Service Engineering Life-cycles

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Abstract. Presently the interoperability of organizations and systems are based on exchanges of products and services. Products are any more-or-less tangible things such as energy, goods, documents and data; while services are actions performed by an actor for the profit of another. Currently System Engineering standards like ISO-15288 are mainly focused on product development and exchange. Consequently, this paper provides foundation principles of service engineering with description of terms and concepts; life-cycles for service offer, provision and consumption; service usage for product development; and service provision based on tangible products. Different examples show how these foundation principles can be applied through concrete cases within different domains. As a conclusion, various challenges are presented to express the need for research and standardization activities.

1 Issues and Stakes

The concept of service has been used in everyday life, as well as in business and industry domains for a very long time through various contexts like public services, consulting and services, in-service operation, etc.. One decade ago emerging information and communication technologies reused the term to dramatically transform enterprise information systems and the Internet. Web services were a buzz word for several years. After this period, as no real engineering process and business logic were foreseen, "SOA (service-oriented approach) is dead" has been declared on blogs of the software community. Fortunately, more mature thinking arose from the enterprise modeling domain, with architecture frameworks –Like DoDAF, MODAF, NAF, TOGAF– and engineering standards –like CMMI for services– which highlighted the concept of service as being a serious paradigm for interaction between organizations and systems. In particular the service-orientation is now widely adopted in the Net-Centric Operation and Net-Centric Warfare approaches of the military domain [Ref. 2].

Presently and maybe for some time it is possible to say that products and services are complementary inputs and deliverables of organizations and systems [Ref. 3]. The aims are the increase of interoperability, and loosely coupled cooperation and collaboration for the interest of each participant and also bringing the benefits of synergy.

The concept of service is currently poorly formalized even if significantly used in organizations:

- At a business level, the service offer and service level agreement are generally based on commercial documents with very light technical data. The consequence is that most of the time the service provision is performed in a "best effort" manner.
- At the IT level, the state of the art is service description and execution within a software functional scope. The concern is connectivity and exchange of applications to insure a functional flow with the major constraint of quality of service. I.E. service-oriented architecture (SOA) is generally achieved with application encapsulation within a "web

service" technology approach and an IT infrastructure providing an "enterprise service bus" (ESB) for connectivity and exchanges.

- At an information system level the most advanced practices are the modeling of the business process –but without any consideration of contracts and a light description of behavior– and automated software generation.

The main consequences of no real architecting and/or engineering process at the system level are: a problem of governance, uncertainty of the viability of the service-orientation and unpredictability of large scale service-oriented systems.

2 Terminology around products, services and systems

Currently the INCOSE System Engineering Handbook [Ref. 1] describes a system engineering project as being:

*[V3.2.1, Table1-1]: "a endeavor with start and finish criteria undertaken to create a product or **service** in accordance with specified resources and requirements*"

Regarding System Engineering process, quotations are based on the ISO/IEC-15288[Ref. 5] and underline that both product and service are to be considered. For example with acquisition:

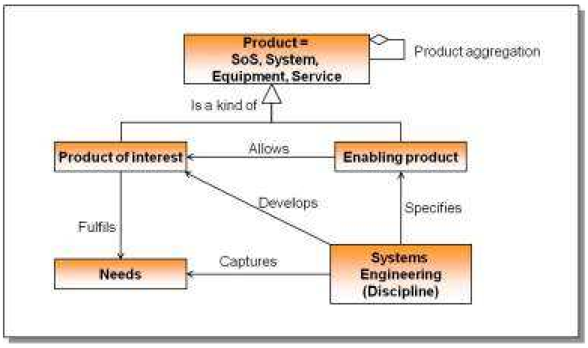
*Acquisition Process [V3.2.1, Section 6.1.1.1] The purpose of the Acquisition Process is to obtain a product or **service** in accordance with the acquirer's requirements.*

The handbook also describes that services may be system elements:

***System [INCOSE]**: an integrated set of elements, subsystems, or assemblies that accomplish a defined objective. These elements include products (hardware, software, firmware), processes, people, information, techniques, facilities, **services**, and other support elements.*

This definition is close to the EIA 632 standard [Ref. 7] that assimilates the system to an aggregation of products, such as physical items, components, and software; but also possibly non-tangible products such as services.

*System [EIA-632]: An aggregation of end products and enabling products to achieve a given purpose. NOTE-The term product is used in this standard to mean: a physical item, such as a satellite (end product), or any of its component parts (end products); a software item such as a stand-alone application to run within an existing system (end product); or a document such as a plan, or a **service** such as test, training, or maintenance support, or equipment such as a simulator (enabling products).*



As result of the two latter quotations the following meta-model can be formalized:

Systems Engineering has to develop products in accordance with stakeholders' needs. Each product-of-interest life-cycle can require enabling-products for its viability.

