A METHODOLOGY USING UML & SADT TO DEVELOP AN EFFECTIVE BUSINESS MODEL IN HEALTHCARE

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By

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To My Wife & Parents

Abstract

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A Methodology Using UML & SADT to Develop an Effective Business Model in
HealthCare

Key Words: Business Modeling, Healthcare, UML and SADT.

A business process model is an abstraction of business functionality in terms of modeling the goals, processes, objects and any other associated events of an enterprise. An effective business model can show how an enterprise and its subsets function today, and how one may plan for it to function in the future. Effective business modeling to gain insights towards improvements in hospital areas has been used infrequently by industrial engineers. This thesis presents a methodology using UML (Unified Modeling language) and SADT (Structured Analysis & Design Technique) that may be utilized to develop an effective business process model in the medical imaging area of a major Canadian hospital (St Michael's Hospital). The effectiveness of this business model may clear the way towards a comprehensive analysis for improvements.

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Chapter 1

Introduction

1.1 The Purpose

The purpose of this thesis is to design and implement an effective methodology using various tools including UML (Unified Modeling Language) and SADT (Structured Analysis and Design Technique) in ultrasound modality in medical imaging at St Michael's hospital. This approach will help fully visualize, understand, analyze and improve the medical imaging business processes. This approach is not designed only for the health care industry -- it is a tool that can be used and implemented in other industries as well.

A business model is an abstraction of business functionality in terms of modeling the goals, processes, objects and any other associated events of the business. A business model can show how a business functions today or how to plan for it to function in the future. Business modeling is done to design and analyze a business and mold it to meet business goals.

Summarizing the Purpose:

Design a methodology using UML & SADT to develop an effective business model in healthcare industry

1.2 The Methodology

A work-flow business methodology designed and developed in this project consists of six different templates, The Behavior Template, The Use-Case Template, The Sequence Template, The Activity Template, The Business Template as part of UML and

The SADT Template as part of SADT. Each of those templates has its own methodologies and targets in order to help achieving the thesis purpose. At the end, results including areas of improvements are illustrated to help SMH (St Michael's Hospital) rise above deficiencies in the medical imaging business process.

UML and SADT are two different techniques that together are used to design the approach and to accomplish the final purpose. Each of these techniques is explained extensively in the following chapters.

Summarizing the Methodology:

The methodology presented consists of six different templates, The Behavior, the Use-Case, the Sequence, the Activity, the Business Template as part of UML and the SADT Template. Each of those templates has their own methodologies and targets in order to help achieving thesis purpose.

1.3 The Case Study

Due to the professional collaboration and agreement involving the School of Information Technology Management at Ryerson University and St Michael's Hospital, access to the medical imaging department at St. Michael's Hospital was made available. Throughout this access and the cooperation of the medical imaging staff, valuable and important information about medical imaging has been made available.

1.4 St Michael's Hospital

St Michael's Hospital is a catholic hospital founded in 1892 by the Sisters of St. Joseph to care for the sick and the poor of Toronto's inner city, St. Michael's Hospital has a long and proud history of caring and compassion. Since that time, the hospital has preserved this commitment to compassion and excellence, while evolving into a center for innovation in patient care, teaching and research. A leader in inner city health, as

well as a major tertiary referral center, St. Michael's Hospital has over 550 inpatient beds, extensive outpatient clinics, and is downtown Toronto's designated trauma center for adults. The hospital is recognized for excellence in teaching, and is a research leader in many areas including inner city health, cardiac gene therapy, and trauma/critical care [1].

1.5 Medical Imaging at St Michael's Hospital

Medical imaging or radiology is a medical science that uses electromagnetic radiation, ultrasonography or radioactivity for evaluation of body tissues in order to diagnose injury and disease. This can be done with different techniques or modalities which are using some kind of electromagnetic radiation technique [2]. These modalities differ from one to another in exam procedures and machines used but the business process around them are more or less the same, (see figure 1.1) that is why in this thesis one modality was chosen on which to perform the developed business model and that modality was US (Ultrasound). The Ultrasound Modality as a part of Medical imaging in St Michael's hospital is the area of study.

Figure 1.1 The business process around different modality is the same

St Michael's Hospital is in the middle of a massive change in medical imaging information technology. New automated integrated information systems with its components are applied in medical imaging department. The entire workflow has been digitized. It is believed that having such a system will improve the service delivery for patients by moving toward a paperless environment, accelerating reports turn-around-time, improving access to images from all hospitals workstations and giving long term solutions to archiving bottleneck and lack of space. Decisions and diagnosis of patient's conditions are now made much quicker with the fast availability of information.

Through the process of applying the new automated integrated system in medical imaging, St Michael's hospital migrated the medical imaging process to several databases, interfaces and standards including PACS (Picture Archiving Communication System), RIS (Radiology Information System), DICOM (Digital Imaging and Communication in Medicine) interface standard, and HL-7 (High Level -7) interface standard (see figure 1.2). All those data bases, interfaces and standards are discussed more in depth in chapter 3.

Figure 1.2 Medical Imaging integrated automated system [3]

1.6 The Road Map

This thesis consists of two parts:

1.6.1 Part A

Part A illustrates the body of the thesis and consists of 4 chapters,

- 1) Chapter 1, (Introduction) introduces readers to the aim of the dissertation, thesis problem, medical imaging in St Michael's Hospital and the methodology developed.
- 2) Chapter 2, (Literature Review) discusses different topics related to the methodologies and techniques used in this thesis.
- 3) Chapter 3, (The Methodology) launches the methodology used in this thesis. It illustrates each template and gives a description of the objects and processes that were considered in this methodology.
- 4) Chapter 4, (Discussion, Evaluation, Conclusion and Future Work) evaluates the effectiveness of the methodology developed and the area of improvements in the medical imaging business process at St Michael's Hospital. This chapter also rounds off the thesis by illustrating the conclusion. It will also show the future work and what has to be done toward the methodology created in order to improve it.

1.6.2 Part B

Business templates are described in chapter 3. However, further details of the business processes are provided in appendices A to E.

- Appendix A, Use-Case Template.
- Appendix B, Business Template.

- Appendix C, Activity Template.
- Appendix D, Sequence Template.
- Appendix E, SADT Template.

Chapter 2

Literature Review

2.1 What is Business Modeling?

In a generic sense, business modeling “is a set of activities to help visualize, analyze, improve and understand business processes. As applied to software systems, business models act as a blueprint that will help system analysts, designers, and developers make informed decisions about the processes they are automating and the technologies most appropriate for implementing them” [4]. There are three basic reasons for the need to model a business (see figure 2.1):

- To re-engineer a business process, this involves analyzing and fundamentally re-thinking how the business operates and interacts with the outside world. For this highest-risk form of process and system design, business process modeling is absolutely crucial.
- To improve a business process, it is considered as an incremental “bite-sized” process re-engineering; it starts with identifying an area of the business with the most critical problems and then targeting analysis to that area. The goal is generally to streamline how the business works, and/or to enhance its competitiveness. Its micro-focus means it usually entails lower risk and a higher success rate than reengineer a complete business process.
- To automate a business process, this is the level of endeavor that usually relate to software development. The goal here is to reduce the resource requirements associated with a process by enabling more of it to happen without human intervention. In this

context, a business process model allows a person to understand the environment in which a software system will function.

Figure 2.1 Three basic reasons for the need to model a business process

Whether planning to re-engineer the business or just automating an existing process, business modeling is the first step toward defining a software system that will solve the precise business problem [5]. In the case of an established small company with a simple organizational structure, or if a team is attempting to automate or improve a very well-understood business problem, then few benefits from business modeling may be realized. However, in a new startup operation or entering a new business area or automating a complex process, modeling can provide critical insight into where automation can deliver the greatest ROI (Return of Investment) [6]. If working with large legacy systems or in a large enterprise that is attempting to automate a mission critical process, then business modeling is almost certainly among the best things you can do to support project success.

2.2 Business Modeling Using UML

The nature of software development is changing in response to new business demands. Innovative organizations are rethinking traditional business processes and extending key internal processes beyond organizational boundaries to reach suppliers, customers, partners, and government agencies.

In a world in which the risks associated with the failure of key processes has never been greater, it is no wonder how business modeling is catching on like never before. When business requirements are poorly defined, the resulting inadequacies compound themselves and reverberate throughout the integrated enterprise. With a clearly explicit model of the business, however, companies have a foundation upon which to build and deliver successful systems that ultimately deliver optimal value to customers. UML exceeds all other alternatives for developing a solid business model [5] that can be applied to the development of a successful software system as it unifies development and business teams by integrating the modeling and development languages across every phase of the effort, UML facilitates the specification of a robust, component-based architecture whose design and development can be controlled, managed, and verified, leading to reduced costs and shorter development cycles and it helps, at every step in the process, to keep a person focused not just on technical innovation or even greater efficiency but also on the value to deliver to customers[7].

2.3 The Business Value of UML

UML is generally thought of as a language that helps visualize, specify, construct, and document software-intensive systems. However, the designers of the UML made it possible to enhance the language so that it can be applied to many different domains. This

feature has enabled it to rapidly emerge as the premier language for both traditional business modeling (see figure 2.2) and the system analysis and design that follow [4].

Figure 2.2 UML is the premier language for business modeling [5]

UML has been successfully applied to the modeling of just about any system, from data structures to embedded real-time systems, to XML (Extensible Markup Language) schemas, and to real world organizations from family businesses to multinational enterprises. So it's not surprising that business analysts find UML very handy for visualizing organizational processes. But then UML is far more than just handy; it's a powerful, flexible notation available for business modeling today. It helps manage complexity and improve system quality [5].

As shown in figure 2.3, there are six reasons why using UML among all other tools and techniques is more beneficial [8].

Figure 2.3 Six reasons why UML [8]

2.3.1 UML Provides a Common Language

UML enables to model business processes using the same symbols, diagrams, and other forms of notation that software teams use to model the systems to create and automate processes. This ability to work using a common language enables something that was not previously possible in software development: business people and systems people can communicate! [5] See figure 2.4. The idea sounds simple enough, but until UML was applied to business modeling, there was always a disconnection between the design of the business and the design of the system within it. The UML largely eliminates that separation in perspective between developers, business management, and customers [4]. When starting with an UML based model, key business considerations are more likely to be included in the system requirements, and that ultimately leads to a system that serves customers better.

Figure 2.4 Business people & system people can communicate through UML

2.3.2 UML is Visual

The viewpoint offered by flowcharts and spreadsheets are too linear to effectively model a business [5]. A limited viewpoint can yield false impressions of what drives a business process, where it is bottlenecked, or how information flows. To fully model a business, questions about whom, how, what, why, and when things are happening need to be answered as shown in figure 2.5.

UML allows visually modeling how a business operates. In this context, relationships, activities, and the flow of information, materials, and services all become more obvious. These visual representations enable spotting bottlenecks, understanding how information flows (or doesn't),

Figure 2.5 Business Modeling employs UML which allows visual modeling to answer all critical questions related

A well-constructed visual model of a business such as those the UML makes possible will answer all of these fundamental questions [4]:

- Who are the internal and external customers of the process or who will benefit from this business system?
- Where can a system best add value to the business process?
- What events within and/or outside the organization trigger each business process?
- What end products do those business processes produce?
- What internal deliverables do those business processes entail?
- What is the organizational structure that supports the business?
- What roles and responsibilities within that organizational structure should be part of the system?

Having answers to these questions and the ability to follow up on related concerns will help gaining valuable insight into the business process.

2.3.3 UML is Object-Oriented

UML is used to diagram software systems from an object-oriented perspective. When modeling a business with UML, business concerns are clearly outlined relative to the appropriate business objects in the form of a business plan model. Objects are entities that parallel objects in the "real world": They have some properties (such as name and address), relate in various ways to other things around them, and exhibit some sort of behavior when acted upon [5].

Object-oriented models can therefore very closely approximate actual business objects and systems, even to the extent of portraying how different parts of the system work together dynamically. This means object oriented models are therefore more

tangible and well described, and overall more flexible and intuitive than other modeling techniques [7]. For example, in an object-oriented description of a worker's role, it would likely include information about (see figure 2.6):

- Behavior, such as job responsibilities with respect to other workers in the business.
- State, such as how the role relates to other objects and to the process.
- Properties, such as quality checklist items or a job description.

Figure 2.6 An object oriented description of a worker's role of the business process

2.3.4 UML Describes Business Processes both Structurally and Dynamically

The more automated a business becomes, the more its interrelated software systems form the core of the business value it delivers to customers [4]. Understanding how those systems interact and how to guide their successful development in response to a changing business landscape is critical to success. The value of UML in this context is that it allows looking at things inside the business both structurally and dynamically. The

UML has many different diagram types that enable a person to represent information from many different angles. These diagrams will completely describe the business and provide meaningful information to the varying levels of stakeholders. UML “use-cases” are used to describe business processes from the viewpoint of how actors use the business to attain some goal [5]. A use-case will describe a complete business process from start to finish, from an external perspective. This is in direct contrast to many traditional business-modeling methodologies, which decompose, or break down, process along functional lines. In such decomposition, the whole is not necessarily the sum of its parts, the descriptions of the processes become isolated from each other, and their relationships become less apparent. The value of UML becomes especially evident when turning a business modeling process loose on a business problem. With conventional methodologies, key issues can be easily misinterpreted, because these methodologies often overlook dynamic relationships that impact the process.

UML, in contrast, provides rich alternatives for describing the dynamic, real-world connections that are part and parcel of modern business systems. The multiple views that a UML model provides really help a person to understand a problem from all sides. Also, because UML provides a common language and a shared basis for discussion among development and business staff, there's no need to translate the model into words and risk diluting its meaning.

2.3.5 UML Helps Focus on the Customer

The UML business modeling methodology revolves around business use-cases, which emphasize how a business process delivers value to the customer. This customer-centric perspective helps to conceive an external view of the system that is created. This

is an especially powerful and useful approach in e-business contexts, where an external focus is even more critical to success.

In UML, a business use-case is defined as: “A set of actions performed by the business that yields an observable result of value to a particular business customer or a collection of activities that takes in one or more kinds of input and creates an output that is of value to a customer” [6]. Business processes are what drive automated business systems; they comprise the tangible behavior of the organization. Because business processes are the means for delivering value to customers, the success of an organization hinges on the performance of its business processes (whether they are automated or not). UML business process modeling is built from the ground up to tell a story about how a business process works and how a customer uses that process. What better basis upon which to design a software system for optimal process performance -- and ultimate business success?

