INTERNATIONAL STANDARD

IEC 61400-25-1

First edition
2006-12

Wind turbines –

**Part 25-1:
Communications for monitoring
and control of wind power plants –
Overall description of principles and models**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINES –

Part 25-1: Communications for monitoring and control of wind power plants – Overall description of principles and models

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61400-25-1 has been prepared by IEC technical committee 88: Wind turbines.

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

The text of this standard is based on the following documents:

FDIS	Report on voting
88/274/FDIS	88/280/RVD

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

A list of all parts of the IEC 61400 series, under the general title *Wind turbines* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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- withdrawn,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.

INTRODUCTION

The IEC 61400-25 series addresses vendors (manufacturers, suppliers), operators, owners, planners, and designers of wind power plants as well as system integrators and utility companies operating in the wind energy market. The IEC 61400-25 series is intended to be accepted and to be used world-wide as the international standard for communications in the domain of wind power plants.

The IEC 61400-25 series has been developed in order to provide a uniform communications basis for the monitoring and control of wind power plants. It defines wind power plant specific information, the mechanisms for information exchange and the mapping to communication protocols. In this regard, the IEC 61400-25 series defines details required to exchange the available information with wind power plant components in a manufacturer-independent environment. This is done by definitions made in this part of the IEC 61400-25 series or by reference to other standards.

The wind power plant specific information describes the crucial and common process and configuration information. The information is hierarchically structured and covers for example common information found in the rotor, generator, converter, grid connection and the like. The information may be simple data (including timestamp and quality) and configuration values or more comprehensive attributes and descriptive information, for example engineering unit, scale, description, reference, statistical or historical information. All information of a wind power plant defined in the IEC 61400-25 series is name tagged. A concise meaning of each data is given. The standardised wind power plant information can be extended by means of a name space extension rule. All data, attributes and descriptive information can be exchanged by corresponding services.

The implementation of the IEC 61400-25 series allows SCADA systems (supervisory control and data acquisition) to communicate with wind turbines from multiple vendors. The standardised self-description (contained either in a XML file or retrieved online from a device) can be used to configure SCADA applications. Standardisation of SCADA applications are excluded in the IEC 61400-25 series but standardised common wind turbine information provides means for re-use of applications and operator screens for wind turbines from different vendors. From a utility perspective unified definitions of common data minimise conversion and re-calculation of data values for evaluation and comparison of all their wind power plants.

The IEC 61400-25 series can be applied to any wind power plant operation concept, i.e. both individual wind turbines, clusters and more integrated groups of wind turbines. The application area of the IEC 61400-25 series covers components required for the operation of wind power plants, i.e. not only the wind turbine generator, but also the meteorological system, the electrical system, and the wind power plant management system. The wind power plant specific information in the IEC 61400-25 series excludes information associated with feeders and substations. Substation communication is covered within the IEC 61850 series of standards.

The intention of the IEC 61400-25 series is to enable components from different vendors to communicate with other components, at any location. Object-oriented data structures can make the engineering and handling of large amounts of information provided by wind power plants less time-consuming and more efficient. The IEC 61400-25 series supports scalability, connectivity, and interoperability.

The IEC 61400-25 series is a basis for simplifying the contracting of the roles the wind turbine and SCADA systems have to play. The crucial part of the wind power plant information, the information exchange methods, and the communication stacks are standardised. They build a basis to which procurement specifications and contracts could easily refer.

The IEC 61400-25 series is organised in several parts. IEC 61400-25-1 offers an introductory orientation, crucial requirements, and a modelling guide.

NOTE 1 Performance of the IEC 61400-25 series implementations are application specific. The IEC 61400-25 series does not guarantee a certain level of performance. This is beyond the scope of the IEC 61400-25 series. However, there is no underlying limitation in the communications technology to prevent high speed application (millisecond level responses).

NOTE 2 IEC 61400-25-4 is, at the time of the publication of IEC 61400-25-1 (this part), still to be published. With IEC 61400-25-4 the mapping of the information and information exchange models to a specific communication profile will be described/defined in detail. IEC 61400-25-4 may consist of more than one normative mapping but at least one of the optional mappings has to be selected in order to be in conformance with the IEC 61400-25 series. IEC 61400-25-4 is expected to include the following mappings:

Webservices

IEC 61850-8-1 MMS

OPC XML DA

IEC 60870-5-104

DNP3

Each of the different mappings specifies individually which and how information models (IEC 61400-25-2) and information exchange models (IEC 61400-25-3) will be supported. The mapping will only reflect the information model and the information exchange services given in IEC 61400-25-2 and IEC 61400-25-3. The individual selected mapping will as a minimum support the mandatory data and data attributes, and the associated services. A specific mapping may, for implementation reasons or due to underlying properties of the communication protocol used, need to extend and clarify individual information or individual services in IEC 61400-25-2 and IEC 61400-25-3. IEC 61400-25-4 will in this sense have the highest priority of the ranking order in regards of implementation.

WIND TURBINES –

Part 25-1: Communications for monitoring and control of wind power plants – Overall description of principles and models

1 Scope

The focus of the IEC 61400-25 series is on the communications between wind power plant components such as wind turbines and actors such as SCADA Systems. Internal communication within wind power plant components is beyond the scope of the IEC 61400-25 series.

The IEC 61400-25 series is designed for a communication environment supported by a client-server model. Three areas are defined, that are modelled separately to ensure the scalability of implementations:

1) wind power plant information models,
2) information exchange model, and
3) mapping of these two models to a standard communication profile.

The wind power plant information model and the information exchange model, viewed together, constitute an interface between client and server. In this conjunction, the wind power plant information model serves as an interpretation frame for accessible wind power plant data. The wind power plant information model is used by the server to offer the client a uniform, component-oriented view of the wind power plant data. The information exchange model reflects the whole active functionality of the server. The IEC 61400-25 series enables connectivity between a heterogeneous combination of client and servers from different manufacturers and suppliers.

As depicted in Figure 1, the IEC 61400-25 series defines a server with the following aspects:

– information provided by a wind power plant component, for example, ‘wind turbine rotor speed’ or ‘total power production of a certain time interval’ is modelled and made available for access. The information modelled in the IEC 61400-25 series is defined in IEC 61400-25-2.
– services to exchange values of the modelled information defined in IEC 61400-25-3.
– mapping to a communication profile, providing a protocol stack to carry the exchanged values from the modelled information (IEC 61400-25-4).

The IEC 61400-25 series only defines how to model the information, information exchange and mapping to specific communication protocols. The IEC 61400-25 series excludes a definition of how and where to implement the communication interface, the application program interface and implementation recommendations. However, the objective of the IEC 61400-25 series is that the information associated with a single wind power plant component (such as a wind turbine) is accessible through a corresponding logical device.

IEC 61400-25-1 gives an overall description of the principles and models used in the IEC 61400-25 series of standards.

NOTE The IEC 61400-25 series focuses on the common, non-vendor-specific information. Those information items that tend to vary greatly between vendor-specific implementations can for example be specified in bilateral agreements, in user groups, or in amendments to the IEC 61400-25 series.

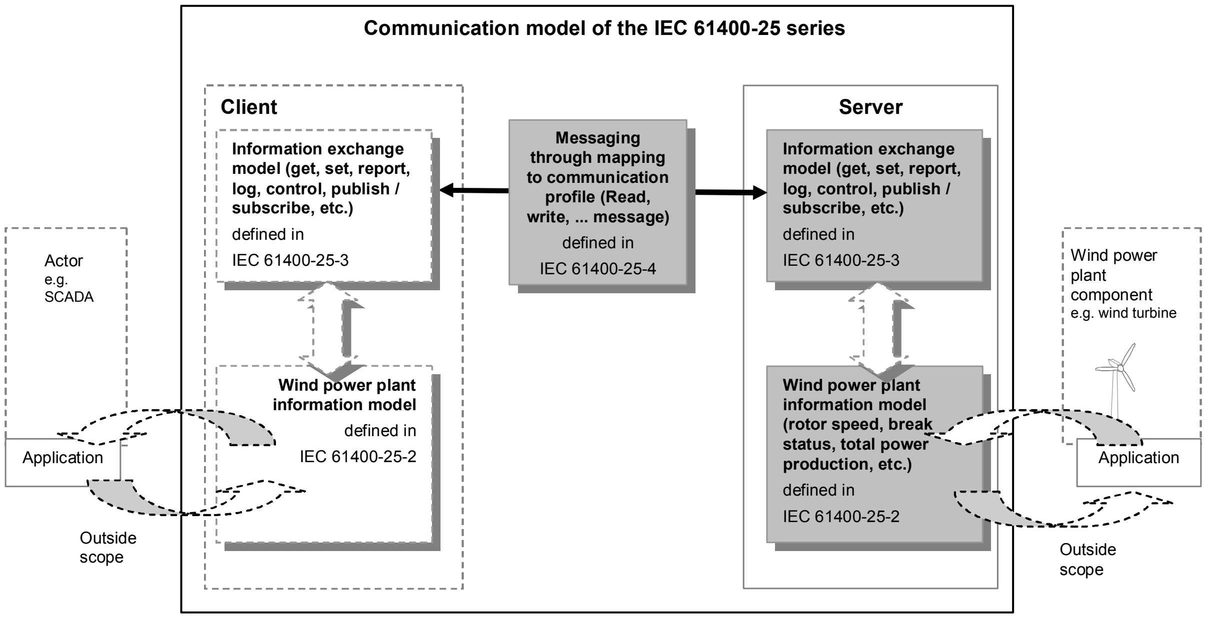

Figure 1 – Conceptual communication model of the IEC 61400-25 series

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61400-12-1, *Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines*

