"Last year, my father had chest pains and needed to see a specialist in Manila. We sold our cows and our land so he can go. I had to take leave from my job to accompany him. It turned out to be pneumonia, which could have been diagnosed and treated here."

- a local from Batanes, the northernmost region of the Philippines, to Moca team members, June, 2009

Moca: Mobile Care for Diagnosis, Screening and Treatment

There is a wide rural-urban divide in health care delivery, especially in developing nations. Medical specialists in these countries are scarce and are often only found in the cities. For people living in remote villages, travel to see these specialists might deprive them of a whole day's income. And for many rural clinics, the time it takes to send information to the nearest physician and receive a diagnosis and advice on treatment is measured not in minutes or hours but in days and weeks. As a result, diagnosis and treatment are often delayed and It is difficult to incentivize the patient to return for the diagnosis or treatment, and this lack of follow-up often leads to worse outcomes and more costly, unaffordable care for the rural patient.

Moca is a cell phone-based application for the Google Android operating system that offers an end-to-end remote medical diagnostic platform for connecting health care workers in resource-poor environments to remote expert help. Moca leverages the 80-90% of the world's population that lives within range of a cell phone tower. Moca offers an open-source software platform that links remote users with cell phones to medical professionals via a web-accessible, centralized health record system. While there is no shortage of untrained or semi-trained health workers in many of these countries, many are unable to provide the needed medical care due to a lack of expertise and specialization. Moca's ability to link rural health care workers to trained medical professionals addresses this problem.

Our Technology

Moca is a reliable tool that allows health workers to transmit any medical file, whether text notes, audio, photo, video or even information rich x-rays and ultrasound images through a cell phone 1) to a central server for archiving and incorporation into an electronic medical record, and 2) to a remote specialist for real-time decision support. When strong cellular connectivity is not available, Moca solves the problem using packetization, synchronization and multi-modal transfer. Moca integrates with OpenMRS, an open-source medical records system commonly used in developing countries to facilitate longitudinal care and patient tracking. The platform enables collaborative quality assessment among partner organizations, which will be crucial in setting the standards for telemedicine technology and medical care in resource-poor settings.

Using mobile technologies for tele-health in developing nations requires the health worker to deal with multiple standards, different networks, and local challenges ranging from intermittent connectivity to cultural differences. Moca realizes that few instantiations of remote medical diagnostics are the same. Unlike hodge-podge solutions, Moca is highly customizable, allowing clinicians to create their own workflows for common procedures (**Fig 1**). These workflows can be dynamically loaded onto phones running Moca. The front-end for data and media capture is accessible through a fully-programmable interface. The back-end provides an intuitive user interface for management of medical media. Moca was built for integration with OpenMRS, but can be quickly ported to other commonly used medical record systems. This system design allows for maximum modularity and interoperation.

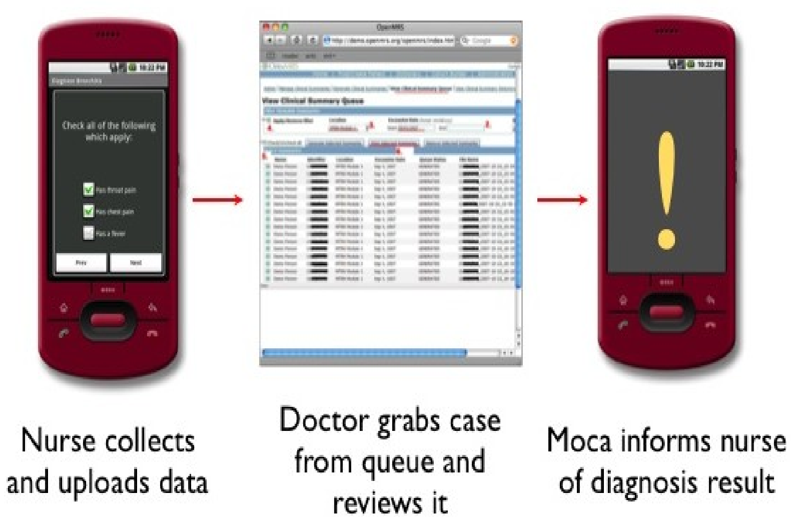

Figure 1 The Moca Workflow

Using the Moca application, health workers run a procedure and collect patient data on the phone. Moca then uploads the information to OpenMRS for doctor review. After reviewing the case, doctors notify health workers by sending diagnosis and treatment recommendations to the Moca application. Clinicians have the ability to build unique procedures for health care workers and organizations. Procedures are step-by-step workflows, and are at the core of Moca. In most scenarios, a procedure is a set of pages that have questions or prompts. For instance, a page might prompt a user to take a picture or record audio. Other pages in a procedure might ask the user to enter text, check boxes or record video from a connected medical device. Procedures in Moca are defined in an extremely compact XML format. While it is easy to write a procedure in our procedure format, in the future we will develop graphical tools to define procedures. To promote greater interoperability, we plan on integrating the X-Forms implementation, created under OpenROSA, a popular consortium to standardize medical data collection tools. In addition to pages with question-response pairs, a procedure has the ability to branch. Branching is defined in the Procedure XML, and allows for any arbitrary logic to be performed on other previously answered questions. This extremely powerful feature can be used to do everything from skipping certain questions if they are irrelevant given prior responses, to allowing physicians to create complete decision tree diagnosis utilities.