These products may be systems of systems, systems, Equipment or services.

Figure 1: Product definition including service

These definitions above are considered for the rest of this document.

Regarding definitions of the term service, the INCOSE handbook does not provide one. However numerous definitions for the notion of service exist in various fields. In particular, the selection presented below shows that the term is also employed on economy, quality management, or software engineering.
The CMMI for services standard [Ref. 10] simply defines that "*a service is an intangible, non-storable product*". A very simple and clear definition of the term "service" is also given by the NATO Architecture Framework (NAF)[Ref. 8], even if this definition suffers from the fact it does not distinguish between the supplied service and the supplier's activity.

Service[NAF V3] = Function, capability or behavior that is provided by a producer to a consumer.

The following ISO definition[Ref. 6] provides a more detailed explanation highlighting that the service provider activity is normally internal and has to meet the customer expectation:

Service provided by a service provider to a customer ISO-8402:1992:

The result generated by activities at the interface between the supplier and the customer and by supplier internal activities to meet the customer needs.

Note 1: The supplier or the customer may be represented at the interface by personnel or equipment.
Note 2: Customer activities at the interface with the supplier may be essential to the service delivery.
Note 3: Delivery or use of tangible products may form part of the service delivery.
Note 4: A service may be linked with the manufacture and supply of tangible product.

The current version of the INCOSE Body of Knowledge[Ref. 4] is close to this. Whereas the OASIS SOA Reference Model [Ref. 11] assimilates a service as a mechanism enabling access to a desired capability.

Service [OASIS SOA reference model V1]: a mechanism to enable access to a set of one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description. A service is provided by one entity – the service provider – for use by others, but the eventual consumers of the service may not be known to the service provider and may demonstrate uses of the service beyond the scope originally conceived by the provider.

All of the above definitions are compatible with the purpose of this paper.

3 Foundations for service

The main actors of an interaction using a service are:

- The service consumer or user who is motivated by goals when using the service.
- The service provider who performs a course of action to deliver the service to the consumer. This action is expected to produce an effect to fulfill, or at least contribute to, the consumer's goals.

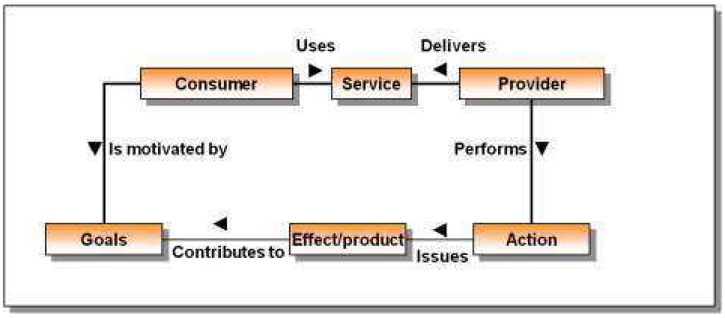


Figure 2: Main concepts of interaction with a service

However other stakeholders can be considered in a more detailed interaction:

- As a participant, a mediator can be involved in the preparation or operational phase of a service. His role is to facilitate the service interaction, for example with semantic or syntax adaptation.
- As a non-participant, other parties may impact or may be impacted by the service provision. For example:
    - A sponsor expects benefits of the service performance
    - An analysis service could be performed by a medical laboratory for a doctor with a patient blood sample. In this case the patient is not participating in the analysis but is interested in the result.

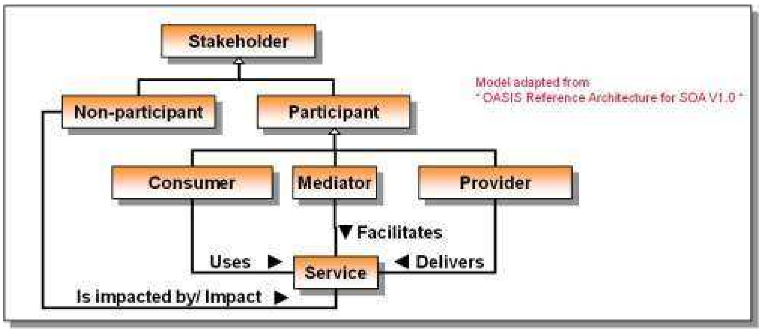


Figure 3: Service stakeholders

Other main concepts often used to describe service interaction are:

- The contract which is a moral, legal or normative reference expected to be known by all the participants of a service interaction. It may or may not be known by non-participants and may be referenced in the service impact.
- The quality of service, which can be considered as:
    - Being expected by participants, when more or less formalized in the contract with possible hypotheses.
    - Effective when evaluated during service monitoring.
- The service-level agreement (SLA) of the stakeholders to interact under conditions written in the contract.
  Note: currently there is a lot of confusion between the contract and the service-level agreement. As example[Ref. 9]:

