

Telecontrol equipment and systems —

**Part 6-505: Telecontrol protocols
compatible with ISO standards and
ITU-T recommendations —
TASE.2 User guide**

ICS 33.200

National foreword

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Telecontrol equipment and systems –

Part 6-505: Telecontrol protocols compatible with ISO standards and ITU-T recommendations – TASE.2 User guide



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

TELECONTROL EQUIPMENT AND SYSTEMS –

**Part 6-505: Telecontrol protocols compatible with
ISO standards and ITU-T recommendations –
TASE.2 User guide**

FOREWORD

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Technical reports do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful by the maintenance team.

IEC 60870-6-505, which is a technical report, has been prepared by IEC technical committee 57: Power system control and associated communications.

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

Enquiry draft	Report on voting
57/548/CDV	57/580/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.

This document, which is purely informative, is not to be regarded as an International Standard.

The committee has decided that the contents of this publication will remain unchanged until 2007.
At this date, the publication will be

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- withdrawn;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

INTRODUCTION

A large number of utilities use the Telecontrol Application Service Element.2 (TASE.2), an international standard protocol for communication of real-time data. TASE.2 provides a common means for all utilities to exchange data between not only control centers, but power plants and substations as well. The adoption of TASE.2 has led to the availability of competitively priced data communication products based on TASE.2 from multiple vendors at a fraction of the cost of a proprietary system. This report provides guidance for utility users who are evaluating, procuring, and configuring TASE.2, as well as aid to vendors implementing TASE.2 in their products. The individual server and data objects comprising TASE.2 are described, with cross references to the specification. This provides the reader the basic understanding needed to use the TASE.2 specifications in an informed manner. The guide then addresses practical issues that arise in connection with TASE.2 use.

TELECONTROL EQUIPMENT AND SYSTEMS –

Part 6-505: Telecontrol protocols compatible with ISO standards and ITU-T recommendations – TASE.2 User guide

1 Scope

This technical report provides a set of guidelines on the use of the following TASE.2 international standards:

IEC 60870-6-503

IEC 60870-6-702

IEC 60870-6-802

These standards specify a method of exchanging time-critical control center data through wide- and local-area networks using a full ISO compliant protocol stack. They contain provisions for supporting both centralized and distributed architectures. These standards include the exchange of real-time indications, control operations, time series data, scheduling and accounting information, unstructured ASCII or binary files, remote program control, and event notification.

However, the style of the TASE.2 standards may make them somewhat difficult to read for someone either not familiar with the precise syntax of the language used to describe the protocol or with all the background leading up to the development of these specifications. Furthermore, certain types of information that may be very useful to a user of TASE.2 but not necessary for specifying the protocol or services provided by TASE.2 have been omitted. Thus the need for this User Guide.

1.1 Intended users

This User Guide is intended for a broad audience of readers from an end user trying to decide if TASE.2 is appropriate for their data transfer needs to a vendor planning to implement TASE.2, with the goal of offering a TASE.2 product. In particular, this guide should be helpful to the following:

- An end user, such as an electric utility, with the need to transfer real-time data to another utility or utilities or to another internal control center, who is trying to evaluate which protocol is the most appropriate.
- An end user who has already decided to use TASE.2 and now needs guidance in how to procure TASE.2.
- An end user who has procured TASE.2 and is now concerned about how to map their actual data into TASE.2 data objects exactly.
- An end user who is looking for conventions and answers to practical questions regarding configuring TASE.2 software and networks.
- A vendor with a project to implement the TASE.2 specification either as a special project or to offer a standard product.

1.2 Organization

This guide first introduces the background and concepts of TASE.2 to provide a framework for understanding the TASE.2 specification. Then the individual server and data objects comprising TASE.2 are described with cross references into the specification. At this point, (i.e., Clauses 1-8) the reader should have all the necessary basic understanding to use the TASE.2 specifications intelligently. The remainder of the guide (Clauses 9-20) address practical issues that arise in connection with the use of TASE.2.

1.3 TASE.2 Version

This edition of the TASE.2 User Guide was prepared using the Second Edition of the TASE.2 standards, which at the time of the preparation of this report was the 2000 edition.

2 Reference documents

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 60870-5-101:1995, *Telecontrol equipment and systems – Part 5: Transmission protocols - Section 101: Companion standard for basic telecontrol tasks*

IEC 60870-6-503:2002, *Telecontrol equipment and systems – Part 6-503: Telecontrol protocols compatible with ISO standards and ITU-T recommendations – TASE.2 Services and protocol*

IEC 60870-6-702:1998, *Telecontrol equipment and systems – Part 6-702: Telecontrol protocols compatible with ISO standards and ITU-T recommendations – Functional profile for providing the TASE.2 application service in end systems*

IEC 60870-6-802:2002, *Telecontrol equipment and systems – Part 6-802: Telecontrol protocols compatible with ISO standards and ITU-T recommendations – TASE.2 Object models*

ISO/IEC 8802-2:1998, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*

ISO/IEC 9506 (all parts), *Industrial automation systems – Manufacturing message specification*

3 Definitions

For the purposes of this technical report, the following definitions apply.

3.1 action

activity performed by the TASE.2 server triggered by some local predefined stimulus or set of circumstances

3.2 accounting information

set of information which describes an account for a utility. See IEC 60870-6-802 for more details

3.3**bilateral agreement**

agreement between two control centers which identifies the data elements and objects that can be accessed and the level of access permitted

3.4**bilateral table**

computer representation of the Bilateral Agreement. The representation used is a local matter

3.5**client**

TASE.2 user who requests services or objects owned by another TASE.2 user acting as a server. The client is a communicating entity which makes use of the VCC for the lifetime of an association via one or more TASE.2 service requests

3.6**data set**

object which provides services to group data values for singular operations by a TASE.2 client

3.7**data value**

object which represents some alphanumeric quantity that is part of the Virtual Control Center (VCC) which is visible to a TASE.2 user. Data Values exist as part of the implementation of the control center and represent either real entities within the utility such as current, or derived values calculated in the control center. Data Value objects include services for accessing and managing them

