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Information technology — Future Network — Problem statement and requirements —

Part 7: Service composition

Technologies de l'information — Réseaux du futur — Énoncé du problème et exigences —

Partie 7: Composition des services

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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ISO/IEC TR 29181-7 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

ISO/IEC TR 29181 consists of the following parts, under the general title *Information technology — Future Network — Problem statement and requirements*:

— *Part 1: Overall aspects*

— *Part 3: Switching and routing*

— *Part 4: Mobility*

— *Part 6: Media transport*

— *Part 7: Service composition*

The following parts are under preparation:

— *Part 2: Naming and addressing*

— *Part 5: Security*

Introduction

The development of the networks during the last years has shown that it becomes harder to integrate new functionality in order to fulfill the demands of new applications and the capabilities of new transport technologies. Especially the core mechanisms are hard to change as it lies in a rigid and ossified architecture.

The current picture of the networks shows a large, heterogeneous, dynamic and complex distributed system. Lots of patches aimed to amend different issues that have arisen during last years. Current networks have to deal with new services, applications and computing paradigms such as new modes of interaction, identification, context-awareness, energy efficiency, seamless service discovery and composition, mobility, ubiquity, etc. At this point, current networks must look for clean solutions to known issues.

The development of a new network architecture has been discussed for some time now. Several proposals are considered in this sense, evolutionary (incremental) approaches and revolutionary (clean-slate). Currently, the general idea in SC6 WG7 is to standardize an architecture to solve current networks faults.

The Future Network (FN) will define a scalable, flexible and robust architecture which will aim at providing services taking into account the changing conditions of the context and thus, offering customized communication and seamless delivery of data. To achieve this, it is necessary to provide service composition capabilities by means of a specific framework that will contribute to create a scalable, modular, and service-aware FN.

The FN introduces a new architecture where the necessary functionality for establishing communications in any node connected to the network (user devices and network elements), is not fixed but dynamically composed, as appropriate to user service requirements, network transfer capabilities and surrounding context in the user and the network environments. In essence, a service-oriented paradigm is followed. Communications are accomplished by assembling appropriate atomic services, each performing a specific communication function. As such, service functionalities can be combined to create higher level communication services, which in turn can be combined with other services as well to enrich existing services or to create new composed ones, until the whole spectrum of required functionality for end-user communications is in place

Service composition is the technology that supports the composition of those activities required to reuse and combine existing services to enrich current services and to create new services. This technology provides a natural way of combining existing services including both atomic and composite services. Such kind of recursive composition of composite services is one of the most attractive and challengeable features of the service composition, allowing to rapidly and easily create new services. Thus, the service composition provides benefits on improved usability of existing services, faster time for service creation and reduced time to market for new services.

Information technology — Future Network — Problem statement and requirements —

Part 7: Service composition

1 Scope

This part of ISO/IEC TR 29181 describes the problem statement, requirements and a functional building block for the FN from the perspective of service composition. The goal of this part of ISO/IEC TR 29181 is to:

a) analyze and classify problems of the current solutions on the service composition,

b) identify requirements on the service composition for the FN,

c) describe some technical aspects of the service composition for the FN, and

d) propose a functional building block of the service composition including functional components and their reference points among them.

This part of ISO/IEC TR 29181 also introduces various on-going standardization and research activities related to service composition.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC TR 29181-1, *Information technology — Future Network — Problem statement and requirements — Part 1: Overall aspects*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC TR 29181-1 and the following apply.

3.1
Atomic Service (AS)
well-defined and self-contained function or role commonly used in networking protocols (acknowledgments, sequence numbers, flow control, etc.) to establish communications for consuming composite services

3.2
Atomic Mechanism (AM)
specific implementation which provides the desired atomic mechanism functionality

3.3
Composite Service (CS)
service that is composed of more than one atomic service

NOTE The composite service logic needs to be specified in a workflow to describe the composition and execution process.

3.4
Service Composition Algorithm (SCA)
mechanism in charge of selecting and associating the specific atomic mechanisms which will create a composite service, specified in the form of a workflow

3.5
Workflow (WF)
formal representation of a CS

NOTE The result of the service composition process is the definition of a set of CSs which will be executed at the nodes involved in a communication. The atomic services are selected according to their specifications and functionalities. Concretely, the algorithm (SCA) will generate the final CS and represented by a WF.

3.6
Patterns or templates
commonly used and well-known WF

NOTE Patterns or templates can improve and speed up the selection process carried out by the execution of SCAs in specific cases.

