

## COLLABORATION IN A WEB ENABLED DESIGN MANAGEMENT SYSTEM – A CASE STUDY IN KOLKATA, INDIA

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**SUMMARY:** Project specific websites for construction management have become common in developed countries. Such a web space was introduced in Kolkata, India in 2006 for a hotel restoration and development project. The collaboration performances of the participants are presented in this case study. Relevant literature and the background conditions were first studied for planning of the web site. The response and participation of the end users were the most important aspects for success of such a collaborative web site. A number of tools like sociogram, sociometry, statistical analysis, social network analysis and factor analysis have been used to investigate the users' participation in the web site. The responses in the web forum followed a Pareto distribution in conformity with the literature. A sociogram and indexes as proposed in Moreno methods in sociometry were reported. A social network analysis was executed. These results could be used for comparisons with similar internet forums. It can be also used in future for checking performance of this web space. A factor analysis was performed to map the users' opinion about the web site. Users felt that the web site performed well in respect of coordination and benefit perspective but expected more in the areas of quality improvement and users' satisfaction perspective.

**KEYWORDS:** web enabled project management, collaborative design, social network analysis, factor analysis

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### 1. INTRODUCTION

A Majority of the construction firms in India are family operated small business. The industry is highly fragmented. Information technology (IT) applications are slow to percolate through the industry. Computer applications in design and drafting have become routine in India but even large corporations employ very little IT for construction management. Ahuja et al (2009) conducted a questionnaire survey across India. They found that internet enabled communication technology was in use in the industry, but comprehensive web based project management solution had not been adopted by any of the respondent organizations. The project management (PM) productivity has therefore remained low. The situation is not unique only for India. Shen et al (2009) remarked in the context of industrially advanced countries that despite the emergence and adoption of IT to assist construction management the industry's productivity has remained low.

Project specific web space for management that is in use in the developed nations for the last ten years has not yet taken a root in India. A project specific construction management web space has been installed in Kolkata, India in 2006 for a hotel restoration and expansion project. Observations and experiences about its implementation are presented in this case study. Users' responses and opinions are very important for success of a collaborative web site. This was particularly important in the present case because the system was new and many of the users were not computer savvy. It was therefore decided that the responses of the users would be studied closely after introduction of the system.

A 'Literature Review' about the web implementation of construction informatics provided guidelines for selection of components that should be included in the proposed web space. The plan for the study is presented in the 'Method' section. The present status of IT application in construction management in Kolkata, India has been investigated in 'Case Background' for assessing the local condition before implementation of the system. The scope of the study is also described. The scheme and facilities of the web site is presented in 'Case Description'. The interaction of the users in the website is presented in 'Results'. Quantitative estimates about users' responses, social networking behavior and opinions are also assessed in this section. The impact of the study is presented in 'Discussions' and 'Conclusion'.

## 2. LITERATURE REVIEW

Project management through web based platform has lately become an important topic in construction. Substantial researches have been undertaken in developed countries for web enabled construction knowledge management system. For example, the e-COGNOS project had been initiated by a consortium of the European construction industries. It aims at specifying and developing an open model-based infrastructure and a tool set to promote knowledge management within collaborative construction environments (Wetherill et al 2002). Sanchez et al (2009) proposed a model that relies on a business process management strategy. In this approach, the e-Business interfaces are independent of the PMC's (Project Management Consultant) management system allowing the firm to use always the same interface to receive and notify events. In addition, the firms only deal with the information they need without being aware of the complexity of the whole project.

According to the European Construction Technology Platform (ECTP 2009), the future construction sector will involve innovative business concepts that will be enabled by seamless communication throughout the construction life-cycles (e-NVISION 2007). Researchers have been developing languages and computing machinery for making web content unambiguously interpretable by computer programs, with a view to automation of a diversity of web tasks. In addition, researchers are developing automated reasoning machinery to address some of the more difficult tasks necessary for seamless interoperation including a richer form of automated web service. (e-NVISION 2007).

The process of e-Tendering, e-Procurement, e-Site and e-Quality, where "e" stands both for electronic and envisioning, constitute the core construction processes of the e-NVISION e-Business platform. The main objective of this project is to integrate the enterprise applications with the overall goal of facilitating the participation in European e-Business scenarios (e-NVISION 2009). The future e-Site scenario's main objective is to coordinate operations on the site in real time taking into account the events that occur at the building site: breakdown of machinery, unacceptable weather conditions, absence of manpower, change in the documentation, etc. In order to fulfill this objective a semantic model has been defined for the documentation needed to control the construction site, including the design documentation, scheduling and payment information (Bilbao 2008).

In Istanbul Technical University's Project Management Center, a research project in enabling an effective management system was undertaken (Dikbas et al 1999). The model entails an automated system for multiple construction projects, enabling efficient budget utilization by offering an elaborate decision-support system. Being web-based, the system provides easy and rapid access to project information ensuring timely decision-making.

In Japan, Sunaga et al (2000) conducted case studies for application of IT in building construction. They examined the feasibilities and the problems of IT adoption. They found that in order to obtain high efficiencies of IT adoption, the business process change needs to expand to a wider transformation of the entire process. They found that cost of maintenance is an issue for smaller sites. They also found that a practical evaluation method of effectiveness for IT adoption needs to be developed.

In a survey in US, roughly eighty percent of owners surveyed thought project collaboration software could help to reduce miscommunication and project disputes (Cox 2007). At the same time, owners appear to be reluctant

to mandate its use. Given that these tools have only been available since the late 1990's, it is encouraging that nearly a third of owners surveyed reported that they are using these tools and roughly one-third of owners reported that using these tools have shown sufficient benefit. Issa et al (2003) reported a study about E-Business Implementation in the US Construction Industry. The study focuses on determining the level of adoption of e-Business within project management systems by general contractors. The e-Business Assessment Survey used in this study showed that the US construction industry respondents were actually receptive to implement e-Business solutions that were designed specifically for the construction industry.

Rivard et al (2004) gathered eleven case studies across Canada for observing the impact of IT on construction industry. The case studies cover architecture, engineering, construction management, and specialized contractors. The following technologies were demonstrated: 3D CAD; custom Web sites; commercial Web portals; and in-house software development. They have agreed that electronic document transfer is the most efficient method. They have further observed that the short time-line and the tight budgets make it difficult to introduce new technologies on projects; it is costly to maintain trained CAD and IT personnel; and companies that lag behind reduce the potential benefits of IT.

Dave and Koskela (2009) reported a case study for implementation of a web site for knowledge sharing within a company. The company operates geographically dispersed workshops for maintaining machinery. Due to a lack of sharing procedure, the knowledge for maintenance was not retained. Wiki, blog and internet forums were considered for networking. With the proposed platform, all operators should have either direct or indirect access to company's information systems. Users should be able to store rich content i.e. photo and drawings with the posts. Forum software called phpBB ([www.phpbb.com](http://www.phpbb.com)) was finally selected as the knowledge sharing platform due to its market leading position, ease of use, active community development and support. For performance evaluation criteria such as number of new topics started, numbers of posts per topic etc were suggested. The objective of the project was considered successful because the solution provided a searchable knowledge repository capturing both tacit and explicit knowledge and requiring minimal maintenance. It could not have been done without application of web 2.0 technologies.

Nitithamyong, Skibniewski (2004) described research conducted on the identification of factors determining success of web-based construction project management systems. The effectiveness of the services provided by the application service providers is evaluated. They have reported that about 16% of the US firms in construction trade avail the services of web based project management systems. The facilities offered by a number of service providers are compared. A number of such service providers were consulted in connection with the development of the web site for the present case study. Details about the study were reported by Guha (2007).

Chan and Leung (2004) proposed a metadata based information system for data exchange among web based documents for construction project management. The system retrieves useful data from the original documents, reorganizes the information according to specific tasks or users, and displays the information in an integrated web page. There are five packages in the conceptual model, representing five important feature categories: Document Management, Workflow Management, Team Communication, My Project Place, and Administrative Project. The study bridges the gap between present and future development of the internet by exploring the possibility of intelligent search as one direction for the development of a Web-based project management tool. Such intelligent data exchange is a web 2.0 technology. It has been decided that the facility is not appropriate for the present case which would be a first generation web collaboration system.