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

IEC 61850-7-1:2003, *Communication networks and systems in substations – Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models*

IEC 61850-7-2:2003, *Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*

IEC 61850-7-3:2003, *Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes*

IEC 61850-7-4:2003, *Communication networks and systems in substations – Part 7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes*

IEC 61850-8-1:2004, *Communication networks and systems in substations – Part 8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*

ISO 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

3 Terms and definitions

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

3.1
actor
role a system plays in the context of monitoring and control, while it is not directly involved in wind power plant operation, such as Supervisory Control and Data Acquisition System (SCADA)

NOTE There are many other designations for example Central Management System, Monitoring and Control System, Remote Control System

3.2
alarm
wind power plant state information. Statement of safety intervention by the wind turbine control system (i.e. on/off)

3.3
characteristic values
properties of analogue information (min, max, avg, dev, etc.)

3.4
command
controllable data for system behaviour (enable/disable, active/deactivate, etc.)

3.5
communication function
used by an actor to configure, perform and monitor the information exchange with wind power plants, for example operational and management function

3.6
control
operational function used for changing and modifying, intervening, switching, controlling, parameterisation and optimising of wind power plants

3.7
counting value
total number of occurrences of a specific event

3.8
data retrieval
operational function used for collecting of wind power plant data

3.9
diagnostics
management function used to set up and provide for self-monitoring of the communication system

3.10
electrical system
component of a wind power plant responsible for collecting and transmitting the energy produced in wind turbines

3.11
event
state transition (status, alarm, command)

3.12
Intelligent Electronic Device
IED
any device incorporating one or more processors, with the capability to receive data from an external sender or to send data to an external receiver

NOTE For example wind turbine controller. An IED may have connections as a client, or as a server, or both, with other IED.

3.13
information
content of communication. The basic element is raw data from the wind power plant component, which shall be processed into specified information according to the IEC 61400-25 series. Wind power plant information categories: source information (analogue and state information), derived information (statistical and historical information). Information is defined as data (usually processed and derived data, and information describing other data)

3.14
information exchange
communication process between two systems, such as wind power component and actor, with the goal to provide and to get relevant information. Requires specific communication functions, consisting of one or more services

3.15
information model
knowledge concerning functions and devices in which the functions are implemented

NOTE This knowledge is made visible and accessible through the means of the IEC 61400-25 series. The model describes in an abstract way a communication oriented representation of a real function or device.

3.16
log
wind power plant historical information. Chronological list of source information for a period of time

3.17
logging
operational function. The praxis of recording sequential data often chronologically. The result of the logging is a log

3.18
logical device
entity that represent a set of typical wind power plant functions

3.19
management function
required for the administration of the information exchange in a certain level. Management functions are user/access management, time synchronisation, diagnostics, and configuration

3.20
mandatory
defined content shall be provided in compliance to the IEC 61400-25 series

3.21
measured data
sampled value of a process quantity with associated data attributes such as time stamp and quality

3.22
meteorological system
component of a wind power plant responsible for the monitoring of the ambient conditions, for example the wind speed, wind direction, pressure, temperature etc. It supplies data for various purposes for example to correlate the meteorological data to the electrical energy output by individual wind turbines to the potentially usable wind energy

3.23
monitoring
operational function used for local or remote observation of a system or a process for any changes which may occur over time. The term can also be used for observation of the behaviour of a data value or a group of data values

3.24
operational function
function to obtain information and to send instructions for the normal daily operation of wind power plants. Types: monitoring, logging, reporting, data retrieval, control

3.25
optional
defined content can be optionally provided in compliance with the IEC 61400-25 series

3.26
parameter
controllable information intended for obtaining or correcting a system behaviour

3.27
processed data
measured value, with the associated data attributes such as time stamp and quality, which has been processed according the calculation method attribute

3.28
profile(s)
format(s) used by a particular protocol to transmit data objects or commands, etc.

3.29
protocol stack
particular software implementation of a computer networking protocol suite. The terms are often used interchangeably. Strictly speaking, the suite is the definition of the protocols and the stack is the software implementation of them

3.30
report
actual information send by the function reporting. A report can contain all kinds of information defined in IEC 61400-25-2

3.31
reporting
operational function to transfer data from a server to a client, initiated by a server application process

3.32
Supervisory Control and Data Acquisition
SCADA
system based on a processor unit which receives information from IEDs, determines the control requirements and sends commands to IEDs. A computer system that for example dispatchers use to monitor the power distribution throughout a service or control area

3.33
status
state condition of a component or system (st1/st2/..stn)

3.34
statistical information
result of applying a statistical algorithm to a set of data in order to get minimum, maximum, mean standard deviation, etc.

3.35
timing data
time duration of a specific state

3.36
time synchronisation
synchronization is the coordination of occurrences to operate in unison with respect to time. This process can be a premeditated arrangement set forth on a parallel time scape, or it can be an observable coincidence in eventuality

3.37
three phase data
measured value in a three phase electrical circuit with associated data attributes such as time stamp, quality and calculation method

3.38
transient log
event triggered chronological list of high resolution information for a short period of time (event driven report)

3.39
user/access management
management function used for setting up, modifying, deleting users (administratively), assigning access rights (administratively) and monitoring access

NOTE A management function does not necessarily include communication services.

3.40
wind power plant
complete system consisting of any number of technical subsystems referred to in the IEC 61400-25 series as wind power plant components, for example one or more wind turbines

NOTE The main objective of a wind power plant is to generate electrical energy from the wind.

3.41
wind power plant analogue information
continuous information concerning the actual condition or behaviour of a component or system

NOTE Types are, for example, measured value, processed value, three phase value, setpoint, parameter.

3.42
wind power plant component
technical system employed in the operation of wind power plants, such as wind turbine, meteorological, electrical and wind power plant management system

3.43
wind power plant management system
component of a wind power plant, which is responsible to ensure that the complete system adapts itself to the static and dynamic conditions and requirements of the electrical power connection (i.e., interoperation of the WTs with substation and other power network related devices)

NOTE A wind power plant management system may include other functions (e.g. Shadow control functionality, noise or sound reduction, ice warning, Lightning protection) not modelled in the IEC 61400-25 series.

3.44
wind turbine
main component of a wind power plant. It is responsible for generating energy and meets the task of using the wind potential of a certain location that converts kinetic wind energy into electric energy

4 Abbreviated terms

ACSI	Abstract Communication Service Interface (defined e.g. in IEC 61850-7-2)
CDC	Common Data Class
DC	Data Class
DNP3	Distributed Network Protocol version 3
IED	Intelligent Electronic Device
IEM	Information Exchange Model
LCB	Log Control Block
LD	Logical Device
LN	Logical Node
O&M	Operation and maintenance
OSI	Open Systems Interconnection
RCB	Report Control Block
SCADA	Supervisory Control and Data Acquisition
SCSM	Specific Communication Service Mapping (defined e.g. in IEC 61850-8-1)
WPP	Wind Power Plant
WT	Wind Turbine
XML	Extensible Mark-up Language

5 Overall description of the IEC 61400-25 series

5.1 General

The main objective of the IEC 61400-25 series is to create a standard basis for manufacturer-independent communications for monitoring and control. Manufacturers and suppliers of wind power plant components shall implement the IEC 61400-25 series in their devices and systems.

Clause 5 provides a general overview of the context, models, modelling approach, and application possibilities of the IEC 61400-25 series.

