Application of RFID Technology and GSM Network to Control Maintenance Activities of Radio Networks.

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ABSTRACT

GSM (Global System for Mobile communication) systems require continuous maintenance to provide a better performance and higher quality service on the network. Preventive and corrective maintenance have to be carried out to improve the performance and life of the network, thereby reducing the overall operating cost of GSM network. BTSs (Base Transceiver Stations) are the main elements of radio networks, which are installed at different geographical locations across the coverage area of the network. A general system is required to record and track maintenance activities of maintenance teams assigned to the BTSs. This system must be capable of recording all activities and be able to generate different types of reports.

A new technique is proposed as a solution to overcome the limitations of supervision of scheduled-maintenance tasks and generating maintenance reports. The proposed method uses the combination of RFID (Radio-Frequency Identification) technology and GSM networks to send required information in the form of SMS (Short Message Service) to a central database, which is installed in the Operation and Maintenance Center. In order to study and evaluate the performance of the proposed method, required equipment was installed on two sites on the network, to perform different tests.

The proposed method is an effective method and an accurate way to control maintenance tasks in a regular GSM network compared to the other conventional techniques. It is also more productive for generating reports and following the maintenance plans on the network.

(Keywords: GSM, global system for mobile communication, BTS, base transceiver station, RFID, radio-frequency identification, preventive maintenance)

INTRODUCTION

Generally, running mobile networks requires tremendous investments. One way of extending the life of a network is to maintain the equipment with corresponding maintenance systems. GSM networks have been one of the fastest-growing industries in the world. According to literature, the total global subscribers have reached 5.13 billion by the end of 2017, up from just 4 billion in 2012 [7].

The radio network is a huge concern in these systems, as downtimes are very costly and occur frequently. Therefore, condition monitoring and maintenance of the radio network components is very important in order to reduce unscheduled downtime and associated costs. This requires sophisticated fault analysis. Early diagnosis of faults within a radio network can prevent major component failures and allows scheduling of efficient condition-based maintenance repair activities.

Since radio network equipment are located at remote locations that may be difficult to access, their maintenance becomes vital task. Reports show that replacement of a low cost unit can turn into an expensive project involving container replacement and loss of network coverage. Historical data from 2013 shows that almost 16% of total corrective maintenance activities cover BTS equipment [4]. Thus, an effective and efficient approach to condition monitoring and fault diagnosis of radio network equipment needs to be developed in order to make customer service more efficient.

Many projects try to install RFID–GSM applications with related application to manage maintenance tasks. The advantage of this method is better planning, control and

documentation. It also improves the quality of the job remarkably. The limitations in data transfer between tags and tag readers, lower data quality, longer service process times, and ineffective maintenance history capture were improved by this work. Although, previous studies explored the promising of applying RFID in facilities maintenance, they did not focus on GSM maintenance [8]. In addition, using SMS service in the same network to manage its maintenance was not discussed.

The aim of this study is to develop mobile-based RFID maintenance system to increase the network maintenance efficiency. To achieve this goal, first GSM network and maintenance procedures are reviewed then RFID-GSM integrated technology is investigated. Different RFID scenarios are reviewed in this study and then a SQL (Structured Query Language) database is established based on the GSM network maintenance requirements to keep the data in the centralized location. The efficiency of the proposed system is examined by testing it on a live GSM network. Results and conclusions are also presented in this paper.

PROBLEM MOTIVATION

Maintenance reports are not always reliable. Always reports were submitted with the unexpected delay. There was no record of their actions, so maintenance history cannot be audited. Hence, effort is being made to sort out this issue by deploying a new method of reporting and auditing the tasks.

Objectives and Scope of the Project

The project aim is to study installing a RFID – GSM model on a cellular network to organize maintenance tasks, based on sending SMS and collecting related information in a database . This will allow the management team to track scheduled activities.

