Improving contractor social networking on IBS infrastructure maintenance projects: a review

Zul-Atfi Bin Ismail
School of Environmental Engineering, Universiti Malaysia Perlis, Arau, Malaysia

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Abstract

Purpose – A key factor adversely affecting contractor social networking performance is the improper handling and information management of contractor's services delivery on websites. Contractor social networking is particularly problematic on industrialised building system (IBS) infrastructure maintenance projects where contractor's certified quality product and firms are not matched with maintenance specialisation services. The paper aims to discuss this issue.

Design/methodology/approach – This paper reports on the early stages of research which is developing a new information and communications technology (ICT)-based approach to managing contractor social networking on IBS infrastructure maintenance schemes. As a precursor to this work, the paper reviews current contractor social networking websites practices on IBS infrastructure maintenance projects and explores the ICT tools and techniques currently being employed on such projects.

Findings – The findings reveal the need for more sophisticated contractor social networking websites solutions which accord with the needs of IBS infrastructure maintenance schemes.

Originality/value – The paper concludes by presenting a research framework for developing such a system in the future.

Keywords Innovation, Technology, Integration

Paper type Technical paper

1. Introduction

"The age of technology and the communication revolution have provided the construction industry with new opportunities to advance contracting and grow business. It's not surprising that companies of any size present their new services on the social media today" (Clark, 2014). Many construction companies such as industrialised building system (IBS) infrastructure maintenance contractor aim to provide their certified quality product and firms as valuable as possible in order to meet a client's needs on their services offered. IBS infrastructure maintenance involves the critical and unique prefabricated components and onsite installation that utilises techniques, products, components or infrastructure systems from the structural classification (e.g. bridge, tunnel and dam) and should need critical contractor networking attention towards their specialisation services delivery information on websites. There are many factors affecting contractor social networking performance on such projects. Kostora (2015), Ruan *et al.* (2012), Larsen (2011) and Chowdhury *et al.* (2011) suggested that the main reasons for poor contractor social networking performance on websites were fault information exchange, less working relationship, general description of maintenance knowledge exchange in a tweet, ignoring contractual relationship and using less task dependency in maintenance activities to manage project process that turn client or participant misinterpretation from an online engagement easily. Online engagement is commonly defined as the interaction between

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construction team across a range of contractor social networks. Creative (2015) also suggested that inaccurate content production including content strategy was a major cause of misconceptions communication. Thus, it would seem that poor communication content is a major cause of poor contractor social networking performance in IBS infrastructure maintenance projects. The conflict of interest is potential to be emerging with the communication misconceptions of services-based specifications and impact of the client's satisfaction (Glick and Guggemos, 2009). In addition, the clients facing difficulty to consider the specific contractor through generic communication contributed to the ineffective marketing approach such as trust and relationship development while the contractor's social network services delivery cannot have refined it accordingly (Blismas and Wakefield, 2009).

In order to make contractor social networking on website effective for IBS infrastructure maintenance projects, there should be complementary between the contractor and client for implementing an integrated approach in the social engagement (e.g. social network analysis (SNA)) to facilitate new communication platforms that business best for IBS infrastructure maintenance projects in the future. This paper reviews current contractor social networking websites practices on IBS infrastructure maintenance projects and explores the information and communications technology (ICT) tools and techniques implemented. It starts with a review of current contractor social networking practices in infrastructure maintenance projects and the common problems. The ways in which contractor social networking are managed on IBS infrastructure maintenance projects are discussed and areas for improvement are highlighted. The paper concludes with a discussion of the findings showing the outline features of a research framework for more sophisticated contractor social networking websites solutions which accord with the needs of IBS infrastructure maintenance schemes.

2. Research methodology

This research is to develop a system to improve the contractor social networking websites used in social networking processes at IBS infrastructure maintenance projects. The contractor social networking processes are to identify avenues of team structure optimisation, to assess and plan the IBS infrastructure maintenance implementation. The new system is expected to integrate the contractor social networking processes and information database to provide efficient mechanisms of contractor social networking websites at IBS infrastructure maintenance projects. The literature review was conducted at the beginning of the research to examine and analyse the contractor social networking practices and integration of ICT into the contractor's services delivery on websites. Second, the multiple case studies were to review the current practice of contractor social networking and ICT implementation in the real situation. The causal explanation of the problems was also investigated in order to establish the requirement for facilitating particular social networking processes to be transformed into the system approaches in managing maintenance at IBS infrastructure. The next stage involved the building of process prototype model for in-depth understanding of the conventional processes and to propose the particular flow of process to be transformed into the ICT-based system.