> ***Contract [ITIL V3 Glossary]*** *= A legally binding Agreement between two or more parties.*
>
> *Service Level Agreement (SLA) [ITIL V3 Glossary] = (Service Design) (Continual Service Improvement) An Agreement between a Service Provider and a Customer. The SLA describes the Service, documents Service Level Targets, and specifies the responsibilities of the Service Provider and the Customer. A single SLA may cover multiple Services or multiple Customers.*

- Several other service-level protocols can also be introduced in service life-cycles, like service-level objective and service-level specification to formalize expectations; and service-level monitoring to control performance.

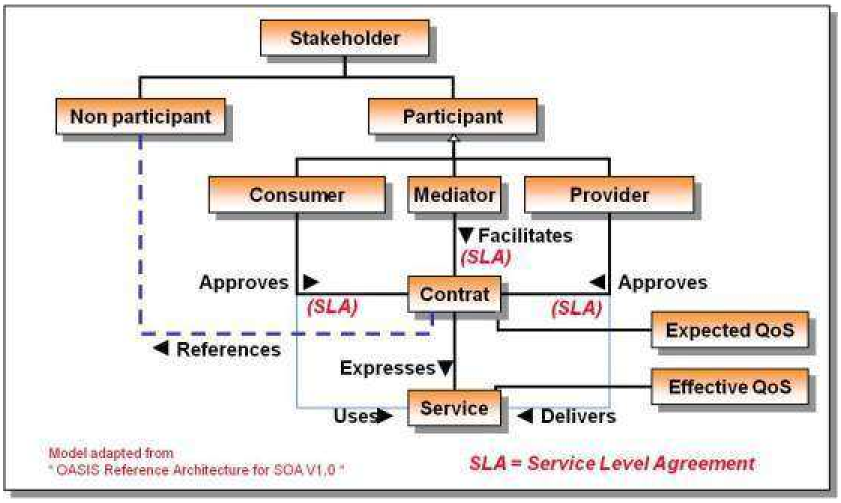


Figure 4: Contract, agreement and quality of service

Two last concepts are generally useful in service management infrastructures:

- Service repository: repositories host usable service descriptions. They are filled by providers to declare their service offers, and inquired by consumers looking for suitable services.
- Service registry: registries are used to log activities per service and evolution of the effective quality of service.

4 Life-cycles

The aim of service offer production is to develop a strategic business (often described by a "business plan"), use patterns and service delivery, and prepare all the necessary capabilities to make the service usable. It is preferable to talk about "capability" or ability, since service employment conditions are partially known at this stage. In particular, "non-functional" aspects (performance, security, dependability) and resource dimensioning can be specified in developed service contracts.

The availability of a service offer is formalized by the publication of an offer in a repository for use by involved stakeholders, at least providers and users / clients, but also authorities or agents such as mediators. A special case is when a service offer is produced by the provider. Nevertheless the two distinct roles and activities have to be considered.

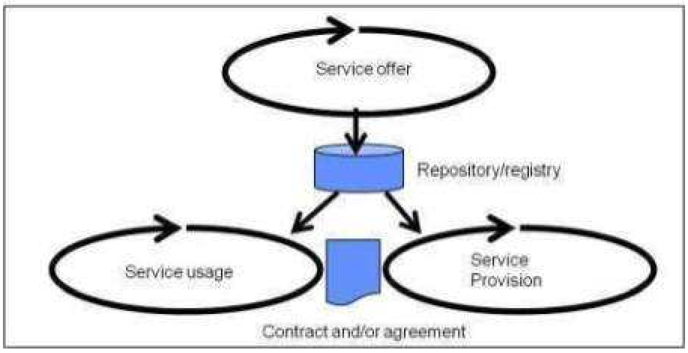


Figure 5: Three life-cycles for a Service

A service is set up when a provider and a user build a service agreement on the use and purpose of that service. This agreement may be more or less formalized by a contract. The provider may then adjust the service functionality, allocate the means to fulfill the capabilities and perform the service according to the quality (QoS) expected in the operational context. During the service preparation phase provider and user / customer must implement their respective operational process enabling the dialog between service provider / performer and the user in order to ensure the service provision. This process can be:

- Orchestrated by an external actor.
- Scheduled only by the bilateral and basic operations of exchanges. This is called choreography.

Driven by either the user or the provider in a client-server approach the process then proceeds according to the schedule set up, achieving the purpose specified in the contract or stopping the exchange by the will of any of stakeholders (the provider, a mediator or an agent, the user, the customer, the orchestrator or any entity having authority to request termination.

