Addis Ababa University

College of Natural and Computational Sciences

School of Information Sciences

Developing Patient Information Record System Integration framework for Ethiopian Hospitals

By

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October 1, 2020

Addis Ababa

Ethiopia

Addis Ababa University

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Master's Program (MSc.) In Information Sciences

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Declaration

I declare that this thesis is my original work and it has not been presented for a degree in any other Universities. All the material sources used in this work are scientifically acknowledged.

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10/1/2020

This thesis has been submitted to the school of Information Science for examination with my approval as University Advisors:

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Signature_____

10/1/2020

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Acknowledgement

In the present world there is a race of existence in which those are having will to come forward succeed. With this willing I passed through a lot to finalize this research thesis. First of all I would like to thank the supreme power the almighty God who guided me through everything. Next to him I want to thank my husband and my families for their support. I would also like to show my biggest respect and thanks for my advisor Dr. Gashaw Kebede for his follow-up and support. I would also like to thank Addis Ababa university school of information science and system for providing this master's program. I would also like to thank Jimma University for the sponsorship it provided through all my studies. Finally I thank my classmates and those special people who played great role for the fulfillment of this study.

List of acronyms and abbreviations

ADM	Architecture Development Method
DI	Data Integration
DICOM	Digital Imaging and Communications in Medicine
EAI	Enterprise Application Integration
EDI	Electronic Document Integration
E-health	Electronic health
FCL	Framework Class Library
FEAF	Federal Enterprise Architecture Framework
GGH	Girum General Hospital
HIS	Health Information System
HL	Health Level
KGH	Kadisco General Hospital
M-health	Mobile health
OAUTHC	Obafemi Awolowo University Teaching Hospitals Complex (Nigeria)
OECD	Organization for Economic Co-operation and Development
TEAF	Treasury Enterprise Architecture Framework
TOGAF	The Open Group Architecture Framework
WHO	World Health Organization

Abstract

Health information system integration is bringing together different systems into one so that the system is able to deliver the overarching functionality and ensuring that the different systems function together as a system. This research mainly focused on the problem that describe public health information from one hospital may not be used by other hospital in the absence of integrated HIS. The main objective of the study is developing patient information record integration framework of health information systems for hospitals with specific objectives of, setting the architecture vision and business architecture of hospitals based on the existing system of hospitals information system and to propose the way the new systematic approach can be used to implement integrated patient information record. The scope of the study covers two private hospitals namely Girum General Hospital and Kadisco General Hospital. The open group architecture framework (TOGAF) has been employed as methodology and through this methodology interview and observation were the data collection mechanisms. The finding of the study was that, There is a better way to integrate patient record system of hospitals by using an enterprise architecture specifically, TOGAF for this study. This was done by employing architecture development method life cycle of TOGAF. The architecture vision and principle has been set the business, data, application and technology architecture has been described for both the baseline and the targeted system. TOGAF supported opportunities and solutions have been set as a systematic ways to implement the integrated patient information record system for the hospitals. Requirement management was also prepared and recommendations have been given to hospitals to use TOGAF to review and develop their health information system. This study plays a role in showing ways to integrate HIS of hospitals. Future studies can be done on how the private, the government and different health sectors can be integrated to give better services.

CHAPTER ONE

1. Introduction

1.1 Background of the research

Health information system is an information system that captures store, manage and transmit information related to health of individuals or the activities of organizations that work within the health sector. According to Penerai, (2000) Health information system (HIS) is any form of structured repository of data, information, or knowledge that can be used to support health care delivery or to promote health development. "The HIS contain data and concepts in health services given to patients to improve the management of the health service" Almunawar & Anshari, (2018). Health information can be the aggregate information about all patients that have attended or been admitted to a hospital, or attended a health center, outlying clinic or a community immunization or health screening program. HIS is also defined as "a set of components and procedures organized with the objective of generating information which will improve health care management decisions at all levels of the health system" Lippeveld, Sauerborn, & Bodart , (2000).

According to the 2007 report of world health organization, HIS provides the underpinnings for decision-making and has four key functions: data generation, compilation, analysis and synthesis, and communication and use. HIS collects data from health and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts the data into information for health-related decision-making.

To make HIS more effective we can bring the idea of integration here. Integrating different HIS in different healthcare services adds value to the system through new ways. HIS integration is connecting different HIS of different health sectors to interconnect and compress their values and build well manageable system. According to Galimoto,(2007) Integrating HIS are advocated as a means to improve the general quality of health services provided as there is lack of timely reporting and feedback; and poor use of the information with the fragmented HIS. Integrated service delivery is the organization and management of health services so that people get the care they need, when they need it, in ways that are user-friendly, achieve the desired results and provide value for money.

According to 2008 report of WHO Ethiopia has a poor health status in relation to other low-income countries, even within Sub-Saharan Africa; the most serious global health problems are in poorer countries, and good health information is vital in tackling these problems. As the report of WHO shows there is a need by the hospitals of developing countries to use the limited resource effectively in order to

provide an efficient and equitable health service to the communities. This then requires sound management that is based on information, which is crucial at each level of the health service management. Correct and up-to-date information is critical, not only for the provision of high-quality clinical care, but also for continuing health care, maintaining health care at an optimal level, clinical and health service research, and planning and management of health systems.

Though there are much more hospitals than the previous time trying to reach the populations in our country Ethiopia, very few of these hospitals have implemented their own HIS that is independent and that enables them easily contain patients profile; enable health-care managers to determine resource needs and help public health decision-making etc. However, at the country level Public health surveillance cannot bring together information from facilities and communities with a main focus on defining problems and providing a timely basis for action. This is because of the inexistence of integrated health information system.

According to Osijek, (2018) HIS integration can be of three types; the first one is Enterprise Application Integration (EAI) which is service based integration**.** It's also a process that communicates with different services, gathers data and then proceeds with further steps based on desired action or a workflow. Process can be triggered with exposed service. The second is the Data Integration (DI) which focuses on integrating different databases and services for management reporting or any kid of reporting by gathering data from all city services, aggregating and transforming them into central place for interactive reporting. And the third type of integration is Electronic Document Integration/Interchange (EDI) which is core business to business-oriented process. It functions on paperless exchange of documents and electronic standards Osijek, (2018).

1.2 Statement of problem

The researcher is initiated by observing some problems that faces different health sectors due to absence of integrated HIS specifically the absence of integrated patient medical record.

As the 2010 report of Federal Ministry of Health shows, in the absence of an integrated patient medical record in our country, 'public health information from one hospital may not be used to other location/hospital'. This inaccessibility of information to other locations makes patients not to get effective treatment and they need to take the same checkup they have already taken and which again costs them more money. Patients cannot also get timely treatment as they have to wait for the processing/creating of their patient profile/ information which could have been accessed from the integrated database. Patients need to have their health information report with them but, with the existing HIS of our country they do

not have their health report with them which is well processed, which continue their whole medication and meaningful information to any hospital and to them.

Hospitals and health centers also face problem due to the absence of integrated patient record system. In independent patient record system, different hospitals need to create their own patient recording profile which creates redundancy and overload of patient information in their database but if they could share the existing information with other hospitals with the integrated system they could solve this problem.

According to Mwanyika, (2014) the inexistence of integrated patient record system also creates additional workload for health workers as they have to collect data from different hospitals and have to report for the surveillance system; doing this in the absence of an integrated patient record of our country creates repetition of data collection and creation of repeated reports. If hospitals in Addis Ababa have, an integrated patient medical record in their HIS, this repetition of data collection and reporting can be solved and the surveillance system will have clear report.

This study tries to investigate the structure of patient medical record in HIS of different hospitals to identify the parts which obstruct them not to integrate and design an integrated framework by employing the open group enterprise architecture as a method to overcome this obstructs.

1.3 Research questions

This research mainly addresses the question "how to develop patient information record system integration framework of different private hospitals" accordingly this study answers the following research questions.

1. How the existing patient records in HIS of different hospitals are characterized?
2. Which enterprise architecture is better in designing a framework for an integrated patient record system?
3. What kind of patient record systems integration framework can be developed for Ethiopian hospitals and health centers?

1.4 Objective of the study

The main objective of the study is developing patient information record integration framework of health information systems for Addis Ababa private hospitals.

To achieve the general objective stated above the study specifically intends to accomplish the following:

- To identify and evaluate the existing HIS of different hospitals

- To set the architecture vision and business architecture of hospitals based on the existing system of hospitals information system
- To design and organize data architecture by defining data entity catalog
- To categorize opportunities and Solutions that identify and scope change initiatives
- To suggest Requirement management that the hospitals need to do to meet the architecture vision
- To evaluate the integration framework for patient record system

1.5 Significance of the study

According to 2008 report of WHO, integrated health service delivery is "the organization and management of health services so that people get the care they need, when they need it, in ways that are user-friendly, achieve the desired results and provide value for money". HIS are open to, and accessed by, healthcare professionals. These include those who deal directly with patients, clinicians, and public health officials. Healthcare professionals collect data and compile it for use in making health care decisions for individual clients, client groups, and the general public. A patient medical record is one component of HIS which enables Medical information of each patient to be collected and stored/kept. This record includes patient health information, test results, doctor and specialist visits, and healthcare treatments.

This study helps different health sectors and clinics by suggesting a way for integrating their health information systems. This integration framework can solve the above stated problems by introducing smooth and clear way of integrating patient information record of different hospitals by using TOGAF tools for data collection and requirements gathering.

This study will add knowledge of how the existing HIS are characterized by evaluating different HIS of different health sectors. The study turned as initiation for a future study by showing on what level the HIS integration is found in Ethiopia.

1.6 Scope and Limitation of the study

The scope of this study ranges in designing the integrated patient record system of two private hospitals in Addis Ababa namely Girum General Hospital and Kadisco General Hospital, Initiated by the problem of patient information inaccessibility in an integrated way for different health sectors. Health information systems of the two hospitals were used as a source of data as well as structure and organization of their health information system is input for the study. The open group architecture framework (TOGAF) approaches is used in integrating the patient information record system.

Most of Ethiopian hospitals mainly (governments) are not in progress using HIS and because of this insufficient sample size of hospitals were faced as limitation of the study. Limited access to data was also another limitation to the study, the cause is information of hospitals information system is very sensitive and hospitals are not willing to share the information. Lack of much previous research studies on health information integration by using the open group architecture framework (TOGAF) has been another limitation of the study.

1.7 Justification of the study

TOGAF architecture describes the building blocks that make up the whole information system. It provides a plan from which products can be procured, and systems developed that will work together to implement the overall system. It thus enables hospitals to identify the parts which obstruct them not to integrate.

TOGAF architecture also assures to business survival and success for the hospitals, and thus enables effective management and exploitation of information to the management team.

The needs of the hospitals for an integrated IT strategy are assured, allowing the closest possible cooperation across the extended hospital enterprise. And thus it enables public health information from one hospital to be used in other hospital. Patients can also get good service and they have their health information report with them as making report will be simple with TOGAF architecture. Hospitals can also save their time of making patient recording profile as they can access from one whole database.

TOGAF also enables improved interoperability and easier system and network management and thus repetition of data collection and reporting can be solved and the surveillance system will have clear report

TOGAF architecture permits to achieve the right balance between IT efficiency and business innovation and thus enables managed innovation within the hospitals.

1.8 Organization of the study

The study has been organized by using TOGAF reporting procedure. The existing HIS of the two hospitals are discussed and evaluated by using different TOGAF catalogs. The current status of the main architectures (business, data, application and technology) has been presented and the target architectures are designed. The gap analysis is performed for each baseline and target architecture. The gap analysis result found is an input to design an integrated patient record system of both hospitals. The integrated patient record system is designed and an evaluation is performed to see the confirmation of the integrated framework.

CHAPTER TWO

2. Literature Review

This chapter covers both theoretical and empirical literature review on health information record system; systems integration, the integration of the medical record systems; different enterprise architectures which help to develop the integration of patient information record and TOGAF as an integration methodology.

2.1 Health information systems

HIS is "any form of structured repository of data, information, or knowledge that can be used to support health care delivery or to promote health development" Penerai, (2000). This definition is of relatively little value as the term HIS is widely used to include applications that are not immediately related to health development, such as computerized hospital billing systems and human resource management system.

As it has been described on the report of OECD guideline, Complete and consistent information is the basis of decision-making across all health system building blocks. It is essential for health system policy development and implementation, governance and regulation, health research, human resources development, health education and training, service delivery and financing.

HIS is sometimes equated with monitoring and evaluation. In addition to being essential for monitoring and evaluation, the information system also serves broader objectives, such as giving an alert and early warning capability, supporting patient and health facility management, enabling planning, underpinning and stimulating research, permitting health situation and trends analyses, orienting global reporting, and reinforcing communication of health challenges to diverse users. Information is of little value if it is not available in formats that meet the needs of multiple users, i.e. policy-makers, planners, managers, health-care providers, communities and individuals. Dissemination and communication are therefore essential attributes of the health information system WHO, (2008)

The above paragraph describes that information is the very basis for the occurrence of HIS. The information in this context then would be the patient's information which mostly kept in computer as automated form and also in different form paper in manual systems. Different scholars have defined patient record system differently. Perreault, Shortliffe, & Fagan, (1991) , Defined patient record system as "a repository of electronically maintained information about an individual's life time health status and health care". The computer-based patient record system may be linked with different information

management tool to provide clinical notices; it can also be linked with knowledge sources for health care decision support and collective data for further analysis.

According to Perreault, Shortliffe, & Fagan, (1991) origin of patient record system goes back to the first records of cause and mortality in the 18th century. Surprisingly it precedes the computer technology by 200 years. Even though most HIS are running on computer currently it is necessary to see HIS is different from simple data on computer as its conceptual structure is different. In the 19th century, physicians began keeping little organized notes of their patient's diseases, and how they had treated them. And in the 1940s, hospital- accrediting bodies in the USA began to insist on the availability of accurate, well organized medical records as a condition for accreditation. From these two scholars preview of history of patient information record we can understand that it emerged around the 19th century and it was mostly text based, therefore and difficult to analyze.

Nowadays patient record system is being widely used in most countries including the developing countries. According to Dick & steen, (1997), Patient record is the principal repository for information concerning patient's health care. It touches everyone affected with providing receiving the healthcare services. Patient record system is the set of components that form the mechanism by which patient records are created, used, stored and retrieved. It is mainly located within the health care provider or mostly hospitals. Patient record system totally includes people, data, rules, procedures, process, storage devices, communication and support facilities. This definition of patient record system will be used through the study as it is found to cover the detailed meaning of patient record system.

2.2 System Integration

The White Paper on Integration Basics by Walsh, (2018) defines integration as "the process of inter-connecting one system with another system in order to provide a useful exchange of information, data and/or control between the systems". Systems integration is a process whereby a unified system is created from components that were not specifically designed to work together this mean that the parts that make an integrated system have their own right. The report also tells that a successful integration is one that meets the system owner's needs in the most cost-effective way. And this need can be achieved by using the existing capabilities of the systems involved. Developing system integration can be a complex and costly process if its necessity is not certain. The reports in its finding, the integration rule of thumb, show that system integration project should be started by identifying and evaluating the requirements for the integration.

Integrating different/ independent information system has different advantages Stouten & Rousseau, (2018). The first and most advantage is that it helps any company to save time and money for its function. Stouten & Rousseau, (2018) has identified four major benefits an integrated system can give for an organization. The first benefit is that it enables organizational change readiness by making it remain competitive and ensuring the systems future as possible. Integrated information system also creates improved data accuracy by reducing the need to duplicate data entry in multiple systems. Integrated information system also increases productivity of the organization as it helps employees to achieve task faster and make the decision-making process ease. It enhances employee communication and collaboration which in turn helps to increase productivity and share needed information in the needed time. According to Stouten & Rousseau, (2018) the last but no least advantage of an integrated information system is creating a real time visibility of needed information.

2.3 Patient record system integration

Many countries such as Ethiopia and Kenya are struggling on how to make multiple information systems across the health care domain "speak the same language." This ability of applications and systems to connect and share health information to interoperate supports important capabilities, including continuity of care, health system management and surveillance, and the financial transaction processing needed to support united health care and monitor progress of its initiatives (Ritz, Althauser, & Wilson, 2014).

Health care providers and facilities are not until now using electronic information systems in many countries. In this condition, integration among systems may, not be an initial concern. However, as the use of ICT certainly grows and the cost to a nation for supporting united health care grows, system-to-system interoperability more and more becomes a concern for all the providers, patients, payers, and policy makers who need data from information systems to monitor and manage health services. By establishing a standards-based approach early in the process, a network effect can be created that reveals value from the many individual, disparate investments in E-health and M-health (Ritz, Althauser, & Wilson, 2014).

In the concept of HIS integration there is a crucial point that must be valued: there is no interoperability without standards. Even though some might argue that a point-to-point integration between two systems can be implemented without either party adopting standards and this is true. Interoperability, however, can be thought of as many-to-many integration where the integrating parties do not know ahead of time with whom they will be connecting. To do this, there must first be an arrangement regarding how the connectivity will be achieved. This pre-agreement is accomplished by the adoption of standards (Hesp, 2015).

As a primary aim of all healthcare organizations is to provide cost effective, high-quality, shared and seamless healthcare delivery and to reduce medical errors, safeguard patients' data and streamline clinical and administrative tasks; these aims are more easily achieved through the integration of hospital information systems that helps to easily manage healthcare data and processes (Hesp, 2015).

One of the main issues impacting on healthcare organizations' ability to achieve these aims is the large number of disparate and heterogeneous information systems that are characteristic of this domain. Many of these information systems have been designed and developed by different vendors to support specific processes in individual departments. This ad-hoc approach has resulted in the healthcare domain being left with keys of technologies and created independent information systems that are hard to integrate. "These islands of information systems have a number of drawbacks that affect healthcare organizations. Because there is no sharing of data or process, each system stores and manages its own data. The resulting process and data redundancy lead to data integrity problems. In turn, this reduces the effectiveness of the data for decision-making and analysis. This also leads to high operational costs caused by increased maintenance requirements" (Sabooniha, Toohey, & Lee, 2012).

Information communication technologies are making a strong and powerful existence in the diverse fields of health. However, Integration and development of information and communication systems in different fields of health is a challenging task Due to a very sensitive nature of medical information, such systems are faced with a number of stringent requirements, like security and confidentiality of patients' related data, different media types management, diversity of medical data that need to be processed etc. (Katehakis, Sfakianakis, Tsiknakis, & Orphanoudakis, 2001).

People have parts of their medical record located in all the places where clinical services have been applied to them (e.g. in community doctors, primary care, and secondary care). All these segments, which are related to personal healthcare delivery and well-being, reside in disparate and in most cases not directly accessible places. Despite the fact that today the World Wide Web (WWW) provides the means for global access to all kinds of information, personal health information still remains fragmented, and not directly accessible in a unified way. Depending on this fact the study will try to integrate the patient record system of our country Ethiopia to address those problems

2.4 Enterprise architecture for health crae organization

Enterprise architecture (EA) has been defriend differently by different scholars. As a root definition enterprise architecture is a method or produce that links business and information technology (IT). In the same context, Kamran, (2016) argued that Enterprise architecture is a tool that generates a linking between business functions and information technology. It is also a tool for the plan of actions; the main task of EA is to describe the layout of an organization's components and relationships among them as

well as to align IT and Business (Kamran, 2016). Enterprise architecture offers rules for decision making within an organization. EA can also perform radical changes in a firm; the intention of EA is to offer a big picture about how business functions and IT work combine within a framework. The goal of EA is to improve managerial decision by coordinating the different bodies of the organization as technology, business functions and operational functions.

Enterprise architectural framework is an instrument which is used to design IT architecture, logical structure and organizing complex information of organization. This intention and goal of enterprise architecture is achieved because EA provides environment for software, network and hardware to work jointly (Sajid & Ahsan, 2016).

EA describes the methods for designing health information systems in terms of a well-defined set of building blocks, and showing how the building blocks fit together and how the communication between the building blocks can be achieved. EA approach can also be used to simplify the complexity of health information systems by allowing for important interrelationships to be identified, including which components need to be aligned to which parts and in so doing reduce the risks and incentives of fragmentation, duplication, and lack of interoperability (Mwanyika, 2014).

There are many architecture frameworks which are used in development of organization's enterprise architecture, four top architecture frameworks that are discussed in different literatures are the following.

The Zach man Framework for Enterprise Architecture is one of the pioneers of enterprise architecture. It suggests a logical structure to categorize and comprise the detailed description of organization. A basic intention of the Zach man framework is to bring an infrastructure which helps the enterprise in developing, integration, design, management and access organization's information system. This framework concern with information technology in organization and usually represent as a 6 x 6 matrix. In which rows show perspective such as Scope (Planer), Enterprise Model (owner), System Model (designer), Technology Model (builder), Detailed Representations, Functioning Enterprise (Subcontractor)) and columns represent six basic questions (What, How, Where, Who, When, Why) in the scenario of perspective (Sajid & Ahsan, 2016)

Another study by Urbaczewski & Mrdalj, (2006) supports the above idea by describing that ZFAE provides a way of organizing artifacts (design documents, specifications and models) in two dimensions the first dimension is based on six perspectives or views: Planner, Owner, Designer, Builder, Subcontractor, and User. The second dimension is based on the descriptive focus of the artifacts: what, how, where, who, when, why.

The Federal Enterprise Architecture Framework (FEAF) took a perspective that an enterprise is built by segments and a segment is a major line-of-business functionality. These segments are developed individually and considered to be their own enterprise within federal enterprise. There are two types of segments; core-mission-area segments and business services segments (Urbaczewski & Mrdalj, 2006).
According to Sajid & Ahsan, (2016), FEAF is developed by employing the classification of five models which are for references namely (a) the Performance Reference (b) a Business Reference, (c) A Service component reference, (d) Data Reference, and (e) Technical Reference Model. This framework facilitates U.S. Federal Agencies to share information and design common process between other agencies. The FEAF also focus on functional roles and EA core team member's responsibilities.

Treasury Enterprise Architecture Framework (TEAF) is inspired with Zach man Framework and assists Treasury's business activity. TEAF provide guideline for developing and redesign business methods for different departments in order to fulfill requirements of modern legislation in an expeditiously changing technology environment. TEAF describes four basic activities (i) enterprise architecture strategy (ii) enterprise architecture management process (iii) enterprise architecture approach (iv)development of enterprise architecture repository (Sajid & Ahsan, 2016).

The Open Group Architectural Framework (TOGAF) is based on "United State Defense Department Technical Architecture Framework" for Information Management and introduced in 1995. Any organization can use TOGAF freely to design enterprise architecture as it is publicly available and free to use. TOGAF enable any organization to evaluate and build the right architecture. It is divided into four categories as follows, according to Sajid & Ahsan, (2016):

- **Business architecture** - describes the processes the business uses to meet its goals
- **Application architecture** - describes how specific applications are designed and how they interact with each other
- **Data Architecture** - describes how the enterprise data sources are organized and Accessed
- **Technical Architecture** - describes the hardware and software infrastructure that applications and their interactions

2.5 Comparison of major enterprise architectures

There are many architecture frameworks that are used in the development of organization's enterprise architecture, but in this study the two mostly used and accepted enterprise architectures TOGAF and ZEAF were compared.

The Open Group Architecture Framework (TOGAF) is an enterprise architecture methodology that offers a high-level framework for enterprise software development TOGAF helps organize the development

process through a systematic approach aimed at reducing errors, maintaining timelines, staying on budget and aligning IT with business units to produce quality results. Like other IT management frameworks, TOGAF helps businesses align IT goals with overall business goals, while helping to organize cross departmental IT efforts (Chaczko, Kohli, Klempous, & Nikodem, 2010). TOGAF helps businesses define and organize requirements before a project starts, keeping the process moving quickly with few errors. Because of these characteristics of TOGAF it is expected to be the choice for designing an integrated information system for different hospitals by broadening the idea that TOGAF helps to organize cross departmental IT efforts. TOGAF has different business benefits by helping organizations implement software technology in a structured and organized way, with a focus on governance and meeting business objectives. Software development relies on collaboration between multiple departments and business units both inside and outside of IT, and TOGAF helps address any issues around getting key stakeholders on the same page. Other "advantage of using TOGAF is that The Architecture Development Method (ADM) is at the heart of TOGAF which helps businesses establish a process around the lifecycle of enterprise architecture" (Chaczko, Kohli, Klempous, & Nikodem, 2010). So the researcher can easily design an architecture based on the life cycle of TOGAF enterprise architecture. The ADM can also be adapted and customized to a specific organizational need, which can then help inform the business's approach to information architecture.

Zach man enterprise architecture Framework **(**ZEAF**)** suggests a logical structure to categorize, arrange and depict the detailed picture of a firm. According to Sajid & Ahsan, (2016) "A primary objective of the Zach man framework is to create an infrastructure that supports a firm or organization in developing, integration, design, management and access organization's information system" The Zach man framework concerns IT in an organization or firm and is normally depicted in six rows and six columns. The rows show perspective, such as Planer (Scope), owner (Enterprise Model), designer (System Model), builder (Technology Model), Subcontractor (Detailed Representations), Actual System (Functioning Enterprise) and the columns represent six basic questions (What, How, Where, Who, When, Why) in the scenario of perspective (Muhammad and Kamran, 2016).

The above two major enterprise architectures were compared based on their structure and other criteria. Zachman Enterprise Architecture's segments are independent and there is no continuity between the cells. There is also no solution suggested for the continuity of the cells. This in turn causes difficulty in understanding how the structure interacts with each other. The Zachman framework does not address semantic behavior and that's why it is failing to determine behavior's effectiveness of the interactions and functioning of components. There are no clear rules or principles defined in the Zach man framework.

TOGAF has advantages when compared with Zach man framework (Sajid and Ahsan, 2015). The advantages are listed as follows:

I. It provides verified methods; these methods are developed by comprehensive research.
II. It provides shared vocabulary and that's why everyone can read and understand information in organizations.
III. It gives a visual representation to business concepts.
IV. It provides knowledge about an organization and enables managers to make better informed decisions.
V. It ensures that IT solutions are aligned to the needs of the business.
VI. It increases data sharing, enhanced reliability of the solutions as well as easier maintenance.

In their study of selecting better enterprise architecture for knowledge based medical diagnosis system, Sajid & Ahsan (2015), compare TOGAF and ZEAF based on different criteria's. The first criteria contain nine points as shown in table 2.1.

Criteria	**TOGAF**	**ZEAF**
Methodology to categorize the different architectural artifacts	Poor	Good
Methodology to guide a step-by-step process for designing EA	Good	Poor
Instructions for building a set of reference models	Good	Poor
Focus on a technology that reduced expenses and increased income	Good	Poor
Practice guidance	Good	Poor
Governance guidance	Good	Poor
Guidance on effective autonomous separate sections of the organization which is used for managing complexity	Good	Poor
Catalogue management about architectural assets that can be reused in future	Good	Poor
Information availability	Good	Poor

Table 2.1 The TOGAF and ZEAF comparison Sajid & Ahsan (2015)

As we can see from the above table TOGAF found to be good in eight points and ZEAF was found to be poor on eight points and good in one criteria.

The other comparison criteria also contained nine points and the criteria are listed as follows according to (Muhammad and Kamran, 2016).

Criteria	TOGAF	ZEAF
Definition of Architecture and Understanding	Fully supports	Partially support
Process of Architecture	Fully supports	No support
Evolution of Architecture Support	Fully supports	No support
Standardization	Fully supports	No support
Knowledge-Based Architecture	Fully supports	No support
Drivers of Business	Fully supports	Partially support
Model of Business	Fully supports	Fully supports
Visualization tool	Fully supports	Fully supports

Table 2.2 The TOGAF and ZEAF comparison Muhammad and Kamran (2016)

Here from the above table we can see that the TOGAF secures 8 numbers in Full Support while the ZEAF secures only 2 numbers.

From these two comparisons one can easily understand that TOGAF is the best enterprise architecture for developing an integration prototype for case of our countries hospital by enabling the researcher to develop best architecture by following the lifecycle of TOGAF.

TOGAF life cycle contains eight phases to design an architecture framework. The preliminary phase is just the initiation phase where architecture overview is set. The architecture vision is the first phase of TOGAF life cycle in which the architecture principle and vision is set. The second phase is the business architecture which defines business principles and business goals of organizations. Information system architecture covers the road map of the architecture. Technology architecture is the fourth phase of TOGAF life cycle that set technology architecture of an organization. Opportunities and solutions present the implementation and migration plan for the organization. Migration planning sets request for architecture work. Implementation governance phase defines solution building blocks. And the last phase of TOGAF change management phase represents requirement impact assessment.