Subclause 5.2 provides a top-down view on wind power plants and shows the areas where the IEC 61400-25 series can be applied. It explains what is to be understood under the term ‘wind power plant’, which operation concepts are distinguished and which components are used to run wind power plants.

Subclause 5.3 describes the demands made with reference to the communication taking place within the framework of the monitoring and control of wind power plants. It explains which general communication capabilities wind power plants shall possess and which contents and functions are required for communication.

Subclause 5.4 provides an overview of the communication model defined by the IEC 61400-25 series. The server-client communication environment that served as the basis when developing the IEC 61400-25 series is introduced briefly. Next, three server-client application topologies are introduced, illustrating the communication architectures that are possible by way of an example. Finally, the three areas defined by the IEC 61400-25 series to be implemented as the standard for the monitoring and control of wind power plants will be introduced on a generally understandable level.

5.2 Top-down view on wind power plants

5.2.1 Definition of wind power plants

Wind power plants constitute complete systems consisting of any number of technical subsystems with clearly separated tasks. The subsystems are referred to in the further discourse as wind power plant components and will be described in 5.2.2.

5.2.2 Wind power plant components

Wind power plant components are technical systems employed in the operation of wind power plants. They consist of various sub-components, which will not be differentiated in the following. All wind power plant components fall within the application area of the IEC 61400-25 series.

The information modelled in the IEC 61400-25 series covers the following corresponding components:

Wind turbine

- rotor,
- transmission,
- generator,
- converter,
- nacelle,
- yaw system,
- tower,
- alarm system.

Meteorological system

- meteorological conditions of the wind power plant.

Wind power plant management system

- wind power plant control.

Electrical system

- wind power plant grid connection.

The wind turbine (with its many sub-components) is the main component of a wind power plant. The wind turbine is responsible for generating energy and meets the task of using the wind potential of a certain location to convert wind into electrical energy.

Vendors of wind turbines usually guarantee their customers a certain power curve and technical availability in terms of energy production. To enable both the operators and owners to verify the guaranteed performance of the wind turbines used, well-founded data providing information on the wind conditions at the particular location shall be available.

According to the standard IEC 61400-12-1, a separate wind power plant component, the reference met mast, referred to in the further discourse as a meteorological system, should be used for the measuring of the wind conditions, for example the wind speed, at a particular location. The meteorological system supplies the data that may be required to correlate the produced power output of individual wind turbines to the useable wind potential. On this basis, it is possible to draw well-founded conclusions as to the real performance of a certain wind turbine.

In addition to several wind turbines, integrated operation requires further components; the energy produced in decentralised feeder and/or substations shall be collected and transported to the final user via suitable power networks. This task is covered by the electrical system.

NOTE All electrical system issues concerning substations are targeted in the scope of the IEC 61850 series.

Another component, the wind power plant management system, ensures that the complete system adapts itself to the static and dynamic conditions and requirements of the electrical power connection (substation, utility network).

5.3 Generic requirements on communication

5.3.1 Communication capability

Wind power plants are monitored and controlled by various external actors, such as local or remote SCADA systems, local real time build-in control systems, energy dispatch centres etc.

The objective of the monitoring of wind power plants is to provide the actors with information on the complete system and the installed components. This information is deemed to be an important knowledge basis for the control of wind power plants. For example, a SCADA system which wants to stop the operation of a certain wind turbine in an integrated operation, shall know how this component can be identified within the complete system and in which status it is currently operating. The SCADA system shall, however, also know to which device within the integrated operation it shall send which commands to make sure that the relevant component is controlled as intended. To be able to check whether or not the command has been executed, the SCADA system additionally requires a feedback from the wind power plant.

Thus, wind power plants and external actors shall meet an essential prerequisite to be able to exchange information within the framework of monitoring and control: They shall be able to communicate with the outside world.

Typically, any wind power plant component, which needs to exchange information with other components and actors, is therefore equipped with a so-called intelligent electronic device (IED), which can send data to external receivers and receive data from external senders. A wind turbine usually possesses a wind turbine controller, which is primarily responsible for the internal monitoring and control of the wind power plant component, but also allows external monitoring and control.

5.3.2 Communication content

Information is the content of the communication that takes place within the framework of monitoring and control. The basic elements are raw data from the wind power plant component, which shall be processed into specified information according to the IEC 61400-25 series. There are five types of information that can be differentiated and are important for the monitoring and control of wind power plants:

– process information,
– statistical information,
– historical information,
– control information,

– descriptive information.

Process, statistical and historical information provide the contents required for the monitoring and control of wind power plants; this information shall be communicated by the wind power plants. Process information provides information on the behaviour of certain complete systems and their components, on their current states. Statistical information is often useful to evaluate the operation of a wind power plant. By using historical Information, it might be possible to track the operational trends in logs and reports.

Control information is intended to transmit the contents required for the control of wind power plants, such as access profiles, set points, parameters and commands; this information shall first be communicated to wind power plants by certain actors. Wind power plants shall store control information and provide this for further communication to sub-processes.

Descriptive information is the type and the accuracy of the information, as well as the time and the data description.

5.3.3 Communication functions

The actors communication for monitoring and controlling the wind power plants require special functions to configure, perform and monitor the information exchange with wind power plants. These functions can be divided into the following two main categories:

– operational functions,
– management functions.

Operational functions (manual or automatic) are used by the actors to obtain information on wind power plants and to send control instructions to wind power plants. The operational functions include:

– monitoring,
– control,
– data retrieval,
– logging,
– reporting.

Table 1 provides an overview of the ranges of application of the operational functions.

Table 1 – Operational functions

Operational functions	Range of application (practical use)
Monitoring	Operational function used for local or remote observation of a system or a process for any changes which may occur over time. The term can also be used for observation of the behaviour of a data value or a group of data values.
Control	Changing and modifying, intervening, switching, controlling, parameterisation, optimising of wind power plants.
Data retrieval	Collecting of wind power plant data.
Logging	Logging is a function intended for sequential recording of data and events in chronological order. The result of the logging is a log.
Reporting	The reporting is a function intended to transfer data from a server to a client, initiated by a server application process.

Management functions are required for the higher-lever management of the information exchange. They are used by actors to secure integrity of the monitoring and control process. The management functions included are as follows:

- user/access management,
- time synchronization,
- diagnostics (self-monitoring),
- system setup.

Table 2 provides an overview of the ranges of application of the management functions.

Table 2 – Management functions

Management functions	Range of application (practical use)
User/access management	Setting up, modifying, deleting users (administratively), assigning access rights (administratively), monitoring access
Time synchronisation	Synchronisation of devices within a communication system.
Diagnostics (self-monitoring)	This function is used to set up and provide for self-monitoring of the communication system.
System setup functions	Defining how the information exchange will take place; setting, changing and receiving (retrieval) of system setup data.

5.4 Communication model of the IEC 61400-25 series

5.4.1 General

The IEC 61400-25 series defines a communication model for the monitoring and control of wind power plants, taking into account all requirements made with reference to the communication, on an abstract level. The communication model comprises three separately defined areas:

- information model,
- information exchange model,
- mapping of the information model and the information exchange model to standard communication profiles.

The communication model is embedded in an abstract environment where two entities may communicate via a common communication channel. These two entities are referred to in the further discourse as server and client (see Figure 1). The server assumes the role of an information and service provider supplying the client the contents and functions required for the communication. The client assumes the role of a user who possesses certain rights to use and manage the server.

The IEC 61400-25 series leaves it open how and in which physical device the server is to be implemented in practice. The objective of the IEC 61400-25 series is that the information associated with a single wind power plant component (such as the wind turbine) is accessible through a corresponding logical device. Also, the IEC 61400-25 series does not specify how objects in the wind power plant information model are distributed among the servers.

5.4.2 Information model

The wind power plant information model (see Figure 2) provides the contents required for the information exchange that takes place within the framework of the monitoring and control between client and server.

