Integrating SOA and Cloud Computing for SME Business Objective

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Abstract: - There is a need to understand the existing and future state architecture before you begin selecting platforms and technology, Service Oriented Architecture (SOA) and Cloud, together can provide a complete service based solutions for SMEs. Both SOA and cloud deals with delivering services to business with improved agility, increased speed and reduced cost that can lead to greater innovation and effective returns on investment. In this we proposed an architecture that uses SOA principles to create an overall strategic plan and focus how architectural context support the use of cloud computing

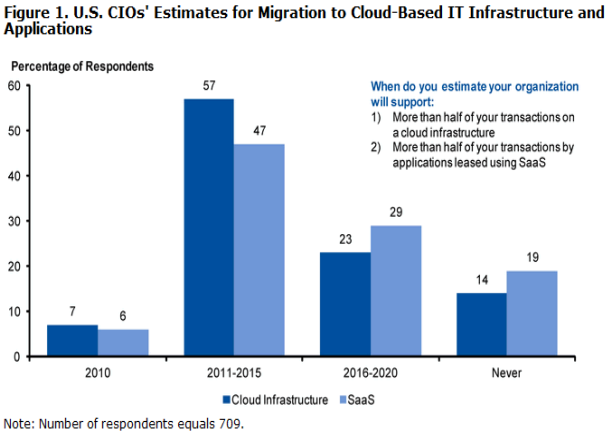
Key-Words: - SOA, Clouds, Agility, Adhoc model, Architecture

1 Introduction

The concept of Service Oriented Architecture (SOA), as related to cloud computing is simple. It is necessary to understand that when we are dealing with clouds, we're dealing with services, and when we're dealing with services we should we dealing with SOA.

In SOA world we talk of services and only services, where services are in form of software, live components and objects (technical things), but when it comes to realization in the real world it is outcome based. It is generally found people saying 'we are doing SOA so we are ready for the cloud', but the difference between SOA services and the cloud context is huge. Typically Cloud is focused only towards the outcome, not the technology. "In cloud the service terminology you are focusing on is a relationship between service provider and consumer not technology provider and consumer". (David L. 2010). The following graph shows estimates of migration to cloud-based IT infrastructure and applications which supports the evolving nature of business solutions.

SOA based design involves defining sets of services that may exist physically within the data center, on a public cloud, or perhaps in both places (hybrid cloud). and we need to consider the quality of the services design, the granularity, or how well the services approach a "functional primitive," and thus providing more value.



Source: Maverick Research: A Workforce Without Humans: Three Ways Technology Will Eliminate Skilled Jobs in the U.S. Through 2020 by Kenneth F. Brant by Johan Jacobs (http://softwarestrategiesblog.com)

According to David L. "The ability to design, define, and develop services at a primitive level goes to the value of those services considering that it's much easier to create composites out of groups of primitive services. Thus, allowing you to mix and match services to live up to the exact purpose/requirements of the composite service, process, or application, rather than attempting to deal with services that are to high level, or course grained, and thus not an exact fit for your requirements."[David L. 2009].

As an analogy it is found that it is much easier to build a custom designed home using fastener, wood, axe or other materials than to build a house from pieces of another home. In context of cloud computing services are exposed that provide very primitive and low-level functions, and thus are more useful to those that want to consume them. Public clouds providers get this, and thus provide many primitive APIs that seem complex, but provide much more value to those looking to create business solution.

SOA is considered to handle adhoc business requirements and provides an interface between business needs and IT requirements. The following picture illustrates how SOA is used to bridge the gap between business and IT architecture at enterprise level, process level and infrastructure level. (Trend 1: Business Centric SOA, (zhanglj, 2007) (see figure 2)

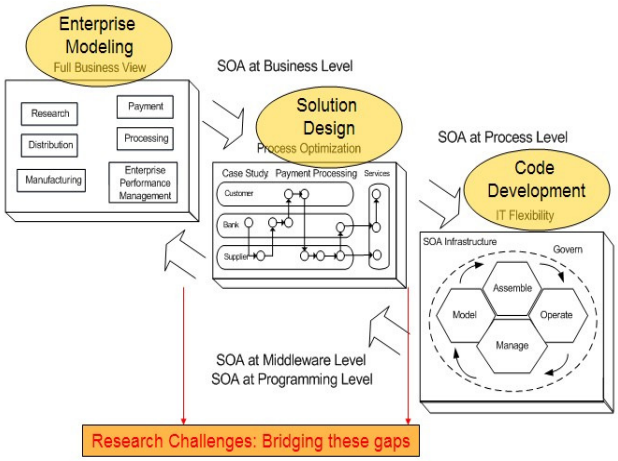


Fig 2 Business and IT collaboration with SOA

From a dynamic perspective, there are three fundamental concepts which are important to understand: the service must be visible to service providers and consumers, the clear interface for interaction between them is defined, and how the real world is affected from interaction between services. (See figure 3)

