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Modeling Virtual Organization for Home Healthcare Using UML

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***Abstract*—** Healthcare is one of the essential services required by all, technological developments in recent years have enhanced the way we receive the service. Researches show that a decentralized healthcare provision is what is required to improve quality and reduce cost. Providing healthcare at home is one way of healthcare decentralization. Home Healthcare (HHC) is gaining popularity as more and more patients prefer to receive the care in the comfort of their homes. Providing care at home requires many professionals, organizations and agencies to collaborate and work together. In this paper we apply the concept of Virtual Organization (VO) to HHC as a framework for managing the collaboration of different participants of HHC. To visualize how the VO concept may facilitate the management of possible collaboration, in this paper, we use UML use case and sequence diagram notations to model the structural and behavioral aspect VO of a HHC case study. We later evaluate the suitability of UML model in modeling VO for HHC. Our evaluation show that using the UML standard notations all aspects of HHC virtual organization cannot be modeled and therefore we suggest that UML notations require to be extend to.

***Keywords*—** Virtual Organization (VO), Unified Modeling Language (UML), Home Healthcare (HHC)

I. INTRODUCTION

In this paper we use UML (Use Case and Sequence) diagrams to model the structural and behavioral aspect of Home Healthcare Virtual Organization. Technological developments have raised human expectations in many areas of life; healthcare is one such area that has received a great amount of attention from researchers and system developers. Good healthcare is what we all expect; we spend a lot of time and resources in improving the services that are provided through it.

In recent years investments in Health Information technologies have increased in hopes that healthcare quality increases and at the same time the cost of the care reduces [1] .Team based healthcare provision is gaining momentum due to the use of information technology. This means moving away from a single provider of healthcare to multiple providers collaborating and working together across multiple teams [2]. Despite the fact that many countries now have provided a modern healthcare system to their citizens, but factors such as cost and timely service provision are remain to be great challenges.

Home care has established its foundations and it is practiced daily, for instance cancer patients that are in receipt of chemotherapy can now receive their dose of drugs at home using a convenient infusion pump [3]. [4] Identifies attributes such as access, availability, cost, fairness and as quality related attributes that can be used to assess patient satisfaction in healthcare. HHC is gaining more attention as its effect on patients' well being is becoming more apparent by care providers and patients. HHC is highly complex "its complexity frequently astounds nurses when they first step into patients' homes to provide patient care" [5]. It is complex because different individuals, organizations, professionals, governmental and none governmental agencies work together and collaborate, either directly face to face or indirectly using electronic mediums such as the internet.

The seamless organization of indirect collaboration of theses stakeholders may benefit from employing a virtual model where the roles and organizational structures of the collaboration are defined. Defining a virtual model may help to anticipate how best to bring stakeholders of healthcare together to provide the best possible care, avoid problems and delays, and more importantly, the models can be reused and adjusted as required for different areas of healthcare.

In an ideal VO the needs of a patient can be fulfilled though a dynamically formed consortium of geographically dispersed medical specialist when needed, this can provide an environment where patients feel secure knowing that care can be provided when required. However it is important to mention that not all type of cares can be provided in VO settings, for instance healthcare that require physical engagement is beyond the scope of virtual healthcare organization. Online messaging, automatic mailing list servers, videoconferencing, chat rooms and asynchronous communication are some of the technologies used by virtual communities. Structural and behaviors

modeling of virtual collaboration in a typical virtual community provides a simple view that can be used to avoid or manage practical constraints such as time conflicts and coordination challenges. [6] Suggests the concept of "virtual disease management" where patients suffering from chronic illness can be managed.

Models and visualization techniques are used in many fields of science to facilitate a better understanding of a particular scenario, however "Visualization of aspects of virtual collaboration has received relatively little research attention in the past" [7]. In this paper we focus on modeling the abstract view of HHC VO. The practicality of how to implement the models is beyond the scope of this paper instead we consider structural and behavioral aspects of VO for HHC and use UML to model those aspects. In the context of this paper the interrelationship between actor, tasks and resources constitute structural aspect of VO in HHC. As for the behavioral aspect what happens in terms of interactions and communications between the components of the structural aspect is considered in the models.

The first aim of the paper is to show how virtual models using UML can help managers and system developers understand VOs in healthcare. The second aim is to examine the suitability of UML in modeling VO in healthcare. We develop a simple, nontrivial HHC case study and use UML (Use Case and Sequence) diagrams to model it. We have evaluated the models and the results show that UML need to be extended in order to cover all aspects of health case scenarios.