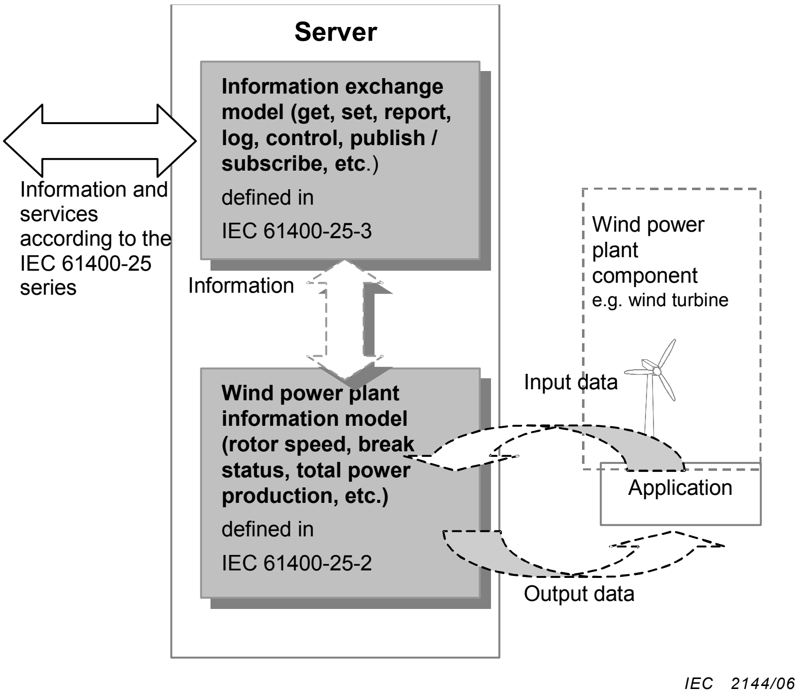

Figure 2 – Data processing by the server (conceptual)

The model is deemed to be a standard frame of interpretation via which the server may process all data, which is provided by wind power plants for the external monitoring and control, into relevant and semantically standardized information, and may grant the client access to these data in a component-oriented view.

When developing the wind power plant information model, the paradigm of object orientation has been taken into account. This approach allows wind power plants to be viewed as information objects and modelling of an appropriate information architecture.

Clause 6 describes in detail the logical structure of the wind power plant information model and the method by which wind power plants shall be modelled as information objects.

The IEC 61400-25 series utilises the concept of object modelling to represent the systems and components of a wind power plants to communicate with. This means that all of the components in the real world are identified as objects that have data such as analogue values, binary status, commands and set points and these objects and data are mapped into generic, logical representations of the real world components as a wind power plant information model.

Breaking a real world component down into objects to produce a model of that object involves identifying all of the data and functionality of each component object. Each data has a name and a simple or complex type (a class) and represents data in the device to be read or updated.

Instead of dealing with lists of numbered quantities, an object-modelling approach lets us organise and define standard names for standard things, independent of the manufacturer of the equipment. If the equipment has a shaft for which the rotational speed is available for reading, it has the same name regardless of the vendor of that equipment and can be read by any client program that knows the information model.

In addition to reading and updating process information, other functionalities of the device may include things such as historical logs of information, report by exception capabilities, and actions within the device that are initiated by internal or external command and control inputs.

All of these items imply some type of information exchange between the outside world and the real world device represented by the wind power plant information model.

5.4.3 Information exchange model and relation to wind power plant information models

The information exchange mechanisms rely on standardised wind power information models. These information models and the modelling methods are the core of the IEC 61400-25 series. The IEC 61400-25 series uses the approach to model the information found in real components as depicted in the conceptual overview in Figure 3. All information made available to be exchanged with other components is defined in the IEC 61400-25 series. The model provides for the wind power plant automation system an image of the real world (power system process, generator, etc.).

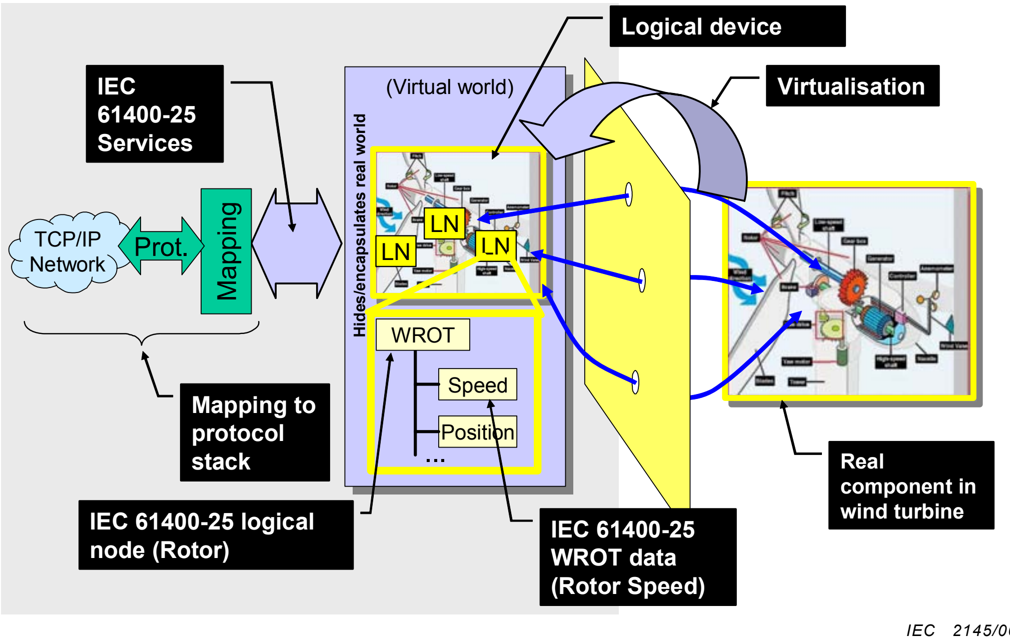

Figure 3 – Modelling approach (conceptual)

The IEC 61400-25 series defines the information and information exchange in a way that is independent of a concrete implementation (i.e., it uses abstract models). The IEC 61400-25 series also uses the concept of virtualisation. Virtualisation provides a view of those aspects of a real device that are of interest for the information exchange with other devices. Only those details that are required to provide interoperability of devices are defined in the IEC 61400-25 series.

The approach of the IEC 61400-25 series is to decompose the functions into the smallest entities, which are used to exchange information. The granularity is given by a reasonable distributed allocation of these entities to dedicated devices (IED). These entities are called logical nodes (e.g., a virtual representation of a rotor class, with the standardised class name WROT). The logical nodes are modelled and defined from the conceptual application point of view. Logical nodes are collected in a logical device representing for example a complete wind turbine.

Real components on the right hand side of Figure 3 are modelled into a virtual model in the middle of the figure. The logical nodes correspond to functions in the real physical devices. In this example, the logical node WROT represents a specific rotor of the turbine to the right.

Based on their functionality, a logical node contains a list of data (e.g., rotor speed) with dedicated information. The data have a structure and a well-defined semantic (meaning in the context of wind power plant systems). The information represented by the data are exchanged by the services according to the information exchange services defined.

The logical nodes and the data contained are crucial for the information model and the information exchange services for wind turbines to reach interoperability.

The logical nodes and the data contained are configured by the control information, for example parameters, commands to be accepted, set point ranges, etc.

5.4.4 Mapping to communication profile

The information exchange between server and client requires a uniform communication protocol on both sides. A specific mapping to a communication profile defines how the objects in the wind power plant information model and the functions and services defined in the information exchange model are implemented using a specific protocol stack, i.e. a complete communication protocol. IEC 61400-25-4 specifies in detail the communication protocols applied in the IEC 61400-25 series.

The mapping to protocol stacks specified in future IEC 61400-25-4 is oriented in its structure towards the OSI reference model (ISO 7498-1:1994). According to the OSI reference model, the communication realised between client and server is divided into seven layers. Whereas layer 7, 6 and 5 are concerned with application issues (often named as the A-Profile), the lower four layer are concerned with data transport issues (often named as the T-Profile).

6 Wind power plant information model

6.1 General

This clause provides a detailed description regarding the wind power plant information model. Common wind power plant relevant information is defined, structured and described unambiguously from viewpoint of object orientation.

Subclause 6.2 describes the modelling methodology used to represent and structure relevant information.

IEC 61400-25-2 defines logical nodes to group related information. It also defines common data classes as building blocks that contain wind power plant specific properties of the information. This part also comprises the common data classes inherited from IEC 61850-7-3.

6.2 Information modelling methodology

6.2.1 Wind power plant information

For modelling purposes, information could be LNs, data or data attributes. Data consists of data attributes that can be for example the value (of a measurand, state, setpoint etc.), accompanying name, time, quality, accuracy, unit etc.

A wind power plant comprises different types of information. Besides source data, wind turbine controllers usually derive a huge amount of additional information (10 min averages, alarms, logs, counters, timers, etc.). This valuable information is locally stored and available for future use or analysis. In Table 3, the relations between different information categories are shown and their definition will be used in the IEC 61400-25 series.