An Internet-based project management system called Total Information Transfer System has been developed by Deng et al (2001). Major functions like file transfer; email, chat, internet video, remote data collection etc have been planned. After consideration for the present project, it has been decided that chat, video etc would not be feasible on account of cost and internet behavior of the participants. For file transfer required for drawings and documents posting, service provider's facilities have been used in the present case.

At University of Salford UK, WISPER which is a collaborative project management environment has been developed Faraj et al (2000). This environment supports design, CAD, visualization, virtual reality, Drawing Web Format (DWF), estimating, planning, specifications, supplier information and remote operations. It provides flexibility and portability, thereby enabling construction professionals to contribute as well as to perform and manage their own activities. After evaluating the issues for the present case, it was felt that the designers would be reluctant to shift from their existing delivery models only for one site. The drafting and technical system shall remain underutilized. The web system for the present case shall be kept very simple.

Katranuschkov et al (2001) reported about a major research project for concurrent engineering sponsored by European Framework Information Society. The goal was to develop an open collaboration platform where new services and tools may be easily integrated and where providers of engineering information, services and tools meet stakeholders. However, the main business goal was to hide the complexities and present the user with a simple interface. In a similar research Hearn et al (2002) observed that the real challenge is to convince the organizations that the additional effort for implementation would generate adequate benefit to the people in the organization. It is decided that the system operation of the system shall be kept very simple.

Ahuja et al (2009) reported a survey comprising of 149 usable responses about adoption of IT for building project management across India. The survey analysis showed that initial cost is not a barrier for larger firms and they have higher adoption of IT. The IT adoption differs for three groups of sample organizations i.e. PM consultants, builders and architectural organizations and decreases in this order. Comprehensive web based PM solution had not been adopted by any of the respondents. It was found that only in about 3% of the surveyed organizations, external or collaborative use of IT was more than the internal use of IT. Only about 1% of the surveyed organizations partially adopted web based PM. Survey results categorize issues at three levels namely industries, organizations and people and the issues identified are technical, managerial and people issues.

Scores of 'off the shelf' systems both open source and commercial, are available for web enabled project management. A few of these were discussed by Guha (2007) in connection with the development of a PM web space suitable for Kolkata, India. Alshawi and Ingirige (2003) also listed a few 'off the shelf' systems as sample for web enabled project management. These systems cover a wide range of facilities and functionalities, which have made these cost effective and efficient. Some of the software offer more comprehensive solutions for the entire life cycle of the project including capability of performing the e-commerce function. Andresen et al (2003) used a commercial 'off the shelf' system called Byggeweb (2009) for three projects in a Danish case study and found that these were implemented too quickly, resulting in users losing patience and thereafter completing their task using traditional means. The evaluation revealed that the project web did not produce a positive payback in monetary terms but a number of non-economically measurable benefits were identified.

Rivard et al (2004) analyzed different types of web enabled PM systems in Canada including custom websites, commercial portals and in-house systems and found that implementation is a difficult process both for financial and technical reasons. Scheer et al (2007) studied the development of a customized web enabled PM system in Brazil where the users did not have any prior experience with project extranet. They concluded that the knowledge managers have to revise their design practices, technology and knowledge base for success of even the customized system. The key differences between 'Off the shelf' and customized software are three folds namely cost, generic build and updates. 'Off the shelf' system is generally economical and very sophisticated but generic build. Customized systems are costly but can be tailor made for the client's business model and field issues can be responded through updates. Even the hybrid approach that builds up a customized system from numbers of previously used 'Off the shelf' modules may encounter substantial hindrances. Practicing professionals like (Krishnamurthy 2008) and (Murthy 2008) felt that each approach has its merits and problems.

These case studies spanning across continents consistently indicate that design management for construction through collaborative web spaces is at present an effective means of control for the construction industry in most economies. However, the implementation and technology adoption demands thorough preparation for success both for 'off the shelf' and customized systems. The system must be simple, economical and extremely user friendly for successful implementation and client acceptance. It is particularly applicable for an emerging market with tight budgets like in India. Therefore it was decided that a web space having such characteristics shall be installed for the present case for design and construction management in Kolkata, India. The system was customized with open source software for cost control. Popular brands like PhpBB, B2evolution, dot project etc were used with a hope that the system would remain user friendly. It was further decided that the response of the users would be also studied for improvements in future editions.

### **3. METHODS**

Posts to the web site forum are studied in different ways to investigate the users' responses in the proposed PM solution. A poll among the users is also conducted to map the opinion of the participants about the system. Since web enabled design collaboration is relatively new in Kolkata interviews for survey among the professionals has been conducted and results of another survey (Guha 2007) has been consulted to assess the awareness and acceptability of the concept during installation of the forum in the website.

The characteristics of the posts in the forum are studied in different ways namely sociogram, sociometry, post analysis and social network analysis (SNA). Each of the methods is briefly presented. Sociograms are maps of informal networks of relationships, displaying the connections between people based on specific criteria. It is a scheme for structural analysis of a networked community (Freeman 2000). The degree of involvement of the actors in the community can be traced in sociogram. In this case, the key actors for the web enabled team are identified based on the forum postings. Sociometry is a quantitative measure for interpersonal relationships in a networked community. All groups have intricate networks, based on both short and long term interactions. Even the network comprising of professionals assembled for a task like in the present case reflect alliances, agendas, sub systems, sub groups and isolates gathering around identifiable individuals based on their knowledge experiences and powers. It is hypothesized that similar traces can be identified from the forum posts. Sociometry has methods for displaying interpersonal choices, attractions and rejections and assists in exploring relationship dynamics. Sociometric analysis has been conducted to explore the group dynamics of the collaboration team.

Forum posts analysis of the collaboration forum reveals its statistical characteristics which can be compared with other similar forums and performances of these can be compared. Kaltenbrunner (2009) found that users systematically invest more time in certain discussions. It is the topic of the conversation, not the characteristics of those participating that keeps users interested for a topic. E-mail communication as shown in FIG 3 is agent based where as forum communication presented in Table 4 is topic based. In a forum, the focus is on the posts and analysis of it becomes more important (Malsch et al 2004). For a properly functional forum the probability density of the posts should match with that of similar forums. The probability density of the posts have been estimated and compared with similar study in literature.

A social network is a set of actors that have relationships with one another. Networks have many actors, and multiple kinds of relations between pairs of actors. SNA is a further development of sociometry. Sociometrists explore and measure informal networks of relationships. Often they work in situ with groups. Their intention is individual and group development through increased spontaneity (Jones 2009). The present day SNA on the other hand tends to regard the relationship strengths as stochastic and is targeted to deal with large unseen relationships that often takes place in the internet. Cross et al (2009) found SNA a valuable means for strategic collaboration. Park et al (2009) used SNA for investigating collaborations of Korean construction firms in international contracts. Howard and Petersen (2001) used SNA for analyzing the management team of a Dutch housing project. For the manipulation of network data, it is most useful in SNA to record information as matrices. For visualizing patterns, graphs are often useful (Hanneman and Riddle 2005). Several software are available for SNA. In this case, visone (Brandes & Wagner 2004), an open source software is used. The indices used in the software for describing the network are presented by Baur (2008).

These methods namely sociogram, sociometric analysis, forum post analysis and SNA are simultaneously applied to the internet forum to record the characteristics of the collaboration network in a comprehensive manner for future comparison. In addition, a poll has been conducted among the design team members for assessing the opinion of the members about the collaboration system. A factor analysis is applied as a data structure detection method. The aim of factor analysis is to explain the outcome of many variables in the data matrix using fewer variables, the so-called factors (Härdle and Léopold 2007). Combining two or more correlated variables into one factor, is the basic idea of factor analysis. Computationally, it is done by a variance maximizing (varimax) rotation of the original variable space and the variances extracted by the factors are called eigenvalues (Statsoft 2009). The factor analysis has been conducted on the poll results to reduce the opinions to a few key issues. The selection of numbers of the reduced factors is a matter of judgment. However, guidelines like criterion proposed by Kaiser (1970) and scree test proposed by Cattell (1966) both of which are frequently used by the analysts have been applied to reduce to key factors. The key opinions are then mapped in a radar diagram (Schultz 2002) to obtain an insight about the opinions of the users. Radar diagram is a combined polar plot of multiple variables of a data set sometimes used to aid identification of composite performance measure elements needing improvement. Mohamed and Stewart (2002) and Obonyo and Wu (2008) also used radar diagrams to present the choices of the participants in construction issues.