2.6 Related works

Most studies on HIS integration focuses on how hospitals can have computer based and smart system to ease their work. There are also many studies focusing on how enterprise architecture can be used to implement HIS, its interoperability and integration. Most of the studies suggest that TOGAF is the most appropriate framework for hospitals. Though there are no studies that used TOGAF EA as methodology to develop patient information system integration in our country, there are studies that are conducted

internationally. Bobarshad, Saghafi, & Rezaei (2018), on their article entitled "Hospital enterprise architecture framework", described "the process of creating a TOGAF Enterprise architecture framework, for hospital starts with recognizing the present original situation of the hospital, and it all continues with designing a long-term plan in which there is a way to achieving all the objectives of a Hospital". The scholars argued that, TOGAF defines a hospital as a set of units which have common aims, and it also creates a logical structure for classifying and organizing complicated information and it also explains different perspectives.

Bobarshad, Saghafi, & Rezaei, (2018), used exploratory research method and survey in case as strategy in the first place. The study was organized in four stages. In the first step, the framework was chosen according to implementation capability then recognizing and choosing the best common characteristics for hospital enterprise architecture framework takes place and in the third step they choose the best hospital enterprise architecture framework which is found to be TOGAF. Lastly they presented TOGAF conceptual model.

In the conceptual framework, hospital has its perspective, driver, a strategy, standards, and capabilities which are the TOGAF inputs. The necessary Components for every input in this framework extracted from Dr. Shariati hospital and desirable situation analysis of other hospitals in other countries examining observation on the steady existing situation and then it was customized in accordance with existing conditions of Dr. Shariati hospital.

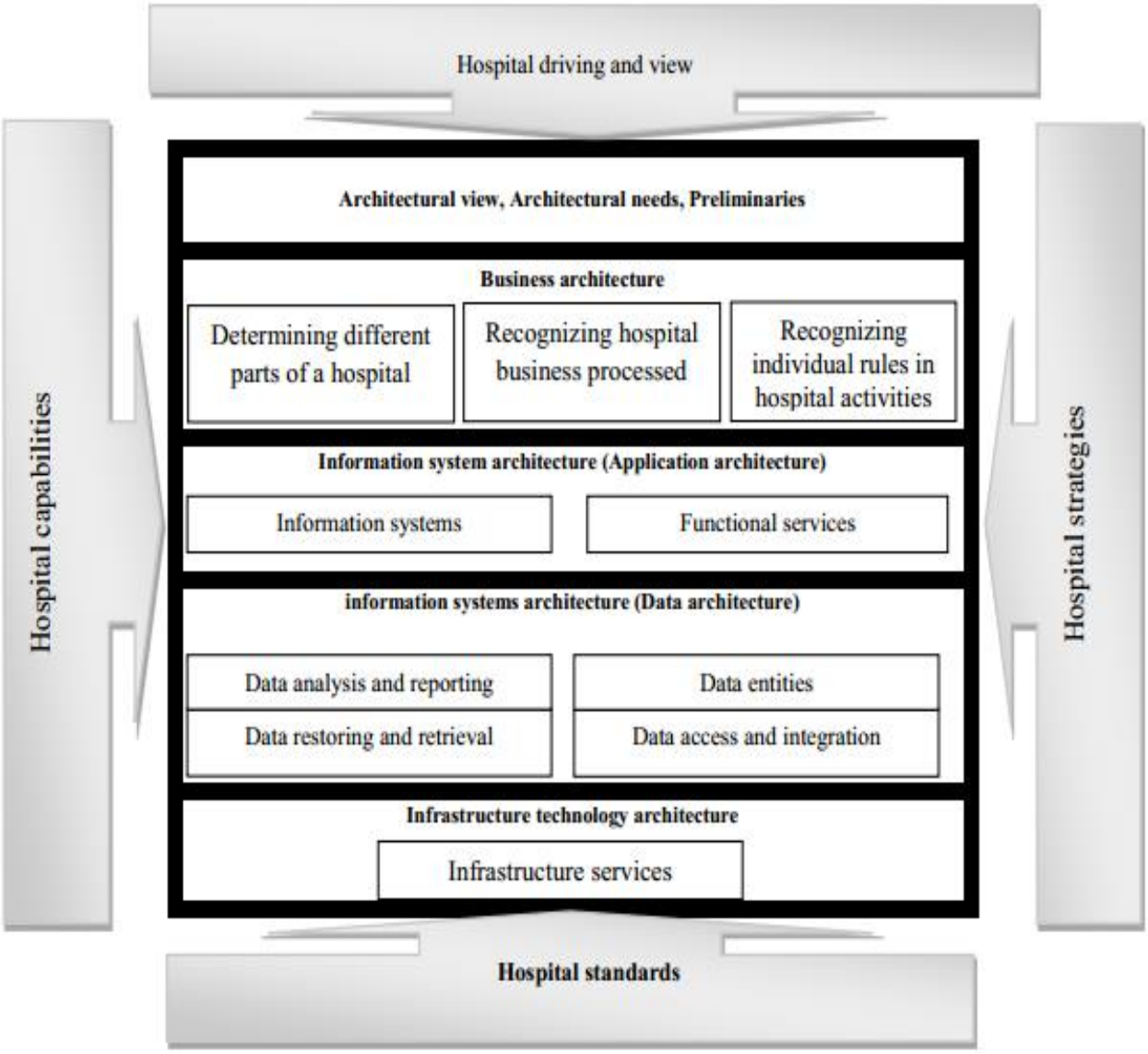


Figure 2.1 General content of TOGAF conceptual framework in the hospital (Bobarshad, Saghafi and Rezaei, 2018)

This TOGAF conceptual framework presented by Bobarshad, Saghafi, & Rezaei (2018), includes the four main layers of enterprise architecture. Business architecture: the highest level of an architecture Enterprise which aims at recognizing and describing operational areas, operational lines, and Enterprise's responsibilities; The layer of application of information system: which involves job processes, Information Systems, applications and system's interaction methods; Information system (data) architectural layer**:** which responsible for describing information headlines, data's logical models, and

physical models; Technological infrastructure of the architectural layer: technical reference and Technical standards of models which should be considered in Enterprise.

One of the findings of this research was introducing TOGAF as a framework with the highest appropriateness with hospital's procedures in mind. Since having access to all details and information of this framework is possible, it can be understood and implemented easily. It is also supportable by architectural modeling tools and can be updated and customized in the field of Hospital it can also be used for health information systems integration. As one can define and create base line business architecture by reviewing the different business vision of different hospitals.

The gap from this study was, the study tries to show that TOGAF can be used for hospital information system integration and development theoretically. It does not show how to use each phases of TOGAF in designing an integrated HIS fro different hospitals.

The researchers, Chaczko, Kohli, Klempous, & Nikodem, (2010), tried to deliver an approach in architecting solutions which can be utilized as framework to address common issues in integration of enterprise level solutions. They used TOGAF version as methodology to demonstrate the feasibility of proposed solution**.** They firstly aimed at building a new IT Integration Platform/framework that would be able to respond to new business demands of the organization (Hospitals/Medical facilities) for the future (Scalability/new applications/new devices/ more users). Then they designed the architectural model by defining what the architecture would continue and does. The next step they jump to was defining the business model of the architecture by identifying different users of the integrated system and client system to be integrated. They developed integrated information system architecture as follows.

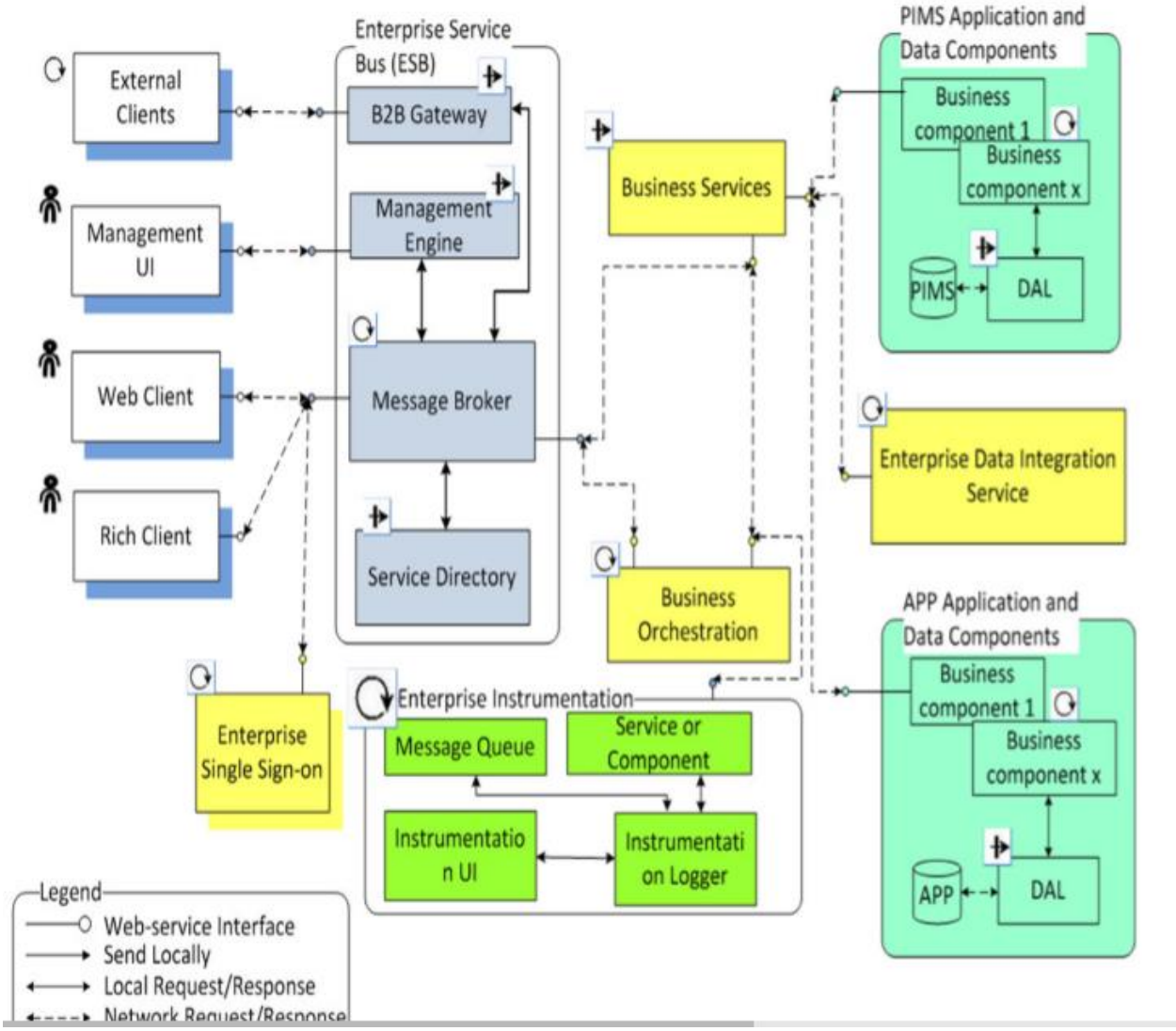


Figure 2.2 Conceptual hospital system integration architecture (Chaczko, Kohli, Klempous, & Nikodem, 2010)

They designed the database to be a combination of the Database Components of all the smart hospital system applications installed in the system. The Application Components of all the smart hospital system applications deployed are hosted on SHS Application Servers which have an agent each. Each agent knows the SHS Application Components that are available on the server. Then they evaluated the technology architecture by cross checking the reviews/pros/cons/stability from various accompanying documentation and blogs by originators. They presented the opportunities and solutions by the integration solution can be viewed in form of core quality attributes, which can be considered: performance, usability, reliability and security. They also set implementation governance which covers the management and control of all aspects of the development and evolution of enterprise architectures and other

architectures within the enterprise. Lastly they set migration planning and architecture change management.

Researchers Chaczko, Kohli, Klempous, & Nikodem, (2010) were able to design TOGAF based Integration framework that enables fast and efficient enough to be able to simultaneously service several hospitals and mobile units in geographically diverse areas of the country (Austria). This way of solving an integration problem of patient information system in our country can be followed as it can play very great role for our countries health care organizations.

The gap from this study was, it focused on integrating the data architectures of different hospitals. But it will be feasible if organizations are integrated from their beginning (from the business strategy and idea)

The study by Azanfack & Soriyan,(2011) titled as "Integration of Patient Information System with Picture Archiving and Communication System through Radiology Information System platform: case of OAUTHC" used an interview to identify the basic requirements for designing the integrated system. After identifying the requirement for the designing the integrated system, they classified the integration process in to four steps. In the first step they evaluated the existing system by examining the application architecture and technical infrastructure of existing systems to determine or identify the functionality that must be shared. On their second step of integration process they designed/developed the integration model thirdly they selected technology and technical standard adoption and on the last step they specified their technical interface.

By using those steps Azanfack & Soriyan, (2011) followed the agile method for System Development Life Cycle and Digital Imaging and Communications in Medicine (DICOM) and the Health Level 7 (HL7) messaging technology were employed for the interface and medical images viewed from the PACS. Then they propose the integration framework they developed which looks like the following.

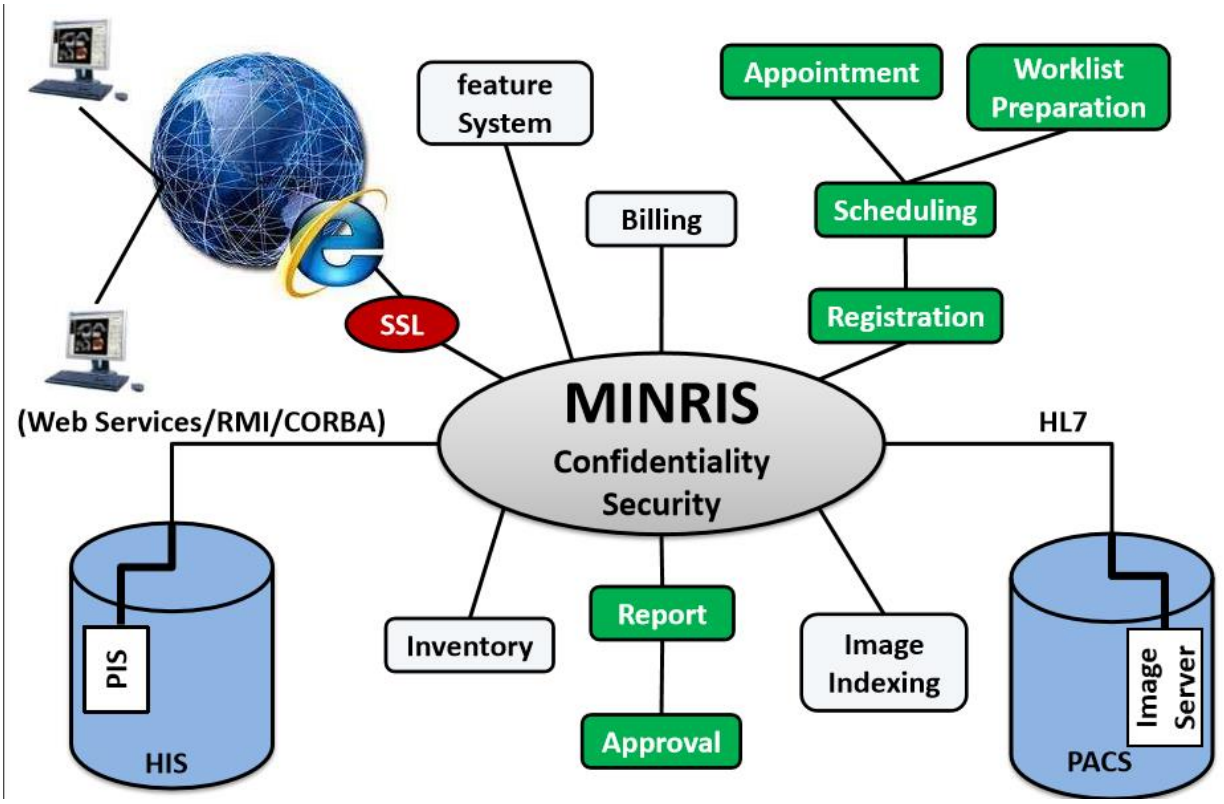


Figure 2.3 health information system integration framework (Chaczko, Kohli, Klempous, & Nikodem, 2010)

From this integration framework they were able to conclude that, the system allows the user to work in a consistent environment without switching between applications and also the system will respond quickly to the needs of imaging specialties and help clinicians in their decision process.

The gap of the study is, the study presented an integration framework that can be used by the health professional of the hospital only. It does not support report generation for external user of the report from the hospitals. It also does not support patient information access by patients themselves.

In the article entitled "Using TOGAF for Building a National Implementation Strategy for E-Health Services and Technologies in Burundi" Verbeke, Nyssen, Kaze, & Mugisho, (2015) has tried to show how an industrial framework like TOGAF can be used to provide a reliable estimation of the existing human and material resources and issues related to health information management in Burundi. Their study used the main four sub architecture of the TOGAF namely, business architecture, application architecture, data architecture and technology architecture. In their study Verbeke, Nyssen, Kaze, & Mugisho, (2015) first Analyzed the regulatory documents and strategic plans related to the Burundian

health system. Then field visits and semi-structured interviews were organized with a sample of relevant structures of the MoH of their country.

By using the TOGAF methodology simplifying it to their use, they found it an appropriate instruments to quantitatively and qualitatively describe the status of health ICT tools deployment in the health sector of a low-resource country like Burundi.

The gap from this study is that, the research shows the theoretical usage of TOGAF for designing implementation strategy for E- health. It does not present how hospitals can use this enterprise architecture for organizing their existing system and how they can integrate their system.

As we can see from the above works integrating HIS are done theoretically by setting TOGAF is the best enterprise architecture to be used in hospitals system integration and development. They also used different methodologies; thus, this study tries to show how TOGAF as a methodology can be used in Ethiopian hospitals to design and integrate patient information system. So the study added new knowledge and way on integrating an information system of different health organizations. It also plays its very role for future studies on the area.

CHAPTER THREE

3. Methodology

To make this study successful the open group enterprise architecture framework (TOGAF) is employed as a methodology. TOGAF supports the idea of integrating patient information record in HIS of different hospitals in that it supports in less rework on the present systems to fit in to the newly developed framework. According to Chaczko et al.,_(-2007), TOGAF also provides flatter transition of the system from the direct role of an application integration framework for legacy systems to its eventual role as pure system integration framework. TOGAF framework will also encounter business case requirements so; it will allow the existing patient information record systems to be open for feature rich front end which in turn provides secure interfaces. So, this study is presented by employing the whole life cycle of TOGAF enterprise architecture

3.1 The open group architecture framework (TOGAF)

TOGAF is based on "United States Defense Department Technical Architecture Framework". The TOGAF was introduced in 1995 for information management. It is a generic framework and, for this reason, any firm may employ the TOGAF freely to design EA (Sajid & Ahsan, 2016). TOGAF enables any organization to evaluate and build their appropriate architecture. The TOGAF is split in to four categories

i) Business architecture: it explains the method of a business to achieve its objective. It also provides an overview of different parts of the organization and the relation between them.
ii) Data architecture explains methods of data storage and retrieval.
iii) Application architecture de0als with the development of different applications and the interaction between them.
iv) Technical architecture explains how software and hardware infrastructure support various applications and their relations.

Figure 3.1 lifecycle of TOGAF enterprise architecture (The Open Group, 2011)

As we can see from the above Figure 3.1 TOGAF architecture has eight main phases which help to design best architecture for any enterprise organization. On the preliminary phase The Principles catalog which captures principles of the business and architecture principles that describe what a "good" solution or architecture should look like will be drawn as a startup.

3.2 Stages in TOGAF

As it has been described above the life cycle or stages of the open group architecture framework is used as a method to develop patient information record system of hospitals integration framework. Different activities are performed in the stages of TOGAF. Each of TOGAF phases are used to organize and analyze data collected through interview an output of each phase is used to design the patient information record system integration.

3.2.1 Preliminary Phase

This preliminary phase is about defining "How we do Architecture" in the enterprise concerned. There are two main aspects: defining the framework to be used; and defining the architecture principles that will inform any architecture work. This phase is used in the study as data organization and startup the study.

3.2.2Architecture vision

In this very first stage of TOGAF the architecture vision is identified and set. The objective of this stage is to define the scope of and to identify and prioritize the component of the baseline architecture effort, to define the relevant stakeholders and their concern and objectives, to define the key business requirements to be addressed in the architecture effort and the constraints that must be dealt with and to articulate an architecture vision that demonstrate response to those requirements and constraints. This setting of architecture vision is done depending on the information that is collected from the existing system of hospitals information system by using TOGAF data collection instruments. Key steps in this phase are: establishing the project by conducting the necessary procedures to secure enterprise wide recognition of the project, Identify the hospitals goal and the business driver, Review the architecture principle, Define the scope (what is inside and outside the scope of the baseline architecture), Define the constraints that must deal with, Identify stakeholders and concerns and finally develop statement of the architecture work. In this phase Stakeholder Map Matrix Value Chain Diagram and Solution Concept Diagram are used as tool to collect necessary information and design the architecture vision. This stage of TOGAF is presented as data collection step. Observation was used to identify the gap and problem for the study. The researcher also employs an interview to collect the business vision of hospitals and there is also document analysis to see how the patient information is kept and recorded in different hospitals. The collected data is then analyzed by using TOGAF data analysis tools and the integration framework for the two hospitals was designed by using TOGAF.

3.2.3Business Architecture

In this stage of TOGAF the business architecture is designed the objective of this stage is to describe the baseline business architecture, to develop target business architecture, describe the product and organizational process, to analyze the gaps between the baseline and target business architectures, to select the relevant tools and techniques used in the association with the selected viewpoints. Knowledge of the business architecture is a prerequisite for architecture work in the other domains (data, application and technology), and so it is the first architecture activity that needs to be undertaken therefore the business architecture (baseline and target) of both hospitals are identified and described by using catalogs such us (organization catalog and role catalog) and business interaction matrix.

3.2.4Data Architecture

In this phase the data architecture (both baseline and target data architectures) are designed by defining data entity catalog, diagrams (like class diagram and data dissemination diagrams) and data entity matrix. The objective of this phase is to develop the target architecture that enables business architecture and architecture vision while addressing the request for architecture work and stakeholder concerns, to identify candidate architecture roadmap components based up on gaps between the baseline and the target data architectures, to define major types and sources of data necessary to support the business in way that is understandable by stakeholders, complete and consistent and stable. The steps in this phase include: creating data architecture models, selecting the data architecture building block, conduct checkpoint review of the architecture model, review qualitative criteria, complete the data architecture, conduct checkpoint/impact analysis, perform gap analysis and create report. So in this step based on the business architecture the data architecture is designed by taking the data from the hospitals.

3.2.5Technology architecture

In this phase of TOGAF the technology architecture is designed that forms the basis for the implementation work by identifying catalog (Technology Standards catalog and Technology Portfolio catalog), Technology matrix and different diagrams (Environments and Locations diagram, Platform Decomposition diagram). The key steps of this phase includes: developing baseline technology architecture description to convert the description of the existing system in to services terminology using the organizations architecture, developing target technology architecture to perform an analysis of the technology architecture from number of different concerns(requirements)/ viewpoints and to document each relevant viewpoints.

3.2.6Opportunities & Solutions

The objective of this phase is to evaluate and select among the implementation options identified in the development of the various target architectures, to identify the strategic parameters for change and the top-level work packages or projects to be undertaken in moving from the current environment to the target, to assess the dependencies costs and benefits of the various projects, to generate an overall implementation and migration strategy and detailed implementation plan. The key steps in this phase include: identifying key business drivers constraining sequence of implementation for example: introduction of new customer service, reviewing gap analysis from the technology architecture phase, brainstorming technical requirements from functional perspective, brainstorming co-existence and interoperability requirements, perform architecture assessment and gap analysis and identifying major work packages or projects. In this phase the implementation description has been made depending on the

architecture review, the hardware and software facilities has been identified and the performance monitoring has been done which brought an improved data accessibility.

3.2.7 Requirement management

In this phase of TOGAF things that the enterprise needs to do to meet its objectives are done and the requirements generated from architecture engagements are typically implemented through change initiatives identified and scoped in Phase E. The objective of this phase is to provide a process to manage architecture requirements throughout the phases of the ADM cycle, to identify requirements for the enterprise store them and feed them in and out of the relevant ADM phases which dispose of address and prioritize requirements. The key steps in this phase included: identifying document requirements, baseline requirements, monitoring baseline requirements, identifying changed requirement ;remove, add, modify and re assess priorities, identifying changed requirement and record priorities; identify and resolve conflicts, generate requirement impact statements, assessing impact of changed requirement on current and previous ADM phases, updating requirements repository and finally assessing and revising gap analysis for past phases.

3.5 Sampling

The purposive sampling has been used throughout the study. As it's known even though their work style differs hospitals main aim is to give health services for patients. So depending on these idea two private hospitals has been selected form Addis Ababa Girum General Hospital and Kadisco General Hospital. The reason for choosing private hospital is that most of government hospitals in our country do not have their own health information system installed yet it is also difficult to get organized information from government hospitals as it does not have well organized information system. Both Hospitals follow the same business strategy and their work process is the same so the study can begin with these hospitals to show how TOGAF can be used to integrate HIS of different and other hospitals can use the framework by customizing according to their needs.

3.6Data collection

The main data collection instrument in this study were an interview and observation of how HIS functions. Data has been collected from two main hospital parts, the administrative staff and the health information expertise (ICT) staff. Two of the hospitals have well-structured health information system. These are Kadisco General Hospital and Girum General Hospital.

One administrative staff, one HIS administrator, two users of the system (one doctor and one nurse) from each hospital has been interviewed (the interview checklist is attached below in the appendix) regarding

the use of computerized HIS. Therefore, a total of eight people were interviewed from these two hospitals.

3.7 Evaluation

In the evaluation step the researcher has to observe and measure how well the artifact supports a solution to the problem. Evaluation refers to the observation and measurement of how well the artifact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from use of the artifact in the demonstration. In this study the methodologies and technologies for integrating HIS are evaluated before the implementation of the integration.

CHAPTER FOUR

4. Results

This chapter presents and interpreted the information collected on the current hospitals health information system. The main parts of information collection deals with the function, structure, the vision and mission of the hospitals. The purpose of the study is developing Patient Information Record System Integration framework for two private Addis Ababa Hospitals by employing TOGAF as tool and methodology.

The data collected from the interview has been analyzed by using TOGAF data analysis tool (Archimate) which helps to design any enterprise architecture by employing the open group architecture framework. It enables the researcher by converting the data collected form the interview in to meaning full information and designs.

The report of the result has been organized by fo llowing TOGAF approach. The existing enterprise has been discussed, the architecture vision and principle has been set, the business architecture, data architecture, application architecture, technology architecture of the hospitals has been described for both the baseline and target. The opportunities and solutions with the requirements management has been presented for the target architectures and the summary have been done depending on the gap analysis done between the baseline architecture and the target architecture. A diagram showing how the integrated patient record system looks like has been designed and recommendations have been suggested.

4.1 The preliminary phase

In TOGAF reporting the preliminary phase is the first section that presents the overview of the architecture. It is about defining "where, what, why, who, and how we do architecture" in the enterprise concerned. The main aspects are, Defining the enterprise, Identifying key drivers and elements in the organizational context, defining the requirements for architecture work, Defining the Architecture Principles that will inform any architecture work and Defining the framework to be used.

The enterprise

Two hospitals have been used as an enterprise in this study Kadisco General Hospital and Girum General Hospital. The enterprise wide concept is defined as follows.

4.1.1 Kadisco General Hospital (KGH)

KGH is the sister company of one of the leading paint manufacturing company Kadisco chemical industry, Kadisco group and SMATARA forwarding company. After a long exhausting period of planning and preparation, KADISCO general hospital was inaugurate on May 1 2007 G.C, and commenced to render its services (Admasu, 2020).

Its objectives are mainly oriented to secure the societies health through modern preventive and diagnostic health practices. The hospital building is erected and stretched on a wide flat area in the Gerji region commonly known as 46 mazorya. The hospital is uniquely designed to accommodate a grand entrance with wide reception and corridors, spacious bedrooms and health care units. Wide range of medical equipment units and other facility sections are also available allowing to the following objectives according to (Admasu, 2020):

- ⇨ Maximize comfort of the patients and visitors.
- ⇨ Create a conductive atmosphere, which inspires and enables health.
- ⇨ Efficiently and ethically deliver health services by professionals and other staff members.
- ⇨ Create a space, which accommodates and allow the effective utilization of man power and medical equipment.
- ⇨ Provide Credit facility for companies such as ECA, Banks and insurances etc.
- ⇨ Maintain each space and corners constantly clean etc.

