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Cloud Governance Model and Security Solutions for Cloud Service Providers

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Abstract

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<p>This study aimed to help IT professionals involved in providing cloud services with the specialization of private, public or hybrid clouds. Giant cloud services providers such as Google, Microsoft, Sun, Amazon, EBay, SalesForce.com and ORACLE are dominating the cloud world by providing different applications to any organization or individual interested all around the world.</p> <p>Since the subject of cloud computing and cloud governance model is vast, the study had to be conducted in a selective manner which would suite the investigation. The companies were Ficolo, ORACLE and Synechron. Each company's background together with their specific cloud governance model, Service Oriented Architecture (SOA), was observed and evaluated. After a thorough comparison and analysis a new SOA framework was proposed along with its detailed components.</p> <p>To make the study complete, the most important issues in relation to cloud security were also discussed. The undeniable doubt of customers to the cloud world is the handing over of their data with full confidence to a cloud provider or a third party. This then gives the opportunity for cloud providers to address the challenges by designing up-to-date models and methodologies.</p> <p>Therefore in order to evaluate real time applications related to governance and security issues, the study has followed standards designed by NIST, ISO 27001 and BSI 100-2 IT-Grundschutz. These standards were referred specifically during the design of the improved SOA Governance Framework and security recommendations.</p>	
Key Words	IT, SOA, NIST, Cloud Computing and Cloud Governance Model

Contents

Abstract

Abbreviations

1 Introduction	1
2 Cloud Computing	3
2.1 Classification of Cloud Computing	4
2.1.1 Service Models	4
2.1.2 Deployment Model	5
2.2 Businesses and Cloud Computing	6
2.3 Cloud Service Providers Requirements	6
2.4 Cloud Data Management Application	8
2.5 Cloud Programming	9
2.6 Cloud Technology Implementation	10
2.7 Risks for Cloud Providers and IT Vendors	11
3 Cloud Governance	13
3.1 Background	13
3.1.1 Information Technology (IT)	14
3.1.2 Corporate Governance	14
3.1.3 Service-Oriented Architecture Governance (SOA)	14
3.2 Cloud Infrastructure in Finland	15
3.3 Cloud Governance Compatibility in Existing Systems	16
3.3.1 Ficolo's Collocation Cloud Services	17
3.3.2 ORACLE's SOA Cloud Governance	18
3.3.3 Synechron's Cloud Governance	21
3.4 Comparative Analysis	23
3.5 Proposed Model	25
3.6 Governance Technology	28
4 Cloud Security Model	29
4.1 Model Driven Security	29
4.2 Cloud Security Threats	30
4.3 Cloud Security Solutions	31
4.3.1 Security as a Service (SecaaS)	31

4.3.2 Security as a Platform	32
4.3.3 Security as an Infrastructure	32
4.4 Recommendation	34
5 Conclusion	35
References	36
Appendices	40
Appendix 1: Definitions	40
Appendix 2: Ficolo's Cloud Service Features	45
Appendix 3: ORACLE's SOA Governance Suite	46
Appendix 4: Questionnaire answered by Ficolo	48

Abbreviations

APIs	Application Programming Interface
CEO	Chief Executive Officer
CPU	Central Processing Unit
CRM	Customer Relationship Management
DSL	Return on Investment
EA Framework	Enterprise Architecture Framework
EAL	Evaluation Assurance Level
EC2	Amazon Elastic Compute Cloud
HR	Human Resources
IaaS	Infrastructure as a Service
IDS	Intrusion Detection Software
ISO	International Organization for Standardization
ISVs	Independent Software Vendors
IT	Information Technology
NIST	National Institute of Science and Technology
PaaS	Platform as a Service
QoS	Quality of Services
RDS	Amazon Relational Database Service
REST	Representational State Transfer
ROI	Return of Investment

SaaS	Software as a Service
SLA	Service Level Agreement
SNS	Amazon Simple Notification Service
SOA	Service Oriented Architecture
SQS	Simple Queue Service
UML	Unified Modeling Language

1 Introduction

The recent booming of cloud computing has become the biggest turnover for enterprises with the issues of establishing a team of IT experts with complicated servers that need regular maintenance, security, power and cooling systems throughout. The concept of cloud computing seems very new even though applications such as time sharing, virtual machine, “the network is the computer” by Sun Enterprise and Grid technology have been implemented since 1960, 1982 and 1990 respectively.

What makes cloud computing realistic now is the maturation of the Internet as an IT platform visualization of hardware commoditization, standardization and open source software. [1] The key catalysts before cloud computing officially being commercialized to the public were: Google, Yahoo, Amazon and Microsoft which have created the undeniable Internet search, electronic commerce and instant messaging in the form of cloud phenomena. According to the some studies done in 2008, Microsoft simply loaded a container with almost 9000 new servers which were simply plugged to data center and came to life instantly. [2]

The intriguing part about cloud computing is that it works as electricity does where users plug in when needed. As an end user it might be irrelevant to know where it comes from but very crucial for each and every provider in the cloud system. Every customer pays will be obliged to pay only for the amount consumed within that certain period of time. This principle is known as *pay-as-you-go* approach. In addition cloud computing is highly praised for being environmental friendly in regard to energy consumption and carbon emissions in terms of significantly creating the running of relatively few large cloud data centers rather than tens of thousands of individual company data centers that are rarely used to their full capacity.

The giant providers such as Microsoft, Google, EBay, Amazon, Yahoo, Salesforce.com and Sun Enterprises have established a fixed cost system in building, maintaining and controlling according to the number of clients they have established. EBay, Gmail, MySpace, Google Apps, Facebook, 3Tera and Office Live are the first pioneers to clear the path towards cloud computing and be a business phenomenon and a signpost.

This then leads to the dynamic concepts of cloud computing and its applications. The companies listed in the previous page have designed their own approaches to how their cloud services (public, private or hybrid) are different from the traditional IT outsourcing. This thesis based these issues to thoroughly go through the background, definition, characteristics and real-time application of cloud computing technology in regards to its governance model and security issue applied by cloud service providers.

The goal of this study was to analyze and find out the drawbacks on the existing governance models implemented by the three selected companies: ORACLE, Synechron and Ficolo which is known as Service Oriented Architecture (SOA) in order to propose improvements that would lead to the design of a new and improved model. The model can be taken as a whole or a supplementary to the companies' current working models. However since the study was conducted for this academic work only, the companies have not yet commented on the proposal.

The scope of the study on the other hand has several limitations considering the vast nature of the topic. The proposed model was generalized knowing that different organizations with similar areas of specialty were not taken into consideration and most of them did not take the same level of governance. The framework is not a complete version of the SOA governance model for the subjected companies but open for improvements.

2 Cloud Computing

After the stages of technology evolvement the Internet technology has become ubiquitous. Every process of digital access has become extremely reliable and up-to-date. This phenomenon of digital world worship became inevitable to the real implementation of cloud technology. It has become clear that outstanding applications of the future were to be accessed via the web. The concept of cloud computing was launched in 2006 by Eric Schimdt, from Google, who employed it to describe a virtualized business model for information technologies as a service. This concept relies on J. McCarthy's who was convinced in the 1960's that, in the future information facilities would be readily available to the public, just like any other public utility. [3]

Even though cloud computing is given different definitions, it is wise not to mix the term "cloud" with its generic understanding of it being the actual cloud in the sky. It might however lead to its similar concept when combined with the word "computing". Cloud Computing is an easy approach to the maximization of information technology capacity without any investment on actual infrastructures.

There are five characters that define cloud computing at its best: Dynamic Computing Infrastructure, IT Service-Centric Approach, Self-Service Based Usage Model, Minimally or Self-Managed Platform and Consumption-based Billing. [4] Dynamic Computing Infrastructure states that in order to have a high level of assurance in availability the foundation of the dynamic infrastructure has to be standardized, scalable to match the secured physical infrastructure. Then the service needs to be visualized and utilized. IT service-center approach in addition states that the user of the cloud service has to be able to access in to the system whenever needed and should not be bothered by the complexity of the network environment.

Self-service based usage model deals with ease of the system for users to easily be able to upload, build, deploy, schedule, manage, and report on their business services on demand. This takes in to consideration of saving time and money and allows the administrative staff to focus on more strategic, high-valued responsibilities. Minimally or self-managed platform is about providing the best services in terms of self-resource recovery deployment, easy configuration and reporting capability which resources can be allocated and reallocated by multiple group of users and tools for controlling the

access level of resources and policies. Finally Consumption-based billing means any customers must be able to pay for the amount of resource it has used and charge either in timely rate or number of applications used by a certain number of users at the same time.

To summarize these characters make cloud computing not to be dependent on platforms and become highly compatible for easy access and conversion on any file from one location over another. At the same time cloud computing provides a significant increase on businesses agility by reducing all the capital equipment costs and operating expenses.

2.1 Classification of Cloud Computing

In this paper the service model and deployment model will be described to capture the idea of how computing controls the cloud and utilize resources by automatically measuring and updating them constantly. According to the NIST most recent publication there are three layers of services models and four deployment models. [5]

2.1.1 Service Models

The three layers of service models lay the foundation for service platform on which the software can be built: Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS) and Cloud Infrastructure as a Service (IaaS).

SaaS is an application that is offered to customers that cannot be owned, installed, maintained or updated for personal use instead provided to the general public for use. Their service can be classified as free of charge or the other way round depending on the time spent on each application. Best examples are emails, business social emails, Google wave communication, Google applications such as Google doc, Pixlr, FotoFlexer, Photo Express and Jaycut. However there are special cases in SaaS desktop application such as StartForce, eyeOS and IT Farm which can be installed and used from personal computer.

