New Goal-Oriented Requirements Extraction Framework for e-Health Services: A Case Study of Diagnostic Testing During the COVID-19 Outbreak

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Abstract

Many e-health projects and innovations are not established based on robust system requirements engineering phase. In order to ensure the success delivery of e-health services to stakeholders, all characteristics of e-health systems and applications must be understood in terms of technological perspectives as well as the all system requirements. Thus, this paper aims to introduce the Goal-Oriented Requirements Extraction Approach (GOREA). It is an elicitation approach that uses, specifically, healthcare business goals to derive the requirements of e-health system to be developed. It consists of two major phases: (1) modelling e-health business requirements phase; and (2) modelling e-health Information Technology (IT) and systems requirements phase. The modelling e-health business requirements phase is divided into two main stages: (1) model e-health business strategy stage; and (2) model e-health business environment stage. The modelling e-health IT and systems requirements phase illustrates the process of obtaining requirements of e-health system from the organizational goals that are determined in the previous phase. It consists of four main steps that deals with business goals of e-health system: (1) modelling e-health business process (BP) step; (2) modelling e-health business goals step; (3) analyzing e-health business goals step; and (4) eliciting e-health system requirements step. A case study based on the basic operations and services in hospital emergency unit for checking patient against COVID-19 virus and taking its diagnostic testing has been set and used to examine the validity of the proposed approach by achieving the conformance of the developed system to the business goals. The results indicate that: (1) the proposed GOREA has a positive influence on the system implementation according to e-health business expectations; and (2) it can successfully fulfil the need of e-health business in order to save the citizens life by checking them against COVID-19 virus.

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New Goal-Oriented Requirements Extraction Framework for e-Health Services: A Case Study of Diagnostic Testing During the COVID-19 Outbreak

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ABSTRACT

Many e-health projects and innovations are not established based on robust system requirements engineering phase. In order to ensure the success delivery of e-health services to stakeholders, all characteristics of e-health systems and applications must be understood in terms of technological perspectives as well as the all system requirements. Thus, this paper aims to introduce the Goal-Oriented Requirements Extraction Approach (GOREA). It is an elicitation approach that uses, specifically, healthcare business goals to derive the requirements of e-health system to be developed. It consists of two major phases: (1) modelling e-health business requirements phase; and (2) modelling e-health Information Technology (IT) and systems requirements phase. The modelling e-health business requirements phase is divided into two main stages: (1) model e-health business strategy stage; and (2) model e-health business environment stage. The modelling e-health IT and systems requirements phase illustrates the process of obtaining requirements of e-health system from the organizational goals that are determined in the previous phase. It consists of four main steps that deals with business goals of e-health system: (1) modelling e-health business process (BP) step; (2) modelling e-health business goals step; (3) analyzing e-health business goals step; and (4) eliciting e-health system requirements step. A case study based on the basic operations and services in hospital emergency unit for checking patient against COVID-19 virus and taking its diagnostic testing has been set and used to examine the validity of the proposed approach by achieving the conformance of the developed system to the business goals. The results indicate that: (1) the proposed GOREA has a positive influence on the system implementation according to e-health business expectations; and (2) it can successfully fulfil the need of e-health business in order to save the citizens life by checking them against COVID-19 virus.

I. INTRODUCTION

With the massive increased in trend toward introducing national and regional initiatives that targeting digitalized all possible health services, the number of e-health projects and innovations have been increased. Many e-health projects were established, aiming at achieving the excellence of healthcare services and their coverage to be delivered to client. There are several varying environmental and social factors that their changes have either direct or indirect influence on these trendy e-health applications and systems, such as the population change and cost of living and the lifestyles of people [1].

There are many e-health applications and systems that have failed to add any quality value or to improve the efficiency of services within the health sector. These projects are eliminated from the market and vanished [2]. On the other hand, many e-health systems are successfully introduced to the market and the feedback of end-users was extremely positive, which reached an acceptance level of quality and pleasant of customers. These successful and robust systems are resulted from the development of the e-health initiatives that can be utilized in the daily practice of healthcare organizations [3-4].

Most e-health projects are not business-driven project. As they mainly focus on technical abilities rather than proven needs. This brings key problems to the projects, as it suffers of requirements ambiguity with a remarkable gap between stakeholders of the project that never solved [5]. Complex health environment provides a large variety of e-health services and processes that is hard to comprehend their obligations and requirements.

Many e-health projects and innovations are not established based on robust system requirements engineering phase. In order to ensure the success delivery of e-health services to stakeholders, all characteristics of e-health systems and applications must be understood in terms of technological perspectives as well as the all system requirements. It is worth mentioning that the characteristics of e-health include a strategy of thinking, which involves the enhancement of national, regional and global health services [6].

E-health systems have a wide spectrum of stakeholders, including patients, processionals and organizations. This leads to the variation and possible inconsistency of e-health goals, based on perspectives of each stakeholders' type. Thus, each stakeholders' group, which may have specific perspectives, concerns more with some of e-health services and goals they target to achieve [7-8].

In this occasion, requirements engineering can bring an effective solution that help how to deal with this variation of the system stakeholders and their requirements, in order to deliver successful e-health systems to facilitate healthcare services.

The process of specifying the requirements is considered one of the hardest phases of the development lifecycle of software systems, including e-health applications where the requirement extraction is a step of the requirement engineering phase. Stakeholders are involved at this phase to enable developers to understand, determined and extract their desires in a form of system requirements in an iterative way [9].

Adopting clear, or even formal, requirements engineering process at the early stage of development brings many benefits to the rest of development phases. This critical and initial phase produces a prioritized list of system requirements that are easy to be decomposed into final executable system components and reduce the development time and the project costs at testing and maintenance stages [10-11].

