Review on Mobile Workforce Management System for Electricity Supply Industries

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Abstract— **Mobile Workforce Management System (MWMS) is seen to be used to a great extent by many electricity utilities around the world. MWMS is particularly useful for these utilities as more than two-thirds of their workforce are mobile and would need a centralized control system to function efficiently. This paper presents an overview of the electricity utilities that implement and use MWMS. The discussions include background of the projects, project descriptions, and benefits of the projects. We present a table that summarizes all our findings and provide the discussion on the trend of the applications, hardware, functions covered and potential future applications. A few discussions on how to improve the existing systems, particularly incorporation of Knowledge Management (KM) is also presented in this paper. It is a hope that our findings can provide some basic ideas for other researchers to go further in MWMS research area, particularly in its adoption to Electricity Supply Industry (ESI).**

Keywords: Mobile application, electricity supply industry

I. INTRODUCTION

Electricity industry plays an important role in a nation's economic growth [1]. As such, a stable, uninterrupted, cost effective and efficient electricity supply contributes to the growth of a nation. However, the sophistication and complexity of the electricity network infrastructure have made maintenance and asset management cumbersome and costly. Thus, a highly-productive mobile workforce is deemed as one of the mechanisms that can be exploited by the electricity companies to ensure that they can deliver continuous services that meet the customer requirements and standards. There are a number of MWMS available nowadays. The applications differ from one to another ranging from public transport [2], road services [3], sales force, construction sites, home care service, medical service and taxi coordination [4].

Corporations today are facing increased requirements and challenges to enable and empower their mobile workforce. Gartner's prediction in 2009 that the number of mobile application tools and platforms in use by enterprises will increase 30% by 2011 shows that organizations are very serious in keeping up with the state-of-the-art business technology applications, specifically for mobile workers to stay ahead of their competitors and provide the best customer service experience to their clients [5]. Confronted by increased costs, competitive pressures, an aging workforce and today's economic challenges, many companies are looking for opportunities to reduce their costs, and improve service levels. Integrating a mobile and wireless solution that automates manual processes empowers employees with the information they need to improve job performance.

For electricity providers, the nature of the product delivery demands a high level of service response time. Mobile workforce management solutions combined with utility mapping capabilities is needed for organization to realize shorter resolution times for improved outage management. As for the typical utility company, two-thirds of total employees are field-based. This makes the automation of field personnel and the extension of critical business applications to remote users a key opportunity for productivity improvement and cost reduction.

II. RELATED WORKS

Numerous researches have been conducted in the area of MWMS for electricity supply industries. As reported in [11] the adoption of mobile solutions is notably high in electricity services. This section describes several applications developed for electricity companies. For each research studies, we begin with background introduction, then explain the project descriptions, and finally present the benefits of the projects.

EPRICSG presents results of examining applications of wireless technologies that may present business potential for energy companies [7]. EPRICSG is a subsidiary of the EPRI (Electric Power Research Institute). Several utilities were interviewed in an attempt to quantify Automated Field-Force Management (AFFM) experiences. They reported that Boston Edison Company had started utilized real-time wireless data communications with a Global Positioning System (GPS) for an automated customer service dispatching and communication system since late 1995 [7]. Boston Edison Company is a regulated public utility that provides electricity to the Boston area. Its activities include the generation, purchase, transmission, distribution, and sale of electric power [8]. The system had improved response time to customers' service calls and requests for billing information. Another company reported

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by EPRICSG used MWMS since 1996 was PECO Energy [7]. PECO Energy is an electricity provider serving customers in the City of Philadelphia and surrounding counties such as Bucks, Chester, Delaware, Montgomery and York [9]. Their MWMS centralized all field support functions and combined many job functions such as schedule maintenance and longer-term project work. The system had enabled PECO to schedule 20% of all service appointments to within an hour of the time requested by customers.