2.3.6 UML Helps Derive Better System Requirements

With its rich descriptions of relationships among components, business actors, and other entities, UML makes it far easier than other modeling approaches to identify where a system best fits within a business context [8]. This, in turn, enables to more readily validate software requirements. The end result is a working business system that can solve different business problems, meet the real needs of the business, and deliver optimal value to customers.

2.4 Business Modeling Using SADT

SADT was created to describe activities. Douglas T. Ross, an inventor of SADT or IDEF (Integrated DEFinition), described it as “graphic language for blueprinting systems and business processes” that has its roots in “cell modeling ‘of human-directed

actives” [9]. Ross and his colleagues developed SADT during the 1960s and early 1970s to describe such complex systems as the design of a “factory of the future” and the US Air Force computer-Aided Manufacturing Project.

Since its commercial introduction in 1973, SADT has been applied successfully in hundreds of business modeling projects involving thousands of people in such diverse industries as aerospace, telecommunications, and software development. A broad range of functions is represented in these applications, for example, a model of a foundry production system [10], a description of a training system for the US Army [11], and quality assurance models in the airframe industry [12]. In services, SADT has been used most frequently to model back-office operations. For example, bank managers have used this methodology to describe and improve cheque-processing operations [13], as well as cash management and wholesale lockbox systems [14]. It was recommended that SADT be used to delineate hospital processes before initiating any improvement efforts [15].

Several themes recur in these applications that make SADT especially effective for business process modeling,

- First, SADT models can help employees at every level to understand what happens in delivering a product or service.
- Second, SADT is the methodology that structurally provides for such important attributes of service description as [16]:
 - Who or what performs the activity (“mechanisms” in SADT terms); and
 - What guides or limits the activity (“controls”).
- Finally, SADT is valuable in improving internal communication because the model-building process includes a protocol to involve employees, other people who perform activities, management, and customers.

The resulting dialogue not only clarifies activities and actors' roles, but also promotes consideration of process redundancies and improvement. The model-building process represents the key to gaining organizational consensus on process. In short, SADT seems tailor-made for business process modeling [17].

The SADT modeling process results in a set of interrelated diagrams that collectively describe a system. The top diagrams below, which are arranged hierarchically and become increasingly more detailed at each successive level. A methodology and graphic language, complete with grammar, provide the business modeler with a precise and easily comprehensible format for describing a service process [11]. Now we will see how it works.

2.4.1 Starting SADT

Creating a business process model is a disciplined process that begins in three steps [18]:

1. Formulate the questions that we want our description to answer.
2. State the purpose of the model.
3. Determine the viewpoint of the model.

Formulating the questions is an essential first step because the questions determine the level of detail the description must attain. Once the questions are answered, the desired level of detail has been achieved. SADT does not have a method for formulating questions, and for a business analyst and modeler, weeding out unrelated questions is a matter of experience and skill.

After formulating these questions, summarize them in a statement of the purpose of the model. No matter how straight forward a process at hand might be, stating the purpose will help the modeler to decide whether or not something should be included in a model. For example, the purpose the description is “to identify the sequence of activities

to be implemented, and their interrelationships, in order to ensure the smooth flow of work and the timely and accurate processing of individuals”.

It is also important to specify the viewpoint of the model. From whose perspective is the model built? Each role has a unique perspective on the process. For example, the viewpoint is that of the manager who is responsible for directing the activities of the professional and administrative staff.

The questions, purpose, and viewpoint serve to keep the business process modeling consistent and focused because unnecessary details in the process of building the model can be excluded. By providing these relevance criteria, the business- process modeling helps the business modeler to avoid the temptation of creating a”complete” model, which certainly would be futile. In focused approaches like SADT, it is preferable to develop a library of small models that relate with each others and make the complexities of the process or system comprehensible [11].

When there is a need for another purpose or a need to describe a business process from a different viewpoint – that of another staff member from another field with the business process, perhaps – then there is a need to prepare another business model, which may have some elements in common with the first, but will also differ in some important aspects. Attempts to combine the viewpoints undoubtedly will diminish the quality of the model, if not render it useless.

Figure 2.7 represents the generic picture of the SADT modeling technique which means: under control, input is transformed into output by the mechanism. This diagram also represents the main concept of SADT modeling, The ICOM concept.

Figure 2.7 Generic Structure “The ICOM Concept”

2.4.2 Is SADT Effective for Business Process Modeling?

The versatility of this approach, as evidenced in the success with which SADT has been used in a range of industries and functions, suggests that it can be an effective tool in business process modeling. To have an effective SADT for business process modeling [19]:

- First, the graphic presentation of the model must be comprehensible to employees. SADT diagrams are easy for employees to read and understand because they have been involved in the model-building process.
- Second, well-documented graphic language, developed initially to describe systems in general, which ensures that descriptions of one or more processes within one organization will be consistent.
- Third, the legitimacy achieved through management support – suggests that business management must make a commitment to process modeling; which admittedly is difficult and time consuming.

A modeler must be identified – an employee or a consultant who brings experience, art, and inspiration to the modeling process. Employees, particularly those who have experience with and insights into the process, must collaborate with the modeler and become more involved with the process so that the organization learns from them and through them. Such commitment is necessary if business management wants to take charge of and deliver products and services that satisfy customer's needs.

2.5 Summary

This chapter started with the definition of business process modeling. The author defined business modeling using UML and identified the reasons to model a business process using UML. Then, the author described business modeling using SADT, how to start SADT in business modeling and whether SADT is effective for business modeling or not.

The methodology to be represented in the next chapter was designed in two-steps, The first step was to extract and structure the description of activities in order to understand the business process and to know what is going to be done, who is going to do it, when and where it will be done, how and why it will be done, and interdependencies of processes. This step is to be illustrated using the UML in the ultrasound department at St Michael's Hospital, by means of the Behavior template, Activity template, Sequence template, Use Case template and Business template. The second step is the translation of the UML templates into the SADT template to demonstrate activities explicitly, show entities within the data flow, whilst controls are presented implicitly, throughout the mechanisms.

Chapter 3

The Methodology

3.1 Chapter Overview

Chapter 3 defines the methodology of the thesis, illustrates the methodology structure, demonstrates the “templates” used and reveals the purpose and benefits out of each one of them.

3.2 Defining the Methodology

The methodology introduced here could function as a plan for conducting a business, an up-to-date picture of how the business is performed, a description that allows for changes and improvements of the process, an abstraction that enables a person to eliminate irrelevant details and focus on one or more important aspects at a time, a basis among different decision makers in the business to reach agreement on the key fundamentals and to work toward common goals and establish means of analyzing and designing software systems. It is flexible enough and may be applied to a diversity of industries and not only health care medical imaging industry.

The methodology created is designed out of two different techniques; UML (Unified Modeling Language) and SADT (Structured Analysis Data Technique). Both techniques are merged together and manipulated to form the foundation of the methodology.

3.3 The Methodology Structure

Throughout the design of this methodology and its tactics and techniques, many phases of tries and demos were implemented till achieved the final result aimed for. This methodology comprises six different templates (See figure 3.1) which are working, reusable

and illustrative examples of how different aspects of business can be modeled. These templates are as follows:

- **Behavior Template:** It shows the main packages and actors of the business process before going into much detail with the rest of the templates.
- **Use-Case Template:** The use-case template is usually considered to be the second step in the methodology where a reader is first to be introduced to the processes “referred as use-cases” connected to the actors of the business model.
- **Activity Template:** The activity template is used to model the dynamic aspects of the business process. It is essentially a flow chart showing flow of control from one activity to another.
- **Sequence Template:** The sequence template in this methodology consists of a large number of interaction diagrams “Sequence Diagrams” that emphasize the ordering of actions for each actor which is a good way to model the dynamic aspects of the business process in terms of building up the storyboards of scenario and actions involving the interaction of ultrasound business process actors.
- **Business Template:** The business template demonstrates a set of objects, interfaces and collaborations and their relationships. It is used to model the static view, the simple collaborations, the entities behavior and the logical database schema of the ultrasound medical imaging business process.
- **SADT Template:** Hierarchical and structured design techniques as SADT have been used to describe activities and data within large and complex systems and further improve the methodology and so improve the ultrasound business process.

Figure 3.1 The methodology templates

Now, the following section gets more into details about those templates:

3.3.1 The Behavior Template

The behavior template is designed as a tool to capture the overall behavior of a system. It shows the main packages and actors of the business process before going into much detail with the rest of the templates. It is a description of a set of sequence of actions that the business process performs to yield an observable result. The behavior template is a graphical representation of the one aspect of a static view of a system. It specifies the desired behavior of a business process and does not dictate the way that behavior is to be carried out or implemented. Figure 3.2 represents a diagram of the overall behavior of an ultrasound medical imaging business process. This diagram commonly contains packages as main scenarios, main actors of the system, generalizations and associations.

Figure 3.2 Ultrasound behavior template

As shown in figure 3.2, the behavior template is a sequence of 3 major packages, starting with the ultrasound scheduling and registration, ending with the ultrasound exam process. Within the ultrasound exam process, there are 5 main scenarios, Ultrasound Inpatient Exam Process, Ultrasound Outpatient Exam Process, Ultrasound Specials Exam Process, Ultrasound Portable Exam Process and Ultrasound On-call Exam Process.

The purpose of Ultrasound Scheduling is to schedule an appointment for the patient based on an MD (Medical Directive) request. Actors involved in this scenario are the ultrasound receptionist and the MD. The purpose of Ultrasound Registration is to register patient information in the system if a new patient and update patient information if it's not the first time for the patient to be in the hospital. Actors involved in the registration are the ultrasound receptionist, the MD and the patient.

As mentioned previously, the ultrasound exam process consists of 5 main different packages; each of these packages has a certain way or technique in implementing the ultrasound exam process. The purpose of the ultrasound Inpatient/outpatient exam process is to perform an ultrasound exam over an inpatient/outpatient based on the MD request, generate the findings (images), scan patient and generate a technical report, a preliminary report and a final report over those images to help the MD with diagnosing the patient condition. Actors involved are the MD, the inpatient/outpatient, the US (Ultrasound) receptionist, the sonographer, the porter, the radiologist and the transcriber.

The Ultrasound Specials Exam is a process where a biopsy is performed (taking a specimen from a patient) with the help of ultrasound exam based on the MD special request after taking the patient consent. The findings generated from this process are both images and the specimen but the final outcome is the lab results after the specimen is sent to the lab with

a lab requisition for further analysis. The actors participating in this process are the MD, the patient, the US receptionist, the sonographer, the porter, the radiologist, the transcriber and the nurse.

The ultrasound portable exam process is same as both the ultrasound inpatient/outpatient exam process and specials exam process together. It is a process that is utilizing a portable unit as mobile unit instead of the regular ultrasound exam unit. The purpose of the portable ultrasound exam unit is to perform an ultrasound exam over a patient in a ward, nursery or ICU (Intensive Care Unit) and not in the exam room. This is done due to a portable request from the MD as it's preferable to have the exam in the previous mentioned places rather than the exam room. A portable exam unit is also used for performing a biopsy (taking specimen from patient). Once exam is done, the mobile unit moves back to the exam room. In the exam room, the portable unit is connected back to the hospital network where the images are pushed and saved. Actors involved in the Portable exam process are the MD, the patient, the US receptionist, the sonographer, the porter, the radiologist, the nurse and the transcriber.

Final Package in the behavior template and within the ultrasound exam process is the ultrasound on-call exam process. It is the same process as both the inpatient/outpatient exam processes with only one major difference: the process is brought into play after the working hours in the hospital. The main floor receptionist, the patient, the sonographer (resident on call), the radiologist (resident on call), the porter, the nurse and the transcriber are the actors involved in this process.

3.3.2 The Use-Case Template

The use-case template is allowing the analyst to be first introduced to the processes “referred as use-cases” connected to the actors of the business model. The use-case template is a structure describing user processes [8]. The goal of the use-case template is to clearly explain what are the processes (use-cases) involved in a business process, how many processes are there, how the actors of the system are linked to these processes and finally gives a clear description of these use-cases. Use-case template is divided into two major divisions: the use-case graph and use-case description. Both divisions are working together in serving the main goals of the use-case template.

3.3.2.1 Use-Case Graph

The use-case graph is planned and designed to visibly demonstrate the uses-cases and actors in the business process and how the actors are linked to their processes. It also shows the automated processes from the non automated ones referred to as physical processes. The construction of the use-case graph is simple and clear and can be applied to all kind of business processes in different industries and not only health care medical imaging. However, throughout the process of constructing the graph a business analyst could go through many different tries and designs until a final structure is designed and accomplished.

Figure 3.3 represents the use-case graph of the ultrasound business process. The graph index is located in the bottom left of the diagram. The index is designed to display the main components used to construct the graph. The processes represented in this graph are divided into the physical and the automated processes. In ultrasound business process we have an estimate of 48 physical processes and 25 automated processes. To illustrate the

deference among these processes, the automated processes were placed in grey shadowed rectangles.

In ultrasound business process there are 10 main actors represented in this diagram. These actors are the ultrasound receptionist, the sonographer, the radiologist, the nurse, the porter, the transcriber, the patient, the sonographer on resident, the radiologist on resident and finally the MD. All of these actors are defined and further explained in the following templates.

Taking the ultrasound receptionist as an example on how to read and understand this graph, 16 physical processes and 11 automated processes are attached to the ultrasound receptionist. The automated processes are located in the shadowed grey area. Both those physical and automated processes are not in order. Another actor that can do the same job as the US receptionist is the main floor receptionist where he/she is active in the after working hours scenario like On-call ultrasound exam which is shown in the note icon attached to the main floor receptionist on the graph.

Part of the previous example to understand, as well, is that some processes can not be achieved or accomplished without having a certain process achieved first. For instance, none of the automated processes are achievable without having the receptionist logging to the RIS first and the receptionist won't be able to print out patient hospital card without generating patient information on ADT system. Also, what a reader can get from the same graph is that some processes can be an extension to another process, the automated process of rebooking the ultrasound exam order is actually an extension of first generating the ultrasound exam order and the physical process of paging the exam unit of the STAT exam is an extension of

the process of informing the exam unit of the exam time in non STAT cases by phone, fax and internal mail.

