ISSN(Online): 2319 - 8753
ISSN (Print) :2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

Implementation Barriers of Mobile Environmental Information System for Environmental Surveillance on Construction Sites

Aizul Nahar Harun [1], Erik Bichard [2]

Academic Staff, School of Professional and Continuing Studies, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia[1]

Professor of Regeneration and Sustainable Development, School of Built Environment, University of Salford, Salford, United Kingdom[2]

ABSTRACT: The use of Mobile Environmental Information System (MEIS) which integrates the use of mobile web, devices and wireless sensor networks has the potential to enhance environmental information management and communication processes among users and play an important role in field data acquisition and validation, to provide real-time environmental data monitoring and, more importantly, to provide warning signs in the areas of construction activities that require immediate corrective action. However, the understanding on the anticipated barriers for any proposed systems that may arise during the implementation of the system are important to ensure the sustainability of the systems in the long run. In this paper, this issue was addressed through the prototype demonstration and evaluation sessions where the respondents had the opportunity to highlight the implementation barriers while testing the functions of the ENSOCS web by using smartphones to perform the pre-defined tasks. As a result, the practitioners in Malaysia and the UK had highlighted that these barriers include return on investment, operational cost, legality issues, work procedures issues, technology and technical issues, technology adoption barriers and network infrastructure. Therefore, from this research, the developers of mobile applications would obtain valuable input with regards to understanding the requirements of construction environmental management teams as well as the limitation for the implementation of MEIS within the construction industry.

KEYWORDS: Mobile Environmental Information System, Environmental Surveillance, Construction

I. INTRODUCTION

It is widely accepted that Information and Communication Technology (ICT) contributes to the construction industry in supporting tasks, easing communication barriers, speeding up processes and response time and in managing information [1-3] and, as a result, brings increased effectiveness into the process of construction [4]. But unfortunately, the industry remains behind other industries in many areas and it is still in the relatively early stage of adopting modern internet technology [4-6]. Adoption is high in the design phase and in facility management but the use of ICT by contractors and site workers is surprisingly low [7]. As construction work is mainly work out in the field and workers are highly mobile [8-9], the traditional way of doing things is definitely not able to fulfil industry needs. Currently, the delivery of necessary information to a construction site or of collected data back to the office is problematic and slow [9].

Additionally, in some countries like Malaysia, research on, and the use of, IT and IT-enabled products for environmental sustainability in the field (including within the construction industry) is low. Tushi et al. [10] in their review of the literature from 2007 to 2013 have revealed that, based on the number of researches, most studies on Green IS tend to focus on developed nations such as Australia (9), USA (6), UK (2), Sweden (2), New Zealand (1) and The Netherlands (1). A lesser number of studies have reviewed still developing nations such as China (2),

ISSN(Online): 2319 - 8753
ISSN (Print) :2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

Morocco (1), Hong Kong (1), Serbia (1), South Africa (1), India (1) and Bangladesh (1) while research looking at multiple countries has recorded (5) and none at all have focussed on Malaysia. Their findings might be limited to their research methods but, based on the author's 10 years' working experience (2000-2010) as an environmental auditor and manager at a well-known Malaysian public listed company and subsidiary within the field of construction and oil and gas, it is fair to assume that the use of IT and IT-enabled products, especially for environmental surveillance, among practitioners in Malaysia is still low as people generally only use desktop software and word processing software (e.g. Microsoft Word, Lotus Word, Microsoft Excel, etc.) for the preparation of inspection reports, and use emails and intranets for communication and the sharing of information and documents. Malaysian practitioners currently rely on traditional communication tools (e.g. letters, e-mails, faxes and telephones) and paper-based documents (e.g. the paper form of checklists, plans and manuals) while performing environmental surveillance and, subsequently, manual reporting and record keeping processes e.g. paper-based reporting and filing cabinets. It is envisaged that such current reliance on traditional communication tools will be re-confirmed in this research.

