A Proposed GSM Biometric Attendance Management System for Ghana Education

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---**ABSTRACT**--
The purpose of this research is to implement interactive and reliable attendance management using GSM/GPRS signal to transfer and retrieve data from remote locations in Ghana tested with alert and management functionality on real time. It also discussed the technological approach in automating subject and attendance administration in the schools and also ascertained the business success with attendance management systems for Ghana education service. Rapid application development (RAD) software development methodology was deployed to build the Biometric Attendance System (BAS). The BAS was designed and implemented. The system provides users with an efficient way of generating reports and retrieving of attendance information of a teacher in specific districts. It supports unified access and management through a simple standard web browser interface. It is recommended that evaluation of the system be carried out in future works to ascertain the success of the system.

Keywords - **Biometric System, GSM, Education, Cellular System.**

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I. INTRODUCTION

Organizations have become concerned with the issue of absenteeism in their various organizations. Employers across the UK have become significantly more concerned over the levels of sickness absence in their workforce (Bevan, 2003) as Ghana ranks first in teacher absenteeism in West Africa; reports from the World Bank and the United Nations International Children's Emergency Fund (UNICEF) have revealed (http://www.dailyguideghana.com). The latter case was mentioned by Mr Alex Kyeremeh, a Deputy Minister of Education, who made this known at a stakeholders' forum on education at Dormaa- Ahenkro, in the Brong Ahafo Region of Ghana (www.dailyguideghana.com, 2014). The Northern Network for Education Development (NNED) conducted a research to find the extent of absenteeism in public schools by surveying "30 schools sampled out of the lot in two of the three northern regions and found out that there was an average of 30 percent absenteeism. Among this percentage, 48 percent were caused by unpreventable factors such as pregnancy, malaria or lack of accommodation" (www.nnedghana.org). That means there is a large proportion unexplained. The Government has taken some measures to address this issue and has succeeded to some extent. "We carried out surprise visits at 11,594 schools at the basic levels and are happy to announce that teacher absenteeism in Ghana has declined from 27 percent to 11" (www.thebftonline.com, 2014).
The Government has even further gone on to establish a committee to design modalities with the aim of achieving Zero Absenteeism in Ghana.
"The Ghana Education Service (GES) was established as part of the Ministry of Education of Ghana under the Civil Service Law 327 and under the PNDC Law 1993 with the mandate to provide relevant education to all Ghanaians. It is responsible for instituting the national education curriculum, appointing and managing the work and issues of teachers and other educational workers. The Ghana Education Service (GES) is mandated among others to maintain high standards of education at the first and second cycle levels. To ensure the achievement of its mandate, GES employed its own workers who are categorized into teaching and non-teaching staff" (www.moe.gov.gh). The Director of GES, Mr Enoch Cobbinah accompanied the Minister of Education, Prof. Naana Jane Opoku-Agyemang to pay unannounced visits to the Dangbe West District of the Greater Accra Region and found many teachers and heads absent from their posts. It decided to sanction them as a measure to curb the act or its future occurrence (www. graphic.com.gh, 2014). In 2003, the Nkoranza District Directorate of the Ghana Education Service (GES) has established some measures to check absenteeism and malingering among students and teachers by residing district circuit supervisors close to the schools to establish more frequent checks on teachers and students alike. They also provided some bicycles to the teachers who lived far from the schools to enable commute quicker to the schools (www.modernghana.com, 2003). In 2014, Vice President of Ghana Mr. Kwesi Bekoe Amissah-Arthur voiced his displeasure among others at the issue absenteeism by teachers in public schools at the World Teachers Day Celebration in Cape Coast. He condemned the behavior as inexcusable and unacceptable (www.regional.citifmonline.com). The issue has been bothering all stakeholders within the country and can be has attracted views from governmental as well as non-governmental agencies/organizations. In government, views have been expressed from even the top hierarchy and this problem remains a grass-root problem. It is the teachers and other educational workers who have been indulging in these acts. It can be inferred even at this point that the current mechanisms and proposed or attempted solutions have not yielded the desired results and impact.

