Mobile decision support system for outreach health worker

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Abstract –**People in rural areas do not have convenient access to quality healthcare close to their locations. Although there are health care centers in villages, they are not staffed and most lack in basic infrastructural facilities. Villagers are forced to travel long distances to district head quarters or major cities to avail of medical facilities, often at high cost, which they can ill afford. We developed a mobile based decision support framework on the Android open platform and demonstrated the feasibility of building the complete end to end system for large scale deployment to outreach health worker. The decision support system enables the outreach health worker to deliver consistent and quality primary healthcare to rural population. The same platform can host other revenue generating opportunities for the outreach worker to keep them motivated and providing them a means of livelihood.**

Keywords: Android, Decision Support System, Rural Health

I. INTRODUCTION

There are 142,000 rural sub centers in India which forms the first peripheral contact point for the rural population with the primary care system. The rural sub centers are typically manned by one male and one female paramedic. In reality, most of the rural sub centers are not staffed and do not have resources to provide even basic health advice services. Accessing basic healthcare for rural and disadvantaged population in urban areas is becoming expensive. Rural population travel a long distance, forgo their wage for that day to get basic healthcare access.

India's National Rural Health Mission (NRHM) has implemented a program called ASHA or Accredited Social Health Worker to address the easy access to basic healthcare issue for the rural population. ASHA worker will provide the first contact care to people in rural areas. It is expected that every district will have 1000 ASHA workers [1]. ASHA worker is primarily a resident of the village in the age group of 25-45 years, and having formal education till 8th standard and a volunteer with no fixed salary [2]. The voluntary nature and the no fixed regular income have resulted in low motivation and high attrition of ASHA workers. Each ASHA worker undergoes 23 days of basic training and it takes them months to become effective on the field. This high turnover and lower motivation has a direct bearing on the quality and consistency of the first contact health service delivered to the rural population.

Our solution focuses on three main aspects to deliver quality health care at affordable cost:

- Provide an open platform based mobile decision support system which aids the outreach health worker in the treating common diseases (E.g. Child and Women health guidelines of World Health Organization [8]. This enables ASHA workers who are new to the system to become productive and provide quick and safe treatment plan on site.
- Provide revenue generation opportunities (microfinance, micro distribution, data collection and insurance) for the outreach worker using the same mobile platform. This enables the outreach worker to earn a livelihood and be motivated to reach out.
- Collect health and demographic data sets to be used for accurate planning and resource allocation by Govt. agencies.

We have developed a decision support system for the ASHA volunteer on the open Android [4] mobile operating system. We ported the open source CLIPS rule engine (C Language Integrated Production System) [5] on Android based mobile platform and built a context management framework around it. Based on the ASHA volunteer profile, we designed the input screens which walk the ASHA volunteer through the inputs required as per the child and women health guidelines. These guidelines have been encoded as CLIPS rules, which use the input data from health worker and generate treatment recommendations. The data and treatment recommendation can be stored on the backend sever over public data link infrastructure used for planning and resource allocation by Govt. agencies.

There is ongoing work to extend the decision support platform built on the Android platform to collect physiological (E.g. Heart Rate, Sp02, BP, temperature etc.), spatial (E.g. home, gym, office, and park), temporal (E.g. morning, evening, night), environmental context (E.g. humidity, temperature) data and generate higher level context information. This will be used to select the treatment plan and recommendations based on the current context.

II. MOBILE DECISION SUPPORT SYSTEM

There are two major components in the ecosystem [Figure 1.], the hand held smart phone based decision support system for ASHA worker and the backend context sensitive health telemetry platform which provides rule updates and alert based on the data it receives from the hand held device.

Based on the demographic data of the patient (man, woman, child and age), the decision support system selects the appropriate primary health guidelines which prompts the ASHA worker to capture the relevant observations from the patient. If required, some of the vital signs are also captured with the help of portable sensors which feed data directly via a Bluetooth connection. Once all the data is captured, the disease rule sets are run and based on the results of the rules and the context (e.g. location, skill of the ASHA worker, availability of drugs), the system provides treatment recommendations.

