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Dynamic Service Composition for Telecommunication Services and Its Challenges

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Abstract

As communication networks have evolved towards IP (Internet Protocol) networks, telecommunication operators has expanded its reach to internet multimedia web content services while operating circuit-switch networks in parallel. With the adoption of SOA (Service Oriented Architecture) that enables service capability interfaces to be published and integrated with other service capabilities into new composite service, service composition allows telecommunication providers to accelerate more new services provisioning. From the perspective of telecommunication providers to deliver integrated composite service from different providers and different network protocols, this paper is aimed to present the current service composition based on middleware approaches; discuss the requirements of meeting the challenges; and compare the approaches.

Keywords: *Service Composition Converged Services, Middleware.*

1. Introduction

As communication networks have evolved from circuit-switch to packet-switch centric over IP (Internet Protocol) networks which realized the transformation toward Next Generation Network (NGN), telecommunication operators has expanded its reach beyond the traditional communication service capabilities (i.e. application functions) to IP domain. This expansion includes web content services, audio/video streaming, and even broadcasting services. The need of this expansion comes with several reasons, obvious ones are due to:
i) High demand of wireless networks, various service capabilities are needed to be integrated with their complementary characteristics in order to provide better user connection access and personalized services regardless of the location and time;
ii) Accelerate more new converged services provisioning, telecommunication providers want to enable third-party companies to provide services through their service delivery environment, including the offer of their access network capabilities to be reused by third-party service providers.

In order to realize dynamic composite services creation at run time, service composition approach(s) that can support service capabilities from both telecommunication access networks (e.g. voice mail, location, etc.) and IP domains (e.g. internet web services) is essential. This implies the need to support different protocols from different networks.

Consequently, the composition approach is required to manage and control various multiple services interaction during the composition process, this implies the need of mechanisms to manage and control the conflicts of interactions (such as service functions incompatibility) that potentially may occur between the service capabilities running on different protocols and access networks.

Research and implementation work of service composition approaches have been done widely from internet web services aspect, but scarcely include telecommunication services perspectives.

From standardization body effort, there was a vision of Service Creation Environment (SCE) emerged in the intelligent network concept defined by the ITU-T (International Telecommunications Union). The SCE is aimed to enable telecommunication operators to create new services without the need of changing software for cutting cost and time to service provisioning.

The SCE is later evolved into a service delivery architecture that allows re-use of service capabilities (i.e. service

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application functions) and thus enables integration of multiple service capabilities. This evolution is then path the way of the development of next generation IP Multimedia Subsystem (IMS) standard specifications by 3GPP (3rd Generation Partnership Project) from the aspect of sustaining high Quality-of-Service (QoS) for multimedia support and interoperability between networks.

The IMS architecture is specified as a horizontal architecture with the objective of enabling different common service capabilities be invoked, combined and quickly deployed made available to service provisioning. Service Broker as defined in 3GPP study report [1] is a functional component of IMS that aimed to support dynamic service capabilities interaction between any types of IMS application server during runtime in an IMS environment. However, IMS Service Broker does not solve all the problems of service interactions for composition [2].

This paper is aimed to present the overview of service composition; analysis of the composition requirements; discuss the current service composition approaches; and the challenges in realizing the service composition from the perspective of integrating services from different protocols with different characteristics.

2. Overview of Service Composition Principles and its Environments

To position service composition in a communication service delivery framework, Fig. 1 gives a simplified layered view of where service composition functions are possibly resided or interacted depending on different approaches applied.

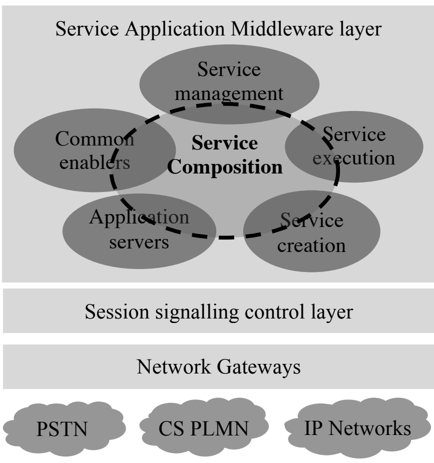

Fig. 1. A layered view of service composition in a telecommunication service delivery environment

The top layer is where application functions and service components reside. The key components of this layer are Application Servers that might be running on different protocols (such as HTTP and SIP) and common server components that help serve the multimedia content delivery such as the Media Server, Instant Messaging and Presence Server. For the session signalling control layer, it is basically responsible for the registration, security and signalling control logic.

