DGIWG – 306

DGIWG Service Architecture

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i. Preface

The structure of this document is based on the RM-ODP reference model.

ii. Submitting organizations

Sweden: Lars Schylberg

France: Cyril Minoux

iii. Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

Person	Company	Phone	Email
Lars Schylberg (LS)	Geo.SE, (SAAB)	+46858084087	lars.schylberg@saabgroup.com
Cyril Minoux (CM)	France Ministry of Defense, Délégation Générale pour l'Armement DGA/DET/CEP/ASC/EN	+33 1 46 19 60 55	cyril.minoux@dga.defense.gouv.fr

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v. Future work

Future work may include addressing some requirements that are not addressed in the scope of this technical report.

Executive summary

In the context of network-centric operations, as well as initiatives like NATO CoreGIS or the INSPIRE European directive, DGIWG member nations are in the process of setting up their own spatial data infrastructures. These nations will soon provide their operational units with services (catalogues, data access services and processing services), provided as Core Geospatial Services on national wide-area networks, and will eventually end up on both strategic and tactical Command and Control Systems.

Once nations are provided with services, and if they make the effort of solving network connectivity and security issues on specific deployments for some multi-lateral operations, they will expect the geospatial component of their information system to interoperate seamlessly and not be the bottleneck of their operational interoperability.

To achieve this, the interface and behaviour of various services will need to be specified. Many of the services are already specified by ISO/TC 211 and OGC, and DGIWG are providing military implementation profiles/documents to be able to include them efficiently in a military environment. A preliminary step is to ensure that nations willing to interoperate share a common vision of distributed spatial data infrastructure and break down high-level functional requirements into the same services decomposition. To facilitate this is the purpose of this document.

Acknowledgement

The reference model and diagrams of the information and computational viewpoints are issued from work on geospatial services funded by the French Ministry of Defence through the ENVOL research and technology program.

1 Introduction

1.1 Scope

This document is a reference model for geospatial service oriented architectures ensuring a common vision of components and their interactions.

1.2 Structure

The document is structured on the five viewpoints of RM-ODP – Enterprise, Information, Computational, Engineering, and Technology – which is the reference model used by DGIWG and by other bodies such as OGC and the EC ORCHESTRA Project.

1.3 Delimitation

This report only deals with geospatial business, and does not address network security at a military level, which is handled by other experts in charge of the information security business.

1.4 Intended audience

Other groups within DGIWG Technical Panels and system architects within nations that are defining and designing geospatial services and spatial data infrastructures for C3I systems or other defence purposes.

2 References

[1] Unified Modelling Language (UML), version 2.0, http://www.uml.org/#UML2.0

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[14] OASIS/ebXML Registry Services Specification v2.5

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[23] 06-083r8, Web Coverage Service (WCS) Implementation Specification, Version 1.1.0

[24] OGC 05-035r2, Gazetteer Service - Application Profile of the Web Feature Service Implementation Specification, Version 0.9.3

[25] Mani, A. and Nagarajan, A. 2002, Understanding quality of service for Web Services. IBM. 02 Jan 2002. http://www-128.ibm.com/developerworks/webservices/library/ws-quality.html

[26] AMEC, 2006 WFS Considerations for CGDI Government Partners v1.0, http://www.geoconnections.org/developersCorner/devCorner_devNetwork/keyDocs/WFS_Considerations_for_CGDI_Government_Partners_v1.0.pdf

3 Terms, definitions and abbreviations

3.1 Abbreviations

Frequently used abbreviated terms:

CoI	Community of Interest
CRS	Coordinate Reference System
DCP	Distributed Computing Platform
DIGEST	The Digital Geographic Information Exchange Standard (from DGIWG)
DGIWG	Defence Geospatial Information Working Group
GeoDRM	Geospatial Digital Rights Management Reference Model
GeoRSS	Geographically Encoded Objects for RSS feeds
GeoTIFF	Tagged Image File Format (TIFF) with georeferencing
GML	Geography Markup Language
HTTP	Hypertext Transfer Protocol
IA	Information Assurance
ISO	International Organization for Standardization
KVP	Keyword Value Pair
MOM	Message Oriented Middleware
NCW	Network-Centric Warfare
NEC	Network Enabled Capability
NNEC	NATO Network Enabled Capability
OGC	Open GIS Consortium, also referred to as OpenGIS®
OWS	OGC Web Services
QoS	Quality of Service
RM-ODP	Reference Model of Open Distributed Processing

RSS	Really Simple Syndication
SITP	Services and Interfaces Technical Panel
SMC	Service Management and Control
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
UDDI	Universal Description, Discovery and Integration
UML	Unified Modelling Language
WCS	Web Coverage Service
WFS	Web Feature Service
WG	Working Group
WMS	Web Map Service
WSDL	Web Service Definition Language
XML	Extensible Markup Language

3.2 Conventions

3.2.1 UML notation

UML notation is used in accordance with Unified Modelling Language (UML), version 2.0 [1].

4 Enterprise Viewpoint

The Enterprise Viewpoint defines the purpose, scope and polices of the system and its environment.

4.1 Objectives

In the context of network-centric operations, setting up national spatial data infrastructures addresses the requirement to have every relevant operational user (such as producers, end-users or managers) work together in a collaborative environment with a common environmental assessment.

Member nations participating in the Services and Interfaces Technical Panel (SITP) are in process of setting up their own service oriented architectures for dissemination and access to geospatial information. These nations will provide their operational units with services (such as catalogues, data access services, or processing services)

Geospatial information is currently shared between nations or users as datasets an may use data exchange standards like GeoTIFF or DIGEST for that purpose. When moving from data-oriented systems towards service-oriented architectures, it is of interest for the participating nations to enable services to be plug and play (abstraction made from the transport layer connectivity which is out of scope of the geospatial business and of this document for that precise reason).

To achieve service level interoperability, the interface and behaviour of these services (among them S05 "Data Access Service", S07 "Catalogue Service", S09 "Gazetteer Service") need to be specified. ISO/TC 211 and OGC are the main sources for these specifications, and it is SITP that makes military profiles or implementation documents.

The purpose of this document is twofold:

- to ensure that DGIWG nations, willing to interoperate, have a common vision of distributed spatial data infrastructure and break down the high-level functional requirements into a service decomposition which reflects the functional requirements to ensure a flexible and dynamic system architecture. As such it also helps to identify and prioritize the components that are needed to enable geospatial information interoperability at a service level – (Refer to the "roadmap" in Figure 15) ;
- to define the roles of SITP project teams regarding their relation to other components, enabling them to establish an enterprise viewpoint and assisting to define their scope boundaries[1].

4.2 Use Cases

Use cases for geospatial data infrastructure include the set up of:

- Core Geospatial Services on national wide-area-networks ;
- Core Geospatial Services deployed on strategic networks to work within or in conjunction with Strategic Command and Control Systems ;
- Core Geospatial Services in deployed network (with good bandwidth) ;
- Core Geospatial Services deployed on tactical networks to work within or in conjunction with Tactical Command and Control Systems ;
- Specific deployments for interoperability trials ;
- Specific deployments for multilateral operations (i.e NATO, EU, UN, or other coalitions).

Once nations are provided with services, they will be willing to interoperate as soon as they have solved network connectivity, security and disclosure policy issues. They will require the geospatial component of their information system to interoperate seamlessly.

5 Information Viewpoint

The information viewpoint is concerned with the semantics of information and information processing. An information specification of a Reference Model of Open Distributed Processing (RM-ODP) system is a model of both the information that it holds, and of the information processing that it carries out.

Each particular service will need to define its syntactical interfaces through operations and its semantics through description of the meaning of the operations and their legal sequencing. This section contains a description of various services. There exist multiple

[1] eg : should the catalogue service deal with both data and services, or should services be catalogued through a separate registry (e.g. using UDDI) ?

possible taxonomies for services, based on various classification dimensions. The one that is used here is based on the extended Open System Environment (OSE) model. The basis of the information viewpoint is the more general OSE model [ISO/IEC TR 14252].

5.1 A Geospatial Web Service: description and reference model

A **web service** is a software component that provides a number of functionalities to its network environment. From a terminology perspective functions proposed by a web service are called **operations**. An operation is an individual function provided by a service. It receives input parameters (the request) and produces a response containing a set of output parameters. **This constitutes its "provider" interface.**

In a distributed environment hosting various resources of all kinds, web services may need to use other resources available from the distributed platform in order to perform the requested functions. For example a coordinate conversion service may need to get geodetic parameters from a centralized registry service, or a service producing animations such as mpeg may need to rely on some video-encoding backend. Given this fact, a service may not only interact with client applications but also interact as a client to other services or resources.

As a consequence a web service could be described on an abstract level as a component with two interfaces: a "provider" interface and a "consumer" interface. Exceptions from this general rule will occur i.e. services not relying on other services will only require a provider interface.

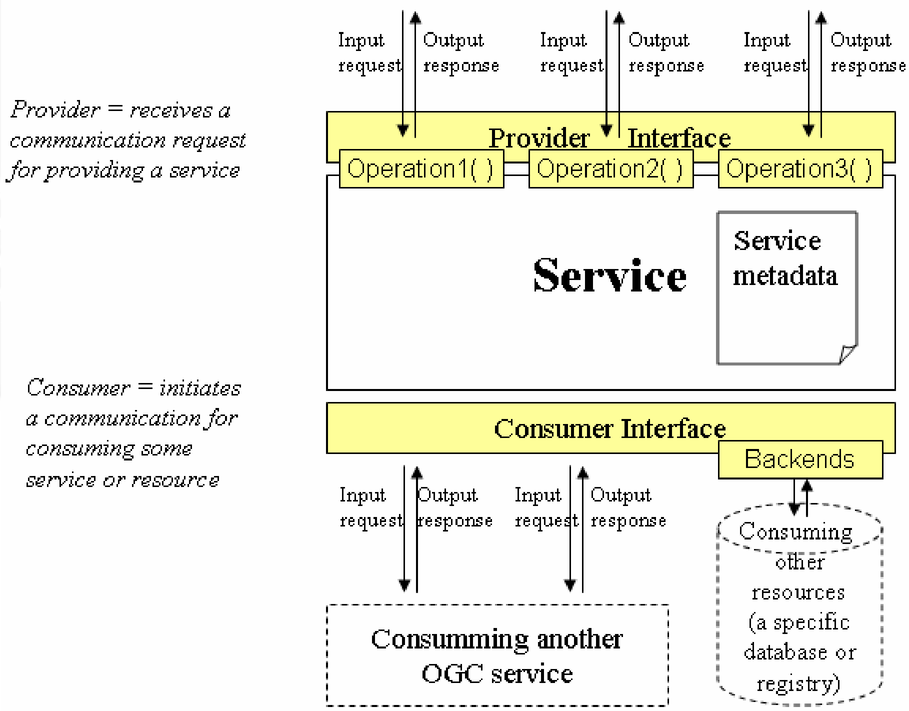

Figure 1 Reference model for a geospatial web service.

Finally, in dynamic discovery environments, it is usually necessary to associate relevant information to the service, in order to describe the features it implements, especially when optional features or behaviour are allowed. **These constitute the service metadata**. Example and use cases include: what version of a given specification is implemented in order to support version negotiation; or what coordinate reference systems are supported by a data access service.

5.1.1 Guidelines for web services specifications

From the above analysis, we can identify a few points that need to be addressed by a geospatial web service specification.

1. **The set of operations** provided by the service must be specified ;
2. for each of these operations:
    a. **the request's and the response's parameters** must be specified. These specifications must cover both encoding format and semantics. More specifically: name of each parameter, definition in natural language, cardinality, type, value domain, encoding specification.
    b. **the service's behaviour** with respect to the input parameters and the current state of the exchange between the client and the server must be specified. More specifically : what are the pre-conditions and the post-conditions given some of the input parameters' values
3. **the relevant metadata elements** must be specified in order to describe the service's support on all features that are subject to implementations' variability. For example if there is no mandatory input format specified in the specification, then the supported input formats must be advertised as a service metadata ;
4. while the three previous points address the "provider interface", one must check for any needs of **specifying the "consumer" interface of the service.** If so, it is necessary to define the set of services or resources it is supposed to make use of, and the corresponding interaction sequence (behaviour). The same kind of work has to be performed as for task 1. and 2. (which were dealing with the "provider" interface) : semantics, encoding, behaviour.

