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Cell Phones and Tele-Medicine

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***Abstract* - The growing power and sophistication of cellular phones and Personal Digital Assistants (PDAs) make those devices increasingly feasible platforms for mobile tele-health applications, including telemedicine. These mobile telemedicine solutions can offer remote monitoring services to patients on the go, increasing their independence with potentially better outcomes. A proposal for a cellphone-based mobile telemedicine system is outlined herein, as well as specific recommendations to accelerate the wide deployment of mobile telemedicine solutions.**

I. INTRODUCTION

The growing power and sophistication of both cellular phones and Personal Digital Assistants (PDAs) presents a unique opportunity to view them as Mobile Computing and Communication Devices (MCCDs). Moore's Law is now applicable to MCCDs: CPU power and RAM capabilities are increasing rapidly. MCCDs can now run an increasingly sophisticated range of software applications, using an expanding range of operating systems such as Windows CE, GNU/Linux, and Palm OS. Bandwidth is also increasing rapidly, allowing MCCDs to transfer most of the processing-intensive tasks (such as visual recognition and database storage and retrieval) to remote servers that reduce demands on the local device. Battery life is the only area where the rate of improvement has been significantly slow. Some recent MCCDs are starting to push the boundary of what a traditional cellular phone or PDA was originally intended to do. Late-model MCCDs include cameras (both for still photography as well as video-capable); MP3 players; expansion slots (for additional memory and storage space); and other Personal Computer-level devices, extensions and attachments.

This paper outlines the significant opportunity that exists to use those inexpensive, mass-produced and very powerful MCCDs to serve as building blocks for affordable, standards-compliant mobile telemedicine solutions that could be useful to both patients and payers that can not afford the currently available traditional telemedicine systems.

Section II outlines the market opportunity for telemedicine in developed countries. Section III presents an overview of why mobile solutions are desirable in the telemedicine market. Section IV outlines some of the challenges of deploying telemedicine solutions. Section V offers details of how a MCCD-based mobile telemedicine solution might look like. Section VI concludes with a call for further research as well as more active standardization and harmonization efforts.

II. THE MARKET OPPORTUNITY FOR TELEMEDICINE

The health care systems in all developed countries face an economic tsunami in the next few decades due to the convergence of three dramatic forces.

a) Demographic changes:

A significant percentage of the population of developed countries will be over the age of 60 by 2050. According to data from the United Nations (UN) in [1], by 2050 Japan will have 42.4% of its population in the 60 and above age range. Spain, 40.9 %. And the USA, 25.5%.

This demographic shift will put tremendous pressure on developed countries' health care systems due to two inter-related factors:

- A diminishing number of working adults contributing to the health care funds
- An increasing number of older citizens demanding health care benefits

In some developed countries there will be as many people over 60 as working-age adults in the next few decades.[1] [2] reports that the ratio of elderly adults aged 60 and over to working-age adults aged 15–59 will go from 0.39 in 2000 to 1.00 in 2040 in Japan. In Spain, the ratio will go from 0.35 to 0.99 in the same period. In the USA, the ratio will go from 0.26 in 2000 to 0.47 by 2040.

b) Growing health care costs:

Developed countries already spend some of the highest percentages of Gross Domestic Product (GDP) in health care in the world. The USA spends over 13% of GDP in health care costs, and is increasing at a rate in excess of 10% per year.

c) Increased life expectancy:

Not only are there larger numbers of older adults in developed countries, demanding more health care services, but those older adults are also living longer. According to [1] the life expectancy at birth (both sexes combined) in Japan will go from 80.5 to 88.1 years. In Spain, from 78.4 to 84.1 years. In the USA, from 76.2 to 81.6 years. Therefore those large numbers of elderly adults living longer will consume health care services for far more years than their average predecessor in earlier generations ever did.

Mobile telemedicine solutions could be used as healthcare cost-containment mechanisms. Given the impact of the above

[1] http://www.watsonwyatt.com/research/resrender.asp?id=W-637&page=1

economic factors in the overall national budgets of the member states, mobile telemedicine presents itself as a potentially good opportunity to deliver better health-related services at lower costs while increasing patients' ability to remain independent and able to continue their daily activities outside their residence. For older adults, mobile telemedicine solutions could enhance their ability to stay at home ("aging in place").