The rest of this paper is organized in the following way: Section two provides the background for the research, section three presents some related work for the research topic. In section four we have present a nontrivial home healthcare case study and model the structural and behavior of a possible virtual organization using UML. In section five we evaluate the models to see how suitable UML is for modeling virtual organization in healthcare and we conclude in section six.

II. BACKGROUND

In this section we present a general background of the research topic

A. *Virtual Collaboration*

First, Collaboration is the term widely used to convey the act of working with others, it is defined as working jointly to solve a problem, create or discover something [8] and the collaborating parties should share a joint responsibility and ownership and outcome [9]. Collaboration has always been the key factor in human survival, from the days when collaboration was needed to hunt, until today's modern world of electronic communication. Traditionally collaboration was done in a face to face medium, however recent technological discoveries such as the internet and telecommunications have introduced a new type of collaboration known as "virtual collaboration" [10] [11]. When virtual collaboration is mentioned one cannot over look the role of technology in connecting and providing the medium required for members to collaborate.[12] identifies three technologies that serves the creation of Virtual collaboration, (1) telecommunication providing the means for communication (2) database providing the resources required and (3) multimedia providing the virtual rendering for members to immerse themselves during collaboration.

In real world, arguably, technology has adversely influenced the quality and quantity of direct human interaction instead; mediated interaction is on the rise where members use websites, discussion boards, blogs and wikis to interact [13]. Human by nature is a social being that need to have relationships with one another, in the absence of real world interaction a virtual world could be the alternative. Virtual interaction and collaboration can facilitate the delivery of a number of essential services, for example the concept has been researched for potential benefits in education, e-commerce, teleworking and teleconferences [14] [15].

B. *Virtual Community*

With the emergence of virtual collaboration a new type of community known as "virtual community" (VC) developed. It is described as a group of people that exchange words and ideas in cyber space without having a face to face encounter [16] [17] or a number of agents working together in a medium, where agents could be human, organization, software and each agent plays a role during communication [18]. Howard Rheingold also define VC as ''social aggregations that emerge from the net when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace'' [19]. The attributes of this kind of community can be hard to generalize because of its multi-dimensionality nature however [20] identifies some core attributes of VC which we can be summarized as

- Common goals and needs
- Active and shared participation between its members
- Access to, and share available resource
- Repository of information that can support and serve members
- Shared context of social conventions

There a number of business virtual community success stories such as Amazon, ebay, and Gum tree. In these communities collaboration between members of the community take place on the web to buy, sell, rate and advertise for material and services.

C. *Healthcare Virtual Community*

Health virtual communities are defined by [21] as groups of clinical specialties, technologies, patients, educators,

healthcare providers who are collaborating using communication technologies. Some examples of virtual community in healthcare such as AIDSPortal, Novartis's CFVoice and Mayo Clinic can be found at http://www.freshminds.net/2009/04/examples-of-online-communities-in-healthcare/.[22] Argues that virtual communities "empower patients with knowledge, facilitate health information dissemination, and provide social and psychological support". The concept of virtual community in healthcare is researched by a few researchers, [23] is one such research where the authors propose a virtual community with a mission. They have reviewed "the state of the art in virtual community" in search of ways to manage quality in healthcare and support patients. The e-patient which refers to those who use the online services to search and look for health information is on the rise due to the proliferation of the internet. According to [24] 33 million Americans regularly search the internet for healthcare information.

D. Virtual Organisation

The invention of telecommunication and the internet has opened the way for collaboration over time and space in an organized consortium of collaborators known as VO as explained in [25] [26]. The rapid formation characteristics of VO and no long term commitments for the members of a VO makes the concept very appealing to rapidly changing business environments as well as non business public service providers. Consider a simple scenario where an emergency situation could be dealt with quickly by forming a VO consisting of police, medical staff, fire brigade, air ambulance. VO in terms of business is described as "A loosely bound consortium of organizations that together address a specific demand that none of them can (at the given time) address alone and once the demand has been satisfied the VO might disband" [27].

Theoretically the dynamic nature of VO could offer solutions to many different problems that require timely solution, however when it comes to the application of the concept there are a number of structural, functional and behavior barriers that yet to be finalized. A structural model that could show how the different stakeholders in a typical VO may come together during collaboration in a given time may help the beneficiaries of the VO to plan ahead and anticipate possible outcomes. The structure of VO is important for the description and analysis of different aspects of it as claimed by [28]. The practicality issues of VO creation are beyond the scope of this research. We follow the direction of other researches such as [29] and "concentrate on the functional and behavioral aspect in which partners and resources are involved without committing to the way in which they are effectively implemented".

