

Lappeenranta University of Technology

School of Business and Management

Department of Innovation and Software

Computer Science degree programme

Mudari Bhupesh

**BUILDING IT ARCHITECTURE FOR DEVELOPING NATIONS USING  
TOGAF**

Examiner: Prof. Kari Smolander

Supervisor: Associate Prof. Erja Mustonen-Ollila

## **ABSTRACT**

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Master's Thesis 2015

71 Pages, 19 Figures, 6 Tables, 1 Appendix

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**Key Words:** Enterprise Architecture, TOGAF, Developing Nations

#### **Abstract**

Developing nations vary in data usage techniques with respect to developed nations because of lack of standard information technology architecture. With the concept of globalization in the modern times, there is a necessity of information sharing between different developing nations for better advancements in socio-economic and science and technology fields. A robust IT architecture is needed and has to be built between different developing nations which eases information sharing and other data usage methods. A framework like TOGAF may work in this case as a normal IT framework may not fit to meet the requirements of an enterprise architecture. The intention of the thesis is to build an enterprise architecture between different developing nations using a framework TOGAF.

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---This achievement is for you---

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## LIST OF ABBREVIATIONS

<b>CIO</b>	----- Chief Information Officer
<b>DoC</b>	----- Department of Commerce
<b>EA</b>	----- Enterprise Architecture
<b>FEAF</b>	----- Federal Enterprise Architecture Framework
<b>GDP</b>	----- Gross Domestic Profit
<b>ICT</b>	----- Information and Communication Technology
<b>IEC</b>	----- International Electro technical Commission
<b>ISO</b>	----- International Standard Organization
<b>IT</b>	----- Information Technology
<b>KPI</b>	----- Key Process Indicators
<b>TOGAF</b>	----- The Open Group Architecture Framework
<b>SOA</b>	----- Service Oriented Architecture
<b>UIDAI</b>	----- Unique Identification Authority of India
<b>UNESCO</b>	----- United Nations Educational, Scientific and Cultural Organization

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# **1 Introduction**

## **1.1 Motivation**

With the advent of information technology, different countries adopted various technological services to improve their standard of living. A good number of countries went further, in applying technological services in several work areas of man-kind. For example, using information technology in food production, transport, education, constructions, defense, so on. A significant growth in per capita income of those countries who followed technology in different areas has been observed from time to time. Standard of living, industrialization, infrastructure, education and other areas observed a potential growth and hence countries which followed technological services wisely are now known as developed countries [1]. On the other hand, developing countries are those countries where the standard of living, infrastructure, education, industrialization, transportation and other areas need improvement and has to be improved in several different ways. Though developing countries [2] follow technological services but the degree of potential use of services is not up-to the mark. One good reason, for not using technological services [3] wisely is improper usage of data or information. There is abundant of data or information available, but the information is not being utilized to its full potential.

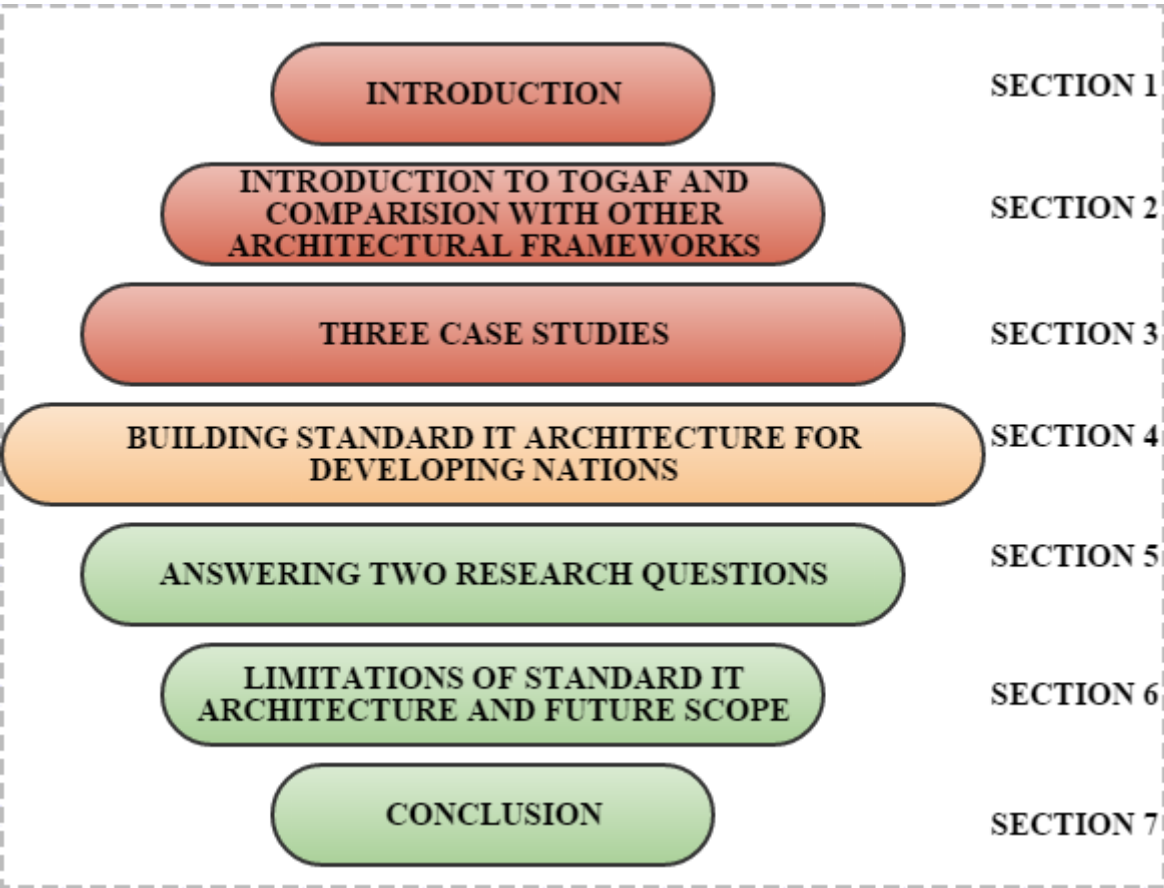
A good number of examples to describe how data usage is being done in developed and developing countries is illustrated in this section. In a university if a student needs a research article which is not available in a university library or in any other libraries in town then there is no way to contact higher universities. There is no direct channel through which a person can order a book or article from a different library from a different location. Contrast to this, in Europe or in America if a student needs a book or research article from a different library from a different country he or she can order it through their universities library portal [4] or can make an order from library information desk. Another example to consider is, in Nordic countries (or other developed countries), every person is assigned a social security code and with the help of that code a person can be identified uniquely. His or her information can be retrieved even when the person is moving to different countries. This is not the same case in the developing countries. Developing countries have security codes which are valid in their own regions and are invalid if

a person moves out of that region. No information about that particular person can be accessed if a person moves out his own region. This makes things difficult when security reasons are concerned. Even if data sharing is done still there are different interoperability problems [5] because of poor quality information sharing equipment and systems. Another example to consider is due to globalization each and every country needs to access or share information from other countries information repositories to improve their own developmental methods. The data or information can be related to agriculture, education, healthcare, and infrastructure, so on. If there is no proper information sharing then comes the imbalance between the states and there may arise security issues. So information sharing between states plays a key role in the modern economics. Likewise, there are several instances and examples of how data is being shared among the developed and developing nations. Therefore, in the following sections of the thesis, one can look into the succeeding ways of dealing with the problem of improper sharing of information among different developing nations.

## **1.2 Structure of the Thesis**

The structure of the thesis is kept simple and easy to understand. The first section of thesis starts with introduction where the motivation behind the thesis is explained followed by concepts and research methodologies from where problem statement is analyzed along with research questions. The second section introduces TOGAF followed by comparison between other different architectural frameworks. Comparison between TOGAF and other frameworks is important as it proves how TOGAF can fit for developing a robust and flexible enterprise architecture between developing nations. The third section of thesis is about three different case studies [57] that are used to stress the need of a standard IT architecture between developing nations and the degree of change an enterprise architecture can bring in different fields of a countries development. The three case studies are AADHAAR a nation-wide unique identification method introduced by government of India for security and personal identification of its citizens, secondly, importance of cross-border architecture in health care systems and thirdly, educational systems and the impact of standard IT architecture on developing countries educational systems. Fourth section of thesis highlights the building characteristics of a standard IT architecture based on TOGAF paradigms. Therefore, types of documents that a cross-border

architecture should possess, different types of phases and maturity levels involved in developing the standard IT architecture and finally proposing a common standard IT architectural model for different developing nations. In the fifth section, based on the case studies, findings from characteristics and architecture proposal, answers the two research questions are mentioned. The sixth section is about limitations of standard IT architecture and seventh section concludes the whole thesis work. Appropriate references and appendices are followed at the end of seven sections of the thesis.



**Figure 1:** Structure of the thesis

### 1.3 Concepts and Research Approach

The first part of this section explains the concepts involved in the thesis work and their explanations. Later the research methodologies which were followed to bring out the problem statement and research questions are discussed. Starting with the concepts, as the thesis deals with building an architecture for developing nations, the key highlights of the entire thesis work rounds around architectures. Generally, architecture forms a backbone for any entity that has to be build. The theory, functionalities, enhancements and improvements, services, so on which are involved in building an entity, form a part of the architecture. In other words, architecture is the backbone for the life of an entity that is built. When discussing architecture between different nations, a normal architecture may not work in this case (as several different entities are involved). Only an enterprise architecture better suits and can help in further enhancements of the architecture when required. In specific a framework like TOGAF which meets different international information technology architectural standards and has the capabilities of meeting different stakeholder's requirements can be used in building architecture between different nations.

There are three types of research approaches involved through which problem statement has been stated in the next section. Three research approaches involved are the *general research* [6] and *grounded theory approach* [56] [58] where the necessity of architecture between different nations is discussed through interviews and case studies, *top-down approach* [7] where the entire architecture is studied from its major entities and drilled down till the basic segments and lastly, *bottom-up approach* [7] where each one of the entities and services that are needed for architecture are studied and their integration and interactions discussed as to form entire whole architecture. In the general study approach, interviews from different architects working in several different companies were conducted where the necessity of cross-border architecture was discussed. Questions which were asked to different professionals are attached as an appendix at the end of the references. Based on their work experience and professionalism their answers were analyzed. Interviews were also conducted on service industry specialists and their perspectives are collected for the architecture implementation. Also, three different case studies are discussed which describe the necessity of cross-border architecture among different developing nations.

Following table gives a clear idea of the need of a common information technology architecture between different developing nations.

**Table 1:** Real-time Industry experts view on building cross-border enterprise architecture

	<b>IT Experts</b>	<b>Service Industry Specialists</b>	<b>Other Technicians</b>
<b>Data Sharing</b>	<b>Agreed</b> (Data Sharing becomes easy for usage)	<b>Agreed</b> (Market comparisons becomes easy)	<b>Agreed</b> (Easy information obtaining repositories)
<b>Complexity</b>	<b>Partly Agreed</b> (Though complex can be implemented)	<b>Disagreed</b> (Completely agreed complex and hard to implement)	<b>Disagreed</b> (Completely agreed complex and cannot be implemented)
<b>Implementation</b>	<b>Agreed</b> (Though hard implementation is possible)	<b>Agreed</b> (Hard to implement but possible)	<b>Disagreed</b> (Difficult to implement as cross-border standards are involved)
<b>Time</b>	<b>Partly agreed</b> (Involved time and effort as different standards should be considered)	<b>Partly agreed</b> (Different standards, Services, people involvement takes place. So, lot of time investment)	<b>Partly agreed</b> (If implementation is possible, then several different entities should be considered which involves time)
<b>Costs</b>	<b>Disagreed</b> (Very high costs involved)	<b>Disagreed</b> (Very high costs involved)	<b>Disagreed</b> (Very high costs involved)
<b>Security</b>	<b>Agreed</b> (Security can be implemented if all standards are followed)	<b>Agreed</b> (It's possible to implement as security goes with time)	<b>Agreed</b> (If architecture is implemented practically then security implementation should not be a problem)

The different colors green, blue and red reflects the level of acceptance from a different category of people. In overall, experts from information technology field, service industry specialists and other technical persons are considered to check their acceptance level for building a cross-border enterprise architecture. Different factors like data sharing, security, implementation policies, costs, time involvement, data sharing features were considered when interviews were conducted on experts to get more knowledge of enterprise architecture implementation. For top-down and bottom-up approaches three different case studies were considered where the first case deals with a top-down approach, the second case deals with a bottom-up approach and the third involves both. The three case studies are discussed in the later sections of the thesis.

#### **1.4 Problem Statement**

From various discussions and conducted interviews and from the case studies (described in the later sections) one important point to stress is that there is a need for a cross-border architecture for the better development of developing nations. There is no proper distribution of information among different developing nations. Though the data is available still the data is not being used properly which results in an imbalance of information sharing. Even if there are any data sharing features in the present administrative services of developing nations they are age-old and cannot match with the modern high technological data sharing methods. One important point that gets highlighted in the case of developing nations data usage methods is that a robust information technology architecture is needed which not only helps in data sharing but also plays a key role in different scientific and research processes. Furthermore, the architecture should be defined in such a way that it should meet the requirements of different stakeholders who are involved in the architecture usage.

There is a need for such a framework on which different services located at different locations can work on a single platform at a given point of time. Several different processes, services, stakeholders, information systems, security standards run simultaneously and continuously on a single cross-border framework which also should follow different IT governance and service-oriented architecture principles. From all the above discussions, two important questions can be framed which are also the research questions for the thesis.

1. “What is the role of a standard IT architecture in the progress of a developing nation?”
2. “Changes of kind When, what and how an IT architecture using TOGAF framework can bring for the developing nations?”

The focus of thesis work majorly rounds in answering these research questions. The insight of the above mentioned two research questions is described in the next section.

### **1.5 Research Questions**

The main focus of the thesis is in answering the two research questions which are as stated:

1. What is the role of a standard IT architecture in the progress of a developing nation?

As the point of discussion is about developing nations and information sharing among different developing nations, there is a need for a standard IT architecture which helps in the better socio-economic developments. An important point to highlight is can an IT architecture really bring a progress for a developing nation and in what ways. Another point to discuss is how standard an IT architecture should be in order to meet the different requirements that arise among different developing nations at different points of time.

2. Changes of kind When, what and how an IT architecture using TOGAF framework can bring for the developing nations?

The question highlights the changes of when, what and how the IT architecture can bring for developing nations. A key point to highlight in the research question is the need of TOGAF framework. Why one should consider TOGAF as there are different frameworks which can support for building an IT architecture and even if TOGAF is considered, then to what degree TOGAF can bring the mentioned changes in the case of cross-border architecture between developing nations. How different TOGAF related IT architecture is from that of IT architecture developed from other different frameworks are the points that need to be discussed in the later sections.

## **1.6 Goals of thesis**

The goals of the thesis are to address and answer the framed research questions as well as mentioning the further enhancements (if there are any) for the developed information technology architecture using TOGAF framework. Also, thesis highlights the necessity of TOGAF in building cross-border IT architecture for developing nations when compared to different IT frameworks that are available in the modern times. The three case studies discussed to highlight the point of usage of different research approaches of top-down and bottom-up and help in finding the answers for the research questions.

## **1.7 Limitations of thesis**

The thesis is theoretical considering the ICT standards, there can be several different changes when the real implementation of the IT architecture is concerned. Different nations have different government policies, languages, security norms and people choices, so on which also play a major role in building a cross-border architecture. The architecture is discussed from a technology point of view and none of the other factors are taken into consideration. Also, a framework like TOGAF improves its standard from time to time and hence architectural improvements are necessary on a time basis.

## **2 Introduction to *The Open Group Architecture Framework***

The Open Group Architecture Framework (TOGAF) [8] is a framework which helps to address and define new solutions for organizations based on their business needs. In short, with the help of TOGAF, an organization can build or define enterprise architecture depending on their business needs. Architecture is a backbone for any organization and defining architecture at the enterprise level is more complex and critical work. Enterprise Architecture is a blue-print which defines the objectives that an organization should achieve in its near future as well as its current goals [9]. Enterprise Architecture has several different embedded architectures that define its functionality [10]. Each layer has their own set of stake holders with different requirements. An Enterprise Architecture should be defined ensuring that each stake holder can understand the language of architecture and can address or find a solution for their individual needs. Also, enterprise architecture should help in defining solutions with less time, money and minimal resource utilization [8]. TOGAF is a framework, which has defined guidelines, for the development of IT standards keeping in mind for all enterprises like small, medium and large [11].

TOGAF has been developed by “The Open Group” with its first version in 1995 [12]. TOGAF is a framework with a set of supporting tools and detailed methods with which any organization can wish to develop their own enterprise architecture [13]. According to ‘The Open Group’, enterprise reflects a collection of organizations that have a common set of goals [12]. In other words, an enterprise can be a single entity or a group of entities which run to achieve a set of goals. An important aspect of TOGAF is that it subsets and supports different architectures that underlie in an enterprise architecture. For example, for any EA there is a business, data, application and technology architectures which form different layers with different stake holders at each level. Also, TOGAF clearly defines relationships between different architecture entities, their artifacts, stakeholders, deliverables and building blocks [13]. TOGAF also provides a clear balance of ISO\IEC concepts and terminology.

