International Journal of Computer Sciences and Engineering Open Access
Survey Paper Volume-4, Special Issue-4, June 2016 E-ISSN: 2347-2693

Enterprise Architecture and Services in Cloud Computing: A Survey

Ms. Sajjan R.S.[1], Ms. Biradar Rekha Yashwantrao[2], Mr. Torvi Harshal[3]
[1, 2, 3] Department of Computer Science and Engineering, V.V.P. Institute of Engineering and Technology, Solapur, Maharashtra, India

Available online at: www.ijcseonline.org

Received: May/26/2016 Revised: Jun/02/2016 Accepted: Jun/12/2016 Published: Jun/30/2016

***Abstract*—Cloud computing provides services such as software, platform, storage, applications, network, etc, over the Internet based on a pay-as-you-use approach. Cloud computing is a business model or key tool in the IT world. Organizations experience increasing pressure to change or move organization to respond continuously in changing environment. Enterprise Architecture can be used to solve this challenge. With cloud services and deployment models, the organizations can upgrade their existing Information Technology provision. Enterprise Architecture is a layered architecture which helps not only to build Information Technology models but also makes the organization up to date. Enterprise Architecture describes the process for an organization to achieve short-term and long-term goals. Enterprises incorporating appropriate Enterprise Architecture can upgrade their architectures by integrating the existing infrastructure with the Platform as a Service and Infrastructure as a Service support. They can extend 4-dimensions of Enterprise Architecture such as, data, business, application and technology architecture by utilizing the Platform as a Service and Software as a Service. Thus, Cloud Computing can provide a foundation to build new Enterprise Architecture for organization, on demand with cost effective manner.**

Keywords-Cloud Computing; Enterprise Architecture; Enterprise Architecture Framework; Cloud Computing and Enterprise Architecture

I. INTRODUCTION

Business environment is moving at a grate rate. To deal effectively with this problem, organizations need to change or move organization to respond continuously in changing environment. It is little bit difficult to design and implement robust architecture that will provides response to the immediate needs to the enterprise and in consistent manner with the long-term strategic vision of the organization. Enterprise is any collection of organization that has common set of goals. Architecture is a layout, collection of components, relationship between components, guidelines [1]. Enterprise Architecture (EA) defines the components, structure and processing of an organization. With the adoption of EA, an organization can be one step ahead to achieve its objectives or goals. With the adoption of EA, an organization can move easily to respond in changing environment. EA includes 4 architectures, such as Business, Data or Information, Application and Technology Architecture. The Data or Information Architecture, Application Architecture and Technology Architecture are grouped into logical architecture known as IT Architecture or Information Technology Architecture. Business executives focus on Business Architecture and IT executives focus on IT Architecture.

EA primarily focused on IT architecture, which is concerned with the logical and physical description of data or information, applications and technological assets [2].EA represents a new way of managing enterprise with cloud computing. EA integrates IT architecture with Cloud Computing. To do this enterprise need to incorporate EA frameworks. Enterprise with appropriate EA framework, e.g. an approach based on Zachman's framework [3] or TOGAF (The Open Group Architecture Framework) [4], are enabled to take advantages offered by Cloud provisions. The advantages of cloud provision are scalability, flexibility, availability and utilization of services on demand. Organization can use EA as tool and methodology to get success very quickly. EA enables the alignment of business processes and missions by providing the right platform and technology. IT and business executives can transform data about technology into powerful management vision. The right EA can set the business direction. Cloud Computing and EA can be linked to provide organization better flexibility, availability and scalability. In this, Cloud computing directly beneficial to the organization and the organization becomes a Cloud Enterprise.

This paper is the survey on Enterprise Architecture and Services in Cloud Computing. There is no accepted definition of Enterprise Architecture. Also there is no complete description of framework. This survey illustrates that it is necessary to conduct more research on Enterprise Architecture and Frameworks. When we inquire about EA, we will certainly find that there are many views.