The network gateway layer sits on top of the connectivity level to bridge the session signalling and the legacy networks and is comprised of gateway components such as Signalling Gateway (SGW), which translates between SIP and SS7 signalling and the Media Gateway (MGW) translates between IP and the legacy transport network.

Since Service Oriented Architecture (SOA) has been adopted in software engineering methodology, application functionalities are modeled as services and published as interfaces. SOA enables the realization of loosely couple architecture systems that are able to interact, compose and integrate in an open and dynamic heterogeneous networks environment. The mechanism of combining two or more services into a new composite service is known as service composition.

Fig. 2 elaborates the generic service composition model (SCM) with its components as defined in [3]. Following is the summarized function of each component based on previous works:

- Translator: Application makes functionalities request by sending requests to the middleware layer, which described with different system languages or approaches. The Translator component translates the request language to a system comprehensible language to be used.

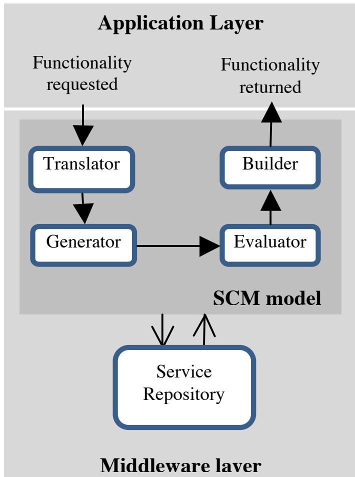

Fig. 2. A generic service composition model [3]

- Generator: The Generator plays the role of composing needed and available functionalities. It generates one or more composition plans with same or different services available. Composing service is essentially achieved by chaining service interfaces which is usually described with a specific language or presented as a graph.
- Evaluator: This component selects the most appropriate composition plan performed by Generator for a given context such as application, service technology model, network condition and non-functional quality of service considerations.
- Builder: The Builder executes the chosen composition plan based on Evaluator decision and generates an implementation marching the required composite service. The requesting application can execute the composite service once it is available.

From telecommunication service provisioning perspective, service composition to form a new communication service includes the integration of multiple service capabilities acting on a single communication session (i.e. call instance on asynchronous mode) – this characteristic distinguishes its composition behavior from mere web service compositions

which act on a multi-session request/response synchronous communication mode.
For the clarity of this paper in seeding its context, we denote "a new composite telecommunication service created from the integration of multiple service capabilities running on different communication protocols by various providers" as 'converged service' throughout the rest of this paper.

3. Requirements of Converged Service Composition

To identify the characteristics of a converged service composition environment, we use a semantic net diagram in Fig. 3 to show the attributes and their possible relevance. Based on the attributes in Fig. 3, we generalize and group them into the requirement criteria of service composition approaches for a converged service.

I. Interoperability

This criterion enables two or more service capabilities to exchange information and utilize the exchanged information. The exchanged information contains different communication formats. For services delivery environment that consists of different devices, service capabilities and networks that operate on different communication protocols, interoperability is required at all levels.
Interoperability issues from IMS service composition aspect on different types of application server with different data formats and different signaling protocols has been studied in more detailed in [2].