4 Abbreviations and acronyms

ACCS	Auto-Configuration for Communication Security
AM	Atomic Mechanism
AS	Atomic Service
BPEL	Business Process Execution Language
CBA	Component Based Architecture
CBC	Component Based Computing
CS	Composite Service
DAML	DARPA Agent Markup Language
EBS	Effective Bit Strength
HSP	Heuristic Search Planner
FN	Future Network
IP	Internet Protocol
IPSec	Internet Protocol Security
JSON	JavaScript Object Notation
MOVE	Materialized Ontology View Extractor

MPLS	MultiProtocol Label Switching
NAT	Network Address Translator
NGSON	Next Generation Service Overlay Network
OWL	Ontology Web Language
OWL-S	Ontology Web Language for Services
PDDL	Planning Domain Definition Language
QoS	Quality of Service
RNA	Recursive Network Architecture
SDF	Service Delivery Framework
SIDE	Service Integration Development Environment
SLA	Service Level Agreement
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SON	Service Oriented Network
SONATE	Service Oriented Network Architecture
TCP	Transmission Control Protocol
TCS	Taxonomical Classification System
TLS	Transport Layer Security
UCPOP	Universal Conditional Partial Order Planner
UDDI	Universal Description Discovery and Integration
WSMO	Web Service Modeling Ontology
WF	Workflow
WS	Web Service
WSDL	Web Service Description Language
XML	eXtensible Markage Language
XSRL	XML Web-services Request Language

5 Overview

A service is a set of functions or tasks that provided by software or a system, usually accessible through an application programming interface (API). Considering different types of services, a service can be classified as an atomic service or composite service. Each atomic service provides one concrete and well-defined function.

Different implementations of an atomic service may exist in different nodes or co-exist in the same node. The description information of the atomic service should be published and registered to a service registry before providing the service functionality. On the other hand, a composite service is composed of more than one atomic service. Each composite service implies consuming different atomic services and/or sometimes other composite services, with possible dependences appearing between them.

Service composition is the technology that supports the composition of those activities required to reuse and combine existing services to create new services. This technology provides a natural way of combining existing services including both atomic and composite services. Such kind of recursive composition of composite services is one of the most attractive and challengeable features of the service composition, allowing to rapidly and easily create new services. Thus, the service composition provides benefits on improved usability of existing services, faster time for service creation and reduced time to market for new services.

Different design approaches for service composition are used in service oriented computing areas. These approaches can be classified on user defined, semi-automatic or automatic approaches. Under this classification, there are several design mechanisms such as template-based, instance-based, declaration-based, workflow-based, ontology-based, AI planning-based, so on as described in Appendix A.5.5. These design approaches allow building composite services to specify service composition suited for specific service or business needs.

The FN introduces a new architecture where the necessary functionality for establishing communications in any node connected to the network (user devices and network elements), is not fixed but dynamically composed, as appropriate to user service requirements, network transfer capabilities and surrounding context in the user and the network environments. In essence, a service-oriented paradigm is followed. Communications are accomplished by assembling appropriate atomic services, each performing a specific communication function. As such, service functionalities can be combined to create higher level communication services, which in turn can be combined with other services as well to enrich existing services or to create new composed ones, until the whole spectrum of required functionality for end-user communications is in place.

The process of combining available services to create a desired communication service is called service composition.

As opposed to the stringent protocol-oriented approach of current TCP-/IP based communications, the proposed service-oriented and functionality-composed approach adopts a loosely-coupled design. As such, it is beneficial in many aspects:

- It is flexible in building multi-feature and customized communication services
- It allows users to participate in the provision of the services they desire (e.g. user-control routing for performance or cost reasons)
- It provides for adaptation to heterogeneous networks from the very same terminal device
- It facilitates the deployment of new network, service and/or information access technologies from network and user access perspectives
- It avoids redundancy of functionality both in terms of duplication and unnecessary placement

The FN service composition prompts for baring user devices and smart networks. Smart networks would equip on-the-fly with the necessary communication functionalities as appropriate to changing user needs and requirements while, at the same time, they would choreographise themselves to deliver the requested services at the desired quality levels.

Figure 1 illustrates a conceptual architecture of service composition in the FN that is composed by the following functional building blocks.