E. Unified Modelling Language (UML)

VO is a dynamic consortium of geographically dispersed participants that come together for a purpose, to accurately model the dynamicity of VO a modeling language is required that can adhere to this requirement. UML is used to analyze, construct models, and describe complex systems, using object oriented methodology and it has become industry standards [30]. UML has provided four kinds of dynamic diagrams, namely, the Sequence diagram, collaboration diagram, state chart diagram and activity diagram [31]

III. RELATED WORK

There a number of researchers who have attempted to use UML diagrams to model some aspects of healthcare. [1] Has used UML to model the execution procedure of treatment provision to patients, it has concluded that UML diagrams "cannot be used directly in the hospital domain because of the large degree of variations of the order how doctor execute various treatment procedures". UML has been used to model a number of healthcare related processes such as optimizing hospital processes [32], organizing hospital-based cancer registration process [33]. [34] Has developed a framework from software engineers' point of view for collaboration in healthcare during service provision. A patient centric system for virtual medical teams delivering healthcare to patients at their homes is developed by [35], the system aims to support "dynamic creation, management and coordination" of the virtual team. When it comes to the practicality of information exchange [36] suggests a typology that includes giving and seeking information, support and encouragement statements and personal opinions. However as far as we know, no researchers have attempted to model and apply VO concept in HHC sector.

IV. CASE STUDIES AND MODELS

HHC is a term used to represent the provision of heath service to patients in their living environments as opposed to hospitals. HHC is growing fast because more and more patients wish to receive treatments in the comfort of their homes. A workforce ranging from professional medical care providers to nonmedical service providers are realizing HHC for millions of patients who are recovering from surgery, or illness or chronically ill or terminally ill. Caring for patients in their home settings presents multiple challenges that require access to real time information. Care givers need to answer patient needs and provide on scene advice and guidance that can best serve the patient. For the purpose of this study we consider the following case study, the concept is taken and simplified from [5] case 6.3.

A HHC agency would like to set up a VO that consists of a nurse, a physician, a rehabilitation therapist, a home care assistant, a quality director, a psychologist, a medical equipment provider, a safety equipment provider, a counselor, a clinical manager, a community agency, a

pharmacy, an administrative staff, a financial specialist and a home monitoring system provider to provide HHC to an elderly female patient who recently had a right hip total joint arthroplasty and she has been admitted to the HHC agency. The agency assigns a Nurse and the Nurse has to review the patient's referral documents as well as fill in a physical assessment form to identify the needs of the patient as well as provide information to the team members "In HHC, the leader of the interdisciplinary team is usually the nurse" [5]. The patient has a history of other illnesses such as hypertension, osteoarthritis and coronary artery disease. The patient lives alone and has a niece who visits her occasionally to care for her as much as she can. The patient has to take regular medications and her ability to move is currently limited by her recent operation. This case was chosen because it "illustrates how the HHC nurse can work with the multidisciplinary team and the patient to identify mutually agreeable goals" [5] which fits the definition of VO given in section 2 D.

A. *Modeling Methodology*

To understand a complex process it has to be described in detail [37] suggests modeling the process is one way of doing it because modeling "increases the readability of a process and its evaluation". The concept of VO supports collaboration over time and space, but before such a concept is realized in healthcare there is an axiom that states we need to model something before we can automate it [38]. The ability of Service Oriented Architecture to show a number of service providers working together makes it a good candidate to be used for modeling in healthcare. But SOA has mainly been used to model the technical aspects of interoperability in healthcare systems "not modeling the actual healthcare processes" [2]. UML is one of the most widely used modeling languages that can be used to model the behavioral, structural, and conceptual aspect of a process [39]. We are going to use Sequence and Use Case diagrams of UML to model a case study in HHC provision using the concept of VO. Use Case diagrams represent the relationship between external actors and their role in carrying out a function within a system whereas Sequence diagrams describe the temporal communication that occurs in a specific system process.

UML Use Case diagram is used to represent the requirement of a system; we are going to use this diagram to show the static structure of tasks and actors that carry out the tasks in healthcare VO. Tasks are carried out by actors, for instance in a typical healthcare scenario actors can be patients, doctors, ambulance staff, medical companies, whereas tasks can be prescribe medicine, take a test, discharge and admit patients. Sequence diagram of UML is extremely useful to show behaviors of objects in a typical object oriented system. In object oriented analysis and design Sequence diagrams are used to show the interactions between the objects that make up a system; it also shows the functional responsibilities of each of the objects. We are going to use Sequence diagram to show collaboration in VO and adapt the object oriented concept but, instead of objects, we have VO participants and resources interacting.