3.8**instance**

implementation of TASE.2 executed in either the client or the server role

3.9**interchange schedule**

set of information that specifies how energy is transferred from one system to another. See IEC 60870-6-802 for more details

3.10**object**

abstract entity used to implement the TASE.2 protocol and to represent data and optionally provide services for accessing that data within a VCC

3.11**object model**

abstract representation that is used for real data, devices, operator stations, programs, event conditions, and event enrollments

3.12**operation**

activity which is performed by the TASE.2 server at the request of the TASE.2 client

3.13**server**

TASE.2 user that is the source of data and provides services for accessing that data. A TASE.2 server behaves as a VCC over the lifetime of an association

3.14**service**

activity which is either a TASE.2 action or operation

3.15

tagged

the term is derived from the practice of putting a physical tag on a device as it is turned off for servicing or locked out from network access as a safety measure. The TASE.2 term tagged is used to signal such a condition to the TASE.2 user

3.16

time series

set of values of a given element that is taken at different times as specified by a single time interval. A time series is implemented through the transfer set mechanism as defined within this specification

3.17

transfer account

set of information that associates interchange scheduling information with either hourly or profile data

3.18

transfer conditions

events or circumstances under which a TASE.2 server reports the values of a data set, values in a time series, or all transfer account information

3.19

transfer set

object used to control data exchange by associating data values with transmission parameters such as time intervals, for example. There are four types of Transfer Sets: Data Set Transfer Sets, Time Series Transfer Sets, Transfer Account Transfer Sets, and information Message Transfer Sets

3.20

user

implementation of TASE.2 executed in either the client or the server role

3.21

Virtual Control Center (VCC)

abstract representation of a real control center which describes a set of behaviour with regards to communication and data management functionality and limitations. VCC is a concept taken from the underlying MMS services

4 Abbreviations

For the purpose of this standard, the following abbreviations apply.

ACSE	Association Control Service Element
API	Application Program Interface
BCD	Binary Coded Decimal
COV	Change Of Value
DIS	Draft International Standard
EPRI	Electric Power Research Institute
HLO	Hot line order
ICC	Inter-Control Center
ICCP	Inter-Control Center Communications Protocol
IDEC	Inter-utility Data Exchange Consortium
IP	Internet Protocol

KQH	Kilovar hour readings
KWH	Kilowatt hour readings
LFC	Load Following
MMS	Manufacturing Messaging Specification
MOD	Motor operated disconnect
PDU	Protocol Data Unit
QOS	Quality of Service
RBE	Report by Exception
ROSE	Remote Operations Service Element
TAL	Time Allowed to Live
TASE	Tele-control Application Service Element, (IEC's designation of an international standard protocol for utility data exchange)
TASE.1	TASE based on the ELCOM-90 protocol
TASE.2	TASE based on the ICCP protocol
TCP	Transmission Control Protocol
TLE	Time Limit for Execution
TOD	Time of Day
UCA	Utility Communications Architecture
UCS	Utility Communications Standards working group
UDP	User Datagram Protocol
VCC	Virtual Control Center
VMD	Virtual Manufacturing Device
WSCC	Western System Coordinating Council
WEICG	WSCC Energy Management Systems Inter-utility Communications Guidelines

5 TASE.2 background

Inter-utility real-time data exchange has become critical to the operation of inter-connected systems within the electric power utility industry. The ability to exchange power system data with boundary control areas and beyond provides visibility for disturbance detection and reconstruction, improved modelling capability and enhanced operation through future security control centers or independent system operators.

Historically, utilities have relied on in-house or proprietary, non-IS standard protocols such as those developed by the Western Systems Coordinating Council (WSCC), ELCOM, and the Inter-utility Data Exchange Consortium (IDEC) to exchange real-time data. TASE.2 began as an effort by power utilities, several major data exchange protocol support groups for the protocols mentioned above, EPRI, consultants and a number of SCADA/EMS and protocol vendors to develop a comprehensive, international standard for real-time data exchange within the electric power utilities industry.

By giving all interested parties an opportunity to provide requirements input and to participate in the protocol definition process, it was expected that the final product would both meet the needs of and be accepted by the electric power utility industry. To accomplish this goal, the Utility Communications Specification (UCS) Working Group was formed in September 1991 to:

- 1) develop the protocol specification;
- 2) develop a prototype implementation to test the specification;
- 3) submit the specification for standardization;
- 4) perform inter-operability tests among the developing vendors.

UCS submitted TASE.2 to the IEC Technical Committee (TC) 57 Working Group (WG) 07 as a proposed protocol standard. Another proposed standard based on ELCOM-90 over ROSE was also being considered by WG 07. TC 57 decided on a multi-standard approach to allow (1) a quick implementation to meet European Common Market requirements by 1992 and (2) also allow long term development of a more comprehensive protocol. The first protocol was designated TASE.1 (Telecontrol Application Service Element-1). The second protocol, based on TASE.2 over MMS, was designated TASE.2.

Successful first implementations of TASE.2 between SCADA/EMS control centers led to further expansion to allow communications between control centers and power plants. This expansion did not impact the basic services, but did lead to the development of specific power plant objects. These objects were incorporated into TASE.2. Similarly, protection event data objects were also added to support substation communications. The second edition of the TASE.2 standards also includes one new object for the exchange of general data reports and another new object for sending acknowledgements of complex data objects.

6 TASE.2 Overview

6.1 TASE.2 Concepts

6.1.1 Protocol Architecture

TASE.2 maximizes the use of existing standard protocols in all layers up to and including the lower layers of layer 7 in the OSI reference model. This has the benefit of requiring new protocol development for TASE.2 only in the upper sublayer of layer 7.

The protocol stack used by TASE.2 is shown in Figure 1. The upper three layers conform to the standard 7-layer OSI protocol stack with control center applications at the top. TASE.2 specifies the use of the Manufacturing Messaging Specification (MMS) for the messaging services needed by TASE.2 in layer 7. MMS specifies the mechanics of naming, listing, and addressing variables, and of message control and interpretation, while TASE.2 specifies such things as the control center object formats and methods for data requests and reporting. Applications at different control centers, possibly written by different vendors, but both conforming to these mechanics, formats, and methods, may interoperate to share data, control utility devices, output information messages, or define and execute remote programs.