A reader can notice that some processes shown in this graph are achieved through the contribution of 2 different actors and not only one and other processes can be implemented by various actors and not only one. Filling the lab requisition physical process for example can be achieved by the Nurse, the Sonographer or the MD While the physical process of filling the preliminary report paper form can not be completed without both the radiologist and sonographer contribution.

Ultrasound Use-Case Graph

Figure 3.3 Use-Case Graph

3.3.2.2 Use-Case Description

Each of the processes shown in the use-case graph is assigned with an identity code. These identity codes either start with PUC (Physical Use-case) or AUC (Automated use-case) followed by a number. The PUC code refers to use-cases that are completed without using information technology. Meanwhile, The AUC code refers to use-cases that are executed using information technology. With the identity code, readers can refer to the use-case template description in appendix (A) to get a comprehensive description of each process of the ultrasound medical imaging business process.

Identity Code	AUC-01
Use-Case Name	Login.
Purpose	Login to medical imaging system for processing the patient scheduling, registration and execution of the ultrasound exam.
Actors Involved	Radiologist, US Receptionist, Transcriber and Sonographer
Requirements	User name, Password, Workstation, SAN, PACS.

Identity Code	PUC-02
Use-Case Name	Prepare patient chart
Purpose	Through out scheduling and registration process of a patient, patient chart is prepared as part of the process.
Actors Involved	US Receptionist.
Requirements	None.

Figure 3.4 An Example of the Use-Case Description

Figure 3.4 is an example of the use-case description, where each process is identified with an identity code which works as a reference number that a reader can use to get a full description on the process wanted. The number of process description is exact as the number of processes represented in the use-case graph. Each process is represented in a small schedule of two column and five rows. The first row represents the identity code, the second row refers to the process name, the third row is an explanation of the process purpose, the fourth row declares the actors involved in the process and finally the fifth row that shows the requirements of the process to be achieved.

3.3.3 The Activity Template

The activity template is used to model the dynamic aspects of the business process. It is essentially a flow chart showing flow of control from one activity to another. It looks at the operations that are passed among objects, encourages a person to notice and document parallel and concurrent activities. An activity template is also used to succinctly depict the course of events in the package [7]. As of this, each package represented in the behavior template is represented with an activity chart (see figure 3.5).

Figure 3.5 An activity diagram is used to succinctly depict the course of events in the package

Figure 3.5 is a small demonstration of how each package in the behavior template has an activity diagram modeling the operations and actions involved within this package. The ultrasound scheduling package of the behavior template is associated with the ultrasound scheduling process activity diagram shown in figure 3.6. Similar to the previous example, the rest of the packages involved in the behavior template are associated with activity diagrams

involved in the activity template. Due to having several activity diagrams entailed in constructing the activity model template, one diagram is presented in this chapter and the rest are included in appendix (C).

The activity diagram of the ultrasound scheduling process shown in figure 3.6 models the various activities, actions and processes in the ultrasound scheduling process only. The scheduling process is executed by the ultrasound receptionist and the medical directive (MD). The chain of activities required for this scenario “scheduling process” and all other scenarios are modeled using fork and join bars, initial state, final state, states, actions, decision nodes and notes. Figure 3.6 illustrates the ultrasound scheduling process scenario using the activity diagram.

Ultrasound Scheduling Process Activity Diagram

Index

Figure 3.6 Ultrasound Scheduling Process Activity Diagram

3.3.4 The Sequence Template

The sequence template in this methodology consists of a large number of interactions “Sequence Diagrams” that emphasize the ordering of actions for each actor. A good way to model the dynamic aspects of the business process is by building up the storyboards of scenario and actions involving the interaction of ultrasound business process actors [8].

The sequence model diagram represented in figure 3.7 is a display of the ultrasound radiologist’s sequence of actions. This diagram would show the objects displayed in order along the X-axis from left to right, and the actions ordered from top to bottom along the Y-axis. It also shows the object lifeline, a vertical dashed line, which represents the duration of an object over the ultrasound business process cycle.

Figure 3.7 consists of 18 objects participating in the ultrasound medical imaging business process. All the objects are linked by the association instances as per their sequence of participation of the ultrasound business process for each actor and not only the radiologist. The actions are self explanatory and follow the process logic of the radiologist’s role in the ultrasound business process. Other sequence diagrams that participate in constructing the sequence template are incorporated in appendix (D).

3.3.5 The Business Template

The business template demonstrates a set of objects, interfaces and collaborations and their relationships. It is used to model the static view, the simple collaborations, the entities behavior and the logical database scheme of the ultrasound medical imaging business process [5].

The business template consists of 2 major parts:

1. A business object diagram capturing all information of the business cycle in ultrasound medical imaging department (see figure 3.8).
2. An object description model in which all objects on the business cycle are fully illustrated (see figure 3.9).

Both divisions are working together in serving the main goals of the business template.

3.3.5.1 The Business Object Diagram

The business object diagram is planned and designed to visibly demonstrate the static view of the ultrasound business process. It clearly shows the associations of all objects of the business process. The construction of the business object diagram is simple and clear and can be applied to all kind of business processes in different industries and not only health care medical imaging. However, throughout the process of constructing the diagram a business analyst could go through many different tries and designs until a final structure is designed and accomplished.

Figure 3.8 represents the ultrasound business object diagram. The graph index is located in the bottom left of the diagram. The index is designed to display the main components used to construct the graph. The automated portion of the business process that includes the logical database schema of the ultrasound department is introduced in the grey shadowed area in the right bottom of the diagram. A total of 49 objects including actors, forms, locations, findings, workstations, databases and software are presented. All objects are coded with a certain code as

shown in the diagram. The codes and the description of each object are discussed in the following section. This diagram works as a map which introduces the path and the location of each object of the business process.

The reader can easily locate an object and understand the path this object takes within the business object diagram. For instance, Images (code OD-27) are generated by the Ultrasound Sonographer (code OD-02) on the Modality Workstation (code OD-34) and saved in PACS (code OD-33). Another example is the final report (code OD-45) which is recorded by the Ultrasound Radiologist (code OD-03) through using the Voice Dictation Workstation (code OD-50). The final report (code OD-45) is also transcribed and printed by the Transcriber (code OD-09) using the same Voice Dictation Workstation (code OD-50) and saving the transcribed final report in SAN (code OD-32) through OpenLink (code OD-30) interface.

Figure 3.8 Ultrasound business object diagram.

3.3.5.2 The Object Description Model

The object description model is the second division of the business template where each object represented in the business object diagram is assigned with an identity code that is illustrated in the object description model. The identity code structure is the first two letters of Object and Description followed by the object number. For instance, (OD-01) is the object number for the ultrasound receptionist. With the identity code, readers can refer to the use-case template description in appendix (B) to get a comprehensive description of each object of the ultrasound medical imaging business process.

Figure 3.9 is an example and part of the object description model, where each process is identified with an identity code that works as a reference number that a reader can use to get a full description of the object wanted. The number of schedules is exact as the number of objects represented in the business object diagram. Each object of the business process is actually represented in schedule of two column and five rows. The first row represents the identity code, the second row refers to the object name, the third row is the object definition, the fourth row indicates the attributes of each object and finally the fifth row shows the operations that each object is involved in.

Name	Transcriber.
Identity Code	OD-09
Defining Quality	Transcriber is the person responsible of transcribing the final ultrasound report based on the radiologist recordings of the exam results.
Attributes	<ul style="list-style-type: none"> • Name. • Job Description. • Shift Hours. • Hospital Employee #. • System Login User Name and Password. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Login to system. • Find Radiologists voice records. • Transcribe voice records. • Save file. • Print File. • Deliver final report to Receptionist.

Name	Picture Archive Communication System (PACS)
Identity Code	OD-33
Defining Quality	The Acquisition, Archival and Retrieval of Digital images over a Computer network, for Diagnosis and Review at dedicated workstations as MV1000, MV300 workstation in medical imaging department or any other. PACS is part of the SAN storage network dedicated only for images storage.
Attributes	<ul style="list-style-type: none"> • Software. • Capacity. • Hardware. • Back up solutions. • Workstations.
Operations	<ul style="list-style-type: none"> • Save and store images. • Restore images.

Figure 3.9 Object Description Model example

For the reader to comprehend how to interpret the object description model, the author meant to take one of the two objects represented in figure 3.9 as an example. The name is the transcriber. The Identity code is (OD-09). The defining quality is the person responsible of transcribing the final ultrasound report based on the radiologist recordings of the exam results. The transcriber attributes are the name, the job description, the shift hours, the hospital employee #, the system login user name and password and the status (full time, part time or volunteer). The operations in which the transcriber is involved in are login to system, find radiologists voice

records, transcribe voice records, save file, print file, and deliver final report to receptionist. The same way all other schedules represented in the object description model is interpreted.

3.3.6 The SADT Template

At this point in the thesis, Hierarchical and structured design techniques such as SADT will be used to describe activities and data within large and complex system, Variations of the UML methodology have been used and now SADT will be used to further improve the methodology and so improve the ultrasound business process.

The main purpose of using the SADT template within this methodology is to:

- Break up the ultrasound medical imaging business process in a further detailed manner for analysis in terms of breaking down all objects of the ultrasound business process previously presented in the business template to four major dependent units. Input, Output, Control and Mechanism (as shown in figure 3.10).
- Achieve a comprehensive analysis and continuous improvement of the ultrasound business process.
- Attain a completed pictorial view which adds to the knowledge of the software developer and a business analyst.

Figure 3.10 The SADT "ICOM" box

Various kinds of processes can be identified within an enterprise: individual human work processes, organizationally defined processes, operational processes, production processes, management and change processes, etc. In the context of Ultrasound Medical Imaging business process, the main types of processes encountered are individual processes (e.g., ultrasound exam ordering processes and, broadly speaking, decision-making processes), and organizational or logistic processes (e.g. patient registration, sample and patient chart transportation, etc.). Processes and their related set of activities can be considered as scenarios (Scheduling, Registration, Inpatient Exam, Outpatient Exam, Specials Exam, Portable Exam and On-Call exam) according to which a user interacts with its environment (US Receptionist, Patient, Radiologist, Sonographer and etc.) and has a set of responsibilities and reaches goals.

The SADT model always bounds its subject – in the first SADT diagram we define the overall ultrasound business process boundary (Top Diagram). We have considered various scenarios such as scheduling, registration and executing the ultrasound exam. The complete

SADT methodology includes the construction of multiple diagrams to properly describe a complex system. Various diagrams have been developed to explain the stages of the business process in ultrasound medical imaging and effect of interaction between diagrams.

3.3.6.1 Elements of the SADT Technique

The major element of SADT is the 'Diagram'. The SADT model is thought of as a tree shaped collection of Diagrams, the Top Diagram being most general (high level) and bottom diagram being most detailed. In other words, the top diagram is like a parent for child diagrams which show more detail of the parent diagrams. In this model, the project name is '*Ultrasound business process modeling*' which shows various factors affecting the ultrasound business process. The purpose and viewpoint guidelines are located in the Top Diagram:

- **Purpose:** To break up the ultrasound medical imaging business process into sub process in a detailed systematic manner, to enable and analysis for improvements.
- **Viewpoint:** Perspective of business analyst.

A diagram is named with a title, placed in the bottom center half portion of the diagram. Each Diagram has standard identification number, author, project name, date, diagram revision and diagram status. Figure 3.11 highlights the outline for ultrasound business process (the Top Diagram) and illustrates how The ICOM box formalism makes the description of the process easier.

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The boxes on SADT diagrams represent processes. A SADT diagram typically contains from three to twelve boxes and it differs from one process to another. The small numbers of boxes are essential to limit the complexity of the model. Each side of the box has special meaning. The top Side of the box is reserved for controls, left for inputs, right for outputs and below for mechanisms. The inputs are transformed into outputs, controls constrain the process and mechanisms describe how the process is accomplished.

In a SADT diagram, boxes are placed in an orderly manner which is called 'Dominance' first box on the left is the most dominant or the first step in the process (refer to figure 3.12 & 3.13). In the ultrasound business process "Scheduling" is the most dominant or the first in the process hence arranged in the topmost left corner of the diagram and numbered as 1. The least dominant being the last in the process is "Ultrasound exam" which is placed last right hand side of the diagram. The result is the staircase template as shown in boxes 1 to 7. Box numbers provide the unique identity to the system activities and automatically organize the activities in model hierarchy. Hence the analyst can organize the model into relative order of dominance.

Diagram arrows represent flow of information, meaning the ending arrow shows the earlier box influences the box touched by the arrow. A Box and the arrows that touch it define the precise boundary of the diagram, which decomposes the box. The diagram, which is made after decomposing of the box, is called Child Diagram. The Child diagram describes everything about the box and associated arrows and describes nothing about outside the boundary. The box being decomposed is called as Parent Diagram. The Box titled "Scheduling" in Diagram DAM004 is a parent for Boxes shown in Diagram DAM006. The notation DAM006 is placed on the bottom left corner of box 'Scheduling' in Diagram DAM004 to show that scheduling will be decomposed in Diagram DAM006 later. A SADT model is a hierarchically organized set of diagrams and is Decomposition of Bounded Subject.

3.3.6.2 Context Diagram

The Diagram DAM004 contains the little section on the right hand top most corner and is called Context Diagram. This context diagram defines the subject of the diagram and acts as boundary for next level. Everything inside the box is a part of the system being described and outside the box is the environment. As shown in figure 3.12, scheduling box in diagram DAM004 is parent to diagram DAM006 and decomposed scheduling process is shown in DAM006 (figure 3.13) on the next page.

The SADT model is a complex system up to twelve boxes interconnected by arrows in a diagram. We need many such diagrams to define a system. When the diagrams are collected and connected together they become the SADT model (See Appendix E). The model evolve through top down approach and hence single box gives rise to 3 to 12 boxes and every box itself give rise to another layer of diagrams. Again every box represents one process itself and is a subject embedded in the boundary. Once the downward link is made the parent diagram is summarized and referenced on the child diagram as shown in DAM004.

Figure 3.13, DAM006, in the context area of the SADT form (upper right hand corner) the author draws one tiny square for each box on the parent diagram, shades in the box that decomposes and places the parent diagram (DAM004) near the shaded box. This forms the upward link to the parent diagram. Such a method linking together diagrams by unique version numbers ensures that intended version becomes part of the model. In other words, the Context Diagram controls the induction of the diagram in model hierarchy.

