

How to Specify Services?

An Analysis of Community and CCSDS Service Specification Concepts

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1 INTRODUCTION

1.1 Purpose

The purpose of this document is to analyse the concepts used to specify service within the open software community as well as within the CCSDS.

The goal is to understand how services are defined within different standards, to formulate a vision for how the services are to be defined within CCSDS, and to create a roadmap defining how to migrate to the harmonized approach.

1.2 Scope

The analysis focus on how services are defined. The analysis covers the following standards and recommendations

- W3C WSDL [WSDL].
- OASIS Reference Model for Service Oriented Architectures [RMSOA].
- OMG SOA SIG UMPS [SOASIG-UMPS].
- CCSDS Cross Support Reference Model [CS-RM].
- CCSDS Cross Support Transfer Service [CS-TS].
- CCSDS Service Management [CS-SM].
- CCSDS SM&C [SM&C].

The analysis does not describe the basic concepts of service oriented architectures, which is assumed known by the reader.

The analysis is not an analysis of specific message technologies. It is considered whether the service specification approaches ensures technology abstraction, but specific mappings are not considered.

The analysis does not cover specific services, only the concepts of how these are defined. The analysis therefore do not cover any possible overlap in scope of service specification such as data transfer services.

The analysis does not create a formal terminology baseline. In the description of existing standards, the terminology of the standards are used. Else the terminology chosen is the commonly used.

Analysis of the different concepts for applying QoS and Security (including access control) is considered out of the scope of this document. It is considered how these concepts relate to the overall service reference model.

The analysis links the service concepts to the system reference architecture, but does not contain an analysis or evaluation of reference architectures.

1.3 Abbreviations

Abbreviation	Description
3WC	World Wide Web Consortium. Standardization organization.
ASN.1	Abstract Syntax Notation 1.
CSRM	Cross Support reference Model

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CSTS	Cross Support Transfer Service
OASIS	Organization for the Advancement of Structured Information Standards. Standardization organization.
OCL	Object Constraint Language. Formal language for defining syntax constraints within UML models.
OMG	Object Management Group. Standardization organization.
RASDS	Reference Architecture for Space Data Systems [RASDS].
RMSOA	Reference Model for Service Oriented Architectures. OASIS standard [RMSOA].
SM	Service Management. CCSDS standard [CS-SM].
SM&C	Spacecraft Monitor and Control. CCSDS standard [SM&C].
SOA	Service Oriented Architecture
TS	Transfer Service
UML	Unified Modelling Language
UMPS	UML Profile and Metamodel for Services

1.4 Terminology

The terminology used within the different standards differs. The table below lists the terms used within the different standards. The terms used are consistent within the given standard, but not across standards.

Term	Standard	Description
Service	SM&C	"A service is an operation, or set of operations, that is well defined, self-contained and does not depend on the state or context of another service." [SM&C-MAL]
	RMSOA	"A service is a mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description." [RMSOA]
	WSDL	"[A] service is an entity, which is defined by ports that are service endpoints capable of receiving (and replying to) a set of messages defined by that port's type." [WSDL]
Operation procedure	SM	A standard message exchange sequence of an operation.
Procedure	CSTS	Combination of service operations invoked in a specific sequence.
Pattern		"A form or model proposed for imitation." [WEBSTER] Different kinds of patterns exist (exchange, interaction, design, architecture, business, ...). In regards to service, exchange and interaction patterns are typically used.

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Interaction Pattern	SM&C	A standard message exchange sequence of an operation.
Abstract Message	SM&C	Technology independent specification of information content, without restriction in order of format.
Reference Model	<p>“A reference model is an abstract framework for understanding significant relationships among the entities of some environment. It enables the development of specific reference or concrete architectures using consistent standards or specifications supporting that environment. A reference model consists of a minimal set of unifying concepts, axioms and relationships within a particular problem domain, and is independent of specific standards, technologies, implementations, or other concrete details.” [RMSOA, section 1.1]</p>	
Common Headers	CSTS	Standard header corresponding to a standard message exchange sequence of an operation.
Community	Term used to indicate the software development community in large. Can be seen as represented by the W3C, OpenGroup and OMG, which are considered some of the main drivers of the service concept development.	
Cross Support Reference Model	SM	<p>Definition of the context of Space Link Extension (SLE) services, i.e. the main actors and concepts of the data exchange.</p> <p>The reference model does not cover a specification of how services are to be defined.</p> <p>Is used as reference model by the cross support transfer services and service management.</p>
	CSTS	
Cross Support Transfer Service	SM	Data transfer services of the Space Link Extension.
	CSTS	
Service Management	SM	Service negotiation and management of Cross Support Transfer Services.
	CSTS	