B. *Structural Models*

A model is a representation of an important aspect of real world, but not the same as real world. One of the main challenges in modeling a given process is requirement gathering, for this we have relied on [5] to get all our requirement, the book is scientifically sound since it is the work of many professionals and researchers in the field. We have also relied on the book for the case study development. In a typical HHC environment nurses provide care to patients in their living environment, they may live alone or live with family members. Before the modeling begins it is important to identify all the main actors and their roles in HHC see table 1.

No.	Actor	Role description
1	Patient	Ask for healthcare services to be provided in a home environment settings
2	Nurse	Nurse assess physical, mental, spiritual, cultural, social, functional, safety, medication and equipment needs and the environment requirement of the patient
3	Physician	approve recommendation from nurse, agrees with plans of care and authorise and sign the plan of care for the patient
4	Psychologist	Assess the psychosocial needs of the patient
5	Rehabilitation therapists	Develop a rehabilitation plan for the patient and observe its implementation
6	Family member	Look after the patient and provide daily needs for the patient
7	Home care assistants	Provide personal care, such as bathing, dressing, and grooming
8	Home Health Agency	Manage and organise the provision of the HHC through identifying and obtaining required specialist and resources.
9	Medical equipment provider	Provides medical equipments such as oxygen and wound care dressings at the patients living environment
10	Safety equipment provider	Provide safety equipments such as grabbing bar at the patients home
11	Counsellor	Provide emotional and psychological counselling to the patient
12	clinical manager	Sometimes called a coordinator or supervisor who works primarily in the office coordinating the interdisciplinary clinical team members)
13	intake/referrals department	Takes the referrals made by hospital discharge planners, physicians, and other referral sources and obtains the initial information about patients that the agency will admit for HHC services.
14	community resource agencies	Medical Social Workers (MSWs) help patients and their families identify needs and community resources that can help meet those needs
15	Quality director	Oversee the quality of the HHC provided to the patient
16	Financial department	Send bills to the patients and other insurance providers, pay the staff for the patient visits they make
17	Administrative support	Staffs who help with telephone calls, data entry, and scheduling
18	Pharmacy	Provide required medical needs to the patients
19	Home monitoring system providers	Provide emergency response systems

Table 1 HHC actors and roles

Now we have all the main requirements to start the process of modeling the entire case study using UML Use Case diagram notation and the result is shown in figure 1.

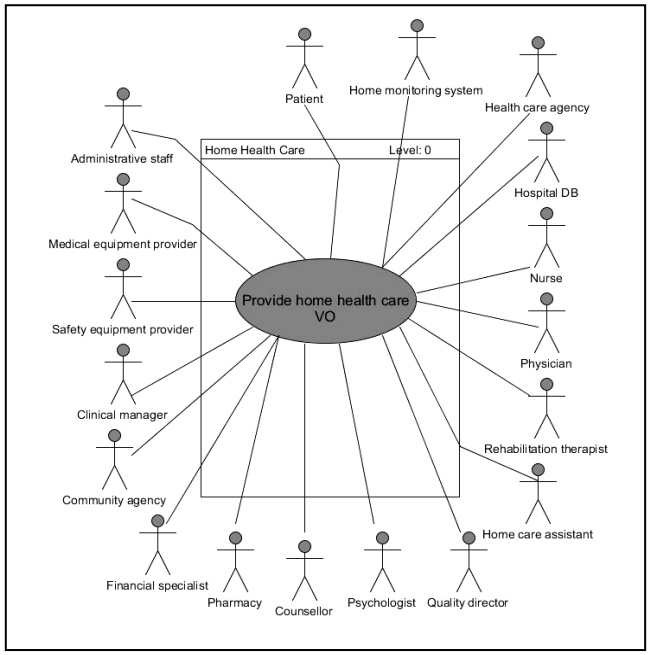

Figure-1 Level 0 Healthcare VO

In a typical VO members collaborate and share resources to achieve a predefined goal. As explained we have chosen UML use case diagram to model the structural aspect of the case study described in section 4. Figure 1 is the use case model of a VO called "Provide home healthcare", it shows all the actors that have participated in the VO and it is the highest level of abstract that represents the entire VO. The main actor is the Nurse that has to examine the patients and collaborate with all other participants such as Home Care Assistants and Medical Equipment Providers. Each member has a specific and important role in providing the HHC fit to the need of the patient.

