Smartphone Based Interface for Epidemic Surveillance System

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***Abstract*—Accurate and timely patients data collection has been a challenge for developing countries. Traditional methods used for patients data collection in epidemic outbreaks has proven to be insufficient. Emerging technology calls for faster, reliable and easy data collection tools. This paper presents the design and implementation of mobile based patients data collection system for epidemic surveillance especially in remote areas. It shows how the emerging technology of smart phones can revolutionize the traditional data collection methods. An easy and user friendly interface is developed for medical staff to provide them with much easier system than inept existing systems. The system provides solid basis for government organizations in order to take on-time precautionary steps. The proposed system can be used at health departments as part of electronic health record systems for timely, accurate and easy collection of data from disease struck regions in the developing countries that lack basic infrastructure for the surveillance of disease.**

***Index Terms*—epidemic surveillance, android, acquisition, data transmission, data visualization**

I. Introduction

Most developing countries have to face a number of epidemics including cholera, malaria and dengue. A significant number of the registered cases result in deaths due to insufficient health data, limited resources, outdated technology and unsuitable planning and management. Being an integral part of many administrative and research tasks in disease control, it is important that the policy makers and health service providers receive accurate data in a timely manner [1]. The collection of data is a challenge in the developing world due to lack of modern facilities [2, 10]. The timely availability of data becomes even more critical in disasters such as floods, earthquakes and epidemic outbreaks. An epidemic becomes more imminent in areas affected by such disasters and the collection and maintenance of patient data become very difficult for governments. Most of the developing world relies on traditional data collection methods i.e. pen and paper. Data processing becomes complicated and time consuming with these methods [3, 10]. With the advancement of technology and the introduction of smart phones, several studies focus on mobile interfaces for improving data collection in the developing world [2]. Reportedly, seventy percent of cellular phones subscribers globally live in middle and low income countries [4]. Smart phones are an easily affordable means of data collection due to their large memory, connectivity and long lasting battery [5]. So, there should be smart phones based patients data collection systems [6].

This paper describes the development and implementation of an android based interface for patients data collection in remote and disaster affected areas as well as in urban units. We will call our proposed system as Patients Data Collection Tool (PDCT) throughout this paper. Being a part of the project Dengue Epidemic Surveillance Modeling, Visualization, and Response Management System, PDCT focuses on surveillance of infectious disease outbreaks in developing world. The proposed structure consists of three main modules:

- Data Acquisition, cleaning and transformation
- Data Transmission (Client/Server Communication)
- Data Visualization using temporal charts

It provides administrative organizations with an economical pocket tool for on-site patients data collection in disaster affected areas. The centrally linked systems can communicate their collected data with a central database that further allows visualizing data on each android device.

II. Literature Review

Pen-and-paper has been the most common platform for data collection for decades. But the limitations of this system such as fragmentation, limited accessibility and often illegible hand writing demanded a shift towards a more reliable source of data collection [11]. The solution was found as Personal Digital Assistants (PDAs) with first example of CyberTracker [12]. PDAs were far better than pen and paper [7] and successfully revolutionized conventional methods. Many physicians started using PDAs in clinics. But PDAs have many hardware and software limitations such as small screen size, difficult input methods, inflexible table structure, and asynchronous hotsyncing [13]. Furthermore the falling prices of Java-enabled phones made Java Platform, Micro Edition (J2ME) phone-based data collection clients popular [10]. J2ME was much more economical compared to PDAs but some of its features