1.5 Reference Documents

Mnemonic	Description
[CS-RM]	“Cross Support Concept – Part 1: Space Link Extension Services”, CCSDS 910.3-G-3, Green Book, March 2006
[CS-SM]	“Space Link Extension – Service Management – Service Specification”, CCSDS 910.11-R-1, Red Book, March 2006
[CS-TS]	“Cross Support Reference Model-Part 1: Space Link Extension Services”, CCSDS 910.4-B-2, Blue Book, October 2005
[C-TIME]	“Time Code Formats”, CCSDS 301.0-B-3, Blue Book, January 2002.
[OGSA]	http://www.globus.org/ogsa/
[RASDS]	“Reference Architecture for Space Data Systems”, CCSDS 311.0-R-0, Red Book, January 2006

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[RMSOA]	"Reference Model for Service Oriented Architecture 1.0", SOA-RM, 12 October 2006.
[SM&C-MAL]	"Spacecraft Monitor and Control – Message Abstraction Layer", CCSDS 521.0-R-1, Red Book, July 2007
[SM-RED]	"Space Link Extension – Service Management – Service Specification", CCSDS 910.11-R-1, Red Book, March 2006.
[SOASIG]	http://soa.omg.org
[SOASIG-UMPS]	"UML Profile and Metamodel for Services (UMPS) SOA RFP", soa/06-09-09
[WEBSTER]	http://www.m-w.com/dictionary
[WSDL]	"Web Service Description Language", issue 1.1, 15 March 2001

2 BACKGROUND

Within CCSDS different groups work with recommendations based on service concepts.

The service concepts are typically developed specifically for the needs of the group. A limited corporation and coordination occurs between groups, but no set of CCSDS wide service concepts have emerged.

Within each group considerable effort goes into agreeing on a set of service concepts. Typically the effort results in the development of a service reference model describing how services are to be defined. The service reference model forms the baseline for the specification of the services of the group.

This leads to a number of problems

- Duplication of effort when developing the recommendations.

Each group working with recommendations will encounter the same type of problems, such as considerations how to bind consumer and provider, which sequence messages should be exchanged in, how the protocol react to failures and the format of the data carried.

Agreement and specification of the solution to such questions are in themselves effort intensive. The result will typically also need a series of iterations before it reaches a mature and consistent state. This prolongs the time it takes to develop a recommendation.

- Prolonged learning curves for implementers of the recommendations.

Readers of the recommendations have to learn a new set of concepts for each recommendation. This prolongs the time it take to implement a recommendation, and hinders the development of a generic service framework.

- Problems developing concepts across recommendations.

Recommendations such as security affecting different CCSDS areas can only define in very general terms how they are to be implemented within each area. It is left to the specific area to interpretate the recommendations and incorporate the concepts in the areas service concepts.

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A harmonized approach to service specification within CCSDS promises to solve these problems. The effort invested in defining a consistent service reference model would help ensure that all future groups start on a solid and well proven baseline.

3 ANALYSIS

This section describes the different service concepts used within the community as well as within CCSDS.

The focus is on identifying how services are defined within the different standards;

1. How is the content of the exchanged messages defined?
2. How is the sequence of the message exchange defined?
3. What is meant with an operation?
4. What is meant with a service?
5. How (if) is the state of services defined?

The goal is to provide an overview of the commonly used service concepts, and of the service concepts used within CCSDS. This provides the baseline for identifying similarities and major discrepancies, and for defining a service reference model.