The main contribution of this paper is to analyse the contents of existing bridge resilience databases on contractor social networking and provide an approach for future courses of action to optimise their potential applications by contractors. First, an analysis of the contractor social networking databases in infrastructure maintenance projects was completed based on reference literature. A revision of the scope and characteristics of existing databases in different processes, presenting some of the challenges in this field, is therefore presented in sections "Identification", "Assessing" and "Planning". Next, a critical and comparative analysis of them was undertaken, going from simple databases to

diagnosis support-platforms. The corresponding results are included in section "Improving contractor social networking in IBS infrastructure maintenance projects". Finally, a proposal for the development of a knowledge-based identification, assessing and planning app tool for IBS infrastructure maintenance projects was designed and is presented in the section "Need for improvement" of this paper.

3. Contractor social networking in infrastructure maintenance projects

SNA is an important function of analytical tool in the contractor social networking research in order to provide indications of knowledge integration collaborative working and effective communication in infrastructure maintenance projects (Loosemore, 1998; Chinowsky *et al.*, 2008; El-Sheikha and Pryke, 2010; Larsen, 2011). Cross and Prusak (2002) and Cohen *et al.* (2001) defined SNA functions which include providing a method to understand informal networks within and between organisations, managing the informal networks systematically, supporting collaboration, commitment, ready access to knowledge and talent, and coherent organisational behaviour. The less effective of SNA such as improper handling and information management of contractor's services delivery on websites during organisation and coordination of infrastructure maintenance projects will influence the trust principle, project progress and the quality services. Kostora (2015) stated that posts for document element and knowledge section in information management may range from 15 to 85 per cent of total project's organisation and coordination posts. In addition, Ireland (2010) indicated that almost 91 per cent of the total project planning post of any industrial organisation consists of project's organisation and coordination posts. Therefore, there is a need for efficient contractor social networking in order to control information technology post productivity in infrastructure maintenance projects.

There are many issues which contribute to poor contractor social networking in infrastructure maintenance projects. Styhre and Gluch (2010) suggested that inefficient use of information in decisional process, lack of a proper work coordination, inappropriate services delivery and less integration of inspection and maintenance data all adversely affect contractor social networking. In addition, the common issues in relation to contractor social networking are as follows:

- improper detail working of ties and interactions (Ruan *et al.*, 2013);
- deficient quality control (Ruan *et al.*, 2012);
- lack of consistency and completeness of infrastructure data (Wambeke *et al.*, 2011);
- lack of experienced worker (Wambeke *et al.*, 2011);
- insufficient information about maintenance, repair and renewal planning (Styhre and Gluch, 2010);
- insufficient information among clients and contractors about IBSs on infrastructure (Chinowsky *et al.*, 2010);
- insufficient coordination among client and contractor organisation (Park *et al.*, 2011); and
- communication issues among team players (El-Sheikha and Pryke, 2010).

The processes involved in contractor social networking consist of three stages: identification, assessing and planning on infrastructure maintenance projects. A good contractor social networking environment enables appropriate infrastructure components monitoring on onsite or off-site maintenance projects. Each stage is clarified in detail in order to better understand the actual process in contractor social networking practices in most infrastructure maintenance projects in Malaysia.

Identification

According to the definition of Ehrlich and Chang (2006), the process of identification social network approaches or social relationships survey is "the informal networks within and between organisations of the construction and services of an infrastructure in sufficient collaboration to enable a contractor to advise what impact the condition and the circumstances of that project infrastructure performance will have upon the client based on trust and mutual support". This is an essential scheme and requirement to successful communication and interdisciplinary interaction as well as making appropriate recommendations for optimising team structure. Malisiovas and Song (2014) described that social network identification as a measurement analysis to collect information about the density, centrality, betweenness, geodesic distance, average shortest path and modularity condition of the network structures for a defined purpose to provide detailed information comprised of information diffusion effect, list of communication and information-sharing problems that may be required for social relationships survey. Hu and Racherla (2008) and De Nooy *et al.* (2005) also mentioned that identification process includes investigating the conditions of social structures by analysing the interactions and interrelationships of a set of actors to support collaboration (e.g. designer and contractor) or problem solving for the completion and quality of social networks. The correct identification process of industrial network issues at the interpersonal level in specific conditions for social network study covers identifying principle method of SNA which related to individuals, organisations and knowledge diffusion in the infrastructure maintenance research domain (Park *et al.*, 2011). In addition, the social relationships survey is also undertaken with the help of project managers and construction managers to improve the quality of international project planning and the capabilities of a firm (e.g. interfirm relationships) including to establish the extent for proper collaboration work to which this requirement is being met (Park and Han, 2012). Therefore, the perfect identification process on condition of a social network becoming the measurement marker for high-performance teams will provide guides for all the subsequent quantitative information in relation to the complex and interactive processes that would be put onto the social network in order to keep the social network with better performance especially for the infrastructure maintenance projects. It also enables the impact of an identified social network on the absence of knowledge sharing across an organisation for any signs of abnormal collaboration of the team structure such as reoccurrence incidences of communication problems towards decision-making teams, organisational disintegration and high fragmentation of project networks to be solved.