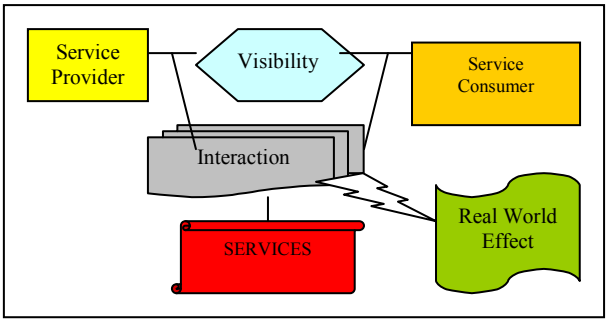


Fig 3. Service Model

These services should be loosely coupled and have minimum interdependency otherwise they can cause disruptions when any of services fails or changes.

In SOA – Cloud Integrated environment, all of the services are not hosted but are owned by the SMEs only. In order to achieve the business objective using such integrated architecture service governance is needed which includes location of services, service security, services dependencies, service monitoring, service compliances etc. According to D.S. Linthicum "Governance places a layer of processes and technology around the services so that anything occurring will be quickly known"

1.1Service Oriented Architecture (SOA)

Service-oriented architectures are typically highly dynamic and flexible: Components and services are only loosely coupled and communicate according to standardized protocols; interface specifications are exchanged at run-time and, thus, clients can replace services at run-time. This might be advantageous if a new service provides a better alternative to the former one concerning functionality or quality of service. Or, it might become necessary for self-healing purposes, e.g., if a service is not reachable any longer because of network problems. [Paderborn, 2003]

SOA starts with business. An SOA is a component model that inter-relates services (the different functional units of an application or an enterprise) through well-defined interfaces and protocols between these services. Service-oriented architectures are not new, but an alternative model to the more traditionally tightly-coupled object-oriented models that have emerged in the past decades.

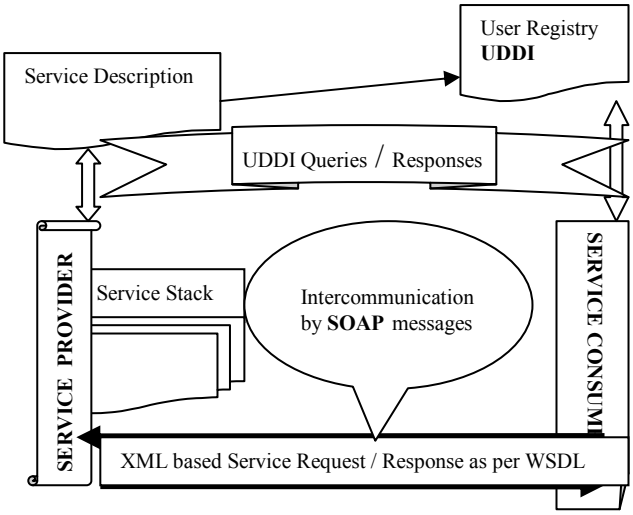


Fig 4.Base SOA Model

Figure 4 represents the SOA base model; primarily it consists of service provider, service consumer and Service registry. A WSDL document describing the service details need to registered in central database, UDDI registry. Any registered user can search this registry for desired services and download the WSDL file, through the information available in WSDL files the customer can contact service provider directly. All intermediary communication is done via a special protocol Simple Object Access Protocol (SOAP), which basically exchanges messages via TCP/IP

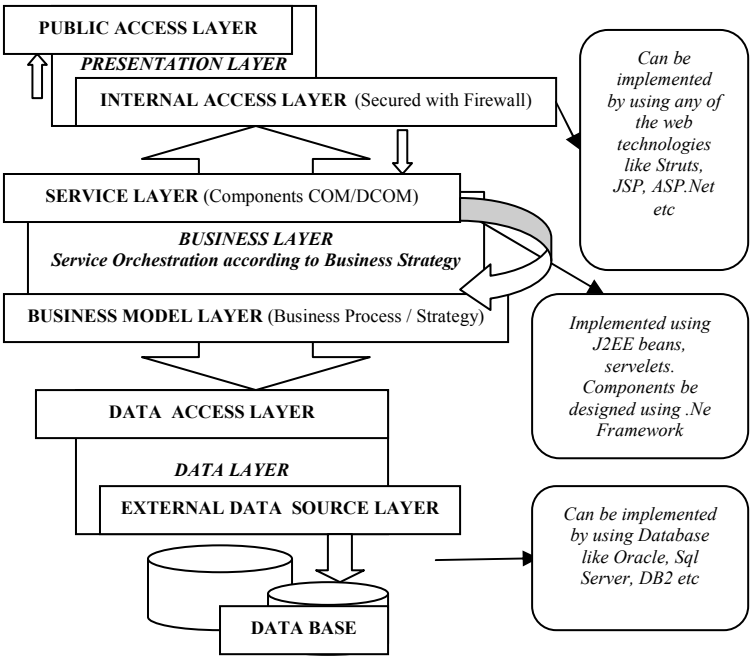


Fig 5. SOA Layered View [Seth A, 2011]