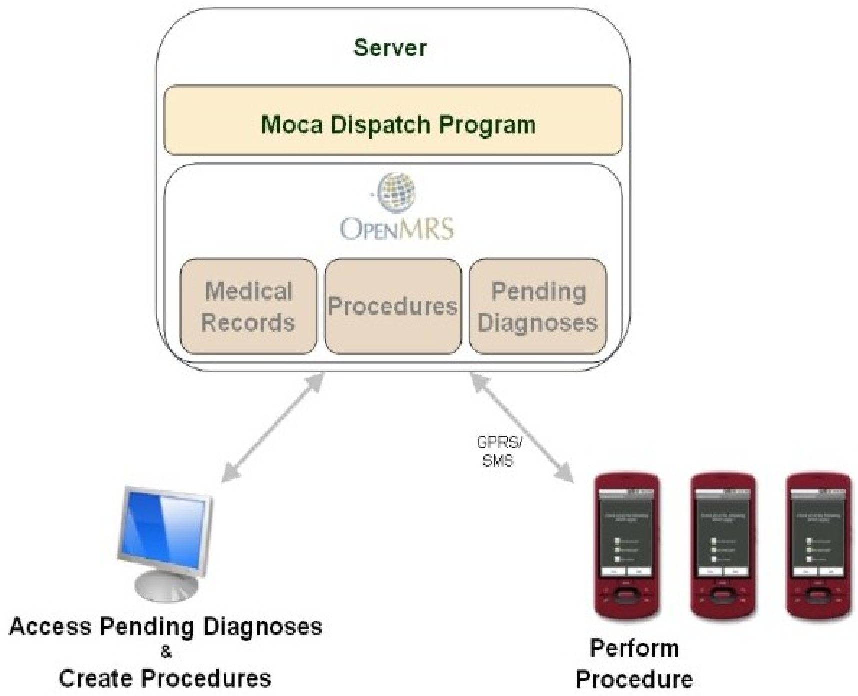

Figure 2 Moca Dispatch Server

The complete Moca system (**Fig 2**) consists of at least one (and in most instances several) phones and a web-connected server. The server runs both the medical records system of choice, such as OpenMRS, and the Moca Dispatch Server (MDS). The MDS runs on the server that is responsible for communication to and from phones registered in the system. It takes care of receiving data via the lower-level synchronization and packetization that the Moca-enabled phones perform. In addition, the MDS can be modified to interface with any medical records system. Using our custom MDS plug-in, Moca is fully-compatible with OpenMRS. We have extended OpenMRS to have a queue of pending diagnoses in addition to allowing data such as images to be tagged to a patient record.

A key challenge facing remote diagnostic platforms that utilize cellular networks in developing nations is the lack of adequate connectivity. Moca employs three strategies to ensure reliable, low-cost data transfers:

1. **Packetization**: Some acquired data are extremely large, such as video and high-resolution images, which require an inordinate amount of time to upload over GPRS. Oftentimes, half-complete transfers are interrupted and fail mid-upload due to poor service, and all data is lost on the receiving end. Using packetization algorithms, Moca uploads large files in smaller chunks so that little bandwidth is wasted in the case of a dropped connection.
2. **Synchronization**: When a procedure is completed, the medical data is stored in a local, on-phone database. At this point, the procedure can be rerun for the next patient. A background service in Moca is constantly listening for cellular service. As soon as service is available, all completed procedures in the database are uploaded to the server.
3. **Multi-modal transfers**: Moca has the ability to transfer data over a number of common interfaces, including GPRS, WiFi, SMS and USB tether. The different interfaces are used for specific purposes. Images and audio are relayed via GPRS, WiFi or USB tether, while text can be optionally sent via SMS. This is particularly useful if the phone is outside the coverage area, since the cellular network operator will automatically store and forward the SMS as soon as the phone reenters the service area.

Moca provides the equipment and the service for a complete mobile diagnostics platform. The client-interface will consist of an open interface between a mobile medical device and a Google Android-compatible cell phone. A unique software platform will translate the medical data into a cell phone-compatible format. The images will then be transmitted over our software system that has been designed to handle large data transfers over cell phone networks with intermittent connectivity. Remote diagnostics are relayed back to the health worker via SMS, providing rapid diagnosis and treatment follow-up. Moreover, patient scheduling (via SMS) will be possible, improving follow-up compliance and optimizing human resources.

Our Competitive Advantage

A fundamental goal of all tele-health focused organizations is to introduce an application that will enable a clinical transition in health systems to one that incorporates mobile innovation and ultimately reduces negative health outcomes in resource-poor developing countries. The shift towards the adoption of emerging tele-medicine applications in resource-poor developing countries is happening in tandem with advancing mobile technology in the developed world. Where phones with GPS and web-browsing are commonplace in the developed world, the developing world is using the more basic SMS and MMS technologies in enterprising ways. Given the number of people living in range of a cell tower coupled with the efforts of national and grassroots-level organizations working to provide access to smartphones and cutting-edge technologies has resulted in the rapid uptake of mobile technologies by the general population in developing countries.

Within the health sector, mobile communication is able to retrieve and transmit a wide array of information which can be divided into the following user-specific categories: education and awareness, remote data collection, remote monitoring and diagnostics and treatment support in health systems management. On the front of education and awareness, several groups are using SMS technology to coordinate information and for interactive text messaging. One such example is Project Masiluleke, which transmits over 1 million text messages throughout South Africa with information encouraging users to be tested and treated for HIV/AIDS. Frontline SMS is free and open-source software that enables users to create communication hubs in the developing world by connecting a laptop to a cell phone for larger-scale text messaging. Rapid Android is similar software that uses Google's open-source Android platform to create a mini-server for data analysis directly from your cell phone.

