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TECHNICAL REPORT

colour inside

Power systems management and associated information exchange – Part 1: Reference architecture

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE –

Part 1: Reference architecture

FOREWORD

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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 62357-1, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This first edition cancels and replaces the first edition of IEC 62357 published in 2003 and constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

a) update of the description of the various standards activities within TC 57 and the way they individually and collectively contribute to meeting the objectives of TC 57;

b) update of the areas where harmonization of existing standards within TC 57 is needed and provision of detailed recommendations regarding harmonization of the CIM IEC 61968/61970 and IEC 61850 standards;

c) definition of a new layered architecture to help direct longer term goals and activities to ensure compatibility of all new standards developed in TC 57;

d) alignment of the architecture on other internationally recognized architecture standards, such as the UN/CEFACT Core Components Technical Specification;

e) incorporation of lessons learned during development of the current standards and their application on actual utility projects;

f) provision of new guidance on the role of TC 57 standards in the Smart Grid.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
57/1184/DTR	57/1255/RVC

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

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

A list of all parts in the IEC 62357 series, published under the general title *Power systems management and associated information exchange*, can be found on the IEC website.

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

0.1 General

The objectives of IEC/TR 62357-1 are to

– provide a framework to show how the various standardisation activities within IEC Technical Committee 57 relate to each other and how they individually and collectively contribute to meeting the objectives of IEC Technical Committee 57, and

– develop a strategy to combine and harmonize the work of these various activities to help facilitate a single, comprehensive plan for deployment of these standards in product development and system implementations.

IEC/TR 62357-1 provides updates and defines a layered reference architecture to help direct longer term goals and activities, specifically to ensure compatibility of all new standards developed in TC 57 by benefitting from lessons learned during development of the current standards and their application on actual utility projects as well as through application of other internationally recognized architecture standards, such as the UN/CEFACT Core Components Technical Specification.

The second edition of IEC 62357-1 currently being prepared will reflect the progress recently achieved from the international Smart Grid (SG) initiatives and the CIGRE D2.24 large system architecture vision. This second edition will also reflect the most recent editions of the TC 57 standards including IEC 61850 series and IEC 61968 series, IEC 61970 series, and IEC 62325 series.

0.2 Objectives and overview of this technical report

0.2.1 Overview

IEC TC 57 is chartered with developing standards for electric power system management and associated information exchange in the areas of generation, transmission and distribution real-time operations and planning as well as information exchange to support wholesale energy market operations. This technical report has three objectives with respect to TC 57's current and future work. It also has a fourth objective regarding the role of TC 57 standards in development and implementation of the Smart Grid.

0.2.2 Existing TC 57 standards and architecture

The first objective of this technical report is to provide a reference architecture to show how the various existing standards activities within IEC TC 57 relate to each other today and how they individually and collectively contribute to meeting the objectives of TC 57. Clause 3 describes each of the working groups and their current scope of work, while Clause 4 shows how all the standards developed to date fit into an overall architecture

0.2.3 Areas for harmonization

The second objective is to identify areas where harmonization between TC 57 standards is needed and to suggest possible approaches to achieve it in order to facilitate a single, comprehensive, optimal plan for deployment of these standards in product development and system implementations. Clause 5 describes the data modelling and service definition approaches currently used in TC 57. Clause 6 describes way these modelling standards and services are mapped to concrete technologies, while Clause 7 discusses the harmonization needed to ensure that these existing modelling and technology mapping standards are compatible, if not totally integrated.

0.2.4 Future vision for TC 57 standards architecture

The third objective is to define a vision for the future reference architecture that will help direct longer term goals and activities. More specifically the goal is to ensure compatibility of all new standards developed in TC 57 by benefitting from lessons learned during development of the current standards and their application on actual utility projects as well as through application of other internationally recognized architecture standards, such as the UN/CEFACT Core Components Technical Specification.

Clause 8 defines the fundamental architecture principles established to guide the structure of new standards work, specifically proposing a layered architecture that recognizes internationally accepted concepts for a layered architecture including an abstract information model, a business context layer, message assembly layer, and an implementation or technology mapping layer. Clause 9 discusses the conclusions.

