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A thought on the goals and realization of pervasive healthcare

Yuan Zhang¹,²*, Zhongtian Jia¹ and Yuehui Chen¹

¹Shandong Provincial Key Laboratory of Network Based Intelligent Computing, Jinan, 250022, China.
²Shandong University, Jinan, 250061, China.

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Although the advancement of previous pervasive healthcare schemes has demonstrated clever technical ingenuity and their effectiveness in certain scenarios, fundamental design philosophy still lacks a satisfying answer. In this paper, we summarize the characteristics of future pervasive healthcare as availability, transparency, awareness and trustworthiness, which should be the keys to its elegance and power. Innovations in traditional healthcare delivery systems, including human-centric technical design, user active self-care, physician support and leadership, safe and concurrent data management are brought forth accordingly. The art of success lies in an incorporated strength of several aspects, among which technology serves as a platform for further cooperation. The paper thus analyzes the way leading to this promising paradigm.

Key words: Pervasive healthcare, availability, transparency, awareness, trustworthiness, integrated strength.

INTRODUCTION

The current performance of clinic-focused healthcare is facing changed social and economic circumstances. One of these trends all over the world has been the continuous elderly population increase, resulting in an ever growing proportion of healthcare dollars supporting chronic diseases (Cutler et al., 2006). An equally important force to the rising healthcare costs is the recognition of improving their quality of daily life for the chronically ill people and the elders (Dorr et al., 2007). With the socio-economic changes in the context of a public healthcare system. However, people often experience their healthcare as fragmented, episodic, and not matched to their expectations (Brantes et al., 2009).

This situation requires a radical re-examination of how to transform the health delivery system from reactive status to a proactive approach. Combining this observation with the opportunities afforded by wireless networking and information communication technology (Streitz, 2005), pervasive healthcare (PHC) should reach beyond simply remote monitoring devices and services to offer telemedicine at home (Pau et al., 2009; Eric et al., 2010), but should examine a broader agenda. Although significant progress has been made over the past few years, the effectiveness of PHC does not represent so remarkably thus far. One of the main reasons consists in the lack of fundamental design philosophy. This article provides insight into the objectives of future PHC, and analyzes the combined forces to implement it.

METHODS

The so-called PHC applications open up new possibilities for supporting real-time monitoring, diagnosis and treatment, by bridging temporal and spatial gaps between patients and physicians. Although the designs of the previous schemes have demonstrated clever engineering ingenuity and their effectiveness in certain settings, critical theoretical foundation is still in its early stage of development.

Many fundamental questions lack a satisfying answer. For instance, what are the ultimate goals of future PHC and how do we prepare for it? How should the technical professionals design the healthcare system to facilitate users’ perception and willingness to use a technology? This work is an exploratory study, with the aim of determining factors that lead to successful IT technology based healthcare. The two steps of the methodology are:

(i) Proposing PHC goals from our healthcare project experience

*Corresponding author. E-mail: yzhang@ujn.edu.cn.
and the existing literature; (ii) Analyzing manageable strategies to implement PHC.

RESULTS

The most human-centric healthcare designs are those that weave themselves into the fabric of everyday life, until we are unconscious of them. In a PHC service, we can expect the four goals of ubiquity as 1) availability, 2) transparency, 3) awareness and 4) trustworthiness; which highlight this bright paradigm (Figure 1). A PHC should be available anywhere and anytime, which is ‘availability’. This remarkable feature of always being on means real-time response. A PHC consumer (not only patient) will send out appropriate physiological and behavioral data from embedded, intelligent and networked devices in a sentient and ambient manner, and expect instantaneous receipt of medical information and relevant expertise. This implies an updated methodology of moving ‘from managing illness to maintaining wellness’. Prevention is always better than cure. Imagine an everlasting service session under any connection with any device, or seamlessness (Beshears et al., 2005), it will highly alleviate the present healthcare problems caused by being reactive in nature.

The components of PHC should not intrude on the user’s consciousness but hide the underlying technologies from him, which implies ‘transparency’. It is not the device but an environment. The user can thus concentrate on the task at hand. It rightly outperforms one of the ongoing research fields of building wearable health monitoring facilities that utilizes emerging wireless body area networks (Li et al., 2008; Hanson et al., 2009). Instead of carrying a device with you wherever you go (Łukowicz, 2008; Bächlin et al., 2010), a device (normally a wireless sensor) is available wherever you are in need. The ultimate goal is that, the system will recognize the user wherever he or she logs on, on any network, with any equipment, at any time, with the applications in a given state and have them adapt in the best possible way given these surrounding conditions. It is a comprehensive intelligent environment rather than a collection of services supplied by individual devices (Koch et al., 2009; Cook et al., 2009). Such service is therefore TPO (time, place, and occasion) based, well satisfying the consumer demand. A user’s context can be quite rich, consisting of attributes such as physical location, physiological state (e.g. body temperature and heart rate), emotional state, personal history, daily behavioral patterns, and so on. A key challenge is to obtain the information needed to function with regard to the rich and time-varying context parameters (Rick and John, 2004). Unless carefully designed, a proactive system can annoy a user and thus defeat the objective of invisibility. Self-tuning can be an important tool in this effort. Ubiquitous devices should extend the human senses by providing adaptive ‘awareness’ of the surrounding environment, through which we set up mutual realization between the user-context and the service-feedback.

