

Mobile Phone as a Tool for Data Collection in Field Research

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Abstract—The necessity of accurate and timely field data is shared among organizations engaged in fundamentally different activities, public services or commercial operations. Basically, there are three major components in the process of the qualitative research: data collection, interpretation and organization of data, and analytic process. Representative technological advancements in terms of innovation have been made in mobile devices (mobile phone, PDA's, tablets, laptops, etc). Resources that can be potentially applied on the data collection activity for field researches in order to improve this process.

This paper presents and discuss the main features of a mobile phone based solution for field data collection, composed of basically three modules: a survey editor, a server web application and a client mobile application. The data gathering process begins with the survey creation module, which enables the production of tailored questionnaires. The field workforce receives the questionnaire(s) on their mobile phones to collect the interviews responses and sending them back to a server for immediate analysis.

Keywords—Data Gathering, Field Research, Mobile Phone, Survey.

I. INTRODUCTION

DATA gathering is one of the main activities of the field research. The field research is needed in many scientific disciplines as well as in many areas of industry and it can be developed under a quantitative, a qualitative or both approaches. Any type of research that produces findings not arrived at by statistical procedures or other means of quantification are considered qualitative [1]. Some of the data may be quantified as with census or background information about people or objects studied, but the bulk of the analysis is interpretative. The term “qualitative research” can refer to research about person's life style, experiences, behaviors, emotions, and feelings as well as about organizational functioning, social movements, cultural phenomena, and interactions among different nations.

The main contribution of qualitative research is the culturally specific and contextually rich data it produces [2]. Basically, there are three major components in the process of the qualitative research: data collection, interpretation and organization of data, and analytic process. Data might consist

of interviews and observations but also might include documents, audio recordings, videos and photos.

Remarkable advancements in terms of technological innovation have been made in mobile devices (mobile phone, PDA's, tablets, laptops, etc). Many of these devices present a rich graphic user interface, connectivity by Bluetooth, GPRS and various add-on accessories such as GPS, digital cameras, scanners and so on. Features and resources that can be potentially applied on the data collection activity for field researches in order to improve this process.

This paper presents a mobile phone based solution for field data collection, composed basically by three modules: a survey editor, a server web application and a client mobile application. The data gathering process begins with the survey creation module, which enables the production of tailored questionnaires. The questionnaires become available on a web server and they are delivered to the field workforce wirelessly using a regular mobile telecommunications network. The field workforce receives the questionnaire(s) on their mobile phones to enter and store the interviews responses. As well, it is also possible to send responses back to the server for instant analysis, again via a mobile network.

In order to present the main features of our solution, this paper is organized as follows. We first comment about some data gathering solutions in section 2 then the main motivations to or work are explained in section 3. In section 4, we present a textual overview about how a mobile phone application can fulfill some data gathering activity requirements and in section 5, we discuss some conclusions we consider relevant in our work.

II. DATA GATHERING SOLUTION

Pen-and-paper based solutions for field data gathering are often very time-consuming due to several drawbacks, including problems with carrying the necessary papers in and out, especially at remote locations. There is also a considerable rework needed for legacy systems data entry which usually leads to typing errors. Data input accuracy is very hard to assess due to handwriting issues and the transfer phase. In some situations, such as during disease outbreaks, natural disasters or out-of-stock of medicines, the time span from data gathering to summary generation does not support immediate corrective actions. A pen-and-paper based solution is technologically very simple to be set up. However, it does not completely fulfill the needs for up-to-date, reliable data collected neither an integrated solution that provides seamless

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data flow from on-field data gathering through centralized database to full in-depth reports.

In [3] it is emphasized the crucial role the mobile technology can play in the field data collection and maintenance process in the utility industry. The application of the mobile technology in the collection and maintenance of spatial information is presented with a use case about some African countries infrastructure (including information about some essential items such as water, electricity, roads, communication networks, etc). The design and implementation of a field data collection prototype is described highlighting the investigation of some usability requirements for a field data collection application and how to meet these requirements from a usability-engineering standpoint. The usability of mobile phone based solutions is also highlighted in [4], mentioning the necessity of carefully planned user interface and offline functionalities in cases where there is no network coverage.

Nevertheless, mobile devices present some limitations related to storage space, memory, processor capacity, battery life and screen size etc. PDA's based solution for field data gathering, for instance, may use interesting features, such as portability and touch screen interface but usually, PDA's are not network connectable, some only by Wi-Fi enabled and still have a low battery life. Laptops in the other hand are powerful and full featured but still too big to carry on longer field surveys and also low battery life.

Mobile phones are devices widely available, somehow easy to use due to widespread cell phones usage, always connected when within a mobile/Wi-Fi network and low profile. Our mobile phone based solution envisages enhancing field data gathering activity with the multimedia resources and connectivity features built-in these devices.