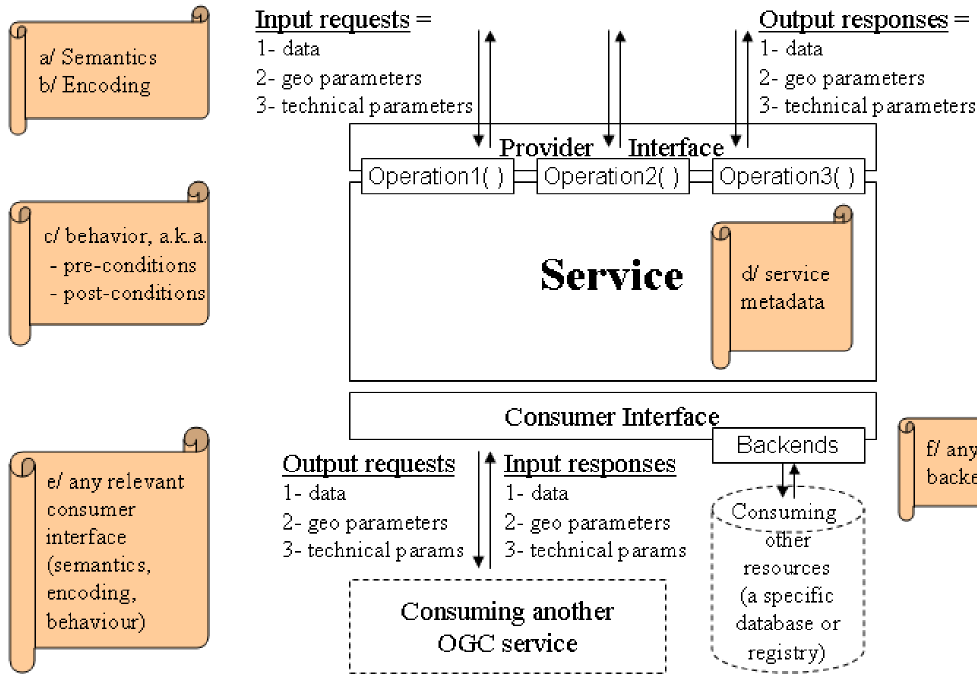

Figure 2 Content of a geospatial web services specification

When using XML messaging, specifications of the request and the response parameters will usually involve XML-Schema. However, this is not sufficient for most of the aspects of the request and the response specification (bullet 2.a above), and tables and natural language on semantics as well as behaviour specifications must be included along with the XML-Schema.

Although WSDL can be used in order to further formalize the aspects of the web services' specification not covered by XML-Schema, specifically behaviour, it is complex enough to require a natural language specification before formalization. It remains of value for web service compliance testing, semantic interoperability, or service chaining.

5.1.2 Guidelines for implementation profiles of a web service

The web services specification may identify a set of possible features that do not all have to be implemented (i.e. Optional), because it may depend on the type of resources that have to be managed by the service, or on the deployment context.

When setting up an interoperability program within a Community of Interest (CoI), organizations have to agree on:

- the set of the features that are optional in the base specification and that the CoI needs to turn as mandatory in the profile ;
- the type of data/information they want to have published through or the characteristics of the processes they want processing services to perform ;
- how this publication needs to be organized or presented ;
- the various parameters of quality of service based on-
  1/ standard IT QoS concepts (see chapter 6.3)

2/ geospatial quality considerations including quality of data, precision of coordinate transformations, reliability of a line-of-sight computation, etc.

Using these parameters, a Service Level Agreement applicable to the members of a geospatial community can be reached.

Finally, in the context of military networks, implementation profiles should account for potentially limited networks in terms of bandwidth or connectivity, and make technical choices accordingly. For example, data access services (§ 6.5) could provide parameters to choose the image format or even tune the compression level (bandwidth issues), while processing services (§ 6.4) could be implemented for generating datasets for offline transfer (connectivity issues). This is however only a reminder for any implementation profile project pertaining to geospatial web services in a military environment, and can't be addressed by this document, as technical choices on that respect highly depend on each service's functionalities.

5.2 Service Metadata

Following the recommendation of ISO 19119 UML metadata model, service metadata must contain the following information [13]:

- the service type should be stated using the relevant OGC acronym (e.g. WMS, WFS, WCS) ;
- all versions implemented by the service and matching DGIWG's nations requirements must be declared ; this makes the service Type Version element of ISO 19119 service metadata model mandatory ;
- "Access Properties" and "restrictions" metadata elements as appropriate for a Community of Interest ; the "restrictions" element may be used to convey security classification metadata ;
- each operation supported must be declared using its name ;
- no other elements than those defined in the bullet points above are mandatory ;
- a Point of Contact responsible for the maintenance of the service must be provided ;
- information of compliance to a DGIWG metadata profile.

5.3 Quality of service / Service Level Agreement support

Interoperability in the realm of web services will require mandating to match some minimal performance requirements, for example in terms of responsiveness or availability.

The following criteria are commonly used in the general IT community [25]

Criteria	Definition
Availability	Availability is the quality aspect of whether the Web service is present or ready for immediate use. Availability represents the probability that a service is available. Larger values represent that the service is always ready to use while smaller values indicate unpredictability of whether the service will be available at a particular time.
Accessibility	Accessibility is the quality aspect of a service that represents the degree it is capable of serving a Web service request. It may be expressed as a probability measure denoting the success rate or chance of a successful service instantiation at a point in time. There could be situations when a Web service is available but not accessible. High accessibility of Web services can be achieved by building highly scalable systems. *Scalability* refers to the ability to consistently serve the requests despite variations in the volume of requests.
Integrity	Integrity is the quality aspect of how the Web service maintains the correctness of the interaction in respect to the source. Proper execution of Web service transactions will provide the correctness of interaction. A *transaction* refers to a sequence of activities to be treated as a single unit of work. All the activities have to be completed to make the transaction successful. When a transaction does not complete, all the changes made are rolled back.
Performance	Performance is the quality aspect of Web service, which is measured in terms of throughput and latency. Higher throughput and lower latency values represent good performance of a Web service. *Throughput* represents the number of Web service requests served at a given time period. *Latency* is the round-trip time between sending a request and receiving the response.
Reliability	Reliability is the quality aspect of a Web service that represents the degree of being capable of maintaining the service and service quality. The number of failures per month or year represents a measure of reliability of a Web service. In another sense, reliability refers to the assured and ordered delivery for messages being sent and received by service requestors and service providers.
Regulatory	Regulatory is the quality aspect of the Web service in conformance with the rules, the law, compliance with standards, and the established service level agreement. Web services use a lot of standards such as SOAP, UDDI, and WSDL. Strict adherence to correct versions of standards (for example, SOAP version 1.2) by service providers is necessary for proper invocation of Web services by service requestors.
Security	Security is the quality aspect of the Web service of providing confidentiality and non-repudiation by authenticating the parties involved, encrypting messages, and providing access control. Security has added importance because Web service invocation occurs over the public Internet. The service provider can have different approaches and levels of providing security depending on the service requestor.

Table 1 : Commonly used Quality of Service criteria.

As network and information security is out of scope of this document, and considering the available elements identified by the ISO 19119 service metadata model, we suggest restricting the scope of quality of service criteria to the following set.

Security and integrity quality of service metadata are likely to be imposed by the network / information security community when integrating geospatial web services into command and control systems networks.

Quality of service criteria	Corresponding ISO 19119 metadata element	Guidelines
Availability	_	Natural language specification, not included in service metadata. It needs to be specified in any application profile.
Accessibility	accessProperties restrictions	to be specified and / or superseded by a SITP project about Access Rights Management
Performance	_	Natural language specification, not included in service metadata. It needs to be specified in any application profile in terms of responsiveness of the software itself (abstraction made from the network connection)
Reliability	point of contact information	
Regulatory	serviceType serviceTypeVersion	This does not allow however to express compliance with a specific DGIWG profile

Table 2 : guidelines for specifying Quality of Service for a geospatial web service

Once a Service Level Agreement has been established for a particular deployment, it is the responsibility of the implementation to match the expected Quality of Service.

6 Computational Viewpoint

This paragraph provides a decomposition of service-oriented geospatial data infrastructures into functional components. Annex A provides a “proof-of-concept” of this decomposition by mapping it to the taxonomy that can be found in the ISO 19119 "Services Architecture" standard. One of the benefits of the following diagrams over a taxonomy is their ability to depict the interactions and dependencies between these functional components: it is important when working on one of these components to be aware of its context.

6.1 Architecture overview

Geospatial information systems have to deal with two information domains:

- **Quasi-static information domain**: products that are produced or updated in a rather slow process (~ daily, monthly or yearly) are stored in persistent databases and are accessed by clients upon their request ;
- **Real-time information domain**: data coming out from sensors is sent to a set of subscribed users continuously or periodically.

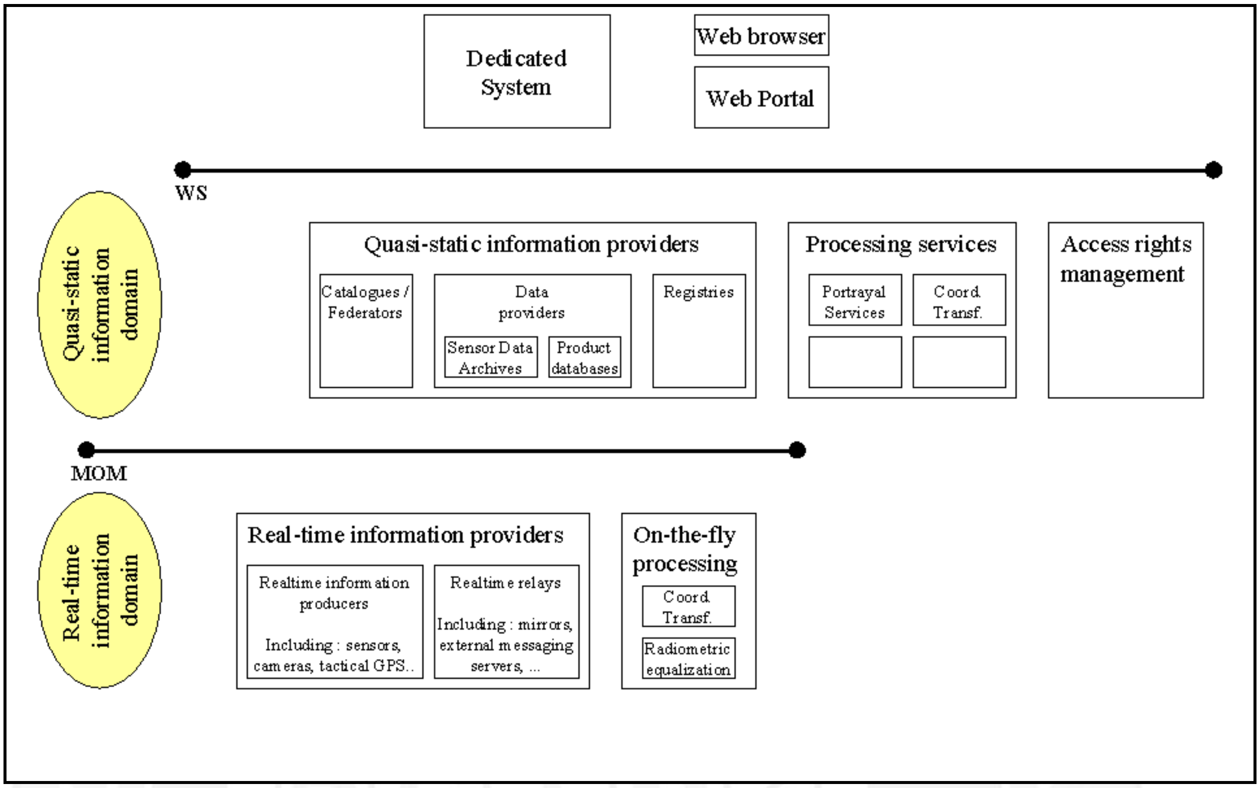

Figure 3 Components and subcomponents of a spatial data infrastructure

Within each domain, components can be grouped into families whenever their role regarding the overall system is technically similar in terms of inputs / outputs types. Simply put, we have services that provide information, services that process information and services that manage access rights.