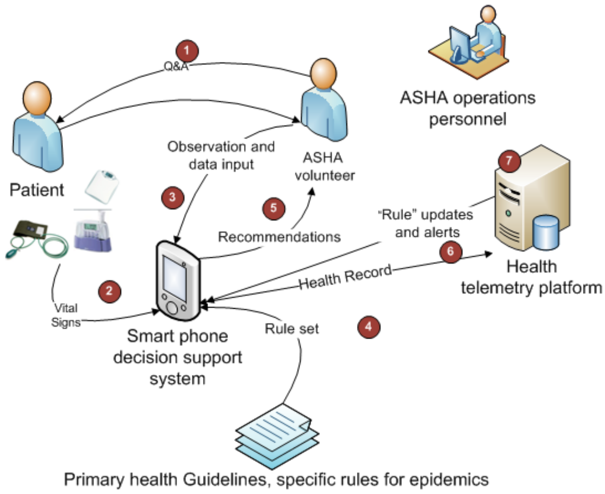

Figure 1. ASHA decision support system work flow

The health record is also sent to the backend server via the public wireless infrastructure (GSM/CDMA). The backend telemetry health server has two functions. To store the health record used by Govt. agencies for planning purpose, and to send updated rules and alerts. For e.g. if there is a large number of fever cases from various ASHA workers in a particular region, the server generates "epidemic alerts" to keep the ASHA worker informed to take appropriate measures.

III. USAGE OF CONTEXT IN DECISION SUPPORT

For guided response to common ailments, The medical guideline recommends the three steps: Assess the patient, mostly verbal questions and observations, classify the symptoms E.g. dysentery, severe pneumonia etc as per the recommended rules, and for each of the assessed symptoms suggest a *treatment* plan that can be carried out by the local health worker. All the three steps have detailed guidelines on 'how' to do each step. In the Indian context, with the diversity of languages, skills sets of ASHA workers, climate, literacy rate, access to next level health facility and prevalence of certain type region specific preventable diseases, all the three steps can change based on the environment context.

Previous work [8] talks of a context based decision support system for health workers where the scope is mostly varying the treatment procedure based on static data like availability of health worker resources. Our core system goes beyond this and builds a framework where assessment, classification and treatment procedure can change based on the environment context at hand and is dynamic in nature [Figure 2.].

Let us look at an example of how our decision support system uses the context to help the ASHA worker in her job. An ASHA worker is treating a sick child whose age is greater than two years (demographic context), is a resident of an area labeled as anemia prone (location context) , iron supplement tablets (environment context) and the time of day evening (temporal context). Based on the demographic context (child > 2 years) and the location (GPS co-ordinates), the system picks up the appropriate assessment questions. The treatment plan now takes into account the iron supplement status and the time of day and gives a recommendation to be back after a day to collect the tablets. The hand held system raises an alert to the backend system to send the required tablets to the ASHA volunteer.

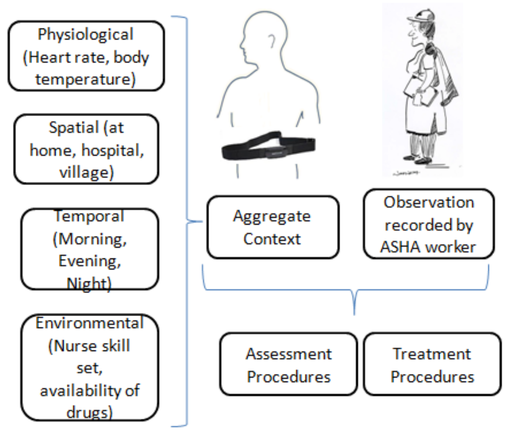

Figure 2. Dynamic selection of assessment and treatment procedures based on context