Mobile telemedicine solutions are ideally suited for patients with chronic diseases, such as: diabetes; heart condition; chronic heart failure; asthma; etc. MCCDs used as mobile telemedicine platforms could potentially help to increase the patient's compliance with a personalized disease management program. Specialists estimate, for example, that more than half of all hospital admissions and sick days linked to asthma and about half of the major complications linked to diabetes (such as amputations, blindness, and stroke) could be avoided with better monitoring and care. One German study showed that medical costs for a diabetic who didn't suffer complications came to around €2,000 ($1,760) a year, while annual medical costs when complications developed exceeded €5,000.[2]

III. WHY MOBILE TELEMEDICINE SOLUTIONS?

In the past, the doctor used to come to the patient's home. Currently, the patient needs to go to the doctor's office. With mobile telemedicine, data off the patient's body can go to the doctor, transparently. The patient's doctor can also have visibility into the patient's body, and be able to proactively respond to the patient's dynamic biological signs.

Many of the currently available telemedicine systems are restricted to the monitoring of patients within their home. As effective as those solutions might be, they do not provide a satisfactory quality of life as the patient's home may act as a "virtual prison" that the patient does not feel comfortable to leave. In addition, home-centric solutions may not provide the greatest possible financial savings for care providers as the patient may need to be escorted when outside the home and require all provisions and services to be delivered there.[3]

MCCDs are one of the few electronic devices that are very close to, or on, a person's body during most of the day. These devices can then be used to bridge on-the-body medical sensors with remote monitoring systems to give caregivers (and patients themselves) peace of mind through an active monitoring of the patient's vital signs.

Given the wide deployment of both mobile phones and PDAs, MCCDs become an ideal platform for providing telemedicine services to an increasingly mobile (yet aging) population. Furthermore, these mobile telemedicine systems can also enable the patients to take more responsibility to manage their own wellness and health.

MCCDs have features that make them uniquely suitable for telemedicine applications. MCCDs are:

- **Discreet** high-tech consumer electronic products that do not draw attention to the wearer's physical condition. Nobody would need to know when an individual is using her MCCD as a mobile telemedicine device.
- **Powerful** enough to replace the functionality of multiple dedicated units with a single, powerful multi-purpose device.
- **Comfortable** to wear for extended periods of time, without restricting the individual's movements.
- **Constant** sources of real-time feedback to physician, case manager or care giver. (Neither them nor the patient herself want to know after the fact that there was an irregularity with their heart because the data had to be manually uploaded to the doctor via a phone line or some other means.)
- **Automated** sources of readings of vitals, as some patients do not want to have to self-administer readings. Or to reduce patient-induced transcription errors when registering the readings off sensors.
- **Portable** enough to allow an individual to have its body being monitoring with no restrictions on time, location or schedules.

MCCDs can open the door to integrated wellness, healthcare and fitness systems under a pervasive, mobile data-intensive healthcare infrastructure (or "Medisphere") that goes with the patient throughout the day and night. This Medisphere is envisioned as the extension of healthcare services and infrastructure beyond the physical facilities of healthcare providers. Mobile telemedicine solutions allow service providers to push their facilities out into the community, erasing all distinctions between "residents" and "home-bound" patients. Literally every body can be a mobile telemedicine user with different levels of access based on the particular needs of each patient. These remote services can allow healthcare providers to earn additional revenue without the added cost of expensive buildings or equipment.

Mobile telemedicine solutions using MCCDs can easily leverage the extensive and fairly reliable wireless mobile communication networks already available across the world. Most of those networks offer Internet Protocol (IP)-based data transmission capabilities, and some wireless operators have deployed high-bandwidth networks.

These wireless networks have extensive security, billing, authentication and provisioning mechanisms already in place that could be extended to facilitate the massive deployment of mobile telemedicine solutions. Wireless networks allow for the inter-operability ("roaming") of visiting customers, and their devices, into foreign networks. Some forward-looking wireless carriers are already looking to open their networks to the deployment of mobile telemedicine solutions as a tremendous growth opportunity.