There are various requirements engineering strategies and methods used for capturing end user requirements for different kinds of software and applications. Business goals analysis is an effective strategy can be used for this purpose [12]. Electronic systems, as e-health, are normally adopted as a part of public or private organizations that fall in enterprise, education or healthcare domain and even more. These applications are used to achieve some business or organizational goals. Considering these goals at the requirements engineering phase can brings benefits to the development lifecycle [13].

It is worth mentioning that the process of specifying business goals is not a simple mission due to a number of reasons. Variation of stakeholders, their backgrounds and perspectives; Some business goals are ambiguous and hard to measure automatically via the system; and Goals are not fine-grained, which need to be structured and decomposed systematically [14].

Therefore, this paper introduces the Goal-Oriented Requirements Extraction Approach (GOREA). It is an elicitation approach that uses, specifically, healthcare business goals to derive the requirements of e-health system to be developed. GOREA consists of two major phases: (1) modelling e-health business requirements phase; and (2) modelling e-health Information technology (IT) and systems requirements phase. The modelling e-health business requirements phase is divided into two main stages: (1) model e-health business strategy stage; and (2) model e-health business environment stage. The modelling e-health IT and systems requirements phase illustrates the process of obtaining requirements of e-health system from the organizational goals that are determined in the previous

phase. It consists of four main steps that deals with business goals of e-health system: (1) modelling e-health BP step; (2) modelling e-health business goals step; (3) analyzing e-health business goals step; and (4) eliciting e-health system requirements step. A case study based on the basic operations and services in hospital emergency unit for checking patient against COVID-19 virus and taking its diagnostic testing has been set and used to examine the validity of the proposed approach by achieving the conformance of the developed system to the business goals.

The remainder of this paper is organized as follows. Section II outlines the research background and related work. Section III presents the proposed goal-oriented requirements extraction approach (GOREA). Section IV represents the proposed framework validation throughout the case study. Section V outlines the summary and recommendation for future works.

II. Background & Related Work

In this paper a technique for modelling e-health system that meet healthcare organizational goals is discussed. Related theoretical backgrounds regarding requirement engineering, e-health environment and goal-oriented approach are also covered in the following subsections.

A. Requirements Engineering

The term requirement engineering is broadly defined as the application of engineering activities to the development of formal software requirements. This includes the process of defining, documenting and maintaining the requirements, as well as identifying stakeholders of the system and their demands [10]. According to [15-16], there are three important dimensions of requirement engineering, namely, business goals, functions and constraints.

These three dimensions contribute in the development process of applications and systems at the requirements engineering phase, in which they present a comprehensive view about what the system should do and how the system do some jobs [17]. The answers of What and How questions, as well as their relationships to stakeholders can be derived after requirements analysis step. Additionally, all business goals must be used in formulating related system functions that are responsible for achieving these goals with determined constraints, if exist, to be evolved throughout the development process [18].

There are four main steps that are performed in the requirements engineering stage, namely, requirements elicitation, requirements negotiation, requirements specification and requirements validation [19]. All these steps are important, the most critical step is the elicitation process that include understanding the organization's environment of where the e-system is employed. From this, several sub activities are considered, including requirements formulating, categorization and measuring.

B. Understanding the e-Health Business Environment

In the last recent decades, there are several major issues affect the performance of e-health applications and systems negatively. These issues have been arising due to the accelerated changes of computer technology and customer expectations. These rapid evolvements of technology lead to increase the number of innovations in the domain of e-health by focusing on following the wave of the most recent technology trends, instead of paying adequate attentions to their quality. In order to handle this issue, the organizational healthcare environment and goals must be deeply understood and formulated in terms of system requirements. The application of requirements engineering is not intensively investigated deeply, according to the literature [20].

Introducing a successful e-health system that brings business values to health organizations can be achieved by the developers' clear understanding of the healthcare environment and its goals, not only by focusing on the recent technologies in the market. To reach to this goal, the requirements engineering approach must be applied in a context of health environment and their business goals, which is the contribution of this paper.

C. Goal-oriented Approaches for Requirements Elicitation

Many goal-oriented approaches, such as GOMS, *i**, EKD and goal-based workflow approach, have been utilized as part of requirements elicitation process. They are used in expressing the organizational goals, for both groups and individuals, which at the end help to understand the overall behaviour of the organizations. There are four main modelling concepts in GOAM, namely, goal, task, device and active. The business goals are represented in this approach as external tasks and system's states that stakeholders aim to accomplish using such a device. The devices can alter the system's state to the new pre-defined one. Besides, business tasks or processes are expressed in GOAM as internal tasks, which is defined as a series of activities and steps required to achieve a business goal using a specific device. Furthermore, the action is considered as an atomic operation that does not include any structured components or control flow [21].

In the *i** approach, modelling dependency

relationships between actors is used to express the work structure within the business. Where it is assumed that all actors have the right to perform their allocated tasks with some forms of constraints. This means that each task, or group of tasks, has one or more business goal, attached to these tasks, to achieve by the actors. There is a distribution strategy of goals, where the dependencies between actors are cooperate and accumulate to achieve different kinds of business goals (functional and constraints) and complete all business processes (BPs) [22].

On the other hand, the organization is modelled as a network of connected processes that are collaborated to realize business goals in EKD. The organizational structure is derived from the network of business goals as goals-means relationship. In the goal-based workflow approach, there are three key concepts used for goal modelling, namely, goals, actors (users), and resources. The modelling process represent how actors can satisfy goals using available resources [23].