4.1.2Girum General Hospital (GGH)

GGH is a private health facility established in 2007 G.C. by an American medical board certified physician Dr. Girum Berhane and his family with the main objective of introducing the ART and SCIENCE OF MEDICINE to Ethiopia by instituting an efficient hospital management system, a variety of medical specialties, investigating on latest medical devices that enables to offer advanced quality healthcare services in nation to hold the patient referral abroad and hence to create a medical tourism center in Ethiopia in short run (Mikiyas, 2020).

4.1.2.1 Key drivers and elements of KGH

Basic elements in KGH include Hospital administration, Medical staff, Nursing staff, allied health professionals, services and main objective of the hospital.

Hospital administration/ management: are a staff related to leadership management and administration of public health system and hospital networks in the organization. It includes Human resource management, Finance management and the Medical director.

Medical staff: include number of doctors like, specialists, consultants and the resident. Together they manage and assess medical care of the patients. These doctors have role and responsibilities depending on their experience level. Specialists/consultants see patients for specific time; the resident doctor looks after patients on the ward.

Nursing staff: includes groups of nurses like nurses unit manager, nurse practitioner and enrolled nurses that manage most of the ongoing care and treatment for the patients. They asses plan and administer daily treatment and manage general health of the patient.

Allied health professionals: are practitioners who works as a part of multidisciplinary health care team they assess, diagnose and treat conditions and work to prevent diseases. It includes laboratory assistants, occupational therapist and pharmacists.

Services: KGH have five main modules or services. The HMIS (Hospital Management Information System) module contains Reception and other departments that give computerized services to facilitate and speed the work load. It includes Administrative staff, Accounting staff, and Credit follow up team, marketing department, laboratory department, doctors, nurses and radiology departments.

The Human Resource module does not directly deal with patients but it deals with filling employee document, recruiting employee, taking attendance of employee, payroll, management, and also accounting functions within a business.

The finance module is about controlling the overall finance of the hospital and also checks if the patient has paid what is expected in order to get the service needed.

The last module which is inventory works on recording and holding the medical items. Accordingly it takes medicine from suppliers to the store by checking the stock. Nurses also take medical item they need by ordering in this module.

Main objective of KGH is to be the most efficient, competent and courteous provider of comprehensive health care.

4.1.2.2Key drivers and elements of GGH

The main driver and elements of GGH is almost the same as that of KGH they differ on the process they provide. The key elements of GGH are Hospital administration, Medical staff, Nursing staff, allied health professionals, and services according to the website of GGH (Mikiyas, 2020).

Hospital management: are a staff related to leadership management and administration of public health system and hospital networks in the organization. It includes Finance management and the Medical director.

Medical staff: contains groups of doctors who are specialized in some areas and resident doctors to heck up patients.

Nursing staff: is collection of nurses who treat patients daily and collects vital patient information based on their experiences/ specialty.

Allied health professionals are other health professionals that support the health service given by the hospital. It includes laboratory assistances, therapists and pharmacies.

Services: GGH contains six main modules or services under its health information system. Each module contains different works in them.

The registrar module is the same with Reception in Kadisco general hospital. Its main focus is on patient registration and also patient reservation.

Under treatment module there exists out patient service and inpatient service. It is where the patient is identified, if he/she is under outpatient or in patient.

The nursing module is all about the nurse's work. It includes vital data identification; assigning to the right doctor and giving the necessary treatment.

Admission module works with the registrar to approve the patient current status and also clarifying for the patient services.

Report is another module where everybody using the system keeps what has been done under them.

HIS is the hospital information system including all health related service such as; Radiology, laboratory, MRI, CT scan, Ultrasound and pharmacy.

4.1.3Requirements for architecture

The business essentials behind the enterprise architecture work drive the requirements and performance metrics for the architecture work. The hospital organization which is composed of different groups is requirement for developing the architecture.

- ⇨ The Hospital owner: The hospital owner of KGH is Kadisco chemical industry, Kadisco group and SMATARA forwarding company. The owner of GGH is Dr. Girum Berhane and his family.
- ⇨ The management: the hospital management of KGH is formed of three main groups, the hospital admin (medical director), human resource team and the finance team. The management of GGH is formed of the medical director, the hospital administrator and patient care manager.
- ⇨ The employee: in KGH there are among eighteen nurses, fifteen doctors, seven laboratory technicians, three pharmacist, one x-ray expert, two ultrasound experts, and two anesthesia experts. In GGH there are twenty four doctors, twenty nurses, nine laboratory technicians, five pharmacist, one x-ray expert, two ultrasound experts, and two anesthesia experts.
- ⇨ The services: services in KGH are Nursing services, Administrative, Emergency Room, Catering, Surgical, Dermatology, Physio Therapy, Dental, OBY GYN, Orthopedics', Pediatric, Laboratory, ICU, ENT, Pharmacy, Radiology, Urology, Gastro logy, Anesthesia, Breast Clinic and Spinal Neuro Surgery. Services in GGH are adult intensive care, Cardiothoracic surgeon, CT scan, Dermatology, Endoscopy, ENT, Gastro enter ology, general surgery, gynecology & obstetrics, hematology specialist, infectious diseases, internal medicine, interventional cardiologist, mammography, MRI, neonatal intensive care, nephrologists, neurosurgery, oncologist, orthopedics, otorhinolaryngology, pediatric cardiologist, pediatric surgeon, psychiatry, pulmonologist, ultrasound, urology and X-ray

4.1.5 Architecture Principle

According to Chokshi (2017), most health providers use one or more of the following business principles. The principles are:

- ⇨ Identifying and stratifying an attributed population (i.e. the population they're responsible for)
- ⇨ Grounding in high-quality, community-based care
- ⇨ Meeting patients where they are, both physically and in terms of their health trajectory
- ⇨ Using data to guide care delivery and drive improvement

So depending on these hospital business principles the researcher has captured the following architecture principle for the integrated HIS.

- ⇨ The integrated HIS considers each and every user of the legacy system

- ⇨ The integrated HIS uses patient data form the legacy system
- ⇨ The integrated HIS allows using new technologies for designing and implementation
- ⇨ The integrated HIS allows any hospital with HIS to use
- ⇨ The integrated HIS framework should be designed by using each stage of TOGAF

4.2 Architecture Vision

Under this first stage of TOGAF the following sub steps were done to articulate the architecture vision.

- ⇨ Define the scope of the baseline architecture
- ⇨ Identify and prioritize component of baseline architecture framework
- ⇨ Define relevant stakeholders with their objectives
- ⇨ Articulate the architecture vision

4.2.1 Scope of the baseline architecture

The scope of two hospital data; Girum General Hospital and Kadisco General Hospital is discussed here.

KGH is oriented to secure the societies health through modern preventive and diagnostic health practices. The hospital building is erected and stretched on a wide flat area in the Gerji region commonly known as 46 mazorya. The hospital is uniquely designed to accommodate a grand entrance with wide reception and corridors, spacious bedrooms and health care units. Wide range of medical equipment units and other facility sections are also available.

KGH utilized .NET Framework to design its HIS with a large class library named as Framework Class Library (FCL). It uses Sql server to design database server.

KGH has five main modules or services. The HMIS contains(Reception, Administrative staff, Accounting staff, and Credit follow up team, marketing department, laboratory department, doctors, nurses and radiology departments), Human Resource, Finance and Inventory.

GGH focuses on introducing the ART and SCIENCE OF MEDICINE to Ethiopia by instituting an efficient hospital management system, a variety of medical specialties, investigating on latest medical devices that enable to offer advanced quality healthcare services in nation to hold the patient referral abroad and hence to create a medical tourism center in Ethiopia in short run.

GGH utilized .NET Framework (used VB SIX) to design its HIS with a large class library named as Framework Class Library (FCL). It uses Sql server to design database server.

GGH contains six main modules; registrar, treatment, nursing, Admission, Report and HIS (Radiology, laboratory, MRI, CT scan, Ultrasound and pharmacy)

4.2.2 Component of baseline architecture (KGH and GGH)

User component: components of KGH are Hospital administration: includes Human resource management, Finance management and the Medical director, Medical staff: include number of doctors like, specialists, consultants and the resident, Nursing staff: includes groups of nurses like nurses unit manager, nurse practitioner and enrolled nurses, allied health professionals: includes laboratory assistants, occupational therapist and pharmacists. components of GGH are Hospital management: includes Finance management and the Medical director, Medical staff: contains groups of doctors who are specialized in some areas and resident doctors to heck up patients, Nursing staff: collection of nurses who treat patients daily and collects vital patient information based on their experiences/ specialty and allied health professionals: includes laboratory assistances, therapists and pharmacies.

HIS component: the HIS of KGH is composed of three main components, Input: is the resources initially used to develop the HIS like, legislative, data, regulatory, and planning frameworks, Process: is how indicators and data sources are selected and data are collected and managed and Output: deal with the production, dissemination, and use of information. These components have formed four main modules (HR, HMIS, Finance and Inventory) in which different services are comprised. The HIS of KGH is again composed of three main components, Input: is the HIS resources required to ensure a fully functioning HIS, Such resources involve personnel, financing, logistics support, information and communications technology (ICT), Process: are indicators and data sources with a number of other data-collection approaches and sources occasional health surveys and information produced by community based organizations. And Output: are the production, dissemination, and use of information produced from the system.

Technology component: the HIS of KGH used Net framework which provides in comparison to the advantages provided by other platforms. Net framework has its own eight different components that make it function well. They are NET Class Library, Common Language runtime, Dynamic Language runtime, Application domains, .Net Framework Security, Cross Language interoperability, Side by side execution and Common Type System. The HIS of GGH also used Net framework and therefore their platform component is similar. Net framework has its own eight different components that make it function well. They are NET Class Library, Common Language runtime, Dynamic Language runtime, Application domains, .Net Framework Security, Cross Language interoperability, Side by side execution and Common Type System.

4.2.3 Stakeholders of the system (KGH and GGH)

Existing stakeholders (Parties that have interest in integrated health information system and can either affect or be affected by the business) of KGH and GGH are:

- ⇨ The hospital owner which is the Kadisco chemical industry, Kadisco group and SMATARA forwarding company and an American medical board certified physician Dr. Girum Berhane and his family for GGH.
- ⇨ Hospital administration/management: includes those people who lead and manage the hospital organization. There is one medical director with vise director they deal with managing and controlling the health services provided by the hospital. There is also one human resource with its own secretary to control and manage the employee status. Other part is the finance with vice finance officer that control the all issues related to the finance either service payment or employee salary.
- ⇨ Medical staff: the medical staff contains different groups of doctors who work in the hospital there are four doctors in the Emergency Room, there are three specialists in Surgical, there is one specialist in Dermatology, there are two Physio Therapy specialists, there is one Dental doctor, there are three doctors working in the OBY GYN, there is one Orthopedics, there are two Pediatric doctors , there are two Radiologists, there is one Urologist, there are two Gastro specialists, there is one specialist doctor in breast clinic and there is one spinal Neuro surgeon. Each doctor under each specialty is assigned medical treatments for patients assigned for them.
- ⇨ Nursing staff: there are among eighteen nurses which are again classified to different treatments .They assess plan and administer daily treatment and manage general health of the patient
- ⇨ Allied health professionals: part of multidisciplinary health care team they assess, diagnose and treat conditions. There are three pharmacist, one x-ray expert, two ultrasound experts, and two anesthesia

4.2.4 Architecture vision

The two hospitals described above uses the same architecture for their HIS to perform; the three tier architecture which makes a logical separation between the presentation layer, the business logic layer, and the database layer; and it makes different collection of applications that behave and look differently, and are hard to integrate. Some of the challenges of the three tier architecture are:

- ⇨ The Three-tier nature makes it difficult for developers to change an application with the agility and flexibility they need to keep pace with the expectations of mobile users, and for operations teams to scale the application up and down to match demand.
- ⇨ A Three-tier design hinders agility at several phases of the application development process. Even if application functionality is distributed in a modular fashion, a change to any module requires rebuilding and testing the entire application. This can be quite time-consuming.
- ⇨ The flexibility to choose from an array of solutions isn't available with a 3-tier design, where solutions are typically built from a set of highly interdependent coupled components.
- ⇨ The Three-tier architecture lacks scalability; applications running on the three-tier architecture are normally unable to scale specific pieces of the application independently because the entire application is coupled together.

TOGAF enterprise architecture however, address those challenges appearing because of the three tier architecture by reducing cost, time, and risk involved in the development of enterprise infrastructure. Organizations can also realize quick benefits from implementation due to improved flexibility and freedom. This allows for steady business growth and easy restructuring. The following are the architecture vision which is mainly derived from the vision and the mission of the hospitals.

- ⇨ The integrated HIS aims to provide the most efficient, competent and courteous provider of comprehensive health care.
- ⇨ The integrated HIS responds to new business demands of the organization (Hospitals) for the future (Scalability/new applications/new devices/ more users).
- ⇨ The integrated HIS can be deployed quickly at any new location within restricted time frame, and with minimal configuration and no new development / customization required.
- ⇨ The integrated HIS is fast and efficient enough to be able to simultaneously service several hospitals and mobile units in geographically diverse areas of the country.
- ⇨ The integrated HIS have no additional operational costs compared to the current infrastructure.
- ⇨ The integrated HIS provides a single user interface for all the applications to the user
  Provide flexibility in choice of application providers, to avoid vendor lock-in.

4.2.5Architecture Vision Diagrams

Value chain diagram is a diagram that helps to visually analyze a company's business activities. It allows ways figuring organizations can create a competitive advantage. It is the conceptual description of value-added in the form of a value chain. An organization is split into 'primary activities' and 'support activities'. Figure 4.1 presents the architectural vision as a value chain diagram where the

Primary activities are directly concerned with creating and delivering a product/service. The primary activities are:

- ⇨ Reception takes patient, register patient, finance check patient payment for the service
- ⇨ Doctors check patient, order laboratory examination; see laboratory and other examination and orders medication.
- ⇨ Nurses collect vital information from patients, assign patients to doctors and treat the patient with medication.
- ⇨ Laboratory does the laboratory examination, sends the laboratory result to the doctors.
- ⇨ Pharmacies give the medicine ordered by the doctors.

The above activities are identified as the primary activities as they are the main duties that the hospitals perform to give service/ health care for its customers/ patients.

Support activities assist the primary activities in helping the organization achieve its competitive/main advantage. The support activities are:

- ⇨ Human resource controls the employee status whether they are on their profession or not, control if employees are performing their assigned tasks,
- ⇨ Technology development team/ system admin check and adopt new technologies.
- ⇨ Procurement helps in buying and selling tools in the hospitals.
- ⇨ Ministry of health/ MOH gives health service police when it is necessary and gets report form HIS when needed.

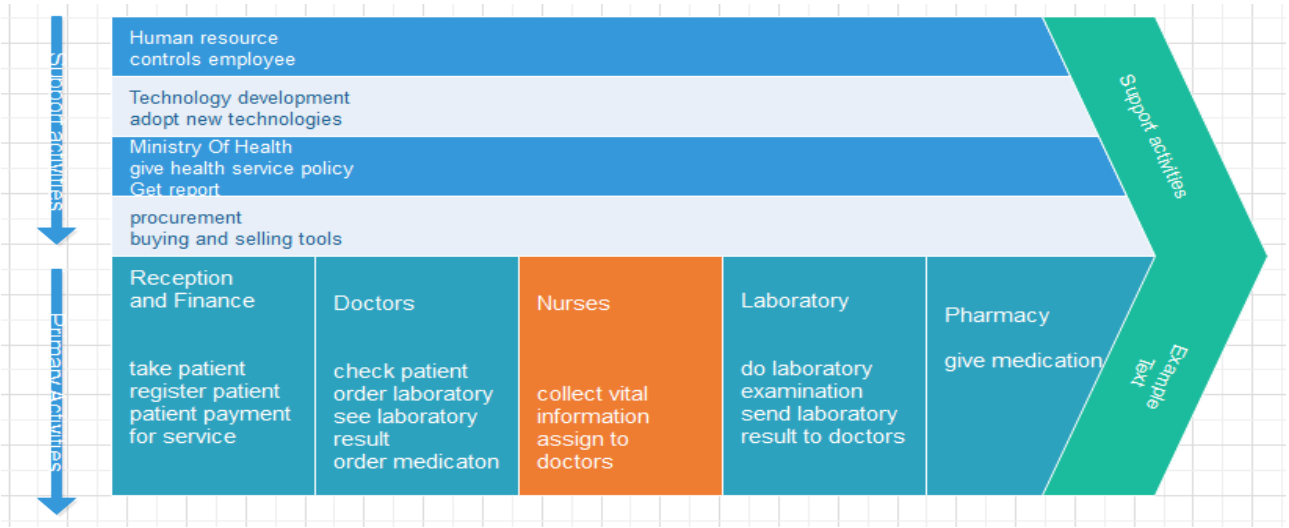


Figure 4.1 Value chain diagram

A **solution concept diagram** provides a high-level orientation of the solution that is envisaged in order to meet the objectives of the architecture engagement. Solution concept diagram represents a pencil sketch of the expected solution at the outset of the engagement. The purpose of this diagram is to quickly on-board and align stakeholders for a particular change initiative. Figure 4.2 presents a pencil sketch of the solution concept diagram according to the Figure there are three main participators, users (employees, doctors and nurses) get simplified work interface and external user gets reports when they need, system administrator can simply control they system and human resource can purely control and check employee's status.

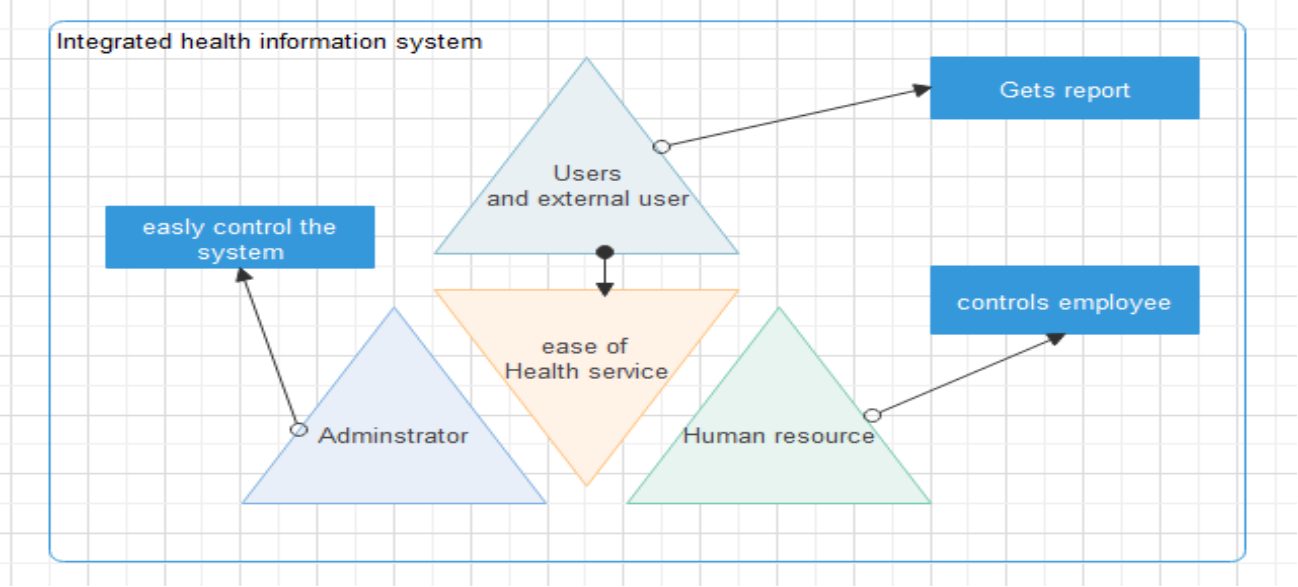


Figure 4.2 solution concept diagram

Stakeholder	Involvement	Class	Artifacts
System Administrator	The system admin controls the system and gives privilege for user	Keep Informed	Business Footprint Application Communication Functional Decomposition
Medical Director	The medical director is interested in the high-level drivers, goals and objectives of the hospital	Keep Satisfied	Goal/Objective/Service Model
Human resource	The human resource controls the employee status (hire and fire	Keep Informed	Hospital actors/employees

	employee)		
Employees	Does each assigned work from the HR according to their privilege	Keep Satisfied	Organization Chart
Customers/Patients	Get health service from the hospital	Keep Satisfied	Organizational component

Table 4.1 stakeholder map matrix

Table 4.1 presents the stakeholder map matrix which is used to analyze a project stakeholder to determine the actions which are necessary to align their goals with the project. The stakeholders are listed with their involvement on the integrated health information system with their class or status along with the artifacts they use.

4.3 Business architecture

This stage of TOGAF is the second phase where the researcher describes baseline business architecture, describe product and organization process and also select relevant tools and techniques. The objectives of this second stage according to TOGAF framework are:

- ⇨ To describe the baseline business architecture,
- ⇨ To develop target business architecture,
- ⇨ To describe the product and organizational process,
- ⇨ To analyze the gaps between the baseline and target business architectures, and
- ⇨ To select the relevant tools and techniques to be use in the association with the selected viewpoints.

4.3.1 Baseline Business Architecture (KGH)

KGH is the sister company of one of the leading paint manufacturing company Kadisco chemical industry, Kadisco group and SMATARA forwarding company. After a long exhausting period of planning and preparation, KADISCO general hospital was inaugurate on May 1 2007, and commenced to render its services promptly.

Its objectives are mainly oriented to secure the societies health through modern preventive and diagnostic health practices. The hospital building is erected and stretched on a wide flat area in the Gerji region commonly known as 46 mazorya. The hospital is uniquely designed to accommodate a grand entrance with wide reception and corridors, spacious bedrooms and health care units.

4.3.1.1Business strategy of KGH

Business strategy is a set of competitive moves and actions that a business uses to attract customers, compete successfully, strengthening performance, and achieve organizational goals. It outlines how business should be carried out to reach the desired ends. It includes, Mission, Business Goal and Business Strategies / Objectives.

Mission	Goal	Objectives	Action
To provide accessibility to high quality health care	To expand other departments such as ophthalmology telepath ology To meet the needs of the society.	• To secure the societies health through modern preventive and diagnostic health practices. • To be the most efficient, competent and courteous provider of comprehensive health care	• Maximize comfort of the patients and visitors • Create a conductive atmosphere, which inspires and enables health • Efficiently and ethically deliver health services by professionals and other staff members. • Provide Credit facility for companies such as ECA, Banks and insurances

Table 4.2 business strategy of KGH Source (Researchers data collection)

4.3.1.2 Governance of KGH

KGH governance fills traditional medical values back into the system and aims to bring the field of healthcare back to a state of sustainable quality of care. Boards of directors are responsible for the governance of their companies. The medical board of KGH contains ten members with one President one Vice President and a Secretary. The medical board creates the hospitals governing rule depending on the Ethiopian general hospital standard.

4.3.1.3 Organization of KGH

KGH follows functional organization structure in which people who do similar tasks are grouped together based on their specialty. KGH is organized in to the following departments.

⇨ The Hospital owner

- ⇨ The hospital admin (medical director)
- ⇨ The human resource team
- ⇨ The finance team.
- ⇨ The reception
- ⇨ The medical staff
- ⇨ The nursing staff
- ⇨ The laboratory staff
- ⇨ The services

4.3.1.4 Patient process of KGH

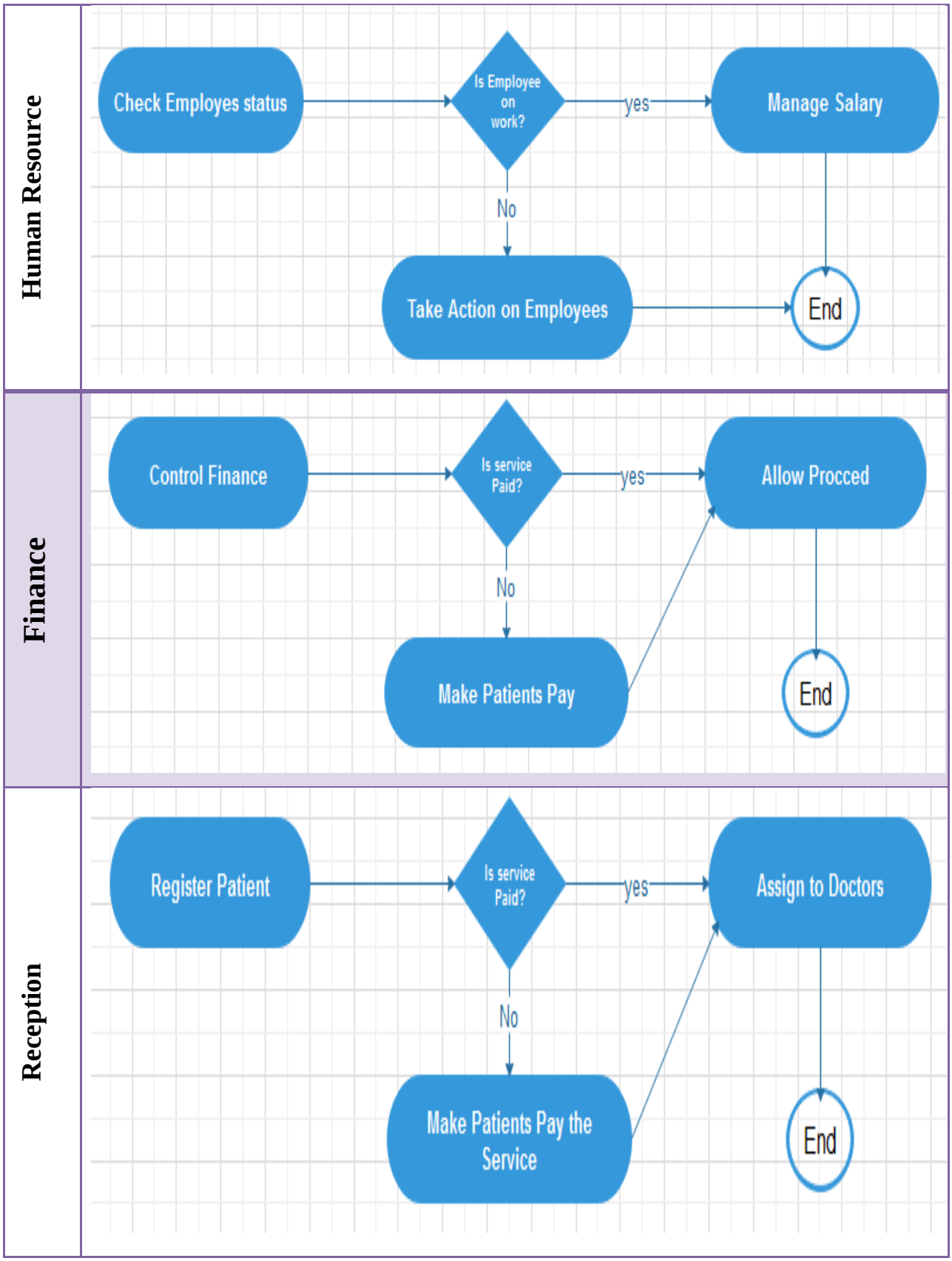
In KGH one patient should pass through the following different stages to get the service he/she needs.