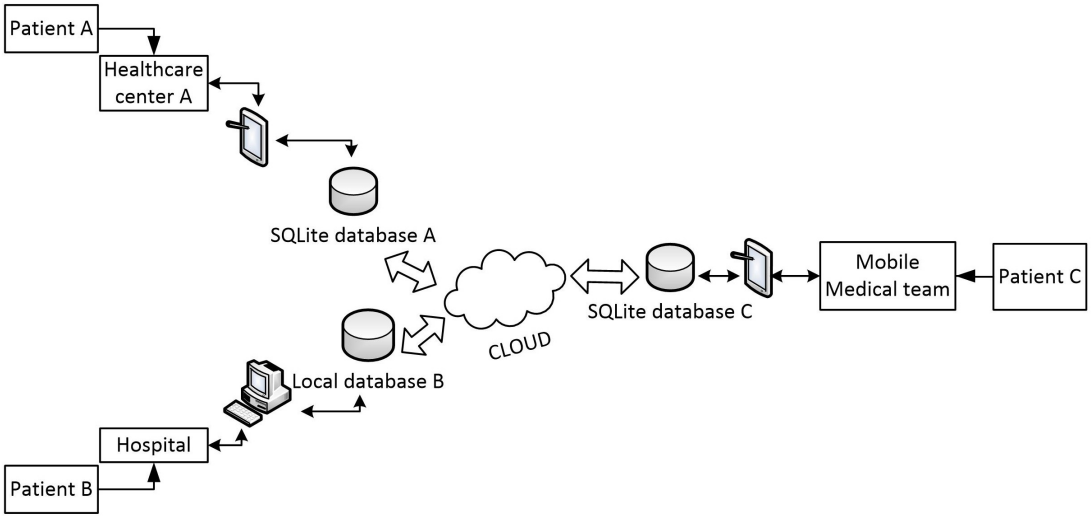

Fig. 1: View of our proposed system

like insufficient support for data types, limited processing power, restricted storage and lack of connectivity limited the use of J2ME [2]. Moreover, the limited compatibility of J2ME devices and difficult information flow also made J2ME applications complicated to use. In the field of emerging technology of smart phones, Open Data Kit (ODK) [2] and EpiCollect [9] are two most familiar android data collection tools so far.

ODK consists of four modules i.e. ODK Collect, Aggregate, Voice and Build. ODK Collect is an open source mobile platform that renders an application or survey form and supports many data types that include text, location, images, audio, video, and barcodes [2]. ODK Build helps to build a form for survey or data collection to integrate it with ODK Collect running on android devices. ODK Aggregate can link android application with cloud servers such as Google App Engine, Amazon Web Services and Tomcat Server to store data received from ODK Collect. ODK provides vast range of use for patients data collection, managing medical record, surveys, microfinance institutions transactions tracking, geo-tagged reports of interventions for funders, capturing images and locations of damaged areas after an earthquake etc [10].

EpiCollect is an android data collection tool for epidemiologists and ecologists during their field surveys. It links different android devices with a common server via web services for client-server communication. EpiCollect is a GPS based android application that submits data collected from different places to the server. This data can be displayed on both, android devices and server computer. Similarly, the visualizations can be observed on Google Earth and Google Maps on all the android device and server [9]. Though EpiCollect is a great motivation for our system due to its client-server communication and data visualization schemes but it cant be replacement of PDCT due to its specificity.

Open Data Kit, though an efficient tool for data collection on android applications, cant be extended to our system due to some of its limitations. ODK Collect is not user friendly application for patients data collection. Placing the ODK build form into the application directory /odk/forms limits the circle of users or requires trained staff. Moreover, searching in filled forms is difficult as title for all entries is named as table name. No searching is available to find a particular entry in the list. Furthermore, ODK aggregate puts data integrity on risk due to its security issues. Supported servers i.e. Google App Engine, Tomcat Server and Amazon Web Services are not suitable due to charges, connectivity and security issues. But PDCT provides user with a friendly plug and play application ensuring encrypted communication with servers over cloud.

III. Materials and Methods

PDCT was developed on open source Android Operating System SDK. Testing was done on commercially available different android sets of version 4.1 and above. Client side UI was developed in XML and scripting in JAVA while server side UI was developed in HTML and scripting in PHP. The client-server communication was done on JSON SOAP messages. All the data are stored in SQLite database in android and PostgreSQL Server on server side.

IV. Proposed Architecture

Our proposed system is a part of patients data collection system developed for our aforementioned project. The data is collected from hospitals, healthcare centers and mobile medical teams. Data is collected in hospitals using desktop based applications while in remote areas the ideal choice is to collect data using smart phone applications. Our system is based on client-server model of communication which means that data from all field sources are received on the same server. Our proposed system as a part of the whole system is shown in Fig 1.

