Employing Mobile and Ubiquitous Computing to Assist the Developing World Improve Healthcare

International Association of Science and Technology for Development (IASTED)

Executive Summary

Patricia N. Mechael (Mechael, 2008) put together a very good overview of mobile and ubiquitous health care for the Millennium Village ™ Project. She then updated her thoughts in a short follow on paper. This paper builds upon her work to both update it to account for the explosive growth in capabilities, the growth of crowdsourcing, and provides a demonstration scenario to show how mobile and ubiquitous computing can greatly assist medical professionals in the developing world.

Mobile network and service availability is key to any analysis. These services are now part of the communications grid in virtually every area of the developed world. Likewise, they are growing rapidly in the developing world as well. International Communications Union statistics show mobile cellular subscriptions more than tripled in the developing world from 2005 to 2010 and mobile broadband exploded. There are now 333 million mobile cellular subscribers and 29 million mobile broadband subscribers in Africa and all indications are these trends will continue. The developing world now has access to mobile communications and more people are accessing them than ever before. The capabilities are now in place to extend mobile and ubiquitous computing to help the developing world tackle critical healthcare problems.

What are Mobile and Ubiquitous Computing?

Mobile computing

Wikipedia defines mobile computing as:

> Mobile computing is a form of human–computer interaction where a computer is expected to be transported during normal usage. Mobile computing has three aspects: mobile communication, mobile hardware and mobile software. The first aspect addresses communication issues in ad-hoc and infrastructure networks as well as communication properties, protocols, data formats and concrete technologies. The second aspect focuses on the hardware, i.e. mobile devices or device components. The third aspect deals with the characteristics and requirements of mobile applications.

Ubiquitous computing

Wikipedia defines ubiquitous computing as:

> Ubiquitous computing (ubicomp) is a post-desktop model of human-computer interaction in which information processing has been thoroughly integrated into everyday objects and activities. In the course of ordinary activities, someone "using" ubiquitous computing engages many computational devices and systems simultaneously, and may not necessarily even be aware that they are doing so. This model is usually considered an

advancement from the desktop paradigm. More formally Ubiquitous computing is defined as "machines that fit the human environment instead of forcing humans to enter theirs." This paradigm is also described as pervasive computing, ambient intelligence, where each term emphasizes slightly different aspects.

Putting the two concepts together

Ubiquitous computing is an extension of the mobile computing concept. Mobile computing provides the backbone for ubiquitous computing. Without the communications network and effective software operating on mobile devices, there will be no ubiquitous computing.

But for ubiquitous computing to flourish, it must be aware of the entire environment of devices, whether they are mobile or stationary and be able to interact with them. That means that devices must be discoverable and have interfaces that expose information to mobile devices with the required security controls. It also means that environments such as hospitals need to allow mobile and wireless networks and block them only in sensitive areas that impact patient health or security.

What does this mean for the medical community?

We keep in mind a commonly used concept with dealing with mobile applications: exposing data and interface. The medical community has a special charter, back by laws and custom, to protect patient privacy. Therefore the medical community cannot simply expose devices and information to every mobile device that enters its network. Administrators must know what to restrict and what to expose and carefully establish a balance that ensures they follow the law and protect patients and provide as much information as they can to both the general public and to authorized users. While this is primarily an issue for the developed world, it will become increasingly important to the developing world as well.

What does this mean for users?

The first significant consideration for any user is that a mobile device must be aware of its location and broadcast status. That means that a user will trade off some privacy in exchange for greater information and the ability to interface with the digital network. The more that a user participates in ubiquitous computing, the more information that he or she exposes to others. While each individual interaction may not provide a great deal of private information, the sum of the interactions could provide a great deal of private information concerning interests, concerns and daily routines that could be used by others if not properly safeguarded. In many ways, these trade-offs happen every day as more and more users participate in social networking applications and expose their mobile device's location to take advantage of navigation systems and even other applications. This could create security issues in parts of a crisis response operation.

Are these concepts for real or just another idea that will fizzle?

These concepts are increasingly rooted in both the computing environment and popular mindset. While a major network outage, such as a terrorist attack on the information network backbones

or huge privacy issue that significantly affects the lives and wealth of a many people at once may change these trends, for the moment, ubiquitous computing and social networking continue to grow. Many users, while still concerned about privacy are willing to trade some degree of privacy for increased mobile utility. Likewise, many institutions are also willing to trade-off some security for increased mobile effectiveness. The rapid adoption of the iPAD in the corporate computing environment is one example (King).