II. LITERATURE REVIEW

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III. METHODOLOGY

The biometric attendance was designed and developed with the Rapid Application Development (RAD) model. The RAD model would enable us to create this solution without the need to carry out prolonged planning activities since the specifications are well known.

3.1 Business Modeling Phase

Business Modeling Phase seeks to understand the workflow as required under the project. It involves the studying of the attendance system as it currently exists with GES to understand how their mechanism operates by observing the workflows and interviewing of the relevant entities. It also includes the analysis of factors that are necessary for the smooth flow of information.

3.2 Data Modeling Phase

The second phase to analyze the information gathered in the business modeling phase from a data point of view. Each flow is analyzed carefully with the objective of finding out what data is required, how it is used and how and where it flows to. The attributes that define the data objects are clearly defined as well as the establishment of relationships between the various data objects.

3.3 Process Modeling Phase

The data objects model created in the Data Modeling phase are extended to show the processes that each object is processed on. These may include adding, retrieving, modifying or even deletion of data or parts of its attributes (www.tutorialspoint.com).

3.4 Application Generation Phase

The fourth phase of the RAD system development model involves the conversion of the process model and data model into a solution. These include the coding of the software using established automation tools to create the application and database. It also involves the integration and configuration of the biometric devices. This prototype is then taken through the final step that involves testing and turnover

### 3.5 Testing and Turnover Phase

Testing and Turnover Phase requires that a systematic and thorough search is done to. It is worth noting that, even though the previous phase where programming was done would have come along with some sort of unit testing, it is

still important to carry out this form of comprehensive testing.
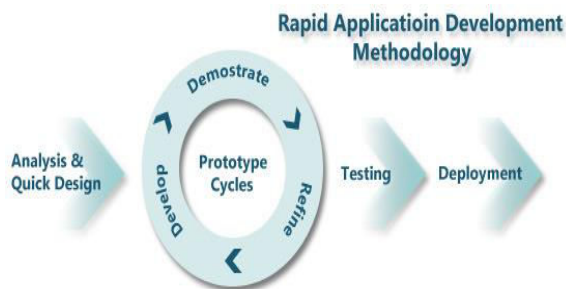
Figure 1: Rapid Application Development Model

The RAD allows changing requirements to be considered. Iteration is quicker as there is drastic reduction in development time. It encourages the flow of feedback from the customer/client. Also, it accommodates integration of component and modules from the very beginning to solve the issues of unpredictability that might occur as a result of integration. RAD however requires highly skilled developers/designers. Its dependency on model is immense and it implies that careful care and expertise be taken to prepare this. Its lifecycle is such that it would require involvement as it scaled or evolves with time (www.tutorialspoint.com).
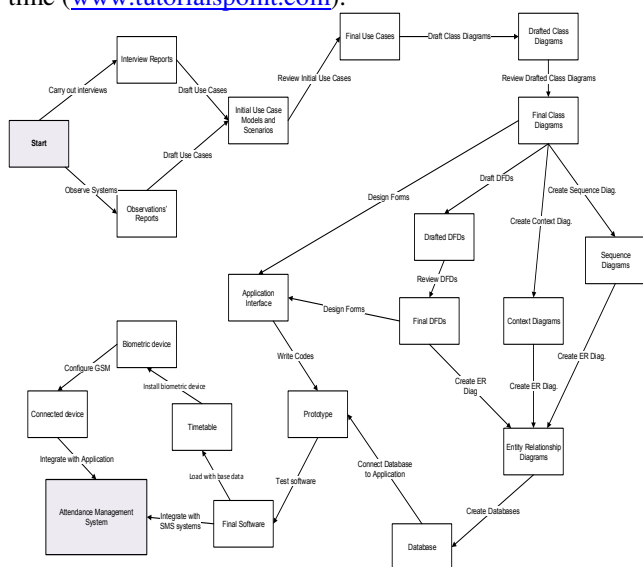