IEEE 1471-2000 standard defines "*Architecture as the fundamental organization of a system, embodied in its*

components, their relationships to each other, and the principles governing its design and evolution" [1]. Many organizations have gained the profit from EA. The selection of the most appropriate EA Framework (EAF) for the organization has become a critical decision when utilizing EA. Many EA frameworks has same goal, the research results shows that the selection of an EA framework is industry-specific. The research result also shows that which cloud service and deployment model will be used in organization. And it also shows how cloud can be beneficial to organization. This literature review based on a large collection of both academic papers and industry trade articles. An organization can adopt some features of two or more EA frameworks.

II. CLOUD COMPUTING

Cloud computing is emerging computing technology as well as a business model in the IT world. Cloud computing can serve the whole world. With the Internet and central remote servers Cloud computing maintains data and application. In Cloud Computing, the services are delivered on demand. The Cloud Computing minimizes the usage cost of computing resource and makes the use of increasing computing power.

Cloud computing is a computing system used everywhere and provides convenient on-demand access to computing resources [5].

A. *Characteristics of Cloud Computing*

NIST defines the five characteristics of cloud computing [5]:

- On-demand self-service- Computer services such as applications, hardware, and network or server service can be provided on demand [5].
- Broad network access- Cloud computing services are available over the Internet and accessed through mobile phones, tablets, laptops, and workstations, etc. [5].
- Resource pooling- As per the consumers need different physical and virtual resources can be assigned dynamically. Examples of resources include storage, memory, and network bandwidth [5].
- Rapid elasticity-Cloud Capabilities can be easily assigned and released automatically. The cloud capabilities are available to the consumer in any quantity at any time [5].
- Measured service-Cloud systems automatically control and optimize resource by calculating cost of use [5].

B. *Cloud Service Models*

Cloud computing provides 3 service models.

- SaaS (Software as a service): With this service, customers can use applications or software's through the Internet.
- PaaS (Platform as a service): With this service, customers are allowed to develop and run Web applications without building their own infrastructure.
- IaaS (Infrastructure as a service): With this service, customers can use computers, and other resources such as hardware, servers, storage, etc.

C. *Cloud Deployment Models*

Cloud computing can be deployed in 4 ways, such as Public, Private, Hybrid or Community Clouds.

- Public Cloud: This is used by general public and it is not secure. This service can be free of charge or on the basis of a pay-as-you-use policy.
- Private Cloud: This is used exclusively by single organization. The enterprise can control security issues.
- Community Cloud: It is a combination of public and private cloud and used by a group with similar needs. It is managed by multiple organizations in the group.
- Hybrid Cloud: Hybrid Cloud is an integration of multiple clouds.

III. ENTERPRISE ARCHITECTURE

A. *Enterprise Architecture*

IEEE defines architecture as: *"Architecture is the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution*" [1].

The Open Group's Architectural Framework (TOGAF) defines architecture as: *"The structure of components, their interrelationships, and the principles and guidelines governing their design and evolution over time*" [4].

Enterprise Architecture (EA) provides a new approach to change or move the components of an organization whenever required, so that organization can achieve objectives. To analysis, design, planning, and implementation of enterprise, an organization must use suitable process [6]. EA is solution for that. Through 4-dimensions or architectures, such as technology, application, information and business, EA guides the organizations. Agility, optimization and higher efficiency

can be achieved easily by incorporating EA. So, EA helps enterprises as well as clients' to achieve success. EA is advantageous to any organizations, for example government or private organization. Also EA can be applied and useful to different levels of organizations such as departments. As a result, the relationships will build within the organizations as well as outside the organization [6].Following are the 4 architectural layers of EA and it is shown in the figure 1.