4.1 Life-cycle representation

The life-cycle of a system reflects its evolution over time. In line with ISO-15288 and the the INCOSE SE Handbook, a definition is "*life-cycle: evolution of a system, product, service, project or other human-made entity from conception through retirement*" and a high-level structure is described in Table 1.

Table 1: Life-cycle stages defined by INCOSE
(SE Handbook V3.2.1, Table 3-1)

<table>
<tr><th>LIFE-CYCLE STAGES</th><th>Purpose</th><th>Decision Gates</th></tr>
<tr><td>EXPLORATORY RESEARCH</td><td>Identify stakeholders' needs
Explore ideas and technologies</td><td rowspan="7">Decision Options
• Proceed with next stage
• Proceed and respond to action items
• Continue this stage
• Return to preceding stage
• Put a hold on project activity
• Terminate project.</td></tr>
<tr><td>CONCEPT</td><td>Refine stakeholders' needs
Explore feasible concepts
Propose viable solutions</td></tr>
<tr><td>DEVELOPMENT</td><td>Refine system requirements
Create solution description
Build system
Verify and validate system</td></tr>
<tr><td>PRODUCTION</td><td>Produce systems
Inspect and verify</td></tr>
<tr><td>UTILIZATION</td><td>Operate system to satisfy users' needs</td></tr>
<tr><td>SUPPORT</td><td>Provide sustained system capability</td></tr>
<tr><td>RETIREMENT</td><td>Store, archive, or dispose of the system</td></tr>
</table>

4.2 Service offer development life-cycle

The main phases for a service offer are:

- Exploratory research to at least capture the concerns and needs of actual or prospective stakeholders (identification of use cases, clients or prospects, industrial equipment, etc.); but also for market analysis and study of competition if the development is out of a client request.
- Conceptualization to formalize requirements, define and evaluate envisioned capabilities.
- Development, to implement a solution in terms of capacity and its integration in representative or prospective operational environments (integration, verification, and pre-validation).

- Preparation for in-service with service offer delivery towards the entities responsible for publication, and possibly control, labeling and/or certification by regulatory authorities,
- Provisioning, for adjustment of the solution to fit the context of service delivery, particularly to reflect the required quality of service. This adjustment covers functional and non-functional properties and allocated resources.
- Support for the correction of defects (for example, with the treatment of functional software bugs) and replacement of defective or obsolete means.
- Change management to update the service offer in order to meet the expectations of active contracts associated with the offer and support the evolution of the service.
- Offer retirement in two possible ways: either withdrawal of the offer from publication while keeping capabilities for other usage or total disposal of the offer.

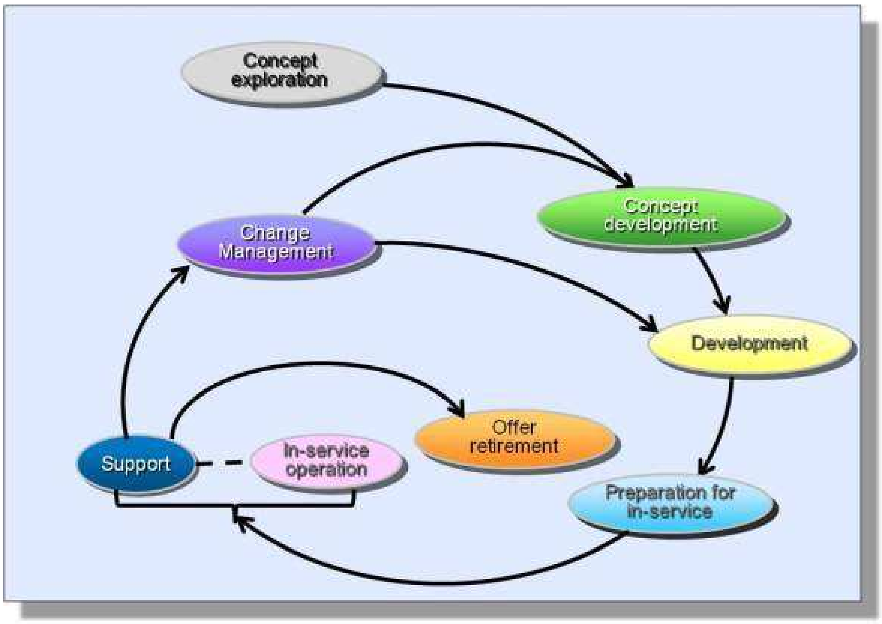


Figure 6: Service offer life-cycle

4.3 Service provision life-cycle

The main phases for service provision are:

- Exploratory research involving customers to analyze their needs. In each case, analysis of the other involved stakeholders is also performed to define a full specification of expectations. This work would be anticipated and complemented by market research and competition. This phase may require the development of new service offers.
  Note: If the consumer and the service requestor are different, both are considered stakeholders. The capture of their needs remains the priority.
- Conceptualization for the evaluation of usable offers for provision and formalization of expectations. If necessary, there may also be a request for new offers and help by third-party entities for mediation, scheduling and activity performance.
- Contracting to establish a service-level agreement, possibly with the help of a mediator. The contract expresses the mutual commitment of all stakeholders to technical economic, legal, and other necessary clauses. Preparation of in-service operation including sizing resources for activity and service exchange. This step requires the setting up of exchange protocols with the user(s), or agent consuming the service.

