

# Preliminary Investigations of Challenges in Dynamic Integration of Heterogeneous Services

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## ABSTRACT

The progress of technology prompted the proliferation of services. Services are distinct, loosely coupled units of functionalities that are self-contained. These services are however developed by various vendors without following appropriate standards. However, the need for interoperability and reusability prompts the need for service integration. Service integration is not a new arena but emphasis is mostly on homogeneous services. However, the challenge lies on the integration of heterogeneous services to enforce reusability and maximize Total Cost of Deployment (TCD) and Total Cost of Ownership (TCO) at organization level.

The issue of service integration has become critical, due to the increase of these diverse services as they have different platforms, architecture and use different programming languages. The current methods of integrating heterogeneous services are manual integration methods. Therefore, the challenge with the current methods is time consumption, lack of flexibility, cost (TCO and TCD), total time to development, because the process is manual.

In this paper, we explore the challenges regarding dynamic integration of heterogeneous services and identify key issues that need to be addressed, in order to develop a successful mechanism that will enable dynamic integration of heterogeneous services.

**Keywords:** Integration, heterogeneous service, dynamic integration and services.

## 1. INTRODUCTION

The increase in demand of Information Technology (IT) and online-services has led many business enterprises to embrace the aspect of heterogeneous services [1]. By heterogeneous services we refer to multiple disparate online services that have been developed by different vendors on different platforms using different architectures [2]. Many business enterprises seek to increase the maximum value of their online-services; however, the challenge of integrating complex online-services is increasing [2].

More recently, online-services have become an increasingly popular means of delivering valuable, IT-enabler business services [3]. Online-services are services that are provided over the Internet [3]. These services allow unlimited access to the information. These services need to interact with each other. Online-services that are composed into advanced business processes can interoperate with other services in order to support business processes spanning across organizational boundaries. As the need for these services to communicate with

each other to achieve a specific business goal rises, the service integration has become more of a challenge as it reduces the productivity of the business enterprise because it currently uses manual methods [4].

Over the last decade, manufacturing firms and business enterprises have displayed increasing interest to shift from selling physical products to service provisioning for customer needs [4]. Internet is a key component of this revolution arena as it accelerates a distributed hosting of heterogeneous information, accessible to a multiplicity of devices through various protocols and standards [5]. The Internet has extended traditional business networks by allowing different digital resources to collaborate in order to create value for organizations [6]. From the technological perspective, the increased development of online-services in this new economy raises a number of challenges in integration arena that need to be addressed.

The remainder of this paper is structured in eight main sections. Section 2 describes online-services, what is an online-service. How these online-services communicate with each other. Section 3 explains the concept of heterogeneous service integration. Section 4, describes service integration, explains the current method of integrating services and provides the approaches that have been proposed to resolve the challenge of heterogeneous service integration. Section 5; identifies the current challenges of integrating heterogeneous services and discusses possible conceptual solution for minimizing the challenge of dynamic service integration. . Section 6 designates the related work. Section 7; demonstrates the benefits of integrating heterogeneous services and requirements that need to be addressed to support the concept of service integration. In the same section we discuss the importance of dynamic service integration. Section 8, concludes the paper.

## 2. ONLINE SERVICES

For many business enterprises, adopting online-services is one major step towards cost efficiency and effective IT-enabled business. Amazon and eBay are high-profile examples of corporations which have made their core applications accessible over the Internet as online-services [8]. Online-services are diverse [9]. However, there are services that have similar architecture, characteristics and are developed using a similar programming language, which are called homogeneous services. There are services that have been developed on different platforms, using different architectures and are developed using different programming languages such as heterogeneous services.

Homogeneous services are services that have similar architecture and run on a similar platform [9]. Cloud services that are developed using similar architecture and run on a similar platform are an example of homogeneous services. Integrating such services with other cloud services that are using a similar platform is cumbersome as it uses a manual method of integration. One of the characteristics of homogeneous services is that, they have same features and similar architecture [8]. Homogeneous services have a uniform structure and similar architecture.

Figure 1 below demonstrates an example of homogenous services.

