# Using Reputation System in Ubiquitous Healthcare

Weiwei Yuan, Donghai Guan, Sungyoung Lee Department of Computer Engineering Kyung Hee University Suwon, Korea {weiwei, donghai, sylee}@oslab.khu.ac.kr

Abstract— The patients benefit from the ubiquitous healthcare system by accessing healthcare services ubiquitously in unfamiliar environments. However, the patients confront the problem that they usually do not have enough knowledge about the healthcare providers in these unfamiliar environments. By collecting, distributing and aggregating feedbacks of the healthcare providers' past behaviors, reputation system is therefore a method to help the patients choose reliable healthcare providers as well as help the healthcare providers build up the trustworthiness and attract more patients in unfamiliar environments. This paper contributes to analyze the importance of using reputation system in ubiquitous healthcare. We analyze the relationship of security, trust and reputation in ubiquitous healthcare in details. We also illustrate how to use reputation system on decision making by analyzing a scenario. The requirements and challenges of reputation system in ubiquitous healthcare are addressed in details based on the analysis of the scenario.

#### I. INTRODUCTION

Ubiquitous healthcare is the application of ubiquitous computing technologies for healthcare, health, and wellness management [1, 2]. Ubiquitous healthcare enables the patients to access healthcare anywhere, anytime - ubiquitously. E.g. if a tourist from New York has sudden apoplexy in Chicago, he can have reliable, accurate and rapid healthcare services just as what he used to have in his hometown with his own GP. The ubiquitous healthcare system can provide various services, such as ubiquitous emergency response or ubiquitous access to the tourist's medical data and make suitable treatments. However, there are two sides to every question. Though patients benefit from the ubiquitous healthcare system by ubiquitously accessing healthcare services in unfamiliar environment, they also confront the problem that they usually do not have enough knowledge about the healthcare providers in unacquainted environments. Since a quack may make the patient even worse, it is extraordinary important to find reliable healthcare providers. Trust is considered as the cornerstone of effective patient-physician relationships and encourages the usage of healthcare services and facilitates.

Reputation system is a way to maintain trust in ubiquitous healthcare system where patients interact with healthcare providers that (1) they might have never met, not even heard of, (2) or their own personal interaction experience is not enough to make the decision. This is achieved by the provision of information about the healthcare providers' past Heejo Lee Department of Computer Science and Engineering Korea University Seoul, Korea heejo@korea.ac.kr

performance [3], i.e. the reputation system is used to collect, distribute and aggregate feedbacks about the healthcare providers' past behaviors.

Reputation system can increase both patients' trust and healthcare providers' trustworthiness and, therefore, encourage the transactions between patients and healthcare providers. If there is no reputation system, patients could not distinguish between healthcare providers offering high or low quality of services. Hence, more and more healthcare providers offering high quality services will leave the ubiquitous healthcare system since they can not effectively attract patients. Finally there are only healthcare providers offering low quality services remain in the ubiquitous healthcare system and no patient is willing to pursuit the healthcare services in this environment.

To the best of our knowledge, no literature has systemically focused on how to use the reputation system in ubiquitous healthcare. The reason may be that to involve ubiquitous technologies in the healthcare system is still in the beginning stage and the research on reputation is very rare in ubiquitous healthcare. Our paper contributes to analyze the importance of using reputation system in ubiquitous healthcare. We analyze the relationship of security, trust and reputation in ubiquitous healthcare in details. We also give a scenario using reputation system in ubiquitous healthcare and illustrate how to use reputation system on decision making based on the analysis of the scenario. The requirements and challenges of reputation system in ubiquitous healthcare are also addressed in this paper. Finally we make a discussion on the future works.

# II. SECURITY, TRUST AND REPUTATION IN UBIQUITOUS HEALTHCARE

## A. Security and Trust

Trust is the belief or faith that one person or agent has in another person or agent with respect to certain activities at a given time [4]. Trust is needed in ubiquitous healthcare system due to the following two reasons:

Firstly, in ubiquitous healthcare system, the healthcare providers (e.g. physicians, nurses, GPs, insurance companies) are able to join the environment dynamically. It is not sufficient to authenticate these dynamically joint healthcare providers since they are foreign to the system. Consider the scenario of ubiquitous access to the medical data as an example. The ambulance paramedic needs to remotely access the patient's

Dr. Sungyoung Lee is the corresponding author.

Electronic Patient Record (EPR) to check if the patient has any contraindications. The patient is fall unable to give the ambulance paramedic permission to access his EPR. Suppose the ambulance paramedic is foreign to the ubiquitous healthcare system which is in charge of the patient's EPR. Unless it is known in advance which user is going to access the patient's EPR and what his access rights are, the traditional authentication and access control are not going to work. Trust system is suitable to deal with these kinds of scenarios since trust system is capable of deciding on the runtime whether to provide services to service requesters which are either unfamiliar with services.