Table 3 – Wind power plant information categories

Category		Description
Process information		
State information		Discrete information concerning the current condition or behaviour of a component or system
	Status	Condition of a component or system (st1/st2/..stn)
	Alarm	Statement of safety intervention by for example the turbine control system
	Event	State transition (status, alarm, command)
Analogue information		Continuous information concerning the current condition or behaviour of a component or system
	Measured data	(Sampled) value of a process quantity
	Processed data	Measured value, which has been processed (10m-average/…)
	Three phase data	Measured value of a three phase electric power quantity
Control information		
Control information		Discrete information concerning the current condition or behaviour of a component or system
	Command	Controllable status for system behaviour (enable/disable, activate/deactivate etc)
	Set point	Reference value for a process quantity
	Parameter	Controllable value for system behaviour (adjustment)
Derived information		
Statistical information		The result of applying a statistical algorithm to a set of data.
	Timing data	Total time duration of a specific state
	Counting data	Total number of occurrences of a specific event
	Characteristic data	Properties of information or data observed (min, max, average, std. dev, etc.)
Historical information		Information about the time passed
	Log	Chronological list of events for a specific period of time
	Transient log	Event triggered chronological list of high resolution source information for a short period of time.
	Report	Periodical notification comprising the information that represent the state and data requested in the report control block.

6.2.2 Modelling approach

Because all the information categories as listed in Table 3 comprise their own formats and properties, the IEC 61400-25 series has to define a general wind power plant information model. The structure of this top-down view model is hierarchical and based on the modelling approach as defined in IEC 61850-7-1 Clause 6 (Modelling approach of the IEC 61850 series) where the basis are described in IEC 61850-7-2:2003, Clause 5. Hierarchical means that different levels of common information are distinguished and grouped together into classes. Lower level classes will automatically inherit properties as specified by upper level classes. The structure of the wind power plant information model is concisely given in Figure 4. Each level will be discussed separately in more detail.

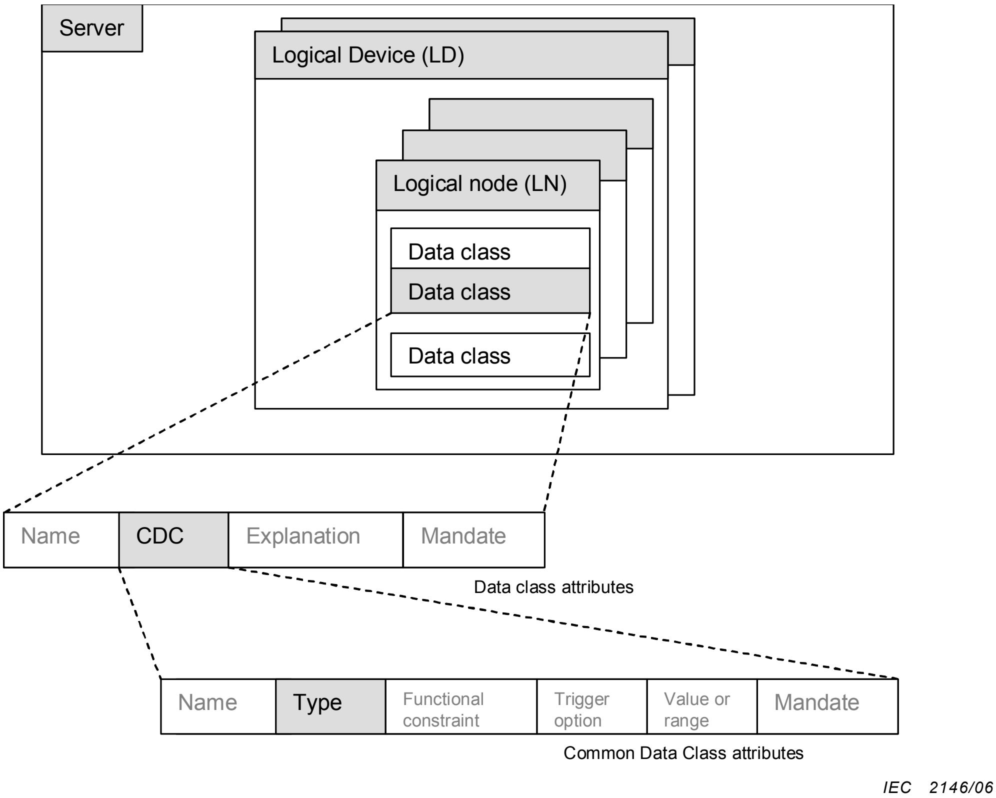

Figure 4 – Structure of wind power plant information model

The highest level is called Logical Device (LD), which is decomposed into Logical Nodes (LN). A logical node consists of a collection of related data, called data classes (DC). Each data class inherit a collection of properties, as defined by a so-called Common Data Class (CDC) to which it is assigned. A common data class consists of a collection of data records. The most basic detail of data can be found in the type-definition of a common data class.

6.2.3 Logical devices

A server hosts at least one logical device. The IEC 61400-25 series could for example be used to assign a logical device to a specific wind turbine of a wind power plant. Thus a logical device contains a collection of specific logical nodes belonging to this wind turbine. The logical node zero (LLN0) is destined to provide common information about the logical device (e.g. logical device nameplate and health) and the logical node physical device (LPHD) represents common data of the physical device that is hosting the logical device (e.g. physical device nameplate and health).

6.2.4 Logical nodes

Within a logical device, all wind turbine information will be distributed in different 'containers', called logical nodes. In the IEC 61400-25 series a set of specific logical node classes for wind power plants have been specified (IEC 61400-25-2), some of these shall be mandatory (indicated with an ‘M’ in tables) and others optional (indicated with an ‘O’ in tables). The basic rules for the use of Logical Nodes and Data classes and their extensions are defined in Annex A of IEC 61850-7-4 and in the Clause 14 of 61850-7-1. The specific LN's are originated by a physical turbine break down into functional systems (e.g. rotor, transmission, generator, yaw system, etc), but collections of common information can also be represented in a specific LN (e.g. alarm log, event log, etc). The names of wind power plant specific logical nodes shall be unique and always begin with 'W', followed by three capitals representing the content.

The Logical Node data is represented by named attributes that can have simple or complex types (a 32 bit integer or a complex structure variable made up of a collection of named simple and complex component types). In the first generation of wind power plant communications, this data would have been represented as a linear, memory mapped address space with all data having the same type. In this model, this data is named and has whatever types are appropriate to represent the underlying data. The specific internal organisation and implementation of the data storage and management scheme are independent of the outside world view.

Inside a LN, information is specified by data classes. All logical nodes have a standardised and similar table structure as shown in Table 4. The table represents and visualises the different data class attributes in a logical node.

Table 4 – General table structure of a logical node (LN)

Wxxx class			
Attribute name	**Attribute type**	**Explanation**	**M/O**
Data			
Common Information			
Data class name	CDC	Description and range	
Status Information			
Data class name	CDC	Description and range	
Analogue Information			
Data class name	CDC	Description and range	
Control Information			
Data class name	CDC	Description and range	

For the sake of convenience, all information in a logical node is categorised in compliance with the wind power plant information decomposition of Table 3.

In Table 5 all data class attributes inside a logical node are explained briefly.

Table 5 – Data class attributes in a logical node

Data class attribute	**Description**
Attribute Name	Name of the data class
Attribute Type	Common data class that defines common data properties. The CDCs are defined in IEC 61400-25-3
Explanation	Short explanation of the content of the data class
Mandate	M: Mandatory, O: Optional

If an optional logical node is used, its mandatory (M) data class attributes shall also be used. Optional (O) defined data class attributes are instantiated as needed by the user.

7 Wind power plant information exchange model

7.1 General

Clause 7 provides an overview of the information exchange models that can be applied by a client and a server to access the content and structure of the wind power plant information model defined in Clause 6.

7.2 Information exchange modelling methodology

7.2.1 Wind power plant information exchange

The primary objective of the wind power plant information exchange model defined in the IEC 61400-25-3 is to exchange information provided by the instantiated information model of the various classes, such as Logical Nodes, Data, DataAttributes or control blocks. The IEM defines a server that provides:

- an instance of the wind power plant information model, and
- required functions including the associated services (Get, Set, Control, Query, Report, etc.) which enable a client to access the instantiated information model.

The IEC 61400-25 series defines the server role only. A client issues service requests to the server, by sending request messages, and receives response messages or reports from the server.

A server provides access to its wind power plant information model instance for multiple clients, as illustrated in Figure 5. Each client can, independently of other clients, communicate with the server.