In the scope of remote data collection, smartphones and PDAs are being used on the ground to collect data and health information to reduce negative health outcomes. EpiSurveyor is an open-source cell phone-based application at the forefront of mobile data collection. EpiSurveyor is designed to create and deploy field-based survey forms from a cell phone or laptop to a remote server where all data is backed up. Another front-runner in mobile data collection is the Android-based Open Data Kit system, which integrates with Google's App Engine to collect and store a variety of data types. JavaROSA is an X-Forms-based open-source application developed by OpenROSA which runs on J2ME software, allowing it to integrate with a wide array of mobile devices.

Mobile communication has also taken on the challenge of medication compliance in patients. In the developing world, this is especially important as patients often travel large distances just to receive an initial check-up. Health workers can now use software such as CommCare, which assists them in managing in-home visits and scheduling. A health worker can also use CommCare to collect and report data to help monitor and evaluate community health programs. Similarly, GeoChat is an open-source technology that allows users to geospatially monitor activity over any phone and on any platform. By maintaining a system for patient follow-up which accounts for time and location, groups such as these ensure that appointments will not be missed and medication regimens will be strictly followed. In Thailand, the TB-DOTS program has seen a jump from 30% to 90% of medication compliance thanks to applications like these.

The application of mobile technologies in delivering or enabling distance health care, known as mHealth, is not an entirely new concept. The final division under the umbrella of tele-medicine, and also the most relevant to Moca's mission and goals, is that of mobile diagnostics and treatment support. A number of techniques adapted for awareness campaigns, remote surveying and tracking, treatment recommendation and administration reminders, remote diagnosis support and more have been trialed around the world, mainly for research purposes. This includes applications which are designed to communicate medical records and diagnostic information between remote health workers and remote physicians. One of the front-runners in mobile diagnostics is the group Click Diagnostics. This is a team that shares Moca's mission to provide access to quality medical care for the developing world through tele-medicine. Click Diagnostics provides a proprietary solution to a variety of problems that arise in the management of health systems in the developing world. By using SMS and MMS technology, this team has created a for-profit model for the communication of medical data from the field to a medical database or medical staff. However, so far these trials have been focused on very specific clinical applications, in very specific regions. Moca aims to develop an all-encompassing framework for mobile diagnostics that is designed to be extended to a multitude of different clinical applications in any number of regions. It is important to emphasize how we differ from other key players in this field.

In general, all of the above projects are aimed at low-end hardware and SMS-mediated data transfer. The interfaces are platform-dependent, and do not naturally integrate with other systems. Other key differences between the above projects and Moca are as follows.

Moca:

1. can upload any type of data file (formatted or not), and packetizes it to ensure delivery of large files (such as ultrasound videos) even in areas of low bandwidth and poor connectivity.
2. caches the medical record on the phone and dynamically synchronizes with the back-end whenever cellular connectivity is available.
3. is designed to provide feedback to the user concerning the quality of the data they have captured to improve data quality at the source.
4. is designed to adjudicate between several experts and capture the diagnosis and treatment recommendation. The labels can be used to provide quality assessment auditing and to develop intelligent decision software for delivering diagnoses.
5. is designed to provide both patients and health care workers with software to aid medical decision support. We envision our system as an accessible mobile doctor for every family.
6. is both a student and a teacher. It learns from the experts, and also from the changing medical landscape over time. It can provide instruction to sparsely trained health care workers as to why a diagnosis was given. This will allow health care workers (and heads of families) to attain a deeper understanding of the medical decision process. This enables the user to judge when the software may be in error and when to make his or her own decision if the case is unclassifiable by the software.

In addition, Moca is not limited to the cell phone handset. Written in both the Android operating system and Java, it can be installed on any phone or netbook computer running the Android operating system. In fact, in Fall 2009 Google is slated to release a cheaply available netbook pre-installed with the Android-based operating system, Chrome OS. We are also developing a web-based system that will increase access through its platform-independence. This kind of system will be paired with secure remote servers operated by Moca, which reduces deployment time and costs by removing the requirement to purchase and maintain the medical record server on-site. This compellingly powerful capability allows our organization to very easily and rapidly scale up from a few distributed deployments to tens, hundreds or even thousands worldwide.

Our approach is not a 'one-size-fits-all' philosophy. By working collaboratively with both local doctors and developers in the target country, we are able to co-create targeted solutions for our partners. Our partners on the ground share and own the system, which motivates its use and enables it to scale in the face of changing needs and technical problems. Additionally, firms and hospitals that currently implement tele-health solutions have internally developed "strung together" systems. In our discussions with these firms, we have learned about several problems plaguing these systems: they were expensive to build, and yet are not robust and flexible; and there is a need for better workflow management as well as analytical tools on the back-end to deliver metrics and quality assurance. In creating Moca, we have had numerous dialogues with potential adopters of our tele-health system to understand and overcome these problems in our system.

Finally, Moca is a collaborative solution operating under the GNU GPL license. We enable entrepreneurs, companies, governments and NGOs to bring down the barriers in deploying a tele-health system while increasing its effectiveness. Moca is in the business of improving the health of its users. It is the combination of Moca's scalability, reliability in resource poor locations, and cost-effective and collaborative solution that makes Moca the best solution for improving health care systems in developing countries.