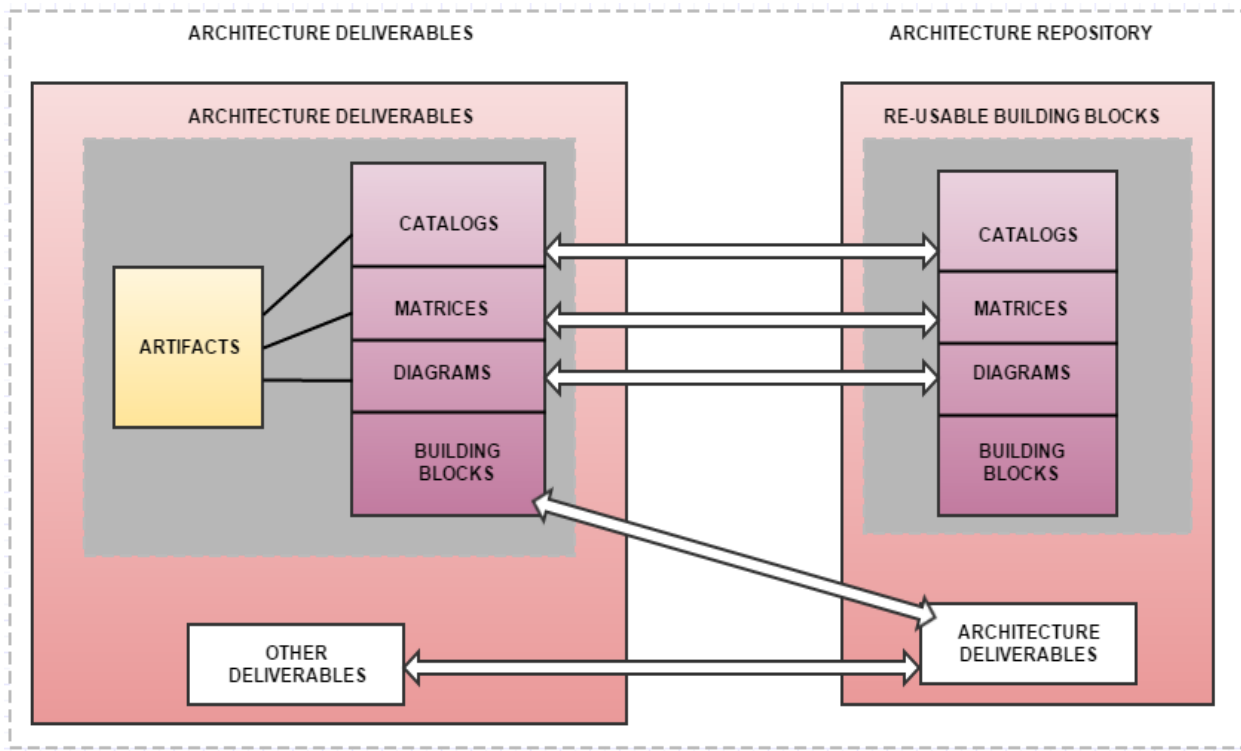
## 2.1 Need for TOGAF

As the thesis topic deals with the development of IT architecture for developing nations, the idea in turn reflects the complexity of different entities being involved while developing the enterprise architecture. Considering each nation has an entity with their architectural goals as subsets, the starting point to analyze is that does TOGAF meets or has the capabilities in defining enterprise architecture between different nations.

In this section of the thesis, we highlight the need of TOGAF in developing EA for developing nations. Developing nations are striving hard to maintain pace in fast changing information technology industry. As there is a rapid progress of several different technologies and socio-financial changes in their respective societies, there is a need for nations to exchange information to maintain the pace either through mutual agreements or through maintaining a common resource sharing platform. With the internet, the concept of globalization has come into existence and there is a need for sharing information among different nations [14] [15] [16]. For each nation, there are different factors that define their architectural needs as subsets. For example, the architectural subsets can be in terms educational and research facts, agricultural developments data, natural resource information, so on. In order to maintain such high amounts of data, normal information technology architecture may not support as there are several different information repositories and stakeholders who access the data on a daily basis. To achieve high stability and security in data sharing there should be a rigid de facto architecture which should address all the needs at the enterprise level (i.e., Enterprise level reflects cross-border data and information sharing capabilities).

Enterprise architecture may involve very large and complex business frameworks, which need proper planning and integration methodologies [17]. A framework like TOGAF can work in defining architectural subsets and the relationships between different entities of those subsets. TOGAF is flexible and adaptable when used with respect to the pre-existing architectures [18]. For any enterprise architecture to become a complete architecture, it should address different architectural domains like business, data, application and technology [13]. Again at each level there are different processes and stake holders who work on the data. Understanding the terminology and key concepts of processes is also a major concern while defining EA for different nations since every nation has their own native language.

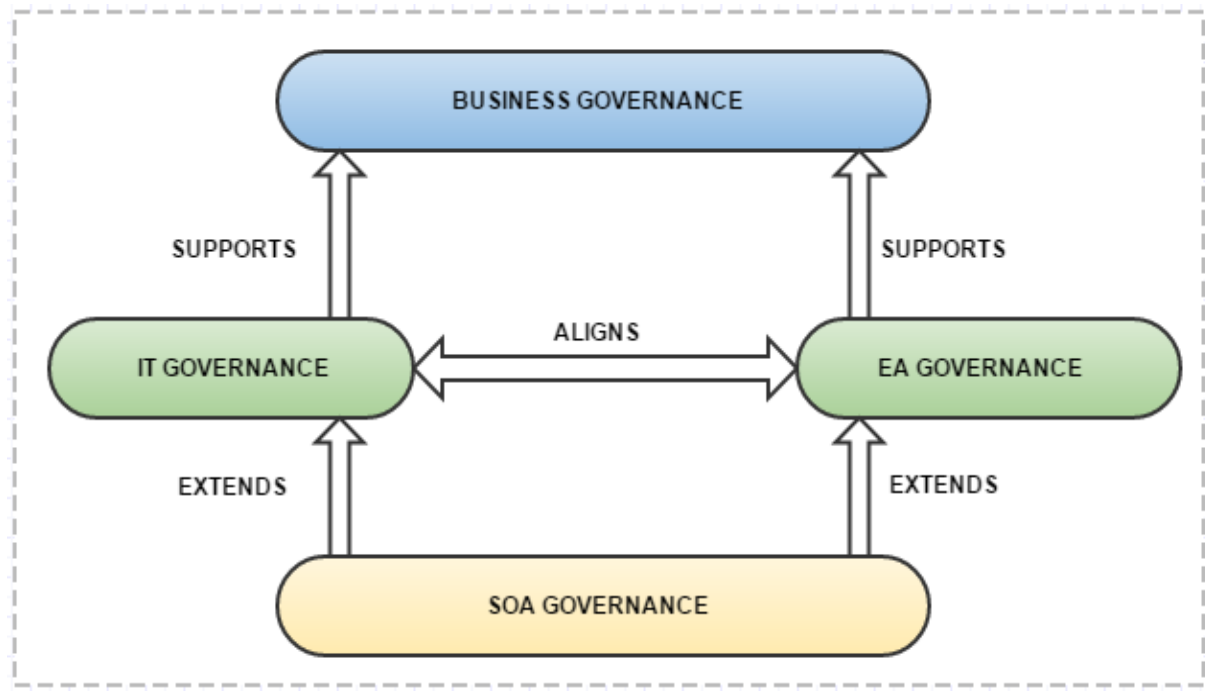
Figure below shows the TOGAF way of representing different relationships between different artifacts and business processes.



**Figure 2:** Relationships between deliverables, artifacts and building blocks [13]

With the help of architecture repository, architecture deliverables can be maintained for the target architecture which is under development. At the same time, architecture repository possess reusable building blocks by which, any changes in the current developing architecture can be noted and can be later used for any other modifications. Therefore, a standard framework like TOGAF helps in providing architectural repository building blocks which help in any enterprise architecture development where each architectural building block can be re-usable. One important feature of TOGAF is that it follows Service Oriented Architecture governance [59] framework in which every service is self-contained and can support other self-contained services. Therefore, an enterprise architecture based on TOGAF is business driven with vendor neutrality. At the same time, the architecture also possesses all SOA enterprise characteristics like information hiding, service contract agreement, service design capabilities, so on. In figure 3, the service oriented governance principles are extended in attaining both IT and EA governance both of which in turn supports for a stable business governance. Meaning, with the

help of SOA governing principles of TOGAF, service orientation is attained from both technology as well as enterprise level point of view, for a newly developed enterprise architecture. As a result, a stable business governance is possible for the proposed enterprise architecture. Through SOA governance framework, it is easy to replace an existing service with a new service which has more advanced features than the later in case of architectural improvements.



**Figure 3:** Open Group SOA governance framework [19]

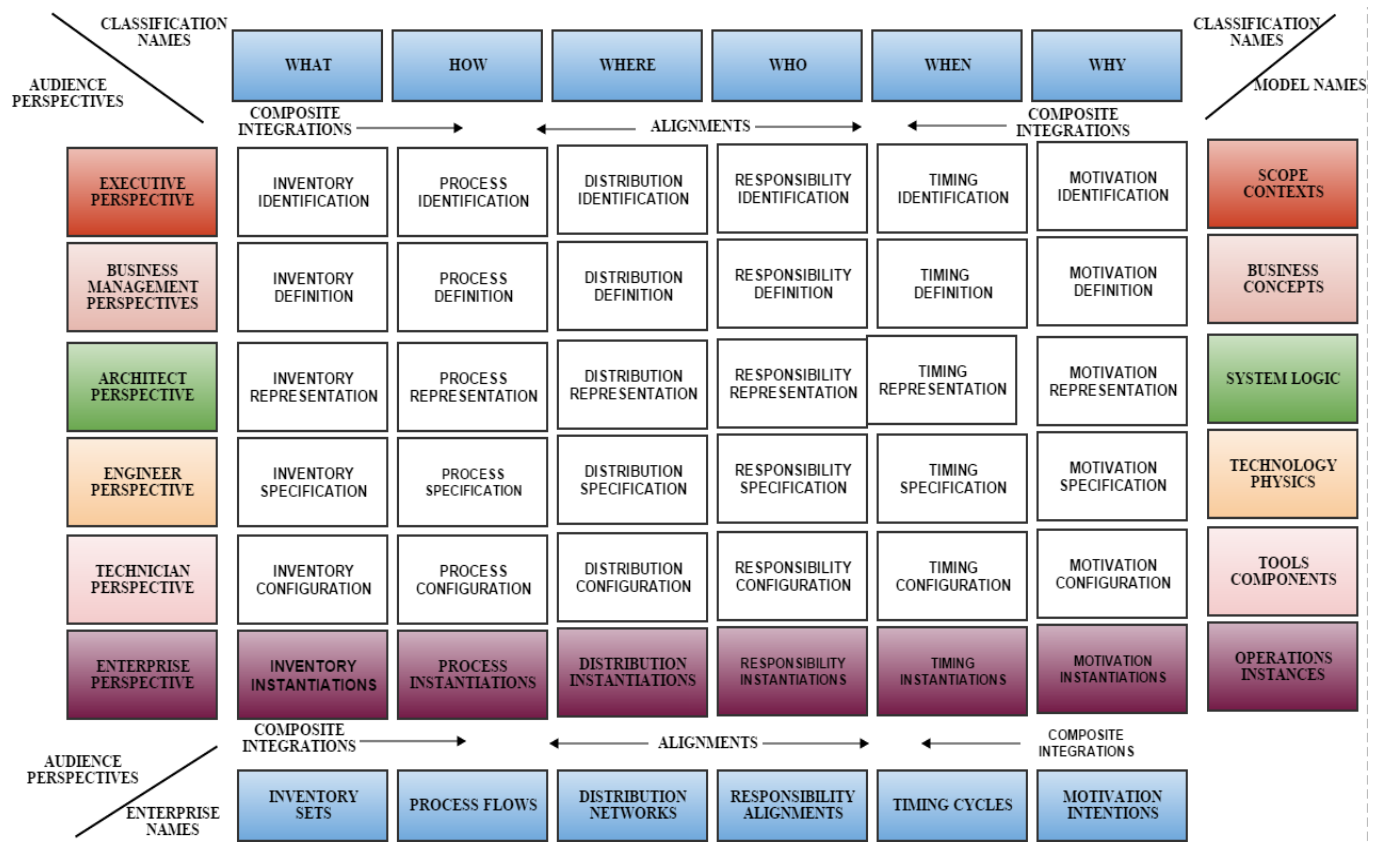
## 2.2 TOGAF Versus Other frameworks

There are different frameworks which support in building EA's. Among the different frameworks the four majorly used and leading frameworks for building EA's are Zachman EA framework, Gartner EA framework, Federal EA framework and TOGAF [20]. It is difficult to compare or contrast other frameworks, since each framework has been developed for a different purpose to produce a different outcome with different business processes, stakeholders, customers, suppliers and deliverables [21]. One good reason of comparison depends on the type of Enterprise Architecture that is planned for or it can be the type of result or outcomes expected

from the Enterprise Architecture. As the concerned topic of the thesis deals with building an enterprise architecture for developing nations, based on some key factors one can adopt TOGAF in comparison to the other leading enterprise architectures. The key factors of comparison in case of thesis work are Identification, Selection, Modeling complexity, Governance, Implementation, Validity and Enhancement Capabilities [10][21][22]. The purpose of comparison is to check how good TOGAF fits in building an EA for developing nations and comparison factors can change when the actual EA is implemented in reality. At first based on the key factors we compare TOGAF with Zachman framework then TOGAF with Gartner framework and at last TOGAF comparison is done with Federal EA framework.

### **2.2.1 TOGAF versus Zachman Enterprise Architecture Framework**

To begin with, Zachman framework is a 6x6 matrix where rows of the matrix represents stakeholders view of an enterprise and columns represent the different areas of their work [23]. Zachman framework provides a set of essential components that are necessary from an Enterprise Architecture point of view and does not give any implementation details. In other words, Zachman framework is in no way related to process implementation but rather provides a structure which can be used in building enterprise architecture [23]. In terms of key factors of comparison Zachman frameworks provides an Identification and to some extent selection of essential components that are needed to build an enterprise architecture without providing much details of modeling complexity, governance, implementation, validity and enhancement capabilities. Zachman framework provides a meta-model and describes more about set or architectures rather than consider single system architecture [24]. The framework doesn't speak much about processes which form a part of any enterprise architecture and also lacks in communication plans, operating locations, networking protocols and other technological details [24]. Also, Zachman framework recommends that all cells of 6x6 matrix should be covered without leaving any while building enterprise architecture [25].



**Figure 4: Zachman Framework [23]**

In figure 23, Zachman framework explains organization of architectural artifacts in a what, how, where, who, when and why manner based on three perspectives of audience, model and enterprise names. Based on model names what types of artifacts different kind of audiences should maintain following set of enterprise goals related to inventory rules, process understandings, distribution networks, role responsibilities, location timing and different motivational events. For example, at a given point of time, a business management executive on an enterprise level should maintain conceptual related business artifacts following inventory rules or process flow documents or location based events or any other distribution networks which describe a what or how or when events. Therefore, Zachman framework gives a clear idea of organizing of various artifacts without going in their inner details and also not describing about process understanding.

On the other hand, TOGAF has pre-defined set of guidelines at every stage of building enterprise architecture. In contrast to Zachman framework, TOGAF defines different architectural subsets (i.e., business, data, application and technology) that define enterprise architecture. Therefore, when enterprise architecture has different single system architectures or sub-architectures still it becomes easy to handle the information details of each and every under lied architectures. The iterative and recursive cycles of different processes of TOGAF helps in understanding the ‘as-is’ and ‘to-be’ features of any enterprise architecture. Based on key factors, TOGAF has clear pre-defined guidelines starting from identification, selection to validity and enhancement capabilities. Service Oriented Architecture governance feature of TOGAF provides more flexibility in adopting new architectural services during enhancement phases of enterprise architecture building.

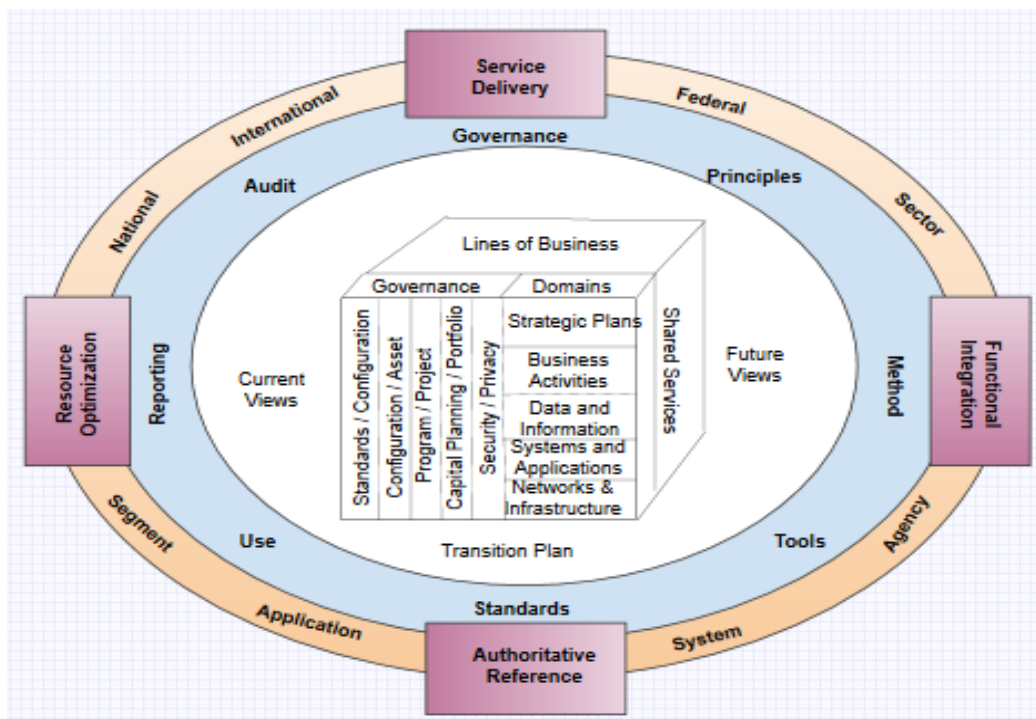
### **2.2.2 TOGAF versus Gartner Enterprise Architecture Framework**

Gartner framework is a practice based enterprise architecture framework [55]. A practice based framework never depends or derives any taxonomy nor a process or a methodology [55]. Gartner based architectures follow the best practices that are being followed at that present time when an architecture is under construction. Therefore, Gartner based architectural systems are followed based on practices rather than any assumptions based on taxonomy or process or methodology. For example, if an architecture for an educational system has to be proposed then according to Gartner framework, one has to consult the best architects who have worked in building educational based enterprise systems. Gartner framework gives more realistic and accurate architecture building information or data as the framework follows pre-existing best practices. On the other hand, TOGAF based architectural systems follow process based methods where each and every process of the enterprise architecture is studied in detail. The topic of thesis deals with an enterprise and standard IT architecture for developing countries and hence, there may involve several different processes from different regions. Therefore, TOGAF architectural framework best suits in studying, analyzing and building the different architectural domains involved during the architecture development phase. Also, there is no such practice system or architecture that exists which has been developed between different developing countries so as to follow as a standard example for the architecture implementation. Neither any practice based systems exist in the current times which can be followed as a model example in constructing a

cross-border based enterprise architecture. Therefore, TOGAF best suits over Gartner framework in building an enterprise architecture between different developing nations.

