Identification and Specification of Generic and Specific Enablers of the Future Internet - illustrated by the Geospatial and Environmental Domain

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Abstract. The identification and specification of generic and specific enablers of the Future Internet is based on a use-case oriented methodology taking into account life cycle and architectural constraints. The approach is illustrated by examples from the geospatial and environmental domain that are both elaborated in the ENVIROFI usage area project as part of the Future Internet Public Private Partnership program. The approach claims to be applicable to other thematic domains and usage areas.

Keywords: Future Internet, Architecture, Enablers, Geospatial, Environmental

1 Introduction

The presented approach for identification and specification of generic and specific future internet enablers has been developed and applied in the context of the ENVIROFI usage area project [1] as part of the Future Internet Public Private Partnership (FI PPP) program. ENVIROFI addresses, in particular, the geospatial and environmental domain. However, the suggested methodology for enabler identification and specification is designed to be independent of thematic domains and usage areas, and thus claims to be applicable more broadly. The methodology starts with use case modeling, potentially linked with user stories from an agile modeling approach. It continues with a use case analysis activity that is closely related to a system description approach using RM-ODP, including a mapping to enablers that takes into account life cycle and architectural constraints.

In section 2 we first present the methodology. Section 3 describes the life cycle-based approach whereas section 4 focuses on the architectural approach for the identification of enablers. Section 5 presents conclusions and outlines further work.

2 Methodology for Enabler Identification and Specification

This section provides an overview of the methodology illustrated for geospatial and environmental usage areas. It is based on use case modeling and combines the SERVUS methodology [2] with agile modeling and SoaML. SERVUS is a Design Methodology for Information Systems based upon Geospatial Service-oriented Architectures and the Modelling of Use Cases and Capabilities as Resources.

2.1 Use Case Modelling

The methodology requires that requirements for enablers are elaborated in a first step as user stories and use cases by the experts of thematic domains. Applying an iterative approach, the use cases are matched in a second step with the capabilities of the emerging Future Internet platform, encompassing both generic enablers (to be provided by the FI-WARE project as part of the core platform) and specific enablers, provided by usage area projects, e.g. environmental enablers to be provided by ENVIROFI as illustrated in Figure 1.

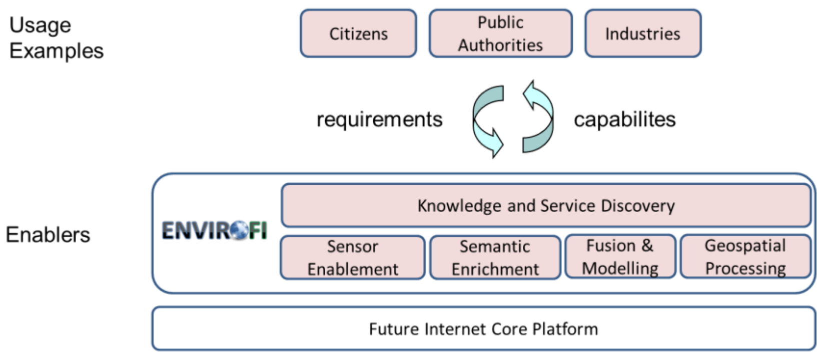

Fig. 1. Overall Idea of the ENVIROFI Use Case Analysis

Use case modelling has been proven to be an efficient and powerful approach to reach a common understanding of the system itself and its behaviour. In interdisciplinary projects, involving thematic experts from different domains (e.g., air and water) as well as software experts, it is as challenging as essential to reach consensus on a common terminology. Use cases represent the most common practices for capturing and deriving requirements. The requirements of the system are described in a narrative way with minimal technical jargon. In a nutshell, “a use case describes who can do what with the system and for what” [3]. Those quotes of Cockburn indicate that the most important basis to implement case studies is use case modelling.