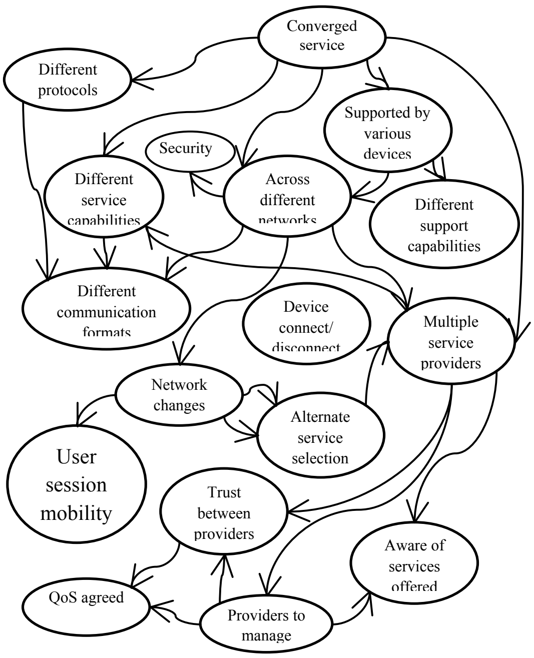

Fig. 3. The characteristics of a converged service composition environment

Service composition approach needs to take considerations of the context of its environment in order to take advantage of all the application functionalities available besides taking precaution of possible system conflicts.

II. Discoverability

Discoverability is the ability to identify and locate access devices and services requested. Service composition approach needs to have this capability to discover the surrounding entities that are requested from a dynamic network environment. User devices access networks can be changed due to different access locations. When changing network, the previous services will need to be re-established or alternate service(s) is required.

III. Adaptability

Adaptability is the ability to adapt to environmental change such as user session connection/disconnection due to network change, and service execution environment changes due to user's mobility. This ability is required in order to substitute available matched service capabilities in the new environment to ensure continuous service delivery. Adaptability also includes the ability to compose new service independently of user and application requests when relevant service matching is met based on the current context though not requested by users or applications.
The adaptability feature should be able to manage its resources, service capabilities, security and performance in case of failures or changes occurred, with little or no human intervention. This ability is needed in order to enable human to focus on the creation and supervision of high-level management policies instead of handling the complexity that occurs in the environment which mostly causes longer time and effort for human to solve.

IV. Context awareness

Context awareness is the ability of having awareness of devices connecting and disconnecting, service capabilities offered and access, quality of service attributes change and network access connection change.
This ability is needed in order to provide best service with the surrounding context.

V. Quality of service (QoS) management

This criterion takes non-functional parameters into consideration such as services compatibility, service provider policy-based agreements, and device characteristics. We consider QoS includes trust management because when multiple services from multiple providers interact, it is essential to establish mutual trust with agreements. The mutual trust is not only for authentication and billing, but also for the verification of service capabilities behaviour in composition. Further, it is important to ensure system performance from the aspect of protection of arbitrary and malicious service behavior.
In order to have quality of service with mutual trust agreement, it is important that service capabilities providers need to have control on this requirement. This requirement aspect indirectly influences the service delivery layer architecture of the converged service composition approach.

4. Related Work and Approaches

There are lots of research work have been done and implemented on service composition from academic and commercial widely from web services aspect, but scarcely include telecommunication services perspectives.
Service composition approaches can be grouped based on different aspects. The aspect that is usually found in bibliography divides service composition into three characteristics: static (services to be composed at design time) and dynamic (composed at run time), automatic (no human

intervention) and manual composition (user –driven composition).

There are numerous studies on the state of art and survey on web service composition approaches. In [4] [5] [6], the state of art and challenges of service composition is discussed. Surveys from different aspects are conducted in several papers: [7] focuses on service composition in pervasive environments and [8] discusses the composition issues in pervasive environment; [9] surveys from Artificial Intelligent (AI) planning aspect whereas [10] gives the overview from semantic aspect; [11] presents the survey on tools to automate service composition; [12][13] presents a survey on web service composition methods based on Quality of Service (QoS); several studies on service composition formal languages and models are presented in [14][15][16]. Work in [17] examines media-oriented service composition approaches with service overlay networks.

As there are tremendous works on service composition in the bibliography, in this paper we focus on the service composition approaches for discussion based on their relevance in supporting converged services. As discussed in Section 2, the requirement of providers needing to manage QoS with mutual trust agreement systematically indirectly influences the service delivery layer architecture of the converged service composition approach. From service delivery architecture aspect, middleware, broker, and related approaches will give control for service providers to manage QoS. With this reason, we selectively discuss existing work based on the middleware approaches inclusive of works from Standardization.

i) Middleware approaches

Middleware approaches to explore different middleware solutions. The SOA architecture enables the realization of exposing service functionalities and access to available system resources from different providers, organizations and networks. In SOA, the challenge of service composition mechanism is to enable services adaptable, reconfigurable and fault-tolerant. Most of the solutions used middleware approaches to tackle the problems especially on service discovery and invocation.