SYSTEM ARCHITECTURE - GENERAL GSM CONCEPT

A cellular network is divided into three main areas [4]:

1. Radio access network or Base Station Subsystem (BSS)
2. Core network or Network Switching Subsystem (NSS)
3. Management network or Operation and Maintenance Subsystem (OMSS)

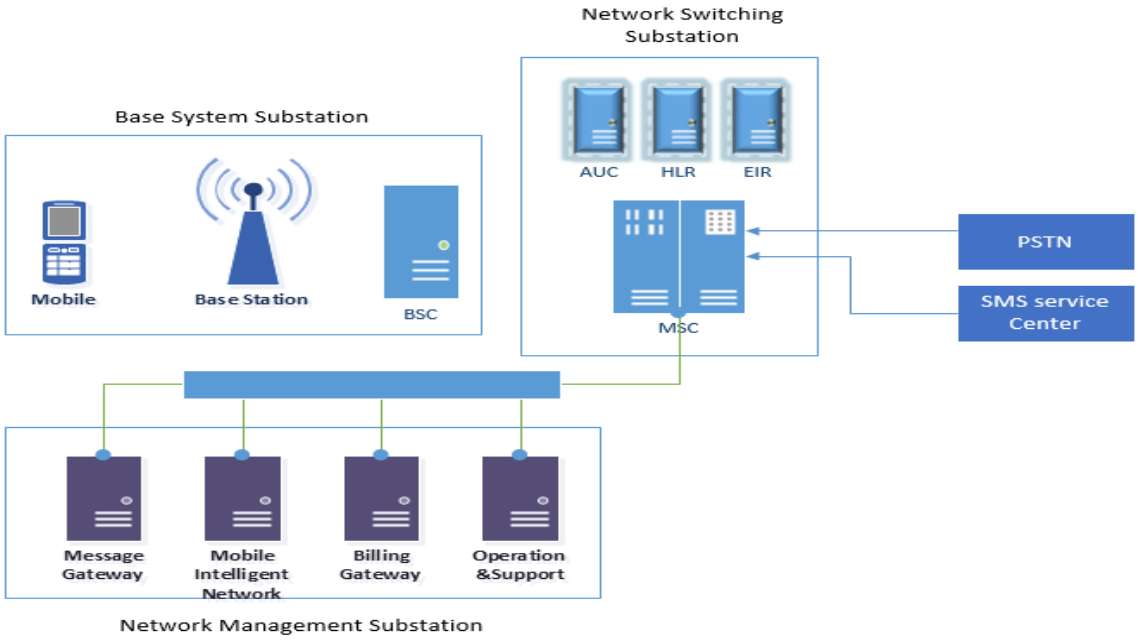

Figure 1: Subsystems in the GSM Standard.

Radio access network or BSS (Base Station Subsystem) has the following elements:

BSC (Base Station Controller) controls a group of BTSs. BSC also manages the radio resources and items like handovers within group of BTSs

BTS (Base Transceiver Station) communicates directly with MS (Mobile Stations) to establish a call.

Figure 1 shows the system architecture of a GSM network with essential components. The core part consists of Mobile Switching Centres and databases, which store the data required for routing and service provisions. The main elements in the core part of network are:

MSC (Visitor Location Register) is the main elements of NSS in a GSM network and act as a switching center in the network.

HLR (Home Location Register) is database that keeps administrative information of subscribers.

VLR (Visitor Location Register) is a database that selects and keeps some information of subscriber that is required to establish a call.

AC (Authentication Centre) is a database that maintains security information of the subscriptions.

EIR (Equipment Identity Register) is a database that keeps security information of mobile set.

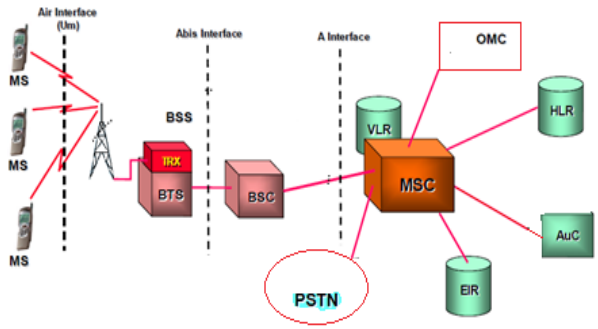

Figure 2: GSM Architecture (how different network elements form a GSM network).