PaaS on the other hand is a software environment that can be used by a customer to develop and run end user applications. The customer needs to acquire the applications from the cloud infrastructure which are created using programming

languages and tools supported by the provider. Another best example is Microsoft Windows applications. The platform is deployed and configured by the provider.

Finally IaaS has the capability of provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operation; storage, deploying applications, and possibly limiting the control over the selected networking components for instance creating a host firewall.

2.1.2 Deployment Model

The deployment model comprises four layers that are determined by customers' desire for service procedures. These are Private Cloud, Community Cloud, Public Cloud and Hybrid Cloud. Private Cloud is a dedicated cloud infrastructure that is privately operated by an organization which is either managed by a third party or the organization itself. The data center could exist in the organization's premises or elsewhere. Community Cloud on the other hand is shared by several organizations and supports a specific community that has shared concerns for instance mission, security requirements, policy, and compliance considerations. It may be managed by the organizations or a third party and may exist on premise or off premise.

Meanwhile Public Cloud provides an infrastructure that is available to the general public or a large industry group which is normally owned by an organization engaged in selling cloud services. However if any organization wants the benefit of both the public and private, Hybrid Cloud can be the best choice. It provides composition of two or more clouds (private, community, or public) that remain to have unique entities but are bound together by standardized or proprietary technology that enables data and application portability for instance cloud bursting for load balancing between clouds.

Generally defining clearly on which area of cloud to specialize would lead to a scalable Software as a Service (SaaS), Platform as a Service (PaaS) or Infrastructure as a Service (IaaS) provider. Since cloud services are classified under web applications, it is wise to consider all the features each of these services to fit accordingly. For instance if the web application has inherent programming, it will create bottleneck and difficulty in profiling the codes.

2.2 Businesses and Cloud Computing

Cloud computing is now the most fundamental approach to IT solutions regarding downsizing of recurring costs and emphasizing on saving and capitalizing. The financial crisis of 2007-2008 shocked the global market to its worst turmoil since the Great Depression of 1930. Cloud computing, therefore, offers the possibility of increasing computing capacity and introducing new products and services with a rapid time management and providing best security, reliability, efficiency and transparency to deliver more interactive services to citizens and businesses.

The adaptation of cloud computing where any business from all around the world do not need to run the applications within their company. They just need start sharing applications from a data center by plugging in as a utility and start uploading. It is similar to Gmail which runs in a cloud; once logged in, it can be customized according to the specification the user intends. On the other hand, there will be a central location with a predefined subscription fee, where all the needed software applications can easily be access through web browsers rather than purchasing and installing the application in individual computers. [6]

Cloud technology has changed the perception towards not only for consumer applications but also business applications, which leads to the concept of Enterprise Cloud Computing. Businesses run all kinds of applications such as CRM, Accounting, and HR with consequent costs in maintaining, updating software applications. It is also estimated that enterprises spend between two and ten percent of their revenues on IT. Therefore by separating which department(s) to export to in an enterprise cloud infrastructure, companies can easily keep track of their IT transactions.

2.3 Cloud Service Providers Requirements

As described section 2.2, cloud computing has revolutionized IT at its best in terms of efficiency and changing the flow of information by creating a powerful resource over the global network. However it has brought trouble in many boardrooms as the potential of cloud computing comes to the attention of more managers who work in IT departments. In the 1980s and 1990s, many IT departments were highly resistant to the use of PCs for serious computing. Even at some point it was believed that Microsoft Windows would never be rolled out since it was not stable and would never

catch on even though now half is becoming true. However the most speculated issue was on the impact of cloud computing dissolving IT departments at least to a linear manner. The cloud does carry a significant disruption for business to continue as usual which leads to two major challenges.

First, when cloud providers introduce their service for the first time to any enterprise, they have to be able to develop functionality that expands usage and spread across the enterprise without the direct involvement of IT departments. Creating assurance and strategic control of the system requires an immense responsibility and dedication to gain the ongoing attention of the C-suite and extend its strategic role. Second strong strategies have to be implemented in providing an ecosystem cloud service. Effective supervision of usage, SLAs, performance, robustness and business dependency is vital. Monitoring the external provider's services must be done, but internal cloud monitoring should also be introduced. Third the providers must submit details on trust, security or certification of data security, reliability, grantee for all performances, confidentiality, availability, option to test with non- sensitive data before importing any critical data, establish remedies for cross border legal issues if the provider is not same place as the clients, ability to classify data sensitivity to entrust in the cloud, encryption of data management and protection of guarantee in the case of data loss or breach of information.

When looking at facts of how cloud computing has been standing since the 2008 economic crisis, it has indeed become extremely embraceable. The stable design in cloud model offers small and medium businesses to focus on high return and low cost with the risk of depending on a virtual space that can be a prime target for attackers and opportunists.

In general one of the most important areas customers need to investigate before contracting with a cloud provider is how much flexibility and control they will have over their data and business applications. Two major questions such as customers' ability to move in and out of the cloud easily specially from private to a public cloud and the portability of cloud applications have to be raised. In other words, customers level of capacity to move their systems back on-premise if their business requirements or regulatory needs change has to be identified before hand.

To address the above issues detailed methodologies in chapter 3 and 4 will be showed with actual case studies and thorough analysis. The study will help to understand how cloud transformed IT companies from constant maintenance to innovation.

2.4 Cloud Data Management Application

In section 2.1 the characteristics of cloud computing were discussed thoroughly, so that it will lead to the design of data management applications to move into the cloud. Therefore this section will focus on the two major components: transactional data management and analytical data management.

Transactional data management deals with the database industry such as banking system, online booking and electronic commerce. These applications rely on Atomicity, Consistency, Isolation, Durability (ACID) guarantee that a database system provide. The transactional database market is dominated by ORACLE, IBM DB2, Microsoft SQL Server and Sybase.

IBM released a shared-nothing implementation of DB2 in the mid-1990s which is now available as a “Database Partitioning Feature” (DPF) add-on to their flagship product, but is designed to help scale analytical applications running on data warehouses, not transactional data management. Neither Microsoft SQL Server nor Sybase can also be deployed using a shared-nothing architecture. However in the year 2008, ORACLE has introduced a shared-nothing architecture at a storage layer but to be implemented on data warehouses. [7] Therefore it can be concluded that transactional data management is not suitable for cloud computing considering that the shared data system takes into account only consistency and availability and leaves out tolerance during face to face data replication over a large geographic distance. In addition it has an enormous risk in storing data on an untrusted host.

Analytical data management on the other hand refers to applications that query a data store for use in business planning, problem solving and decision support. Analytical systems tend to be read-mostly with occasional batch inserts and it also consists of \$3.98 billion of the \$14.6 billion database market (27%) and is growing at a rate of 10.3% annually.

Teradata, Netezza, Greenplum, DATAlegro which recently have been acquired by Microsoft, Vertica, and Aster Data all use a shared-nothing architecture at least in the storage layer in their analytical DBMS products, with IBM DB2 and recently ORACLE also adding shared-nothing analytical products. Generally analytical data management is a great suite to run cloud deployment since it does not require ACID guarantee, and sensitive data is included after the encryption function is applied.

2.5 Cloud Programming

Cloud computing is associated with Web 2.0 and in particular the key element of trends of online applications known as Software as a Service (SaaS) and Hardware as a Service (HaaS). SaaS application is software that is easily accessed through web browsers anytime and anywhere. It differentiates itself from any online banking or email account, is by being a non downloadable application that shares similar effects as to Microsoft Office. Best example is Google Docs. On the other hand HaaS relates to the outsourcing of support and network purchases as a complete package in order to have the latest and reliable equipment through the entire investment process. Best examples of HaaS are Security as a service, servers, desktops and backup as a service.

Based on the support of SaaS and HaaS, providers can establish the infrastructure towards cloud computing by including technologies that consists of virtualization, organized work flow and service flow, web service oriented architecture, all rounded storage system and clear programming models. Being the best in the cloud industry requires a highly qualified expertise with the capability of creating and implementing the strategies towards design, development, maintenance and updating of cloud applications.

On the other hand customers willing to put all the faith over their confidential data raise the dint towards security. Assuring every customer at most level of confidentiality also requires expert knowledge, time and dedication. Usually developing from the scratch makes the delegation at the higher expertise and the person responsible to acquire a good programming skill.

The experts have to know APIs especially if Google App Engine and Salesforce.com is to be used while some development tools have extensions to permit deployment in the cloud and programmers have to learn those features. On the other hand cloud computing is more on an operating system level than a language concept. As for programming languages, any browser-based or server-based language is likely to be used such as JavaScript, PHP, ASP, AJAX, Perl, Java, and SQL. On the server side of the programming Cloud Computing Providers usually use JAVA and C-Sharp. In the case of Microsoft SQL Azure, there are technical challenges beyond a 'regular' web development environment.

The programmer might have to come up with ways to speed on sparse columns, extended stored procedures, Service Broker, or Common Language Runtime (CLR) and CLR User-Defined Types. [8]

In general to implement a new programming language to operate in the cloud on client machines are not used because optimization for cloud computing; easy to learn, fast, efficient, powerful, modern are critical. Cloud hosting products help developers to have the ability to launch and increase the size of a server, without having any kind of delay. Developers are able to create the application in a completely customized environment, and then expand it into a production machine without any significant hassle. If obstacles are encountered along the way, the machine can be destroyed with relative ease.