NODE: US/A1
TITLE: A Detailed Overall Ultrasound Business Process Diagram

Number: DAM004

Figure 3.12 A Detailed Overall Ultrasound Business Process Diagram

Scheduling Reference in Parent Diagram DAM004

NODE :

US/A2

TITLE :

Scheduling

Number:

DAM006

Figure 3.13 Scheduling

3.3.6.3 Node Number

A SADT diagram identifies each diagram in a particular way called as node number. The node numbers for the context diagram has the form of the model name or abbreviation, slash, the capital letter A (for activity diagram), a hyphen and zero (Refer to Appendix E).

- ✓ In figure 1, the node number for Single Box Diagram DAM000 titled '*Outline of an Ultrasound Business Process*' is US/A-0.
- ✓ In figure 2, the node number of the diagram DAM004 titled '*A Detailed Overall Ultrasound Business Process Diagram*' is US/A1.
- ✓ In figure 3, the node number of the diagram titled '*Scheduling*' DAM006 is US/A2.

Node numbers are used to identify the unique versions of the diagram and they are also used to link downward and upward model hierarchy. Here the node US/A-0 later decomposes into diagrams having node numbers US/A1 and US/A2.

3.3.6.4 ICOM Codes

SADT Diagrams have external arrows, arrows that appear to come from and go to the edge of the paper. These arrows are the interface between the diagram and rest of the model. SADT requires all external arrows on a diagram to agree with the arrows that form the boundary of the diagram. Usually all external arrows match in number and name with the arrows that touch the boundary box on the parent diagram.

SADT allows us to precisely identify and validate arrow connections between diagrams – this is referred to as ICOM encoding, which stands for Input, Control, Output and Mechanism (figure 3.10). ICOM codes are powerful and give analyst a way to quickly verify that the external arrows of a diagram match the boundary arrows of the corresponding box on the parent diagram. They also ensure consistent

decomposition because we account for all arrows entering and leaving the diagram. ICOM codes are one of the most important contributions SADT has made to technology of graphic modeling.

The Diagram also shows the subject boundary and diagram that decomposes it. As shown in figure 1 the diagram DAM000 ICOM codes produced are,

- Input (I): Patient to be diagnosed.
- Control (C): Miscellaneous Forms, Patient Information, MD Information, Exam Orders and Requisitions, Patient Health History, MD specifications.
- Output (O): Patient Diagnostic Results.
- Mechanism (M): Information Technology, Equipments, Work Areas, Qualified Technicians and Administrative personnel.

The Listings of SADT Diagrams included are:

Diagram Number	Node	Title
DAM000	US/A-0	Outline of an Ultrasound Business Process
DAM002	US/A0	Overall Ultrasound Business Process Diagram
DAM004	US/A1	A Detailed Overall Ultrasound Business Process Diagram
DAM006	US/A2	Scheduling
DAM008	US/A4	Registering
DAM010	US/A5	Examining Inpatient
DAM012	US/A6	Examining Outpatient
DAM014	US/A7	Performing Specials Exam (Biopsy)
DAM016	US/A8	Executing Portable Exam
DAM018	US/A9	Executing On-call Exam

Table 1 List of SADT Diagrams

3.4 Summary

The author has introduced a business modeling methodology based on 2 major diagramming tools in the market of system design and improvements. It is explained further in this chapter by designing the ultrasound module business process in the medical imaging department at St Michael's Hospital. All data introduced in this chapter are real life data.

The author believes that having such a methodology can be really helpful for business designers in the course of accomplishing the blue print of the early design stages of a business process and obtaining a comprehensive analytical tool for further enhancements in the process of analyzing and improving any business process in any field of industry and not only ultrasound medical imaging business process.

Chapter 4

Discussion, Evaluation, Conclusion & Future Work

4.1 Discussion

“Anyone who has played chess knows that you need a methodology with one or different tactics to win. Even poor tactics are better than no tactics at all. During the game, not everything that happens one wants. But the methodology nevertheless points in a direction, making the decision-making easier and faster” [5]. A methodology is proposed to elicit users' needs using UML and SADT, and it is applied to the field of ultrasound medical imaging.

4.1.1 The Methodology

The methodology introduced is not a theoretical exercise but it was carried out for a real life situation. Part of the role of a business analyst is to create tools that would help in understanding, designing, analyzing and improving a business process.

The methodology designed consisted of two-steps, from process modeling to the definition of requirements of the information system. The first step was to extract and structure the description of activities in order to understand the business process and to know what is going to be done, who is going to do it, when and where it will be done, how and why it will be done, and interdependencies of processes. This step was illustrated using the UML Technique in the ultrasound department at St Michael's Hospital, by means of the Behavior template, Activity template, Sequence template, Use Case template and Business template. The second step was the translation of the UML templates into SADT template to demonstrate activities explicitly, show

entities within the data flow, whilst controls are presented implicitly, throughout the mechanisms [20, 21].

The methodology is of value in introducing a quality paradigm into the design of a business process [22], which helps to satisfy four objectives:

- 1) A systematic description of the business process activities.
- 2) An elicitation of useful data to perform a simulation study.
- 3) Supplying contextual data that helps in the decision-making process.
- 4) Maintaining a continuous involvement of the actors.

This methodology has demonstrated the usability of SADT and UML for modeling business processes. It also revealed that these two methods complement each other for modeling business processes for better results due to their simplicity and understandability. It seemed appropriate during the designing of this methodology to develop UML and SADT templates during the preliminary phase of business process modeling in order to build up “AS IS” state (refer to chapter 3) and then use this methodology to transfer or move to the “TO BE” state.

4.1.2 Area of improvements in the Ultrasound Business Process

Health care industry represented in ultrasound business process remains fundamentally human and information technology activities. Their improvement requires a better understanding of the co-ordination between actors and information system. This could be achieved by analyzing the scenarios and the data exchanged between actors and information system during the processes [22].

A better understanding of a business process and the measurement of its performance depend on the understanding of all its activities. Although hospital business processes are complex and not very well known or categorized [23], the way to build a systemic view of

hospital activities starts with the modeling of processes and ends with the analyzing of processes to discover the areas of improvements that a business analyst can actually eliminate the weaknesses of the business process [24].

St Michael's hospital main strategy is to increase the automation of their business process, move toward a paperless environment and reduce costs in order to present a better and faster service to patients. Throughout the stages of modeling the ultrasound business process at St Michael's hospital using the methodology presented, different parts were found in the business model that can be adapted as a part of the business process improvement phase.

The hospital strategy was the main focus while analyzing the business process and trying to get a better performance out of it. Two areas of improvements were found during the analysis process with the help of the methodology where the ultrasound business process performance can increase with decreasing the service delivery time and increasing the automation of the system:

- 1) Reduce paper flow in the business process.
- 2) Changing old techniques to new faster ones.

4.1.2.1 Reduce Paper Flow in the Business Process

One of the major areas of improvement that the hospital needs to work on in order to increase the performance of its departments is to actually work on reducing the paper flow and start using the digital alternative instead. St Michaels's hospital spent millions of dollars to achieve a fully digital environment. As a result, the methodology was designed to work on fulfilling the hospital vision and strategy and try to reduce the paper flow among the business process objects and the processes that go with it.

Figure 4.1 represents the business template of the ultrasound business process methodology. The red color objects and associations are the paper forms to be reduced, locations that either send or receive paper forms and processes involved in the processing them.

4.1.2.1.1 Preliminary Report Form

Both radiologist and sonographer fill in preliminary report paper form (OD-27) after executing Ultrasound exam. This preliminary report is given to patient or attached to patient chart based on MD request. The preliminary report form includes both radiologist and sonographer first impression of the patient diagnosis after the ultrasound exam. It starts right after ultrasound exam. Many types of paper forms are available depending on the patient condition and what part of the body is to be diagnosed.

The preliminary report paper form is not entered and saved in SAN (Storage Area Network) database. The form is actually attached to the patient chart. As a result, it will take longer time to retrieve the form, which leads to a poor and long patient service. The processes accompanying this paper form from filling the form by both the sonographer and radiologists and attaching the form to the patient chart take long time to achieve.

The recommended solution is to use the preliminary report electronic form presented by the SCA (Soarian Clinical Access System) that can be easily filled with any workstation in the medical imaging department and saved electronically to the patient file.

4.1.2.1.2 Lab Requisition Form

Lab Requisition (OD-14) is presented when a special ultrasound exam is performed. (Radiologist performs Biopsy on patient). Sonographer, MD, or patient nurse is the one to fill it in. This lab requisition is a paper form that is sent to lab with the specimen taken. It shows what

type of analyzing is required inside the lab, gives a definition of the specimen and shows patient information.

In the scenario of Special Ultrasound exam where a biopsy is performed, a lab requisition paper form is filled out and sent to the lab for further analysis on the specimen. The form is not saved electronically in patient file. With the use of the Soarian Clinical Access (SCA), the lab requisition paper form can actually be replaced with an electronic lab requisition form. This will increase the business process automation, reduce paper flow and decrease the patient service time.

Figure 4.1 Ultrasound business process template before improvement.

4.1.2.1.3 Portable Request Form

The portable request is a paper form sent to the ultrasound department to request a portable ultrasound exam. This form is sent from the clinics, nursery, and ICU or operation room. It is either sent by fax, drop off or internal mail. The ultrasound receptionist who generates a portable ultrasound exam order and attaches both the portable request and the exam order print out to the patient chart receives this paper form.

The portable exam paper form time consuming problem can be solved by first having a permanent ultrasound unit in both nursery and ICU. It is not possible to have the same for the operation rooms due to the large number available and budget limitation. This will decrease significantly the number of portable request received and so solve part of the problem. The second solution is to have portable ultrasound requests generated electronically from their destination and that would save significantly the service time of processing the portable exam request paper form to generate a portable ultrasound exam order.

4.1.2.1.4 Technical Report

Technical Report Form shown in figure 4.1 is a paper form that is filled out by the Sonographer only and has the technical information of the condition worked on. The technical information included in this form helps in the decision making process on the condition worked on by both the sonographer and the radiologist.

This form can be generated electronically using modality workstation (D-34) while performing the exam on the patient and save in attached to patient file in SAN (Storage Area Network) (OD-32). This electronic alternative form would decrease the delivery time of the final report and increase the automation of the ultrasound business process.

4.1.2.1.5 Patient Chart

The patient chart (OD-41) is prepared and updated by the ultrasound receptionist. It contains all patient information and results in hard copies. It goes with patient everywhere inside the medical imaging department before sending it as it is to the MD for final decision on the medication required.

It is a file that contains all other paper formats related to each patient. App and prep sheet print out, requisition forms print out, ultrasound exam print out, preliminary report paper form, Images print out, additional images print out, portable request paper form and lab requisition paper form are different kind of forms and print outs which are filled in the patient chart. By the end of the ultrasound exam process, this patient chart is sent to the MD after having the final report generated and printed out by the transcriber filed in.

All the information included in the patient chart is available electronically in the hospital data base system and can be accessible through any workstation inside the hospital and online from out side the hospital through web based applications like Magicweb (OD-46). Having a patient chart hard copy as it is right now and not getting the total advantage of the new information technology system that St Michael's hospital has implemented for the past 3 years is a major disadvantage and a pull back in the way of achieving a fully automated business process, minimizing the patient service time and reducing costs. The ultrasound business process and the rest of the medical imaging modules are already re-engineered to have a fully automated business process with no paper hard copies.

Figure 4.2 represents the ultrasound business process with minimal paper flow after executing the first area of improvement in reducing the paper flow in the ultrasound business process. The preliminary report form is generated and saved electronically using the any of the

MV1000 and MV300 workstations (OD-37) in which an access to the SCA (OD-35) is giving to the user by those workstations. The lab requisition is filled, saved and sent electronically to lab. The portable request form is generated and sent by electronic means only from the OR and the clinics and not from the ICU (OD-23) or the nursery (OD-24) where a permanent ultrasound exam unit is available. The technical report form is created and saved electronically using the modality workstation while performing the exam by the sonographer. All images are generated and saved in each patient file automatically as there is no need to have a print out of those images unless it is requested to be sent to a physician outside the hospital and doesn't have an access to Magicweb (OD-46).

The reason for working with the business template and not with any other template in showing the decrease of paper flow as area of improvement is the advantages that the business template presents. The first advantage is that the business diagram covers the entire ultrasound business process with all of its scenarios and objects. The second advantage for using this template is the object description model which is attached to the business diagram within the business template and gives a full description of all objects of the system. The third advantage is the automated portion of the business process that is only represented in the business template and not another template in the methodology created.

However, all templates included in the methodology could be used in the analyses and the enhancement of the business process and not only the business template. In the following part, one of the SADT scenarios that would show the effect of the upgrading recommended will be presented to increase the automation of the business process and advance significantly the service delivery time.

4.1.2.2 Changing old techniques to new faster ones

In the course of analyzing the performance of the business process, a business analyst is required to detect major weaknesses and threats of the system and present an effective more economic solution on how to find a solution to achieve a better more efficient final product. In the health industry and in medical imaging in particular, the final product is the service delivery time. And in this case, the final product is the delivery time of the final report to the MD.

The ultrasound final report is generated in a process that would take up to 3 days for the final report to be produced. Producing a final report requires a two stages process. In the first stage, the radiologist currently logs in to voice dictation workstation to record his/her acoustic report and saves it in SAN. In the second stage, the transcriber logs in to the system to transcribe the acoustic final report, converts it to text and saves it to SAN under each patient file as shown in figure 4.3.

As a result, the final report of not only the ultrasound module but also all other modules in medical imaging at St Michael's hospital currently lacks the efficient delivery time. Implementing the following technology could cut the process time of delivering the final report.

4.1.2.2.1 Speech Recognition (SR)

SR recognition is defined as the ability of the machine to recognize acoustic data and convert it to text automatically. SR is accurate, fast, integrated, flexible and reliable when accompanied with the required tools [25]. SR components are the speech engine, application, hardware, integration with PACS/RIS and technical support.