Figure 2 shows, how these parts are connected and forms a mobile network.

As we mentioned earlier in the GSM network, BTS is a piece of equipment that facilitates wireless communication between user equipment and network. Following are the main sections of a BTS. Figure 3 shows all BTS parts.

- Power
- Power plant (is used in BTS to provide DC power from AC power
- BTS cabinet
- Tower and antenna
- ACU (Air conditioner unit)

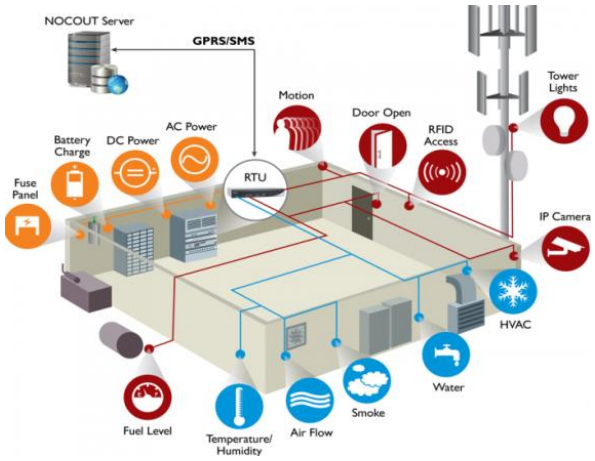

Figure 3: BTS (has different parts that are working together as a cell).

EFFECTIVENESS OF MAINTENANCE POLICIES FOR CELLULAR SYSTEM

Studies show BTS failures are the second most important cause of GSM network downtimes [2]. Having a strategy to put this equipment in proper working condition is mandatory. Maintenance activities are divided into planned and unplanned. Under these two groups, there are different subgroups.

Figure 4 shows these categories. The most important types of maintenance jobs are preventative and corrective. Preventative maintenance is any maintenance that is designed to retain the healthy condition of equipment and prevent failure. Corrective maintenance is a maintenance task performed to resolve equipment failure and restore it to operational condition.

A field operation team carried out the preventive and corrective maintenance for BTS system for the following sections. Each part has detailed maintenance procedure which is out of scope of this paper:

- BTS- Antenna and Feeder
- BTS Equipment
- Electrical
- Air Conditioner
- Shelter

- Tower
- Fence
- Battery and Rectifier

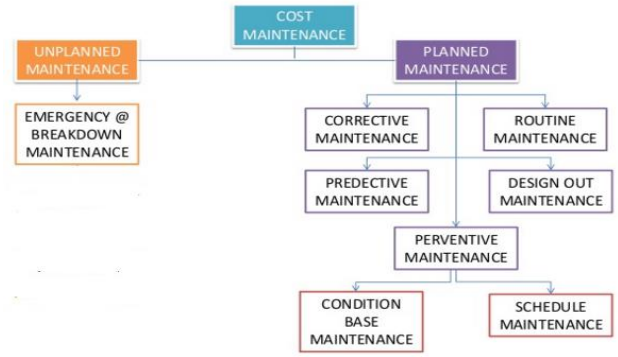

Figure 4: Overview of the Different Types of Maintenance Strategies.

Figure 5 shows the cost per unit of operating time. It is clear that the corrective maintenance costs increase as the maintenance interval increases. In other words, the less often you perform a preventive maintenance action, the higher your corrective costs will be. Obviously, as we let a component operate for longer times, its failure rate increases to a point that it is more likely to fail, thus requiring more corrective actions. The opposite is also true for the preventive maintenance costs. The longer you wait to perform a preventive maintenance, the costs decreases. If you do preventive maintenance too often, the costs increase. In case we combine both costs, we can see that there is an optimum point that minimizes the costs. In other word, there should be a balance between the risk (costs) associated with a failure and maximizing the time between preventive maintenance [5].