According to [24], a requirement engineering approach that is based on goal modelling introduced, to enhance the business goals' understanding for system developers. Four major attributes are used for the requirements elicitation steps, namely, who, where, when and why. The who attribute is used for specifying stakeholders of the systems. The where attribute is used for the location of a goal to be considered. The when attribute is used for describing the timeframe for achieving such a goal a stakeholder, and the why attribute is used to describe the reasons for implementing a goal and what each goal included.

In balance, it is clear to notice that all the above-mentioned approaches are process-oriented, in which they focus on presenting the alignment between the technology and the organization (business). This may raise some drawbacks when dealing with organizations that have more complex goals to achieve. In the context of healthcare organizations, the objectives of e-health and the related goals are considered complex in which it decomposed into a series of sub-goals that must be achieved first before reaching the complete major one.

III. THE PROPOSED GOAL-ORIENTED REQUIREMENTS EXTRACTION APPROACH (GOREA)

As it mentioned earlier in this paper, there are many projects and innovations have been applied in the healthcare domain to produce various kinds of e-health applications and systems. These systems provide efficient health services and products and enhances the overall quality of services (QoSs) to their audiences. In order to build successful e-health applications and systems that satisfies the innovation goals and audience needs, the system requirements must be formulated after the clear understanding of the health environment, the business goals and activities, and the structure of health services, which is considered a quite challenging task. Not only this, but also to ensure the developing e-health services, the business goal modelling is required to be a part of requirements engineering phase in the e-health development lifecycle. In the proposed approach, the e-health system requirements are derived from the user-defined organizational goals. It focuses on the clear understanding of the environment of e-health to

GOREA consists of two major phases: (1) modelling e-health business requirements phase [25]; and (2) modelling e-health IT and systems requirements phase [26-27] as shown in figure 1.

The modelling e-health business requirements phase is divided into two main stages: (1) model e-health business strategy stage; and (2) model e-health business environment stage. The modelling e-health business strategy stage includes three main elements: (1) business goals; (2) business rules; and (3) role model. It is responsible for describing the strategy plan of the e-health system, including visions, business goals and the evaluation plan for the strategy. Furthermore, the modelling e-health business environment stage includes three main elements: (1) BPs; (2) decision model; and (3) process activities. It demonstrates all e-health information and primary services, business processes, activities and hardware infrastructure

Modelling E-Health Business Requirements Phase

Model E-Health Business Strategy Stage
- Business Goals
- Business Rules
- Role Model

Model E-Health Business Environment Stage
- Business Processes (BPs)
- Decision Model
- Process Activities

Modelling E-Health IT & Systems Requirements Phase
- Modelling E-Health Business Process (BP) Step
- Modelling E-Health Business Goals (BGs) Step
- Analyzing E-Health Business Goals (BGs) Step

FIGURE 1: The Proposed Goal-Oriented Requirements Extraction Approach (GOREA) Framework

across the geographical boundaries of the system.

The modelling e-health IT and systems requirements phase illustrates the process of obtaining requirements of e-health system from the organizational goals that are determined in the previous phase. It consists of four main steps that deals with business goals of e-health

system: (1) modelling e-health BP step; (2) modelling e-health business goals step; (3) analyzing e-health business goals step; and (4) eliciting e-health system requirements step.

A. Modelling e-Health Business Requirements Phase

At the modelling e-Health business requirements phase, the efficiency and accuracy or extracting the e-health system requirements are targeted to be improved by considering the understanding of the health environment. It is divided into two main stages: (1) model e-health business strategy stage; and (2) model e-health business environment stage. The modelling e-health business strategy stage is responsible for describing the strategy plan of the e-health system, including visions, business goals and the evaluation plan for strategy. Moreover, the modelling e-health business environment stage demonstrates all e-health information and primary services, business processes, activities and hardware infrastructure across the geographical boundaries of the system. These two stages is discussed in the following subsections.

1) MODEL E-HEALTH BUSINESS STRATEGY STAGE

At this stage, the relationships and interactions between the four critical attributes (actor, role, interaction and

activity) are presented as a conceptual view. It demonstrates logically how e-health services can be provided, arranged and delivered. Responsibilities and roles of e-health actors are set and allocated also at this stage.

In order to specify business goals of the e-health organization, four main concepts must be clearly defined, which are objectives, aims, resources and executive managers. There are some interrelations between these concepts, for instance, the organizational aims of e-health must be delivered to meet the e-health organizational objectives. Objectives must be aligned to the available resources. This organizational level of the e-health system can be attained when clear responsibilities and roles are set and distributed (managed) across e-health actors. At the end, organizational goals must be clearly determined and attached to some related e-health services. This step is very critical for managers to ensure the performance of achieving the business aims and outcomes.

In addition, this stage aims to present an effective e-health strategic plan for the organization, a number of elements should be considered, participated, such as goals, direction and advantage, along with organizational resources, stakeholders and business environment. The goal represents a boundary of the plan that include all activities to be performed. The direction represents the

movement steps of the organization toward achieving the goals (including strategic goals and operational goals). The advantage represents the value added to the services and products provided to meet the expectation and satisfaction of all kinds of stakeholders [24].

As a part of developing the strategic plan for e-health, the organizational vision, mission statement, aims, values, short-term goals and targets and more components are defined. The roadmap for achieving the mission statement of the health organization must be identified and explained via the goals and targets in the business strategy planning.

Additionally, the value added to the stakeholders must be stated (implicitly) in the e-health's vision and the way of using the available resources to achieve business goals must be planned and included in the business strategy within the health organization. Lastly, the evaluation method for measuring the overall performance of the organization must be well-defined. For instance, measuring the quality of services is considered a very important to evaluate whether the provided health services meet the expectations of stakeholders or not.