A key problem when describing and defining service concepts is terminology. In few fields is the terminology so overloaded as when discussing services. In the following sections, the terminology of each standard is used to describe itself. The terminology is therefore consistent within that section, if consistent within the analysed standard, however a term used in one section is not necessarily consistent with the usage of the same or similar terms in other sections. One of the first tasks for a service reference model should be define a consistent terminology within CCSDS.

3.1 WSDL (W3C)

“WSDL is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information.” [WSDL].

A message is a data container, consisting of different parts. Each part has a well defined type.

A port type is a named set of service operations. The port type defines the sequence of message exchange through a port. An exchange contains one or more messages flowing in any direction and any sequence between endpoints. WSDL provides a set of primitive port types called operations; One-Way (in), Request-Response (in-out), Solicit-Response (out-in), Notification (out). Additional types can be defined.

A binding is the definition of the messages exchange with a port type. The binding specifies the data types exchanged.

A port is the realization of a specific binding and therefore also of a specific port type. A port can therefore be seen as a specific instance of a port type.

An endpoint is the realization of a port, i.e. a specific implementation of a port. A service endpoint can therefore be seen as the realization of a service interface. The endpoint binds the service interface to a specific technology and implementation, and provides the service.

Each service is an entity, which is defined by ports that are service endpoints capable of receiving (and replying to) a set of messages defined by that port's type. Each port is, in

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fact a binding of a port type and an access protocol that tells how the messages should be encoded and sent to the port. A service may have several different access points and protocols for each port type.

All elements of WSDL are defined in XML, including the message content.

WSDL defines the basic protocol of services. It does not define the behaviour of a service, including the service state. WSDL can therefore be used to express service interactions, but not the semantics behind the interaction. Different groups work on extensions to the WSDL specification supporting the specification of the service semantics [OGSA] and state. This is unlikely to ever become part of W3C standards, as W3C sees services as atomic and stateless.

3.2 Reference Model for Service Oriented Architectures (OASIS)

The OASIS Reference Model for Service Oriented Architectures (**RMSOA**) [RMSOA] does not prescribe how services are to be defined.

The figure below illustrates RMSOA's scope [RMSOA, figure 1].

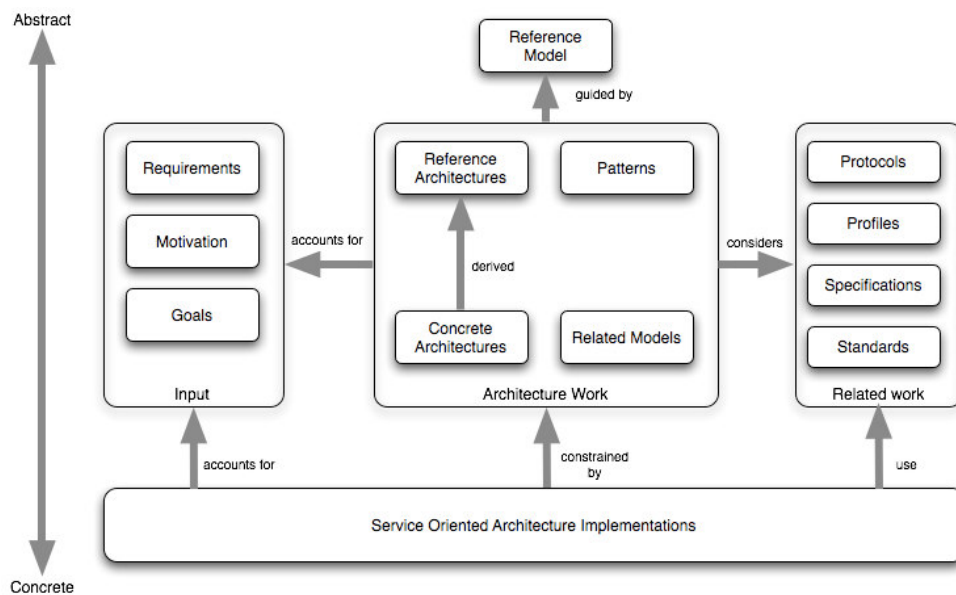


Figure 3-1; OASIS RMSOA Scope

The reference model is defines the core concepts in an abstract manner. It provides the baseline for defining 'Architectural Work' which is a domain specific reference model, including a reference architecture and patterns used within the domain.

