Construction Sites Communications: A Framework for enabling the use of Internet Protocol Telephony in Construction Sites (IPTCS)

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ABSTRACT: Over the past decades, construction firms have been using several off-the-shelf telecommunications services to provide the communication means necessary to their mobile personnel on the jobsite. Despite this the traditional telecommunication systems are nowadays offering a wider range of services to the construction industry, but they are still considered expensive and inflexible. This paper reports on the possibilities of using Internet Protocol (IP) Telephony in the construction industry. The take up of this technology within the industry has not been observed despite the technological advancements in this area. This could be attributed to two main reasons, the slow nature of construction firms to embrace new technologies on the one hand, and the lack of awareness of technologies' developers and systems integrators to take into consideration the unique nature of construction sites environments needs on the other hand. This issue could possibly be resolved if the two sectors come to understand one another's requirements. To eliminate the underlying gap between the parties and overcome the implementation barriers of IP Telephony, the authors propose a theoretical framework, referred to in this paper as IPTCS (Internet Protocol Telephony in Construction Sites). It is expected that such a framework will add value to both the services providers and the construction industry supply chain alike.

KEYWORDS: IP Telephony in construction sites; construction sites communications; mobile computing in construction; ICT; VoIP; IPTCS Framework.

1. INTRODUCTION

Overtime, mobile solutions, as part of a larger strategy that includes unified communication and IP telephony, should make communications more efficient and lower costs for telephony use and network traffic (IDC, 2002). On construction sites, workers should be able to benefit from sophisticated communications technologies in order to contribute to the construction performance (Beyh & Kagioglou, 2003). This could be achieved through the integration of Internet Protocol (IP) Telephony into construction sites communications infrastructures. However, the take up of this technology within the industry has not been observed despite the technological advancements in this area, including mobile applications as for example Mobile Voice over IP (Mills-Tettey & Kotz, 2002, Ralph, 2002, Yi-Bing *et al.*, 2001). This could be attributed to two main reasons, the nature of construction firms to slowly embrace new technologies on the one hand, and the lack of awareness of technologies' developers and systems integrators to take into consideration the unique nature of construction sites environments needs on the other hand. This issue could possibly be resolved if the two sectors come to understand one another's requirements. To narrow the wide gap between the parties and overcome the implementation barriers of IP Telephony, the authors propose a theoretical integrated framework. It is expected that such a framework will add value to both the services providers and the construction industry supply chain alike.

This paper is organised as follow: Sections one and four provide introduction and conclusion respectively. Section 2 briefly describes the Internet Protocol paradigm and section three presents the IPTCS Framework (Internet Protocol Telephony in Construction Sites) developed by the authors at the Salford Centre for Research & Innovation within the School of Construction & Property Management at the University of Salford.

2. INTERNET TELEPHONY

Internet Protocol (IP) Telephony has first emerged from a combination of three core technological components including 1) the Internet, 2) Computer technology and 3) Telephony. The earliest history of IP Telephony was plagued with poor voice quality and substantial delays (Beyh & Kagioglou, 2003) and its use was restricted almost to computer hobbyist (Dettmer, 2002). IP Telephony uses data packets to transmit voice, Video and other services over the Internet instead of the transport over the Public Switched Telecommunications Network (PSTN). This mechanism significantly decreases call charges (Das, 2000) and allow convergence between different telecommunications services over a single data network. The technology is now reaching a high level of advancements and describes a total end-to-end solution from a user's perspective that gives the opportunity for advanced applications potentially yielding real business benefits (Catchpole *et al.*, 2001). However, despite its continuing improvements, IP Telephony still is at its very early stage of diffusion within the business environment and its slow uptake is likely to continue for many years ahead.

3. FRAMEWORK FOR ENABLING IP TELEPHONY IN CONSTRUCTION SITES

Constructions sites generally lack effective and adequate communication means where the entire supply chain along with the work forces are constantly put in a continuing collaboration process. One of the key success factors identified by Kennedy & Sidwell (2001) as prerequisite in implementing re-engineering in a construction industry context is an effective communication cycle between major project participants which is found to help avoiding rework and reduce time. Moreover, in many cases, the participants are geographically distributed, making the need for effective communication technologies acute (Anumba et al., 2001). Furthermore, introducing Internet Telephony to the construction industry as an adequate communication means that is able to succeed where the traditional telecommunications systems have failed is believed to be a very challenging path and it may not be easy to cross over without a clear understanding of the different issues and steps involved in the integration process. Based on this philosophy, the authors believe that there is a justified need for a common framework that will help ITSPs, Construction Firms and Equipment Vendors alike to come together in order to accelerate the integration of IP Telephony in construction sites environments.