Currently, the most common practice for data collection and archiving is to ask the mobile health worker to fill out paper forms in the field, which then have to be brought in and processed manually by clinic record by record later. Not only is this method slow and tedious, but there is also a much higher risk of transcription errors and data loss. The cost of storing, maintaining, and transporting records is also much higher. In response to these problems, some have adopted software that runs on their laptop computers for data collection and record keeping. However, this comes with its own host of complications. Laptops are expensive, and require a great deal of upfront investment. This also attracts theft, something that can be difficult to guard against. Laptops are portable, but not mobile, in the sense that they can be used anywhere, but cannot be used while moving from one place to another. Also, since laptops do not have any built-in networking capabilities, health workers must wait until returning to base before any data can be transferred.

Many studies have been conducted using PDAs instead, which solves many of the problems that laptops face. However, they still do not integrate networking capabilities and require health workers to carry multiple devices. With Moca, we've found that the best solution is to deploy community health workers with Moca-ready cell phones. This method encompasses all the benefits of the PDA, but also enables real-time, on-the-ground data reporting, using the phone's own connection to the cellular network. Cell phones are explosively growing in the developing world; within the next three years, there will be another billion people who own a cellphone—the fastest adoption of a new technology in history. They are also the first telecommunications technology to have more users in the developing world than in the West. Many of these countries have "leapfrogged" the desktop computer and laptop phases the West went though, and have gone on to directly adopt technologies such as the smartphone, technologies that seem at first though to be far too advanced. However, it is clear that the pace of the cell telecoms revolution is not slowing, and that in a short period of time, smartphones, netbooks and personal computer or sensor networks will merge in a range of convergent devices, which resemble today's smart phones. Moca is designed for the future, and applicable to the present.

The Pilot Project: mRadiology in Batanes, Philippines

Through our partnerships and volunteer work, we identified the Philippines as an ideal target market for tele-health. We envision Moca to serve as the mobile clinical information platform for the entire country. With grant funding, several Moca team members, including Ted Chan, Leo Anthony Celi, Katherine Kuan, Zack Anderson, Nicole Prowell and Crystal Mao, were able to visit the Philippines analyzing the state of rural health care there. From this experience, the team has developed a business plan to improve access to specialist care and radiology services (Appendix D).

We have partnered with the National Tele-health Center (NThC) of the University of the Philippines for the pilot implementation of our clinical information system. NThC was established in June 1998 through a University of the Philippines Board of Regents Resolution with the mandate to increase access to health information and services through information and communications technology. The NThC has all the footprints that Moca requires of its partner organizations (Appendix C). We are aware that the success of Moca relies on our partner organizations' ability to implement and sustain the projects.

We have chosen Batanes to implement a tele-radiology project using Moca. The Province of Batanes is the northernmost and the smallest province of the Philippines, both in terms of population and land area. The provincial capital is Basco in Batan Island. The province is composed of ten islands, called the Batanes Islands, and located approximately 162-km north of the Luzon mainland and 860-km from Metro Manila, the capital of the Philippines. Of this group of islands, the largest and most economically important are Itbayat, Batan and Sabtang. These three are also the only inhabited islands. Batanes is a 6th-class municipality, with a doctor to patient ratio of 10:17,000. The province is staffed by general practitioners (GPs), and only one specialist, an anesthesiologist. The locals are mostly fishermen, government employees and cattle herders. Poultry, fish and livestock serve as their sources of food and income. The people who will benefit from Moca deployment and implementation in Batanes are the ones who will be needing specialty care. Batanes General Hospital is their most advanced health facility in the province and is located in the capital, Basco, in Batan Island. Itbayat is an island municipality which is a 3-hour boat ride from Batan Island; Sabtang is another island municipality, a 30-minute boat ride from Batan Island. Having Moca will markedly reduce the need to travel to the capital for those who live in Itbayat and Sabtang, and to Manila for those who live in Batanes should they require specialty care that cannot be provided by Batanes General Hospital.

Batanes is a remote province with mostly general practitioners manning the health care system. These general practitioners have expressed their need to access to specialists' opinion for a subset of their cases. Although the province has a radiology machine, it does not have a radiologist available. When an x-ray of a patient is taken, the hospital sends the plates to the nearest hospital in the Luzon mainland via courier services. To maximize the courier service, they try to accumulate a certain number of x-ray plates before sending them. When the mainland radiologist reads the plate, they return the plates and results via courier services. In effect, the turn-around time for this process is two to three weeks. Although wireless internet is already present in the provincial capital, the farther municipalities within the province only have GPRS connectivity at most.

The Provincial Government of Batanes, headed by Governor Telesforo Castillejos, has been an ardent supporter of the tele-health services provided by NThC. They have entered into a Memorandum of Agreement with NThC to expand these services in the province. He is willing to provide funding should the Moca tele-health platform be fully introduced to their province. The Provincial Health Office (PHO), led by Dr. Roel Nicolas, has also shown support for Moca’s deployment in their province. He has already earmarked sufficient funding from their capital outlay for the procurement of the Android-enabled phones once these are locally available. The Provincial Health Office shall be the link between the Province of Batanes and the NThC. Finally, and most importantly, Municipal Health Officers have signified their interest and support to use Moca in the outskirt municipalities of the province, where only GPRS signals are available. They are willing to include Moca in the municipal investment plan. Some of the risks we have identified during our recent visit to the site are as follows:

1. Intermittent network connectivity in the province. During our trip to Batanes in June 2009, GPRS signal was not available province-wide. When this was reported to the Central office of the telephone company, the GPRS service went up a few days before our departure. Hence, we were able to demonstrate to the PHO that the system works on GPRS.
2. Technical support for the Android phone. We have to await the formal introduction of the phone into the Philippine market so that we can be assured of technical support should there be problems encountered. This is predicted to occur by the third quarter of this year.
3. Although cultural and workflow issues were not identified during the initial introduction of the technology to the Batanes health care workers, we suspect that these will arise once the system is fully operational.