RMSOA defines seven principle concepts behind services and service oriented architectures. The principle concepts are subdivided into more specific concepts. Relationships exist between the principle concepts.

Service. "A service is a mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description." [RMSOA]

Visibility. To be accessible, a service must be visible to the consumer, i.e. its existence must be advertised to the consumer. Visibility is subdivided into the concepts of awareness, willingness and reachability of the service.

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Service Description. The service description covers the specification of the service, its behaviour, information model, reachability and the contracts and policies applicable to the service.

Execution context. The context is the collection of policies, contracts and agreements applicable to a service interaction.

Interaction. The interaction protocol of the service must be understood by the consumer and provider. Interaction is subdivided into the concepts of a formal information model defining structure and semantic, and a behaviour model.

Contract and Policies. Contracts defines an agreement by two or more parties in regards to the service behaviour. The policies defines the constraints on the interaction, such as security measurements.

Real world effect. The effect that a service has must be communicated to the consumer. The effect includes the concepts of service state, which may affect the interaction.

The concepts and relationships defined by the reference model are intended to be the basis for describing references architectures and patterns that will be used to define domain specific SOA designs. They are therefore completely technology independent.

3.3 SOA SIG (OMG)

“Primary goals:

- To support an MDA approach to SOA that links architectural, business and technology views of services, including Business Process Management (BPM) and Event-Driven Architecture (EDA).
- Identify and foster development of OMG modeling standards for SOA that integrate with and complement standards developed by other organizations such as W3C, Open Group and OASIS.
- To improve awareness and understanding of SOA by OMG members.
- To coordinate SOA related efforts within OMG.” [SOASIG]

The SOA SIG has issued the Request for Proposal (**RFP**) ‘UML Profile and Metamodel for Services (UPMS)’ [SOASIG-UPMS]. The RFP covers the creation of a UML modeling profile for services. The RFP was issued June 2007 and is expected to enter implementation soon. The UMPS profile is within the RFP required aligned with the concepts in OASIS [SOASIG-UMPS, section 6.4.4]. The UMPS profile is required to take WSDL into consideration [SOASIG-UMPS, section 6.4.6].

3.4 Cross Support Reference Model (CCSDS)

The CCSDS Cross Support Reference Model (**CSRM**) [CS-RM] describes the background to the services and the functional components of the ground element of a Space Data System that provide the services.

It describes the SLE Data Transfer (predecessor of Cross Support Transfer Services) and SLE Service Management interfaces where Cross Support may occur and provides example scenarios to show how the concept may be applied in practice.

The recommendation does not define how services are to be specified.

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3.5 Cross Support Transfer Service (CCSDS)

The CCSDS Cross Support Transfer Services (**CSTS**) [CS-TS] creates an extensible framework for defining data transfer services such as Space Link Extension (SLE) services. It has been based on the cross support reference model [CS-RM]

A message is a container of data. The message structures are defined in table form, as well as in ASN.1. The messages contains mandatory fields, optional fields, and extension fields which can be used by concrete services to carry service specific information.

An operation is an action that one object can request of another through a bound port pair. The operations are based on standard operation headers corresponding to different exchange sequences; Unconfirmed (in/out), Confirmed (in-out) or Acknowledged (in-out-out). The data of the message carried in the operation is defined for each concrete operation.

The purpose of a procedure is to encapsulate generic behaviour required by transfer services. It describes the sequence of activities to be performed based on operations. A procedure is not a user side choreography. The procedure is part of the service specification and is therefore maintained at the provider side. This also means that as part of an operation invocation, the procedure identifier is passed to identify the procedure to which the operation is connected. It is as such not possible to call operations on a service, only procedures which starts the execution of operations.

The procedure has a state, also maintained by the provider. The state of the service instance depends on the state of the 'prime' procedure.