The IPTCS Framework is based on four main inter-related variables identified as important to the implementation problem as shown in Fig. 1.

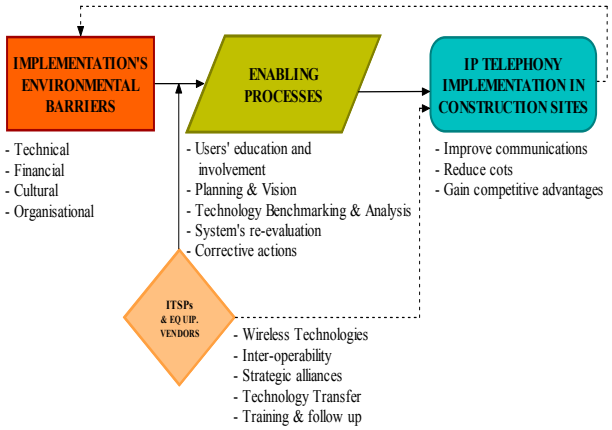

Figure 1: Internet Protocol Telephony in Construction Sites (IPTCS) Framework

There is however a certain number of assumptions made regarding the profile of each variable and the definition they have been assigned:

- **Independent variable:** Environmental Barriers
- **Moderating variable:** ITSPs & Equipment Vendors
- **Intervening variable:** Enabling Processes
- **Dependent variable:** IP Telephony Implementation in Construction Sites

3.1. Environmental Barriers

Sekaran (2000) indicates that an independent variable is a variable that influences the dependent variable in a negative or positive way. It is assumed that the slow uptake of IP Telephony within the construction industry is proportionally related to several environmental barriers such as technical, financial, cultural and organisational affecting its adoption by construction firms (Fig. 2).

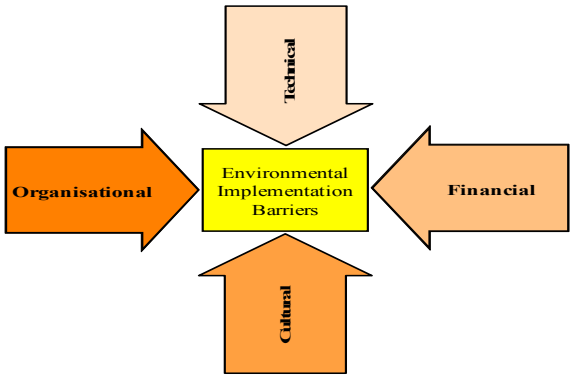

Figure 2: Environmental Barriers

Technical Barriers:

Wireless Voice and Data over Internet Protocol solutions will undoubtedly fill in an important role in the evolution of enterprise communications. The impact of successful, widespread adoption of advanced ICTs in the construction industry could be very significant as stated by Bower et al. (2001) who further indicate that "with the increasing accessibility and affordability of communication technologies could come the emergence of globally-based virtual organisations operating in knowledge-driven markets from geographically remote locations". However, there are numerous reasons why these solutions have not yet reached their full potential in the construction sector as for example, one impediment for many people and firms is simply "the fear of technology" as 10-15 % of the population will retire out of the industry before they ever embrace technology according to Stark (2003). Yet, in order to drive construction firms to look closely at such a technology, IP Telephony and wireless technologies system developers and equipment vendors must meet several concurrent goals to overcome the technical barriers preventing its integration in today's demanding construction sites environment and similar terrain topologies. Therefore, they must address the various needs of the construction industry. Moreover, considerable technical improvements are constantly being observed and recently an exciting opportunity for Voice over Internet Protocol has emerged using a Personal Digital Assistant (PDA) empowered by a Wi-Fi (Wireless-Fidelity) VoIP system developed by Pocket Presence (Linden & Blom, 2002). But the delivery of wireless XoIP (Voice, Video and Data over Internet Protocol) services on portable handheld and computing devices to construction sites should be taking into consideration several important factors that must entirely comply with such environment. These technical barriers include but are not limited to the following issues:

- XoIP wireless devices must be robust, water proof, resistant to dust and shock and equipped with adequate and self sufficient power supply similar to the traditional systems conditions as identified by Bowden (2002)
- XoIP features and services must exceed the capabilities of traditional and conventional phone systems
- Sound and video transmission quality must meet an appropriate level required by the information need under consideration in construction sites.
- Mobile and wireless devices must be interoperable and "plug-and-play" enabled in order to be seamlessly deployable
- Internet bandwidth must be prepared to meet IP Telephony requirements