#### **4. CASE BACKGROUND**

The literature review indicated that level of acceptance of IT in construction management would depend among other factors upon the existing technology status. The existing technology status in Kolkata, India is therefore studied. The adoption of IT in any industry in a developing economy is susceptible to myriad hindrances. The construction industry is resistant to changes in IT based design collaboration even in a developed economy

(Brandon 2009). The issues about technology adoption are studied in this section. The scope of the present research could thereafter be developed and is also presented here.

#### 4.1 Technology Status

Rapid development of internet technology allowed business firms to communicate in an efficient manner. In case of Indian architectural, engineering and construction (AEC) firms, communication by e-mails has become standard and file transfer sites are used for transferring larger files like drawings. Successful completion of projects would demand collaboration of many and often geographically separated team members. Numerous e-mails would be inefficient because of duplications. Some stakeholders might still miss the required information in time. Dedicated web sites that are open to review by all stakeholders are a better method to manage project specific knowledge. In a developing country like Nigeria, Olukayode and Odusami (2005) studied about the use of IT in quantity survey and found that users are conservative in adopting IT but cost is the most inhibiting factor for IT use. Issa et al (2003) studied about spread of e-business in construction industry. They found that US construction industry is actually receptive to internet technologies and are not unwilling to implement suitable systems but conservative and careful to adopt new technologies.

Becerik (2004) presented a chart showing the AEC Industry’s adoption cycles for different technologies which is reproduced at Fig 1 and shown in black lines. The chart is further extrapolated for Indian condition and shown in blue. In Fig 1, Becerik found that about fifty percent of the AEC firms’ drawings in US are generated in 2D CAD by 1985. Same situation has been more or less arrived in India by 2005 and is presented in Fig 1. Based on the 2D CAD status the graphs for other technologies like 3 & 4 D CAD, Construction project Extranet (CPE) etc have been shifted to the same degree to extrapolate the Indian scenario in Fig 1. It indicates that web enabled collaboration or CPE is about to start in India in about 2010 and would spread in next five years. The present application is therefore consistent with the predicted technology adoption cycle.

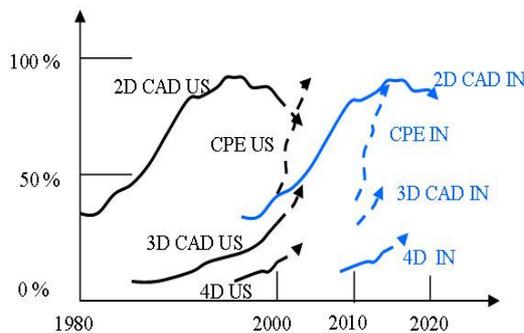


FIG. 1: AEC Industry’s adoption cycles for different technologies

In 2006, interviews were conducted with the managers of several leading firms in construction trade in Kolkata, India. The role of IT in their respective firms was discussed. The branches of national level firms were only surveyed. Information derived from the survey is presented in the Table1. It has been found that national level firms extensively use computers for drafting and scheduling. However, none of the industry leaders used any web based collaboration system or BIM for projects managed from their Kolkata office. Software vendors like resellers of Autodesk, Primavera and Microsoft in Kolkata were contacted but they could not provide information about any users of Buzzsaw, Primavera Project Portfolio or Microsoft Project Server in Kolkata.

TABLE 1: Evolution of web based communication and its application in the case study

Business Type	Nos. Surve-eyed	Type of software use			
		Drafting	Scheduling	Collaboration	BIM
Developer	3	No manual drafting	Commercial software	Emails are only used	No
Consultant	3	-Do-	-Do-	-Do-	No
Contractors	4	Occasional manual drafting	-Do-	-Do-	No

In Kolkata, the construction industry stakeholders mostly used paper based tools for their routine PM work. A survey was conducted among construction managers in Kolkata in 2006. About twenty senior professionals of

different construction firms were interviewed. The queries were intended to assess the current level of IT application in PM. The result of the survey (Guha 2007) is presented in Fig 2. Forty six percent of the managers opine that the existing PM reports are helpful. Only fifteen percent are aware about the commercial websites providing services in PM but about sixty five percent feel that such system would be helpful.

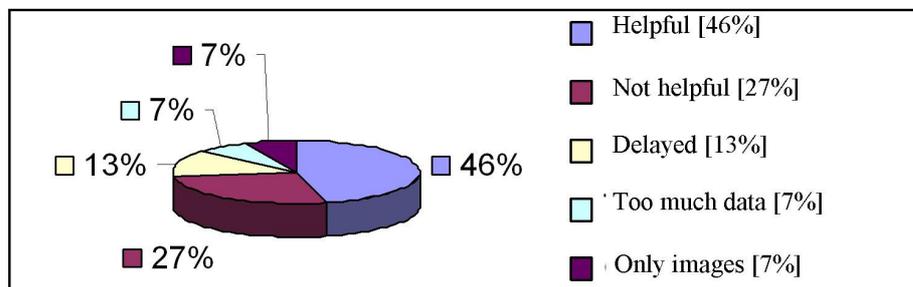


FIG. 2: Levels of IT application for PM in Kolkata, India

The proposed web enabled collaboration seems to be one of the first such operations in Kolkata. None of the stakeholders had any prior experience in such system. Interviews among stakeholders revealed that majority of the participants were above thirty five years of age and did not have any IT curriculum in their education. The stakeholders now use e-mails routinely but have almost no prior experience in social networking like forums and blogs. The web enabled collaboration system was not specified in terms of reference to the consultants and the use was on a voluntary basis. Resistance and apathy was expected from the stakeholders. Records about implementation were therefore maintained for future study.

First generation CPE applications have to be simple in any country. In one of the older survey (Howard et al 1998) in Scandinavia, internet use for PM was measured but project specific website was not even separately mentioned. In a later survey (Samuelson 2008), it was stated that use of project web started by 2000. In 2001, Katranuschkov et al (2001) commented that internet was only recently used for collaboration and mentioned about rented web spaces like Bricnet, Buzzsaw and Citadon. Project specific websites were only loosely structured till such time. The present situation in Kolkata, India is comparable to such period. The proposed first generation web enabled system is loosely structured compared to that of the matured systems now in use in the developed economy.

The present trend of the web is towards collaboration. O'Reilly (2004) coined the word web 2.0 to distinguish it from the first generation web service. The main feature of web 2.0 is that the users modify the web content. Klinc et al (2009) commented that social network services like blogs, wiki, RSS etc that are available in web 2.0 is very important because users could see only the information that are important to them. Additional details about web 2.0 technology available in the present case are presented in Table3.

Alshawi and Ingirige (2003) presented five case studies with the main benefits for each case. These cases are compared with the present case study in Table 2. In most cases, time and cost were saved by electronic delivery of drawings and documents. In the present case, stakeholders did not agree to discard hard copy documents while using an introductory system. The cost on this account could not be saved. However, other benefits like remote progress monitoring saved cost and time of the stakeholders.

TABLE 2: Comparison with the case studies reported by Alshawi and Ingiride

Project & System	Brief Description	Main Benefits	Comparison with our case study
INMANCO (Building Information Warehouse system was used).	This case is concerned with an electronic document management system through the web.	Cost savings through electronic document management avoiding hard copy	For important documents a follow up hard copy was still required
ALCOA (Custom built solutions were used)	The objective was to make world wide connectivity so that the team could collaborate.	Elimination of paper reports as information was sent on electronic form via the web.	Similar to ALCOA

CATHQUARTER ('ProjectsOnline' system was used)	The project involved collaboration between a Dublin based architect and a Northern Ireland engineering group	Any member can access or submit drawings, documents, etc., and view all project information on one secure location.	Widely separated stakeholders could follow the progress from their home office.
TITS (Linux and Windows was used)	The objective is to transfer information between head office and its overseas construction.	Speedy delivery and savings on communication by reducing IDD phone calls and courier services.	Separate accounting was not maintained so the benefits can not be ascertained
3COM (3COM provided software lotus notes were used)	Drawings were issued electronically. Approvals and confirmations were also accepted	Due to speedy delivery the group was able to save about six weeks and a million British pounds.	Participants were not yet prepared to do away with the hard copy drawings.