Quasi-static information providers include:

- data providers ;
- catalogue providers ;
- registries.

Processing services include:

- coordinate transformation services ;
- portrayal services ;
- image processing services (such as radiometric equalization) ;
- any relevant computation service (such as line of sight or route computation).

Note that nothing prevents information providers from implementing some processing features behind their service interface. Example: Data access services may support several coordinate reference system (CRS) natively. This processing will however be seamless from a client perspective so they are not depicted in the diagram.

There is a key difference in terms of communication protocol between the two information domains depicted in Figure 3 Components and subcomponents of a spatial data infrastructure : in the ***quasi-static information*** domain, the end-user initiates the information transfer (the user sends a request and gets a response), while in the ***realtime information domain*** the data-provider initiates the information transfer (he basically sends a message).

For that reason, and even though communication-middleware are out of scope of this document which focuses on the geospatial application layers, we found relevant to depict the two types of communication middleware :

- a Web Service invocation middleware (typically web services over HTTP) – denoted « WS » in the following diagrams ;
- a Message Oriented Middleware – denoted « MOM » in the following diagrams.

In order to depict this difference, we use the following notations in the rest of this document:

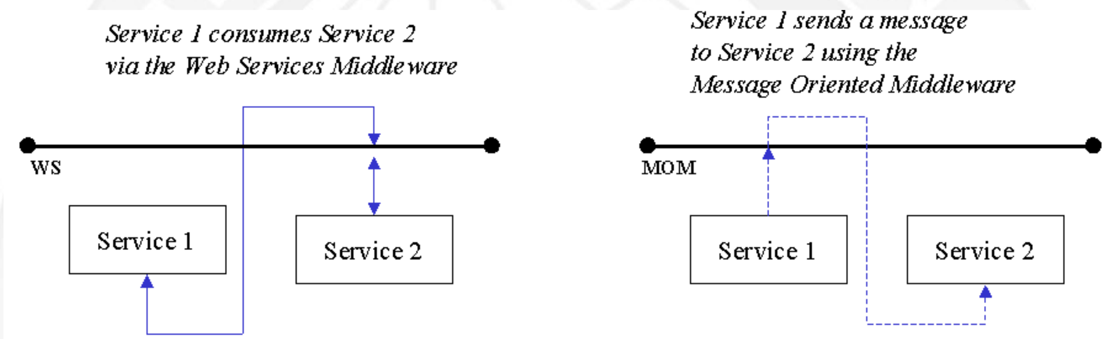

Figure 4 Notation of service communication with Web Services Middleware and Message Oriented Middleware.

6.2 End-user's view of the architecture

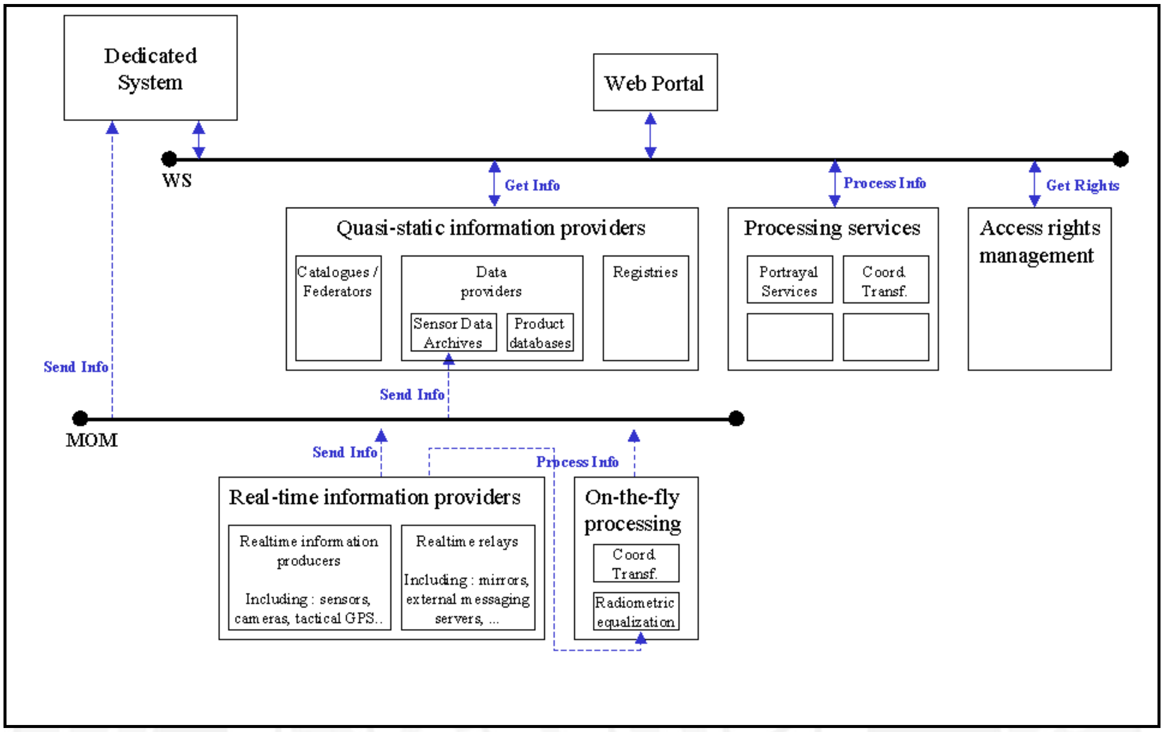

Figure 5 End user's view of the architecture

At this stage, we identify two categories of client applications: web portals and dedicated systems. Web portals may be accessed by a larger audience through web browser but may be limited by the capabilities of the browser interfaces. While client-side technologies have made huge steps forward, one can expect some limitations will remain in web-based application in comparison to dedicated applications. Clients may use any of the components published as services. However, it is likely that only dedicated systems will be able to make use of portrayal-rules and symbol-set registries in order to perform local portrayal of data retrieved as vector features.

In our diagram we intentionally depicted that direct streaming of real-time messages to clients' applications would only target dedicated systems. We could think of a use-case where the portal would host a facility for managing these real-time information streams and display the relevant ones on web-clients. In this case we consider in fact that this real-time information management facility is a sensor data archive hosted on the portal; indeed we prefer to keep both 'information management' and 'information presentation' components separated. In our diagram the portal is primarily responsible for presentation tasks.

While end-users will basically experience the architecture as depicted in Figure 5 End user's view of the architecture, only part of the interactions that occur between the components of the architecture are represented in this view. When building the architecture, it is necessary to have a view of any possible interactions for each component. The next paragraphs describe in greater detail the role of each component, as well as the possible interaction between the components.

6.3 Real-time information providers' view

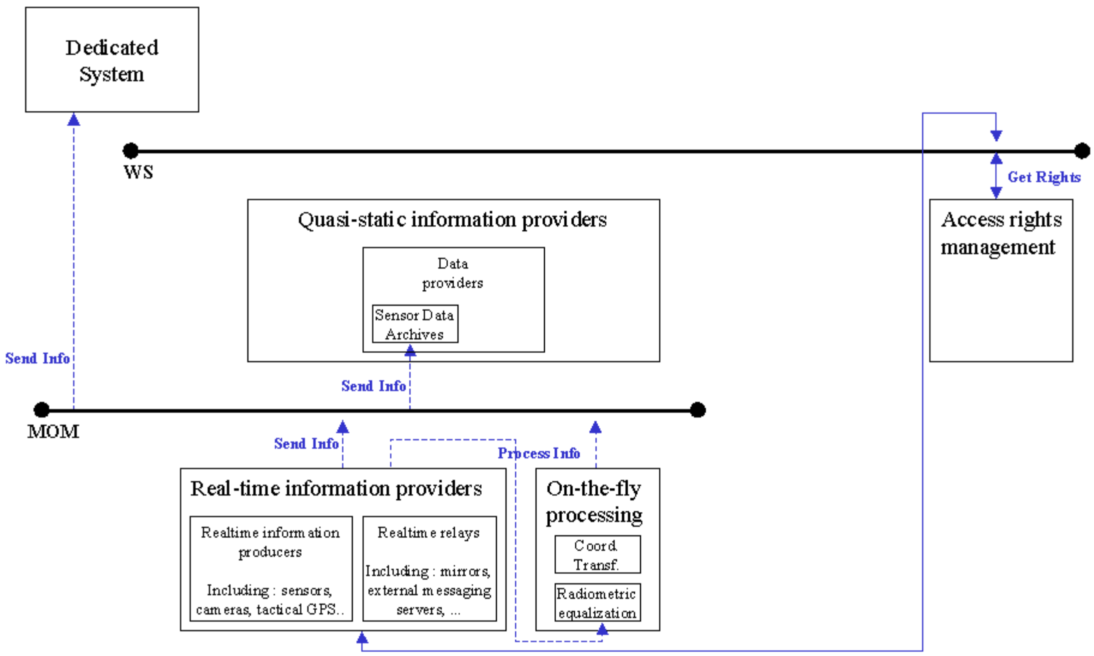

Figure 6 Real-time information providers interactions

Real-time information providers deliver real-time geospatial data. Examples include sensors, video-cameras, and embedded devices transmitting location of a vehicle to a set of command and control systems. This component also encompasses messaging servers when sensors outsource the task of dispatching the information to subscribed users (which is also a good idea to bundle with subscription management facilities).

These information messages are sent by the message oriented middleware either to dedicated client applications that make use of these messages in real-time, or to persistent archive databases of the quasi-static information domain, whenever it makes sense to archive or buffer this information (it is for example relevant to store real-time temperature or wind measures in order to build climatology databases).

Real-time streams can optionally go through on-the-fly processing steps in which case the message is redirected to processing services, which are the actual components which eventually dispatch the information to the clients. For example imagery equalization performed on the output of an image sensor could be necessary depending on the lightning conditions or on the sensor's own features.

The messaging server may use the access-rights management component in order to get the subscriber's privileges.

6.4 Processing services' view

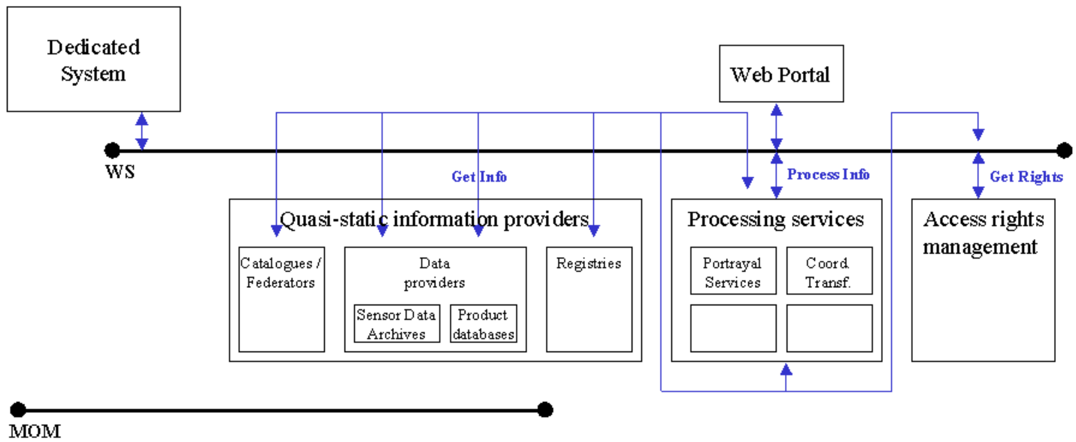

Figure 7 Processing services interactions

Processing services are defined as services taking data as input and outputting data (for example : result of a computation, transformation of the input data).

They also cover formatting services which can be used to generate datasets for offline transfer, which is useful in a military environment where one can encounter connectivity issues.