Furthermore, major technical barriers of IP Telephony deployment are such created by wireless LAN connectivity. In such a networking environment, client devices handle the call set-up and other management issues which are usually controlled by a cell phone service provider infrastructure in the traditional systems. This issue will consequently increase the challenges that may be encountered while deploying an acceptable and effective wireless XoIP network. Moreover, it is well known that transmission of communications over IP network is synonymous to packet loss, delay and jitter issues. These are even higher in a wireless network especially when client devices are roaming between hot spots, unlike circuit-switched communications where voice quality is consistent throughout a call, the quality of a VoIP call can vary on almost a packet-by-packet basis (XACCT, 2001). Also, the fact that several standards exist creates interoperability problems causing communications difficulties between Gateways from different vendors because, many vendors have proprietary solutions, and even Gateways supporting H.323 standard may not work with each others (Nguyen et al., 2001).

Another issue challenging the IP Telephony deployment is related to the Quality of Service (QoS) performances of wireless voice over IP networks. QoS is in fact a critical issue to be resolved for achieving the migration from circuit-switched to packet-switched telephony networking (Mishra & Saran, 2000). The public switched telephone network (PSTN) defines quality of service as a particular level of service, for example "toll-like" service. However, quality of service for voice or other media over the Internet Protocol is defined as a continuum of levels, which are affected by packet delay or loss, line congestion, and hardware quality (Intel, 2002).

Noteworthy that IP Telephony emergency services such as Enhanced 911 or E911 calling standards are still in the early stages of being defined (Avaya, 2002), such services provides crucial information for the different emergency departments in order to provide the most accurate and timely response.

Financial Barriers:

Investing in new communications technologies and systems should have the potential to allowing an adequate and rapid "Return on Investment (ROI), construction firms may not be willing to undertake any new investment of the kind before taking full advantage of their existing systems in which they may have already heavily invested unless there is an immediate need for it. The cost of technology is believed to be an important barrier to adoption that a number of companies point to when explaining their reluctance to implement wireless solutions, even though they recognise the value of the devices and applications (Stark, 2003). These barriers within the construction industry were also identified by Love et *al.* (2001) who state that this business like others relies on cashflow availability and thus, firms could not invest in technologies that would not bring about immediate benefits. The financial barriers they are referring to include:

- The cost of system requirements and maintenance;
- Investment risk;
- Amount of available credit;
- Cost of training and education;
- Losses in productivity; and
- Market uncertainty.

Cultural Barriers:

"Companies that want to survive the increasingly sophisticated and competitive global marketplace will be required more and more to follow technical developments worldwide" as stated by Ashton et *al.* (1991), this is however a serious issue for the construction industry to follow such technological advancements at an early stage of developments and even after maturity because it is well known that in general, people in construction are in their nature, reluctant to change. According to Love et *al.* (2001) it would appear that contractors have ignored emerging technologies that have the ability to provide significant performance improvements. This fact is mainly due to the difficult environment and working conditions that usually physically and mentally affect workers at the jobsite or in the office. The fact that new technologies are continually emerging, they often require significant efforts for training, test, and experimentation. DIST (1998) emphasises the difficulties in the construction industry of adopting new Information and Communication Technologies by a resistance from the management to change and a belief that the industry is doing well without it. Moreover, training any personnel on new technologies take time and considerable efforts for a construction firm to achieve and therefore, adopting new technologies or accepting to experimenting them is often related to what has been learnt previously from past experiences. Therefore, in order to be successful, a migration to, and adoption of new technologies must strongly consider looking at consequences where an attempt to change the users' culture is likely to take place; in fact, change is a complex psychological event as stressed by Andersen (1992) who believes that "Just the thought of changing the fundamental culture or strategy of an organisation can send shock waves throughout the organisation, causing emotional and psychological stress to the individuals", because change is often asking people to do something different, adopt a different belief or attitude, therefore, prior to initiating any change it is necessary to analyse the organisation, the employees and their readiness for change.

It may be therefore debated that people's culture in the construction sector may strongly, negatively or positively affect the decision to integrating new technologies such as IP Telephony communications, this includes the issues arising from the preparation of the migration phase from traditional systems to IP Telephony one. The implementation of internal informational plans, network assessments and upgrade, purchase of new equipments and devices, and personnel training could seriously affect the decision to undertake this move; it is therefore believed that strategies where technological threats and opportunities are well understood should strongly contribute to the acceleration of adoption or in the contrary, the clear denial of such an eventual migration.

