Policy framework for Healthcare responsibility Assignment

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Abstract—**Healthcare service mainly consists of a set of clinical workflows carried out by a group of actors who have multiple responsibilities. Current E-Health system engineering primarily focuses on HC service process requirements while less focus on realizing medical knowledge and higher level guidelines. Also, maintaining interoperability among heterogeneous systems is another major issue that makes less usability of e-Health systems. Thus, it is necessary to design a systematic approach to ensure multiple data sharing requirements of stakeholders. To identify and represent complex higher level rules and guidelines and to facilitate data sharing, this research contributes Healthcare Responsibility Assignment Matrix (HCRAM). The matrix represents the governing perspectives by indicating different roles of stakeholders on specific service processes in HC. Then the identified rules via HCRAM have been realized by indicating them in the process model. The proposed approach contributes the rule driven process model for healthcare system engineering.**

Keywords—HC Service Process, HCRAM, governing perspectives, behavioral rules

I. INTRODUCTION

Requirement engineering in healthcare (HC) mainly focuses on clinical workflow of the organization. Current e-health solution development highlights the importance of considering some other aspects such as interoperability among heterogeneous systems and sharing data to maintain Electronic Health Records (EHR). Even a small activity in HC process should govern by a set of defined rules and guidelines. Because of using electronic form of information, the new set of rules also introduced in addition to former defined rules. Therefore, it is necessary to identify guidelines and rules controls the workflows of the HC processes and information sharing. One promising approach in this direction is SAIF (Service Aware Interoperable Framework) which provides a high level design framework for interoperability among different eHealth systems [1]. The framework highlights the importance of considering governing perspectives, behavioral and informational perspectives in healthcare system engineering. However, the framework does not provide complete mechanism to implement the framework. Also, some laws defined to control the privacy of data sharing that only focuses on security perspectives in health information. Health Insurance Portability and Accountability Act (HIPAA) [2] indicates how to protect sensitive patient health information. However, there is still no mechanism to apply rules in HIPAA [2][3]. The research studies are limited only on technical level implementation of HIPAA [3]. Clinical pathway automation is another practical approach that attempt to realize some clinical guidelines which only focus on specific HC scenarios. Therefore, it is more important to model generic pathway with realizing corresponding guidelines and policies. However, these efforts still incomplete and no systematic guidelines or approaches that could facilitate healthcare policy-based and rule-based service designing and deployment. Higher level policies can be identified as behavioral perspectives of the health system whereas structural perspectives are covered by operational rules. Therefore, it is necessary to identify both structural requirements and behavioral requirements that correspond to Healthcare (HC) service processes such as admission, symptom registration & diagnosis, prescription and treatment. Because, the identification of governing rules and behavioral rules are lack in current e-Health systems compared to structural rules. This incompletion is heading some issues in ultimate system. For instance, the adaptation of decisions at emergency situations has not been captured as a system requirement. As a remedy, this research introduces a RAM matrix to identify the higher-level service policies involved in capturing roles of the HC actors in each task. Then the higher-level rules identified by a matrix is realized in a process model also described.

The remainder of this paper is organized as follows. The related studies of HC standards and applicable Object Management Group (OMG) specifications in health domain for representing health rules and processes have discussed in section II. Proposed framework for rule aligned process model in Healthcare is discussed in Section III. Finally, Section IV concludes the paper and presents directions for future work.

II. RELATED STUDY

In this section, the applicability of well-established modeling specifications in the trading sector for the HC domain and related research studies focused on healthcare service rules are discussed.

Electronic Health Records (EHR) is the main electronic health information repository which is used to get individual patient records. Therefore, maintaining an efficient EHR is important in many ways. As a decision support tool to physician, receiving all diagnosis and medication history of a patient, sharing required information to other new physician or other authorized actor group are some major facilities by EHR [4][5]. Information sharing in EHR should concern several privacy and security requirements[6]. Most of the components of individual medical record in EHR system have different types of authorities. Prior identification of the sharing communication collaborations is more important than later analysis of privacy and security requirements. When higher level design of EHR considers the information sharing aspects, it is easy to identify complete privacy and security requirements of information sharing in procedural level. Limiting to privacy and securing of healthcare data sharing is not sufficient to govern and verify all the guidelines and rules required in HC processes. Recent studies

have focused on information logistics in healthcare as a new avenue to receive efficient information from EHR and other collaborated systems[7]. Identification of information logistics requirements could be the initial step prior to identifying governing rules involved in the HC processes. Information logistics refers receiving right information or right decision to the right person at the right time [8].