2.6 Cloud Technology Implementation

After a sustainable knowledge about cloud computing, one could ask one major question. If all companies stop having any local data center for their specific business orientation and move to the cloud, it would not mean that all of these companies servers and data will be stocked in one instead provided a dedicated areas with their names on it.

If more resources are needed, the chances that the cloud can summon them are higher. It would be expensive for cloud providers to keep massive amounts of surplus facilities sitting around unused day after day waiting for a rare spike. Even though the cloud is not required to perform in certain ways, it gives a multitenant facility for many customers to use the same servers and software. The cloud managers make an

educated guess at how much surplus capacity is safe to maintain; their advanced load-balancing systems can anticipate need, adding more servers for more direct power, while at the same time moving workloads around to underutilized servers.

The cloud's own monitoring system is capable of anticipating need and quickly firing up additional "virtual machines" as needed. Clouds are a form of cluster computing, and so far only a small handful of companies have gained the knowledge of how to build out very large clusters for general public use. These companies include Amazon Web Services, Google's App Engine, Microsoft's Azure cloud, the Rackspace Cloud, Sun Microsystems (now part of ORACLE), IBM, Yahoo!, eBay, and Facebook. Other large Internet companies have also built big data centers with x86 parts, but so far they are not available to the public for on-demand, general-purpose, cloud-style computing uses.

Finland now has over 30 companies involved in cloud technology which are upgrading to an Agile Finnish IT services in the Cloud. Their services focus on web software with superior user experiences which are created with open, green and safe software technology. Open cloud software provides the benefit of superior flexibility and user experience with the grantee of one of the most secure geopolitical places.

Therefore, in chapter 3 and 4 two companies (ORACLE and Synechron) with great reputation in cloud services were tested to determine how they are implementing their cloud services to their best performance. Elaborated technical details with model designs of both companies were extracted that leads to expertise analysis and few recommendations.

2.7 Risks for Cloud Providers and IT Vendors

The level of having to take the enormous responsibilities of licensing software and information technologies to have the best reliability, availability, portability, security and protection brings its own risks in losing customers. Since customers only care about the outcomes delivered to their money's worth, any technology vendor or cloud provider has to constantly design and implement best ways that will help increase customer satisfaction, revenues subscription and licensing opportunities. In addition buying other vendor technologies when needed will create a tremendous purchasing power and establish trust with the end users or customers.

The concept of Pay-As-You-Go (PAYG) model lets customers scale up or down the transaction they continue to have with their provider(s). In order to have a guarantee in future business, customers should be given easy access to add or subtract resources and pay in more than small increments. At the same time cloud providers must be ready to design a service term upon both parties agreement to create rewarding services throughout. The service term should include the level of liability, service termination conditions and service level definitions. Then if the agreement which is known as "enterprise agreement" is decided on, the provider can ask for more payment to gain flexibility and ability to buy the services whenever needed and reduce the problem of insurance premiums. Even though operating expenses can be difficult to predict and control the agreement must include a safety need for extra new services subscriptions that might occur through time. So for now the banner of "pay as you go" will continue to be shouted from the clouds. However as customers and providers struggle to find the right financial models, they may feel less like they are in the cloud than covered with fog.

3 Cloud Governance

Chapter 2 discussed what cloud computing is and how it has become ground breaking in information technology evolution. Its characteristics lead to the right selections and implementations while identifying the crucial requirements that will be needed for effective and reliable cloud service(s). Therefore this chapter will show practical applications (Ficolo, ORACLE and Synechron) of cloud governance and its features.

3.1 Background

Cloud governance is a new term in the IT field and no clear definition has not yet been given to it. However according to the CTO of Vordel, cloud governance involves “applying policies to the use of cloud services”. [30] Similarly, Microsoft defines cloud governance as “defining policies around managing the factors: availability, security, privacy, location of cloud services and compliance and tracking or enforcing the policies at run time when the applications are running”. [9, 34] On the other hand Cloud Security Alliance (CSA) has set a standardized cloud governance features that define and enforce these policies. These features are: IT, Corporate Governance and SOA. Figure 1 shows the relationship between cloud governance models which are to be discussed in the next sections.

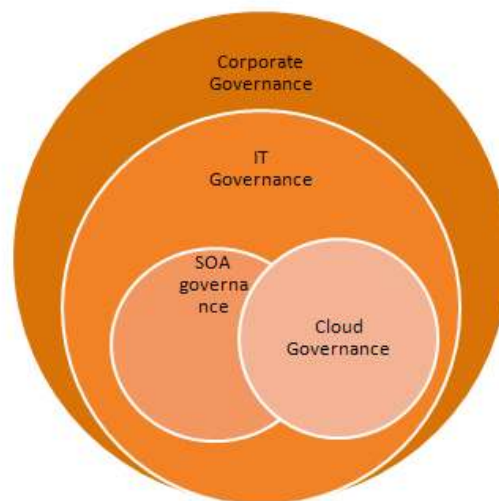


Figure 1 Position of Cloud Governance (Reprinted from Yu He, (2011), [9,137])

Since cloud governance is one of the sub branches of IT governance that controls cloud services as specific type of IT services, in order to deliver the value to support business needs. The overlap and similarities between cloud computing and SOA provide us an indication to sketch a cloud governance model on the basis of exiting SOA governance models as well as cloud governance literatures. [10]

3.1.1 Information Technology (IT)

Information Technology (IT) governance is a type of corporate governance model that has a reference to information technology processes and supports the goal of a business. It focuses on the management and control of IT assets, people, processes and infrastructure that answers the major question: “what decision need to be made, who is accountable in making the decisions and how will the decision will be made?”

3.1.2 Corporate Governance

Corporate Governance Model describes the set of processes, customs, policies, laws and institutions affecting the way in which a corporation is directed, administered or controlled. [9] Corporate Governance tries to cover all the business aspects ranging from human resource to purchasing and marketing by designing a corporate standardized policy throughout. On the other hand it also establishes a chain of command, responsibility, authority and communication especially in empowerment of decision making.

3.1.3 Service-Oriented Architecture Governance (SOA)

SOA governance is an extension of IT governance which implements changes from IT governance to ensure that the concepts and principles for service orientation architecture are managed appropriately and that services are able to deliver in line with the business goals. The cloud services are usually provided via a so-called REST API.

3.2 Cloud Infrastructure in Finland

From the 1960's to 1980's Finland has been researching with the ICT industry to develop an opportunity in the technology sector and create jobs simultaneously. Baltic Sea Region Report by SwedBank suggests that available well-educated workforce, especially in the IT-field, makes Finland attractive and competitive for IT research and development [11].

In Finland some of the network operators have to act under general service obligation. In case of Internet connection, these operators have to provide a decent network connection to everybody on their district. Ministry of Transport and Communications demands, that at least 1 Mbit/s connection must be available to consumers and companies with reasonable price and it must be delivered in reasonable time [12]. This service obligation means that all of Finland is getting broadband access, and everyone in Finland can get online. As much as 89 % of Finns aged 16-74 were using the Internet in spring 2011 [13] and recent studies done by Statistics Finland in 2012 show that these group of age (65%) shop online tremendously. The share of those having bought something from the web during the past three months rose by four percentage points to 47% over the year.

When applications move to the Internet user productivity and connectivity are tied to networking equipment [13]. As cloud services become more popular the Internet traffic increases. Networking company Cisco forecasts that cloud IP-traffic will increase six-fold from 2011 to 2016. The amount of traffic is already beyond comprehension: 57 Exabyte's per month in 2011 [14] and global mobile data traffic grew 70 percent in 2012. This huge data traffic puts requirements to the network.

In addition data connections are not dependent on one operator which makes pricing more competitive. [15] There are several connections to Europe and Russia to ensure redundant, stable and operating connections through the Internet [16]. For instance Google, announced a further €150 million investment, in August 2012, in Phase II of the data center, which would involve the restoration and conversion of their machine design hall known as Alvar Aalto. It is expected to reduce network traffic over the Internet. [17]

Data centers consume electricity abundantly; in order for their power supply to be reliable and have enough capacity. In Finland both transmission and distribution networks have good capacity and reliability records. In addition Finland has strong connections with the Russian and Nordic power systems in case extra power needs to be imported. Electricity generation is based on a versatile mix of resources including renewable [18]. Finland has also some other benefits when it comes to power efficiency and green technology.

Being one of the digitally best connected countries in the world, Finland is well positioned to attract major data centers. Finland has been ranked in the most stable country in the world in a survey based on social, economic, political, and military indicators [27]. As a fact, the last war in Finland ended in April, 1945. Meanwhile many other countries still have war issues. The Northern world being so safe and peaceful, it is a perfect place for data centers. With an excellent police force and a stable political and economic environment, with good Nordic, EU and Russian cooperation, Finland remains a safe and secure country. Not just with the issue of war, also crime statistics remain low compared to the United States and other developed countries. Although the Nordic and Baltic regions have shown an increase in terrorist activity and threat reporting, Finland remains vigilant without becoming paranoid.

3.3 Cloud Governance Compatibility in Existing Systems

At the beginning of this chapter, it was explained in which areas of the organizational problems cloud governance confronts and how many features it has. Therefore on the bases of that this section will discuss what is new for cloud governance and what cloud governance model is derived from.

When analyzing and summarizing the problems for cloud governance, we have found that the problems on cloud governance resemble the problems of SOA governance mentioned in 3.1.3. According to few studies most of cloud services are designed in line with the SOA principles, cloud computing can be treated as one of the implementation and realization approaches for SOA. At the meantime, SOA as well as virtualization technology, realize the “resource pooling” characteristic from cloud. Both of SOA governance and cloud governance require enterprise-wise cooperation like communication between IT and Lines of business, to realize the business value.