The modelling e-health business strategy stage includes three main elements: (1) business goals; (2) business rules; and (3) role model. It is responsible for describing the strategy plan of the e-health system, including

visions, business goals and the evaluation plan for the strategy. These three elements is explained in the following subsections.

- ***BUSINESS GOALS***

The business goals states why the organization exists. They aim to represent why the BPs exist and how to fulfil the organization's mission statement. They are critical aspect for understanding the organization and information systems requirements. In addition, they clarify where the business is going to be, what are need to be achieved and when. Hence, they should be identified clearly at the early stages in order be easily understood.

They are the organizational objectives or targets that need to be completed. Each business goal can carry set of sub-processes or sub-goals where the sub-goals are linked to each other. Thus, they become more complicated to be understood in recently complex business. As a results, they should be analyzed before implementation in order to successfully achieve the organizational objectives. In order to capture and clarify the organizations business goals, the goal model can be considered a useful method to be used [24].

- ***BUSINESS RULES***

The systems analysts should have the knowledge of understanding the set of restrictions of operating the organization in order to understand the organization activities. These restrictions are named the business rules. They can show from the business perspective as there is an obligation conduct, concern, practice action or procedure in the actual organization activity while they identify or constrain some business aspects from the Information System (IS) perspective. The business behaviour can be influenced or controlled by thee business rules via asserting the business structure. The business rules can show what is allowed or not in the organization. Therefore, they can implement the decision making logic in the process.

The business rules can support the organization for achieving their goals, reducing the mistakes, increasing the customer loyalty and improving communication. They include derivation, structural assertion and action assertion. The derivation is the knowledge statement that derived from others organization knowledge. The structural assertion is the statement that express the business structure. The action assertion is the constraint condition that limit or control the organization behaviour [28].

- ***ROLE MODEL***

The organisation activity is performed by its employees who are participating in the BPs execution. All employees cannot complete all or the same activities while they are usually in charge of small task of the organisation activities. Normally, each organisation is divided into different units, such as departments where employees from different organisational department generally participate in the BPs execution. Hence, they have to share and interact resources and information. For example, some employees are playing different role to execute the BPs and thus the role represents the employee responsibility that he/she holds a position in the organisation. The employees' roles and their organisation parts are specified in the roles model.

The role model is used to define the business goals and to capture the business organisational value. The activity represents an atomic action, that the employees who are playing the corresponding role can perform, in the role model. The atomic action can be implied when the action is started, cancelled or completed its execution. Furthermore, it can be implied if there is no any alternative executions exist within the action. For example, the activity does not have any alternative outputs [24].

2) **MODEL E-HEALTH BUSINESS ENVIRONMENT STAGE**

The model e-health business environment stage concerns with all hardware technologies that are related to e-health to be employed and configured for communicating information systems devices to their end users, including transferring and exchanging information between them throughout a suitable technology of computer networks. This includes, cable and wireless networks, Wi-Fi, 3G and 4G mobile networks [29], Bluetooth technology, and software that are used for sending and receiving data within the e-health network. It is worth mentioning that the infrastructure concerns with the interrelation and the integration of hardware and software internally within the e-health system, rather than referring to the interconnection between individual component that forming the e-health system.

It is globally known that the provision of high quality and secure healthcare services depends on having robust e-health hardware infrastructures as well as health information systems. The current advancement trend in e-health systems includes the usage of the most recent technologies in computer networks and hardware, such as, Internet of Things (IoT), cloud and edge computing technologies [30], big data and NoSQL databases technologies, and even more.

It is critical, as a part of the business strategy in e-health, to link the components of the infrastructure to some goals and objectives of e-health that they elements support. This helps to check and ensure the existence of some critical hardware and devices to perform such business process or transmit

some health-related information flow. Additionally, the ability of the adopted technologies to deliver essential e-health services or products to individuals are examined and checked at this level.

The overall infrastructure level of the e-health is expressed using processes and activities. Moreover, the organizational activities are a significant element that must be considered and modelled (via the activities model) in order to determine the resources and other business requirements for ensuring the delivery of services and goals of e-health business organization.

The modelling e-health business environment stage includes three main elements: (1) BPs; (2) decision model; and (3) process activities. It demonstrates all e-health information and primary services, business processes, activities and hardware infrastructure across the geographical boundaries of the system. These three elements is explained in the following subsections.

- ### BUSINESS PROCESSES (BPS)

BPs transfer the inputs to outputs and express the organizations behaviour. They are the set of activities purposed to product an output that add value to the consumer. They are core impression that can be used for business modelling. They may have goals or objectives where they may be affected by business events that happened by the

others BPs or external worlds.[31].

BPs contain two classifications: (1) core or primary BPs; and (2) supportive or secondary BPs. The primary BP is started from outside of the organization, such as the BP activities chain that can realize product delivery for the consumers. However, the secondary BP is generated the conditions for the primary BP to carry them out.

Literature shows that authors have defined BPs in different ways. For example, According to Hammer and Champy, the BPs are the set of activities that obtain number of inputs and create the output as the value to the consumer. In addition, according to Davenport and Short, they are the ways of how simply plan them in order to realize the organizational tasks. According to Eriksson and Penker, they can highlight how to implement the work rather than how to model the business services or products [24].

BPs can include some core elements that related to each other as following:

Process: is the key element of the business which is made up of several business activities and procedures worked together to attain business goals, such as the patient consultation visit to the healthcare center for COVID-19 diagnostic testing management process.

Activity, Function, Task or Operation: is the behaviour carried out in the

organization, such as passing patient details to the pharmacy department.

Service or Product: is the consequently value of the process outcome.

Role: is the actor types which takes part in the BPs, such as the doctor.

Goal: is the aim of process, such as checking the patient automatically.

