Adoption of Emerging Technologies established on Comprehensive Capability Maturity Model Framework: A new practical model

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Abstract

Organizations have adopted information communications technologies (ICT) at various time lines driven by business needs or due to technologies evolution. This has given raise to disparate systems based on various technologies and spaghetti architecture.

This paper discusses why it's critical for organization to adopt the emerging technologies. The reasons behind the current state of the architecture. Suggests how organizations can make use of, The Open Group Architecture Framework (TOGAF) to develop Enterprise Architecture.

Then the paper emphasis on the importance of Capability Maturity Assessment. The current practice of Capability Maturity Assessment by TOGAF, its drawbacks. Then based on the practical experiences, proposes Comprehensive Capability Maturity Model Assessment (CCMM) that covers across the phases of Architecture development method that provides the assessment of maturity to be more realistic.

Keywords: Emerging Technologies, Enterprise Architecture, TOGAF, The Open Group Architecture Framework, Capability Maturity Model. CMM, Architecture Development Method, ADM

Introduction

It's critical for Enterprises to embrace the emerging technologies such as cloud, big data, social media, Internet of Things, analytics etc. for the following purposes:

- to improve the quality of service or products

- to reduce the cost of the services or products

- to reduce the operational cost of technologies services

- to innovate and enhance the services or products offered

Taking by examples the organizations such as Motorola, Nokia, Kodak (Lucas & Goh 2009), It has been proven that organizations have lost their market leadership or perished if they do not adopt technologies for betterment of services or products offered. Thereby it's critical for organizations to adopt technologies for their survival.

Purpose

The purpose of this paper is to propose a Comprehensive Capability Maturity Model (CCMM) that will guide adoption of emerging technologies to meet the organization strategy. The CCMM also helps to enable the business objectives in a cost effective and manage future proofing of technologies stack as far as possible.

Background

Enterprises have adopted information communications technologies (ICT) at various time lines driven by business needs or due to technologies evolution. ICT have evolved from standalone main frames to multi-tier systems to current virtualized environment where the infrastructure stack is a software code (Nelson-Smith 2013) rather than a physical hardware. To manage the information communications technologies effectively and efficiently various frameworks and methodologies have evolved.

The new buzz word 'digital transformation' refers to the changes associated with the application of digital technologies in all aspects of human society achieved through adoption of emerging technologies. With the hyper connected world, it's critical for the enterprises survival to take the path of digital transformation through adoption of emerging technologies.

Technologies evolution has made it affordable by large and small enterprises and common man, hyper connected world that enables social media as part of day to day life enabling its acceptance for personnel and commercial usage. Big data and analytics enable to get new insights of human behavior. Organizations need to reinvent itself in the Digital Age to be competitive or to exist.

Emerging technologies are going through a massive transformation causing technological shifts:

- Mobile networks becoming faster.
- Mobile phones computing capacity similar to computers
- Cloud computing with its unlimited computing power that is affordable by small organizations.
- Infrastructure or Platform or Software-as-a-service compliant with the standard industry certification has created credibility on the security stack. Due to this organizations are replacing on-premises hardware and software with service stack. Social media acceptance by private organization for business and work
- Bring your own device being a norm in organizations
- Employees being more tech savvy and acceptance of technologies for conducting day to day task in office.

Emerging technologies adoption brings in its own challenges such as technical skills, managing risk in embracing new technologies, resistance from the business to learn new way of using the systems, organization culture & risk appetite of organizations and vendor support available, in summary it's art and science to embrace cutting edge technologies. With the emerging technologies that is disruptive in nature organizations need to change the traditional business model across the organization to be successful.

Moving forward to embrace emerging technologies it's critical for the enterprise to assess the current state of the technologies stack, identify the desired future technologies stack (Group 2011). We can give an analogy as doctor assessing the health of the patient before the treatment can be prescribed. Depending on the ailment of the patient the doctor may prescribe ad hoc check or complete end to end health check of the patient

Problem

Digital Technologies that is pervasive and affordable is been used by humans to manage the day to day chores. Humans are becoming dependent on the technologies for day to day chores. Mobile, Social media and globalization has created transparency where humans are able to compare the cost of products or services offered by private or government organization. This has given rise to adopt technologies more efficiently by government or private agencies to improve the quality of service or product.

In the last few decades enterprises have invested millions and billions of dollars on the Technologies. For many organizations, though technologies adoption was inevitable, it has not given the desired benefit. The technologies stack of typical enterprises adopted in the last few years are all based on proprietary (Gunasekaran & Ngai 2004) and hard coded. This has given rise to high operational cost, lock in with the vendor and limiting the innovation that can be achieved with adoption of technologies

In the recent years technologies evolution has given rise to new business model that is utility model pay per usage. This resulted in technologies being seen as commodity, meaning the enterprise can buy both hardware and software technologies on the need basis rather than upfront investment to buy and own the hardware and software. This changed business model of upfront investment the Capital expenditure to Operation expenditure that pay per usage is disrupting the business model. The above factors influences the enterprise to change the existing technologies to adopt the cutting edge technologies with minimal budget and reduced risk.

Impact on the organizations due to ever evolving technologies changes:

- How to identify the technologies that is right and relevant to an organization?