We propose that use cases are described in a semi-formal way, with a use case template based on a structured textual description in tabular form. Furthermore, the

SERVUS design methodology argues that additional information about the requested information resources (e.g. type and format of needed data) is necessary to completely describe a use case from both a user's and system's point of view. This small extension with respect to a classical use case approach heavily facilitates the transition to the abstract design step (e.g., the specification of the information model in the Unified Modelling Language UML) but is still very easy to understand by thematic experts. Furthermore, requirements (for enablers) should be derivable from the use cases. Three types of requirements can be identified:

- Functional requirements,
- Informational requirements,
- Non-functional requirements.

Functional requirements can be derived from the sequence of actions (main success scenario, extensions and alternative paths) as part of the use case description. The informational requirements address data that is exchanged between two communication partners, i.e. between users and the system or between system components. Here, the identification of requested information resources already as part of the use case description is quite helpful. Finally, the non-functional requirements cover all requirements that do not alter the foreseen functionality of the system, e.g. the quality of data and results.

2.2 Use Case Analysis Process

Figure 2 illustrates the use case analysis process [4]. As part of the project planning there needs to be some agreement of how to document use cases. For this continuous activity a project space has to be created which preferably should be supported by a use case server that is accessible by all participants of the analysis process. In ENVIROFI, this use case server is provided in the form of a web-based collaborative tool.

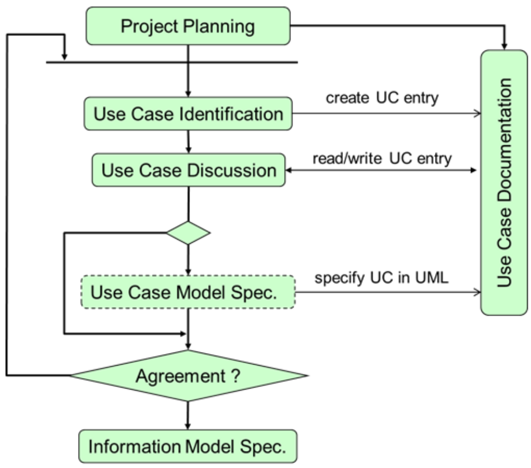

Fig. 2. Procedure of the ENVIROFI Use Case Analysis

As a first step of the analysis iteration loop a set of preliminary use cases (UC) is identified, mostly by those thematic experts who drive the effort. For each of them an entry in the project space has to be generated. As described above, the methodology proposes that use cases are initially described in structured natural language but already contain the list of requested resources. This description is the language which is used in the UC discussion that takes place in workshops that are facilitated by the system analyst. Depending on the level of agreement that can be reached the iteration loop is entered again in order to refine or add new use cases.

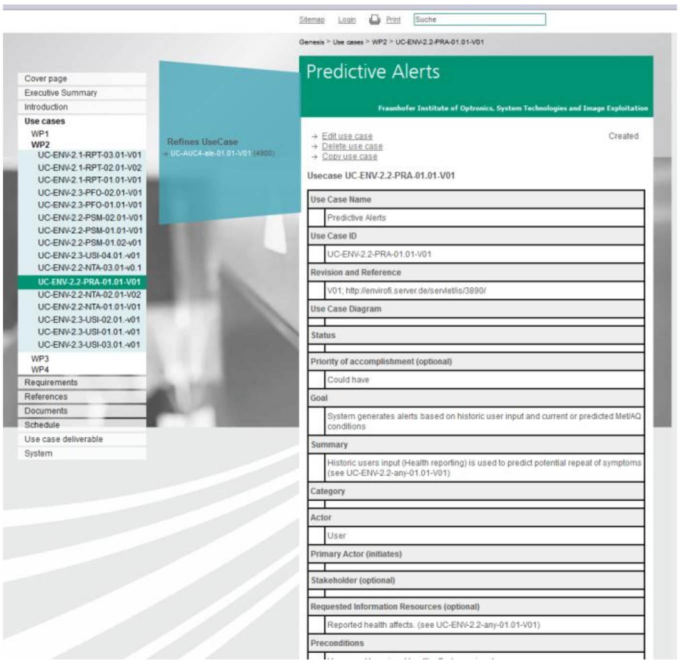

Fig. 3. Screenshot of the Use Case Server (source: Fraunhofer IOSB)

In order to identify inconsistencies and check the completeness of the UC model, the system analyst may transform the semi-structural UC description into formal UML specifications. However, these UML diagrams should still be on a high abstraction level such that a discussion with the end-user is possible. It is the advantage of this formal transition step already in an early analysis phase to detect inconsistencies and missing information as quickly as possible. The UML specification helps to (re-) discuss and check the use cases with the thematic experts.