Rule: is the action, behaviour or constraint that defines for the organization and its BPs, such as for a loan, only considering customers with a clear credit check.

- ### DECISION MODEL

The decision model is an exclusive logical representation for the business logic that shows how and where it can be executed. The business logic is the logic proposed by the business rules. It represents how the business intends to have significant decisions. The decision model can be used for perceive, organize and manage the business rules and logic. It is not the physical model that shows how to implement the business logic in technology or how to communicate it via procedure manuals or training materials [32].

The decision model is not shown how the business logic is related to the processes, use case and software models. However, it is used for fulfilling the business logic. It can be translated into the target technologies throughout the appropriate design methods when the goal is to automate the business logic.

Furthermore, it can be translated into the format that easily referenced by people where the goals are following the business logic by the humans. Thus, it can be used to simply manage and interpret the business logic.

- ### PROCESS ACTIVITIES

The business process model (PM) elaborates the set of activities that are performed to derive specific results. These BP activities are achieved in the exclusive organisational environment. The organisation may has several elements that either can affect the BPs or not. Events are identified as the situations or processes that can trigger a process activity. They have the possibility to carry the changes for the business activities. Preferably, these events attend as the input for the business process model. For example, the transaction may create an alert for the individual in order to manually validate the details. The occurrences of activities help the IT people for developing methods in order to deal with those events. The purpose of process activities is to define the actions of BP activities [24].

The organisational activity is achieved in the environment where different things can be happened. Several of these things cannot affect the organisational activity even though other things are important and can be detected as they may trigger some behaviour and critical

response in the organisation. However, the process events can be used for identifying the detailed activities of the proposed process. They may affect the sequence of the BP and its activities.

B. Modelling e-Health IT & Systems Requirements Phase

The term IT modelling environment became popular and refers to a set of shared IT resources working together to achieve common goals. The IT environment normally includes two main parts: "technical" and "human", where technical includes telecommunications, hardware, software, and networks while human refers to the technical skills (persons) and knowledge required to maintain the IT resources. In the context of organizations, recently BPs have increasingly grown to be more complicated and their goals and objectives have rapidly changed. In this scenario, the IT environment should be flexible and, thus, rapid changes in business goals and objectives can be managed.

In the previous section, a completed definition of the business environment of e-health in developed and discussed throughout its core organization levels, namely, organization, strategy and infrastructure. In this section a definition of the links between fundamental components within those organization level will be discussed in order to support the

achievement of all objectives and goals of e-health system. It includes core business processes and activities, hardware elements and the target people to get benefits of e-health services and meet its objectives and goals.

The process of modelling the environment of e-health system is a significant step that helps in eliciting and specifying all requirements of the system, including business goals, objectives, functional requirements and constraints. following the scenario-based requirement engineering technique, the modelling process can illustrate how to achieve the business goals and objectives from real-world. To facilitate the requirements definition activity, all interrelationships among the elements of the e-health system, including services, business processes, information entities, stakeholders are captured and expressed in some system models at the modelling phase. As these elements collaborate and accumulated to achieve some system goals.

The modelling e-health IT and systems requirements phase illustrates the process of obtaining requirements of e-health system from the organizational goals that are determined in the previous phase. It consists of four main steps that deals with business goals of e-health system: (1) modelling e-health BP step; (2) modelling e-health business goals step; (3) analyzing e-health business goals step;

and (4) eliciting e-health system requirements step. These four steps is explained in the following subsections.

1) MODELLING E-HEALTH BP STEP

There are numerous modelling languages that are introduced over the time for modelling software systems. It can be simply defined into two major kinds, namely, general purposes modelling languages, such as Unified Modeling Language (UML), SysML, Business Process Model and Notation (BPMN), and domain specific modelling languages, such as WebML, WebDSL, mobiCloud, Sculptor, UsiXML and more. The majority of the languages are technical orientation in which they focus more of the technical aspects of the system rather than considered business objectives and goals as a part of their notations [11].

In the context of this work, the BPMN [33] is considered for modelling business processes and goals of a chosen e-health scenario. BPMN, the business process management (BPM) group's initiative, is a widely recognized modelling language that is used by business analysts and software developers in their software engineering activities. The language has the capability to express business task activities and their control flow using simple graphical notations. Similar to UML, BPMN is considered a standard modelling language that

reduces the technical gaps between business level and the implementation details during the development lifecycle.

2) MODELLING E-HEALTH BUSINESS GOALS STEP

Once the e-health BP has been modelled in the first step, there is a need to model the e-health business goal. The first step only shows a business perspective and thus it is hard for IT professionals who have a lack of business knowledge to understand the BP completely. As a results, the goal tree model will be introduced to model the e-health business process and it is considered as step 2 of the second phase (modelling e-health IT and systems requirements phase) of the proposed framework.

The goal tree diagram is represented with the set of nodes and edge where the nodes represent the goals at different levels and edges represent the relationship among these goals. The nodes can be the test group nodes, goal node or the operator nodes. The goal nodes can be utilized to divide the goals into the smaller sub-goals. The operator nodes can be either logic AND & OR operators. They can be utilized to divide the complex goals. The AND type operator only is satisfied if all of its children are satisfied. On the other hand, the OR type operator is satisfied if any one of its children is satisfied.

