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Space data and information transfer systems — Mission operations message abstraction layer

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The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Second edition
2015-12-15

Space data and information transfer systems — Mission operations message abstraction layer

Systèmes de transfert des informations et données spatiales — Couche d'abstraction des messages des opérations de mission

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The Consultative Committee for Space Data Systems

Recommendation for Space Data System Standards

MISSION OPERATIONS MESSAGE ABSTRACTION LAYER

RECOMMENDED STANDARD

CCSDS 521.0-B-2

BLUE BOOK
March 2013

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DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 521.0-B-1	Mission Operations Message Abstraction Layer, Recommended Standard, Issue 1	October 2010	Original issue (superseded)
CCSDS 521.0-B-2	Mission Operations Message Abstraction Layer, Recommended Standard, Issue 2	March 2013	Current issue (note): – addresses the request to add a slight restriction to the MAL data model regarding polymorphism; – adds ability to use external data type specifications such as XML Schemas; – moves XML to the SANA registry; – changes type short forms to integers rather than strings; – shows optional fields in composites; – changes lists to a template rather than explicit types; – adds unsigned integer and File data types.

NOTE – Changes from the original issue are too numerous to permit markup.

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1 INTRODUCTION

1.1 GENERAL

This Recommended Standard defines the Mission Operations (MO) Message Abstraction Layer (MAL) in conformance with the service framework specified in reference [C1], Mission Operations Services Concept.

The MO MAL is a framework that provides generic service patterns to the Mission Operation services defined in reference [C1]. These Mission Operations services are defined in terms of the MAL.

1.2 PURPOSE AND SCOPE

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

a) the concepts that it builds upon;

b) the basic types it provides;

c) the message headers required by the layer;

d) the relationship between, and the valid sequence of, the messages and resulting behaviours.

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 specifies the interaction patterns used to define services;

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

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

f) section 6 is the formal service specification Extensible Markup Language (XML) schema;

g) section 7 is the formal compliance requirements of the MAL.

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1.4 DEFINITION OF TERMS

Software Component (component)**:** A software unit containing 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(s) 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.

Binding: The access mechanism for a Service. Bindings are used to locate and access Service Interfaces. Services use bindings to describe the access mechanisms that consumers have to use to call the Service. The binding specifies unambiguously the protocol stack required to access a Service Interface. Bindings may be defined statically at compile time or they may use a variety of dynamic run-time mechanisms (DNS, ports, discovery).

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.

Service Connection (connection)**:** A communications connection between a Consumed Service Interface and a Provided Service Interface over a specific Binding. When a component consumes the services of a provider component, this link is known as a Service Connection (connection).

Service Extension: Addition of capabilities to a base Service. A Service may extend the capabilities of another Service with additional operations. An extended Service is indistinguishable from the base Service to consumers such that consumers of the base Service can also be consumers of the extended Service without modification.

Protocol Stack: The stack of Protocol Layers required for communication.

Protocol Layer: The implementation of a specific Protocol. It provides a Protocol Service Access Point to layers above and uses the Protocol Service Access Point of the layer below.

Protocol Service Access Point (SAP): The point at which one layer's functions are provided to the layer above. A layer may provide protocol services to one or more higher layers and use the protocol services of one or more lower layers. A SAP defines unambiguously the interface for a protocol that may be used as part of a Service Interface Binding specification.

Protocol: The set of rules and formats (semantic and syntactic) used to determine the communication behaviour of a Protocol Layer in the performance of the layer functions. The state machines that operate and the protocol data units that are exchanged specify a protocol.

Service directory: An entity that provides publish and lookup facilities to service providers and consumers.

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NOTE – Strictly speaking, a directory is not required if a well-known service is to be used; however, in most circumstances a directory provides required flexibility in the location of services. Service location can be statically configured, dynamically discovered through a service directory, or a combination of the two; this is an implementation choice. The service directory is itself, by definition, a service.

1.5 NOMENCLATURE

The following conventions apply throughout 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.

1.6 REFERENCES

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

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

[2] "MIME Media Types." Internet Assigned Numbers Authority. http://www.iana.org/assignments/media-types.

NOTE – Informative references are listed in annex C.

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2 OVERVIEW

2.1 GENERAL

The MO service specifications detail a standard set of services. These services form a contract between a consumer of a service and the provider of that service. Each operation of a service has a set behaviour: a message is sent from the consumer to the provider to instigate the operation, and zero or more messages can be exchanged thereafter depending on the specific pattern and operation. This set of messages, and the pattern in which they are exchanged, needs to be defined for each operation of each service.

An interaction pattern details a standard exchange pattern that removes the need for each operation to detail its exchange pattern individually. By defining a pattern and stating that a given operation is defined in terms of that pattern, the operation definition can focus on the specifics of that operation and rely on the standard pattern to facilitate the interaction.

The MAL defines this set of standard interaction patterns as an abstract interface that is used by the MO services. There are three abstract interfaces defined in the MAL specification: the first is the abstract interface of the MAL that is presented to the higher layers, the second is the abstract interface of the Access Control component, and the third is the abstract interface that a Transport layer must provide to the MAL.

The MO service specifications and the MAL are abstract in their definition; they do not contain any specific information on how to implement them for a particular programming language or transport encoding. Moving from the abstract to the implemented system, two other specifications are needed. One is the Language Mapping that states how the abstract MAL and MO service specifications are to be realised in some specific language: this defines the API in that language. The second is the transport mapping from the abstract MAL data structures into a specific and unambiguous encoding of the messages and to a defined and unambiguous mapping to a specific data transport. It is only when these mappings are defined that is possible to implement services that use the MAL interface and use the transport bindings to exchange data. (For further information on this, see reference [1].)

This document contains the formal specification for these abstract interfaces. More information about the MO Concept can be found in reference [C1], and more information about the Reference Model can be found in reference [1].

2.2 ABSTRACT INTERFACE SPECIFICATIONS

2.2.1 GENERAL

Each abstract interface is defined as a set of interaction patterns. For each pattern defined there is a common layout of the document section.

The following subsections describe the sections and diagram formats specific to the interaction patterns.

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2.2.2 PATTERN OVERVIEW

The overview section of the pattern contains a message exchange sequence, which shows the interaction sequence between a source consumer and a destination provider.

The main aspects to note are the direction of the arrows (giving message direction) and the order of the messages (top down). The bars under the consumer and provider show synchronicity of the message exchange.

