Chapter 1
The mHealth Stack: Technology Enablers for Patient-Centric Mobile Healthcare

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ABSTRACT

Applications accessible through mobile devices, such as mobile phones, are playing an increasingly important part in the delivery of high quality and personalized healthcare services. In this paper, we examine current usage of mobile devices and networks by mobile healthcare applications, and present our views on how mobile devices and networks could be used for creating patient-centered healthcare applications. The patient-centered healthcare paradigm allows for increased quality of care and quality of life for patients while increasing personal freedom to move about and be always connected to care-givers and healthcare services. The structure of our discussion is analogous to layered protocol stack in communications, progressing from the network and radio technologies, servicing middleware, cloud services, health sensors, mobile smartphones, and applications. All these layers come into play to support future mobile healthcare services.

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INTRODUCTION

It is widely recognized that major changes are required for the healthcare system worldwide. Health expenditures are rising; the US expenditure on healthcare was 15% of GDP 2006, 11% in France and Germany, 10% in Canada, and 8% in the United Kingdom and Japan (OECD, 2008). At the same time, quality of care, clinical outcomes, and patient satisfaction are on the decline.

In the United States, Americans are dissatisfied with their healthcare system (Schoen et al., 2007) and the productive efficiency of US healthcare has been found to be inferior to other countries—on a per capita basis, the US healthcare system delivers less in quality-adjusted health than Canada or France, for example (Garber et al., 2008). In response, major stakeholders have proposed comprehensive solutions to these problems. A coalition of employers, primary care societies, health plans, and patient groups known as the Patient-Centered Primary Care Collaborative (PCPCC) supports a model of care delivery called the "Patient-Centered Medical Home" (PCMH) as a solution. The PCMH is a care system in which patients have a single point of entry (their "medical home") that provides continuous and coordinated care to help patients navigate the disparate elements of the medical system.

While there is high-level consensus about the definition of patient-centered care and a vision of what it would look like, the specific attributes of primary care practices and patient services that enable this vision are not as well-defined. Davis (Davis et al., 2005) has proposed a set of key characteristics of "patient-centered" care to stimulate discussion, including:

1. Ongoing, routine patient feedback to a medical practice;
2. Integrated information transfer across a team of providers;
3. High care availability, efficient use of doctor/patient time;
4. Information systems that support high-quality care;
5. Increasing the patient's engagement in care.

This paper focuses on the technology of mobile devices and networks, their current use for mobile healthcare applications, and how they might be used for creating applications supporting the attributes of patient-centered healthcare outlined above. The structure of our discussion is analogous to the layered protocol stack in communications; progressing from mobile devices and associated sensors at the bottom layer, to the networks, middleware, cloud services and applications at successively higher layers that enable current and future mobile healthcare services. As we will discuss, we believe that mobile technologies have a unique and powerful role to play in the delivery of patient-centered healthcare, not simply because they are a popular and convenient form of information and communication technology (ICT) delivery, but because they offer unique characteristics not possible in other forms of ICT.

MOBILE HEALTH VISION

This section outlines on overarching vision of mobile health, i.e., the delivery of healthcare applications over mobile devices. The vision serves as a use case for this paper and paints a picture of what mobile patient-centered healthcare may look like in the future. Some of the technologies and capabilities described are already available today but, on the whole, the use case is forward looking and aims to drive an interesting discussion rather than reflect all possible minutiae of mobile health transmission standards and services.

Figure 1 represents a high-level mobile health use case. Some of the key aspects of this use case are:

- Health sensors
- Mobile patients