Pilot Study

The Moca platform promises to deliver quality healthcare to significant segments of the rural, developing world. However, the project would benefit from a prospective clinical study that will provide descriptive data and empiric evidence that will be used to prove the value of the platform, evaluate areas for improvement in the workflow and refine the clinical information system. As a large archipelago of more than 7000 islands, the large rural population and an existing ICT infrastructure, the Philippines is an ideal test site for a Moca pilot deployment. Potential unique contributions include:

1. Moca will be the first open-source, complete end-to-end (from data capture for longitudinal medical record to point-of-care decision support) diagnostic mobile health information system designed for the developing world
2. Implementation of a permanent electronic medical record for rural patients
3. Assessment of the processes and barriers encountered in implementation
4. Evaluation of the workflow modification introduced by the new information management system

Study Hypotheses

Mobile healthcare provided using the Moca platform improves the delivery of health care in resource-poor settings along the following axes:

1. Quality of care: measured as improved clinical outcome as a result of a more timely interpretation of x-rays by a specialist
2. Efficiency of care: measured as turnaround time to receive the radiologist's report
3. Cost-effectiveness of care: measured as the incremental cost of obtaining radiologic consultation using Moca against the current model, divided by the improvement in clinical outcome
4. Provider and patient satisfaction: measured as a survey of providers and patients

Study Design

Type: prospective, two-cohort study with a controlled, open-label intervention followed by crossover

Exposure variable: healthcare providers who use Moca and those who do not

Outcome variable: turnaround time to receive an x-ray read from a radiologist

	Phase I (1 month)	Phase II (1 month)
Cohort I	Uses Moca	No Moca (paper-based)
Cohort II	No Moca (paper-based)	Uses Moca

Outcome Measures and Statistical Analysis

1. Quality of care metric: diagnostic accuracy of initial interpretation (generalist) vs. final interpretation (radiologist)
2. Efficiency of care process metrics:
    a. Turnaround time for radiologist report (current wait time is one week)
    b. Availability of radiologist report when requested by a provider
    c. Provider productivity measured as number of patients seen
    d. Time to a definitive treatment
    e. Percent of patients requiring a follow-up visit
3. Cost-effectiveness of care
4. Provider and patient satisfaction

Study Timeline

1. Select rural health clinics to participate
2. Perform cohort matching, use block randomization to keep two groups balanced
3. Begin Phase I (1 month)

a. First Moca cohort: training session completed before starting to use Moca to avoid recall bias. A provider can forego Moca for a patient who meets eligibility, but he or she should document why, i.e., “too busy”, “system down”, etc.

b. First paper-based cohort

4. Begin Phase II: Crossover (1 month)

 a. Moca cohort switches to paper-based

 b. Paper-based switches to Moca: training session completed before starting to use Moca to avoid recall bias

5. Record Outcomes

6. Exit Survey

There are very limited studies available evaluating the economic impact of tele-health and tele-medicine projects in the literature. Data obtained from the pilot study will be used to develop a Monte Carlo simulation Markov model to generate the denominator of the cost-effective analysis, and the cost-savings in the cost benefit analysis. This is what is truly required to demonstrate the value of this mobile technology-enabled clinical information system. These analyses will assess cost-effectiveness of tele-health and tele-medicine and guide governments as regards funding allocation.

Implementation Plan

Due to strong business interests in the Philippines, Moca is in the process of forming an arm to seek venture funding based on the attractiveness of the Philippines, ASEAN and global tele-health markets. Based on information from the National Tele-health Center and an analysis performed by our team in the Philippines, we have found a strong demand for the implementation of eRecords systems and tele-health services there. While there are hundreds of requests for eRecords deployments, the NThC does not have the capital or human resources to service these deployments.

Making tele-health succeed will require an integrated service and product offering delivered in a repeatable process. We believe this is an attractive market due to a willingness to pay for initial deployments, plus services revenue and equipment replacement and expansion thereafter. The idea is to provide an integrated offering that allows any doctor in the system to make a qualified referral, even if the only connectivity available is a GPRS network. The products and services delivered by our new organization, MocaHealth, would include the following:

1. **Specialist Medical Care**: Specialists such as radiologist, dermatologists and other field specific experts will be sourced and deliver services via this MocaHealth system. All cases will be received into a internal referral management server and directed to an appropriate specialists. Specialists will be able to work on their cases from anywhere with Internet access. Supply of specialist care will be managed centrally by MocaHealth’s operational team. Some cases will be tele-health referrals done via a Skype like technology, while others will be straight through processing.

2. **Deployment Services**: MocaHealth will sell hospital, clinics, governments and NGOs hardware packages specifically developed for eHealth and tele-health pre-loaded with all the required software to implement tele-health. Products include electronic medical records deployments, integrated tele-health/eHealth packages and innovative equipment. Included in these packages will be training and IT support services for a certain period of time. Longer-term, these service contracts can be renewed. The initial sale will be a bundle of hardware, software, deployment and integration, project management and training. MocaHealth will create recommended bundles to acquire economies of scale in sourcing that can be passed on to the customer, while also offering some equipment and services as add-ons.

3. **Ad-hoc Products**: Ideally, MocaHealth would have a strategic investor (or investors) who would assist the organization in developing the ideal hardware and integrated packages. This includes, but is not limited to, mobile devices, netbooks, portable diagnostics devices and connectivity devices. MocaHealth would then source these products, as well as other equipment necessary and re-sell it.