However, in addition to the usual UML use cases they already comprise the links to the set of requested (information) resources, their representation forms and the requirements to create, read, write or delete them[4]. Once an agreement is reached

[4] inspired by the resource-oriented architectural style as used by RESTful web services [4].

about the set of use case descriptions and related UML specifications it is then up to the system analyst to specify the resulting information model taking the resource model as a modeling framework.

2.3 Reference Model based on ISO RM-ODP

The identification and discussion about enabler requirements analysis cannot take place without having in mind a common reference model of a Future Internet system architecture. Here, we propose to rely upon agreed international standards such as ISO RM-ODP. Inspired by "distributed processing systems based on interacting objects", ISO defined the Reference Model for Open Distributed Processing (ISO/IEC 10746-1:1998). The RM-ODP standards have been adopted widely. They constitute the conceptual basis for the ISO 191xx series of geospatial standards from ISO/TC211. The viewpoints of RM-ODP are applied as follows. The *Enterprise viewpoint* describes the purpose, scope and policies of that system and contains the use cases described above. The *Information viewpoint* describes the semantics of information and information processing and contains the information resources identified as the use case extension. The *computational viewpoint*[5] describes the functional decomposition of the system into components and objects which interact at interfaces. The *Engineering viewpoint* describes the mechanisms and functions required to support distributed interaction between objects in the system. The *Technology viewpoint* describes the choice of technology in that system.

The identification of generic and specific enablers is done based on a combination of top down and bottom up analysis using a complete life cycle approach as well as a complete end to end architectural approach. The two following sections describe the framework for the identification of life-cycle based enablers and architectural based enablers.

3 Life-Cycle Based Enablers

In this section we describe a life-cycle based perspective for the identification of enablers with both a service centric and data centric view.

We re-use components which have been identified in a recent activity of the European Committee for Standardisation (CEN), Technical Committee (TC) 287 for building a reference model for spatial data infrastructures (SDI) [5], see also Fig. 4. Notably, the Service Centric View could be applied to any service-oriented system. Only the Data Centric View contains instantiations, which are specific for the geospatial and environmental domains. Likewise, GeoPortals are a specific type of geospatial applications.

[5] sometimes also referred to as „Service Viewpoint" acknowledging its application in (geospatial) service-oriented architectures [2].

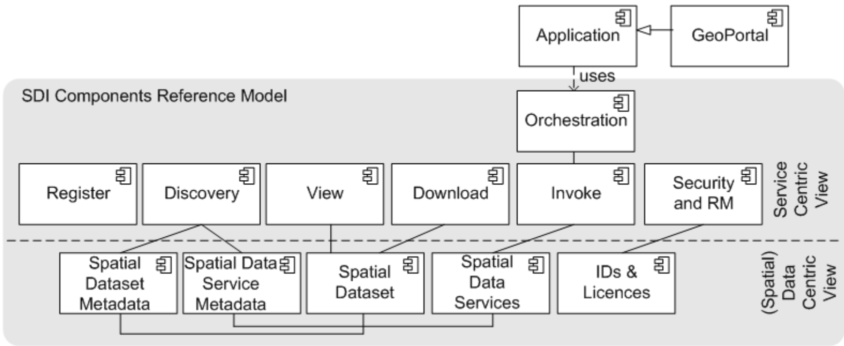

Fig. 4. Core Components of the SDI Reference Model ([5], modified).

The primary organizing structure is determined by the following generic core life cycle components (corresponding to the service centric view in the figure):

- *Register*: for describing and publishing resources.
- *Discovery*: for searching for and discovery of resources.
- *View*: for visualising of resources.
- *Download*: for downloading and exchanging resources.
- *Invoke*: for interacting with resources.
- *Orchestration and Composition*: for providing aggregated resources including in particular workflows for service composition.
- *Security and Rights Management*: for managing access rights to resources.