### 2.2.3 TOGAF versus Federal Enterprise Architecture Framework

The Federal enterprise architecture framework (FEAF) has been developed and published by United States Federal Chief Information Officers (CIO) Council [27]. Federal enterprise framework was built to address different business practices and designs providing enduring standards for developing and documenting architectural descriptions of high-priorities [27]. FEAF has been developed considering the different departments of federal agencies and also the framework is in its preliminary stages of testing its different process segments. The different process architectures are driven by both business and design drivers which are controlled by set



**Figure 5:** Federal Enterprise Architecture Framework [28]

of standards and transitional processes. Though the framework closely matches to TOGAF the framework has not been tested to its potential as it was considered using the federal agencies processes. FEAF has standards that define for identification, selection, modeling, governance, validation and enhancement capabilities [28]. The implementation details depend on the type of

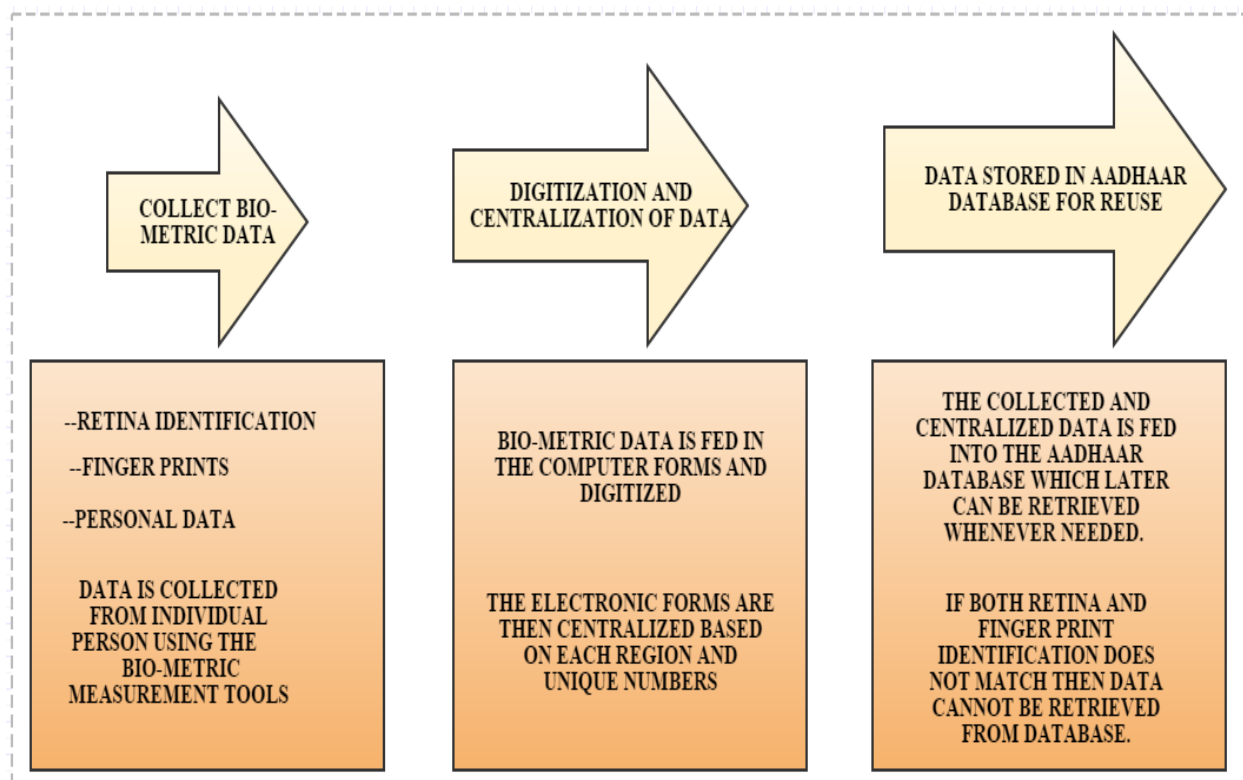
enterprise architecture that is chosen and how many process subsets are involved in that particular architecture. From figure 28, federal enterprise architecture framework can be described as a framework which works for four major expected outcomes of service delivery, functional integration, authoritative reference and resource optimization based on levels of scope of the architecture like international, national, federal, sector, agency, system, segment and application. To describe in short about outcomes and levels of scope, service delivery outcome is about optimizing resources with a coherent and consistent performance towards architectural goals with agile planning and process development [28]. The interoperability between different processes, services and their interactions related to data, business, applications and technology are dealt in functional integration part of the FEFA. Functional integration outcomes are those expected outcomes from different stakeholder's points of view. Resource optimization is related to the most beneficial ways of, maximum utilization of available resources, within the architecture and resources that can be added externally to the ongoing functional framework architecture. The aim of FEFA is to achieve maximum outputs by least utilization of available resources. Authoritative references provide the source of blue prints that are needed for referencing the project flow for later purposes. Blue prints can be related to technology that is being used at different levels of the architecture framework or documentation related to the visions, strategic plans, implementation methodologies, processes utilization, service agreements, licensing, network structure and so on. On the other hand, levels of scope of FEFA describe about the different levels of view from an architectural use point of view. International and national levels of scope is about the users or stakeholders from international or national levels who view the architectural benefits from their own point of view. In other words, stakeholder's thoughts about the expected architecture to meet the demands and outcomes from an international or national perspectives. Federal and sectoral levels of scope describe about whether the expected architecture is a unified one or a sub-divisional framework for proper resource utilization and functionality. Similarly, other levels of scope like agency, segment, system and application describe about the architectural arrangements of systems, applications, segmentation and distribution of work. Also, FEFA has different basic elements, which run the architectural goals in terms of decision-making, solution availability and future planning. At the same time, FEFA provides a clear current, future views of the architecture to be built along with a series of transition plans of architectural progress from time to time.

### **3 Case Studies**

The intention of case studies is to explain why there is a need of cross-border IT architecture and to what degree it can affect the betterment of developing nations. In this section, three case studies [57] are dealt where the first case study explains the top-down research approach using a well implemented and currently ongoing architecture in India and how the same architecture if implemented in other developing nations can help in countries economic progress. The second case study explains about the health care management and how IT architecture can bring out a great change in sharing health care related data in different developing countries. Third case study is about education and other areas which can be improved with the help of cross-border architecture in once own countries economic progress.

#### **3.1 Case Study 1: AADHAAR**

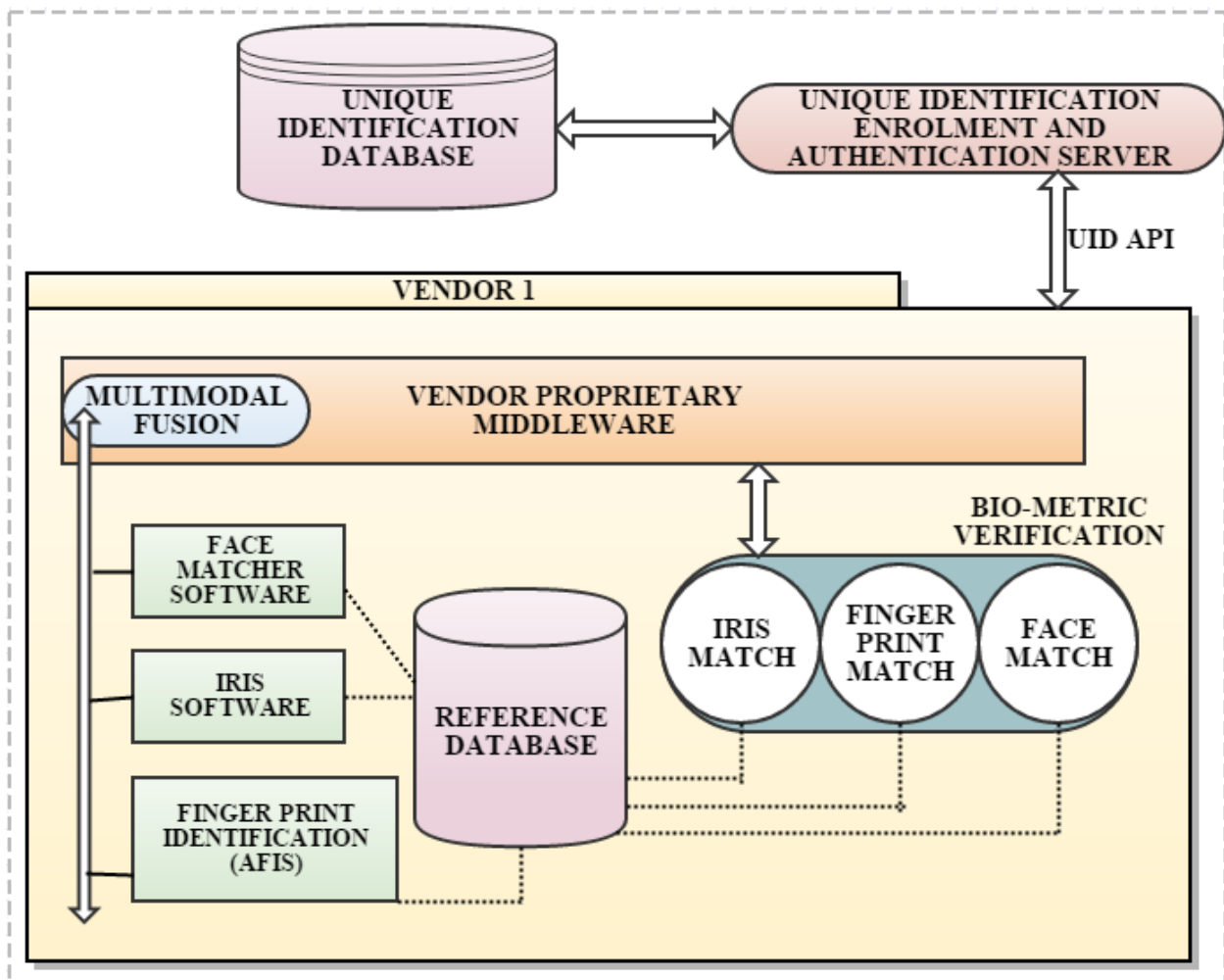
The first case study is about a unique identification card which has been issued by the government of India to its citizens. Aadhaar is the name of the unique identification card which has been developed by Unique Identification Authority of India [29] in the year 2012. Earlier, citizens of India were identified on the basis of family consumer card or using a personal passport. Previous identification methods were creating chaotic situations when dealing with population statistics and in implementing other governmental programs since there was lack of supervision of individual members, on a single family consumer card. Though passport is a unique method of identification still it is not enough to identify individual's financial and social status in a country like India whose population is in billions. Therefore, government of India decided to implement unique identification method to identify its country citizens. The program supervised by government of India is a huge success [31] and also world's biggest biometric database project developed by UIDAI [30].



**Figure 6:** UIDAI Aadhar biometric data collection, centralization and database

From figure 6, at first bio-metric data is collected through methods of retina identification, finger print collections, personal data through population statistics registry or through data identification and measuring tools. After the raw data (i.e., data collected through bio-metric measurement tools) is collected, it is then digitized and centralization of data is done based on each region and assigned unique numbers for every data that has been digitized. The basic idea of aadhaar project is to collect all the biometric information from individual citizen of India, digitize the data in electronic forms and store in the aadhaar database servers. The data can be edited and updated at any point of time only when the biometric identification methods are matched. The information can be used for different governmental programs, individual identification, for maintaining criminal history, so on. Earlier this was not the case in India, identification was based on consumer cards or through address of the person. The centralized form of data usage helps in accessing accurate data of individuals, estimations for statistics, crime monitoring, maintaining health records, allotting social services, so on. In other words, productivity of a country increases using the unique identification of individuals in terms of stopping crime, providing good education and social benefits and for better health services.

Analyzing from the top-down approach, the architecture of aadhaar project is simple and easy to understand. From the figure 7, the unique identification database (UIDB) of aadhaar can store images, demographic data which is obtained from the biometric verification methods like retina scanner, face matcher, fingerprint readers, so on. The biometric devices are referenced to the reference database which is connected to the unique identification authentication server. The authentication and verification of data is done at the authentication server and the data is stored in the UIDB. The connections between verification devices, authentication server, reference database and UIDB are made through open source IT protocols and standards.



**Figure 7:** Aadhaar project internal architecture [26]

In-between the aadhaar services and individual government schemes there is authentication user agency who perform necessary interactions with different stakeholders based on their needs. So,

in aadhaar program, each system has been classified based on its use and is a layered architecture. Aadhaar is a successful project in India and it has new features like face recognition, retina scan in its architecture which is not present in most of the developing countries in unique identification of their citizens. In case there could have been a common architecture between the nations the data about unique identification of citizens could have been reflected in other developing countries. Hence, the other countries get an opportunity to implement such kind of services in their own society. This helps in easy identification of individuals not just in their own regions but also when they travel to other regions. Uniqueness prevails in between those nations who implement the same cross-border information technology architecture. If TOGAF framework is used for the cross-border architecture then most of the problems related to IT standards can be met. As TOGAF itself covers most of the currently used IT standards, then even if other developing countries use other standards still it is easy to adopt the changes in architectures which are followed by their neighboring nations.

### **3.2 Case Study 2: Healthcare Management Systems**

Information technology is gradually improving in developing nations and hence, cost effective e-services are paving their path into communities, giving better opportunities for health institutions to serve people [32]. In parallel, modern health care systems have been improved tremendously when compared to previous health systems. In addition to this, mobile technology has also made good advancements bringing new features into both ICT and health sectors. But on the other hand, no significant improvements were observed in data sharing and accessing from architectural point of view. In health care systems data sharing plays a critical and also vital role. For example, a patient or a customer or any health care institution need key health information or medical reports on a timely basis for diagnosis. If that same information is not obtained and if there are frequent delays in submission of reports for diagnosis then a chaotic situation arises in any health institution. Moreover, in developing countries like India, Pakistan, Bangladesh, Vietnam, Indonesia and so on, majority of people under poverty line rely on government and public health institutions which are mostly decentralized with several unassociated and dispersed medical staff [33][34]. On the other hand, private health institutions maintain their own

proprietary health databases giving restricted access to medical records. Therefore, data access and sharing is in a volatile situation in most of the developing countries.

**Table 2:** Health Care Systems Information in different Developing Countries [34][35][36]

Country	GDP (\$)	Allotted Health Care GDP (\$)	Centralized / Decentralized	Life Expectancy
India	2.06 Trillion	1.3%	Decentralized	66 years
Pakistan	246.9 Billion	1.0 %	Decentralized	67 years
Vietnam	186.2 Billion	6.0%	Partly decentralized	76 years
Bangladesh	173.8 Billion	3.7%	Decentralized	71 years
Indonesia	888.5 Billion	3.1 %	Partly decentralized	71 years
East and Pacific Asia	12.57 Trillion	3.0 % (approx.)	Mostly decentralized	74 years

From the above table, one can infer that majority of the health systems in developing nations are decentralized with less percentage of GDP being allotted from their country's total GDP.

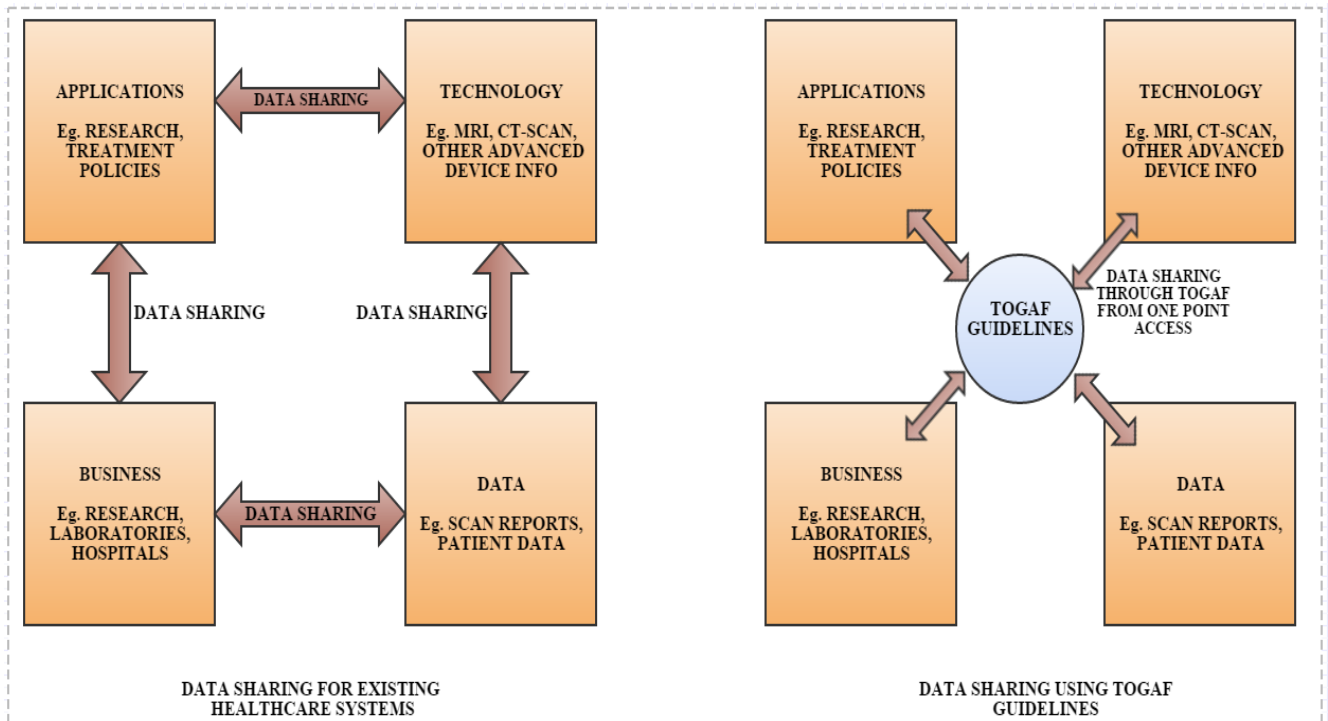
**Table 3:** Health Care Systems Information in different Developed Countries [35][37]

Country	GDP (\$)	Allotted Health Care GDP (\$)	Centralized / Decentralized	Life Expectancy
America	17.42 Trillion	8.1%	Centralized	79 years
Finland	270.7 Billion	7.1 %	Decentralized	81 years
Germany	3.85 Trillion	8.7 %	Decentralized	81 years

In comparison with the developing countries from table 2, developed countries have higher life expectancy and this account mostly to the fast data sharing of information among different health institutions from table 3. Though some of the developed countries have decentralized governance in health care still data sharing is comparable high with respect to developing nations. Current situation of health care for different developing countries does not favor for building common cross-border architecture but improvements in the existing systems can bring favorable results. Improvements like adding previous legacy health systems into their new health databases, unifying health records from location perspective, educating people how to use health records, so on. With the concept of developing cross border architecture among different developing countries, several solutions can be brought to the current existing issues. Firstly, existing health databases and systems are reorganized and integrated. This helps in accessing country's different health systems but also consumes less time to access data from different locations at a given point of time. Secondly, unique changes can brought in data accessing or retrieval involving less costs and time. Any health system can be easily maintained and any new changes or updates can be made with ease by spending less money and brining good accuracy to the health information. Thirdly, government and public health sectors, health care systems can be made available for general people with effective medical facilities. When health systems are integrated, it is easy to get information for any kind of treatment avoiding chaotic situations which exist in previous legacy and age old systems.

