Mobile HER

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Summary – Mobile Electronic Health Records are emerging as a result of the increased importance of healthcare provision in the community, which requires access to EHR systems over a variety of portable and mobile devices. Further development of mobile EHR will be needed to incorporate information captured via an increasing number of sensors and associated devices, often transmitted over public communication networks.

• **Introduction** – Supporting care in the community demands that electronic health records become mobile: they should be accessible via a variety of portable and mobile devices that are used by healthcare professionals in the field to access information about the persons they are advising. In this context, EHR must also incorporate information captured (and often transmitted over public communication networks) outside a traditional healthcare facility and possibly without the supervision of a qualified professional via a variety of sensors and associated devices. These new requirements for EHR place considerable challenges for its evolution and require a revisit of its fundamental structure and facilities.

• **Supporting self-care** – Public expectations of future healthcare are changing. To meet the new demands significant enhancements, well beyond those planned at present, will be required to services and information infrastructures. In particular, the expected changes in the age structure of the population in Europe, North America and elsewhere are likely to create new conditions for healthcare services in particular supporting provision in the community. Adoption of self-care practices is therefore intimately related to changes in attitudes towards healthcare and is associated with increased patient knowledge about their condition, and improved public health and active health seeking behaviours. This approach will require the extension of traditional medical information systems so as to effectively and efficiently provision and collect personalised information when and where needed, often outside the confines of traditional healthcare facilities.

• **Self-care services** – One type of service involves the flexible access to EHR information while healthcare professional are on the move. To address this need, a variety of platforms have been developed and deployed that allow access to existing EHR systems via the use of mobile devices connected over internal or external wireless networks. Different devices can support different types of applications and contexts of use, and can range from mobile phones and Personal Digital Assistants (PDA) at the lower end of capability, to tablet PCs and laptops at high end. For example, the Baycrest Centre for Geriatric Care in Toronto, Canada, has implemented since 2003 such a mobile EHR system to allow flexible access to patient data for their administrative, teaching and health care staff who are reporting significantly increased productivity due to this new capability.

Two main systems modifications are required for the integration of mobile devices in this case: (i) suitable user interfaces that can be used on the small form factor of these devices and that require reduced resources in terms of storage and computing power; and (ii) information security

mechanisms that can provide appropriate levels of protection to the data transferred between the device and the EHR data centre. Practical solutions and industrial products are currently available from different suppliers.

A second type of service relates to the automated collection and interpretation of data recorded via wearable or implantable sensors. For example, the IST project Panaceia has developed an application especially tailored to patients with Adult Congenital Heart Disease to record electro-cardiogram data, which are subsequently transmitted over broadband to the Royal Brompton and Harefield NHS Trust for consideration by a consultant. In this way, patients avoid frequent trips to the hospital for monitoring, reduce the cost of support, and increase their independence. During this trial, simple diagnostic mechanisms performed on the transmitted data were deployed to alert the consultant to conditions that require additional review and help maintain historical data.

A third type of self-care service employs bi-directional communication between the sensors and the medical diagnostic server, under the supervision of trained medical staff. For example in the IST project e-Care, self-care services have been developed that provide feedback to patients about their current condition and supply further information and guidance on actions they need to take by combining their exiting EHR, new data captured by sensors in real-time and the context of their capture. e-Care explored aspects of medication conformance, the effect of alteration of drug prescriptions and modification of treatment plans due to rich sensor data.

• **Extensions to mobile EHR -** While the first type of self-care services open up issues related to access of EHR data from outside the trusted network of the healthcare provider, the second and third types of applications raise more complex issues related to data fidelity, interpretation, decision making, responsibility of care and liability. Indeed, current networking and communication technologies allow for a sustainable distributed and hyper-linked EHR. This EHR contains the entire patient medical data collected by qualified medical institutions and verified by medical staff.

The introduction of automated medical data collection without the intervention of medical staff that can verify its validity or correctness takes the current state-of-the-art a step further. This is a critical distinction since unverified data cannot be trusted in the same way as the usual EHR and must thus be treated differently. Nevertheless, such data, referred to commonly as patient notes rather than patient records, provide valuable information of historic trends and are of considerable assistance to the clinician – in fact, they are the basis for any advanced self-care system.

• **Mobile EHR and patient notes -** One approach that can help address this distinction between EHR and patient notes has been pioneered by the e-Care project and treats each of these information items as an XML document using the i-note specification. Several notes may be grouped together and used for particular diagnostic tasks. Employing an XML-based approach provides a flexible solution that can address the different requirements of heterogeneous systems and provide an appropriate interface to a wide variety of platforms and legacy infrastructures. Data harvested from a variety of sensors need to be processed into i-notes and stored for future use and according to system policy, communicated to the appropriate clinician for analysis. Such

sensed data have to be translated and pre-processed before they are integrated wit mobile EHR as i-notes and for this task a common solution is the use of a body area network that is embedded computing devices that provide the required intelligence and persistence.

• **Conclusions.** Computing and communications technology is rapidly moving towards its fourth era which is often described as ubiquitous and pervasive computing or wireless sensor networks. This shift open ups considerable opportunities for new types of services and applications which slowly but surely are finding their way into medical and healthcare infrastructures. In the following years, as technologies mature the proliferation of new sensing and actuation devices will have a critical role in supporting care in the community and they will require a transformation in EHR systems beyond the current state-of-art, towards greater mobility and decentralisation. But such opportunities also carry related risks of correctness and privacy protection that will also have to be addressed.

• **Resources**

- The International Council on Medical & Care Compunetics http://www.icmcc.org/
- Centre for Pervasive Healthcare, Denmark http://www.pervasivehealthcare.dk/
- The Institute of Biomedical Engineering, UK http://www.imperial.ac.uk/biomedeng
- Virtual Medical Worlds Newsletter http://www.hoise.com/vmw/
- PANACEIA-ITV Project http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1480070
- Patient notes specifications from the e-Care project http://www.vmwsolutions.com

• **Five-year forecast**

- Greater availability of information technology-based healthcare support services especially over the internet and digital TV.
- A variety of new sensors will allow diagnostic procedures to be conducted in the community, especially those related to diabetes monitoring using bio-sensors.
- Sensors and intelligent sensing platforms will further decrease in size and a complete platform will require only a few cubic millimetres.
- New embedded bio-information technologies will enable the administration of drugs via controlled but unsupervised miniaturised release mechanisms.
- Increasing pressure will be placed onto opening up existing healthcare support systems.
- New process and policies will be required to guide the proper use of the new technological capabilities.

• **Forthcoming events**

- 4th International Workshop on Wearable and Implantable Body Sensor Networks http://bsn2007.rwth-aachen.de/
- IEEE Workshop on Pervasive & Ubiquitous Health Care http://www.ubicare.cs.pitt.edu/