In the following example (figure 2-1) it can be seen that the consumer sends an initial message to the provider, which responds with an acknowledgement. The acknowledgment is in response to the initial message, as shown by the connected bars under the consumer and provider.

At some time in the future the provider will send another response:

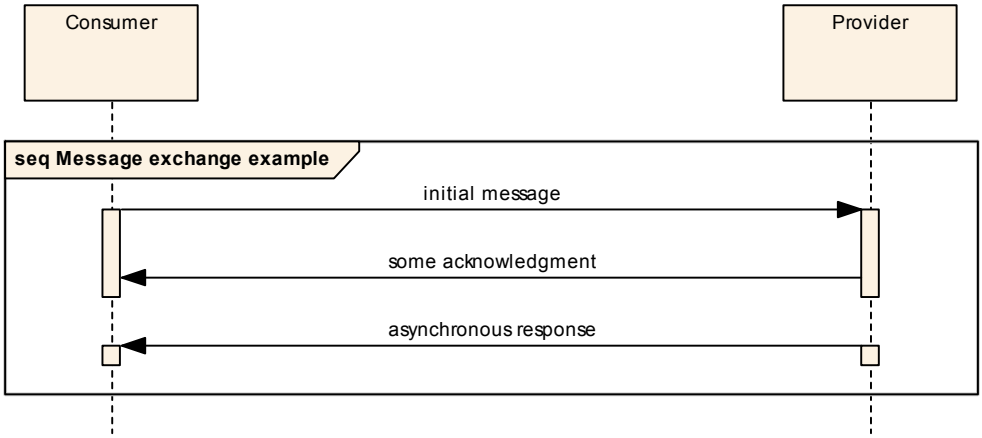

Figure 2-1: Message Exchange Sequence Example

Because the pattern shows the response, the consumer can expect it, but because the bars are not connected it is considered to be indeterminate. This means that although the message will arrive it cannot be determined when arrival will occur. It is important to note that any synchronicity shown is concerned only with messages; it does not imply, or require, a synchronous (blocking) behaviour in either the client or provider, as these are implementation issues.

2.2.3 DESCRIPTION AND USAGE

The Description and Usage sections are used to describe the pattern and define the expected usage respectively.

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2.2.4 ERROR HANDLING

The Error Handling section defines the positions in the pattern where errors are permitted to be generated. It uses the same sequence diagram notation as the nominal pattern sequence from the Overview section.

2.2.5 OPERATION TEMPLATE

Each interaction pattern definition contains a table that defines the template for operations that use that pattern:

Table 2-1: Example Operation Template

Operation Identifier	<<Operation name>>	
Interaction Pattern	<<Interaction pattern name>>	
Pattern Sequence	Message	Body Type
<<Message direction>>	<<Message name>>	<<Message types*>>
…	…	…

The message direction denotes the direction of the message relative to the provider of the pattern and is either IN or OUT. So all messages directed towards the provider are IN messages, and all messages directed away from the provider are OUT messages. It is expected that message names match those defined in the Primitives section.

Blue cells (dark grey when printed on a monochrome printer) contain table headings, light grey cells contain fields that are fixed for a pattern, and white cells contain values that must be provided by the operation or structure.

The Body Type column contains the list of types that make up the Body of a particular message. Zero to many types may be listed here and together define the body of the indicated message.

This document defines a data type specification language in section 4 (referred to as the MAL data types) that is expected to be the default data type specification language. The Body Types are defined using the MAL data types to define the various base data types, the notation used to describe them, and the rules for their combination into complex data structures. This is separate from the encoding technology used which is responsible for mapping the abstract data type notation from the data type specification into an actual 'bits and bytes' representation.

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Even though the Body Types in this specification are defined using the MAL data types, any data type specification language (such as XML Schema) may be used in an actual service specification.

2.2.6 PRIMITIVES

Each pattern defines a set of primitives in a table as below:

Table 2-2: Example Primitive List

Primitive
<<Primitive name>>

For each listed primitive there exists a Request, Message and Indication of the same name. The Requests and Indications are used by the following State Diagrams. Requests are transitions that are triggered by the component being modelled; Indications are transitions that are triggered by an external activity. Messages are the entities that are transferred between the two components to progress the interaction (see figure 2-2).

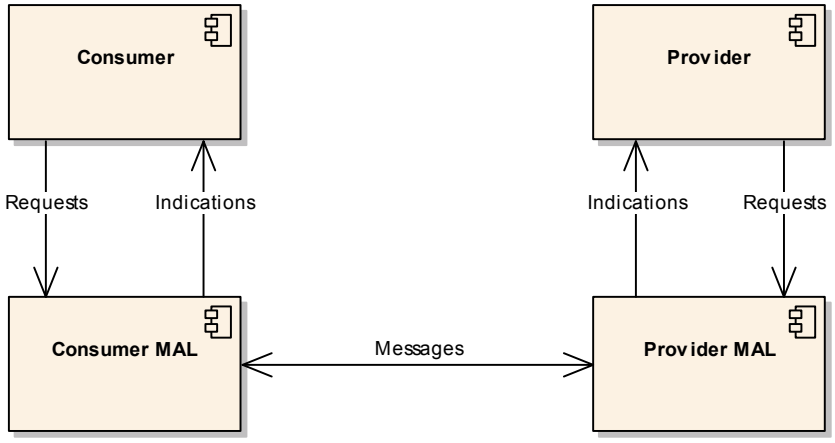

Figure 2-2: Request, Indication, and Message Relationship

Therefore a component issues Requests, which cause Messages to be transmitted, which raise Indications in the destination component.

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2.2.7 STATE CHARTS

For each defined interaction there can also be specified one or more state diagrams (see figure 2-3).