TOGAF framework has predefined set of paradigms which cover basic architecture domains of business, data, application and technology. In modern health care, technology plays a key role among different applications of healthcare data concerning to different business segments. For example, healthcare statistical information (i.e., data) captured by different technical equipment's (i.e., involving technology) can be used for treatments, studies, further research (i.e., applications) in different departments of any health institution or research laboratory (i.e., business segments). TOGAF principles can be implemented right from grass root level in any healthcare management systems architecture. Generally, healthcare management systems are massive enterprise level systems holding key health information. Therefore, instead of opting for loosely coupled architecture framework principles it is always advisable to choose more robust and flexible architectural frameworks like TOGAF, right from basic level.

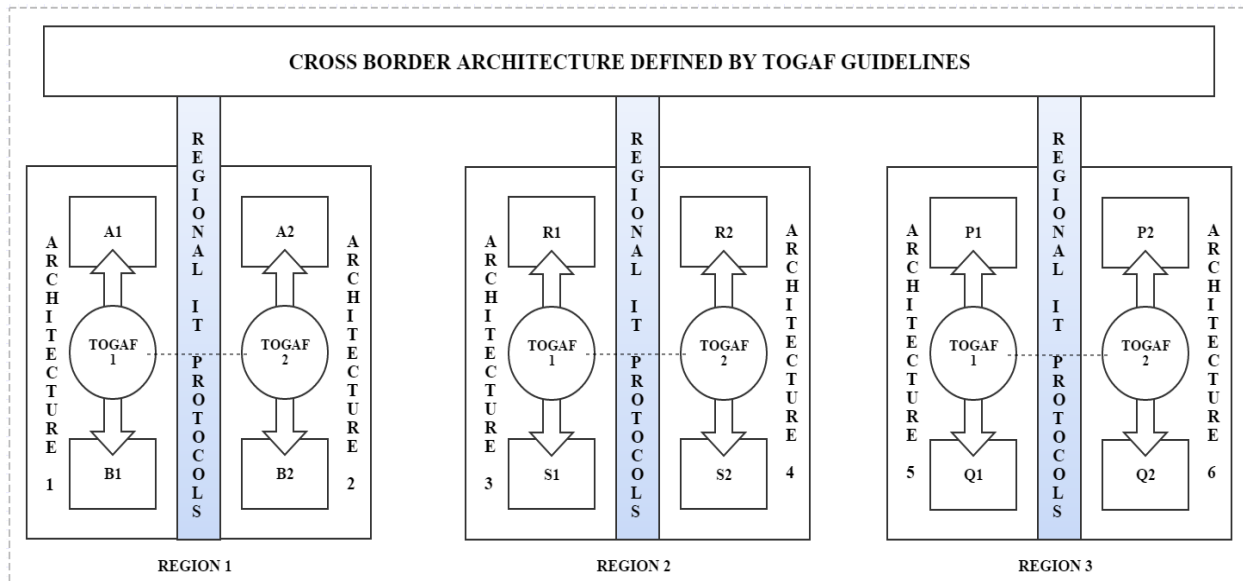
In most of the developing nations, current healthcare systems are organized as shown in the following figure 8. Though Interoperability exists, complexity is more, in exchange of information, involving more time. On the other hand, by using TOGAF guidelines, complexity can be reduced, information access can be improved with less time. Maintenance and enhancement work can be done with ease.



**Figure 8:** Data Sharing in Health Care Systems

In previous existing systems data sharing is being done through two systems at a time and another existing system may not need that information for its operations. For example, if application data need to be accessed from a data system then the information flow happens through either business system or through technology system in which neither the technology system nor business system need that information for its operations at that time. So, there is duplication of data being done in the information flow of previous existing systems. But on the other hand, using TOGAF guidelines, define the guidelines in one particular system and access that information through several different existing systems or from new systems. Therefore, there is no data duplication and information sharing also involves less time.

If each healthcare system is organized and maintained using the TOGAF guidelines then it is not difficult to maintain the organized systems on enterprise level or on a cross-border architecture level. In other words, if every system follows TOGAF guidelines it is easy to structure and organize from a cross-border system architecture point of view.



**Figure 9:** Integrating different regional healthcare systems using a common IT Architecture

In the figure 9, with the help of a common IT architecture, health care systems from different regions can be accessed and data can be retrieved in less time. A healthcare system architecture one of region 1 can easily access a healthcare system architecture two within the same region. Similarly, other architectures within their own regions 2, 3 can be accessed easily respectively. With the help of a cross border architecture defined on TOGAF guidelines, region 1 healthcare systems can be accessed by healthcare systems of region 2 and 3 which was not the case with the existing legacy or age old systems. Each region is defined by their own regional protocol so that security measures can be implemented for no easy intrusion, to access healthcare data. This type of data sharing among different healthcare systems makes work easy and gives an opportunity for providing better treatments and medical services for different developing countries.

From a top down approach, a common IT architecture for different developing countries is a data repository of healthcare data by providing data abstraction for lower level users. Each system is well defined with necessary administration and security protocols for easy data sharing and retrieval methods. Each and every system can access healthcare data of different regions without

any complexity. Also, healthcare systems at different regions are organized and defined so that maintenance and upgrades can be done with ease. On the other hand, from a bottom up approach, a lower level system of each region can access same data of other region as lower level system of that region from a cross border point of view. In other words, data templates are common for users of both region one and two. On providing user authentication details, the data like healthcare case studies, treatment policies, rules and regulations can be accessed without any problem. Each lower level system is completely abstracted with the implementation policies of the other system or other higher level systems. Each system maintains its own unique data and can share or obtain that same data to other higher level systems on providing authentication details. Each region is defined by its own region protocols so that no language barriers can stop from accessing their own or other regions data.

### 3.3 Case Study 3: Educational Systems

Education plays an important role and is like a backbone in any country’s development path. Education is a fundamental right for any citizen of a country and it enrich individual’s creativity and productivity. In developing countries, education helps in awareness and to improve countries socio-economic welfare services. Though education exists in developing countries, unbalanced standards in terms of costs, services and opportunities are hindrances to their success path. People belonging to below poverty line are unable to attain higher education because of cost barriers, poor awareness, unavailability of educational services, so on. Following are some of UNESCO educational statistics of developing countries. In the table 4, only two parameters are considered from different developing countries of Asia but also, there are other several parameters which are hindrances in their development.

**Table 4:** UNESCO statistics of some Developing Countries [38]

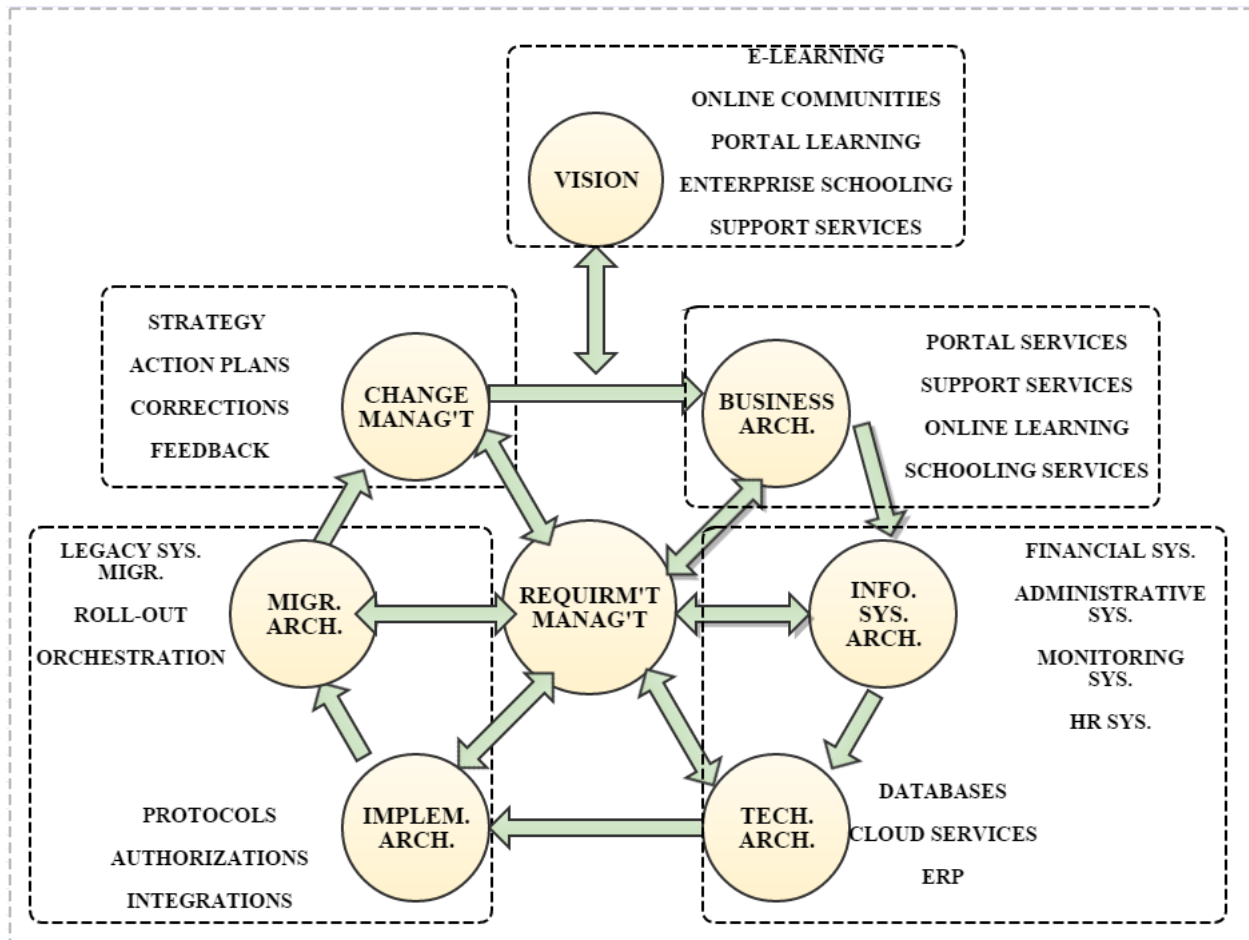
Country	Out of School in Primary age (M/F) (Age 14-25)	Youth Illiteracy (M/F) (Age 14.-24)
India	1723585 (year 2013)	24277115 (Year 2015)
Bangladesh	1335753 (year 2013)	5304568 (Year 2015)
Iran	Appr.3468 (year 2013)	209054 (Year 2015)
Indonesia	Appr.621163 (year 2010)	441045 (Year 2015)

Currently, every country is looking forward to provide digital world services and role of information technology education is key in achieving such a goal. Sharing of ideas, information and other educational services are being done through computers. Therefore, data sharing among different countries plays a vital role from educational and research perspectives. Information and educational services can be brought to the general public at very low costs and with better facilities. In most of the developing countries, there are no shared IT architectural frameworks which are being used for educational purposes. Each educational or research institutions maintain their own databases for information access. Also, each region has their own language barriers within a country and hence, learning tools are very difficult to maintain.

A good example of how IT frameworks in developing and developed countries work for educational purposes is highlighted here. In developed countries, if students unable to find a particular book or a research article in a university library, then they can order that book from different city libraries using their university portal. Even if that book is not available in other city libraries a request for those books or research articles can be made from the same university portal for a low price. Whereas, in developing countries, there is no such facility where one can access a service of ordering books or research articles from a unique portal. Students have no option but search a book or buy online. This is one among those examples where IT services are not being used to a potential level to bring better services for the general public. Educational databases are not being used for the right purposes to bring right results. Therefore, there is a need for a common IT architecture framework on which learning tools can be evenly distributed not just for one region but across different regions and countries. A common learning platform not only helps in career growth but also helps in creative thinking (i.e., thinking beyond classroom knowledge) and provides interactive environment among students, teachers, parents, authors, academicians, so on.

TOGAF has predefined paradigms which have been developed from the educational point of view. In parallel, TOGAF supports SOA principles [39] by which any learning module or service can be revised, updated, replaced without any difficulty. The Advantage of using TOGAF framework over other architectural frameworks is that each and every segment for building enterprise architecture can be clearly stated based on its requirements and vision document. For example, a vision document for a particular architecture motivates for providing e-learning,

portal, online community learning along with support and enterprise schooling services. Therefore, requirement analysis for the vision document can be structured based on TOGAF principles as shown in the following figure. Hence, each service and its objectives are clearly defined and any updates can be made with ease.

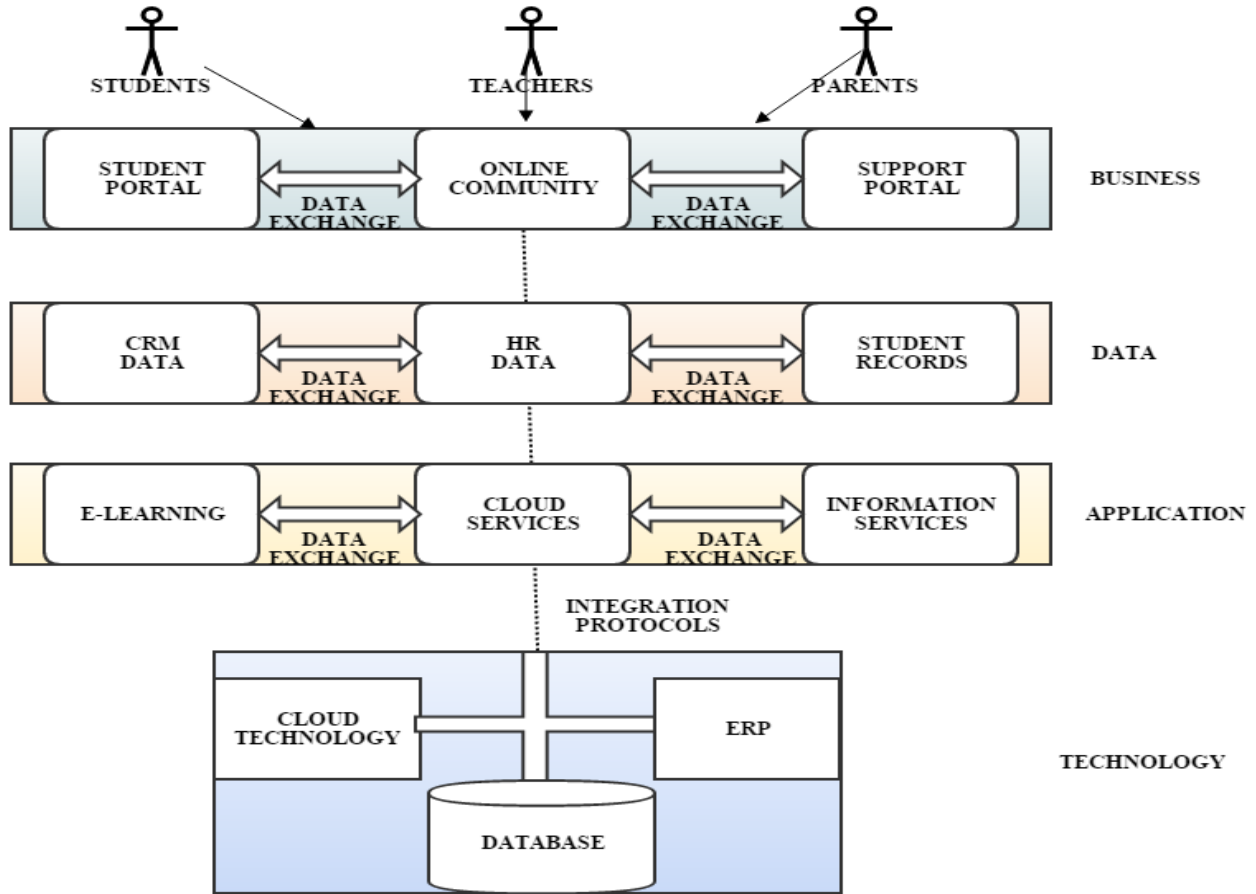


**Figure 10:** Using TOGAF guidelines for Educational Systems

Figure 10 gives an example of how TOGAF can be used in defining educational systems. A simple online educational architecture system can provide basic online services like portal learning, enterprise schooling, support and online communities' services which form the vision of that particular educational architecture. Business scenarios which include portal and support services, online learning and schooling services are included in the business architecture and therefore, information systems needed for basic functions for the target architecture are defined, along with the technology architecture which form the base for a proper functioning of the entire projected architecture. Following the TOGAF guidelines and modifying the basic TOGAF

features based on stake holders requirements, implementation and migration architecture is defined which include type of authorizations that are to be defined, integration of different systems using different types of protocols, age old file systems that are to be migrated, so on, are defined before the target architecture development is started. Finally, change management phase which include, corrections, feedback, action plans and strategies for the possible change management scenarios, so on are also defined in order to achieve a proper functional target architecture.

As the main topic deals with IT architecture between different developing countries, several different low-level learning databases and information systems should be defined and integrated into the main cross-border enterprise architecture. As discussed in the previous case study, as how health care systems can provide efficient services when organized and integrated with the main cross-border architecture, similarly, it is an important task to define lower level learning systems first, to provide better services for students and educational institutions. Simple lower level educational enterprise architecture is depicted below based on the TOGAF guidelines from previous figure 10. Figure 11 is nothing but a real-time expected target architecture which is defined on TOGAF guidelines from figure 10. Technology architecture form the base which is headed by the application layer. Therefore, different technologies and systems which can adapt to that particular technology are defined in technology and application layers respectively. Data layer defines what type of data the target educational architecture can hold and how this stored data can be used for other business scenarios which are defined above the data layer. For example, in an educational architecture, data about student records, human resources data, customer-relationship management data for different business stake holders are key and therefore included in the data layer of the architecture. On top of all, business layer provides all those business related activities, different stake holders would expect from the developed educational architecture. In order to maintain consistent data flow across systems from different boundaries, all lower level enterprise educational systems should be organized and integrated. This helps in data redundancy and speed retrievals of information within and across enterprise systems.