III. MOTIVATION

Over the years, qualitative research methods are gaining popularity outside the traditional academic social sciences, particularly, with its application in public health, education, agriculture and international development research. Qualitative methods provide valuable insights into the local perspectives of populations study, these methods have become important tools within this broader approach to applied research.

Field data collection with a mobile phone has the potential to dramatically improve any service that relies on accurate and up-to-date information, from activities of disease monitoring to agricultural management and emergency response services. There are still many issues to solve and or to improve the process of field data collection. The solution proposed in this paper is presented only through an overview of the main features required, due to Non Disclosure Agreement document that all researchers who have been worked on this project have signed.

A. Field research scenario

This data gathering project has its beginning with a Non-Governmental Organization (NGO) in the country of Ecuador. This organization has asked for a solution to help them to collect health data, improving communication and reducing time of response from its Health Center, located in the countryside of Ecuador in a community named La Y de La Laguna. The Ecuadorian Ministry of Health provides one rural doctor and one dentist and this NGO (Foundation Human Nature – FHN Ecuador) [5] provides international volunteers to assist both in the health center and in outreach programs.

The region where FHN Ecuador NGO concentrates its efforts is called El Páramo, which usually refers to Andean highland areas, but coastal inhabitants also have used the term to refer to the communities along the high-altitude ridge in this nameless region. Nowadays, El Páramo name is used as reference to the region as a whole, where 6000 people live in 26 distinct communities. La Y de La Laguna is the main community in the region due to its central location, and the key commercial center. The outlying communities are connected by muddy footpaths accessible solely by horse, mule, or foot.

El Páramo is partially situated within a national ecological reserve entitled Mache Chindul, which stretches over an area of 119,172 hectares. Mache Chindul is situated in the district of Quinindé, province of Esmeraldas, in the northeast of Ecuador.

B. Local Health Committee

In administering the health center, FHN Ecuador works closely with a local health committee (El Comité de Salud), comprised of members from various nearby communities who represent local interests. These committed individuals are undergoing monthly training workshops and capacities building in order to independently administer the health center in the future.

C. Health Promoters (HP)

Since 2002, each of El Páramos 26 communities elected one male and one female health promoter to undergo training as Community Health Workers. This group attends one workshop per month (lasting 1-3 days) on health-related topics, such as first aid, malaria testing, sexual and reproductive health, basic ophthalmology, medicinal plants, and more. FHN's health promoters are also representatives of the health center' in their communities, spreading health education messages throughout the region.

D. The issue scenario

FHN has related that its HPs always have collected health data in their communities using paper and pen. These data are just compiled and analyzed only after in some cases 3 days travelling by a transportation way available in its original community to La Y. After that, if it is necessary any

providence as medicines or any other resource, it will be provided and then sent to that community. Frequently, this process takes too long and unfortunately the patient dies due to lack of proper treatment. This is the major cry of the inhabitants: improving its communication (from the communities to La Y).

The solution to be developed should fulfill the FHN Ecuador requirements so that it would meet not only the failure of local communication, but also improving field data collection, giving more power to the Health Center, to make faster and accurate decisions.

The region of the La Y community has poor mobile network coverage. The mobile carriers don't show interest in improving its network coverage, despite of the fact that each family has up to 3 or 4 mobiles. All communities are located in the middle of the rainforest, the surface is composed of many hills and only one antenna is located in the city of Quinindé (about one and half hour from La Y). We have had to work on these external and immutable conditions.

IV. SOLUTION OVERVIEW

A multidisciplinary team of researchers at Nokia Technology Institute (INdT), called Community Group has been allocated to develop the solution for this issue identified in Ecuador.

Some requirements were listed in order to create first a prototype that could be tested in loco. These requirements were the result of the first visit made by the INdT researchers team to the La Y de La Laguna and after many interviews with FHN Ecuador and others stakeholders of the project, e.g. NOKIA Community Involvement – Nokia CI.

A. Requirements

At a glimpse the solution would be a mobile enterprise solution for data collection. It would leverage the power of mobile technology and wireless network infrastructure by using Location Based Service (LBS) platform and quasi real-time transmission of data to provide seamless data collection.

The data collection system would include everything needed to empower mobile professionals who work in the field and capture data with an easy-to-use and powerful mobile survey application which would work either online or offline. Besides that, mobilized forms could be sent wirelessly to and from the field workforce, eliminating the need to drive back and forth to the central office. The Total Cost of Ownership (TCO) is reduced while the accuracy and timeliness of your data collection is improved.

Mobile phones have been proved to be a good solution for data gathering [4], even for complex surveys. Because of this among other reasons, the growth of data storage and memory has played a key role. Furthermore, the use of mobile phones featured with QVGA display and QWERTY keyboard can significantly improve user experience while inputting and accessing the data. The solution should provide a way to create surveys and fill out results, sending them to a repository.

