A Context-oriented Service Brokering Platform for the IP Multimedia Subsystem

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Abstract- Growing competition from over-the-top-based 3rd party service providers coupled with falling ARPU has led to the need for a new business model to be adopted by Telecoms operators. Telecoms operators are increasingly embracing SOA-driven business models to drive revenue in Next Generation Networks. Through the SOA model, Telecoms Operators can expose service capabilities using Service brokers. Service brokers will allow for the exposure and reuse of service capabilities to allow for rapid service deployment. Service brokering with a focus on context aware systems will allow for increased cooperation between Telecoms operators and 3rd party service providers to create new innovative services. The use of contextual information comes with the need to be sensitive to privacy when exchanging contextual information between different services. The IP Multimedia Subsystem is naturally defined for use in Service Oriented Architectures and can be extended to include a Service Broker. In this paper we propose a Context-oriented Service Brokering Platform for the IP Multimedia Subsystem. The proposed framework is to be implemented as part of the UCT IMS testbed.

Index Terms—IMS, Service Brokering, Context Aware Services, SOA

I. INTRODUCTION

The growth in popularity and prominence of so-called Over The Top (OTT) Web services has led to competition and/or conflict between Web 2.0 developers and the Telecommunications industry in recent years. However both parties may yet benefit from increased cooperation through the use of Service Brokers. Service Brokers are network entities that support the exposure and reuse of existing services in order to allow rapid deployment of new composite services. Service Brokers therefore have a critical role to play in increasing cooperation between network operators and 3rd Party service providers especially those operating in the Web 2.0 environment. Through the use of an open, composite-service-oriented business model, both Telecoms operators and Web Service providers can benefit from new business opportunities [1].

The deployment of Service Brokers is in line with the growing importance of Service Oriented Architecture (SOA) approach in both the Telecoms and Web 2.0 industries. As Telecoms operators begin to migrate towards Next Generation Networks (NGNs), it is increasingly clear that a 'killer' application will be required to drive Average Revenue Per User (ARPU) and provide a return on investment on expensive new infrastructure. However such a killer application is yet to be found and as ARPU falls, the importance of the aforementioned open business model is growing [9].

One area that holds great potential for innovation and new business opportunities is that of Context aware services. Context aware services make use of contextual information, allowing services to adapt dynamically to changes in a user's context. Contextual information is any information that can enhance or influence the execution of a service. The type of information considered to be contextual therefore varies from service to service. Some examples of context aware services could be location-based services, presence-based services, weather-based services, etc. Contextual information can be input directly from the user, gathered independently using sensors or even inferred by analyzing usage history [2]. Context aware services can therefore take on a new form of responsiveness and dynamic interaction that current static systems are incapable of.

Given the definition of various kinds of contextual information, it is clear that Telecoms operators could theoretically have access to a tremendous amount of contextual information given the fact that service users are typically mobile. The mobile terminals could therefore provide contextual information such as presence, location, etc at any given point in time. Perhaps more important than the access to such contextual information is the pre-existing and robust support systems already deployed in Telecoms operator networks. As the shift towards NGNs takes place in the Telecoms industry, the Internet Protocol (IP) Multimedia Subsystem (IMS) has become increasingly important. The IMS is an overlay architecture designed to provide for and support rapid service deployment in Next Generation Networks. The IMS was originally specified by the 3rd Generation Partnership Project (3GPP) and provides all the aforementioned support systems that have become a hallmark of the Telecoms operator business model. Some of the support functions provided by the IMS include:

- Offline and online charging
- Secure access and authentication
- Quality of Service requirement specification and support

In addition to the support functions, the IMS also has a number of access network agnostic standard services including Presence [22] and Instant Messaging [23]. In addition to the latter, many IMS-based services have been standardized by the Open Mobile Alliance (OMA) [20] as part of a strategy of providing reusable service enablers; this strategy dovetails with the need for a shift SOA-driven business models already discussed. The IMS can therefore be seen as an ideal platform to incorporate SOA principles into the Telecoms operator environment through Service Brokering. Given the growing importance of Context aware services, any such Service Brokering Platform would need to take into account the use of context in construction of new composite services. The existence of such a broker would allow Telecoms operators to leverage access to contextual information whilst supporting the development of new services [8]. More research needs to be done in the area of Context-oriented Service Brokering before such systems become a reality.