Vechan *et al.* (2014) mentioned that the main purpose of social network identification is to inspect and to prevent disorganisation as a part of communication process, as well as to share them with information and knowledge of drawings or documents such as a checklist and punch list for facilitating infrastructure maintenance measures and rectifications action projects in the future. In addition, the consideration of social network identification methods in the IBS maintenance industry has an important implication for the development of an effective project management strategy at the firm level, particularly in terms of recommending refined negative interactions in case of robust project network designs between domestic and global projects, and hence to lengthen the project effectiveness and collaborative ventures between various overseas companies (Park *et al.*, 2011). According to Wood (2012), the IBS infrastructure could permit the reduction or elimination of information-sharing problems, ineffective communication and decision making for maintenance projects to meet long-term needs on networking services when the process of identification social network method is put in the operative way. The requirement for social relationships survey is to reduce the defective mutual interactions and increase the profit and quality of infrastructure maintenance projects. Therefore, it is essential for the contractor social networking process

to consider efficiency in social network identification to ensure the acceptable quality and productivity, resulting in better service to respond to the project networks or communication issue without delay.

Assessing

Social network assessment is concerned with analysing the likely future characteristic and performance of an existing participant relationship (e.g. possible project design, architecture team selection, costing options) (Malisiovas and Song, 2014). It is also known as social network diagnosis or special characteristic diagnosis, and is a tool to cope with the problems of ambiguity and uncertainty decision in collaboration networks and hence support the firm's performance of the maintenance projects. The primary assessment encompasses a wide range of mechanics and dynamics categories that includes the communication, information exchange, knowledge exchange, experience, reliance, trust and values which are used as part of an overall model and social network assessment for organisations in determining recommended actions for enhancing high performance and future collaboration management. The objective of social network assessment in infrastructure maintenance projects is to provide quality business network strategies and also in forecasting the collaboration function for the future planning in infrastructure maintenance programme. Besides, the assessment category can be used as an innovative and transformative tool for appropriate network relationships required in regular project teams (Chinowsky *et al.*, 2008; Vechan *et al.*, 2014). Mutis and Issa (2011) stated that assessment is about systematic coordination of project (priority CSN method) on infrastructure maintenance that considered data content on the critical state of infrastructure maintenance to decide on a priority ranking for communication or coordination of features and service elements in terms of collaborative and decision performances (e.g. effect of social human network and interaction level of multiple actors).

Poor social network assessment of infrastructure maintenance projects could lead to many difficulties, which end up to poor project performance and waste such as project delays, unacceptable qualities and higher cost. A failure in the social network assessment process as also listed by various researchers could result in:

- lack of integration between project team (Lin, 2015);
- poor quality order and information transmission (Lin, 2015);
- lack of information and knowledge integration (Chinowsky *et al.*, 2008; Liu *et al.*, 2015);
- improper order-management of the network;
- defects in completed building;
- over-centralised decision making (Abbasian-Hosseini *et al.*, 2014);
- lack of trust (Abbasian-Hosseini *et al.*, 2014);
- insufficient network about site organisation and their management organisation (Niknam and Karshenas, 2014); and
- no standard format or guidelines for the social network assessment (Niknam and Karshenas, 2014).

In order to avoid failure, it requires the typical assessing of procedure to make it beneficial to predict the social network strategies needed for existing structures of the building and to assist in decision making of maintenance future planning (Niknam and Karshenas, 2014). Keung and Shen (2013) stated that there are about four main processes involved in social network assessment, and this is illustrated in Figure 1. The social network assessment