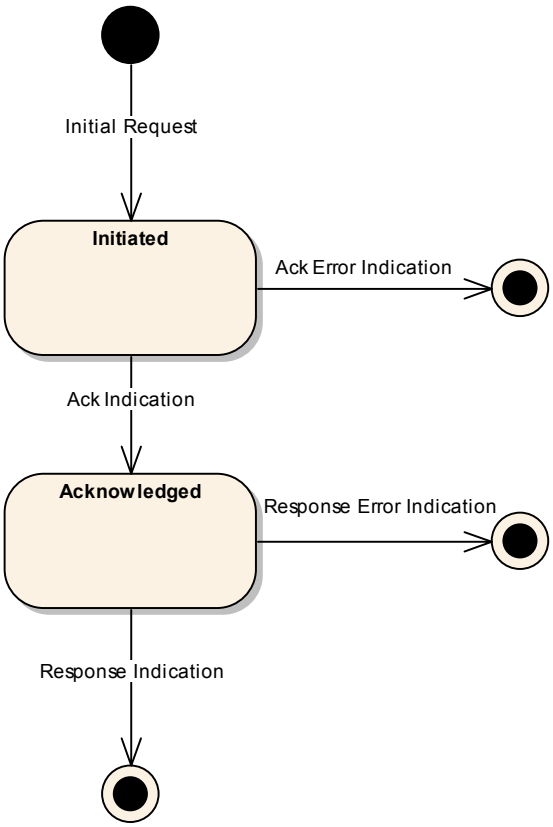

Figure 2-3: Consumer State Diagram Example

The diagrams define the allowed states and transitions between those states. The states are those of the MAL of the relevant component and apply to a single instance of a pattern; for example, figure 2-3 shows the allowed states and transitions for a specific pattern on the consumer, but it is the responsibility of the consumer MAL to maintain that state information and reject invalid state transitions. The state also only applies to a single instance of a pattern; as there can be many interactions concurrently active with one MAL, it needs to be able to track the state of each interaction instance independently.

Figure 2-3 shows the state diagram for the Consumer component from the example in figure 2-1, and includes some error state transitions that are not shown in the example.

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2.2.8 REQUESTS AND INDICATIONS

2.2.8.1 General

For each pattern there are a set of Requests that can be issued and a set of Indications that can be received. These sets are defined in the Primitives section for the pattern. The allowed state transitions are defined in the State Charts section for the pattern.

Each pattern defines the following subsections for each primitive.

2.2.8.2 Function

The Function subsection defines the use of a specific Request or Indication.

2.2.8.3 Semantics

The Semantics subsection defines what information is required for the Request or Indication. It is equivalent to the arguments of a programming language function call.

2.2.8.4 When Generated

The When Generated subsection specifies the circumstances that trigger the generation of the Request or Indication.

2.2.8.5 Effect on Reception

The Effect on Reception subsection specifies what the effects of the reception of a Request by a MAL or an Indication by an Application are. Usually for a Request is it the transmission of a Message to the destination and for an Indication it is pattern specific.

2.2.8.6 Message Header

The MAL defines a standard message header that is used to manage the interaction. The Message Header subsection specifies the values of the fields of the Message Header to be used for the message. The subsection can specify all the fields, or only fields that are different from another Request/Indication.

The full definition of the message header structure is provided in 3.4.

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2.2.9 MESSAGE EXAMPLE DECOMPOSITIONS

Each pattern is illustrated with an example which shows how each message will look when decomposed into a packet structure. It is important to note that such a type of structure is completely dependent on the chosen protocol.

For the example decomposition each message is split into up to three parts (figure 2-4), a standard message header, possibly a standard pattern body, and, finally, possibly a service-specific body:

Figure 2-4: Message Decomposition Key

Each message, in the examples, is split into the relevant fields; the example value is shown in the box, and the field name is given above (figure 2-5):

Message Header																
URI From	*Auth Id*	*URI To*	*Timestamp*	*QoS*	*Priority*	*Domain*	*Zone*	*Session*	*Interaction*	*Stage*	*Trans Id*	*Area*	*Service*	*Operation*	*Version*	*Is Error*
Provider	SC X	Broker		BEST	1	A.B.C	GROUND	LIVE	PUBSUB	3		Example	Example	testPubSub	1	FALSE

Figure 2-5: Message Header Decomposition Example

Field values are there to provide an example, and as such more human-readable values are often used rather than numeric equivalents that may be more efficient. For example, with enumerated values such as 'Session' the textual versions of the enumeration are given rather than the numerical versions, as this is more meaningful to a human. This is for example purposes only, however.

When more complex structures are being shown (figure 2-6), a single field can be part of a more complex structure which is itself part of another composite structure:

List<UpdateHeader>															*List<TestNotify>*				
List count	*UpdateHeader*							*UpdateHeader*							*List count*	*Test Notify*		*Test Notify*	
	Time stamp	*Source URI*	*Update Type*	*EntityKey*				*Time stamp*	*Source URI*	*Update Type*	*EntityKey*					*Time*	*Value*	*Time*	*Value*
				1st	*2nd*	*3rd*	*4th*				*1st*	*2nd*	*3rd*	*4th*					
2		SC X	Update	A	2	1	2		SC X	Update	A	4	1	2	2	Today, 09:30	1234	Today, 09:30	8888

Figure 2-6: Message Body Decomposition Example

In the example above the 'Update Type' field is part of the UpdateHeader structure which is itself part of the overall UpdateHeader list structure. The above example also demonstrates the difference between a pattern body and a service-specific body. The UpdateHeader list is the pattern body and is followed by the service-specific TestNotify part.

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NOTE – The structures used in the body of the examples for each pattern are only examples, and as such no explanation of contained values or meanings is provided or required.

2.3 ABSTRACT SERVICE SPECIFICATIONS

Each abstract service specification Blue Book is specified as an Area that consists of one or more services that are composed of a set of operations. Service Areas provide a simple way of grouping related Services together.

Each service specification includes an overview table that details the Area and Service Identifiers and then lists the operations of that service (see table 2-3).

Table 2-3: Service Overview Table

Area Identifier	Service Identifier	Area Number	Service Number	Area Version
Interaction Pattern	Operation Identifier	Operation Number	Support in replay	Capability Set

The values of table 2-3 are used to populate the [Service Area][Service][Service Operation][Area Version] fields of the Message Header. The Area Number, Service Number, and Operation Number fields provide an alternative numerical identification scheme parallel to the Identifier scheme.

The choice of whether to use Identifiers, numbers, or another alternative in an actual transport is transport specific, as long as it is possible to correctly determine the area, service, operation, and version values from the transmitted information. The numbers are expected to be used by transports that require a more efficient identification mechanism than Identifiers, and will not overlap with existing service definitions. The set of permissible values are in the UShort range and start at ‘1’.

The Area Version is a number that is used to differentiate between issues of a specification. Initially it will be set to the number ‘1’, and future updates to the specification will increase that number. The set of permissible values are in the UOctet range.

Support in replay is used to denote whether a specific operation is allowed to be used in a Replay session and is either of the value ‘Yes’ or ‘No’. For example, only operations that do

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not modify history are usually supported in a replay session; operations such as setting a parameter would not be supported as they modify history.