1. Business Architecture
2. Data or Information Architecture
3. Application Architecture
4. Technology Architecture.

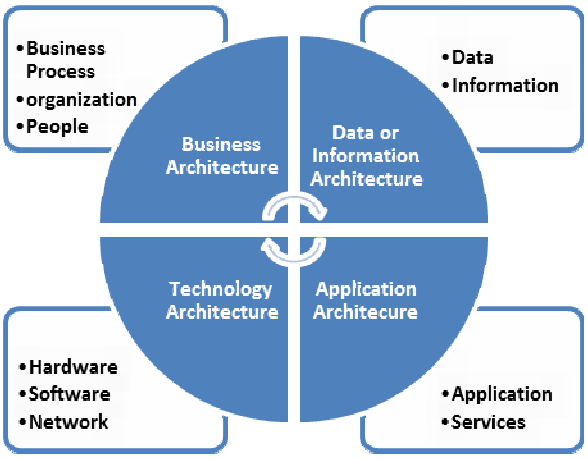

Figure 1: 4-architectures of Enterprise Architecture

This is the continuous process. The business process, organization, people and their responsibilities are defined in Business Architecture. Structure of logical and physical properties of data or information of an organization is defined in Data Architecture. Success of any organization is based on how data collected, how data is stored, and the way in which right and relevant information is extracted. Thus, data architecture is a very important architecture in any EA. Data stored in database can be big data, unstructured data, analytical data, or Meta data. It is handled by Information Architecture. It is also manages data integration, data security, data consistency, data quality, sharing of data. The functions of applications and services, their interactions, and their relationship with the other parts of organization are defined in Application Architecture. The hardware and software needed to develop, deliver, and integrate the services offered by any organization are provided by Technology Architecture. It also provides security related hardware and software, which are required to secure business data, applications, and services.

B. Necessity of Enterprise Architecture

Enterprise Architecture describes the process for an organization to achieve short-term and long-term goals. The first Enterprise Architecture developed in the public domain by John Zachman [3]. Enterprise architecture helps to achieve the right balance between IT architecture and business architecture [4]. It also ensures an integration of IT [4].

Whenever there is change in business environment, EA helps to align business mission, policy, strategies and processes by providing the right technology. For proper business direction we need right enterprise architecture.

Most of the clients of enterprises are demanding EA. By adopting EA [7]

1) An enterprise can set its short-term and long-term goals.
2) An enterprise can define the effective business process such that it will lead toward long-term goals.
3) An enterprise can effectively takes decisions.
4) An enterprise can plan policies for today that will assure tomorrow.
5) An enterprise can coordinate IT.
6) An enterprise can ensure ICS (Integrity Consistency Security) property of data.

EA analyses and controls each and every component of an organization from high-level to low-level. EA can do this by analyzing who, what, why, when, where and how of the organization at every level.

IV. ENTERPRISE ARCHITECTURE FRAMEWORKS

To create and use enterprise architecture, we need EA framework. EA Framework logically divides the organization and set relationship between those logical parts [8]. An EA framework can be used to develop different architectures. EA framework describes a method for defining smallest to largest part of organization. EA framework shows the relationship and interworking between the components of an enterprise [4]. There are many industry specific EA frameworks. Zachman Framework, Department of Defense Architecture Framework (DoDAF), The Open Group Architecture Framework (TOGAF), Reference Model for Open Distributed Processing (RM-ODP), etc. are most used industry standard EA Frameworks. Organization can use any one EA Framework or build a new EA Framework using multiple EA Frameworks depending upon requirement.

A. Zachman Framework

This framework was developed by John Zachman in 1987[3]. This framework provides structure and definition of a complete set of views [3]. These views describe an enterprise. The Zachman Framework collects all the views of an EA. These views can be represented as two-dimensional matrix. The rows describe the type of level and the columns describe the views [9]. As result, we can say that EA is multi-dimensional architecture, which gives attention to each part. The type of level, for example: [9]

- Business Architecture- It is represents entities and their relationship. It also represents a product delivery place that is supply chain.
- Information Technology Architecture- It is logical integration of data, applications, and technology. It also shows dependencies between different parts of organizations.

The six views are: [7, 9]

- What-refers to information
- How- refers to operations
- Where-refers to location
- Who- refers to people and their responsibilities
- When- refers to time or schedule
- Why-refers to the short-term and long-term goals of an enterprise

B. Department of Defense Architecture Framework (DoDAF)

DoDAF is most useful framework for integrated architecture. In Integrated Architecture, architecture data elements are consistently used across all product and views [10]. This architecture provides consistent views of an organization. This framework developed mainly for the use of US Department of Defense. This framework is most suited to large systems with complex interoperability.

It was derived from the C4ISR (Command/Control/Communication/Computers, Intelligence, Surveillance and Reconnaissance) Architecture Framework [10]. C4ISR architecture framework was renamed as DoDAF V1.0 [10]. "Product" or "Views" of the architecture are focused by DoDAF V1.0. The "data" architecture is focused by DoDAF V1.0 [10].