**Figure 11:** A simple enterprise educational architecture using TOGAF

#### 4 Building Information Technology Architecture For Developing Nations

Time, money, effort and standards are different factors which are involved in any architectural development. The key factor in developing information technology architecture for different developing nations are meeting different standards of different regions and their implementation on enterprise level. The term ‘standards’ is used as a simple term in this present context but in real time usage standard has a big role to play, since, every segment of any architecture works, based on a set of authoritative rules. TOGAF defines standards [40] for architectural development, process standards, technical standards, reference standards, product standards, so on. At the same time, different standards of architecture have to meet a certain level of maturity at different stages of architecture development. In reference, TOGAF also defines maturity levels [42] for each standard that has to be met at different development stages. TOGAF supports

different deliverables [41] which act as a backbone of reference and provide a road map in architectural development.

Architecture for different developing countries involves several different scenarios for which a clear road map should be defined. A road map that defines architecture vision, attributes involved, architectural transitions, external inputs, processed involved, stakeholders identification, dependencies, implementation and migration strategies, estimated outputs, time involvement, so on. Based on the architectural requirements for cross-borders and on TOGAF guidelines, a road map can be visualized in a simplistic style. In order to achieve the goals of target architecture (i.e., Cross-border architecture), a clear documentation of the entire work that is need to be done, based on a phase wise analysis, has to be maintained. Though TOGAF, clearly defines useful paradigms for construction of an enterprise architecture, still architectural arrangements and modifications are to be analyzed based on the user and implementation needs.

The intention of the thesis work is to address the benefits that an architecture can bring for a country's economy along with answering the changes of when, what and how the changes can be made. The thesis contributes and highlights the points of organizing the age-old file systems from different business segments and organize them based on TOGAF guidelines and according to the industry needs (i.e., users, business changes, so on). TOGAF paradigms are necessary for any enterprise architecture development explaining the principles and goals of achieving a target architecture. But the framework doesn't explain the transitions from start to end in each phase describing the current state and how a final workable state is achieved. This segment of information has been added as an additional improvement to achieve more clarity in enterprise architecture development in the current thesis work. Following are the different phases in the development of cross-border architecture.

#### **4.1 Explanation of Preliminary Phase**

Building information technology architecture for different developing countries start with a preliminary phase in which a set of activities are involved to achieve estimated outcomes. The preliminary phase can be broadly explained as follows:

*Motivation:*

The ambiguity that exists in data sharing and retrieval, unbalanced legacy and out dated systems, issues concerning to security, socio-economic developmental factors, overcoming language barriers, a unique platform for learning, understanding different region welfare services and accepting as role model prototypes, know-how of different regions and countries, better understanding of cross country features, so on, are some of the motivational factors for developing a common IT architecture between different developing countries.

*Key drivers:*

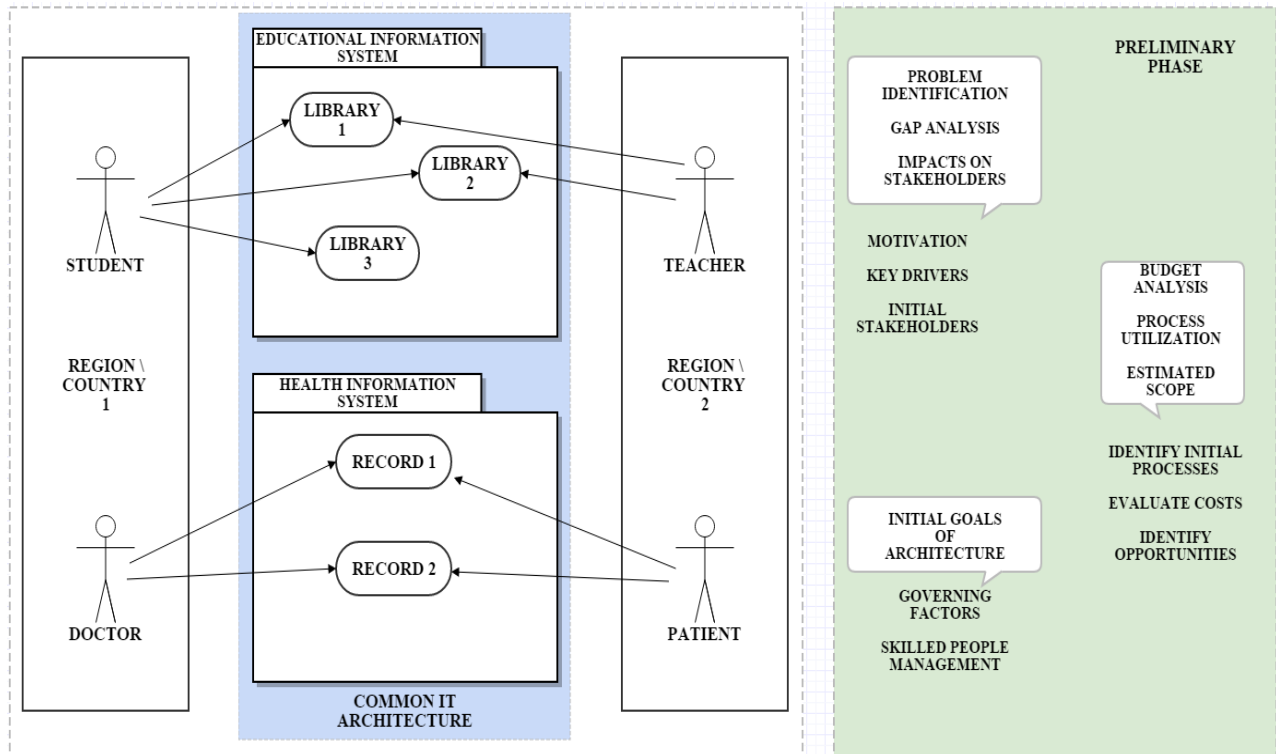
Outdated and unorganized legacy systems, no information consistency in different organizational, healthcare and educational systems, improper data sharing, data redundancy and inconsistency are some of the identified gaps in present IT architectures of developing nations. Therefore, in order to achieve, flexibility in both business and information technology, integration and organization of different legacy and new information systems and to overcome complexity in data sharing and retrieval are the key drivers for developing a complex enterprise architecture between different nations.

*Initial Stakeholders:*

Stakeholders are the ones who use the architecture for real time business scenarios. Stakeholders can be governmental and organizational institutions, healthcare institutions, software firms, educational and research institutions, non-governmental organizations, security firms. Stakeholder's requirements and priorities change from time to time and therefore, architecture should be built robust to meeting the changing demands of users.

*Other factors:*

Other factors like initial cost evaluation, reference repositories, governing factors for both business processes and IT governance (i.e., robust, flexible, service independent), opportunities for further extending the enterprise architecture also form the base of preliminary phase in the architecture development for different nations.



**Figure 12:** Stakeholder identification and Preliminary phase activities along with outcomes

*Expected outcomes of preliminary phase:*

The expected outcome in the initial or preliminary phase are understanding the problem and analyzing the existing gap, so that to which maturity level cross-border architecture should be built to meet user or stakeholder priorities. At the same time, identification of initial goals of the target architecture is achieved for which an estimated budget can be allocated for his development. At the beginning, to make the architecture to work from basic level which type of processes should be used and the processes impact on architecture roughly estimated.

Figure 12 is one of the example of use case diagrams to show the interaction of different users of cross-border architecture from two different regions. From region 1, users like students and doctors can use the information repositories of cross-border architecture simultaneously with users of region 2 who include teachers and patients. Each repository is an information source for their individual needs. Also, the preliminary phase deliverables and outcomes can be seen in one single picture and can figure out that this piece of work in the architecture belongs to this particular deliverable and should result in an expected outcome w.r.t that particular deliverable.

**Table 5:** Preliminary and Vision Phase of IT architecture for developing nations with basic activities and outcomes

Sl.No.	Phase / Activities Involved	Expected Outcomes
1.	<p><i>Preliminary</i></p> <ul style="list-style-type: none"> <li>- Define motivation, key drivers</li> <li>- Identify initial architectural inputs</li> <li>- Identify initial Stakeholders</li> <li>- Identify Common Interests of stakeholders</li> <li>- Initial Costs evaluation</li> <li>- Identifying initial processes of use</li> <li>- Select Reference repositories</li> <li>- Identify principle governing factors</li> <li>- Arranging skilled people for Management</li> <li>- Identify future opportunities and sponsors</li> </ul>	<ul style="list-style-type: none"> <li>- Identity problem</li> <li>- Overcome gap</li> <li>- Architecture impacts on stakeholders</li> <li>- Initial goals of architecture</li> <li>- Budget analysis</li> <li>- Process utilization</li> <li>- Defining estimated scope</li> </ul>
2.	<p><i>Vision</i></p> <ul style="list-style-type: none"> <li>- Define purpose of architecture</li> <li>- Defining Project plan</li> <li>- Clarifying business goals</li> <li>- Identify and apply business and governing principles</li> <li>- Risk analysis and management</li> <li>- Evaluating metrics</li> <li>- Clarifying architectural and business principles</li> <li>- Setting up Key Process Indicators (KPI)</li> <li>- Maintain baseline language for understanding</li> <li>- Highlight stakeholder conflicts and concerns</li> </ul>	<ul style="list-style-type: none"> <li>- Risk Identification</li> <li>- Defined KPI's</li> <li>- Uniform metrics use</li> <li>- Baseline principles, goals identified</li> <li>- Clear project plan for future opportunities</li> <li>- Stakeholders requirements identification</li> <li>- Defined state of work objectives</li> </ul>

## **4.2 Explanation of Vision Phase:**

The vision phase is associated with set of activities along with outcomes for development of cross border architecture between developing nations. This phase is the first phase from where the architecture development begins with basic requirements.

### *Purpose and Project plan for architecture*

The purpose of the architecture is to attain a uniform information sharing platform among different developing nations so that the architecture helps in achieving respective countries developmental goals quickly. With a purpose in hand, a project plan is needed which guides as a reference throughout the development process of cross-border architecture. The project plan should include time deadlines, roles and responsibilities of skilled people at different levels of architecture development process, key process indicators for each development stage, goals of the project, initial risk identification and management should be defined, so on, has to be mentioned and should help as a first reference document for the entire project.

### *Clarifying business goals and governing principles*

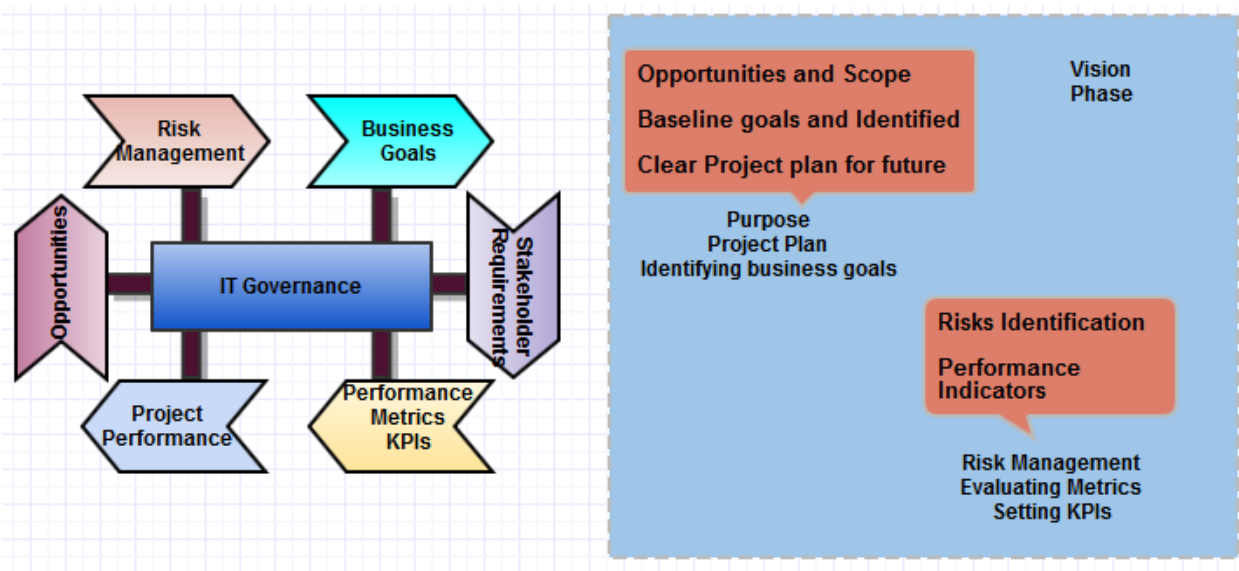
As the architecture involves different nations, goals of each region may differ from goals of another. In parallel, project goals can involve both architectural goals and business goals. Therefore, clarifying business goals from architectural goals is important while defining the project plan. Cross-border architecture is used by different stakeholders with different set of business goals from different regions. While architectural goals are associated with the developmental processes of IT architecture, business goals are associated with stakeholder requirements and needs. Therefore, business goals differ from time to time whereas architectural goals differ with process improvements [43]. Good governing principles are also necessary to define a robust enterprise architecture for developing countries. Governing principles may include plans of how different systems technology is being used to fulfill the business goals [44]. The underlying principles on which different business segments run to perform a service or task.

*Setting Key Process Indicators (KPIs) for different phases of architecture development*

Key process indicators help in tracking the progress of the architecture development at different stages. Unique metrics are used throughout the architecture development to analyze the progress and observe the involved risks. KPIs in the architecture development can be related to time, quality of processes, costs, goals of the project, so on. In other words, KPIs are like performance indicators of project progress.

*Risk Management*

Architecture development for cross-borders may involve different types of risks related to costs, process identification, governing principles, stakeholder's contractual risks, technological risks, timing risks, so on. Risks should be classified as repeatable risks which occur repeatedly in each development phase and non-repeatable risks which may occur in less proportions of architecture development process. Similarly, initial risks during the development phases should be identified and should be marked as either critical risks or non-critical risks. Based on the type of risk identified action plan has to be defined to overcome such risks.



**Figure 13:** IT Governance and Vision Phase for developing nation's architecture

*Other factors:*

Other factors like stake holders conflicts [45] should be overviewed from time to time so that stakeholder requirements can be met based on their preferences. Different stakeholders participating on the same cross-border architecture it is important to meet their requirements and changing demands [46]. At the same time, maintaining a baseline language through the architecture is vital and provides significant outcomes of productivity for general public.

*Expected Outcomes of Vision Phase:*

By formalizing the purpose of cross-border architecture, a clear project plan can be defined which acts as a first reference guide for the architecture development. By identifying initial business goals, opportunities and scope of development of architecture can be gauged beforehand. Risk management helps in identification and classification of different types of risks that are associated at different levels of architecture development between different nations. Key process indicators helps in identifying project progress based on project plan on timely basis.

Figure 13 shows the importance of IT governance in cross-border architecture. For the entire vision of the architecture IT governance forms a base through which other units of architecture functionalities are related. Keeping IT governance at base, the deliverables and outcomes of the vision phase can be analyzed and improvements if needed can be made at the beginning stages of the architecture development. For example, in business goals of vision phase, risk management is one of the business functionalities which has to be observed from time to time for the variations of risks involved. Therefore, each phase of the risk management has to be analyzed and updated right from the vision phase and the observed changes are forwarded to other different phases in the architecture development. Hence, each transition of risks involved can be noted and changes are described to keep track of the overall risk management functionality in cross-border architecture. Similarly, other functionalities in the architecture are observed based on the requirements.

### 4.3 Explanation of Business Architecture Phase:

#### *Defining business process models and their reusability*

Identifying business process models before-hand, helps in building robust and stable architectures [47]. For example, for any manufacturing firm there are different business processes like production, quality control, sales, logistics, so on with different set of activities involved. Defining, involved processes and activities, at the cross-border enterprise level helps in understanding and standardizing the business processes of different countries. In addition, any new processes which are to be proposed if defined before-hand as existing reference, helps in analyzing the business scenarios precisely. First hand referencing help in better understanding and collection of business data and understanding the stakeholder's requirements to fit into the architecture.