- How to future proof technologies? (A million dollar question)

- How to choose the technologies stack that meets the objectives of the business needs?

In this paper we first discuss the emerging technologies, the current technologies stack of typical enterprise, next the factors that contributed to the current technologies stack. Further the paper briefly describes the concepts of enterprise architecture, capability maturity model, the current practices utilized for capability maturity assessment, the proposed approach goes beyond the current practice of maturity assessment, comparison of the current maturity model assessment with proposed maturity model assessment, further research work that needs to done based on the new approach of Comprehensive Maturity Model Assessment (CCMM) and finally the conclusion.

Research Methodology

The research is based on literature review and experience gained through involvement in enterprise architecture projects done in Australia, Brunei, Mongolia, Philippines and Vietnam

Emerging Technologies

Organizations always prefer to embrace cutting edge technologies either that are matured or evolving. This cutting edge technologies also known as Emerging technologies lack key foundational elements, namely a consensus on what classifies a technologies as 'emergent'. The five key attributes of emerging technologies are: radical novelty, relatively fast growth, coherence, prominent impact, and uncertainty and ambiguity (Rotolo, Hicks & Martin 2015).

Technologies that exist, that will evolve in next five to ten years capable of disrupting the existing model and changes the way we communicate in the social fabric of society also known as emerging technologies. This may include cloud computing environment, social media, big data, analytics, Internet of Things and many more.

Emerging technologies affects:

- Lead to the rapid development of new capabilities;

- Are projected to have significant systemic and long-lasting economic, social and political impacts;

- Create new opportunities for and challenges to addressing global issues;

- Have the potential to disrupt or create entire new industries

Open Platform 3.0

The Open Platform 3.0(Group 2016) (Open Platform 3.0 2016) focuses on new and emerging technologies trends converging with each other and leading to new business models and system designs. The emerging technologies can be broadly classified as the following categories:

- Mobility

- Social networks and social enterprise

- Big data analytics

- Cloud computing

- The Internet of Things (networked sensors and controls)

- Other technologies may be taken on board as the Platform develops.
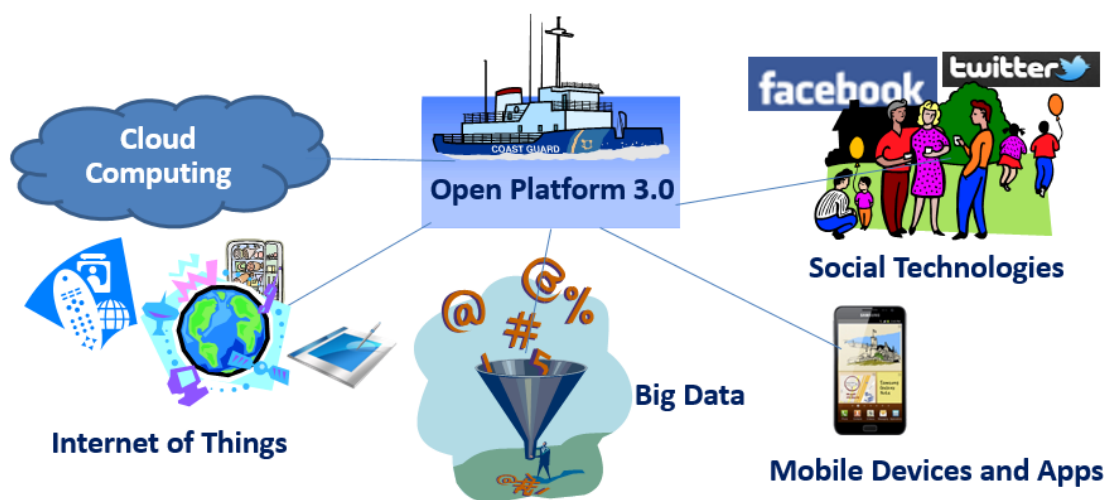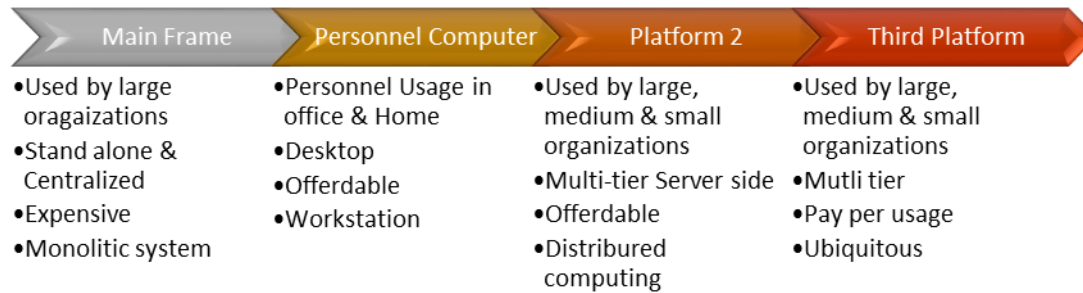

Figure 1. Open Platform 3.0

Open Platform 3.0 advances The Open Group vision of Boundary less Information Flow achieved through global interoperability in a secure, reliable, and timely manner(Group 2016); there by helping enterprises to use these technologies and reap their business benefits. The Open Platform 3.0 describes the business and technical environment and identifies the fundamental requirements for the platform.