Governance related to SOA governance, such as service governance and organizational change, is the most applicable approaches to cloud computing. It is easier to leverage SOA governance approaches to cloud servicers' governance.

Therefore in this chapter the history of cloud technology in Finland and relevant models in relation two prestige companies: Ficolo, ORACLE and Synechron will be illustrated. Since there is a huge privacy issue a general application analysis and recommendations are given based on the information obtained.

3.3.1 Ficolo's Collocation Cloud Services

Ficolo is the first data center that specializes in collocation. It gives its services to large public sector organizations and large listed companies all over the country and since November 2011 it has partnered with DNA for data communication services and devices. It owns one of the largest underground tunnel networks in the Nordic countries, centralized into a safe data center, and is currently building a leading Collocation business and service concept. Ficolo's premises meet the Finnish Communications Regulatory Authority requirements for "important premises", It helps implement a data center solution for customer needs, which meets the requirements for "vitally important premises."

Ficolo's detailed services are most known for private and partnered cloud model strategies through a dedicated or hybrid platform. At the same time they focus on Paas, IaaS, and Security which is mainly on DRaaS (Disaster Recovery) and DCaaS (Data Center as a Service) in their cloud computing layers. In order to make their production cycle more complete they occasionally outsource departments such as Payroll, Human resource, Procurement, CRM, Accounting & Finance and Project Management. The specialization of Ficolo being collocation, their designed model depicts the collaboration of customer and services provider's responsibility in relation to collocation layers. Figure 2 shows the operation and collaboration in which data center services pertain.

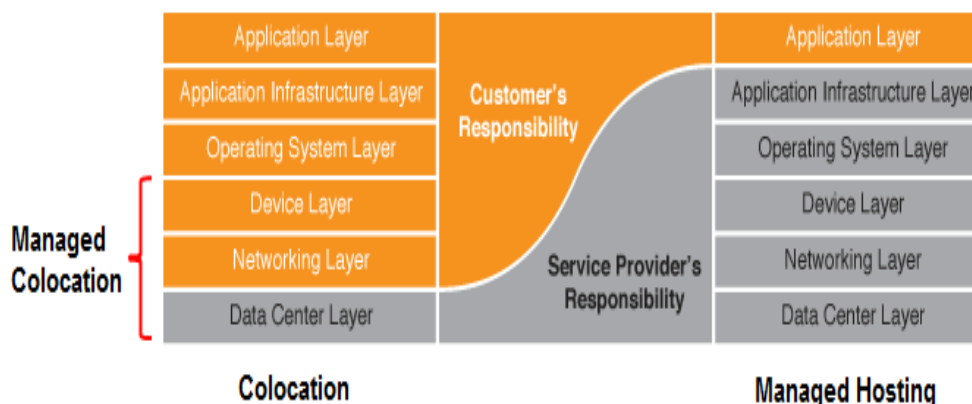


Figure 2 Ficolo's Collocation Collaboration Model (Reprinted from what is Collocation? (2013), [19])

In collocation, customers can conveniently choose which operations they outsource to the service provider and which ones they want to handle in-house. It will help them reduce the risk related to choosing what to outsource and retain full control over their ICT service components.

For further information an interview shown in Appendix 4 was conducted. Even though the strict privacy rule imposed by the company led for the study to only take the technical details for future references when needed.

3.3.2 ORACLE's SOA Cloud Governance

Background

ORACLE has been developing an enterprise comprehensive cloud applications for seven years that are available for the public use with a diverse area of application. ORACLE is trying to provide complete suites: platform services, application service and social services with a common infrastructure services. All these applications have a modern HTML5 and mobile user interface that can run on browsers, iPhones and Ipads. These interfaces are socially enabled where the application users can collaborate with each other over the ORACLE user social network. The concept of the social network is beyond the standards of bringing teams together to communicate, collaborate, team and work together ideas on a project(s). ORACLE has introduced an

application called Social Relationship Management. It is somehow different from the Customer Relationship Management because of its approaches being comprehensive.

ORACLE's cloud is based on open standards like JAVA, SQL, Python and HTML5. To have smooth flow of information with a guarantee of security throughout, every cloud service provider has to be able to maintain models that can help evaluate their current process application and control structure.

Since May 2010 ORACLE has been offering cloud computing in both fully enterprise-grade and support for public and private cloud computing to its 25 million users all over the world. ORACLE also enables organizations to build their own private or leveraged public clouds that will help them provide cloud services to others. These clouds service ORACLE offers are based on the first two models out of the three which were discussed in section 2.2.1. For instance in the case of SaaS customer and ISVs: ORACLE CRM On Demand and ORACLE Platform for SaaS are widely used. On the other hand ORACLE offers a comprehensive PaaS product for public cloud service providers as well as enterprise customers to build their own public clouds. ORACLE calls this the ORACLE PaaS Platform. In Appendix 3 the figure shows the services that are currently provided by ORACLE in a comprehensive platform.

ORACLE's Cloud Governance Model

ORACLE has two approaches to SOA governance model which are the Architecture Governance and the Service Life Cycle Improvement Loop. In the figure 3 the important features such as the Organizational Change, SOA Maturity Level, Roles and Accountability, Policy, Service Life Cycle, Behavioral Impact and Metrics Models are fully and partially integrated. However as shown in Figure 4 ORACLE's SOA Road Map is depicted separately and is not integrated with the overall framework. These figures helped to respectively show the additional phases that need to be taken into consideration for the company's governance model to be fully functional.

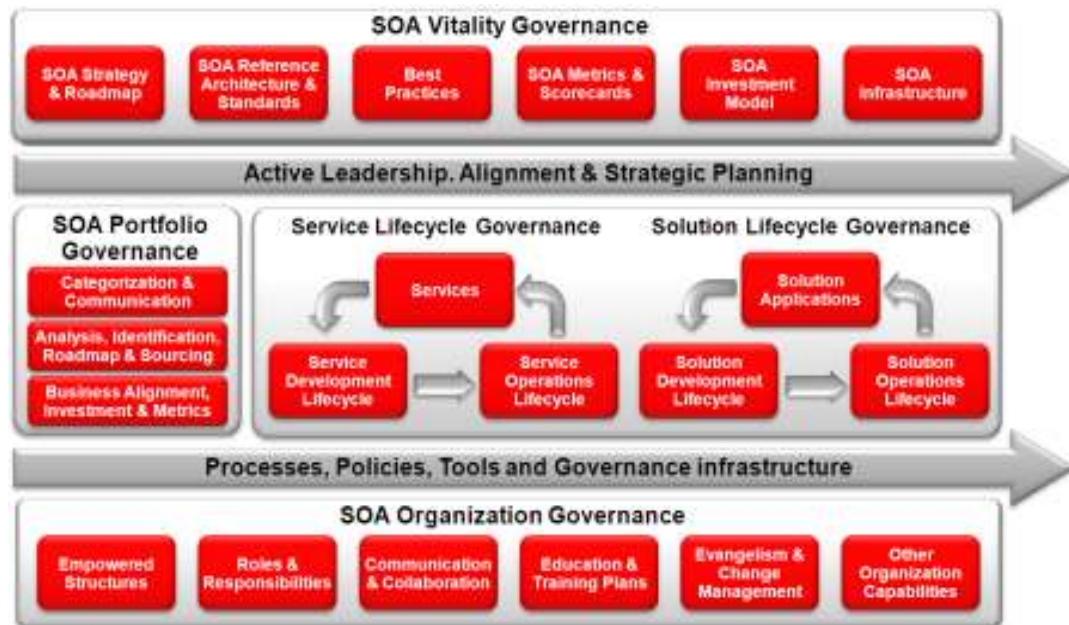


Figure 3 ORACLE's SOA governance Framework Model (Reprinted from Stephen G. Bennett, (2012) [20, 24])

ORACLE's SOA governance framework has similar features as to the existing popular SOA models by: webMethods , IBMand and Software AG. [36, 28-29] Even though ORACLE does not market the standalone SOA Management solution, it is supported by the products of Forrester Wave in order for the customers to have an integrated SOA solution. The framework offers a well-defined structured set of process as compared to Synechron Model in section 3.3.3.

According to the criteria of Forrester 121 in 2012 ORACLE is placed among the strong performers in practice of SOA Management and SLM. Even though SOA has its own flows in the management elements, it compensates them with its strong product architecture. The only critique of ORACLE's SOA governance model is the management loop or life cycle not being integrated with the overall framework.