They may make use of almost any service available within the architecture, as demonstrated by the following use-cases.

- a line-of-sight computation may browse a data catalogue for selecting the most appropriate elevation data source (=> use of a data catalogue) and then use the corresponding WCS for accessing the data (=> use of a data access service) ;
- a coordinate transformation service may rely on its own geodetic codes and parameters database or make use of a centrally-managed registry containing authoritative values ;
- an image source may require both reprojection and equalization, resulting in chaining several processing services ;
- a processing service may want to check the client's profile before it is enacted, using the access rights management component.

6.5 Data access services' view

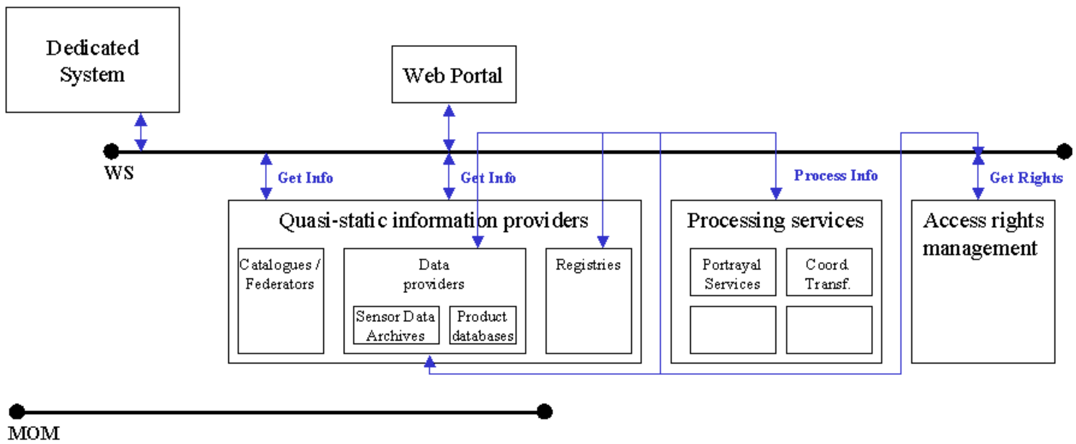

Figure 8 Data access services interactions

Data access services may use registries for example when they perform coordinate transformations seamlessly based on geodetic codes registries or when they render vector features using portrayal rules and symbol sets stored in a portrayal registry.

They may also delegate this kind of processing to software components embedded in external web services. For example, a given community may not enable access to its portrayal rules or symbols, but provide the service that renders features into a map in the appropriate way. This will be the case when portrayal rules involve proprietary algorithms that go beyond the use of database-storable portrayal rules.

Data access services may also want to check whether the user profile conveys the appropriate rights to access the information. At least a difference between end-user and geo-managers is likely to be involved in a spatial data infrastructure, they will then both have a different view of the available resources.

Finally, some data access services may be cascaded, for example when it is used to merge layers coming from various other data access services, or provide additional options like Coordinate Reference System (CRS) or styles.

6.6 Catalogue services' view

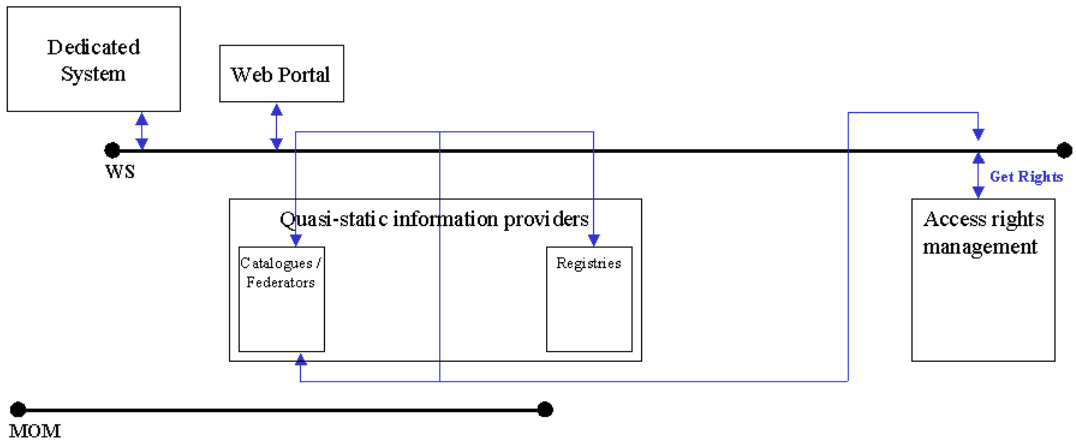

Figure 9 Catalogue services interactions

Catalogues may be federated, which means catalogue services may be enabled to propagate the query of a client to the other catalogues of its network environment, retrieve their results, and merge them with its own results. For that reason, catalogues may request other catalogues.

Catalogues provide access to sets of metadata. The latest metadata standards such as ISO 19115 make use of well-defined code lists (e.g. for security classification constraints, or themes present in a map - whether it is vegetation, transportation, …) which may be maintained in registries which may in turn be made available online through registry services.

Once again, access right management services will be involved when different user profiles need to be managed. For example, producer or managers may retrieve the full list of resources present on the network, while users of data may be restricted to access to a consistent subset of these resources.

7 Engineering Viewpoint

The engineering viewpoint focuses on mechanisms for distribution of services across networks. The approach of ISO 19119 is to distribute services using a multi-tier architecture model. To support flexible deployment, IT architectures are structured as multi-tiered distributed architectures.

The most commonly used multi-tier models today are three or four layers. Figure 10 shows an example of a typical three layers architecture with a client application, a web server with the WMS service and a database server serving the data.

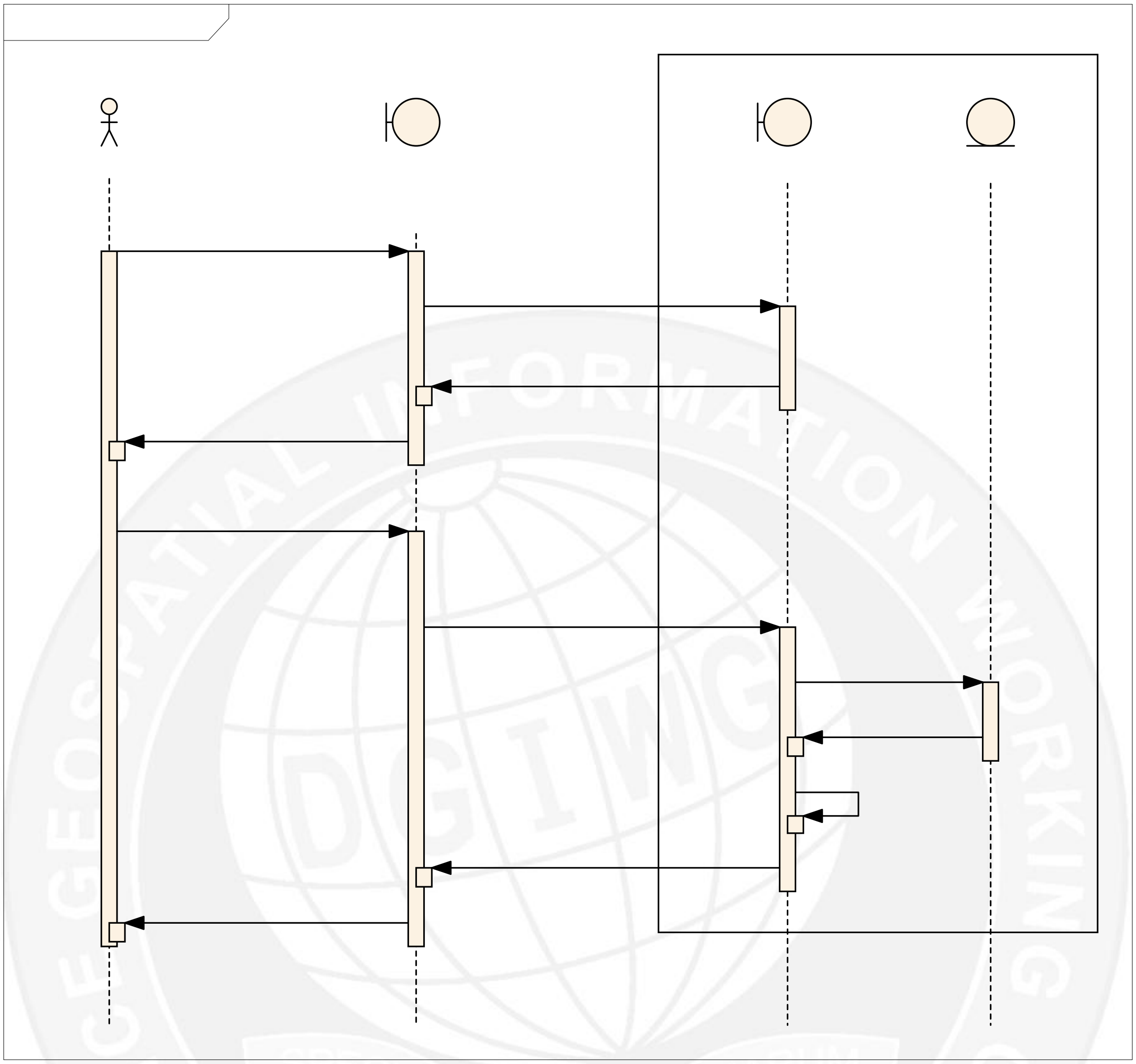

Figure 10 An interaction diagram showing a client application using a WMS service in a typical three layer architecture with client, web server with the WMS service and data served from a database server. This figure has been modified from the source [26].

7.1 Common engineering principles

Simple service architecture is defined by a set of simplifying assumptions that are relevant to implementing a message-based architecture to support service chaining, that is described in the next section. Systems compliant to this set of guidelines shall be referred to as instances of simple service architectures.

- Message-operations. The operations consist of a request and response pairs ;
- Separation of control and data. Operations of an interface separate the control of the service from the access to the data resulting from a service ;
- Stateful vs. stateless service. When possible service invocations are composed of a single request-response pair with no dependence on past or

future interactions, i.e. stateless service. It is the preferred choice, but this requires that any necessary states are held by the client software ;

- Known service type. All service instances are of specific service types and the client knows the type prior to runtime ;
- Adequate hardware. Hardware assignment is transparent to user.

7.2 Service Chaining

A very important mechanism to meet the needs of geographic uses is the combination of services to achieve results specific to a task. ISO 19119 enables this through service chaining. ISO 19119 enables users to combine data and services in ways that are not pre-defined by the data or service providers. This level of data/service interoperability will be achieved in stages. At first service catalogues will hold entries with tight data/service coupling. Eventually the infrastructure will be available for a user to determine which data can be acted on by a loosely coupled service. This capability will be enabled by the infrastructure of the larger domain of IT.

The simplest deployment case is that a client application accesses services directly and has to know about all services. This is shown in Figure 11. A sophisticated way is to chain services like WMS with its cascading capabilities. This is shown in Figure 12.

