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Space data and information transfer systems — Mission operations common object model

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Space data and information transfer systems — Mission operations common object model

Systèmes de transfert des informations et données spatiales — Modèle d'objet commun des opérations de mission

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The Consultative Committee for Space Data Systems

Recommendation for Space Data System Standards

MISSION OPERATIONS COMMON OBJECT MODEL

RECOMMENDED STANDARD

CCSDS 521.1-B-1

BLUE BOOK

February 2014

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1 INTRODUCTION

1.1 GENERAL

This Recommended Standard defines the Mission Operations (MO) Common Object Model (COM) in conformance with the service framework specified in annex B of Mission Operations Services Concept (reference [C1]).

The MO COM is a generic service template that provides a Common Object Model to the Mission Operation services defined in reference [C1]. These Mission Operations services are defined in terms of the COM and the Message Abstraction Layer (MAL) (reference [2]).

1.2 PURPOSE AND SCOPE

This Recommended Standard defines, in an abstract manner, the COM in terms of:

a) the operations necessary to provide the service;

b) the parameter data associated with each operation;

c) the required behaviour of each operation;

d) the use of the model.

It does not specify:

a) individual implementations or products;

b) the implementation of entities or interfaces within real systems;

c) the methods or technologies required for communications.

1.3 DOCUMENT STRUCTURE

This Recommended Standard is organised as follows:

a) section 1 provides purpose and scope, and lists definitions, conventions, and references used throughout the Recommended Standard;

b) section 2 presents an overview of the concepts;

c) section 3 presents the COM specification;

d) section 4 is a formal specification of the COM data structures;

e) section 5 is a formal specification of the COM errors;

f) section 6 details the location of the formal service specification Extensible Markup Language (XML) schema.

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1.4 DEFINITION OF TERMS

Software Component (component)**:** A software unit supporting the business function. Components offer their function as Services, which can either be used internally or which can be made available for use outside the component through Provided Service Interfaces. Components may also depend on services provided by other components through Consumed Service Interfaces.

Hardware Component: A complex physical entity (such as a spacecraft, a tracking system, or a control system) or an individual physical entity of a system (such as an instrument, a computer, or a piece of communications equipment). A Hardware Component may be composed from other Hardware Components. Each Hardware Component may host one or more Software Components. Each Hardware Component has one or more ports where connections to other Hardware Component are made. Any given Port on the Hardware Component may expose one or more Service Interfaces.

Service: A set of capabilities that a component provides to another component via an interface. A Service is defined in terms of the set of operations that can be invoked and performed through the Service Interface. Service specifications define the capabilities, behaviour and external interfaces, but do not define the implementation.

Service Interface: A set of interactions provided by a component for participation with another component for some purpose, along with constraints on how they can occur. A Service Interface is an external interface of a Service where the behaviour of the Service Provider Component is exposed. Each Service will have one defined 'Provided Service Interface', and may have one or more 'Consumed Service Interface' and one 'Management Service Interface'.

Provided Service Interface: A Service Interface that exposes the Service function contained in a component for use by Service Consumers. It receives the MAL messages from a Consumed Service Interface and maps them into API calls on the Provider component.

Consumed Service Interface: The API presented to the consumer component that maps from the Service operations to one or more service data units contained in MAL messages that are transported to the Provided Service Interface.

Management Service Interface: A Service Interface that exposes management functions of a Service function contained in a component for use by Service Consumers.

Service System: The set of Hardware and Software Components used to implement a Service in a real system. Service Systems may be implemented using one or more Hardware and Software Components.

Service Provider (provider)**:** A component that offers a Service to another by means of one of its Provided Service Interfaces.

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Service Consumer (consumer)**:** A component that consumes or uses a Service provided by another component. A component may be a provider of some Services and a consumer of others.

service data unit, SDU: A unit of data that is sent by a Service Interface, and is transmitted semantically unchanged, to a peer Service Interface.

Service Capability Set: A grouping of the service operations that remains sensible and coherent, and also provides a Service Provider with an ability to communicate to a Consumer its capability. The specification of services is based on the expectation that different deployments require different levels of complexity and functionality from a service. To this end a given service may be implementable at one of several distinct levels, corresponding to the inclusion of one or more capability sets.