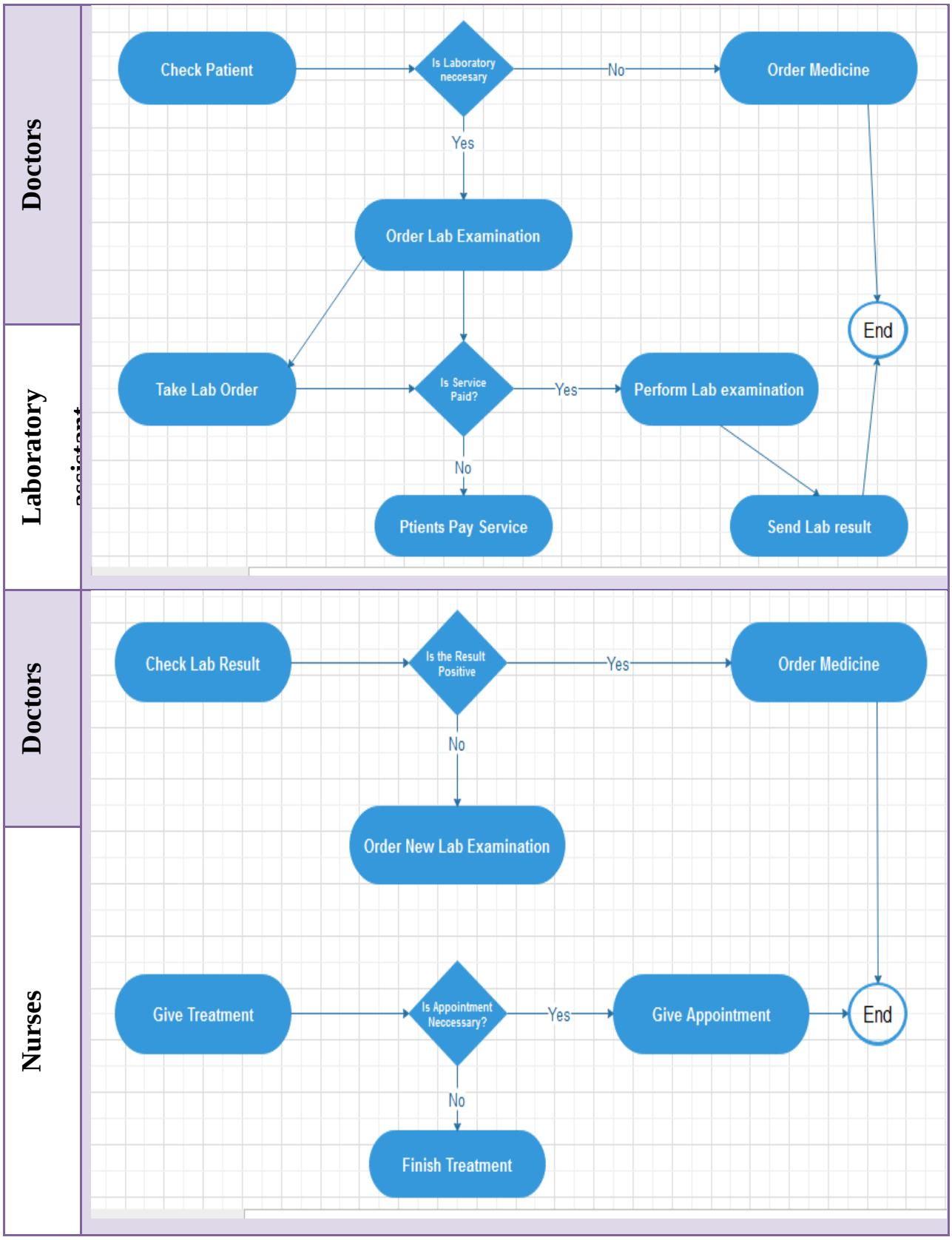
- ⇨ The patient is registered on the system by the reception department
- ⇨ The patient will be assigned a card by the receptionist
- ⇨ The Patient will be assigned to the doctors according to the card
- ⇨ The patient will get check up by the doctor
- ⇨ The doctor will record signs and symptoms on the clinical record
- ⇨ The doctor will order laboratory examination
- ⇨ Laboratory technician will check if the service is paid
- ⇨ Laboratory technician will do laboratory examination for the patient
- ⇨ Laboratory technician pass the result found to the doctors
- ⇨ The doctor orders medicine according to the result observed
- ⇨ The pharmacy gets the order and gives the medicine to the patient if paid.
- ⇨ The pharmacy will print out the prescription if the medicine is not found there.
- ⇨ The reception gives appointment if needed according to the doctor's order.

4.3.1.5 Baseline business architecture diagram (KGH)

According to TOGAF variety of modeling tools and techniques are employed to describe the existing business architecture of enterprises.

Activity Models/ Business Process (KGH) Models describe the functions associated with the enterprise's business activities, the data and/or information exchanged between activities (internal exchanges), and the data and/or information exchanged with other activities that are outside the scope of the model (external exchanges).


Human Resource
Check Employes status
Is Employee on work?
yes
Manage Salary
No
Take Action on Employees
End
Finance
Control Finance
Is service Paid?
yes
Allow Procced
No
Make Patients Pay
End
Reception
Register Patient
Is service Paid?
yes
Assign to Doctors
No
Make Patients Pay the Service
End


Doctors
Laboratory
Check Patient
Is Laboratory neccesary
No
Order Medicine
Yes
Order Lab Examination
End
Take Lab Order
Is Service Paid?
Yes
Perform Lab examination
No
Ptients Pay Service
Send Lab result
Doctors
Nurses
Check Lab Result
Is the Result Positive
Yes
Order Medicine
No
Order New Lab Examination
Give Treatment
Is Appointment Neccessary?
Yes
Give Appointment
End
No
Finish Treatment

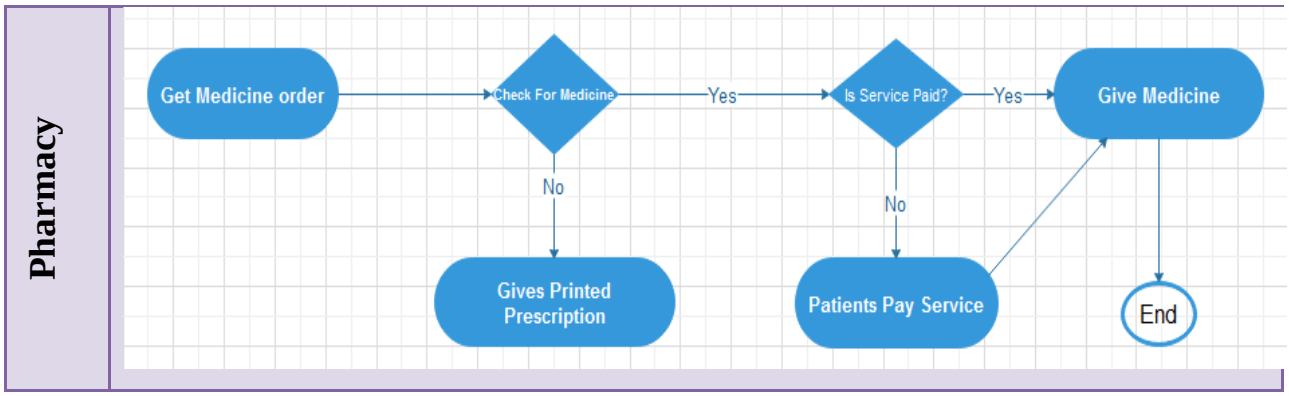


Figure 4.3 Activity diagram of baseline business architecture of KGH

Figure 4.3 above shows the activity diagram of the existing business process of KGH. The human resource controls employee status based on the decision whether the employee is on work or not. The finance checks finance issues and control whether customers have paid or not.

The receptionist then register the patient on the system if the service is paid and the patient is assigned to doctors where they get checkup and ordered laboratory examination if necessary. The laboratory assistant then checks if the service is paid and proceed with the examination if it is paid the send the result to doctors. The doctors check the lab result and give medication if further laboratory or other diagnosis is not needed. The pharmacist gives the medicine if it exists or gives printed format of prescription if the medicine is not found. The nurses then give the necessary treatment and decide if the treatment has to continue or not.

4.3.2Baseline Business Architecture (GGH)

GGH is a private health facility established in 2007 G.C. by an American medical board certified physician Dr. Girum Berhane and his family with the main objective of introducing the ART and SCIENCE OF MEDICINE to Ethiopia by instituting an efficient hospital management system, a variety of medical specialties, investigating on latest medical devices that enables to offer advanced quality healthcare services in nation to hold the patient referral abroad and hence to create a medical tourism center in Ethiopia in short run.

4.3.2.1 Business strategy of GGH

In GGH business strategy is understood as the course of action or set of decisions which assist the hospital in achieving its specific business objectives. It is a master plan that the management of the company implements to secure a competitive position in the health service market.

Mission	Goal	Objective	Actions
To provide excellence and innovation in the care of patients	Providing the best complete clinical care in Ethiopia and neighboring countries.	• Introducing the art and science of medicine to Ethiopia • To benefit human health and improve the quality of life	• -Instituting an efficient hospital management system • -Employing variety of medical specialties • -Investigating on latest medical devices that enables to offer advanced quality healthcare services • -Create a medical tourism center in Ethiopia

Table 4.3 business strategy of GGH Source (from researcher's data collection)

4.3.2.2 Governance of GGH

Governance is a way by which the hospital makes and implements decisions in pursuit of its objectives according to GGH. Similarly boards of directors are responsible for the governance of GGH. The medical board of GGH contains twelve members with one President one Vice President and a Secretary and other decision making members. The medical board builds the hospitals major rule depending on the Ethiopian general hospital standard.

4.3.2.3Organization of GGH

GGH is structured with multiple departments. It also follows functional organization where people who work the same tasks are grouped together based on their specialty. The following are the departments that formulated GGH.

- ⇨ The Hospital owner
- ⇨ The hospital admin (medical director)
- ⇨ The finance team.
- ⇨ The reception
- ⇨ The medical staff

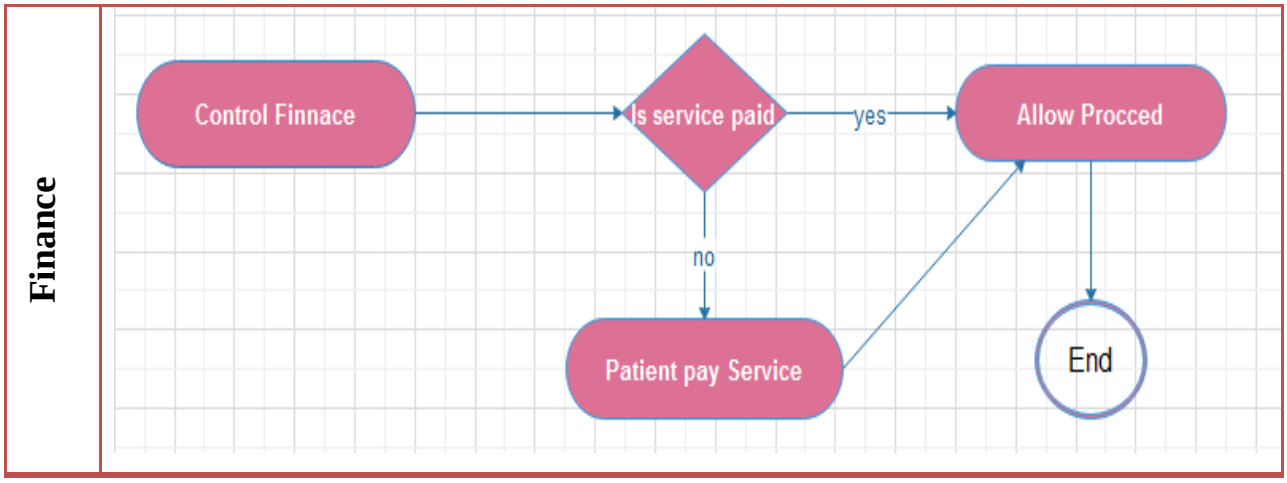
- ⇨ The nursing staff
- ⇨ The laboratory staff
- ⇨ The services
- ⇨ objectives

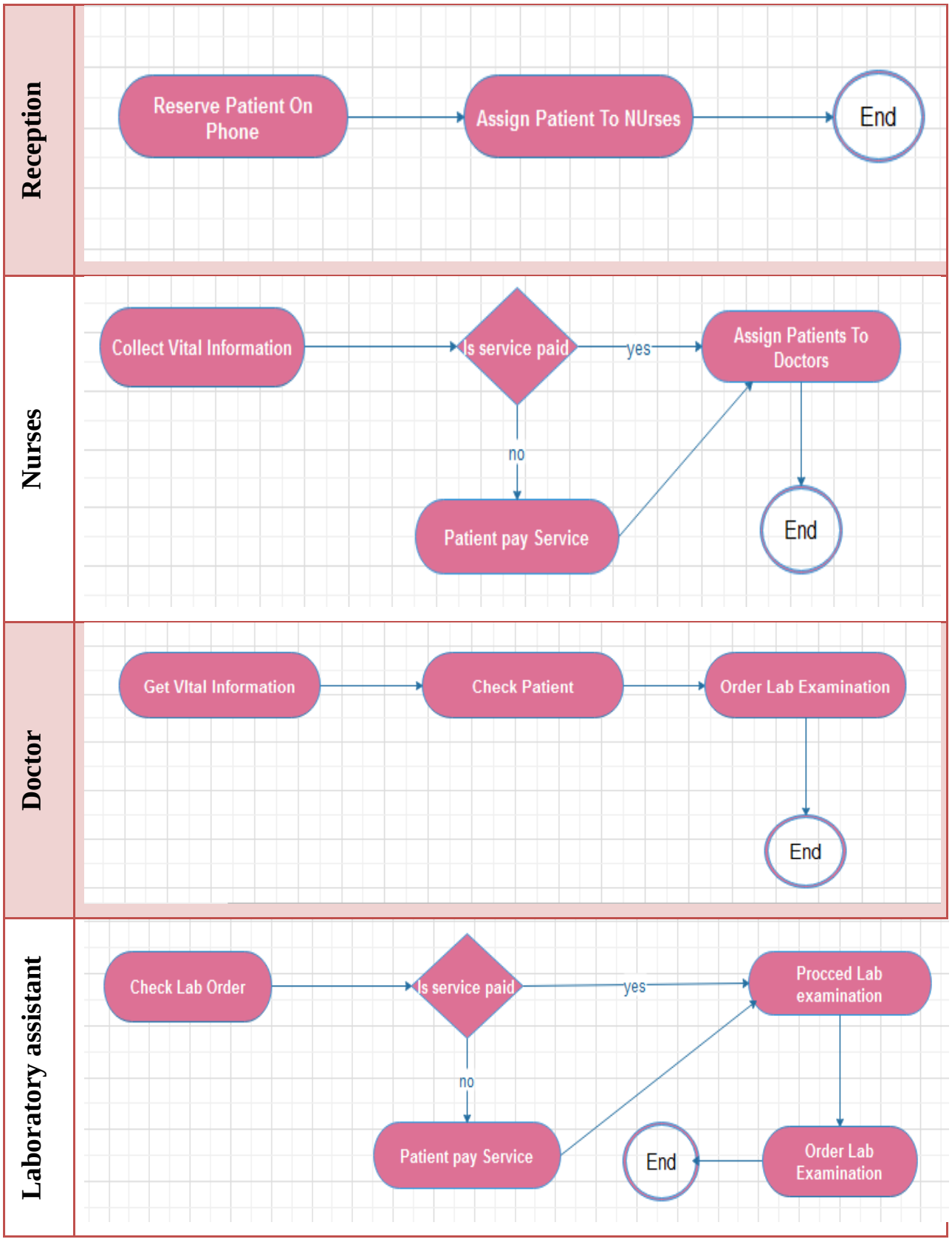
4.3.2.4 Patient process in GGH

The following processes are stages one patient should pass under to get service in Girum General Hospital

- ⇨ Patient talk to the reception and he/she is suggested to see the nurses
- ⇨ Patients see the nurses and asked their symptoms to get vital data
- ⇨ The nurses send the patient to the registrar to be assigned card number and to pay
- ⇨ The patient again goes to nurses and vital data like blood pressure will be collected
- ⇨ The nurses send the patient to the correct specialist doctor by attaching the vital data
- ⇨ The doctor will receive the patient with vital data and checks his patient
- ⇨ The doctor will order the necessary laboratory or any other test that should be taken
- ⇨ The patient will go to the laboratory after payment and gives samples
- ⇨ The laboratory technician will send the result to the doctors
- ⇨ The doctor will order medicine based on the result of the patient
- ⇨ The pharmacist will receive the ordered medicine and will give for the patient /will give the printed prescription for the patient.
- ⇨ If the laboratory ordered is not found in the country the patient will be given waiting time and after the result is attached with in email the patient will be called.

The following **Activity Models/ Business Process** capture the activities performed in business process Of GGH.




Reception
Reserve Patient On Phone
Assign Patient To NUrses
End
Nurses
Collect Vital Information
Is service paid
yes
Assign Patients To Doctors
no
Patient pay Service
End
Doctor
Get VItal Information
Check Patient
Order Lab Examination
End
Laboratory assistant
Check Lab Order
Is service paid
yes
Procced Lab examination
no
Patient pay Service
End
Order Lab Examination

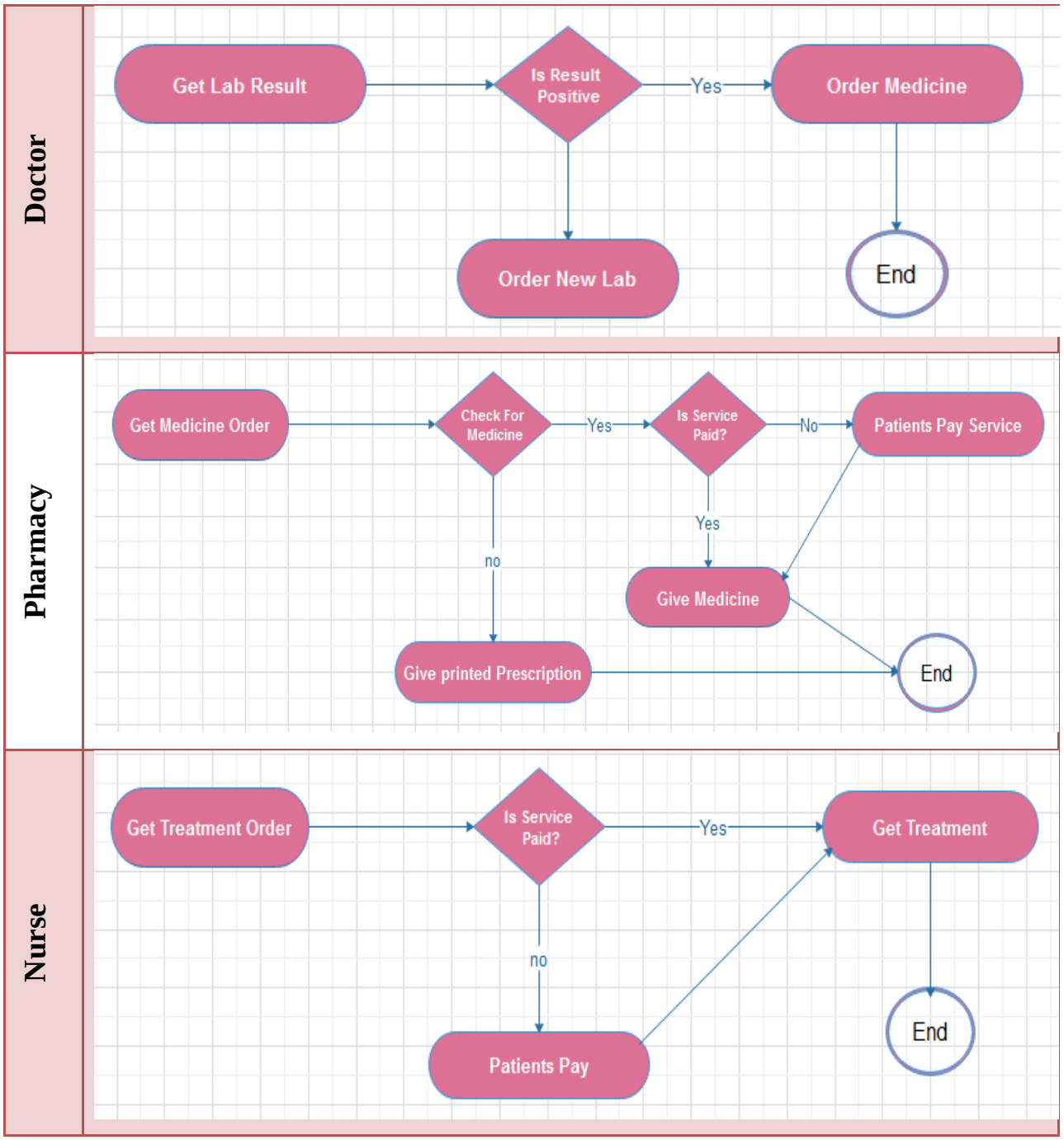


Figure 4.4 Activity diagram of baseline business architecture of GGH

Figure 4.4 show the baseline business architecture of GGH. It describes the business process with the stakeholders of the system. The finance controls the whole finance issues and the human resource are not included in GGH HIS. The receptionist reserves patients for letter checkup over the phone or in person then assigns the patents to nurses where the vital data is collected. Then the nurse checks if the service is paid and assigns the patient to doctors. The doctors checks the patient and orders laboratory examination then the Lab assistant checks if the service is paid and precedes the laboratory examination which the

result is sent back to the doctor. The doctor checks the Lab result and order medicine which is taken form the pharmacy if the it is in the stock. The nurse's then gets treatment order and treats the patient accordingly by checking if the service is paid.

4.3.3 Target Business Architecture

The business architecture of integrated HIS architecture designed below describes how the two hospitals (GGH and KGH) need to operate to achieve the business goals, and respond to the strategic drivers set out in the Architecture Vision, in a way that addresses the Request for Architecture Work and stakeholder concerns.

The following catalogs together with their representing diagrams have been selected to capture and describe the target business architecture as per TOGAF

- ⇨ Business interaction matrix
- ⇨ Actor/ role matrix
- ⇨ Organization/actor catalog
- ⇨ Business service / function catalog
- ⇨ Process/product catalog

4.3.3.1 Business interaction matrix

The purpose of the matrix described in table 4.4 is to depict the relationship interactions between organizations and business functions across the integrated hospitals.

	Providing health service			
Consuming Health service	Registrar	Treatment team	Finance	Human resource
Registrar			Check patient payment	
Treatment team	Serves patient for treatment			Approves employee
Finance		Send patient to pay		
Human resource			Checks work	

Table 4.4 business interaction matrix of the integrated HIS

Table 4.4 above shows the business interaction matrix of the integrated HIS. The first row of the matrix tells that finance is responsible for checking patient payment, the first column shows that the registrars is responsible for serving patient, the treatment team sends patients to pay for the service and the human resource checks employees status.

4.3.3.2 Actor/ Role matrix

The purpose of this matrix is to show which actors perform which roles, supporting definition of security and skills requirements. Understanding Actor-to-Role relationships is a key supporting tool in definition of training needs, user security settings, and organizational change management. Is used to design the target integrated HIS business architecture.

		Business Actors								
Activities	**Receptionist**	**System Admin**	**Human Resource**	**Finance**	**Medical Director**	**Doctors**	**Nurses**	**Laboratory Technician**	**Pharmacist**	**Ministry Of Health**
Control system	I	R	A	I	I	I	I	I	I	I
Give privilege	I	R	I	I	A	I	I	I	I	
Assign patient to doctors	R	I	I	I	I	I	R	I	I	
Assign patient ID	R	A	I	I	I	I	I	I	I	
Reserve patient	R	I	I	I	I	I	R	I	I	
Control employee	I	A	R	I	A	I	I	I	I	I
Collect vital information		I	I	I	I	A	R	I	I	I
Treat patient	I	I	I	I	A	R	R	I	I	I

Check patient	I	I	I	I	A	R	C	I	I	I
Order laboratory	I	I	I	I	I	R	C	C	I	I
Order medicine	I	I	I	I	I	R	C	C	C	I
Check laboratory examination	I	I	I	I	I	C	I	R	I	I
Send laboratory result	I	I	I	I	I	I	I	R	I	I
Give medicine	I	I	I	I	A	R	C	I	R	I
Report	R	C	R	R	R	R	R	R	R	I
Check Reports	I	R	A	I	R	I	I	I	I	R

A= Accountable

C= Consulted

I= Informed

R= Responsible

Table 4.5 Actor/Role matrix of target business architecture

4.3.3.3 Organization/actor catalog

Here the business actors have been identified form the component of the baseline application in order to make clear the user of the integrated system.

The business actors of the integrated system as identified from the baseline actors are the following

- ⇨ System Administrator: an actor with the administrator privilege and give user privilege for other actors of the system and also manage the integrated system

- ⇨ Human resource : responsible to control the employees take on and fired
- ⇨ Finance: responsible body for issues related with patient payment and finance issues
- ⇨ Medical director: responsible to control the health service staff
- ⇨ Employees: they present with different user privilege and they can access the integrated system. They can also directly deal with the information system/data architecture based on the given user privilege.
- ⇨ Ministry of health/MOH: as every hospital in the country are governed under MOH, it can check the integrated system and gather data when necessary based on the privilege allowed.

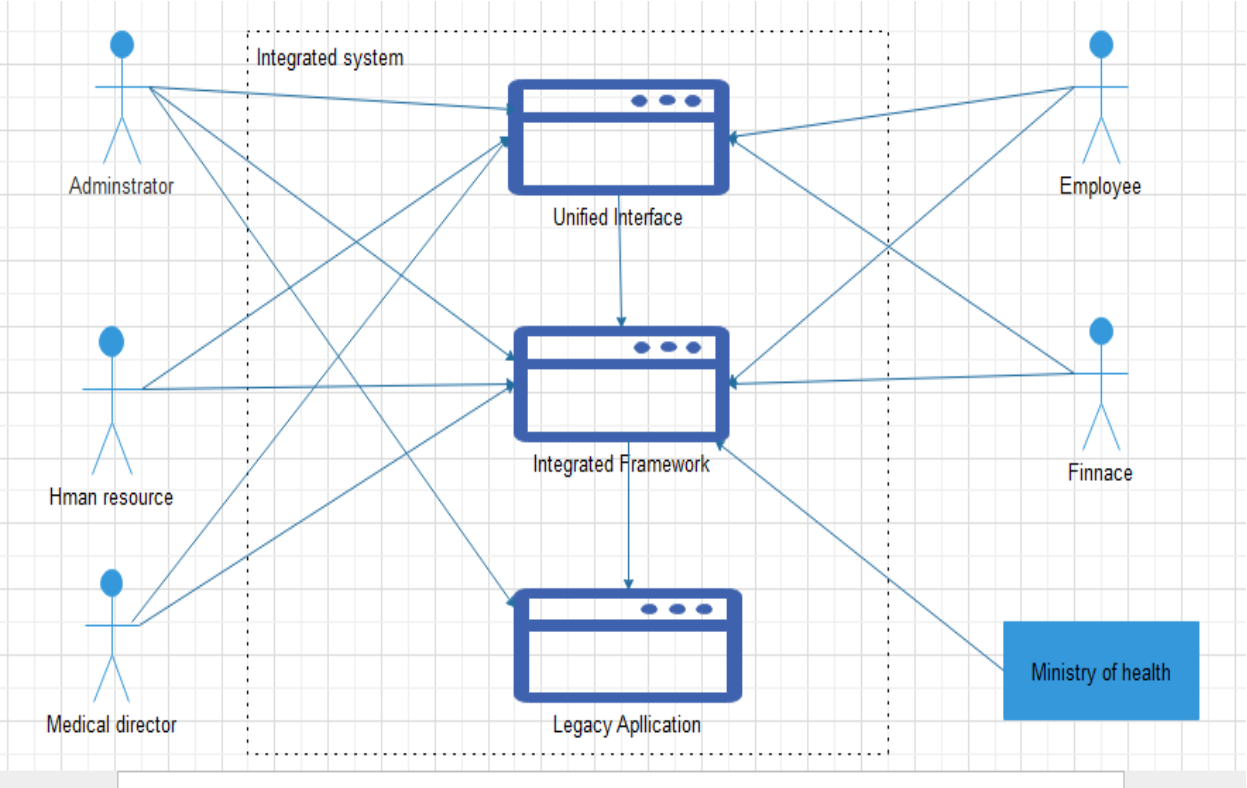


Figure 4.5 boundary context model of the integrated system

4.3.3.4 Business service / function catalog

The purpose of the Business Service/Function catalog is to provide a functional decomposition in a form that can be filtered, reported on, and queried, as a supplement to graphical functional decomposition diagrams. It contains Organization Unit, Business Function, Business Service and Information System Service. It used to describe the product and organizational process of the target business architecture.

4.3.3.4.1 Organization Unit

The followings are Organizational Unit that forms the target business architecture of the integrated HIS.

- ⇨ Boards of director: - that consist of influential members of health care and local communities. To oversee the function given by the hospital is correct and timely.
- ⇨ Hospital department admin: - The top managers of each hospital department report to the core management. These people are responsible for one type of medical or operational service.
- ⇨ Patient care manager: - Within a department, there are the people who directly oversee patient care. Nurse Managers, directors of rehabilitation services and supervising physicians have people under them who give hands-on patient care.
- ⇨ Patient service providers: - service-providing staff ranging from nurses and physical therapists to line cooks and laundry workers.

4.3.3.4.2 Business Function

The business function which is the business function of the target/ newly integrated health information system is to make better ways in serving more patients and drive the business fast.

4.3.3.4.3 Business Service

The integrated health information system/ target architecture provides excellence and innovation in patient care and provides accessibility to high quality health care service as business service.