Technologies has evolved from main frame stand alone, personal computers used for day to day, distributed layers to current open platform 3.0 (Museum 1996),

Main Frame	Personnel Computer	Platform 2	Third Platform
• Used by large oragaizations • Stand alone & Centralized • Expensive • Monolitic system	• Personnel Usage in office & Home • Desktop • Offerdable • Workstation	• Used by large, medium & small organizations • Multi-tier Server side • Offerdable • Distribured computing	• Used by large, medium & small organizations • Mutli tier • Pay per usage • Ubiquitous

Gartner Emerging Technologies Hype Cycle

Gartner's (Walker 2015) releases Emerging Technologies Hype Cycle that brings together the most significant technologies. This provides insight into emerging technologies trends that may disrupt an organization business model. This Hype Cycle provides Market Excitement, Maturity and Benefit of Technologies, so organizations needs to monitor this cycle

Current technologies stack of typical enterprise

Technologies usage in organizations has started since early 1950's from the main frame to current open platform 3.0. Organizations that are large and Government agencies have adopted technologies from last few decades. They have adopted technologies as they evolved and to meet the business needs. This resulted in spaghetti of disparate system connected that is based on various technologies, some technologies are proprietary and some are open standard. The resulting architecture is as below
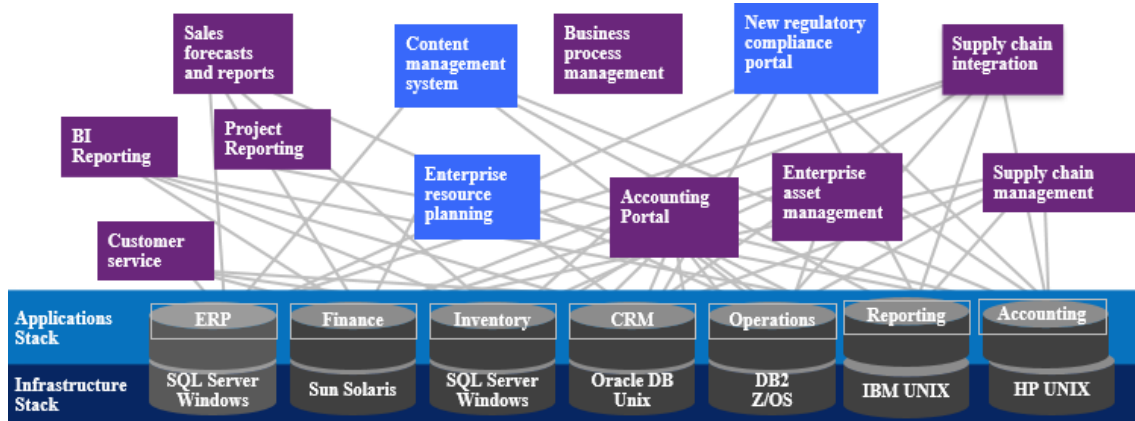

Figure 2. Spaghetti Architecture due to technology adoption at various timeline

The current architecture of typical organization

Architecture is man-made building or structure; a carefully designed object such as a chair, a spoon; a design for a city, town, park, or landscape; a well-designed website, student management system, e-commerce website such as ebay.

The architect models the stakeholders' vision (an individual or organization that has with an interest in the enterprise) and creates an architecture definition that will be the basis of developing an information system (Osvalds 2001).

All the information systems either stand alone or grouped together has followed an Architecture. As technologies has evolved at various time line and the systems are commissioned based on technologies evolution has resulted in an architecture that is rigid. We can relate to massive urbanization, accompanied by the rapid expansion of cities and metropolitan regions that resulted in explosive growth giving raise to unplanned cities (Angel et al. 2012).
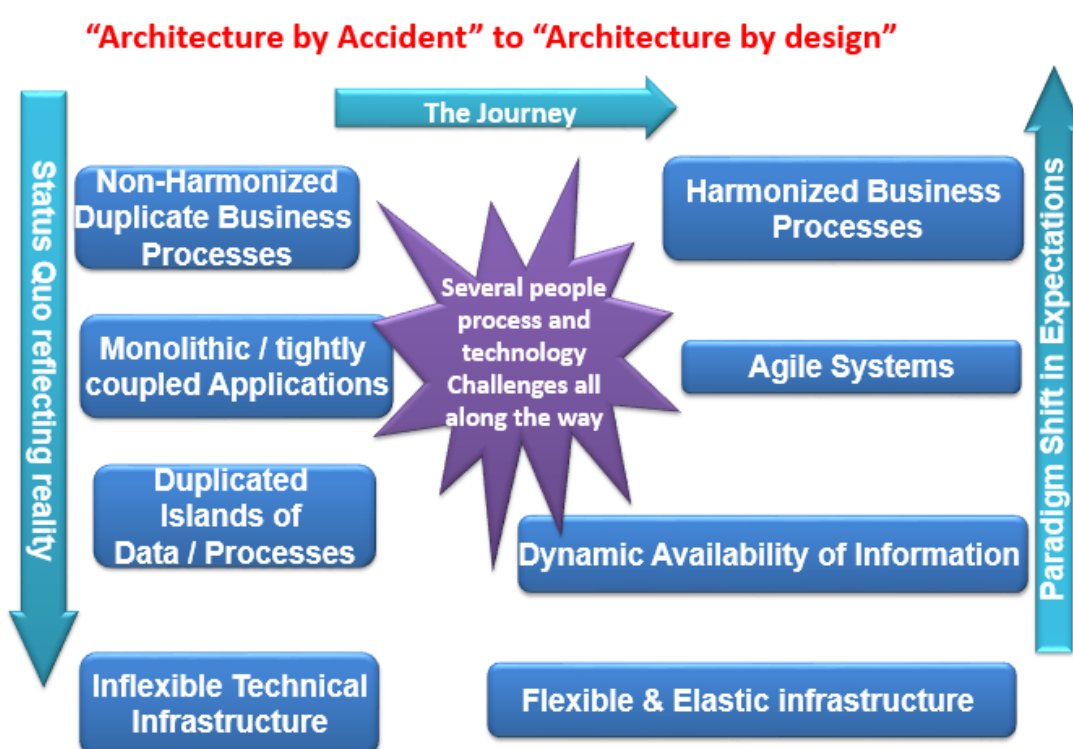

