CONVERGENCE OF CLOUD COMPUTING, SERVICE ORIENTED ARCHITECTURE AND ENTERPRISE ARCHITECTURE

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Abstract

This paper argues that there is a convergence of interoperability of Cloud Computing (CC), Service Oriented Architecture (SOA) and Enterprise Architecture (EA). Furthermore, the paper outlines the existing non dynamic links between EA and SOA that are currently practised in the industry and confirmed by scholarly articles; and provides the state of art of the link that could exist in practice between cloud computing and SOA as researched from the published scholarly material.

Finally, the paper presents the argument that there is a convergence of interoperability of CC, SOA and EA. It further refers to the planned research to test this theory first by developing a logical model of such a feasibility followed by a Proof of Concept.

Keywords

Cloud computing, service oriented architecture, enterprise architecture, interoperability, and convergence.

1. Introduction

Cloud computing is an emerging technology and has been classed as a disruptive technology similar to that of the emergence of the Internet in the enterprises. As such, to understand the implications of this paradigm shift, it requires the same amount of diligence by the users and cloud service providers as when Internet services were launched to make an appropriate level of changes in the areas of transition, service level agreements; and deployment of cloud computing.

Cloud computing is still in its early stages of development and as such has tended to be based on vendor specific technology such as Google, Amazon, Microsoft, and IBM. There is no doubt cloud computing is a large-scale distributed computing ever witnessed before and thus is bound to disrupt businesses at their core. For this reason enterprises need to understand the concept of cloud computing so as to better prepare the businesses in the areas of:

- managing risks,
- return on investments,
- service level agreements; and
- transition to the new paradigm.

Cloud computing is a scalable computing model that delivers a service over a network as opposed to a product. The industry literature suggests that it is an extension of the services provided via virtualisation and grid computing infrastructure along with the use of other enabling technologies such as SOA that will contribute to the business as usual activities within an enterprise. It is the use of enabling technology such as SOA that will be leveraged by the enterprises where enterprises using SOA will need to incorporate cloud computing and SOA into their existing and new enterprise information, communications and technology (ICT) architecture.

This paper:

- outlines the concepts of cloud computing, enterprise architecture and service oriented architecture and presents the state of art of the new paradigm of cloud computing;
- identifies some of the challenges of the deployment of cloud computing;
- presents the current research findings on the links between EA and SOA; and the links between SOA and CC; and
- articulates the first conceptual model of interoperability of cloud computing, enterprise architecture and SOA.

2. Concepts of cloud computing, service oriented architecture and enterprise architecture

2.1 SOA

SOA is a method of design, deployment, and the management of both applications and the software on the infrastructure where all software is organized into business services that are accessible and executable and where service interfaces are based on public standards for interoperability [1]. SOA is also a business-driven IT architectural approach that supports integrating a business as linked, repeatable tasks or services.

The key technical concepts of SOA are:

- services,
- interoperability, and
- loose coupling.

For the purpose of this paper, the writer defines SOA as a set of predefined services that are held in a repository and that can be accessed dynamically when required via the use of web services technology. These services can also be discovered even if and when calls for such services are not clearly defined. These services are built on the specific procedures, policies and framework. The services are based on protocols and can be discovered and published and are independent of platform in a non-coupling manner. The following protocols are commonly used in a SOA environment:

- *Universal Description, Discovery, and Integration, **UDDI**. The UDDI defines the publication and discovery of web service implementations;*
- *the Web Services Description Language, **WSDL**, is an XML-based language that defines Web Services;*
- ***SOAP** is the Service Oriented Architecture Protocol. It is a key SOA in which a network node (the client) sends a request to another node (the server);*
- *the Lightweight Directory Access Protocol or **LDAP** is protocol for querying and modifying directory services; and*
- *extract, transform, and load, **ETL**, is a process of moving data from an older system and loading it into a SOA application* [2].

The diagram below (diagram 1) illustrates how these services can be dynamically called from the repository of services:

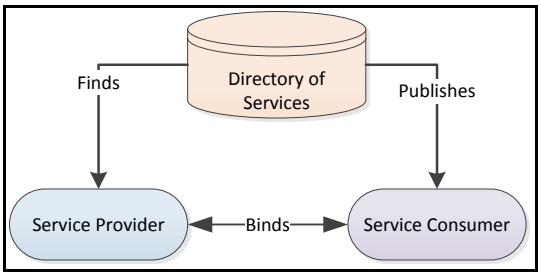

Diagram 1: Concept of Service Oriented Architecture

2.2 Enterprise Architecture

Enterprise architecture is the blueprint for the organisational information technology and communications (ICT) road map. It forms a core and significant part of the ICT strategic plan which is unpinned by the respective corporate business plan.