**Table 6:** Business Architecture, Information systems and Technology Architecture phases involved in developing cross-border architecture for different nations

Sl.No.	Phase / Activities Involved	Expected Outcomes
3.	<p><i>Business Architecture</i></p> <ul style="list-style-type: none"> <li>- Define business process models and activities involved.</li> <li>- Identify process models reusability</li> <li>- Collect business data, reference tools, business scenarios, business gaps, stakeholder business concerns</li> <li>- Define objectives, services and contracts that business architecture should meet.</li> <li>- Define business definition documents and tailor requirements based on those documents</li> </ul>	<ul style="list-style-type: none"> <li>- Processes and their reusability are identified.</li> <li>- Business scenarios and their gaps are identified.</li> <li>- Business gaps are analyzed based on reference models and tools.</li> <li>- Definition documents for business objectives, contracts are defined to help architectural development meeting</li> </ul>

		stakeholder's preferences.
4.	<p><i>Information systems and Technology Architecture</i></p> <ul style="list-style-type: none"> <li>- Define both support and governance methodologies</li> <li>- Select legacy and age old systems</li> <li>- Target, maturity levels for different stages of integration of legacy systems</li> <li>- Define applications, data, standards, tools that are to be used for architecture</li> <li>- Network and reusable building blocks inclusion</li> <li>- Check inter-dependencies with other systems or technology</li> </ul>	<ul style="list-style-type: none"> <li>- SOA principles are used for easy administration of architecture</li> <li>- Legacy and age old systems are organized and updated</li> <li>- Resource traceability is maintained for ease use of difference resources of architecture.</li> </ul>

*Collect business data, business scenarios, business gaps and define objectives, and service contracts*

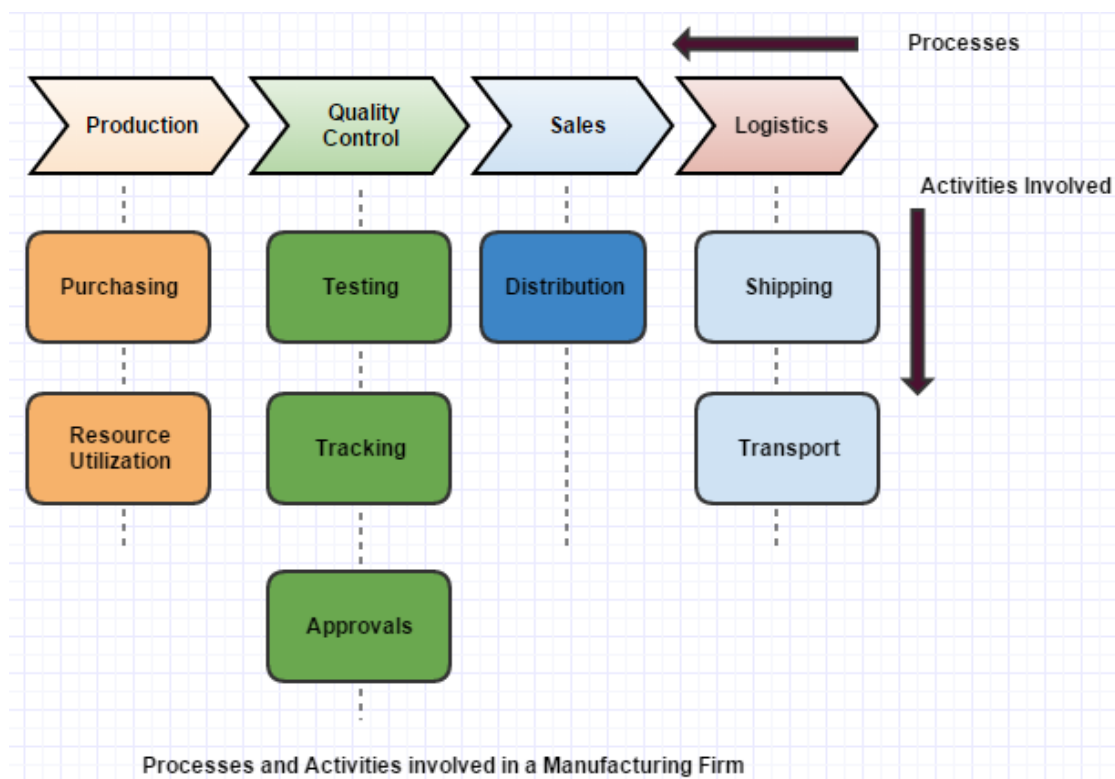
Once business processes are defined, business data and scenarios where data can be utilized have to be gathered. Continuing with the same manufacturing firm example, in production process what type of data should be used and on what scenarios the collected data can be used should be analyzed. Also, if the same data can be reused for other processes and any gap exists in using production data, should also be analyzed before-hand during the development of cross-border enterprise architecture. Having business data and scenarios, objectives of architecture has to be defined. Service contracts are made with different stakeholders, based on the type of objectives cross-border architecture can meet. Objectives can be fast performance, capability of high data storage, multi-tasking with different business processes on different business scenarios, so on.

### *Define Business definition documents*

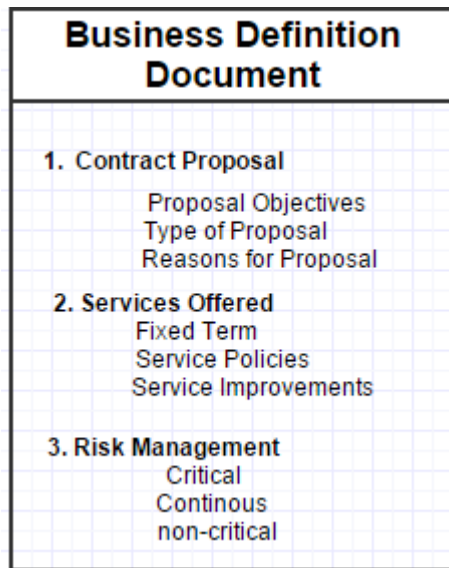
A formal business definition documents are made accepting the service contract requests. Expected target architecture should be built based on the contract requirements and refinements of business scenarios and stakeholders preferences. Business definition documents form initial reference guides for future improvements of architecture.

### *Expected outcomes of Business Architecture*

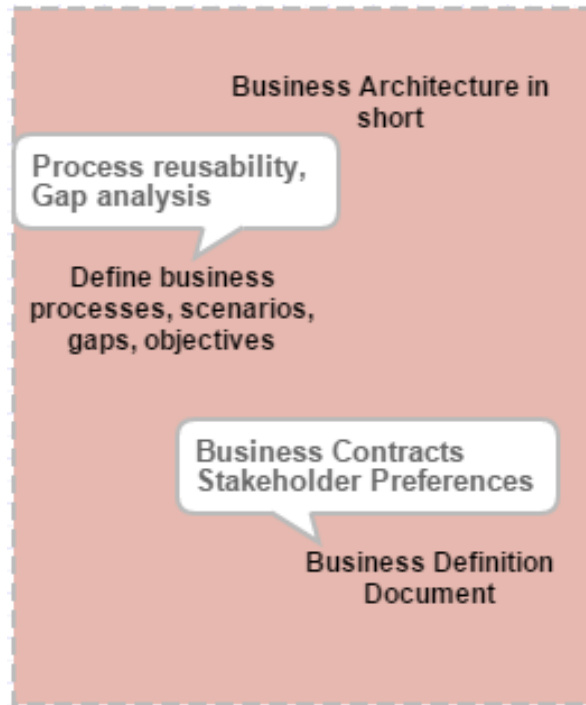
Different activities of business architecture phase help in collection and defining of different business documents, scenarios, process models, business gap analysis, reference modelling tools, so on. As cross-border architecture between different countries involve several different stakeholders, business architecture contents may vary from time to time.



**14(a)**



14(b)



14(c)

**Figure 14 (a), 14(b), 14(c):** Business Architecture for cross-border architecture for different nations in one picture

Figure 14 has three figures 14(a), 14(b), 14(c), which describe about the business architecture of cross-border enterprise architecture in short. Figure 14(c), describes the deliverables and associated outcomes (i.e., text in white ballons in figure 14(c)), whereas, figure 14(a) is one of the outcomes of in a business architecture deliverable representing the process information in a manufacturing firm. On the other hand, figure 14(c) is also an outcome of the business architecture deliverable business definition document depicting the contents of a business definition document. In figure 14(a), processes are shown horizontally and activities involved in a particular process are represented vertically. Therefore, in a production process associated activities are purchasing and resource utilization whereas in logistics process the associated activities are shipping and transport. Hence, in cross-border architecture every single processes along with its sub-processes and activities are observed and each different transitions are maintained. Figure 14(b), is a sample example of representing a business definition document.

#### **4.4 Explanation of Information systems and Technology Phase**

Information systems and technology phase is a phase where the systems that are to be included in the cross-border architecture are discussed. This phase deals with technological side of the architecture. Types of systems that need to be included for the initial stages and then technology that support these systems are identified.

##### *Define support and governance methodologies*

Performance of the architecture depends on the governing methodologies that is defined with [48]. Governing principles can be related to cost management, application development, defining data definitions, handling technology and integration risks, flexibility in handling different data, so on. In parallel, supporting strategies should also aid in maintaining the performance of the architecture. In an architecture involving different countries information continuous support should be provide round the clock for uninterrupted information flow between any two given regions.

##### *Selecting age old and legacy systems and defining maturity levels at different stages of architecture*

Most of the existing data for current operations are being held by legacy and age old systems. Systems carrying old data should be integrated into the new cross-border architecture so that the data can be used for remodeling and updating the current systems. Several update flaws may occur if proper efforts are not taken while integrating the old systems into the new cross-border architecture. Therefore, maturity levels should be defined and checked at different stages of legacy system updates and integration with new architectural systems.

##### *Network and reusable building blocks inclusion*

Information sharing and accessing is performed through different types of networks that support high amounts of data flows round the clock. Such networks should be robust and should be well defined. At the same time, reusable building blocks for such networks should be installed to meet fail-over downtimes.

### *Other factors:*

Checking inter-dependencies with other existing supported architectures and integrating reference model systems for attaining more stability to the current cross-border architecture. For example, an existing architecture supporting rational unified modelling features may be adopted as a reference architecture to support software features into the current developing cross-border architecture. Similarly, applications and standards should be well-defined in order to meet global demands of different region systems.

### *Expected Outcomes from Information systems and technology architecture phase*

Legacy and age old systems should be integrated with the cross-border architecture based on the principles of SOA so that services can be interchangeably utilized for different requirements of the architecture. Resource traceability tools should be installed as performance indicators at different integration points of the architecture between developing nations, so that, performance can be gauged from data, systems and network point of view for the entire architecture.

## **4.5 Explanation of Opportunities and future scope phase**

Following guidelines of TOGAF, the next phases are identifying of opportunities and future scope of cross-border architecture and planning for migration strategies. To start with, identifying opportunities helps in maintaining architecture requirements up to date and also guides information systems to meet new demands and challenges of future. Opportunities can be in terms of technology, business scenarios, business applications, process modeling or improvements, new stakeholder's involvement, change management, implementation and migration planning, so on. With cross-border architecture between different countries, there is a good scope of varying opportunities, as changing business demands favor for better improvements of existing solutions and information systems. Different set of activities are involved in identifying opportunities and scope of cross-border architecture. As the architecture involves different information and business systems, a change in one attribute may result in changes in other attributes [49]. Therefore, opportunities should be identified in such a way that they can reflect to one common solution and help in altering minimal change attributes. Consolidating interoperability with the new opportunities is also a challenging task since new

data should be good enough to match with the existing data and should fit well with the other information systems data. Tailoring of new opportunities helps in identifying those opportunities which are essential for future architectural development process.

An example to reflect change attributes w.r.t cross-border architecture is that, a change in technology architecture may result in changes in application, data and business data. Therefore, mitigation plans should be developed such that gap analysis can be studied and dependencies can be figured out related to new opportunities of technology architecture. Outcomes related to identifying opportunities phase is that, a clear vision plan for future update to the existing architecture is planned and can be developed. New solutions can be designed by identifying new opportunities. Solutions can be related to technology, applications, business or data architectures of the cross-border architecture between different nations. Proper identifying and planning of opportunities helps in developing good migration and implementation strategies. Future scope of architecture between different nations depends on good new opportunities are being identified [49].

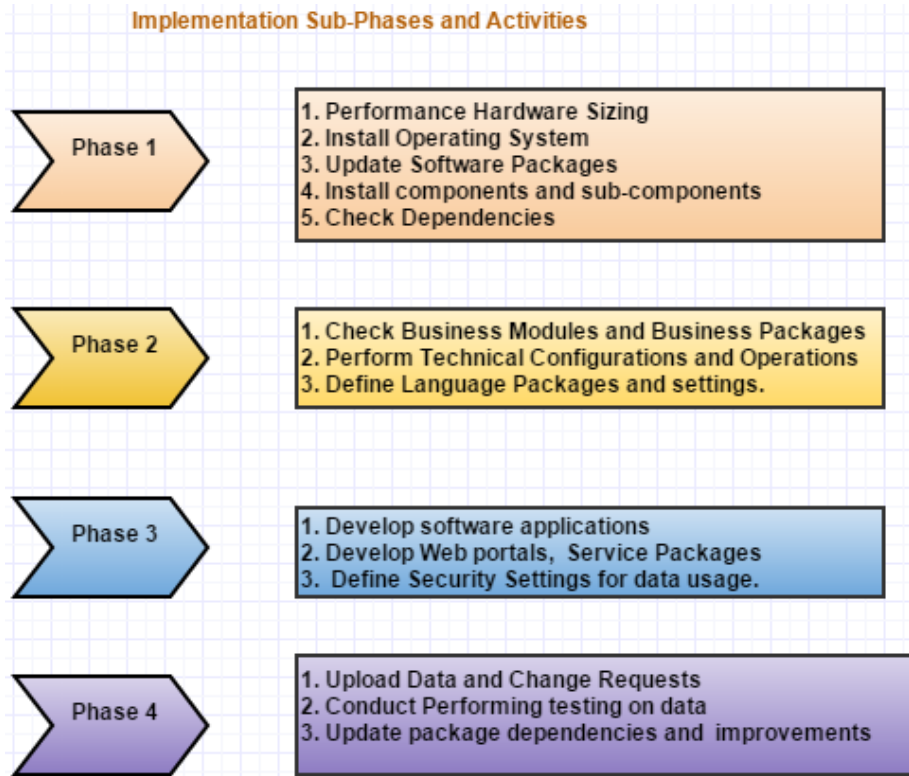
#### **4.6 Explanation of Migration phase**

Architecture development is a step-by-step process and involves a proper planning and implementation strategies. Implementation of architecture is nothing but implementation of set of solutions which are either pre-existing or has to be developed. In other words, migrating the pre-existing or has to defined solutions to fit into the target architecture visualizing from a baseline architecture. Solutions can be software packages, pre-defined libraries or classes, existing frameworks, business components and their connectors, software entities and their sub-systems, so on. With cross-border architecture between different nations, migration may involve, migration of technology solutions or application solutions or business solutions or data solutions either on individual basis or collectively. Migration phase involves set of activities along with expected outcomes [50]. Migration phase involves a migration plan where different set of deliverables that should be migrated to achieve a target architecture should be defined, dependencies of packages if there are any should be highlighted, time period of migration, cost evaluation of entire migration phase, risks involved, so on. Prioritizing the migration phases (i.e., either technology, business, applications or data) is also important since it involves time and

costs [50]. Migration phase should be properly planned since requirements collected from different phases like preliminary, vision, business and technology phases are being shaped into an expected target architecture. On the other hand, migration phase is also a road map for implementation phase since all the deliverables that should be implemented are noted from migration plan. In cross border architecture, migration starts from lower-level systems. Each pre-existing or has to be defined solutions are collected and baselined for the target migration. Different systems of each region are organized for migration and based on a common migration plan, migration process is scheduled. The expected outcomes of migration phase are, a proper road map or finalized document for real implementation is obtained, initial implementation of requirements, processes, technology solutions, data transitions, stakeholders priorities, so on are planned for real implementation on an enterprise level architecture. Migration phase results in identification and structuring of reusable building blocks and also helps in initial risk mitigation before the real implementation architecture. Cross-border architecture is a repository of different solutions related business or technology of different regions. Therefore, outcomes can come into effect with time as migration planning is planned on a step-wise basis.

#### **4.7 Explanation of Implementation Phase**

With respect to cross-border architecture, contractual agreements from different participants like stakeholders, sponsors, governing bodies, intermediaries, implementation teams are to be obtained for reference and for future agreements or improvements of the architecture. Implementation of cross-border architecture is a go-live phase where different deliverables or solutions are deployed and made use for end users of different regions. In Implementation phase collected requirements, business and technology solutions are put to use. Performance of different deliverables, components, interactions between different architectural models, time progress, operating models, service requirements execution, so on, are analyzed and gap analysis if exists are further studied. Impact of implementing solutions on end users, stakeholder concerns about expected target architecture are analyzed and proper plan for future improvements is developed. Implementation phase is also guided by the implementation plan where step-by-step approach of entire cross-border architecture implementation is defined. Following figure is an example of implementation plan.



**Figure 15:** Implementation sub phases and activities involved in each phase

A post installation document has to be developed where procedures after implementation has to be defined. Change request management, contractual improvements, future architecture models enhancements, so on are subjects of discussion after the implementation is completed. Outcomes related to implementation phase are, requirements collected from different phases are put to use on enterprise level, service level agreements, stake holders requirements, governing models and principles are put in use.

Figure 15 shows the different phases in an implementation phase. Implementation can be done for individual systems or a group of systems with same business functionality. Each phase is associated with different set of activities. Every implementation phase has to be done sequentially so that a proper order is maintained and the resultant systems work without any error. Figure 15 shows the technology implementation whereas the business implementation is done based on statistical analysis and discussions with different stakeholders.

#### **4.8 Explanation of Change Management Phase**

From a cross-border perspective, different set of users, stakeholders, organizations and governing bodies make use of the developed enterprise architecture among different nations. Therefore, several changes take place in business policies, service agreements, business and technology standards from time to time. In order to handle changes of different kind from different users, change management helps in maintaining and updating of changes from a cross-border architecture level. Change management is an important and last phase of cross-border architectural development process. Change requests are handled from time to time so that cross culture standards are up to date and can be effectively used through the architecture. Change management phase acts as a feedback phase for the migration and implementation phases. Since any new change in terms of technology, business process modeling or application modeling is updated in the architectural documents and further planned for implementing change solutions to the architecture. Change management involves set of activities and expected outcomes [51]. Activities in change management phase can be, assessment of new changes with that of existing changes, risk factors involved in updating new changes, assessing impacts of new changes at different levels of cross-border architecture, differentiating changes from architectural models (like technology or business or application or data changes) point of view, so on. On the other hand, expected outcomes of change management phase are organizational and governing standards are updated and maintained, proper assessment of changes and the risks associated with those changes are analyzed, comparison of old changes with that of new changes can improve solution building for new business scenarios and this is possible using change management phase of cross-border architecture.

#### **4.9 Maturity Assessment of Cross-Border Architecture among different nations**

Maturity assessment of cross-border architecture is essential since architecture future scope mostly depends on the type of maturity level it has achieved [52]. There are different phases in cross-border architecture development based on TOGAF guidelines. For the cross-border architecture to attain a certain level of maturity, each and every phase of the development process has to attain a same degree of maturity so that the final target architecture itself achieves the expected maturity level. Rather assessing the maturity of entire enterprise architecture as a whole, it is advisable to assess each and every stage or phase of cross-border architecture,

individually, to attain the highest level of maturity. Assessing maturity level of each phase [52] involves assessment of processes, assessment of governing models, business models, stakeholder concerns, business model interactions, technology assessment (like data usage statistics, data traffic load on involved systems, network protocols assessment, so on), people management, document analysis, assessment of risk analysis, so on.

Based on department of Commerce (DoC), maturity level can be assessed based on 5 levels which are: None as 0, Initial as 1, Under development as 2, Defined as 3, Managed as 4 and Optimized as 5 [53]. For each phase of cross-border architecture development, the 5 level assessment process has to be applied, so that maximum assessment can be carried on every deliverables that are involved in the architecture development process. As TOGAF framework is being used as a reference model, TOGAF itself supports different maturity assessment methodologies apart from following DoC maturity levels. According to TOGAF paradigms, TOGAF stress on assessing individual deliverables and sub-deliverables to attain a high degree of architecture maturity. Based on the maturity level a performance role matrix is defined for each deliverables and action plan of improvements is finalized. Therefore, any major or minor change or a new development has to undergo a through maturity assessment in a cross-border architecture. The developments are refined to the highest level of maturity assessment so as to meet the industry standards and stakeholders expectations. Action plan of improvements involves a team of industry experts who plan the degree of ‘action of improvements’ should be followed based on the level of maturity that a deliverable has attained from the performance role matrix.