At the front end, there is a presentation layer which takes care of the front end user interaction. At the next, the business layer maps to composite layer in five layered architecture. This layer is sub layered to service layer and business model layer. The service layer comprise of all the services that are identified during analysis phase and are meaningful to the business. Business Model Layer defines the business processes and organizational business strategy. In Nutshell, Business layer performs the service orchestration task as per the business strategy. In layered architecture, the communication flows only within the two adjacent layers and no layer over cross the other layer. Thus, business layer is accessed only through presentation layer and the business model layer in turn accessible only through the service layer. The back end layer in the model reflects the data layer that directly interacts with the business layer at one end and database at the other (see figure 5). [Seth A, 2011]

1.2 Cloud Computing

There have been many definitions of Cloud Computing by different researchers. Barkley RAD defines Cloud Computing as:

"Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as Software as a Service (SaaS). The datacenter hardware and

software is what we will call a Cloud. When a Cloud is made available in a pay-as-you-go manner to the general public, we call it a Public Cloud; the service being sold is Utility Computing. We use the term Private Cloud to refer to internal datacenters of a business or other organization, not made available to the general public. Thus, Cloud Computing is the sum of SaaS and Utility Computing, but does not include Private Clouds. People can be users or providers of SaaS, or users or providers of Utility Computing." (Armbrust et al., 2009, p6)

Fig 6. Cloud Vendors

Cloud Computing is new technology and still at its infant stage. Therefore, most of the enterprises are not very confident to adopt it. In this paper we discussed the benefits that an enterprise can have while they adopt SOA- Cloud Computing integrated architecture in terms of Cost benefits and computational advantages. It has been estimated that the cost advantages of Cloud Computing to be three to five times for business applications and more than five times for consumer applications (Lynch, 2008). According to a Gartner press release from June 2008, Cloud Computing will be "no less influential than e-business" (Gartner, 2008).

1.2.1 Essential Characteristics of Cloud Computing

There are 5 essential characteristics of Cloud Computing which explains there relation and difference from the traditional computing

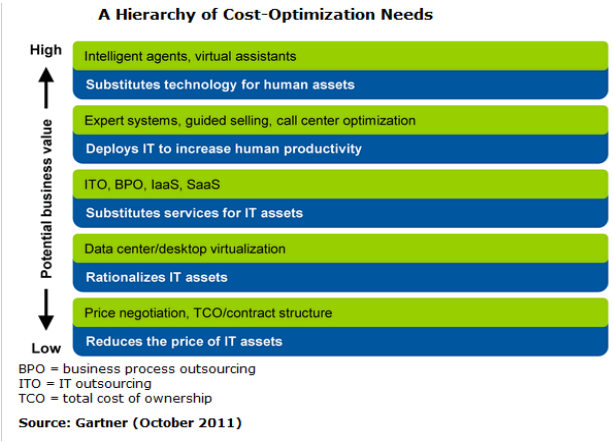


Fig 7. Hierarchy of Cost, customiztion needs
Source: Maverick Research: A Workforce Without Humans: Three Ways Technology Will Eliminate Skilled Jobs in the U.S. Through 2020 by Kenneth F. Brant by Johan Jacobs

- *On-demand-self-service:* Consumer can provision or un-provision the services when needed, without the human interaction with the service provider.
- *Broad Network Access:* It has capabilities over the network and accessed through standard mechanism.
- *Resource pooling:* The computing resources of the provider are pooled to serve multiple consumers which are using a multi-tenant model, with various physical and virtual resources dynamically assigned, depending on consumer demand.
- *Rapid Elasticity:* Services can be rapidly and elastically provisioned.
- *Measured Service:* Cloud Computing systems automatically control and optimize resource usage by providing a metering capability to the type of services (e.g. storage, processing, bandwidth, or active user accounts) (Cloud Security Alliance, 2009, p15)

1.2.2Cloud Service Models

There are 3 Cloud Services Models and these 3 fundamental classifications are often referred to as "SPI model" i.e. software, platform or infrastructure as a service. (see figure 8)

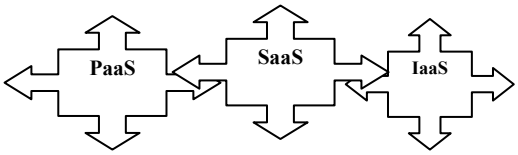


Fig 8. Cloud Service Models

- *Cloud Software as Service:* This is a capability in which the consumer can use the provider's applications running on the cloud.
- *Cloud Platform as Service:* In this type of service, the consumer can deploy, the consumer created or acquired applications created by using programming languages or tools provided by provider, on the cloud infrastructure.
- *Cloud Infrastructure as Service :* This is a capability provided to the consumer by which, it can provision processing, storage, networks and other fundamental computing resources where the consumers can deploy and run the software (i.e. operating systems, applications) (Cloud Security Alliance, 2009, p16).