The need to form a VO usually arises when a number of participants can see a shared goal. [40] defines a VO as an infrastructure that creates a "temporary network of independent companies, suppliers, customers, and even rivals - linked by information technology to share skills, costs, and access to one another's markets" The goal of the VO modeled in figure 1 is to provide HHC to the patient described in the case study in section 4.

The practicality issues of VO creation are beyond the scope of this paper instead we follow a similar way as [29] and "concentrate on the functional and behavioral aspect in which partners and resources are involved without committing to the way in which they are effectively implemented". To evaluate further the suitability of UML Use Case diagram for modeling VO HHC, we have modeled two more VOs that represent functions at two different levels of abstraction see Figure 2 and Figure 3 and the models have been evaluated in section 5.

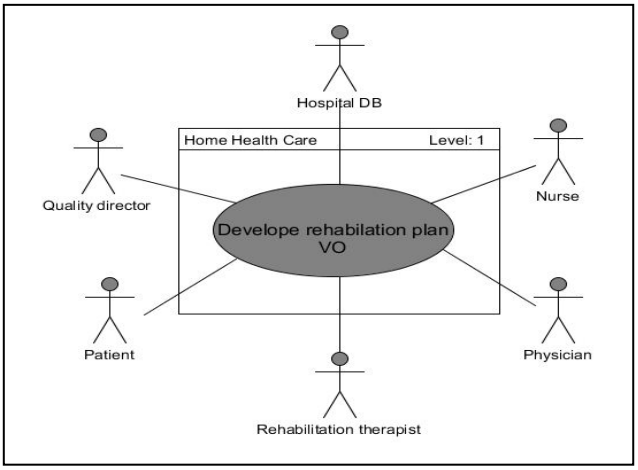

Figure-2 a Sub VO Task within HHC VO

Figure 2 is the use case diagram for the "Develop rehabilitation plan" VO which is a sub task of the more general VO shown in figure 1. It is important to mention that there may be many more tasks in level 1, but since our aim is to show the suitability of UML Use Case diagram in modeling VO one example is enough to be used for evaluation later on.

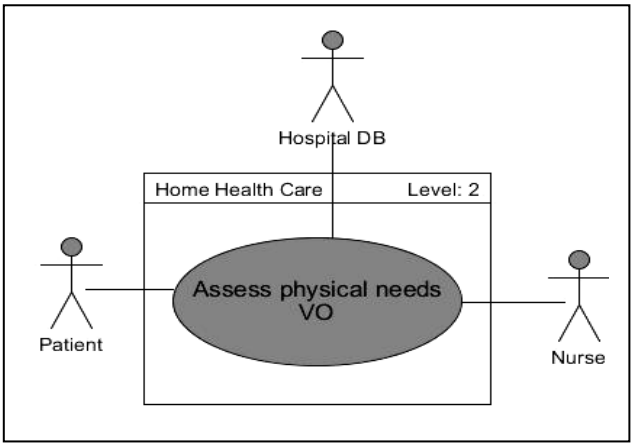

Figure- 3 A Sub VO Within Develop Rehabilitation Plan VO

Figure 3 is the use case diagram for the "Assess physical needs" VO, which is a sub task of "Develop rehabilitation plan" that is managed and organized by the member "Nurse". The diagram represents level 2 of the Use Case diagram. Figure 4 is the result of putting the three levels of VO diagram together.

