Current Mobile Technology Roles to Support Collaborative Maintenance

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Abstract

The primary objective of this research is to identify the benefits of collaborative maintenance and the current roles of mobile technology in supporting of daily collaborative maintenance practice. Based on Delphi study research method, four categories of benefits were found, namely, networking/communication, coordination, cooperation and productivity or collaboration, while flexibility and empowering management are the current mobile technology roles in supporting collaborative maintenance. It is evident that current maintenance working circumstances are more complex and therefore need to be managed by multiple and interlinked activities. Hence, an integrated high-level maintenance system which contains multiple sub-systems requires the collaboration of many stakeholders such as departments or units to improve resources, information sharing and maintenance practices. Combined improvement in processing that empower maintenance management and make it flexible allows organisations to use their maintenance resources faster, properly and more profitably.

Keywords: Mobile technology, collaborative maintenance.

Introduction

Mobile technologies are considered as business enablers, and they have the ability to assist asset maintenance practice. On the one hand, mobile technology is able to sustain collaborative information exchange, while on the other hand, it provides a variety of advantages to the business, such as the ability to work cooperatively or independently. By implementing mobile collaboration technology, organizations can ensure that their maintenance personnel are always reachable anytime, in the context of their site, meaning they are more available for planned and/or unplanned maintenance and provide information as quickly as possible (Tsirulnik, 2009; Saran, 2006; Koseoglu & Bouchlaghem, 2004). Moreover, Smailagic et al., (1997) argue that a combination of mobile/wearable computers with wireless technology develops greater effectiveness and accuracy in maintenance. Through the use of digital data, voice, and visuals, this technology connects maintenance workers in a specific place with a distant knowledge center. With these features, a less-than-expert maintenance staff may do basic repair maintenance with the aid of a remote expert's console.

The purpose of this research is to discuss how organizations that manage engineering assets are using mobile technologies for collaborative maintenance. This report presents findings from a global Delphi survey to identify the functions of mobile technology. The purpose of this research is to discuss how organizations that manage engineering assets are using mobile technologies for collaborative maintenance. This report presents findings from a global Delphi survey to identify the functions of mobile technology.

The remaining parts of this work are organized in the following way: Work on mobile maintenance units, Maintenance of assets performed in collaboration, Technology on mobile devices for use in cooperative maintenance, Method of research, and The results of the research, followed by the discussion and the conclusion

Mobile maintenance work

Increasing the inventiveness, efficiency, and effectiveness of collaboration and communication in the workplace is a major motivation for the development of cutting-edge mobile technologies and applications. This includes reducing reliance on constraints for collaboration sceneries such as time and location. Collaborative workplaces of the future are expected to be more adaptable in terms of working environment, bringing the "collaboration anytime, anywhere" ideal closer to fruition. The time and place of work, the nature of the tasks to be performed, the needs of the market, the limitations of the organization, the backgrounds of the individuals involved, and the composition of the teams all contribute to better accommodate the demands and possibilities of the mobile worker and team, the "mobile workplace" is progressively responding without regard to time, place, or anything else that could be relevant to the situation, to the ever-evolving requirements and possibilities of the mobile worker and team. It follows that the internet itself may soon replace the office as the primary location for doing work. The mobile workplace then develops towards a scenario of work organisation, which is characterized by empowerment of workers being part of ad-hoc temporary project teams and networked organisations, and by a high level of awareness of and responsiveness to context (Schaffers et al., 2006).

Collaborative asset maintenance

The process of gathering information that is complete, consistent, and up-to-date throughout a whole business is a challenging one. As a result, companies have been working on expanding their use of various IT systems to aid in the administration of their company's data. Such systems aim to improve the way in which information is gathered, managed, distributed, and presented to the people in key business functions and operations, in other words, these systems aim to improve the collaboration and information management (Liang & Huang, 2002).

A system to support collaboration and information management should be able to offer a shared information work space; a communication space to negotiate collective interpretations and shared meanings; and a coordination space to support cooperative work action, in other words, a shared information work space that facilitates access to information content, organizational communications, and group collaboration (Pereira & Soaresa, 2007).