**Figure 3. AS IS Current Architecture TO BE Dynamic Architecture**

Enterprise architecture

Enterprise as per The Open Group (Group 2011) is a collection of organizations that has a common set of goals. For example, a government agency, a whole corporation, a division of a corporation, a single department, or a chain of geographically distant organizations linked together by common ownership.

Enterprise in the context of ''enterprise architecture'' denote an organization information and technologies services, processes, and infrastructure and the architecture that cut across the multiple systems, functional groups within the enterprise.

According to Gartner (Gartner 2008) Enterprise architecture is the process of translating business vision and strategy into effective enterprise change by creating, communicating and improving the key requirements, principles and models that describe the enterprise's future state and enable its evolution.

The scope of the enterprise architecture includes the people, processes, information and technologies of the enterprise, and their relationships to one another and to the external environment. Enterprise architects compose holistic solutions that address the business challenges of the enterprise and support the governance needed to implement them.
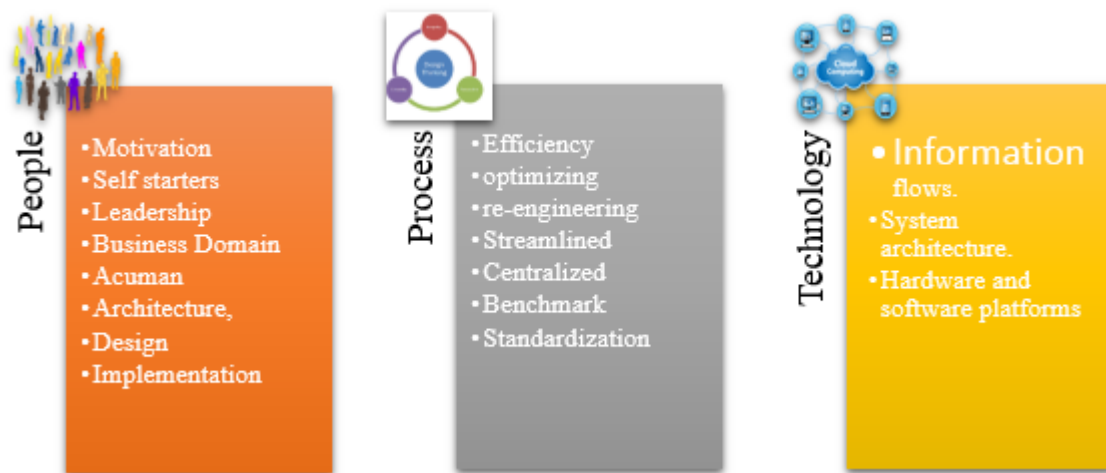
Figure 4 People, Process and Technology

According oxford dictionary an framework is a basic structure underlying a system, concept, or text: To implement enterprise architecture we need an framework based on open standards well accepted in the industry as they are seventy seven enterprise architecture frameworks (Takahiro Yamada 2016).

Benefits of Enterprise Architecture

Organizations tremendously benefit with incorporation of enterprise architecture practice

- A more efficient business operation:

    o Lower business operation costs

    o More agile organization

    o Business capabilities shared across the organization

    o Lower change management costs

- o More flexible workforce

- o Improved business productivity

- A more efficient IT operation:

  - o Lower software development, support, and maintenance costs

  - o Increased portability of applications

  - o Improved interoperability and easier system and network management

  - o Improved ability to address critical enterprise-wide issues like security

  - o Easier upgrade and exchange of system components

- without sacrificing architectural coherence

  - o The ability to procure heterogeneous, multi-vendor open systems

  - o The ability to secure more economic capabilities(Group 2011)

What is The Open Group Architecture Framework (TOGAF)?

TOGAF is an architecture framework - The Open Group Architecture Framework. TOGAF provides the methods and tools for assisting in the acceptance, production, use, and maintenance of an enterprise architecture. It is based on an iterative process model supported by best practices and a re-usable set of existing architecture assets. TOGAF embraces ISO/IEC 42010:2007 terminology though not completely (Group 2011).