Secondly, traditional security mechanisms typically protect users from anonymous intrusions, attacks, vulnerabilities etc by restricting access to only authorized users. However, information providers may act deceitfully by providing false or misleading information. Traditional security mechanisms are unable to protect against these types of threats. For example, due to economic interests, some physicians or hospitals may advocate that they are able to cure certain diseases even they do not have enough capability. Trust and reputation system can provide protection against such kinds of threats [5].

The difference between traditional security mechanism (e.g. authentication) and trust was first described in [6] as hard security and soft security separately (as shown in Fig. 1). Soft security is based on so called social control mechanisms since it is accomplished through the interactions of participants themselves rather than through some central authority when trying to know something about the participant. Hard security on the other hand provides a safe environment and secure communications for ubiquitous healthcare system based on the central authority. As one of the soft security mechanisms, trust system helps build not only patients' confidence but also a stable environment for patients and healthcare providers to carry out transactions with a reduction of risk in ubiquitous healthcare system.



Figure 1. The relationship between security and trust.

#### B. Trust and Reputation

Reputation is what is generally said or believed about a person's or thing's character or standing [7]. Reputation is closely related to trust, but there are also distinct differences. Trust system gives a score that reflects the truster's subjective view on the trustee's trustworthiness, whereas reputation

system gives the trustee's reputation score as seen by the whole community. An individual's subjective trust can be derived from a combination of (1) his Personal Interaction Experience on the transactions with the trustee, (2) and Reputation of the trutee.

We illustrate in Fig. 2 how to use trust system and reputation system on decision making in ubiquitous healthcare system. As shown in Fig. 2, when a user gives a request to ubiquitous healthcare system and want to access certain services, the decision making procedure is as follows:

- The system checks the requester's access right, i.e. using hard security mechanisms to check whether the user has enough access rights. The system gives the permission if the user's access right is enough.
- In case the service requester is foreign to ubiquitous healthcare system or does not have enough access rights to certain service, the system uses trust system, a kind of soft security mechanisms based on social control mechanisms, to make the decision. The trust system first uses the truster's own personal interaction experience on decision making. The truster allows the service requester to access the service if the truster has good personal interaction experience on the trustee.
- In case the truster does not have any personal interaction experience with the trustee or the interaction experience on the transactions between the truster and trustee is not satisfiable enough, the trust system involves reputation system. Reputation and truster's personal interaction experience (if any) are used simultaneously on decision making in this case. Personal interaction experience usually carries more weight than reputation. But in the absence of personal interaction experience, which is always the case in ubiquitous healthcare, trust often has to be based on ratings from others. Reputation is the collective measure of trustworthiness based on the ratings from members in a community.



Figure 2. The relationship between trust and reputation

#### III. REPUTATION SYSTEM IN UBIQUITOUS HEALTHCARE

#### A. A Scenario using Reputation System in Ubiquitous Healthcare

Fig. 3 gives a scenario using reputation system in ubiquitous healthcare system. The user, Bob, is tying to find a physician to cure the pain in his shoulder. He does not have any knowledge about the local physicians since he is a visitor to the city. He uses his cell phone to get in touch with the local ubiquitous healthcare system. In his requests, Bob gives the keyword "shoulder". The ubiquitous healthcare system detects Bob's location according to his cell phone and lists the physicians who are related to the given keyword around Bob's location. Along with the list, the system also gives the reputation of each listed physician. The reputation of each physician is calculated by the ratings given by the physician's previous patients. After the transaction with the physician, each patient is requested to give his rating on the physician. The ubiquitous healthcare system collects the ratings given by all the previous patients and calculates the reputation of each physician. When giving the rating, the patients are also encouraged to give text description about the physician and the transactions. Later on, the following users, e.g. Bob, can have further understandings about the physician by reading the text descriptions. With the help of the reputation, it is relatively easy for Bob to find a reliable physician. Bob can then make an appointment by his cell phone and the ubiquitous healthcare system will give information on how to contact the chosen physician in details.



Figure 3. A scenario using reputation system in ubiquitous healthcare.

#### *B.* Requirements of Reputation System in Ubiquitous Healthcare

A desirable reputation system in ubiquitous healthcare system should meet the following requirements:

• Ratings given by previous patients should be captured, distributed and visible in the future. This depends on the protocol with which ratings are provided, and this

is usually not a problem for centralized systems, but represents a major challenge for distributed systems [6]. This also depends on the willingness of raters to provide ratings, for which there must be some form of incentive.

- Ratings about the previous transactions must have influence on the current and future transactions. At the same time, adding any single rating should not influence the reputation significantly. This depends on the usability of reputation system and how people and systems respond to it.
- The reputation system should be capable of distinguishing between a new healthcare provider of unknown quality and a healthcare provider with poor long-term performance.
- It should be impossible or difficult for the healthcare provider to change his identity for the purpose of erasing his past behavior.
- The reputation system should realize and reflect recent trends in healthcare provider's performance. For example, a healthcare provider that has acted well for a long time but suddenly goes downhill should be quickly recognized as untrustworthy.

## C. Changellges of Reputation System in Ubiquitous Healthcare

The reputation system faces several challenges in ubiquitous healthcare as mentioned in the following aspects.