Figure 2: Product Flow Diagram

Fig. 2 offers a different approach to the planning of the project into distinguishable components that would allow easy identification and tracking. This approach is based on the model (RAD) chosen its management approach as well. It enables level categorization of products under each level with the aim of identifying the products that are to be delivered under each phase and stage. The items that are not broken down at any point in time are the low-level items of interest.
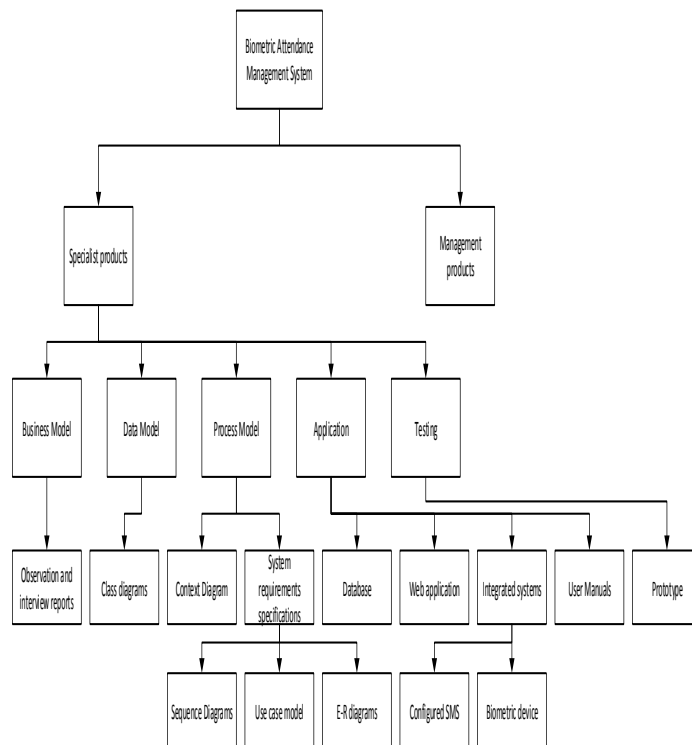
Figure 3: Product Breakdown Structure

IV. THE PROPOSED SYSTEM

The new systems proposed to introduce an automated teacher attendance management system that would serve as a real-time mechanism to deal with the issue of absenteeism. It affords some good opportunities that would add value to the attendance management process.
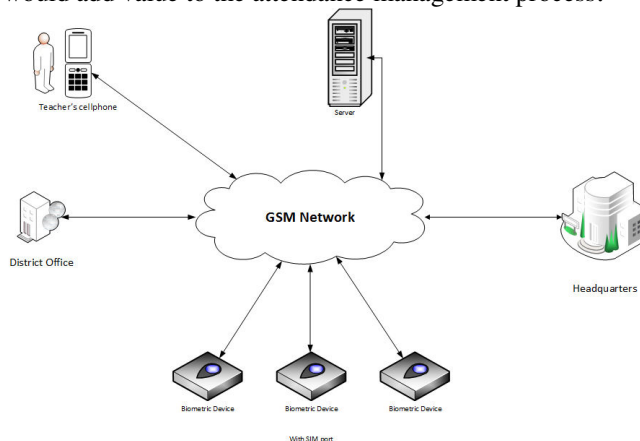
Figure 4: Architecture of the Proposed System

Fig. 4 presents a general overview of how the system is to work. Several biometric devices sited at various schools would be used by the teachers for recording their attendance to school at the stipulated time. These biometric devices would send attendance data in real time to the central server. The GES staff who reside in the district offices and the headquarters and are interested in these data as part of their work would have access to the stored data in different forms for use in other functions. The data generated would reach the server via a modem

that is attached to it. This modem would also have a SIM card in it to facilitate easy communication using the GSM network for which both SIMs are compatible. In an expanded view, all the sites that have the biometric devices would all use GSM as to communicate with the central server.