Irrespective of any domain there are four layers called as core architecture and two layers cross cutting across the core layers accepted in overall enterprise architecture that TOGAF supports:
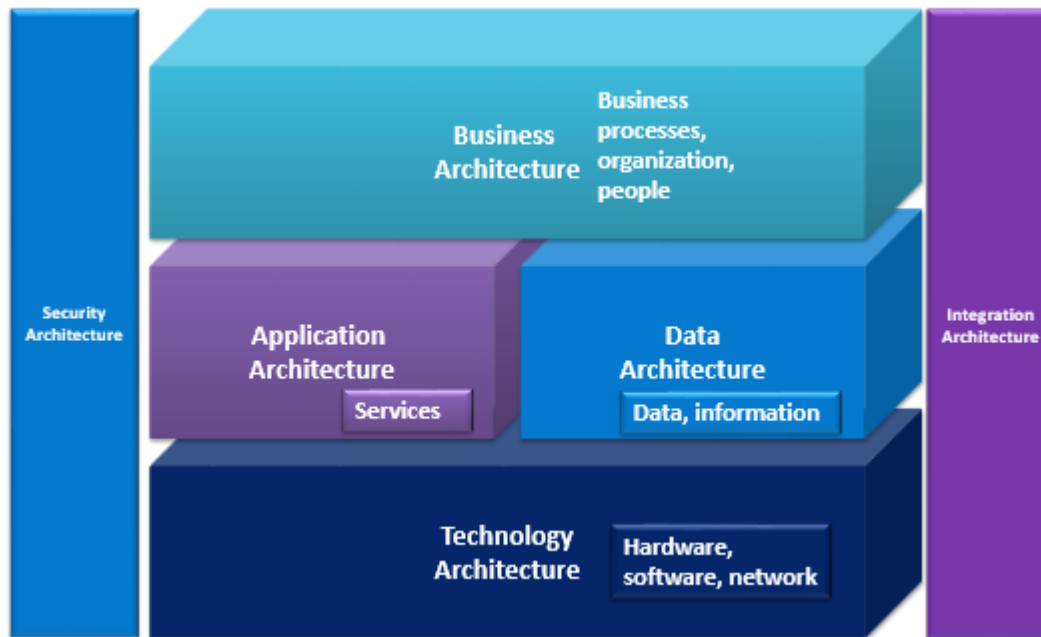
Figure 5 Core Architecture Stack

- The Business Architecture defines the business strategy, governance, organization, and key business processes and functions.

- The Data Architecture describes the structure of an organization's logical and physical data assets and data management resources. It identifies for structured, unstructured and hybrid data.

- The Application Architecture provides a blueprint of application systems to be deployed, their interactions, and their relationships to the core business processes of the organization.

- The Technology Architecture describes the logical software and hardware capabilities that are required to support the deployment of business, data, and application services.

The two cross cutting architecture layer cutting across the core layers are:

- Security Architecture: Security concerns are pervasive throughout the architecture domains and in all phases of the architecture development. Security Architecture is a set of design artefacts that are relevant for describing an object such that it can be produced to requirements as well as maintained over the period of its useful life. The design artefact describe the structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time (Architecture 2016).

- Integration Architecture: Integration of core architectures, in business architecture its function / process; in information architecture its disparate applications / data and in technology architecture its diverse technology stack

Architecture Development Method (ADM) Phases:

The ADM describes a method for developing and managing the lifecycle of an enterprise architecture, and it's the core of TOGAF. When an organization sets up EA practice first cycle is run to identify two to five year roadmap. Subsequently its run for every key initiatives that arises based on business needs or compliances requirements, organization merger or acquisitions. ADM is iterative and incremental process across the life cycle of Enterprise Architecture.

Architecture Development Method with identified frameworks

Ensure the architecture support the business needs

Start Enterprise Architecture Practice; Frameworks: COBIT, PMP, PRICE2, ITIL, ITSM, SABSA,

Preliminary

Set the scope for Portfolio / Programme / Project for the ADM cycle; Frameworks: PMP, PRINCE2, ITIL, ITSM, SABSA

Continual monitoring of all the phases of the ADM; Framework: COBIT, ITIL, SABSA

Develop Business Architecture. Identify the gaps based on baseline and target architectures; Frameworks: BABOK, BIZBOK® GUIDE

A Architecture Vision

H Architectural Change Management

B Business Architecture

Develop Information Systems Architectures of Application / Data. Identify the gaps based on baseline and target architectures. Framework: DMBok

G Implementa-tion Goveranance

Requirements Management

C Information Systems Architecture

Analyze costs, benefits and risks; develop detailed Implementation and Migration Plan; Framework: PMP, PRINCE2, ITIL, ITSM

Develop Technology Architecture Identify the gaps based on baseline and target architectures

F Migration planning

D Technology Architecture

E Opportunities and Solutions

Ensure that every stage of a TOGAF project is based on and validates business requirements; Framework: ITSM, ITIL

Based on the consolidated gap analysis, identify the projects; Framework: PMP, PRINCE2, ITIL, ITSM