3.6 Service Management (CCSDS)

The CCSDS Service Management (**CSSM**) [CS-SM] specifies the services required to manage the exchanged of data between space mission and space link service providers for the purposes of negotiating, configuring and executing the Tracking, Telemetry, and Command (TT&C) functions and Space Link Extension (SLE) transfer services. It has been based on the cross support reference model [CS-RM].

Messages are defined as UML diagrams and in table format. Technology independent basic types are used. Messages can be extended for concrete services using UML inheritance.

The sequence messages are exchange in are defined based on operation procedure patterns. Three operation procedure patterns are supported; Notified (out), 2-phase (in-out), 3-phase (in-out-out). The operation procedures also defines the messages carried in the exchange.

Each operation is defined based on an operation procedure. The concrete operation may extend the message types carried through inheritance.

A service is defined based on a set of operations.

States are only mentioned in connection with the activation of operations, but no service states as such are defined.

The recommendation is compatible with WSDL [CS-SM, section 2.5].

3.7 SM&C (CCSDS)

The SM&C provides the Message Abstraction Layer (**MAL**) [SM&C-MAL] recommendation, defining the service concepts and how to specify services.

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Messages are defined as abstract message packages, intended to be specialised for a specific service. A message package contains a Message Exchange Pattern (**MEP**) header, a pattern body and a service specific data field. The messages are defined textually based on a set of basic types in a technology independent manner. The basic types can be mapped to different technologies. The specification of the abstract messages is intended not to impose any restriction of format and order of the fields in the messages.

The message exchange sequence is defined as Interaction Patterns. The interaction patterns are used as generic templates for service operations. The following interaction patterns have been defined; send (in), Submit (in-out), Request (in-out), Invoke (in-out-out), progress (in-out-N*out), publish-subscribe (in-out, N*in, N*out, in-out)

“A service is an operation, or set of operations, that is well defined, self-contained and does not depend on the state or context of another service.” [SM&C-MAL].

A specific service is specified as a set of operations, each based on an interaction pattern. Each operation overloads the message types of the interaction pattern to suite the specific service.

The SM&C does not define a set of standard service states. States are defined as part of the specific service specification.

3.8 Summary

To understand the connections between the analysed standards, they have been separated into levels of abstraction following the RMSOA classification. The figure below illustrates the classification.