A service composition layer that ensures policies are enforced is discussed in [18]. The service composition layer takes policies as inputs and domain knowledge of the system. Services interfaces are defined to enable interoperability with different service discovery model and communication protocols. Users are be able to describe, browse and edit their policies by interaction through a multi-modal interface in which policies can be expressed using a combination of text, speech and diagrammatic representations.

Broker method for service composition in mobile environment presented in [19] is a distributed architecture with associated protocols, mobile service topology and device resources. The associated protocols are based on brokerage mechanisms and apply a distributed service discovery process over ad-hoc network access connectivity. The composition protocols replies on device-specific value, taking consideration of service available on the devices, energy and computational resources, and service topology of the mobile environment. The architecture consists of a composition manager that handles the service discovery, integration and execution of a composite service request.

The approach in [20] develops composite telecommunication services for mobile phones. A model-driven service creation environment with a repository is used to import and export the definition of services and a life-cycle manager in order to activate and execute services. A SPATEL service description language is developed (which customised based on UML language) is defined to describe service interfaces and composition logics that suit telecommunication domain.

A light-weight Java-based framework [21] KitCAT, is used to support telecommunication service mash-up between the integration between SIP and HTTP-based service functionalities, with the use of BPEL engine to provide the orchestration capabilities for web services based on Java-to-SIP and SIP-to-Java function interfaces through SOAP interfaces.

There are numerous works for service composition in IMS service layer. Method proposed in [22] extends the IMS application layer to integrate different protocols SIP, HTTP and RTSP service delivery. According to [22] an application policy function uses protocol specific extensions to integrate services. Based on the policy function, service invocation and integration is realized via static behavioural descriptions within the function.

An integrated telecommunication and internet service delivery platform for interworking between web services and IMS services is presented in [23]. It proposes a SIP –based Micro Service Orchestration and Web Services bus to integrate the services and underlying network resources. The platform is also aimed to support integration of CAMEL or Parlay services, SIP, Diameter and web services. A policy manager to support user defined policies and its enforcement on a per service session basis. A Service Provider Deliver Environment is proposed for creation, deployment and delivery of service functionalities. A service broker is used to manage service orchestration function.

The work in [24] presents the study on SCXML workflow engine for real-time network-centric service composition between SIP-based and IN/CAMEL services based on a session control abstraction layer for IMS.

A decision-making mechanism for a personalized communication controller in IMS based on XACML policy framework is introduced in [25]. The policy-based workflow framework provides static and features are handled as variables in the workflow system. Another policy-based Service Broker middleware with feature interaction function proposed in [26]. It derives general policy taxonomy to control system behavior, and also for network operator, service providers and users' preferences enforcement.

Several works focus on service creation environment for the purpose of speeding up and simplifying service creation and development process. An Eclipse IDE plug-in service template toolkit for rapid service creation is proposed in [27], by using a model to separate workflow definition and service provider configuration. The model used is based on template profiles to describe business parameters and a template deployment package including telecommunication service logic, which can be composed with BPEL or SCXML.

Work in [28] introduces a graphical service creation platform for users with no computer programming skill. The platform architecture runs on distributed environment for service creation and service execution with a service repository. The platform environment is aimed to support interoperability between web services and telecommunication services under a telecommunication operator-owned infrastructure. In the platform environment, users are provided with a web portal for service creation, a service life-cycle manager to automate deployment tasks, a user information manager to handle profile and context data. The composition logics are realised based on BPEL engine.

MySIM [29] is a spontaneous middleware that composes services without the intervention of users and applications in the environment. MySIM enables the adaptation of the application execution to services available by redirecting the request call to services with better QoS. MySIM adopts approaches of middleware and semantic which it applies reflexive mechanisms for syntactic interface matching and ontology reasoning for semantic matching.