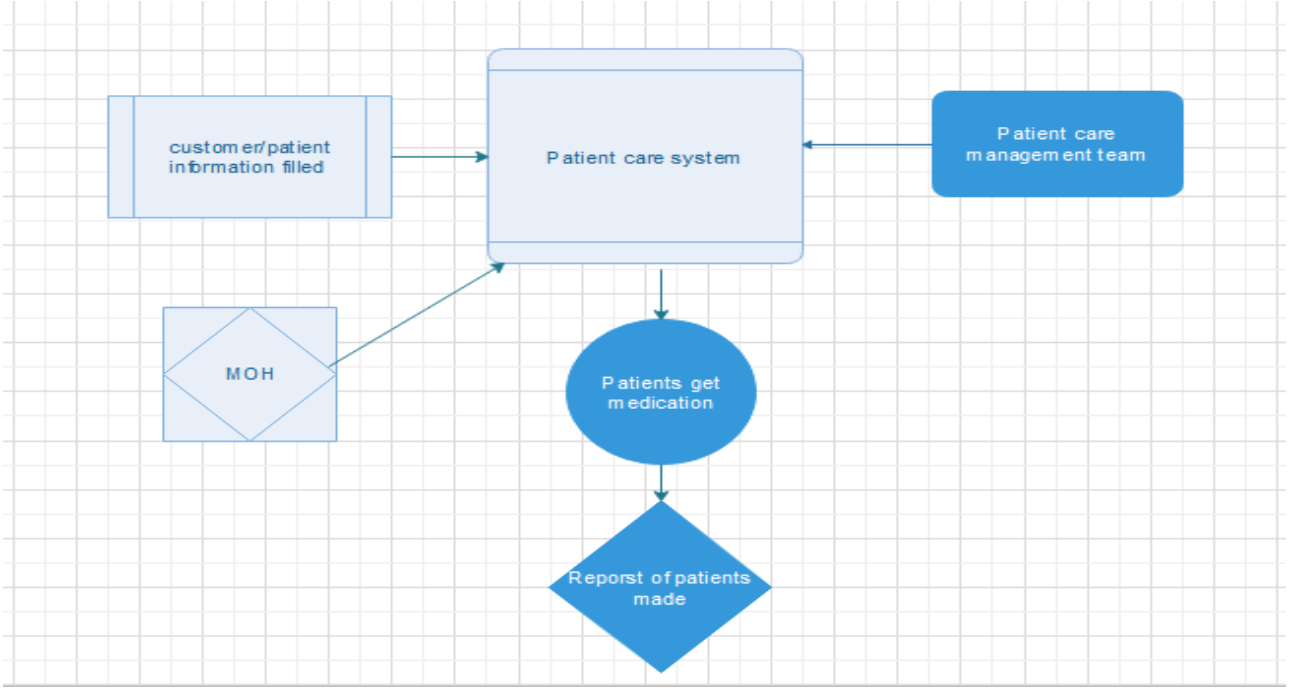


Figure 4.6 business service diagram of the integrated system

4.3.3.5 Process/product catalog

The Process/Event/Control/Product catalog provides a hierarchy of processes, events that trigger processes, outputs from processes, and controls applied to the execution of processes. This catalog provides a supplement to any Process Flow diagrams that are created and allows an enterprise to filter, report, and query across organizations and processes to identify scope, commonality, or impact. It is used to describe the product and organizational process of the target business architecture.

The following process are identified from the baseline business process to describe the product and organizational process of the target business architecture for the integrated HIS.

- ⇨ Patient registration
- ⇨ System control
- ⇨ Employee status control
- ⇨ Check payment
- ⇨ Patient assignment to physicians
- ⇨ Check up from doctors
- ⇨ Laboratory check up
- ⇨ Give medication according to the result
- ⇨ Prepare reports

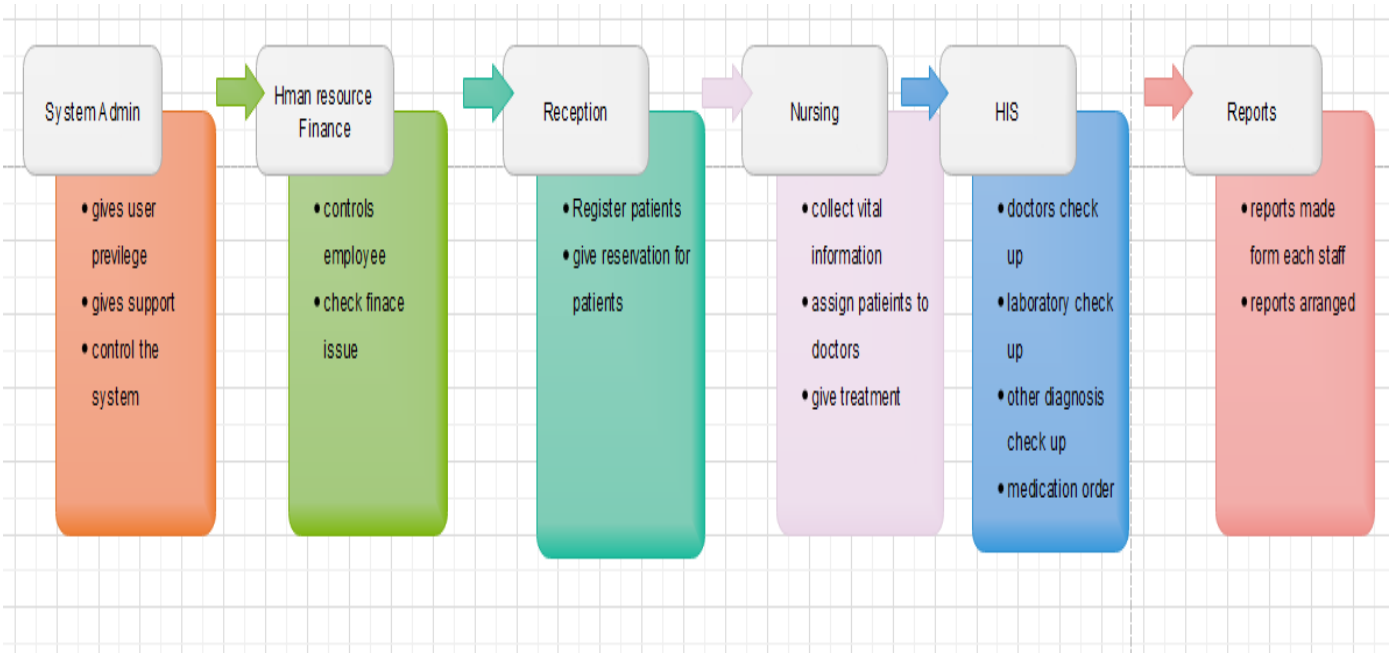


Figure 4.7 functional decomposition diagram of the target business architecture

4.3.4 Gap analysis

Gap analysis of the baseline business architecture and the target business architecture highlights services and/or functions that have been accidentally left out, deliberately eliminated, or are yet to be developed or procured (*TOGAF 9 manual*). The most critical source of gaps that has been considered is stakeholder concerns that have not been addressed in the baseline architectural work. Other potential sources of gaps are People gap, Process gap, Tools gap and Information gap.

Target / Basline	System Admin	Human resource	Finnace	Reception	Medical Director	Employee	MOH	Stakeholders Gap
Finnace			I					System Admin
Reception				I				MOH
Doctors						I		Medical Director
Nurses						I		HR
Laboratory						I		
Pharmacy						I		

I = Included under

Figure 4.8 Gap analysis of baseline and target business stakeholders

Figure 4.8 shows the gap analysis between the baseline and the target business stakeholders. As the matrix shows the six stakeholders (finance, reception, doctors, nurses, lab assistants and pharmacists) are all included in both the baseline and target business architecture while those system admin, Ministry Of Health, medical director and the human resource are eliminated in the baseline business architecture. Thus the eliminated stakeholders are found necessary stakeholders in defining the integrated business architecture as they directly or indirectly affect the business processes of the hospitals.

Target / Basline	System Control	Finnace Control	Employee Control	Patient Registration	Patient Assignment	Doctors Checkup	Laboratory Checkup	Medication	Report	Process Gap
Patient registration				I						Employee control
Patient assignment					I					Report generation
Patient checkup						I				Medical Director
Laboratory checkup							I			System Control
Medication								I		
Check payment		I								

I= included

Figure 4.9 Gap analysis of baseline and target business process

Figure 4.9 shows the gap analysis of baseline and target business process. . The baseline business processes are patient registration, patient assignment to doctors, patients get checkup by doctors, laboratory checkups, medication based on the laboratory result, and the finances checks financial issues.

The target business architecture identifies three more process, the human resource controls employee status, the system administrator controls the HIS system and all employees are supposed to produce their work reports.

So depending on this gap analysis the researcher has identified process and stakeholders that should participate in the integrated HIS system and used them accordingly.

4.4 Data architecture

Under this third stage of TOGAF Data Entity/Data Component Catalog is discussed to identify and maintain a list of all the data use across the hospitals including data entities and also the data components where data entities are stored. It contains the Data Entity, Logical Data Component and Physical Data Component. The objectives of this phase are to

- ⇨ Describe Data Baseline architecture
- ⇨ Define Principles, Reference Models, Viewpoints and Tools
- ⇨ Describe Architecture Model

- ⇨ Select Data architecture building blocks
- ⇨ Complete the Data architecture
- ⇨ Do Gap analysis

4.4.1 Baseline data architecture

The baseline data architecture defines the business information needed to support the business functions that are encompassed in the baseline business model. It essentially contains information on high-level data areas and their classes. Additionally, it identifies the need for data warehouses and data marts. The following tools are recommended in TOGAF to present the outputs of the baseline data architecture.

- ⇨ Conceptual data model
- ⇨ Logical data model

4.4.1.1 Conceptual data model of KGH

The following conceptual data model shows view of the data required supporting business processes, record business events, and track related performance measures in KGH.

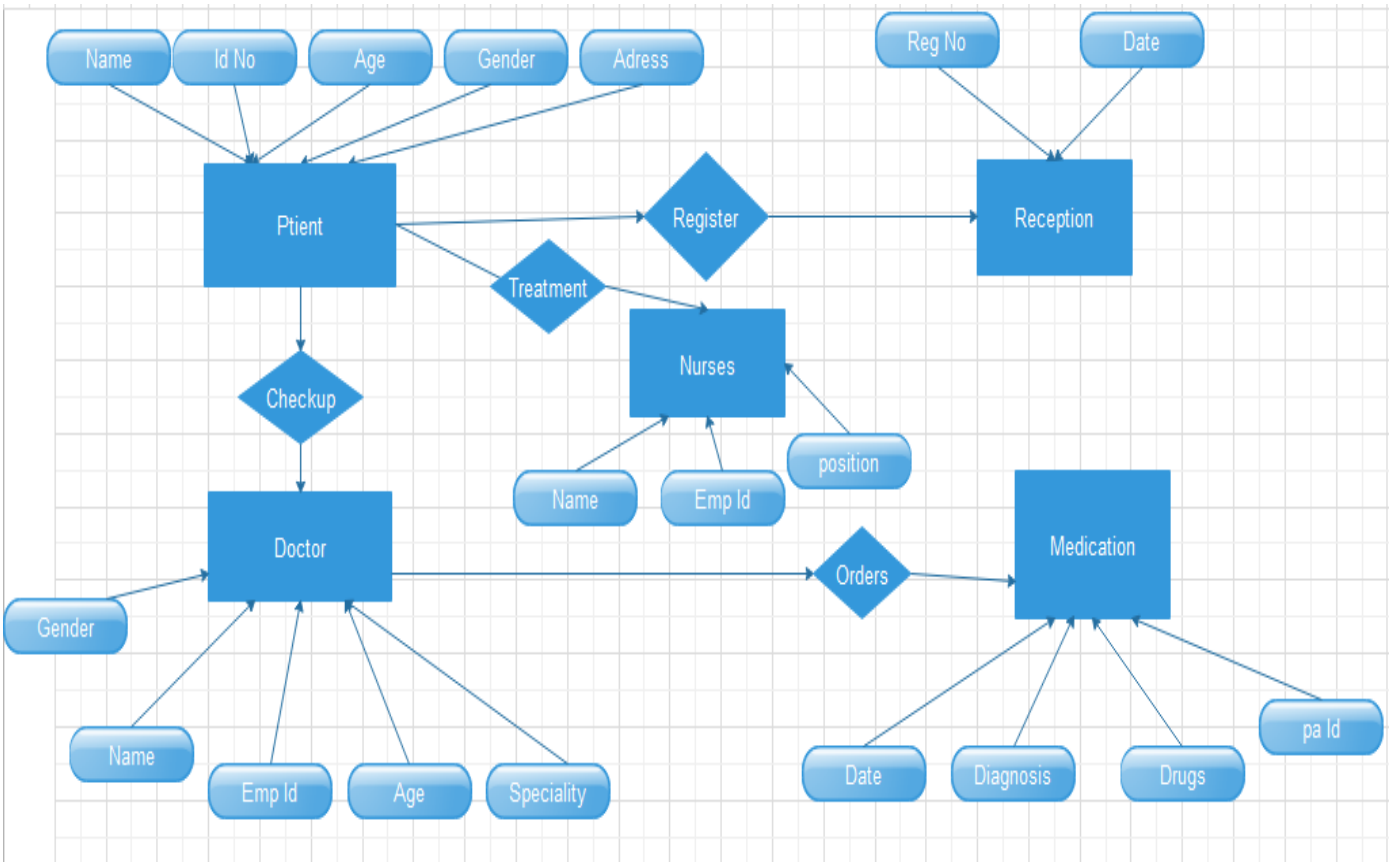


Figure 4.10 Conceptual data model of Kadisco general hospital

Figure 4.10 above shows the conceptual data model of KGH. Main entities that participate in the business process are identified with their describing attribute. The patient, the reception/ registration, the doctor, the nurse and medication are the main entitles that perform the overall work. Patients are described by their name, Id no given from the hospital, age, gender and their address. Thus patients are registered on the HIS by the reception which has two attributes, registration number and date of registration. Patients also gets checkup from the doctor with five attributes, name, gender, employee Id given by the hospital, age and specialty or position of the doctor. This doctor orders medication including date of medication, diagnosis type, drugs ordered and patient Id as an attribute.

4.4.1.2Logical data model of KGH

The following logical data model describes the data of hospital in as much detail as possible, without regard to how they will be physical implemented in the database. It includes all entities and relationships among them. All attributes for each entity are specified.

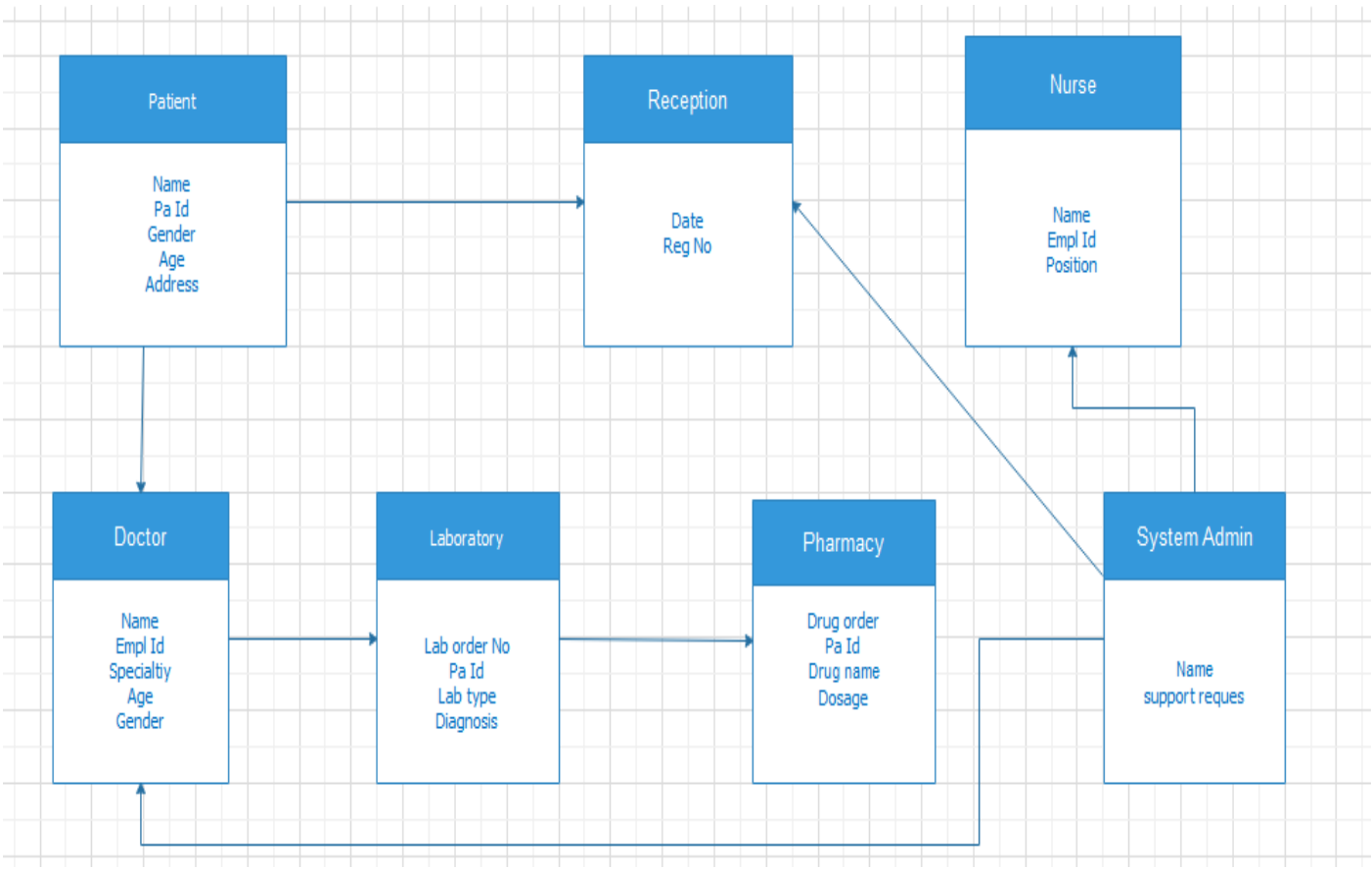


Figure 4.11 logical data model of Kadisco general hospital

Figure 4.11 describes the logical data model of KGH. It contains all entities that participate in the business process. It also presents their describing attribute under them. The system administrator which gives privilege for the users is one entity with name and support request as an attribute. The patient is another entity with name, patient ID, gender, age and address as an attribute. The reception which registers patient information on the HIS is also another entity. Nurses and doctors are entitles with name and employee ID as an attribute. Pharmacy and laboratory is also another entity.

4.4.1.3Conceptual data model of GGH

Conceptual data mode of GGH shows the structured business view of the data required supporting business processes of GGH, business events, and track related performance measures. This model focuses on identifying the data used in the business not it's processing flow.

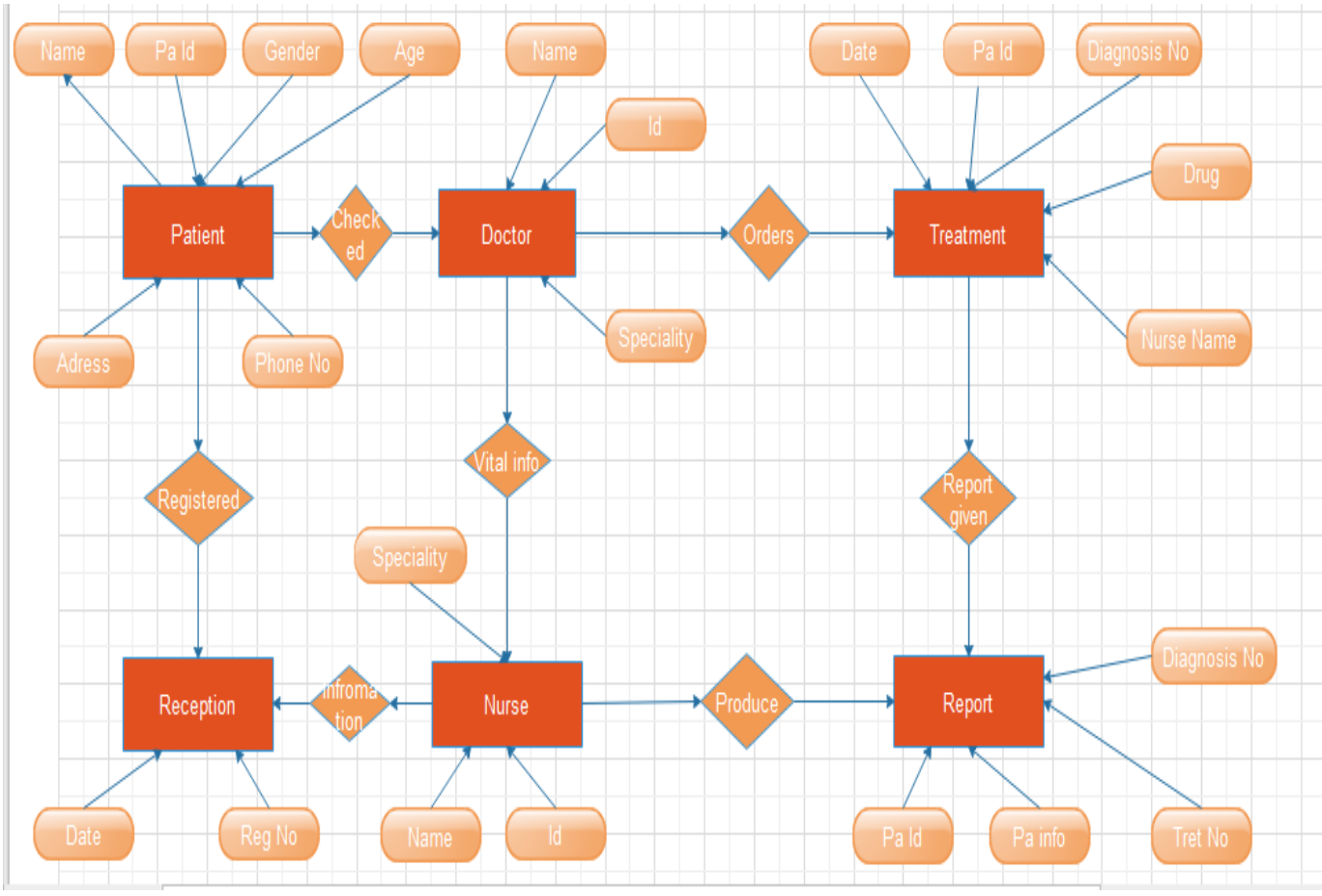


Figure 4.12 conceptual data model of GGH

Figure 4.12 show the conceptual data model of Girum General Hospital which is composed of six main entitles (patient, doctor, treatment, reception, nurse and report). Patients is described by name, patient id given by the reception, gender, phone number and address and those attributes are recorded on the HIS. The patient is registered on the HIS through reception by including the date and registration number. Nurses collect vital information and send the information with the patient to the doctors; nurses are identified by their name, Id and specialty. Doctors check the patient and order treatment for the patient. Their attribute are name, Id and specialty. The treatment is given by the nurses and the doctors passing through the laboratory diagnosis. The treatment is described by date, patient Id, diagnosis number, nurse name and drug. Report is produced the treatment including diagnosis number, patient Id, patient information and treatment number.

4.4.1.4 Logical data model of GGH

A logical data model shows data in detailed format. It includes all entities of GGH and relationships among them. All attributes for each entity are specified.

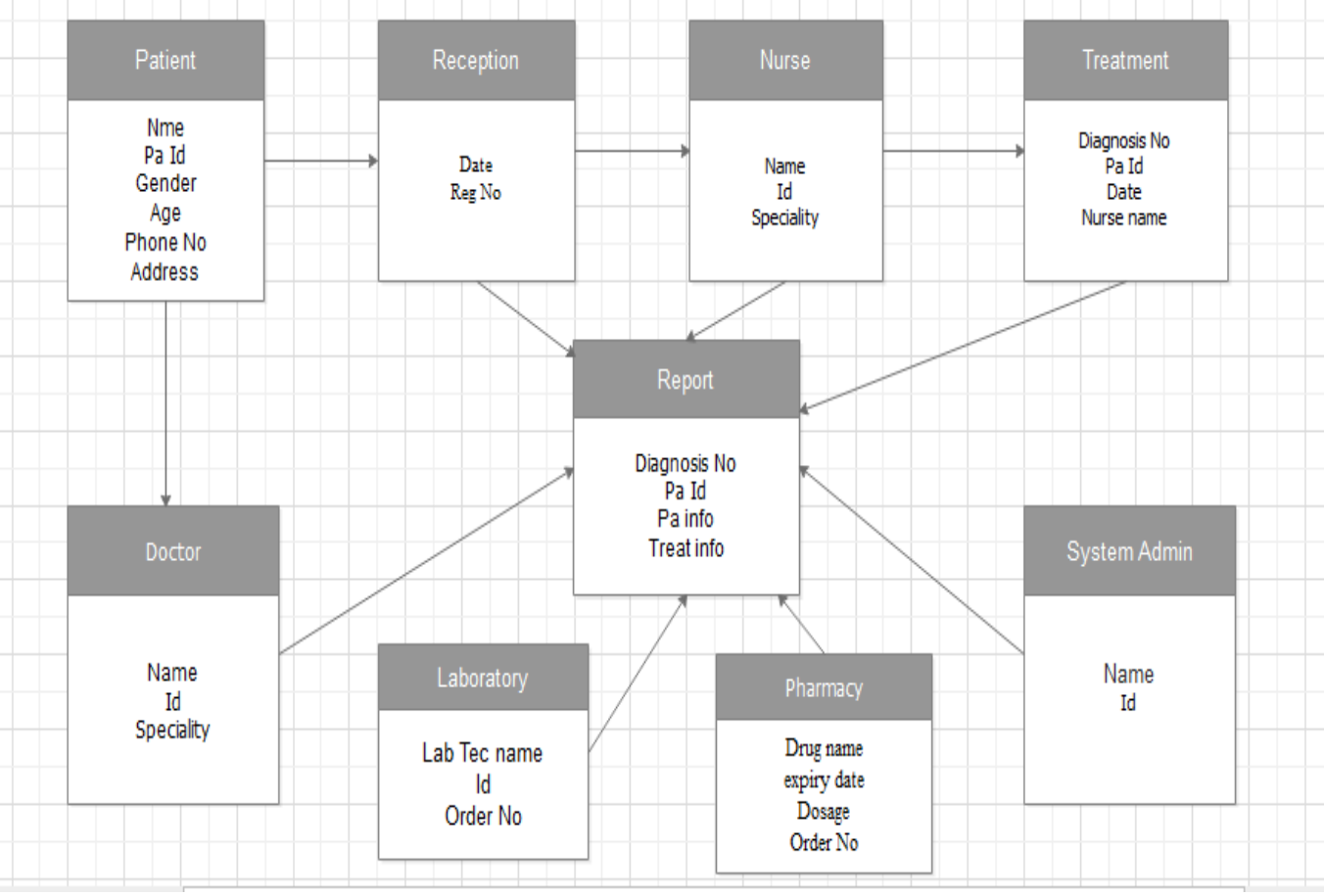


Figure 4.13 logical data model of GGH

Figure 4.13 above shows the logical data model of Girum General Hospital with a detailed entity and attributes representation. All entities that form the business process of GGH are patient, reception, nurse, treatment, doctor, Laboratory, Pharmacy System administrator and the report. Each is presented with their attributes to describe them. Entirely entitles except the patient produce report to the HIS of GGH and that information is checked and used by different bodies like ministry of health when necessary.

4.4.2 Target Data architecture

The target data architecture of the integrated HIS describes the data structures used by a business and its computer applications software. It is designed by first defining Principles, Reference Models, Viewpoints and Tools and defining architecture model and lastly finalizing the target data architecture.

4.4.2.1 Principles of target data architecture

Principles govern the design of new data services, changes to existing datasets and impact analysis of larger internal and external change. So six point data principle of the integrated HIS is defined below focusing on, information is used rather than data to shape the principle around the value of data.

1. **Patient information is a valued asset: -**The patient information is assumed and valued as it is the hospitals asset. The full value of information lies also on report generation.
2. **Patient information is managed: -** information should be protected and used according to its value. The responsible body for the information should also be clear. The organizational culture must support best practice information management and ensure employee responsible for processing appropriately.
3. **Patient information is standardized and linkable: -** hospitals should use widely accepted open standard. And information should be linked to bring more value.
4. **Patient information is reused: -** patient information should be used more than once for one or more purpose. Information can either be reused internally through the hospitals or externally by different bodies like Ministry Of Health.
5. **Information is accessible:-**patient information and other information should be accessible in the whole hospital organization when it is needed.
6. **Information is reported: -** Patient and other information produced by the hospital organization should be reported for the necessary body.