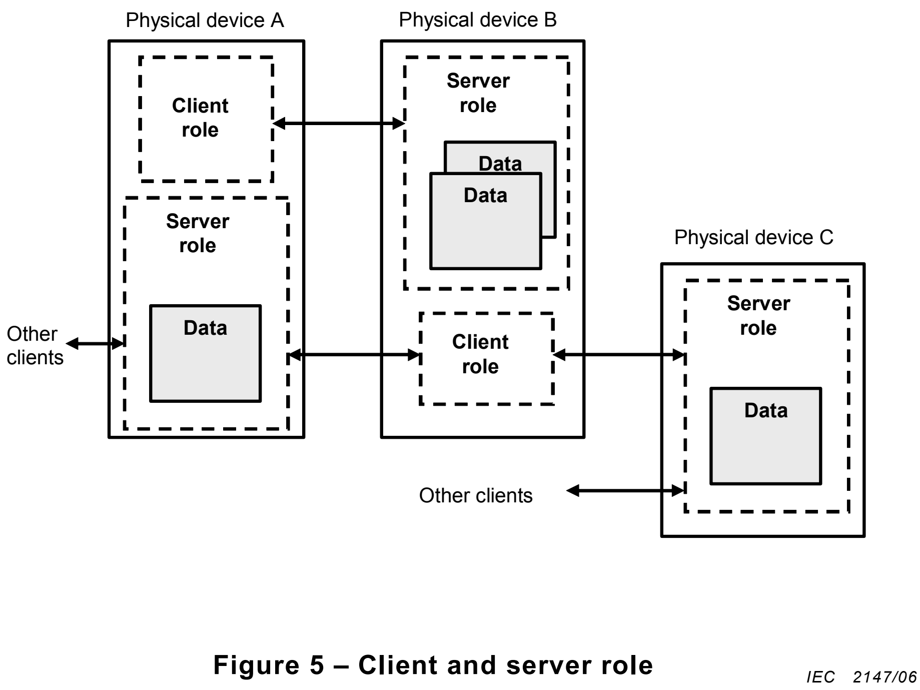

Figure 5 – Client and server role

As shown in Figure 5, physical devices may implement the client, the server role, or both roles.

The client plays the complementary role of the server with regard to the services.

NOTE The IEC 61400-25 series does not define any application program interface – neither in the server nor in the client. It defines the externally visible view of the information contained in server and how this information can be sent and received.

7.2.2 Service models

The wind power plant information model in the server supports the access services as depicted in Figure 6.

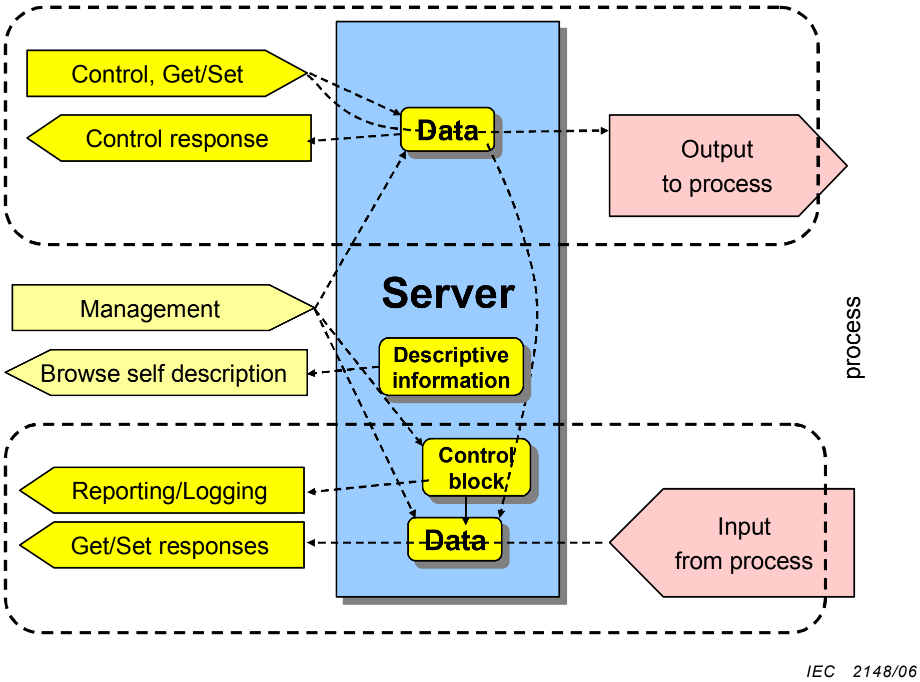

Figure 6 – IEM Service models

The focus of the server is to provide data that make up the wind power plant information model. The data attributes contain the values used for the information exchange. The IEM provides services for:

- control of external operational devices or internal device functions,
- monitoring of both process and processed data, and
- management of devices as well as retrieving the wind power plant information model.

The wind power plant information model data instances contained in the server can be accessed by the services Get, Set, Control for immediate action (return information, set values to data, control device or function).

Reporting and logging provide the means to autonomously and spontaneously send information from the server to the client issued by a server-internal event (reporting) or to store this information in the server for later retrieval (logging).

7.2.3 Abstract communication service interface

The set of basic services that the communications interface uses to accomplish the information exchange between the outside world and various components of the real world device are referred to as the Abstract Communication Service Interface (ACSI). The basic methodology of these services is described in detail in IEC 61850-7-1 and 61850-7-2. Table 6 of IEC 61850-7-1 describes the ACSI models and services. The following describes the services in the specific wind power plant context.

Figure 7 graphically illustrates the various components of the ACSI models. This figure is used to provide a narrative description of how a typical device interacts with the outside world using these services.

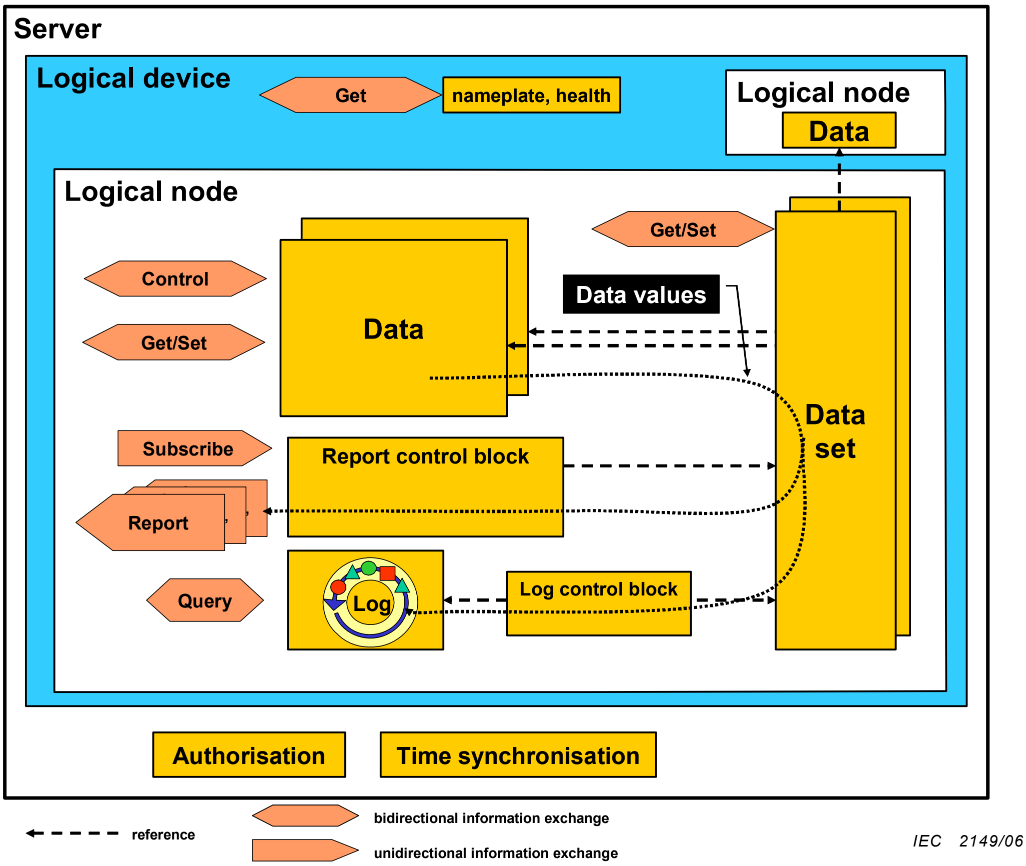

Figure 7 – Conceptual information exchange model for a wind power plant

A physical device with a communications interface is represented as a server. It has an communication network address and is accessible over a network by an external client. The server can accept a connection from one or more external clients, authenticate that connection, and support services to provide information to the client. This server contains one or more logical devices, which contains one or more logical nodes that represent the basic building blocks (objects) that represent various functionalities of the logical device. The logical node contains data that can be written to or read individually and in groups (data sets), responds to control inputs, provides solicited and unsolicited reports, and contains logs that can be queried. This representation is generic, but quite powerful in terms of the services it provides and can be used to represent any real world physical device with a communications interface.