#### 4.1 Technology Adoption

A few theoretical researches about technology adoption have been consulted to obtain an insight of the issues. Gallivan (2001) proposed a hybrid model for innovation adoption with a view to improve the traditional framework. He suggested a model that can explain the interplay among organizational context variables and other characteristics that, in aggregate, shape assimilation processes. The study describes the implementation of a client-server technology and helps to fill in the gaps that intervene between managerial goal-setting for an innovation and evaluation of its benefits by examining the processes that link objectives with outcomes. Venkatesh et al (2003) compared the performances of eight IT acceptance models in four organizations over a six month period and found that the models could explain only between 17 to 53 percent of the variance in user intentions to use IT. They proposed a unified model with an adjusted  $R^2$  of about 70 percent. O'Brien (2000) argued that the implementation and sociological issues associated with project web sites should be addressed for making it successful communication vehicles. He felt that planning about how individuals should use the tools in a project web space requires due attention.

Mitropoulos and Tatum (1999) examined how contractors make decisions to adopt a new technology. The study focused on eight cases of adoption of electronic document management (EDM) and 3D computer-aided design systems. The paper summarizes the findings and the recommendations focus on the strategies that managers can use to increase the likelihood of successful adoption of new technologies. Howard and Petersen (2001) studied a Dutch government housing project since 1995. They concluded that the level of IT use was not up to the plan but new technologies including project webs have emerged during the process.

Björk (2002) studied the introduction of EDM technology in the construction industry mainly for the developed economies. He found that the barriers for rapid introduction of EDM in construction can be classified into technical, behavioral, cost-related, organizational and legal aspects. In the present case, the behavioral barriers that people resist to change their way of work seems to be particularly relevant. This has necessitated for measuring the usage of the web space as proposed in this study. Hjelt and Björk (2007) investigated attitudes toward EDM from the perspective of individual end-users based on a survey and usage log files of the total population of over 300 users. The detailed version of the study has been presented by Hjelt (2006). The proposed model shows that adoption factors are influenced both by the service quality and by end-users. The individual's involvement in the information process is a key factor. The model highlights that end-users are subjected to social influences not only from PM but also from their organizations.

Sulankivi (2004) investigated project specific website for multi partner projects and found significant qualitative benefits can be achieved. The web space makes it possible to change the traditional information flow radically improving it during the design and construction stages. The enhanced information flow simplifies daily routines and allows to work as one team. In addition, quantitative benefits like time and cost reduction is also achieved.

The IT-Barometer, a comprehensive survey for IT application in construction was carried out in 2007 in Sweden and Finland, as a follow-up to the 1998 and 2000 surveys (Samuelson 2008). The survey was based on questionnaire from the whole country, divided into all stakeholders. The use of project webs and electronic trade already started at the time of the survey in 2000 is now widespread in 2007.

## 4.1 Scope of study

After literature review and background studies it is recognized that successful deployment of a web enabled design management system would depend on key factors like users' acceptance and cost. A paradigm shift in work flow model of the consultants is also required for success of such systems. These changes would not come in a single project. The consultant community as a group would progressively look for web collaboration only if they find it economical, convenient and effective. The web system designer should therefore be sensitive about the continued usage of the installed system to respond to the stakeholders' requirements in time. This study is intended for a quantitative measure of such use of the web system in objective manner. For such research objectives, the scope of the study includes the following:

- i) Identifying the key members and the degree of participation of the stakeholders with the help of sociograms.
- ii) Group behaviors of the stakeholders and individual's satisfaction from sociometric analysis.
- iii) Forum posts analysis for investigation of its statistical characteristics for objective comparisons.
- iv) A SNA for rigorous measurement of the interrelationship among the stakeholders.
- v) An opinion poll among the participants and a factor analysis for the key factors of satisfaction.

## 5. CASE DESCRIPTION

At the project commencement, client's project manager requested stakeholders to mark a copy of all e-mails to the architect's coordinator. The communication pattern has been collected from emails marked to the coordinator for the first two months and is presented in FIG 3. This web collaboration system was started after about first two months of the commencement of the project. An organizational chart showing each participating member with their respective ID in parenthesis is presented in the FIG 4. In total, twenty four members participated in the internet forum. The consulting architect viewed the web service but communicated separately only with the architect on record. They have not been included in this network. At the start, the architect (ID 08) and later the PMC (ID 15) acted as coordinators. The coordinators are highlighted in FIG: 4. The internet forum was created within a web site ([www.sssolutionsonline.com](http://www.sssolutionsonline.com)). A restricted web space within the web site that can be accessed with a password issued by the coordinator contained periodic PM reports uploaded by the PMC. These reports are either in static web pages or in portable document files (pdf). In addition, collaboration facilities of web 2.0 like blogs, forums and wikis are provided within the restricted space as shown in Table 3.

TABLE 3: *Evolution of web based communication and its application in the case study*

Communication Mode	Technology	Present application	Developer
Blogs	Web 2.0	Included	b2evolution
Bulletin board	Web 1.0	Included	
Chat rooms	Web 1.0	Not available	
Discussion forums	Web 1.0	Included	Php bb
Instant messaging	Web 1.0	Not available	
Really Simple Syndication (RSS)	Web 2.0	Not available	
Static web page	Web 1.0	Included	
Web conferencing	Web 1.0	Not available	
Wikis	Web 2.0	Included	wikipedia