- In-service operation for carrying out the activities necessary to deliver the service with the expected quality.
- Support activities with observation, analysis of possible deficiencies in the service provision and resource replacement when necessary.
- Change management for service upgrades to meet the expectations of active contracts. This may imply requests for changes in the supply of a service which in turn may cause a change in service offers, with a further iteration from conceptualizing to contracting stages.
- End of service when the service is completed, or for various other reasons. Resources and means are then made available for other uses.

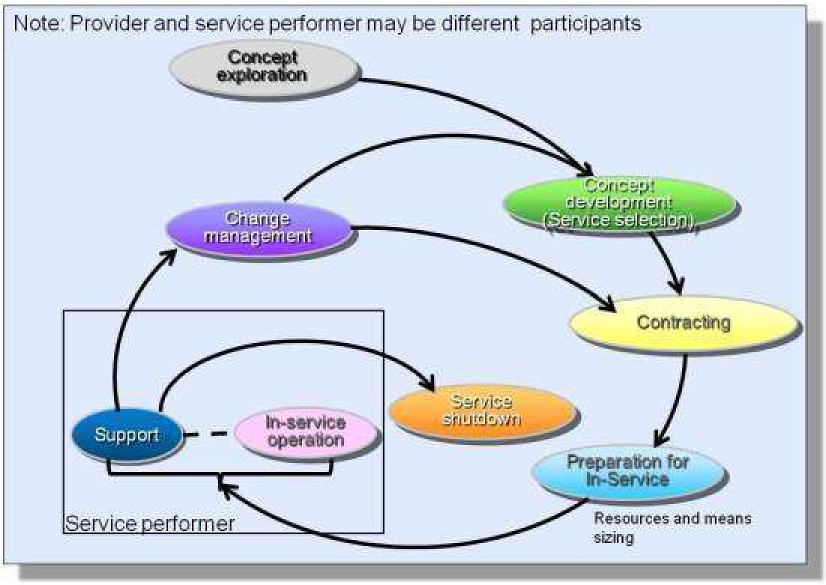


Figure 7: Service provision life-cycle

4.4 Service usage life-cycle

The main phases for the use of a service mirror those of service provision:

- Exploratory research involving stakeholders for the analysis of service supplies and providers. Specification of needs can lead to a request of new service offers.
- Conceptualization for evaluation of service offers with respect to the expectations. If necessary, there are specifications and requests for third-party help to perform mediation, scheduling and usage.
- Contracting to establish a service-level agreement in accordance with the service provider.
  Note: In the contracting phase users are stakeholders, although they do not necessarily take place in the negotiation.
- Preparation of in-service operation including sizing resources and the setting up of exchange protocols with the provider.
- In-service operation for carrying out the activities necessary to activate the service and deliver the results.
- Support for the observation and the reporting of defects in the service usage.
- Change management to adapt the service usage with the commitment expressed in the contract. This may also imply requests for change of the service provision and/or service provider; with a new cycle, from conceptualization to the contracting phase.

- End of service when the service is completed or for various reasons, with resources released.

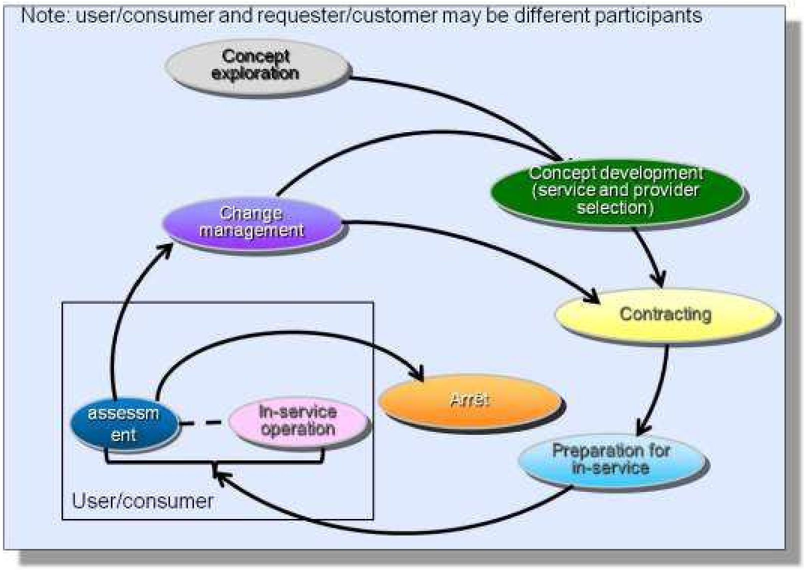


Figure 8: Service provision life-cycle

5 First attempt at Service Engineering

Service engineering is considered here from two perspectives whether the service is considered as a contributing product, or conversely, as a product of interest. These two points are presented below.