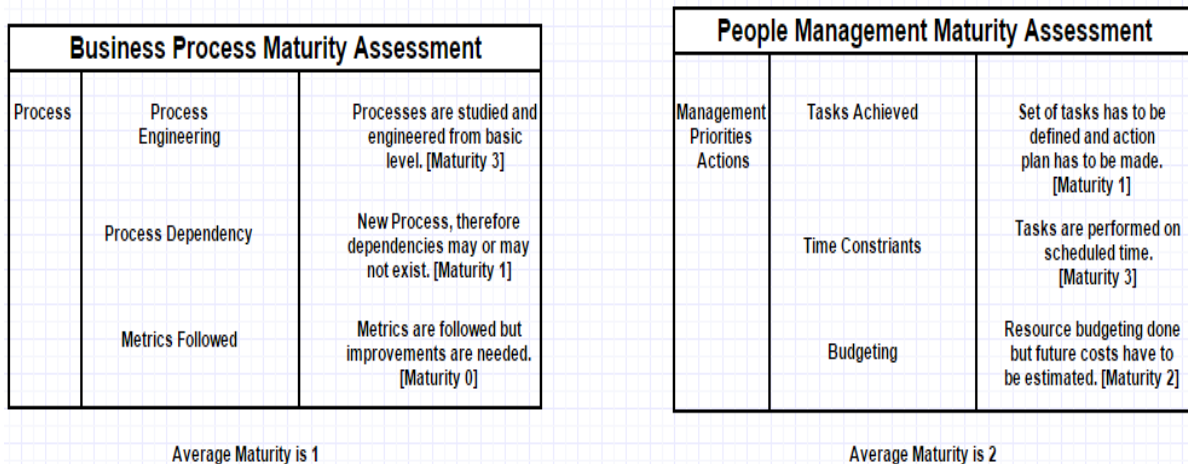


Figure 16(a)

<b>Sample Role Matrix for Maturity Assessment of Cross-Border Architecture</b>			
<b>Deliverable</b>	<b>Average Maturity</b>	<b>Action</b>	<b>Action Plan or Improvements</b>
Process	1	Yes	Assessment of Metrics and Process Dependency should be performed.
Management Priorities	2	Yes	Task achievements and budgeting should be overviewed.

Figure 16(b)

<b>Detailed Action Plan</b>	
Process Improvement	Processes are analyzed and metrics are to be applied where necessary. Also, check dependency packages if involved and perform process assessment again.
Management Priorities	Management people has to take responsibility of tasks scheduling, achievements and budget forecasting.

Figure 16(c)

**Figure 16 (a), (b), (c):** Sample Maturity Assessment of Cross Border Architecture in One Big Picture

Figure 16 has three figures, Figure 16(a), 16(b), 16(c). Figure 16(a) describes about the maturity level of individual activities that are being performed during the implementation of cross-border architecture. Each associated activity is given a maturity number and average maturity is taken on the entire activity that is being performed. For example, for business processes involved during the development of architecture, maturity level is awarded for each and every associated activity and then an average maturity is taken on entire business process assessment. Figure 16(b) shows the sample role matrix where the average maturities for different activities are grouped together and short description of action plan is listed. Figure 16(c) shows the detailed action plan where the type of actions should be taken to avoid future problems during the

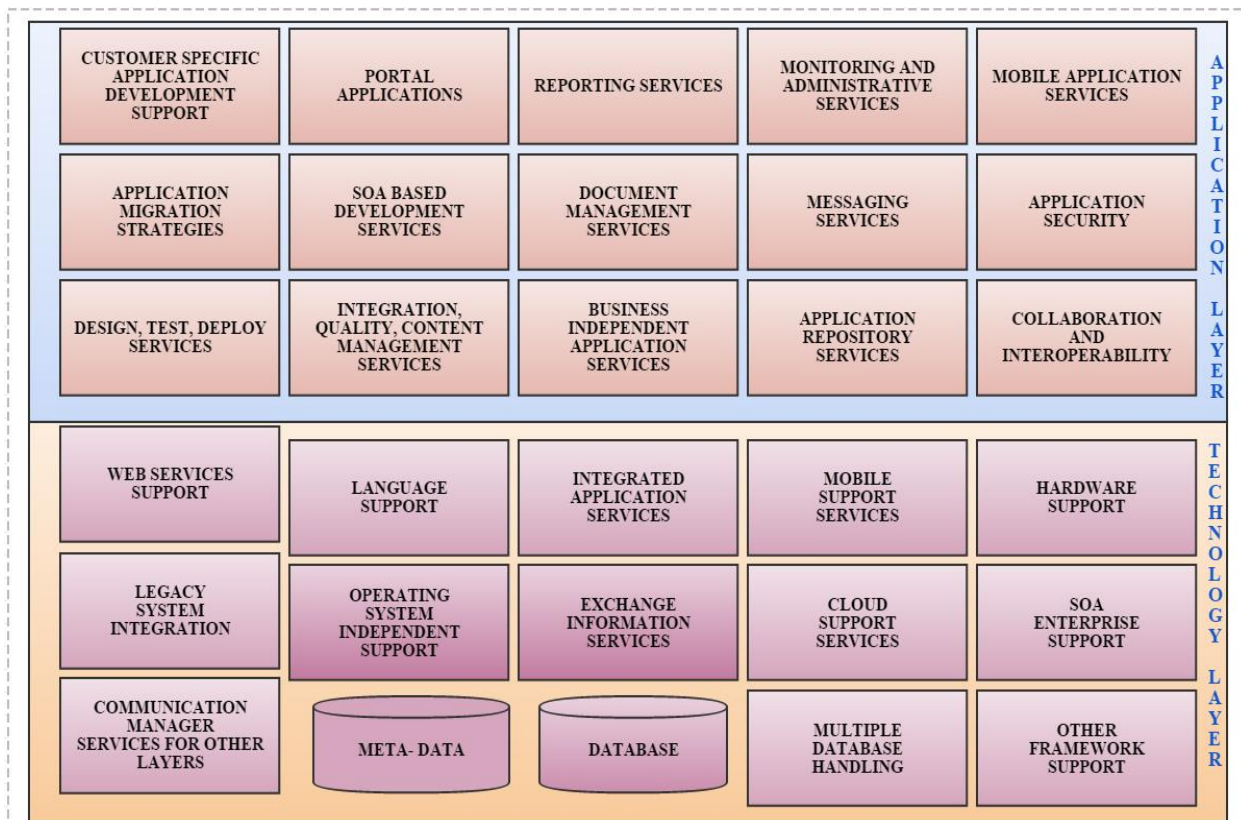
development of cross-border architecture are described. Based on the detailed action plan, again process improvisation and assessment is done in figure 16(a). This assessment cycles goes through till a refined and error free activity is obtained.

#### **4.10 Architecture Proposal**

Proposed concept of Cross-border architecture between different countries is based on TOGAF framework. An architecture where different information systems participate in data sharing and provide unique information repository services for people of different regions and countries. In this section, a clear understanding of different entities participating at different architectural models of cross-border and their interactions for data flow are highlighted. Cross-border architecture should meet demands of different business areas and of different regions. Therefore, services in the architecture should be robust and flexible to provide round the clock information sharing features. At the same time, architecture should capable of handling multiple tasks from different users and should be ready to meet updates of different business scenarios. Following TOGAF guidelines, cross-border architecture supports four different architecture domains (i.e., technology, application, business, data) where each domain is robust and fault-tolerance [54]. Robust to provide timely response based on the queries of different users and fault-tolerance to provide uninterrupted service usage at different architectural domains. The technology domains provides all technological features that cross-border architecture needs and application domain provides application based support for the entire architecture. Each service of an architecture domain is capable of providing service of its own and also, capable to provide a service in group along with other services in that domain. The technology domain of cross-border architecture supports services like multiple database handling, cloud services, legacy system integration, support for other frameworks integration, mobile support services and so on. The services listed are limited in the present context but in real time usage, cross-border architecture between different developing nations is capable of handling several different services along with updated services. On the other hand, application domain of cross-border architecture handles services like design, test, deployment of applications, document management services, providing security to different applications of the architecture, collaboration and interoperability with other applications and also with other domains within the architecture, business independent and SOA based development application services, document management services and so on. While the

technology layer keeps of technology changes, application layer takes care of application handling and application service management throughout the cross-border architecture. Each service can exist on its own along with group of services to provide better services for users.

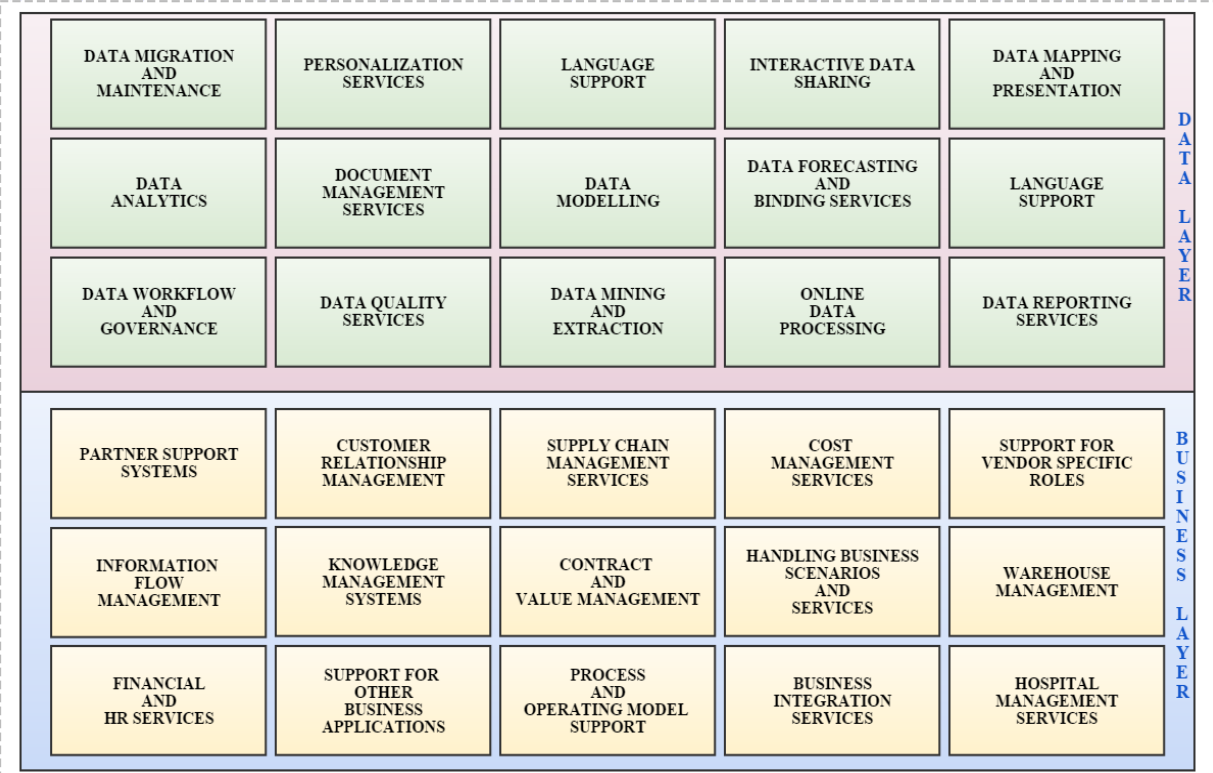
Following figure 17, depicts technology and application layers of cross-border architecture. In the present context, services listed in the figure are limited but in real time usage different layers of the architecture can handle several different services. Services in the technology layer can work together to provide or to bring new changes for the architecture to meet new demands in technology and also provide services for its higher layers of application, business and data.



**Figure 17:** Technology and Application layer of Cross-border Architecture between different Nations

On the other hand, business layer of the cross-border architecture provide services related to different business segments from different stakeholders of different regions. The services in the business layer can be support for integration of business scenarios and events, cost management

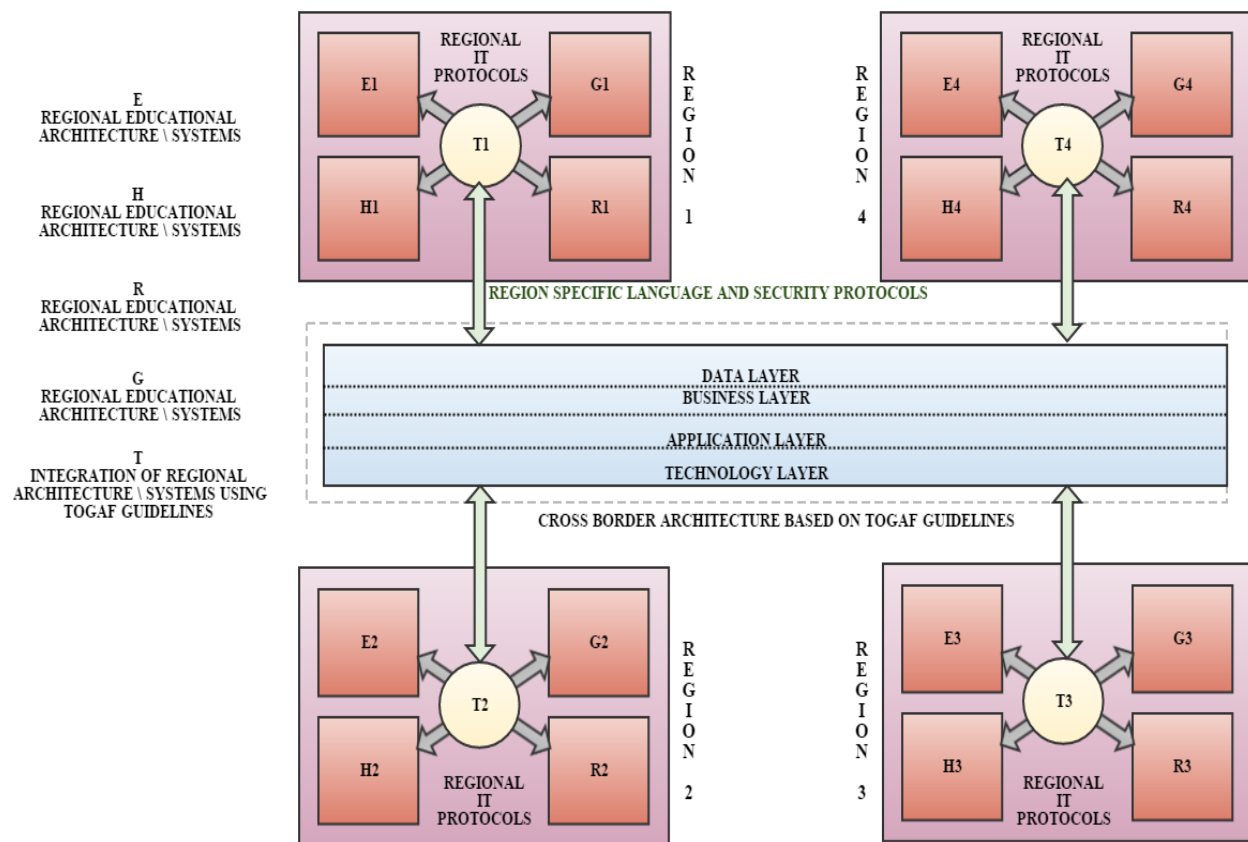
services, contract and value management services, financial and human resource services, customer relationship management, supply chain management and so on. In specific, business services of the architecture provide business related solutions and their updates to the users. Along with business services, the business layer also interacts with application, technology and data layers to provide profound and innovative solutions for future needs. For example, a customer relationship management service of business layer interacts with the language support of data and technology layers in order to obtain a new application for language enhancement for customers who are new to the cross-border architecture. Therefore, from a cross-border architecture perspective, every service of different layers of the architecture work on a hand-in-hand basis.



**Figure 18:** Business and Data Layer of Cross-border architecture between different developing nations

Similarly, Data layer for the cross-border architecture handles services of data quality, mining and extraction, data governance, data reporting, online data support, language support, data forecasting and modelling, workflow management, data analytics and so on, which are shown in figure 18.

Based on the different layers and services of cross-border architecture, the architectural model can be defined in the following figure. Cross-border architecture is a common platform which provides repository and data sharing among different developing regions. The architecture usage is not just restricted to developing nations but can be extended for other nations based on purpose and usage methods. Figure below shows the proposed block diagram of cross-border architecture between different developing nations.



**Figure 19:** Cross-Border Architecture between Different Developing Nations Using TOGAF

In the picture figure 19, there are four different regions which access and share information from a cross-border architecture based on TOGAF guidelines. Each region in itself has a TOGAF defined architectural arrangement of different business systems which are connected by regional

IT protocols. Regional systems can be related to educational systems, healthcare systems, research based systems or governmental and non-governmental systems. Therefore, each system can access data from their respective regional systems and also share or access information from cross-border territories using TOGAF defined cross-border architecture. Hence, from regional point of view, there is no duplication of data, as regional TOGAF maintained architecture handles a one-point access data sharing system. In parallel, the system regional system can access data from other regions information systems provided correct user authentications to access other regional systems data. Therefore, TOGAF based cross-border architecture between different nations act as a data sharing and accessing repository for different region users. Having discussed different topics on the importance of an architecture between different nations, the next section of the thesis deals in answering the research questions which have been mentioned at the starting section.

## **5 Answering Research Questions**

1. What is the role of a standard IT architecture in the progress of a developing nation?

At present, a standard architecture does not exist between different developing nations by which information sharing takes place. This forms a hindrance in the development of one region when compared to other regions. Nations with organized information sharing resources are achieving their goals at a rapid pace when compared to the nations with unorganized information systems. Therefore, a standard IT architecture is needed where data sharing and accessing of information is unique and individuals from different regions can access same quality and quantity of data as other region people does. Having a standard IT architecture sharing of information becomes easy and hence, information repositories helps in providing better services for citizens in different walks of life. A cross-border architecture based on TOGAF guidelines meet the requirements of providing better services on a cross-border level. Information flow between different nations becomes easy and every nation gets an opportunity to learn new things about other nation's culture, economics and standard of living from different sources of information. At the same

time, cross-border architecture also helps individual's education, knowledge sharing, research analysis, understanding cross country business and so on. Therefore, a cross-border architecture can be used as a standard IT architecture which can bring several different enhanced services for different citizens of different nations.