4.1.1 Key Features of the System and System Components

- The biometric devices that have been chosen possess SIM card slots that ensures that they are compatible with mobile network technologies such as GSM, GPRS, and EDGE etc. This capability means that there would not be a need to acquire two or more separate devices for enabling connection.
- The GSM network chosen offers relatively lower cost as compared to other. This is readily available as there are network providers who offer such services. There would be no need to create a dedicated network as the cost and time for this would be very large considering the wide geographical bounds.
- The centralization of database would ensure that there would be no need to install databases or storage media at the various sites to store or retrieve data. When a user is to be authenticated, the GSM network would enable connection to the server and this also happens when attendance is being clocked.
- In the current system it takes time for data to be prepared and even longer to reach to transform or reach its intended target. This new system would ensure that the data generated would be in real time.
- The application that is to be used by the circuit supervisors and other administrative workers, who use the attendance management system, would be designed using web technologies. This means the users would require only a connection and basic web browser on their client machines to gain access.
- Reports required by the various administrative workers would be pre-configured and would be available for use "at the click of a button". This means all reports formats would be considered by during designing and development.
- Unlike the current system that is mostly paper-based and unidirectional, this new system would incorporate a feedback mechanism to give feedback to the teachers at certain times.
- The system would incorporate an access-rights mechanism for checking abuse or unauthorized use of the system.

4.1.2 Functional requirements of the new system

The analyses of the current and new system based on the proposed architecture have helped in the identification of the following functional requirements:

- The system should allow the administrator to add and manage teacher details. They should also be able to add and manage courses and the times they are supposed to be taught by the respective teachers. This would create a prepopulated list for use within the system.
- The biometric device should enable one-time registration of teachers. This should be done with the database enabled. This would be done against the prepopulated data of teachers within the system.
- The biometric device should be used by the teacher to clock attendance and have data generated and sent to the server in real time.
- The biometric device should verify the individual who is attempting to clock in by checking for the essential elements within the centralized database. The response should be matched by the matcher and indicate successful/unsuccessful authentication to the user. A successful authentication would automatically indicate attendance clocked within the system database.
- The database should maintain proper data on teachers from various schools within various districts within the country such that it can support easy searching and transformation.
- The accompanying application should be such that every user would require a set of security login credentials to gain access.
- The application should be preconfigured with formatted reports that would be generated upon minimal user interaction.
- The feedback mechanism should send information to teachers when prompted as well send predefined feedback at specific periods.

4.1.3 Non-Functional Requirements of the New System

In trying to assess what non-functional requirements this system holds we consider some work done by Kotonya and Sommerville (1998) who provide a three-item categorization of information systems. These are product requirements, organizational requirements and external requirements. They further go on to breakdown these three items into several sub items that even though granular are still generic and can be adapted for use in different information systems projects. For the purposes of this project, we only consider those that are essential and relevant.

- *Usability:* The system should be streamlined in such a way as to rid of unwanted steps. This would ensure that very simple flows exist. The system should be user-friendly, self-intuitive and easy to remember.
- **Reliability:** The system should produce output as expected and in a timely manner at an appreciable amount of time. It should not be compromised or open to manipulation by users.
- **Availability:** The system should always be available to the user at any time and from anywhere.

- **Standards:** The system should perform at acceptable levels of standard to be compared to any similar software and make it easy for evaluation of performance.
- **Safety:** The biometric devices used for attendance clocking should be safe to use. They should be mounted at safe locations in the schools and contain components that would not cause any damage to any user or individual near it. The GSM communication should not interfere with any other communication setup.
- **Privacy:** Data gathered and stored must be properly secured with appropriate access control policies in place to prevent unauthorized access or use. The communication medium should not give way to any interception of data at any point in time.
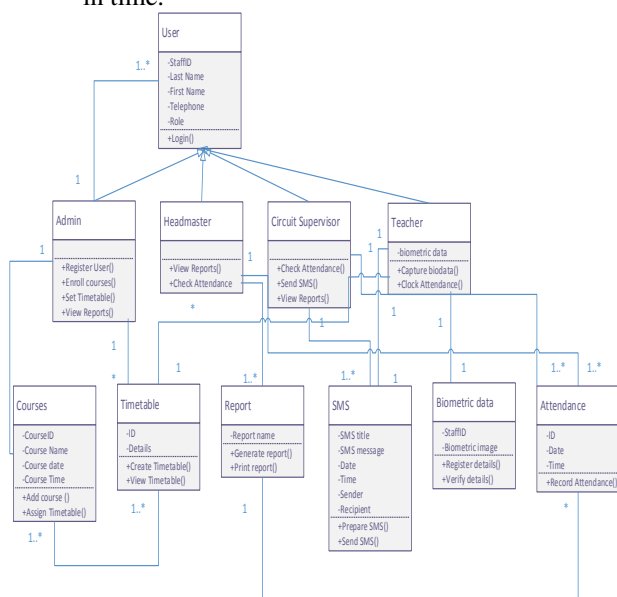
Figure 5: Class Diagram