RADIO FREQUENCY IDENTIFICATION (RFID)

Radio Frequency Identification or RFID is a wireless use of electromagnetic waves to transfer data, for the purposes of automatically identifying and tracking tags attached to objects. The technology has been in the spotlight since Wal-Mart, in 2005, announced its decision that the suppliers must be ready to track goods using RFID tags [1].

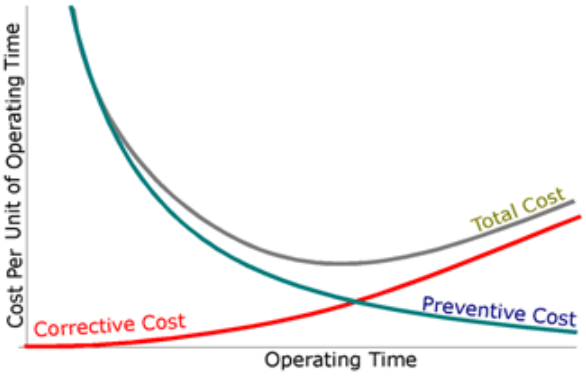

Figure 5: Cost per Unit of Operation Vs Operation Time.

Radio Frequency Identification (RFID) technology

RFID Technology is a kind of wireless sensor, which works by electronic magnetic signal (Figure 6). Today, RFID is a perfect solution for automatically identifying objects and process in many technologies. An RFID system consists of three main components, an antenna, a transceiver, and a transponder. Tag is a small device consisting of an integrated circuit and an antenna incorporated into any object or living being for tracking and identification. A RFID reader reads the tag then sends the information about the identification and location of the object to a computer [3].

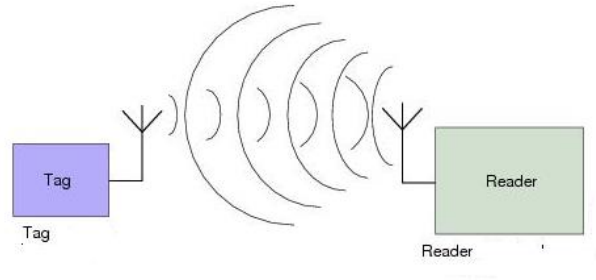

Figure 6: RFID Technology is a kind of Wireless Sensor.

RFID Integrated with Mobile

RFID integrated on Smartphone in two different ways:

1. RFID tags integrated to a Smartphone
2. RFID reader integrated to Smartphone

A Smartphone-RFID tag is a programmable RFID tag, which is connected to GSM network. This system has two antennae one for connecting to GSM network and the other for close communication on RFID field. That is responsible for communicating with RFID reader. When the tag is in the range of Reader, it can read or write to the tag like a normal tag.

A Smartphone with a RFID reader is a device that can act like a tag reader. It can connect to GSM network to transfer data to any destination through mobile network. In most cases, like supply-chain projects, the reader is fixed and tags are mobile part of the system. When tags are in a range of the reader, information will be read. Figure 7 shows the communication scenario through GSM network. The RFID reader will read the information when the tag is in RFID range then the Smartphone transmits the data by SMS over the GSM to central data.

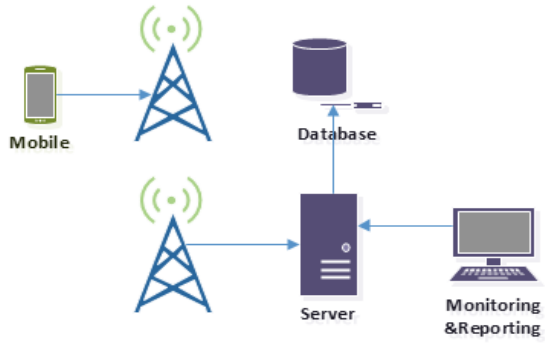

Figure 7: RFID-Communication Scenario through GSM.

MATERIALS AND METHODS

System Software and Application

To improve the efficiency of maintenance on GSM network, RFID technology can be deployed as an efficient solution. An RFID-GSM reader is provided for each maintenance team. After finishing the assigned tasks, they should stay in the range of related tag then all information will be read by a reader and it will be sent to a central database by SMS. Then this Information will be accessible on the database. This model provides simultaneous access for different teams. This means they can send their information in one time. The management part of this application will provide the different method of reporting for managers.