As stated above, understanding the relationships and dependencies among Cloud Computing models is critical for understanding the security risks of it. For all the cloud services IaaS is the foundation and PaaS is build on it, while SaaS is build on PaaS and IaaS as described in the cloud reference model diagram (Cloud Security Alliance, 2009, p18).(see fig 9)

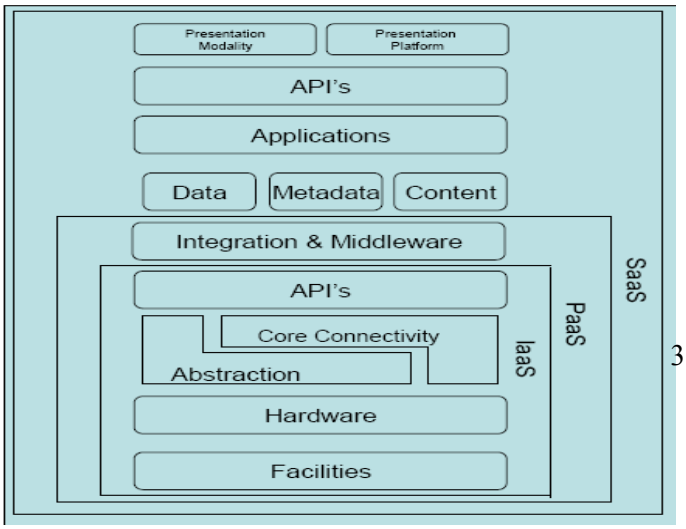


Fig 9 Cloud Reference Model

1.2.3Cloud Deployment Models

- *Public Cloud:* The cloud infrastructure is available to the general public.
- *Private Cloud:* The type of the cloud, that is available solely for a single organization.
- *Community Cloud:* In this type of cloud deployment model, the infrastructure of the cloud is shared by several organizations and supports a specific community with shared concerns.
- *Hybrid Cloud:* This is a cloud infrastructure that is a composition of two or more clouds i.e. private, community or public (Cloud Security Alliance, 2009, p17).

1.2.4Pros and Cons of Cloud Architecture

One of the main advantages of cloud computing is, "that the computational work is moved from the users' terminal to data centers where the cloud applications are deployed. This in turn lessens the restrictions on the hardware requirements needed at the users' end, allows them to obtain superb performance to some of their CPU-intensive and memory intensive workloads without necessitating huge capital investments in their local machine" (Youse et al., 2009).

Pros

1. Client side installation expenses is not required
2. Generally based on Pay per use and plug and play mechanics
3. Not bounded with operating system, ay machine connected with internet can be used as an access point.
4. If executable be run locally, the risk of viral infection can be reduced
5. Application can be continuously updated by a application provider without shipping and issuing installation disk

Cons

1. Performance may be affected since all data; user files, input, etc have to be sent to servers and back. Delay and round trip consume time and can be serious problem
2. Security is compromised because all confidential data (i.e. passwords, credit card information etc) have to travel across over insecure networks.
3. Complete dependence on underlying network to access the application, when the network is down the user has no option the access the application.

2 Integration Need

SMEs believe that the two greatest challenges that they have experienced in managing their profitability are threat from competitors and cost of managing changing demands of the business i.e agility.

As the market demand changes there will a change in enterprise solution, This evolution converted the single tier application to distributed cloud application (see fig 12). To understand the SOA and Cloud together, we can take an analogy of library. The books in a library represents services that the customer can access, here library is analogous to cloud which comprises on number of

books (services). Books (services) are reusable and several books might make up a complete topic (application). Series of books to be used in order and a sort of link (interface) to connect to one book to other in order to complete one topic (application) requires a defined process or architecture (SOA)

SOA related requirements are to provide improved governance and management of services within the cloud environment where they may not be under direct control. Governance is a word that monitors prominence within the SOA environment; it is applicable at two phases of SOA development i.e. design time and run time. Design time governance relates to defining policies for services and run time governance monitors actually applying those design time policies to real time traffic.