Application	ICCP IEC 60870-6-503/802	
	MMS	
	ACSE	
Presentation	ISO Presentation	
Session	ISO Session	
Transport	ISO Transport Class 4	TCP
Network	ISO CLNP	IP
Data Link	ISO 8802-2 LLC, FDDI, FR, ISDN, etc.	
Physical	Ethernet LAN, WAN, Point-to-Point Circuit, ATM, SDH, etc.	

Figure 1 – TASE.2 Protocol Architecture

TASE.2 also utilizes the services of the Application Control Service Element (ACSE) in layer 7 to establish and manage logical associations or connections between sites. TASE.2 relies on the ISO Presentation Layer 6 and Session Layer 5 as well.

Because of the protocol architecture, TASE.2 is independent of the lower layers, so that as new protocols evolve in the lower layers, TASE.2 will be able to operate over them with only configuration changes. Thus TASE.2 is able to operate over either an ISO-compliant transport layer or a TCP/IP transport service, as long as ISO layers 5-7 are maintained.

IEC 60870-6-702, which is a Protocol Conformance Protocol Specification (PICS), provides details on the requirements of each of the protocols in Layers 5-7. This information is especially important to protocol stack providers.

6.1.2 Application Program Interface (API)

An Application Program Interface (API) is not specified in the TASE.2 specification – only the protocol and service definitions are specified and are the subject of standardization. Each vendor implementing TASE.2 is free to choose the API most suitable for their product or for their intended customers. Figure 2 illustrates this concept.

For example, an Energy Management System/Supervisory Control And Data Acquisition (EMS/SCADA) vendor may choose to provide an API optimized for interfacing with several different types of applications, such as:

- A proprietary real-time SCADA database for the storing and retrieving of real-time power system data, such as analogs, status, and accumulator values, on a periodic basis or when a value changes
- A Relational Data Base Management System (RDBMS) for the storing and retrieving of historical or other non-real time data, or of Block 8 transfer account or device outage data objects.
- Scheduling and accounting applications to send, for example (1) interchange schedules once an hour or once a day and (2) binary files containing accounting data spreadsheet files.
- Dispatcher console operator message application and/or alarm processor application to send ASCII text messages to be displayed on a dispatcher's console display at another control center

These are just a few examples of the types of APIs an EMS/SCADA vendor may provide for its TASE.2 product. How they are implemented is considered a "local implementation issue" in the TASE.2 specification. As long as the protocol services are implemented according to the specification, interoperability is assured between different TASE.2 vendor's products.

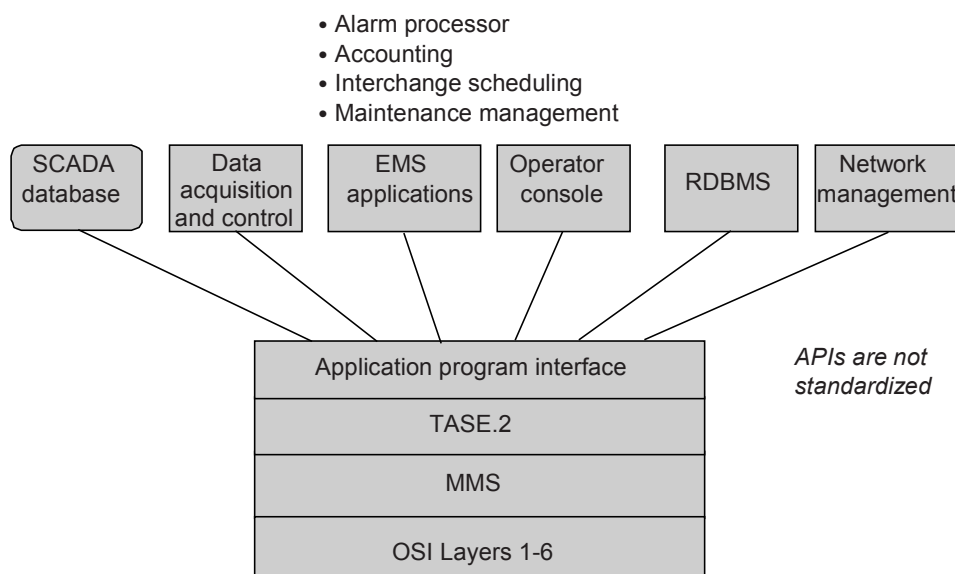


Figure 2 – Application Program Interface (API)

6.1.3 Client/Server Model

TASE.2 is based on client/server concepts. All data transfers originate with a request from a control center (the client) to another control center which owns and manages the data (the server). For example, if a Control Center X application needs data from the Control Center Y SCADA database, the Control Center X application acting as the client may request Control Center Y acting as the server to send the data under conditions specified by the client.

There are various services provided in TASE.2 to accomplish data transfers, depending on the type of request. For example, if the client makes a one-shot request, the data will be returned as a response to the request. However, if the client makes a request for the periodic transfer of data or the transfer of data only when it changes, then the client will first establish the reporting mechanism with the server (i.e., specify reporting conditions such as periodicity for periodic transfers or other trigger conditions such as report-by-exception only), and the server will then send the data as an unsolicited *report* whenever the reporting conditions are satisfied.

A control center may function as both a client and a server.

6.1.4 Multiple Associations and Sites

TASE.2 uses the ISO ACSE to establish logical associations. Multiple associations may be established from a client to multiple, different control center servers. Although TASE.2 may be operated over a point-to-point link, it is envisioned that most installations will operate over a router-based Wide Area Network (WAN). As noted previously, TASE.2 is independent of the underlying transport network, so any combination of subnetworks may comprise the WAN, including the LANs within a site.