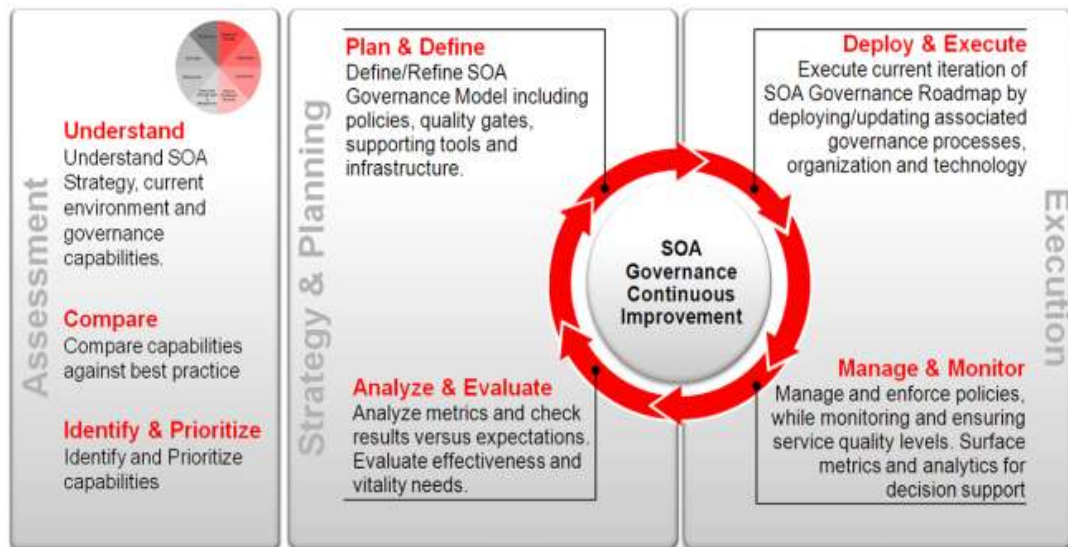


Figure 4 SOA Governance Continuous Improvement Loop (Reprinted from Stephen G. Bennett, (2012) [20, 39])

The three phases show the priorities a SOA governance model has given in order to tackle the challenges by refining the process and enforcing of the policies in each service level. In section 3.5 a combined version of these two models will be shown as a recommendation.

3.3.3 Synechron's Cloud Governance

Background

Synechron is a privately owned company, which was founded in 2001, specializing in outsource services related with financial and digital media technologies. The branches are located in USA, Canada, UK, the Netherlands, Japan, Hong Kong, Singapore, UAE and India by partnering with the four giant companies such as Microsoft, ORACLE, Pega and Pentaho.

To deliver their most appropriate solutions to their respected clients, Synechron has multiple Centers of Excellence (CoEs) that covers Microsoft, Java & QA & Testing Technologies. Since the company is not technology restricted and have an agnostic platform unlike ORACLE and the other big competitors, it has the advantage of maneuvering according to their clients model references and start from the scratch.

Synechron's Cloud Governance Model

Synechrons SLA governance model is the only one in academic field discussing aspects of cloud governance in general. Even though their strategy is to separately value the cloud diligence with the rest of Cloud Adoption Road Map. Compared with the previous model (ORACLE's SOA), Synechron's model does not begin from the business strategy and it neglects the organizational alignment, roles and responsibilities adjustment. This model outlines the necessary components for cloud governance and concentrates on policy modeling, operational model and other management activities such as service management, engineering solutions, cost-benefit analysis and policy management. However, the gap between IT and organizational alignment will probably lead to the devaluation of the introduction of cloud computing.

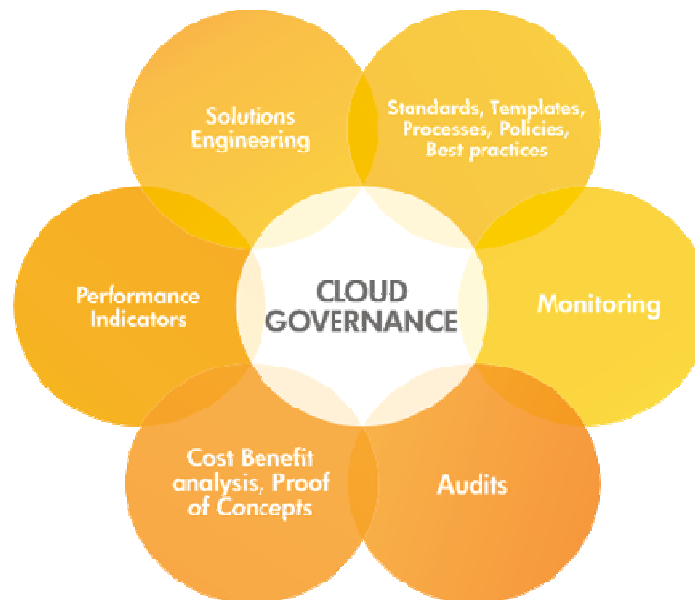


Figure 5 Synechron's Cloud Governance Model (Reprinted from Synechron: Cloud Governance SLA. 2013, [21])

The model is implemented by using IaaS providers such as Amazon Web Service (AWS), Rackspace, Terremark and vCloud. Since every service is developed from scratch and the pay-as-you-go model is used Elastic Compute Cloud (EC2 Compute), S3 storage, Simple Queue Service (SQS), Relational Database Service (RDS), Simple

Notification Service (SNS), SimpleDB and CloudWatch from Amazon AWS are the key elements to their success stories (refer to Appendix 1; No 22-26). Amazon AWS is known for its offers in complete set of infrastructures and platforms, Synechron can benefit from virtual applications running in a cloud without building their own in their premises.

3.4 Comparative Analysis

In this section a comparative analysis among the models is provided. According to the SOA and Cloud Governance approaches, eight criteria are summarized and evaluated in table 1. Therefore for better understanding each criteria is defined briefly.

- ❖ Change management means reducing the risk of misunderstanding the impact of change so that the pending factors will not affect the co-dependency over technical assets.
- ❖ SOA Road Map means having consistent support and maintenance over the life cycle of assets and having the planning, identifying, deploying and executing phases.
- ❖ Accountability refers to the level of definition over roles and responsibility in the assets management.
- ❖ Level of Metrics means a better understanding of assets in terms of definition, collection, compensation, and design time and run-time metrics. It should determine the process goals and metrics that will define what the process must deliver to support objectives and how to measure it.
- ❖ Governance Life Cycle Management is a way of creating a flexible policy that compromises service with life cycle management systems.
- ❖ Application of Solution shows how equipped is the system in designing and implementing problem solving methodologies.
- ❖ Policy or privacy catalogue should indicate detailed policies implemented to build up the confidence in safeguarding the data passed upon.
- ❖ Life Cycle Management manages the lifecycle of an IT service, from planning and optimizing the IT service through the design and delivery of the IT service, to its operation and support.

<input checked="" type="checkbox"/> Fully Integrated <input checked="" type="checkbox"/> Partially Integrated <input checked="" type="checkbox"/> Not Integrated	ORACLE	Synechron
Change Management	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Road Map	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Accountability	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Level of Metrics	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Governance Life Cycle approach	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Application of Solution	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Policy/ Privacy Catalogue	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Pricing and support	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Service Life Cycle Management	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Table 1: Comparative Analysis

ORACLE has built its own Enterprise Manager that will enable administrators to create a resource management quota throughout their business life cycle. It has also focused on different domains of policies and governance but little attention has been paid to the roles and responsibilities. In addition the Road Map is not integrated with the higher governance framework which has a major influence on cloud services to be successful as planned.

Synechron manages and monitors its cloud system through the help of Ganglia, Nagios and other remote system mechanisms. The law of compliance is ensured by using SLA and regular audit through SAS70 Type II, ISO/IEC 27001:2005. In the case of Hybrid model, customers have to consider two choices: In-house data center SLA or public cloud service SLA. In general SOA governance model is best known for its precise strategies and service definition approaches. However, both models presented

by these two companies the details presented in table 1 have not been shown for instance ORACLE uses a service portfolio as a key point of policies but not as a service definitions or management changes.

3.5 Proposed Model

As mentioned in section 3.1.3 the major goal of SOA is to help make a good decision within the context of problems especially related with the dissatisfaction of stakeholders, poor market competition and resource management. On the other hand the core components of SOA are processing domains, management guidelines and maturity models. Process domains deal with the actual delivery of service, security management, service support for customers or users, data management and operational facilities.

The model depicted in Figure 6 is derived from the comparative analysis of both ORACLE and Synechron to reach to the level for both to benefit from for future reference. The entire model is composed of four most important aspects of a feasible Cloud Governance Model: Sustained adoption, IT Optimization, Service Standardization, Seamless Management and Framework Definition. These features try to create balanced outsourcing alternatives, integrated business IT solutions along with consumption, crystallize an industry level standard for service providers, have a healthy combination of physical and virtual resources and compose other referencing models to make the SOA framework more consistent.

The framework is designed with a similar principle followed by IT-Grundschatz Methodology by including cloud security risk, integration, portability, interoperability, designing and migrating applications to appropriate cloud patterns, initiative for consumer onboard and prioritization and investment choices. Even though IT-Grundschatz Methodology is mainly applicable for managing security issues which are to be implemented in a comprehensive and coherent set of organizational and technical security measures, it also collaborates with the basic infrastructure of building an all rounded governance model.