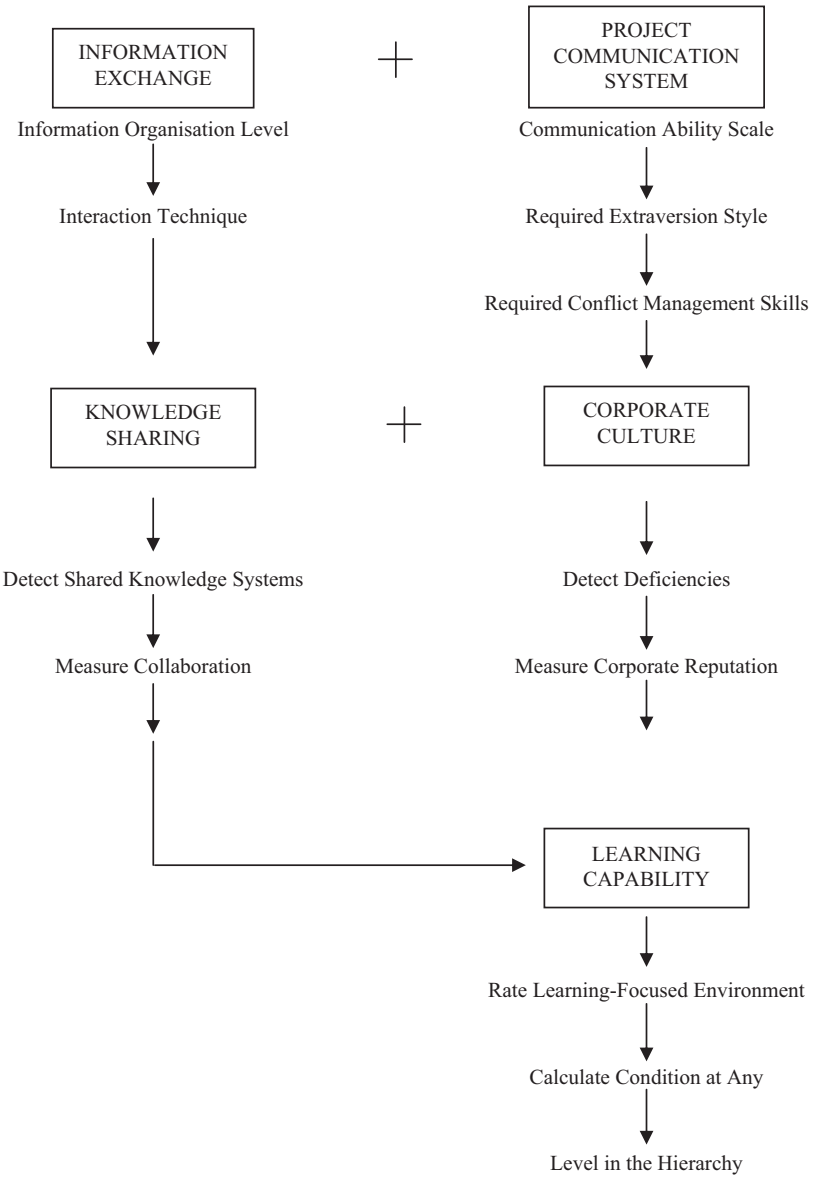

Figure 1.
Typical assessing procedure

Source: Keung and Shen (2013)

begins with categorising the parameters in the formation of the measurement model to determine the information exchange between project members level, followed by the selection of project communication system needed as the team communication to engage in network activities with each other and to work together effectively to accomplish tasks. The next step requires the knowledge sharing for collaboration and corporate culture for promoting networking in order to develop a joint competitive advantage and form effective

relationships between a company and its constituents, respectively, and ends with the results of the competence of human resources measurement of learning capability in intra- and inter-organisational settings based on training and experience.

The contractor social networking of infrastructure maintenance projects from an accurate assessment of interfirm networking conditions and causes of impaired social interaction, at the expertise level of hypercompetitive business environment as well as with the specialized approaches and methods, are challenges of many contractor companies (Keung and Shen, 2013). Therefore, social network assessment is needed to develop a set of criteria in order to implement a more intricate strategy capable of assessing organisation and coordination failures for infrastructure maintenance projects using the results of the level efficiency of rating in need of contractor social networking based on weights of indicators. In determining strategic social network assessment alternatives, as aforementioned, the overall performance of the organisation and coordination assessments must be used by considering information exchange between project members, project communication system, knowledge sharing for collaboration, corporate culture for promoting networking and learning capability in intra- and inter-organisational settings for the evaluation. An extended implementation of the social network assessment must also ensure to follow the standard requirement of assessment process in selecting an effective contractor social networking of infrastructure maintenance projects.