As computing and network increasingly pervade the everyday life they bring significant safety challenges simultaneously in the deployment of technologies for healthcare services (Streitz and Nixon, 2005). By nature, any processes in the healthcare system involve coordination of a heterogeneous set of professionals, patients, organizations and sectors; which deal with sensitive medical data, and should be dynamically adapt to inevitable evolutional treatment (Deng et al., 2009). A companying goal of PHC is to address these issues in a strategic and interdisciplinary effort aimed at ‘trustworthiness’. For instance, protection of the users’ identities and medical information from non-authorized parties is a matter of both technical access control and physician self-discipline (Rohm and Milne, 2004). Unfortunately, wireless has long presented operators of networks with much more security vulnerabilities compared to traditional wired networks (John, 2003; Arbaugh, 2003).

DISCUSSION

While PHC systems bear the potential to provide users with a new quality of medical care, the complexity of such systems raised fundamental questions of technology, cognitive and cost acceptance. Much skepticism has surged forth about the proliferation and diffusion of PHC. This is primarily caused by fear of change, resistance from healthcare professionals, user concerns over privacy and security issues, competing interests among innovations for venture capitalists and funding sources, and continuing political uncertainties. How do we nurture and renew our spirits through opportunities to actualize this public dream? In our opinion, it will mature with an integrated strength of individual self-care, technology development, healthcare enterprises’ participance,
practitioner's passion and authority support. Among these pieces, technology serves as a platform for further cooperation. Radio frequency identification (RFID) systems and wireless sensor networks (WSN) are emerging as the most significant technologies in PHC, due to their important advantages and their diverse application areas (Liu et al., 2008; Alemdar et al., 2010; Loa et al., 2011).

Although their evolution has followed separate research and development paths, the integration of RFID and WSN can fully contribute to PHC utility by complimenting each other. A networked wireless sensor normally senses objects by their physical, chemical or biological properties, without which an object (person) becomes difficult to be identified. By applying RFID to WSN, any RFID-tagged object can be easily sensed, opening a door to seamless human-environment interaction. Besides specific information communication technologies, 'understanding human values' is a key factor for technical professionals in creating any successful PHC application. Always design healthcare systems with care, keeping in mind both users and other stakeholders. It is already PHC at the very start, reducing resistance to new technology by users and healthcare and social-care professionals (Little et al., 2008).

However, the user-centered design for PHC faces additional problems when involving non-typical users because they have diverse backgrounds, skills, living conditions, abilities, needs and desires. Relying only on experienced and technology-prone user groups, which might have been typical users in the past decade, is not sufficient anymore. There is a major necessity to understand in which way physical, emotional and cognitive abilities may impact the usage and acceptance of PHC technologies. Future customer rigid demand is what the prevailing motivation for PHC research and development. Today our most severe healthcare problems involve chronic diseases, suicide, drug abuse, and genetic disorders. New discoveries in basic science confirm what many have known intuitively: there is often close relation between physical and mental phenomena. The aforementioned healthcare problems have a significant emotional and behavioral component, and we need to combine in our design the physical and mental elements of healthcare delivery by the pervasive environment. It is what we call 'dual cultivation of both body and mind'.

Since the days of Hippocrates, the relationship between patients and physicians has been close and personal. In most cases, it is by consulting in person, can the physician dispense treatment. PHC infrastructure and interfaces will offer convenient mechanisms for transmitting medical and clinical knowledge to residents, non-experts, and healthcare workers, encouraging innovations in non-tethered medical interventions. The ambient mode indicates a focus on preventive measures, and a greater emphasis on 'self-care'. It makes PHC new

wine in a new bottle. Users are encouraged to actively participate in their own care, rather than a passive reception. From the standpoint of doctors, however, early study has shown that, providing the high quality preventive care tasks for patients would add approximately 7.4 h to the already busy day (Yarnall et al., 2003). It should be reasonable to implement hierarchical management strategy that makes good use of community resources, and to train specialist for specific healthcare consultation.

Self-care is a fundamental consequence not only of technology, but also of human psychology. One example of the many successful programs envisioned is that of using or continuously monitoring data in relation to chronic illness. In a longer perspective it will support the doctors in making more accurate assessments and giving advice to patients, allowing the patient to become a more energetic part of his or her own treatment by subtly changing the life styles or daily routines. As a result, physical health as well as quality life can be gained through such painless, transparent, and far less costly means of daily self-care (Arnich et al., 2010). The patient-physician relationship is an integrative form characterized by reciprocal rights and responsibilities. Compared to patient visits, currently many doctors deem that they cannot guarantee the safety and accuracy of diagnosis, and are not able to provide hands-on quality medical services accordingly, through the remote treatment system. It is commonly believed that if something goes wrong, doctors will be held responsible for it. How to ameliorate this situation? On one hand, technologies such as inexpensive, interactive web-based videoconferencing and remote vital sign detection will diminish the difference between physical and virtual consultation. On the other hand, creating a "culture of safety" contributes greatly to the effectiveness of patient safety (Shortell and Singer, 2008).

In the healthcare industry, forward-looking corporations all wish to stake out a niche in the billion-dollar PHC marketplace, leading to a chaos of coexistence of too many incompatible standards and different platforms. However, desirable it might be in other markets, the atomistic competition that economists set, as the ideal market structure for producing and distributing most goods and services is far from ideal for healthcare. The lack of standards or at least a coalescing consensus on standards, can be detrimental to building PHC infrastructures for rapid transmission of PHC products and services. Due to the diversity of PHC application scenarios (Hayes et al., 2007; Giani et al., 2008; Curtis et al., 2008; Kim et al., 2008; Morris and Guilak, 2009; Lee et al., 2009), it is unlikely to establish a unified protocol suite or standard set, especially with regard to the bottom two layers, by traditional international institutions such as ITU-T (International Telecommunication Union - Telecommunication Standardization Sector), IETF (Institute of Electrical and Electronics Engineers), IETF
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