It is also important to note that, although the traditional methods are robust, they are certainly time consuming and challenging [11]. Paper based checklists, plans and manuals, for instance, are difficult to carry in big quantities and offer very limited sources of information at a particular time [12]. Most importantly, due to its nature, using paper documentation means that practitioners are often unable to react swiftly to a rapidly changing context. Paper documentation can often fail to demonstrate the interrelationship between activities and their consequences in a timely manner. Moreover, the traditional paper based method is labour-intensive and exposed to deficiencies and discrepancies [11, 13].
In contrast to the traditional paper based method, the use of mobile devices and real-time data streaming through the Web has the potential to enhance information management and communication processes among participants and play an important role in field data acquisition and validation, to detect potential environmental impacts [14] and, more importantly, to provide warning signs in the areas of construction activities that require immediate corrective action [15]. The ability to identify potential environmental impacts as early as possible is vital to any project of any size and scale because ''prevention is always better than cure'' (Nikander & Eloranta, 1997, cited in [15]). Environmental professionals can easily carry mobile devices with wireless communication connection to field locations for their data collection and validation tasks. They can easily retrieve data and information from the web servers and/or perform real-time data updates, can exchange data between those servers and can receive a warning sign alert from an environmental sensor on their mobile devices, simultaneously.

Furthermore, the Web also creates an opportunity for the development of an exclusive Knowledge Base for environmental management. This Knowledge Base can include rules, guidelines, best practices, and so forth, for the prevention and resolution of impacts and practices; this knowledge deriving from the practical experience of experts and professionals in the field. This would allow for knowledge sharing and junior environmental staff, in particular, would benefit from this Knowledge Base for their on-job training [16]. In addition, the Web would also enable new opportunities for the development of distributed systems that can cross organisational boundaries and provide unique opportunities for teamwork and workflow automation. Independent project participants could share the same system over the Web even if they are using different hardware platforms [17].

However it is important to note that the use of mobile devices and real-time data streaming through the Web as well as physical surveillance for environmental management at the construction site would add value to the existing method and in some situation complements each other [18]. Therefore, within this research a prototype of a mobile environmental information system (MEIS) which is better known as "ENSOCS mobile web" was prepared [19]. It was designed and developed for internet browsing via a Smartphone and works together with telemetry sensors to provide real-time environmental data monitoring; additionally the environmental enforcement officer uses a mobile online checklist and tools to carry out the physical environmental surveillance. Fig. 1 shows the system architecture of ENSOCS.

ISSN(Online): 2319 - 8753
ISSN (Print) :2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

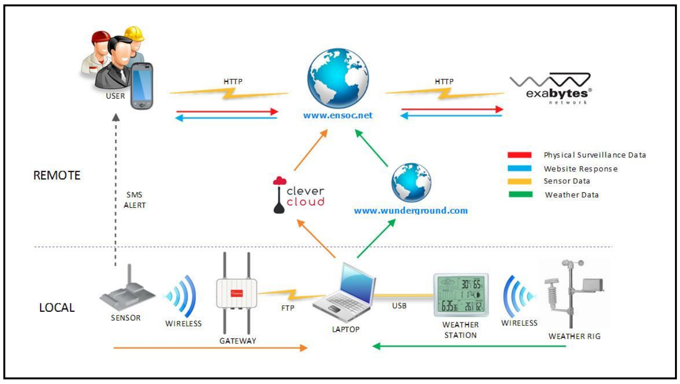

Fig. 1. System Architecture of ENSOCS

As shown in Fig. 1, the ENSOCS architecture follows the four-layer structure of the Internet of Things (IoT). In the Sensing and Control Layer, the Wireless Sensor Networks capture the reading of PM10 concentrations and noise levels, while the weather station obtains weather conditions' data. GPS and WLAN are also being used for the determination of the current location of the user. The server system (MySQL Database server and the web server) at the Middleware Layer will process location data gathered from the built-in smartphone, the sensor data, the data input from the user and the weather data. The server will then intelligently choose the right information and services from the servers available in the system. In the Application Layer, a mobile device is able to deliver the inputs from the user and, at the same time, receive the Short Messaging System (SMS), location coordinates, sensor and weather data from the built-in GPS, the wireless sensor network (WSN) and the weather station. Finally, the Networking Layer of the ENSOCS prototype consists of the Wireless Local Area Network (WLAN) and Local Area Network (LAN).
It is anticipated that the ENSOCS could improve environmental surveillance processes by providing a tool for environmental enforcement officers to assist in managing their environmental surveillance activities and in enhancing their decision-making capabilities. However, to ensure the success of its implementation in the future, it is important to researchers studying the obstacles that may arise during the implementation of the system. Therefore, this issue has been addressed in this research through the prototype demonstration and evaluation sessions with the practitioners in Malaysia and the UK.