Enterprises generally use either vendor specific technology architecture such Microsoft's application architecture and or an architecture framework such as the Open Group Architecture Framework (TOGAF) or Zachman [3]. There are two key enterprise frameworks, namely Zachman and TOGAF frameworks. The Zachman frameworks focuses on the process of what, how, where, who, when and why. It also includes such models as business, system, technology. TOGAF) is a framework using a detailed method and a set of supporting tools for developing enterprise architecture. The Open Group describes itself as *a vendor neutral and technology-neutral consortium, whose vision of Boundary will enable access to integrated information, within and among enterprises, based on open standards and global interoperability*. TOGAF is a freely available framework, architectural development methodology and tool set for creating a number of architectural solutions

The key parts of an EA include information architecture, infrastructure architecture, applications architecture, and governance including management practices.

The diagram below (diagram 2) illustrates various parts of generic enterprise architecture:

- Information architecture
- Application architecture
- Infrastructure architecture
- Governance and security architecture
- Management practices

Diagram 2: Enterprise Architecture: Generic Components

SOA, Virturallisation and Grid are the major trends in ICT architecture. Cloud computing is not an architectural trend but such a deployment has drawn attention by enterprise architects to ensure that cloud computing aligns with any given enterprise architecture.

2.3 Cloud Computing

There are various definitions articulated by experts of cloud computing. For the purpose of this paper, a definition of cloud computing has been adopted from NTIS [5].

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.

The five base characteristics of cloud computing are:

- on demand,
- broad network access,
- resource pooling,
- rapid elasticity; and

- measured service.

NIST identifies three of the key cloud computing services as Saas, Paaas, and Iaas.

The four deployment models of clouds computing as identified by NIST are:

- private Cloud,
- community Cloud,
- public Cloud; and
- hybrid Cloud.

3. Challenges

The key challenges for the vendors will be to make their cloud computing service more interoperable with their respective partner cloud computing products and services so that a user can be selective with her/his choice of the services across multiple service providers. Also the service level agreements between a vendor and a user will be a challenge as much as the challenge of deploying a sound service level agreement among the vendors.

For the enterprises the challenges will be vast and varied. Firstly the enterprises will require a mindset change from computing being a product to a cloud computing as a service. Other challenges that will need to be addressed are:

- billing,
- security,
- compliance,
- significant change to the role of the IT project managers,
- IT support and downtime,
- understanding the complexity of cloud computing infrastructure; and
- complex nature of setting up management services such as backup and recovery and contingency plan.

For the research community there are a number of areas of research with the shift to the cloud computing paradigm. Some of these are:

- aligning business to cloud computing;
- deployment of the kind of enterprise cloud – private or public;
- service level agreements;
- data security and storage;
- migration of the legacy systems to a cloud computing environment; and
- Interoperability between and among EA, CC and enabling technologies such as SOA.

Literature reviewed indicate a number of challenges to those enterprises that uptake cloud computing deployment. Wyld [6] has outlined the following challenges which will be experienced by the USA federal government in deploying cloud computing:

- scalability,
- reliability,
- security of data,
- interoperability,
- review of procurement practices,
- resolving certain political and legal issues,
- regulating cloud market,
- redefining roles of the IT Workforce,
- assessment of ROI (return on investment) of cloud computing; and
- setting up of a government cloud coordinator agency.

It is the challenge of interoperability that this research paper examines in a three dimensional interoperability of CC, SOA and EA.

4. Related Literature

There are a number of vendors who have taken the lead to deploy cloud computing and are driving the core components of the cloud architecture

based on the respective vendor technology. Buyya [7] clearly defines the layers of service offerings of cloud computing and identifies the key layers in delivery of the cloud computing services. Such layers include:

- *Infrastructure as a Service ("IaaS") - some service providers offer cloud-based storage, much the same as a campus storage area network (or SAN);*
- *Computing as a Service ("CaaS") - sometimes included in IaaS, CaaS service providers offer access to raw computing power on virtual servers, such as Amazon's EC2 service;*
- *Platform as a Service ("PaaS") - certain providers are opening up application platforms (as opposed to the applications themselves) to permit customers to build their own applications using that platform's underlying operating system(s), data models and databases, pre-built application components and interfaces;*
- *Software as a Service ("SaaS") - application service providers have been hosting applications for quite some time, but the difference with SaaS in the cloud is that the servers hosting the applications are also virtualized* (Source: Buyya)

Buyya's research is relevant to this study as his research proposes the concept of market oriented architecture which is expected to be vital in negotiating service level agreements (SLA) between vendors who provide cloud services and the agencies utilizing such services. Furthermore, such architecture for SLA's could also have an impact on the implementation of the convergence of such architectural services within an enterprise.

Wei and Blake [9] confirm that the there is an overlap of services between service oriented architecture and cloud computing. As such the challenges for one could be leveraged as an opportunity for the other. This research is also relevant to the writer's study as Wei and Blake's research argues the application of uniform standards to achieve interoperability between cloud and SOA.