Thermopylae Sciences + Technology (TST) clearly sees this trend in its growing ubiquitous applications in a variety of areas from national security to aid in disaster relief to conference and sport venue management. TST now has mobile and ubiquitous computing applications that have run the gamut from supporting the Haiti earthquake response (January 2010) to helping sports fans follow their passion in basketball, hockey, and auto racing. While sporting events may sound a bit strange in the healthcare context, the technologies developed to support them can also support remote healthcare workers struggling to provide care to villages or in response to a disaster.

With the rise of social networking, many people are now very comfortable with exchanging data online, often of a personal nature, as long as they feel they get fair value in the exchange. More and more people are turning on GIS location devices on cellphones and smartphones and participating in mobile data exchange.

Likewise, the capability of mobile devices is expanding dramatically. Consider the camera that is now common on cellphones and smartphones. At one time, it simply took pictures that had to be downloaded. Then it had the capability to immediately send the photos to other people online. Now, through 'enhanced reality', the camera is an interactive device that helps users to navigate complex venues or gain information about places and things. Another example is maps. At one point, the phone merely provided a flat map and pictures. Now phones have complete navigation capabilities, to include turn-by-turn navigation with voice directions and the ability to determine optimal routing based upon traffic. And of course, you can quickly find a place to eat or refuel along the way.

These two applications are simply the tip of the iceberg of what we will see in the coming years as bandwidth improves, devices have increased computing capacity and more devices are web/WiFi enabled. The trend is clearly toward ubiquitous computing.

Crowdsourcing

Crowdsourcing is a way to gather information and ideas from a wide variety of people to include local inhabitants, healthcare workers, aid and relief workers: basically anyone with a cell phone or a smart phone that wants to contribute information to help solve issues. It provides a dynamic platform for multiple users, from a wide spectrum of people, to input data into a common situational picture. Once users see the power of mutually shared information, crowdsourcing

programs often go viral is users add more information and new users see the value of the program and grow rapidly.

To do this, crowdsourcing provides an opportunity for a "viral" distribution of the application and reporting capability through smartphone applications, smartphone web pages, traditional web pages, and SMS texting. This combination provides an integrated information umbrella that includes not only smartphone technology, but also existing cell phones and traditional web pages into a holistic architecture that provides a rich information environment for decision-makers.

Las Vegas Motor Speedway—a case study of mobile and ubiquitous Computing

While at first blush, supporting auto racing events may not seem to have much in common with medical applications and patient support, the concepts are quite similar. In both cases, users desire to share information, find critical services, and navigate through often confusing venues. Users are able to easily navigate around the speedway, find services, and use the camera on their phones to access enhanced GIS capabilities that provide interaction with the environment to obtain additional information about events and services.

These capabilities can readily be exported to hospitals to help family members find a patient's room, assist in entering critical patient medical information and other services. Likewise, they can be used by healthcare professionals to quickly read charts electronically, as well as monitors and other devices monitoring the patient as well as the patient's records. They can also be used to provide critical telemedicine capabilities to the developing world as well assist in diagnosis, train local healthcare providers, and provision mobile applications, assist in routing, track their locations, and provide critical and timely warnings and alerts to healthcare, aid, and relief workers responding to a crisis. They are also integral to an effective crowdsourcing solution.

Crowdsourcing in Haiti—Rapidly responding to a crisis in an uncertain situation

When disaster struck in Haiti in January 2010, relief efforts were hamstrung by the poor quality of information available on Haiti and the lack of detail on most maps. Crowdsouring rapidly came to the rescue. Aid and relief workers and Haitians were able to interactively work together to rapidly build accurate geospatial maps that showed the conditions on the ground. In a relatively short period, Haiti went from being on the least geospatially documented countries to one of the most documented countries in the world.

US SOUTHERN Command, the U.S. geographic command that has responsibility for U.S. military operations in Haiti rapidly built a geospatial 3D User Defined Operational Picture (3D UDOP) using TST's geospatial capabilities that facilitated Crowdsourcing. They were able to deploy 3D UDOP within six days and rapidly built up rich maps with photos, details and narrative comments that helped to guide relief efforts.