As a result, CTs enable enterprises to instantly assemble dispersed personnel to accomplish activities requiring collective involvement, things like project teams, planning, consultations, and upkeep. Collaboration tools could make it easier for people to talk to each other, share information, and make better decisions in EAM domains. Some current collaborative maintenance actions that stand out in more than one way are, but are not limited to:

- Improve maintenance and communication with customers via an agent-based collaborative maintenance chain that connects the asset operating site, research center, system providers, and suppliers (Trappey et al., 2008).
- The incremental update of a live, dynamic case-base that is supported by a distributed and interactive maintenance process is facilitated, monitored, and controlled via collaborative maintenance (Ferrario & Smyth, 2000).

- Remote sensing, diagnosis and collaborative maintenance: web-based maintenance systems using virtual instrument to enable the international experts to share their advice in the maintenance process when needed (Wang et al., 2004).
- Agent-based distributed collaborative monitoring and maintenance in manufacturing: using intelligent software agents to tailor the maintenance schedule for geographically dispersed field mechanics and brokers (Wang et al., 2005).
- Collaborative maintenance in large open source projects: analyse the involving of the virtual team among open source maintenance that distributed in various part in the world (Besten, Dalle & Galia, 2006).
- A framework for digital cooperative maintenance that boosts production-system efficiency. The architecture incorporates maintenance elements such as operational reliability, maintenance economics, human factors in maintenance, maintenance program, and maintenance optimization in a virtual collaborative architecture (Jenab & Zolfaghari, 2008).

In practice, Lazkiewicz (2003) explain that a collaborative maintenance can manifest itself in a wide variety of ways, such as online condition-based or real-time manufacturing process control monitoring, direct access to technical assistance. In an economic downturn, collaborative maintenance is a cost-effective method for businesses seeking to stay competitive. Due to its scalability to any organization size, both big and small businesses may benefit from a degree of cooperation adapted to the organization's need.

Fundamental to collaborative maintenance is the notion that all maintenance stakeholders must be dedicated to contributing to the enhancement of the whole, the development of the relationship, and the achievement of the organization's business objective. The fast development of computer technology and information systems has enabled personnel to communicate and interact across time and/or location to exchange expertise and information.

Organisations contemplating the installation of a collaborative maintenance system should first conduct a comprehensive review of the complete maintenance operation, including the technical, organizational, and employees who serve each assignment. Maintenance managers can identify which areas/tasks are running efficiently and which need assistance based upon the result of assessment (Lazkiewicz, 2003).

Mobile technology in collaborative maintenance

Consumer applications of mobile technologies and solutions are very popular, and their use will continue to grow. Mobile maintenance solutions are still not used by a lot of industries on a large scale. One reason is that not enough people have the skills and knowledge to use mobile solutions successfully at work. Many companies have had bad experiences when they tried to use mobile solutions for maintenance. This could be because they didn't have the right devices or because they weren't ready for the process. The advantages of mobile solutions, such as those used in the maintenance industry, are sometimes not observed or are simply not recognized. Mobile technologies as such are nowadays mature enough to face the challenge and requirements of professional use in engineering industry (Backman and Helaakoski, 2011).

The use and adoption of mobile services has been studied globally and extensively from context-driven organisational problem solving of view (Sheng, Siau & Nah, 2010; Bardram & Bossen, 2005; Haaparanta & Ketamo, 2005; O'connell & Bjorkback, 2006; Cass, Shove & Urry, 2005; Perry et al., 2001; Lamming et al., 2000; Malladi & Agrawal, 2002; Charterjee et al., 2009; Sarker & Wells, 2003 and Burley & Scheepers, 2002). When considering use of mobile solutions in industry and especially in maintenance the available studies and researches focus mainly on e- maintenance (Marquez & Iung, 2008; Muller, Marquez & Iung, 2008, Koc et al., 2004, and Campos, 2009). The term e-maintenance is still a vast notion, of which mobile solutions might be a component.

Some e-maintenance specific case studies focus on mobile device architectures where the mobile device can for example help the maintenance engineer to perform maintenance tasks (Campos, Jantunen & Prakash, 2009). Mobile applications may bring facility management directly to everyday field operations, resulting in more effective regular maintenance.

