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A Mobile-based Monitoring System for Micro Small Medium Enterprises (MSMEs) with Offline Data Synchronization

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Abstract

Objectives: The use of technology has become ubiquitous in different areas of businesses and plays a significant role in gathering huge amount of data. In Philippines, for example, a government agency, Department of Trade and Industry (DTI) is entrusted with a project to assist and monitor the status of Micro Small Medium Enterprises (MSMEs), some of which are located in rural or remote places. There are number of approaches that are able to address registration and monitoring of clients or business establishments records through mobile-based application. However, there may be times that poor connectivity or no network connectivity is experienced with LTE or wi-fi network. Hence, one of the major challenges in dealing with mobile computing is on how to provide the clients with the same user experience even when there are some issues on connectivity. In this study, we developed a mobile-based application that may significantly improve the process whereby clients or users have the chance to access data that is stored in a stationary database or some other data repository at any time and any place. **Methods**: We introduce an innovative approach for efficient tracking and monitoring data leveraging the strength of data synchronization and replication. A mobile-based platform using a centralized database was designed and developed to facilitate quick registration of clients and easy portfolio monitoring of the business establishments. **Application**: The mobile-based system is an application that runs through android platform necessary for MSMEs' efficient registration and monitoring purposes whereby users in remote areas are provided with the same user experience despite issues on connectivity (i.e. from "poor" to "no network" connectivity). We deployed the system in the Department of Industry (DTI) provincial office, which covers thousands of MSMEs. **Findings**: Experiments reveal that our approach provides effective results, which gains high acceptability of the users.

Keywords: Agile Approach, Agile Software Development Method, Context Diagram, Micro Small Medium Enterprises (MSME), Mobile-based Application, Monitoring System, Offline Data Synchronization

1. Introduction

Micro Small Medium Enterprises (MSME) is defined as any form of business activity, which is engaged either in industry or agricultural services. It can either be a single proprietorship, partnership or corporation or cooperative whose total assets include those generated from loans but exclude the land whereby the office, plant and equipment of the business entity are located[1].

MSME became a popular enterprise in the Philippines, such that there is a spread of vast amount of business inclined individuals with the supervision of the Department of Trade and Industry (DTI). Because of its growing number of MSME business owners, the

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Department of Trade and Industry, thoroughly and carefully manage and monitor the data they have gathered from the respective business owners, some of which are located in rural or remote areas. Traditionally, the client's profile and portfolio are tracked manually or by using spreadsheets office productivity tool. In effect, searching of documents is time-consuming, which may lead to low productivity. As the number of MSME members increases, monitoring of business establishments status can be a tedious task. People involved in monitoring, experienced time delays and data inconsistencies in preparing the reports. As a result, creation of appropriate technology or system becomes apparently invaluable for the monitoring staff of DTI. As DTI prioritizes to help future and budding entrepreneurs in visualizing and expanding their business, respectively[2], it is high time to develop a system that enables effective monitoring of status (e.g. no. of employees, assets, etc.) of every MSME in a province or any area within the region of interest. With this, all necessary information relative to online monitoring and tracking of client's (MSMEs) profile is considered, which paves the way to acquire the latest and accurate information. This may help the organization lessen the bulk of the workload in profiling and monitoring the clients (e.g. conducting surveys in selected sectors, status monitoring, etc.). This would better explore avenues of improving the processing speed and promotes higher manpower productivity[3,4]. Additionally, the system can provide needed information to authorized personnel by accessing the system online, thereby promoting higher productivity as it reduces time requirement to process each transaction.

In this study, we develop an MSME monitoring, which is an effective way to perform client profiling and portfolio monitoring. It runs in a mobile-based platform using the centralized database and was designed to register, track and monitor the business establishments under DTI's supervision. Some of the data collected include the DTI Business Name (BN), Security Exchange Commission (SEC) and Cooperatives Development Authority (CDA) registration for sole, cooperation and cooperative proprietorship, respectively. The application allows system management and migration and integration of existing data. It consists of three modules that include 1. Migration of data, 2. Profiling and 3. Portfolio monitoring. The mobile-based application also involves development of modules for conducting surveys through mobile application. Although the application provides good results, there may be times that a loss of network connectivity is experienced with LTE or wi-fi network[5]. Hence, one of the major challenges in dealing with mobile computing is on how to provide the clients with the same user experience even when there are some issues on connectivity. There may also be times when users of mobile phones keep on spotting different places and more often than not, they experience poor signal coverage and even bad data connectivity. As such, most of the mobile-based applications fail to function as they are heavily dependent on strong wi-fi or data network connectivity.