Object: A thing which is recognised as being capable of an independent existence and which can be uniquely identified. An object may be a physical object such as a spacecraft or a ground station, an event such as an eclipse, or a concept such as telemetry parameter. It forms the fundamental part of a service specification, e.g., a parameter definition, a parameter value at a given point in time, a command. There are no requirements on what an object may be except that it must be possible to uniquely identify an instance of it.

Event: A specific object representing 'something that happens in the system at a given point in time'.

Activity: Anything that has a measurable period of time (a command, a remote procedure, a schedule, etc.).

1.5 CONVENTIONS

1.5.1 NOMENCLATURE

The following conventions apply for the normative specifications in this Recommended Standard:

a) the words 'shall' and 'must' imply a binding and verifiable specification;

b) the word 'should' implies an optional, but desirable, specification;

c) the word 'may' implies an optional specification;

d) the words 'is', 'are', and 'will' imply statements of fact.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

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1.5.2 INFORMATIVE TEXT

In the normative sections of this document sections (3-6), informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

- Overview;
- Background;
- Rationale;
- Discussion.

1.5.3 DRAWING CONVENTIONS

In figures illustrating this document, UML modelling diagrams are used. (See reference [1] for further information regarding diagrams types and their meaning.)

1.6 REFERENCES

The following publications contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All publications are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the publications indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS publications.

[1] *Mission Operations Reference Model*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 520.1-M-1. Washington, D.C.: CCSDS, July 2010.

[2] *Mission Operations Message Abstraction Layer*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 521.0-B-2. Washington, D.C.: CCSDS, March 2013.

NOTE – Informative references are listed in annex C.

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2 OVERVIEW

2.1 GENERAL

This document contains the formal specification for the Common Object Model (COM). The COM provides a standard object model for MO Services to utilise. The following diagram presents the set of standards documentation in support of the Mission Operations Services Concept. The COM belongs to the Specifications documentation.