Multiple associations may also be established to the *same* control center for the purpose of providing associations with different Quality Of Service (QOS). A TASE.2 client then uses the association with the appropriate QOS for the operation to be performed. For example, to ensure the real time data messages are not delayed by non-real data transfers, both a High and Low priority association may be established, with a separate message queue for each. TASE.2 will check the High priority message queue and service any messages queued before servicing the Low priority message queue. This permits a common data link to be shared for the transfer of both high priority SCADA data and lower priority information message transfers.

Figure 3 illustrates a TASE.2 network serving four utilities. As shown, Utility A is a client to server C (Association C1) and a server for four associations: two to client C (Association A1 and A2), one to client B (Association A3), and one to client D (Association A4). The association to client B (A3) would presumably be accomplished via a router at utility C, but could follow any path available if a WAN is provided to interconnect all utilities. Each of the other utilities shown have similar associations established to meet their individual needs. Utility D functions only as a client. Utilities B and C function as both clients and servers. The point made by this diagram is that TASE.2 provides the capability for any type of interconnectivity needed via configuration of the TASE.2 software.

Only a client is allowed to initially establish an association in TASE.2. When the TASE.2 users at each end of an association are capable of being both a client and a server, then the side to initiate the association is a system configuration issue.

TASE.2 optionally *permits* an established association to be used by either a client or server application at a site, independent of how the association was established. How associations are actually started and used in any actual configuration of TASE.2 is a system configuration issue for each particular installation. However, if a site that can utilise one association for both client-server directions (i.e., dual use) attempts to establish an association with a site that does not support dual use, it is the responsibility of the dual use site to fall back to single use associations.

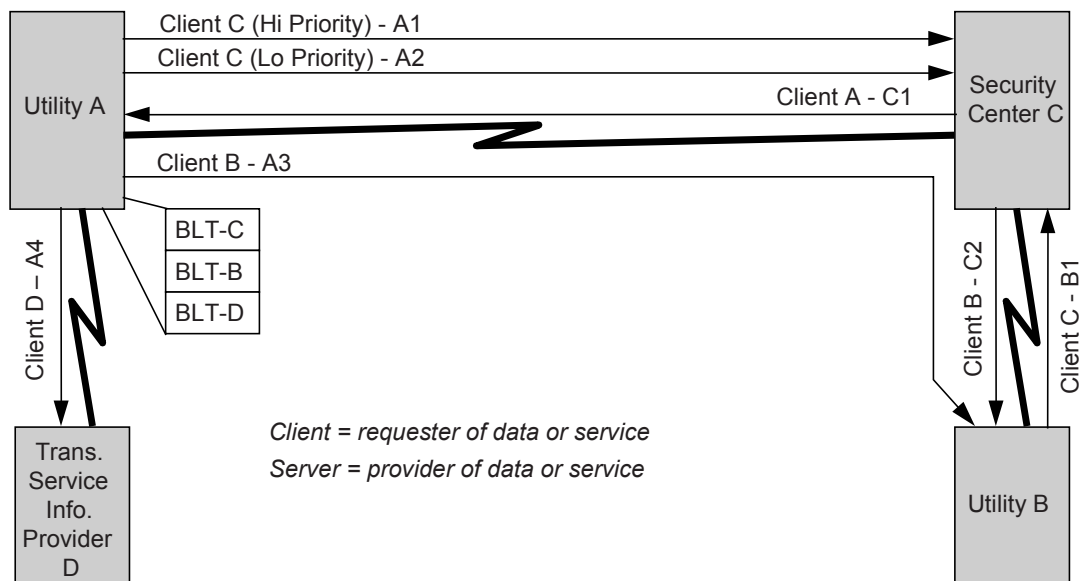


Figure 3 – TASE.2 Client/Server Model with Multiple Associations

6.1.5 Access Control via Bilateral Tables

To provide access control, the server checks each client request to ensure that that particular client has access rights to the data or capability requested. Access control is provided through the use of Bilateral Tables (BLTs) defined for each TASE.2 client that has one or more associations with a TASE.2 server. BLTs provide execute, read/write, read only, or no access for each item (which includes data values, devices, and programs) that can be requested by a client.

A BLT is the computer version of a bilateral agreement established by two control centers. Each control center acting as a *server* specifies for each control center acting as a *client* which objects it is willing to make available, and for each available object, which types of access are supported. It is only necessary for the server to maintain the BLT on-line, which serves as a kind of “shopping list” of available data objects from which the client can choose using the TASE.2 protocol services. For example, as shown in Figure 3, Utility A acting as a server maintains a separate BLT for each client utility (for example, Utilities B-D), providing different access rights for each client utility.

Once an association is established, before any other operations are attempted, the TASE.2 client reads the BLT version attribute and the TASE.2 version attribute maintained at the server. The client then compares the returned values with the values of its versions, and if there is a mismatch with either attribute, the client is required to conclude the association until the mismatches are resolved. Additionally, for any operations used by the TASE.2 client on any data objects after the association has been established, if the TASE.2 server is using an access control mechanism, it must perform the general validity check to ensure that all identifiers referenced in the operation are valid and covered in the Bilateral Table.

If inconsistencies are detected in the bilateral tables applicable to a particular association, the TASE.2 client may use the Get Data Value Names operation described in Subclause 7.2 below to obtain a list of the names of all the Data Value objects which it can access (as defined in the BLT version at the TASE.2 server). These can then be compared to the list of objects that the client believes should be accessible at that server. Any observed differences should be addressed by the network administrator and resolved to obtain identical BLT records at both the client and server.

6.1.6 Use of Object Models

Object model concepts are used in two different ways in TASE.2. Figure 4 illustrates these concepts.