II. METHODOLOGY

An effective prototype testing has to be able to elicit feedback from users as to whether they can use the application without (or almost without) difficulty and how they liked using the application, as well as to evaluate the levels of task performance achieved by the users [20]. There are various concepts, methodologies and approaches commonly used in traditional human-computer interaction research for the testing of desktop applications. However, these may not be directly applicable to a mobile environment due to the unique features of mobile devices such as limited bandwidth, unreliability of wireless networks, as well as changing contexts (environmental factors) [21-22]. Zhang and Adipat [21] argue that participants involved in a controlled laboratory setting may not experience the potential adverse effects that are caused by changing and unpredictable network conditions and other environmental factors. Therefore, the testing of a mobile application tested in a real environment may not work as well as it does when tested in a controlled laboratory setting.

Taking into account these issues, the ENSOCS prototype needs to be tested in a real environment, within actual on-going construction projects. However, it is important to note that a construction site is considered to be one of the most dangerous working places where there are always safety concerns for the employees. Most construction activity is difficult, dangerous, dirty, and can involve heavy machinery and scaffolding high above ground level. Most accidents that happen on construction sites are caused by a lack of training, carelessness, a failure in the interaction between the work team, workplace, equipment and materials, and not following basic safety rules while working in

ISSN(Online): 2319 - 8753
ISSN (Print) :2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

the site [23-24]. The most serious accidents which happen can result in injuries and death. For example in 2012, 177 accident cases on construction sites were reported in Malaysia [25]. Within this figure, almost 37.9% or 67 cases resulted in death, while 6.8% or 12 cases resulted in permanent disabilities. For such reasons, construction companies need to comply with any requirements (in addition to any security policy) that are created in order to meet federal, state and local laws. In addition, construction companies also have contractual agreements with clients that are associated with information protection and the control of the entry and exit from the project site. These limit the access to the site as well as the information associated with it.

Therefore, to find actual on-going construction sites that can be used for the case studies is difficult. Not many companies would allow outsiders to come in and explore their site or put any installation upon it for the purpose of gathering information from it. Furthermore, the requirement of this research is to walk through a site and install the wireless sensor networks on site that will capture the readings of air and noise level quality which would reflect the level of compliance as regards statutory requirements. Thus, it is not surprising that many parties voiced their concern over the future use of the data and on guaranteeing the safety of the author during his stay at the site. Because of this, only two companies in Malaysia and one in the UK expressed their willingness to allow the use of their construction sites as the case studies in this research. Details of the case studies and the rationale behind the selection are explained in the Table 1.

Table 1 Details of the Case Studies and Justifications

Case Study Id.	Location	Rationale for Selection
Case Study A	Selangor, Malaysia	Case Study A is one of the on-going mega infrastructure projects in Malaysia. The main contractor for Case Study A is a well-known public listed company in Malaysia. As an iconic development in Malaysia, they aim to put environmental protection at the highest standard.
Case Study B	Putrajaya, Malaysia	Case study B is the development of a structural building within a 2 acres' piece of land in Putrajaya. Putrajaya is the Federal Government Administrative Centre of Malaysia which is being developed based on 2 underlying concepts; Putrajaya as a garden city (sustainable development) and Putrajaya as an intelligent city. To achieve these aims, all the development must abide by stringent statutory environmental requirements such as the Environmental Quality Act 1974, the Environmental Impact Assessment Approval Conditions and Putrajaya Environmental Management Guidelines 1998. Thus, every contractor is required to conduct their own environmental audit, surveillance and measurements while going through enforcement programmes by the clients and the authorities.
Case Study C	Manchester, United Kingdom	The building construction company for Case Study C was one of the top ten construction companies, in terms of turnover, in the UK in 2013 [26]. In addition, the company has put in place their own online environmental monitoring system for waste management. It is not a mobile system for environmental surveillance or quality monitoring, but at least their personnel are being exposed to the use of IT systems for environmental management.