Facilitate efficient information logistics that assist to make better individual care is main objective of EHR. Also, sharing information of EHR to improve the better care is required to adhere to the standards. To achieve interoperability among heterogeneous systems and to satisfy information logistics the HC systems must conform to the HC global standards such as HL7 and SAIF [9][10]. HL7 messaging structure is globally used as standard messaging structure and it is important to keep interoperability among heterogeneous system communications. However, HL7 supports only technical level message passing and less support in realizing higher level rules and structural semantics in HC. Lacking in realizing rules is heading towards the necessity of aligning rules and HL7 message structures.

HL7 SAIF is a higher level framework that consists of four sub frameworks to address interoperability issues in different health system communications. The sub frameworks describe the importance of considering standards, guidelines, behavioral semantics and static semantics in addition to information requirements in e-Health solution development and integration. However, it is impossible to derive complete system requirements by following the guidelines given in this framework. The tools and methods required to derive system requirements is not specified with the framework and it is limited to give higher level requirements. The importance of considering structural and behavioral perspectives is described in SAIF,

Also, it is important to identify the reasons for aligning guidelines or standards with information requirements. Information requirements could be changed according to the dynamic environment of the healthcare, and defined guidelines. Some related research studies only focus on the data and information communication between clients and healthcare providers. They attempt to control accessibility of different pieces of HC information considering their information requirements [11]. Analyzing clinical pathways is more efficient in identifying complete guidelines and standards in the healthcare work flows compared to the controlling data accessibility for different stakeholders. Each sub framework in HL7 SAIF describes the importance of capturing higher level requirements in terms of governing perspectives, behavioral aspects and informational aspects. Most of the e-health systems focuses on informational aspects of healthcare scenarios where limited focus on higher level governance aspects and behavioral aspects. Even though the interoperability framework discusses the importance of higher level requirements in HC domain, the application process of the framework is incomplete.

Governance perspectives in healthcare can be described in terms of rules and guidelines associated with processes. Business rules in the trading sector follow many established tools and methods to represent the rules and mapping them between higher level and lower levels [12][13]. Importance of Goal oriented process requirement identification in HC domain is analysed in recent research study and proposed mapping guidelines between high level and low level goals related to HC processes[14].

Semantics of Business Vocabulary and Business Rules (SBVR) is an OMG standard that allows documenting the semantic of business vocabularies and business rules. SBVR has applied in realizing rules in specific scenarios such as diabetics' management in order to extending the limited parameters used in the current diagnosis process. The limitation of digitizing healthcare policies is also discussed in the recent study with specifying the applicability of SBVR and RM- ODP in the formalism of HC policies. However, the study only focuses to policies regarding HC information sharing and disseminating[15]. The approach proposed in the research [15] does not assist to identification and realization of complete set of policies in clinical work flow.

While adhering to the governance requirements as defined in specific HC standards such as SAIF, HIPAA or other clinical guidelines, the applicability of existing business ontologies in adopting and realizing HC service rules should be examined.

Business process modeling methods in trading sector is successfully adopted in HC scenarios in several studies [15][16]. BPMN is a process modeling notation specified by OMG which is capable to extend according to different requirements. However, the rule aligned processes is not defined in HC domain. It is well established concept in trading sector. Due to the complexity of collaborations in healthcare service, it is difficult to identify an approach for this misalignment between processes and rules.

There are many emergency situations in HC where the predefined policies should be changed. Some are only defined in the legal documents. Specifically delegation of authority for certain task is involved a set of rules. A set of actors perform different roles in the same task which is defined as a higher level policy but not realized in the system requirement. Also HC policy realization plays important role in interoperability of heterogeneous HC systems. It is easy to identify the relative rule or policy corresponding to certain information transformation.