3) ANALYZING E-HEALTH

BUSINESS GOALS STEP

After the e-health business goal has been modelled in the second step, it has to be analyzed. It has to be interpreted to classify those activities that can be automated and those that can be manual. For instance, checking a bed availability at the hospital in the patient process flow in the emergency department in Saudi Arabian hospitals that carry out COVID-19 testing is considered automatic activities, while the clinical examination is considered as manual activity. Thus, the existing system is analyzed by checking its activities to solve the errors and avoid the manual activities in this step. The goal tree model is used for presenting this process. Thus, the goal tree model is labelled using symbols (A) for automatic act (M) for manual ac

4) ELICITIN HEALTH SYSTEM REQUIR STEP

The e-health goals are compl analyzed in third s it is ready to deri and system goals. chart diagram [3₄ to derive these system goals a considered as step second phase (mo health IT and requirements phas proposed framewc

The UML s diagram is a log utilized for analy specifying the system lifecycle, all key acto

exchanged information between system components within the framework in terms of states and transitions. It can be used by system analysis or developers to represent the system behaviour at the early stage of development. The state represents a situation of the system or a part of it in the execution lifecycle. This situation might be waiting for a coming event or another task execution before it triggered. On the other hand, the transitions show the change of system state or the internal interaction between its components when such condition is met. In the proposed framework, the UML state-chart enables system analyst, at the requirement engineering stage, to clarify requirements and remove any ambiguity related to it by providing all possible

World Health Organization temporarily named this virus as the 2019 novel coronavirus (2019-nCoV) [35-38].

The Saudi Ministry of Health (SMoH) has carried out different actions to fight against the coronavirus disease (COVID-19). One of these steps is taken by introducing COVID-19 community testing. According to recent SMoH announcements, the test is available at hospitals around the kingdom and thus people just need to drop in at the hospital and take the test.

A. Modelling E-Health BP Step

The process loop of proposed case study starts from the step of arriving at the emergency department of a hospital. The commonly used BPMN notation is utilized here to

emergency unit or to pharmacy for minor situations.

The second stage starts when a patient register in the emergency department. A second condition assessment is applied to the patient in the triage area by a nurse to determine to what degree the patient condition is serious. The COVID-19 test is also taken during this phase.

In some situations where a patient needs to have to take chest screening or other COVID-19 checking steps, further clinical examinations are applied. The confirmed cases who received a negative result of COVID-19 test are directed to apply stay-at-home rule for a period determined by the hospital. During this period the case will be on contact with the hospital providing all updates. On the other hand, in positive

FIGURE 2: BPMN for Patient Process Flow
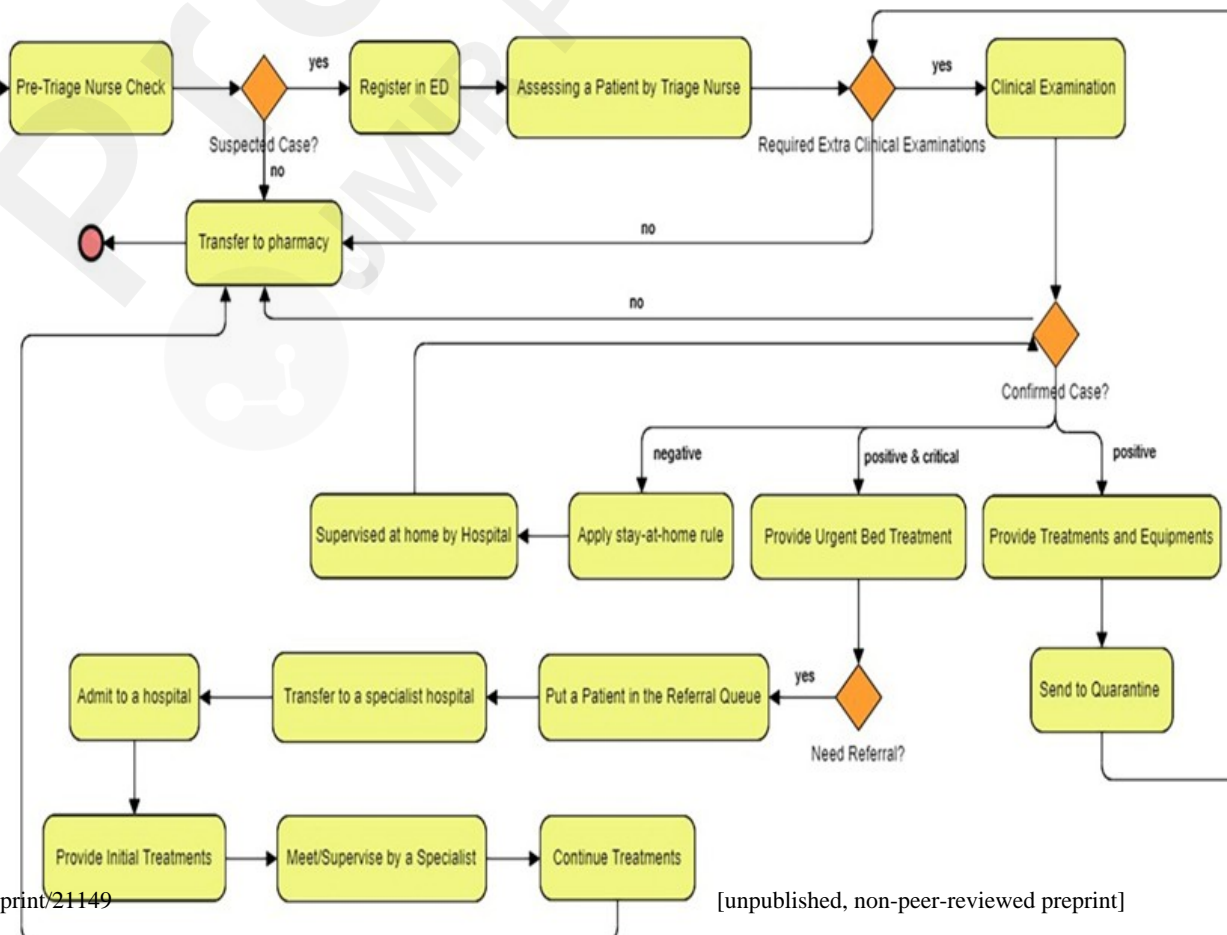
requirements elicitation. Each business goal can be decomposed into a number of smaller sub-goals that need to be achieved first in order to fulfil the complete the main business goal. Goal modelling via goal tree diagram is considered a common technique used for analyzing business goals to show a hierarchal structure that contains goals and sub-goals. Hexagonal shapes in the diagram are used to represent goals and sub-goals. Figure 3 below demonstrates conceptually the goal tree of the COVID-19 diagnosis and testing in emergency department.