Related to the data centric and service centric view shown in figure 4 we illustrate the requirements of the environmental usage area following a life-cycle centric approach. First, we introduce the roles, which are involved in generating knowledge about our environment and define the overall added-value chain. In a second step, we present common requirements for future eEnvironment services. In doing so, we provide a bridge between practical environmental applications and the wider political framework. The presented findings could equally be applied to other geospatial and non-geospatial domains beyond the environmental domain.

3.1 The Value Chain of Environmental Knowledge Generation

Analyzing the requirements of eEnvironment services for the terrestrial, atmospheric and marine sphere, we could extract a total of six roles, which contribute to the generation of environmental knowledge [6]:

1. *Observer*, being the initial source of information about the environment. This may reach from sensor measuring weather conditions to citizen observing species occurrences.
2. *Publisher*, making a resource, such as an observation, discoverable to a wider audience, e.g. by providing required resource descriptions (metadata).
3. *Discoverer*, being the entity that finds a resource, e.g. species occurrence data, based on all available descriptions.

4. *Service Provider*, making information or an environmental model accessible to (and usable by) the wider audience, e.g. by offering a standard based service for data download.
5. *Service Orchestrator*, being responsible for combining existing services in a way that they create information for a distinct purpose, i.e. environmental application focusing on a particular sphere, such as terrestrial biodiversity.
6. *Decision Maker*, consuming an environmental application in order to retrieve decision supporting material and making a final decision based on the information available, e.g. designating a new protected area.

Consequently, the process workflow can be summarized as in the figure below (Fig. 5). Notably, following this workflow services may themselves get published in order to serve as building blocks for more complex eEnvironment solutions.

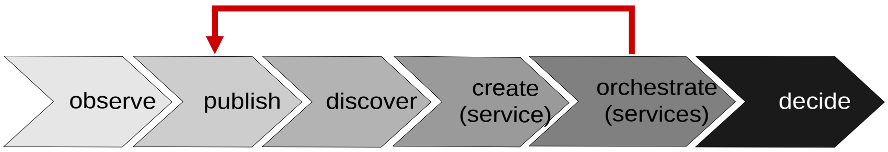

Fig. 5: Added value chain of environmental knowledge generation [6]

3.2 Overview of Stakeholders

The tasks identified above (section 3.1) are played by a variety of individuals and organizations. Those have been again extracted from requirements of eEnvironment. In a nutshell, those can be defined as:

- *Citizens* of a particular social, political, or national community;
- *Environmental agencies* on sub-national, national and European level;
- *Public authorities* of national and regional and other level;
- *Industries* from the primary, secondary and service sector;
- *Platform providers* offering frameworks on which applications may be run;
- *Infrastructure providers* offering physical components and essential services;
- *Sensor network owners* holding the sensor and basic communication hardware.

	observe	provide	discover	create	orchestrate	decide
Citizens	x	x	x	x	x	x
Environmental agencies	x	x		x		x
Public authorities		x		x		x
Industries			x	x	x	x
Platform providers				x		
Infrastructure providers				x		
Sensor network owners	x	(x)		(x)		x

Tab. 1. Added-value chain of environmental knowledge generation [6].

Table 1 provides an overview of the manifold mappings between these stakeholders and the different roles in the value chain of environmental knowledge generation. Notably, citizens can play all roles, they may even discover available information and provide new services (mash-ups). The decisions they may take are on individual level, such as “Should I travel through an area with bad air quality?”.