In this context, the mechanism of data synchronization can have two main viewpoints that include uploading and downloading. Uploading happens when there is a transfer of data to a remote server from the mobile device. On the other hand, downloading happens when there is a transfer of data to a mobile device from the remote back-end server. When either of these two happens, the mobile application user should be informed whether there is a success or failure of the data synchronization. This can be done either directly (i.e. by sending notification or dialog) or indirectly (i.e. by storing it in a log) with its corresponding error information in the event of failure.

To further improve the performance of the mobile-based application, we leverage offline data synchronization. The integration of data synchronization to our mobile application will significantly reduce the drawbacks of a mobile app when used in areas where poor connectivity is being experienced. The mobile app with data synchronization is developed for conducting surveys, i.e. for selected or dominant sectors, which are the target sectors of DTI. It has the capability of performing offline data synchronization should there be target places for surveys that do not have internet connection. What makes our mobile-based application advantageous over any other application is that it functions well even when there is poor connection or even when there is no

connectivity at all, as it does allow local storage of data and push to the server once a connection is established.

MSME-IMS generally aims to implement a system for MSME data management, in terms of profiling, portfolio monitoring through mobile-based surveys to selected or dominant sectors. Accurate and efficient tracking of the information of the clients with businesses or establishments being registered are to be considered as follows:

- Efficient client profiling and portfolio monitoring. Data is stored in secured, flexible and scalable database system, updating of records can be delegated to users.
- Mobility. Application can be accessed anytime and from anywhere using android table or mobile phone and
- Automated Processing. Promotes higher manpower productivity as it eliminates manual registration, portfolio monitoring and redundant encoding of relevant data. The system can respond quickly to queries and required period reports.
- Furthermore, MSME monitoring system is a user-friendly system which offers the following:
- Graphical user interface. It allows users to select commands, start programs and check the list of files and other options by pointing to the icons or graphical representations.
- User-friendly environment. Menu-driven screen layouts, function-key driven or prompts for error messages and instructions.
- Security and integrity. Provides password to ensure access control to the system and provides security level definition for different types of users.
- Maintainability. Provide changes/updates to existing menus and programs via the screen layout;
- Flexibility. Provides set-up of libraries and parameters specific to the users.
- System administration utilities. Set-up of activities, users, menus and
- Client/server architecture. Runs on network environment using client/server architecture.

In this study, we make three contributions. First, we present an innovative approach for efficient tracking and monitoring of enterprise's relevant information (e.g. business name, type of business, initial capital, assets, etc.). Second, we provide a comfortable user experience in profiling and portfolio tracking of MSME. Lastly, we study in depth the effect of offline data synchronization to our MSME monitoring system.

2. Materials and Methods

Our work performs tasks relative to online client registration and portfolio tracking and monitoring. Information needed is readily available since it allows concurrent access to database, thereby minimizing efforts to make manual updates of the client's record. Figure 1 presents the architecture of the proposed system. The system runs in a mobile-based platform where user sends or receives data from a centralized database. Data can be accessed through the database server in which information inputted in the web app can also be accessed in the mobile app with the dependency of an internet connection. The user then can perform the CRUD (Create Read Update Delete) operations necessary for data manipulation.

Synchronization of data occurs once an internet connection is detected; otherwise, the data entered in the mobile shall remain being stored locally and temporarily. Also, we developed a web-based application for easy system maintenance and management as well as for printing of reports.