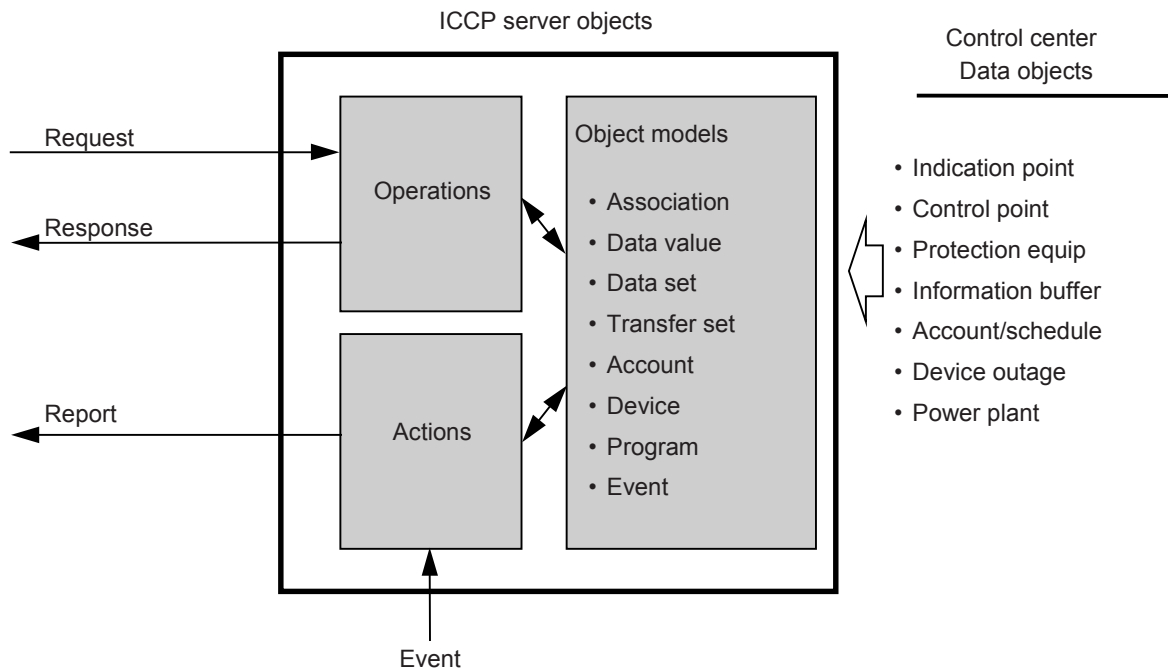


Figure 4 – TASE.2 Object Models

6.1.6.1 TASE.2 Server Objects

Firstly, all TASE.2 services are provided via TASE.2 server objects which may be thought of as classical objects with data attributes and methods as defined in object-oriented design methodologies. There are two basic types of methods in TASE.2 called *operations* and *actions*. An *operation* is client-initiated via a *request* to a server, typically followed by a *response* from the server. An *action*, on the other hand, is a server-initiated function. An example of an *action* is the transfer of data via a *report* to a client in response to a timer expiring or some other external event at the server, such as a change in status of a breaker.

IEC 60870-6-503 contains all the TASE.2 server object definitions. These objects are required to implement the TASE.2 protocol and are sometimes referred to as “internal” objects. Explanations of these objects is included in this guide in the TASE.2 Server Object Description subclause.

6.1.6.2 TASE.2 Data Objects

Secondly, all other data and control elements typically exchanged between control centers are defined as “data objects”. These range from simple to complex data structures. In contrast to the “server objects”, these objects are not required to implement the TASE.2 protocol, and so are sometimes referred to as “external” objects.

The standard Control Center Data Objects are defined in IEC 60870-6-802. They are also described in this guide in the Conformance Block clause. Supported data types include control messages, status, analogs, quality codes, schedules, text and simple files. Furthermore, additional data objects can be defined by TASE.2 users and transferred using existing TASE.2 server objects with no change in the TASE.2 protocol software contained in IEC 60870-6-503. The approach to defining new data objects is described in this guide in Clause 10.

6.1.6.3 Object Model Notation

The TASE.2 specification uses a formal method of describing objects. The first level is known as an Abstract Object Model. This model comprises a Name for the model, followed by a list of Attributes, headed by one Attribute known as a Key Attribute. In some cases, an Attribute listed actually another object model inherited by the new object model. The meaning of each attribute is provided after the formal object model is presented.

Some object models, especially those used to describe control center data objects, contain Constraints, which provide alternative lists of Attributes within a single object model. These Constraints thus provide some flexibility in how the object can be used. All abstract models are described first in the specification.

Abstract object models then have to be mapped to concrete Structures with Components. Each Component is mapped to a data type. The services are mapped to MMS services. This must be specified to ensure that each implementer of TASE.2 uses the same data types and MMS services to implement the abstract models so that interoperability can be achieved with other vendor's TASE.2 products.

Clause 7 describes in more detail the organization of the TASE.2 specification and the use of these models.

6.1.7 Conformance Blocks and Services

Conformance blocks are defined for TASE.2 for server objects in Clause 9 of IEC 60870-6-503 as a way of grouping TASE.2 objects together to provide fundamental types of services. A vendor need not implement all defined conformance blocks (nine in all). However, any implementation claiming conformance to TASE.2 must fully support Block 1, as defined in Clause 8 of this guide. Likewise, a TASE.2 end user need not procure all TASE.2 conformance blocks, only the ones actually needed to meet the user's data transfer requirements.

Conformance blocks are also defined in Clause 9 of IEC 60870-6-802 for data objects as a way of specifying which server object services are needed to transfer each data object defined in IEC 60870-6-802.

6.2 TASE.2 Specification Organization

The TASE.2 specification organization is dictated by the rules and guidelines governing IEC/ISO standards documentation. The IEC numbers for the three parts of the specification were assigned by the IEC, basically by assigning the next sequential numbers available in the IEC 60870-6-500, -700, and -800 series of documents. The 500 series numbers are reserved for protocol standards and service specifications. The 700 series is reserved for Application profiles. The 800 series is reserved for Information Structure profiles, also known as Interchange Format and Representation profiles. This follows the classification scheme adopted for OSI functional profiles.

This subclause should explain how the IEC documents are organized and why (i.e., separation into parts 503, 702, and 802).

6.2.1 IEC 60870-6-503

TASE.2 Part 503, known officially as IEC 60870-6-503, TASE.2 Services and Protocol, defines the mechanism for exchanging time-critical data between control centers. The data exchange mechanism is defined in terms of TASE.2 server object models. It defines a standard way of using the ISO/IEC 9506 MMS services to implement the data exchanges.