DoDAF has various views to arrange DODAF models. Each view describes the architecture as follows: [11].

- All Viewpoints (AV): It describes the architecture plans, scope, objectives and final results.
- Capability Viewpoint (CV): It describes working ability or capability of the different parts of an organization.
- Data and Information Viewpoint (DIV): It describes physical and logical views of the data.
- Operational Viewpoint (OV): It focuses on the behaviors, operational requirements of an enterprise. It is used to define operations of Business and Data Architecture.
- Project Viewpoint (PV): It describes operational dependencies and SDLC methodology for various projects need to developed.
- Services Viewpoint (SvcV): It describes services and their interconnection. It also describes functions performed by services.
- Standard Viewpoint (StdV): It describes what to implement and what not to implement for architecture.
- System Viewpoint (SV): It describes the supporting system, which is used to develop and deliver service or product successfully.

C. The Open Group Architecture Framework (TOGAF)

TOGAF is an industry standard general framework and is freely available. TOGAF is a high level approach to design. The TOGAF V1.0 was based on the Technical Architecture Framework for Information Management (TAFIM) [4]. TAFIM was developed by the US Department of Defense (DoD) [4].

TOGAF provides the EA which is consistent, responsive in changing environment. The current and future needs of the business are defined in TOGAF. As TOGAF was based on DoD architecture framework, it strongly coordinates components of enterprise and also standardizes the architectural process.

TOGAF divides the framework into four levels: [12]

- Business Architecture
- Data Architecture
- Application Architecture
- Technology Architecture

TOGAF ADM (Architecture Development Method) describes method for developing and controlling the enterprise's life cycle. It integrates all the resources of an organization. This can be used to create foundation of the architecture [12]. ADM is an iterative process. ADM phases are as follows: [12]

- Phase A describes the scope, vision and business outcomes.
- Phase B describes what operations to be performed to achieve business vision and goals.
- Phase C describes data and application required.
- Phase D describes technology required to execute the applications.
- Phase E describes the current and future state.
- Phase F describes the agile process management and migration.
- Phase G establishes the connection between architecture.
- Phase H maintains the life cycle.

D. Reference Model of Open Distributed Processing (RM-ODP)

This uses a well understood object modeling technique and developed by International Organization for Standardization (ISO) and International Tele-communications Unit (ITU). The purpose of this architecture is to provide a common well-defined architecture for a distributed processing and its environment [13].RM-ODP provides portability in distributed environment, interworking between different Object Modeling Technique systems and transparency between distributed processing [14].

The RM-ODP divides the framework into 5 viewpoints [13], [14]

- Enterprise Viewpoint: This viewpoint defines enterprises rules and regulations, short-term and long-term goals.
- Information Viewpoint: This viewpoint is concerned with the information or data
- Computational Viewpoint: This viewpoint divides the system according its functions.
- Engineering Viewpoint: This viewpoint is concerned with the infrastructure needed for system.
- Technology Viewpoint: This viewpoint is concerned with the technology needed for system.

E. Federal Enterprise Architecture Framework (FEAF)

FEAF was developed by CIO (Chief Information Office) to share the information among all government agencies. FEAF v2 divides the architecture into 6 sub architectures [15].

- *Strategy or Performance Architecture*: It describes the strategies for the organization which are required to achieve better performance.
- *Business Architecture*: It describes the policies which help people to work in collaboration.
- *Data Architecture*: It describes data and their meanings. It also describes data access methods.
- *Application Architecture*: It describes system and application related strategies and type of data that application supports.
- *Infrastructure Architecture*: It describes infrastructure needed to execute applications in terms of hardware, network and cloud.
- *Security Architecture*: It describes security considerations related to different types of data, business mission and process.

These sub architectures are also known as reference models [15].

V. CLOUD COMPUTING AND ENTERPRISE ARCHITECTURES

Various EA frameworks mentioned above clearly states that each EA framework has more or less features than other. Basically all EA frameworks divide the architecture into minimum 4 sub architectures. These are business, data, application and technology architecture. The organization must include these 4 architectures to incorporate EA. There exists a connection between the different architectural representations of an EA and the Cloud environment. To build enterprise architectures by using the Cloud environment, organizations needs to provide IT as a platform. Any organization can use following views to build IT architecture [7].