0.2.5 Role of TC 57 standards in the smart grid

The fourth objective is to provide an overview of the TC 57 standards and their role in the Smart Grid. Now that the TC 57 standards, such as the IEC 61968 series, IEC 61970 series and IEC 61850 series, have been recognized as pillars for realization of the Smart Grid objectives of interoperability and device management, it is imperative that a correct understanding of these standards and their application be made available to the key stakeholders and all other interested parties involved in implementing the Smart Grid.

0.3 Rationale

The need for this technical report was motivated by three major factors:

a) there are multiple independent standards initiatives that need to be coordinated and harmonized to facilitate information exchange between systems using these various standards;

b) there is a need to have a comprehensive vision of how to deploy these standards for actual system implementations and integration efforts;

c) there needs to be a vision of the future so that additional work can take into account the evolving communications and modelling technologies, and can be incorporated within a clearly defined architectural framework.

There are several different initiatives within TC 57, each dealing with a selected part of real-time operations and planning. Each has a specific objective and may have sufficient breadth of scope to provide the bulk of the relevant standards needed for product vendors to develop products based on those standards.

0.4 Trend toward model driven architectures and integration

In today's utility enterprise, where information exchange between the various generation, distributed resource, transmission, and distribution management systems, as well as customer systems and other IT systems is not only desirable but necessary, each system plays the role of either the supplier or consumer of information, or more typically both. That means that both data semantics and syntax need to be preserved across system boundaries, where system boundaries in this context are interfaces where data is made publicly accessible to other systems or where requests for data residing in other systems are initiated. In other words, the "*what*" of the information exchange is actually much more important for system integration purposes than "*how*" the data is transported between systems.

Most previous efforts to define system architectures have dealt primarily with the *how* (i.e., definition of protocols for transporting the data), with a focus on utilizing as many existing ISO or TCP/IP standards as possible to provide the various layers in the ISO OSI seven-layer

reference model for protocol profiles.[1] However, the increasing use of object modelling techniques to define the data for information exchange within the different standards initiatives has properly shifted the focus away from the *how* to the *what.* Of even more importance, this trend has resulted in the separation of the data from the protocol standards, creating a new layer of abstraction for the data model as well as the data exchange methods that is independent of the underlying infrastructure. The consequence of this is that a common data model and a few generic data-driven interface patterns can be used for all information exchange independent of the underlying protocols selected for a given system implementation. This new architecture is known as a Model-Driven Architecture (MDA), or when applied to integration of systems and applications, as Model-Driven Integration (MDI). Actual implementations can then take advantage of the current industry architectural trends, such as Service Oriented Architectures (SOA) and the use of Web services.

Standardization efforts within TC 57 began several years prior to development of the MDA/MDI architectural concepts. As a result, there was little or no collaboration between working groups. Each working group chose its own modelling language/notation and more importantly generated their own object and service model definitions. This was not done intentionally, and in fact each initiative had perfectly good reasons for their choices given the limited scope of their domain of application. But the consequence is that instead of one object model for each physical entity in the generation, transmission and distribution operations domains being standardized, at least two or more object models exist in most cases with different definitions for classes, attributes, data types, and relationships between classes. Furthermore, in most cases different modelling languages have been used as well.

0.5 Purpose of the reference architecture

To achieve the first objective of this technical report, a reference architecture for power system information exchange is defined to describe all the existing object models, services, and protocols within TC 57 and how they relate to each other. Then, to meet the second objective, a strategy is developed to show where harmonization is needed, and if possible, to recommend how to achieve a common model. Where changes cannot be made due to maturity of standards, then recommendations for adapters to make the necessary transformations between models are made. The third objective of this technical report is achieved by defining a new future reference architecture that recognizes the importance of a single, internally consistent semantic layer to avoid unnecessary seams (i.e., the concept of a seamless architecture), while facilitating information exchange over a variety of industry-standard transport infrastructures. This new reference architecture provides a framework for growth and incorporation of new, evolving technologies without invalidating the existing standards developed by TC 57.

0.6 Scope of reference architecture

0.6.1 General

Originally the charter and title of TC 57 was "Power system control and associated telecommunications". The focus was on developing different protocol standards to address the data communications requirements of different parts of power system control, such as data communications over low-speed serial lines, distribution line carrier protocols, and inter-control center communications protocols.