4.4.2.2 Reference Model

The following Data reference model depicted in Figure 4.4 is used from the architecture continuum to enable information sharing and reuse across the integrated patient record system. It provides a standard means by which data may be described, categorized, and shared.

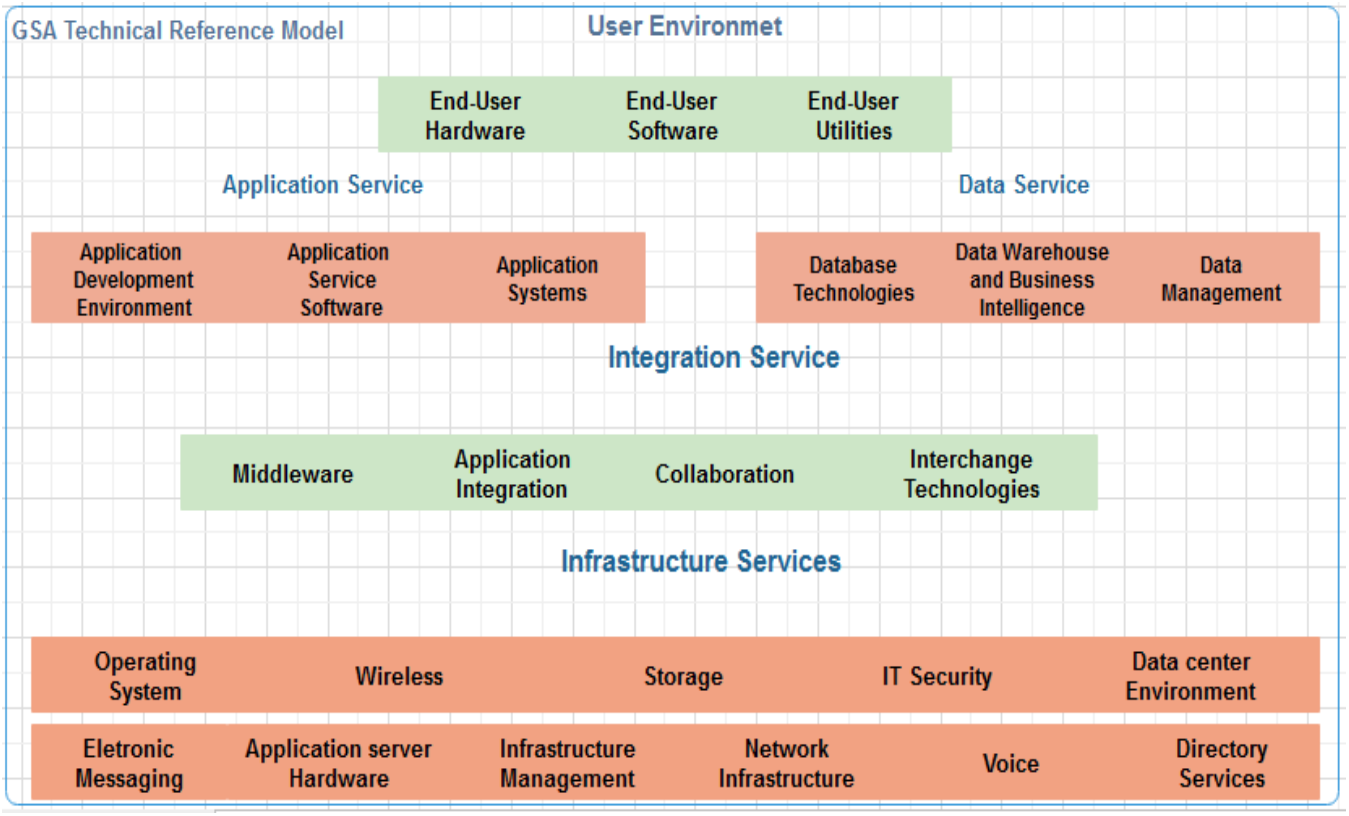


Figure 4.14 Data reference model from the architecture continuum

The Architecture Continuum represents a structuring of Architecture Building Blocks which are re-usable architecture assets for any enterprise. It evolves through their development lifecycle from abstract and generic entities to fully expressed Organization-Specific Architecture assets. The reference model above reflects data reference model on three standardization areas.

- ⇨ Data Description: Provides a means to uniformly describe data, thereby supporting its discovery and sharing.
- ⇨ Data Context: Facilitates discovery of data through an approach to the categorization of data according to taxonomies. Additionally, enables the definition of authoritative data assets within a community of interest.
- ⇨ Data Sharing: Supports the access and exchange of data where access consists of ad hoc requests (such as a query of a data asset), and exchange consists of fixed, re-occurring transactions between

parties. Enabled by capabilities provided by both the Data Context and Data Description standardization areas.

4.4.2.3 Viewpoints of the targeted data architecture

The following viewpoint defines the stakeholders whose concerns are reflected in the viewpoint and the guidelines, principles, and template models for constructing its views. The relevant data architecture viewpoints are the stakeholders and users of the integrated HIS. These stakeholders are:

- ⇨ Hospital owner :the viewpoint of the hospital owner is managerial view point on the guideline of business availability concerns depending on the first principle and the second principle (Patient information is a valued asset and Patient information is managed)
- ⇨ Hospital administration/management: managerial view point on security, availability and safety of service concerns as a guideline and depending on the third principle (Patient information is standardized and linkable)
- ⇨ Medical staff: user view point with individual function and feature of the system concerns as guideline and depending on the fourth and fifth principle (Patient information is reused and Information is accessible)
- ⇨ Nursing Staff: user view point with individual function and feature of the system concerns as a guide line and depending on the fourth and fifth principle (Patient information is reused and Information is accessible)
- ⇨ Allied health professionals end user view point individual function and feature of the system concerns as a guideline and depending on the fourth and fifth principle (Patient information is reused and Information is accessible)
- ⇨ Patients: end user view point with service availability concerns as a guideline and depending on the sixth principle **(**Information is reported).

4.4.2.4Tools for target data architecture

IDEF which is a family of modeling languages in the field of systems and software engineering is selected to describe data capture, modeling, and analysis, in association with the selected viewpoints. IDEF1X is specifically used for data modeling by combining elements of the relational data model, the E-R model, and generalization in a way specifically intended to support data modeling.

4.4.2.5 Architecture Model

The architecture model has been created for each viewpoint/stakeholders specific view required, using IDEF1X for the target data architecture. Each stakeholders/viewpoints has been assigned their attribute and the relationship between them was formed.

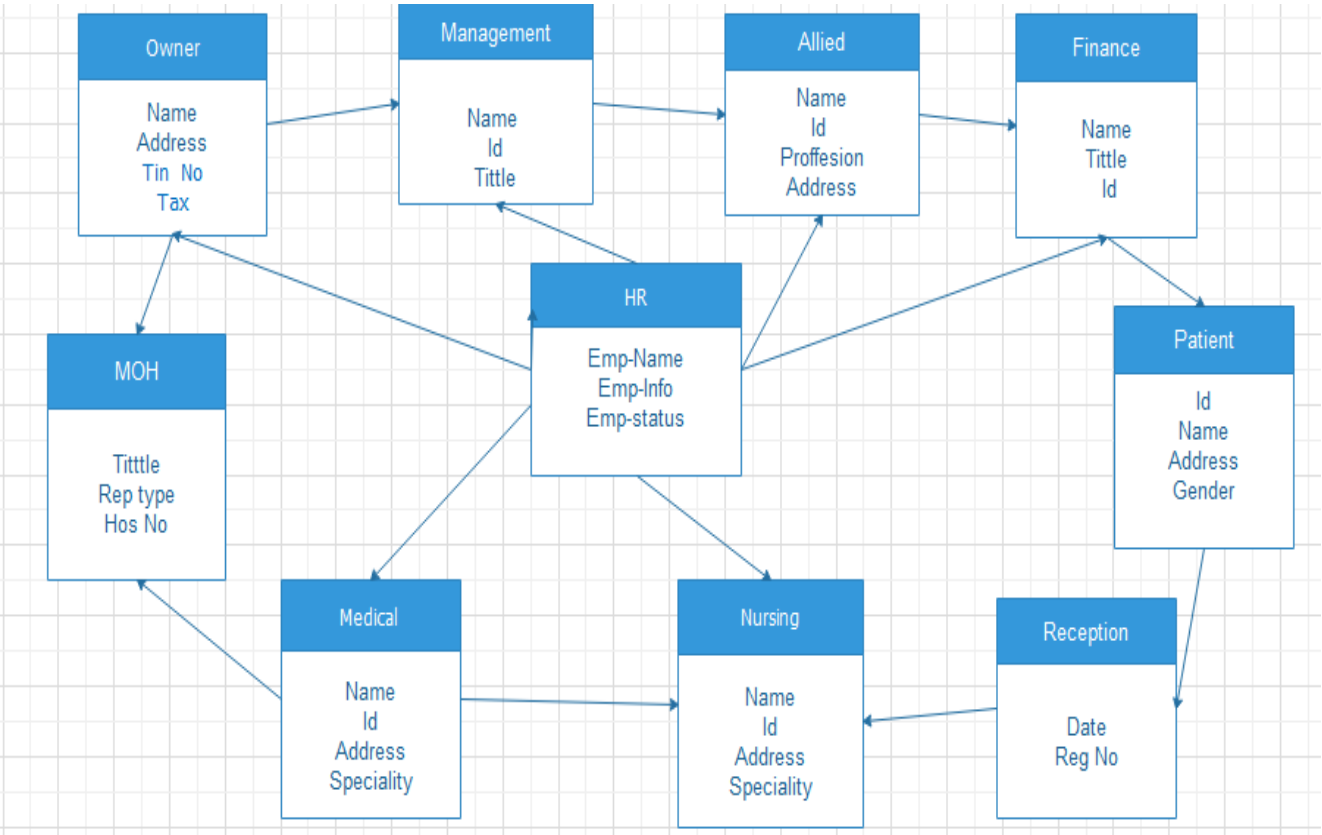


Figure 4.15 Architecture model of the target data architecture

Figure 4.15 above shows the logical architecture model of the integrated/ target data architecture. It is formed of ten entities with their representing attribute. This architecture model is formed of entities that make both main activities such as hospital owner, Medical staff, Nursing staff, allied health professionals and patients and support activities such as human resource, finance.

4.4.2.6 Data architecture building blocks of the target architecture

There are among eight building blocks for the integrated HIS. These building blocks are: Patients, Information, Service delivery, Human resource, Medicine and technologies, Financing and Leadership and governance. The capability of this architecture building block is to meet the business need across the integrated patient record system. The data building block listed above are specified for the integrated patient record system (they form the data architecture model when they are joined).

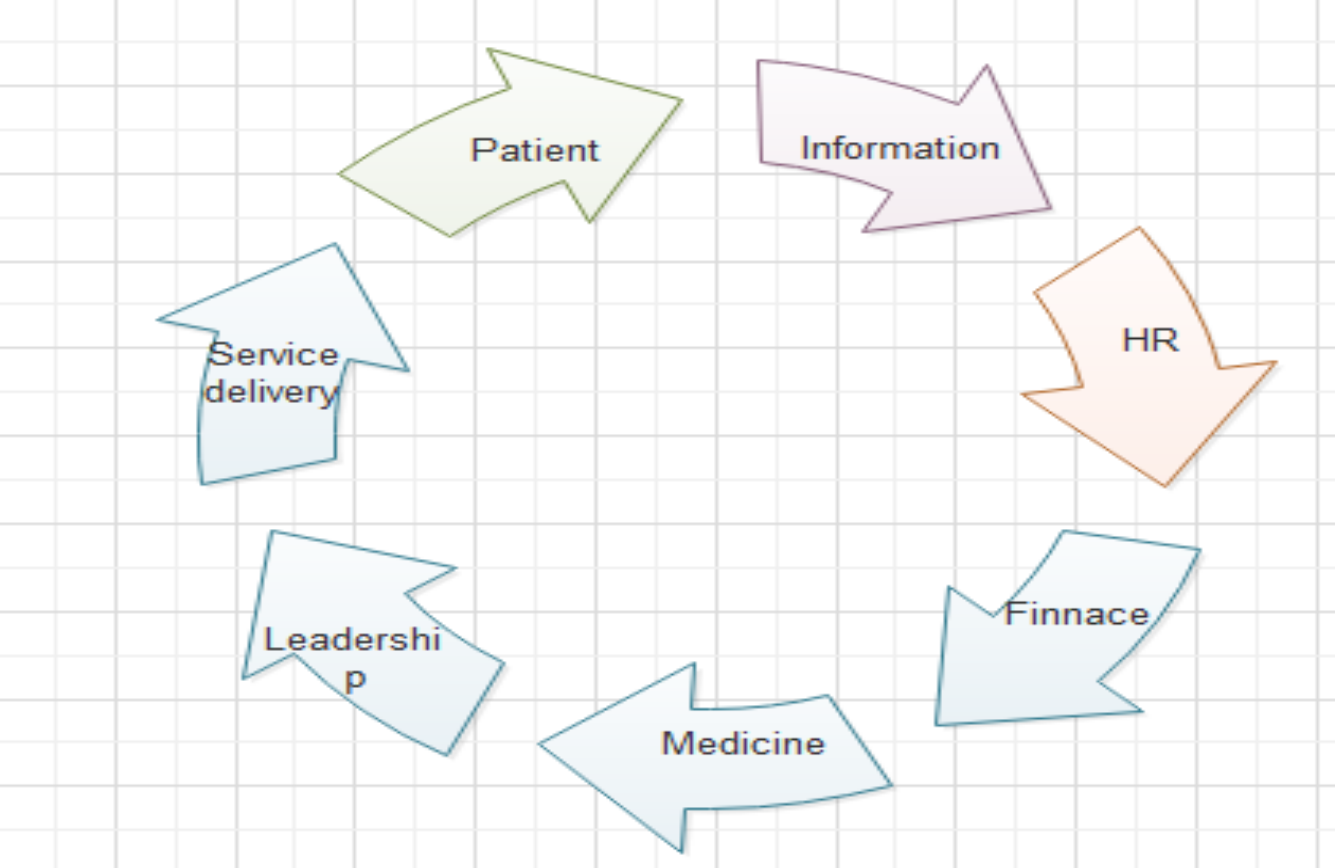


Figure 4.16 Architecture building block of the integrated HIS

4.4.2.7 Checkpoint review

Here the review of the architecture model and building blocks with stakeholders has been conducted by using Entity-Business Function matrices. The purpose of the Data Entity/Business Function matrix is to show the relationship between data entities and business functions within the enterprise. Business functions are supported by business services with explicitly defined boundaries and will be supported and realized by business processes.

	Data entity				
Business Function	Patient/Customer	HR and Finance	Reception	Health Service	Report
Assign patient	X		X	X	X

Check payment		X		X	X
Laboratory order	X	X		X	X
Medication order	X	X		X	X
Patient treatment	X	X	X	X	X
Laboratory examination	X	X		X	X
Vital information collection	X	X	X	X	X
Report	X	X	X	X	X

X= Data entity is used with business function

Table 4.6 Data Entity/Business Function matrix for integrated health information system

4.4.2.8Review the qualitative criteria

The opportunities presented by the integration solution can be viewed in form of core quality attributes, the criteria's used are:

- **Performance:** There will be clear separation of middleware that uses high-performance enterprise-class message and also use of web-services for other messaging (especially internal) results in this factor becomes a performance constraint.
- **Usability:** A separate module devoted to providing management services of the system is an enabler for the usability attribute. This will allow system administrators to easily track transactions through the system for Troubleshooting, Debugging and Auditing.
- **Security:** The entire integrated HIS System will be running within a corporate firewalled environment. The Security aspect is covered from 5 angles: single sign on which is on authentication gateway, encrypted data access within Business services, Random queue number allocation by message broker, double firewall and Instrumentation.
- **Reliability:** Runtime reliability is ensured in the system by having redundant failover modules identified and implemented during deployment. Stateless services allow load-balancing of critical components using specialized hardware devices. Non-runtime reliability is assured by having all newly developed modules specifically designed to cater to the boundary conditions of Initialization, Failure, Recovery and Termination.

4.4.2.8Data architecture (Completed)

Under this sub section of data architecture the integrated HIS data architecture has been presented completely by using three TOGAF recommended tools the system/data matrix, class diagram and data dissemination diagram.

System/Data Matrix: The purpose of the System/Data matrix is to depict the relationship between systems (i.e., application components) and the data entities that are accessed and updated by them. Systems will create, read, update, and delete specific data entities that are associated with them.

Application	Description	Data entity	Data entity type
Registration service	Application where patients are registered	Patient/ Customer data	Master data
Health service	Application where patients get checkup and medical orders	Patient/ Customer data	Master data Historical data
Laboratory service	Patients get laboratory examination and result	Patients vital information	Master data
Pharmacy service	Patients get drugs	Disease result /Patient data	Historical data
HR service	Patients and employees are served with issues related to finance	Employee work report Employee data Patient data	Master data Historical data

Table 4.7 System/Data Matrix of integrated health information system

Class Diagram: The purpose of class diagram is to depict the relationships among the critical data entities (or classes) within the enterprise. These entities are used to define business processes (products handled by processes), and derived to define service application components, exchange data between services and repository data schemas.

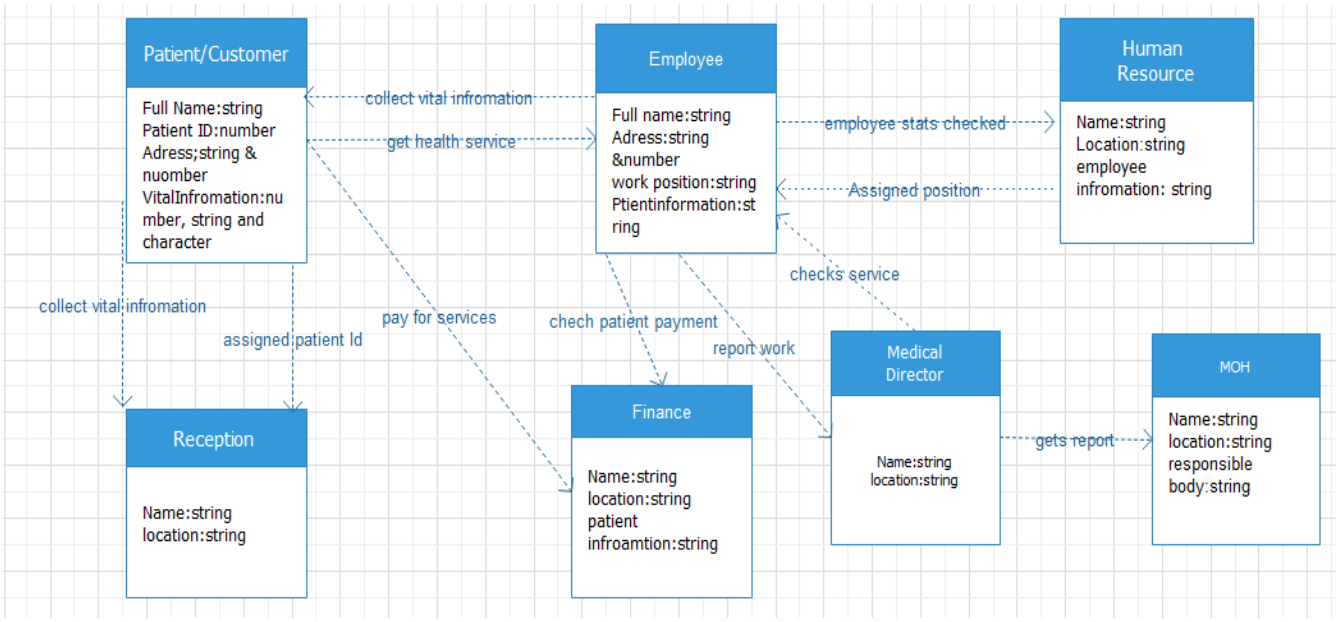


Figure 4.17 class diagram of the integrated health information system

Data Dissemination Diagram: The purpose is to show the relationship between data entity, business service, and application components. The diagram shows how the logical entities are to be physically realized by application components and data replication and system ownership of the master reference for data.

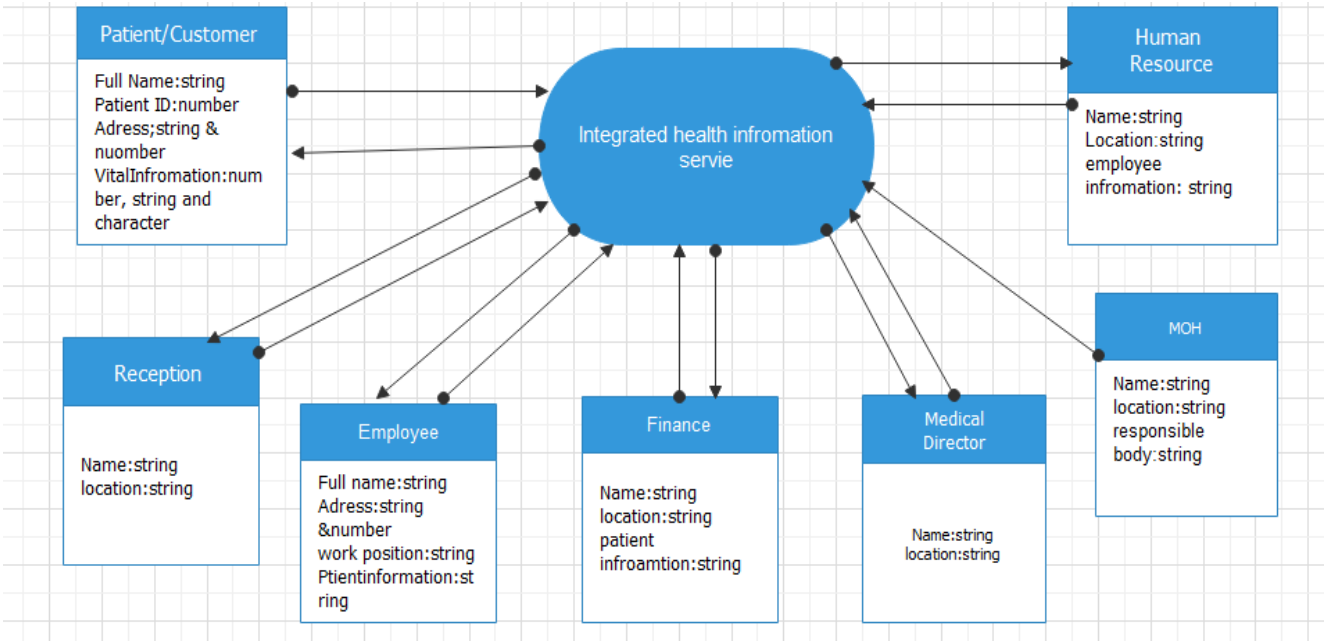


Figure 4.18 Data Dissemination diagram of integrated health information system

Business service	Data entities	Application
Integrated health information service	Employee	Reservation/reception
	Patients	Finance
	Finance and Human Resource	Heath service
	Medical Director	Reporting
	Ministry Of Health	

Table 4.8 description of data dissemination diagram

4.4.3 Gap analysis

The entities of the baseline data architecture and the target data architecture has been presented to do the gap analysis between the baseline and the target data architecture. The eliminated data entities from the baseline data architecture has been identified and used in the target data architecture development.

Baseline \ Target	Patient	Reception	Doctor	Nurse	Allied	System admin	Finance	Management	eliminated entities
Patient	I								Human resourse
Reception		I							Ministry of health
Doctor			I						Report
Nurse				I					
Allied					I				
System admin						I			
Finnace							i		
Management								I	

I= the entities are included in both baseline and target data architecture

Figure 4.19 gap analysis of the baseline and target data architecture

Figure 4.19 shows the gap analysis of baseline and target data architecture. The eliminated data entities form the baseline data architecture were, the human resource is not included in GGH HIS, Report is not found in KGH HIS and Ministry Of Health is not included in both Hospitals.

Other than the above data entities the conceptual and logical data model of both hospitals covers only the main business process entities. Like the doctors, nurses, allied health professionals (pharmacy and laboratory technician), patients and reception. The objects that help with the support activities like, management, HR and finance has not been included. They are prepared and used in the target data architecture as they are necessary to complete the business process.

To summarize and conclude this sub section TOGAF architecture the baseline data architecture of both hospitals has been described by using the conceptual and logical data model view. Data principle has been set in order to make clear the use of the data in the integrated means. Architecture model with data building block has also been set and discussed and finally the data architecture has been completed and gap analysis between the baseline data architecture and the target data architecture has been done. Based on the gap analysis, the target data architecture of the integrated HIS has been designed based on seven data building block, Patients, Information, Human Resource, Finance, Medicine, leadership and governance and service delivery. Each entity in the logical data model is grouped under this data building block. Doing so, the researcher has finally designed the data base architecture to present how the integrated HIS looks like in data perspective.

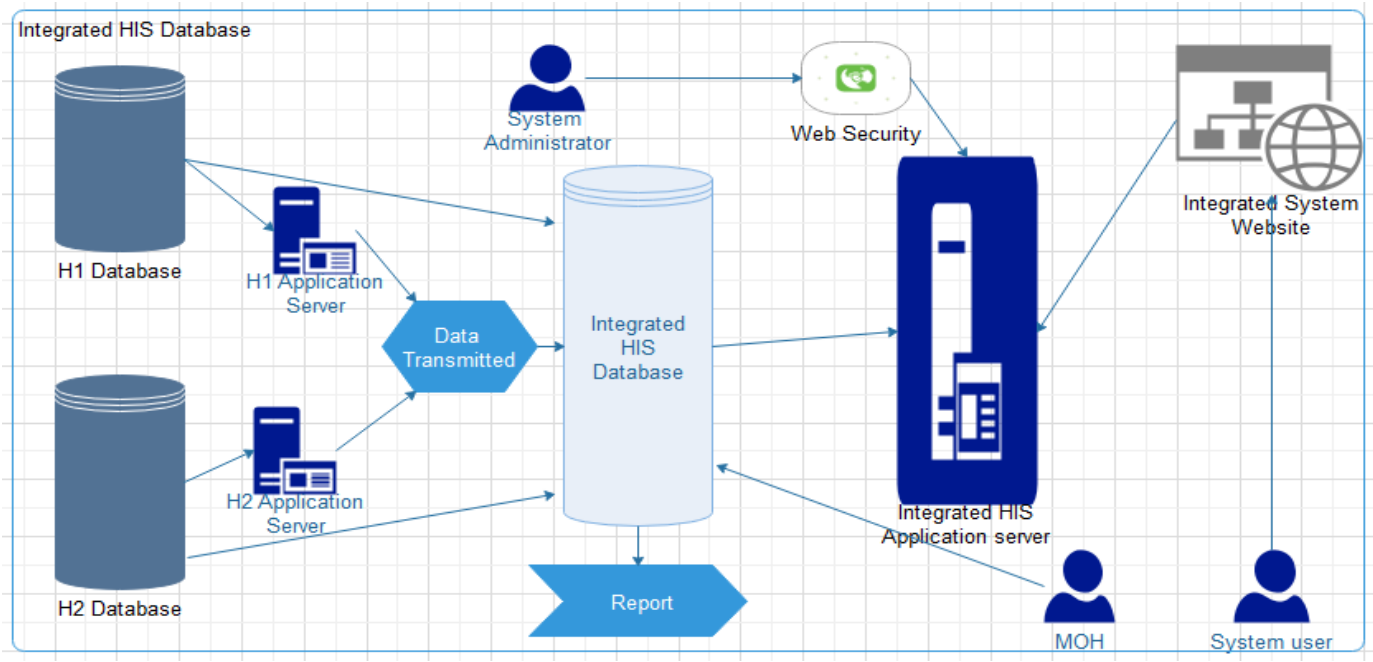


Figure 4.20 Integrated Health record system Database design architecture

Figure 4.20 shows the integrated HIS database share data from the legacy application databases by a data transmitter. There is one main integrated HIS application server from which clients can share data. The entities are grouped as system administrator, system user: including the human resource, finance, employees on the health service like, doctors, nurses, laboratory technician, pharmacist and receptionists. The external user represents Ministry Of Health. The security of the system is controlled by the system administrator (providing user privilege so that, user access their provided component only).

When patient data is converted form the legacy database of hospitals to the new designed integrated health information system database, data duplication may occur as one patient may get service form both or more hospitals. To limit this data duplication the researcher choose to merge the duplicated data by re writing the data; This required manually reconciling conflicting data in the two data stores, and modifying the associated business logic to conform to this.

4.5 Application Architecture

Application architecture is a map of how an organization's software applications are assembled as part of its overarching enterprise architecture and how those applications interact with each other to meet business or user requirements. The objective here is to define the major kinds of application system necessary to process the data and support the business. The steps are presented below.