IV. ARCHITECTURE OF MOBILE DECISION SUPPORT SYSTEM

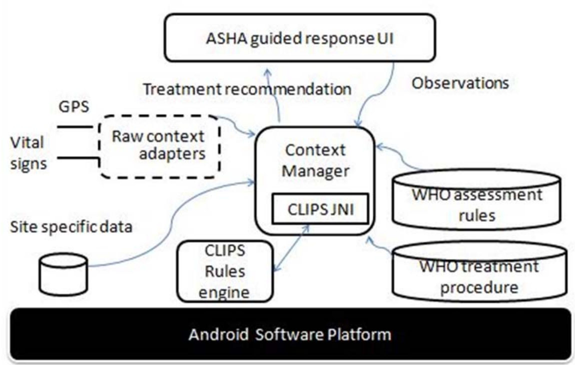

Figure 3. Software architecture

Google Android 2.2 mobile OS is used as the base platform. CLIPS rules engine has been ported and made as a library using the Google Native Development kit. Context Manager (in JAVA) takes in raw context from multiple sources and based on the aggregate context, chooses the appropriate disease assessment rules. The observations from the ASHA guided response UI along with the site specific data is sent to the CLIPS rules engine using the CLIPS JAVA Native Interface. The rule engine generates patient state assessment based on the observation and context data. The Context manager uses the site specific data and the patient state assessment to generate specific treatment recommendation for the patient.

We have built the core context manager, user interface and the CLIPS JNI interface and integrated it to work on the Android based mobile device. Our next step is to start on the raw context software adapters and explore integration with generic Bluetooth based vital sign sensors.

V. RESULTS AND DISCUSSION

We implemented the core decision support system on Android platform incorporating the complete diarrhea guidelines. The entire application is able to run on an Android phone with 512MB memory. We have the basic framework in place now to build the rest of the system including the context adapters and the server component for data capture and analysis.

The knowledge of diarrhea disease is implemented as set of 29 rules. It takes around 5 milliseconds to process the rules for diarrhea in an android phone with 512 MB RAM and CPU 1 GHz.

We plan to take the system and conduct field trials with the current set of capabilities to gather field feedback which can be incorporated into the system before we start building in rest of the capabilities. Android based tablets are now appearing in the market and the price points are going down. We plan to explore e-tablet option and seek usability feedback compared to the phone form factor.

VI. BENEFITS

Our Mobile Decision Support System (M-DSS) provides following benefits:

- M-DSS improves efficiency and effectiveness of Primary Medical Care. Today's primary medical care is limited by the skill level of the ASHA worker. Even with a very high level of sophistication of the ASHA worker, it is extremely difficult, if not impossible, for her to remember and process the complex rules for assessing and classifying an ailment and to eventually provide the appropriate treatment. However, our mobile-based decision support system empowers an ASHA volunteer to perform at the highest level of competency, regardless of his/her skill level, as the knowledge needed for him/her to do assessment and classification of ailments, and to provide appropriate treatment is encoded in his/her mobile handset.
- Improves the time to deliver treatment immensely. Many a time, after doing the diagnosis, an ASHA worker is not able to offer the desired treatment due to the unavailability of the appropriate medication. Furthermore, the delay in communicating the information back to the healthcare center further delays the overall delivery of medical treatment. The mobile based decision support system will also collect statistics on the availability of drugs with the ASHA worker, and will remind as well as send a request for replenishment to the backend support system.
- The same platform will also be able to generate epidemic alerts based on the type of first level treatment being offered by the ASHA worker – for e.g., if the number of dysentery cases increase in a certain time frame, the system is capable of generating "possible food or water contamination alerts", and enables ASHA worker to proactively work with the village sanitation committee to mitigate these problems before they turn into a full blown epidemic.
- The mobile platform works on the public wireless technologies like GSM/CDMA and being portable, enables various type of data collection and real time updates. The platform enables birth/death data to be instantly updated, periodic updates of sanitation and wellness data which can be used by Govt. for planning and deployment of resources based on valid data which is not stale.
- Since the core context framework is generic, and with the underlying platform being an open Android mobile platform, various applications like micro finance, insurance, survey, retail **Error! Reference source not found.** can be built on top of this platform. These applications enable the ASHA worker to generate revenue for herself and keep her motivated to do her regular ASHA work.