The Capability set field is a numerical identifier that holds the Service Capability Set number for that operation. Operations that hold the same number within a service specification are considered to be part of the same Service Capability Set. The set of permissible values are in the UShort range.

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3 ABSTRACT SERVICE SPECIFICATIONS

3.1 OVERVIEW

There are three abstract interfaces defined in this specification. The first is the abstract interface of the MAL. The MAL abstract interface defines the interactions that are presented to the higher layers, the information and interaction between the two interacting components, and also the expected behaviour of the application layer that uses the MAL. It is detailed in 3.5.

The second is the abstract interface of the Access Control component. To support the access control and security aspects of the reference model in reference [1] the MAL requires a standard abstract interface to an Access Control component. The access control component only has the single interaction that is used by the MAL as defined in the Reference Model (reference [1]). The implementation of the Access Control component is deployment specific, as is the security policy and rules to be used; however, the interaction with that component is part of the MAL standard. It is detailed in 3.6.

The third is the abstract interface that a Transport layer provides to the MAL. It specifies what facilities must be made available to a compliant MAL and also the required behaviour of the Transport. It is detailed in 3.7.

General constraints that apply to all patterns are defined in 3.2, 3.3, and 3.4.

3.2 TRANSACTION HANDLING

3.2.1 The message header shall contain a transaction identifier field providing a mechanism for the originating MAL of a message exchange to uniquely identify the response, or set of responses, to a message.

3.2.2 Each instance of a pattern shall be considered a single transaction.

3.2.3 The transaction identifier shall be:

a) used by the originating MAL to identify messages in a particular instance of an interaction pattern, and

b) returned by the service provider in matching messages (returns from submits, etc.).

3.2.4 The originating MAL shall ensure that the combination of the following Message Header fields form a unique index: pattern type, transaction identifier, the source address, the session, the domain, the network, the service area, the service, and operation.

3.3 STATE TRANSITIONS

3.3.1 Each pattern shall specify the set of states that both the provider and consumer can attain during the execution of the pattern.

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3.3.2 To move between the states, each pattern shall define the set of legal transitions either as a Request or an Indication.

3.3.3 For a Request to be issued, the source entity shall be in the correct state.

3.3.4 Issuing a Request when in the incorrect state shall cause an INCORRECT_STATE error to be raised by the local MAL, and the pattern shall end at this point.

3.3.5 For Indications, the receiving entity shall be required to be in the correct state.

3.3.6 Reception of an Indication in a state other than the correct one shall cause an INCORRECT_STATE error to be raised by the local MAL, and the pattern shall end at this point.

3.4 MESSAGE COMPOSITION

3.4.1 MESSAGE HEADER FIELD VALUES

3.4.1.1 The header fields, with the values specified in table 3-1, shall be used for all interaction patterns.

3.4.1.2 Each interaction pattern may override the values in table 3-1 with values defined in the relevant Request and Indication section for that pattern.

3.4.1.3 The Domain shall be defined as a list of identifiers.

3.4.1.4 The most significant domain part shall be listed first in the list (for example, Agency), and each subsequent domain identifier in the list narrows the preceding domain.

3.4.1.5 Each Identifier part of the Domain shall be allowed the full range of Identifier values with the restriction that it is NOT allowed to contain the '.' character.

3.4.1.6 The contents of URI From and URI To shall be transport specific (see reference [1] for more information).

3.4.1.7 Authentication Id, QoSLevel, Priority, Network Zone, and Session fields shall be populated as defined in reference [1].

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Table 3-1: MAL Message Header Fields

Field	Type	Value
URI From	URI	Message Source URI
Authentication Id	Blob	Source Authentication Identifier
URI To	URI	Message Destination URI
Timestamp	Time	Message generation timestamp
QoSlevel	QoSLevel	The QoS level of the message
Priority	UInteger	The QoS priority of the message
Domain	List<Identifier>	Domain of the message
Network Zone	Identifier	Network zone of the message
Session	SessionType	Type of session of the message
Session Name	Identifier	Name of the session of the message
Interaction Type	InteractionType	Interaction Pattern Type
Interaction Stage	UOctet	Interaction Pattern Stage
Transaction Id	Long	Unique to consumer
Service Area	UShort	Service Area
Service	UShort	Service
Operation	UShort	Service Operation
Area version	UOctet	Areaversion
Is Error Message	Boolean	'True' if this is an error message; else 'False'

3.4.2 MESSAGE BODY

3.4.2.1 The message body shall be composed of the types listed in the Body Type column of the operation template in a service specification.

3.4.2.2 Zero to many types may be listed in the Body Type column, each type being one part of the message body, and together form the complete body of the indicated message.

3.4.2.3 The listed types should use the MAL data type specification (or service-specific types derived from these) as defined in section 4 of this specification; however, any data type specification (such as XML Schema) may be used.

3.4.2.4 How the message body is actually encoded shall be dependent on the encoding technology used, but all message parts are expected to be supplied.

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3.4.3 ERROR MESSAGES

3.4.3.1 A service specification shall define which error numbers may be returned for a specific operation and also if any extra information is provided with the error message.

3.4.3.2 The service specification shall specify the data type of the extra information for the specific error.

3.4.3.3 A UInteger value containing the Error Number (see section 5) shall immediately follow the Message Header.

3.4.3.4 The extra information value shall immediately follow the Error Number.

3.4.3.5 If no extra information is provided by an error, then the extra information value shall be set to NULL.

3.5 MAL SERVICE INTERFACE

3.5.1 SEND INTERACTION PATTERN

3.5.1.1 Overview

The SEND pattern is the most basic interaction (figure 3-1); it is a single message from the consumer to the provider. No acknowledgement is sent by the provider.