Organisational Barriers:

Andersen (1992) stresses that "the construction industry and its employees are being impacted by technology. The industry is affected by the use of computers; fax machines, telecommunications, new products, equipment, and robotics. Demographics clearly indicate the lack of technological skills in the upcoming work force. The educational level of employees will need to be increased to meet these challenges. Current employees will need training, retraining, and cross training to keep abreast of new technology". Bennett and Durkin (2000) indicate that organisational change significantly influences employee commitment to the organisation especially when the perceived values of the organisation have changed. Moreover, various

situations or events occurring within organisations are shown to influence commitment levels among employees. One particular situation that has received a fair amount of attention is when an employee's work environment undergoes significant changes (Meyer & Allen, 1997).

3.2. Moderating variable

Internet Telephony Service Providers (ITSPs) and Equipment Vendors (EVs) are assumed to have a strong contingent effect on the relationship between the environmental barriers and the implementation of IP Telephony in construction sites. They are selected as moderating variable to discover whether they modify the relationship of the independent variable to an observed phenomenon (Burns Robert, 2000). This phenomenon is represented in this given situation by the implementation of IP Telephony in Construction Sites. Moreover, ITSPs and EVs are expected to play a strategic role vis-à-vis construction firms in order to encourage the migration from traditional telecommunication systems to IP Telephony ones. Although, IP Telephony may not be for everyone, particularly organisations that have basic phone systems and need only a phone to dial out and receive calls (Chan, 2003), ITSPs and EVs could demonstrate a real interest to construction firms in terms of building open solutions that fit with their working environments. Furthermore, most organisations have made significant investments in their existing voice, video, and data networks which they naturally need to protect, therefore, a low-risk migration path is required from the old world to the new world as stressed by Cisco (2002), the role of ITSPs and EVs in this given situation is to develop solutions that facilitate the deployment of/or transition to IP Telephony networking in mobile and difficult environments. Such transition should be transparent to users and there must be a strategic alignment between what does already exist and what would come as a replacement to it, equipment, handsets, dialling plans and services including voice messaging, call restrictions, call transfer, multiparty conferencing, etc. need to be similar or even easier to use than in the traditional systems.

3.3. Intervening Variable

An intervening variable is a variable that helps to conceptualise and explain the influence or effects of the independent variable on the dependent one (Burns Robert, 2000, Sekaran, 2000). This is defined as a set of an established Enabling Process that surfaces between the barriers and the implementation of IP telephony at the jobsite (see fig. 3).

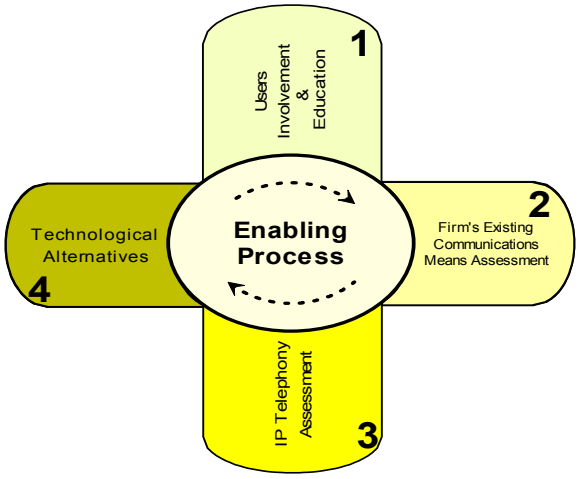

Figure 3: The Enabling Process of IP Telephony in Construction

In an age where technology itself is becoming an increasingly important component of the ability of companies to compete and even survive, the capacity to identify emerging technologies and manage them are vitally important issues (du Preez & Pistorius, 2002). Moreover, most changes (social, economical, environmental, etc) are directly caused by and/or related to the development, perception and use of technology as indicated by Drejer (2002) who further stresses that "Key traits of the technologically related changes are that they tend to transgress physical, organisational as well as disciplinary boundaries. Fig. 3 represents the main steps involved in the process that is believed to enabling IP Telephony communications within the construction industry. A collaborative working body including ITSPs, Equipment Vendors and end users from the construction industry sector is to be structured; such collaborative work must look at the following process:

Users Involvement & Education:

The involvement of the end users in the conceptualisation of the communication network that is intended to be integrated to/or replacing their existing systems could naturally narrow the adoption gaps and would further contribute to a rapid implementation within the firm. Stitz of McAnninch Corp. as indicated by Stark (2003) has involved his field personnel in decision along the way for the adoption of a new wireless technology, because they are, after all, going to be the primary users of these tools saying:

> "I think the biggest reason (adoption) is working so well is

> because I involved them from the start. I asked them what information they would like to see and how they would like to see it, and they actually helped me design the specs for the software. They were involved from step one, so I think that helped a lot".