2.1 Overview of Agile Development Methodology

During application development, we adopt agile System Development Life Cycle (SDLC) where dynamic participation of DTI staff is of high consideration so as to promote development iteration, which consequently, ensures on-time delivery of the desired output. Figure 2 shows the representation on how agile software development method was implemented. We chose to do things in small increments, with minimal planning

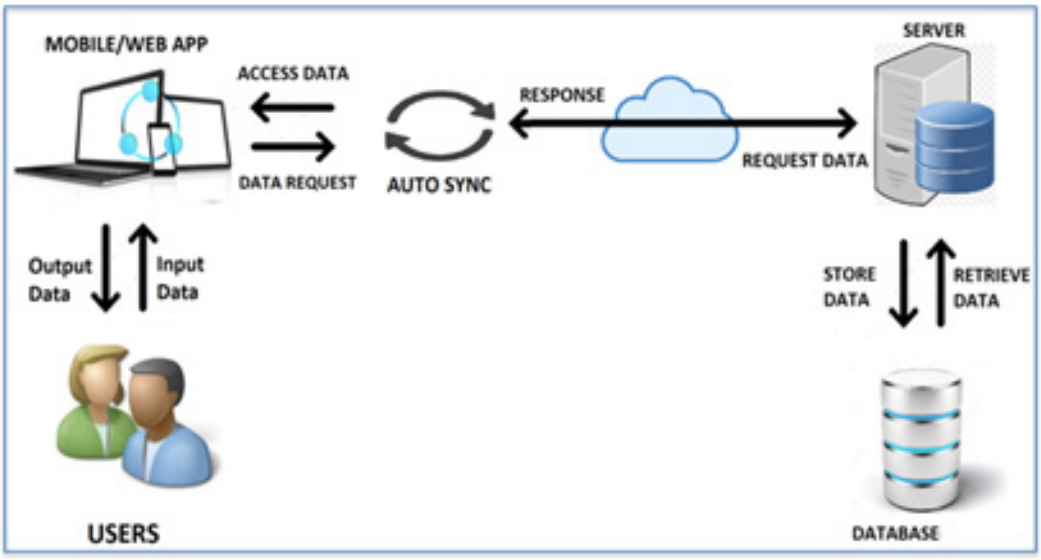


Figure 1. Proposed system architecture.

rather than plan at length. As such, we emphasize the stakeholder's involvement, which helps to minimize the overall risk and allows the project to adapt to changes more quickly. That is, at the end of each iteration, the stakeholder is consulted about the product and comments are noted. The system is designed to run in a mobile-based platform where the user gets information from the server through internet connection. With the rapid growth of the internet and digital age, the software engineering profession has long been altered or changed. The new light or agile software development methodologies (SDMs) have replaced the traditional approach of software

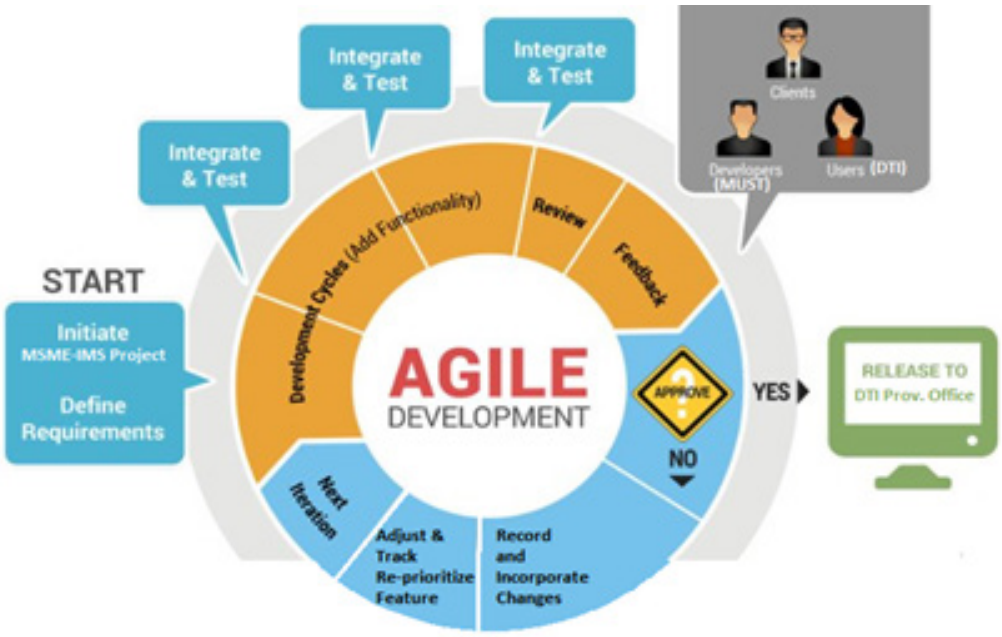


Figure 2. Agile development methodology.