Planning

Ricardo *et al.* (2014) define effective social network planning as using the appropriate method in providing a critical node (e.g. individuals, groups, teams or entire organisations) and relationship (e.g. nature or direction) in project stages of infrastructure maintenance management and production process including design, manufacturing, transportation and installation. This involves all decisions at all levels of the team member network centrality related to maintaining a high level of availability, reliability, value of the infrastructure and its components and its ability to perform to a standard level of coordination (Dogan *et al.*, 2012). Therefore, social network planning provides measurement to ensure that infrastructures are performed in advance and that a various part of the organisation is required in guiding the process of developing a comprehensive contractor social networking programs and recommendations (Sepasgozar and Bernold, 2012). Planning of social network is the predetermined tasks that cover at two different decision levels: strategic or tactical. Decisions at the strategic level are about organising the long-term vision of organisation as a corporate business planning and tactical decisions issuing way to business within a present strategy for achieving long-, medium- and short-term goals and targets (Ozorhon *et al.*, 2007; Bakht and El-Diraby, 2015). The importance of social network planning of infrastructure maintenance projects is highlighted by the fact that they are not strategic, expensive and engage critical decisions. Estimated costs for repair and maintenance allocating may range from 16 to 50 per cent (Lee, 1996; CIDB, 2007) and 5 to 10 per cent depending on the type of infrastructure (Ali, 2009) from total construction costs. Because complex and critical infrastructure construction frequencies are rising rapidly, it requires planned social network strategy considerations to enhance efficiency of the characteristics that influence the maintenance project performance. The selection of planned social network strategy to optimise infrastructure maintenance performance becomes an important decision in infrastructure industry as it can enhance the cost and risk management process, provide highly efficient utilisation of project team resource, increase collaboration value, organisational communication, improve quality and durability (Son *et al.*, 2010; Park and Han, 2012).

A social network plan requires a micro-management between costs and risks of inspections, repairs and replacements of components to determine strategically optimal

contractor social networking actions for an infrastructure system. Micro-management is the organisation and coordination style where the managers are heavily engaged in the daily affairs and specific tasks of contractors while the opposite (not micro-management) is giving a degree of autonomy to contractors. Due to the frequency of repair and maintenance programs, there are quality considerations when designing a social network planning system (Du and El-Gafy, 2015). The strategic performance of social network planning selection is an important function on the technical level in the designing of a social network planning system in order to enhance production control, provide social impact and building relationships among construction teams that can contribute to maximise infrastructure system's reliability-related functions (e.g. availability), improve accuracy and reliability maintenance planning of deteriorating infrastructures (Lin *et al.*, 2015). In addition, maintenance strategy decision making is also becoming extremely important part of social network planning on constructed infrastructures, which have several benefits (Priven and Sacks, 2015) such as:

- assessing contractor performance and working relationships, as well as determining whether the correlation between social network and communication and project workflow quality needs to be established;
- determining the key social network planning measures (e.g. failure of probability of a network and intensity of communication); and
- organising the social network planning in maintenance scheme (e.g. communication channel classification and networks importance).

The social network planning must be managed strategically both in terms of performance and maintenance conflict of infrastructures during their whole life cycle (design, construction, use and maintenance). Most of the studies have assumed that social network planning is irrelevant, leads to the downtime, loss of infrastructure and market opportunities, which attribute a high proportion of costs and performance deterioration (Ekwo, 2013; Albert and Hallowell, 2014). Therefore, planning and implementation of social network strategies, which reduce the conflict of infrastructure and the performance degradation for continuous improvement in maintenance performance, can often be the social network planning system reliability and maintainability.

4. IBS infrastructure maintenance projects

In most of the IBS infrastructures, there is a lack of measurement tools available for social networking process to contractors in Malaysia to enable them to understand level of assessment of contractor social networking websites practices. The social networking processes involved the identification, assessing and planning of management for infrastructure structure and facility. The existing literature revealed that the app has contributed to the crucial problems in bridge resilience for the IBS infrastructures as Maintenance and Development Unit (UPS) (Venkittaraman and Banerjee, 2014). The maintenance management issues evolved to the point that they affect the maintenance efficiency such as inadequate technical knowledge, shoddy workmanship, improper assembly of the components and poor quality IBS products (Zhou *et al.*, 2010). However, the approaches to address the problems are undertaken by staff through proper prioritising of bridge maintenance, the improvement of the standard inspection with the detailing specification data of building defects and to allocate the applicable financial contingency for maintenance control such as leaked concrete and structure crack.