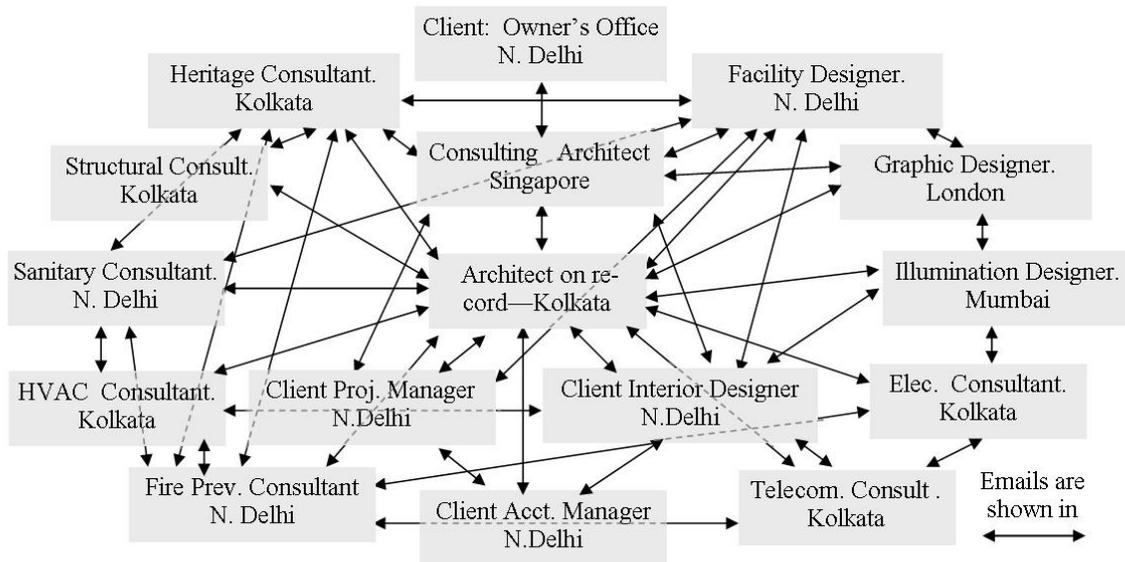


FIG. 3: E-mail communication pattern among stake holders

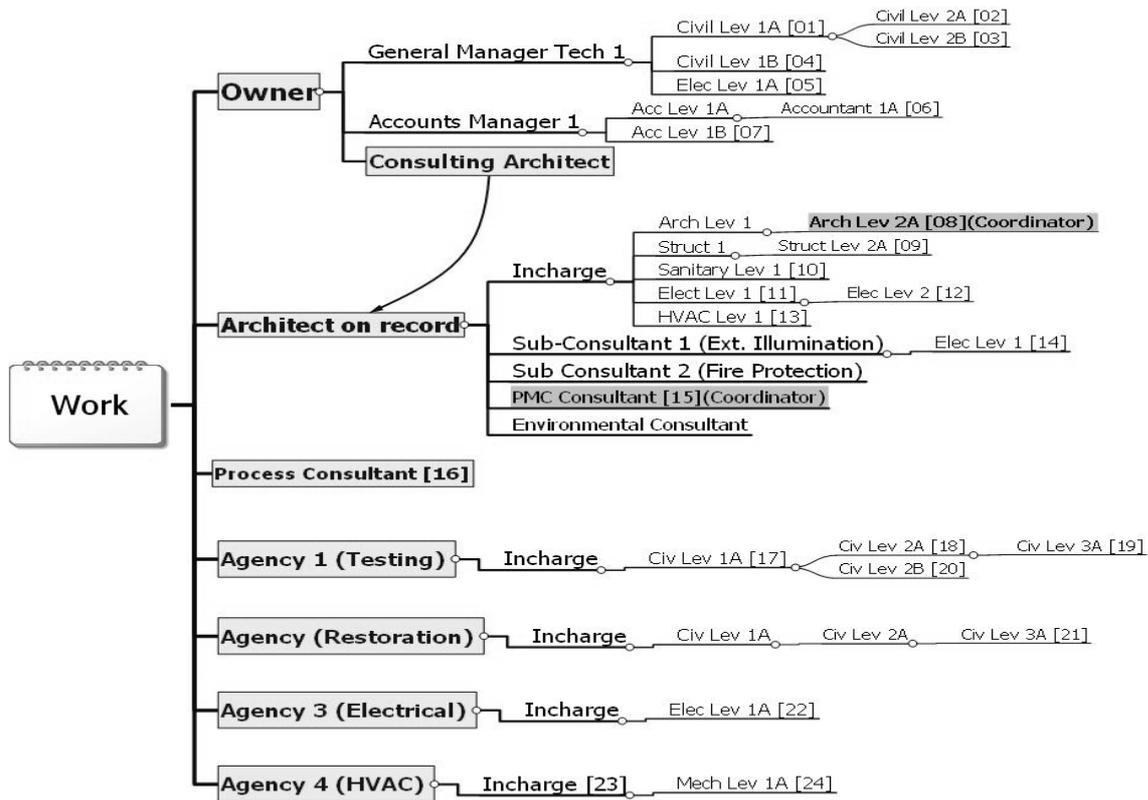


FIG. 4: Organizational charts showing the participants

The first ten topics that the stakeholders discussed in the internet forum are presented in Table 4 as samples. A schematic view of the web site facilities are presented in FIG. 5. The PMC monitored the progress and prepared the formal reports for tasks, schedules etc. Industry standard software like Microsoft Project was used for work plan and progress monitoring. The formal reports were uploaded fortnightly in the website. The fortnightly report generated in a standardized format was used as a progress monitoring tool by the stake holders. The participating consultants were made aware about their progress performance with respect to their earlier commitments. More importantly, the consultants could see the progress of other teams and could anticipate the time in advance for their required inputs.

Table 4 Sample Topic Descriptions

Topic	Brief description	Topic Owner	Posts	From	To
01	Soil survey for building plan sanction	Architect Coordinator(8)	5	05/04/06	05/07/06
02	Environmental Impact Statement	Architect Coordinator (8)	10	05/07/06	05/25/06
03	Fire water tank size requirement	Architect Coordinator (8)	7	5/10/06	5/14/06
04	Plant room location	Architect Coordinator (8)	18	06/02/06	6/30/06
05	Existing transformer room	Process Consultant(16)	16	06/01/06	06/14/06
06	Floor Space Index Estimate	Architect Coordinator (8)	8	06/12/06	06/20/06
07	Proposed layout of services	Process Consultant (16)	36	07/10/06	08/6/06
08	Structural audit of existing building	PMC (15)	23	05/10/06	06/20/06
09	Structural load requirements	Struct. Consultant (9)	5	06/23/06	07/14/06
10	Service area requirements	Architect Coordinator (8)	2	06/24/06	07/16/06

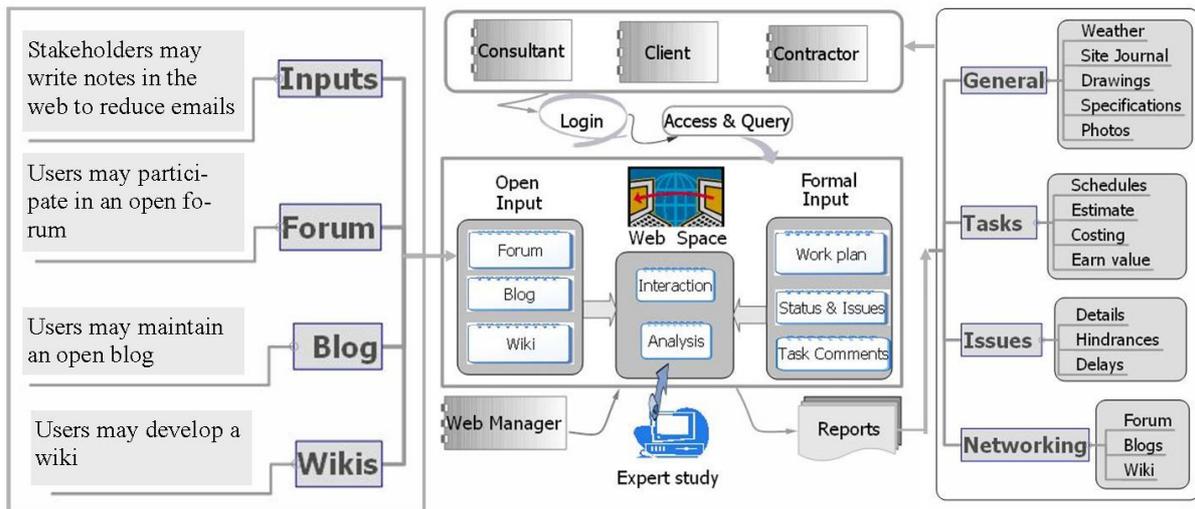


FIG. 5: Schematic view of the website ([www.sssolutionsonline.com](http://www.sssolutionsonline.com)) components

## 6. RESULTS

The success of the proposed web space mainly depended upon the users' reactions and is investigated in this section. Several methods like sociogram, post analysis, social network analysis and opinion poll have been used to investigate the users' response. A sociogram has been derived for finding the topic owners that have been responded well. Statistics of the responses in the forum have been analyzed for estimating the probability distribution of posts for future comparison with similar forums. A goodness of fit has been estimated to obtain an insight about the findings. A social network analysis has been presented for investigating the internet behaviors of the design team members. After about six months of installation of the system, an opinion poll was conducted among the users. A factor analysis of the opinion poll has been performed and their opinions were mapped for improvements in future editions of the web space.

### 6.1 Sociogram and sociometry

The discussion forum in the website was used by a number of stakeholders to clarify technical queries. The summary of the first ten items in the discussion forum is presented in Table 4. The communication pattern in FIG 3 and the organization chart in FIG 4 do not indicate about the degree of collaboration that has taken place among the forum participants.

Scientists sometimes use sociograms to identify the important individuals in a group. Moreno first introduced the concept in 1934 Marineau (1989). Northway (1940) originally proposed a target sociogram similar to FIG. 6. Andresen et al (2003) created sociograms similar to FIG. 6 for displaying the volume of communication of stakeholders in a web enabled PM system. In FIG. 6, each nested concentric circle represents a frequency at which the posts are made. Points in the central circle are more central in the sense that they were chosen more often. Points at the edge were chosen less often. The lines connecting them represent the primary links of forum posts between stakeholders. The activities for the first three months of the forum participants represented by their IDs shown in FIG.4 are presented in FIG. 6. The target sociogram is prepared by an application from Adit Software (2009). The posts of PMC (ID15), architect (ID8) and process consultants (ID16) are more popular in

the forum. ID7 (Accountant) was a viewer but did not post any message and is not connected with any link lines. ID15 (PMC) was found to be the most important member of the forum which was expected anyway. However, owner's managers represented by IDs 1 through 7 who were expected to participate and take lead role in the forum did not use the facility extensively.

There are a number of indexes in Moreno's analysis that provide the sociometric status of a group. Postings in the forum were analyzed in Sociometric Pro (2009) software where the index definitions are available. The indexes are presented in FIG. 6. It may be noted that in FIG. 6 the group indexes are increasing with time. It indicates that the activities in the forum are increasing gradually. Private indexes of important forum participants highlighted in FIG. 6 are also presented. The performance of individuals at a given time can be traced. The indexes can be used to compare the collaboration performance with similar forums or with this forum in future.