System Development Process

The RFID-GSM maintenance system scenario is illustrated in Figure 8. Each activity is explained as follows:

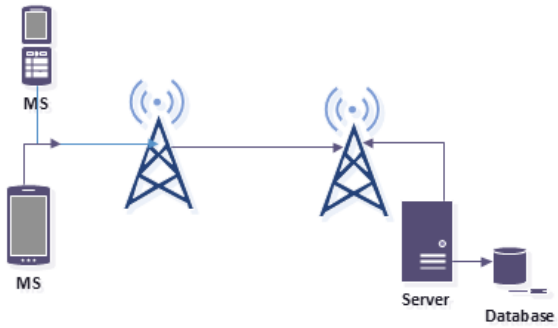

Figure 8: RFID-Maintenance system by GSM

1. Required hardware and software. System software is an application provided by West Industry Supplier Co. (Wisco) which is a company distributing systems to automate data collection in various industry. This software can be installed on a Windows system. This software can collect information accurately and keeps data in a database. A portable RFID reader/writer is required for each maintenance team. This device is compatible with the GSM network and can send information by SMS. The server hardware and software requirements are summarized as follow:

    - Database server: Dell enterprise personal computer
    - Operation system: Windows XP professional
    - Database format: My SQL
    - RFID device
    - RFID tag

2. Central database. For this plan, MySQL database has been used. Different information can be saved in this database. It can keep huge amount of maintenance information. Table 1 shows an example of proposed records:
3.
    - start date
    - end date
    - inspector name
    - checkpoint name
    - event name
    - event value

Table 1: RFID-Database Records.

Events (detail)

Start Date	9/19/2011 12:00:00 AM
End Date	12/19/2011 12:00:00 AM

Item	Date Time	Inspector name	Checkpoint name	Event Number	Event name	Event Value

System Software Architecture

The application runs on a main server. Then maintenance team sends data to the server at any time. In case of any outage, SMS will be retrieved from the SMS center even after 24 hours. The system concept, shown in Figure 9, has three parts. The central database is responsible for saving and keeping the data. This includes all the records that maintenance team need. The application will connect to database to retrieve information. A variety of reports can be generated based on our demands.

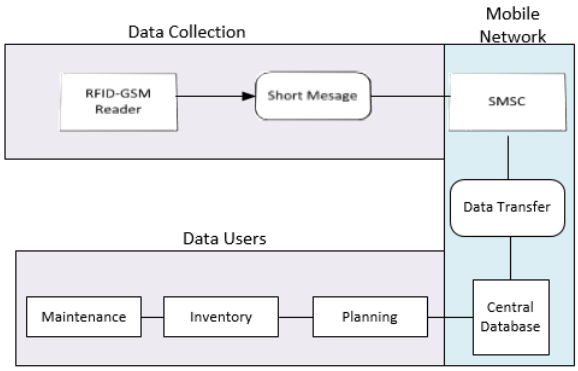

Figure 9: RFID-Software Structure.

CASE STUDY

We installed all required equipment for two BTS sites in different geographical areas. MySQL database was installed on a Windows server at the operations center.

System Implementation

The following parts were provided for a pilot system to be installed on the network:

1. Sensor 1 Qty
2. USB Port Cable 1 Qty
3. ID Sensor or tag 5 Qty
4. Computer Server 1 Qty
5. Inspector ID or Tag reader 5 Qty

Four ID-tags were installed on two BTS sites (T1620 & T1307). Two ID tags were installed on the towers. The purpose of these tags was to control the antenna and tower's activities. The next two tags were installed on AC PDB. These two IDs allow us to manage maintenance on power and batteries. After that, tags were registered in the Smart Inspector application and required information was written on tags. Five Tag-readers were distributed between maintenance team members as well. This group will do maintenance tasks across the network. To check the capability of proposed method six different tasks were registered in Smart Pack software.

