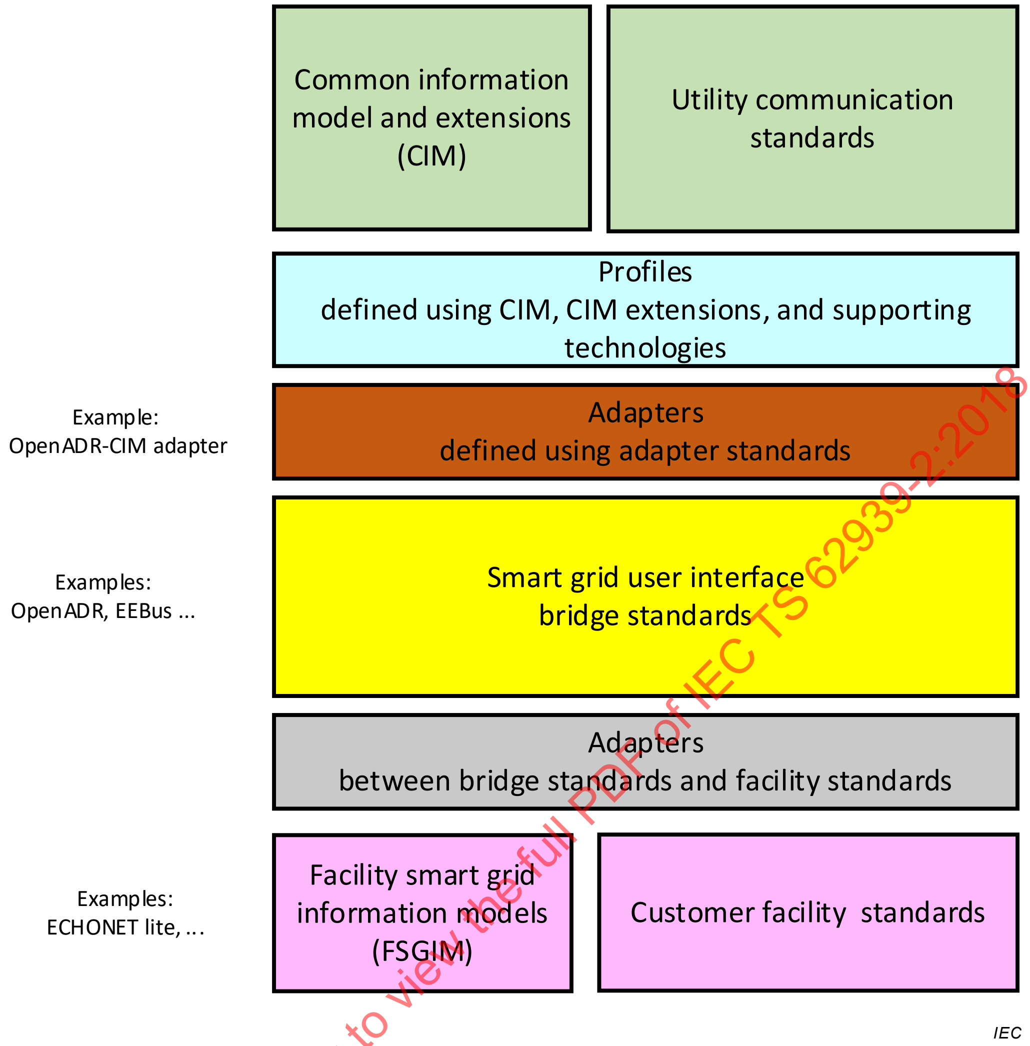

Figure 3 – Layered structure

The upper layer contains the CIM and utility communication standards. The CIM and its extensions are defined for the business functions to support the operation and planning of the electrical grid. The utility communication standards are the communication protocols using the CIM and its extensions, such as the message scheme in IEC 61968-1.

The bottom layer consists of the facility smart grid information models (FSGIMs) and customer facility standards applied to the customer facility. There are many widely-used standards for home/building/industry and other management and control systems, such as ECHONET Lite, etc. However, most of them are not originally designed to have the ability to communicate with the grid on multi-domain applications.

Therefore, SGUI bridge standards, in the middle of Figure 3, create the bridges for the customer premise systems to connect to the utility systems on specific applications. For example, the customer system may need the price signal from the electricity market to help make decisions on how to best control the smart equipment in buildings. On the other hand, the utility may need information about the real-time energy utilization behaviours of the customer to assess and adjust the distribution system reconfiguration schedule. In this case, OpenADR[2] and EEBus, can be considered as examples of SGUI bridges to carry such messages.

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[2] OpenADR is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of this product.