One of the most comprehensive study released in March, 2011 done this year on by Microsoft Global SMB Cloud Adoption says that 39% of SMEs with 2-250 employees expect to be paying for cloud services within 3 years will be an increase of 34% (see fig 10)

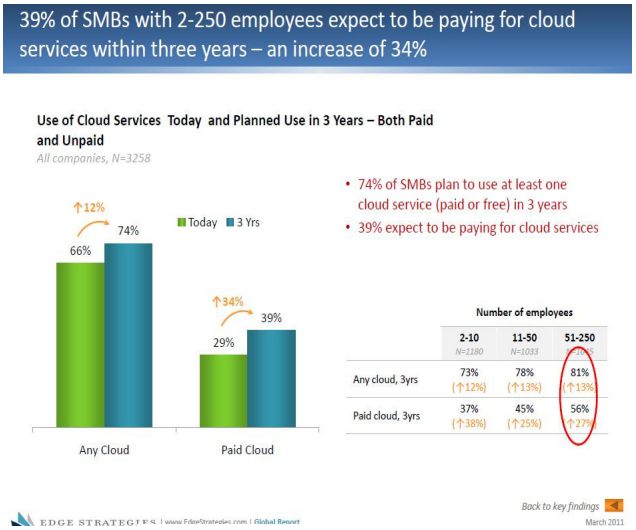


Fig 10 Microsoft Global SMB Cloud Adoption

For successful cloud computing application, the solid architecture is required. ie SOA is required. SOA provides an architecture necessary to integrate your existing enterprise IT assets with the emerging world of cloud computing. The lack of proper SOA architecture leads to failure in cloud computing world.

As it is well said by Chris Hardings[2010].(Service Oriented Architecture and the cloud)"Today, the popular cloud platform services are running mostly at the operating systems and programming languages rather than at the level of SOA platform. They support standards such as Linux and Java, rather than WS- Messaging and WSDL. To be really useful for SOA, Cloud platforms should include enterprise service buses, service registries and other SOA platform components in other words SOA- as a service". Further Forrester found that SaaS will outgrow all other cloud services, achieving 37% adoption in 2011 growing to 50% by 2012.(see fig 11)

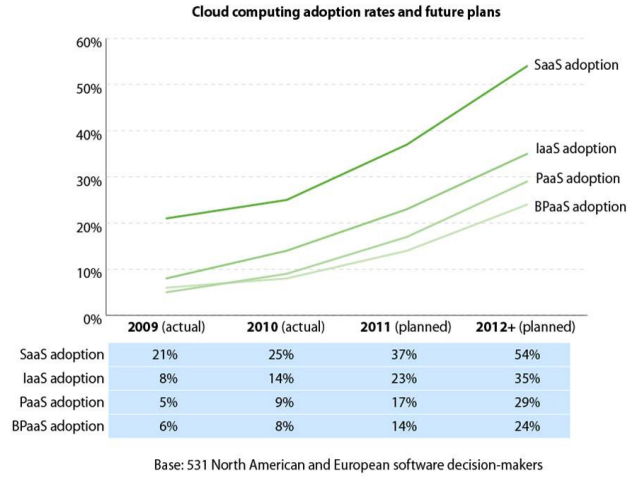


Fig 11 SaaS will outgrow all other cloud services

We proposed architecture in our study that uses SOA principles to create an overall strategic plan and architectural framework, There are important overlaps between cloud computing and SOA, The key benefit of SOA –cloud integrated enterprise solution is the ability to make system –to system interface consistent in the enterprise architecture. This also facilitates the "on demand" access to virtualized IT resources that are housed outside of your own data center.

Cloud computing itself is a deploying architecture not an architectural approach. SOA provides a backbone to allow both the enterprise back end servers and front end applications to easily access cloud services. The integrated SOA cloud architecture for SME moves successfully the existing SOA architecture to support new cloud capabilities

3. Proposed SOA –Cloud Integrated Architecture

According to the literature available and the needs of the SME, the desired Architecture should meet the following goals:

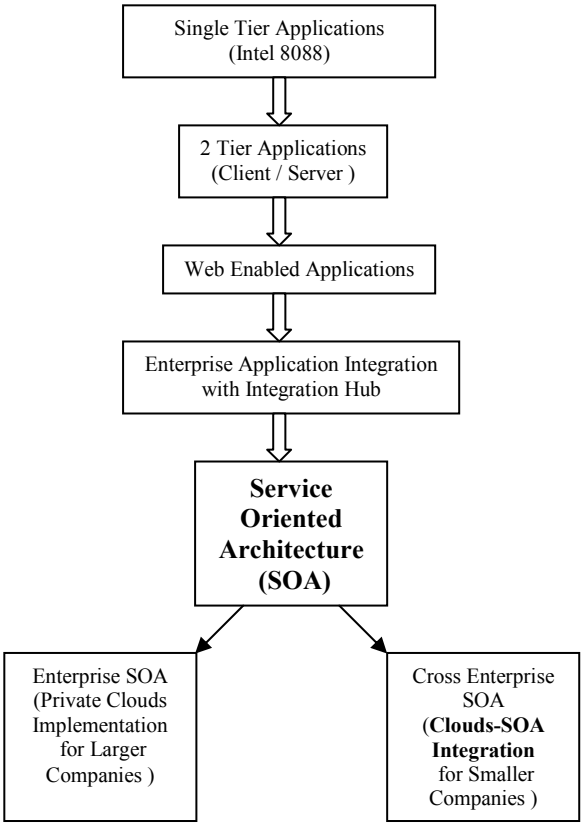


Fig 12 Evolution of Enterprise Solutions

1. It should consists of number of services ,each capable of handling a single business tasks
2. Services must be loosely coupled, in order to minimizes the dependency on others
3. It should use standardized and open communication protocols.
4. Implementation details should be clearly separated from service contracts / interfaces