The first architecture outlined is illustrated in Fig. 1 below.



Fig. 1 Initial Block Diagram

Its basic workflow would be described as follow:

- 1) Create questionnaire(s) using the survey creator;
- 2) Make these questionnaire(s) available on a server via internet, yet using the survey creator;
- 3) Remotely provision survey(s) to the mobile phones in the field using the server-side platform;
- 4) Collecting responses using mobile phones;
- 5) Transmit data using the mobile and wireless network, and;
- 6) Analyze and monitor collected results via web, which is part of the server-side platform. An additional step can involve integration with back-office system and so that a Connector API can be used.

Fig. 2 shows more details about this workflow.

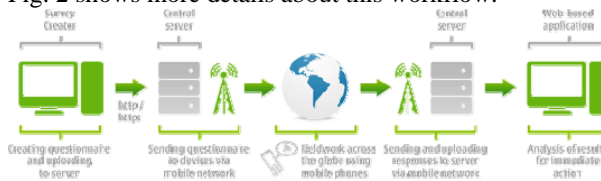


Fig. 2 System workflow

Modules Requirements Elicitation [6]

This section intends to show requirements listed for each module of data gathering system.

B. Survey Creator

Its main feature is to create new surveys and to make them available to a server. However, in order to accomplish these requirements, the Survey Creator module must:

- 1) Create new survey questionnaire file;
- 2) Open and edit any existing survey browsing the file system;
- 3) Real time preview of the question while editing it;
- 4) Manage several types of questions: string, date, numeric, multiple or exclusive choice and image question detail screen;
- 5) Render selected questions on mobile device in the preview screen;
- 6) Provide search capabilities on the questionnaire tree;
- 7) Upload survey questionnaires to the server;
- 8) User authentication and authorization while uploading survey questionnaire to server
- 9) Support to different languages (English/Spanish and Portuguese);

10) Organize questions within a category;

C. Mobile Client Application

The fieldworker will use a mobile phone to collect data. This application must be well designed, due to its critical role in the system. Developing a mobile application may seem the same that a desktop application. As a matter of fact both have to be most usable and considering user in front of everything [7]. According to [3],[8] mobile applications have a number of unique features and characteristics that are intrinsic to mobile computing, such as: memory limited, processor speed, battery consumption and life, dependent on mobile network (performance and reliability), screen size (most important).

Our end users, the Health Promoters, can find themselves in awkward situations where they need to crawl, climb or walk while they collect data. Their hands are also used to manipulate other objects than mobile phone. Everything must be analyzed to bring up to the user an exciting experience using this solution.

Some usability requirements must be addressed by this mobile application, enumerating as the most important ones: intuitive user interface and the user interface must provide an efficiency optimized, due to a high rate of user interaction and nature of work to be done.

A set of features of mobile application is shown as follow:

- 1) Languages support (Spanish/ English/ Portuguese)
- 2) Automatic application installation
- 3) Check for new survey questionnaire(s) to download
- 4) Browse survey responses (previous, next, go to, last, first)
- 5) Answer survey questionnaires
- 6) Manage skip logic question(s)
- 7) Mark/Unmark survey responses for sending (one or several) to server
- 8) Send/Receive Survey(s) through Short Message Service (SMS), General Packet Radio Service (GPRS), HTTP connection and cable;
- 9) Send Survey(s) response (Results) through SMS message(s), GPRS - HTTP connection and cable;
- 10) Receive SMS message(s)/notification(s) from server directly to mobile inbox
- 11) Global Position System (GPS) support: survey responses containing geographical coordinates
- 12) User Interface (UI) related improvements using a low-level (canvas) UI Framework
- 13) Camera support
- 14) Provide security of the data collected

D. Server

Server is the key component for the gathering solution. It works as a central component for surveys distribution among mobile devices, results centralization, and general administration. In order to communicate with Mobile Client and Survey Creator, Server application must provide some HTTP Interfaces.

The Web Server User Interface layer must be a cross-

browser web application, composed by two main areas: administrative and operational. The operational area must show all Surveys registered to each user and its results received and also, the mobile device, which has sent them.

Some requirements defined for the Server application:

- 1) User registration, authentication and authorization;
- 2) User management (add, edit, delete operations);
- 3) Receive new survey questionnaire(s) from Survey Creator via HTTP;
- 4) Send survey questionnaire to a mobile phone via Cable, SMS, GPRS and HTTP;
- 5) Parse and store survey responses in a database;
- 6) Receive compressed and binary SMS messages containing fragmented survey responses from mobile phones;
- 7) Export survey responses [full content] to CSV and XLS format;
- 8) Simple navigation/pagination component for all lists (preview, next, last and first);
- 9) Mobile registration (International Mobile Equipment Identity (IMEI) number, phone, owner, device model);
- 10) Plot a survey response on the map using its geographical coordinates;
- 11) Cross-browser support.