Profile and adapter are the two layers between the CIM standards and the SGUI bridge standards. Sometimes the CIM supports similar applications for grid operations but cannot be used for customer facility management and control because the information requirements for the grid and customers are different. In most cases, there are no one-to-one standardized CIM profiles that match the application profiles defined in bridge standards. As a consequence, the extended CIM profiles have to be defined by using the CIM, CIM extensions and supporting technologies to match the bridge standards. The adapter layer can then transfer the message format between the extended CIM profiles and the bridge profiles according to the mapping roles. For example, the OpenADR-CIM adapter is used for adapting from the OpenADR to the CIM (IEC 62746-10-3).

The layer between the SGUI bridge standards and the bottom layer stands for another kind of adapter. These adapters fulfill the mappings between the bridge standards and the facility standards as adapters between the CIM and the bridge do. In some cases, this layer can be ignored in actual practice when a customer facility 'gateway' directly supports the bridge standard communications to control the smart equipment.

OpenADR 2.0 profiles are an example of a SGUI bridge standard for demand response application. The additional CIM profiles have to be defined by using the CIM and its extensions to match the OpenADR 2.0 profiles. Two adapters, one for mappings between the additional CIM profiles and the OpenADR 2.0 profiles and another for mappings between the OpenADR 2.0 profiles and the SEP[3] 2.0 in the customer facility, are implemented. The DR messages can then be sent or received between the customer equipment and the grid through these four layers under the SGUI reference architecture. In these circumstances, systems both from the utility and customer facility have no need to change.

6 Requirements for implementation

6.1 Message transmission

Given that the fundamental function of SGUI architecture is to exchange information, the SGUI should support:

a) rationalized use cases for each application or service,

b) state-of-the-art underlying communication technologies,

c) the technical independence of each layer in the reference architecture, and

d) synchronous/asynchronous and bi-directional interaction patterns.

6.2 Data transformation

An adapter should have the ability to fulfill the data transformation according to the mapping roles, which consist of:

a) data meaning transformation from one profile definition into another. In some cases, there may be no direct mapping between two related objects in the models after comparison. However, some indirect connections can be found with the help of a third model under proper calculations or conversion. For example, a meter always records the 'power consumption' from the point of view of customer use. But the control center in the utility is concerned about the 'feeder remaining capacity'. So, by taking the parameters of 'operational voltages' and 'accumulated service-on time' into consideration, the data mapping can be built between these two relevant objects in different models after calculations;

b) data format transformation from one description language style into another. For example, EMS uses RDF language to represent the power system static model and measurement data from SCADA, while OpenADR 2.0b uses the XSD (profile) to organize the demand response service data. So the adapter should transform the relevant data from the XSD format into the RDF format or vice versa depending on the use case.

3 SEP is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of this product.

6.3 Communication protocol mapping

Apart from data transformation, the communication protocol mapping is another core ability that the adapter may have. The power system applies the IEC 61970-1 and IEC 61968-1 message scheme or abstract data service to the exchange model data for inter- and intra-application between the control center and other business systems, while the communication services defined in the SGUI bridge standard (for example, the register service in OpenADR 2.0) and facility standards are quite different.

For the adapters between the utility communication standards and the SGUI bridge standards, when exchanging information:

a) with the EMS, the adapter needs to implement the service mappings to the component interface specification (CIS) in IEC 61970-1;

b) with the DMS, the adapter needs to implement the service mappings to the information exchange model (IEM) in IEC 61968-1;

c) with the substation and field device, the adapter needs to implement the service mapping to the abstract communication service interface (ACSI) in IEC TR 61850-1.

On the other hand, when exchanging information with the customer facility systems, the bridge services may be mapped into the corresponding communication interfaces in the facility protocols.

6.4 Monitoring and management

The process of data generation, transformation and interaction has to be monitored to ensure operational safety. The SGUI may

a) record activities including actors, applications, steps and events,

b) analyze the performance, quality and quantity and other indicators to reveal the SGUI operation status,

c) handle the errors (critical mistake) or warnings (tolerable flaws), generate the reports and real-time alarm, execute error corrections according to the pre-designed solutions to help stop the emergency.

6.5 Other requirements

a) Simplicity: The profile, adapter and bridge should be as simple as possible to enable fast response to industry requirements and ease of use and maintenance as indicated in 5.2.

b) Customization: Users with different characteristics and scale can have different requirements, for example the simple home user versus an industry park aggregated user. The SGUI should be adjustable to various use cases.

c) Updatability: The components of the SGUI should be kept up to date to follow the changing requirements of business functions in utility and applications in customer facilities.