CellChek: A Cost-effective Cell Phone-based Patient Monitoring and Advising System

Wireless Intelligent Networks Center (WINC), Nile University, Egypt

Project Manager: Tamer ElBatt

I. Background Information

According to World Bank and ITU reports in 2012, the number of mobile subscribers world-wide has exceeded 6 billion, as of July 2012, which constitutes more than three quarters global penetration. Similar trends hold for the Middle East and North Africa (MENA) region and developing countries. For instance, the number of mobile subscribers in Egypt has exceeded 92 million in April 2012 (~112% penetration), as opposed to only 36% fixed Internet penetration in 2011. The ubiquity of mobile phones along with the growing need for enhanced medical services worldwide present a unique opportunity to save costs and introduce mHealth services, especially for low-income communities where qualified healthcare services are either too costly or not immediately available.

II. Goals & timeframe

We introduce the novel concept of "cost-effective" mobile healthcare and develop a system prototype, coined *CellChek*, for remote patient monitoring and advising using widely-available, affordable mobile phones. *CellChek* "optimally" leverages the multiple wireless interfaces onboard most mobile phones today to save the cost of uploading patients' medical data to healthcare professionals. This research project has been funded by *Microsoft Research* under the "Mobile Healthcare for Africa Awards" program in Fall 2009. The project has been awarded in April 2010 and started in Oct. 2010 and has been completed in Sept. 2011. The project team is continuously exploring collaboration and funding opportunities, nationally, regionally and internationally, to further mature the *CellChek* system and associated technologies and transition it to the end users for maximum benefit to the society.

III. Project's added-value and importance

Cost-effective mobile healthcare is expected to have significant impact on the health of the society in general and under-served, low-income communities, including the elderly community, in particular. With the continuous advances in healthcare, drug discovery, and quality of life, the number of elderly citizens has been increasing rapidly. In addition, with the continuous pressure of daily life, it is becoming more common for elderly people to be living alone for extended periods of time during the day and throughout the year. Despite the fact that the Egyptian government considers elderly care as one of the most fundamental human issues that receives the

state's due attention, the number of elderly homes in 2006 of 104, benefiting about 2400 senior citizens, is far from covering the millions of Egyptians whose age is above 65 years. The percentage of the elderly in the population has been steadily increasing according to the general census of the population in Egypt reaching 5.1% in 1950 and up to 6.3% in 2000. It is projected to increase to 11.5% in 2025 and further reach up to 20.8% by 2050. This highlights the pressing need for Information and Communications Technology (ICT) help to improve the effectiveness and timeliness of healthcare services offered to this important sector of the Egyptian society. In 1996, the census shows that majority of the elderly in Egypt are in the age group 60-64 years and constitute 41% of the overall ratio of the elderly, followed by the age group of 65-70 years (27%), followed by the age group 70+ years (32%).

To close this gap and to provide support for the increasing number of elderly citizens who live alone, mobile healthcare aims at providing ubiquitous healthcare, based on the use of the widespread sensor-rich mobile phones along with emerging wireless-enabled medical devices. The system is capable of sending patient reminders, including "Time for Medication", detecting emergency situations, and periodic checks, among other services.

Emergency situations such as sudden falling, strokes, heart attacks, and long periods of inactivity, can be detected by gathering and transferring sensor data from the elderly citizens in a timely manner. This data can be processed on the mobile phone, to generate alerts, or sent directly to the medical personnel for 24/7 monitoring and analysis.

The cost-effective mobile healthcare paradigm addresses problems related to sensors integration and communication. In particular, we addressed the problems of leveraging built-in phones sensors and attaching portable non-intrusive medical devices to the elderly person to remotely monitor vital signs, such as heart pulse rate, ECG, and motion.

Such system is expected to have a significant impact on the healthcare services offered to the elderly, not only in Egypt, but also throughout the region and around the world. It is expected that the system will reduce the load on the public health system for an important and precious age group that bears the experience, history and culture of any nation represented by the elderly citizens.

IV. Challenges

Despite the remarkable progress achieved in mobile communications and computing, fully leveraging ubiquitous mobile communications for healthcare services in underserved communities remains a daunting challenge. This project involves a number of technical and business-related challenges:

- How to decide the "optimal" (i.e. minimum cost to the user) wireless access technology for uploading the patient's collected data to the healthcare facility remains an open question. This clearly depends on the pricing of the data plan and SMS services, size and type of the data (text, image, video), availability of public vs. subscription-only WiFi.
- How to send SMS advisory/warning messages from the healthcare provider (HCP) to a target group of patients/citizens depending on their GPS locations, in a cost- and resource-effective manner, is another research challenge targeted by *CellChek*. This could be for healthcare as well as other emergency purposes, e.g. in case of major natural disasters.
- A unique set of challenges inherent to mobile phone usage in low-income communities need to be addressed, e.g., expensive data plans, predominantly pre-paid plans, limited public WiFi access.
- Developing data accounting models for 3G data transfer, based on predominant data pricing planes of major cellular operators.