development. The characterization of agile SDMs include: 1, Iterative development; 2. Continuous code integration; and 3. The ability to address the changing requirements of the business[6]. It is worth noting that with the advent of agile methodologies, software developers are becoming more productive and able to produce application software, which are of much higher quality, given a short period of time. Agile SDMs share considerable number of qualities, such as prototyping, iterative software development and nominal documentation. After all, agile approach was introduced to improve the process of software development by eliminating barriers in accepting changes of the business requirements during the process. Additionally, with an agile approach, freezing in business requirements as well as locking up in the design details is unnecessary while developing a software[7].

2.2 Offline Data Synchronization of MSME-IMS: An Overview

Data Synchronization in the app utilizes the $http GET method to requests data from a specified source and POST method to submit data to be processed to a specified source[5]. The $http service facilitates communication with the remote HTTP servers via the browser's XMLHttpRequest object. It works as a request response between a client and a server. Upon a successful response from the server, the array of data retrieved via HTTP request is then being loop and the result of each loop data is stored locally to SQLite database.

Figure 3 shows the architecture of mobile offline data synchronization. The sync service has the responsibility of saving the data locally in SQLite Database (i.e. in mobile device) that are extracted by syncing the data from the server to the mobile device. Offline data synchronization in android-based applications can be performed using Sync Adapter along with the Sync Service. A sync adapter is responsible for handling background syncs on android platform. It is a plug-in that syncs data from your mobile app to a remote server and is registered on the platform of a sync manager. Sync manager is in-charge of running it, which can be performed or triggered when requested, needed or scheduled. As such, sync adapter has several advantages and is considered superior among other approaches[5]. These include: 1. Battery efficiency; 2, User

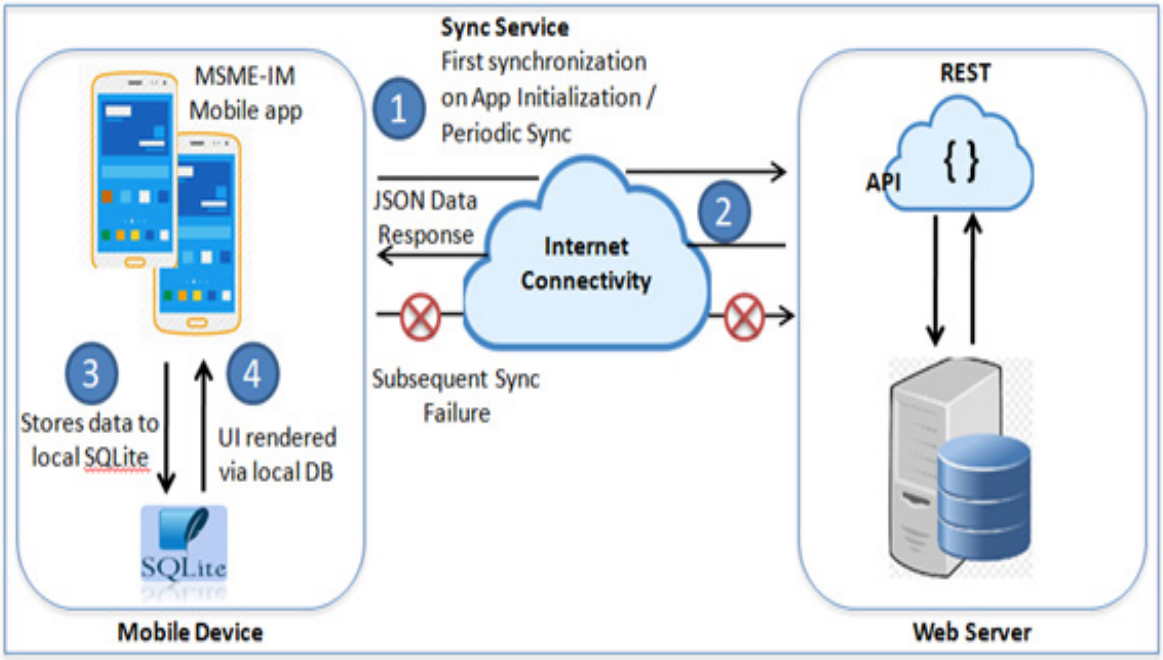


Figure 3. Proposed architecture of MSME-IM mobile offline data synchronization.