4. **Consulting Services**: MocaHealth would be available for strategy consulting and execution for out-of-the-box projects in the eHealth and tele-health space.

There is strong demand for many of these services. Dr. Alvin Marcelo, Director of the Philippines National Tele-health Center, indicated hundreds of requests for CHITS installations (Community Health Information Tracking System, a tele-health system originated in the Philippines), along with others calling out for tele-health equipment and support. Meanwhile, NGOs are funding deployments of systems such as OpenMRS and VistA (an electronic health record system used by United States Department of Veteran Affairs' medical system). However, the NThC is a small organization and cannot scale to provide these services on a wide basis. Since these systems are open-source, MocaHealth can provide these services as the choice contractor.

There would be a six month stage where the company would handle legal and administrative logistics, including acquiring an office and forming a legal entity. More importantly is the construction of an operational and technology infrastructure to support the system. A Chief Technical Officer would lead a team of developers to build a system utilizing a combination of open-source software and newly developed code. The primary investments would be in personnel and the cost of systems (laptops, servers and peripherals). We have attached a spreadsheet (Appendix E) with a proposed staffing plan and capital investments. A summary of our schedule for implementation is as follows:

Date of Funding: Set up legal and administrative structure, bank accounts and corporate permits.

Months 1 to 3: Co-pilot in Batanes or Capiz, two districts in which we are currently deploying. Freeze business requirements and begin integration of selected solutions. Staff Chief Technical Officer. Meet with key stakeholders at PhilHealth, Department of Health and the National Tele-health Center.

Months 3 to 6: Focus on technical and product development and creation of marketing collateral. Hire VP of Sales and formalize sales strategies. Begin hiring and training radiologists on the system. Recruit specialists to be part of the specialist network.

Month 6: Product launch. Scale up technical support and deployment organization.

Month 12: Reach target of 10 paying clients.

Month 24: Achieve profitability and reach 200 customers and PHP$50,000,000 in revenue (approximately USD$1 million).

Based on our financial modeling, we believe that with USD$750,000 would be sufficient to seed the organization to sustainability by staffing the leadership, sales and developer teams necessary to provide a quality product offering. This would allow us to build the end-to-end technology with web entry capabilities, medical record integration and a triage system. By the end of this stage, the team would have a saleable set of commercial services and products that would offer substantial value to rural health care providers. We believe that with USD$250,000 in angel funding from Lien, we could raise the rest.

The Moca team has met with several senior executives from the Philippines from companies such as Globe, Ayala, Smart and IMI. Based on an evaluation of our business plan (Appendix D), these executives indicated that if a prototype of the system is completed they would seriously consider venture funding.

Moca's Vision: Diagnostic Support for All

The business model of health care delivery in richer regions is predicated on a return model which generates the vast majority of the revenue through support contracts, cabling and disposable sensors. But delivery of such medical products and accessories is problematic outside of the intended market. Even when equipment is donated, as is the usually the case for third world countries, it can rapidly become obsolete and cost the recipient money to store or dispose of the equipment, creating additional burdens from a well-intentioned gift. For many years, non-profit organizations have wondered why Coca Cola can deliver to almost any remote place on the planet and yet we are unable to deliver health care in these same locations. Finally, an industry has appeared that accomplishes this: the telecommunications industry. The user-driven demand for cheap communication perhaps overrides many of our other impulses, and the poorest sections of humanity are reallocating their small amounts of disposable income to cell phones and air time. This has led to a formal and informal infrastructure that maintains and delivers communication facilities around the globe. By 'piggy-backing' on this system and leveraging the desire for humans to communicate we have an advantageous setting to deliver health care at a vastly reduced cost.

Another cell phone trend which is making this idea a reality is the rapidly increasing quality and variety of sensors which come with the phone. Doctors can use the camera for tele-dermatology or tele-radiology, the audio microphone to record heart and lung sounds, the accelerometer to record physical activity and compliance post hospitalization and the GPS, WiFi or GSM signal to provide location triangulation functionality. Furthermore, cell phones are more frequently being made with standard robust connectors (such as USB ports and audio jacks) and therefore they can connect with many standard peripheral devices to provide an almost limitless extension of monitoring capabilities. Some examples are blood glucose levels, medication compliance pill boxes, asthma or respiration tracking, heart rate, weight and oxygen saturation. We are currently beginning two programs to extend the diagnostic capabilities of the cell phone in this manner (see next section).The fact that cell phones have several means of transmitting and receiving data (GPRS, Bluetooth, WiFi, radio, USB port, etc) also means that they can provide the seamless ability to connect with remote databases to provide real-time support and data back-up in a highly redundant manner.

An additional advantage to using cell phones for data entry and retrieval is that, unlike laptops, cell phones provide familiar interfaces to almost anyone, are cheap and quick to replace, run on batteries for an entire day, are easy to charge (from the car cigarette lighter for example) and are more difficult (and less attractive) to steal since, for instance, users can more easily hide them in their pockets. Moreover, cell phones are the classic data encryption paradigm: something you have and something you know. By requiring passwords, authenticated from a pre-approved phone, it is easy to maintain data privacy while monitoring and managing access to medical data.