Therefore, responsibility assignment of each task must be identified clearly as a higher level requirement in HC. The Responsibility Assignment Matrix (RAM) is an appropriate tool for analyse the responsibilities of the HC processes. The matrix indicates combinations of actor involvement for a specific task. The matrix originally consists of four parameters; Responsible (R) Accountable (A) Consulted (C) and Informed (I). Different expanded versions of the RAM has been introduced and utilized in business related domains [17] [18]. A recent study by Stephen et al 2017 explained the utilization of RAM in project management with identification of distinction between the terms accountability and responsibility. Defining and identifying distinction of the parameters should be done corresponding to the domain applied. Some of the same parameters are applicable in the HC processes in order to define behavioral perspectives in HC processes. Therefore our proposed study is expected to utilize the novel combination of role parameters in HC.

III. METHODOLOGY & PROPOSED FRAMEWORK

The approach was implemented according to the stages in the methodology of design science study [17]. Under many

global norms, E-Health system engineering attempts to work. The significance of capturing behavioral aspects and knowledge aspects in requirement engineering was highlighted with respect to the global standard SAIF. However, it does not provide the appropriate method to derive the informational requirement from behavioral requirements. The artifacts proposed here is the higher level framework that capture and present the behavioral rules in healthcare and then to map them as information in terms of BPMN. The rigorous existing tools and methodologies have been used in each phase of the proposed solution.

The proposed work consists of two major phases. Responsibility assignment matrix has been proposed considering behavioral aspects of clinical work flow as a first phase. Then how the identified rules in the matrix are captured in the process model is described in the next phase.

A. Healthcare Responsibility Assignment Matrix (HCRAM):

Behavioral business rules are considered as elements of governance which concerned regulating and governing the actions of an enterprise according to SBVR [13][12]. Identification of HC behavioral perspectives should be performed in order to realize governing aspects in HC. Each process in the healthcare is accomplished by a set of tasks which are govern and performed by different HC actors. For instance, patient registration process is performed by a set of actors where each actor is assigned to a different role. Behavioral rules can be defined as policy level decisions which control the specific activity.

The role of each actor involvement and authority delegation requirements can be considered as higher level decisions attached to each task. RACI matrix could be adopted to describe these structural rules in HC service process.

Generic clinical workflow mainly consist of registration, diagnose and treatment processes. Generic diagnosis includes performing a clinical history and interview, conducting a physical exam, performing diagnostic testing, and referring or consulting with other clinicians. Performing these activities should conformed different behavioral and structural requirements. The information generated in the HC processes resulted in the form of documents and many structural rules should be followed by these documents. For example, some necessities that should be fulfilled with the prescription or registration form. The content of the prescription would be medication information and the drug dosage. According to the taxonomy of SBVR, behavioral rules can be categorized into few enforcement levels such as obligation, prohibition or restricted permission for performing some particular activity. Diagnosis process could be conducted by a team or individual. Prescribe activity has some behavioral perspectives. For instance, the physician must prescribe the medicine for patient. Also, the prescription cannot be proceeding without the authorization of the physician. Most of the behavioral perspectives with corresponding enforcement level can be analyzed using the Responsibility Assignment Matrix (RAM).

B. HCRAM (Healthcare Responsibility Assignment Matrix)

Responsibility Assignment Matrix (RAM) has been applied and used in assigning responsibility in different domains. Most studies utilized RAM to analyze and identify roles of the actors in different tasks. According to the requirement, the different factors proposed and the unique combinations to the domain have been utilized.

When consider HC domain, the relationship between task and actor is complex to specify according to the policy specified for the certain task.

In some situations in HC, more than one actor could be involved with the task with different responsibility. Also the authorship variation occurs corresponding to some tasks. Same actor can be assigned with different roles for the same task. This collaborative nature of the role task relationship types should be identified and modeled explicitly. HCRAM consists of four parameters which essentially identified along with HC tasks.

- Perform (P): A key factor that can be used to describe the actor who carries out the task. Mostly HC tasks are carried out by the actor whom may not be responsible to the task. Nurses are performed some tasks in which the responsibility or the authority is with doctor.
- Consult (C): Those whose opinions are sought. Subject matter experts should be consulted in many complex situations in healthcare. There are situations in which patient should be directed to further diagnose. Therefore some tasks in a diagnose process should assigned to consultant.
- Accountable (A): Accountability is taking responsibility of actions. Some actors in HC are accountable for certain tasks and they may not require performing the task. In HC it is important to aware about accountability for a certain task. Even though a task has higher level authority, a team member who performs the part of duty may accountable for it.
- Informed (I): Informed actor is the person who necessarily be informed when the task is performed or completed. For instance, physician would be the informed actor when the initial medical history is recorded by the nurse. Also sub tasks of diagnosis process can have several informed actors. The completion of patient admission process must be informed to the higher level authority in HC. Then only further decisions could be taken in some situations.