In this paper we propose the deployment of a Context-oriented Service Brokering Platform (SBP) in the (University of Cape Town) UCT IMS testbed driven by the UCT IMS Client [21]. In conjunction with the SBP, a new context-driven application will be introduced to test the SBP and verify the proposed framework. The remainder of the paper is composed as follows: section II reviews related work in the area of Service Brokering and Context aware services; section III highlights the requirements for a Context-oriented Service Brokering Platform. Section IV introduces the proposed framework including the Service Broker model and the test application. Section V discusses the metrics that will be used to verify the model. Section VI provides a conclusion to the paper.

II. RELATED WORK

The adoption of SOA principles by the Web services/Computer Science industry and the Telecoms industry has led to a great deal of research in both the pervasive computing paradigm and from a Telecoms perspective. There are therefore a number of proposed architectures for Service Brokers, however it is mostly those proposed by Web/Computer Science industry that identify context as a key driver of future services.

A. Service Brokering in the IMS

The IMS currently only supports static chaining of services using initial Filter Criteria (iFC) techniques [19]. The static service chaining technique relies on the Serving Call Session Control Function (S-CSCF) to take on the burden of monitoring all executing services. In this model, Application Servers (AS's) are not aware of each other and may only communicate via the S-CSCF. There is therefore limited capacity for cooperative execution of services via service blending and/or composition.

In order to address this problem the 3GPP has recently introduced a new functional entity to the IMS called the Service Capability Interaction Manager or SCIM [18]. The SCIM is envisioned as a network function that will allow dynamic blending of services and therefore support some form of service composition. However, the 3GPP has only provided a high level definition of the functionality of the SCIM as at time of writing. The need for a detailed specification of the SCIM has therefore produced a variety of research describing SCIM-based brokering architectures. Some research has proposed Service Brokering as a functional element of the SCIM tasked with creating a workflow for blended services [4]. However the latter approach creates a bottleneck in the network due to its centralized architecture. A more distributed approach would alleviate the burden placed on the SCIM that results in low fault tolerance when orchestrating blended services [15]. In fact increasingly sophisticated systems have been proposed that rely on distributed solutions to the problem of Service Brokering [6]. The blended service SCIM approach limits the Service Broker to coordinating the interaction of features amongst service capabilities as opposed to specifically creating new services based on service requests, which is the essence of Service Brokering [10]. There are some proposed solutions that make use of OMA-compliant proprietary architecture to develop multi-faceted Service Brokering systems that support Service Composition through Policy Enforcement [3]. Besides Policy Enforcement, Service Composition in the IMS would allow for charging through various methods as illustrated in [13].

B. Incorporation of 3rd Party Service Providers

In order to incorporate 3rd Party Services in SOA-driven business models, it has become clear that some form of network abstraction is required [9]. The use of Parlay X API's specified by the OMA is one of the proposed solutions to incorporate Web Services in particular [3]. However these API's do introduce a new set of problems in terms of compatibility with existing Web 2.0 approaches [9]. In order to allow incorporation of 3rd Party Services and therefore a myriad of service capabilities; Service Brokers must support service discovery and an accompanying system for describing services [3]. Increased network abstraction would ideally allow service providers and network operators to share revenue through the creation of new Telecoms services.

There is a variety of research that envisions the user as a provider of 3rd Party Services through sophisticated composition environments. The latter functionality is envisioned as a possible killer application for the IMS [17]. The user would then have the power to personalize services through an extensive user profile that would form part of the Service Brokering process [14]. These user-centric approaches incorporate context awareness and offer a promising alternative to current service creation.

C. Service Brokering for Web Service and Pervasive computing environments

A large body of research work is aimed at providing services in the Web 2.0 and Pervasive computing environments. There are thus a number of novel proposed frameworks for implementing Service Composition by for example using a conversation model [5]. Notably, some of the proposed composition models offer a delegation approach that could potentially be absorbed into IMS-based solutions. The use of a hierarchical distributed model for service brokering similar to that proposed in [12] could potentially help reduce fault tolerance by allowing greater authority for individual service components.

D. *Policy in Context Aware Systems*

The reliance on sensitive contextual information such as location and presence in context aware systems has led to the need for increased security around user Privacy [11]. Ensuring adequate measures are in place to guard user privacy will therefore ensure User Quality of Experience when using SOA-driven Context Aware Systems. Privacy would form part of any policies to be applied in policy-driven systems in which Policy Enforcement forms a critical part of system execution. A good example of such a system can be found in [3]. It is clear that Service Level Agreements will have to be put in place to ensure that all newly created composite services take into account the importance of policy particularly the controversial issue of user privacy.