As for the respondent for this research, the selection of the respondent was a made easier as they were nominated by the management of the companies for each case study. For this research, the selected three (3) environmental managers and six (6) officers in Malaysia and another two (2) environmental managers and two (2) officers the United

Kingdom were involved in the interviews during the prototype demonstration and evaluation sessions. In these sessions, they had the opportunity to test the functions of the ENSOCS web by using smartphones. Prior to this, the respondent were asked to fill in a questionnaire about their details and their current practices in environmental surveillance and monitoring. The respondents were then required to evaluate the ENSOCS web. In order to perform this evaluation, the respondents were asked to perform pre-defined tasks as follows:

- Task 1 - Pretend that you are new to environmental inspection on a construction site, and not very familiar with best practice in sedimentation control. Find out the best practice for sedimentation control and the important areas to emphasise during a site inspection particularly on sedimentation control. Please write down the first three sentences under the heading of "Check".
- Task 2 - You would like to carry out an environmental inspection on the selected construction site for the first time, and are wondering what surrounding environmental sensitive receptors there are and the potential source of pollution from the activities on site. Find and write down a list of environmental sensitive receptors which are associated with the said construction site.
- Task 3 - Pretend you are now attending an environmental meeting at the site office, and you are required to update your management on the status of the environmental checking and corrective action. Retrieve all the relevant previous inspection reports and obtain real-time environmental monitoring data. Please write down the date, reference number and the subject of the latest inspection report. Next, write down the frame number and MCP value for the real-time environmental monitoring data.
- Task 4 - At the construction site, you have spotted that oil containers are placed on the bare ground and oil spill has been spotted on the ground. Take a photo of this non-compliance using your smartphone. Then by browsing the ENSOCS web through your smartphone, prepare the report by inserting this finding into the Web, provide other relevant information to support this finding, and submit and review the report.
- Task 5 - Email the report as in Task 4 to the relevant authorised person.
- Task 6 - Update the report as in Task 4 by uploading and attaching the photograph to the report.

The participants were then interviewed (which always involved a discussion) about the anticipated barrier in the implementation of the system for environmental surveillance on construction sites. The findings give an indication of the practicality and provide useful feedback for any future implementation. Each evaluation session took almost two hours to be completed. This included the presentation, demonstration, walk around the construction sites, evaluation and interviewing.

III. RESULTS AND DISCUSSION

Based on the questionnaires and interviews with respondents of this research in the UK and Malaysia, a large number of them claimed that they have a deep interest in the concepts presented. In fact, they were amazed, satisfied and agreed that this prototype could improve existing environmental surveillance activities. However, at the mean time, several major barriers to the implementation of such a system in environmental surveillance were highlighted by the respondents. These barriers include return on investment, operational cost, legality issues, work procedures issues, technology and technical issues, technology adoption barriers and network infrastructure.

a. Return on Investment

The decision to adopt this kind of system is subject to the approval of the top management of the company who are always concerned about return on investment. Therefore, it is crucial to identify the 'benefits' it produces as compared to the existing methods in order to justify the acceptance of the system by industry. Construction companies are profit-oriented companies. Thus, it is important for them to know the return on investment (ROI) so that they can ensure that they will achieve positive outcomes in terms of finances and business operations. However, addressing specific ROI issues is beyond the scope of this research.

b. Operational Cost

Various implementational cost barriers were identified during the evaluation process. Details of these cost barriers are:

- It requires specialist dedicated and competent resources, i.e. staff with the knowledge to administer and maintain the system. Appointment of new staff would add to company expenditure.
- It is anticipated that, in future, the system can only be used by a license holder. There will be a cost in obtaining the license.
- A majority of the respondents would refuse to use their smartphones for their work duties. But for those who would be willing to do so, they would ask the company to bear the cost of the telephone bills. Thus, there is likely to be costs incurred in giving smartphones to staff members and an incurred cost of telephone bills.
- Proper training is needed for the system to be fully utilised by the targeted user. Cost to provide sufficient training is anticipated.

This finding shows that cost is an obstacle for the implementation of the prototype. It is good to reveal these issues and this area would provide a basis for future research.

c. Legality Issues

It was pointed out that agreement between the client and the contractors pertaining the usage of the system would be required prior to implementation. It was also pointed out that the photographs attached to the report produced by the prototype might not be valid due to an absence of a date stamp. But this should not be a problem if the prototype is used for internal reporting purposes. The respondents of Case Study 3 (UK) had faced a similar problem with their existing system for waste management. Their immediate action was just to stick to a manual camera to capture an image while using the system. However, given that the role of mobile devices in helping to resolve various tasks have now been recognized, of course, they will continually be improved and will be equipped with the latest technologies in the future.

d. Work Procedures

The respondents highlighted that the implementation of this prototype would affect current working procedures. Therefore, they anticipated that some changes to the current working procedures would have to be made if their company pursued adopting the prototype. The following are the details that would affect the work procedures:

i. Some companies will not allow their workers to use a phone at construction sites except for within the designated areas.

ii. The client has to put in the requirement/request in order to instruct and enforce the contractor to use the system.