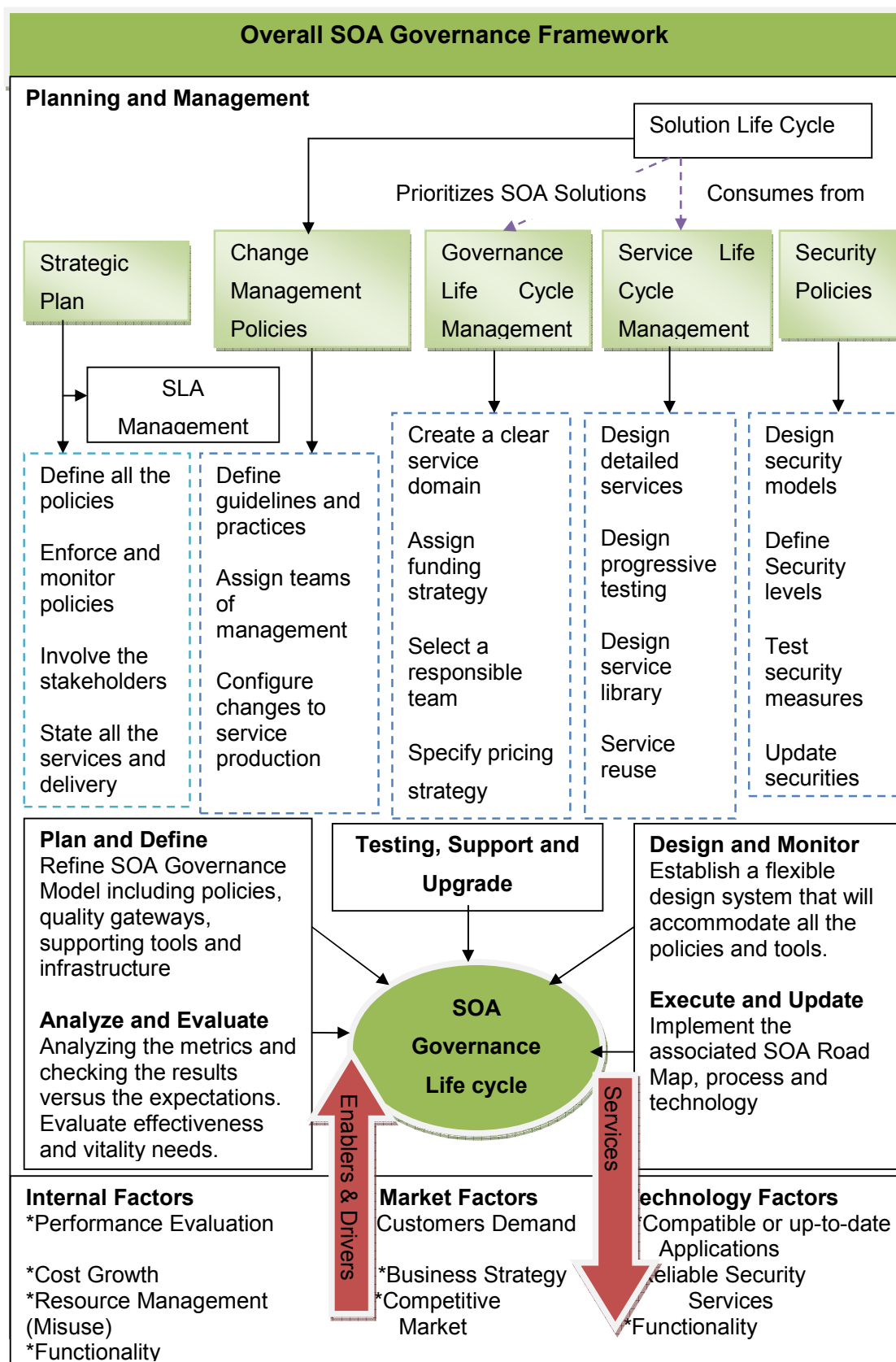


Figure 6 Proposed SOA Cloud Governance Framework

The framework presented in figure 6 offers a holistic view of the whole components of a cloud governance model. Therefore all the major components are described below according to the context of SOA governance model.

- ❖ **Strategic Planning** helps to define the goals and to decide on which services organizations should focus and coordinate. The major issue with companies which decide to be cloud providers is to just be the first in new technology ventures. Instead it should be about creating a business scenario that can be used to adopt cloud computing with clearly stated goals and objectives. It is also a high level strategic determination that will show how the stakeholders can be involved and help them participate in the decision making process of service and deployment model implementations.
- ❖ **Change Management** Policy is a guideline that helps decide which teams to be involved and which internal and external policies to be used. Policies such as Run-time enforcement tools from SOA will help monitor and extend in accordance with the cloud services.
- ❖ **SLA Management** helps maintain the quality of the strategic planning along with the policy management.
- ❖ **Solution Lifecycle** will support the design, development, deployment, management change and the governance life cycle. It helps make sure that the business process functioning according to the rules and associated technologies maintain a proper cost allocation and service deployment throughout.
- ❖ **Roles and Responsibilities** is a process of assigning who is doing what, where and when it should be done. Every organization has its own way of assigning roles to a new system based on an existing system.
- ❖ **Security Policy** is the most curtail part in cloud technology. Since all customers are handing over all their data and information in confidence to their provider or third party, designing state of the art security policy will create a long term business transaction with a full fledged confidence. It has to consist of authentication, authorization, privacy, integrity and non-repudiation.

- ❖ **SOA RoadMap** has to consist of the four major parts in any production line: planning, problem identification, design, execution, testing and upgrading. The roadmap helps identify on-demand resources, reference architecture, design choices, programming techniques and platforms.

In general every cloud provider or third party has to know thoroughly the advantages and disadvantages of cloud computing since it is among new technology ventures and it is at its peak moment. Customers are usually drawn because of its simplified architecture and efficient use of computer CPU, scalability, load balancing, low copex and high availability. However it also has its flows in terms of security, privacy and high usage of certain CPUs, interoperability, vendor lock-in, high opex and SLA critical. Therefore in chapter 4 addressing the security related issues will be discussed accordingly.

3.6 Governance Technology

Any cloud provider with a SOA governance model needs to focus on runtime service executions to help leverage its cloud computing services. Currently the players of SOA governance are using enough design and implementations, which does not require them to use extra design tools. However it is not to say that design time governance is not important. Instead it plays a significant role as a good starting point for proper planning and management.

Design-time governance comes into play only when service and API development reaches a particular scale. The initial impression of SOA was the imposition of complicated design that created a barrier to adoption rather than an enabler. The doubt on SOA falls on two different realms – the realm of a client's software deployed in the cloud (private or public) and the realm of vendor services consumed by the clients as it should be. Since both design time and run-time target at different phase of service it will not create any problems. Therefore to avoid these doubts SOA can use registries or repositories to help ease the design time governance together with the discovery (not necessary automated or on-line) services which are suitable for the client needs.

4 Cloud Security Model

The key selling points for any cloud service provider is to provide solid security models and policies to all clients entails. Even though creating best suited security policies could require a huge amount of resource and patience, it will give the chance for end user to relay on an automated security systems throughout.

In this chapter the focus will be in the challenges involved in maintaining a reliable security policy automation in at the application layer of cloud computing: SaaS, PaaS and IaaS. In addition securities related to models will be discussed to initiate for those security applications which are more complex and dynamic. These applications are SOA, Cloud Application Mashups and other “Plug and Play” application environments. They are implemented for different business areas with different security support systems that will help elaborating how much their capital expenditures and maintenance are reduced from half to none.

4.1 Model Driven Security

The sole purpose of model driven security is to apply all the reasoning integrated to the software development approaches that leads to better security and compliance policy management. [24] The models have to fit into the high level security requirement abstraction in order to be depicted onto other designing models such as UML, DSL or EA Frameworks. Standardization, protocols, policies, responsibility assignment, contribution level, and planning towards solutions have to also be their major characteristics.

A particular case observed at ORACLE was that, the company has depicted all its security policies and guarantees towards giving to all its clients. However few experts oppose in some of those promises. First, the policy known as “bill of rights”, for instance was supposed to give a better understanding to the clients to how much damage or delay could create to their business while ORACLE turns off and investigates. Therefore, a more triggering procedure should be included in the policy.

Second, the exceptions given during downtime or availability of data, seems more far-fetched after knowing that it is measured only against planned availability. Third, to avoid clients performing their own monitoring to their data once in a while, ORACLE does that by running few scripts every one minute. Clients should mention in the contract that they require independent monitoring for future security. Fourth, ORACLE makes a major change in its cloud infrastructure twice a year for the system to be down at least 24 hours which makes clients with a constant need of their data to be out of service. Therefore all clients must make sure that they get in writing that ORACLE will suffer some agreed-upon penalty for falling short of its service availability pledge.

4.2 Cloud Security Threats

Companies are investing highly towards maintaining the best security system even though the treats are still at large and even the Cloud Security Alliance (CSA) have release the “Notorious Nine” treats for the year 2013. Since many companies are moving from server to service based technology, each department has shifted their techniques to how they design and deliver business outputs, while at the same time advancements in information breach, loss and tampering has doubled. Social media has become the first issue for companies where their employees disregard the limitation in the use of companies’ resources for personal gains and amusement. These recent treats validated by CSA are Data Breaching, Data Loss, Account Hijacking, insecure APIs, Denial of Service, Malicious Insiders, Abuse of Cloud Service, Insufficient Due Diligence and Shared Technology Issues.

Most of the treats are self-explanatory where each of them have their own unique differences. Therefore to prevent that from happening data governance models that compromise of retention policy, secure disposal, non-production data, information leakage, risk assessment, Encryption, Encryption Key Management, User Id Credentials, Data security or integrity, Remote user-multi factor authentication.

Since most information these days is shared and linked from one provider to another it is clear that companies will be prone to be victims to cyber-attacks. The reality is that most of the attacks happen because of the loose security procedures implemented by companies where their security system is entirely relied on password system.

4.3 Cloud Security Solutions

Cloud security can be divided according to the type of cloud service the providers give to their clients. Knowing the programmers are the key users in the cloud world it is wise to utilize and choose the best management system that implements both the virtual security along with the physical security system. In this section cloud security is viewed as a service, platform and infrastructure.