PERSE [30] introduces a sematic middleware that handles common functionalities for instance service registration, discovery and composition. It also supports interoperability between different syntactic and semantic service description languages and formal specification of service communication which enables automatic reasoning about service behaviour and supports of QoS requirements.

SesCo [31] employs a service-oriented middleware platform named Pervasive Information Communities Organization (PICO) to represent resources as services as directed attributed graph. It stores a repository of graphs as a reference to compose multiple services into integrated service dynamically based on their syntactic and semantic descriptions. SesCo suggests a hierarchical service overlay technique using LATCH protocol which enables the aggregation exploitation of the presence of heterogeneity through service interaction.

Work in [32] proposes middleware architecture called Component Runtime Environment (CoRE) that discovers the requested service semantics via the Component Service Model with Semantics (CosMoS), and composes a service based on its semantics through the Semantic Graph-Based Service Composition (SeGSeC) mechanism.

An ontology-based framework is proposed in [33] for automatic service composition. An algorithm to produce composite services based on high level declarative descriptions by using composibility rules to compare semantic and syntactic functions of web services for matching purposes.

A QoS broker based process model is proposed in [34]. The broker publishes web service interfaces to the UDDI registry (Universal Description, Discovery and Integration). The broker quality analyzer verifies QoS certificate by either user or other web service provider to select the best service among the collection of similar functionality base don rating factor.

ii) Standardization Approaches

Service Capability Interaction Manager (SCIM) was introduced in the 3GPP TS23.002 [35] for the aim of supporting “interaction management”, but definition is vague from the aspects of detailed structure and functionality. In [35], it is stated that the SCIM components are “represented by the ‘dotted boxes’ inside the SIP Application Server“, and the internal structure of Application Server is beyond the scope of the 3GPP. In short, the SCIM is a term for managing service capability interaction without standardized requirements. As the result, the SCIM components in 3GPP became the function that presumably would resolve all the service component interaction challenges - which consequently causing the current implementation at present are mostly proprietary.

In [36], 3GPP standardization proposes SCIM as ‘a specialized type of SIP Application Server, the service capability interaction manager (SCIM) which controls the interaction management between other application servers”.

Service Broker was first proposed in the 3GPP Release 8 as a study item, which is aimed to "manage the interactions among multiple Application Servers" [1].The function of Service Broker should enable the “applications to reside in any type of IMS Application Servers including an IMS-SSF, SIP AS, OSA SCS or other (e.g. OMA enabler) or any combination of the above”. Apparently, the aim was to further study the SCIM-like functions via Service Broker.

The Service Broker defined in the 3GPP study report [1] is aimed to control service capabilities interaction between any types of IMS application servers. Service Broker should support dynamic service interactions and orchestration in an IMS environment at runtime by composing modular service capabilities to create and provide new integrated services.

Supporting dynamic service capabilities integration requires mechanisms to manage and control the conflicts of interactions that potentially may occur between the service capabilities. Nevertheless, Service Broker function in realizing the interaction management remains vague, for instance, the mechanism of how it should control multiple invocations of service capabilities between application servers from different service providers, and also the mechanism of how it should manage the incompatibilities between the invocations. Due to its definition is still not clearly specified in the standards, at present the Service Broker function is mostly implemented in proprietary manner. A more detailed specific analysis on Service Broker and its issues was presented in [2].

Despite the unclear definition of SCIM and Service Broker in 3GPP, there is an Implementation Agreement in Multi-Service Forum [37] for SCIM/Service Broker function for interoperability purposes. The specification of its procedures for ‘interaction management’ is also remained imprecise.

5. Comparisons of Approaches of Converged Service Composition

The following matrix in Table 1 shows the comparison of the service composition approaches discussed earlier corresponding to the requirement criteria discussed in previous Section 3.

Standardization approaches are not included in the comparison because the SCIM definition [36] from the aspects of detailed structure and functionality is beyond the 3GPP scope. The Service Broker function [1] remains imprecise and as study item.

6. Discussion

There is no truly dynamic and automatic interoperability in real time based on the existing approaches. The current approaches do not propose or include composition that delivers new composite service in real-time automatically, except [29] without user intervention and upon the middleware own decision based on semantic and syntactic matching.