With the back-end in the cloud, Moca can quickly and easily scale up operations, and can benefit from the power of these computing systems. The key to cloud computing is to have the right partners. We have begun talks with Google.org in Cambridge, MA, USA, to determine if we can use the back-end computational and storage facilities of Google to store (de-identified or encrypted) patient data as a back-up to local hospitals and medical centers. This will also provide a strong computational platform to begin data mining to spot anomalies in the data, predict adverse events (such as disease outbreaks or drug stock-outs) and to train algorithms to repeat the expertise of human experts. It will be key to split the data between de-identified data (such as history of weight, glucose levels etc), and identifiable data (such as location, name etc). The latter will be encrypted, and a key will only be available to the hospital and perhaps one or two other nominated parties such as the patient and the government.

Moca aims to provide a solution to the shortage of trained doctors by recognizing the massive opportunity that cell phones present is their ability to provide medical decision support. Moca has the potential to expand its infrastructure in the Philippines to provide health care to more citizens than was previously possible. Moca will not only be a tool for maximizing health care delivery, but can improve the health of the Philippine nation as a whole. We have the health of the developing world in mind and are working hard to address this huge unmet need, beginning with rural health care.

Key Team Members

Leo Anthony Celi, M.D., M.Sc.

Leo is a perpetual student, having recently completed graduate studies in biomedical informatics at MIT and is currently pursuing a Masters in Public Health at Harvard. He is trained in internal medicine (Cleveland Clinic), infectious diseases (Harvard) and critical care medicine (Stanford) and has worked in the academe (Harvard and Stanford) and industry (Visicu), both here and abroad (University of Otago, New Zealand). Prior to returning to the US, he was the New Zealand representative to the Quality and Safety Committee of the Australia New Zealand Intensive Care Society. His research interests are diverse, and include the use of artificial intelligence in clinical decision support, quality improvement in the ICU, respiratory and endothelial physiology, end-of-life care and health care systems, among others. He is an adviser to the Next Billion Network project at the MIT Media Lab.

Ted Chan

Ted's strengths are strategy, operations and marketing. Ted has worked for two leading professional services firms, holding both strategy consulting roles and serving as Head of Information Technology for one firm. He holds the Project Management Professional (PMP) designation from the Project Management Institute, and is a Disaster Recovery Institute Certified Business Continuity Planner (CBCP). Ted was an early stage member of Moca, the founder of MassWrestling.com and several other successful enterprises. Ted holds a degree in Organizational Psychology and History with High Honors from Swarthmore College, as well as a certificate in Emergency Management and Organizational Continuity from Boston University. Ted has an MBA from the MIT Sloan School of Management, where he was part of the Entrepreneurship and Innovation program.

Gari Clifford, M.Sc., Ph.D., SMIEEE

Gari is currently a Principal Research Scientist in the Laboratory for Computational Physiology (http://lcp.mit.edu/) at the Harvard-MIT Division of Health Sciences where he is the engineering manager of a R01 NIH-funded research program, "Integrating Data, Models, and Reasoning in Critical Care" (http://mimic.mit.edu/), and a part-time contributor to the well-known Physionet Research Resource (http://www.physionet.org/). His role is to manage a large inter-disciplinary team of students, medical staff, and engineers to build massive medical databases and develop intelligent decision support algorithms to provide early warning signals of life-threatening events. Dr. Clifford holds a Bachelor's degree in Physics and Electronics, a Masters in Mathematics and Theoretical Physics from Southampton University and a Ph.D. in Neural Networks and Biomedical Engineering from Oxford University. He is also a Senior Member of the IEEE and has worked in industry on the design and production of several CE- and FDA-approved medical devices with over 15 years of experience.

Ben Goldthwaite

Ben is a software specialist with 20 years of industry experience. He led development and implementation teams in the US and Asia while working as IT Director for contract electronics manufacturer Sanmina-SCI Corporation. Ben's accomplishments over 11 years included managing development of web and traditional client applications used by product engineering groups to automate data set up tasks. He performed project management functions, mentored staff, and led process improvement initiatives including Agile/Scrum. Ben also developed software, designed databases and created a decision support system. Earlier in his career, Ben joined software vendor Valor Computerized Systems, Inc. at the startup phase as employee number four. As Regional Applications Manager, he partnered with sales to grow the business in US, Canada, and Asia. Ben consulted with customers on system integration and automation to facilitate ROI of the companies CAM and data archiving products. He developed custom software programs to meet specific client needs. Ben was also responsible for customer support, including technical liaison to Israel R&D team for crisis management and new capabilities. Prior to Valor, Ben worked as Software Engineer for four years at Orbotech, Inc. He provided pre- and post-sales support and end-user training for the companies Plotter/AOI equipment and CAM software. Ben consulted for key clients, performed workflow audits and full life cycle custom software development.

Aamir Khan, M.D. (Adviser)

Aamir is the Executive Director of InterActive Research and Development as well as serving as associate faculty at Johns Hopkins University and the Aga Khan University in Karachi, Pakistan. Dr. Khan trained as an epidemiologist at the Aga Khan University and at the Johns Hopkins Bloomberg School of Public Health. He joined the faculty at Johns Hopkins in the Division of Disease Prevention and Control in 1998, where he earned his Ph.D. in International Health with a focus on infectious disease surveillance and vaccine trials. He has coordinated research on behalf of Johns Hopkins on the persistent excretion of poliovirus in seven countries, pneumonia surveillance in the northern areas of Pakistan and measles surveillance and vaccine trials in Karachi. He is the Site Principal Investigator on the Global Alliance for Vaccines and Immunizations (GAVI) PneumoADIP funded grant for preparations for a pneumococcal vaccine trial in Karachi. He is also the Director of the Center for Injection Safety (CIS), Karachi, Pakistan (there are 6 centers in total; they, together, make up IRD), in collaboration with the Safe Injection Global Network and Becton Dickinson. Dr. Khan's significant experience in public health and his broad global network will be critical in shaping the direction of the IIH program. It was his frustration with running into health problems that require engineering solutions that gave him the initial idea for the Innovations in International Health program. His organization will provide students with numerous design challenges, give feedback on the proposed designs and provide resources to enable the students to run field trials on their prototypes in Pakistan.