III. REQUIREMENTS FOR A CONTEXT-ORIENTED SERVICE BROKERING PLATFORM

Based on the discussion of related works, it is clear that there are a number of requirements for a context-oriented SBP. The SBP would have to satisfy the 3GPP Service Brokering "wish list" discussed in [16] and also take into account the needs of Context aware services. An outline of the requirements of the SBP is given below:

1. Support the introduction of new composite applications through discovery and composition of service capabilities
2. Support the introduction of 3rd Party Services and/or users as service creators through an open architecture and Service Level Agreements
3. Have a minimal impact on session handling in terms of interaction with AS's through efficient use of resources
4. Allow for personalized control of services through user profile management
5. Support exchange of context information between services in an efficient manner
6. Provide an open implementation to allow for extension and further testing
7. Use a distributed approach to maximize fault tolerance
8. Allow for the application of operator policies particularly with regards to QoS, authentication, security, charging, etc
9. Ensure privacy protection for sensitive contextual information

The requirements above are quite extensive; the next section will present the proposed framework that addresses the requirements.

IV. ARCHITECTURE OF PROPOSED FRAMEWORK

We propose a framework that supports service composition through a delegated distributive approach. The composition and management of services will be the core focus of the framework. Supplementary functionality such as service discovery will therefore be simplified.

A. *Overview of SBP Architecture*

The SBP Architecture is presented in Figure 1. The architecture is a distributed solution similar to that proposed in [16] whereby the central node of the SBP coordinates a number of lightweight nodes that reside on Application Servers. The SBP is effectively a specialized Application Server that communicates with the S-CSCF via the ISC interface and the HSS via the *Sh* interface as illustrated in figure 1. The lightweight, SBP Delegate Nodes (DN's) allow Application Servers/Service Capabilities to communicate directly with each other. The Open Service Architecture Service Capability Server (OSA-SCS) will support Parlay X-based Web Service implementations. The DN's and central node interact in a hierarchy according to the rank of assigned to each service capability. The DN's are therefore tasked with varying workloads depending on the capacity and/or importance of a given service capability. The hierarchical model is derived from the distributed brokering model used in [12]. The *sh* interface to the HSS will be used to acquire and store user profile information as required.

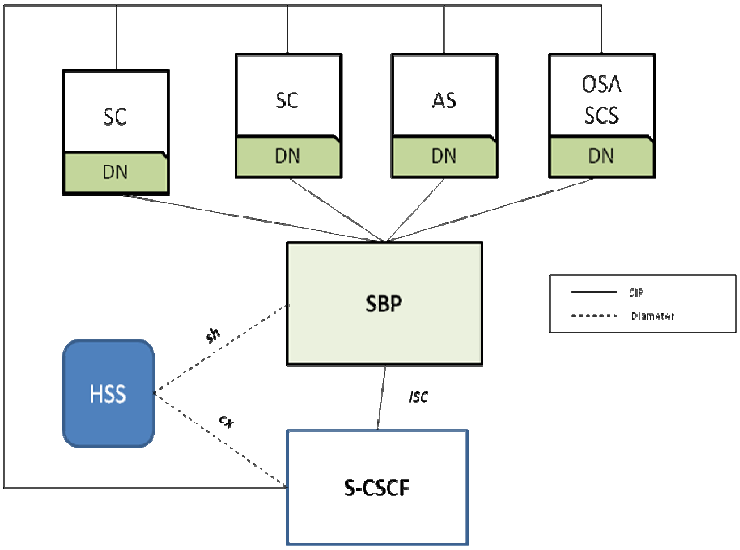

Figure 1: Conceptual Overview of Architecture

B. *Service Discovery and Selection*

In order to simplify the framework, service requests are provided as a list of known capabilities. Services will therefore be discovered based on the services available in the IMS testbed. To allow for distributive delegation, service profiles will be semantically enriched based on techniques used in [7].

C. *Service Composition and Management*

After the required services are selected, the inputs and outputs of each capability will be analyzed to determine dependencies based on reliance on contextual information.

Service capabilities will therefore be classed as context providing and context consuming. An example of a context providing service capability is a location provider; an example of a context consuming service is a location-based advertising service. The analysis of the different context-related Input/Output requirements will be used to generate a workflow enriched with delegation data.