A document that defines a standard way to use selected MMS services for exchanging electric utility data is known as an MMS Companion Standard for Electric Utility Data Exchange. And since MMS Companion Standards must follow a consistent format dictated by the MMS standards development groups, IEC 60870-6-503 is formatted as it is largely to conform to the guidelines established for MMS Companion Standards. This means that readability is sometimes sacrificed to follow these guidelines.

The ordering of the information presented in the document follows the “onion skin” analogy. That is, reading this document is like peeling off multiple layers of onion skins, with each new layer taking the reader to a deeper level of specification. This means that the same models are discussed at different levels several times throughout the specification. The order is as follows:

Layer 1

Subclause 5.1: Informal TASE.2 Model Description. The informal model of TASE.2 describes the various TASE.2 server objects in the context of the utility control center environment using plain English narrative.

Layer 2

Subclause 5.2: Formal TASE.2 Model Description. The formal model covers the same ground, only here more formality is introduced. Specifically, the entire control center with its software applications that are involved in data exchange are represented as a Virtual Control Center (VCC), comprising several object models. In this subclause, formal abstract models with attributes are introduced. Some models are represented as a hierarchy of object models, each of which is described. Each attribute for each object model is defined. Each operation and action is described again in more detail.

Layer 3

This layer covers three major clauses:

Clause 6: Mapping of TASE.2 Object Models onto MMS Object Models. In this clause, the abstract object models are repeated, only this time each attribute is mapped directly to either a basic MMS attribute type or to a more complex TASE.2 data type defined in Clause 8, so that standard MMS protocols can be used for the actual transmission of data. For example, in Subclause 5.2 the Data Set Name attribute of the Data Set object model is defined as “the attribute that uniquely identifies the Data Set.” In Clause 6, the description for the Data Set Name attribute states that “this attribute shall be represented as the MMS Variable List Name attribute.”

Clause 7: Mapping of TASE.2 Operations and Action onto MMS Services. This clause does for operations and actions what Clause 6 does for attributes. It maps them onto MMS services, describing both the client and server roles in sufficient detail so that a software vendor can implement each service in such a way that interoperability with other vendor’s TASE.2 products is assured.

Many of the TASE.2 operations use the MMS Read and Write services. These services have the ability to read or write, respectively, to one or more MMS variables at a time. A positive MMS Read or Write service response is sent back to the client from the server if the MMS service request was acceptable to the VMD, and additionally:

- a) if it is an MMS Read service request, the VMD attempted to determine the value of each of the MMS variables in the request; or
- b) if it is an MMS Write service request, the VMD attempted to replace the value of each of the specified MMS variables with the value supplied in the request.

Because of this, a positive MMS service response could be sent back from the server but indicate a failure on reading or writing to any or all of the MMS variables. This is true even when only one MMS variable is indicated in the MMS Read or Write service request.

Clause 8: Standardized Application-Specific Objects. This clause specifies certain TASE.2 objects and complex data types used in Clause 6 and maps them onto MMS standard objects and basic MMS data types. This clause deals only with the objects required for TASE.2 internal use as distinguished from control center data objects, which are the subject of IEC 60870-6-802.

The last part of IEC 60870-6-503, Clause 9, defines the Conformance Blocks, which are described elsewhere in this guide.

6.2.2 IEC 60870-6-802

TASE.2 Part 802, known officially as IEC 60870-6-802, TASE.2 Object Models, defines the control center data objects, which represent the control center data actually exchanged between control centers. This document is structured in a fashion somewhat similar to IEC 60870-6-503, but with only two layers:

Layer 1

Clause 5: Object Models. This clause defines the standard abstract object models for the data to be exchanged with TASE.2. This uses the same notation that was used in IEC 60870-6-503 to describe the TASE.2 server object models, defining each attribute for each model. This is the clause to browse or read to determine if there are appropriate standard objects available to meet a specific utility data exchange requirements. It is organized based on the classes of data typically exchanged between control centers. The order is Supervisory Control and Data Acquisition, Transfer Accounts, Device Outage, Information Buffer, and Power Plant objects.

Layer 2

This layer comprises two clauses.

Clause 6: MMS Types for Object Exchange. This clause defines the data types to be used for exchanging the standard objects. This includes basic types, such as Data_Discrete, which is defined as an integer {width 32}. But it also includes complex data types based on the abstract models defined in Clause 5. Each abstract model must be mapped to one or more concrete object types, which are defined in terms of structures with components. For example, an Indication Point object which contains an analog point value with quality and time tag (but no change-of-value counter) is mapped to the Data_DiscreteQTimeTag type, which is a complex type with a structure containing the components Value, TimeStamp, and Flags. Each component is also mapped to a data type, in this case Data_Discrete, Data_TimeStamp, and Data_Flags, respectively. In all cases, each type maps down to a supported MMS type for data exchange.

This clause contains both the basic types and complex structure types, ordered the same as Clause 5. The exception is the Matrix Data Type, which is used by several different objects, as described in Clause 7.

Clause 7: Mapping of Object Models to MMS Types. These clauses defines the mapping of each object attribute from Clause 5 to one or more of the TASE.2 types defined in Clause 6.

Clause 8, Use of Supervisory Control Objects, provides examples in the use of the Supervisory Control objects in order to introduce some conventions in assigning meaning to certain attributes which are generic in nature.

Clause 9, Conformance, identifies the IEC 60870-6-503 Conformance Block required to provide the necessary services for exchanging each data object described in IEC 60870-6-802.

6.2.3 IEC 60870-6-702

This document is a Protocol Implementation Conformance Specification (PICS) which defines the Application Profile (Layers 5-7) for use with TASE.2. It is needed for vendors implementing protocol stacks that support the TASE.2 application layer. Most users of TASE.2 will not be concerned with this specification. Therefore this guide does not deal specifically with IEC 60870-6-702.

7 TASE.2 Server Objects

7.1 Association

Association objects are used to establish an association, or logical connection, between two TASE.2 instances. Such an association is typically long-running, staying in place as long as both TASE.2 instances are running and the underlying communications links are maintained.