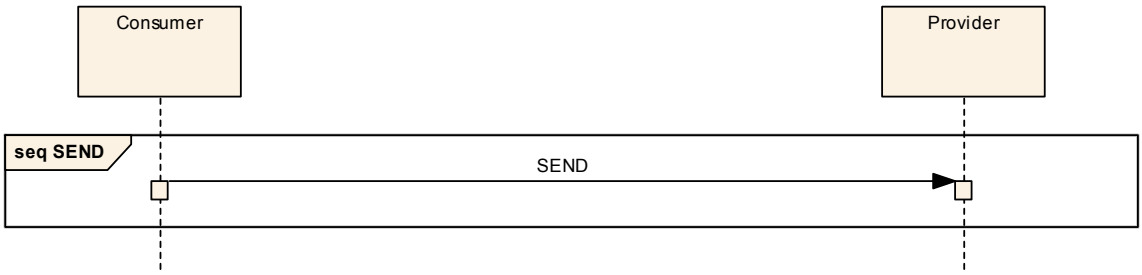

Figure 3-1: SEND Interaction Pattern Message Sequence

3.5.1.2 Description

The SEND pattern is the basic interaction of which all other patterns can be considered extensions. It is the simple passing of a message from a consumer to a provider. Because there is no message 'conversation' implied with a simple SEND, there is no requirement for a transaction identifier in the message. However, one may be specified. No return message is sent from the provider to the consumer, so the consumer has no indication the provider has received the message.

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3.5.1.3 Usage

The SEND pattern is expected to be used for non-critical messages where the possible loss of one or more of these messages is not considered critical. An example would be regular heartbeat-type messages.

3.5.1.4 Error Handling

Errors (see section 5) may be generated by the consumer service layers, but no error can be generated by the provider as the interaction pattern does not allow for the provider to return an error.

3.5.1.5 Operation Template

The SEND template only contains the operation name and the type of the structure that is sent as the message body:

Table 3-2: SEND Operation Template

Operation Identifier	<<Operation name>>	
Interaction Pattern	SEND	
Pattern Sequence	Message	Body Type
IN	SEND	<<Body type>>

3.5.1.6 Primitives

Table 3-3: SEND Primitive List

Primitive
SEND

3.5.1.7 State Charts

3.5.1.7.1 Consumer Side

The state chart contains only one transition from the initial state to the final one, so it is not represented. This transition is triggered by the primitive **SEND Request**.

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3.5.1.7.2 Provider Side

The state chart contains only one transition from the initial state to the final one, so it is not represented. This transition is triggered by the primitive **SEND Indication**.

3.5.1.8 Requests and Indications

3.5.1.8.1 SEND

3.5.1.8.1.1 Function

3.5.1.8.1.1.1 The **SEND Request** primitive shall be used by the consumer application to initiate a SEND Interaction.

3.5.1.8.1.1.2 The **SEND Indication** primitive shall be used by the provider MAL to deliver a **SEND Message** to a provider and initiate a SEND Interaction.

3.5.1.8.1.2 Semantics

SEND Request and **SEND Indication** shall provide parameters as follows:

(SEND Message Header, SEND Message Body, QoS properties)

3.5.1.8.1.3 When Generated

a) A **SEND Request** may be generated by the consumer application at any time.

b) A **SEND Indication** shall be generated by the provider MAL upon reception of a **SEND Message**, once checked via the Access Control interface, from a consumer.

3.5.1.8.1.4 Effect on Reception

a) Reception of a **SEND Request** shall, once checked via the Access Control interface, cause the consumer MAL to initiate a SEND Interaction by transmitting a **SEND Message** to the provider.

b) The pattern shall end at this point for the consumer.

c) On reception of a **SEND Indication** a provider shall process the operation.

d) The pattern shall end at this point for the provider.

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3.5.1.8.1.5 Message Header

a) For the **SEND Message** the message header fields shall be as defined in 3.4 except for the fields in table 3-4.

b) The contents of the **SEND Message** body, as specified in the operation template, shall immediately follow the message header.

Table 3-4: SEND Message Header Fields

Field	Value
URI From	Consumer URI
Authentication Id	Consumer Authentication Identifier
URI To	Provider URI
Interaction Type	SEND
Interaction Stage	Not used
Transaction Id	Not used

3.5.1.9 Example

The following example shows a simple example service with a single SEND pattern-based operation:

Operation Identifier	testSend	
Interaction Pattern	SEND	
Pattern Sequence	Message	Body Type
IN	SEND	TestBody

The TestBody structure is defined below:

Name	TestBody		
Extends	Composite		
Short Form Part	Example Only		
Field	Type	Nullable	Comment
FirstItem	String	Yes	Example String item
SecondItem	Integer	Yes	Example Integer item

This corresponds to the following message:

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Message Header																	Test Body	
URI From	Auth Id	URI To	Timestamp	QoS	Priority	Domain	Zone	Session	Interaction	Stage	Trans Id	Area	Service	Operation	Version	Is Error	First Item	Second Item
Consumer	Op A	Provider		BEST	1	A.B.C	GROUND	LIVE	SEND		1233	Example	Example	testSend	1	FALSE	Hello	1234

NOTE – An actual service specification, rather than the example given here, would fully specify the meaning of, and required values of, all structures used by the service.

3.5.2 SUBMIT INTERACTION PATTERN

3.5.2.1 Overview

The SUBMIT pattern is a simple confirmed message exchange pattern (figure 3-2). The consumer sends a message to a provider and the provider acknowledges it.

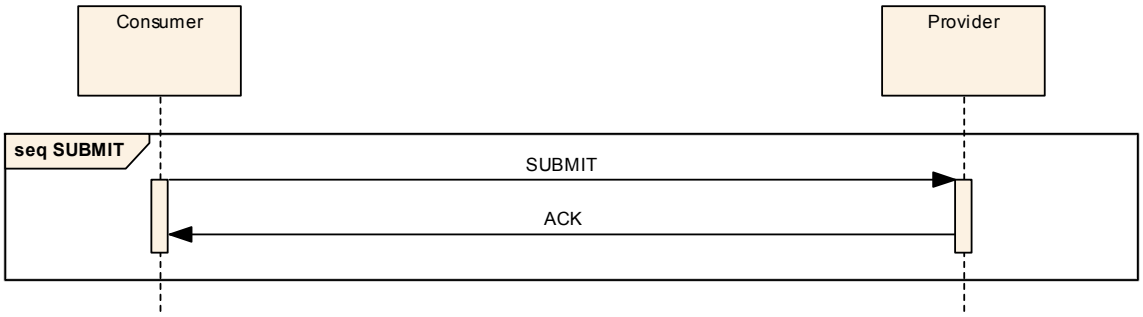

Figure 3-2: SUBMIT Interaction Pattern Message Sequence

The meaning of the return acknowledgement is operation specific. Each operation specification details the exact meaning of the operation's return acknowledgement for its context.

3.5.2.2 Description

The SUBMIT pattern extends the SEND pattern by providing a return acknowledgment message from the provider back to the consumer. The service specification details the meaning of the acknowledgment message for a specific operation.