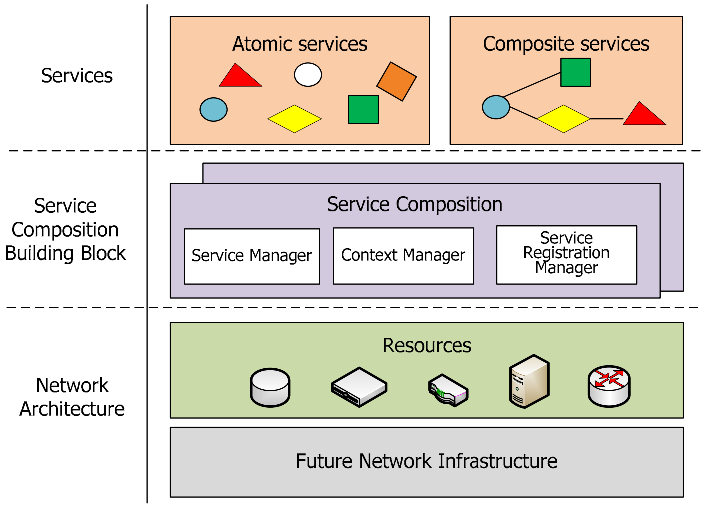

Figure 1 — Conceptual architecture of service composition

- Services

  - From the service composition perspective, services can be classified by atomic services or composite services

  - Atomic service corresponds to a base service that cannot be further decomposed and it does not contain other services

  - Composite service corresponds to a service that is composed of more than one service which can be an atomic service or also composite service itself. It contains an execution sequence of the composite services

  - Figure 2 illustrates a possible taxonomy where services can be classified in different arrangements such as granularity, scope, execution, usage, order, and purpose [1].

    - Granularity: services can be classified as atomic or composite.

      Each atomic service provides one concrete and well-defined networking function (along with the reverse function, if any). Different algorithms and implementations of an atomic service may exist (e.g. different congestion control algorithms), and co-exist in the same node, using attributes to both describe the different possibilities and to tune/configure the atomic service in order to use it to fulfill specific workflows needs. Atomic Services will abstract specific implementations of different functionalities. The specific implementation will be called Atomic Mechanism.

      Each composed service or application implies consuming different atomic and sometimes other composed services, with possible dependences appearing between them. In addition, they can involve one or more nodes, depending on the complexity of the service.

    - Execution/Distribution:

      Isolated: local execution of the service.

      Distributed: execution distributed between two nodes, regardless their location. It includes support for end-to-end, section and hop-by-hop distribution/allocation of services.

- Scope: services can be applied with different scopes or considerations depending on the desired result.

  Network: services are executed to optimize communication according network context.

  Application: services are executed to optimize application behavior and interconnection to meet application requirements according to context characteristics.

- Usage: rules governing the service usage.

  Mandatory: usage of this service is mandatory as it is basic for establishing a communication (e.g. forwarding).

  Optional: usage of this service is optional, its usage will depend on application requirements and context characteristics.

- Purpose: which is the purpose of the service. Some examples are shown next.

  Delivery: to deliver data between two different entities involved in the delivery chain (they can be adjacent or non-adjacent nodes or they can be two end applications, depending on the scope of the service).

  Mobility: services related to application, user and node mobility.

  Storage: services dealing with the storage of data.

  Security: services dealing with security issues.

  Data Adaptation: services dealing with adapting and transforming data for different objectives, interoperability, customization and optimization of data.

  Addressing: services dealing with the identification and labeling of resources.

  Management: services dealing with the management of the different entities in the network (nodes, applications, services, etc.).

  Signaling: services dealing with interchange of signaling and control data.

  Presentation: services dealing with the presentation of contents and user/application interfaces.

- Order: order/existence of the AS in workflow composition may be dependent of another service.

  Dependent: needs the use of another AS.

  Independent: no need of other AS execution.