Nevertheless, the tools are not being used to overcome incomprehensiveness of the app-integrated process as these are mostly used to record and exchange information related to the maintenance components within IBS infrastructure. There was an inadequate use of

modem ICT tools such as a framework that defines metrics or indicators that satisfactorily characterize Malaysia's bridge infrastructure, which could provide real-time diagnosis information of IBS infrastructure maintenance (Karamlou and Bocchini, 2014). The apps mostly used at the IBS infrastructure provided no proper framework that can be referred as an integrated process app for collaborative data environment in terms of bridge resilience such as specification, structure risk and condition in detail that could help the maintenance management staff to conduct effective execution on the defect (Deco *et al.*, 2013). In addition, the transformation to the new app framework that involved an initial determination of the context of the resilience assessment, followed by a detailed assessment of resilience measures, which combine to generate a resilience score ranging from 4 (very high resilience) to 1 (low resilience), is mostly suggested to facilitate user at the IBS infrastructure in assessing defects efficiently including defect control using ICT.

5. Contractor social networking practices in IBS infrastructure maintenance projects

With the maturing of contractor social networking tools and platforms, an increasing number of smart mobile device application (app) services are being adopted in various industry functions, including real estate, waste management, transportation, supply chain and maintenance management (Sattineni and Schmidt, 2015). Nevertheless, some industry practitioners still hesitate to adopt this innovative tool. According to the survey conducted by Ekow and Kofi (2016), maintenance participants did not identify much value in using app, except for the last few years. However, according to Zheng *et al.* (2016) and Azhar and Cox (2015), the actual benefits of app along with its team networking realisation capabilities have now comprehended and utilised to the best benefits of all stakeholders of an IBS infrastructure maintenance project such that contractor social networking can be integrated into the project management and working process, which also can be used by most AEC sector for maintenance quality control and efficient information utilisation. Currently, in the IBS infrastructure maintenance project worldwide, work has been carried out into the use of app in manufacturing, components tracking, waste reduction and supply chain management (Son *et al.*, 2012; Davies and Harty, 2013; Kelm *et al.*, 2013; Kim *et al.*, 2013). Apps contain the information needed for particular phases of a building's life cycle (scheduling, analyses, cost evaluation, etc.) and should offer construction new opportunities to improve the communication and collaboration between participants through higher interoperability of data. It can provide potential savings (cost and efficiency), and can also be suitable for maintenance and support in the following ways (Joyce, 2011a; Colonna, 2012; Razmerita *et al.*, 2014):

- BIM 360 Field—to plan maintenance work and to perform repairs in facilities using decision-making process.
- PunchIt/iSite Monitor—to assess the condition of building carefully and entirety through visual inspection, scoring, photos and layout plan tag.
- Tradies App—to facilitate in making decision for maintenance application of buildings based on the knowledge base from the database collection.
- Procore for iPhone—for identifying any maintenance or repair items, as well as any imminent hazards using three separate levels: hands on, visual and testing.
- OnSite Photo/Onsite Punchlist—to define the different parameters (e.g. main defects and severity of defects) in carrying out the defect mapping for buildings condition.
- Plan Grid—to investigate and classify the latent defect or the defect in part of the difficult captured level into grid location.

- OnSite Files—for examining both the building underlying structure and its external shell, respectively.
- Aconex Mobile—to minimise the total maintenance time and cost in scheduling planned maintenance activities.
- Foreman's Mate—to schedule the maintenance activities through the defect performance based on the severe rank level.
- Drawvis—to provide managing of a spare part and schedule the maintenance service.

Table I shows ten current app systems that are selected based on major functions in the comparison over current technologies where there is the same gap among those systems which is the defect diagnosis and analysis support function.

6. Improving contractor social networking in IBS infrastructure maintenance projects

Currently, in the IBS infrastructure maintenance project worldwide, work has been carried out into the use of app in contractor social networking such as BIM 360 Field, iSite Monitor, Plan Grid and Aconex Mobile. App tools contain the information needed for particular phases of a building's life-cycle (scheduling, analyses, cost evaluation, etc.) and should offer construction new opportunities to improve the communication and collaboration between participants through higher interoperability of data (Joyce, 2011a, b). It can provide potential savings (cost and efficiency), and can also be suitable for faster information sharing to a larger network of people and organisations (Chen and Kamara, 2011). However, Sattineni and Schmidt (2015) state that the app is yet to be mainstream as a communication tool throughout maintenance industry and also attribute to the lack of understanding due to technical difficulties on parameters and indicators of measuring the resilience. The weakness of app in the IBS bridge infrastructure maintenance industry is that it is only limited to the level of awareness and the utilisation of contractor social networking applications on app devices concerning the sustainable development towards vulnerable communities. In particular, the improvements of perceived usefulness and perceived ease of use of maintenance-related applications on maintenance professional's intentions to use such applications offer fruitful avenues for future research. The researchers stated that proper resolution strategies of contractor social networking are essential during the maintenance period in order to get a better improvement on its acceptance and utilisation by maintenance professionals (Silvius, 2016).