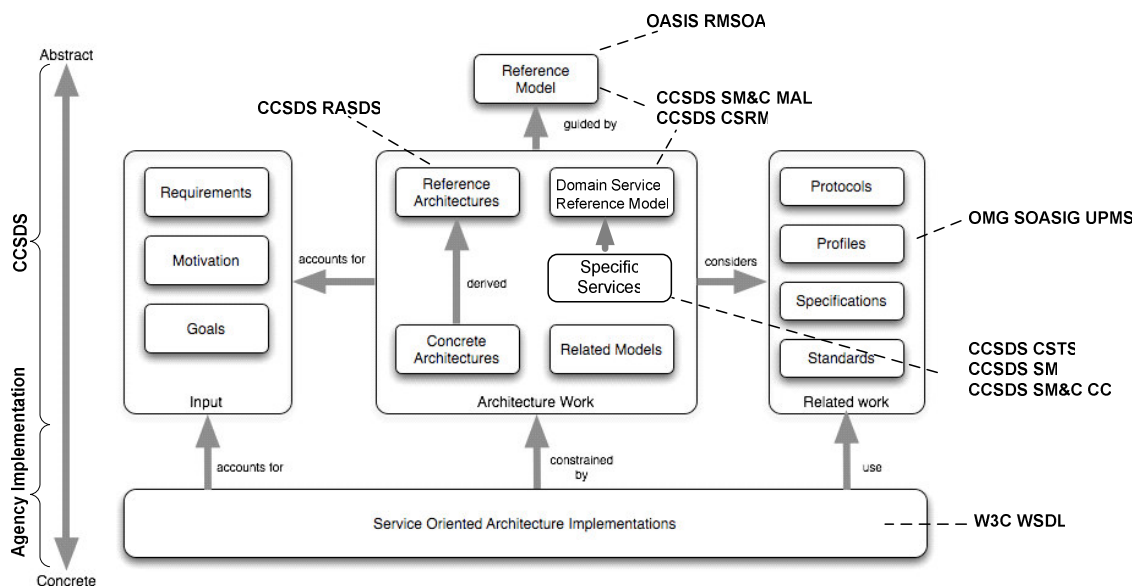


Figure 3-2; Overview

The three community standards, W3C WSDL, OASIS RMSOA and OMG SOASIG UMPS are not in contradiction, even though terminology differs.

OASIS RMSOA defines a reference architecture for service oriented architectures. The reference architecture is not technology dependent, and do not specify how services are defined, only what a specification should contain.

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OMG SOASIG UMPS among other aims at defining a technology independent format for specifying services.

W3C WSDL is a specific format for specifying services. It meets part of the RMSOA requirements, but do not cover the service semantics as required within RMSOA.

The SM&C service reference model used as specified within the Message Abstraction Layer (MAL) [SM&C-MAL] is simple, and follows common concepts from the community. It is in line with the OASIS RMSOA and can be mapped to WSDL. It is expected that the OMG SOASIG UML service profile can be used to model MAL concepts.

The cross support reference model is similar in scope with OASIS RMSOA, i.e. it defines a reference model for a service oriented system, without defining how services are to be defined. The cross support service model is focused at the specific problem of cross support data transfer between two entities related to a space link extension, and is therefore less general.

The SM concepts are very similar to the SM&C concepts. Harmonization of the two would be a minimum of effort.

The CSTS concept of procedures deviates heavily from the concepts of all other specifications, and the service concepts therefore also deviates.

Within most other service concepts, the service operations are offered by the service provider, and choreographed by the consumer. The service may expect operations to be invoked in a specific order, and will response with error or warnings if operations are invoked in the wrong order. However the responsibility of the correct invocation order lies on the consumer. The order may be defined by a user scenario, defined separately from the formal specification. Users who want to use the service in a slightly different scenario can do this without changing the actual service specification.

The concept of procedures strongly couples the operations of a service; an operation must within its invocation carry information relating it to a specific procedure, to allow the service to relate the operation with any previous or following operations. A consumer cannot choreograph the service himself, but must use the predefined chorography defined by the service procedures. In other words; the consumer can only start an already existing procedure.

4 VISION

The aim of the harmonization of CCSDS service concepts is to ensure that each CCSDS group can focus on defining the semantics of the concrete service, not on defining service concepts, and to ensure consistency in the specifications.

4.1 Overview

The figure below illustrates the envisioned process.

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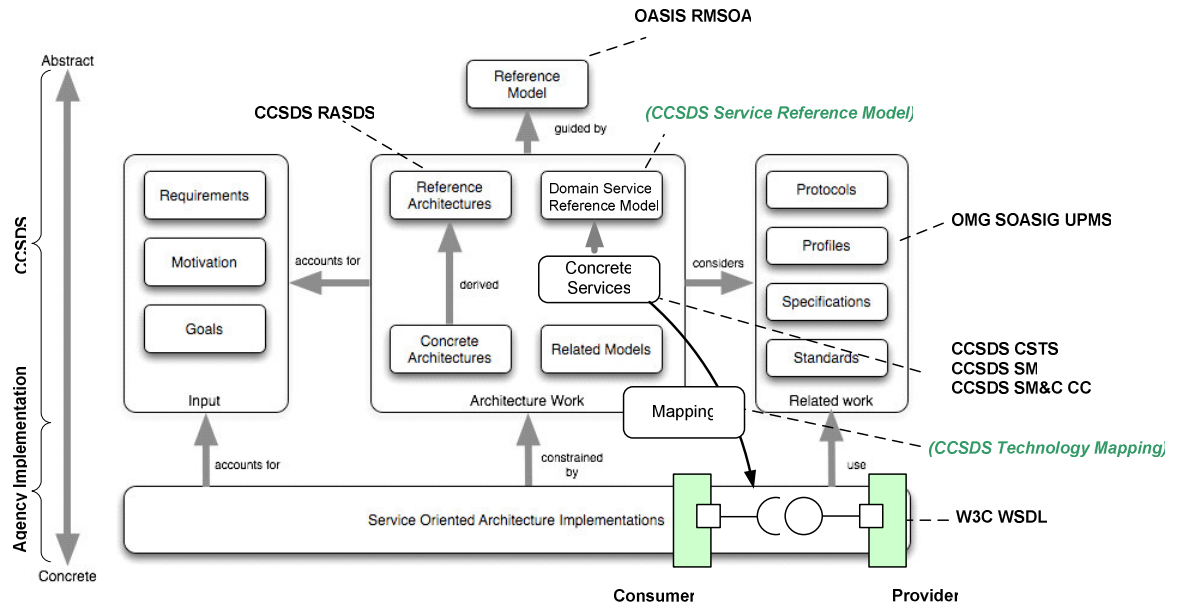