4.3.1 Security as a Service (SecaaS)

In order to create a long term relationship between providers and customers, security framework has to be documented to indicate its precise maturity. As systems upgrade and treats modify their shape, security standardization should be able to stabilize the whole function. Cloud as a platform is one the best example in adoption of SecaaS on a global scale. When the security gets to be implemented worldwide, security void will be minimized. When providing security as a service it has to be Ubiquitous and very appealing to customers. However in reality vendor have been facing with a lack of transparency in deploying security controls which has led to the dropping of three times lower in year 2013.

To avoid such circumstances providers have to supply automated and continuous notification throughout the supply chain. They would have to also implement a secured log in for any internal operation in service level agreement compliances. At the same time customers must demand an additional third-party audit and SLA mediation service to make sure that their information is kept as agreed upon. Lastly all parties involved should integrate interface monitoring in accordance with the standards set by SCAP, NIST, CYBEX OR RID.

To summarize, Security as a Service is one best examples to HaaS. It helps create a constant virus definition, provide high security expertise, to have faster user provisioning, outsource administrative tasks to reduce costs and allow organization to devote more time to competency and lastly implement a web interface that allows some in-house administrative tasks together with the view of environmental security on on-going activities.

4.3.2 Security as a Platform

Every cloud provider's design can have its own security platform that can provide an abstraction layer in the form of APIs that helps developers integrate security and management details. For instance ORACLE has a security platform known as OPSS (Oracle Platform Security Service). It is used for securing applications which are deployed in any supported platform or stand-alone. Independent vendors can benefit from its enterprise-based security framework suitable for Java SE and Java EE applications.

For a security platform to function properly it has to be able to support the main features such as authentication, identity assertion, authorization based standardized permissions, specification and management of application policies, secure storage and access of system credentials, auditing, role mappings, role of API, identity virtualization, security configuration and management. In general the benefits of having platform security are to assist developers focus on applications and domain problems, to optimize development time by offering abstraction layers to provide security maintenance and compensation if data is lost or delayed and to allow updates in security rules without affecting any application code.

4.3.3 Security as an Infrastructure

Cloud-based services are most known for their cost reduction benefits even though they have their drawbacks especially if resource monopolization related issues happen which might lead to data suffocation unnecessarily. In order to avoid that cloud providers range their infrastructure services from storage to full server ownership. As customers grow along with their specification, it is mandatory for cloud providers to expand their infrastructures accordingly. However all cloud providers have to be equipped to allocate their resources among customers and avoid the risk of data loss, breach or damage.

Addressing the above issues will create a link in understanding the risk that could incur during resource sharing, high traffic and even sometimes to the maximum of confiscation of actual servers during a certain criminal investigation, which might have a direct or indirect relation to the business transactions. On the other hand knowing how all the virtual servers are allocated throughout the IaaS infrastructure, especially

by limiting it to single business process, could lead to an efficient IaaS backup and a stable security system. To benefit from IaaS, the key features listed below have to be at least fulfilled at all times.

- ❖ Encrypting all password and API keys (avoid all post-it and other predictable passwords).
- ❖ Establishing standardized procedures that will help maintain change control and server provisioning authorization in the daily operation of an IaaS implementation.
- ❖ Providing an extended access control in order for customers to assign the level of data access within their organization or third parties.
- ❖ Providing management utilization such as Access Control Markup Language (XACML or ACML). It is used to describe policy management and access decisions. XACML on the other hand is used to allow organizations to implement a common authorization standard across all systems and applications by providing a standardized language, a method of access control, and policy enforcement. [27]
- ❖ Maintaining user provisioning and de-provisioning system: User provisioning is the process of allocating users to systems and applications and effectively granting identities access to information and systems. it integrates Service Provisioning Markup Language (SPML). SPML provides future benefits of interoperability and integrate proprietary cloud solution.
- ❖ Creating a standard to set the foundation for a consistent and secure method of service offering and use.

Security should not be seen on one side only because if customers are not strict and responsible enough with their data or information, it is the easiest way in for any attackers standing by. The end users have to sign a legal document that will tie them to any information leakage, breach or disruption that might occur in regards to them. The organizations have to be cautious and update in their employees' information and whereabouts while they are in or out of their premises. On the other hand cloud providers have to also prepare and present a detailed agreement on the level of accessing customers data incase data breach, tampering and loss occurs and clearly assign a defined location for each customers' data.

4.4 Recommendation

Some recommendations have been identified to help cloud providers achieve in providing a reliable and effective cloud computing solutions: [26]

- ❖ Provide a certification of adequate information security.
- ❖ Design a redundant system for key supply units such as Internet connection, air conditioning, power and wiring.
- ❖ Deploy certified hypervisors (Common Criteria EAL 4 at least)
- ❖ Design security measures against network-based attacks (IPS/IDS systems, firewall and Application Layer Gateway.
- ❖ Design an encrypted communication system such as TSL or SSL among the customer and cloud computing locations.
- ❖ Avoid redundant networking of the cloud centers.
- ❖ Automate checking of customer applications for vulnerabilities, particularly before going live (PaaS)
- ❖ Maintain an isolated virtual machine for all customers.
- ❖ Implement an encrypted access key control mechanism.
- ❖ Provide customers with access to a crypto overview
- ❖ Have a firewall designed to pass only controlled traffic.
- ❖ Implement a strict protocol access and review access rights regularly.

These points are also related to the concept of IT-Grundschutz methodology. IT-Grundschutz generally defines the concept of security starting from scope definition to structure analysis. Scope definition deals with containing all aspects, components that support business process, organizational units which are administered internally. Structure Analysis analyzes existing infrastructure based on the security applications and frameworks.

In general for cloud providers to apply these recommendations, intensive expertise with the capacity of resolving any irruption at times of security automation, software, and platform and infrastructure development lifecycle is required. Besides they have to differentiate how governance and management function according to their specialty.

5 Conclusion

The overall objective of the thesis was to carry out a real-time analysis on the cloud governance model and create a generic SOA governance model. The SOA governance model was given a high priority because of the wide application of its features in both the selected companies. The strict privacy (proprietary risks) procedure implemented by Ficolo, led the study to focus only on ORACLE's and Synchron's existing models. Their models were thoroughly analyzed to give a combined new proposed SOA framework.

The analysis showed that enterprises usually tend to focus on the SOA Governance in a reactionary manner in which the governance is not taken seriously until serious challenges are encountered. The SOA Governance provides the tools to address the lifecycle involved in designing and implementing complex software applications. These life cycles are reference to SOA Road Map which initiates multiple projects to progress in parallel and yet remain coordinated to ultimately result in a common end goal. Therefore SOA Roadmap has to be a priority in establishing a SOA Governance model.

The SOA governance model should not remain static knowing that businesses are dynamic by nature. The whole framework has to be open for improvement, elasticity and regular reviewing. It has to incorporate a high-level management, planning, updating (applications, machines and employees) and most of all security mechanisms.

When security is designed and implemented in accordance with governance models major component such as digital figure print handling on the Internet has to be described. Even though cloud providers design state of the art privacy, security policies and applications, they also have to be prepared for any surprises that can be thrown at them.

Generally this study aimed to clarify and shown how SOA, cloud computing and data security can complement one another in order to emphasize on service, management, resource allocation, customers preferences and technology factors. Cloud governance should not be complicated, but instead open for any improvements along the way.

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Appendices

Appendix 1: Definitions

No.	Terms	Description
1.	SLA Management	Is a contract between cloud service consumers and providers. SLA management enables consumer organizations to ensure their benefits and the value of cloud services through legitimate contracts.
2.	Collocation	Is a hosting option for small businesses who want the features of a large IT department without the costs. Collocation allows others to place their server machine(s) in someone else's rack and share their bandwidth as their own.
3.	COBIT	Is a supporting toolset that allows managers to bridge the gap between control requirements, technical issues and business risks. The framework provides good practices across a domain and process framework.
4.	SOA Governance Framework	Helps to create alignment and enable collaboration across disparate groups while allowing individual participants to maintain distinct views of services and policies.
5.	Google Docs	Is a word processing, spreadsheet, drawing and presentations package that runs in a web browser. The application also includes an online storage facility. While anybody can register to use Google Docs for free, it also forms part of the paid, "productivity version" of Google Apps.
6.	Google Apps	Is a paid online software suite that includes Google Docs, Google's Gmail cloud based e-mail, Google Colander, Google Video private video hosting and the Google Sites websites building tools.

7.	Collocation	Is a part of an operation and collaboration model to which data center services pertain.
8.	eyeOs	is a web desktop following the cloud computing concept that seeks to enable collaboration and communication among users. It is mainly written in PHP, XML, and JavaScript. It is a private-cloud application platform with a web-based desktop interface.
9.	StartForce	Is one of the many web desktop applications available on the Internet. These are virtual computers that can be accessed through web browser. The idea is anyone would be able to view their familiar desktop and get access to all of their files whether they are at home, work, the library or even the other side of the world.
10.	Pixlr	Is an online image editing software designed for both non-professional and professional users. For instance these users can edit web images to be posted on social networks such as Facebook, MySpace, Bebo, or image sites like Flickr, Fotolog, Photobucket etc.
11.	FotoFkexer	Is a detailed online photo editor that allows users to conveniently customize their favorite photographs. The application allows users to access photos uploaded to PhotoBucket, My Space, Facebook, Flickr, Picasa and other popular websites to edit using FotoFlexer.
12.	Photo Express	Is also another image editing which helps transform ordinary, lackluster pictures into extraordinary, artistic greeting cards, calendars, banners, and even animated Web cards, or Web pages.
13.	JayCut	Was an Internet based video editing software tool.
14.	Linux	Is a Unix-like computer operating system assembled under the model of free and open source software development and distribution.