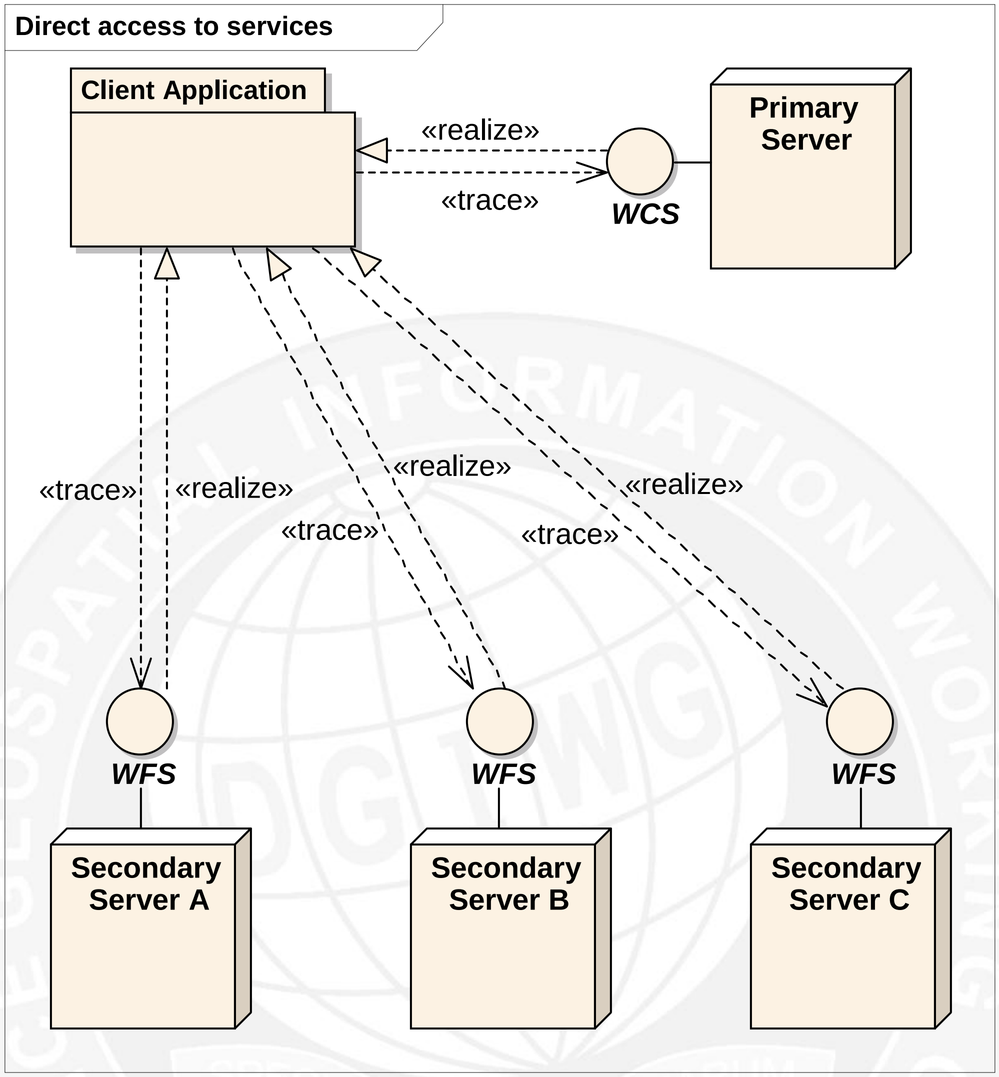

Figure 11 – Web Feature Service Interaction Diagram with direct access to each service.

A Service Chain is defined as a sequence of services where, for each adjacent pair of services, occurrence of the first action is necessary for the occurrence of the second action. The action of making the input of one service dependent upon another service leads to treating service chains as directed graphs, where each service is a node in the graph and references to service interactions form the edges. In some cases the directed graph structure is implicit. In other cases it is necessary to make the notion of a processing graph explicit and allow such graphs to be considered as entities in their own right. Explicit representation of a service chain allows the chain to be visually represented and passed to a chain execution service, e.g., workflow service

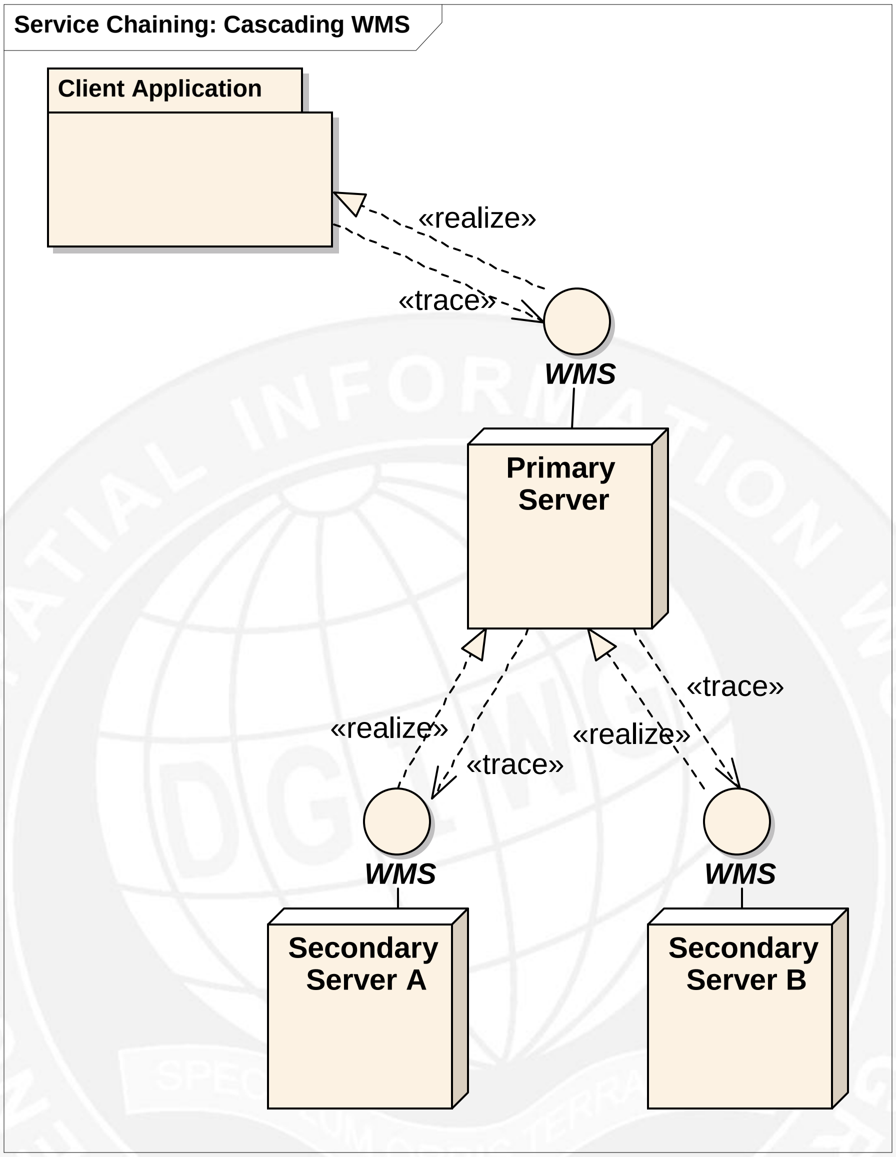

Figure 12 – Service chaining example with a cascading WMS service that uses two other WMS services.

There are many options for service chaining, e.g., is the chain explicit, how is the progress of the chain controlled? Different approaches reflect different priorities for different applications: user in the loop vs. user supervision. To demonstrate the breadth of the trade space defined by these variations, three architecture patterns are offered in ISO 19119:

- User defined (transparent) chaining where users can manage the workflow ;
- Workflow-managed (translucent) chaining where users may invoke a Workflow Management service that controls the chain and they are aware of the individual services;
- Aggregate service (opaque) where users may invoke a service that carries out the chain, with them remaining unaware of the individual services.

In addition to the difference in visibility of the services to the user, a key distinction between these patterns is the difference in control. In transparent chaining the control is exclusively with the user. In translucent, a workflow service is present which controls the chain execution, perhaps with oversight by the user. In the aggregate pattern, the aggregate service exclusively performs the control function with no visibility by the user.

The three chaining patterns discussed could be combined in a variety of ways. Each of the lowest level services could in turn implement a chain. This is recursive composition of services supported by the opaque pattern. A service chain can become a new service. The ability to define recursive composition of services provides scalability and support for top down progressive refinement as well as for bottom-up aggregation.

The patterns could be used to define how a library of chains is constructed. A knowledgeable user could build chains using the transparent pattern. Through iterative use of the transparent pattern a chain is constructed that produces valid results. Chains are then made available for wider use following the translucent pattern. Certain chains may become routinely used and an aggregate service is built as an interface.

An example need for a translucent or opaque chaining pattern occurs in decision support. The Decision-Maker is an individual using decision support aids to help make a decision. An example of decision support aids is a service chain. The Decision Support Aid Developer is an individual who integrates chains of services into decision support aids.

7.3 Service chaining and service metadata

So far we have discussed how to construct chains and not addressed if the results of a chain are semantically valid. It is assumed that human users will determine semantic validity of the results of a service chain. Several factors to consider in the semantic evaluation of a chain result are listed in ISO 19119.

- Appropriateness of starting data: are the based datasets suited to the subsequent processing? For example, accuracy and resolution of the data, as well as thematic values are relevant ;
- Affect of services on data: how do the individual services effect the data, e.g., error sources and propagation ;
- Sequence of the services: how does the order of the chain affect the results? For example, should a spatial operation, e.g., orthorectification, be performed before or after a thematic operation, e.g., resampling the attribute values?

To evaluate the fitness for use of a service in a specific context, users will review a description of the service. These service descriptions are also called service metadata.

Service metadata records can be managed and searched using a catalogue service as is done for dataset metadata. In order to provide a catalogue for discovering services, a schema for describing a service is needed. ISO 19119 defines a metadata model for service instances. In order to place the Service Metadata in context three types of entities need to be described:

- Service Instance: a service instance is the service itself, hosted on a specific set of hardware and accessible over a network ;
- Service Metadata: a service metadata record describes a service instance including a description of the services operations and an "address" to access the specific service instance ;
- Service Type: in some cases a service metadata record will describe a service instance which is of a "well known type". By well-known type, it is meant that the service conforms to a published definition of a service type, i.e., a platform-specific service specification. Some clients will be able access only services of well-known type. A user could search the service metadata catalogue to find instances of a specific well known service type. A service registry is defined to be the service that provides details on service types.

A service instance may be tightly-coupled with a dataset instance, or it may be un-associated with specific data instances, i.e. loosely-coupled. Loosely-coupled services may have an association with data types through the service type definition. In the tightly-coupled case, the service metadata shall describe both the service and the geographic dataset, the latter being defined in accordance with ISO 19115. For the loosely-coupled case, dataset metadata need not be provided in the service metadata.

The structure of service metadata includes three major classes: a section of basic service metadata that provides a general description of the service and sections that describe the operations and data available from a particular service.

7.4 Access Right Management with OGC GeoDRM

The OGC document OGC GeoDRM RM [15] defines a reference model for digital rights management (DRM) functionality for geospatial resources (GeoDRM). As such, it is connected to the general DRM market in that geospatial resources must be treated like other digital resources, such as music, text, or services. It is not OGCs intention to reinvent a market that already exists and is thriving, but to make sure that a larger market has access to geospatial resources through a mechanism that it understands and that is similar to the ones already in use.

The document OGC GeoDRM RM is not yet an OGC Standard. It is currently distributed for review and comments. It is in this context presented as one possible security model candidate for DGIWG.

7.4.1 Motivation

For the licensing of digital content, different standards already exist. However, the existing standards (e.g. MPEG-REL or ISO-REL, ISO 21000) describe the licensing of digital media content and cannot be used for licensing of geographic information unless they are extended. Therefore, this DRM Rights Model for geographic information is necessary and its relevance can be explained by examining its various aspects:

- First, the Rights Model for digital geographic content must accommodate licensing for different types of business relationships and participants with different roles ;
- Second, licensing in the GeoDRM domain must support the licensing of digital content, based on different infrastructures: licensing can take place for a

static product as it can be delivered on CD-ROM. However, even more important is the aspect that licensing can also take place on geographic information as it can be dynamically "created" by using OpenGIS Web Services ;

- Third, licensing of geographic information requires support to declare and enforce rights, as they are based on the geometry of the digital content.

7.4.2 Scope

The standard outlined in OGC GeoDRM RM [15] defines:

- A conceptual model for digital rights management of geospatial resources, providing a framework and reference for more detailed specification in this area ;

- A metadata model for the expression of rights that associate users to the acts that they can perform against a particular geospatial resource, and associated information used in the enforcement and granting of those rights, such as owner metadata, available rights and issuer of those rights ;

- Requirements that are placed on rights management systems for the enforcement of those rights. A rights management system must be necessary and sufficient: it must implement only those restrictions necessary to enforce the rights defined therein, and it must be sufficient to enforce those rights ;

- How this is to work conceptually in the larger DRM context to assure the ubiquity of geospatial resources in the general services market.