[2] http://www.mckinseyquarterly.com/article_print.asp?ar=1118&L2=12&L3=.

[3] Paraphrased from Francisco Del Pozo, e-mail message.

It is important to note that the high penetration rate of cell phones (and their easy interoperability across different operators' networks) is due in large part to the use of open industry standards (like the Global Standard for Mobile communication, GSM) for the building of those wireless networks.

IV. Challenges to deploying telemedicine

Telemedicine is over thirty years old as an industry. Starting with the pioneering efforts of the National Aeronautics and Space Administration (NASA). NASA's efforts in telemedicine began in the early 1960s when humans began flying in space. Physiological parameters were telemetered from both the spacecraft and the space suits during missions. These early efforts and the enhancement in communications satellites fostered the development of telemedicine and many of the medical devices in the delivery of health care today.[4]

There have been many projects in the last 30 years (both at the academic as well as commercial level) utilizing telemedicine systems in both the US and abroad. Please see [3] for a retrospective bibliography with 1634 citations about telemedicine.[5]

And yet, in spite of its demonstrated economic and improved outcomes, telemedicine solutions have not been widely deployed. Not to the extent that their potential to improve patient outcomes and reduce costs would indicate. The author is of the opinion that the biggest challenges to the massive deployment of telemedicine systems are not necessarily technology-related issues. Rather, the outstanding issues are, in no particular order:

- **Proprietary, incompatible systems**. Most currently available telemedicine systems are vendor-specific and do not fully inter-operate with products from other vendors.
- **Limited variety of solutions.** There is a limited availability of solutions for various degrees of user requirements. Imagine that all potential beneficiaries of telemedicine systems are represented in a pyramid, with the most severe cases at the top of the pyramid. A large number of telemedicine vendors offer high-end solutions for the sickest patients, at the top of our imaginary pyramid, at very high price points. There seems to be a limited number of offerings for patients in the middle and bottom of our imaginary telemedicine pyramid, in terms of illness severity. Even though the largest numbers of potential beneficiaries of telemedicine solutions are located in the middle and bottom of the pyramid.
- **Overall business model** for telemedicine seems to be still in flux. Specifically: who should pay for the deployment of these systems? Should insurance companies cover the cost of telemedicine solutions? What are the revenue opportunities for all the players in the value chain?
- **Proven, compelling ROI.** Have past telemedicine demonstration projects clearly shown an ROI? It is not clear if there have been enough large-scale demonstration projects to validate the economic model for large telemedicine deployments.
- **Solid commercialization plan**: how to effectively deploy hundreds of thousands of telemedicine systems in a robust, secure and scalable manner? While addressing user support, training, and documentation needs.
- **Legal issues**, such as the rendering of medical advise across state (and even national) borders. This issue is related to medical practice licenses being usually geography-constrained, even down to the state level (in the case of the USA). Additional items are: the lack of harmonization of laws affecting telemedicine across state and national borders, and unclear liability boundaries.

There are many groups that have addressed (and continue to work on) some of the above issues. ISO has worked on a "Health informatics – Interoperability of telehealth systems and networks" document.[6] The American Telemedicine Association[7] has several Working Groups looking into the issues. The International Telecommunications Union (ITU) has also conducted workshops to define standards in e-health and telemedicine.[8] In 1999 the International Bar Association (IBA), Section on Legal Practice Committee 2 (Law and Medicine) proposed a "Draft International Convention on Telemedicine and Telehealth" to create a legal framework for telemedicine.[9]

V. A proposed mobile telemedicine solution

This is a potential scenario for a complete mobile telemedicine solution using MCCDs. The first phase of the proposed solution is the Data Collection Stage.

A. Monitoring Device

These are approved, commercial off-the-shelf (COTS) sensors (external or implantable) that collect information (such as blood pressure; heart rate; motion; etc.) off the patient's body. These sensors communicate via short-range radio frequency (RF) with the data capture element.