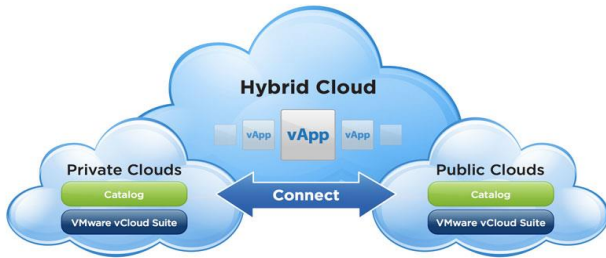


Figure 1: Homogeneous Cloud Services [9]

The figure1 above illustrates the example of homogeneous services. This demonstrates how homogeneous services look like.

The challenge with these services is the manual integration method that requires user-involvement. The method becomes strenuous when there are multiple homogeneous services that need to be integrated. The manual integration approach is cumbersome as it requires user-involvement and it reduces the integration speed due to the fact that a user needs to be heavily involved when integration is taking place.

This is the reason why manual integration is not sufficient and flexible enough. Hence there is a need to explore and evaluate this challenge and develop a mechanism that will minimize this issue in the near future.

Currently, online-services communicate using standard protocols providing broad interoperability. Services have an interface and are message-oriented. The functionality provided by services is defined by meta-data describing the interface to the service and its operations.

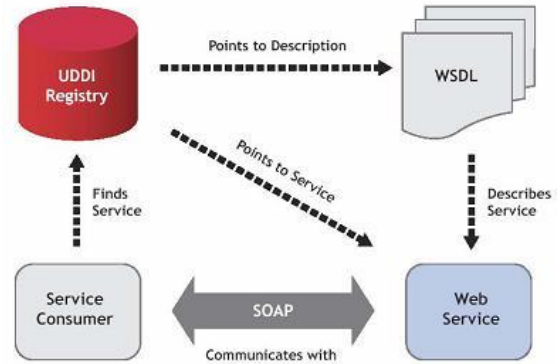


Figure 2: Service interaction protocols [10]

Figure2 above illustrates the Service Oriented Architecture (SOA) architecture that depicts how these services are currently invoked and the protocols that are used to provide interaction between these services. The Extensible Markup Language (XML), Web Service Definition Language (WSDL), Simple Object Access Protocol (SOAP), Open Data (OData) and Representational State Transfer (REST) are the common standards protocols that are used to integrate these services [10].

The challenge with the manual integration method is that when these services need to interact, the Application Programming Interfaces (APIs) have to be configured to allow an exchange of information between these services [10].

The communication between these services is facilitated through use of SOAP, XML, REST and many more. However, the developers have to configure an API whenever a new service needs to communicate with other services, especially if it is a diverse service.

This current method results to a need for user involvement whenever there is a change requirement in the current service, they need to configure an API that will cater for the new change. This becomes a challenge when many services need to communicate with each other.

Hence, the manual integration method is regarded as inadequate as it delays the productivity of the business, since it requires user-involvement. The following section will discuss heterogeneous services.

### 3. HETEROGENEOUS SERVICES

Heterogeneous services are services that are developed by diverse vendors for different purposes on different platform, using different architectures; different protocols and different programming languages [12]. Most services are heterogeneous by nature, which means they are executed under different platforms, designed using different architectures and programming languages [12].

Heterogeneity of these services makes it hard for a firm to standardize the quality of its services. Figure 3 below illustrates the heterogeneous services.

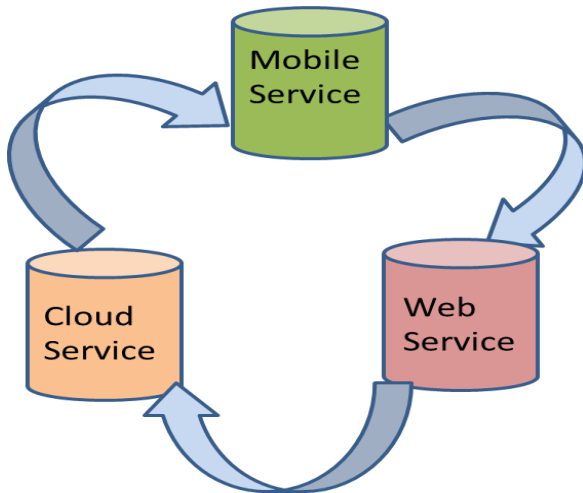


Figure 3: Heterogeneous Services.