NODE :

US/A4

TITLE :

Examining Inpatient

Number:

DAM010

Figure 4.3 SADT Inpatient Diagram

The speech engine is the core of the SR system [26]. It is the computer translation of acoustic data to written words. The computer must receive an analog signal (voice) and convert it to a digital one. The speech engine features the capabilities of comparing signal to library of signals to determine which sound is being made, determining which sounds go together to form words and punctuation, applying logic to word building and distinguishing between commands and speech [25]. The workstation hardware consists of the speech mike, the sound card, the CPU, the operating system and the server. The SR hardware is crucial for the success of the SR system. The efficient hardware must guarantee the SR process to be fast, redundant, backed up, secured and supportable [26]. The SR infrastructure is compatible with the medical imaging infrastructure and can be integrated with both PACS (OD-33) and SAN (OD-32). Figure 4.4 illustrates an example of integrated SR, PACS and RIS [27]. Speech recognition system can be implemented in different industries and not only the health care business.

Figure 4.4 Example of the SR integration with PACS and RIS [27]

By replacing the voice dictation workstation (OD-46) with the SR system, the final report would be produced in a faster more efficient way than the on hand process presented in figure 4.3. The current scenario of producing the final US report requires the involvement of both the radiologist and the transcriber in producing the final ultrasound report, while the scenario proposed that has the SR system built in requires the involvement of the radiologist only generate the final US report.

Implementing the SR system would decrease the delivery time by reducing the number of processes to one process as a replacement of two processes to generate the final US report (see figure 4.5). As a result, SR system would be a significant solution to overcome the weakness of the

long delivery time of final US report to MD (OD-05). It will also increase the ultrasound business process automation and reduce expenses.

Figure 4.5 is a clear example of the improvement accompanied with the implementation of the SR system. Instead of having the process of recording the final report then the process of having the transcriber to transcribe to acoustic final report to text, the processing of the text final US report will happen in one single process with one actor involved and that is generating the text final US report in one process when having the SR system processing successfully employed in the hospital.

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4.2 Evaluation

The methodology adopted was based on the integration of two different modeling techniques to model a business process. The design of this methodology took a lot of time and effort to achieve what is presented in this thesis. This methodology was first decided to be designed by utilizing UML only in different templates and then use it in a real life situation and not in a theoretical one to see how practical the methodology is in designing, analyzing and improving a business process. Having no background on the health care industry and especially medical imaging gave an advantage to see how useful the methodology is to make a business analyst capture all elements of the system and understand the business process to analyze and improve in advance.

The first initiative through the design of this methodology was to actually select one module of the medical imaging department and work on. A decision was taken to select ultrasound medical imaging as our case study. The first design of the methodology consisted of 5 different templates, the behavioral, the use-case, the sequence, the activity and the business template. Each of these templates was designed using UML icons but also with a lot of modifications to serve the purpose of each template in modeling the ultrasound business process.

4.2.1 The Behavior Template in UML

The behavior template is not one of the UML structure diagrams although all icons are taken from UML. For instance, the package icon is taken from the UML static structure along with the association and generalization but the actor icon was taken from the UML use-case structure.

4.2.2 The Use-Case Template in UML

The first part of the use-case template is the use-case diagram, which was designed using UML use-case structure. The ability to differ between the automated use-cases and the physical ones was added to the use-case diagram by having the automated use-case grouped in grey shadowed areas.

Also, the use-case description is presented in (Appendix A). The use case description has a great value in tracking down all processes by an identity code and having a description for each one of the use cases of the ultrasound business process.

4.2.3 The Activity Template in UML

The activity template in this methodology is the same as the activity structure in UML. More flexibility was given to the design aspect of the activity diagram by introducing the connector node, which gives the business analyst more flexibility in designing the activity template of complex and large business processes applications.

4.2.4 The Sequence Template in UML

The sequence template represented in this methodology is very much similar to the sequence structure in UML. The sequence diagram was redesigned to serve the concept of business process modeling by having the sequence diagram focused only on the actor and the exact order of actions that the actor should take to fulfill his/her part of the business process. It also shows the lifeline and the object role in completing each actor sequence of actions. Finally, the group of sequence diagrams represented within the sequence template is defined based on the actor and not the scenario.

4.2.5 The Business Template in UML

The business template was designed based on the concept of the Static Structure class diagram in UML. The class diagram represented in the business template was modified to increase the ability to design and understand a business process in a flexible more clear way. The reader or the business analyst is given the ability to group the business process infrastructure of automated portion in one area of the diagram and that is very important in understanding the business process infrastructure and covering all aspects of it. The main actors of the business process were given an actor icon to help distinguishing the actors of the business process from among all the rest of the objects to simplify the class diagram especially with the complicated static structure. One of the main modifications that were added to the UML class diagram is the join bar icon that increases the ability integration among the business process objects.

Also, the Object Description (Appendix B) was presented within the business template. The object description has a great value in tracking down all objects by an identity code and having a description for all objects of the ultrasound business process.

4.2.6 SADT in the Methodology

Throughout the process of constructing the methodology using UML, it became increasingly important that a common “big picture” of all business process entities, actors, infrastructure and activities to be developed and shared. And because all objects of the system must be integrated, coordinated and changed need to be modeled. The use of SADT was necessary in this methodology after using the UML templates to provide useful means of describing and breaking down the business process objects to input, output, control and mechanism. It was essential to use the SADT template to demonstrate the business process

set of activities that take certain inputs, and by means of some mechanism, and subject to certain controls, transform the inputs to outputs.

4.3 Conclusion

A better understanding of the business process and the measurement of its performance depend on the understanding of all its activities and objects. Although hospital processes are complex and not very well known or categorized, the way to build a systematic view of hospital activities starts with the modeling of the processes. Then business process ontology has to be found for the processes to be interrelated, and their characteristics to be shared [28].

As the boundary of an enterprise is extended, it becomes increasingly important that a common “big picture” of needed business, people and IT system activities and relationships between these activities is developed and shared by all the parties involved. Because “things” must be integrated, coordinated and changed they need to be modeled. Modeling methods included in the methodology typified by SADT and UML provided useful means in:

- Providing a systematic approach in dealing with business process modeling.
- Delivering contextual data that helps in the decision-making process.
- Supplying several independent views of a business process represented by the methodology templates.
- Describing a business process objects, activities and entities, their relationships and behaviors.
- Increasing the capability of the business process to be upgraded in a modular technique.
- Analyzing a business process for improvements.
- Showing a path for a comprehensive SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis and ways to demonstrate the weaknesses and strengths of a system.

- Granting practical resources in employee orientation and training as a means of helping employees understand the business process, the flow of work, the functions of each employee, description of each object and activity of the system, etc.

Nevertheless, the design issues in this methodology remains and can be classified into the following categories:

1. Time consuming, the design and implementation of this methodology took a long time, from the phase of data collection to the phase of designing a methodology.
2. Group work contribution, this methodology should be considered as a group work contribution in designing and modeling the business process with the help of the methodology represented. The amount of work and effort a business analyst can put in the design process is difficult and huge. This can be easier if that amount of work and effort was distributed among a group of business analysts.
3. The tools used to design the diagrams, Visio, Rational Rose and Smart Draw are all tools used in the design and generating of the business process. The tools were efficient with the availability of icons and symbols to be used in the drawing process. However, through the process of designing and maintaining a business process like the ultrasound business process, there were numerous problems faced while designing and drawing each template in the methodology. For instance, it took too much time moving front and back with every template in the methodology to implement the designs and modifications independently on each template. This costs lots of time and effort in applying the improvements of the business process within the methodology. Trying to develop and maintain the methodology in a “real-world” industrial setting would be so difficult that any expected benefits of the methodology would be negated.

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APPENDIX [A]

USE-CASE TEMPLATE

Ultrasound Use-Case Graph

Ultrasound Use Case Graph

Use-Case Description

Automated Use-cases (AUC)

Use-Case	Login
Identity Code	AUC-01
Purpose	Login to medical imaging system for processing the patient scheduling, registration and execution of the ultrasound exam.
Actors Involved	Radiologist, US Receptionist, Transcriber and Sonographer
Requirements	User name, Password, Workstation, SAN, PACS and OpenLink.

Use-Case	Logout
Identity Code	AUC-02
Purpose	Logout from medical imaging system after processing the patient scheduling, registration and execution of the US exam.
Actors Involved	Radiologist, US Receptionist, Transcriber and Sonographer
Requirements	Workstation, SAN, PACS and OpenLink.

Use-Case	Save Data
Identity Code	AUC-03
Purpose	Save data to medical imaging system. It differs from one actor to the other on what information and changes to be saved. Example; US receptionist save data regarding patient scheduling and registration while radiologist saves information on patient diagnosis and exam results.
Actors Involved	US Receptionist, Sonographer, Radiologist and Transcriber.
Requirements	Workstation, SAN, PACS and OpenLink.

Use-Case	Generate appointment and preparation sheet
Identity Code	AUC-04
Purpose	Generate appointment and prep sheet of the exam date and time, exam type and what procedures as to be taken prior to the exam from all patients, medical imaging staff and MD.
Actors Involved	US Receptionist
Requirements	RIS Workstation, SAN and OpenLink.

Use-Case	Print appointment and preparation sheet
Identity Code	AUC-05
Purpose	Print appointment and prep sheet of the exam date and time. Keep it in patient chart and send a copy by fax to MD

Actors Involved	US Receptionist
Requirements	RIS Workstation, SAN and OpenLink.

Use-Case	Identify patient
Identity Code	AUC-06
Purpose	Through the process of registration, identifying patient by inquiring about OHIP Card, Requisition Form & Hospital Card. Entering information into system to get patient electronic file on the screen and double check on patient information such as patient address, family doctor and etc.
Actors Involved	US Receptionist
Requirements	RIS Workstation, SAN and OpenLink.

Use-Case	Inform ultrasound exam unit
Identity Code	AUC-07
Purpose	After identifying patient and after generating exam order. Exam unit is informed of ultrasound exam through the medical imaging system.
Actors Involved	US Receptionist.
Requirements	RIS Workstation, SAN and OpenLink.

Use-Case	Generate new patient in ADT system.
Identity Code	AUC-08
Purpose	Incase of new patient. ADT system is used to register the patient. Both Receptionist and main desk scheduling clerk are using the system
Actors Involved	US Receptionist, Main Floor Receptionist.
Requirements	RIS Workstation, HIS Workstation, ADT, SAN and OpenLink.

Use-Case	Print out patient's hospital card
Identity Code	AUC-09
Purpose	Incase of a new patient and during the registration process using ADT system, a hospital card will be printed out and given to the patient to use after
Actors Involved	US Receptionist, Main Floor Receptionist.
Requirements	RIS Workstation, HIS Workstation, ADT, SAN and OpenLink.

Use-Case	Generate ultrasound exam order
Identity Code	AUC-10
Purpose	An ultrasound exam order is generated with all the information needed such as exam type, date and time, etc.
Actors Involved	US Receptionist.
Requirements	RIS Workstation, SAN and OpenLink.

Use-Case	Rebook ultrasound exam order
-----------------	------------------------------

Identity Code	AUC-11
Purpose	Rebooking an exam order is a process that is done under certain factors occurred and forced toward that such as patient is not ready or didn't show up for any reason but called.
Actors Involved	US Receptionist.
Requirements	RIS Workstation, SAN and OpenLink.

Use-Case	Pick up patient info in Modality workstation
Identity Code	AUC-12
Purpose	Open patient file prior to exam during the preparation of the exam room.
Actors Involved	Sonographer.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Update MWL
Identity Code	AUC-13
Purpose	Sonographer is updating MWL Before executing the exam after login and pick up Pt Information.
Actors Involved	Sonographer.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Generate requested images
Identity Code	AUC-14
Purpose	Once the exam is executed, the sonographer is responsible for generating the requested images.
Actors Involved	Sonographer.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Generate Additional Images
Identity Code	AUC-15
Purpose	There might be a need for additional images based on the radiologist request.
Actors Involved	Sonographer.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Push images into PACS [29]
Identity Code	AUC-16
Purpose	After the exam is executed, images are pushed into PACS using DICOM protocol through OpenLink Interface
Actors Involved	Sonographer.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Execute ultrasound exam
Identity Code	AUC-17

Purpose	This is where the sonographer executes the ultrasound exam on patient.
Actors Involved	Sonographer and Patient.
Requirements	SCA, PACS, OpenLink, SAN Modality Workstation.

Use-Case	Assist in executing the exam
Identity Code	AUC-18
Purpose	Sonographer is assisting the radiologist through the whole process of executing the special ultrasound exam (Performing Biopsy).
Actors Involved	Sonographer, Radiologist and Patient.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Review and Prepare PX films
Identity Code	AUC-19
Purpose	Sonographer is responsible for reviewing and preparing PX films before on system executing exam.
Actors Involved	Sonographer.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Review ultrasound images
Identity Code	AUC-20
Purpose	<ul style="list-style-type: none"> • Radiologist is responsible for reviewing the images of the patient and may ask for additional images. • While the radiologist is performing a Biopsy on the patient, he/she reviews all images prior to and during performing such a process.
Actors Involved	Radiologist.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Review additional ultrasound images
Identity Code	AUC-21
Purpose	<ul style="list-style-type: none"> • Radiologist is responsible for reviewing the additional images of the patient. • While the radiologist is performing a Biopsy on the patient, he/she reviews all images prior to and during performing such a process.
Actors Involved	Radiologist.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Execute ultrasound special exam
Identity Code	AUC-22
Purpose	As it is a special exam. Performing a BIOPSY is part of it. This exam is executed through the radiologist with the help of the Sonographer.

Actors Involved	Radiologist, Sonographer.
Requirements	SCA, PACS, OpenLink, SAN and Modality Workstation.

Use-Case	Record final Report on Voice dictation workstation
Identity Code	AUC-23
Purpose	Record final Report on Voice dictation workstation after exam.
Actors Involved	Radiologist.
Requirements	SCA, PACS, OpenLink, SAN and Voice dictation workstation.

Use-Case	Transcribe Final Report
Identity Code	AUC-24
Purpose	Transcribe final Report using Voice dictation workstation.
Actors Involved	Transcriber.
Requirements	SCA, PACS, SAN and Voice dictation workstation.

Physical Use-Cases (PUC)

Use-Case	Inform ultrasound exam unit
Identity Code	PUC-01
Purpose	Inform US exam unit through sending the patient chart which includes the patient information as well as the US exam order.
Actors Involved	US Receptionist.
Requirements	Porter, Internal Mail Paging or Fax.

Use-Case	Prepare patient chart
Identity Code	PUC-02
Purpose	Through out scheduling and registration process of a patient, patient chart is prepared as part of the process.
Actors Involved	US Receptionist.
Requirements	None.