The proposed solution is a starting point for new horizontal applications, which take advantage of existing distributed and heterogeneous services in order to offer new business functions. First, we focused onto the question on how to retrieve and to inject data into existing legacy applications running at SME. A first inventory of existing applications resulted in a list of heterogeneous applications, using different technologies, design paradigms and offering different integration possibilities, such as a document management system with clearly documented APIs, Classical Client/Server applications accessible through JDBC, Custom built applications accessible through DLLs, Web Services or monolithical WinDev3 applications. Looking into the above needs we proposed the following SOA-Cloud integrated architecture (see fig 13)

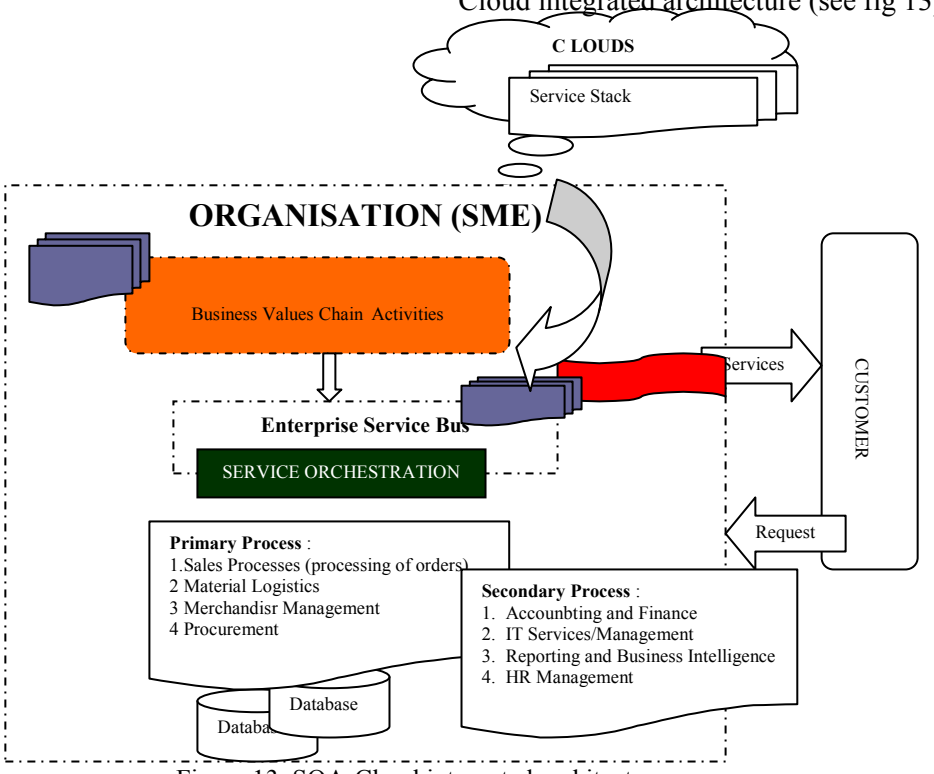


Figure 13. SOA-Cloud integrated architecture

The figure shows the SME in the center of the figure and the specific process witin the company is shown as business value chain activities. The primary process initiates with customer request for a particular service followed by order processing, material logistics, merchandise management and procurement and finally terminate with an eventual customer service. The secondary processes shown within the figure are intermediate process that are

necessary and are required to maintain the business. In order to provide customer with a service (application) needed, the company may use either their own inbuilt services or can share services available on clouds. The sequencing and interfacing within service to produce desired output is handled by Enterprise Service Bus (ESB) ie the ESB is responsible for service orchestration.

3.1 Description of ESB

"An **enterprise service bus** (ESB) is a software architecture model used for designing and implementing the interaction and communication between mutually interacting software applications in Service Oriented Architecture. As software architecture model for distributed computing it is a specialty variant of the more general client server software architecture model and promotes strictly asynchronous message oriented design for communication and interaction between applications. Its primary use is in Enterprise Application Integration of heterogeneous and complex landscapes."(wikipedia.org)

For the implementation of an ESB, we can use Project Open ESB taken from Java-Source.net to implement an Enterprise Service Bus (ESB) runtime with service engines and binding components. Open ESB allows you to easily integrate enterprise applications and web services as loosely coupled composite applications. This allows you to seamlessly compose and recompose your composite applications, realizing the benefits of a true Service-Oriented Architecture (SOA). [Java-Source.net]

The Proposed Architecture lives up to above defined goals

1. It consists of services, capable of handling single task independently.
2. Services are loosely coupled as the services are deployed independently and share no objects definitions or other dependencies.
3. The communication protocol used within the system are SOAP,WSDL,XML etc which are open and standardized, they are deployed in a widely documented and well understood web service RPC pattern.
4. Services implementations are clearly separated as interfaces provided to use these services are described in WSDL files.