Interoperability and discoverability are currently resolved by ontology and semantic-based languages and service description model. On a more practical perspective, the use of semantic and ontology based languages is insufficient to realize full interoperability for service composition. The reason is due to service providers use different ontology domains and transformations from one domain to another.

Semantic and syntactic matching between different service ontology domains and different service descriptions defined by different providers requires not only textual mapping but also interpretation accuracy in term of understanding the functionalities of services, before services are considered interoperable.

No approaches propose or mention mechanism to manage their service capabilities, security, and performance as a whole, in case of failures or changes during service composition, with little or no human intervention. Adapting to contexts is proposed in several approaches with semantic-based descriptions of user, device and services. Adaptation during service composition between service providers is a challenge for semantic-based contextual description due to different taxonomy defined and across different domains. The approach in [19] defined a protocol that is able to adapt the changing of service topology and resources, and deals with the fault during discovery and execution.

The approaches listed in the comparison do not propose or mentions solutions to address security problems and mutual trust management. The lack of security and mutual trust management is an obstacle to true dynamic and automatic service composition in real time. Process model in [34] does support QoS certification for user-to-provider and provider-to-provider agreement, but without mentioning security aspect in case of failure of changes occur. As a result, converged services are still mostly created manually by hand, supported by tools for high-level programming languages and script languages.

Table 1. Comparison of differences service composition based on middleware approaches

Requirement / Approach	Interoperability	Discoverability	Adaptability	Context awareness	QoS
MySIM [29]	Supported by event-based integration	Semantic-based discovery	Supported by service input/output level	~	Supported service operation inputs/outputs level
Scooby [18]	Ontology-based policy expression	Service descriptions	~	User context	
PERSE [30]	Semantic-based syntactic service descriptions interoperability	Semantic service description	supported at service description level	Semantic service description	Based on non-functional properties specification
SeGSeC [32]	Semantic- based composition	Supported with semantic	~	Supported with semantic	~
SeSCo [31]	Semantic-based composition to generate Service graph	Supported with ontology-based sematic	Supported at device context level	~	Supported at device context level
Broker [19]	Supported with semantic and user historical context pattern	Use DAML to describe service and group-based discovery protocol	Service topology and resources changes, discovery or execution level fault	~	~
WebDG [33]	Ontology-based web service composition	Supported with ontology	~	Supported but no detail provided	Supported but no detail provided
IMS/HTTP/RTSP blending [22]	Policy-based integration for different protocols integration	~	~	~	Policy enforcement at protocol specific extension
SPATEL [20]	Semantic-based with UML extended service description language	Supported with semantic tag	~	~	Supported with semantic tag
SDP[23]	Semantic-based	~	Adapt at user policy level	~	Enforces user defined policy
KitCAT [21]	BPEL engine for orchestration	Supported with interface information	~	~	~
Extended SCIM[24]	SCXML workflow for service composition	Supported with no detail provided	Adapt at policy level	~	Business rules as policy
XACML extension [25]	Policy-based integration with XACML	~	Supported by back-to-back user agent at policy level	Device, session and user context	Supported using its policy control
Eclipse plug-in toolkit [27]	Composition at service creation level with BPEL/SCXML	~	~	~	~
Service creation platform [28]	Composition at service creation level with BPEL	~	~	~	~
Service Broker [26]	Semantic service description model with Java execution	Supported with service description model	Service provider and user preference context level	Service context, presence	Supported with global policy and service policy
QoS Process model [34]	Composition process model based on UDDI registry information and Web service level agreement	Web service level discovery using UDDI	~	~	We service level QoS verified using WSDL
Note: Symbol "~" indicates either 'not supported' or 'not mentioned' in the reference					

7. Conclusion

We discussed existing approaches addressing the problems of service composition with solutions that based on middleware architectural solutions. Even though there are tremendous approaches and techniques proposed for service composition, there is still no true automatic and dynamic composition in real time for converged service.

Out of all approaches, semantic-based and syntactic service descriptions are the most commonly adopted method for service composition. To achieve more accurate and secured composition and practical applications (though might not fully true in real time in near future), requirements of QoS that include security and trust management and adaptive to face failures will need to be further imposed on composition engine.

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