Figure 4-1; Structure of Standards

At the highest level of abstraction, a reference model exist. The reference model could be the OASIS RMSOA. The reference model defines the service concepts in general terms, without defining any specific characteristics of services. Defining the reference model based on a community standard aligns the space domain with the rest of industry.

The CCSDS Service Reference Model is an instantiation of the reference model for the space data system domain. The CCSDS service reference model defines a set of specific building blocks such as basic types, abstract messages and exchange patterns.

Based on the CCSDS service reference model, concrete services are specified.

The CCSDS Service Reference Model and the concrete services are defined using a combination of textual description, and formal notation such as the OMG SOASIG UMPs. Basing the formal notation on an open standard ensures that community tools developed to support the standard can be used within the space domain.

Based on formal technology mappings, the specific services are mapped to a specific technology platform, i.e. the interfaces of the service are created for the specific technology.

The services are thereafter implemented.

In the following sections, the envisioned process of specification and implementation is described in further details.

4.2 Specification Process

The specification process covers the work done within CCSDS.

The basis for a harmonization of service concepts is a complete service reference architecture provide the terms, concepts and building blocks to be used to define services.

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The CCSDS service reference model is expected to cover

- Basic data types. Specification of the basic data types used, defined in a technology independent manner.
- Message content. The messages carried by the service operations, defined based on the data types.
- Message exchange sequences. The sequences messages are exchanged as part of one operation.

For readability the concepts should be defined textually. To ensure consistency and support automation in the implementation of the standard, the building blocks should also be defined in a formal, machine readable way, such as the OMG SOASIG UMPS.

The reference model must remain technology independent, and make no assumptions on the architecture of the systems providing the services and the technologies used to exchange the messages.

Groups defining data types, such as time formats, provide a specification of the types in the format of the reference models formal specification. This allows the creation of a formal information model, which can be used as part of the specific service recommendations. This could for example be the CCSDS time [C-TIME] recommendation which provide time types. The information model is based on the basic types from the CCSDS service reference model, and extended within each recommendation with additional types.

Groups defining a service between entities uses the building block of the reference model to specify the specific service. In addition the data types of other recommendations can be used, and/or new types defined.

Groups defining concepts affecting all services, such as service level security, focus on how the concepts are integrated into the service reference model. This could for example be the specification of security fields in the abstract messages and the associated behaviour.

The usage of a common service reference model ensures that the recommendations of all groups is harmonized and mutually supportive. Combined the recommendations will define a consistent information model and set of services. As the specifications are based on a formal notation, automated consistency checks can be created and used to validate the specifications. For example could the Object Constraint Language (OCL) be used to validate formal models based on the OMG SOASIG UMPS.

The technology mapping is done based on the CCSDS service reference model. The mapping defines the translation of the basic types into constructs in the specific technology. The recommendations can be reused across recommendations, as the mapping is based on the shared CCSDS service reference model. This would allow for example CSTS recommendations to be mapped into WSDL.

4.3 Implementation Process

The implementation process covers the work done as part of the prototype activities, as well as following the formal approval of a CCSDS recommendation.