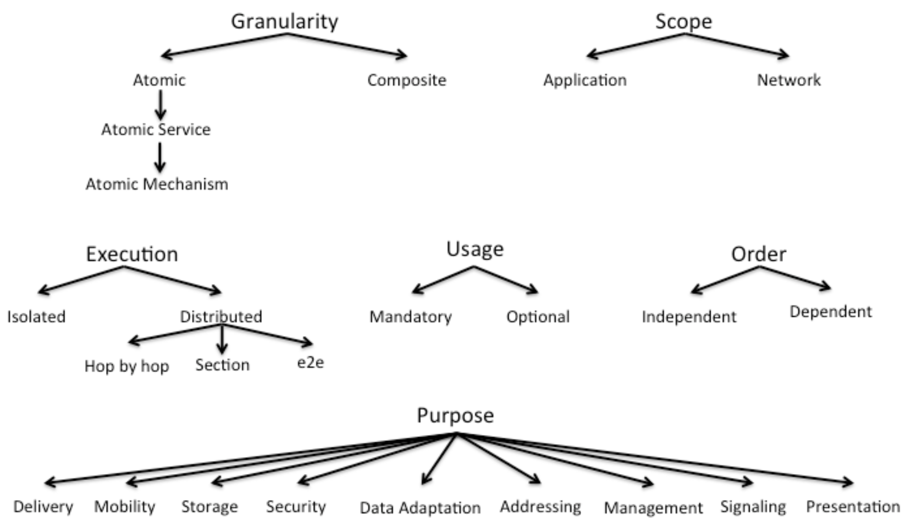

Figure 2 — Service taxonomy

- Service Composition Building Block

  - The FN architecture consists on different architectural components as building blocks that provide a set of supporting technologies such as naming and addressing, switching and routing, media distribution, security, and mobility

  - Service composition is one of the architectural building block identified to support composite services and it is composed by a set of managers such as service manager, context manager, and service registration manager. These managers provide a set of supporting functions such as service selection, service chaining, interpretation of composition description, service execution monitoring, service validation, service adaptation.

  - In the FN, both static and dynamic service composition are supported

- Network Architecture

  - The FN supports the virtualization of different kind of resources that are spread across different locations such as storage, computing power, processing power and network

  - Thus, proper amount of resources can be flexibly dedicated to each atomic service and composite service. For this purpose, the service composition building block should support some mechanisms to coordinate virtualized resources required by composite services.

6 Problem Statement

6.1 General problems

Several challenges might be faced for designing an integral solution for the service composition in the FN that allows to overcome the current technologies and deficiencies.

A new concept and definition of services for the FN will be closely connected to the innovation of heterogeneous environments formed by different kind of networks and users with different requirements. The FN design will allow adopting futuristic capabilities. Complex and personalized users' requirements introduce the need of networks able to be self-configurable and self-evolvable. Considering this, the service composition technology should be also extended to cover possible changes derived from the service and network evolution.

New distributed software systems have become more dynamic, allowing transparent distribution, self-reconfiguration, portability, etc. Based on that, new paradigms deviated from the end-to-end principle have emerged, such as Pervasive and Ubiquitous Computing or the Internet of the Things.

In addition, the continuous evolution of applications and services are increasing current networks complexity, adding more and diverse requirements (e.g. mobility, security or multihoming) that are not efficiently covered by current TCP/IP protocol stack, as detailed in ISO/IEC TR 29181-2/3/4/5. New features such as data and service identification, context-awareness, seamless service discovery and composition, etc. are required in order to meet the new demanded services and modes of interaction. The lack of these features is withering as well the evolution of networks and slowing down or stopping solutions for known open issues like mobility, flexibility, security, etc. A service-aware architecture should help the deployment of clean-slate solutions in all these aspects.

Nowadays, network level services are executed without taking into account the characteristics of the surrounding context. Consequently, the current architecture fails to provide information of the underlying network technologies, the capabilities of the devices involved in a communication or the characteristics of the users interacting. This provokes that similar or redundant network services (e.g. error correction, retransmission, encryption) are executed at different levels wasting computing resources, introducing unnecessary redundancies and sometimes degrading communication performance. Furthermore, in certain environments, the execution of certain functions can be counterproductive for the correct operation of an application or network service (e.g. TCP's congestion control in wireless networks), making it necessary to modify existing protocols in order to adapt them to environments with restrictions.

This situation is mainly provoked by the rigid and layered communication stack which difficult inter-layer communication. For example, in constrained networks, the need for efficiency in both communication and node performance and energy consumption has led to the prevention of layering and related complex abstractions-by fine-tuning network protocols to application requirements. These approaches result in network architectures that are tightly coupled with the applications, and thus are application-dependent. Therefore, in order to keep the required application-agnostic network architecture simple but flexible, as well as sufficiently optimized, these non-layered solutions should be generalized, thereby converging in modular network architecture able to perform optimally according to different application needs and heterogeneous node capabilities (ISO/IEC TR 29181-1).

However, there are some problems that hindered the deployment of service composition at a macro level. Applying service composition techniques at transport layer means a change of paradigm, which can affect the design of the whole architecture. The inertia caused by the usage of TCP/IP stack and its ossification makes a clean integration of service composition impossible.