The class diagram shown in Fig. 5 views various users and artefacts as objects that possess set of attributes as well as operations that they perform or can be performed on them. The class diagram also shows the relationships between the various the various objects. The users who would use the web application all have similar attributes and thus have been generalized but their operations differ. The teacher as a user has additional attribute that make it differ from other users because of the biometric data that is captured in addition to the other attribute. The lower level of the diagram contains various objects of interest as seen within the application. These together with the user classes can be used as the building blocks for database tables as it relationships. Also, the operations contained within the classes coupled with the relationships shown can assist in the coding phase of the application development as well as the integration.

Various Unified Modeling Language (UML) approaches have given us the opportunity to prepare designs as required by the business, data and data modelling phases of the system. These designs have all led to the development of a good application database as well as a good functioning application interface that is also functional. The technicalities that one would have considered to be sophisticated were made very clear using the widely accepted specification documents. The systematic manner of the documents went a long way to aid in the development and integration of the system.

V. CONCLUSION AND FURTHER RESEARCH

The objective of the GSM-based biometric attendance system was to create a highly reliable platform for both teachers and educational administrators in their attempt to track, monitor and record teacher attendance respectively. At the end the project has achieved the following objectives initially discussed and outline below:

- Gathering of information and analyses of the current system to better understand its mechanisms and associated pros and cons.
- Designing and developing a robust and centralized database that stores data regarding subject been taught as well as profiles of teachers.
- Designing and developing a web application interface integrated with the database to allow supervisors have access to stored data created by teachers' attendances, confirm attendances, print reports, send feedback to teachers etc.

Gathering information from the various stakeholders took a little longer than estimated. The channels that were in place at the GES required that some high level of approval had to be given before the relevant people could offer assistance. Information gathered was always pointing to manual systems and forms of attendance management. Some artefacts were shown to give further clarity on the various explanations and insights given. The next objective was to design and develop a robust and centralized solution. This objective was broken down into two parts but from a developmental point-of-view this discussion has been merged into one. The system development model chosen was the Rapid Application Development (RAD) model. The model requires that very refined designs be made produced to speed up the actual development. The design of the system came up from the second (Data Modelling) and third (Process Modelling) phases of the RAD model. The designs involved the use of standard UML approaches to ensure that consistency is achieved. Diagrams such as the class diagram eased the consideration that went into the creation of the database while the use of use cases and sequence diagrams depicted the flow of the application design.

5.1 Challenges

The system was not tested at other remote locations where GSM/GPRS has weak signal strength. It was tested at Akuapim south district where GSM/GPRS has strong signal strength. This limitation is due to lack of funds to travel to other areas within the country. The system can be viewed via a mobile browser, it is not responsive to varying screen sizes. The system is best viewed on 800 by 600 screen resolution. It is not adaptable to other screen resolutions. It was also difficult to get willing GES-

enrolled teachers and other staff whose data could be used for use in this project.

5.2 Recommendations for Further Work

The research has shown to hold very good prospect for the management of attendance of teachers employed by the GES. It uses could be adapted for other public as well as private institution as well. The availability of the system is very dependent on the strength and speed of the GSM network technology adopted. That infers that its use can be limited in this regard. As a recommendation, other forms of network connectivity that spans wide geographical areas should be researched into.

The third point is to have a system that offers an adaptive or alternative form of biometric attendance clocking. There could be instances where someone may have injured the required finger or for some unfortunate reason may have lost it. This should not mean the person cannot clock attendance. Other forms of biometry should be explored to ensure that electronic attendance clocking is always available. The systems justification would be further enhanced if its use is not limited only to its primary objective of effectively managing attendance. It can be integrated with other systems such as payroll systems, appraisal systems, Learning Management Systems (LMS) or even Enterprise Resource Planning systems to provide data or enable functional use.

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