4.5.1 Baseline Applications Architecture (KGH)

The name, who maintains, owner, other users, Business functions supported, in KGH has been described. The HIS of KGH contains four main applications they discussed as below.

- **Administration:** maintained by the human resource, the system/hospital owner and the management. The business functions under administration are, controlling the system, control employee status, control finance flow and administrate and govern the organization.
- **Registration:** maintained by the reception body. The business functions here are, accept and register patient on the HIS, assign patients to physician.
- **Finance:** maintained by the finance officer. It controls and check finance issues such as patient payment and credit service
- **Health service:** maintained by the medical director, other users are doctors, nurses and allied health professionals. The main business function is providing the patient health service depending on the information collected from the patient and diagnosis done.

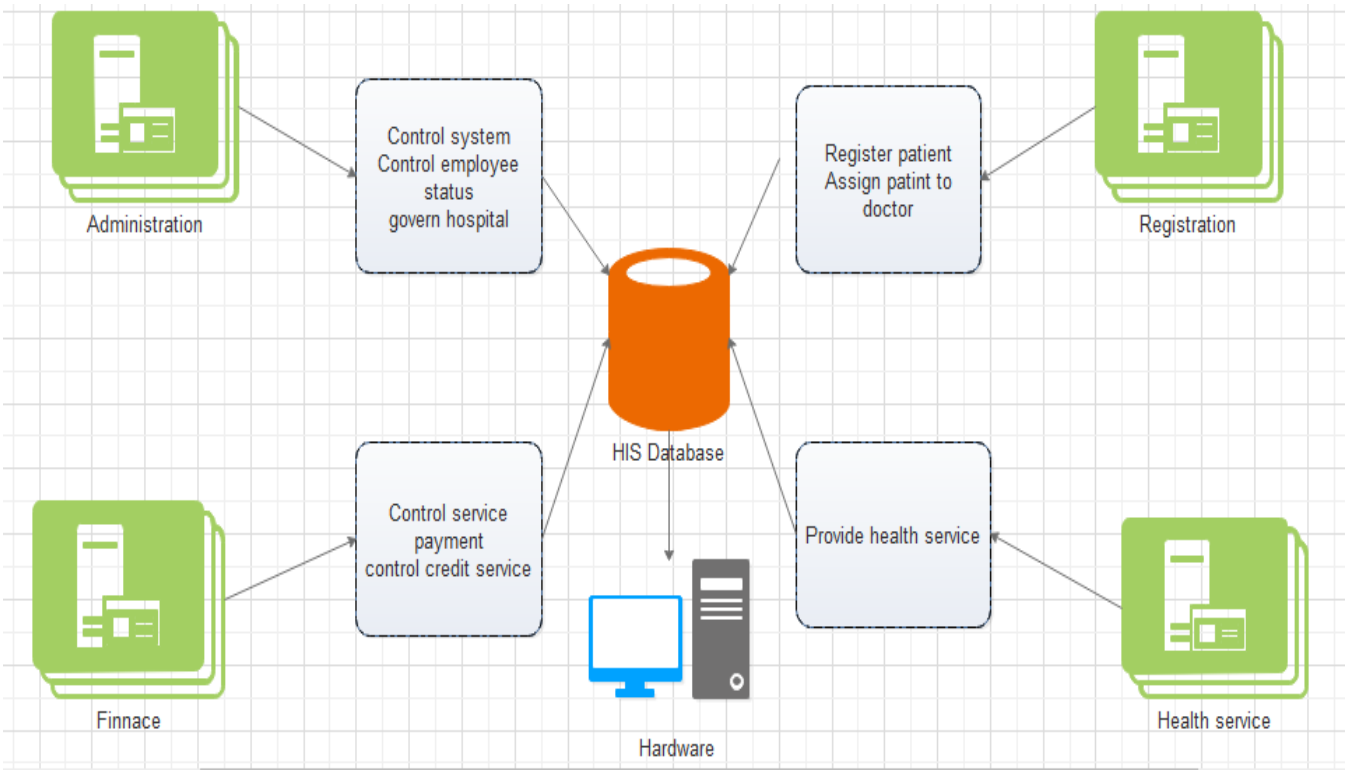


Figure 4.21 baseline application architecture of KGH

4.5.2 Baseline Applications Architecture (GGH)

The name, who maintains, owner, other users, Business functions supported, in KGH has been described. The HIS of GGH contains five main applications**.**

- **Administration:** maintained by the management team containing seven members. The main business function is controlling the system, finance, and health service and report generation.
- **Finance:** administrated by the finance offices group. The main business service is controlling the service payment and credit service of other organization.
- **Registration:** administered by the reception body. The main business function is registering, keeping and identifying status of registered patient.
- **Information:** vital information collection is done by the nurses. The business function is collecting the vital information from patients and assigning that information to the doctors.
- **Treatment**: is maintained by the medical director, doctors, nurses, laboratory, pharmacy and other allied health professionals. The business function is providing health service for patients.
- **Report**: is maintained by employees who process health service such as doctors and nurses. The business function is producing the work report to be checked by the administrator.

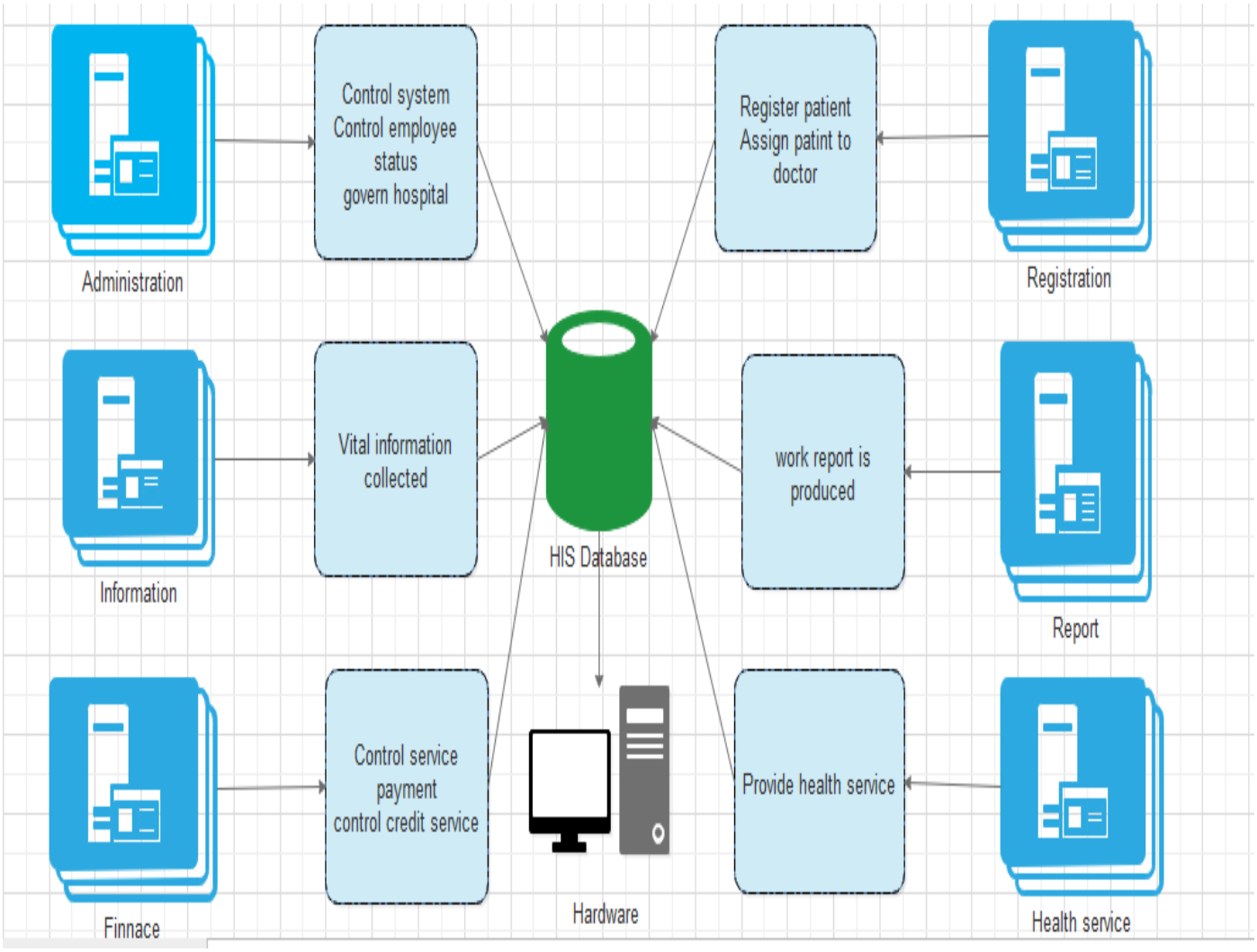


Figure 4.22 baseline application architecture of GGH

4.5.3 Application Principles for targeted architecture

Application principle is a proposition or value that is a guide for behavior or evaluation of the application architecture. The following three application principles have been set for the integrated HIS application architecture.

- **Technology independence:** the applications should be independent of technologies. Thus they run in different technologies to enable the system user access the information system.
- **Ease of use:** the applications should be easy for use so that any user of the system can simply understand and use the information system.
- **Unified user interface:** unified user interface should be designed to enable different hospitals use the same platform for their information system.

4.5.4 Target Application Architecture

The target application architecture specifies the technologies to be used to implement one or more information systems in terms of DATA, PROCESS, and INTERFACE, and how these components interact across a network. The application architecture of the target integrated HIS is shown below by using a diagram that relates the users of the system the application and the technology aspects such as the HIS database, the server and the hardware devices to be used in the integrated HIS.

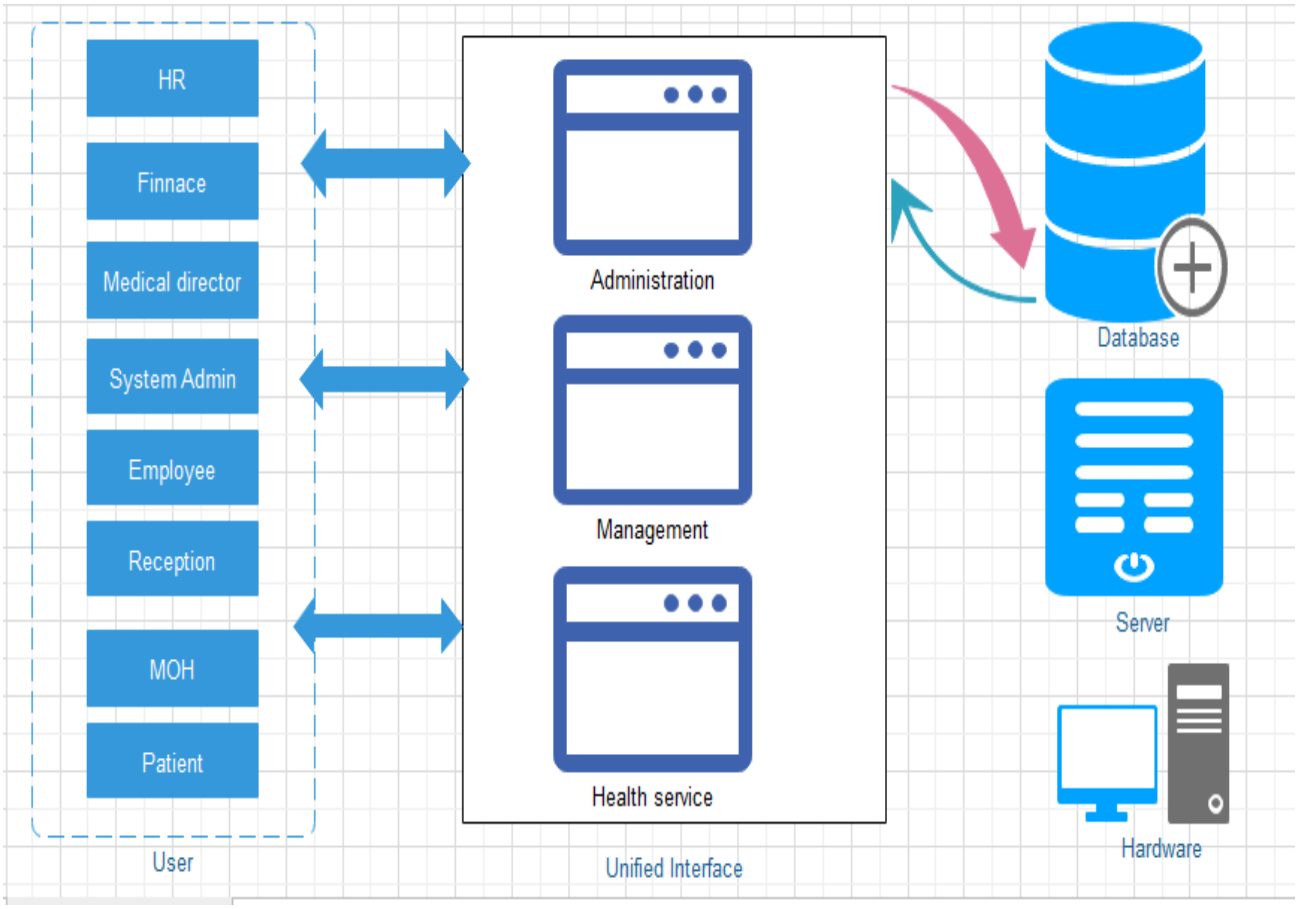


Figure 4.23 application architecture model of the target application architecture

4.5.5 Gap Analysis

The baseline application architectures presented in the above section shows that both hospitals application are dependent on each other and perform their tasks. The users have not been clearly defined. But in the target application architecture the researcher has defined the real user of the integrated HIS application and unified interface platform has been designed based on the application architecture defined above. The target application architecture will meet the application principle by its unified interface and also being technology independent.

4.6 Technology Architecture

Technology architecture is a description of the structure and interaction of the platform services, and logical and physical technology components. The objective of this stage of TOGAF includes:

- ⇨ Technology Baseline Description.
- ⇨ Target Technology Architecture
- ⇨ Gap analysis

4.6.1 Baseline technology Architecture

To present the baseline technology architecture major hardware and software platform type is described with their Name , Users, description of what the hardware / software platform is, Business functions supported, Organizational units supported , Networks accessed, Applications and data supported and System inter-dependencies.

As the technology of both hospitals is the same the baseline technology architecture is taken as the one. The main software platforms in the hospitals are:

- ⇨ **Electronic Health Record:** the hospital organization such as the reception the doctors nurses and other allied health professionals use the electronic health record. This software platform helps the hospitals by keeping the information of patients on their system. The business function supported under here is patient information registration (starting from vital information to health service information). The whole organizational unit uses this platform. It accesses the hospitals network provided by Ethio telecom.
- ⇨ **Patient Scheduling**: patient scheduling for the health service is another software platform used by mostly the medical services providers such as reception doctors and nurses. It is a platform that does the patient schedule based on the step they were registered on the system. The business function is providing patients the correct schedule to get the services.
- ⇨ **Practice Management**: is a software platform that supports the management team of the hospitals. Its business function is to enable the hospital management (the owners and management team).
- ⇨ **Clinical Documentation**: is the platform that provides the hospitals in preparing the documentation for the health services provided by the hospital organization team.

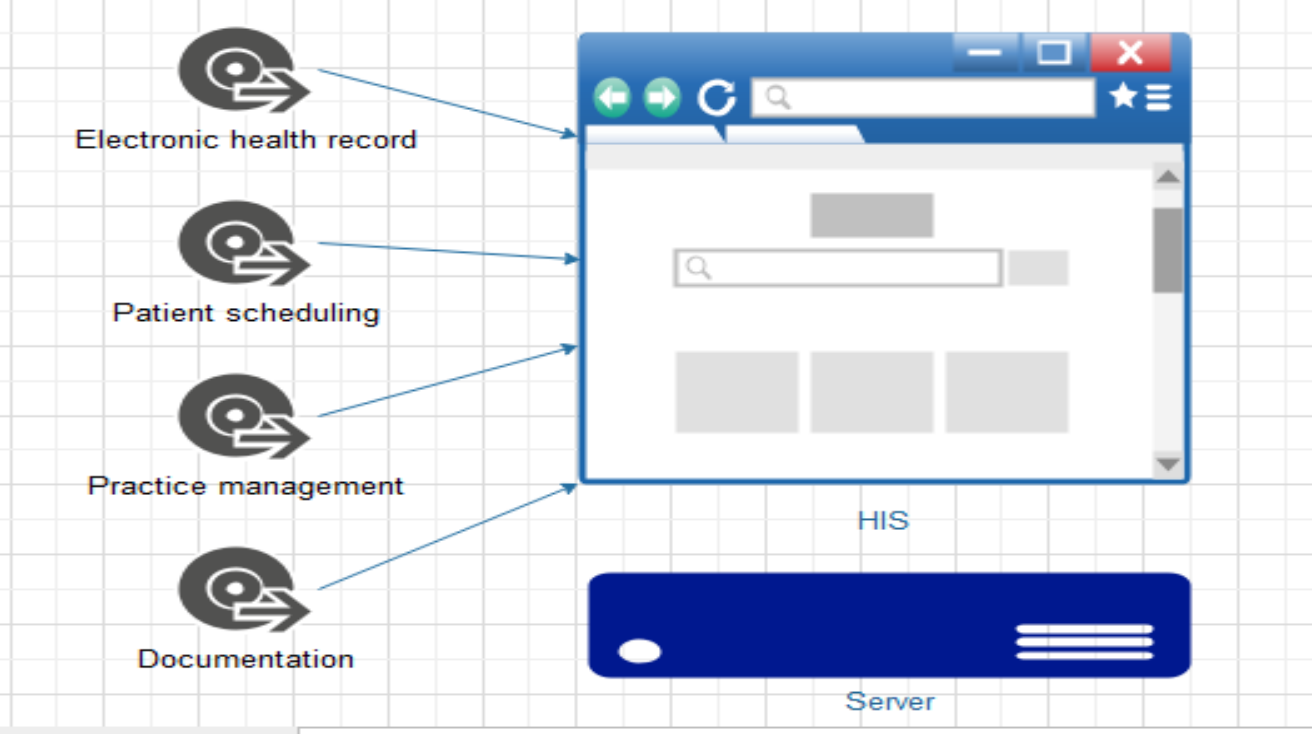


Figure 4.24 software platform of the baseline technology architecture

The main hardware platforms of the hospitals are identified as following.

- **Server**: is a computer designed to process requests and deliver health related data to another module of the system over the internet or a local network of the hospitals.
- **Computers:** both hospitals have different kinds of computers and other diagnosis performing machines to enable them Figure out the patients' health.
- **Data backup setup**: data backup is the result of copying or archiving files and folders for the purpose of being able to restore them in case of data loss. As data loss can be caused by many things ranging from computer viruses to hardware failures to file corruption to fire, flood, or theft.
- **Network:** is a collection of computers, servers, mainframes, network devices, peripherals, or other devices connected to one another to allow the sharing of data

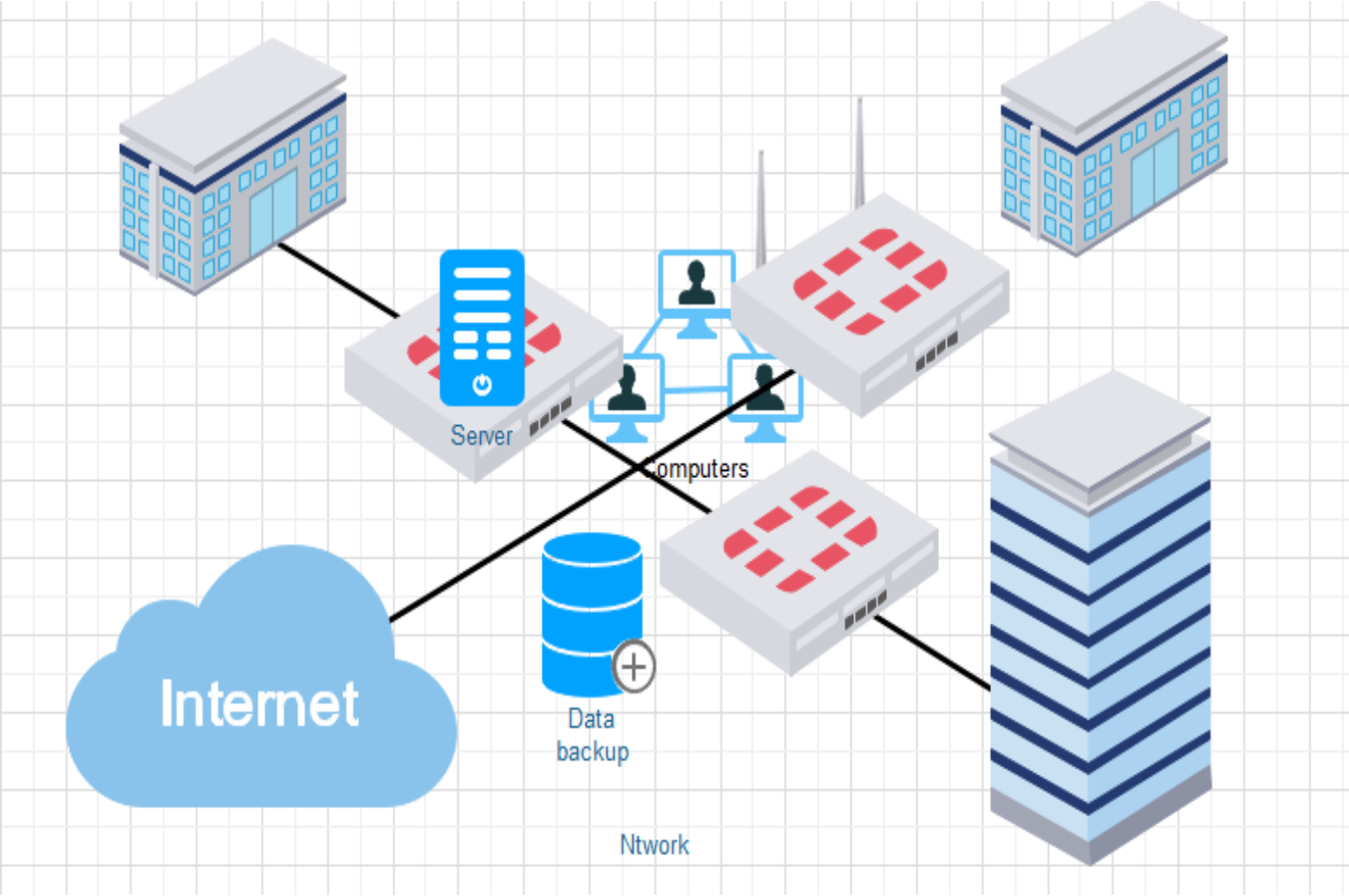


Figure 4.25 hardware platform of the baseline technology architecture

4.6.2 Target technology architecture

The technology architecture of the integrated HIS is done depending on the baseline technology architecture as the current technology existing in both hospitals is identical. The target technology architecture has been presented by using the following TOGAF tools.

4.6.2.1 Platform decomposition diagram

The Platform Decomposition diagram shows the technology platform that supports the operations of the Information Systems Architecture. The diagram covers all aspects of the infrastructure platform and provides an overview of the hospitals technology platform.

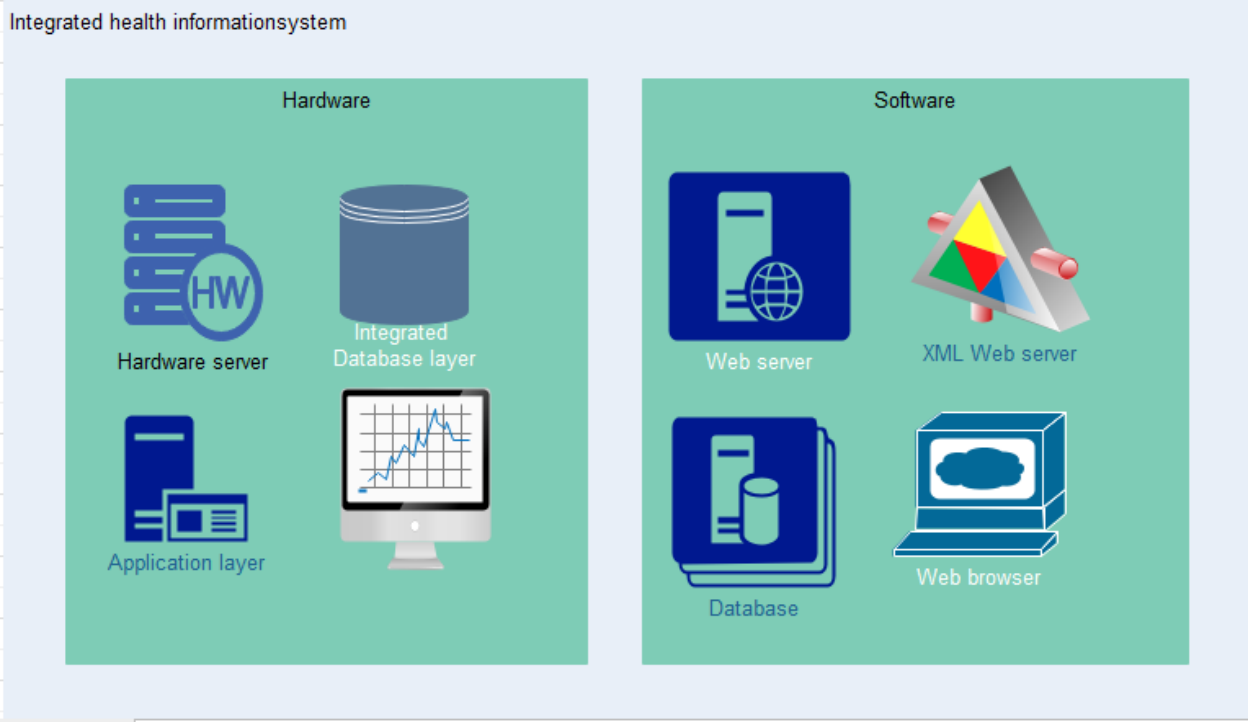


Figure 4.26 technology component of the integrated health information system

Figure 4.26 shows the hardware and software technology component. There is computer access, hardware server, application layer and database layer for an integrated health information system in the hardware technology component. On the software technology component part there is web server which serves all applications there is also XML web server to design the web. The database design for integrated HIS is also software component which is accessed through the web server by using any web browser.

4.6.2.2 Environments and Location Diagram

Environment and Location diagram represents which locations host which applications; Identifies what technologies and/or applications are used at which locations; Identifies the locations from which business users typically interact with the applications; also show the existence and location of different deployment environments: including non-production environments, such as development and pre-production.

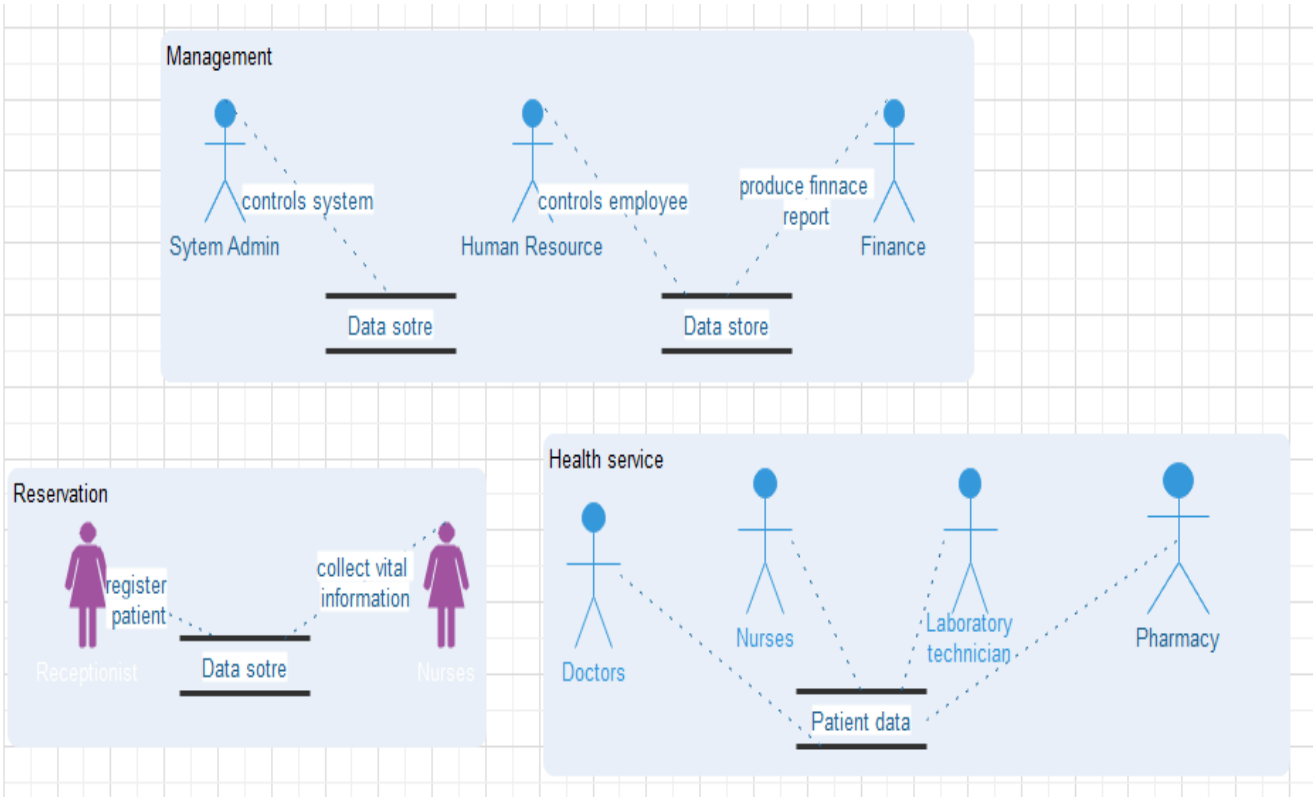


Figure 4.27 Location diagram of target integrated HIS

As Figure 4.27 displays the integrated health information system is classified in three locations the management that includes the system administrator, the human resource and the finance. These parts of management location focuses on controlling the system and the health service.