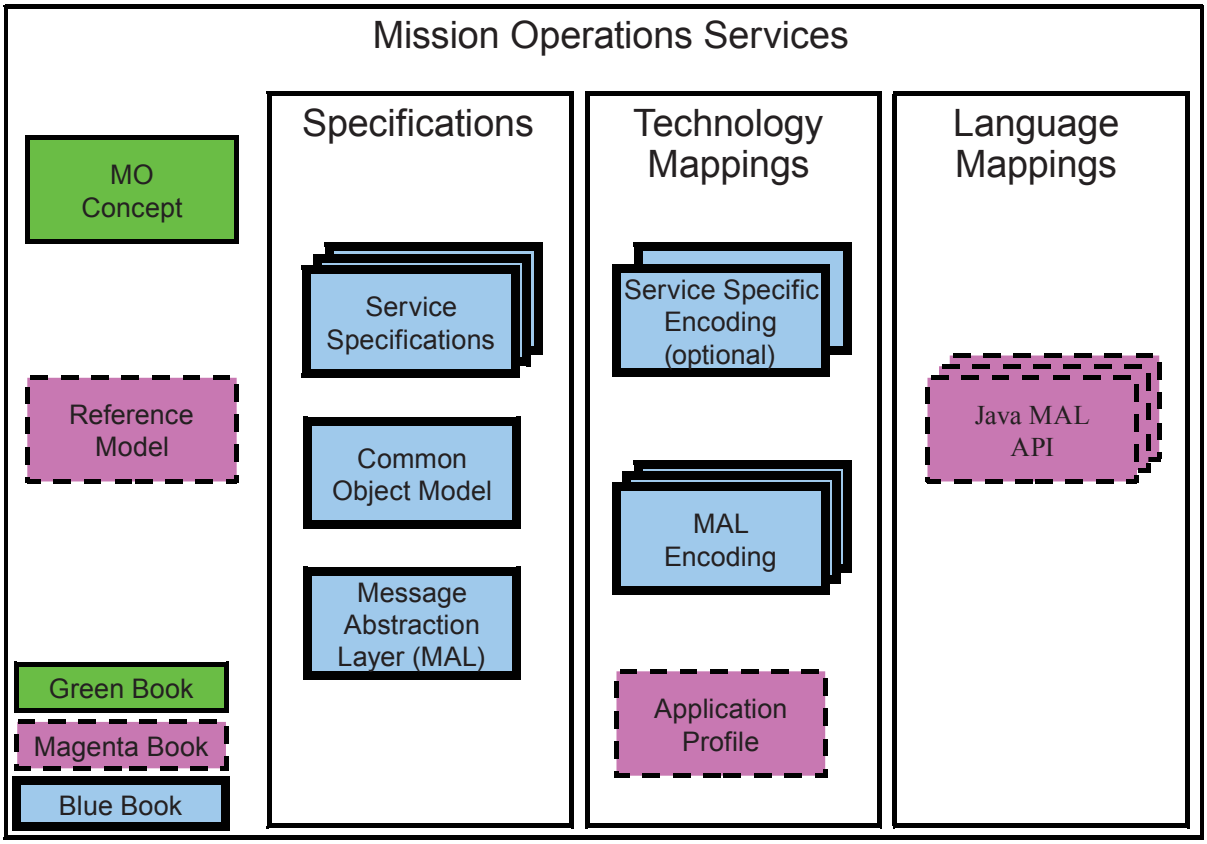

Figure 2-1: Mission Operations Services Concept Document Set

(For further information about the MO Concept, see reference [C1], and for the Reference Model, see reference [1].)

The COM Specification is split into two parts. The first specifies the common object model, and the second specifies the standard COM support services. The services and structures are defined in terms of the MAL so it is possible to deploy them over any supported protocol and message transport.

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2.2 COMMON OBJECT MODEL

2.2.1 GENERAL

The COM provides a standard data object model for MO Services to utilise. Whereas the MAL provides the building blocks that can be used to define the operations of a MO service, the COM provides the building blocks for the specification of the data objects of a service. This builds upon the MAL to define a standard data model for an MO service.

An object is defined as a thing which is recognised as being capable of an independent existence and which can be uniquely identified. An object may be a physical object such as a spacecraft or a ground station, an event such as an eclipse, or a concept such as telemetry parameter. It forms the fundamental part of a service specification, e.g., a parameter definition, a parameter value at a given point in time, a command.

The object model is based on the principle of RESTful architectures; namely, each object can be identified by a unique identifier. There are no requirements on what an object may be except that it must be possible to uniquely identify an instance of it so that it can be referenced.

Each service that utilises the COM must define the object, or set of objects, that form the data model of the service.

2.2.2 COMMON MODEL OBJECT STRUCTURE

Whilst the COM does not limit what may be considered an object by a service specification, it does define how objects are referenced and how they can reference each other. Each object can link to up to two other objects as is shown in figure 2-2.

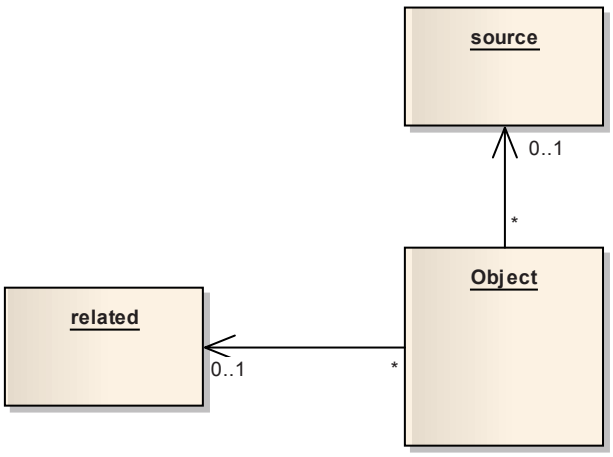

Figure 2-2: COM Structure

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The two links have different roles, the related role is expected to be used to link to a related object (for example a parameter value object could link to a parameter definition object), and the source link would be used to link to an unrelated object (for example the operator who requested its value change). It is service specific how these links are to be used.

Each linked object can define its links (so a parameter definition object could define a related link to a parameter name object if this was required) and therefore provides the ability to have 'n' levels of hierarchy.

2.2.3 COMMON MODEL OBJECT IDENTIFICATION

The identity of an object is composed of several parts, the domain of the object, the type of the object, and then the object instance identifier. Objects in one session are conceptually separate from objects in a different session (the rules of the MAL data model require this); the network zone is ignored and does not form part of object identification.