VII. TECHNOLOGY CHALLENGE

Designing such a system has got following challenges:

- User interface which can adapt to different mobile interface capabilities
- Ability to load different application widgets, guidelines over the air
- Rules engine which can fit into the small footprint of a mobile device or an e-Tablet
- Supporting multiple languages (e.g. Hindi, Kannada)
- Lack of reliable GPRS connectivity in rural India
- Keeping the total cost of each deployment kit(end user device and vital sign sensors cost in the range of 100-150$
- Interfacing with multiple partners like microfinance, insurance, social enterprises and their IT systems to generate revenues for the company as well as outreach worker

- Installing, upgrading and configuring decision support application on various kind of android devices

We have been able to address few of the challenges in the core decision support built on the Android platform. With Android based smart phone prices coming down in India, the distinction between a feature phone and a smart phone in term of prices is narrowing down. Huawei has launched their IDEOS low cost Android 2.2 based phone in India with a target price of around 4,600 Rupees [3]. Android based smart phones being an open platform, the price point is approaching < 100$ mark with new features being released at regular intervals. We decided to base a large part of our application stack on open platforms to keep the cost low. We were able to fit the generic open source rules engine on a 512 MB RAM Android Phone and a complete decision support system having the child and women health rules is being built.

Ability to load different application widgets, data and rules over the air is another challenge which is now possible with Android Cloud to Device Messaging Framework [7]. This service provides a lightweight mechanism where the server informs the Android applications to fetch the updated applications and data. Android C2DM is currently in Google Labs and would be shortly available to all Android developers. Even the latest android release (Android 2.3) does not fully provide support for Indian languages like Hindi, Kannada. However simple Hindi characters can be displayed in android phone but complex Hindi word like अन्ग्रेज़ी (“English”) are wrongly displayed as अनगरेज़ी. We will have to wait till android fully supports Indian languages like Hindi and Kannada.

When GPRS connectivity is not available the application would have to queue any communication request to the back end server and the moment GPRS connectivity becomes available, the application would have send each communication request to the server one by one.

VIII. ECONOMIC CHALLENGE/CONSIDERATION

As mentioned in VII, we need to keep the cost per device to ~150$. Android was chosen as the base platform along with open source frameworks for the core of the rules engine and it works in various kinds of devices from mobile to TV.

The other challenge is to provide a continuous revenue stream for the outreach worker so that she is motivated to do the job and has incentives to match the extra effort she puts in. The current platform can support various applications like survey applications, micro banking application, etc on top of the generic context manager framework. The objective is to provide a continuous revenue generation opportunity to all partners involved in the project.

IX. UNIQUENESS

We followed a platforms approach in building the mobile decision support system which takes in raw context data from multiple sources like environment, temporal, physiological sensors, spatial and, visual observations and aids in the decision support process. This multiple context sources integrated into the decision support process is unique in nature. The framework supports integration of any number of context sources in future. The same platform can be leveraged to offer other revenue generating opportunities. These functionalities packaged in an Android based smart phone hardware device which is portable and easy to use by volunteers like ASHA is novel.

X. CASE STUDY

The rural decision support system has been successfully demonstrated to various mobile operators and Govt. health agencies in India and so far the feedbacks have been very positive.

In addition to that we have agreed to work with a social enterprise for joint field trials in rural India and seek feedbacks from the ASHA workers. We will incorporate all feedbacks received from various stake holders and plan to go for full scale deployment of the decision support application in rural India.

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