5.1 Use of Services within Product Engineering

The supplied services can be used as a paradigm of interaction at various levels:

- Services brought by systems towards organizations in support of functional processes.
- Services exchanged between organizations. This allows the necessary interactions between operational processes to satisfy the objectives of these organizations or those of an upper organization,
- Services exchanged inside a system or inside an information system to realize a functional continuity,
- Services exchanged between systems of systems for functional couplings in the aim of achieving one or several emergent effects. It results from these exchanges the constitution of systems of systems of an upper order.

In all these cases, the interactions can be more or less formalized and contractualized between the stakeholders. No hypothesis is made here on the degree of automation, or computerization of the interaction in a service form. The quality insurance of the service will be more or less satisfactory depending on the rigor of management and of the execution of the service.
The characteristic of the engineering including services to build a product is that it uses these services by taking into account the performance and the quality of the services without being concerned by the tangible products supporting these services. In other words, the specific global engineering of the product does not have “to see” the internal implementation of the service. If necessary, the supplier of a service may change this implementation as long as the service contract is respected (for maintenance reasons, for instance).

Another interest of this engineering approach is to allow the choice of services and associated suppliers for a given use case. This may be necessary to allow the consumer to adapt himself easily to a problem of obsolescence of service or to a loss of provider. This also allows the choice of services with a better flexibility, (possibly at any time), in order to optimize various criteria (performance, costs, safety, security, etc.).

This is possible particularly if the engineering can be based on logics of directories of services with suppliers and services varied in number and qualities. On the other hand, the difficulty is that each elementary particular configuration (services, suppliers, consumers) will have to be globally tested. The phases of integration, verification, validation and qualification (IVVQ) must be applied on each of these cases.

A tendency observed in fully-dynamic architectures is to perform these phases increasingly "in the fly". This would assimilate to a functional integration (or shrinkage) with the possibility of aft return if the integration step is unsuccessful. This requires accommodating variation of the operational efficiency in the time without compromising the expected outcome of the system. Thus this approach will be limited for a long time in the critical systems.

5.2 Use of Products within Service Engineering

The different engineering processes that enable the production of a service offer, the service itself and the consumption of the service involves the development or acquisition of functional and structural means for these purposes. In particular this requires the establishment of:

- An exchange infrastructure, possibly involving the use of mediation and performance agents,
- The functions and process enabling the exchange of services,
- The functions and activities enabling the provision of the service,
- The resources supporting these functions and activities.

The development or acquisition of these structural and functional means can follow current well-known engineering processes, for example the ISO standard 15288. However during the design independence must be guaranteed between:

- The service definition and those of the needed means. I.e. as far as possible service definition must not reference needed means.
- Provider means and consumer ones.

It must be noted that the engineering of the means to support the services can involve products which are themselves services. This is the case when the means interact, at least partially, through the exchange of services to assure a resultant service. A dependence of services may therefore result.

One of the difficulties of the engineering of services is to avoid cyclic dependences among the services. This problem is well known in the functional integration of systems and organizations, and is just as difficult to resolve in large developments.

An example of cyclic dependence of services is given hereunder:

- Service A depends on service B.
- B depends on C.
- C depends on A.

This case here is simple and may be easily avoided. It is not necessarily the same in architectures of several hundreds or thousands of services, the functional outline of which is evolutionary in the time and especially when the integration is performed "in the fly" as mentioned previously.

6 Examples

The following three examples illustrate the concept of service in various domains.

6.1 Example 1: Services within Enterprise Information Systems

The information system architectures have evolved according new modes of cooperation and collaboration within and among enterprises. Thus, enterprise information systems have gradually evolved to sustain business networks. It is therefore appropriate for companies to create opportunistic relationships with their partners quicker than their competitors to remain competitive.

This requirement of reactivity must then be respected in the short-lived collaborations of the organizations with a high level of interoperability. In addition, the life-cycle of information technology objects (management applications, operating systems, middle-ware, servers, networks, etc.) is increasingly short. Therefore architectures have to face technology obsolescence efficiently.