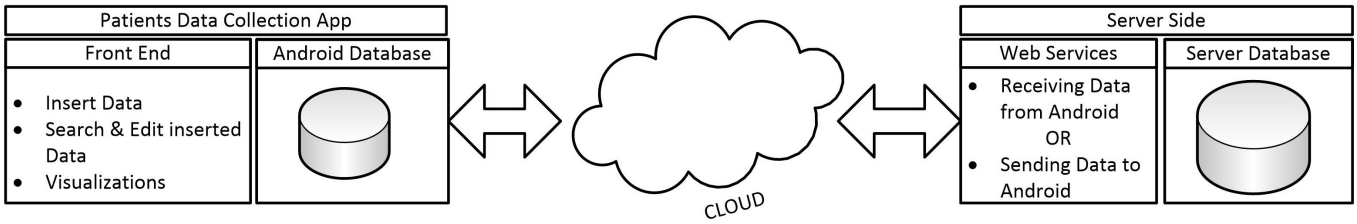

Fig. 2: PDCT flow diagram

A. User Interface

User Interface of PDCT is designed using XML. PDCT user interface consists of eleven pages including title page. Home page allows selection of one of the three available modes. Add Record covers two pages; one for personal data Fig 3b and one for symptoms Fig 3d. View Record shows all data in the form of a list on one page Fig 3c and contains two more pages that are used for editing an individuals data. Statistics cover four pages; one for selecting charts type Fig 3e and other three for showing those charts.

B. The Framework

The framework of our proposed system consists of three components:

- PDCT that runs on android devices.
- Server DATABASE which is a global data bank that can be used by any device running PDCT
- Web services that act as a bridge between PDCT database and server database.

PDCT consists of generic software for all commercially available androids of version 4.0 or above. This allows medical staff to collect and save patients data. The collection and storage of data does not require network connectivity. Data are stored in local database and can be fed to server later on availability of network. Similarly, the visualization module of our project does not require network connectivity. The visualizations are created using built-in algorithms. Due to these features, PDCT can be used effectively in remote areas that lack technological infrastructure such as computers and internet. To enable client-server communication, we have developed web services. This communication is done in JSON SOAP messages and data are inserted to and retrieved from server database through these web services. The layer architecture of proposed system is shown in Fig 2.

1) PDCT Flow: When PDCT is launched on smartphone, three modes are initially available; Add Record, View Record and Statistics Fig 3a.

Add Record enables user to register a newly reported patient data. Selecting this option generates a unique ID for the patient automatically. The user has to enter two details. All personal details of a patient i.e. name, CNIC, age, gender and address is required in the first step Fig 3b. On successful validation of fed data, the application requires the symptoms complained by the patient such as cough, cholera and stroke in the next step Fig 3c. On pressing save button, the complete record of the patient is saved in mobile database.

View Record allows the data stored in local database to be viewed. The user can search for a particular patient using queries of first name, last name and CNIC, as shown in Fig 3d. The complete profile of an individual can be viewed and updated on selection from the list.

This mode is the key mode as it also acts as client-server communication platform. Data are sent to and retrieved from server from here. If network connectivity is available, either all the available or selected data may be sent to server flushing it from local database in order to avoid database overpopulation. Furthermore, data of a specific individual can be retrieved from server.

Visualizations allows the plotting number of cases recorded versus different parameters such as age, gender and time Fig 3e. The visualizations are based on server data and are done through MPAndroidChart library. This mode enhances PDCT universality to researchers, control room monitors and policy makers for quick responses on the basis of timely visualizations. The visualizations are based on server data gathered from multiple PDCTs. It gives a researcher similar display and analysis tools on their smartphone phone that they would have in their lab PCs. Number of patients versus age trend is shown in Fig 4.

2) Databases: When a new case is reported, it is first stored in the smartphones local database. The default database available within Google Android, SQLite is an open source database. SQLite supports all standard database features and SQL queries. It requires a small runtime memory (approx. 250Kbyte) [14].

We hold a postgreSQL central server database for storing data collected from all sources. This server is located at Center for System Simulation and Visual Analytic Research (C-SVAR)[1]. When the data is sent to server, it is saved on the central database. PostgreSQL database is an Object-Relational Database Management System (ORDBMS). This database, as its primary functions, can save data securely. It allows data retrieval at the request of other software applications such as PDCT. This request is interpreted through web services.

3) Web Services: For client-server communication, web services are established. The services are deployed in JAVA language and communicate via JSON SOAP messages. The client (PDCT) sends a query regarding data storage or retrieval in JSON SOAP message which is interpreted by these services.