3.3 Requirements for a Next Generation of eEnvironment Services

Given the above, we can now identify the requirements for a next generation of eEnvironment services in Europe. They can be summarized as follows:

- publication, discovery, access and visualization of environmental data sets;
- planning, publication, discovery, access and visualization of measurements;
- publication, discovery, access and visualization of objective, semi-objective and subjective observations by end users;
- transformation of data sets and fusion of observations;
- publication, discovery and access to environmental models and simulations;
- composition and invocation of workflows;
- support and enforcement of data and service policies based on identity, licenses, trust chains, etc.;
- publication, discovery, access, visualization and annotation support for controlled vocabularies, taxonomies, and ontologies;
- integration with the Semantic Web and Web 2.0; and
- interoperability with existing and planned infrastructures in the context of:
  - the most relevant initiatives at international level, such as INSPIRE [7], GMES [8], SEIS [9], GEOSS[10],
  - relevant well-established communities, including research and e-government infrastructures [11], and
  - the mode relevant policies on international level, above all related to Public Sector Information (PSI) [12].

Specific components (environmental enablers) should support these requirements. They should be designed and developed leveraging existing architectural approaches and technical specifications, and re-using/extending existing tools. Particular attention should be paid to open international standards and communities-of-practice specifications, and to open source components in order to make the resulting system more flexible and scalable (see also [13]).

4 Architectural Based Enablers

The life cycle based enablers and relevant applications can further be described in terms of their architectural components and enablers/services. The following figure shows how the different types of enablers can be related in the context of a complete end-to-end ICT architecture.

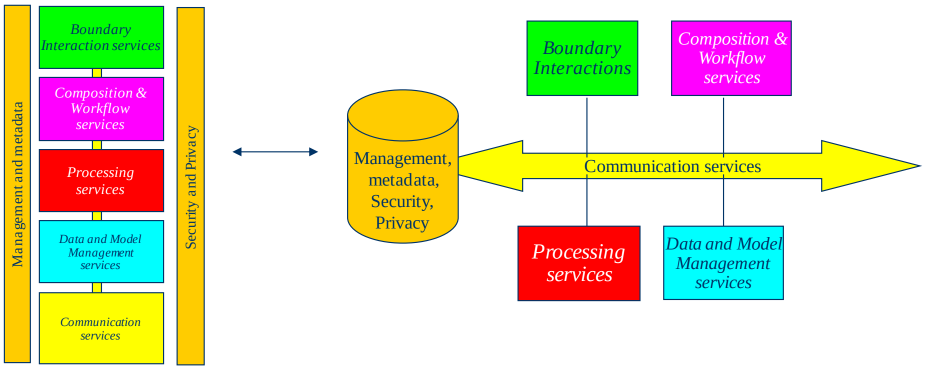

Fig.3. Relationships of enablers in both a layered and a bus architecture

Figure 3 shows the relationship of different enabler categories both in a layered architecture and also as a bus architecture. The taxonomy of the enabler types is in accordance with ISO 19119 Geographic information – Services, clause 8.3. [14]. The approach is to define both generic domain independent and specific enablers, such as geospatial and environmental specific enablers, in each of the following six groups, color coded in the figure:

- **Boundary Interaction Enablers** are enablers for management of user interfaces, graphics, multimedia and for presentation of compound documents. Boundary Interaction services have been defined to not only include human interaction services, but also other system boundaries like sensor and actuator services. Specific enablers focus on providing capabilities for managing the interface between humans and Geographic Information Systems and location based sensors and actuators. This class includes also graphic representation of features, as described in ISO 19117.

- **Workflow/Task Enablers** are services for support of specific tasks or work-related activities conducted by humans. These enablers support use of resources and development of products involving a sequence of activities or steps that may be conducted by different persons. The specific enablers focus on workflow for tasks associated with geographic and environmental information — involving processing of orders for buying and selling of geographic information and services. These services are described in more detail in ISO 19119.

- **Processing Enablers** perform large-scale computations involving substantial amounts of data. Examples include enablers for providing the time of day, spelling checkers and services that perform coordinate transformations (e.g., that accept a set of coordinates expressed using one reference system and converting them to a set of coordinates in a different reference system). A processing service does not include capabilities for providing persistent storage of data or transfer of data over networks. The specific enablers focus on processing of geographic information. ISO 19116 is an example of a processing service. Other examples include services for coordinate transformation, metric translation and format conversion.