Use-Case	Page if STAT US exam
Identity Code	PUC-03
Purpose	Incase of an emergency (STAT), Exam unit is phoned or paged.
Actors Involved	US Receptionist.
Requirements	Phone or pager.

Use-Case	Receive ultrasound requisition forms
Identity Code	PUC-04
Purpose	US receptionist receives requisitions through fax, mail or phone before entering them to system.
Actors Involved	US Receptionist.

Requirements	Phone and Fax.
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Use-Case	Receive patient chart after exam
Identity Code	PUC-05
Purpose	US receptionist receives patient chart after exam including the preliminary report
Actors Involved	US Receptionist.
Requirements	None.

Use-Case	Notify sonographer & Radiologist on resident
Identity Code	PUC-06
Purpose	Main floor Receptionist notifies sonographer and radiologist on resident of exam.
Actors Involved	Main floor Receptionist.
Requirements	Phone or pager.

Use-Case	Direct patient to Ward
Identity Code	PUC-07
Purpose	After identifying patient and informing the exam unit and incase of not a STAT exam, patient is directed to Ward.
Actors Involved	Receptionist and Patient.
Requirements	None.

Use-Case	Inform MD to contact radiologist
Identity Code	PUC-08
Purpose	Receptionist confirms to the MD to contact the radiologist to explain the special exam procedure as so the radiologist will explain to the receptionist what to exactly write on the special order. As under what category this exam goes. The receptionist could ask the radiologist to call MD.
Actors Involved	Receptionist, MD and Radiologist.
Requirements	Phone, Fax or Mail.

Use-Case	Prepare consent form for the patient to sign
Identity Code	PUC-09
Purpose	Receptionist will prepare the consent form for the patient to sign for the ultrasound special exam.
Actors Involved	Receptionist and Patient.
Requirements	Consent Form.

Use-Case	Send Patient Chart to MD
Identity Code	PUC-10
Purpose	US receptionist mails patient chart including the preliminary report of the ultrasound images to MD.
Actors Involved	Receptionist

Requirements	Mail.
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Use-Case	Place requisition forms in slots
Identity Code	PUC-11
Purpose	US receptionist places requisition forms in slots based on date and time of exam after scheduling process 2 weeks prior to exam.
Actors Involved	Receptionist
Requirements	None.

Use-Case	Inform Ward of US unit presence
Identity Code	PUC-12
Purpose	Receptionist informs the ward on the Ultrasound unit presence and when.
Actors Involved	Receptionist
Requirements	Phone, Pager or Fax.

Use-Case	Send radiologist's notes in patient chart to MD
Identity Code	PUC-13
Purpose	US receptionist faxes or mails the preliminary report of the ultrasound images to MD.
Actors Involved	Receptionist
Requirements	Mail or Fax.

Use-Case	Send out Appt and Prep Sheet to MD
Identity Code	PUC-14
Purpose	US receptionist sends out appt and prep sheet to MD. MD feeds back the appt and prep sheet to patient.
Actors Involved	Receptionist
Requirements	Mail or Fax.

Use-Case	Direct patient to discharge office
Identity Code	PUC-15
Purpose	Incase patient is not a Canadian resident then he/she's sent to discharge office.
Actors Involved	Receptionist and patient.
Requirements	None.

Use-Case	Send patient to ward or waiting area
Identity Code	PUC-16
Purpose	<ul style="list-style-type: none"> Once the US receptionist finishes registration process of the patient, he/she sends patient to waiting room or direct him /her to ward.

	<ul style="list-style-type: none"> After identifying patient and informing the exam unit and in case of not a STAT exam, patient is directed to Waiting Area
Actors Involved	Receptionist and patient.
Requirements	None.

Use-Case	Pick up patient & patient chart
Identity Code	PUC-17
Purpose	Porter is responsible for picking up patient from Ward. Porter is also responsible for picking up patient chart from US receptionist desk.
Actors Involved	Porter
Requirements	Phone, Fax, Internal Mail or Pager.

Use-Case	Deliver patient & patient chart to ultrasound exam room
Identity Code	PUC-18
Purpose	Porter delivers the patient and the patient chart to the exam room where the exam will be executed.
Actors Involved	Porter.
Requirements	None.

Use-Case	Return patient & patient chart
Identity Code	PUC-19
Purpose	Porter returns patient to ward or waiting area & patient chart to US Receptionist when the exam is done.
Actors Involved	Porter.
Requirements	None.

Use-Case	Deliver Specimen & lab requisition to lab
Identity Code	PUC-20
Purpose	After the exam is done, porter is responsible of delivering the specimen sample and the lab requisition to laboratory for further analyzing of the specimen based on what is required on the lab requisition.
Actors Involved	Porter.
Requirements	None.

Use-Case	Pick up specimen & lab requisition
Identity Code	PUC-21
Purpose	Porter picks up Specimen samples and lab requisition from ultrasound exam room after the execution of the exam in order to deliver them to the lab.
Actors Involved	Porter.
Requirements	None.

Use-Case	Arrive hospital for appointment
Identity Code	PUC-22
Purpose	Patient should have OHIP card, Hospital card and requisition form when he arrives to hospital
Actors Involved	Patient
Requirements	OHIP card, Hospital Card and Requisition form.

Use-Case	Sign MOHR RELEASE FORM
Identity Code	PUC-23
Purpose	Incase patient doesn't have his/her OHIB card then he/she has to sign their MOHR RELEASE FORM.
Actors Involved	Patient
Requirements	MOHR RELEASE FORM.

Use-Case	Sign Consent Form
Identity Code	PUC-24
Purpose	Before anything is done, radiologist has to get the patient consent on what exactly is going to happen on the special exam (before performing a biopsy)
Actors Involved	Patient
Requirements	Consent Form

Use-Case	Contact radiologist
Identity Code	PUC-25
Purpose	MD is responsible of contacting the radiologist in order to inform him/her with the requirements of the special exam and what specimen sample is needed.
Actors Involved	MD
Requirements	Phone, Mail or Fax.

Use-Case	Generate requisition form
Identity Code	PUC-26
Purpose	MD prepares and prints out requisition form that is sent to hospital.
Actors Involved	MD
Requirements	None

Use-Case	Send requisition form
Identity Code	PUC-27
Purpose	MD is responsible of sending the requisition form to the hospital through fax, mail or drop off.
Actors Involved	MD
Requirements	Phone, Mail or Fax.

Use-Case	Contact US receptionist
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Identity Code	PUC-28
Purpose	MD contacts receptionist for informing him/her on the required details of the exam process.
Actors Involved	MD
Requirements	Phone, Mail or Fax.

Use-Case	Receive patient chart
Identity Code	PUC-29
Purpose	MD (Medical Directive) receives patient chart including preliminary report. There are different channels for the MD to receive it like mail or fax.
Actors Involved	MD
Requirements	Phone, Mail or Fax.

Use-Case	Instruct patient to change
Identity Code	PUC-30
Purpose	Sonographer is instructing patient to change prior to exam
Actors Involved	Sonographer and patient.
Requirements	None.

Use-Case	Identify patient
Identity Code	PUC-31
Purpose	Sonographer is identifying patient before executing the exam through reviewing patient information from patient chart.
Actors Involved	Sonographer and patient.
Requirements	Patient Chart.

Use-Case	Fill in preliminary report
Identity Code	PUC-32
Purpose	Once the exam is executed the sonographer fills in a preliminary report paper form of the exam. This report is filed in patient chart which is returned with the patient.
Actors Involved	Sonographer.
Requirements	Preliminary Report Form.

Use-Case	Move back US portable unit to US exam room
Identity Code	PUC-33
Purpose	Sonographer moves back the US portable unit to US exam room.
Actors Involved	Sonographer.
Requirements	Portable Unit.

Use-Case	Move US portable unit to proper destination
Identity Code	PUC-34
Purpose	Sonographer moves the US portable unit to patient

	destination (Ward, Nursery, ICU, ER or OR) prior to exam.
Actors Involved	Sonographer.
Requirements	Portable Unit.

Use-Case	Assist in Performing Biopsy (Special or Portable Exam)
Identity Code	PUC-35
Purpose	Sonographer is responsible of helping the radiologist with taking sample specimen of the patient.
Actors Involved	Sonographer.
Requirements	None.

Use-Case	Fill in Technical Report
Identity Code	PUC-36
Purpose	Sonographer is responsible of Filling the Technical report form with patient condition technical information like size, weight etc.
Actors Involved	Sonographer.
Requirements	Technical Report Form

Use-Case	Give preliminary report to patient
Identity Code	PUC-37
Purpose	Radiologist and sonographer gives patient a copy of preliminary report before leaving based on his/her request to give to his/her MD.
Actors Involved	Sonographer and Radiologist.
Requirements	Preliminary Report Form.

Use-Case	Explain exam procedures to patient
Identity Code	PUC-38
Purpose	Radiologist or even sonographer explains exam procedures to patient prior to the executing of US exam.
Actors Involved	Sonographer and Radiologist.
Requirements	None.

Use-Case	Make preliminary report available on patient chart
Identity Code	PUC-39
Purpose	Sonographer and radiologist prepare a copy of the preliminary report and add to patient chart.
Actors Involved	Sonographer and Radiologist.
Requirements	Preliminary Report Form

Use-Case	Prepare Lab Requisition.
Identity Code	PUC-40
Purpose	When the exam is done, sonographer is preparing the lab requisition that is sent with the labeled specimen to the lab for

	further analysis.
Actors Involved	Sonographer and Nurse.
Requirements	Lab Requisition

Use-Case	Request Additional Images
Identity Code	PUC-41
Purpose	Radiologist is responsible of requesting additional images after scanning patient if he/she decides more images are required.
Actors Involved	Radiologist
Requirements	Images.

Use-Case	Scan Patient
Identity Code	PUC-42
Purpose	Radiologist is responsible of scanning patient before and after exam.
Actors Involved	Radiologist and Patient.
Requirements	None.

Use-Case	Fill in Preliminary Report
Identity Code	PUC-43
Purpose	Once the exam is executed the radiologist fills a preliminary report of the exam. This report is filed in patient chart.
Actors Involved	Radiologist.
Requirements	Preliminary Report and Patient Chart.

Use-Case	Review Sonographer comments in Preliminary Report
Identity Code	PUC-44
Purpose	Radiologist reviews sonographer preliminary report comments before writing his own.
Actors Involved	Radiologist.
Requirements	Preliminary Report.

Use-Case	Review Sonographer comments in Preliminary Report
Identity Code	PUC-45
Purpose	Radiologist informs receptionist with specific exam as he receives a call from MD whom explain what he wants to the radiologist and the radiologist informs exactly the receptionist on what the MD wants so the receptionist would be able to generate the proper exam order.
Actors Involved	Radiologist.
Requirements	Phone, Internal Mail and Fax.

Use-Case	Explain procedures to patient
Identity Code	PUC-46

Purpose	It is important and before taking the consent of the patient to go on with the exam procedure that the radiologist should explain the procedure of the exam to the patient so the patient has a good idea on what is he/she giving the consent for.
Actors Involved	Radiologist and Patient
Requirements	None.

Use-Case	Take samples(Perform Biopsy)
Identity Code	PUC-47
Purpose	Radiologist will perform the BIOPSY on the patient in order to get the required sample by the MD. This is a process that is done with the help and assistance of the technologist (sonographer) as well.
Actors Involved	Radiologist , Patient and Sonographer
Requirements	None

APPENDIX [B]

BUSINESS TEMPLATE

Object Description

Ultrasound Receptionist

Name	Ultrasound Receptionist
Identity Code	OD-01
Defining Quality	US receptionist is responsible for receiving the patient and patient requisition, scheduling patient appointment and registering patient information.
Attributes	<ul style="list-style-type: none"> • Name. • Job Description. • Shift Hours. • Hospital Employee #. • System Login User Name and Password. • Extension & Pager Number. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Login to System. • Receive patient. • Receive requisition form. • Identify patient. • Generate patient Information in System. • Schedule patient new appointment. • Coordinate new appointment with existing ones. • File patient file until 2 weeks to the patient exam. • Sort and place patient files work in slots until the day of exam • Prepare patient chart. • Ask patient for OHIP card. • Ask Patient for requisition form. • Ask patient for hospital card. • Create a new patient in ADT register. • Update patient information. • Complete registration in ADT system. • Verify requisition information. • Print out appointment & prep sheet. • Send appointment & prep sheet to MD. • Call MD. • Check if patient is prepped or not. • Place an exam order in System. • Re-book exam for un-prepped patient. • Send patient preliminary report to referring MD after examination • Direct patient to proper destination.

Ultrasound Sonographer

Name	Ultrasound Sonographer
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Identity Code	OD-02
Defining Quality	US Sonographer is the technologist that is responsible for Performing the exam; Generate the findings and Write findings reports.
Attributes	<ul style="list-style-type: none"> • Name. • Job Description. • Shift Hours. • Hospital Employee #. • System Login User Name and Password. • Extension & Pager Number. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Receive patient. • Identify patient. • Login to System. • Check PX films. • Update & pick up patient on Modality workstation. • Prepare US exam room. • Take patient to US exam room. • Direct patient to change clothes. • Explain exam procedures to patient. • Execute exam. • Generate images. • Generate additional images. • Push images to PACS. • Write technical report on system Terminal. • Assist in taking specimen. • Fill in lab requisition. • Label specimen. • Fill in preliminary report (in case if specialist (MD) needs to have it after the exam ASAP). • File preliminary report in patient chart. • Give outpatient copy of preliminary report. • Clean up patient.

Ultrasound Radiologist

Name	Ultrasound Radiologist
Identity Code	OD-03
Defining Quality	Radiologist is responsible for performing the exam in some cases, Review findings and reports, Scan Patient and Perform biopsy.
Attributes	<ul style="list-style-type: none"> • Name. • Job Description. • Shift Hours. • Hospital Employee #. • System Login User Name and Password. • Extension & Pager Number.

	<ul style="list-style-type: none"> • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Login in to system. • Check patient Images. • Scan Patient. • Ask for additional images. • Review additional images. • Review Technical report. • Contact MD in case of special exam. • Inform receptionist in case of special exam. • Inform exam unit when ready. • Okay the exam before performing. • Enter a note in patient chart in case of a portable exam. • Ask for patient consent. • Perform biopsy by taking a sample in special exam. • Write preliminary report. • File preliminary report in patient chart. • Give patient Copy of preliminary report if requested.