These capabilities can be readily exported to assist healthcare in developing areas. For example, healthcare workers can use smartphones to update information about disease outbreaks, the location of medical clinics and problems with roads and other issues. They can also remotely update records and access information they need on the fly. Nurses and paraprofessionals can access telemedicine and eLearning to enhance their capabilities. Local citizens can also report medical issues and provide information to healthcare professionals using a variety of mobile devices.

Ushahidi

The Ushahidi project developed to post-election turmoil in Kenya in 2008 and was used to map violence and other incidents through both reports submitted via the web and mobile phones. Since then it has grown to include developmental and other efforts in many parts of the world. The group's efforts then expanded to help map violence and other issues in South Africa, Gaza, India and Pakistan. It is now tracking swine flu outbreaks throughout the world. It is proof that Crowdsourcing techniques work and that the developing world has the communications backbone to support them.

How can these capabilities enhance patient care?

As noted above existing solutions can be easily exported to help healthcare professionals enhance healthcare in both the developing and the developed world. The key issues are not technology and capabilities. Rather they are policy and bandwidth.

Policy issues revolve around regulatory requirements, internal data sharing policies designed to protect proprietary technical or financial information, and data ownership issues. In addition, IT departments are extremely concerned with viruses, intrusions and other data protection issues. Health care professionals and IT managers will need to work through some complex policy and process issues as more mobile devices and ubiquitous computing enter the healthcare space. The Veterans Administration is working through some processes to address at least the vulnerability issues by keeping all devices on a virtual network to separate them from the rest of the network (Hayes). Healthcare Information Exchange (HIE) and other programs may help to resolve some of the legal and regulatory issues (Hudock). The medical community will need to balance the needs for crisis response and healthcare in remote areas with privacy and security concerns.

Bandwidth is also a critical concern. Mobile devices will consume bandwidth. As more medical devices provide easily accessible data, more mobile devices will try to access the data. WiFi bandwidth seems to get consumed as soon as it is provided. For example, see Vaughn-Nichol's article that references the problems that Apple's CEO had with bandwidth during a critical tradeshow demonstration. In the short-term, bandwidth will almost certainly remain a challenge. This problem is even more acute in remote areas with developing countries than in a first world hospital. However, bandwidth and technology will almost certainly improve. Depending upon what analyst you want to believe, we will get through it sooner rather than later in the developed

world. As the ITU study shows, mobile computing and network availability is growing rapidly in the developing world.

For now, let us set aside the policy and bandwidth issues to focus on why mobile and ubiquitous computing is important. If the importance is strong enough, the policy and bandwidth issues will almost continue to evolve to manifest the capabilities. In the case of mobile and ubiquitous computing to support the developing world, the policy issues are less thorny and the bandwidth issues are already starting to mitigate—at least until even more smart devices arrive and consume more bandwidth.

Applications to assist the developing world

The developing world has critical need for the capabilities inherent in mobile and ubiquitous computing. These needs run the gamut from day-to-day clinical operations, to remote education and telemedicine to monitoring and reporting on infectious diseases to responding to natural and manmade disasters.

A hypothetical storm in East Africa may provide an excellent example of how these capabilities can work together. The storm threatens to break a key dam and start a series of floods that could spread a cholera epidemic and require massive evacuations from some very remote areas.

Aid and relief workers and engineers move out into the potential flood zone to gather data, inspect the dam and warn the populace. They establish a Crowdsourcing website to allow all interested parties to update the situation using cell phones and smart phones. As engineers confirm that the dam could break or need to release a dangerous flow, other users then develop potential flood zone maps. Healthcare and relief workers take this data to determine potential refugee camps and likely areas for cholera outbreaks. Workers using their smart phones quickly add data to the Crowdsourcing site and mark places on the map and upload pictures to help guide relief efforts if the dam either has to release water or breaks.

A coordination center monitoring the crowdsourced data as well location tracking of healthcare and relief workers can rapidly begin to gather data, coordinate efforts and rapidly disseminate warnings and information. Cell and smart phones with GPS capability automatically send their locations to a central coordination center. The coordination center is able to monitor the storm and the condition of the dam. Using the tracking system, they are able to warn healthcare and relief workers to move away from potentially dangerous locations or to change their routes to avoid dangerous areas.

Likewise, as refugees start to congregate both the refugees and the aid workers can use their cell and smart phones to mark their locations on the coordination center's map and add critical information such number of people, condition of the site and any health and safety concerns. They can also mark locations where cholera and other infections have broken out. Analysts can then take this information as it comes in, analyze potential flood patterns and estimate the

potential locations for further cholera and other healthcare issues to pre-stage medical and aid resources.