settings; 3. Data responsiveness; and 4. Retry mechanism. To foster efficiency of battery, the system implements schedules for running the sync while other syncs are running or when other requests for network was already in place on the device. The setting screen is where sync adapters on the mobile device can be accessed according to the level of authority of the user's account. This provides end users to alter preferences on syncs, check any sync issues or problems or disable sync. Furthermore, sync adapter has the advantage on user settings. For example, if content provider is used for manipulating or accessing data, the sync adapter is able to observe or track any changes that were performed on it. Lastly, it has an advantage of having a retry mechanism, whereby the sync manager is able to implement retry for failed asyncs, making use of the backoffs and timeouts.

2.3 Context Diagram of the Proposed System

As our study includes database creation and manipulation for MSME tracking and portfolio monitoring, context diagram plays a significant role during the design and development of the system. Our context diagram presents the bird's eye view of the swine counting and production monitoring system. It defines the boundary between the system and its environment, showing the entities that interact with it. Figure 4 presents the context diagram of our proposed system. The diagram clearly depicts that updates can originate either from the different entities (e.g. MSME, owner or proprietor, employee, management, etc). The system can automatically perform monitoring of MSME business status. The System Administrator is responsible for storing new entry record, process updates for checking and correcting erroneous record and is privileged to retrieve, view and print records with full access to the system. The System Administrator is also responsible for adding new user/s and maintains maximum level of security of the system. The privilege granted for the client user is to enter new data, search, view and print the reports only. In some cases where data is not in the list, the user should seek for assistance from the System Administrator. On the other hand, the client user can request an upload or update of data.

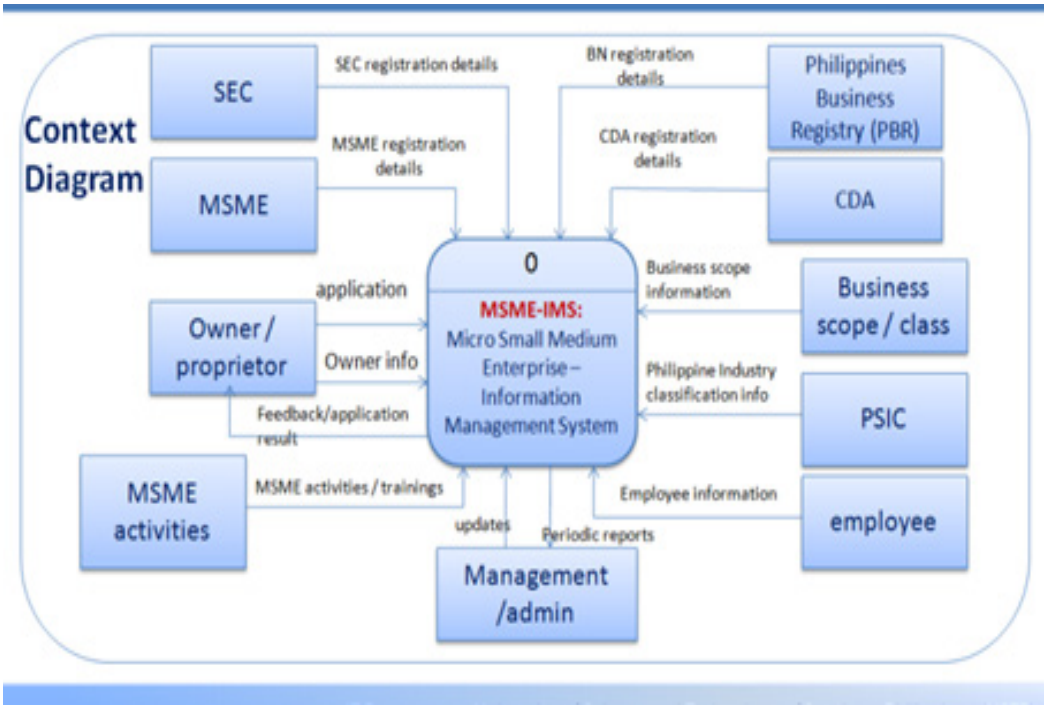


Figure 4. Context diagram of MSME-IMS.