[4] http://tie.telemed.org/telemed101/understand/tm_history.asp

[5] http://www.nlm.nih.gov/pubs/cbm/telembib.html

[6] http://www.americantelemed.org/ICOT/ISO-TH-TR-Pt1-Nov-15-2002.pdf

[7] http://www. americantelemed.org

[8] http://www.itu.int/ITU-T/worksem/e-health/

[9] http://www.mcguirewoods.com/news-resources/publications/products_liability/article493.asp

B. Data Capture

The MCCD will receive the short-range RF signals from the patient's sensors using either an attachment or via a built-in RF receiver. The MCCD will perform the basic data pre-processing and packaging for transmission. This can be achieved with one of the programming languages available for MCCDs (such as Java, BREW, .NET or others).

C. Carrier Pipe

The MCCD will utilize the infrastructure provided by a wireless carrier to transmit the patient's data over the wireless networks in a secure and reliable manner. Appropriate encryption and authentication protocols could be used as required.

The second phase of the proposed mobile telemedicine solution is the Server Processing Stage.

D. Application Server

The data captured by the patient's sensors will be safely and securely stored on a server. The raw data could be pre-processed based on rules set by the third-party.

E. Back-end Integration

The application server will transmit the data to a third party-owned system. A typical third party could be a Disease Management service provider, a managed care organization, or any entity duly authorized to access the patient's data under applicable laws and regulations.

F. Business Intelligence

The third-party organization will apply its expertise ("Business Intelligence") to turn the patient's body data into meaningful, actionable knowledge about the patient's disease or health status. The third party organization, would then issue medical opinions based on its interpretation of such body data.

G. Provider Access

The third-party organization, when necessary, will contact the patient's health care provider, physician, case manager or caregiver directly. Those authorized individuals would then have access to the most relevant information about the patient in order to best serve the patient's needs.

VI. Industry Standardization and Harmonization Required.

There is an urgent need for clear, comprehensive and universally accepted open standards for telemedicine devices, as well as for the communication protocols amongst those devices. Those standards must be based on unencumbered Intellectual Property Rights (IPR). Based on other industries' experiences, it is necessary for industry players (suppliers, buyers as well as users) to have access to such open standards in order to reach a critical adoption rate for telemedicine systems.

For example, the World Wide Web was built on open, unencumbered standards. Unencumbered standards allow all parties to participate without paying a toll tax. Another great example of the power of open standards is the IEEE and the way its members work, through open discussions, to create and implement standards.[10] IEEE standards are at the heart of many of the electronic and computing systems prevalent today throughout the world. In terms of data exchange standards, the Clinical Data Interchange Standards Consortium has developed several XML-based open standards[11] that could be extended to cover telemedicine systems. Another source of data exchange standards is the Health Level Seven (HL7) organization.[12]

Some of the largest buyers of telemedicine solutions, such as the Veterans Health Administration (VHA) in the US, are also clear on the value of having standardized solutions available to their members: "..My personal belief is that the value of home-telehealth will come from developing large uniform networks in which the hardware and software systems are compatible."[13]

There is also an opportunity for interested parties in the industry to join forces and collaboratively work to solve some of the previously identified non-technical challenges: everything from the business issues to the harmonization of laws and regulations across jurisdictions. Academic researchers have an opportunity, as well as a challenge, to perform translational research in telemedicine. Researchers can bring existing telemedicine research to companies that wish to implement such research in products and solutions that address the real needs of both patients and their care providers.

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References

[1] Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2003). *World Population Prospects: The 2002 Revision. Highlights*. New York: United Nations.

[2] Center for Strategic and International Studies and Watson Wyatt Worldwide (2003). *The 2003 Aging Vulnerability Index: An Assessment of the Capacity of Twelve Developed Countries to Meet the Aging Challenge.*

[3] National Library of Medicine. *Current Bibliographies in Medicine: Telemedicine: Past, Present, Future*. CBM 95-3, 1995.

[10] http://www.ieee.org/organizations/corporate/vision.htm

[11] http://www.cdisc.org/standards/index.html

[12] http://www.hl7.org/

[13] http://www.va.gov/telemed/newsletters/spring02.pdf