Different from MWMS applications discussed before, Public Service Electric & Gas focused more on task scheduling [7]. The system matches each field workers' location and skill level with pending work orders and expected time required to complete the work and automatically makes assignments. Barnes et al. described the application of MWMS in DELTA Utility Services, a company based in New Zealand [10]. DELTA manages distributed assets in the ESI and had started using MWMS since year 2000. Their (electricity) network designers used the mobile application to access their assets information from any location. The mobile application had improved accuracy and timeliness of information.

Another project by Brodt and Verburg reported that Nuon used MWMS mainly for handling cases like power failures [11]. Nuon is a national distributor of gas and electricity in The Netherlands that handled large number of remote workers. Response times to power outages are regulated by European Law. The mobile solution was developed to obtain these target response time.

Southern California Edison [12] started to implement MWMS in 2007. Due to the size and nature of the work at hand, there are many timing and resource dependencies between different field crews that need to work in sync for tasks to be completed effectively. There are two modules; ClickSchedule and ClickAnalyze. ClickSchedule used automated workflows that alert and warn planners, equipment managers, material managers, schedulers and coordinators if there are any issues that need to be addressed prior to releasing the work to the field resources. It will then automatically and sequentially schedules the necessary field crews. If a team in this cycle is no longer available it will automatically reschedule the job and reapportion the remaining crews to new tasks. ClickAnalyze is mainly for business intelligence reporting. Using operational and historical data collected in ClickAnalyze, senior executives will be able to accurately understand the impact of projects on field resources.

EDF Energy, the largest electricity producer in UK also utilizing the benefits of MWMS since 2001. EDF Energy provides power to a quarter of the UK's population via their electricity distribution networks in London, the South East and the East of England. The company mobile workforce solution was developed to improve scheduling efficiencies around meter-reading. The functionalities were then expanded to include managing a sales force of several hundred door-to-door field people. The system is able to automate scheduling by considering numerous variables such as resource availability, skill, location, equipment, as well as real-time events in the field like unscheduled emergencies or jobs that take longer than expected [13]. The most recent project conducted by Tenaga Nasional Berhad (TNB). Expected to start using MFFA (an acronym for Mobile Field Force Automation) this year [14], the development team is currently conducting user training at 3 states branches in Malaysia. TNB is the largest electricity utility in Malaysia with core businesses rest in the generation, transmission and distribution of electricity. The system is divided into 3 modules; Job Management, SMS and GIS module. The system is integrated where it allows for communication between customer call center, distributed network information system and supply management center. Table 1 summarizes the input, strengths and weaknesses of the existing tools. Table 1 contains the following columns:

Source: indicates the literature reference where the research was originally proposed.
Description of Application: refers to the functions supported by the developed mobile system.
Hardware: states the type of mobile device.
Specific Benefits: states the benefits of the application to company.

TABLE I REVIEWS OF PAST AND EXISTING MOBILE APPLICATIONS

Source	Description of Application	Hardware	Specific Benefits
EPRICSG [2]	**Boston Edison Company** • Utilizes real-time wireless data communications with a Global • Positioning System (GPS) • Locates service vehicles automatically so that available field workers closest to emergency calls could be identified • Handles customer appointment requests • Able to send and receive information to and from the home office while at the customer's residence	Pen-based, hand-held computers	• Improved customer service • Accurate, real-time data access • Scalable: can be used for additional field applications with no additional fixed costs • Reduced operating expense • Reduced non-payments of bills • Lowered number of recurring orders • Reduced errors • Eliminated many paper forms