The algorithm will perform the following steps:

1. Analyse semantic-enriched service profiles to determine ontological relationships between selected services
2. Based on (1), determine relative rank of each service
3. Use service ranks to determine order of execution and possible parallel paths
4. Construct distributed workflows and integrate policy and privacy settings
5. Delegate partial workflows to ranking DN's

Once each DN has received a partial workflow and rank, it will begin execution based on its rank and workflow. DN's will communicate using Simple Object Access Protocol (SOAP) as proposed in [10]. DN's will oversee execution of partial workflows at each application/service capability and provide feedback to the SBP based on the completion of critical paths. In the event of the failure of a DN, the ranking DN will report failure to the SBP to allow for reconstruction of a partial workflow and all lower ranking DNs will have execution paused to prevent a system fail. In the event of SBP failure, partial workflows and ranks will be used collaboratively to continue execution. The highest ranking DN will therefore be promoted to SBP and attempt to manage the service in the interim by prompting lower ranked DN's to continue execution. It should be note that this emergency technique would have the obvious downside of a greatly increased signal load on the S-CSCF.

D. Policy Management

In order to simplify the architecture, policy management will be provided via Policy documents stored in an XML Document Management Server (XDMS). The SBP will therefore require a data federator similar to the one used in [4] to retrieve the Policy documents via XML Configuration Access Protocol (XCAP). Though the services used will be limited to those available in the UCT IMS testbed and model services developed specially for the framework; Policy documentation will be graded to allow for testing with various types of policies such as network Quality of Service (QoS) requirements. User profile information downloaded from the Home Subscriber Server (HSS) will be enriched – and the IMS Service Control (ISC) interface extended if need be – to allow for the exchange of enriched user profile information particularly with regards to privacy settings and user QoS limitations. Charging of the composite service is a topic in its own right and therefore is out of the scope of this framework.

E. HGX: A Context-Aware application

The proposed test application, HGX (Hunter-Gatherer Exchange) is a mobile social network for tourists. The service functionality focuses on the location of collectible tourist artifacts particularly curios and art, recommended destinations and tourist interaction. The service incorporates a location-aware advertising service that provides targeted ads to tourists on the move. The key features of the HGX service are:

- **Presence:** allows users to set their availability to receive adverts and/or messages from other users
- **Location:** allows users to publish their location to each other
- **Instant Messaging:** Allows users to hold discussions about curios, services, destinations, etc. It may also allow providers of tourism services to communicate directly with potential customers at a negligible cost to both parties
- **Advertising:** Serves adverts based on user location informing user of nearby services, possible points of interest, etc based on user preferences
- **Media Streaming:** Users can listen to podcasts that provide a walkthrough of a particular area.

The listed service capabilities described already exist in one or more form in the IMS testbed. This is based on the intention to model location as presence to complete the required list of capabilities. The advertising system could make use of the media streaming, location and presence functionality. HGX will be modeled as a 3rd Party Service that will be created via the SBP as illustrated in Figure 2.

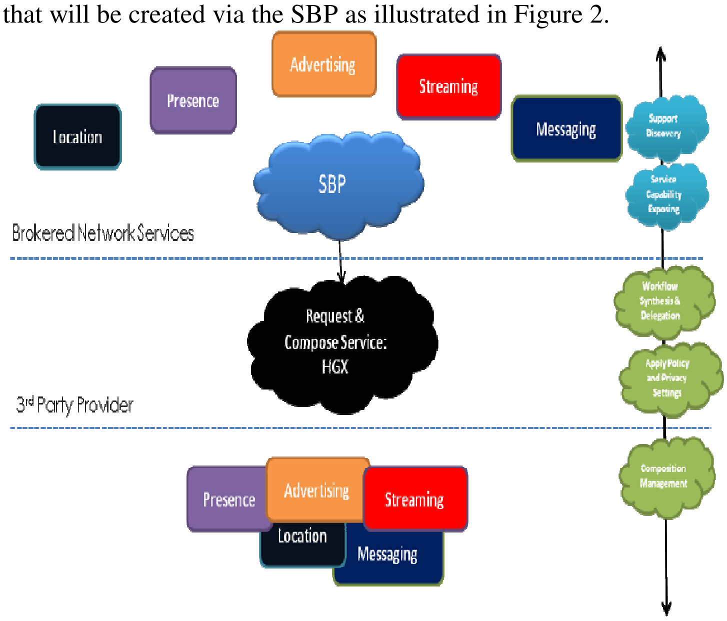

Figure 2: Evaluation Model

As can be seen in Figure 2, the SBP will be used to compose the HGX service using the brokered network services provided in the UCT IMS testbed. The contextual information providers in the case of HGX will be the Presence and Location (emulated using a second Presence service) services. The main service consumers are the Messaging (presence-based) and Advertising (based on presence, streaming and location) advertising service capabilities. During workflow synthesis and delegation, the SBP will take the differing needs with regards to presence and location dependencies into account as per the algorithm in subsection (C).