Three operations are defined for Association objects:

- 1) Associate - used by a client to establish an association with a server.
- 2) Conclude - used by either a client or server to provide an orderly termination to an association (for example, for some planned maintenance or if there is a BLT or TASE.2 version mismatch).
- 3) Abort - used by either client or server to terminate an association when there are failures in the underlying communications mechanisms.

There are no actions defined for Association objects.

7.2 Data Value

Data Value objects represent values of control center data elements, including SCADA points, such as analog measurements and digital status, or data structures. Any data element or object that is uniquely identified by a single MMS Named Variable (with persistence) could conceivably be represented via the Data Value object. However, the only objects currently defined as Data Value objects are Indication Point, Protection Equipment Event objects, and Tag Value¹.

There are four operations defined for Data Value objects:

- 1) Get Data Value - can be used to request the value of a single SCADA point.
- 2) Set Data Value - intended to permit a data value to be written or set at a local control center by a remote control center. In practice, few vendors or utilities actually permit the Set capability in a TASE.2 client because of the desire to keep the ability to change data with the owner of the data, which will be the TASE.2 server. Note that the Device object defined below is intended to permit remote supervisory control operations.
- 3) Get Data Value Names - allows client to obtain a list of the names of all the Data Value objects at a remote control center for which that client has permission (via the BLT). This operation can be used to determine which points can be viewed by the client as an aide in defining data sets or one shot requests for data, as described later.
- 4) Get Data Value Type - allows client to obtain the Type attribute for a Data Value object.

There are no actions defined for Data Value objects.

¹ The second edition of TASE.2 added Tag Values to the objects considered as Data Value objects.

7.3 Data Set

Data Set objects are ordered lists of Data Value objects maintained by a TASE.2 server². This object enables a client to remotely define Data Sets via TASE.2. The Data Set object can be used by a client, for example, to remotely define a list of SCADA points to be reported as a group. A specific Data Value object can be included in more than one Data Set if desired. The establishment of the reporting criteria and the actual transfer of data values is accomplished using the Transfer Set object, as described below.

There are six operations defined for Data Set objects:

- 1) Create Data Set - allows a client to create a Data Set object at a remote server. In addition to specifying the list of Data Value objects to be included in the Data Set, the client can also specify which of the following parameters (referred to as Special Transfer Objects) will be included in a Transfer Report containing the actual data values:
 - Transfer Set name - identifies the Transfer Set object that generated the report.
 - Data Set Conditions Detected - identifies the event that triggered the sending of the report. The list of possible trigger events is:
 - Interval time-out;
 - Object change;
 - Operator request;
 - Integrity time-out;
 - Other external event.
 - Event Code Detected - identifies the event code if the trigger was Other External Event (see B. above).
 - Transfer Set Time Stamp - specifies the time the Transfer Report was generated at the server.
- 2) Delete Data Set - allows a client to delete a previously defined Data Set object.
- 3) Get Data Set Element Values - allows a client to obtain the value of each of the Data Value objects included in the referenced Data Set object. This operation permits a one-shot request of all values of the list of Data Value objects included in the referenced Data Set.
- 4) Set Data Set Element Values - allows a client to set the value of each of the Data Value objects included in a Data Set. In practice, this is not usually permitted.
- 5) Get Data Set Names - allows a client to get the names of all the Data Set objects currently defined at a server.
- 6) Get Data Set Element Names - allows a client to obtain the list of names of all the Data Value objects currently included in a specific Data Set object at a server.

There are no actions defined for the Data Set object.

Typical use: transfer of SCADA data to and from a real-time SCADA database on an EMS/SCADA system.

² Since Tag Values were added to the objects considered as Data Value objects in the second edition of TASE.2, Tag Values can be reported in data sets whenever they change or periodically, rather than having to request current values via polling individually with the Get Tag operation defined for Device objects, which was the only mechanism provided in the first edition of TASE.2.

7.4 Transfer Set

Transfer Set objects residing at a TASE.2 server are used by a TASE.2 client to establish the actual transfer of data values. While Data Value objects can be individually requested via a one-shot request, receiving the requested value in response, more complex data transfers require the use of a Transfer Set. In particular, the transfer of groups of data defined in Data Set objects requires the use of a Transfer Set. The exchange of most all other data in TASE.2 requires a Transfer Set to be established first.

The Transfer Set object permits information to be exchanged on a periodic basis, on change of state or value, in response to a particular server event, or on operator request. The Transfer Set object provides the operations needed by a client to set up instances of Transfer Sets for each desired data exchange.

7.4.1 Four Transfer Set Object Models

Because of the unique requirements for transferring different types of data between control centers, TASE.2 provides four types of Transfer Set objects:

- 1) **Data Set Transfer Set** - used for establishing the transfer of Data Sets defined and created using the Data Set object.
- 2) **Time Series Transfer Set** - used for transferring the data values of a single Data Value object at different incremental times as specified by a delta time interval
- 3) **Transfer Account Transfer Set** - used for transferring many different types of data objects. In TASE.2, a Transfer Account is a generic term applied to a whole class of data objects used to represent information on schedules, accounts, device outages, curves, and other entities used by control centers which have only one thing in common – the use of complex data structures to represent data. Initially, the type of data envisioned was accounting or scheduling data, which represent an amount of energy transferred from one utility to another on a periodic basis, hence the name Account or Transfer Account.

As currently defined in IEC 60870-6-503, this transfer set is used to transfer any of the data objects defined as “Block 8 objects”. This includes the following:

— **Transfer Account** - this is a container type of object which can be used for the exchange of any periodic or profile data for control center energy scheduling, accounting, or monitoring applications.

— **General Data Report** - this is another container object that can be used to exchange report data with control. This object is designed for sending one or more matrices of data. Each matrix may contain one or more rows of data with one or more user-defined column headings. Unlike the Transfer Account object, there is no temporal relationship between rows.

— **General Data Response** - this object is used to send a response to a Block 8 General Data Report object or any other Block 8 object that needs an acknowledgement. It further supports transactions involving multiple data transfers.

— **Device Outage** - this is a data object designed to exchange information about device outages, either for scheduling outages or reporting actual outages. Devices can include almost any type of physical component in a power system that is routinely monitored for status today.