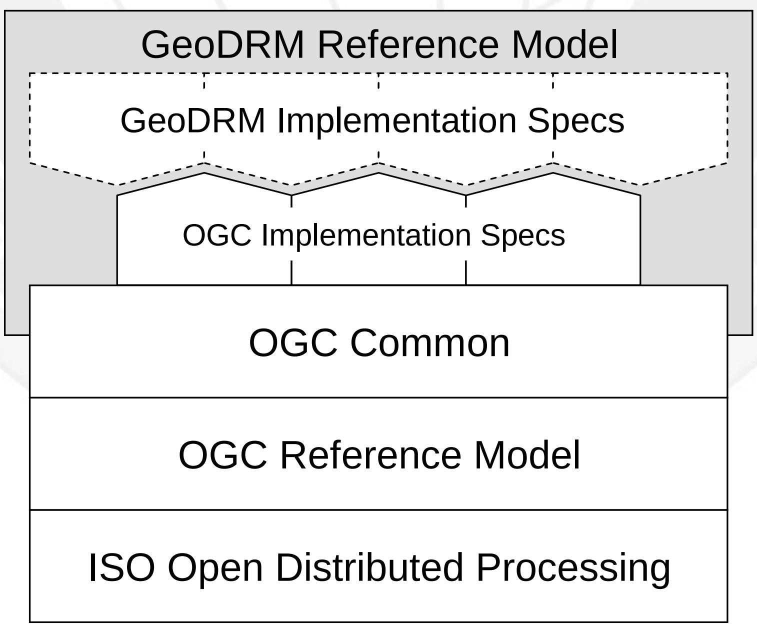

Figure 13 - GeoDRM Reference Model Context

Figure 13 - GeoDRM Reference Model Context shows a simplified view of how the Geospatial Digital Rights Management Reference Model (indicated in grey) relates to the ISO Open Distributed Processing standard, OGC Reference Model and OWS Common initiative. The purpose of the standard is to define the conceptual framework and rights model for the future GeoDRM Implementation Standards, which will enable the digital rights management of geospatial resources.

7.4.3 GeoDRM Roadmap

In order to support GeoDRM-enabled licensing of geographic information, as it can be available offline or online in a Spatial Data Infrastructure (SDI), different functionalities can be identified as necessary. The following list of possible packages is listed as part of the GeoDRM Roadmap:

- **Rights Model**: The definition of an abstract Rights Model is the topic of the specification. It defines the basis for developing a geo-specific Rights Expression Language as well as other specifications necessary to establish a GeoDRM- enabled SDI;
- **Rights Expression Language**: This package provides the capabilities to express usage rights in the form of a machine-readable and machine-processible representation. The definition of a geo-specific Rights Expression Language is not part of the specification, but is to be defined upon the Rights Model declared in the specification ;
- **Encryption**: This package includes required functionality to protect a GeoDRM- enabled SDI against fraud. First, encryption enables the protection of a licence so that it cannot be modified by an adversary in order to obtain additional rights. Second, encryption is also useful to protect the digital geographic content against unlicensed use. Because security and trust are not geo-specific, no standardization is planned by OGC ;
- **Trust**: Every type of business relationship that has been represented in an electronic way needs a mechanism to differentiate between reliable and unreliable partners. In that sense, trust tells a relying partner that the other behaves in a certain predictable (loyal) way. One mechanism to establish trust between entities in an SOA can be done by adding authenticity information on the digital content that is been exchanged between the partners. This mechanism, typically called a Digital Signature, is not geo-specific and therefore is not a relevant topic for standardization by OGC ;
- **Licence Verification**: This package defines the functionality that is required to validate a licence. The licence verification has to occur before the rights of the licence can be enforced. Because document authentication is not geo-specific, it is not a topic for standardization by OGC ;
- **Enforcement and Authorization**: The rights expressed in a GeoLicence need to be enforced. The acceptance or denial decision for a particular request (with its associated licences) is based on the authorization decision, as it is derived by the authorization engine. Because enforcement and authorization is geo-specific, the appropriate standardization is upcoming work to be based on this specification ;
- **Authentication**: The basic requirement for trust, licence verification and enforcement/authorization is proof of identity, as it is provided by the functionality of this package. Different international standards, which define

how to enable this functionality, exist. Because authentication is not geo-specific, it is not a topic for standardization by OGC.

7.4.4 GeoDRM Basics

The use of GeoDRM is first a metadata-tracking problem. Both resources and principals are associated to descriptions (metadata) and those descriptions must be tracked and matched for the controlled actions to proceed. The resource metadata is the resource identity and description, and the principal metadata is the set of licences he has or has access to.

Second, the use of GeoDRM is an enforcement problem. Once identity and licences have been checked, the results enter into the stage where the principal wishes to take action with respect to that resource. The GeoDRM system controls the scope of those actions to a degree determined by design of the system. This “degree of control” is a measure of trust. The more the principals can be trusted, the less control is needed. In a zero or negative trust (distrust) environment the control may be great and will be critical for protection against malicious or licence-inconsistent acts of users.

7.4.5 GeoDRM Gatekeeper Metaphor

The GeoDRM system acts as a gatekeeper, making the decision to allow or disallow request for processing based on the information verified and passed to it by the local secure process controller. In general, the components are location independent as long as secure communication can be assured between the three basic components:

A security system capable of validating the documents and resource data supplied to in external request for processing.

A GeoDRM logic module (here called Gatekeeper) that would decide on the consistency of:

- the request ;
- the licences available to the principal making the request ;
- and the processes available to the system, either directly or through other gateway/gatekeeper pairs.

A processing node to supply a secured environment where licensed resources can be used without leakage. The only data in or out of the system is under the control of the security system and the consent of the gatekeeper GeoDRM.

7.4.6 Developmental Guidelines

In developing the specification several design guidelines have been followed. These include, but are not limited to, the following “best practices”:

- The GeoDRM Model must support ubiquitous geographic information ;
- Keep the DRM policy really simple, but no simpler ;
- Keep DRM as coarse-grained as possible while maintaining basic requirements ;
- Apply as little DRM as possible, but no less ;

- Delegate licence creation maintenance, enforcement and security ;
- Licence management should be transparent to the end-user, licence flows should be identical to unlicensed ones where feasible ;
- Adapt to fit common business, trading, pricing and licensing models ;
- Accept manageable risks then manage them.

The ultimate goal of geographic standards is to make geographic information and services available and readily usable to the entire information services community. Therefore the use of geographic information and other information should be minimally different.

7.4.7 Risk management

Managing risk is about balancing trust with protection and remediation. The optimal balance among these components depends on the specific business context. For example, where high levels of trust exist, lower levels of protection and remediation may be acceptable.

7.4.8 Trust

Digital rights management is about trust. Internet commerce cannot occur without some level of mutual trust, even more so when the parties are not in personal contact and resources are ethereal like digital data.

The business environment for a DRM system can vary widely. In one extreme, everyone is trusted and the DRM is simply an aid for tracking process and data flows for the purposes of the system (possibly including remediation if the trust is broken). In the other extreme, no one is truly trusted and the DRM controls all resource flows that involve licences. In this case, the licensed resources are “locked” from general use and all software handling licensed transactions is “trusted” in the sense that it is integrated sufficiently with the DRM system to prevent the gatekeeper from being bypassed, and a licensed resource “leaking” into a freely available world.

7.4.9 Protection - security

A DRM system enhances the altruistic trust by providing before the fact (*ex ante facto*) protections. The user, through trusted software, knows that he can legally do that which he is allowed to do and the owner of the resource knows that abuse of the contract is at least difficult. The degree of difficulty should be proportional to the risk to the resource, where valuable resources are generally protected more than ones of lesser value.

7.4.10 Remediation - enforcement

Remediation is an act or process of correcting a fault or deficiency. Since no protection system is perfect, there is an additional need to track licensable acts. This tracking allows the software to act as the first step in any remediation steps taken after the fact (*ex post facto*). The actual remedial actions may be stated in the contract, or in the written or common law.

7.4.11 GeoLicence Delegation and Management

Geospatial DRM is essentially the process of creating, delegating, managing, tracking, validating and enforcing GeoLicences.

The intention is that a GeoDRM-enabled network of services will automate some or all of these functions. Various actors within the GeoDRM-enabled system will perform these key functions.

A key aspect of a scalable network is the ability to delegate responsibility to these actors in a controlled and managed way. The system would not be scalable if the administrative burden was placed on the content owner alone.

Therefore a key capability for the success of a GeoDRM-enabled system is the ability to delegate these key functions. By necessity, intermediary actors may be needed to perform these administrative functions.

7.4.12 NNEC Security Requirements

Guidelines and detailed specification for how services might be incorporated in the NNEC infrastructure is yet unknown. But the OGC GeoDRM specification conform to some the security tenets that are expressed in the NATO NNEC Feasibility Study:

- “Information Object Protection” and “Information Object Content Labeling” by metadata and licence ;
- “Risk Management” by protection and remediation ;
- “User Transparency of IA Services” by its development guidelines.

Further studies have to be conducted how the NATO NNEC coupling security requirements will affect the usage of OGC and ISO geo-standards in a military environment.

8 Technology Viewpoint

The technology viewpoint of ISO RM-ODP is concerned with the underlying infrastructure in a distributed system. To achieve interoperability in the technology viewpoint, an infrastructure that allows the components of a distributed system to interoperate is needed. The infrastructure described in this chapter is the OGC implementation standards. Figure 12 shows abbreviations of all OGC standards and mappings to the described framework in this report. The standards are described in following sections in chapter 9.2.

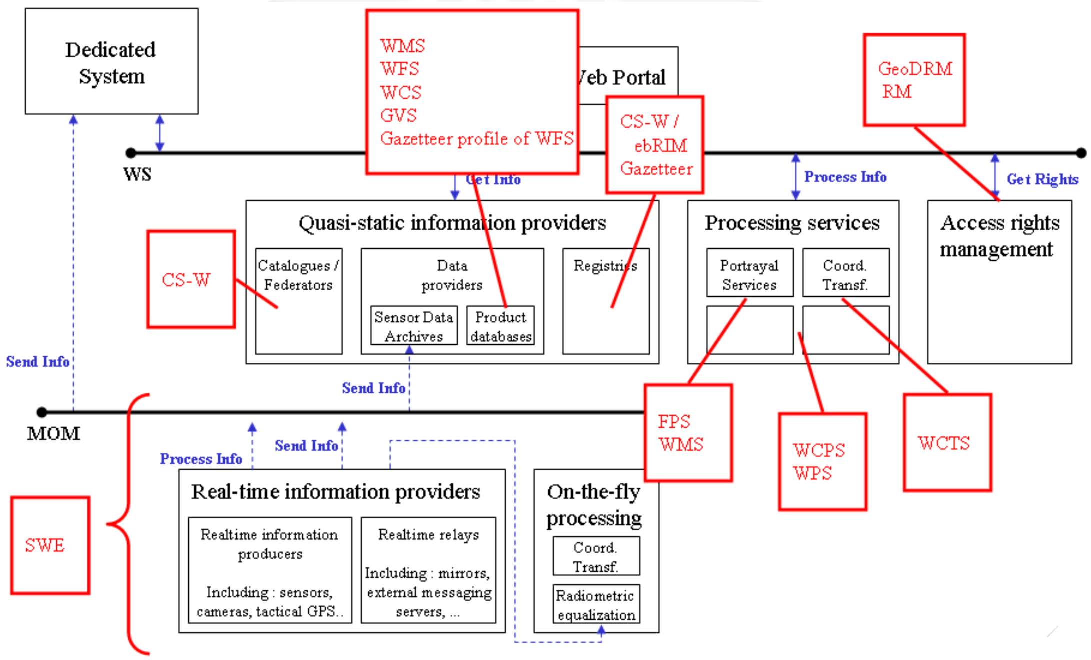

Figure 14– Static architecture with mapping to OGC standard specifications.

8.1 OGC Service Specifications and DGIWG Roadmap

Considering the maturity of the technologies and the requirement of nations to be interoperable, the following roadmap has been defined within SITP (see figure 15).