Patient Nurse

Name	Patient Nurse.
Identity Code	OD-04
Defining Quality	Patient Nurse role comes into picture in ultrasound in case of a portable exam. He/she mainly help in executing exam as well as fill in some related forms.
Attributes	<ul style="list-style-type: none"> • Name. • Shift hours. • Department. • Hospital employee #. • System login user name and password. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Assist in portable exam by helping in taking a specimen (perform biopsy). • Fill in lab requisition. • Label specimen.

MD

Name	MD (Medical Directive)
Identity Code	OD-05
Defining Quality	Medical directive is responsible for creating the requisition for an ultrasound exam and schedule an appointment for the patient exam in the hospital.
Attributes	<ul style="list-style-type: none"> • Name. • Address. • Phone number. • Cell phone number.

	<ul style="list-style-type: none"> • Fax number. • Email Address. • Medical field. • Hospital employee number. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Fill in requisition form. • Send requisition form to hospital. • Inform patient of new appointment. • Give a copy of requisition form to patient. • Contact radiologist in case of special exam.

Porter

Name	Porter
Identity Code	OD-06
Defining Quality	Porter part is not critical but in the same time we can't neglect. Mainly porter is responsible for taking the patient from one location to another as well as transporting the paper work and samples.
Attributes	<ul style="list-style-type: none"> • Porter name. • Hospital #. • Login name and password to RIS terminal. • Porter department. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Login to RIS terminal. • Pick up patient. • Pick up patient chart from receptionist. • Deliver patient to exam room. • Deliver patient chart to exam room • Collect specimen after biopsy. • Deliver specimen to lab • Pick up lab requisition.

Patient

Name	Patient
Identity Code	OD-07
Defining Quality	Patient is the input of the health care business process. We have 2 different Types of patients, which are inpatient and outpatient. Inpatient is the one that spends more than one day in hospital. Outpatient is the one that comes to the hospital and leaves in the same day.
Attributes	<ul style="list-style-type: none"> • Name. • Address. • Phone number. • DOB (date of birth). • OHIP card number. • Hospital card number. • Inpatient.

	<ul style="list-style-type: none"> • Outpatient. • Prepped or un-prepped patient. • Patient condition.
Operations	<ul style="list-style-type: none"> • Arrive to hospital. • Present OHIP card. • Present hospital card. • Give consent to the exam procedures. • Prepare for US exam. • Present a copy of the MD requisition form.

Hospital Main Floor Receptionist

Name	Hospital Main Floor Receptionist.
Identity Code	OD-08
Defining Quality	Hospital main floor receptionist is the one taking over ultrasound receptionist duties after regular business hours. (On-call exam)
Attributes	<ul style="list-style-type: none"> • Name. • Job Description. • Shift Hours. • Hospital Employee #. • System Login User Name and Password. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Login to system. • Receive patient. • Ask Patient their name. • Generate patient in Hospital System. • Prepare patient chart. • Ask patient for OHIP card. • Ask Patient for requisition form if there is any. • Ask patient for hospital card. • Create a new patient in ADT register. • Update patient information. • Check-in patient. • Complete registration in hospital data base system. • Verify requisition information. • Call MD. • Check if patient is prepped or not. • Place an exam order in the system. • Re-book exam for un-prepped patient. • Direct patient to proper destination.

Transcriber

Name	Transcriber.
Identity Code	OD-09

Defining Quality	Transcriber is the person responsible of transcribing the final ultrasound report based on the radiologist recordings of the exam results.
Attributes	<ul style="list-style-type: none"> • Name. • Job Description. • Shift Hours. • Hospital Employee #. • System Login User Name and Password. • Status (Full time, Part time or volunteer).
Operations	<ul style="list-style-type: none"> • Login to system. • Find Radiologists voice records. • Transcribe voice records. • Save file. • Print File. • Deliver final report to Receptionist.

Requisition Form

Name	Requisition Form
Identity Code	OD-10
Defining Quality	Requisition form is sent to hospital via fax, drop off or even mail. It is sent from the MD to request ultrasound exam modality and type of ultrasound examination required. Ultrasound Receptionist receives, verifies, adds on, enters into System, saves and prints out the requisition form.
Attributes	<ul style="list-style-type: none"> • Ultrasound Exam Type Description. • Name and signature of the MD who completed the form. • Patient's name. • Patient's date of birth (DOB). • Patient hospital ID number. • Patient location with in hospital. • MD Phone Number. • MD Fax Number. • MD Address. • Patient clinical history that describes the reason of the examination. • Indicate if Patient has any isolation precautions and identify if it's an urgent exam or not.
Operations	<ul style="list-style-type: none"> • Send. • Received • Verify. • Add on. • Enter into System. • Save into System. • Print out. • Add to patient chart. • Sort in Slots.

Ultrasound Exam Order

Name	Ultrasound Exam Order
Identity Code	OD-11
Defining Quality	<p>The US receptionist generates exam order after receiving the requisition form. Most of the information of the exam order is gathered from the requisition form plus when and where the exam is held. Exam order has many types:</p> <ol style="list-style-type: none"> 1. Inpatient exam order. 2. Outpatient exam order. 3. Specials exam order. 4. Portable exam order. 5. On-call exam order.
Attribute	<ul style="list-style-type: none"> • Standard name of US procedure. • Patient's name. • Patient's date of birth (DOB). • Patient hospital ID number. • Patient location within the hospital. • MD contact information. • Show if Patient has any isolation precautions. • Identify if it's an urgent exam or not. • Identify when exam will be held and where.
Operations	<ul style="list-style-type: none"> • Generate. • Save into system. • Print. • Add to patient chart. • Send to Ultrasound exam unit.

Appointment & Prep Sheet

Name	Appointment and Prep Sheet
Identity Code	OD-12
Defining Quality	<p>The US receptionist prepares appointment and prep sheet during the scheduling process of the exam. This sheet is generated within the radiology information system. It is also printed and sent out to referring MD.</p>
Attributes	<ul style="list-style-type: none"> • Patient name. • Patient address. • Patient phone number. • MD name. • MD address. • MD contact information (fax, phone number, cell number, pager number, e-mail and mailing address). • Appointment day. • Appointment night. • Procedures should be taken by patient to get ready for exam.
Operations	<ul style="list-style-type: none"> • Generate.

- Send to MD and Patient prior to exam.

MOHR Release Form

Name	MOHR Release Form
Identity Code	OD-13
Defining Quality	This form is presented to patient to sign during the registration process if patient does not have an OHIP card.
Attributes	<ul style="list-style-type: none"> • Patient Information. • Patient Signature. • Provider Facility Information. • Health Number Disclosure.
Operations	<ul style="list-style-type: none"> • Fill In. • Sign. • Send to Ministry of Health.

Lab Requisition

Name	Lab Requisition
Identity Code	OD-14
Defining Quality	Lab Requisition is presented when a special ultrasound exam is performed. (Radiologist performs Biopsy on patient). Sonographer, MD, or patient nurse is the one to fill it in. This lab requisition is sent to lab with the specimen taken. It shows what type of analyzing is required inside the lab, gives a definition of the specimen and shows patient information.
Attributes	<ul style="list-style-type: none"> • Patient name. • Referring MD. • Specimen name and information. • Type of analysis required. • Date on when results required.
Operations	<ul style="list-style-type: none"> • Complete Form. • Send to lab along with specimen. • Print out.

Patient Consent Form

Name	Patient Consent Form
Identity Code	OD-15
Defining Quality	This form is provided to patient to sign in case of the need to perform a special exam on him/her. This special exam will not be performed without the patient consent form signed from patient. It also could be signed from patient relatives in some cases. This form is then presented to the radiologist to proceed with the exam.
Attributes	<ul style="list-style-type: none"> • Patient name. • Patient address. • Date. • Patient signature. • Procedure details. • Radiologist name.

	<ul style="list-style-type: none"> • Radiologist signature.
Operations	<ul style="list-style-type: none"> • Present by US receptionist. • Sign by patient before executing specials exam. • Send to radiologist to start exam. • Save into system.

OHIP Card

Name	OHIP Card
Identity Code	OD-16
Defining Quality	OHIP card is the Ontario health card. It's health coverage for patients. Patients who are Canadian residents but don't have it at the moment sign a MOHR release form.
Attributes	<ul style="list-style-type: none"> • Patient name. • Patient day of birth (DOB). • Issuing and expiration date. • Patient address. • Patient health number.
Operations	<ul style="list-style-type: none"> • Present card. • Process information.

Hospital Card

Name	Hospital card.
Identity Code	OD-17
Defining Quality	Hospital card is carried out by the hospital for patients. It gives patients their own hospital identification numbers. It has also patient information and the patient family doctor name and information. Generated by the receptionist through the registration process by ADT system in case if patient's first time or patients don't have it. Presented by the patient every time he/she arrives at the hospital.
Attributes	<ul style="list-style-type: none"> • Patient name. • Address. • Date of birth (DOB). • Phone number. • Patient identification number. • MD information.
Operations	<ul style="list-style-type: none"> • Generate. • Give patient. • Present.

Waiting Area

Name	Waiting Area
Identity Code	OD-18
Defining Quality	Waiting areas are specific locations within the radiology department for outpatients. Outpatients wait in those waiting areas locations for several reasons such as waiting for the results of the US registration, US exam or

	even lab results at some point.
Attributes	<ul style="list-style-type: none"> • Location inside the radiology department. • Capacity. • Number of patients inside.
Operations	<ul style="list-style-type: none"> • Wait for exam. • Wait for results.

Ward

Name	Ward
Identity Code	OD-19
Defining Quality	Wards are the patient's residence inside the hospital. Some ultrasound exams are carried out inside wards, as the patient could be in critical condition to move to US exam room. Wards are designed to take one or more than one patient. It is equipped with beds, medical equipments and preparations.
Attributes	<ul style="list-style-type: none"> • Location in Hospital. • Capacity. • Medical equipment inside Department • Availability to receive a new patient.
Operations	<ul style="list-style-type: none"> • Receive patient. • Execute ultrasound exams in some cases.

Ultrasound Exam Room

Name	Ultrasound Exam Room
Identity Code	OD-20
Defining Quality	The exam room is the ultra sound main room. It is where the exam is executed. It is equipped with ultrasound equipments and Novius workstations. Sonographer and radiologist are the main actors inside this room where they execute the exam.
Attributes	<ul style="list-style-type: none"> • Location. • Room number and location. • Availability. • Prepared or not. • Capacity.
Operations	<ul style="list-style-type: none"> • Receive Patient. • Change clothes. • Perform exam in.

Discharge Office

Name	Discharge office
Identity Code	OD-21
Defining Quality	Discharge office is where the patient is sent to when he/she is not Canadian resident. It means that the patient is not covered and this is where he/she has to pay for service provided within the hospital.
Attributes	<ul style="list-style-type: none"> • Location.

	<ul style="list-style-type: none"> • No of tellers. • Payments. • Bills. • Shift hours.
Operations	<ul style="list-style-type: none"> • Receive payments. • Generate Bills.

Lab

Name	Lab
Identity Code	OD-22
Defining Quality	Lab in ultrasound comes to picture in the special exam scenario. The lab receives the specimens that have been taken through the biopsy process in the special ultrasound process. The lab also receives the lab requisition with the specimen. It is responsible for analyzing the specimen.
Attributes	<ul style="list-style-type: none"> • Location. • Shift hours. • Specialization.
Operations	<ul style="list-style-type: none"> • Receive Lab requisitions. • Receive labeled specimens. • Analyze Specimens.

Intensive Care Unit (ICU)

Name	Intensive care unit (ICU)
Identity Code	OD-23
Defining Quality	The intensive care unit (ICU) is where critical cases of patients are kept. Those units are carefully designed and equipped with complicated efficient medical equipment, which serve the purpose of taking good care of those cases. The role of ICU in ultrasound that it could act like an exam room for critical cases.
Attributes	<ul style="list-style-type: none"> • Location. • Capacity. • Number of patients. • Department. • Room number.
Operations	<ul style="list-style-type: none"> • Send Portable request. • Perform as US exam room in portable exam.

Nursery

Name	Nursery
Identity Code	OD-24
Defining Quality	A nursery is the department where all babies and kids are treated and kept in the hospital. This department is equipped with all materials and equipments needed to deal with infants and kids.
Attributes	<ul style="list-style-type: none"> • Location. • Capacity. • Number of patients.

	<ul style="list-style-type: none"> • Department • Room number.
Operations	<ul style="list-style-type: none"> • Send ultrasound portable request. • Perform as US exam room in ultrasound portable exam.

Operating Room (OR)

Name	Operation Room (OR)
Identity Code	OD-25
Defining Quality	The operating room is where most of the surgeries are executed in Hospital. Operating rooms are well prepared for surgeries with equipments.
Attributes	<ul style="list-style-type: none"> • Location. • Department. • Room number. • Availability.
Operations	<ul style="list-style-type: none"> • Send ultrasound portable request. • Perform as US exam room in ultrasound portable exam.

Images

Name	Images
Identity Code	OD-26
Defining Quality	Images are the main results or findings of the ultrasound exam process. Those results are pushed to PACS (Picture Archiving and Communication Systems). Those images are pulled back from PACS for the radiologist to review and write a preliminary report. The sonographer also writes a preliminary report after pulling those pictures from PACS. Through SCA (Soarian Clinical Access) workstations inside hospital, those images could be reviewed with referring patient information and reports.
Attributes	<ul style="list-style-type: none"> • Number of images. • Referring patient information. • Date. • Time. • MD information. • Image name • Image description.
Operations	<ul style="list-style-type: none"> • Save to PACS. • Use to write preliminary report. • Accessible.

Preliminary Report Form

Name	Preliminary Report Form
Identity Code	OD-27
Defining Quality	Both radiologist and sonographer fill in preliminary report paper form after executing US exam. This preliminary report is given to outpatient or put inside patient chart based on MD request.

Attributes	<ul style="list-style-type: none"> • Date/Time. • Sonographer Information. • MD information. • Radiologist Information. • Patient Information. • Comments. • Patient condition.
Operations	<ul style="list-style-type: none"> • Fill in. • Put in patient chart. • Give to patient if requested by MD.