3.5.2.3 Usage

The SUBMIT pattern is used for simple operations that complete quickly but must be confirmed to the consumer.

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3.5.2.4 Error Handling

a) The return acknowledgment shall be replaced with an error message (see section 5) if an error occurs during the processing of the operation as shown in figure 3-3.

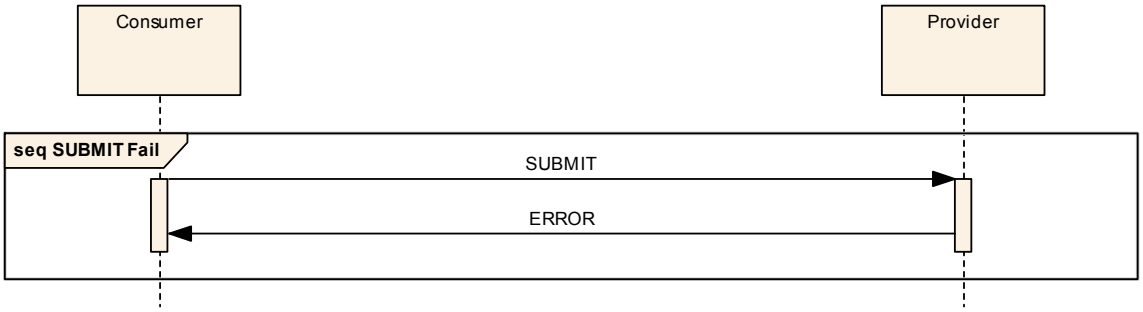

Figure 3-3: SUBMIT Interaction Pattern Error Sequence

b) Either the acknowledgment or the error message shall be returned but never both.

c) The service specification shall specify that the acknowledgement is not returned until all processing that can generate an error has been completed, if a service is required to be able to return an error during the processing of the message.

3.5.2.5 Operation Template

The SUBMIT template only contains the operation name and the type of the structure that is submitted as the Submit message body:

Table 3-5: SUBMIT Operation Template

Operation Identifier	<<Operation name>>	
Interaction Pattern	SUBMIT	
Pattern Sequence	Message	Body Type
IN	SUBMIT	<<Body type>>

The return acknowledgement message does not have a body to keep the operation as simple as possible. Because of this it is not shown in the operation template.

NOTE – If a service-defined return message is required, for example, to return an identifier for the operation, then the REQUEST pattern should be used instead of the SUBMIT pattern.

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3.5.2.6 Primitives

Table 3-6: SUBMIT Primitive List

Primitive
SUBMIT
ACK
ERROR

3.5.2.7 State Charts

3.5.2.7.1 Consumer Side

Figure 3-4 shows the consumer side state chart for the SUBMIT pattern:

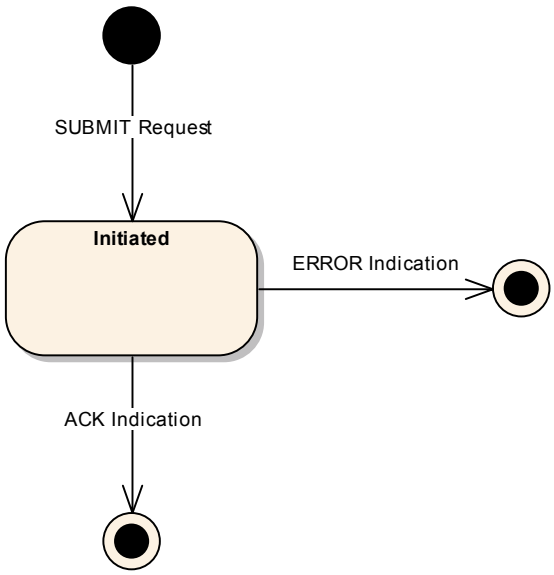

Figure 3-4: SUBMIT Consumer State Chart

a) The initial transition is triggered by the primitive **SUBMIT Request** and shall lead to the **Initiated State**.

b) There are two possible transitions from the **Initiated State**:

   1) the first is the indication of an acknowledgement, **ACK Indication**, and shall lead to the final state;

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2) the second is the indication of an error, **ERROR Indication**, and shall lead to the final state.

3.5.2.7.2 Provider Side

Figure 3-5 shows the provider side state chart for the SUBMIT pattern:

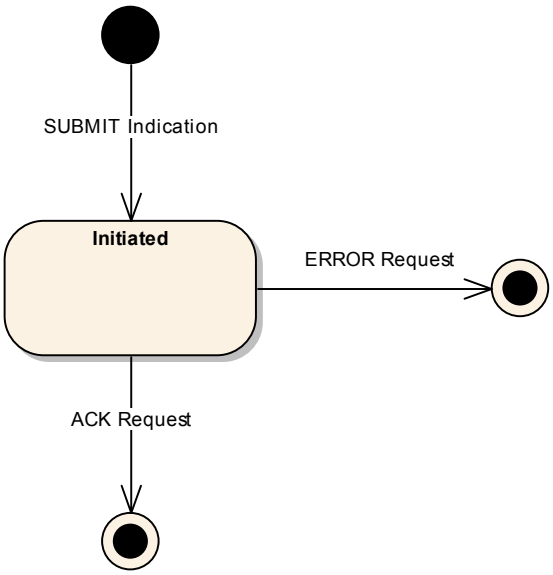

Figure 3-5: SUBMIT Provider State Chart

a) The initial transition is triggered by the primitive **SUBMIT Indication** and shall lead to the **Initiated State**.

b) There are two possible transitions from the **Initiated State**:

1) the first is the transmission of an acknowledgement, **ACK Request**, and shall lead to the final state;

2) the second is the transmission of an error, **ERROR Request**, and shall lead to the final state.

3.5.2.8 Requests and Indications

3.5.2.8.1 SUBMIT

3.5.2.8.1.1 Function

a) The **SUBMIT Request** primitive shall be used by the consumer application to initiate a SUBMIT Interaction.

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b) The **SUBMIT Indication** primitive shall be used by the provider MAL to deliver a **SUBMIT Message** to a provider and initiate a SUBMIT Interaction.

3.5.2.8.1.2 Semantics

SUBMIT Request and **SUBMIT Indication** shall provide parameters as follows:

(SUBMIT Message Header, SUBMIT Message Body, QoS properties)

3.5.2.8.1.3 When Generated

a) A **SUBMIT Request** may be generated by the consumer application at any time.

b) A **SUBMIT Indication** shall be generated by the provider MAL upon reception of a **SUBMIT Message**, once checked via the Access Control interface, from a consumer.