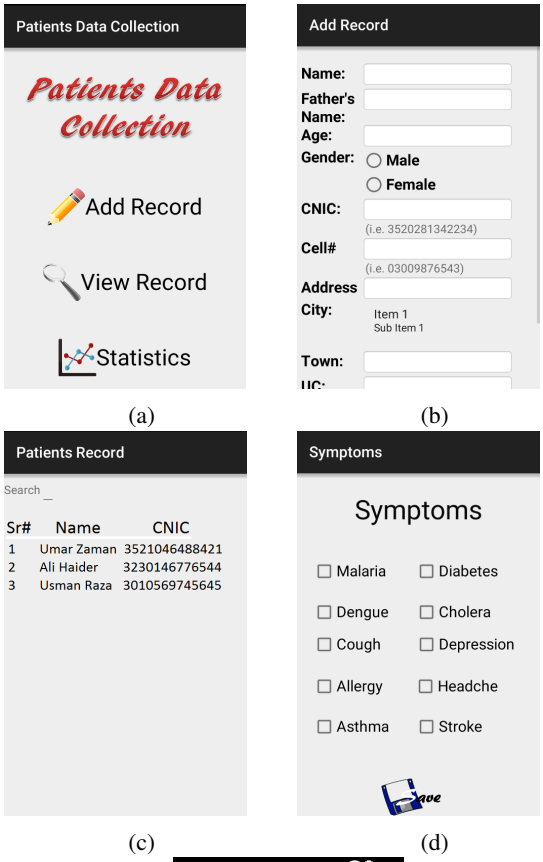

Fig. 3: Screenshots of PDCT

The server then responds and performs queried operation. Similarly, on data retrieval request, these services send queried data in JSON SOAP message which is then decoded by PDCT.

V. Conclusion

The Patients Data Collection Tool is a handy tool for collection of patient data from far-flung areas. This eliminates the number of unregistered cases. With an easy to understand interface, the tool provides an effective means of collecting, cleaning, transforming, communicating and visualizing data. Timely reporting of data enables the healthcare officials to act on the disease threat on time. The database queries provide

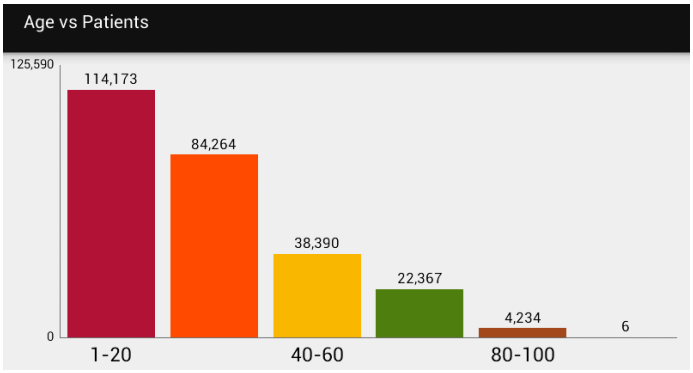

Fig. 4: Age vs. Patients trend visualized by PDCT

deeper insight into the disease dynamics by displaying gender-wise and age-wise data in selected regions.

In comparison to desktop based data collection tools, PDCT is an efficient tool that provides a better user experience and mobility, hence allowing a greater outreach as well. The integration of PDCT in global Electronic Health Record Systems can prevent data collection delays and integrity risks in disaster-effected regions. The visualization charts can also help the health officials in understanding the dynamics of disease. The user can contrast and compare the changing trends in age, gender and region over time, hence allowing informed and detailed analysis of the epidemic.

VI. Further Work

Our enhancements to the Patient Data Collection Tool will include adding geographical visualizations in which the number of patients can be viewed on geographical maps, hence giving a better measure of disease spread with respect to region. To improve the analytical capability of the tool, climate data will also be integrated. The tool can then correlate climate data with the number of patients, hence allowing health officials a better understanding of the behavior of disease and the effect of climate on the number of patients. We will also increase the scope of the tool to a global level where it can be used as an automated tool to collect, transform, transmit and visualize data of patients all around the world. Industrial standards of data collection, transmission, security and visualization will be employed to enhance the user experience and make the tool compatible will existing data collection systems being used worldwide.

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