- To build the technical architecture of an EA, we can use the IaaS and PaaS services of Cloud Computing
- To build the application architecture of an EA, we can use the SaaS services of Cloud Computing. The applications are available to customers, as and when required.
- To build the data or information architecture, we can use the Cloud Computing IaaS offerings.

Cloud Computing and EA can be linked together to provide better flexibility, availability and scalability. In this the Cloud Computing is directly beneficial to the organization and the organization becomes a Cloud Enterprise with business functions and IT resources and/or functionality provided through the Cloud. Cloud enterprises are the Service-Oriented Enterprises (SOEs) [16].

A. Cloud deployment model used for IT architecture

As mentioned above, IT architecture is a combination of data, application and technology architectures. Which cloud deployment model will be best suitable for IT architecture? The answer to this question is based upon organization. One of the answers to this question can be: [7]

- Public Cloud can be used to deploy applications that don't need to be secure and required to be used outside of the organization. This cloud provides flexibility and there is no limitation on users.
- Applications that need to be secure can be deployed in a Private Cloud and required to be used only inside of the organization
- A hybrid cloud is combination of Public Cloud and Private Cloud. It deploys non-secure applications on the public cloud and takes the advantage of flexibility and scalability. It deploys secure applications on the private cloud. Building hybrid cloud is very difficult. Secure applications can be used inside of the

organization, where as non-secure applications can be used outside of the organization.
- Multiple organizations with the same need can be deployed in a Community Cloud.

Cloud deployment models such as Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud has various advantages as well as disadvantages. Major problem areas in the public clouds are listed below [16]:

- It does not provide security.
- It is not easily controlled and manageable.
- If number of user's increased, resources may not be available easily.
- If number of user's increased, access to service may be delayed.
- If number of user's increased, performance and throughput may be decreased.

Private clouds are solving most of the problem areas of public clouds. Private cloud is limited for set of users. Community clouds only useful for a particular community.

B. Benefits of Cloud Enterprise Architecture

With the integration of Cloud Computing with Enterprise Architecture, organization can able to take cloud benefits such as scalability, flexibility, etc [17].

- Helps to achieve current and future goals- We need to understand all the aspects of enterprise.
- High Speed -By adopting new technologies, IT performs functionalities faster. Thus the organization can respond faster.
- Consistent data and operations- All the aspects of enterprise must be consistent to make consistent business decisions.
- More reliability and security - A reliable and secure architecture model gives consistency.
- New innovations- Most of the times faster response leads to new innovations in terms of technology.
- Cost effective- Cloud Computing can reduces the cost needed buy new software's, hardware's, etc.
- Increases Agility- Organization can able to take cloud benefits such as scalability, flexibility.

VI. CONCLUSION

To respond continuously in changing environment, organizations need to incorporate appropriate EA. Cloud enterprise can take the advantages of cloud services, such as flexibility and scalability. People can use the services of Cloud Computing to use storage devices, network, applications, etc over the Internet on demand. Cloud Computing helps organizations to reduce cost and reduce maintenance. Agility and effectiveness can be increased by integrating Cloud Services and Organization. EA can be used to make today's policy for tomorrow's growth and success. Enterprises need a strong vision to integrate with cloud offerings to have appropriate architecture to correctly align IT resources. The aim is to provide some general information for organizations or enterprises who wish to integrate existing IT provision with Cloud infrastructures available outside the organizational boundaries. Enterprise architecture framework describes every level of the organization. A well designed EA can serve as tool and methodology providing a strategic architecture that will help to achieve desired objective.

VII. ACKNOWLEDGMENT

It is my privilege and duty to acknowledge the kind of help and guidance received from several people in preparation of this paper. It would not have been possible to prepare this paper in this form without their valuable help, cooperation and guidance.