3.5.2.8.1.4 Effect on Reception

a) Reception of a **SUBMIT Request** shall, once checked via the Access Control interface, cause the consumer MAL to initiate a SUBMIT Interaction by transmitting a **SUBMIT Message** to the provider.

b) The consumer MAL shall then enter the **Initiated State**.

c) On reception of a **SUBMIT Indication** by the provider, the provider MAL shall enter the **Initiated State**.

d) The provider shall then start processing the operation at this point.

3.5.2.8.1.5 Message Header

a) For the **SUBMIT Message** the message header fields shall be as defined in 3.4 except for the fields in table 3-7.

b) The contents of the Message Body, as specified in the operation template, shall immediately follow the message header.

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Table 3-7: SUBMIT Message Header Fields

Field	Value
URI From	Consumer URI
Authentication Id	Consumer Authentication Identifier
URI To	Provider URI
Interaction Type	SUBMIT
Interaction Stage	1
Transaction Id	Provided by consumer MAL

3.5.2.8.2 ACK

3.5.2.8.2.1 Function

a) The **ACK Request** primitive shall be used by the provider application to acknowledge a SUBMIT Interaction.

b) The **ACK Indication** primitive shall be used by the consumer MAL to deliver an **ACK Message** to a consumer.

3.5.2.8.2.2 Semantics

ACK Request and **ACK Indication** shall provide parameters as follows:

(ACK Message Header, QoS properties)

3.5.2.8.2.3 When Generated

a) An **ACK Request** shall be used by the provider application with the provider MAL in the **Initiated State** to acknowledge a SUBMIT Interaction.

b) An **ACK Indication** shall be generated by the consumer MAL in the **Initiated State** upon reception of an **ACK Message**, once checked via the Access Control interface, from a provider.

3.5.2.8.2.4 Effect on Reception

a) Reception of an **ACK Request** shall, once checked via the Access Control interface, cause the provider MAL to transmit an **ACK Message** to the consumer.

b) The pattern shall end at this point for the provider.

c) On reception of an **ACK Indication** a consumer shall end the interaction pattern with success.

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3.5.2.8.2.5 Message Header

For the **ACK message** the message header fields shall be as defined in 3.4 except for the fields in table 3-8.

Table 3-8: Submit ACK Message Header Fields

Field	Value
URI From	Provider URI
Authentication Id	Provider Authentication Identifier
URI To	Consumer URI
Interaction Type	SUBMIT
Interaction Stage	2
Transaction Id	Transaction Id from initial message

3.5.2.8.3 ERROR

3.5.2.8.3.1 Function

a) The **ERROR Request** primitive shall be used by the provider application to end a SUBMIT Interaction with an error.

b) The **ERROR Indication** primitive shall be used by the consumer MAL to deliver an **ERROR Message** to a consumer.

3.5.2.8.3.2 Semantics

ERROR Request and **ERROR Indication** shall provide parameters as follows:

(ERROR Message Header, Error Number, Extra Information, QoS properties)

3.5.2.8.3.3 When Generated

a) An **ERROR Request** shall be used by the provider application with the provider MAL in the **Initiated State** to transmit an error.

b) An **ERROR Indication** shall be generated by the consumer MAL in the **Initiated State** upon one of two events:

1) the reception of an **ERROR Message**, once checked via the Access Control interface, from a provider;

2) an error raised by the local communication layer.

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3.5.2.8.3.4 Effect on Reception

a) Reception of an **ERROR Request** shall, once checked via the Access Control interface, cause the provider MAL to transmit an **ERROR Message** to the consumer.

b) The pattern shall end at this point for the provider.

c) On reception of an **ERROR Indication** a consumer shall end the interaction with an error.

3.5.2.8.3.5 Message Header

a) For the **ERROR Message** the message header fields shall be the same as for the **ACK Message** except for the 'Is Error Message' field which is set to TRUE.

b) The Error number and any extra information (referred to as the 'Error information' from this point onwards) shall immediately follow the message header.

3.5.2.9 Example

The following example shows a simple example service with a single SUBMIT pattern-based operation:

Operation Identifier	testSubmit	
Interaction Pattern	SUBMIT	
Pattern Sequence	Message	Body Type
IN	SUBMIT	TestBody

The TestBody structure is defined in 3.5.1.9. This corresponds to the following message being transmitted:

Message Header																	Test Body	
URI From	*Auth Id*	*URI To*	*Timestamp*	*QoS*	*Priority*	*Domain*	*Zone*	*Session*	*Interaction*	*Stage*	*Trans Id*	*Area*	*Service*	*Operation*	*Version*	*Is Error*	*First Item*	*Second Item*
Consumer	Op A	Provider		BEST	1	A.B.C	GROUND	LIVE	SUBMIT	1	1234	Example	Example	testSubmit	1	FALSE	Hello	1234

and corresponds to the following acknowledgement being returned:

Message Header																
URI From	*Auth Id*	*URI To*	*Timestamp*	*QoS*	*Priority*	*Domain*	*Zone*	*Session*	*Interaction*	*Stage*	*Trans Id*	*Area*	*Service*	*Operation*	*Version*	*Is Error*
Provider	SC X	Consumer		BEST	1	A.B.C	GROUND	LIVE	SUBMIT	2	1234	Example	Example	testSubmit	1	FALSE

NOTE – An actual service specification, rather than the example given here, would fully specify the meaning of, and required values of, all structures used by the service.

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3.5.3 REQUEST INTERACTION PATTERN

3.5.3.1 Overview

The REQUEST pattern extends the SUBMIT pattern by replacing the simple acknowledgement with a data response message (figure 3-6). No acknowledgement other than the data response is sent.