These services are independent and perform diverse tasks, which increase the need for service integration. Integration of such online-services is a complex issue because they were developed from various patterns using different protocols from different architectures [13]. One of the characteristics of heterogeneous services is that these services are different and have a diverse structure and implementation approach. For example, having a mobile platform that mixes web applications, and server applications together into an architecture that delivers on the business requirements, requires more attention and time.

It is important to point out that each individual web application and server application interfaces with XMPP or a database only, and that each is independent of the other.

The only greatest detractor from using a manual integration in heterogeneous services is the human resource factor. When integrating services, it is important to keep in mind the skill sets of developers, the quantity of those developers, and the ability for those developers to work within a heterogeneous environment.

It is very common, to have a team of developers aligned with a particular technology such as a Microsoft system which often has employed developers that follow the Microsoft path of technologies (.NET, SQL Server, Windows). Whereas with an Open Source system, it is more common to have a crew of developers that are well versed in working with Linux/Unix based technologies (Red Hat Linux, Apache, MySQL, PHP).

The occurrence of this manual method makes heterogeneous service integration harder and cumbersome. Another disastrous commonality between developers aligned with a particular platform is that they are often reluctant to learn and evolve their skill set outside of their realm of specialization. Integrating heterogeneous services has become complex, due to different tools and technologies that are used for each service [14]. Hence this paper seeks to investigate the challenges of dynamic integration of heterogeneous services and how it can be resolved.

#### 4. SERVICE INTEGRATION

Integration across the globe has become a major challenge for service providers [15]. Integration is a crucial aspect in business enterprise that determines the fast delivery of online-services to the customer. Service integration is thus defined as a process of

bringing together the components into one service to ensure that the services function together to achieve (a) specified business goal(s) [15]. Service integration is an important way to make use of existing services and build large systems [16].

Integration allows cloud and core business enterprises to share data while dealing with the different ways of data structure [16]. This is achieved through data mediation; however a flexible integration method is required since the source and target system interface changes more frequently [17]. Some organizations decide to build integration technology themselves, coding an integration server from scratch. This requires some set of skills such as semantic mediation, connectivity, validation, routing and many more [18]. Semantic is the process of dealing with the difference in data structures within a system, while connectivity is the ability to adapt to the interfaces provided by the cloud base system such as APIs [18].

Increasing heterogeneity of services in a large scale of online-services remains a problem in terms of dynamic integration as they are currently integrated in a manual manner [18].

Figure 4 below gives a clear view of how these services are integrated and the method that is used to integrate them.

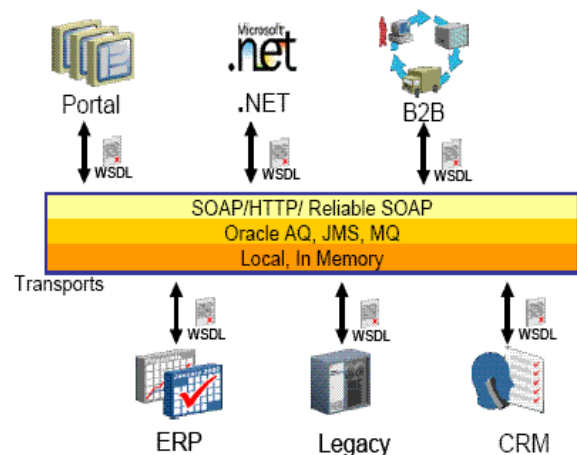


Figure 4: Integration method using Web Services [18]

In the world of IT, there is no trend that has more impact on business than the online-service integration. From enterprise services such as Salesforce, to infrastructure platform such as Amazon, to social media; the online-service integration is changing the IT landscape [19]. It has become imperative to investigate the challenges of services integration and implement a strategy that enables scalability in delivery, without proportionate increase in the cost.

In this section, we have discussed the service integration and how the services are currently integrated. The following section, will discuss the challenges of integrating heterogeneous services.