Research method

With the help of this research, we can better understand the roles that mobile technology plays in facilitating collaborative engineering asset maintenance and implement appropriate practices moving forward. To more precisely construct the consensus from the panel expert's viewpoint, the Delphi approach is used. The Delphi study is a group process to solicit expert responses toward reaching consensus on a particular problem, topic, or issue by subjecting them to a series of in-depth questionnaires, interspersed with controlled feedback (Dalkey & Helmer, 1963). Consensus agreement can vary from 51% (Loughlin and Moore, 1979), 70 % (Sumsion, 1998) to 80% (Green et al., 1999) among participants. The consensus degree of agreement for this study's analysis was set between 70% and 100% agreement or disagreement.

There are several applications for the Delphi method: There is little written on mobile collaboration technologies for engineering asset maintenance, and much little in the way of actual evidence to back up any claims that have been made. The Delphi study carried out in this research comprised three rounds (Linstone & Turoff, 1975) and aimed to address the following research questions: What is the current role of mobile technologies in support of collaborative maintenance in engineering physical assets?

Invited to participate in the Delphi survey were 47 specialists with strong academic credentials, research expertise, and professional careers in the field of mobile asset maintenance. Twenty individuals were willing to engage in the study. There were eight professors and twelve professionals from ten nations. The demographic information of the respondents is provided in the following tables:

Table 1: Respondents by geographic location

Location of expert	**Participants**	
	Frequency	**Percentage (%)**
Australia	2	10
Canada	3	15
France	1	5
Germany	1	5
Greece	1	5
Malawi	1	5
Qatar	1	5
Singapore	1	5
United Arab Emirates	1	5
US	8	40
Total	20	100

Table 2: Respondents' (Academicians) Profile

Characteristic (Variables)		**Frequency**	**Percentage (%)**
Level of Academic Education	Bachelor	-	0
	Master	-	0
	PhD	8	100
Experience in Mobile Technology and Collaborative Maintenance	1 – 5 Years	-	0
	6 – 10 Years	2	25
	10 – 15 Years	2	25
	More than 15 Years	4	50

Table 3: Respondents' (Professionals) Profile

Characteristic (Variables)		Frequency	Percentage (%)
Level of Academic Education	Bachelor	5	42
	Master	5	42
	PhD	2	16
Maintenance Professional Qualification	CPMM	5	42
	CMRP	12	100
	CMRT	12	100
Experience in Mobile Technology and Collaborative Maintenance	1 – 5 Years	-	0
	6 – 10 Years	2	17
	10 – 15 Years	3	25
	More than 15 Years	7	58

In order to facilitate the Delphi process, an email-based survey with three rounds was created. The first stage (concept generation/problem identification) included an open call for suggestions for potential mobile technology positions. To answer the third study question, participants were asked to describe the ways in which mobile technology contributes to the state of the art in collaborative asset maintenance. After two reminders, we still haven't heard back from any of the twenty specialists we contacted. At this time, we have received a withdrawal from one responder. In the "Eliciting agreement" step, we double-checked the current mobile technology job classification system. The researchers wanted the specialists to verify their evaluations and categorizations of the data. The experts were also tasked with reclassifying the item(s) or combining them into new categories. In the last phase (achieving consensus), participants rate the extent to which various categories of existing mobile technology facilitate effective collaborative maintenance practices.

Research findings

Current Mobile Technology Roles

The following uses of mobile technology in maintenance support cooperation systems have been confirmed. This list is based on the second-round suggestions of 19 members of an expert panel and is supplemented by a study of the relevant literature. Then, in the final round, 18 experts graded each member of the cast based on their performance in their assigned part. IBM SPSS Statistic software was used to analyze the data, and frequency, mean, and standard deviation (SD) were determined for each agreement level of mobile technology jobs. Those with the highest rating and smallest SD were considered to have the greatest consensus (Jones & Hunter, 1955). Agreement was defined as a percentage between 70% and 100%. We ranked them in Table 4, and then spoke about them in order.