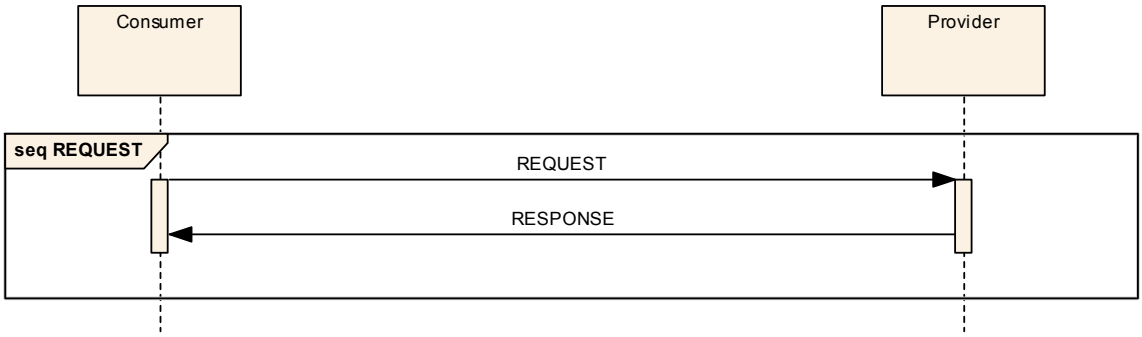

Figure 3-6: REQUEST Interaction Pattern Message Sequence

3.5.3.2 Description

The REQUEST pattern provides a simple request/response message exchange. Unlike the SUBMIT pattern, no acknowledgement is sent upon reception of the request; however, a data response is sent. The lack of an acknowledgement and only the return data response for this pattern means that it is primarily expected to be used for situations where the operation takes minimal time.

3.5.3.3 Usage

It is expected that the REQUEST pattern is to be used only for operations that complete in a relatively short period of time. If a more extended or indeterminate period is possible then the more advanced INVOKE or PROGRESS patterns should be specified.

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3.5.3.4 Error Handling

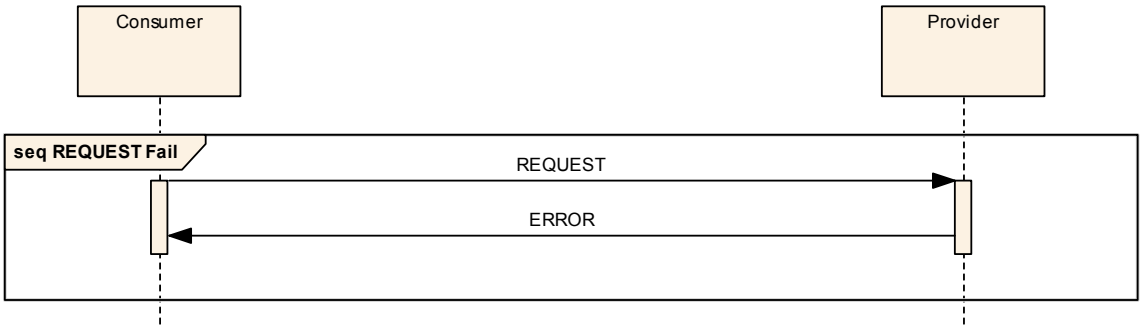

Figure 3-7: REQUEST Interaction Pattern Error Sequence

a) The data response shall be replaced with an error message (see section 5) if an error occurs during the processing of the operation (figure 3-7).

b) Either the data response or the error message shall be returned but never both.

3.5.3.5 Operation Template

The REQUEST pattern template extends the SUBMIT template by adding the requirement for a return type:

Table 3-9: REQUEST Operation Template

Operation Identifier	<<Operation name>>	
Interaction Pattern	REQUEST	
Pattern Sequence	Message	Body Type
IN	REQUEST	<<Request type>>
OUT	RESPONSE	<<Response type>>

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3.5.3.6 Primitives

Table 3-10: REQUEST Primitive List

Primitive
REQUEST
RESPONSE
ERROR

3.5.3.7 State Charts

3.5.3.7.1 Consumer Side

Figure 3-8 shows the consumer side state chart for the REQUEST pattern:

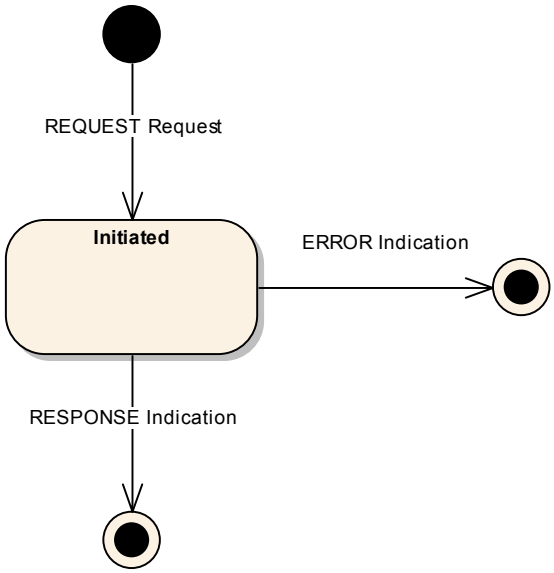

Figure 3-8: REQUEST Consumer State Chart

a) The initial transition is triggered by the primitive **REQUEST Request** and shall lead to the **Initiated State**.

b) There are two possible transitions from the **Initiated State**:

   1) the first is the indication of a response, **RESPONSE Indication**, and shall lead to the final state;

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2) the second is the indication of an error, **ERROR Indication**, and shall lead to the final state.

3.5.3.7.2 Provider Side

Figure 3-9 shows the provider side state chart for the REQUEST pattern:

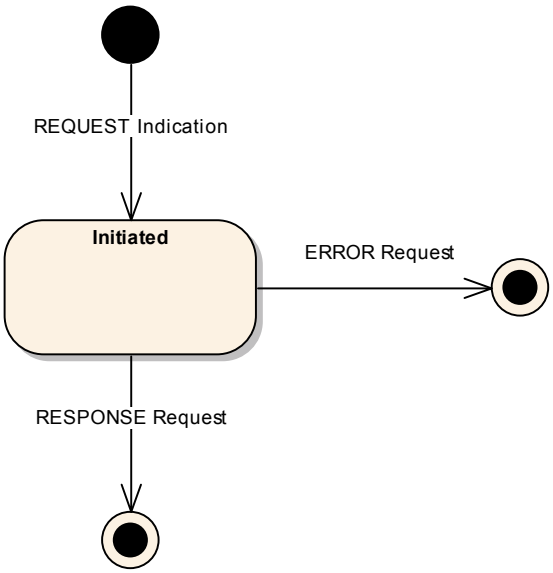

Figure 3-9: REQUEST Provider State Chart

a) The initial transition is triggered by the primitive **REQUEST Indication** and shall lead to the **Initiated State**.

b) There are two possible transitions from the **Initiated State**:

1) the first is the transmission of a response, **RESPONSE Request**, and shall lead to the final state;

2) the second is the transmission of an error, **ERROR Request**, and shall lead to the final state.

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