Later as the scope of the TC 57 work broadened to include data exchange between applications within an energy management system as well as inter-computer system data exchange between distribution management systems and deregulated energy market communications, the charter was changed to "Power system management and associated information exchange", so that the focus shifted from lower lever protocol development to

1 The original EPRI UCA project, for example, had the focus of settling on the use of MMS and a few standard profiles for transporting data rather than on the semantics of information transfer between systems.

development of more abstract data models and generic interfaces at higher levels in the architecture. This shift resulted in the creation of new working groups to address the new business functions embraced by the new TC 57 charter, which includes:

- energy management,
- SCADA and network operation,
- substation protection, monitoring, and control,
- distribution automation,
- distributed energy resources (DER),
- demand response and load control,
- meter reading and control,
- customers,
- work,
- network expansion planning,
- operational planning and optimization,
- maintenance and construction,
- records and asset management,
- market operations,
- reservations,
- financial,
- energy scheduling.

0.6.2 IEC standards included in reference architecture

The scope of the reference architecture for power system information exchange embraces all these areas from both the abstract information modelling perspective (i.e., platform independent models) as well as the technology mappings for implementation (i.e., platform specific models).

Figure 1 shows where some of these standards are used in the utility operations environment. Not all standards listed above are shown and not all end field devices/systems are shown. More detailed descriptions and illustrations are provided in Clause 3.

The reference architecture for power system information exchange includes the following IEC TC 57 standards (responsible working groups are shown in parentheses):

IEC 60495, *Single sideband power-line carrier terminals (WG20)*

IEC 60663, *Planning of (single-sideband) power line carrier systems (WG20)*

IEC 60870-5 (all parts), *Telecontrol equipment and systems – Part 5: Transmission protocols (WG3)*

NOTE 1 IEC 60870-5 series covers reliable data acquisition and control on narrow-band serial data links or over TCP/IP networks between SCADA masters and substations.

IEC 60870-6 (all parts), *Telecontrol equipment and systems – Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations (WG7)*

NOTE 2 IEC 60870-6 series covers the exchange of real-time operational data between control centres over Wide Area Networks (WANs). This series is known officially as TASE-2 and unofficially as ICCP.

IEC 61334 (all parts), *Distribution automation using distribution line carrier systems (WG9)*

NOTE 3 IEC 61334 series covers data communications over distribution line carrier systems.

IEC 61400-25 (all parts), *Wind turbines – Part 25-1: Communications for monitoring and control of wind power plants*

NOTE 4 IEC 61400-25 series covers monitoring and control of wind power plants and associated communication. The standards developed by JWG 25 are based on IEC 61850 series.

IEC 61850 (all parts), *Communication networks and systems for power utility automation (WG10, WG17, WG18)*

NOTE 5 IEC 61850 series covers communication networks and systems in substations. These standards are known unofficially as the UCA2 protocol standards. They also include standards for hydroelectric power plant communication, monitoring, and control of distributed energy resources and hydroelectric power plants.

IEC 61968 (all parts), *Application integration at electric utilities – System interfaces for distribution management (WG14)*

NOTE 6 IEC 61968 series covers Distribution Management System (DMS) interfaces for information exchange with other IT systems. These include the distribution management parts of the CIM and extensible Markup Language (XML) message standards for information exchange between a variety of business systems, such as meter data management, asset management, work order management, Geographical Information Systems (GIS), etc.

IEC 61970 (all parts), *Energy management system application program interface (EMS-API) (WG13)*

NOTE 7 IEC 61970 series facilitate integration of applications within a control centre, exchange of network power system models with other control centres, and interactions with external operations in distribution as well as other external sources/sinks of information needed for real-time operations. These standards include the generation and transmission parts of the Common Information Model (CIM), profiles for power system model exchange and other information exchanges, and XML file format standards for information exchange.

IEC 62325 (all parts), *Power systems management and associated information exchange – Data and communications security (WG16)*

NOTE 8 IEC 62325 series covers deregulated energy market communications.

IEC 62351 (all parts), *Power systems management and associated information exchange – Data and communications security (WG15)*

NOTE 9 IEC 62351 series covers data and communication security.

IEC 62488 (all parts), *Power line communication systems for power utility applications (WG20)*

NOTE 10 IEC 62488 series covers data power line communication systems for power utility applications.