Figure 6 ADM cycle with the suggested methodologies

Methodologies or framework identified for success of Enterprise Architecture

Table 1: Identified Methodologies list

Description	Focus	Comments
PMBoK : Project Management Book of Knowledge A set of standard terminology and guidelines (a body of knowledge) for project management	Managing Projects	Either one can be used, depends on the organization
PRINCE2 : Project Management in controlled environment Process-based method for effective project management.	Managing Projects	
BIZBOK® GUIDE: A Guide to the Business Architecture Body of Knowledge®	Business Architecture	either one can be used, depends on the organization
BABOK® :A Guide to the Business Analysis Body of Knowledge	Business Architecture	
DAMA DMBOK ®:Data Management Body of Knowledge	Data Architecture	
ITIL : Information Technology Infrastructure Library	Change Management	
ITSM: Information Technology Service Management	Service Management	
COBIT: Control Objectives for Information and Related Technology	Governance: Corporate, Project, Architecture and Risk	
SABSA: Sherwood Applied Business Security Architecture	Security and Risk	

Architecture without Enterprise Architecture Framework

Organizations without enterprise architecture focus have procured the information systems based on the business needs (Gunasekaran & Ngai 2004). As information technologies in last decade was still evolving, proprietary based and organizations being risk avert, they were procuring systems that offered product support. This has caused systems to be hard coded and stuck with a vendor, costing huge maintenance cost and also high cost for system enhancement to meet the changing business needs.

Architecture with Enterprise Architecture Framework practice

Organizations with enterprise architecture practice in place, will develop the architecture building blocks based on the business requirements. Then they will choose the information systems that meets the architecture building blocks. Due to this there is no vendor lock in and also less expensive on maintenance and enhancement of information systems to meet the changing business needs
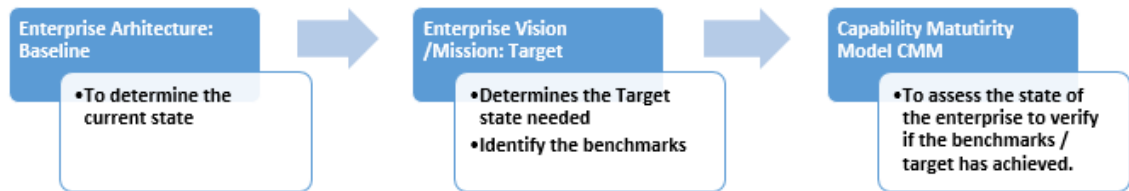
Capability maturity model

What Is a Capability Maturity Model (CMM)?

CMM broadly refers to a process improvement approach that is based on a process model. A process model is a structured collection of practices that describe the characteristics of effective processes; the practices included are those proven by experience to be effective.

CMM can be used to assess an organization against a scale of process maturity levels. Each level ranks the organization according to its standardization of processes in the subject area being assessed. The subject areas can be as diverse as

- Enterprise Architecture Maturity Assessment

- The Strategic Management Maturity Model

- Business Transformation Readiness Assessment

- Business Process Maturity Model (BPMM)

- Business process capability maturity model

- Data Maturity model

- The Data Warehouse Capability Maturity Model

- Information technology (IT) services

- P3M3® Portfolio, Programme and Project Management Maturity Model

- Project management,

- Organizational Change Management Maturity

- Risk management,

- Software engineering,

- Systems engineering

- System acquisition,

- Personnel management.

Figure 7. Capability Maturity Model overview

Maturity model provides

- a place to start

- the benefit of a community's experience and knowledge

- a common language and a shared vision

- a way to define what improvement and "maturity" mean for an organization

- a framework for prioritizing actions

- a way to define what improvement means for the Enterprise

Capability Maturity Models (CMMs) address this problem by providing an effective and proven method for an organization to gradually gain control over and improve its change processes.

IT strategy and roadmap development is most complex exercise for enterprise leaders due to the nature of diversified IT systems and architectures to address the adoption of emerging technologies. Therefore, it is important to assess the organization maturity before starting any major business transformation / periodically to identify the current maturity level which will help to define IT strategy to be realistic.

The current practices utilized for Enterprise Architecture Maturity assessment

The current Capability Maturity Model is based on US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM). This maturity model was developed in 2001 and last updated on December 2007(Commerce 2007). Information technologies as changed leaps and bounds, the maturity model has not been updated to keep in tune with the current requirement. The DoC ACMM has three sections, six levels and nine architecture characteristics.

The ACMM comprises three sections:

1. The IT architecture maturity model

2. IT architecture characteristics of operating units' processes at different maturity levels

3. The IT architecture capability maturity model scorecard

The six levels are:

- 0 : None

- 1 : Initial

- 2 : Under development

- 3 : Defined

- 4 : Managed

- 5 : Measured

The nine IT architecture characteristics are:

- IT architecture process

- IT architecture development

- Business linkage

- Senior management involvement

- Operating unit participation

- Architecture communication

- IT security

- Architecture governance

- IT investment and acquisition strategy

Why is Capability Maturity Model Assessment needed?

Before giving a treatment to a patient doctor diagnoses the patient health condition to assess the current health condition. Based on the results the treatment is prescribed to the patient.

Similarly the purpose of the assessment in an organization is to estimate the level of maturity of the enterprise IT architecture and tentatively identify various improvement areas.

We can relate to humans, those who take precautions pro-actively based on the age and condition, the other who are reactive take treatment based on the ailment. Irrespective it's necessary to do the health check on the entire system to suggest a proper treatment

Similarly it's necessary to do the maturity assessment in a holistic approach that covers the entire organization. Said that it's essential to identify the existing methods, methodologies, framework that are utilized. This gives an understanding of the current working style. Based on the target maturity model

identified it's possible to recommend the appropriate framework or method or methodologies that are suitable for the enterprise.