After completing the conceptual goal tree, it would be possible to analyze and trace all goals and sub-goals, represented in the tree, to obtain complete valid system requirements. From these requirements, stakeholders, and logical boundaries of subsystems, including technical and manual components, can be extracted. At this level, each business goal that appears in Figure 3 goal tree is examined against its nature and its actual associated business processes that must be accomplished to achieve
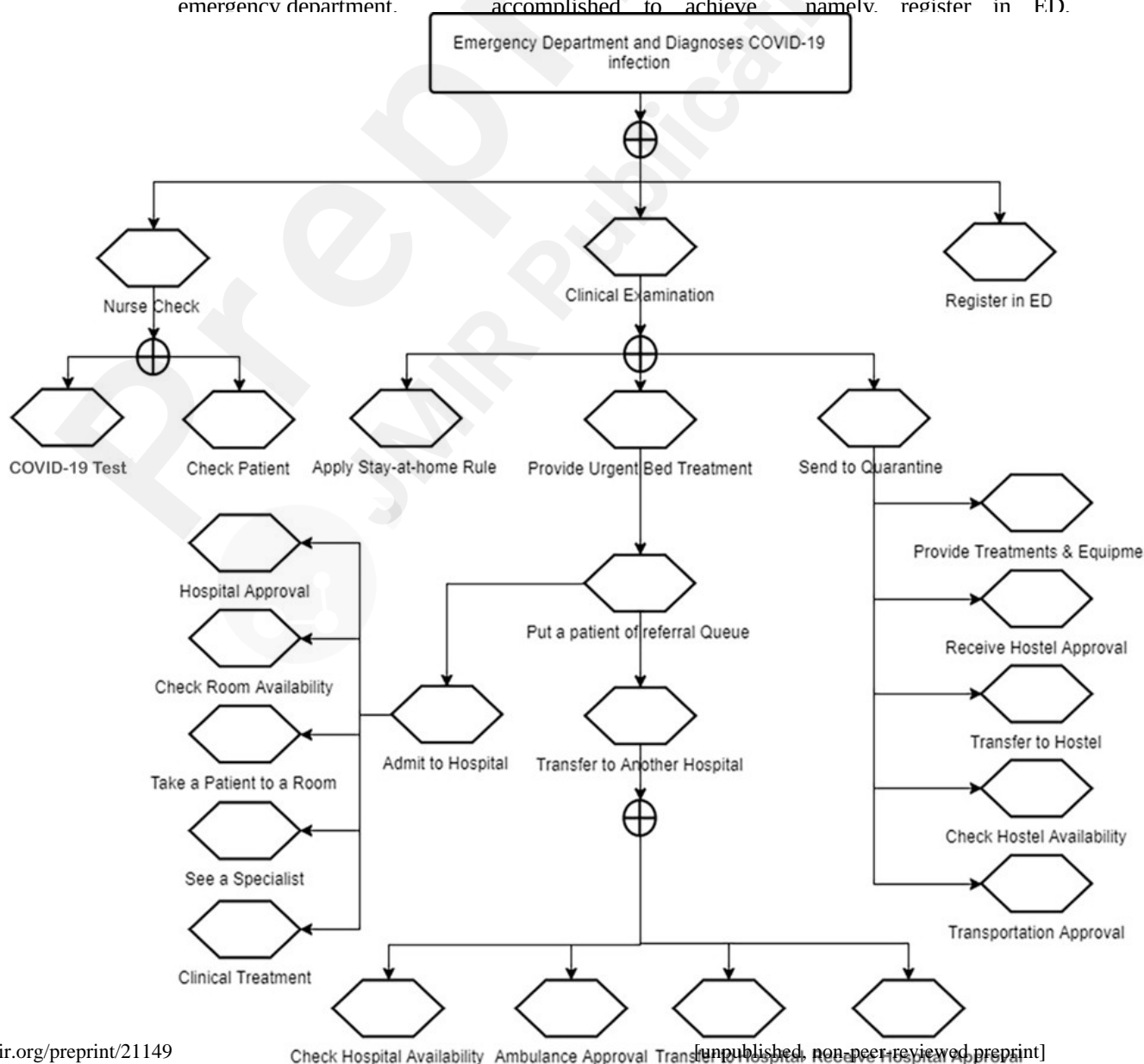
As it can see in Figure 4, there are 10 goals that must be implemented manually, namely, register in ED,

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B. Mod...
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FIGURE 3: Goal Tree Model for Patient Process Flow