The service specification is mapped to different technologies based on the standard technology mappings. The mapping can be manual, or tool chains can be used. The output is the interfaces of the entities in the service exchange, including the message types encoded based on the selected technology.

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It can be envisioned to build standard message layers based on the service reference model, to manage the protocols based on the service reference architecture. This would simplify the protocol management of the service.

Cross service concepts such as service level security can be implemented once and re-used across specific service implementations.

The development is reduced to the implementation of the service specific processing.

5 ROADMAP

The following steps must be taken to implement the vision of harmonization of the service concepts within CCSDS as described in section 4

1. Define or select a service reference model. The reference model must define the general service concepts, such as service discovery, service access and actors providing and using the services.
2. Create a domain service reference model, as a refinement of the service reference model. The domain specific model specifies how the service reference model is applied to the space domain.
3. Define a formal approach for specifying services. This among others includes
 - a. Selection of a formal method such as an UML profile.
 - b. Creation of a technology independent information model, allowing messages content to be defined in a generic manner.
 - c. Definition of a set of message exchange patterns, defining the commonly used message exchange sequences.
4. Define the application of Quality of Service attributes which should be managed in a consistent manner across services. This covers attributes such as
 - a. Security.
 - b. Performance.
 - c. Latency.
5. Create a categorisation schema and a service catalogue showing the coverage of the services within a complete space data system.
6. Migrate existing services to the new approach.

6 RECOMMENDATIONS

This section provides a set of recommendations on how to implement the roadmap described in section 5.

The concept of service is used many places within CCSDS, yet no common definition exist. This shift part of the focus of each group working with service concepts away from the specific problems at hand, and into the specification of the reference models.

It is recommended to harmonize the service concepts within CCSDS.

Service concepts have been developed and used within a wide community. Solutions have been developed to most commonly encountered problems. The concepts have been refined based on experience from a wide set of domain.

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Using community concepts ensures that as much of the experience is leveraged as possible, and opens for the possibility of reusing and integrating technologies from non Space Data Systems.

It is recommended to reuse the community service concepts where possible.

The RMSOA is considered an excellent service reference model. It can readily be adopted for space data systems. It also covers the service attributes such as QoS and security in general terms.

It is recommended to use the RMSOA as the baseline for the service reference model.

The Cross Support Reference Model described in section 3.4 and the SM&C MAL described in section 3.7 are examples of domain specific service models. The concepts should be harmonized, based on the defined service reference model.

The SM&C MAL is closely aligned with the existing community service concepts.

It is recommended to harmonize the existing space domain reference models. It is recommended to base the harmonization of the SM&C MAL.

It must be evaluated whether the SM&C MAL can support the other CCSDS service specifications.

The effort of OMG to define a UML modelling profile is expected to become the de facto standard for formal service specification. It is expected that tools will be developed based on the profile. The profile is in development and can therefore not yet be evaluated.

It is recommended to monitor the OMG SOASIG UPMS effort, and evaluate whether the profile is suitable for CCSDS.

A common information model is the core of any attempt to harmonize across areas. A common model ensures that types from one area can readily be used within other areas, and removes duplication of work.

The SM&C MAL already provides part of an information model. The model is not formalized, and does not support the specification of exact types and order of attributes within message types. This would be required to support the automated generation of interfaces specifications.

It is recommended to create a core information model early in the harmonization process. It is recommended to base the information model on the SM&C MAL, but to formalize it further and extend it to support the exact specification of message layout.

The services are part of the functionality of a space data system. The services are provided by the components of a system. It is therefore possible to relate each service with one or more components within a system reference architecture. The reference architecture in this case provides a categorization scheme for the services.

A CCSDS reference architecture is being defined within RASDS. The RASDS is based on the ISO Reference Model for Open Distributed Processing (RMODP) standard (not described in this note as it is an architecture reference model). RMODP among others define a consistent set of functions/services which distributed systems requires, among other to support security.

It is recommended to base the categorization scheme and service catalogue on standard reference architectures such as ISO RMODP.

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