15.	Web 2.0	Refers to the use of the Internet as a social tool and service delivery mechanism. In practical terms this means that Web 2.0 is an umbrella term for the three key Internet developments of interpersonal computing (where two or more people communicate online), web services (where two or more websites are interlinked online), and software as a service (where people connect to online software applications).
16.	Fusion Middleware	Is a platform that enables enterprises to create and run agile, intelligent business applications while maximizing IT efficiency through full utilization of modern hardware and software architectures.
17.	Forrester Wave	Supported products are ORACLE SOA Management Pack Enterprise Edition, ORACLE SOA Suite, ORACLE Service Bus, ORACLE Enterprise Gateway, ORACLE Real User Experience Insight and ORACLE Web Logic Suite.
18.	BSI 100-2	Is an IT-Grundschutz Methodology that progressively describes (step by step) how information security management can be set up and operated in practice.
19.	ISO 27001	Is an information security management system (ISMS) standard published in October 2005 by the International Organization for Standardization (ISO) and the International Electro technical Commission (IEC).
20.	C-Suite	Refers to a corporation's most important senior executives such as chief Executive Officers, Chief Operating Officers and so on.
21.	Host Firewall	A protective boundary for the local computer, which monitors and restricts information that travels between your computer and its attached networks or the Internet.

22.	SQS	Amazon Simple Queue Service (Amazon SQS) is a reliable, highly scalable, hosted queue for storing messages as they travel between computers.
23.	RDS	Amazon Relational Database Service (Amazon RDS) is a web service that makes it easy to set up, operate, and scale a relational database in the cloud.
24.	SNS	Amazon Simple Notification Service (Amazon SNS) is a web service that makes it easy to create topics, operate, and send notifications from the cloud. The service pushes notifications to applications (or people) without their need to poll for updates. Event driven applications can be implemented with this service.
25.	EC2 Compute	Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers.
26.	S3 Storage	Amazon S3 provides a simple web services interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web.
27.	SimpleDB	Amazon SimpleDB is a highly available and flexible non-relational data store that offloads the work of database administration. Developers simply store and query data items via web services requests and Amazon SimpleDB does the rest.

28.	CloudWatch	Amazon CloudWatch provides monitoring for AWS cloud resources and the applications customers run on AWS. Developers and system administrators can use it to collect and track metrics, gain insight, and react immediately to keep their applications and businesses running smoothly.
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Appendix 2: Table 2 Ficolo's Cloud Service Features

	Medium Importance	Very Important	Show- Stopper
Privacy		x	
Availability of services and/or data		x	
Integrity of services and/or data		x	
Confidentiality of corporate data		x	
Repudiation		x	
Loss of control of services and/or data		x	
Lack of liability of providers in case of security incidents		x	
Inconsistency between trans national laws and regulations	x		
Unclear scheme in the pay per use approach	x		
Uncontrolled variable cost			x
Cost and difficulty of migration to the cloud (legacy software etc...)		x	
Intra-clouds (vendor lock-in) migration		x	

Appendix 3: ORACLE's SOA Governance Suite

The Governance Infrastructure includes the following components of ORACLE's SOA Governance Suite: ORACLE Enterprise Repository (OER), ORACLE Service Registry (OSR), Runtime policy validation tooling (OWSM), Service monitoring (Enterprise Manager Management Pack Plus for SOA). The figure below shows how each component is independent over the other and creates a solution to easy and efficient SOA service delivery portfolio. During actual implementation of the product a customer will not be obliged to download all components but instead the only piece needed.

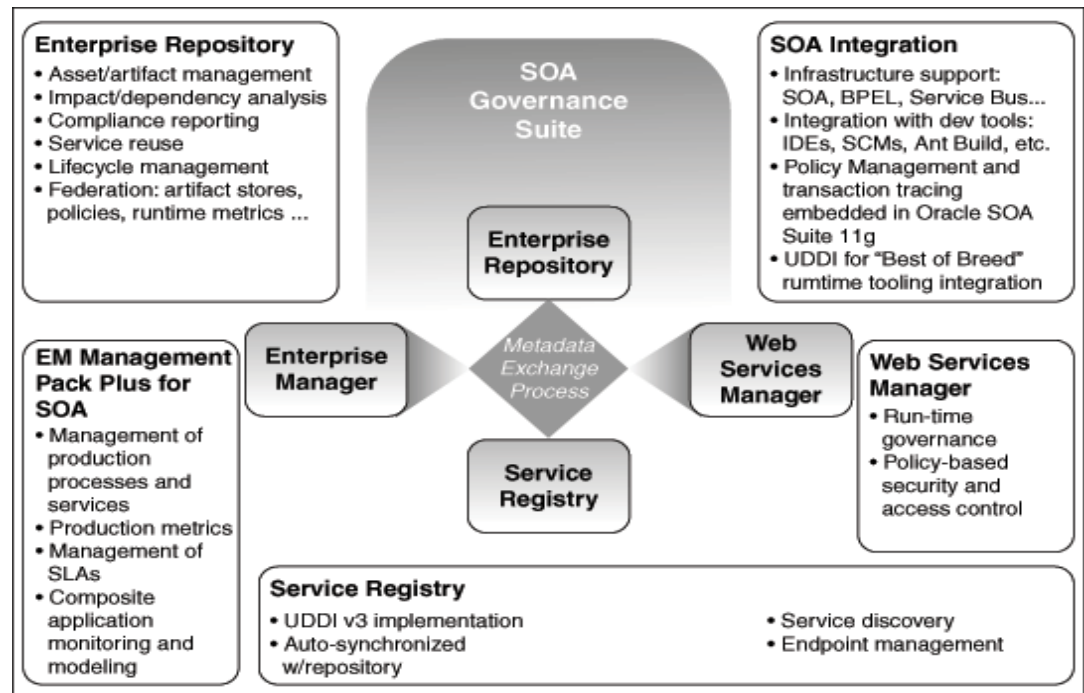


Figure 7: ORACLE'S SOA Governance Suite (reprinted from Vimika Denesh, (2010), [28, 38])

Figure 7 clearly indicates that the major components are key technology enablers. They have to be integrated in order for the key characteristics of SOA governance framework to be complete (Appendix 4): ORACLE Enterprise Repository, and ORACLE Service Registry, ORACLE Web Service Manager and ORACLE Enterprise

Manager SOA Management Pack EE.

ORACLE Enterprise Repository and ORACLE Service Registry. Combines a comprehensive enterprise metadata repository with a Universal Description, Discovery, and Integration-compliant service registry to bridge the entire service lifecycle, providing visibility, traceability, and governance of the enterprise service and asset portfolio to ensure business and architectural alignment and measurable ROI.

ORACLE Web Services Manager. Manages, enforces, and tracks policies applied to SOA for automation of governance across the lifecycle, while providing a foundation for shared services through consumer/provider contract management.

ORACLE Enterprise Manager SOA Management Pack EE manages the health and well-being of the SOA to ensure QoS, while providing operational visibility.[18]

Appendix 4: Table3: Questionnaire answered by Ficolo

No.	Questions	Replies
1.	What is the size of the enterprise do you represent? (Customer level) a) 0-9 Employees b) 10-50 Employees c) 50-250 Employees d) Above 250 Employees	0-9 Employees
2.	In how many countries are you located?	Just in Finland
3.	Is your organization obliged by the Finnish government to where you locate your data center?	Partially
4.	How large are your customers?	Large public sector organizations and large listed companies.
5.	How do you charge for your service(s)?	Different pricing levels: mainly monthly and transaction based fees.
6.	Where does your IT organization stand for with respect to public cloud computing?	Fits perfectly for smaller and medium security needs.
7.	Where does your IT organization stand for with respect to private cloud computing?	Hot solution at the IT Market currently – several implementations.

8.	What are your IT priorities in the year 2013 regarding cost reduction, flexibility, timing in marketing, cost transparency, increasing revenue, dynamically allocating computing resources, improving companies application integration, data quality, improving application functionality and improving application security?	No Answer
9.	Does location affect your organization's strategy when adopting the cloud models which are public, private or partner?	Private and partner partially, public not.
10.	Which layer of the cloud computing would you be most likely to approach? a) SaaS b) PaaS c) IaaS d) Security services in cloud e) Others (please specify)	Paas, IaaS, Security and Mainly DRaaS (Disaster Recovery), DCaaS (Data Center as a Service).
11.	Is it possible to know how your organization model in relation to data protection and security if it is applying public cloud service?	We do not offer public cloud and private cloud but partner partially.
12.	How is the current economic crisis affecting you?	Great option – extended sell cycles.
13.	Is your company open to the idea of outsourcing to multiple providers?	Yes, we do provide outsourcing and utilize outsourcing.
14.	How is Finland's weather helping you in minimizing the cost of maintaining the data center? Since cooling system in server rooms is highly essential.	We do PR.

15.	<p>Which of the following disaster recovery options are of interest to you?</p> <ul style="list-style-type: none"> a) Fully outsources disaster recovery and business continuity b) A contingency plan based on internal resources such as leveraging services, platforms or infrastructures c) Other (please specify) 	All
16.	<p>Which IT services/Applications supporting business processes are most likely to be outsourced to a Cloud computing service provider?</p> <ul style="list-style-type: none"> a) Payroll b) Human Resources c) Procurement d) CRM / Sales Management e) Accounting and Finance f) Project Management g) Application development on the Cloud h) Data analysis i) Other (please specify) 	a), b), c), d), e), f)