4. Testing Strategy

We proposed a hypothesis and then applied T-test method to test for its acceptability. we also used GQM *(Goal / Question / Metrics)* Method to evaluate the effectiveness of the model

Hypothesis: Proposed Integrated SOA-Cloud Model is more efficient in terms of cost and adaptability than traditional ERP systems

The following method is used for the testing of Hypothesis / Proposed model

- *GQM (Goal / Question / Metrics) Method* is adopted to design questionnaire (evaluation metric) on the basis of which effectiveness of the model is evaluated
- *T- Test*. is used to test the hypothesis that the two independent samples come from same normal population

4.1 Data Collection

The study adopted a descriptive type of research in which data was collected from various sources and analyzed to come to conclusion. Primary data was collected by visiting industry person, communicating face to face, conducting telephonic interviews and by mailing metrics designed through GQM. Secondary data was collected through magazines, internet, journals, and research articles on the subject.

For this research, we focused on companies with 10 to 150 employees in the NCR region. This includes a survey conducted through face to face interviews with Senior Management from sixty manufacturing companies The companies that we selected for the survey are from various sectors such as manufacturing of automotive components, polymer items, electrical and power equipments,, industrial items, companies involved in turnkey projects, mineral mining and iron and foundry. The geographical regions that were covered in this study include SMEs located in the Delhi NCR region Sahibabad Industrial Area in Ghaziabad, Faridabad and Noida.

A sample of questions formulated for an interview can be found on Appendix A. Question designed for interview encompassing a wide area covering general questions on enterprises followed by general view of Cloud Computing to effectiveness of a proposed integrated model.

4.1.1 Interviews

According to Preece (2002), there are four types of interviews structure: unstructured, structured, semi-structured and group interviews. If the goal was to gain an overall impression of a subject, then an informal, unstructured interview was often the best

approach. However, if the goal was to get feedback about a specific issue/model then structured interview was better (Preece et al., 2002).

As our aim was to get both the overall understanding of the information system of enterprise and Cloud Computing along with the perceived benefits and drawbacks related to them, hence, the most appropriate method was to conduct semi-structured interview .We followed a Kvale method of conducting interviews,that comprises of seven stages i.e *Thematizing, Designing, Interviewing, Transcribing, Analyzing, Verifying, Reporting*..

Out of the seven steps we opted five steps to validate our study(see figure 14), this includes Thematizing *(*formulating the purpose of an investigation and describe the concept of topic to be investigated before the interview starts), *Designing* (plans the design of the study keeping in mind all the seven stages of investigation before the interview starts), *Interviewing* (conduct the interview based on an interview guide), *Analyzing* (choosing the appropriate method for analysis based on purpose and topic of investigation and the nature of interview material), *Verifying* (ascertain the generalizability, reliability and validity of interview findings) (Kvale, 1996, p88).

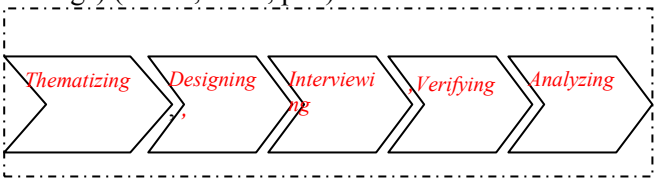


Fig 14. Semi Structured Interview

Kvale (1996) described that crucial point of interviews was the formulation of the question, so one could get the correct information to come to a conclusion. Otherwise one would have got biased in the answers, and would have been inaccurate for the study. Hence, we used all types of interview questions in our semi-structured interviews.

4.2 GQM (Goal / Question / Metrics) Method

This method is adopted from Van Latum, et. al.(1998)[9] (see fig 15) The method works in three stages. At first stage organizational goals are identified in context of business strategies. In second stage questions are raised that comply with the goal identified in first stage. The answers to these questions help to understand the critical factors and risks that may be associated in achieving business objectives. In third stage, metrics are designed to evaluate the model.