Tang [8] documents a view of cloud services within the framework of SOA. This is a significant research work but needs further testing.

5. The Proposed Solution Framework

This section of the paper establishes that non dynamic interoperability exists between EA and SOA. Furthermore it establishes that there is interoperation between SOA and CC. It goes on to articulate the research theory that there is a convergence of the three services as an original piece of research. This concept of the convergence of interoperability of CC, SOA and EA is illustrated in diagram 3:

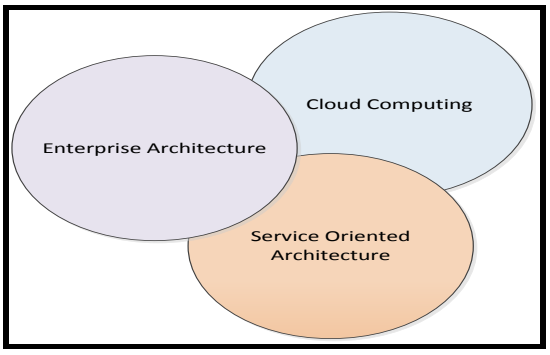

Diagram 3: Conceptual Model of the Interoperability Convergence of Cloud, SOA and EA.

5.1 Interoperability Between Service Oriented Architecture and enterprise Architecture

Government agencies tend to use architecture framework as a backbone of their ICT implementations as such framework lends itself to unpinning the enterprise ICT strategic plans which in turn is driven by a whole of government enterprise policies, governance and legislative requirements. Such enterprises have also used SOA to drive their business processes and business engineering processes.

An example of mapping of EA framework with SOA stack is illustrated by IBM in the diagram below (diagram 3).

EA Framework	SOA Stack
Business architecture	Business process
Application architecture	Services and components
Technology architecture	Integration architecture
Information architecture	Data architecture
Technology architecture	QoS, security, monitoring and infrastructure

Diagram 3: IBM – EA and SOA Stack – a conceptual model

At the base line, a number of business processes are collated to form business architecture. Large and complex enterprises have a number of business processes which in turn run a number of common services across these business processes. As for example, staff details are captured in the following processes:

- HR process,
- finance process,
- buildings/locations process; and
- user provisioning process.

Staff details are clearly a common service across various business processes and can be set up and reused multiple times for different instances. For this reason enabling technologies such as SOA can be used to make dynamic calls for the services that are required for processing a number of different business processes where common services permeate across the enterprises. Creating a dynamic interoperability between SOA and EA is the fundamental to this research.

5.2 Interoperability Between Cloud Computing and Service Oriented Architecture

With the emergence of cloud computing, researchers are finding a place for SOA in the transition of existing applications to CC. This no doubt will be leveraged by the technologies that emerged as part of the web 2.0 technologies, especially those that had been based on SOAP. SOAP is an XML based open source message transport protocol - simple object access protocol. The enabling technologies such as virtualisation at the operating systems and infrastructure level no doubt could be also leveraged in the delivery of services using SOA.

At a conceptual level, services will need to be identified and created in SOA. The aim of using SOA is to create a service once and use it multiple times for a variety of processing.

The created service in SOA dynamically makes a call to the cloud computing services such that the processing occurs. Examples of calls for the cloud services can be found below:

- access software – Saas,
- use disk space – Iaas, and

- access to OS for administration - Paas

While cloud computing does not have a formal architecture, the reviewed literature confirms that there are three stacks in cloud computing, namely, Saas, Iaas and Paas. In some instances these have been expanded as stated by Buyya.

Therefore when linking EA to CC, the enabling technology such as service oriented architecture is deemed necessary to providing an end solution to creating a convergence of interoperability of the SOA, EA and CC.

5.3 Conclusion and Further Research

The gap that has been identified, i.e., the convergence of CC, SOA and EA clearly requires further research. This further research will include extending the Zachman framework by developing a logical model for the purposes of matching and cross matching the services between and among EA, SOA and CC.

The research is significant as such a logical model made available to the industry will provide a sound basis for a migration path to cloud computing for the enterprises that already have an established enterprise architecture that includes SOA and need to extend their service delivery with the deployment of cloud computing services.

Other benefits of this unique piece of research are that a logical model will form a basis for a structured approach to the delivery of cloud computing services across enterprises. In using such a model enterprises will benefit from:

- better alignment of business processing and advocated enterprise architecture by an enterprise;
- a more agile and at the same time stringent life cycle of the services processed; and
- the potential for a tailored service level agreement between the service provided and the customers irrespective of whether the service provider is an in-house ICT section or an external vendor.

6. Next Steps

The next step is to develop a logical model to identify a set of selected components of EA that could be mapped to a service oriented architecture which in turn could call a service from the cloud with the convergence of interoperability of CC, SOA and EA. This will be followed by Proof of Concept to test this model.

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