1. Ensure no loose connections for all terminals in the internal/external.
2. Check all grounding cable and ensure they are ok and greased perfectly.
3. Record running hour of Genset.
4. VSWR Measurement.
5. Check active alarm on smart pack unit.
6. Check Batteries are installed properly and all connection are ok.

Different inspectors checked T1620 and T1307 on different times. Items were checked by RF tags and information was sent by SMS to the database. After that, related reports were extracted from database. Table 2 shows a sample report.

DISCUSSION

The goal of this research was to update a maintenance database after finishing any single job. Each team was provided one RFID reader. After they finished assigned jobs, they tried to read related tag's information.

Equipment identifications are identified through RFID devices. The maximum distance for a reader to read tag information is almost 60cm. Within this distance, any attempt to read the information would be successful. After reading information, it will be sent to database through GSM network by SMS messages. By this method when each team finishes a maintenance job, it will be reported to maintenance office immediately. Moreover, the management team will be sure that maintenance teams are following the maintenance schedule.

Table 2: RFID- GSM Sample Report.

Start Date		10/19/2011 12:00:00 AM				
End Date		12/19/2011 12:00:00 AM				
Item	Date Time	Inspector name	Checkpoint name	Event Number	Event name	Event Value
1	10/19/2011 16:52:10		5	1	Ensure no loose connections for all terminals in the internal/external DB	1
2	10/19/2011 16:54:25		5	1	Ensure no loose connections for all terminals in the internal/external DB	1
3	10/19/2011 16:54:29		5	2	Check all grounding cable and ensure they are ok and greased perfectly	0
4	10/19/2011 17:00:51		5	4	Record running hour of Genset	02356
5	10/30/2011 15:14:59	Alireza		1	Ensure no loose connections for all terminals in the internal/external DB	1
6	10/31/2011 14:19:38	Atiyeh	T1620 AC PDB	1	Ensure no loose connections for all terminals in the internal/external DB	1
7	10/31/2011 14:20:29	Bahareh	T1620 AC PDB	2	Check all grounding cable and ensure they are ok and greased perfectly	0
8	10/31/2011 14:21:09	Farzad	T1620 AC PDB	3	VSWR Measurment	052

The proposed method is multi-user and more than one group can send their data directly and almost real time to the database. In a case of any network outage, SMSC (Message Service Center) can keep the SMS for at least 24Hours.

The traditional way of preparing maintenance reports is time-consuming and keeping track of a team's activities was almost impossible. The RFID-GSM system is connected to a single MY-SQL database, which can gather information from the remote site and provide a different report for the management team at the same time. The database is updated immediately without any delay. Other errors related to data entry like data re-typing, duplicate maintenance, and missing maintenance data will not occur at all. Therefor this method reduces time, errors, and cost of data entry. Data in database will be available for analysis and generate report.

As long as there is network coverage, the data can be sent to the database and because all activities are taking place in one site, there are no reliability issues. The only time there is a possibility to lose connectivity is when the target cell is down. Another important issue is that tags should be far from each other to avoid any mistakes in reading the correct information. This is an important point during the planning phase.

CONCLUSION

This paper presented an RFID-GSM integrated maintenance system for mobile cellular network. The application will receive information by SMS. It has four different parts: a database, application, reporting tools, and remote side. After a maintenance task is finished, information will be sent by RFID-GSM reader. The proposed system was tested on a test-network. The following are benefits of applying RFID-GSM technology in the network:

- Real-time information: easy data transfer between network's cells and maintenance database.

- Increased accuracy: proposed method drastically reduces the chance of errors, preventing missing or duplicate maintenance activities or records.
- The derived results minimize total maintenance time to provide reports.

Apart from all advantages that the proposed method has, there are some problems to wide-spread implement of this method:

- Cost of Materials: the RFID readers are still expensive to combine with a cellular network and this cost for proposed model will be huge if implemented in the whole network.
- Incompatible with Test-network equipment: Smart Inspector software cannot be installed on a system that has HardCat installed on it. They will conflict with each other.
- Managing PM Plan and importing the PM plan based on operator: desire is not easy with this software.

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