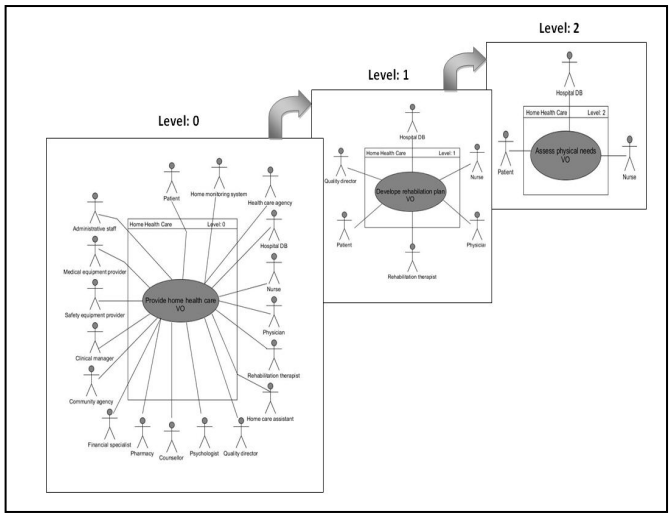

Figure- 4 The VO Model Hierarchy

C. *Behavioural Model*

To model the interaction between members and resources in the "Provide home healthcare" VO we use UML Sequence diagram as we have explained in section 4.1. A typical Sequence diagram shows all the main members collaborating in a given Use Case, it also shows the message exchange, the direction of requests and replies as well as the content of the messages. To draw a Sequence diagram that could represent the message exchange and collaboration between the participants of the VO we have to identify all the main steps that take place in a typical home care provision. For the process of providing HHC [5] identifies a number of steps which can be summarized as the followings:

1- The patient is referred to a HHC agency by the hospitals referral department using a written transfer report that includes the patient's health status and needs.
2- After the referral order is accepted by the home health agency a Nurse will be appointed for the patient to start providing the care.
3- The Nurse receives the patient's referral report and obtains information relating to diagnosis, treatments, medications and other required health concerns.
4- The Nurse carries out a comprehensive assessment to identify the patient needs and report the needs to the physician.
5- The Nurse then device a care plan for proving the HHC to the patient and notifies other team members
6- The plan is implemented once it is approved by a lead physician supervising the healthcare provision.
7- All team members collaborate and share information during the course of the HHC provision to make sure the patient receives a satisfactory healthcare.
8- The quality director assesses the quality of the care and reports any shortcomings
9- Finally the finance department sends bills to the patients and concerning insurance companies as per the terms of the home care provision contract.

Now we have an overall view of the possible steps that take place in providing HHC, the resulting UML Sequence diagram is shown in Figure 5. Since we aim to model the interaction at a high abstract level, the diagram only shows the name of the messages and the complete message syntax has been ignored.

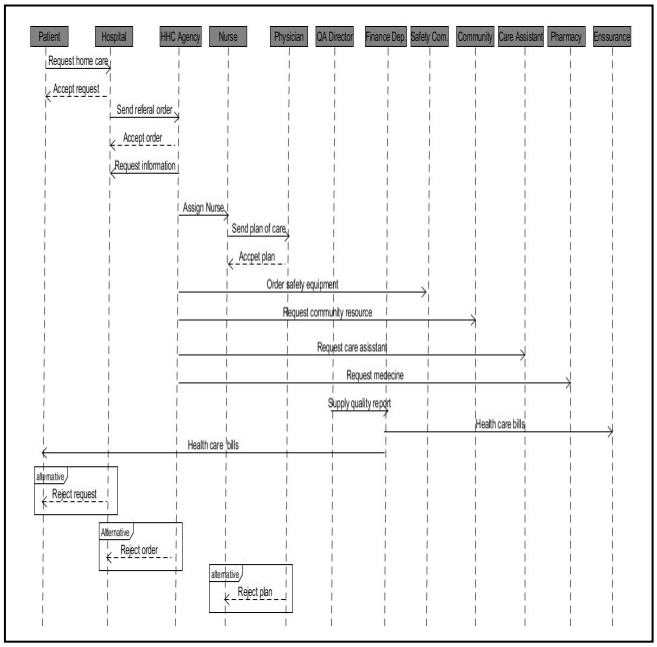

Fig.5 The Collaboration Within The "HHC" VO

V. MODEL EVALUATION AND DISCUSSION

In this section we evaluate the suitability of UML Use Case and Sequence diagrams in modeling VO in healthcare domain.

A. *Evaluation Criterions*

UML diagrams have been used extensively in software development and system modeling; however, arguably, we are the first to use UML to model VO in healthcare domain. This means references that could be relied on to compare our models with are limited. To evaluate the suitability of the models in representing VOs in healthcare we are going to compare the models with 12 features identified by [2]. The features are specific to modeling languages suitable for modeling in healthcare and they are summarized in table 2. It is important to state that the 12 features are not identified specifically for languages that model VOs but we believe they are essential therefore we use them in our evaluation.