V. FRAMEWORK VERIFICATION

In order to verify the framework, it will be compared against the predefined requirements for a context-oriented SBP and a set of predefined metrics. This section outlines the methods and metrics to be used to evaluate the proposed framework.

A. *Framework Implementation*

The first part of testing the proposed framework is to implement it by adding it to the UCT IMS testbed. The SBP will be implemented as a Session Initiation Protocol (SIP) AS using an object-oriented approach. It will consist of logical entities for composition, workflow creation and delegation, policy & user profile support and service management. The UCT IMS client will be extended and modified to act as a front-end for the proposed HGX testing application. The Presence Server will be modified to create a mock location server. The UCT Internet Protocol Television (IPTv) streaming server will be slightly modified to provide a streaming capability. The DN functionality will be modeled as part of each Service Capability. Figure 3 shows the SBP with the various UCT IMS testbed elements.

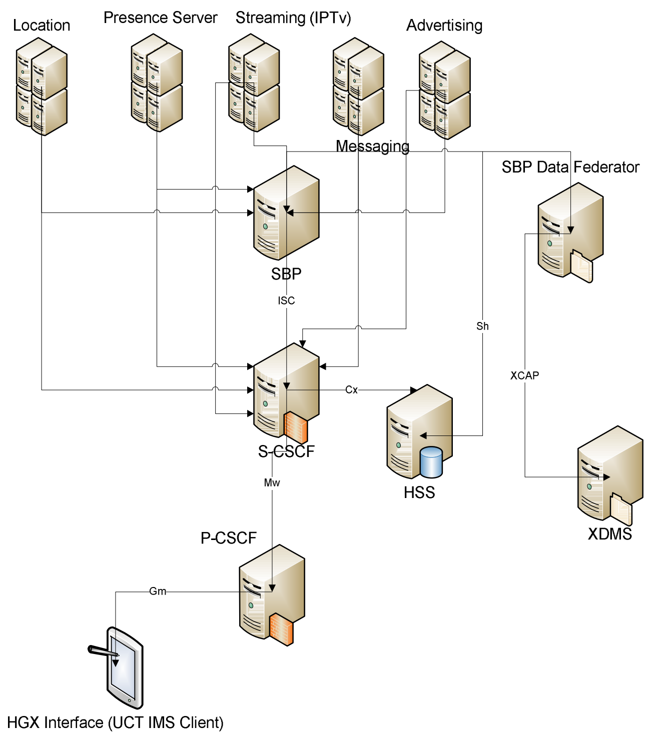

Figure 3: Evaluation Architecture in UCT IMS Testbed

A number of metrics have been defined to measure the performance of the proposed framework. These metrics are derived from the requirements discussed in section III. What follows is a brief description of each of the metrics that are to be measured:

- Session Setup Latency: This is the amount of time between session initiation by the User, composition of the service and service deployment
- Access Latency: The amount time taken to gain access to required information/service capability by a requesting service
- Scalability: The number of users the system can handle before failure
- Contextual Shift Latency: A measure of how long changes in context propagate through the system
- Policy Latency: The amount of time it takes the system to respond to changes in policy

The above metrics will be defined during the implementation phase according to progress made in implementing the proposed frameworks.

VI. CONCLUSION & FUTURE WORK

The rise of Web 2.0 applications has led to the need for the evolution of the Telecommunications business model. In this paper, we have proposed a context-oriented Service Brokering Platform for the IP Multimedia Subsystem. The proposed SBP framework will allow Telecoms operators to leverage existing services for use in innovative new services. The area of Service Brokering particularly for Context aware services remains an open and important research field. The open framework proposed can be built on by subsequent research as work continues towards the construction of an inclusive, SOA-driven architecture; the latter architecture will merge the Web 2.0 and Telecoms services industries to offer added values for users, service providers and operators alike.

The next phase of the project will be implementing the proposed framework. The framework will then be evaluated using the metrics discussed.

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