Crowdsourcing, both from the affected populace and the aid and relief community will add a critical dimension to relief and healthcare support. As experience in the January 2010 Haiti earthquake shows, Crowdsourcing capabilities can be manifested rapidly and provide critical information to support relief efforts. Likewise, the Ushahidi experience clearly shows the communications network is in place to support these efforts, even in the developing world.

The Crowdsourcing center can also manage mobile applications and assist users in provisioning their devices. Capabilities such as Thermopylae's Ubiquity can push application updates out to subscribed devices, while established marketplaces for the iPhone and Android can likewise provide a forum for new applications. The Crowdsourcing center can maintain a marketplace of healthcare and relief applications that users can quickly access and download.

Local healthcare workers can access telemedicine applications through their smart phones to assist in diagnosing and to send critical information, to include photos back to hospitals. Doctors, both local and remote can assist the local workers to make treatment decisions, triage decisions and potentially even walk them through lifesaving procedures. They can also use new barcode capabilities to assist in tagging and reading information.

Conclusions and recommendations

Mobile and ubiquitous computing is a growing capability that will significantly enhance patient care in both the developed and the developing world. While the specific applications of this capability will vary from place-to-place and need-to-need, the underlying principles and technology are the same. As technology continues to improve, these capabilities will become even more important to patient care.

The medical community can enhance and speed the development of these technologies by embracing them and establishing common standards for data exchange between devices, healthcare data exchange, mapping and establishing the capability to rapidly establish Crowdsourcing solutions to respond to healthcare emergencies.

Bibliography

Bednarz, Ann. "Virtual, Mobile, Social Endeavors Drive IT in 2011": *NetworkWorld*(January 3, 2011), http://www.networkworld.com/news/2011/010311-outlook.html?page=1

Brodkin, John. "The Complicated New Face of Personal Computing": *NetworkWorld*, January 3, 2011, http://www.networkworld.com/news/2011/010311-outlook-personal-computing.html?page=1

Gibbs, Mark. "2011 Outlook: Better than 2010 and Really Wild": *NetworkWorld*, January 3, 2011, http://www.networkworld.com/columnists/2011/010311-outlook-backspin.html?page=1

Hayes, Heather. "For the Health of the Network*": FEDTECH* (November 2010, volume 7, number 4), pp 32-33.

Hudock, Robert. "HIE and NHIN Implementation Issues: (a) Data Sharing Agreements, (b) the Master Patient Index, (c) Data Standardization, (d) Consent Requirements, and (e) Duties of

"Key Global Telecom Indicators for the World Telecommunication Service Sector", International Telecommunications Union, 21 October, 2010, http://www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom.html

King, Rachael. "Apple's iPAD Wins Corporate Converts at Wells Fargo, SAP": *Businessweek* (July 6, 2010), http://www.businessweek.com/technology/content/jul2010/tc2010076_193868.htm

"Measuring the Information Society", International Telecommunication Union, 2010, http://www.itu.int/ITU-D/ict/publications/idi/2010/Material/MIS_2010_without%20annex%204-e.pdf

Mechael, Patricia N. . "Towards the Development of an mHealth Strategy: A Literature Review", August 2007, updated by Daniela Sloninsky August 2008: World Health Organization, The Millennium Villages™ Project, http://www.who.int/goe/mobile_health/mHealthReview_Aug09.pdf

Mechael, Patricia N. . "In Search of Scalable mHealth Soultions", http://khup.com/view/19_keyword-mhealth/in-search-of-scalable-mhealth-solutions.html

Network Participants", March 25, 2010, http://law2point0.com/wordpress/2010/03/25/hie-and-nhin-implementation-issues-a-data-sharing-agreements-b-the-master-patient-index-c-data-standardization-d-consent-requirements-and-e-duties-of-network-participants/

Ushahidi website. http://swineflu.ushahidi.com/

Vaughn-Nichols, Steven J. . "There will never be enough Wi-Fi bandwidth", September 11, 2010: *ZDNet*, http://www.zdnet.com/blog/networking/there-will-never-be-enough-wi-fi-bandwidth/105

Vital Wave Consulting. mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World. Washington, D.C. and Berkshire, UK: UN Foundation-Vodafone Foundation Partnership, 2009. http://www.globalproblems-globalsolutions-files.org/unf_website/assets/publications/technology/mhealth/mHealth_for_Development_full.pdf