

Conceptual Modeling of the Healthcare Ecosystem

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Abstract. New paradigms are needed for a more natural model of the healthcare process in order to reduce the semantic gap between its representation and implementation. Starting from a patient-centric perspective and a digital ecosystem framework we develop a conceptual model of the healthcare ecosystem to lay a sound foundation and a common vocabulary for emerging e-health initiatives.

Keywords. Digital ecosystem, conceptual model, virtualization

1. Introduction

Numerous studies prompted the need for a greater role played by information technology in healthcare, its adoption transcending from the academic domain to the policy decision factors, both national and international.

To understand and model healthcare information systems, we need to apply different paradigms, able to capture a more realistic view, bridging the gap between the model and the system that needs modeling. Based on the digital ecosystem paradigm [1] this paper proposes a more natural and expressive model which better captures the complexities of the two complementary views in the healthcare context: a patient-centric view [2] to support an integrated, longitudinal digitalization of the health state of the patient and a healthcare process view to represent the healthcare seen as a business process.

2. Method

2.1. Modeling the health state

We need a comprehensive, uniform view on the healthcare process and on the definition of the patient's health state. The concepts and relations we define will be used as a reference model inside our envisioned digital healthcare ecosystem. In developing our model we have adapted and integrated concepts from Health Level 7 [3] but also from European initiatives in continuity of care such as CONTSYS [4].

By "digital health state" we define the reflection in our digital world of the "real" situation of the health of the patient, a digital representation of it. For us the health state concept is an ideal, because, first, we do not know all information needed to describe the real situation of the health state of a patient, and, second, we can never have a

perfect matching between the “real” situation of the health of a patient and the digitally represented health state. However we like to know as much as possible about it by multiplying the observations because often changes in the health state manifest in an observable way. We define “health condition” as the perceived part of the health state, manifested by symptoms, laboratory analyses and any other objective or subjective observation. We name “health issue” a general medical problem such as asthma.

2.2. Digital Ecosystems

The digital ecosystem approach integrates and uses the concepts of a given natural domain to the digital world, reproducing or interpreting some of the mechanisms of natural ecosystems [5]. It is a self-organizing digital infrastructure aimed at creating a digital environment for networked organizations that supports the cooperation, the knowledge sharing, the development of open and adaptive technologies and evolutionary business models.

The stakeholders are represented in the digital ecosystem as “avatars”, virtual entities able to interact in the digital environment but aiming towards realizing the objective of the stakeholder. In fact this “digitalization” is a complex process in which we must decide what defines the identity and purposes of a stakeholder in order to formalize them in a computable way. We model our avatars so that they reflect those concerns relevant from the healthcare point of view.

The tools the stakeholder uses to achieve his/her goals in the real world are also represented as *digital species* which can evolve, become extinct or recombine in new compositions, offering new services. An avatar is only a type of digital species. Other digital species can exist in the ecosystem. In our envisioned DHE the digital species are not only the representations of the stakeholders in the virtual world, but all the interrelated, interconnected medical devices and clinical software applications such as clinical decision systems, electronic medical records, imaging software, billing software etc. For instance the software applications the stakeholders use or organizations the stakeholders belong to can be represented by digital species in the ecosystem.

We would like to apply the digital ecosystem paradigm in healthcare with an added goal, having the patient at the center of our concerns. By modeling and implementing a *digital healthcare ecosystem* (DHE) we can expose the underlying business processes, allow new operators to enter the healthcare market, increase the semantic and organizational interoperability in this new digital landscape, in the end raising the quality and quantity of the available services to the patient.

3. Results

According our approach two worlds will show up in the health system: one real and another virtual. The real world is reflected in the DHE in the activities, knowledge, goals and organization of the digital species. Changes with relevant medical significance in the real world, for instance a Medical Act due to a caregiver, may bring changes of situation in the DHE. The occurrence of a new situation in the environment may determine digital species to act, that is to modify their environment. Such an activity in our case, itself a Medical Act, is generated by an observation of a condition found in the health of the patient or a lack of knowledge of her/his health state. The

change produced in the DHE will in turn change the knowledge of the real world and will favor some other activities to be executed by the DHE agents.

In our approach changes in the health state of the patient are clinical events that arrive through information flows inside the digital ecosystem and can change the state of the patient's avatar. Reacting to this change in the environment, avatars representing different healthcare providers may converge to create an ad-hoc multidisciplinary team, its structure and objectives being inferred by the care goal solving process. Fig. 1 shows the relation between the two worlds, real and virtual, and how they interact.

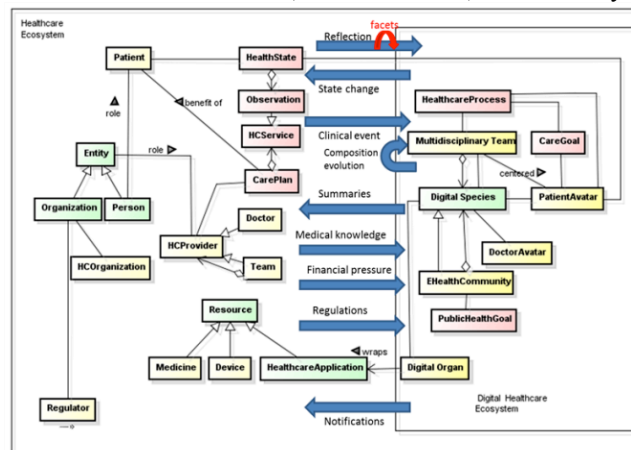


Figure 1. Reflection of the real in the digital world

As the figure shows, the DHE is influenced by the (natural) healthcare ecosystem and in its turn influences the healthcare ecosystem by informational exchanges.

4. Discussion

The changing healthcare industry needs new paradigms and innovation of its core business processes. By promoting a common vocabulary not just of medical concepts but also of medical processes and organizations we foster reuse and seamless integration between medical software systems, seen as self-contained entities in a digital environment.

The contamination of the real to the virtual in analyzing the digital healthcare ecosystems will generate in time a reflection of the virtual in the real, when solutions and resources discovered in the digital world will make their impact in the real world.

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