No.	Categories	Features
1	**Usability**	**1- Tool support:** is the language supported by tools to draw the models **2- Ease of Use**: how easy the language is to be used for modelling a particular case. **3- Scalability:** healthcare is complex and involves many different professionals, organizations and groups. a modelling language should be scalable to represent this complexity **4- Ease of monitoring:** a modelling language should be easy to analyze and follow the processes it models
2	**Capabilities**	**5- Abstraction:** a modelling language should be able to model a healthcare process at an abstract level that is simple and easy to understand. **6- Security:** a modelling language should support modelling security features in healthcare. **7- Privacy:** privacy is very important in healthcare; a modelling language must consider and model privacy issues. **8- Exception handling:** a modelling language should consider exceptions because healthcare processes are keep changing and don't follow a set procedure. **9- Peer-to-peer representation:** a modelling language should be able to model collaboration between actors and resource in a particular healthcare scenario. **10- Human vs automation:** a modelling language should be able to model both human and machines participation in healthcare.
3	**Model evolution**	**11- Reusability:** a modelling language should be able to model multiple actors and processes in healthcare using few numbers of graphical depictions. **12- Maintainability:** the attributes and processes in healthcare are changing fast, a modelling language should be easily maintainable and adaptable as per the changes.

Table 2 Model Evaluation Criterion

B. Use Case model evaluations

The Use Case models are created with the aim to represent the structural view of VO in healthcare domain. Here we evaluate the models compared with the criterion categories described in section A.

Category one: Usability

As we have explained in section 3. UML is widely used by developers and system designers to model different aspects of a system, which means there are wide range of tools available for UML modeling such as UMLet [www.umlet.com],ArgoUML[http://argouml.tigris.org/servlets/ProjectDocumentList] and StarUML [http://staruml.io/]. In terms of ease of use, UML is believed to be relatively easy to learn and there are a lot of literatures and tutorials to teach the meaning and the use of UML. However the language falls short in the scalability features, because of its limited representation on different roles, researches such as [41] support this claim. In figure 1 there are a number of actors such as Healthcare Agency, Nurse, patients, Physicians and so on, each has a specific and changing role that should be represented in the diagram. UML has the same graphical depiction for all actors regardless of their roles which could be confusing from a healthcare professional point of view. A VO model should be both representative and understandable by system developers and healthcare professionals which is not the case in figure 1 for the reasons we explained. The model may be easy for a system analyst or developer to analyse and understand, however to a health professional the role and job of each actor is not clear in the model. The evaluation result for the first category is summarized in table 3.

Category one: Usability	**Tool Support**	**Ease of use**	**Scalability**	**Ease of Monitoring**
Model conformity (Figure 1,2,3)	✓	✓	✘	✘

Table 3 First category evaluation results

Category two: capabilities

This category is very important to healthcare since it contains privacy and security. Normally privacy and security are set and regulated by law in healthcare. For any modeling language to represent healthcare domain it is essential that it provides primitives to accurately represent both security and privacy concerns. UML diagrams have no graphical notation to represent security and privacy visually, but instead languages such as OCL are used alongside it to set constraints which could be used to set privacy limitations. This issue is discussed by [42] however security and privacy issues in UML are yet to be addressed fully.

UML is used widely to model systems and scenarios at an abstract level, the models we have created show that UML is suitable to represent scenarios at an abstract level that can be understood by both system developers and healthcare professionals, but it does not mean that the representation is precise. UML can be used to represent a scenario at different levels of abstraction as we have shown in figure 4.

One other unaddressed issue is that UML notation does not distinguish between human and automated role in its graphical representation and it uses the same "stickman" symbol to represent all roles. As for exception handling no such concern is addressed and no reason is given by OMG as to why it doesn't exist. Finally the peer to peer representation between actors and resources are represented by drawing a line between them, and the collaboration process can be detailed and shown in a Sequence diagram as figure 5. The evaluation result is summarized in table 4.

Category two: Capabilities	Abstraction	Security	Privacy	Exception handling	Peer-to-peer representation	Human vs automation
Model conformity (Figure 1,2,3)	✓	✗	✗	✗	✓	✗

Table 4 Second Catergory Evaluation Results

Category 3: Evolution

The reusability attribute of a modeling language is an important feature necessary to model a scenario in a simple and representative way that users of the model can understand without compromising completeness. The modeling notations used in UML Use Case diagram are reusable since it uses the same notation for example the "stickman" to represent all roles. However even though UML notations are reusable but we believe completeness has been compromised since there are roles in health care that should be represented with different graphical notation. For example a human doctor checking blood pressure and a pressure checking automated device that checks the blood pressure of a patient have the same graphical representation in UML Use Case diagram, whereas it should have been clear which one is human and which is a device. This leads us to conclude that UML Use Case diagrams maintainability while representing health care is poor due to the need to represent the dynamic nature in roles and functions of actors working in the field. The evaluation result for the third category is summarized in table 5.