- **Model/Information Management Enablers** are enablers for management of the development, manipulation and storage of metadata, conceptual schemas and datasets. The specialization of this class of enablers focuses on management and administration of geographic information, including conceptual schemas and data. Specific services within this class are identified in ISO 19119. These services are based on the content of those standards in the ISO 19100 series that standardize the structure of geographic information and the procedures for its administration, including: ISO 19107, ISO 19108, ISO 19109, ISO 19110, ISO 19111, ISO 19112, ISO 19113, ISO 19114 and ISO 19115. Examples of such services are a query and update service for access and manipulation of geographic information and a catalogue service for management of feature catalogues.

- **Communication Enablers** are enablers for encoding and transfer of data across communications networks. The specific enablers focus on the transfer of geographic information across a computer network. Requirements for Transfer and Encoding services are found in ISO 19118.

- **System Management and Security Enablers** are enablers for the management of system components, applications and networks. These services also include management of user accounts and user access privileges. The specific enablers focus on user management and performance management, and on Geo Right Management

The six categories of enablers have been identified through an end-to-end architectural analysis. Since the initial version of this approach in the ISO 19101 and 19119 standards around 2001 they have been found sufficient for most identified service types and enablers, with the escape mechanism that many new instances will be put into the processing category. There are also situations where tools and applications are composite and contain components that will span multiple categories, and also for this reason the life cycle based classification has been found useful as an additional classification. In general, multiple classification schemes from different perspectives should be supported.

The different service types can also be categorized according to their relevance for emerging cloud services, starting with a classification for the application level and software as a service (SaaS), but also further down to platform as a service (PaaS) and infrastructure as a service (IaaS).

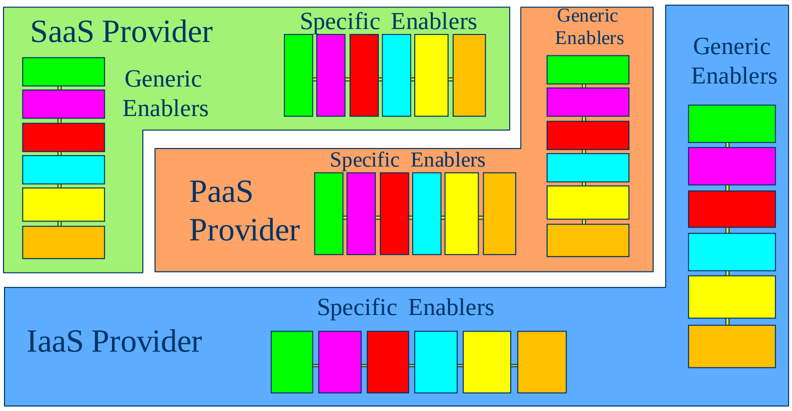

Fig.4. Generic and specific enabler types for SaaS, PaaS and IaaS

The initial generic enabler areas identified by the FI-WARE project is targeted at providing further support in many of the areas identified through the life cycle based perspective and the architectural perspective here. The initial six areas can be mapped to the architectural areas as follows:

1. *Cloud hosting (IaaS)* is addressing generic enablers in particular related to processing and model/information management on the IaaS level.
2. *Data/Context management (with intelligent services)* is related to model/information management enablers on the SaaS and PaaS level.
3. *Application Services framework* – is related to processing and system management enablers on the PaaS level.
4. *IoT Service enablement* – is related to boundary enablers on the SaaS and PaaS level
5. *Interface to Network and Devices (I2ND)* is related to communication enablers on the PaaS and IaaS levels.
6. *Security* is related to System management/Security enablers on the SaaS and PaaS level.

In the ongoing FI PPP activities about the identification of further generic and specific enablers, it is assumed that more enablers will be found for all of the different enabler areas across all of the cloud levels from SaaS to PaaS and IaaS.

5 Conclusions and further work

The presented methodology and approach for the identification and specification of generic and specific Future Internet enablers is currently being used in the ENVIROFI project for the purpose of identifying and specifying enablers in the FI PPP program.

A broader initiative has been started for the further identification of enablers through the ENVIP community and CEN TC287. It is an aim that this approach can be further applied also in other domains and usage areas.

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