Alvin Marcelo, M.D. (Director of the National Tele-health Center)

Alvin is a general and trauma surgeon by training and is currently the director of the University of the Philippines Manila National Telehealth Center. Right after residency training, he took his postdoctoral fellowship in medical informatics at the National Library of Medicine in Bethesda, Maryland with research interests in telepathology, mobile computing, and bibliometric analysis of MEDLINE content. Upon return, he established the Master of Science in Health Informatics program in the University. He is presently the manager of the International Open Source Network for ASEAN+3, a centre of excellence in free and/or open-source software established by UNDP, and he manages the Community Health Information Tracking System (or CHITS), a Stockholm Challenge finalist in the health category in 2006. He is the Philippine representative to the Asia Pacific Association for Medical Informatics (APAMI) and the International Medical Informatics Association (IMIA). Dr. Marcelo is currently a policy consultant for PhilHealth.

Chris Moses

Chris is a senior at MIT, pursuing a Bachelors of Science in Brain and Cognitive Sciences, expected June 2010. Chris is developing a brain-computer interface for accelerated post-stroke recovery. He is president of the international student leadership organization, STeLA (http://web.mit.edu/stela-mit/). He worked for three years as Account Executive at National Mobile Billboards, where he was generated over USD$1 million in sales at the advertising vendor. Chris joined Moca in January 2009, and participates in business development and fundraising efforts.

Jhonatan Rotberg

Jhonatan is the founder and director of the Next Billion Network program at MIT, and the instructor of MIT's NextLab course series. He is the Telmex Researcher at the MIT Media Lab and a Lecturer in the Media Arts and Sciences Program. A serial entrepreneur, he is experienced in the original conception and deployment of innovation, applications and content in developing countries, and in building projects and organizations based on digital technologies. During his career, he has founded and sold various startups in the financial and high-tech sectors. His current focus is on designing innovative mobile technologies that help people reduce friction in their local markets from the bottom-up, and on incubating ventures that allow them to scale and become sustainable in the emerging markets. Previous to joining Grupo Carso, Latin America's largest telecoms provider, he spent 7 years in the financial services practice of Accenture, and in the Investment Banking divisions of Baring Securities and Deutsche Bank. A native of Mexico, Rotberg is a graduate of Brown University.

<u>Luis Sarmenta, PhD</u>

Luis is a Research Scientist at the MIT Media Lab. Originally from the Philippines, he has personally experienced the revolutionary impact that mobile phones have had in the developing world, and thus deeply believes in the enormous life-changing potential of mobile phone applications. While working as a professor at Ateneo de Manila University, he founded and directed an R&D center that worked with the largest mobile operator in the Philippines and produced 30 commercially deployed mobile phone applications and services in its first two years. Sarmenta holds a Ph.D. in EECS from MIT, and has done research and consulting work in a variety of topics including volunteer computing, grid computing, computer security, medical computing, educational computing and others. He was a recipient of the ASEAN Young Scientists and Technologists Award in 2005.

<u>Peter Szolovits, Ph.D. (Adviser)</u>

Pete is Professor of Computer Science and Engineering in the MIT Department of Electrical Engineering and Computer Science (EECS), Professor of Health Sciences and Technology in the Harvard/MIT Division of Health Sciences and Technology (HST) and head of the Clinical Decision-Making Group within the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL). His research centers on the application of AI methods to problems of medical decision making and design of information systems for health care institutions and patients. He has worked on problems of diagnosis, therapy planning, execution and monitoring for various medical conditions, computational aspects of genetic counseling, controlled sharing of health information and privacy and confidentiality issues in medical record systems. His interests in AI include knowledge representation, qualitative reasoning and probabilistic inference. His interests in medical computing include Web-based heterogeneous medical record systems, life-long personal health information systems and design of cryptographic schemes for health identifiers. He teaches classes in artificial intelligence, programming languages, medical computing, medical decision making, knowledge-based systems and probabilistic inference. Prof. Szolovits has served on the editorial board of several journals and as program chairman and on the program committees of national conferences and has been a founder of and consultant for several companies that apply AI to problems of commercial interest. He received his Bachelor's degree in physics and his Ph.D. in information science, both from Caltech. Prof. Szolovits was elected to the Institute of Medicine of the National Academies and is a Fellow of the American Association for Artificial Intelligence, the American College of Medical Informatics and the American Institute for Medical and Biological Engineering. He also serves as a member of the National Research Council's Computer Science and Telecommunications Board.

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Appendix D. Moca Philippines Venture Approach

Appendix E. MocaHealth Financial Model

Appendix F. Stakeholder Analysis

Appendix G. Moca Demonstration Video

This can also be accessed at http://vimeo.com/4118295.

Appendix H. Initial Site Visit Video

This can also be accessed at http://vimeo.com/5716395. Password is “manila”.

Appendix I. Abbreviated Resumes of the Moca Team Members

Appendix J. Abbreviated Resumes of National Tele-health Center Key Members

Appendix K. Journal of Health Informatics in Developing Countries publication

Appendix L. Other mHealth Projects and Software

Appendix M. Future Peripheral Device Projects