The HCRAM matrix proposed for the generic clinical workflow is depicted in the table 1.

TABLE I. HC RAM FOR CLINICAL WORKFLOW

Task Category	***Task***	***Non- medical staff / Administration staff***	***Medical Supporting staff***	***Medical Staff***	***Senior Medical Staff***	***External Collaborator***
Registration	Capture demographic data	P	P/A	I		
	Capture administrative data	P	P/A	I		
	Quick Patient Registration – Enter Minimal amount of data		P	A/ I		

	Admit Patient			P/A		
	Request history information of patient			P/A		
Diagnosing	Symptom Identification			P/A/C	P/A/I	
	Symptom Recording		P/A	P/A	A	
	laboratory test			I		P/A
	Review Results of lab test			P/A/C	P/A	
	refer to an expert			P/A	I	
Medication	Prescribe medicine			P/A		
	Issue medicine			I		P/A
	Directing to Dietician			P/A		C

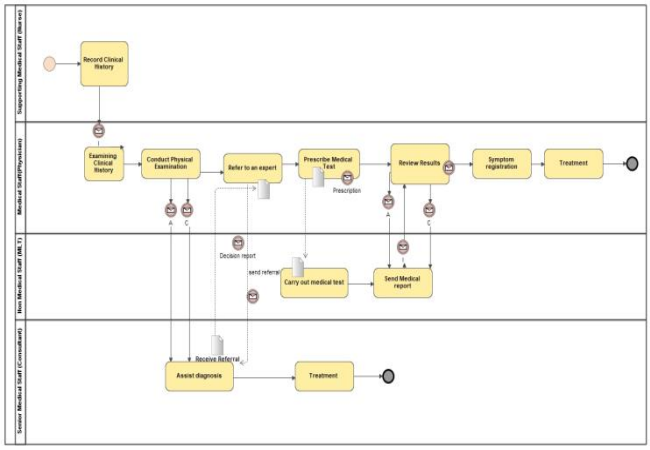

Fig. 1. HC rule aligned BPMN

C. *Realizing rules in the process model:*

BPMN specified by OMG is a process modeling tool which is mainly used in trading sector. It became a promising approach in HC process modeling because of its capability of realizing complex processes. Therefore, the behavioral rules captured by the HCRAM transform into process requirements by means of process model as depicted in Fig. 1.

Mainly the (P) role in each activity can be identifying by each swim lane in the BPMN diagram. However, the shared role for the same activity is difficult to depict in this diagram. Part of physical examination process can be conducted by nurse or perhaps it could be fully performed by a doctor.

Accountability (A) for the tasks is shown as an intermediate event in the sequence flow. Consultant becomes accountable for task diagnosis when he or she was part of diagnosis process.

Consulted (C) role of the diagnosis task is the expert /consultant for a certain diagnosis process.

In the case of review medical report can be informed (I) to the physician by MLT.

The notification of the multiple actor participation for the certain process can be depicted in process diagram by means of HCRAM parameter.

IV. Results and Discussion

This paper discusses the policy framework for clinical workflow that focuses primarily on HC domain behavioral perspectives. The initial phase is proposing healthcare responsibility assignment matrix (HCRAM) by utilizing the concepts RAM. In the identification of dynamic task assignments in clinical workflow, the four main functions defined in the proposed matrix are then applied. As the next phase, the identified requirements in the HCRAM are transformed to the process requirement by means of BPMN. The proposed research contributes to develop a complete and sound health rule oriented process designing framework. The framework can be considered as a methodology that fulfills the requirement of governing perspectives and behavioral perspectives defined in SAIF. Yet another commendable contribution is the facilitation to bi-directional traceability between behavioral perspectives and process perspectives that designers could be achieve with the adoption of the proposed framework. HCRAM matrix can be used to standardize the interoperability and data sharing among eHealth systems as it assist to represent authority delegation of the certain activity.

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