TABLE I (CONT). REVIEWS OF PAST AND EXISTING MOBILE APPLICATIONS

Source	Description of Application	Hardware	Specific Benefits
EPRICSG [2]	**PECO Energy** • Matches available staff skills with service required	-	• Increased service calls attended by field workers
EPRICSG [2]	**Public Service Electric & Gas** • Connects field workers with dispatchers • Matches field worker's location and skill level with pending work orders and expected time required to complete the work • Assigns tasks automatically	-	• Improved customer service • Lowered number of recurring orders • Eliminated many paper forms
Barnes S.J. [5]	**Delta Utility Services** • Allows remote access to its geographical information system (GIS) • Records and tracks the presence and technical specifications of assets	Laptop, with a mobile data card	• Rich GIS data checked on site • Work integration of remote staff • Accurate, real-time data access • Reduced data entry • Enhanced paperless security • Improved customer service
Brodt and Verburg [6]	**Nuon NL** • Enables members of the response team to operate from home • Uses smart allocation system to distribute and allocate various assignments • Enables field service engineer to locate the right power switch automatically by checking power grid layouts or installation schemes	PDA and Tablet-PC with GPS and GPRS	• Reduced response time • Increased safety of employees when solving power failures • Decreased time to build problem history
ClickSoftware [7]	**Southern California Edison** • Alerts and warns planners, equipment managers, material managers, schedulers and construction and coordinators if any issues arise prior to releasing work to field resources • Schedules the field crews, reschedule the job if a team is no longer available and reapportion the remaining crews to new tasks	-	• Optimized scheduling • Utilized field crews more effectively • Better control of excessive overtime • Reduced errors • Reduced costs • Improved customer service
EDF Energy[8]	**EDF Energy, UK** • Allows workers to update Energy South's work management system over the phone. • Assesses the characteristics of job and optimizes the schedule by considering field workers skills, part availability, location, drive-time, workload, and service level agreement	-	• Improved matching of expertise with task. • Optimized scheduling • Increased customer satisfaction
Tenaga Nasional Berhad [14]	**Tenaga Nasional Berhad** • Dispatch job to the field crew • Allows communication (exchange job status, details) between workers using SMS • View network asset details • Search for road, building, substation	PDA	• Expected benefits of MFFA: • Increase production activity • Improved customer service • Accurate, real-time data access

III. DISCUSSION

From comparison of different research projects, we came to the following findings. Most of the utility (electricity) companies used MWMS to achieve the following objectives [7], [10], [11], [14], [15], [13]:

- Improved customer satisfaction,
- Reduced operating expense,
- Reduced non-payments of bills,
- Lowered number of recurring orders,
- Reduced order processing time,
- Reduced errors,
- Eliminated many paper forms,
- Improved collaboration and knowledge transfer,
- Improved productivity of workers,
- Continuous communications with field workers, centralized support staff, utility management, and first responders in emergency situations,
- Increased employee safety and
- Reduced overtime cost.

Despite of the similarities found in the objectives of MWMS, a special method in handling emergency calls is identified. For example, Boston Edison Company that divided the workload assignments for each field workers with 75% of the time allocated to base-line work (scheduled appointments) and 25% of the time reserved for emergency (high priority) calls [7]. From Table 1, it can be seen that companies reported in [7] had started using MWMS since 90's. This proved that MWMS had been adopted a long time ago where the rapid development is seen in term of supported functions and type of technology. Technology in this case refers to hardware and type of network. The recent development of MWMS has started to use technology like SMS, GPRS and GPS. Another trend that can be seen is in term of variety of systems that have been integrated together with the main MWMS application. If the earlier MWMS incorporated customer-related data like scheduled maintenance and complaints, the newer MWMS is started to expand the coverage up to substations or assets info like the location, distance and others.

The used hardware is often a PDA, handheld or PocketPC, whereas the use of notebooks or Tablet PCs for mobile workforces seems to be rather unusual. However, the conclusion is made based to the research projects that explicitly mentioned the type of mobile device used for their application. Some projects did not provide detail discussion and left hardware discussion remained unclear. Despite the lack of explanation on hardware used in MWMS, the choice of hardware used in MWMS must be seriously considered. The modern generation of smart phone offers possibilities that are comparable to computers such as notebooks, and they are much smaller and have much longer battery power supply.