3. Results and Discussion

In what follows, we present some sample screen shots of our mobile-based application, which include modules for conducting surveys that can still work efficiently even without internet connection. This means that if there be target places for surveys that that do not have internet connection, particularly with rural areas, it is capable of performing offline data synchronization. Figure 5 presents sample screen shots of our proposed MSME-Information Management System (MSME-IMS). Figure 5a is the login interfaces where users are required to enter valid username and password before being allowed to use the mobile app. Depending on the level of account (e.g. admin, user level, etc.), user can perform create, search and update tasks. Figure 5b shows the homepage of the application where the user can perform search of records (e.g. list of MSMEs), while Figure 5c presents the screen shot of the options view of MSME. For example, when "Baybay Fishermen's Multipurpose Cooperative" is selected, the following options will be displayed: 1. Update MSME; 2. Visit for Consultation; 3. Assistance Given; and 4. Production capacity. Updating MSME means performing editing on the selected record should there be a need to modify the entered data. Figure 5d, on the other hand, shows the screen shot of the menu where users can choose to register new MSMEs, do data synchronization (i.e. tasks that were performed offline will be synched to the database once the app is connected to the internet whereby able to access the server/database).

Figure 6a presents the screen of the app for setting or performing configuration. The first to fourth button is used for account configuration, networking connectivity, local database and notification configuration, respectively. On the other hand, Figure 6b shows the navigation menu of our mobile application, such us home, notification and settings, among others. Should the user want to logout from the application; logout option should be to be selected.

As discussed in the previous section, our mobile application is capable of performing task even without internet connection. This is made possible through Data Synchronization Page as presented in Figure 6c. By definition, data synchronization ensures consistency of data from source data storage to destination and from destination to source data. Also, it sees to it that

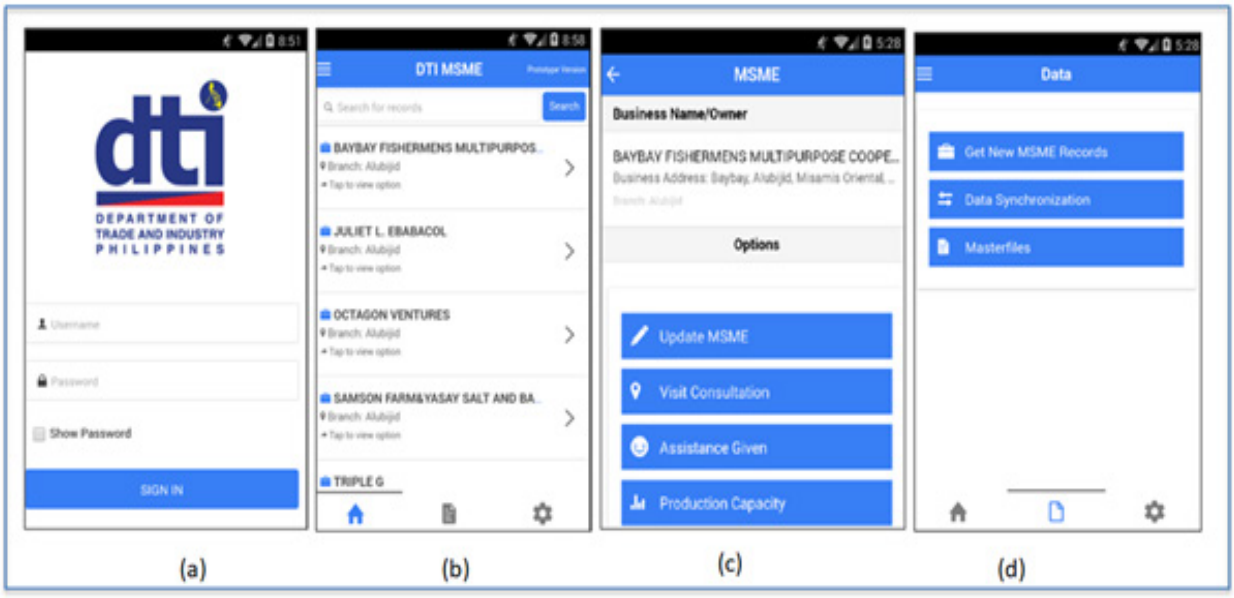


Figure 5. Sample screen shots of our MSME-IMS mobile application. (a) Login interface; (b) Homepage view; (c) MSME options view; and (d) Data page.