Revision to works' procedures can be expected as current work procedures are suited to the traditional work methods. However, the respondents have admitted such a change can be managed as long as there are good tangible benefits on the implementation.

e. Technology and Technical Issues

There was a concern about the technology and the technical issues as follows:

i. Reliability of hardware: This concern was based on experiences of other systems; there were a few occasions where systems were down due to server maintenance, damaged databases and the durability of the mobile devices.

ii. Integration Issues: It would be good to have a prototype that can integrate with the existing company's system.

These technological and technical issues will be addressed in future research, especially with the emergence of new and more robust technologies (e.g. database replication, cloud web hosting), competent resources and the use of a web hosting provider that is reliable and has a proven track-record.

f. Technology Adoption Barriers

Even though all the respondents were active smartphone users, it is important to note that not all construction personnel have a smartphone and are familiar with it. Another important issue, highlighted by the respondents, was that the older generation might find difficulties in adapting to this kind of system. This is due to several reasons such as age factors, low technical literacy or reluctance to change. Human attitude would also affect technology adoption as a good system might be abandoned due to a lazy user. These findings are expected. A recent study by Global Web Index Device has revealed that when it comes to age, the 25-34 years' demographic is the most likely to be connected via smartphone, while those aged between 55 and 64 years are the least likely to own the technology [27]. However, in addressing technology adoption barriers especially among the older generation, proper engagement with targeted users through trainings together with improved interfaces and features that suit their needs would address this issue.

g. Networking Infrastructure

Wireless connection reliability and wireless services may not be available in certain areas, especially in the case of rural areas' project development. These networking issues will be addressed in future research, especially with the emergence of new and more robust technologies (e.g. WiMAX, 4G, 5G). Some of the technologies have matured and are now expanding countrywide. The 4G system promises to bring a communication world with high data rates' transfer, high quality service for multimedia support, seamless connectivity and global roaming across multiple networks [28].

IV. CONCLUSION

We have implemented the prototype demonstration and evaluation sessions with the practitioners in Malaysia and the UK. One of the objectives of this session was to probe respondents' subjective views on the anticipated barrier in the implementation of the system for environmental surveillance on construction sites. In overall, the respondents were amazed, satisfied and agreed that this prototype could improve existing environmental surveillance activities. However, several major implementation barriers as identified in this research should not be neglected in the real implementation in future. As the respondents had highlighted the barriers like return on investment, operational cost, legality issues, work procedures issues, etc., future research to address these issues is definitely needed.

REFERENCES

[1] Jaafar, M., et al., "Integrating information technology in the construction industry: Technology readiness assessment of Malaysian contractors", International Journal of Project Management, Vol. 25(Issue 2), pp. 115-120, 2007.
[2] Bowden, S., et al., "Mobile ICT support for construction process improvement", Automation in Construction, Vol. 15(5), pp. 664-676, 2006.
[3] Peansupap, V. and D.H. Walker, "Factors enabling information and communication technology diffusion and actual implementation in construction organisations", Electronic Journal of Information Technology in Construction, Vol. 10, pp. 193-218, 2005.
[4] Ahmad, I., M.K. Sein, and K. Panthi. "Challenges of integration and ICT's potentials in the globalized construction industry", IEEE Proceedings of Conference on Technology Management for Global Economic Growth 2010 (PICMET 10), 2010.
[5] Klinc, R., Ž. Turk, and M. Dolenc, "ICT enabled communication in construction 2.0", Pollack periodica, Vol. 5(1), pp. 109-120, 2010.
[6] Shen, W., et al., "Systems integration and collaboration in architecture, engineering, construction, and facilities management: A review", Advanced Engineering Informatics, Vol. 24(2), pp. 196-207, 2010.
[7] Löfgren, A., "Mobility In-site: Implementing Mobile Computing in a Construction Enterprise", Communications of the Association for Information Systems, Vol. 20, pp. 594- 604, 2007.
[8] Mitchell, V., et al. "Using mobility as a conceptual framework for informing the design of mobile ICT for construction professionals", Proceedings of the 8th conference on Human-computer interaction with mobile devices and services, 2006.
[9] Vilkko, T., T. Kallonen, and J. Ikonen. "Mobile fieldwork solution for the construction industry", IEEE Proceedings of the 16th International Conference on Software, Telecommunications and Computer Networks 2008 (SoftCOM 2008), 2008
[10] Tushi, B., D. Sedera, and J. Recker, "Green IT Segment Analysis: An Academic Literature Review", Twentieth Americas Conference on Information Systems, 2014.