If one considers that each company has its own operational and managerial autonomy, through its business processes and its functional domains, an enterprise architecture (EA) of services will offer a neutral "space of collaboration" in which there is a repository of services such as for example: architecture patterns (such as Tele-Management Forum Operational Map and Information Framework, etc.), methodologies (such as SOMA, etc.), core services evaluation (CMMI for service), principles of governance (e.g. COBIT, ITIL etc.), reference system data, etc.. Thus, enterprise application integration (EAI) and later enterprise service bus (ESB) have become very effective infrastructure foundations to sustain collaborative services. They have notably contributed to resolve problems of (semantic and syntactic) interoperability between applications, but also problems of application integration in both heterogeneous and distributed information systems.

In these new service-oriented architectures:

- The definition of a service can be developed independently from the applications and stored in enterprise or extended-enterprise repositories. Standard descriptions of the service interface and protocol are now available for this purpose (I.e. WSDL, XML, WS-*). These definition and publishing activities correspond to the service offer cycle described in section 4.2.
- In accordance with the service provision life-cycle described in section 4.3, service implementation is sustained by one or several applications according to the defined quality of service. These applications are developed or used to perform actions in order to provide the expected results and interact with the service consumer via the defined service interface and protocol. Different examples of enterprise information system services are given in Table 2.
- For usage, according to the life-cycle described in section 4.4, the service is searched for in a repository. When suitable the application can bind to a selected service, activate it and get the expected result.
- Optionally, a mediation mechanism can be inserted between the consumer and the provider –in the interface functional chain– to translate or adapt the syntax or semantics of the protocol, exchanged parameters and/or results.
- Additional features can be provided by the infrastructure to monitor and adjust the quality of service via service configuration or change of provider.

Table 2 : Example of Enterprise Information System services

Consumer	Service	Provider	Action	Result/Expectation
HR Application	Data Request (functional service)	Data-warehouse Master Data Management	HR data presentation via Web Services	HR dashboard
Solution provider	Proposal upload (business service)	Proposal requester	Reception of a proposal as answer of a request for proposal	Proposal storage
Enterprise Resource Planning	Product tracking (technical service)	Manufacturing Enterprise System	XML file exchange	Product tracking during manufacturing

6.2 Example 2

The GMES/GMOSAIC project is a Security Pilot Project under the Seventh Framework Programme of the European Community. It aims to provide support to the definition and implementation of security related core services, based on geo-localized datasets owned by the European Space Agency (ESA). Datasets are captured by military and civilian satellites, and used to provide thematic services towards the user community. The latter includes scientists, institutional users, governmental and non-governmental agencies, involved in support of intelligence and early warning and of crisis management operations. Three service segments may be distinguished. Each relies on its own service repository: (i) Ground segment service repository to manage and control satellites that produce spatial data (ii) processing & data storage service repositories to manage and process spatial datasets as of inputs to thematic service production, and (iii) thematic data service repository filled in by GMOSAIC providers for the benefit of the user community.

EU security companies are themselves security service consumers; they consume core services (maps & reports) to provide value added services for their own users. Service setup is enabled by two service agreements: (i) between users and service provider, (ii) between the latter and spatial dataset owners (I.E. ESA).

The thematic service offer life-cycle matches Figure 6, based on thematic scenarios and requests respecting EU intervention policies for regional crises. At setup, service provision is negotiated among selected contributors (providers and building blocks) that fit requested quality and timeliness, and validate products prior to their publication on the portal.

Users can subscribe to the portal, discover existing products (1'to 4') and/or request additional products (1 to 6), according to their profile. Access to service products is managed according to signed agreements (SLA), which respect regulations and European data policies.