REFERENCES

[1] The Institute of Electrical and Electronics Engineers (IEEE) definition of architecture: Rich Hilliard, "*IEEE-Std-1471-2000 Recommended Practice for Architectural Description of Software-Intensive Systems*",http://www.enterprise-architecture.info/Images/Documents/IEEE%201471-2000.pdf

[2] Parneet Kaur and Sachin Majithia, "Various Aspects for Data Migration in Cloud Computing and Related Reviews", International Journal of Computer Sciences and Engineering, Volume-02, Issue-07, Page No (83-85), Jul -2014,

[3] J.A. Zachman, "*A Framework for Information Systems Architecture*", IBM Systems Journal VOL 26. NO 3, 1987, https://www.zachman.com/images/ZI_PIcs/ibmsj2603e.pdf

[4] The_Open_Group_Architecture_Framework, "*TOGAF® Version 9.1, an Open Group Standard*", http://pubs.opengroup.org/architecture/togaf9-doc/arch/

[5] Peter Mell Timothy Grance**",** *The NIST Definition of Cloud Computing*", National Institute of Standards and Technology Special Publication 800-145(September 2011),csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

[6] *"A Common Perspective on Enterprise Architecture* " Developed and Endorsed by The Federation of Enterprise Architecture Professional Organizations, Common-Perspectives-on-Enterprise-Architecture-v15.pdf

[7] Z. Mahmood and R. Hill (eds.), "*Cloud Computing for Enterprise Architectures*", Computer Communications and Networks, DOI 10.1007/978-1-4471-2236-4_1, © Springer-Verlag London Limited 2011, Zaigham Mahmood, "*Cloud Computing for Enterprise*

Architectures: Concepts, Principles and Approaches", Page No. (3-18)

[8] Zachman, J.A, Zachman on the Framework, Zachman Institute for Framework Advancement (ZIFA) , www.zifa.com

[9] 11Mahmood H. Shah and Zaigham Mahmood, "*Frameworks for Building Enterprise Information Architectures*"

[10] James E.A.Richards," *Using the Department of Defense Architecture Framework to Develop Security Requirements",* February 7, 2014 The SANS Institute, https://www.sans.org

[11] DoDAF Architecture Framework Version 2.02, Page No. (3-3,105-202), http://dodcio.defense.gov/Portals/0/Documents/DODAF/DoDAF_v2-02_web.pdf

[12] The_Open_Group_Architecture_Framework, "*TOGAF® Version 9.1, an Open Group Standard* ", http://pubs.opengroup.org/architecture/togaf9-doc/arch/

[13] Antonio Vallecillo, *"RM-ODP: The ISO Reference Model for Open Distributed Processing"*

[14] Kerry Raymond, "*Reference Model for Open Distributed Processing (RM-ODP): Introduction",* Springer.

[15] https://www.whitehouse.gov/sites/default/files/omb/assets/egov_docs/fea_v2.pdf

[16] Z. Mahmood and R. Hill (eds.), "*Cloud Computing for Enterprise Architectures*", Computer Communications and Networks, DOI 10.1007/978-1-4471-2236-4_1, © Springer-Verlag London Limited 2011,Pethuru Raj and Mohanavadivu Periasamy, **"***The Cloud Challenges for Enterprise Architects*", Page No.(198-199)

[17] Z. Mahmood and R. Hill (eds.), "*Cloud Computing for Enterprise Architectures*", Computer Communications and Networks, DOI 10.1007/978-1-4471-2236-4_1, © Springer-Verlag London Limited 2011, Siavash Moshiri and Richard Hill, "*Enterprise Architecture Fundamentals*", page No.(32-38)

Authors Profile

Ms. Sajjan R.S. received her M.Tech in Computer Science and Engineering. She has a working experience of 15 years and is currently the H.O.D. of the Computer Science and Engineering Department. She is currently pursuing Ph.D. Her research interestsis is in Cloud Computing.

Ms. Biradar Rekha Yashwantrao received Bachelor of Engineering in Information Technology from W.I.T., Solapur. She is currently working toward the M.E. in Computer Science & Engineering from Solapur University, Solapur. Her research interests lies in area of programming, real time applications, cloud computing, web development.

Mr. Torvi Harshal received his M.Tech in Computer Science and Engineering. He has a working experience of 7 years and is currently the Asst. Professor in Computer Science and Engineering Department.