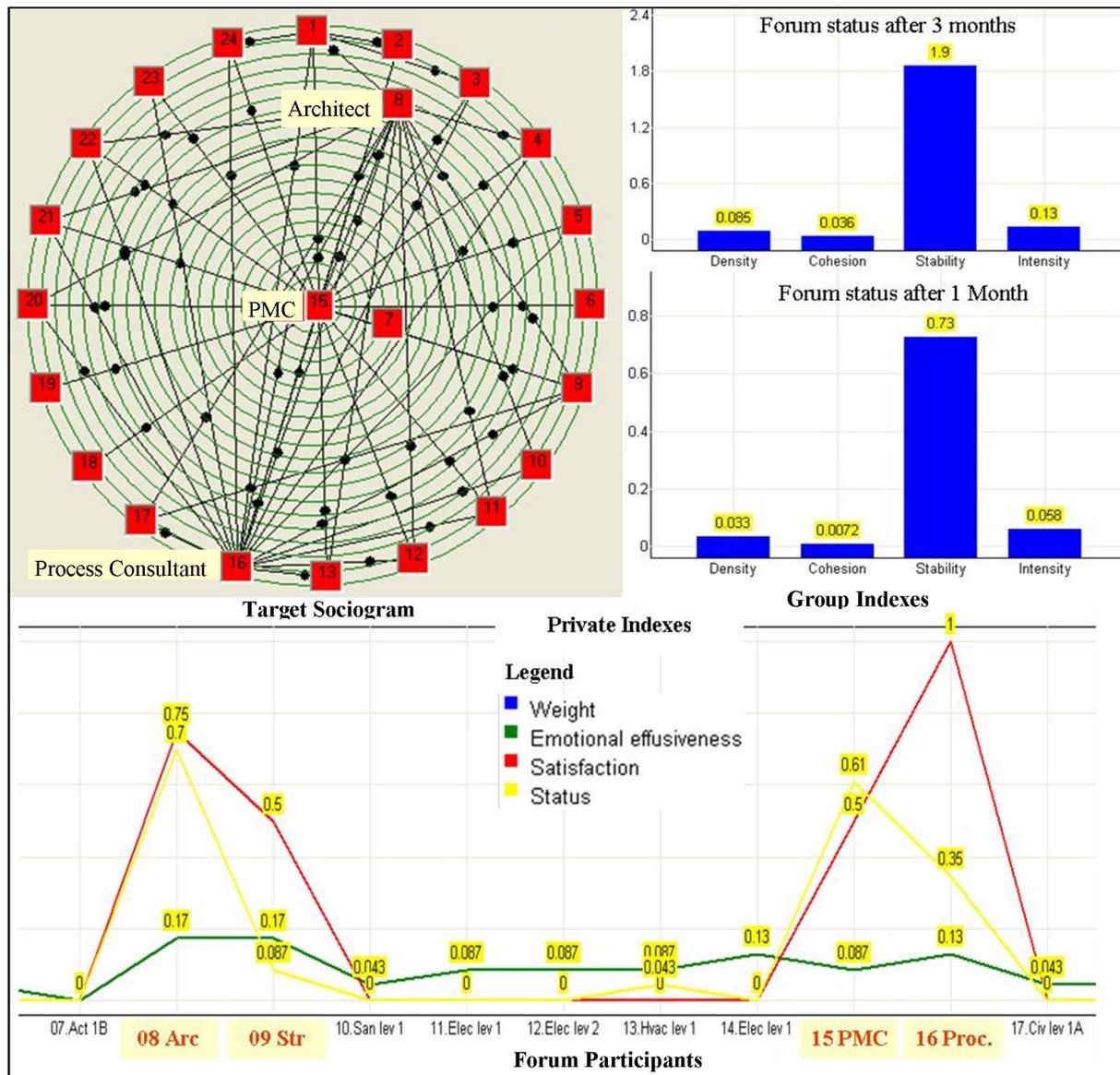


FIG. 6: Sociogram and indexes of the forum posts

## 6.2 Forum posts analysis

Morzy (2009) proposed a data mining model of the internet forums. Forums or discussion boards have become the leading form of peer communication. A statistical analysis of an internet forum consists of identifying basic statistics on topics and posts to map activity, controversy, popularity etc. The analysis of these basic statistics would provide insight into the characteristics of the network. The first such statistic is the distribution of the number of posts per topic. In common forums, many of the topics contain a single post. This is either a question that has never been answered, or a post that did not spark any discussion. In this forum, users are obligated

under a contract with the project sponsors. Therefore users have responded to their relevant assignments and the topics have multiple posts. Morzy (2009) pointed out that the flat architectures, such as PhpBB, where each post is a direct answer to the previous posts; do not allow to create deeply threaded discussions. In this website, the forum is powered by PhpBB. However, the forum is mainly used for clarifications and sustained postings on a particular topic are not expected. The probability distributions of the posts are investigated. Morzy (2009) suggested that the posts should follow the Pareto distribution. The Pareto distribution shows exponentially diminishing probability  $f(x)$  of a random variable  $X$  to take larger values  $x$ . It is often used for representing distributions of national wealth where a small number of population controls bigger share of wealth. Anderson (2006) first adopted the same of idea of Pareto distribution to e-commerce and web analysis. He argued that the dominant 20% of products is favored by the market over the remaining 80% of products (called *long tail*). However, the tail part is stronger and bigger in internet than in traditional markets. Internet shops like Amazon realize their profits within the so called long tail primarily because of their low inventory cost. Morzy (2009) argued that the same principle holds true for internet forums as well.

### Probability Density & Curve Fitting

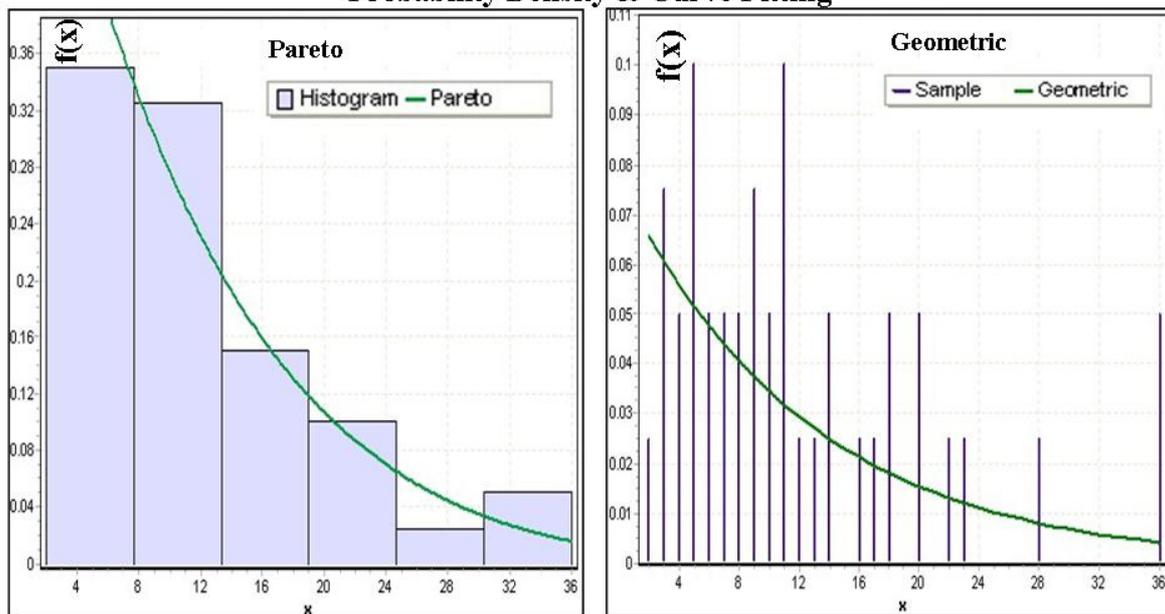


FIG. 7: Probability distributions of the posts

TABLE 5: Goodness of fit estimation

Gen. Pareto Distribution						Geometric Distribution				
Sample: 40 , Statistics: 0.22671 , Rank: 4						Sample: 40 , Statistics: 0.188 , Rank: 3				
Kolmogorov-Smirnov						Kolmogorov-Smirnov				
$\alpha$	0.2	0.15	0.1	0.05	0.01	0.2	0.15	0.1	0.05	0.01
Critical	0.169	0.180	0.192	0.215	0.257	0.233	0.248	0.266	0.296	0.355
Reject?	No	No	No	No	No	No	No	No	No	No
Anderson-Darling						Anderson-Darling				
Sample: 40 , Statistics: 4.0161 , Rank: 35						Sample: 40 , Statistics: 1.469 , Rank: 1				
$\alpha$	0.2	0.15	0.1	0.05	0.01	0.2	0.15	0.1	0.05	0.01
Critical	1.374	1.602	1.928	2.501	3.907	1.374	1.602	1.928	2.501	3.907
Reject?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The goodness of fit of the probability distributions of the posts is estimated both in Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) methods and is presented in Table 5. 'Easy Fit' software has been used for the results presented in Table 5. The posts have been tested with general Pareto distribution in line with observation by Anderson (2006). The software compared it with about forty other distributions available in the software and ranks it in serial 4 as estimated by Kolmogorov-Smirnov method. However, the results estimated by Anderson-Darling method are not similarly good. It seems geometric probability distributions also fits reasonably well for the data as shown in Table 5. These results could be used for comparison with similar cases.