Get/Set and Control services are provided to read (get) and write (set) the data in the Logical Node. Analogue information and status information are normally read only. Control and configuration information are generally read and write. Services are provided to facilitate concepts such as select before operate for control applications.

In addition to individually named data, collections of data (a Data Set) can be defined and given a name. Services are provided to create, delete and list Data Sets, and to get and set values of Data Sets. This arbitrary grouping capability lets client applications define collections of data attributes that are commonly needed and retrieve them with a single get operation using a single name.

Data Sets are the key to two information exchange mechanisms in a Logical Node – reporting and logging. Most physical devices have some kind of internal logging mechanism. These logs may contain periodic recordings of data values, recordings of data values when the value changed by some amount, exceeded a threshold, or some other triggering mechanism. Similarly, physical devices often have the means to send some kind of report directly to a subscribed client under circumstances similar to those just described for logging. In the ACSI models, the information that gets reported or logged is represented by a Data Set. This approach permits specifying the rules for logging and reporting to be defined in a more compact and efficient fashion.

The rules for logging and reporting are defined in the Log Control Block (LCB) and Report Control Block (RCB) respectively. Each log has an associated LCB and each report has an associated RCB that defines the rules for what goes into the logs and reports. These rules determine which Data Set(s) are to be included and under what conditions. This approach provides a very powerful and flexible means of logging and reporting information.

Logs are often a very important aspect of a physical device. The generation of these logs may be the core function of the physical device (a condition monitoring device for example) or may be utilised for diagnostic information. Logs are time ordered collections of data grouped into defined Data Sets. Services are provided to permit an external client to retrieve information from the log either in whole or in part. This is accomplished by providing the means to query the log with filters that specify a time range of interest and which named attributes are to be retrieved.

Services are also provided to permit a client to subscribe to reports that have been defined in the device. These reports can be buffered so that if communications are temporarily disrupted, all of the reports are still sent to the client when communications are re-established.

This overview illustrates the core information exchange capabilities of a physical device using the ACSI approach. For more detailed description of the ACSI, the reader is referred to IEC 61850-7-1 and IEC 61850-7-2.

7.2.4 Service modelling convention

The services are generally defined by:

– a set of rules for the definition of messages so that receivers can unambiguously understand messages sent from a peer,

– the service request parameters as well as results and errors that may be returned to the service caller, and

– an agreed-on action to be executed by the service (which may or may not have an impact on process).

This basic concept of the IEM is depicted in Figure 8.

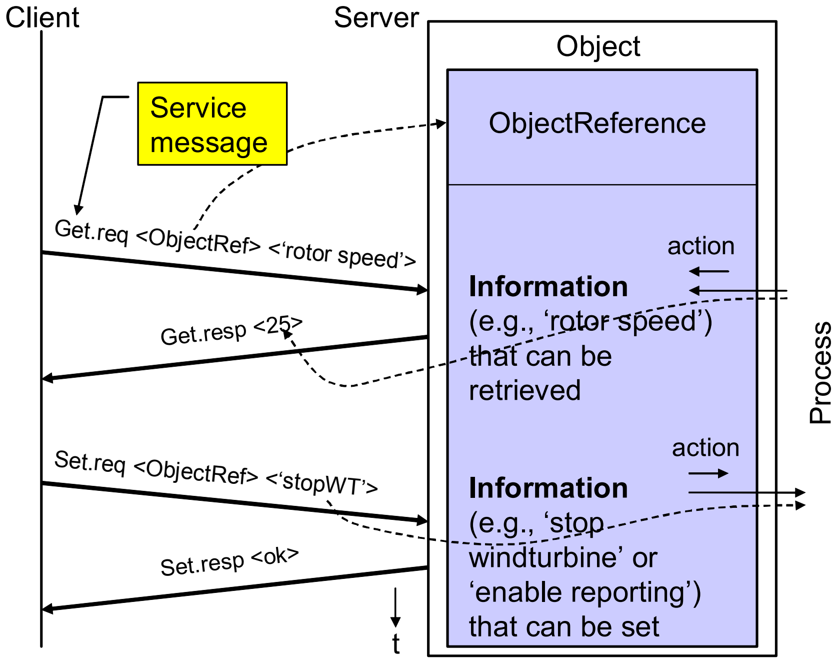

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Figure 8 – IEM service model with examples

All services are based on three message primitives: request, positive response and negative response. The request primitive is used by the client to issue a service call to the server and the response primitives allow the server to return information to the client. A positive response primitive indicates that the service agreed-on action was or will be executed whereas a negative response indicates the action failed to execute or will not be executed. A message primitive may have a number of parameters, called results and errors in case of response primitives.

Each specific service is defined by one or more service tables that summarise the parameters that are required for the processing of a particular primitive as shown in Table 6.

Table 6 – Service table

Parameter name
Request
Parameter 1…
Parameter *n*
Response+
Parameter 1…
Parameter *n*
Response-
Parameter 1…
Parameter *n*

NOTE 1 The service tables of the services defined in IEC 61400-25-3 do not show all parameters required in concrete interface implementations; e.g. the parameter 'association' or 'retransmission time' are not depicted in the service tables. These tables are abstract – local issues and concrete protocol issues are not shown. These specific issues are not required to understand the semantic and behaviour of the service.

Each parameter and the effect this parameter has on the processing of the service are abstractly described in this part of IEC 61400-25.

The sequences of the request/response primitives (messages) for the services are depicted in Figure 9.

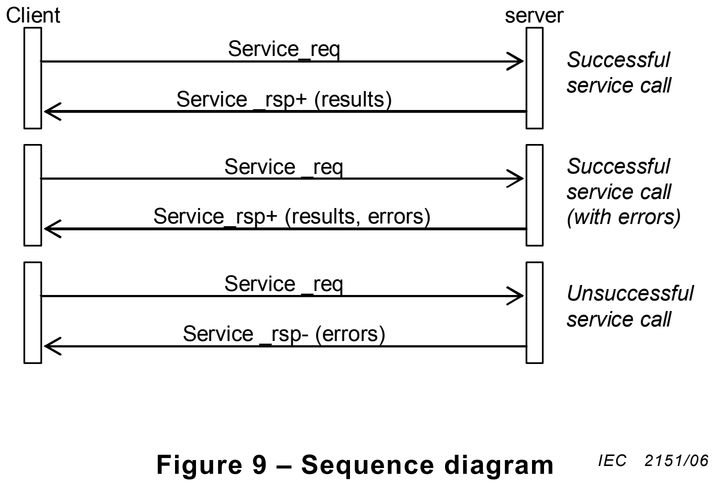

Figure 9 – Sequence diagram

The messages operate on the (attributes of) information objects. There are two kinds of classes that can be instantiated to objects:

1) The wind power plant information model classes such as logical devices, logical nodes, data, and data attributes as defined in Clause 6 (mainly representing process data, e.g., 'rotor speed' or 'stop wind turbine'), and

2) Various (common) control blocks, for example, for reporting and logging. The reporting control block may, for example, be accessed to start or stop reporting values by setting a specific attribute.

The messages described in this clause are conceptual – to understand the IEM.

NOTE 2 The concrete messages may be defined by some well known notation, e.g., tables or XML. Concrete messages can be found in the mappings to specific application layer protocols (see IEC 61400-25-4).

The agreed-on action or actions to be processed on the receipt of a message may be simple, as in the case of the service 'Get', or more complex, as in the case of controlling the behaviour of a real physical device. The later case requires precise description of how the control acts, for example, the server could immediately invoke the process control system to distribute the necessary internal commands to stop the wind turbine or it may first have to check if another client is operating the wind turbine, thus requiring the use of a semaphore (often called Select-before-Operate).

The dynamical behaviour of the reporting and logging models is controlled by common control blocks. The actions of a certain control block object are described by multiple attributes like number of entries/array-elements, which values to be reported or logged, period of periodic reporting/logging, or events to buffer in case the communication link is down. The dynamic behavior is also influenced by the nature of the buffer, for example, circular buffer that wraps.

Actions usually produce results that have to be transmitted back to the client. In case of error occurrence, error messages are sent back. The actions are usually defined by various attributes, formal state machines and plain text.