Despite of large usage of MWMS amongst electricity supply industries, there are some limitations that may hinder adoption of MWMS. Fui et al. presented interesting discussion of interview results with major public utility company [16]. The survey collected information on issues, concerns, and values of mobile applications. While responses on values or benefits of mobile application to the company were almost similar to what have been discussed before, security, cost and employee acceptance issues were mentioned in most interviews [16]. Security concern with regards to incident such as the theft or loss of mobile devices, which are easily misplaced or stolen, could be one of the hinder factors for MWMS adoption. The mobile devices used in MWMS likely contain sensitive or confidential data that can be accessed by unauthorized persons. The company can consider incorporating a few security options like powerful encryption, restricted access, password protection, and customized default settings to solve security concern. As for the cost, the company will have to bear the costs associates to mobile devices, pay service fees for wireless access, and train employees. Limitation that regards to employee acceptance can be alleviated by providing adequate training and conduct a thorough usability test to ensure the system is easy to use.

There are few ideas and suggestions that can be implemented to extend the current works in MWMS. Strengthening security aspects of MWMS is one of them and very crucial to ensure reliability of the system. While many existing systems integrate with other databases like staff and fault databases, integrating MWMS with claim system can save cost where pursuing illegitimate claims can be avoided and at the same time faults repair can be minimized.

The existing MWMS emphasizes more on functional aspects of the system without paying much attention on the management of mobile workers' knowledge. Thus, Knowledge Management (KM) is suggested to be incorporated into MWMS. Detail discussion is presented in next section.

IV. INCORPORATING KNOWLEDGE MANAGEMENT (KM) INTO MWMS

KM can be incorporated into MWMS to capture knowledge on faults. The idea of KM is not new as it has been in discussion for many years. Many knowledge management activities occur in working places and in our daily activities. However, the application of IT tools to facilitate the creation, storage, transfer and application of previously uncodifiable organizational knowledge is a new initiative in organizations [17]. One of the KM techniques that possible to be used in MWMS is case-based reasoning (CBR). CBR is based on a verified set of past successful cases and considered as one of the most successful applied Artificial Intelligence (AI) technologies of recent years. It is based on the premises that new problems are often similar to previously encountered problems and, therefore, that past solutions may be of use in the current situation.

Started in 1977 by Schank and Abelson, many researchers have been conducted in this area such as in [18], [19] and [20]. CBR had been successfully applied in many applications around the world. Aamodt and Plaza [21] have described CBR typically as a cyclical process comprising the four REs:

- RETRIEVE the most similar case(s),
- REUSE the case(s) to attempt to solve the problem,
- REVISE the proposed solution if necessary, and
- RETAIN the new solution as a part of a new case.

Instead of relying solely on general knowledge of a problem domain, or making associations along generalized relationships between problem descriptors and conclusions, CBR is able to utilize the specific knowledge of previously experienced, concrete problem situations (cases). A new problem is solved by finding a similar past case, and reusing it in the new problem situation [21].

The role of knowledge based in MWMS is to support two main functions; knowledge acquisition and service automation. The knowledge acquisition refers to the acquirement of the knowledge and experience of mobile workers in solving faults. The use of KM allows reuse of established solutions, support the tactical and strategic needs of ESI and able to foster knowledge sharing and the creation of new knowledge [22].

V. CONCLUSION

This paper has shown that MWMS application is widespread among electricity utilities. Some of the reasons for this are the need to increase service standards, reduction in hardware costs and also the proliferation of data networks provided by communication companies. MWMS application ranges from receiving emergency calls, asset location search to dispatching of maintenance work. It was seen that this system will have a central server in the utility head quarters which can dispatch work or information to the utility's mobile workforce all over the service area. On the field, utility workers are often equipped with handheld devices which are multipurpose, incorporating GPS, data logger, Internet access and thus becoming a tool that is increasingly indispensable. From the reviews, we found that MWMS helps organizations to become more customer focused and can contribute towards improving service standards. Some further research in this area could be in strengthening security aspects of MWMS and integration with other existing systems. KM that incorporates into MWMS will enable technical team to perceive solutions for problems that have been solved before. This will expedite decision making process that leads to spending more time in attending other problems.

As a future work, research that includes performance evaluation and comparison with other implementations is needed to show advantages or uniqueness of existing MWMS.

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