The maturity models needed for an enterprise is based on the domain, industry vertical, type of enterprise public or private, Country, Culture, the Technologies used etc..

So each Capability Maturity Model is specially identified and tailored based on the above criteria

Capability Maturity Assessment Process

1. Define what to measure.

2. Define what can be measured.

3. Gather the data.

    a. Determine the department

    b. Group the Stakeholder

    c. One to one interview

    d. Organization audit reports

    e. Anonymous online survey

4. Process the data.

5. Analyze the data.

6. Presenting and using the information.

7. Implementing corrective action.

Figure 8. Maturity Assessment Process

Fig 8. Maturity Assessment Process
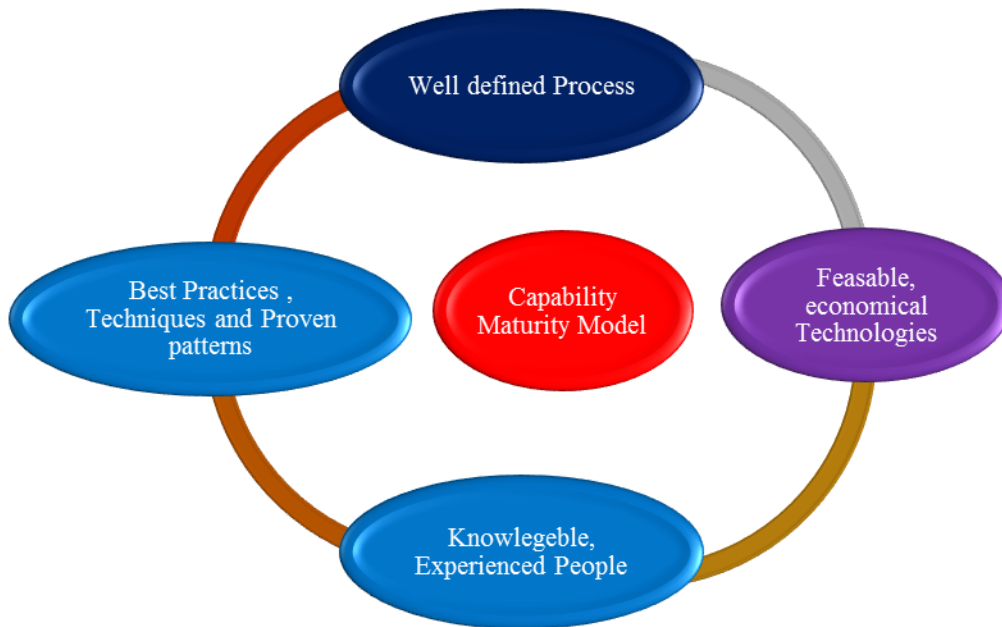
Capability Maturity Model considerations

Figure 9. Capability Maturity Model considerations

Types of Capability maturity model

Maturity assessment has been developed at various time line based on technologies evolution. As organization relied more on technologies it was critical to assess the maturity of the organization to improve the capability of peopled, process and technologies.

From the inception of maturity model by the US Department of Defense Software Engineering Institute (SEI) began in 1986, as now they are more than fifty four maturity models (Wikipedia 2016). It's not possible to go through all the maturity model due to constraints as time, budget and resources, also it's not necessary.