8 Mapping to communication protocols

8.1 General

The specific communication service mapping (SCSM) defines how the services and the models (server, logical devices, logical nodes, data, data sets, report controls, log controls, setting groups, etc.) are mapped to specific communication stacks, i.e. to a complete profile. The mappings and the used application layer define the syntax (concrete encoding) for the data exchanged over the network.

NOTE The concept of the SCSM has been introduced to be independent from communication stacks including application protocols.

According to Figure 10, the SCSM maps the abstract communication services, objects and parameters to the specific application layers. These application layers provide the concrete coding. Depending on the technology of the communication network, these mappings may have different complexities, and some ACSI services may not be supported in all mappings but where a service is provided in a mapping, that service shall be equivalent in its meaning to the same service in the benchmark mapping. An application layer may use one or more stacks (layer 1 to 6).

EXAMPLE The mapping of the service 'GetDataSetValues' (reading many values in one chunk) may have different mappings for AL1 to ALn. For example, a specific AL may support this service directly while another AL supports Get of single values or many values of the same type only. In this case, the mapping has to issue several Gets.

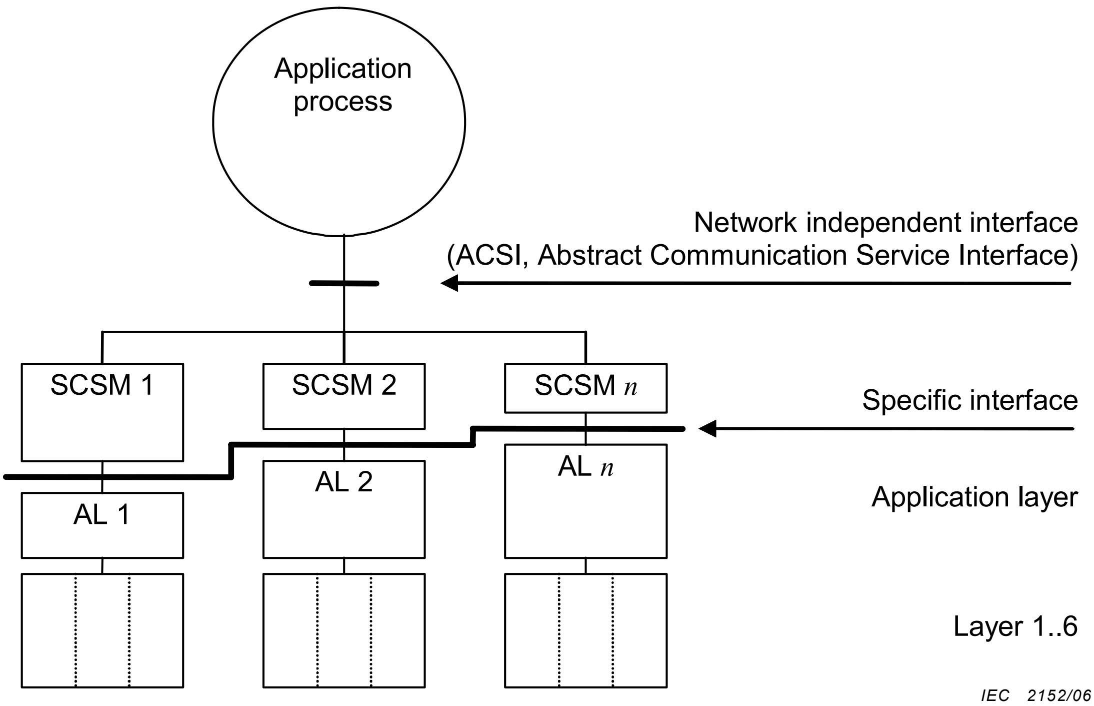

Figure 10 – ACSI mapping to communication stacks/profiles

8.2 Architecture of the mappings

Multiple mappings may be supported by the IEC 61400-25 series. The conceptual architecture of the mappings is shown in Figure 11.

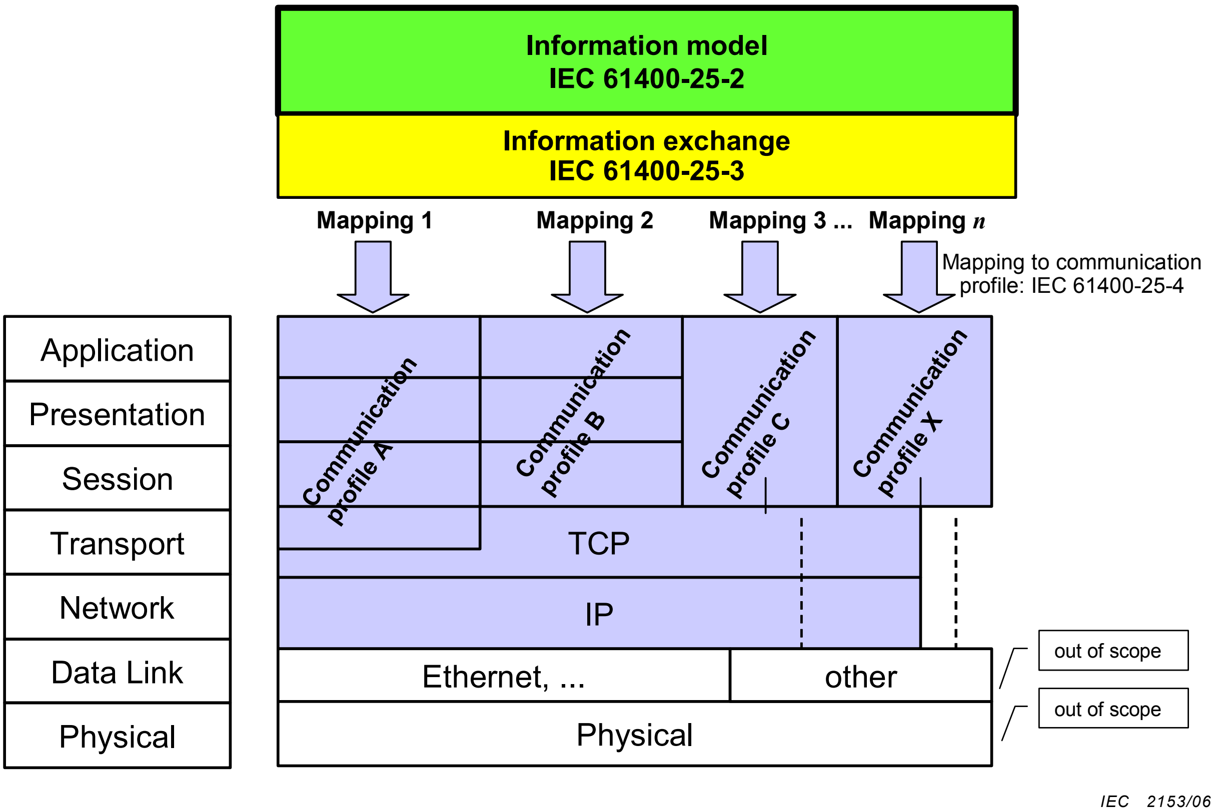

Figure 11 – Communication profiles

The information models and the information exchange models need to be mapped to appropriate protocols. Mapping requirements are defined in IEC 61400-25-4. The protocols TCP and IP shall be the basic lower layer protocols provided by all mappings. Specific data link and physical layers are beyond the scope of the IEC 61400-25 series.

8.3 Mapping of the wind power plant information model

The mapping of the wind power plant information models to a hierarchical structure as defined in Clause 6 and Clause 7 of IEC 61400-25-2, shall be applied for all SCSMs of the IEC 61400-25 series.

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- purchasing agent ❑
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- other...

Q3 I work for/in/as a: *(tick all that apply)*

- manufacturing ❑
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- other...

Q4 This standard will be used for: *(tick all that apply)*

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- product research ❑
- product design/development ❑
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- tenders ❑
- quality assessment ❑
- certification ❑
- technical documentation ❑
- thesis ❑
- manufacturing ❑
- other...

Q5 This standard meets my needs: *(tick one)*

- not at all ❑
- nearly ❑
- fairly well ❑
- exactly ❑

Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

- standard is out of date ❑
- standard is incomplete ❑
- standard is too academic ❑
- standard is too superficial ❑
- title is misleading ❑
- I made the wrong choice ❑
- other ....

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(2) below average,
(3) average,
(4) above average,
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- quality of writing....................................
- technical contents...................................
- logic of arrangement of contents ....
- tables, charts, graphs, figures...............
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Q8 I read/use the: *(tick one)*

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- English text only ❑
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