#### 5. CHALLENGES OF INTEGRATING HETEROGENEOUS SERVICES

A systematic literature review was conducted pertaining the integration of heterogeneous services. A process of testing the system was followed. The applications (E-commerce and E-Learning applications) were developed by different researchers. However the applications had to be integrated on the Tele weaver middleware so that it can be easy to manage those

applications. The Teleweaver is a middleware that has been developed specifically for the applications in Siyakhula Living Lab (SLL). Those applications use different architectures, programming languages and different platforms. This discovered a series of challenges when those applications were integrated [20]. A testing method has been done to discover the challenges of manual integration where we integrated two online-services into the Tele weaver middleware in October 2012 [20].

Those two applications were integrated to Tele weaver using SLIM API and Rest client [20]. This is where it was discovered that manual integration is a major challenge in the aspect of integration.

The first testing that was done was to validate the limitations presented by using Tele Weaver interface to upload the products and information and the one presented by using a stand-alone services. The second testing was to check the flexibility and usability of the application integration services. The final test was done to verify the adequacy of the integration system. The testing was performed on each component of the system to check it against the stated measures [20].

We have also evaluated different approaches that have been developed by different developers and researchers through literature review, where we discovered that there is a still a gap that needs to be filled in the field of integration [20].

The interface configuration, whenever the integration takes place, presents a major challenge in the field of service integration. This delays the productivity. This increases the challenges of integrating heterogeneous services on the fly, as each service is independent and performs its own task, which might be valuable to a cohesive system. However, the need arises for these services to interact with each other to achieve specific business goals. Achieving a seamless flow of information requires a significant integration method [21].

Figure 6 below demonstrates the current method of integrating online-services on ESB, which presents challenges as well as a need to develop an API interface for these services.

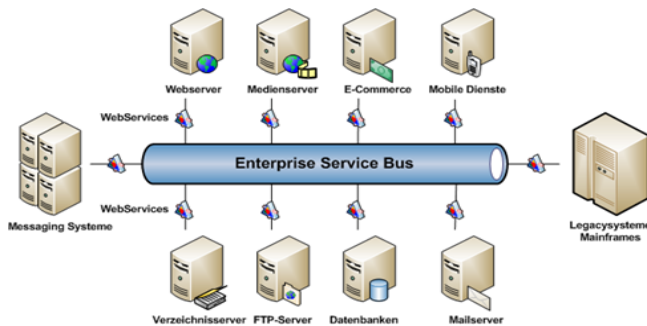


Figure 6: Integration using ESB [21]

There are many platforms that have been developed to alleviate this challenge of heterogeneous service integration. The ESB platform has been developed to eliminate this issue. However many ESB platforms offer a service platform for building and hosting services and do not eliminate the challenge of dynamic integration of heterogeneous service integration [22]. The impact of the adjustments to service contracts can further be kept to a minimum, as the ESB continues to provide a stable interface while making the necessary changes to the messages [23].

The challenge of integrating heterogeneous services is non-trivial due to its unique problems in heterogeneous environment such as the following characteristics: (a) dynamicity of services, (b) different architectures, (c) diverse protocol and languages these services have, (d) different architectures and (e) different platforms of these services [23].

This presents a challenge to the developers and enterprise environment as it delays the growth of the business and the market of the business.

It is very critical to understand the challenges of integrating these heterogeneous services before designing a solution that could address the challenges and analyze the requirements and the benefits of integrating these services. This research paper is stimulated by proliferation of stand-alone heterogeneous services that need to be integrated to achieve a complex business goal. These heterogeneous services must be integrated in a dynamic manner without developing APIs and interface configuration, which is stringent, tedious and cumbersome when the change is required [24]. The following section will discuss the work that has been done by other researchers and developers.

## 6. RELATED WORK

There are numerous approaches that have been implemented to resolve the issue of service integration. The middleware tiers have been developed by different developers and researchers in previous years to solve this issue. However, the gap is still visible. An Enterprise Service Bus (ESB) is a light weight, high performance software architecture for middleware [25]. The ESB was developed to eliminate this issue of dynamic integration of heterogeneous services, and until today there have been no approaches that seem to eradicate this issue.