### 6.3 Social Network

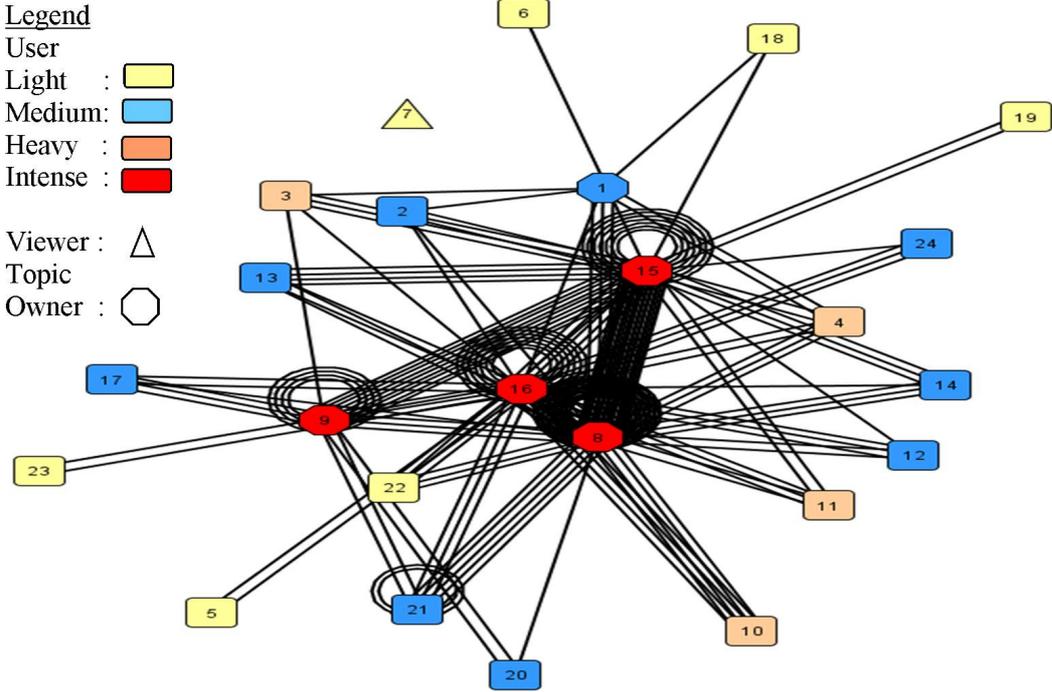


FIG 8: Social network diagram of the users' forum

TABLE 6 : Social Network Analysis Metrics of the Forum Responses

ID	User	Between- Ness (%)	Close- ness (%)	Clustering Coeff. (%)	Degree (%)	Eccentricity (%)	Eigenvector (%)
1	Civ Lev 1(A)	1.1982	4.3740	0.4	2.4725	3.4482	2.0383
2	Civ Lev 2(A)	1.5709	4.3740	0.8333	1.3736	5.1724	1.5709
3	Civ Lev 2(B)	1.5496	4.3740	0.6666	1.6483	5.1724	1.5494
4	Civ Lev 1(B)	0.0717	4.3740	0.8333	2.4725	5.1724	2.9202
5	Ele Lev 1(A)	0.0	3.7225	1.0	0.5494	3.4482	0.4395
6	Acc Lev 1(A)	0.3831	3.499	1.0	0.2747	3.4482	0.3831
7	Acc Lev 1(B)	0.0	0.0	0.0	0.0	0.0	0.0
8	Arc Lev 2(A)	23.3928	6.033	0.2476	25.0000	5.1724	27.8185
9	Str Lev 2(A)	4.3374	4.7286	0.4761	8.5164	5.1724	7.1664
10	San Lev 1	0.0	3.8880	1.0	2.1978	2.1978	3.0583
11	Ele Lev 1	0.0	4.2673	1.0	1.9230	5.1724	2.5153
12	Ele Lev 2(A)	0.0	4.2673	1.0	1.6483	5.1724	2.1321
13	Hvac Lev 1	0.0	4.2673	1.0	2.1978	5.1724	3.0619
14	Ele Lev 1(A)	0.0	4.2673	1.0	1.9230	5.1724	3.0038
15	PMC	34.5178	6.0331	0.19047	19.5054	5.1724	19.5657
16	Proc Consult	36.3396	6.7292	0.1895	17.3076	5.1724	11.2208
17	Civ Lev 1(A)	0.0	3.9763	1.0	1.6483	3.4482	1.4054
18	Civ Lev 2(A)	0.0179	3.6450	0.0	0.5494	3.4482	0.4231
19	Civ Lev 3 (A)	0.0883	4.3740	0.6666	1.6483	5.1724	1.5496
20	Civ Lev 2(B)	0.0	3.6450	1.0	0.8241	3.4482	0.8255
21	Civ Lev 3 (A)	0.0	3.9763	1.0	3.8461	3.4482	3.9756
22	Ele Lev 1(A)	0.0	4.2673	1.0	1.9230	5.1724	2.6769
23	Hvac Inchar	0.0	3.7225	1.0	0.5494	3.4482	0.4395
24	Mec Lev 1(A)	0.0	4.0688	1.0	1.0989	3.4482	1.0424

A social network diagram of the postings in the forum is presented in FIG. 8. The IDs of the stakeholders used in FIG 4 are shown in the network analysis in Figure 8 and color coded based on the activity level. The characteristics of a network are analyzed with graph theory (Hanneman 2005). Various characteristics of the

network based on the graph theory were estimated with the help of 'visone' (Baur 2008) software system and are reported in Table 6. These characteristics describe the attributes of the members in quantitative terms with relation to social network of the forum as of a particular date. Difference of attributes between the two stakeholders would show the individual position of the member in this social network.

For example, the architect (ID:8) and the PMC (ID 15) has a betweenness of 23.3928 and 34.5178 respectively which indicates that PMC is more central to the network in the sense more topics and responses have been exchanged by the PMC. However, the Eigenvector of the architect (ID 8) and the PMC (ID 15) are 27.8185 and 19.5657 respectively. It broadly indicates that more stakeholders responded to architect's topic. In practice, it should be true during design development phase when the architect plays the most important role. PMC's role will increase after design development and during coordination stage. As a result, the Eigenvector of the PM Consultant would possibly change with time. The FIG. 8 and Table 6 show that network is well connected and has no structural holes. There is less chances of communication failure. Such insight about the network is available from the SNA of the case study. The network attributes may also be compared to a similar forum or with this forum in future for investigating the social networking behaviors in the project management forum.

## 6.4 Factor Analysis

Serafeimidis and Smithson (2000) commented that information system evaluation is a difficult problem in both theory and practice. They observed that organizations are adopting more entrepreneurial approach for IT system evaluation. In a case study, they found that failure of an IT system for a utility firm was mainly due to the resistance to organizational change. In the present case similar resistance like insistence for hardcopy drawings was found. Ballantine and Stray (1999) reported that the extent of evaluation depends on organizational factors such as project cost, organization's turnover etc. They also found that IT investment is essentially evaluated like other investments of the firm. Economic and quantitative measures for the success of Information Systems are difficult to obtain Sarrinen (1996). Practitioners relied on subjective assessments. He proposed for a direct assessment similar to cost-benefit analysis. For performance evaluation of a web enabled MIS, Mohamed and Stewart (2002) developed a questionnaire categorized into five distinct perspectives namely operation, benefit, user orientation, strategic competitiveness and technology.