The second location is the reservation which includes the reception and nurses to collect vital information from patients.

The third part is the health service provider which includes the doctors, Nurses, Laboratory technicians and the pharmacy. These whole parts focus on giving health service (checkup, medication, laboratory examination and treatment) for the patients.

4.6.3 Gap analysis

The integrated HIS is independent of technologies being used or planned to be used. Thus there will not be much gap between the existing/ baseline technology architecture and the target/ integrated HIS.

4.7 Opportunities & Solutions

This stage of TOGAF describes the process of identifying delivery vehicles (projects, programs, or portfolios) that effectively deliver the Target Architecture identified in previous phases. It concentrates on how to deliver the architecture. Its objective is to:

- ⇨ Evaluate and select among the implementation options identified in the development of the various Target Architectures (for example, build *versus* buy *versus* re-use options, and sub-options within those major options)
- ⇨ Identify the strategic parameters for change, and the top-level work packages or projects to be undertaken in moving from the current environment to the target
- ⇨ Assess the dependencies, costs, and benefits of the various projects
- ⇨ Generate an overall implementation and migration strategy and a detailed Implementation Plan.

4.7.1 Architecture review

The integrated architecture development is initiated by employing the open group architecture framework. In the preliminary stage the idea of where, what, why, who, and how we do architecture" in the enterprise concerned was discussed. The purpose of the exercise using TOGAF has been to develop an integrated HIS for private hospitals in order to address the problems arising from using different patient record systems by the different private hospitals.

Two hospitals have been used as an enterprise in this study Kadisco General Hospital and Girum General Hospital. Their organization unit has been identified and Requirements for architecture has been identified as, the Hospital owner, the management, the employee and the services. The architecture principle and the architecture vision have been set. Under the business architecture baseline business architecture, target business architecture, product and organizational process and gaps between the baseline and target business architectures have been discussed and clear business process has been identified for the target business architecture. Clear target data architecture has been set depending on the baseline data architecture of the hospitals under the data architecture phase. Both application and technology architecture has been designed.

4.7.2 Implementation description

This phase is the phase where visions and plans become reality. This is the logical conclusion, after evaluating, deciding, visioning, planning. Technical implementation is one part of executing a project. It is the process that turns strategies and plans into actions in order to accomplish strategic objectives and goals. In order to implementations become successful there are steps to follow

- ⇨ The necessary infrastructures such as every hardware platforms and software platforms with the technology must be prepared.
- ⇨ Implement training should take place to make clear that the users of the organizations can use the system.
- ⇨ The hospital data in both hospitals should be converted to the integrated means by following the data architecture model set on the data architecture phase.
- ⇨ Solutions are monitored

The TOGAF phases used in the above study enables both hospitals to implement the integrated HIS environment by providing different benefits/ advantages. The benefits form the architecture development is described below by using benefit diagram.

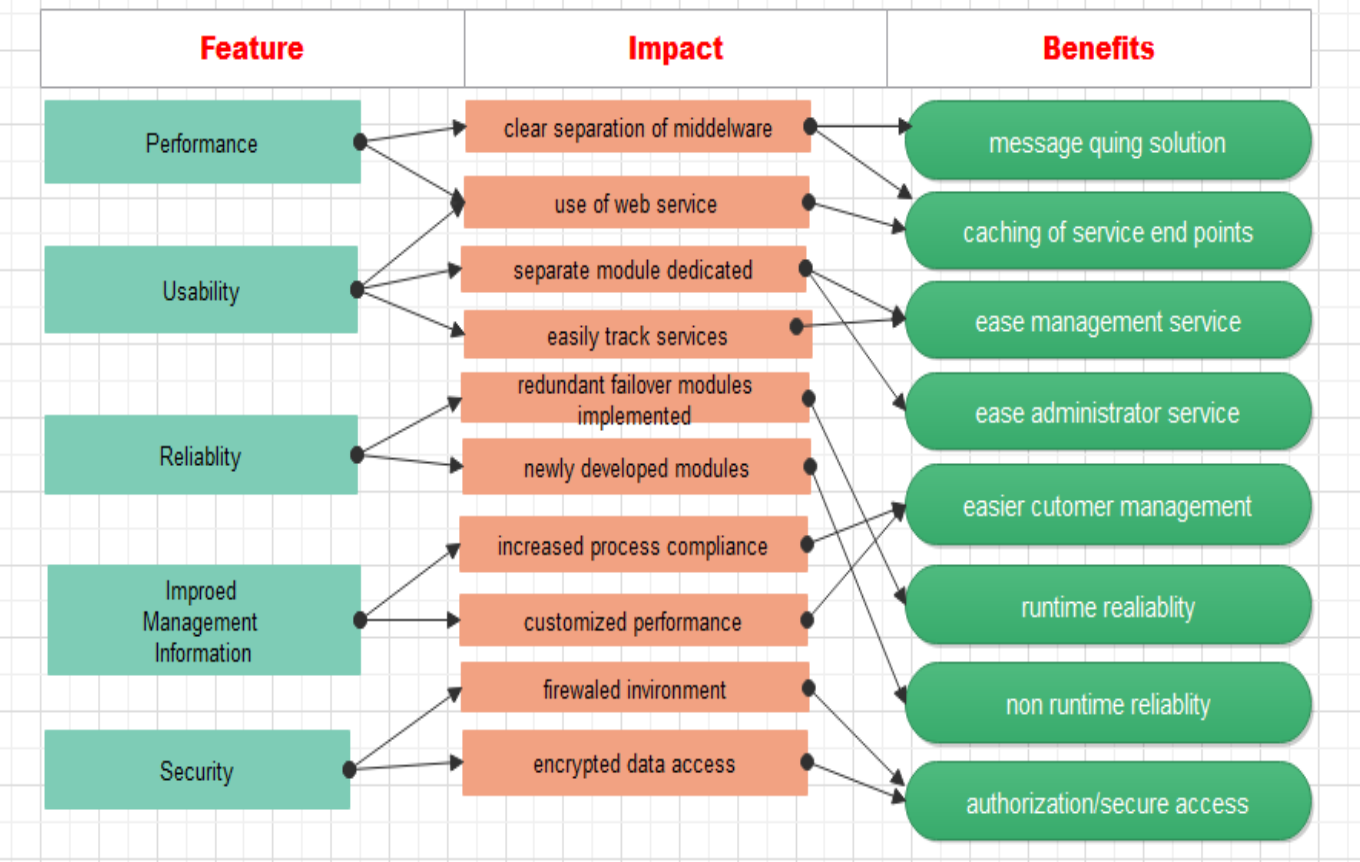


Figure 4.28 Benefit diagram of integrated HIS

Figure 4.12 shows the benefit diagram of the integrated HIS. As it has been shown in the diagram the feature of the new integrated HIS are: performance, usability, reliability, improved management

information and security, each of them with impact/ description and with the benefit they bring to the user of the system.

These benefits are gained from the output of the business architecture as each business process with their corresponding business participants has been identified and set. Under the data architecture also the logical and the conceptual data model of the target architecture has been set and makes simple way for the application architecture to provide unified user interface and the technology architecture also provides clear technological needs and presented location design to show how each users and applications are used in the physical aspect.

4.7.3 Hardware and software facilities

All hardware (physical device used in or with machines) and software (collection of code installed onto computer's hard drive) facilities described under the technology architecture has to be fulfilled to make the implementation successful.

4.7.4 Performance monitoring

Benchmarking is an excellent way to gain feedback about business's performance. Benchmarking compares the measures such as cost, cycle time, productivity, or quality of a specific process or method to what is widely considered to be an industry standard or best practice.

Using an integrated HIS by TOGAF architecture has much advantage for the organizations studied particular and private hospitals in the country in general. It improved data accessibility through the organization as data will be kept in an integrated and unified database. In previous case data accessibility were low and related only to single hospital in it made reporting difficult but currently this can be solved. There will be Better Communication between the overall organization and also better communication between the customer and the health service because information is kept and managed in the integrated means. It will also improve service as patient registration and reservation will be simple hospitals can serve more patients than they had. It reduces other production costs and less time is taken to implement.

Finally the scope of a work package to be implemented as a part of a broader transformation roadmap has presented below by using project context diagram.

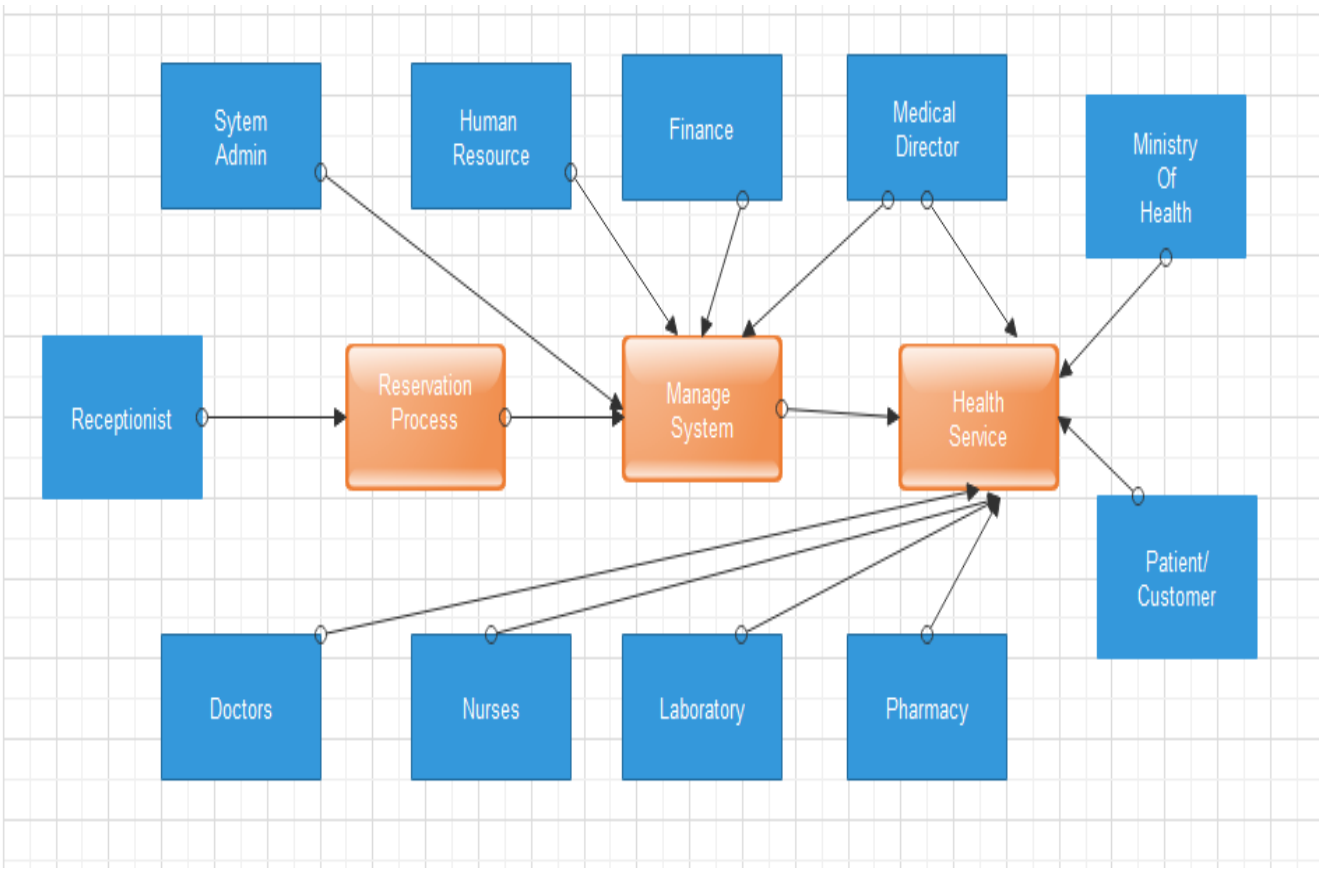


Figure 4.29 project context diagram of the integrated HIS

4.8 Requirement management

The objective of this phase is to provide a process to manage architecture requirements throughout the phases of the architecture development method (ADM) cycle, to identify requirements for the enterprise store them and feed them in and out of the relevant ADM phases which dispose of address and prioritize requirements.

4.8.1 Requirement

The Architecture Requirements Specification is quantitative statements that outline what an implementation project must do in order to comply with the architecture. So the implementation group of hospitals must do the following things.

- ⇨ Prioritize projects*:* prioritizing project is the necessary step and the best way for the hospitals to prioritize their project is by making their base on business value which is clearly stated on the business architecture. Urgent and important projects should also be identified.

- ⇨ Estimate resource requirements and availability: Estimating resource will be easy if schedule is prepared for the project depending on the standard working days and if the cost of the project is calculated and arranged with the project schedule.
- ⇨ Perform cost/benefit assessment of the projects*:* is a technique used to compare the total costs of a project with its benefits, using a common metric (most commonly monetary units). Decisions are based on whether there is a net benefit or cost to the approach.
- ⇨ Perform risk assessment: is done by following five risk assessment steps Identify hazards/ anything that may cause harm, Decide who may be harmed, and how, Assess the risks and take action, Make a record of the findings, Review the risk assessment.
- ⇨ Generate implementation roadmap/ timeline

  Implementation road map can be produced by passing through five steps Identify strategic objectives, Plan for the future, Define functional needs and priorities Measure the cost and Establish realistic timelines

4.8.2 Assumption

The implementation body should follow TOGAF assumption which is described as using the whole architecture development method (ADM) through the whole process of business enterprise design. The open group architecture framework is a methodology to guide a step-by-step process for designing enterprise architectures.

4.8.3 Constraints and Gap

A constraint, in research is any restriction that defines a project's limitations. As the open group architecture framework follows the idea of using ADM phases, the implementation group should define the constraints that may face the project. Constraints related to implementation of the target architecture were recognized and presented as follows

- ⇨ Hospitals had not well organized documentation for their health information system.
- ⇨ The bodies that developed the health system are also changed and there were difficulty in clearly understanding the HIS system in both hospitals.
- ⇨ Both hospitals do not have clearly stated business strategy and business principle
- ⇨ There was no clear framework of the health information system in both hospitals. However the researcher changed the existing data form the hospital to the TOGAF framework architecture.

The research thesis has shown how the open group architecture framework can be used for integration of health information system simply. TOGAF has its own method of developing and managing the lifecycle

of enterprise architecture called ADM. This feature of TOGAF has enabled the researcher to design the integrated HIS system of two different hospitals in to one.

The purpose of developing an EA for the two hospitals is that it combines current requirements and constraints with future development and target state. It also enables more efficient business operation with lower costs, more shared capabilities, lower management costs, more flexible workforce, and more organization, less duplication and redundancies and improved business productivity.

The main architecture building blocks of organizations (business architecture, data architecture, application architecture and technology architecture) have been designed and simplified to be converted to use. Architecture vision that can be used in any organization integration process has been developed. Ways and opportunities to employee this TOGAF presented integration framework was made out. The requirement for the project to be successful has also been set and using the whole architecture development method (ADM) through the whole process of business enterprise design should be taken as an assumption through the implementation of the project. Finally the framework to show how the integrated patient record looks like would is presented below in Figure 4.30.

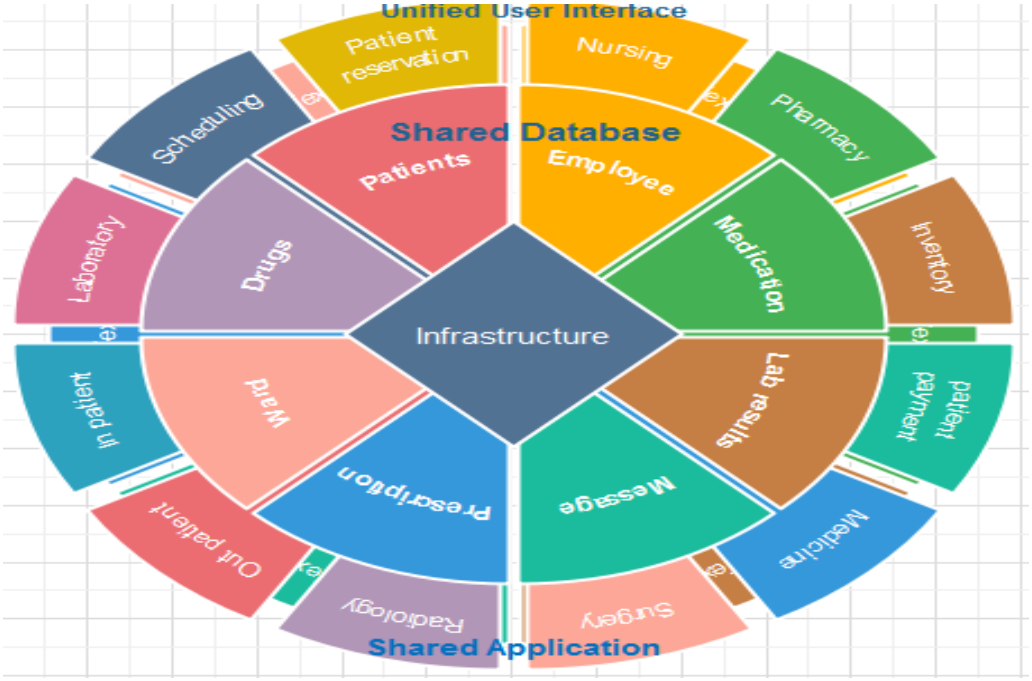


Figure 4.30 Integrated patient record system framework

Figure 4.30 shows how the integrated health information system looks like. The framework shows a unified user interface which covers different shared application to enable the patient record system function. The services /applications are Patient reservation, Nursing, Pharmacy, Scheduling, Laboratory,

Inpatient and Outpatient service, Radiology, Surgery, Medicine, Patient payment service and inventory. There is also the integrated/shared database which includes patient's information, Employee information, Medication, laboratory result information, Messages between the employees, wards, prescription and drug information. In the inner diamond there is the infrastructure requirement including both software and hardware infrastructure to function the integrated HIS.

4.9 Evaluation

Research evaluation is an orderly and objective assessment of continuing or completed project. The aim is to determine the relevance and level of achievement of project objectives, development effectiveness, efficiency, impact and sustainability. It is planned to have some real-world effect. The research followed outcome impact evaluation which assesses the changes that can be recognized to a particular intervention, such as a project, program or policy, both the intended ones, as well as ideally the unintended ones.

Sample Medical doctors (two) and nurses (three) of both hospitals have seen the research document and they have evaluated the research in terms of impacts it can bring if implemented. They presented their ideas as follows.

The integrated HIS framework can be used if implemented with some pre requirements. The interviewee argued that clear and wide training of the new integrated HIS framework should be given if wanted to be used. They like the idea of sharing patient information from the same database for making work progress smooth and short time taking. But they have this request that the security issue should be given big concern. They suggested that if the current real systems are integrated there will not be much difficulty in using the system but they need little clarification.

They brought an idea that the management team of the hospitals has to support this integration by setting clear business strategy and law for their workers and customers. They suggested the idea of integrating hospital system is good idea but should be done carefully and the technologies for supporting both hospitals data should be prepared first. They also expect the integrated HIS framework to add features such as ease of work, online patient registry and report access.

CHAPTER FIVE

5. Conclusion and Recommendation

5.1 Conclusion

In this very last chapter of the research the conclusion of the study has been presented and recommendation that were derived from the conclusion is described.

The research has been initiated by ideas seen from observation in different hospitals and health care providers in Addis Ababa. The problems that initiated the study include (a) public health information from one hospital may not be used in other locations/hospitals. (b) Patients cannot also get timely treatment as they have to wait for the processing/creating of their patient profile anew in each hospital they go, and (c) the inexistence of integrated patient record system also creates additional workload for health workers, repetition of data collection and creation of the repeated reported. Based on this problem the research is initiated with a general objective "developing patient information record system integration framework for Addis Ababa private hospitals".

The open group architecture framework which enables any organization to evaluate and build the right architecture has been used as a methodology. Interview, observation and document analysis have been used as data collection mechanisms. The collected data have been analyzed by using Archimate software tool that supports developing and designing an enterprise structure and architecture by employing the open group architecture framework stages.

As a result of the study the architecture vision and principle has been set to enable as reference and point of view through other architecture process. The business architecture which covers the business aspect of the hospitals have been done by designing both baseline /existing business architecture of the hospitals and the target business architecture that suggest ways for the integrated patient information record system. The data architecture was also developed by covering both baseline data architecture and target data architecture for the new outcome. The baseline and target application and technology architecture were also presented in the way they can support integrating the patient information record system. In the opportunities and solution phase, opportunities that help the hospitals implement TOGAF architecture has been presented and requirements that should be full filled have been described in the requirement management phase. The outcome of the study has been described by showing a sample framework how would the integrated patient record system looks like. An impact evaluation has also been done to show weather the open group architecture framework can be used to integrate the health information system of the selected hospitals. The system administrators of both Girum General Hospital and Kadisco General

Hospital have an idea that the open group architecture framework can be employed to integrate Health information system of their hospitals and the data has been properly used in the study.

The study has addressed the main research question “how to develop patient information record system integration framework of different hospitals?” rose in the first chapter of the study. The open group architecture framework shows how to develop an integrated patient information record system by suggesting ways of architecture development method (ADM) for any organization. All specific objectives have also been addressed through the study. The existing health information systems of two hospitals have been identified and described in TOGAF expression. The architecture vision and business architecture of hospitals based on their existing system of hospitals information system have been set. The data architecture was also established and opportunities & Solutions that identify and scope change initiatives have been identified. The requirement management that the hospitals should follow was presented and the open group architecture framework methodology is proposed as a systematic approach to implement integrated patient information record.

Though the research has the above outcome it only focuses on showing how the open group architecture framework phases can be used in integrating health information system of hospitals. The design and implementation have not been done which has to be explored further the way it has to be implemented. Some of catalogs like (technology standard catalog and requirements catalog) and matrix like (system and function matrix) of TOGAF has been left as the study is done for hospitals and the whole TOGAF catalog are used for an enterprise mostly providing transaction and selling processes.

5.2 Recommendation

The current health information systems in Addis Ababa hospitals are not up to date as most of them still use paper based record system. Even though it has been tried to employee ERP for different government hospitals it has failed for long time. So as a way to make things easy the researcher will recommend the following ideas.

1. Hospitals with computerized health information should implement the integrated HIS framework proposed with trainings.
2. Hospital Governance, leadership should set clear business strategy as they are a starting point for reflection in the planning and practices of organizations
3. TOGAF based change management should be performed in hospitals

5.3 Future research Outcome

This study has presented how TOGAF can be used for integrating hospital information system by presenting two sample hospitals information system. The study presents an integrated HIS framework as an output, the framework is evaluated thus it can become useful if implemented and become real work. So it can be used as a base for implementation of hospital system integration in future studies. Everything that is necessary for implementing the integrated HIS framework is identified and set on the opportunities and the requirement management phase of TOGAF sod depending on this outcome future studies can be done on implementing the integrated HIS framework.

Future studies can also be done on the idea of integrating HIS system of public hospitals and even different health centers found in Ethiopia so that the work environment for health professionals will be simple and can serve more patients. Patients can also get health service wherever they are as their data can be accesses from the integrated HIS database.

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Appendices

Observation checklist

To see the existing system

- ✓ Does the hospital have computerized patient record system?
- ✓ How is the patient record system of the hospital structured?
- ✓ What type of information is kept on the patient record system?
- ✓ Who is mainly using the patient record system of the hospital?

To know the vision and business principle of the hospital

- ✓ What is the vision of the hospital in employees mind?
- ✓ Do the employees keep the business principle?

To see about the architecture framework view of health information system professionals

- ✓ Is there any architecture framework set for health information system?
- ✓ If so, does the framework supports the idea of integration?
- ✓ On what type of data is the patient record system of the hospital dependent?

Interview questions

Phase I preliminary phase

To identify (Scope the enterprise organizations impacted)	Interview question
Identify core enterprise (units) those who are most affected and achieve most value from the work	Who will exactly be using the architecture framework to implement integrated health information system?
Identify soft enterprise (units) those who will see change to their capability and work with core units but are otherwise not directly affected	Will the staff (doctors, nurses…) of your hospitals be affected by the architecture framework?
Identify extended enterprise (units) those units outside the scoped enterprise who will be affected in their own enterprise architecture	Are there different organizations who work with your hospital as a partner?
Identify communities involved (enterprises) those stakeholders who will be affected and who are in groups of communities	What is the participation of patients in the health information system of your hospital
Identify governance involved, including legal frameworks and geographies (enterprises)	Is there any legal issue with the health information system?

Phase A

Architecture vision

To identify	Interview questions
Identify the hospitals goal and the business driver	What are the vision of your hospitals patient record system/ the vision of your hospital?
To identify the business principles and strategic business drivers of the organization	Is there documented business principle in your hospital
	What type of strategic business drivers you hospital follows
To define the relevant stakeholders, and their concerns and objectives	Who is the administrator of the patient record system?
	Who will directly use the patient record system of your hospital and what is their responsibility?
	What is the objective of different departments(staffs) in the patient record system of your hospital
To define the key business requirements to be addressed in this architecture effort, and the constraints that must be dealt with	What constraints should be full filled to run the business?

Phase B

Business architecture

To identify	Interview question
To describe/identify the product and/or service strategy, and the organizational, functional, process, information	What are the services given by your hospitals patient record information system?
	How is the patient record information system organized in your hospital?
	What is the main function of patient record system in your hospital
	What information does the patient record system in your hospital use?
To analyze the gaps between the Baseline and Target Business Architectures	What business architecture/strategy does your hospital follows?
To select and develop the relevant architecture viewpoints that will enable the architect to demonstrate how the stakeholder concerns are addressed in the Business Architecture	What is the role of the staff on the business architecture/strategy of the hospital?

Phase C

Information system architecture

To identify	Interview questions
To define major types and sources of data necessary to support the business in way that is understandable by stakeholders	What type of data does patient record system of your hospital use?
	What source of data does the hospital use to sustain its business?
To conduct checkpoint review of the data architecture model	What data architecture model is your patient record system use currently?

Phase D

Technology architecture

To identify	Interview questions
description of the existing system in to services terminology using the organizations architecture	What technology architecture is being used by your hospital currently?

Phase E

Opportunities and solutions

To identify	Interview questions

To review the target business objectives and capabilities	Where does your hospital want to be in terms of business?
	What is the current capacity of your hospitals information system?
	How many customers does your hospital information system serve?
To review and confirm the enterprise's current parameters for and ability to absorb change	Is your hospital ready to accept technological changes?

Evaluation Interview questions

Dear Sir/Madam,

My I am Bayush Alemayehu and as you remember I am graduate student at Addis Ababa University School of Information sciences currently working a Master's thesis titled "Health Information Record System Integration framework for Ethiopian Hospitals. The purpose of this evaluation interview is to investigate how better the proposed solution meets your objective.

1. Do you found the integrated framework useful?
2. If this integration framework is implemented will you use it?
3. What challenges does exist in the integrated framework?
4. Is there difference between the HIS you are currently using?
5. What do you suggest as health professional on the integrated HIS framework?
6. What feature do you expect to be included in the integrated HIS framework if it is implemented?