#### 1) Unfair Ratings.

In the large-scale, open, dynamic and distributed ubiquitous healthcare environments, there may possibly exist numerous self-interested raters who give unfair ratings to maximize their own gains (perhaps at the cost of others). Therefore, finding ways to avoid or reduce the influence of unfair positive or negative ratings is a fundamental problem in reputation systems.

For the reputation system in ubiquitous healthcare, the possible scenarios for the ratings given by raters are as follows:

- a) Normal Ratings
- Honest raters give honest ratings.
- b) Abnormal Ratings
- Honest raters give inaccurate ratings due to their incorrect observations.
- Honest raters give exceptional ratings compared with ratings given by other raters due to the changing behaviors of healthcare providers in front of different raters.
- Raters give random ratings at ease due to the lack of responsibility to the environments.
- c) Malicious Ratings.
- Raters who acted honest give unfair high or low ratings individually. The past behaviors of these raters were

always honest. However, they suddenly give unfair ratings due to the relationship with the healthcare providers or their own benefits.

- Raters who acted malicious give unfair high or low ratings individually. Different from scenario e, raters in this case always gave malicious ratings in the past.
- A number of raters who acted honest collude to give unfair ratings (more than 50% of total ratings), which causes the flooding of unfair ratings.
- Unfair ratings flooding similar as scenario g, but caused by raters whose past behaviors were always malicious.

#### 2) Free Riders

It is essential for the reputation system to overcome the free riding behavior. Users who attempt to benefit from the resources of others without offering their own resources in exchange are termed "free-riders" [8]. For reputation system in ubiquitous healthcare, "free-riders" refer to those who do not give ratings after the transactions with the healthcare providers. The problem of free rider is caused because there is always no direct incentive for the patients to provide ratings after the transactions. Free ride is a common problem for reputation system in different environments, e.g. e-business. It was found that only about half of the traders in e-business reputation system provide ratings. In particular, Resnick & Zeckhauser (2002) found that 60.7% of the buyers and 51.7% of the sellers on eBay provided ratings about each other.

3) Lack of Negative Ratings

The researches on reputation system in e-business showed that it was hardly to observe any negative ratings, around 1 percent. In particular, it was found that only 0.6% of all the ratings provided by buyers and only 1.6% of all the ratings provided by sellers in eBay were negative, which seems too low to reflect reality. The proportion of negative ratings may even be much less in ubiquitous healthcare system because of the speciality of the services provided by ratees.

The reasons why there is lack of negative ratings may lie in three aspects: (1) courtesy. E.g. some patients may withhold the negative ratings because they are nice, (2) reciprocal behavior. E.g. the patients will get better healthcare services in turn next time by the rated healthcare provider if they give positive ratings, (3) be afraid of retaliation. E.g. the patients is afraid of getting worse healthcare services next time by the rated healthcare provider if they give negative ratings.

# 4) Changing Behaviors

The problem of changing behaviors may appear both on the rater side (the patient) and the ratee side (the healthcare provider). On one hand, the healthcare providers may for example provide good services to all except some small number of patients. Or healthcare providers provide high quality of services on some trivial aspects in order to get high reputation, but provide low quality of services on crucial aspects. E.g. a pharmacy provides high quality of bandage to gain high reputation, but it provides low quality of eye preparations. On the other hand, the raters may also give fair ratings to all except some small number of healthcare providers because of their personal interests.

# 5) Changing Identity

As mentioned in previous section, it is requested that the identity of the healthcare provider should be impossible or difficult to change. In case a healthcare provider has suffered significant loss of reputation it might be in his great interest to change identity in order to cut with the past and start from fresh. However, even though ubiquitous technologies enable the healthcare providers join the healthcare system dynamically, changing identity is not in the general interests of the community and should be prevented or discouraged.

## IV. CONCLUSTIONS AND FUTURE WORK

The concept of reputation differs from trust that reputation reflects the view of the whole environments on the trustee's trustworthiness and trust reflects the truster's own view on trustee's trustworthiness. We introduce in this paper the importance of reputation system in ubiquitous healthcare. By collecting, distributing and aggregating feedback about the healthcare providers' past behaviors, reputation system helps the patient choose reliable healthcare providers as well as helps the healthcare provider build up the trustworthiness and attract more patients in unfamiliar environments. The reputation system in ubiquitous healthcare face with several challenges: (1) Unfair Ratings, (2) Free Riders, (3) Lack of Negative Ratings, (4) Changing Behaviors, (5) and Changing Identity. Among all the challenges, the problems of Unfair Ratings are probably the hardest to solve in any reputation system since it is based on the subjective ratings from ratees and each ratee may have different understandings on the same transaction or healthcare provider. Lack of Negative Ratings is another fundamental problem since there is often is no rational reason to provide ratings.

We plan to focus on more details on the reputation system used in ubiquitous healthcare in the future, such as to solve the problem of Lack of Negative Ratings. An obvious method is to protect the rater's privacy and provide anonymous reviews. Though the research on reputation system in ubiquitous healthcare is still in the beginning stage, we do believe that the usage of reputation system in ubiquitous healthcare presents a promising path for the future research.

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