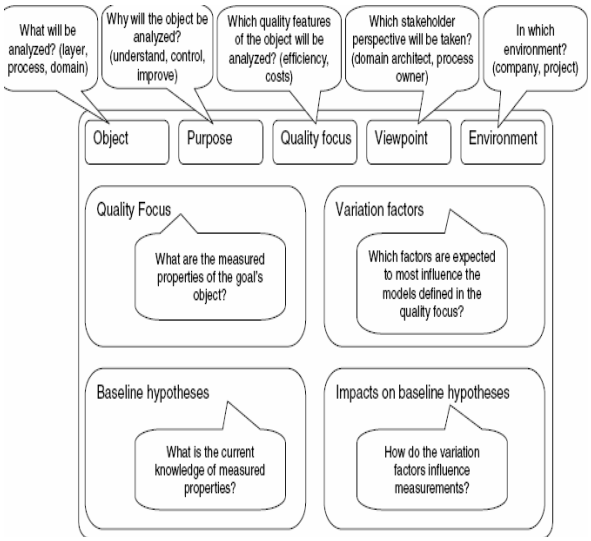


Fig 15. Sample GQM Abstraction Sheet [11]

In this study the last stage come up with the set of questionnaires which is capable to evaluate the proposed model. The designed metrics (questionnaire) is based on proposed model and then the responses are taken from 250-industry person. To evaluate it, average response is calculated and is found that the proposed architecture is very suitable for integrating business activities in SMEs.

The Industry people are asked to answer on 5 point scale, where each point has following significance.

(a) Weak support (**1**) (b) Minimum support (**2**)
(c) Average support (**3**) (d) Good support (**4**)
(e) Strong support (**5**)

4.3 T-test –Analysis and Interpretation

To get the information about the ERP implementation cost, those SMEs were targeted where the IT investment cost ranges from 50 to 90 lakhs. The data collected was analyzed for per user per year cost incurred by the SMEs. The cost incurred for same module if undergone by cloud services by different companies is also analyzed. This is illustrated in Table 1 and Table 2 respectively.

To conduct T-test ERP utilization cost per user was evaluated and then compared with the proposed model Total cost comprises of hardware cost, software cost (including implementing, connectivity and maintenance). The total cost is then divided by the number of effective user of the application; this gives the cost per user.Sample table for calculation of per user cost is shown in table 1.

Table 1.calculation used for 10 companies surveyed

Avg Software cost + Avg. Hardware cost + Implementation +Maintenance cost) = Total cost	No. of effective users	Cost per user
41 + 21 + 15 =77	53	1.45
38 + 23 + 14 =75	57	1.31
45 + 20 + 13 =78	49	1.59
46 + 21 + 16 =83	50	1.66
40 + 25 + 11 =76	65	1.16
35 + 18 + 10 =63	75	0.84
42 + 20 + 09 =71	52	1.36
40 + 20 + 11 =71	90	0.78
36 + 23 + 13 =72	56	1.28
38 + 27 + 11 =76	55	1.38

Table 2.cloud computing prices offered by the different companies for the same units

Company	Cloud Switch	EMC2	SAVVIS	UNISYS	Force.com	SalesForce Enterprises	Layered Tech
Cost /user (for the same module of ERP calculated above) if used cloud – services	**0.82**	**0.89**	**0.88**	**0.67**	**0.9**	**0.69**	**0.82**

After comparing and analyzing the two data collected for using traditional ERP and cloud services (shown above), it was found that cost /user/annum is much less in case of opting cloud services model. Further t test was applied and the following results were obtained (see table 3)

Table 3 Hypothesis T- test

Hypothesis : Proposed Integrated SOA-Cloud Model is more efficient in terms of cost and adaptability than traditional ERP systems					
Mean	S.D	T-test	R- t	Level of Significance (SL)	Degrees of Freedom (DF)
1.12	0.19	0.566	>1.85	5%	9
Result : Accepted					

Further to conclude, one t test is applied at 5 % level of significance using table of t-distribuiton for 9 degrees of freedom, we found from standard table R: t > 1.85, The calculated value for t is 0.566 which is considered within the acceptance region and thus it can be concluded that the proposed hypothesis is accepted at 5 percent level of significance.

A total of 25 companies out of the total sample (66.7%) were impacted by the current economic slowdown globally. Out of total 25 companies, 17 have are very much satisfied with the proposed integrated SOA-Cloud architecture and have expansion plans in the near future. However the rest of the 08 SMEs are not optimistic about a sudden change in the situation and have not planned any expansion as of now(see Table 4).

Table 4. Company impacted by architecture

Total Respondents(%)	Impacted by existed infrastructure	Expansion Plan
66 %	Yes	Yes
34 %	Yes	No

5 Conclusion

The sample questionnaire is prepared based on proposed model and then the response is taken from 250-industry person to evaluate it. The average response is calculated and is found that the proposed architecture is very suitable for the integrating business activities in SMEs

Proposed hypothesis is also accepted at 5 percent level of significance and it can be concluded that the sample data indicates that proposed integrated SOA-Cloud Model is more efficient in terms of cost and adaptability than traditional ERP systems. Further study conducted by the research firm Gartner in the year 2008, adoption of hosted applications reduces cost of ownership by about 30% by lowering the software support, labor and hardware costs. This study further supports the papers findings.

In a nutshell, we conclude that proposed SOA-Cloud integrated model is is ideal for medium and small sized enterprises both in terms of cost benefits However, for enterprises the most important factor to adopt Cloud Computing will stay cost till today but security is still not the added value of Cloud Computing for enterprises despite its benefits.

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