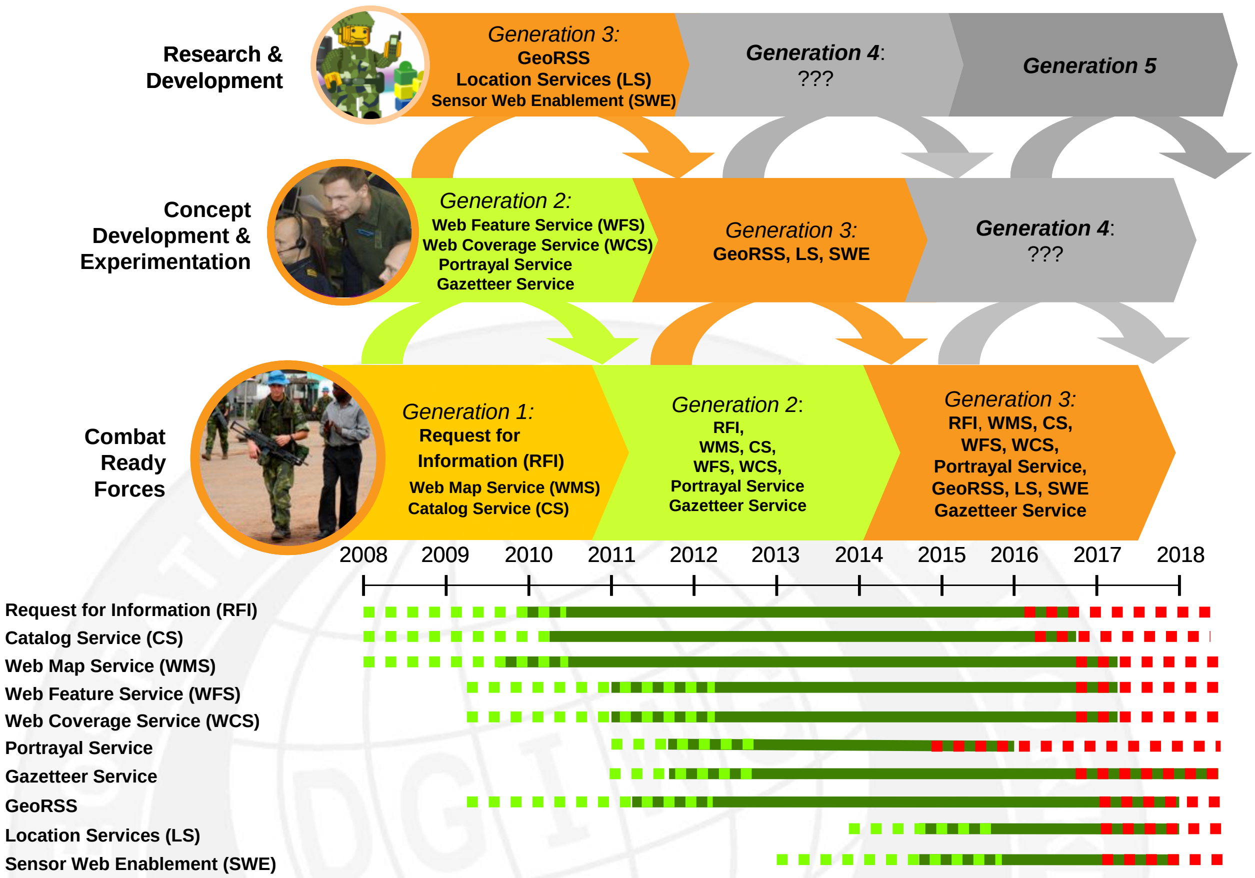

Figure 15 – Identified OGC standards with a life cycle estimation to be used within the DGIWG community. Dotted green line shows emerging technology that is tested and evaluated during this period, solid green line shows technology in use and dotted red lines shows technology that is possible being phased out if new standards come.

8.1.1 Catalogue Service (CS-W)

The OpenGIS Catalogue Services Specification defines common interfaces to discover, browse, and query metadata about data, services, and other potential resources. The development of the DGIWG CS-W Profile is undertaken by the DGIWG Services and Interfaces Technical Panel (SITP) through Project S07. That work is reported in DGIWG Catalogue Service Profile Edition 1.0. CS-W is considered generation 1 functionality.

8.1.2 Web Map Service (WMS)

OpenGIS Web Map Service Implementation Specification [21] is describing the implementation of Web Map Service. The purpose of the WMS is to provide user access to geographic data display as a map or spatially referenced image. WMS is the preferred service to publish geospatial data that is static in nature (being updated at a slow pace, e.g. weekly to yearly), and which contains information that can be efficiently communicated through a rendered picture. Services whose data is primarily geospatial and whose data is time-dependant may also be published through either snapshots or animations of the data. The WMS standard is mature and belongs to generation 1 shown in Figure 15. It is in DGIWG addressed by the S05 working group.

8.1.3 Web Feature Service (WFS)

The OpenGIS Web Feature Service (WFS) Implementation Specification [22] describes data manipulation operations on geographic features. It provides a service interface for access and publishes data that is primarily geospatial and which does not require real-time updates. Typically data is delivered in GML format. The WFS standard is mature and belongs to generation 2 shown in Figure 15.

8.1.4 Web Coverage Service (WCS)

The OpenGIS Web Coverage Service (WCS) Implementation Specification [23] provides interfaces to access geospatial data as coverages, that is, digital geospatial information representing space-time-and multidimensional-varying phenomena. Typical examples are hydrographic and meteorological data, but can also be used for simpler elevation coverages, or imagery data. The WCS standard belongs to generation 2 shown in Figure 15.

8.1.5 Portrayal Service

Portrayal Services is a work item under the DGIWG SITP group S01. One input into this group is OpenGIS Styled Layer Descriptor Profile of the Web Map Service Implementation Specification but other parts are also needed about Portrayal Registries and specific usage in the military community. This is considered to be a generation 2 service in Figure 15**.**

8.1.6 Gazetteer Service

There is growing interest in the development of a common feature-based model for access to named features, often referred to as a gazetteer. The OGC standard as a Gazetteer Service profile of the OGC Web Feature Service is currently under review. Within DGIWG SITP the S09 working group has been examining requirement for a Gazetteer Services. This kind of service is considered as generation 2 functionality in Figure 15.

8.1.7 GeoRSS Service

GeoRSS is a simple proposal for geo-enabling, or tagging, "really simple syndication" (RSS) feeds with location information. GeoRSS standardizes the way in which "where" is encoded with enough simplicity and descriptive power to satisfy most needs to describe the location of Web content. It is extensible and upwardly-compatible with more sophisticated formats like the OGC GML (Geography Markup Language). DGIWG SITP believes this standard could be useful in the military community but no working group has yet been started. It has however been placed as a generation 2 standard in Figure 15. OGC considers GeoRSS as an important stepping stone in the evolution of the geo-semantic web

8.1.8 Location Services (LS)

The OpenGIS Location Services is a set of standards that are processing services originally development within the telecommunication community. The service specifications consist of core services such as Directory Service, Gateway Service, Location Utility, Presentation Service and Route Service. A future LS activity has been discussed within the DGIWG SITP roadmap but no working group has started yet. It is considered to be a future technology and classified as generation 3 in Figure 15.

8.1.9 Sensor Web Enablement (SWE)

In an OGC initiative called Sensor Web Enablement (SWE), members of the OGC are building a framework of open standards for exploiting Web-connected sensors and sensor systems of all types: flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, Webcams, satellite-borne earth imaging devices and countless other sensors and sensor systems. SWE presents many opportunities for adding a real-time sensor dimension to the Internet and the Web.

Sensor Web Enablement standards that have been built and prototyped by members of the OGC include the following pending OpenGIS® Specifications:

1. **Observations & Measurements Schema (O&M)** – Standard models and XML Schema for encoding observations and measurements from a sensor, both archived and real-time ;
2. **Sensor Model Language (SensorML)** – Standard models and XML Schema for describing sensors systems and processes; provides information needed for discovery of sensors, location of sensor observations, processing of low-level sensor observations, and listing of taskable properties ;
3. **Transducer Markup Language (TransducerML or TML)** – The conceptual model and XML Schema for describing transducers and supporting real-time streaming of data to and from sensor systems ;
4. **Sensor Observations Service (SOS)** - Standard web service interface for requesting, filtering, and retrieving observations and sensor system information. This is the intermediary between a client and an observation repository or near real-time sensor channel ;
5. **Sensor Planning Service (SPS)** – Standard web service interface for requesting user-driven acquisitions and observations. This is the intermediary between a client and a sensor collection management environment ;
6. **Sensor Alert Service (SAS)** – Standard web service interface for publishing and subscribing to alerts from sensors ;
7. **Web Notification Services (WNS)** – Standard web service interface for asynchronous delivery of messages or alerts from SAS and SPS web services and other elements of service workflows.

A SWE project has been identified by in the DGIWG SITP roadmap but no working group has started yet. It is considered to be a future technology and classified as generation 3 in Figure 15.

8.1.10 GeoDRM

The OGC Geo Digital Rights Management Framework is introduced in chapter 8.3, but has not been further discussed within DGIWG SITP. The ability to use it in a military environment will depend on each coalition's networks security policies.

Annex A

(Informative)

Compliance with ISO 19119

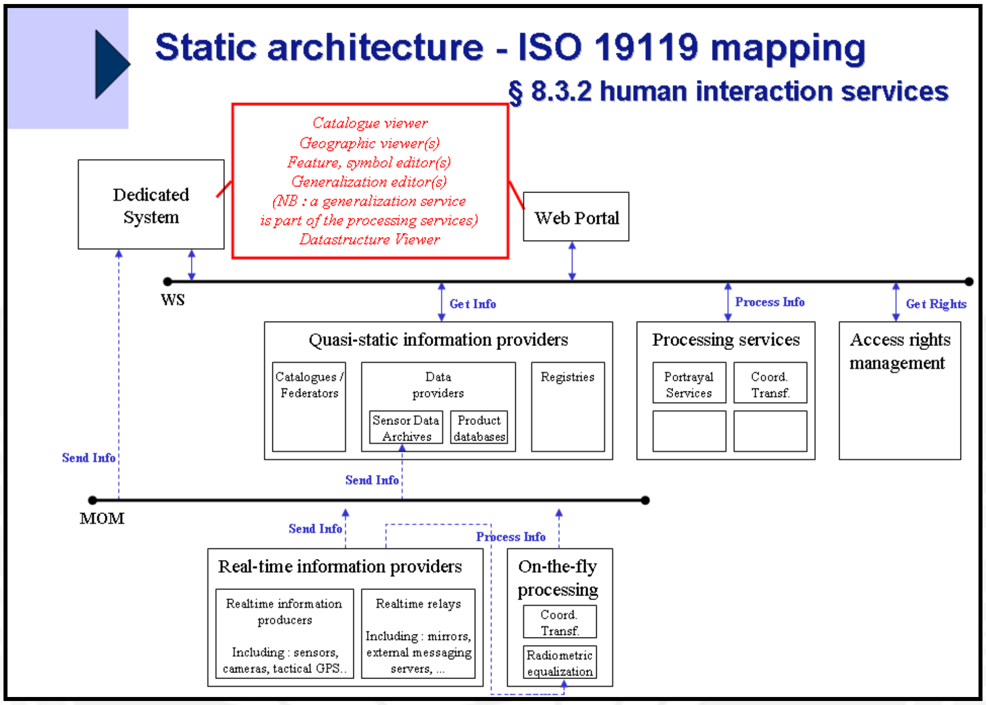

Figure 16 – ISO 19119 mapping of human interaction services

“Human interaction services” among which catalogue viewer, geographic viewer(s), feature / symbol editor(s), generalization editor(s), datastructure viewers can be covered by appropriate web portals or dedicated client systems development.