Finally, one of the major challenges of this project is its "inter-disciplinary nature", esp. cutting across the ICT and healthcare and medical communities. This somewhat slows down the efforts for transitioning the developed concepts and systems to the pilot tests and field trial stage. The government and NGOs are typically key stakeholders in coordinating the efforts and aligning diverse disciplines and projects towards realizing innovative services for the welfare of the society.

V. Relevance of the project to the respective Action Line

This project is highly relevant to the WSIS project due to the following:

- First and foremost, the *CellChek* project is one direct and clear manifestation of the major role the ICT community (government, industry, and academia) could play in enabling enhanced healthcare, among other, services for the welfare of the society. Hence, this is project is in line with WSIS Action Line C7. ICT applications: E-health.
- Under Action Line C7. ICT applications, Item 18. E-health, this project is directly relevant to the following actions:

  o *Promote collaborative efforts of governments, planners, health professionals, and other agencies along with the participation of international organizations for creating a reliable, timely, high quality and affordable health care and health information systems and for promoting continuous medical training, education, and research through the use of ICTs, while respecting and protecting citizens' right to privacy.*
    - *CellChek* is a key enabler for affordable healthcare systems on the move.
  o *Facilitate access to the world's medical knowledge and locally-relevant content resources for strengthening public health research and prevention programmes*

and promoting women's and men's health, such as content on sexual and reproductive health and sexually transmitted infections, and for diseases that attract full attention of the world including HIV/AIDS, malaria and tuberculosis.

- The advisory sub-system of *CellChek* is a key enabler for cost-effective public health services, through efficient broadcast of advisory and warning SMSs to the public, saving huge costs to health authorities, municipal governments and insurance companies.

o *Alert, monitor and control the spread of communicable diseases, through the improvement of common information systems.*

- The patient advisory part of *CellChek*, via cost-effective SMS dissemination, directly targets this objective.

o *Promote the development of international standards for the exchange of health data, taking due account of privacy concerns.*

- Privacy of patient's medical records is a core objective of *CellChek*, however, it is not yet integrated into the system at this stage of the effort.

o *Encourage the adoption of ICTs to improve and extend health care and health information systems to remote and underserved areas and vulnerable populations, recognising women's roles as health providers in their families and communities.*

- **This is the main motivation behind *CellChek* and has been one of its key mandates.**

o *Strengthen and expand ICT-based initiatives for providing medical and humanitarian assistance in disasters and emergencies.*

- An important goal for the remote patient monitoring and advising subsystems of the developed *CellChek* system.

- Offering reliable, ubiquitous and affordable healthcare services has been one of the major challenges the world, developed as well as developing countries, has been facing over the past couple of decades. It has been widely accepted that ICT has a great potential to play a key role in this through emerging e-health, telemedicine, and mHealth, among other, technologies. Cost-effective mHealth, e.g., *CellChek*, constitutes an important step towards this overarching objective.

VI. Conclusion

This project introduces a new research paradigm in the emerging mobile healthcare research arena, namely cost-effective mHealth, targeted towards bringing qualified medical attention to underserved communities at a minimum cost as well as potentially saving major expenses to healthcare authorities and insurance companies worldwide. The problem of providing qualified and timely medical attention to underserved communities around the world, and in developing countries in particular, has been a major challenge for the international community, at least for the last decade. This problem is further aggravated by the fact that healthcare services are either too costly or not immediately available in those parts of the world.

On the other hand, and over the same period of time, the ICT domain has been witnessing a number of major developments and transformations, independently. First, the convergence of sensing and actuation, communications and computing constitutes the key enabler for a multitude of miniaturized and embedded platforms and devices around us, giving rise to a "connected-world", be it in the environment, at home, workplace, industrial plants or even in the human body for treatment and remote monitoring purposes. Second, the wireless technology wide proliferation has inspired many novel applications and services that range from social, business, national security, and defense to education and healthcare-related services. Third, the continuous increase of the number of mobile subscribers around the world and the developing world, as confirmed by recent ITU reports and estimates, creates ample opportunity for ubiquitous (i.e. anywhere, anytime) services.

The novel marriage of the need for healthcare services for low-income communities and the prevailing opportunity presented by the wide proliferation of Internet-capable mobile phones, sets the perfect stage for a new research paradigm introduced in this project, namely cost-effective mobile healthcare. Mobile healthcare is a rapidly growing multi-disciplinary research area as evidenced by recent diverse literature from the wireless communications, sensor networking, mobile computing, and medical communities. Nevertheless, the emphasis on cost savings as a major design driver, rather than after-the-fact issue, is still in its infancy and has not received sufficient attention from the community.

Under this research project, we developed *CellChek* as a proof-of-concept testbed for cost-effective ubiquitous mobile healthcare systems based on the use of sensor-rich mobile phones along with emerging wireless-enabled medical devices.