Azhar and Abeln (2014) investigated the criticisms regarding the requirements for effective use of the app device. There were a few strategy options of the app for managing IBS infrastructure maintenance projects related to contractor social networking including (see Figure 2 and Table II):

- Reasonable level of resources social media literacy on various scales (asset/network/region): the app device requires the contractor to be familiar with the basics of social media platforms. They were required to have basic resources social media skills in order to understand the wide range of land transport system (bridge, road and rail) for effective use of the app device.
- Sufficient link to broader criticality and risk management approaches: administrations were necessary for allowing prioritisation of improvements and interventions for the new contractor social networking applications on app devices on the IBS infrastructure to support daily operations, maintenance and value of social media resources.

Table I. Comparison of app technologies for IBS infrastructure maintenance process

No.	Functions	App system									
		BIM 360 Field	PunchIt/iSite Monitor	Tradies App	Procore for iPhone	OnSite Photo/Onsite Punchlist	Plan Grid	OnSite Files	Aconex Mobile	Foreman's Mate	Drawvis
	Identification process										
1	Asset inventory and registration	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Work order	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Complaint management	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes	–	Yes
	Assessment process										
4	Defect inspection	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Defect diagnosis	–	–	–	–	–	–	–	–	–	–
6	Defect analysis	–	–	–	Yes	Yes	–	–	–	–	–
	Planning process										
7	Maintenance planning/ scheduling	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	Maintenance estimating	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	Maintenance coordination	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

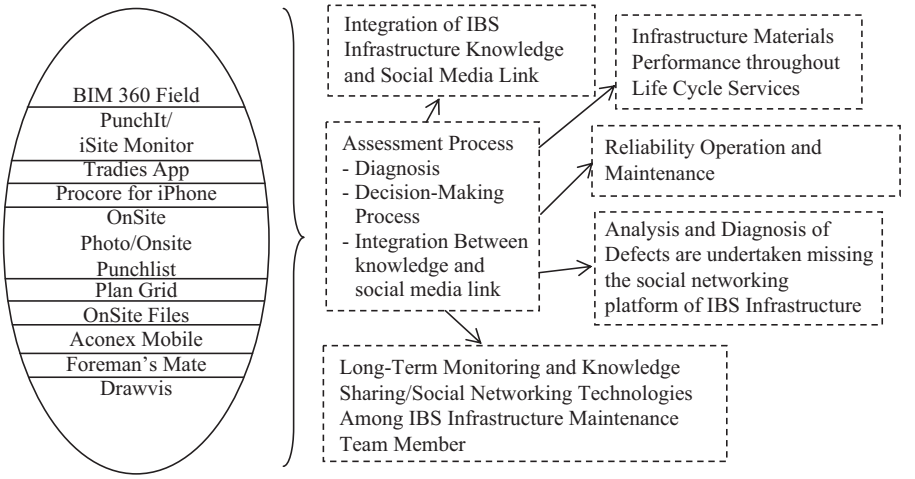

Figure 2.
Key issues in IBS infrastructure maintenance management technology

Strategy option	Description
Advance collaborating of vulnerabilities and resilience characteristic	Require advance collaborating marketing and education to ensure their readiness on social media platforms
High preference for disaster risk function mechanism	Preference of disaster risk function mechanism rather than maintenance alone for reasons of speed of execution, reduced excessive site labour requirements, standardisation for versatility and communicational accuracy and easy site quality monitoring
Standard and easy communication and collaboration between participants preferred	Maximise the utilisation of standard contractor social networking websites and easily accessible

Table II.
Summary of strategy options for contractor social networking

7. Need for improvement

An initial assessment of the tools and techniques currently in use in contractor social networking websites suggests that most of them are under development with a few being used on a commercial basis. Based on the literature, this research is intended to improve information management of contractor social networking on IBS infrastructure maintenance projects through the use of app device. The relevance and capability of the app device to improve contractor's certified quality product and firms as well as maintenance specialisation services have been confirmed and verified through the review of the previous section. The app clearly covers a wide realm of information categories such as company branding, disseminating project news, information on job hiring and client networking. This will be able to create the environment in facilitating contractor social networking to become more easy and effective (Anumba and Wang, 2012). However, more sophisticated contractor social networking websites solutions which accord with the needs of IBS infrastructure maintenance schemes in the future are anticipated to use multiple aspects of communications and collaboration technologies (e.g. marketing, connections, support, education and recruiting) such as integration of social media platforms that constitute vulnerabilities and resilience characteristic (Kudos BIM 360 Field and Plan Grid Publons) (refer Figure 3 and Table II).