Moreover, involving the employees in the conceptualisation process should contribute to the following benefits:

- Developing a clear and shared understanding of what is meant by migrating to IP Telephony communications
- Facilitating the involvement of the employees at all levels and stages of the development and implementation phases
- Developing strategies, set targets and participating in network evaluation measures.

Therefore, the involvement of people within the firm should be a systematic approach to maintaining a successful migration to such new technologies in terms of integration, implementation, evaluation and network sustainability.

Firm's Existing Communications Means Assessment:

This audit exercise will permit the identification of eventual gaps and issues in the firm's IT networks. It will also contribute to defining a clear vision of what is expected from an IT system. A business vision is vital for a good strategy formulation, because it functions as a co-ordinating directive framework (Klouwenberg et al., 1995). A thorough audit should therefore help the construction firms to raise several questions such as:

- Are our existing telecommunications systems adequately supporting our major construction sites communications needs?
- Do these systems satisfy our construction teams' mobility?
- Are they available to the entire construction team members?
- Do these systems permit adequate communications with the supply chain?
- Could an IP Telephony solution improve our global communications mechanism?
- Can new services be created and offered to all members?
- Can we reduce our global communications cost?
- Can IP Telephony improve our communications with our clients and contribute to gaining new markets?

IP Telephony Assessment:

The assessment of IP Telephony systems and the identification of its benefits, advantages and drawbacks should be naturally benchmarked with the firm's existing legacy systems. Despite the rapid growth of the technological developments and advancements in IP Telephony, there is still much more concern with interoperability between equipments and services from different vendors than with the quality of service itself. Therefore, it must be a systematic approach to assess and compare the equipment, software, solutions and services with regards to several criteria such as:

- Interoperability
- Scalability
- Services availability
- Support and maintenance
- Training and knowledge transfer, and
- Cost

As it is the case in the traditional telecommunications systems, services providers are concerned with interconnection between their different networks at a national and international scale; there is also a deep concern with compatibility between equipments from different vendors, this is again true in IT and IP Telephony situation. In the traditional telecommunications world "if a subscriber to a certain mobile communications carrier cannot make a call to a subscriber of another carrier, people lose an incentive to purchase cellular telephones, or try to subscribe to a carrier that boasts dominant number of subscribers" (Watanabe *et al.*, 2003), therefore compatibility will add value to the network providers and equipment vendors as much as to the end users and customers alike and this criteria should also be considered in IP Telephony communications world.

Technological Alternatives:

It is assumed that in most construction projects, the communications infrastructures are absent at the jobsite under consideration. The preparation of an adequate telecommunication network could be seen as an independent project itself leading to frustration, budget and resources involvement and a lot of time anticipation. An alternative to such undesirable but necessary work is that a movable and ready to operate IP Telephony communication unit could be designed to respond to such construction situations. A single Internet over

Satellite (IoS) connection point to the central unit could provide a vital communication link between the movable IP telephony unit on site and the entire supply chain. Such a unit could contain basic or a complete range of IP and legacy communications equipment and users' terminals according to the projects and personnel needs. Knowing that IP Telephony equipments, terminals and solutions are rapidly becoming cheaper comparing to the legacy telecommunications solutions, construction firms would therefore be able to acquire these units more easily.

3.4. Dependent Variable

IP Telephony Implementation in Construction Sites is assumed to be dependable on the relationships and processes set between the other entire ranges of variables (Burns Robert, 2000, Keppel, 1973, Sekaran, 2000). This dependency however, should be further discussed after obtaining the finding results of the ongoing field investigations undertaken by the authors.

4. CONCLUSIONS

This paper has discussed the integration of IP Telephony into construction sites and presented the possible benefits that could be obtained to improve the communications exchange between the project teams while reducing the overall communication costs. A theoretical framework to achieve such integration has been conceptualized. The main steps involved in this framework are explained. However, the authors believe that by identifying the barriers that are actually preventing the adoption of IP Telephony technology by construction firms, the latter along with ITSPs & equipment vendors, will be better positioned to overcome the most encountered challenges in the future and thus, the adoption process could be diffused in construction sites' environment more rapidly.

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