Proposed Maturity Models identified based on TOGAF ADM phases

Organizations are implementing TOGAF framework for their enterprise architecture practice. Based on that we identified the key maturity models that are relevant for the phase of TOGAF Architecture development.
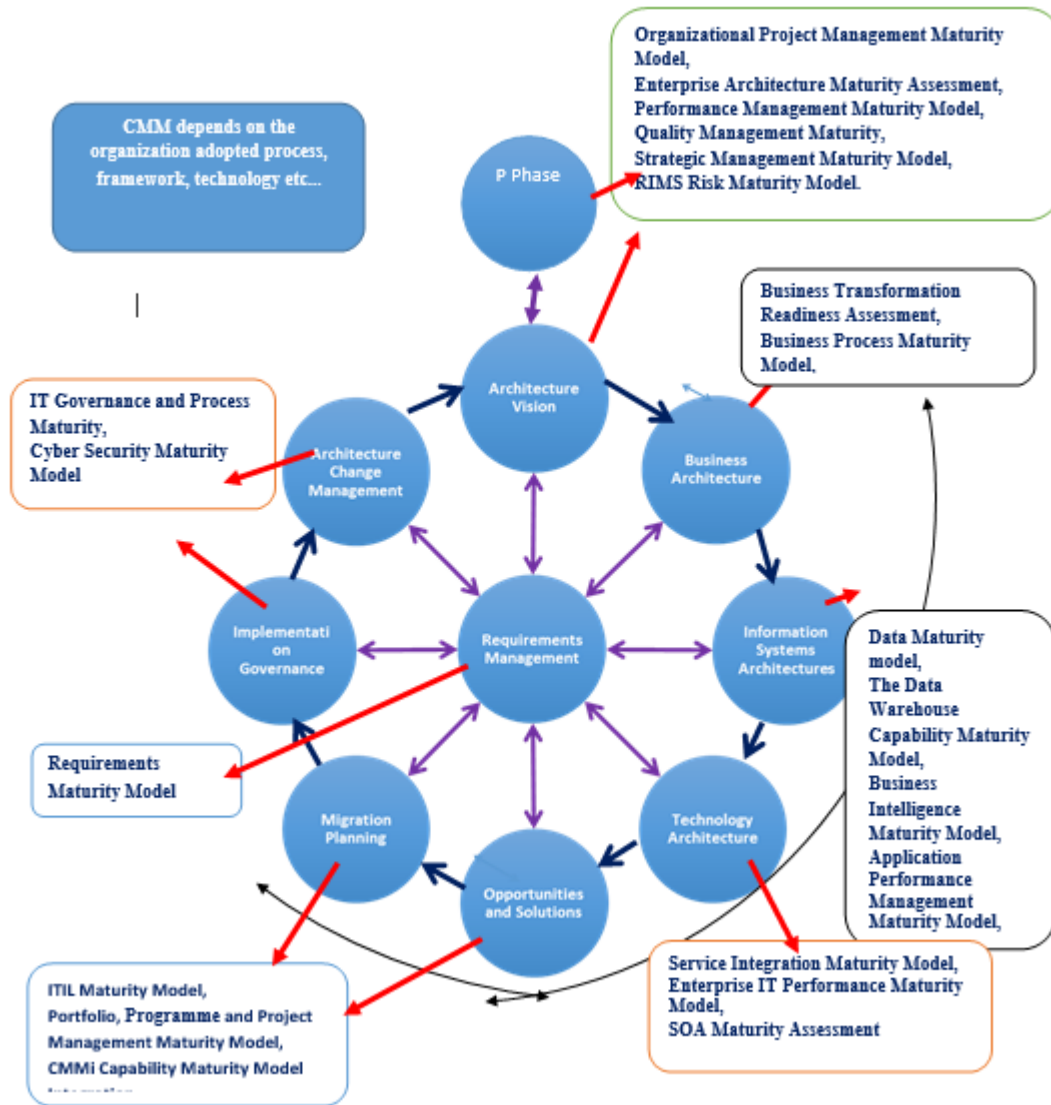
Figure 10. Suggested Maturity Models for the typical organization

Table 2: Maturity Models description and their purpose

ADM Phase	Maturity Model	Purpose
P:Preliminar Phase	Organizational Project Management Maturity Model	Project Management
	Enterprise Architecture Maturity Assessment,	Enterprise Architecture

Phase A: Architecture Vision	Performance Management Maturity Model,	Performance
	Quality Management Maturity,	Quality
	Strategic Management Maturity Model,	Strategy
	RIMS Risk Maturity Model	Risk
Phase B: Business Architecture	Business Transformation Readiness Assessment,	Business Readiness
	Business Process Maturity Model,	Business process
	Business function capability maturity model,	Business function
Phase C: Information Systems Architectures Data & Application	Data Maturity model,	Data Model
	The Data Warehouse Capability Maturity Model,	Data ware house
	Business Intelligence Maturity Model	Business Intelligence
	Data Maturity model,	Data maturity
	Application Performance Management Maturity Model	Application Performance
Phase D: Technology Architecture	Service Integration Maturity Model,	Service Integration
	Enterprise IT Performance Maturity Model,	Information system performance
	SOA Maturity Assessment	Service Orientation Architecture
Phase E: Opportunities & Solutions	ITIL Maturity Model,	Information Infrastructure
Phase F: Migration Planning	Portfolio, Programme and Project Management Maturity Model,	Portfolio, Programme, Project Management
	Capability Maturity Model Integration CMMI	Capability Maturity Model Integration software development
Phase G: Implementation Governance	IT Governance and Process Maturity,	Governance
	Cyber Security Maturity Model	Security

Phase H: Architecture Change Management		
ADM Architecture Requirements Management	Requirements Maturity Model	Requirements

Comparison of the current maturity assessment with proposed

The current maturity model is based on outdated maturity model of US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM). The proposed Comprehensive Capability Maturity Model (CCMM) covers the Architecture Development Method (ADM) phases, as such the assessment is more realistic

Further research work carried on the proposed maturity model assessment

We have identified the maturity model specific to phases of the Architecture Development Method. We have utilized this technique based on our experiences learned from various enterprise architecture projects implemented. But we want to try with wider audience across the globe. As TOGAF is open standard and widely used across the world.

We will be conducting survey with enterprise architect practitioners across the world. We also conduct face to face interviews with the enterprise architect practitioners. Then we correlate the result to identify the key maturity models that are relevant based on TOGAF and organization domain. Also the result produced might be applicable for certain period of time only as the maturity models changes based on the evolution of technologies

Conclusion

Organizations are utilizing The Open Group Architecture Framework (TOGAF) based on open standards to develop enterprise architecture, to help in their transformation to adopt emerging technologies.

The maturity assessment suggested by TOGAF is outdated US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM).

Based on project experience we have identified Comprehensive Capability Maturity Model (CCMM) assessment across the phases of Architecture development method that provides the assessment of maturity more realistic.

This maturity assessment will helps the organization to choose the right technologies stack that serves the business needs in alignment with organization strategy.

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