Category three: Evolution	Reusability	Maintainability
Model conformity (Figure 1,2,3)	✓	✗

Table 5 Third Category Evaluation Result

C. Sequence diagram evaluation

System components interact to accomplish a task, modeling the interactions that take place between the components of a system help users and system developers to understand how it works. In this section we use the evaluation criterion identified in section 5.1 to evaluate the Sequence diagram model in figure 5.

Category 1: Usability

UML Sequence diagram is one of the most widely used models to model the interaction between components of a system. As we have stated it is widely used by developers therefore there are many tools such as the ones mentioned in section 5.2 available to draw the model. There are also many tutorials teaching and showing how to draw and use the diagram and it is believed to be relatively easy to learn. As for scalability, we believe Sequence diagram can represent the message exchange in complex health care scenario. We believe the syntax of UML Sequence diagram contains adequate notations capable of representing the interaction that takes place in a typical health care VO. For example the message syntax consists of:

1- Message guard that can set conditions for a particular collaboration and distinguish it from other messages even if they have the same message name. For example imagine a nurse collaborates with a patient to virtually in a Use Case named" take a tablet treatment" if the patient has to take the table three times day in the morning, midday and evening he message name is the same every time the collaboration takes place. In this particular scenario the guard condition with the message set a condition to be true i.e. to check if it is morning, midday or evening.
2- Message name that gives messages different names, so regardless of the complexity of a virtual collaboration the message naming can give a unique identity to a message.
3- Return value which can show the outcome of the collaboration
4- Parameters that can be used to characterise a message, in the "take tablet treatment" example this feature can be used to tell a patient which tablet to take exactly by giving the tablet name as a parameter.

This shows that Sequence diagram is scalable and easy to monitor since all the message directions and outcomes are easy to be analyzed and followed. The evaluation result for the first criterion is summarized in table 6.

Category one: Usability	Tool Support	Ease of use	Scalability	Ease of Monitoring
Model conformity (Figure 5)	✓	✓	✓	✓

Table 6 First Category Evaluation Result

Category 2: Capabilities

UML Sequence diagram is widely accepted industry standard to represent the interaction between the objects in an object oriented system design. The interaction can be detailed at a system level using system Sequence diagram which shows the entire system as a box and the actors of the system; or at an object level which shows the interaction between the objects involved in carrying out a particular Use Case. As we have explained in category 1 message syntax contains "guard" that can be used to set security condition for the message, however the mechanism of how to use this is unclear and yet to be addressed by current researchers in the field. As for privacy requirement of health care Sequence diagram does not have the facility to represent how a private message can be sent or received. At object level Sequence diagram can represent both human and automated objects effectively, however at the system level this is not the case. The evaluation result for the first criterion is summarized in table 7.

Category two: Capabilities	Abstraction	Security	Privacy	Exception handling	Peer-to-peer representation	Human vs automation
Model conformity	✓	✓	✗	✗	✓	✓

Table 7 Second category valuation result

Category 3: Evolution

UML Sequence diagram is simple to use and has a few notations that can be reused many times to represent different interactions in different scenarios. The simplicity of the diagram notations makes the models easily maintainable because changes to the model can easily be made as per scenario changes. The evaluation result for the third criterion is summarized in table 8

Category three: Evolution	Reusability	Maintainability
Model conformity (Figure 5)	✓	✓

Table 8 Third Category Evaluation Result

D. Overall result of the evaluation

Categories	Category 1:Usability				Category 2: Capability						Category 3: Evolution	
Criterions	Tool Support	Ease of use	Scalability	Ease of Monitoring	Abstraction	Security	Privacy	Exception handling	Peer-to-peer representation	Human vs automation	Reusability	Maintainability
Use Case	✓	✓	✗	✗	✓	✗	✗	✗	✓	✗	✓	✗
Sequence	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓

VI. CONCLUSION

Current researches indicate that VOs are set to play greater roles in bringing together both service providers and receivers. As communication technologies advances the network of virtual collaboration becomes more complex and the need for modeling languages to simplify this complexity is apparent. UML is one of the most widely used modeling languages used to simplify complex scenarios and help system designers and developers to have a common view of the end product. In this paper we have used UML Use Case and Sequence diagram notations to model a health care VO case study. We have evaluated the resulting models against a set of essential criterion for a modeling language suitable for modeling in health care sector. We have found that both diagrams need to be extended in order to represent health care scenarios completely. The result of the evaluation is summarized in table 9 which shows the areas that the model notations need to be extended.

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