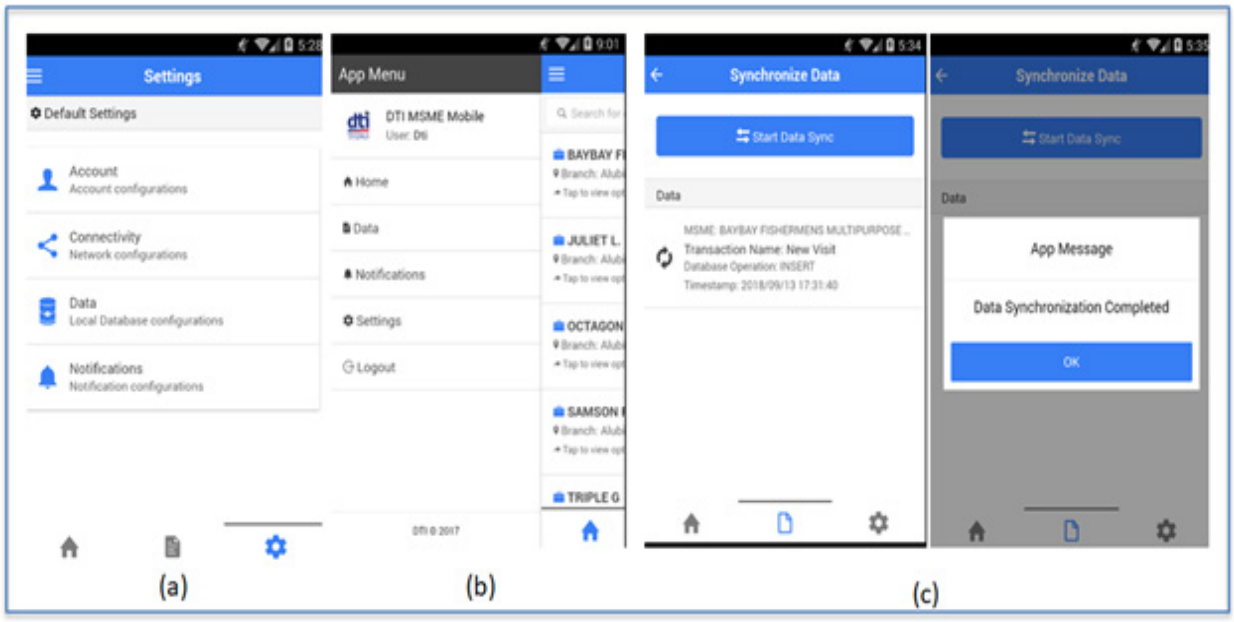


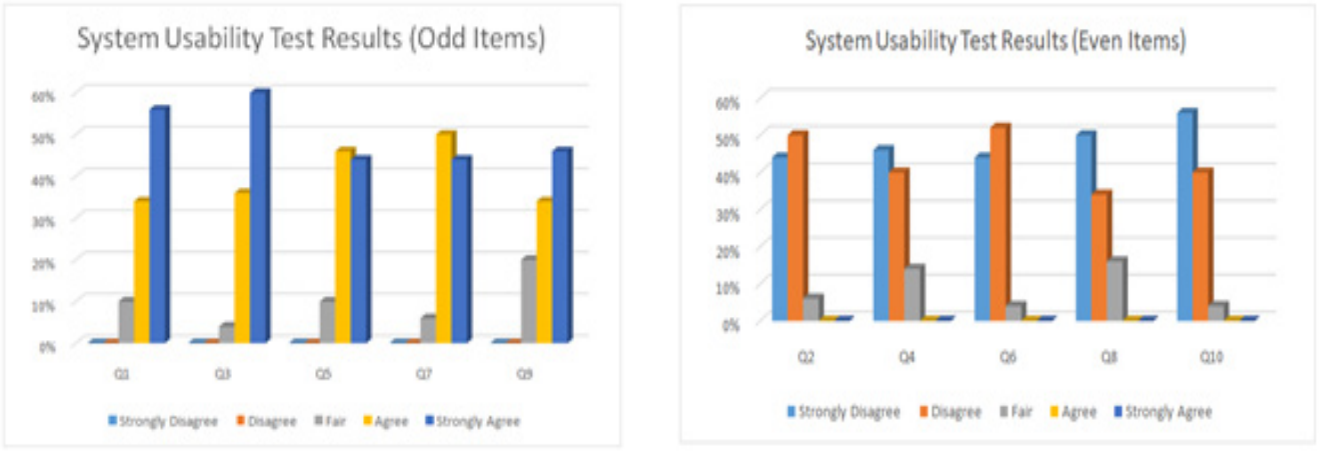
Figure 6. More sample screen shots of our proposed mobile-based MSME-IMS. (a) Setting configuration; (b) Navigation menu; and (c) Data Synchronization.

continuous data harmonization over a period of time is observed. Our mobile app can do updating of data at remote stations by initially storing them to the local storage of the mobile device and perform data replication to the database server once it is connected to the internet.

3.1 System Usability Evaluation

To measure the usability of our system, we utilize System Usability Scale (SUS)[8,9], a standardized measurement metric to test the usability of a web-based application or other interactive application software[4]. In systems engineering, SUS is a simple, ten-item attitude Likert scale, which gives a global view of subjective assessments of usability. According to ISO standard ISO 9241, the system's usability can be measured only by considering the context of use of the system (i.e. who uses the system, what they are using it for and the environment or workplace in which they are using it). Additionally, usability measurements have several different aspects, namely: 1. Effectiveness (can users successfully achieve their objectives); 2. Efficiency (how much effort and resource is expended in achieving those objectives); and 3. Satisfaction (was the experience satisfactory).

Measures of effectiveness and efficiency are also context specific. Effectiveness in using a system for controlling a continuous industrial process would generally be measured in very different terms, say, effectiveness in using a text editor. Thus, it can be difficult, if not impossible, to answer the question "will system X be more usable than system Y?", because the measures of effectiveness and efficiency may be very different. However, it can be argued that given a sufficiently high-level definition of subjective assessments of usability, comparison can be made between systems. Being considered a favorite tool among User Experience (UX) researchers for its simplicity and accuracy, SUS is