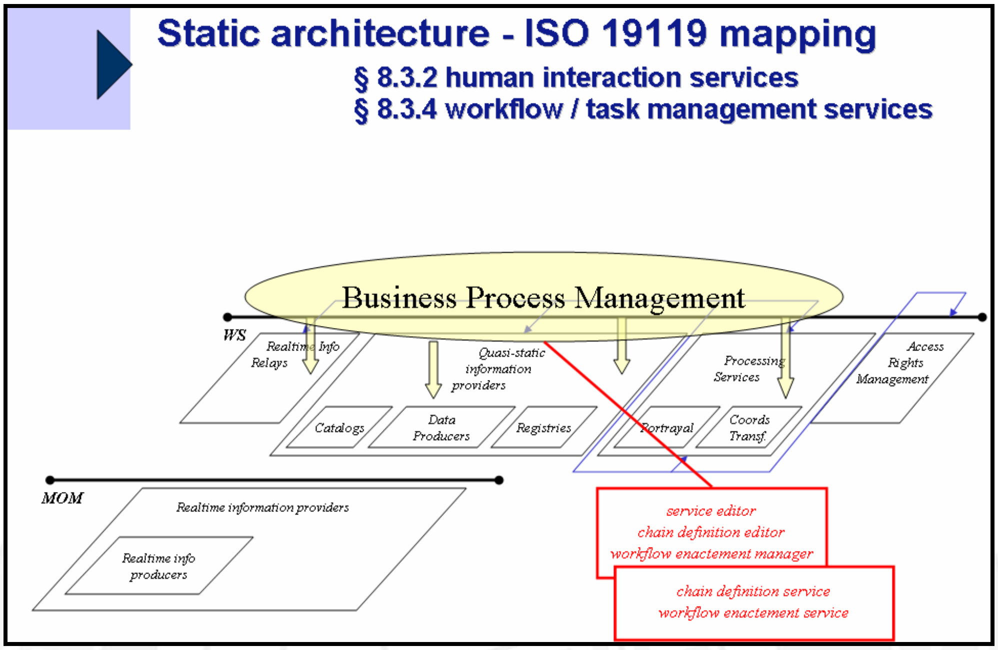

Figure 17 – ISO 19119 mapping of Business Process Management

Business Process Management services are covered at the engineering viewpoint level § 8.2 and 8.3.

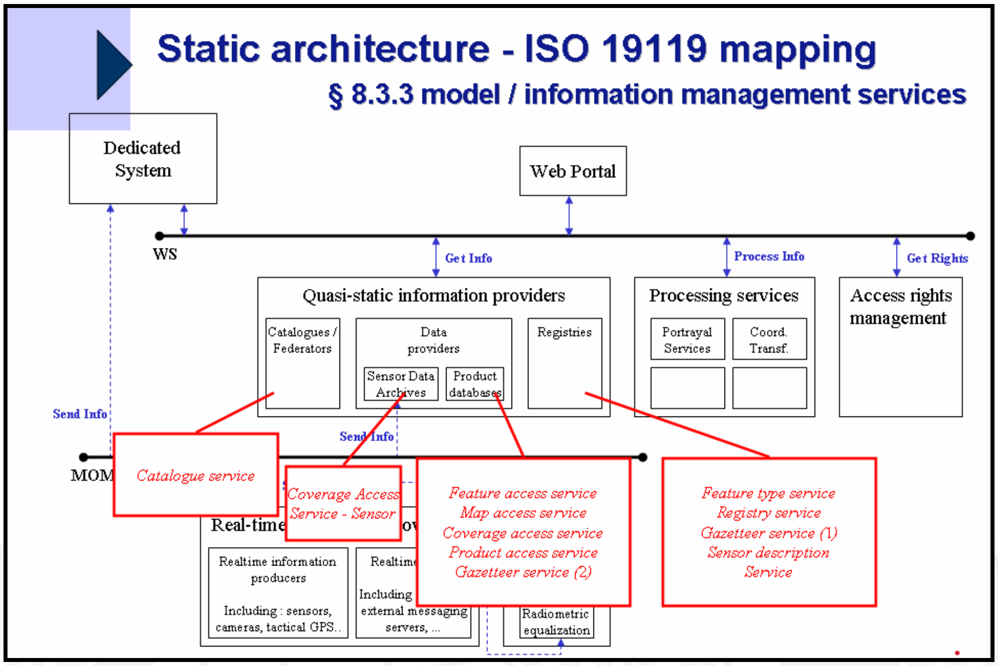

Figure 18 – ISO 19119 mapping of model / information management services

Model / information management services are covered by the provision of catalogue services, registries services, data access services. Note that Gazetteer services can be implemented using registries or data-access (gazetteer profile).

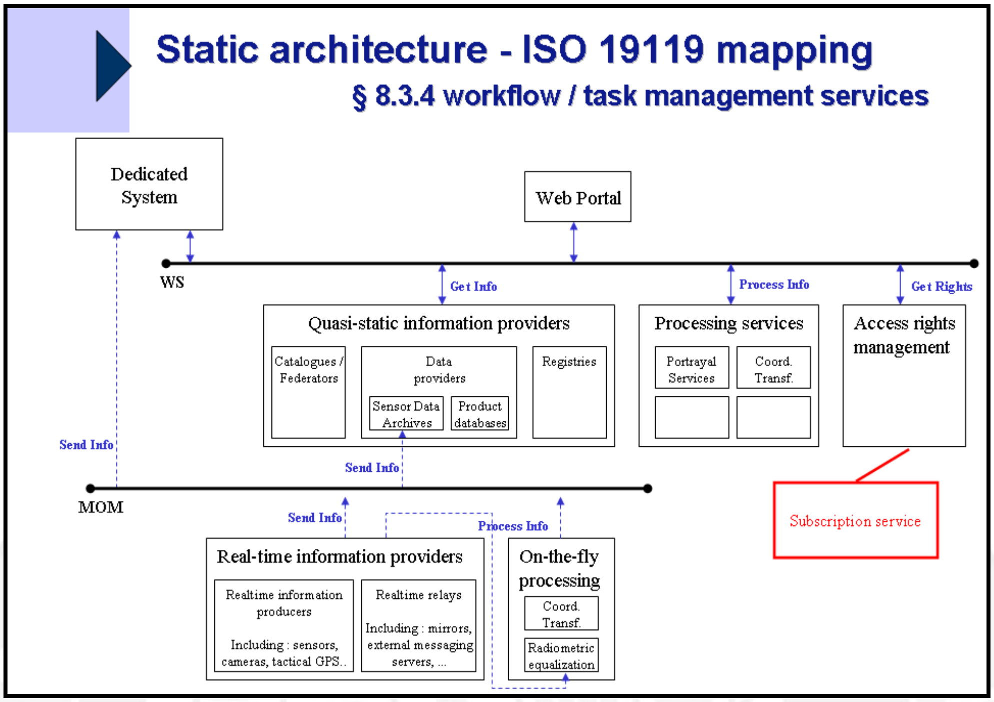

Figure 19 – ISO 19119 mapping of workflow / task management services

Subscription service can be implemented in conjunction with access rights managements.

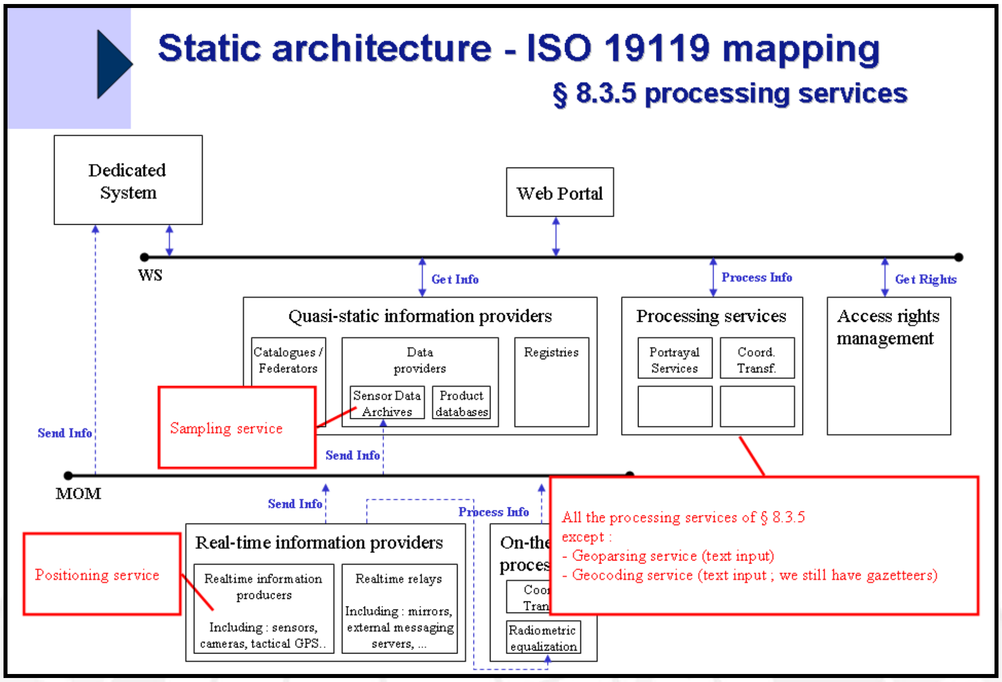

Figure 20 – ISO 19119 mapping of processing services

Resampling is involved within data access services. Positioning services defined as being “provided by a position-providing device” are part of real-time information providers (GPS sensors). All other processing services mentioned in ISO 19119 § 8.3.5, except “geoparsing” and “geocoding” services, are processing geospatial data and are within the scope of the “processing services” of this document.

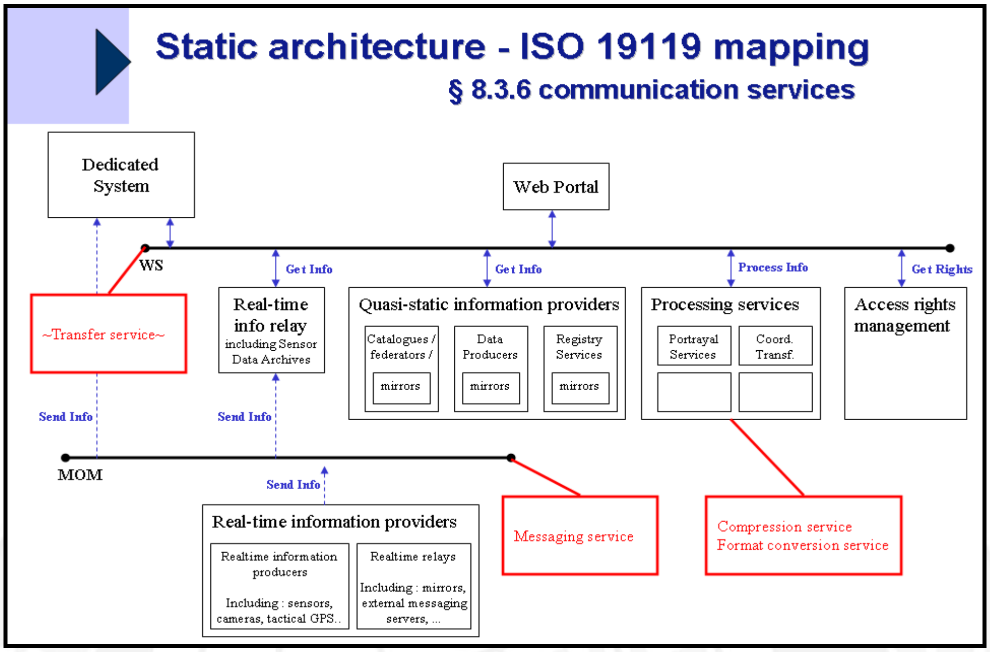

Figure 21 – ISO 19119 mapping of communication services

Compression and formatting services are considered as processing services in this document. The Web Service middleware (WS) and the Message-Oriented Middleware (MOM) are particular cases of transfer services and messaging services respectively.

Finally, a few services mentioned in ISO 19119 are not covered by the current DGIWG Service Architecture :

- order handling services and standing order services ;
- geoparsing and geocoding services ; they deal with processing text data, which is not covered by the current architecture ;
- communication services are used (WS and MOM middleware) but not completely covered, since they are not geospatial-specific services.