Furthermore, a deployment at higher levels is becoming extremely difficult because of the lack of efficient context- and service-aware features and the proliferation of different particular solutions that are not interoperable between different service providers or domains.

Additionally, some scalability aspects may be taken into account, during the service identification and composition process. Depending in which granularity the service is defined, the composition could turn in a high complex process that can last for too much time and this would suppose an unpractical solution. In order to find a feasible solution for service composition, tradeoffs between composition time and optimization should be found.

Currently, services are linked to the physical entities that handle the service. That means that in current set-up, services are addressed through network location of the server and not in a descriptive manner that permit an efficient service discovery. That implies that the service discovery depends basically on the web search engines that permit us do a natural search, or rely on our previous knowledge of where to find the service. Thus, current service discovery processes have a very limited scope. This is especially true for interactive multi-media services and applications, which can dynamically combine different media flows (audio, video, advertisements, etc.) from a multitude of organizationally dispersed sources, content servers, cameras and advertisement/recommendation systems.

For this reason, a shift from current convention towards a more service-oriented architecture is required. Consequently, a generic definition of services and a standard framework to publish and discover them are elementary needed processes. It is important that this definition would be technology and network agnostic.

Thus, services can be discovered and requested at a semantic level, transparently to the exact location of the service and the underlying access and implementation technologies whilst enhancing the interoperability between systems in all kind of environments.

In order to invoke a service available inside a network, a service request and handling mechanisms should be provided by the FN architecture. Ideally, these processes should imply the lightest possible exchange of information between the entities in order to maximize the throughput of networks. Solutions around this issue in current network are performed at an application level and are not suitable as they use heavy communication protocols based on XML (e.g. Web Service technologies). They are not efficient and they are barely prepared for handling a service configuration setup process involving network context and QoS parameters. Service negotiation should be enhanced, allowing users a better control of the services that they are consuming and network administrators of service providers a better management of their resources. Interoperability in service negotiation is a priority as well in order to find mechanisms that alleviate different provider tensions and creating “all party win” situations [2].

A service-oriented landscape where providers can be positioned as competitive collaborators providing multi-provider service compositions is desirable. For that reason, the lack of a negotiation protocol, able to negotiate in-network services between different providers, is an obstacle that should be solved in the FN specification. Furthermore, the introduction of strategies in the network that guarantee a certain level of Quality of Service (QoS) and Quality of Experience (QoE) should be as well a critical need in the FN. Hence, both users and providers, should explicitly specify and agree on the terms of the services that they will receive/provide.

Taking these problems into account, there are some features close related to Service Composition in the FN that should be inherently integrated in its architecture:

- **Dynamic network composition.** Establishing network functions as services that can provide and access easily to all this information should be an essential feature in the FN, in order to have a network that can adapt to current requirements and new ones that eventually rise up. A greater modularity of the network means a better adaptation to new communication paradigms, while decreasing the complexity of the architecture. Unlike static service composition, services can be specified at run time. It means that the capabilities of the service can be extended dynamically, allowing runtime re-composition, decomposition of services, and dynamic adaptation in case of changes in context (services and resources) involved in composite services.

- **Network flexibility.** Network service composition should facilitate in the FN the integration of new functionalities into the network. Instead of tight coupling of functionalities within end-to-end protocols, network services are deployed on arbitrary nodes, are loosely coupled and provide their service to arbitrary other functional blocks. This design originates in the service oriented architecture approach and requires means of service description, discovery and composition. This design approach reduces management efforts and provides a flexible framework to integrate new network services.

- **Inherent cross-layer information exchange.** Cross-layer means that functionalities can be adjusted based on the interaction between different layers. The FN should allow arbitrary composition and information exchange between network services, thus incorporating the benefits of cross-layer design architectures.

- **Context-awareness in service composition.** The FN should support the context management to provide customized and context based services. Thus, different kind of context including user, device, service, resource, and network can be used for discovering, selecting, allocating and composing services to participate in the composition process.

- **Requester empowerment in service choice and routing.** Service requester should have more control over the contents/service that wants to consume. This control must be reflected in flexible routing and service selection according to requester's service definition. Consequently, the FN must build a network architecture that provides more intelligence to the network-side whilst still leaving decision-making processes at the end-points.

- **Semantic Searches oriented to service/resource.** The FN must be focused on a service/data-centric approach that allows executing the search of services and resources based on the requester