ISSN(Online): 2319 - 8753
ISSN (Print) :2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

[11] Vivoni, E.R. and R. Camilli, "Real-time streaming of environmental field data", Computers & Geosciences Vol. 29 (2003), pp. 457–468, 2003.
[12] Chen, Y. and J.M. Kamara, "A framework for using mobile computing for information management on construction sites", Automation in Construction, Vol. 20(7), pp. 776-788, 2011.
[13] Kim, Y.S., et al., "A PDA and wireless web-integrated system for quality inspection and defect management of apartment housing projects", Automation in Construction, Vol. 17 (2008), pp. 163-179, 2008.
[14] Xiang-zheng, D., et al., "Internet based environmental monitoring information system and its application in Yili Prefecture", Journal of Geographical Sciences, Vol. 12(2), pp. 163-170, 2002.
[15] Cheung, S.O., K.K.W. Cheung, and H.C.H. Suen, "CSHM: Web-based safety and health monitoring system for construction management", Journal of Safety Research, Vol. 35(2), pp. 159-170, 2004.
[16] Ooshaksaraie, L., et al., "An Expert System for Construction Sites Best Management Practices", Innovative Computing Technology, pp. 81-93, 2011
[17] Nitithamyong, P. and M.J. Skibniewski, "Web-based construction project management systems: how to make them successful?", Automation in Construction, Vol. 13(4), pp. 491-506, 2004.
[18] Harun, A.N., E. Bichard, and M. Nawi. "Traditional vs Technological Based Surveillance on Construction Site: A Review", Applied Mechanics and Materials, Vol 735, pp. 247-252, 2015.
[19] Harun, A.N. and E. Bichard, "Supporting Environmental Surveillance on Construction Sites using Mobile Environmental Information System", International Journal of Engineering Research and Technology, Vol. 4(March - 2015), pp. 573-581, 2015.
[20] Wichansky, A.M., "Usability testing in 2000 and beyond", Ergonomics, Vol. 43(7), pp. 998-1006, 2000.
[21] Zhang, D. and B. Adipat, "Challenges, methodologies, and issues in the usability testing of mobile applications", International Journal of Human-Computer Interaction, Vol. 18(3), pp. 293-308, 2005.
[22] Kjeldskov, J., et al., "Evaluating the usability of a mobile guide: the influence of location, participants and resources", Behaviour & Information Technology, Vol. 24(1), pp. 51-65, 2005.
[23] Abdullah, D.N.M.A. and G.C.M. Wern., "An Analysis of Accidents Statistics in Malaysian Construction Sector", International Conference on E-business, Management and Economics IPEDR, Vol. 3 (2011), 2010.
[24] Haslam, R., et al., "Contributing factors in construction accidents", Applied Ergonomics, Vol. 36(4), pp. 401-415, 2005.
[25] Department of Occupational Safety and Health Malaysia. "Occupational Accidents Statistics 2012", 2013. [18th May 2014]; Available from: http://www.dosh.gov.my/index.php?option=com_content&view=article&id=795:occupational-accidents-statistics-2012&catid=458&Itemid=695&lang=en.
[26] Hood, N. Top 100 Construction Companies 2013, 2014. [21st July 2014]; Available from: http://www.theconstructionindex.co.uk/market-data/top-100-construction-companies/2013.
[27] Mander, J., "GWI Device Summary Q3 2014", Global Web Index: London, 2014
[28] Supa'at, M., et al., "4G and 5G Communication Technology in Malaysia", in Wireless Communication Technology in Malaysia, A.S.M. Supa'at, S.M. Idrus, and F. Mohamad., Editors, Penerbit UTM: Skudai, 2008.