Table 4: Research Findings

Flexibility	1 Strongly Disagree	2 Disagree	3 Unsure	4 Agree	5 Strongly Agree	Mean	SD
Visualizing collected data, the history of parameters, and trends			1	15	2	4.06	0.42
Contextualizing access to remote data and services: Services and data entry related to tasks are always available to users who are allowed to use them.			2	11	5	4.17	0.62
Important for the time it takes to respond to data or information that can help find problems and fix them quickly.	1			12	5	4.11	0.90
letting people know about the failure through mobile devices		1		14	3	4.06	0.64
Using GPS to find the location of skilled maintenance staff near an asset that has broken down		2		13	3	3.94	0.80
Mobile technology makes it possible to get information directly from all of the possible decision-makers at the right time and place (CMMS, ERP, sensors, etc.).		1	1	11	5	4.11	0.76
Empowering Management							
Management of resources (like materials and people who do maintenance) makes it easier to keep track of tasks, assign them, and report on them.				8	10	4.56	0.51
Spare parts, for example, can be ordered and bought from vendors.			3	12	3	4.0	0.59
Report problems in a clear way and let people know about the workers' actual working hours and availability.			1	12	5	4.2	0.55
allowing organizations to assign maintenance resources on site from anywhere and at any time			1	10	7	4.3	0.59
Improving the accuracy of key data entry for the history of maintenance.			1	6	11	4.6	0.62
How to run a store or warehouse: Q/A			1	10	7	4.3	0.59
Others			1	7	10	4.5	0.62
Early adopters are the first people to use a new technology.		1	2	15		3.8	0.55
Still not very much use		1	2	13	2	3.9	0.68

Discussion

Because of the interconnected and interdependent nature of modern engineering assets maintenance workplaces, it is essential that maintenance personnel in particular be able to effectively communicate, coordinate, and cooperate in order to do even the most menial of jobs. Maintenance tasks may be coordinated in real time regardless of where they are performed thanks to the portability of mobile collaboration devices. In addition, mobile technology enables the visualization of gathered data, the history and trends of parameters, and the reaction to data or information that may facilitate the early repair of errors or the discovery of malfunctions. These features make it easier for supervisors and maintenance managers to pinpoint the location of assets that are malfunctioning, schedule emergency repairs, and locate a qualified expert who is close by.

There are numerous facets of complicated maintenance that are influenced by the development of mobile technology. Incorporating these technologies allows for the ordering and purchasing of maintenance resources at any time and from any location, the immediate reporting of unexpected failures, the continuous or intermittent monitoring of asset condition, and the assignment of the appropriate operation and maintenance personnel to perform the job while on the go.

There are a number of ways in which the utilization of mobile collaboration technology is now very low in the ordinary maintenance practice of the present. The inability to effectively embrace mobile solutions for professional usage is one possible explanation. Due to unreliable or nonexistent networks, a lack of compatible hardware, or just a lack of planning, many businesses have had negative experiences using mobile solutions for maintenance. In addition, the advantages of mobile solutions are not recognized or understood in the maintenance industry.

With the availability of a wireless internetworking connection and the development of mobile technology's hardware and software, including tremendous increases in processing speed capacities, mobile technology is now able to handle sophisticated mobile tasks. Maintenance organizations may now centralize their maintenance helpdesks, facilitating the transfer of digital data, voice, and visuals between onsite maintenance workers and a distant knowledge center.

Conclusion

There hasn't been much of an uptick in the usage of mobile technologies to assist team-based maintenance yet. The reason for this is an inability to properly deploy mobile technologies in a business setting due to a lack of knowledge and expertise. The primary cause of this is the fact that the advantages of mobile technology are either not yet recognized or are simply unknown in the field of maintenance.

To get there, organizations tasked with engineering asset maintenance are looking at methods to better coordinate the intricate tasks carried out by operators and management in their factories. A complete, integrated software solution that not only enhances performance, but can also be developed rapidly and modified to the individual procedures and processes without sacrificing safety, is essential for managing operations in the complex engineering organizations environment. However, real maintenance tasks may only be carried out at the machine's site. This means that technical professionals such as engineers and technicians in different places require access to vital information regardless of where the machine is operating, and that a great deal of data must be transmitted between the specialists, the monitored equipment, and the back office. Moreover, even if the necessary data and technical resources exist at the headquarters, they are seldom made accessible to the appropriate people working at the site when and where they are needed. To boost quality and dependability, maintenance staff need mobile access to data on physical assets at the location where that data is used rather of having to wait until they return to the office. Maintenance management may be made more effective, efficient, and profitable by a combination of processing enhancements that strengthen it and increase its adaptability.

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