Using an ESB can become problematic if large volumes of data need to be sent via the bus as a large number of individual messages [26]. An ESB should support stateless message flows if long-term business processes are to be implemented [27]. Due to the lack of standardization, the ESB market is rather confusing [27]. The ESB doesn't include an orchestration or process choreography component, as it is considered to be part a separate component [27]. Other than ESB, developers have tried some mechanisms that can minimize the challenge of services integration.

Figure 5 below illustrates the approach that has been developed and still being used to integrate heterogeneous services.

The middle tier is the integration method that is still being used to connect the data tier and the presentation tier. As illustrated in the diagram below, in the presentation tier there are different applications that have been developed using different architectures, programming languages and different platforms. These applications are integrated to the data tier using diverse APIs. These APIs allows applications to retrieve information from the database.

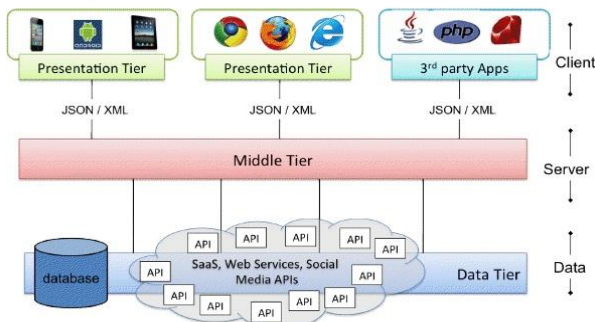


Figure 5: Service integration [27]

Many organizations have spent an enormous amount of years developing methods that could allow integration of their diverse services, with a seamless manner, however the solution has not been found [27].

The cloud hub has been created to provide a faster implementation time and a more robust cloud integration solution [28]. This was done to assist system integrators to deliver business value to clients, rather than consuming time in writing code. However, this does not eliminate the challenge of dynamic integration of services. The established middleware, including enterprise services buses and custom code, have proved to be insufficient to keep up with demand [28]. This is due to the fact that user-involvement is still required in these methods. Dynamic integration is the integration of services at run time, while manual or static integration is integration at development time or hard wiring [29].

With the aim of overcoming heterogeneity, various technologies and standards for the definition of languages, vocabularies and integration patterns are being developed such as RosettaNet [29]. RosettaNet is a system that is designed to define standardized Partner Interface Processes (PIPs) [29]. An ad-hoc service integration method was also developed to handle errors pertain the automatic service integration [30]. The next section will discuss the benefits of dynamic integration of heterogeneous services.

## 7. BENEFITS AND REQUIREMENTS OF HETEROGENEOUS SERVICE INTEGRATION

The key benefits of integrating heterogeneous services is that, it accelerates the delivery of services, minimize user-involvement, provides freedom from vendor lock-in and enable complete services lifecycle management to increase IT service agility, scalability and quick response to changing business environments [31].

As level of online-services becomes more critical, the level of integration becomes deeper. Understanding the requirements of integrating heterogeneous service is imperative, as that will guide the proper solution to the current challenges.

The key requirements of an effective method are: 1) To define different services requirements for both critical and non-critical services. 2) A performance rule that ensures organizations will have high performance service integration. 3) Service integration arrangement that entirely focuses on service performance, usability and availability. 4) Skills and capabilities that facilitate transition and management of services. 5) Open standards and interoperability to support workflow [32].

## 8. CONCLUSION

To leverage the full power of dynamic integration of heterogeneous services, it is essential to understand the challenges of dynamic integration of heterogeneous services and the methods that have been developed by other researchers and developers. To develop a seamless integration of heterogeneous services with a minimal user involvement, it is crucial to understand the current mechanism that is being used. The mechanism that could increase the efficiency of services and cut the operational cost of business enterprises is essential in the field of integration.

The challenges of dynamic integration of heterogeneous service are mentioned by many researchers. This affect lots of business as the user-involvement is required. However, it is important to design and develop a mechanism that could enable the dynamic integration of heterogeneous service with a minimal user-involvement.

In future we will be looking at developing a method that could eliminate these challenges of dynamic integration of heterogeneous services.

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