2. Changes of kind When, what and how an IT architecture using TOGAF framework can bring for the developing nations?

The concept of cross-border architecture can bring major changes for different developing nations in terms of information access and data sharing, provides an opportunity to learn new features in different fields of life, acts as a global repository of information, helps in providing information security for different region people through unique identification methods, helps in organizing one's own legacy systems and other information systems, one point access to data from different locations, different businesses can access information of any related field without any issues and so on. Implementation of cross-border architecture is not a one day process and involves mediation of high rank government officials, stake holders, people interests and choices, security concerns, different standards, mutual agreements and contracts, time and cost evaluation, people management and so on. Therefore, implementation of cross-border architecture is a step-by-step approach and involves great amount of time along with costs and patience. But once if the architecture is implemented on a step-by-step process, developing countries can take a good advantage to bring better and enhanced facilities in different fields for individuals of their region in various walks of life.

## **6 Limitations Of IT Architecture Between Different Developing Nations**

Though there are several different advantages of the cross-border architecture between different developing nations, there are also limitations associated with it. Language barriers, complexity of entire architecture, time and costs involvement, people management, organizing the legacy systems and other information systems, problems with contractual agreements between different nations, problems related to information security, complexity involving information gathering about different business segments, complexity in implementing protocols and standards among cross-border territories, updating architecture based on new changes in different business units, complexity involving migration strategies, maintenance, handling fail-over and downtimes are some of the concerns regarding cross-border architecture implementation. In current situation, the proposal of cross-border architecture is theoretical but in reality, during the implementation time, major concerns and limitations have to be considered and gauged on a higher scale for better performance.

Currently, a significant growth in the third world and developing country markets is observed. Therefore, an open trade contracts might take place across different nations of common zones and need for an enterprise architecture between cross-borders gains importance. Hence, future scope for cross-border architecture implementation is high based on cross-border business contract. In parallel, improvements can be observed in lower level system architecture alignments among different nations which are going to be connected to single cross-border architecture. As the enterprise architecture involves different country business operations, implementation might be a time-consuming process. Also, it is a sequential step-by-step implementation process which might adopt the positives of other well-known enterprise architecture frameworks like Gartrner, Federal enterpriser architecture or the standard Zachmann enterprise framework features. Since, the implementation is time consuming, an alternative approach is to develop the enterprise architecture country wise maintaining common features for cross-border applications and later unite different nation-wide enterprise architectures to one single enterprise cross-border architecture.

## **7 Conclusion**

The progress of developing countries is hindered by the lack of a standard IT architecture which can help in information sharing and provide better and fast services in different walks of life. In order to catch the pace of modern social, economic and technological changes developing nations need a standard IT architecture. Therefore, cross-border architecture based on TOGAF guidelines can fulfill the requirements of a standard IT architecture between different developing nations. With the help of cross-border architecture different developing nations can share information related to different fields like science and technology, education, health care services, security and crime information, geographical information, business changes and processes and so on. As the cross-border architecture acts as an information repository, individual from one region can access data about other region with ease and in quick time. The architecture helps in understanding different individuals, regions, cultures, economies and other features and also provides a good platform for learning and knowledge sharing.

## References

[1] Investopedia. 2015. “Developed Economy”.

[Online] Available: <http://www.investopedia.com/terms/d/developed-economy.asp>

[Accessed 2nd Oct’2015]

[2] Online Dictionary definition. 2015. “The Definition of Developing Country”.

[Online] Available: <http://dictionary.reference.com/browse/developing+country>

[Accessed 2<sup>nd</sup> Oct’2015]

[3] Techopedia. 2015. “What are technological Services?.

[Online] Available: <http://www.techopedia.com/definition/5569/technology-services>

[Accessed 2<sup>nd</sup> Oct’2015]

[4] Lappeenranta University of Technology Library. 2015. “Library Forms”.

[Online] Available: <http://www.lut.fi/web/en/library/library-forms;jsessionid=A54C5BCD00D994FD0394A66772380798.wwwlut2>

[Accessed 2<sup>nd</sup> Oct’2015]

[5] International Telecommunication Union. 2015. “Interoperability problems in developing countries”.

[Online]. Available: [www.itu.int/dms\\_pub/itu-t/oth/06/24/T06240000010002MSWE.doc](http://www.itu.int/dms_pub/itu-t/oth/06/24/T06240000010002MSWE.doc)

[Accessed 3<sup>rd</sup> Oct’2015]

[6] Antti Salovaara, Jani Merikivi. (2015 May 28). “IS Research Progress would benefit from increased falsification of existing theories” 23<sup>rd</sup> ECIS, Münster, Germany. [Online]. Available FTP:

<https://balsa.man.poznan.pl/indico/event/44/session/22/contribution/254/material/paper/0.pdf>

[Accessed]: 5<sup>th</sup> Oct’2015

[7] Bas van Gils, Sven van Dijk. (2012 November 26). Bizzdesign, 2014. [Online]. Available: <http://blog.bizzdesign.com/ea-roadmap-for-success-top-down-versus-bottom-up-architecture> [Accessed]: 5<sup>th</sup> Oct'2015.

[8] The Open Group. 2015. "The Open Group Architecture Framework". [Online] Available: <http://www.opengroup.org/subjectareas/enterprise/togaf> [Accessed]: 23<sup>rd</sup> Sep'2015

[9] Margaret Rouse. (2007 June). TechTarget 2015. [Online] Available: <http://searchcio.techtarget.com/definition/enterprise-architecture>. [Accessed]: 23<sup>rd</sup> Sep'2015

[10] Tanja Ylimäki, "Towards Critical Success Factors for Embedded Architecture" Master's Thesis, Information Technology Research Institute, University of Jyväskylä. (Jyväskylä, 2006). [Online] Available: [https://jyx.jyu.fi/dspace/bitstream/handle/123456789/41413/Report\\_CSFs\\_for\\_EA.pdf?sequence=1](https://jyx.jyu.fi/dspace/bitstream/handle/123456789/41413/Report_CSFs_for_EA.pdf?sequence=1) [Accessed]: 23<sup>rd</sup> Sep'2015.

[11] The Open Group. (2009-2011). "TOGAF standard courses", Edition V9.1. [Online]. Available: <http://www.togaf.info/togafSlides91/TOGAF-V91-M1-Management-Overview.pdf>. [Accessed]: 24<sup>th</sup> Sep'2015. (p.3)

[12] The Open Group. (1999-2000). "TOGAF common set of goals". [Online]. Available: <http://www.togaf.org/togaf9/chap01.html> [Accessed]: 23<sup>rd</sup> Sep'2015.

[13] The Open Group. (1999-2000). "TOGAF core concepts". [Online]. Available: <http://www.togaf.org/togaf9/chap02.html> [Accessed]: 23<sup>rd</sup> Sep'2015

[14] Joe Cackler, Emily Gu, Mike Rodgers. (2008 March 17). "Technology in Developing Economies" Stanford University. [Online]. Available: <http://cs.stanford.edu/people/eroberts/cs181/projects/developing-economies/> [Accessed]: 24<sup>th</sup> Sep'2015.

[15] Surekha Kaul. (2000 October). "Information Resource Sharing Models in Developing Countries" Global 2000 Worldwide Conference, Brighton, UK. 2000.

[Online]. Available: <http://forge.fh-potsdam.de/~IFLA/INSPEL/01-1kasu.pdf> [Accessed]: 24<sup>th</sup> Sep'2015 (p. 9-15)

[16] A.R. Chhachhar, H.B.Makhijani, G.M.Khushk, Z.A.Maher. 2013."Information and Communication Technologies for Rural Development in Developing Countries", Academia.edu, 2013.

[Online]. Available: [http://www.academia.edu/4589970/Information\\_and\\_Communication\\_Technologies\\_for\\_rural\\_development\\_in\\_developing\\_countries](http://www.academia.edu/4589970/Information_and_Communication_Technologies_for_rural_development_in_developing_countries) [Accessed]: 24<sup>th</sup> Sep'2015

[17] The Open Group. 1999-2006. "Introduction to ADM". [Online].

Available: <http://pubs.opengroup.org/architecture/togaf8-doc/arch/chap03.html> [Accessed]: 24<sup>th</sup> Sep'2015

[18] The Open Group. 1999-2011. "Architecture Principles". [Online].

Available: <http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap23.html> [Accessed]: 24<sup>th</sup> Sep'2015

[19] The Open Group. 1999-2011. "SOA Governance". 1999-2011. [Online].

Available: <http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap22.html> [Accessed]: 24<sup>th</sup> Sep'2015

[20] Amitabh Apte. (2013 March 23). "A comparison of the top four enterprise architecture methodologies". EA Voices, 2013. [Online].

Available: <http://eavoices.com/2013/03/23/a-comparison-of-the-top-four-enterprise-architecture-methodologies/> [Accessed]: 25<sup>th</sup> Sep'2015

[21] Mike The Architect. (2013 February 10)"TOGAF Demystification series: Comparing TOGAF to other Frameworks," Mikethearchitect.com, 2013. [Online].

Available: <http://www.mikethearchitect.com/2013/02/togaf-demystification-series-comparing-togaf-to-other-frameworks.html> [Accessed]: 25<sup>th</sup> Sep'15

[22] Roger Sessions. (April 2006). "A better path to Enterprise Architectures". Microsoft.com, 2016. [Online].

Available: <http://msdn.microsoft.com/en-us/library/aa479371.aspx> [Accessed]: 25<sup>th</sup> Sep'15

[23] John A.Zachman. 2008. "John Zachman's concise definition of the Zachman Framework". Zachman International Enterprise Architecture, 2008. [Online].

Available: <http://www.zachman.com/about-the-zachman-framework> [Accessed]: 24<sup>th</sup> Sep'2015

[24] Chris Collins. (2008 February 16). "Introduction to the Zachman Framework". Word Press, 2008. [Online].

Available: <http://ccollins.wordpress.com/2008/02/16/introduction-to-the-zachman-framework/> [Accessed]: 26<sup>th</sup> Sep'15

[25] The Open Group. 1997-2002. "Other Architectures and Architectural Frameworks". [Online]. Available: <http://www.opengroup.org/architecture/0210can/togaf8/doc-review/togaf8cr/c/p4/others/others.htm> [Accessed]: 26<sup>th</sup> Sep'15

[26] UIDAI. 2012. "Aadhaar Technology". Government of India, 2012.

[Online]. Available: <http://uidai.gov.in/aadhaar-technology.html> [Accessed]: 26<sup>th</sup> Sep'15

[27] United States Government Accountability Office. (2001 February). "Federal Enterprise Architecture". [Online]. Available: <http://www.gao.gov/assets/590/588407.pdf> [Accessed]: 26<sup>th</sup> Sep'15

[28] American White House. (2012 May 2). "The Common Approach to Federal Enterprise Architecture". [Online]. 2012. Available: [http://www.whitehouse.gov/sites/default/files/omb/assets/egov\\_docs/common\\_approach\\_to\\_federal\\_ea.pdf](http://www.whitehouse.gov/sites/default/files/omb/assets/egov_docs/common_approach_to_federal_ea.pdf) [Accessed]: 27<sup>th</sup> Sep'15

[29] Unique Identification Authority of India. 2012. "Aadhaar". Government of India, 2012. [Online]. Available: <http://uidai.gov.in/> [Accessed]: 15<sup>th</sup> Oct'15

[30] Saritha Rai. (2012 June 6). “Why India’s identity scheme is groundbreaking”, in BBC India, BBC News, 2012. [Online].

Available: <http://www.bbc.com/news/world-asia-india-18156858> [Accessed]: 15<sup>th</sup> Oct’15

[31] SearchCIO Staff. (2011 September). “Understanding the UID Aadhaar project and IT’s role in its success”. Search CIO.in, 2009-2016. [Online]. Available: <http://searchcio.techtarget.in/tutorial/Aadhar-project-UID-and-the-role-of-IT-in-its-success> [Accessed]: 15<sup>th</sup> Oct’15

[32] Aqil Burney, Nadeem Mahmood, Zain Abbas. “*ICT in healthcare management systems: Prospects for developing countries*” International Journal of Computer Applications, Vol.4, No.2, pp. 0975-8887, 2010.

[33] Anwar Islam, Tuhin Biswas “*Health System in Bangladesh: Challenges and Opportunities*” American Journal of Health Research, Vol.2, No.6, pp. 366-374, 2014.

[34] V.R.Jayaraman. (2014 September 09). “5 things to know about India’s Healthcare System”, Forbes India, 2015. [Online]

Available: <http://forbesindia.com/blog/health/5-things-to-know-about-the-indias-healthcare-system/> [Accessed]: 9<sup>th</sup> Nov’15.

[35] The World Bank Group. 2015. “Health Expenditure total (% of GDP)”. [Online]

Available: <http://data.worldbank.org/indicator/SH.XPD.TOTL.ZS> [Accessed]: 9<sup>th</sup> Nov’15

[36] Lieberman, Capuno, Van Minh “Decentralizing Health: Lessons from Indonesia, The Philippines, and Vietnam”, WorldBank, 2000. [Online].

Available: <http://siteresources.worldbank.org/INTEAPDECEN/Resources/Chapter-8.pdf>. [Accessed]: 9<sup>th</sup> Nov’15

[37] “Compare Countries” in HSPM, European Observatory on Health Systems and Policies, 2015. PDF. [Online]. Available: [file:///X:/HSPM\\_CanFinGerUni\\_.pdf](file:///X:/HSPM_CanFinGerUni_.pdf). [Accessed]: 9<sup>th</sup> Nov’15

[38] “UIS Statistics” in Education, UNESCO.org, 2015. [Online]

Available: <http://data.uis.unesco.org/> [Accessed]: 12<sup>th</sup> Nov’15

[39] The Open Group “Overview of the SOA RA Layers”. 2015. [Online].

Available: [https://www.opengroup.org/soa/source-book/soa\\_refarch/layers.htm](https://www.opengroup.org/soa/source-book/soa_refarch/layers.htm)

[Accessed]: 12<sup>th</sup> Nov’15.

[40] The Open Group “Foundation Architecture: Standards Information Base”. 1999-2006. [Online].

Available: <http://pubs.opengroup.org/architecture/togaf8-doc/arch/chap21.html>

[Accessed]: 15<sup>th</sup> Nov’15.

[41] The TOGAF. “Architecture Deliverables”, 1999-2011. [Online].

Available: [http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap36.html#tag\\_36\\_02\\_09](http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap36.html#tag_36_02_09)

[Accessed]: 14<sup>th</sup> Nov’15.

[42] The Open Group “Architecture Maturity Models”. 1999-2011. [Online].

Available: <http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap51.html>

[Accessed]: 14<sup>th</sup> Nov’15.

[43] Roy Hunter. 2011. “Using Business Architecture to drive IT/Business Alignment”. Oracle.com, 2011. [Online].

Available: <http://www.oracle.com/technetwork/articles/entarch/oea-busarch-280827.html>

[Accessed]: 14<sup>th</sup> Nov’15.

[44] Bredemeyer Consulting. (2009 March 24). “Architecture principles”. 2011. [Online].

Available: <http://www.bredemeyer.com/ArchitectingProcess/ArchitecturePrinciples.htm>

[Accessed]: 15<sup>th</sup> Nov’15

[45] Business case studies. 2015. “Potential stakeholder conflicts” in Corporate responsibility and stakeholders, Business case studies, 1995-2015. [Online].

Available: <http://businesscasestudies.co.uk/reed-elsevier/corporate-responsibility-and-stakeholders/potential-stakeholder-conflict.html#axzz3tXZmBSSE> [Accessed]: 15<sup>th</sup> Nov’15

- [46] Ezekiel Chinyio et al. “Managing Stakeholders Conflicts” in “*Construction Stakeholder Management*”. 1<sup>st</sup> Edition, USA. Wiley-Blackwell publication, 2010. (Chp. 17, pp. 286-315) [Book].
- [47] Remco Dijkman et al. “The Road to a Business Process Architecture: An Overview of Approaches and their Use”, Eindhoven University of Technology, The Netherlands, 2011. Remco, Irene, Hajo. 2009. [Research Article]
- [48] Souza Mendes Guimaraes. (2012 November 20). “*21 principles of enterprise architecture for the financial sector*”, in IBMdeveloperWorks, IBM. [Online]. Available: <http://www.ibm.com/developerworks/rational/library/enterprise-architecture-financial-sector/> [Accessed]: 16<sup>th</sup> Nov’15.
- [49] The Open Group “*Opportunities and Solutions*”. 1999-2011. [Online]. Available: <http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap13.html> [Accessed]: 14<sup>th</sup> Nov’15
- [50] The Open Group “*Migration Planning*”. 1999-2011. [Online]. Available: <http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap14.html> [Accessed]: 15<sup>th</sup> Nov’15
- [51] The Open Group “*Architecture Change Management*”. 1999-2011. [Online]. Available: <http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap16.html> [Accessed]: 15<sup>th</sup> Nov’15
- [52] Gopala Krishana, Prasad Palli. (2013 January). “Maturity Assessment of Enterprise Architecture”, BP Trends, 2013. (pp. 1-8). [Research Article].
- [53] The Open Group “*Architecture Maturity Levels*”. 1999-2011. [Online]. Available: <http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap51.html> [Accessed]: 15<sup>th</sup> Nov’15.
- [54] “What’s the difference between Robustness and Fault-tolerance”. Stack Exchange. 2015. [Online]. Available: <http://programmers.stackexchange.com/questions/219976/whats-the-difference-between-robustness-and-fault-tolerance> [Accessed]: 15<sup>th</sup> Nov’15
- [55] Lise Urbaczewski, Stevan Mrdalj “*Comparison of the Top Four Enterprise Architecture Methodologies*”, Vol. 7, No. 2, pp. 18-23, 2006.

[56] John W. Creswell, “Strategies of Inquires”, in “Research Design: Qualitative, Quantitative and Mixed Methods Approaches”, 2<sup>nd</sup> Edition USA, SAGE 2003, pp. 13-16. [Book]

[57] Robert Stake, “Data Gathering”, in “The Art of Case Study Research”, 1<sup>st</sup> Edition USA, SAGE 1995, pp. 49-68. [Book]

[58] Shahid N Khan, “*Qualitative Research Method: Grounded Theory*”, International Journal of Business Management, Vol. 9, No. 11, pp. 224-233, 2014.

[59] Thomas Erl, “The Architecture of Service-Oriented”, in “SOA Design Patterns”, 1<sup>st</sup> Edition USA. Prentice Hall, Pearson Education Inc. 2008. (pp. 47-79) [Book]

## **Appendix 1**

Interview Questions asked to various industry professionals.

1. Does cross-border IT architecture work between different developing nations?
2. In real-time scenario is it possible to implement an IT architecture between nations?
3. What factors are taken into consideration when building an IT architecture?
4. Different IT architectures used for standards to build an enterprise architecture?
5. Is TOGAF a reliable framework in relation to other standard frameworks?