— **Availability Report** - this is the first of five data objects included in a class of data objects labelled Power Plant objects in IEC 60870-6-802. It is intended for a power plant control system or GCSs to report on predicted availability of generating units and/or to schedule outages. It is similar to the Device Outage object, but differs by having more attributes unique to generation units and power plants and by not including actual status reports (this is handled by the next data object, Real Time Status).

— **Real Time Status** - this object is used by a power plant to report the actual operating status of generating units at the time of the report.

— **Forecast Schedule** - this object is intended for use by an EMS or GCS to deliver a forecasted usage of generating units at a power plant. Similar to the Transfer Account data object, this is another container object with user-defined matrix to specify the number and meaning of each column in the matrix. Rows are separated by a user-selected delta time increment.

— **Curve** - this object is intended for use by a power plant to report various types of curve data, such as heat rate, IO, incremental heat rate, MVAR capacity, opacity, SOX, NOX, and CO2 emission curves. The curve is represented as a sequence of curve segments, with each segment defined in terms of a polynomial.

— **Power System Dynamics** - this is a collection of data elements (rather than an actual object model) which need to be exchanged between a power plant and a GCS or EMS. These are scalar quantities and can be represented individually as Data Value objects.

These objects are described in detail in this guide in Subclause 8.8.

- 4) **Information Message Transfer Set** - used for transferring the Information Buffer data object defined in IEC 60870-6-802. The Information Buffer is intended for sending unstructured ASCII text strings or binary data. It could also be used for sending XML files or other encoded files.

There are four operations defined for Transfer Set objects:

- 1) **Start Transfer** - permits a client to request a server to begin to transfer data under the conditions specified by the client in this operation. The capabilities provided differ in important ways for each type of transfer set:
 - For Data Set Transfer Sets, the client provides the name of the Data Set object to use for grouping Data Values for transfer. A separate Transfer Set is used for each Data Set of interest, permitting different transfer conditions for each. A Data Set Transmission Parameters object is used to specify the transfer conditions, which include a start time, whether to report periodically or by exception only, an interval time between reports for periodic transfers, a buffer time for reporting by exception that starts when the first object change occurs, and whether the transfer is deemed “critical”, which causes an acknowledgement to be returned upon successful receipt of the transfer report. The second edition of TASE.2 also added the capability of requesting all changes in a specific data value object to be reported rather than just the last change. A Data Set Conditions Reported object permits the client to request that the conditions which triggered the transfer report also be included in the report.
 - For Time Series Transfer Sets, the client names the Data Value object of interest.
 - For Transfer Account Transfer Sets, the client can only enable the transfer all Transfer Account objects defined in the Bilateral Table. That is all Block 8 objects get enabled at one time and under one set of conditions.
 - For Information Message Transfer Sets, similar to Transfer Account Transfer Sets, the client can only enable all Information Messages under the same set of conditions.
- 2) **Stop Transfer** - used by a client to stop a data transfer operation (i.e., disable the transfer). A new Start Transfer operation is required to once again enable the transfer.
- 3) **Get Next Data Set Transfer Set Value** - used by the client as the first step in starting a Data Set data transfer. The server maintains a “pool” of available Data Set Transfer Sets for a client to use. The client must obtain the name of the next available Transfer Set, and then perform a Start Transfer operation using the name of that Transfer Set to actually start a transfer. Thus the Start Transfer operation may be thought of as the client “writing” a value of the Transfer Set variable to the server. A Stop Transfer operation actually releases the Transfer Set back into the pool of available Transfer Set names at the server.

- 4) Get Next Time Series Transfer Set Value - similar to the Get Next Data Set Transfer Set Value operation, only this operation is used for starting the reporting of a series of values for the same Data Value object.

NOTE There are no "Get Next Transfer Set Value" operations for Transfer Accounts (i.e., Block 8 objects) or Information Message objects, since the client can only start or stop transfers of all Block 8 objects or Information Message objects, respectively.

There are two actions for Transfer Sets:

- 1) Condition Monitoring - performed by the server for each Transfer as soon as that Set that is Enabled via a Start Transfer operation. Any and all conditions requested in the Start Transfer operation are monitored by the server until a Stop Transfer operation is performed by the client. Note that for Information Message Transfer Set objects, the conditions used are locally defined only and cannot be specified via the Start Transfer operation.
- 2) Transfer Report - a Transfer Report is generated whenever a condition specified by the client has occurred for an enabled Transfer Set. The Transfer Report is the action used to actually transfer data from the server to the client. The server formats and sends a report with the appropriate data for the type of Transfer Set.

Included in the Data Set Transfer Report action may be any of the four Special Transfer Objects specified in the Data Set Create operation to convey information about the Transfer Report generation process. If the Transfer Set has the Report By Exception (RBE) attribute of DSTransmissionPars set to true, then these Special Transfer Objects may be included in the Transfer Report:

- Transfer Set Name - the name of the Transfer Set object which caused the Transfer Report;
- Transfer Set Conditions - a bitstring indicating which Transfer Condition(s) triggered the transfer;
- Transfer Set Time Stamp - the time of generation of the Transfer report;
- Transfer Set Event Code - indicates the external event which caused the Transfer Report to be sent, if the Other External Event condition was being monitored.

7.5 Account

Transfer Account objects (i.e., Block 8 data objects) are usually transferred via the Transfer Account Transfer Set object. However, the Account object provides one operation, the Query Operation, that permits a client to request a particular account object based on the account reference number and optionally start time and duration.

7.6 Device

Device objects represent actual physical devices in the field for the purpose of providing services for a client to control them remotely. Both interlocked (i.e., select-before-operate) and non-interlocked devices are represented.

There are four operations for Device objects:

- 1) Select - used by a client to request selection of an interlocked device only. If successful, the Device state is changed from IDLE to ARMED by the server.
- 2) Operate - used by a client to send a command to a Device object to execute a function. For interlocked devices, the Device state must be ARMED.
- 3) Set Tag - used by a client to set the Tag attribute of a Device object.