There is a substantial scope for further research, which can include the following:

(1) Further research on social networking systems is required to enable the app device to be better integrated into IBS infrastructure maintenance projects in the future.

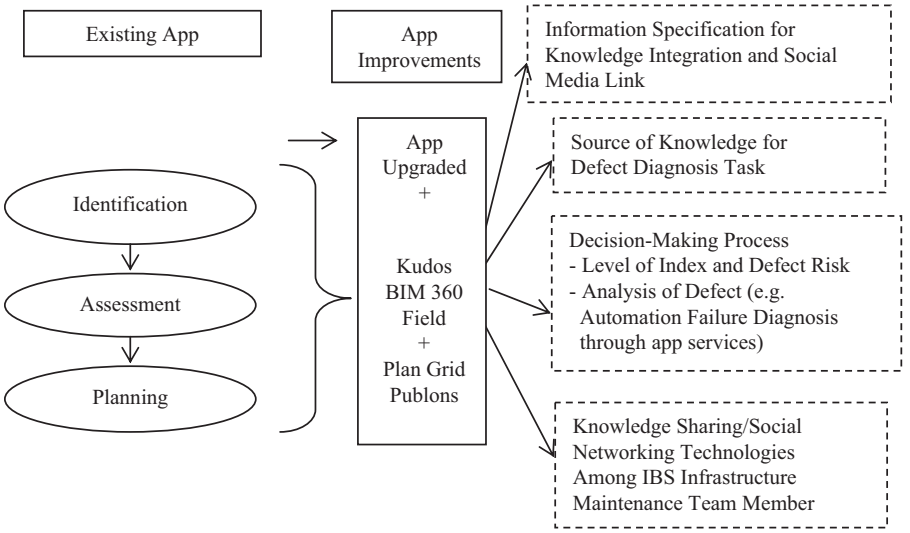

Figure 3.
Key aspect for app improvements key issues in IBS infrastructure maintenance management technology

It is required to study the parameters that relate to infrastructure disaster in the adoption of the contractor social networking application on app devices.

(2) The applicability of the app device in IBS infrastructure is based on the type of impact of bridge resilience projects. It is developed to support the requirement for improving the overall process of small or large scale of contractor social networking. This app performance should also be maximised specifically during maintenance in order to avoid loss of profit for construction companies.

(3) The IBS infrastructure maintenance industry contractors could develop a resilience app framework that defines metrics or indicators. It satisfactorily characterises Malaysia's infrastructure to achieve the best production of contractor social networking websites solutions in terms of time, budget (cost), quality and productivity.

8. Lessons and enlightenments

(1) The information management and the application of contractor social networking databases should be paid high attention. Because of the inadequacy of app tools and limitation of understanding about the management of disaster risk function mechanism, the design of contractor social networking structures is very important. The application of modern app tools such as BIM integration can avoid or alleviate the poor service delivery of main infrastructure.

(2) The appropriate contractor social networking should be selected in IBS infrastructure areas for dams, bridges and other important IBS infrastructures. The complex bridge infrastructure should be given the priority for these types of IBS resilient infrastructures.

(3) The evaluation of existing apps should be processed, especially the contractor social networking application in the large collaboration construction parties.

(4) The contractor social networking quality for IBS maintenance infrastructures should be strictly guaranteed.

(5) The deficiency of communication and collaboration between participants affected the contractor social networking capability in the bridge resilience. The future work should be strengthened to guarantee the information flow in case of interruptions.

9. Conclusion

A brief overview of contractor social networking practices on IBS infrastructure maintenance projects was clearly presented in this paper. The findings from the literature show that the researchers felt that the functionality of the app device was inappropriate for addressing social networking problems, and there are some limitations, which would need to be addressed in the future. It was identified that the main limitation to the use of the app device on IBS infrastructure maintenance projects was primarily the lack of measurement tool for bridge resilience. The realisation of full potential of social media resources should be maximised during communication and collaboration in order to avoid loss of profit for most maintenance contractors. There was also a need for proper training for the effective implementation of the app device in such projects. The development of current social media resources is part of basis for forming an effective framework which then will be used for supporting the improvements of contractor social networking practices. The next stages of this research will investigate the further innovation of app devices on contractor social networking including the extent and nature of mechanisation of the IBS infrastructure maintenance processes (framework development of disaster in infrastructure resilient) in developing such a device in the future.

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Corresponding author
Zul-Atfi Bin Ismail can be contacted at: zulatfippkas@gmail.com