BPs are expressed, namely, patient, medical staff, health unit, medical file, ward clerk, and quarantine recipient. The patient is a person who drops in to the emergency department to diagnose COVID-19 symptoms or to take its active test. The medical staff includes ED staff, hostel staff and in the emergency department as receptionist, triage nurse, or ED doctor. The hospital staff may be a specialist, pharmacist, nurse, or ambulance driver. The hostel staff can be a person who works at the front desk or reception of the hostel to arrange the stay of confirmed cases of patients and discharge them after completing their
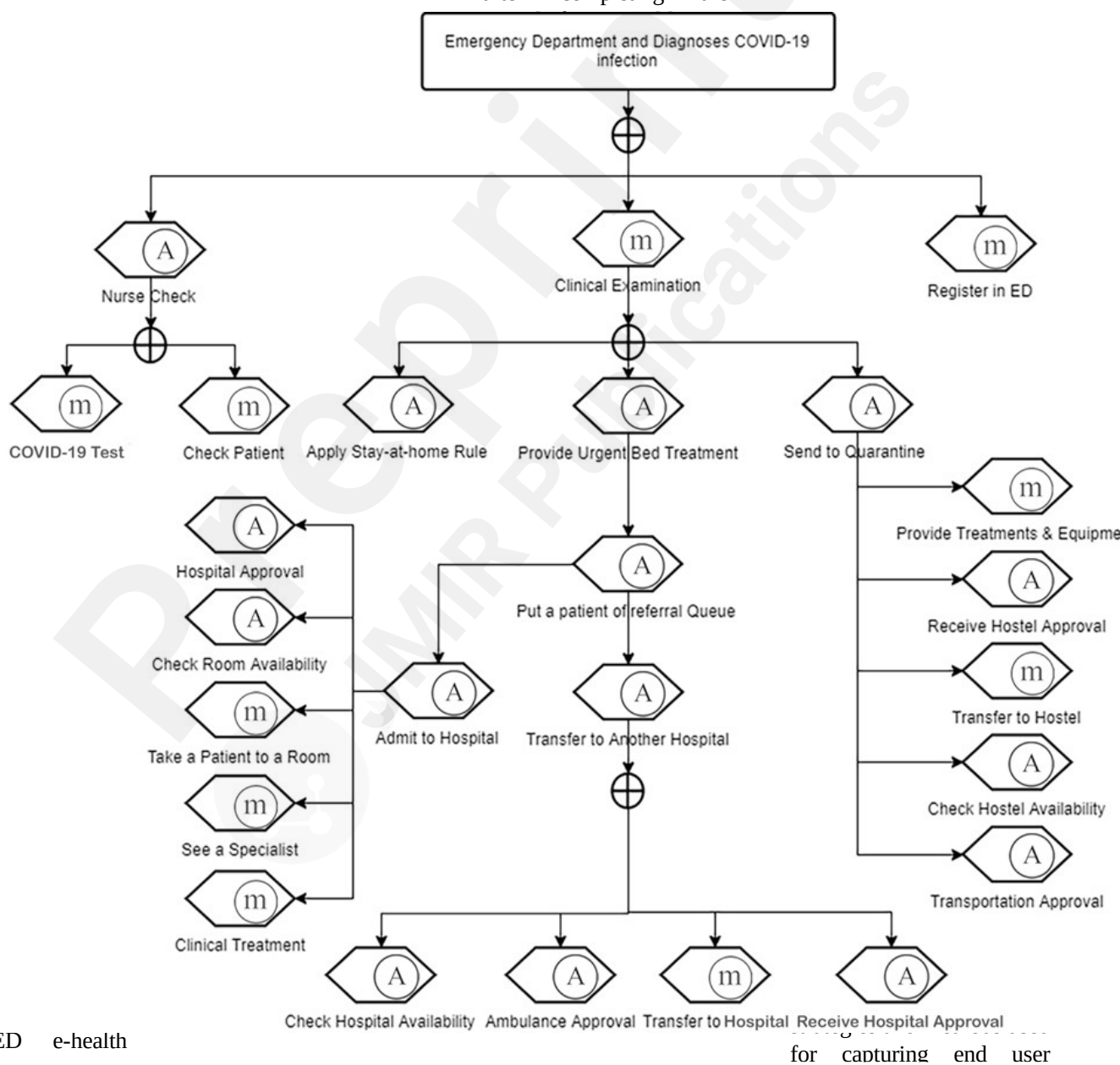

FIGURE 4: Automatic and Manual Function of Goal Tree Model for Patient Process Flow Tree

presented constructing g been accomp that, the step the final requirements demonstrated commonly use chart diag technique clea the e-health b and all require their flow accomplished promising ED e-health system.

In the state-chart diagram (Figure 5), a total of four main kinds of system actors who are participating in the

hospital staff. The ED staff may be a person who works

for capturing end user kinds of software and applications. Business goals analysis is an effective strategy can be used for this

purpose. It is worth mentioning that the process of specifying business goals is not a simple mission due to a number of reasons, such as variation of stakeholders, their backgrounds and perspectives, and some business goals are ambiguous and hard to measure automatically via the system.

Thus, this paper was proposed the Goal-Oriented Requirements Extraction Approach (GOREA). It is an elicitation approach that uses, specifically, healthcare business goals to derive the requirements of e-health system to be developed. This approach includes two major phases: (1) modelling e-health business requirements phase; and (2) modelling e-health IT and systems requirements phase where the first phase includes the model e-health business strategy stage and the model e-health business environment stage. The second phase illustrates the process of obtaining requirements of e-health system from the organizational goals that are determined in the previous phase and It includes four main steps modelling e-health BP step, modelling e-health business goals step, analyzing e-health business goals step and eliciting e-health system requirements step.

To validate the proposed framework, the basic operations and services in hospital emergency unit for checking patient against COVID-19 virus has been used as a case study. The results indicate that the proposed GOREA has a positive influence on the system implementation according to e-health business expectations. Furthermore, it can successfully fulfil the need of e-health business in order to save the citizens life by checking them against COVID-19 virus. However, the proposed approach has some limitations. For example, it is only validated using one e-health business goal and thus it has to be authenticated with different e-health business goals in order to address different e-health problems.

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