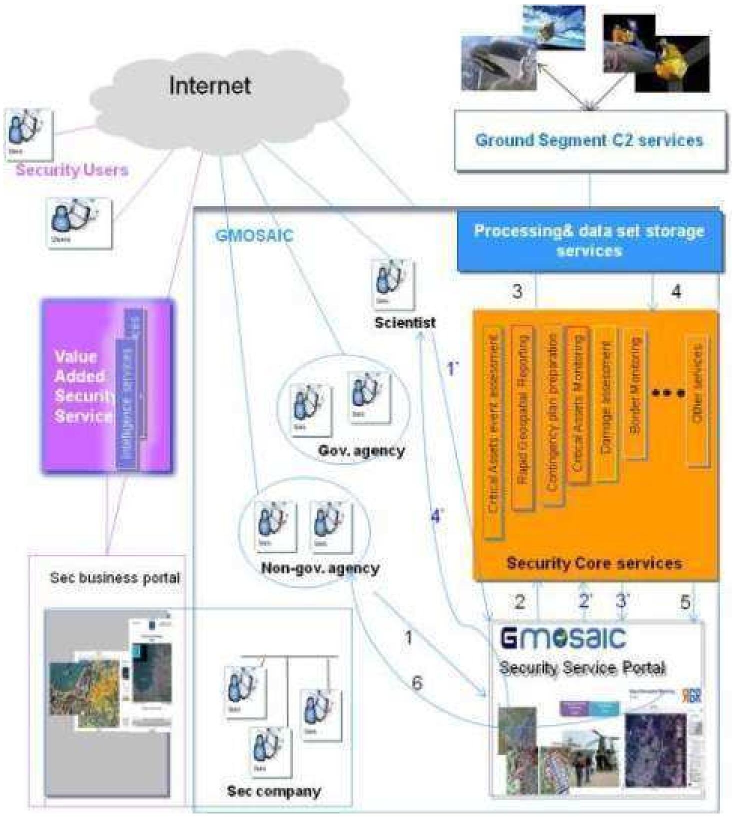


Figure 9 : GMES/GMOSAIC system overview

Table 3: Overview of the GMES/GMOSAIC services

Consumer	Service	Provider	Action	Result/Expectation
Non-Gov agency	Sub scribe to thematic	GMOSAIC Portal	Add subscriber to subscriber list	Notification of subscription
Non-gov agency	Request	GMOSAIC portal	Provide EO data on region in crisis	Contingency plan preparation map
Thematic service provider	Request data set	EO data provider	Grant access to EO data	Geolocalized data to establish thematic map
Scientist	Critical asset map request	GMOSAIC portal	Grant access to thematic historical data	Critical asset evolution map
Gov Agency	Border map request	GMOSAIC portal	Grant access to border maps	Border maps to manage crisis
Sec company	Rapid geospatial reporting map	GMOSAIC portal	Grant access to regional map	Correlate events to update intelligence products
Security user	Request regional reports	Sec business portal	Grant access to intelligence reports	Provide up-to-date intelligence products

6.3 Example 3: Medical practice

When a health hazard occurs several cases may happen:

- The patient may estimate that the situation is not serious and choose to consult a generalist doctor.
- He/she may consider that an emergency consultation is needed in a hospital.

It can be considered that the patient is selecting a medical service, as presented during the CIGI-2011 conference [Ref. 12].

In these two cases the diagnosis may lead to three different prescriptions:

- A treatment which can be pharmaceutical, surgical, rest period, etc..
- A request for further investigation with “in vivo” or “in vitro” analysis made by a laboratory.
- Or a referral to a medical specialist.

In these cases also laboratory analysis and specialist consultancy can be considered as services by the generalist. In the case of a service delivered by the laboratory the doctor makes the diagnosis and prescription; while these are directly performed by a specialist. Table 4 provides the service list for this simple medical scenario.

Regarding the life-cycles described in section 4, for example with the medical laboratory:

- The service offer corresponds to all necessary actions to make the laboratory services defined, known and available. This includes at least the definition of the range of medical services proposed on the market; acquisition and maintenance of facilities; personnel recruitment, training and management.
- The service provision comprises mainly patient welcome or sample reception, request analysis, action planning and personnel management, action performance and result delivery.
- The service usage begins with laboratory selection by the doctor or the patient. Then either the patient goes to the laboratory to get the medical service; or samples are taken by in the doctor surgery and sent to a laboratory. The further service result is provided to the patient and/or the prescription author.

Table 4: Overview of medical services

Consumer	Service	Provider	Action	Expectation
Patient	Consulting	Generalist doctor	• Anamnesis or physical examination • Diagnosis	”Classical” prescription
	Consulting	Emergency doctor	• Anamnesis or physical examination • Diagnosis	Prescription with possible immediate additional actions.
Generalist or emergency doctor	“in vivo” analysis	Imaging center	Image capture and processing	Medical imaging
	“In vitro” analysis	Laboratory	Sampling and analysis	Analysis results
	Specialist consultation	Medical specialist	• Anamnesis or physical examination • Diagnosis elaboration	Prescription

7 Conclusion

Systems engineering reference documents, like ISO-15288 and INCOSE SE Handbook, focus primarily on the product or system and make the assumption that services are simply a kind of product.

This paper goes beyond this assumption, and provides (i) major concepts for service as an interaction paradigm; (ii) basic principles of engineering services; and (iii) a description of life-cycles for offer, provision and usage of services. Examples show, through case studies, how these principles can be applied in various domains.

Services are therefore expected to be used to support interactions at multiple levels among organizations, systems of systems, systems, products, sub-systems, etc. Nevertheless, substantial effort is still required before system engineering standards can integrate proposed life-cycles.

Furthermore, research should put the focus on the dynamics of service-based system engineering, as far as the integration, verification, validation, qualification and acceptance processes of services are concerned.

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