Each service specification is required to list the objects it defines, the structure used to represent the body of the object, and provide each object with a unique (to that service) service object number. The type of an object is the combination of the area number, service number, area version, and service object number. The combined parts are able to fit inside a MAL::Long (for implementations that prefer to index on a single numeric field rather than a structure).

The object instance identifier uniquely identifies an instance of an object for a given domain and object type. The object instance identifier is just a MAL::Long.

2.3 THE SUPPORT SERVICES

The COM specification also includes some support services that build upon the basic object model; these services are:

Event service: An event is a specific object representing 'something that happens in the system at a given point in time'. The event service provides a common mechanism for the distribution of events and also defines how a service that creates events should interact with the archive service.

Archive service: The archive service provides a generic means for persisting objects. It follows the basic Create/Retrieve/Update/Delete (CRUD) principles and therefore fits with most archiving systems. It provides a simple basic set of operations and a basic requirement on the information required to persist service objects in it.

Activity tracking service: The activity tracking service provides the ability to track the progress of activities; an activity is anything that has a measurable period of time (a command, a remote procedure, a schedule, etc.). It defines an event pattern that supports the tracking of activities from the initial consumer request, tracking its progress across a transport link, to reception by the provider and execution in that provider.

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The following subsections cover the COM services in more detail, the actual specification of each service is detailed in section 3.

2.4 EVENT SERVICE

An event is a specific object representing 'something that happens in the system at a given point in time'. The event service defines a single publish/subscribe operation that supports the publishing of events and also the monitoring of events generated by other components.

An event, as it is a COM object, is identified by the normal object fields (domain, object type, and object instance identifier) with the addition of a string name. The name provides a more human friendly means to identify the event.

The body of an event object is assumed to be empty unless one is specified by the service that declares the event.

The COM object links of the event object are used as follows unless stated differently by the relevant service defining the event:

- the source links to the object that caused the event to be generated;
- the related link is service and event-type specific.

When a service implementation requires that the events it generates be persisted, upon event emission, the event should be stored in the COM archive. As an event is just a COM object, the normal archive mechanism (as defined in the archive service) is used to store the event.

2.5 ARCHIVE SERVICE

2.5.1 GENERAL

The archive service provides a basic archiving function for COM objects. It follows the Create Retrieve Update Delete (CRUD) principles and allows simple querying of the archive (more complex queries are supported but the specifications of these are outside this standard).

As changes are made during the lifetime of an object, this information is distributed to consumers using the service defined operations; as long as these updates follow the COM standard for object identification they can also be stored in a COM archive.

By storing these updates in an archive, any historical replay/retrieval functions can correctly reflect the history of the objects.

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2.5.2 ARCHIVE OBJECT IDENTIFICATION

As every COM object is uniquely identified by the set (domain, area, service, area version, object type, object instance identifier) this provides the basic key for the storage of objects.

Additionally, each object may be tagged by a timestamp, the URI of the provider, a source object (the fully qualified identifier of the object which is at the origin of this particular object, if any) and a related object (the identifier of another object which gives additional information on this particular object, if any).

2.5.3 RETRIEVAL OPERATIONS

The retrieval operations provide a consumer with the ability to request stored information from the archive in bulk. There are three different retrieval scenarios that an MO consumer function may use for archive access:

Count A count of objects existing at a given point or range in time is extracted in a single transaction.

Retrieval A block of objects covering a period of time is extracted in a single transaction. If no objects exist for the time period no value is returned.

Monitor A Publish/Subscribe subscription of events generated by the archive to allow active monitoring of an archive for changes as they happen.

The count operation returns the count of objects that satisfy the request criteria and the bulk retrieval returns the COM objects that satisfy the selection criteria. The events generated by the archive allows a consumer to subscribe for changes to the archive.

2.5.4 STORE OPERATION

The store operation provides a consumer with the ability to populate an archive with information. It provides a standard mechanism for a COM archive to be populated in bulk. The following scenarios are foreseen:

Monitored A software component is monitoring information from one or more services and storing this information in a COM archive.

Bulk storage A software component is moving information from one archive, most likely a proprietary information store (possibly on-board), to a COM archive.

Consolidation A software component is consolidating information from one or more COM archives (possibly separated by session) into a single COM archive. This is a refinement of the bulk storage scenario where information is also being retrieved from the COM archives.

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