Specimen/ Sample

Name	Specimen/Sample
Identity Code	OD-28
Defining Quality	A specimen/sample is the result of performing a biopsy in ultrasound special exam. Once the sample is taken it is then labeled and sent to the lab for further analysis.
Attributes	<ul style="list-style-type: none"> • Patient name • Patient's hospital card number. • Specimen description. • Specimen analyses. • Exam required.
Operations	<ul style="list-style-type: none"> • Label specimen. • Send to lab.

Additional Images

Name	Additional Images
Identity Code	OD-29
Defining Quality	The radiologist requires additional images after initially scanning the patient. During the process of ultrasound, sometime radiologist needs additional images. He/she builds his/her decision after scanning the patient.
Attributes	<ul style="list-style-type: none"> • Number of images. • Referring patient information. • Date. • Time. • MD information. • Image name. • Image description.
Operations	<ul style="list-style-type: none"> • Save to PACS. • Use to write preliminary report. • Accessible.

Open Link

Name	Open Link
Identity Code	OD-30
Defining Quality	Main interface engine, It supports data exchange within the hospital. it includes both DICOM (digital imaging and communication in medicine) for images exchange and HL-7 (Health Level 7) for text exchange [29].
Attributes	<ul style="list-style-type: none"> • Working standards. • DICOM is a new protocol to handle images. • HL-7, a protocol to connect computer systems & allow the machines to communicate with one another and to exchange text data. HL7 does not handle image data
Operations	<ul style="list-style-type: none"> • Exchange Images. • Exchange Text.

Radiology Information System (RIS) Workstation

Name	Radiology Information System (RIS) Workstation
Identity Code	OD-31
Defining Quality	Novius is the main software for radiology information system (RIS). It is presented by Seimens medical solutions for schedule and order procedure [30].
Attributes	<ul style="list-style-type: none"> • Login Name. • Login Password. • Card Scan. • Novius. • SCA. • MagicWeb.
Operations	<ul style="list-style-type: none"> • Login/Log out. • Schedule appointment. • Register Patient.

Storage Area Network (SAN)

Name	Storage Area Network (SAN)
Identity Code	OD-32
Defining Quality	A SAN or Storage Area Network, it generally serves to interconnect the storage-related resources that are connected to one or more servers. SAN include specialized software for their management, monitoring and configuration. Software like SCA, MagicWeb and Novius in medical imaging. It is often characterized by its high interconnections data rate (Gigabytes/Sec) between member storage peripherals and by its highly scalable architecture [31].
Attributes	<ul style="list-style-type: none"> • Software. • Capacity. • Hardware. • Back up solutions. • Server Clustering.

	<ul style="list-style-type: none"> • Workstations.
Operations	<ul style="list-style-type: none"> • Save and store data. • Restore Data.

Picture Archive Communication System (PACS)

Name	Picture Archive Communication System (PACS)
Identity Code	OD-33
Defining Quality	The Acquisition, Archival and Retrieval of Digital images over a Computer network, for Diagnosis and Review at dedicated workstations as MV1000, MV300 workstation in medical imaging department or any other. PACS is part of the SAN storage network dedicated only for images storage [32, 29].
Attributes	<ul style="list-style-type: none"> • Software. • Capacity. • Hardware. • Back up solutions. • Workstations.
Operations	<ul style="list-style-type: none"> • Save and store images. • Restore images.

Modality Workstation

Name	Modality Workstation
Identity Code	OD-34
Defining Quality	Modality workstation is designed in close cooperation with sonographer and radiologists to meet the specific demands associated with ultrasound imaging. Everything is provided in one compact package: customized image display, personalized work-lists, full overview, shortcut keypad, image manipulation tools and access to the whole image chain [29].
Attributes	<ul style="list-style-type: none"> • Built using a standard user interface. • Full support for high resolution monitors as well as mixed set-ups of monitors with different levels of resolution • Support for digital dictation. • Personalized workstation appearance • Easy to use shortcut keypad. • Instant access to previous images. • Portable workstations.
Operations	<ul style="list-style-type: none"> • Execute Ultrasound Exam. • Push images into PACS.

Soarian Clinical Access (SCA)

Name	Soarian Clinical Access (SCA)
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Identity Code	OD-35
Defining Quality	SCA is an electronic repository for a wide array of clinical information. It features an "open" design, which means that it is compatible with almost any other computer system and will allow MDs, Radiologists and other clinicians to review patient histories, lab and radiology results, demographics, allergies, and transcription documents from any PC in the hospital. SCA saves time traditionally spent gathering information from separate systems and paper charts. This will allow our medical professionals to spend more time with patients and less time chasing information [33].
Attributes	<ul style="list-style-type: none"> • Login Name. • Login Password. • Card Scan. • MV1000 and MV300 workstations.
Operations	<ul style="list-style-type: none"> • Review patient information and radiology results. • Edit Images or patient information. • Login/Logout.

Admission, Discharge & Transfer (ADT)

Name	Admission, Discharge & Transfer (ADT)
Identity Code	OD-36
Defining Quality	It is used worldwide. ADT in ultrasound is in the registration phase where an ultrasound receptionist has to update patient information or register a new patient. It is used in all hospital departments. ADT has many functions and jobs but in this case we use only registration.
Attributes	<ul style="list-style-type: none"> • User name. • User password. • ADT functions.
Operations	<ul style="list-style-type: none"> • Register patient. • Update patient information. • Print hospital card.

MV1000, MV300 Workstation

Name	MV1000, MV300 Workstation
Identity Code	OD-37
Defining Quality	Diagnostic workstations. MV1000 are for radiologist use only and can edit into PACS. MV300 is for high traffic areas in Medical imaging department and can't be edited on PACS through those machines.
Attributes	<ul style="list-style-type: none"> • Login Name. • Login Password. • Card Scan. • MagicWeb. • SCA.
Operations	<ul style="list-style-type: none"> • Review patient information and radiology results. • Edit Images or patient information.

- Login/Logout.

PX Films

Name	PX Films
Identity Code	OD-38
Defining Quality	PX films are medium-speed panchromatic films that are good choices for medical imaging purposes. They feature extremely fine grain and excellent sharpness.
Attributes	<ul style="list-style-type: none"> • Very high sharpness. • High resolving power. • Excellent for applications that require a high degree of enlargement. • Good rendition of detail.
Operations	<ul style="list-style-type: none"> • Prepare. • Review. • Print images.

Ultrasound Exam Unit

Name	Ultrasound Exam Unit
Identity Code	OD-39
Defining Quality	Ultrasound exam unit consists of ultrasound equipment, Sonographer and Radiologist.
Attributes	<ul style="list-style-type: none"> • Radiologist information. • Sonographer information. • Ultrasound equipments information.
Operations	<ul style="list-style-type: none"> • Perform ultrasound exam. • Generate results.

Ultrasound Portable Exam Unit

Name	Ultrasound Portable Exam unit.
Identity Code	OD-40
Defining Quality	It is the same as ultrasound exam unit but with a difference that is it a portable unit designed to perform exams outside ultrasound exam room as a result of a critical patient case (ICU, Nursery, Operation room and Ward). After executing the exam, it goes back to the ultrasound exam room. Connect to the network and complete exam.
Attributes	<ul style="list-style-type: none"> • Radiologist information. • Sonographer information. • Ultrasound equipments information.
Operations	<ul style="list-style-type: none"> • Perform ultrasound exam. • Generate results.

Patient Chart

Name	Patient Chart
Identity Code	OD-41
Defining Quality	Patient chart is prepared and updated by the ultrasound receptionist. It contains all patient information and results. It is saved in the patient file

	inside the hospital. It is also saved in RIS (Radiology Information System).
Attributes	<ul style="list-style-type: none"> • Patient Information. • MD information. • Ultrasound exam results. • Requisition forms. • Exam orders. • Exam description.
Operations	<ul style="list-style-type: none"> • Move with patient inside hospital. • Review by MD, Radiologist and Sonographer. • Prepare and sort.

Ultrasound Equipments

Name	Ultrasound Equipments
Identity Code	OD-42
Defining Quality	Medical equipments that use sound waves to create images for diagnosing and treating patients. Sonographer selects and set up the proper ultrasound equipment depending on the patients' needs.
Attributes	<ul style="list-style-type: none"> • Brand name. • Software. • Portable. • Disk drive/image archiving capabilities. • Color. • Size. • Technical features.
Operations	<ul style="list-style-type: none"> • Execute exam. • Generate images. • Save images in PACS. • Move in hospital if portable.

Hospital Information System Workstation (HIS)

Name	Hospital Information System Workstation (HIS)
Identity Code	OD-43
Defining Quality	It could be a desktop or a laptop. Any computers inside the hospital in all departments are called hospital terminals or workstations. Those workstations are equipped with SCA and Magic Web to have access to patient's images and reports from all departments.
Attributes	<ul style="list-style-type: none"> • Login Name. • Login Password. • Card Scan. • SCA. • MagicWeb.
Operations	<ul style="list-style-type: none"> • Login/Log out. • Schedule appointment. • Register Patient.

Technical Report

Name	Technical Report
Identity Code	OD-44
Defining Quality	Technical Report Form is a paper form that is filled out by the Sonographer only and has the technical information of the condition worked on. This form is presented to radiologist to give decision on the condition.
Attributes	<ul style="list-style-type: none"> • Patient's Information. • Sonographer's Information. • Condition's technical information. • Comments.
Operations	<ul style="list-style-type: none"> • Fill in. • Put in patient chart. • Give to patient if requested by MD.

Final Report

Name	Final Report
Identity Code	OD-45
Defining Quality	<p>Two stages to produce the final report within the ultrasound medical imaging business process,</p> <ul style="list-style-type: none"> • First stage, an ultrasound radiologist records the final report on the patient condition using a voice dictation workstation. • Second Stage, A transcriber transcribe the recorded final report and save it to the system under patient file so the digital final report would be available on SAN data base.
Attributes	<ul style="list-style-type: none"> • Data/Time. • Radiologist Information. • Patient Information. • Diagnosis. • Voice Dictation. • Transcriber Information.
Operations	<ul style="list-style-type: none"> • Record. • Transcribe. • Save. • Review.

MagicWeb

Name	MagicWeb
Identity Code	OD-46
Defining Quality	A web based application that allows MDs, Radiologists and other clinicians to review patient histories, lab and radiology results, demographics, allergies, and transcription documents from any PC with a standard Internet browser in and outside the hospital. MagicWeb end-user is not allowed to edit any of the information that can be reviewed with

	MagicWeb.
Attributes	<ul style="list-style-type: none"> • Login Name. • Login Password. • Card Scan. • PC.
Operations	<ul style="list-style-type: none"> • Login to MagicWeb. • Review Patient Information. • Log out.

Portable Request

Name	Portable Request
Identity Code	OD-47
Defining Quality	Portable request is a paper form sent to the ultrasound department to request a portable ultrasound exam. This form is sent from the clinics, nursery, ICU, ER or operation room. It is either sent by fax, drop off or internal mail.
Attributes	<ul style="list-style-type: none"> • Exam Date/Time. • Exam Location. • Sender Information.
Operations	<ul style="list-style-type: none"> • Send portable request. • Receive portable request. • Inter portable request information. • Save information.

Fax, Mail, Drop off or Phone

Name	Fax, Mail, Drop Off or Phone
Identity Code	OD-48
Defining Quality	Means and ways to send/receive information from MDs and clinics outside the hospital.
Attributes	<ul style="list-style-type: none"> • Fax. • Mail. • Phone. • Drop off.
Operations	<ul style="list-style-type: none"> • Send/Receive fax. • Receive drop-offs. • Send/Receive Mail. • Send/Receive information via phone.

STAT US Exam Order

Name	STAT US Exam Order
Identity Code	OD-49
Defining Quality	STAT exam order is the emergency exam order it is the same as ultrasound exam order but only with different approaches taken to inform the exam unit rather than through the RIS (Radiology Information System)

	terminal. One of those approaches is simply paging the Sonographer.
Attributes	<ul style="list-style-type: none"> • Standard name of US procedure. • Patient's name. • Patient's date of birth (DOB). • Patient hospital ID number. • Patient location within the hospital. • MD contact information. • Show if Patient has any isolation precautions. • Identify if it's an urgent exam or not. • Identify when exam will be held and where.
Operations	<ul style="list-style-type: none"> • Generate. • Save into system. • Print. • Add to patient chart. • Send to Ultrasound exam unit.

Voice Dictation Workstation

Name	Voice Dictation Workstation
Identity Code	OD-50
Defining Quality	It is a workstation where the radiologist records the final report on and the transcriber use to transcribe the final report.
Attributes	<ul style="list-style-type: none"> • Login Name. • Login Password. • Card Scan. • OpenLink. • SAN.
Operations	<ul style="list-style-type: none"> • Login/Logout. • Record final report. • Transcribe final report. • Save.

APPENDIX [C]

ACTIVITY TEMPLATE

Ultrasound Scheduling Process Activity Diagram

Index

Initial State		Connector		OR
Final State		Decision Node		And
Action		State		Note
					Control Flow

Ultrasound Registration Process Activity Diagram

Ultrasound Outpatient Exam(Part 1) Activity Diagram

Ultrasound Outpatient Exam (Part 2) Activity Diagram

Ultrasound Inpatient Exam(Part 1) Activity Diagram

Ultrasound Inpatient Exam (Part 2) Activity Diagram

Ultrasound Specials Exam (Part 1) Activity Diagram

Ultrasound Portable Exam (Part 1) Activity Diagram

Ultrasound Oncall Exam Activity Diagram

Initial State

Final State

Action

Connector

Decision Node

State

OR
And
Control Flow

Note

APPENDIX [D]

SEQUENCE TEMPLATE

Ultrasound Receptionist Sequence Diagram

Ultrasound Sonographer Sequence Diagram

Actions in Order from top to Bottom

Ultrasound Radiologist Sequence Diagram

Ultrasound Porter Sequence Diagram

MD Ultrasound Sequence Diagram

Patient Ultrasound Sequence Diagram

Transcriber Ultrasound Sequence Diagram

APPENDIX [E]

SADT TEMPLATE

Output

O

Context- None

NODE :
US/A0

TITLE :
Overall Ultrasound Business Process Diagram

NUMBER :
DAM002

NODE :

US/A2

TITLE :

Scheduling

Number:

DAM006

NODE :

US/A3

TITLE :

Registering

Number:

DAM008

NODE :
US/A5

TITLE:
Examining Outpatient

Number:
DAM012

NODE: US/A4

TITLE: Executing On-call Exam

Number: DAM010