a valuable quantitative tool for anyone trying to optimize the user experience[8,10]. Long a favorite among UX researchers for its simplicity and accuracy, SUS is a valuable quantitative tool for anyone trying to optimize the user experience. SUS uses a short, 10-item questionnaire administered at the end of a usability test to calculate a website›s score. Users respond to each question using a 5-point scale from "Strongly disagree" to



(a) (b)

Figure 7. SUS survey results. (a) Odd items results; and (b) Even items results.

"Strongly agree". These answers are then used to generate an extremely reliable overall usability score for your site. We floated survey questionnaires following the 10 item-questions of SUS[9–11]. Fifty (50) respondents were asked to rate each given question from 1 to 5 in accordance to the level of their agreement with the given statement, i.e. 1 being lowest and 5 as the highest, which corresponds to "strongly disagree" and "completely agree" rating, respectively. Survey results reveal that the correspondents are comfortable with the system and are more likely to recommend the proposed system. Figure 7 presents the results of the system's usability test following the SUS instrument. Survey results demonstrate effectiveness of the proposed web and mobile-based monitoring system.

4. Conclusions

In this study, we introduce an innovative approach for efficient tracking and monitoring MSMEs data leveraging the strength of Data synchronization and replication. A mobile-based platform using a centralized database was designed and developed to facilitate quick registration of clients and easy portfolio monitoring of the business establishments under the supervision. Furthermore, we provide a system for client profiling and portfolio tracking using our mobile app whereby ensuring an excellent user experience through offline data synchronization even when a poor or no network connectivity is encountered. Experiments reveal that our approach provides effective results, thus gaining high acceptability of the users.

5. Acknowledgement

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