E. Communication Layer

The system works based on XML files. Survey Creator when generates a new survey, in fact it creates an XML document. This document is saved in a database and then this survey is available on the server module. Its structure allows identify each category of Survey and their respective questions and also the Survey identifier number Survey ID.

At fig. 3 we show the XML file flow in the system.

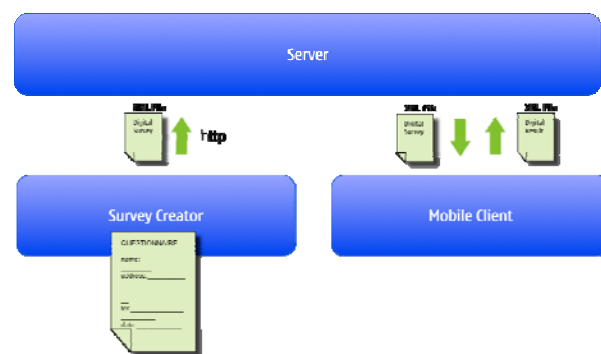


Fig. 3 XML workflow into Data Gathering System

For each survey the Mobile Client will generate the Results. The Results are also XML documents. In this way, every communication represents an exchange of XML files. But how do these XML files are transmitted among each application?

F. Hyper Text Transfer Protocol (HTTP)

No modifications in the structure of XML file are done to transmit them using HTTP connection, allowing the communication between:

- Survey Creator to Server: Uploading an created Survey;
- Server to Mobile Client: Server send to each registered mobile that is able to receive an specific Survey;
- Results from Mobile Client to Client: when user decides to send Results stored in Mobile Client file system;

For an HTTP transfer, it is necessary a transport to open a connection and delivery content, this can be provided by Mobile Network (GPRS), Local Area Network (LAN) or Wi-Fi.

G. Short Message Service (SMS)

The Short Message Service (SMS) provides means of sending messages of limited size to and from GSM/UMTS mobiles [9].

SMS has limited length, often up to 160 characters. Each Survey or Result may have more than this. How to send Surveys or Results by SMS's? We have used two approaches for this development requirement:

- Break up the document in pieces up to 160 characters and compact them all;
- Set as many as necessary SMS's to carry all pieces of 160 characters excerpted from the document. We have had to create a kind of protocol into SMS to allow that other part (receiver) be able to recreate entire Survey or Result.

The server is able to send SMS using an attached modem GSM or a web SMS Broker, a company specialist in sending SMS.

V. CONCLUSIONS

The ability to communicate quickly, accurately, and completely in the field is a challenge to the field research. Many public, private and NGO health organizations need to gather fast and accurate field data into their system for analysis and decision-making. Mobile phone is a device that has the potential to improve any service that relies on accurate and up-to-date information and its built-in multimedia resources enable the collection of several types of data including, text, video, audio recording and photos which makes of this device a representative tool especially for qualitative researches.

Through the sections above, we have presented the main features required for an integrated field data gathering solution, composed by several different platforms (web, mobile phone, mobile network) and which resources are necessary to deal with the challenges of the communication among them. Our solution was designed and implemented

according to the requirements of a field research use case in the public health area and the mobile technology has provided the means to implement many improvements for an efficient field data gathering system.

REFERENCES

- [1] Strauss, A., & Corbin, J. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). Thousand Oaks, CA: Sage.
- [2] Mack N, Woodsong C, MacQueen K, Guest G, Namey E. *Qualitative Research Methods: A Data Collector's Field Guide*. Research Triangle Park, NC, USA: Family Health International; 2005.
- [3] Moe, K; Dwolatzky, B; Olst, R. (2004): Designing a Usable Mobile Application for Field Data Collection. IEEE AFRICON. Pp. 1187--1192.
- [4] Teemu Jalava, Jukka K. Nurminen, "Mobile Phone as an Inspections Tool-Experiences with a Service for Field Force," ainaw, vol. 2, pp.617-622, 21st International Conference on Advanced Information Networking and Applications Workshops (AINAW'07), 2007.
- [5] Foundation Human Nature web site: <http://fhnusa.org/projects/ecuador/health.htm>.
- [6] Nokia Internal Wiki – Data Gathering Project.
- [7] Twentyman, Jessica "Usability: Lovely Software. But I can't work it" FT.com - Financial Times Published: 17 June 2009.
- [8] Zwick, C. Schmitz, B. Kühl K. Designing for Small Screens – AVA - Academia the environment of learning – June 2005 Berlin.
- [9] 3GPP TS 23.040 V9.1.0 (2009-09) 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Technical realization of the Short Message Service (SMS)(Release 9).