TABLE 7: Summary of the opinion poll

No	Questions	Mean	Standard Dev.
01	Reduced response time to answer queries	4.5000	0.5898
02	Enhanced coordination among stakeholders	4.6667	0.4815
03	Helped updating the records	4.0833	0.7173
04	Enabled immediate feedback	4.2917	0.6241
05	Facilitated document transfer	3.6667	0.8681
06	Helped for design improvements	4.3333	0.6370
07	Enabled cost savings in design	3.5000	0.5898
08	Decreased design errors	4.0833	0.7173
09	Led to satisfied stakeholders	4.3333	0.5647
10	Decreased request for information	4.2083	0.6580
11	User friendly system	4.2083	0.8330
12	Secured against unauthorized use	3.4583	0.8330
13	Suitable for use in Indian projects	4.6667	0.4815
14	Reliable throughout the use	4.0000	0.6594
15	Enhanced user's image in industry	3.7083	0.6241
16	Helps to attract sophisticated clients	3.6667	0.7020
17	Increased capacity for remote management	4.4167	0.7173
18	The system's overall performance	4.3333	0.5647
19	Arrangement of training	3.5000	0.7223
20	Increased accuracy in reports	3.7917	0.6580

A similar questionnaire has been prepared and the survey was carried out among the 24 project participants. A Likert-type scale ranging from 1 = "low/strongly disagree" to 5 = "high/strongly agree" was used to assess the responses. The mean ratings and standard deviation for the responses are summarized in Table 7. Higher mean values suggest higher degree of IT-induced performance improvement for the concerned item.

A principal component analysis followed by a varimax rotation carried out on 20 items mentioned in Table 7 using SPSS for determining the underlying factors of IT performance. The initial analysis was run following the Kaiser's criterion of retaining the components with eigenvalues greater than one. The Kaiser's criterion seemed

to be applicable here as the number of variables is less than 30. The analysis extracted eight factors with eigenvalues greater than one which together accounted for 79.71 % of the explained variance. This also seemed to be correct as communalities after extraction found to be greater than 0.7 conforming to Kaiser's criterion. A Scree Plot is also shown in FIG. 9.

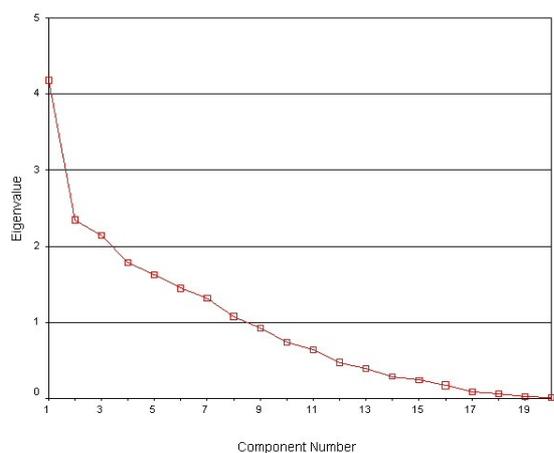


FIG. 9 : A scree plot showing the Eigenvalue and component number

The details of factor loadings, explained variance and eigenvalues of the eight extracted factors are given in Table 8. The items with loadings greater than 0.4, are used to define eight extracted factors.

TABLE 8: Varimax rotated factor loadings for eight-factor solutions

Factors / Perspectives	Question No	Questions	Factor Loadings
User's satisfaction perspective Factor 1, Variance = 13.212, eigenvalue = 4.193	17	Increased capacity for remote management	0.826
	16	Helps to attract sophisticated clients	0.781
	11	User friendly system	0.586
	19	Arrangement of training	0.542
	09	Led to satisfied stakeholders	0.469
	15	Enhanced user's image in industry	0.444
Technical performance perspective Factor 2, Variance = 11.614, eigenvalue = 2.348	06	Helped for design improvements	0.836
	07	Enabled cost savings in design	0.830
	18	The system's overall performance	0.710
Usability perspective Factor 3, Variance = 11.378, eigenvalue = 2.138	12	Secured against unauthorized use	0.941
	03	Helped updating the records	0.718
	13	Suitable for use in Indian projects	0.534
	19	Arrangement of training	0.422
Timely performance perspective Factor 4, Variance = 10.109, eigenvalue = 1.785	04	Enabled immediate feedback	-0.872
	10	Decreased request for information	-0.663
	18	The system's overall performance	0.472
Quality improvement perspective Factor 5, Variance = 8.774, eigenvalue = 1.631	20	Increased accuracy in reports	0.865
	15	Enhanced user's image in industry	0.528
	13	Suitable for use in Indian projects	0.517
Coordination perspective Factor 6, Variance = 8.665, eigenvalue = 1.446	02	Enhanced coordination among stakeholders	-0.836
	14	Reliable throughout the use	0.665
	10	Decreased request for information	0.404
System performance perspective	05	Facilitated document transfer	0.877
	09	Led to satisfied stakeholders	0.519

Factor 7, Variance = 8.117, eigenvalue = 1.325	11	User friendly system	0.461
	19	Arrangement of training	-0.428
Benefit perspective Factor 8, Variance = 7.837, eigenvalue = 1.075	01	Reduced response time to answer queries	0.893
	08	Decreased design errors	-0.635

To understand the user's perception on the web enabled MIS, an overall score of each extracted factor defined on a scale from 0 to 100% is calculated based on the mean scores for each item related to that factor as shown in Table 8. There are a few items which has factor loading greater than 0.4 for more than on factor. They are considered under that factor for which their loading is maximum while calculating the factor's overall score.

For example, the overall score for the first factor is calculated by the summation of mean scores for items D3, D2, C1 and E2 divided by the total possible maximum score of these four indicators i.e.  $(4.42 + 3.67 + 4.21 + 3.50)/(4 \times 5) = 0.7896 = 78.96\%$ . B3 and D1 are excluded from the calculation of performance score of Factor 1 as they have higher loadings in other factors. Each factor's overall score was plotted on a radar diagram as shown in Figure 10. Scores for the eight extracted factors are as follows: Factor 1: 78.96%, Factor 2: 81.11%, Factor 3: 81.39%, Factor 4: 85.00%, Factor 5: 75.00%, Factor 6: 86.67%, Factor 7: 80.00%, Factor 8: 85.80%. Each factors are weighted equally in contributing to the overall performance of the web based MIS and the overall score is estimated to be 81.74%.

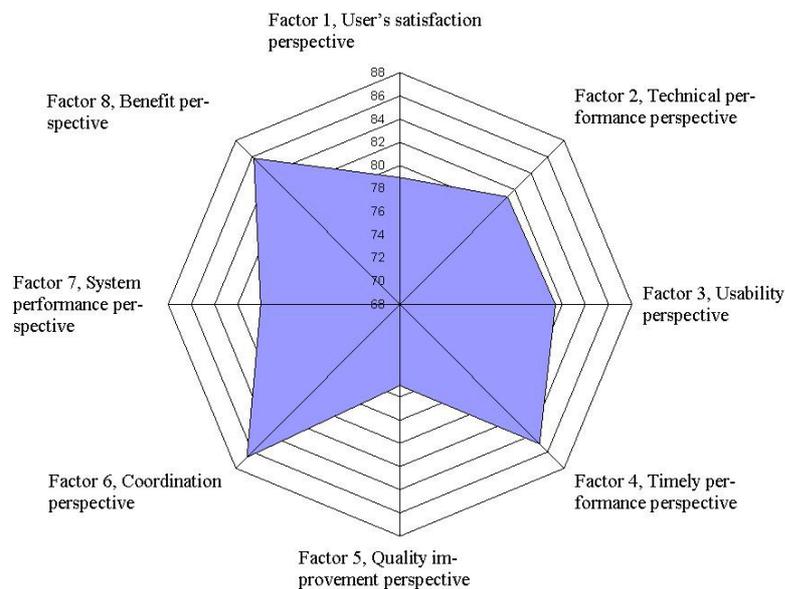


FIG. 10: Radar diagram showing average score of each extracted factors

The radar diagram in FIG. 10 reflects areas where organizational efforts are required to improve the utilization of the web based MIS, under investigation, to its maximum potential. The IT induced improvement is most pronounced for Factor 6, i.e. coordination perspective. For the quality improvement perspective i.e. Factor 5 the IT induced performance improvement is found to be the least where organizational attention is necessary.

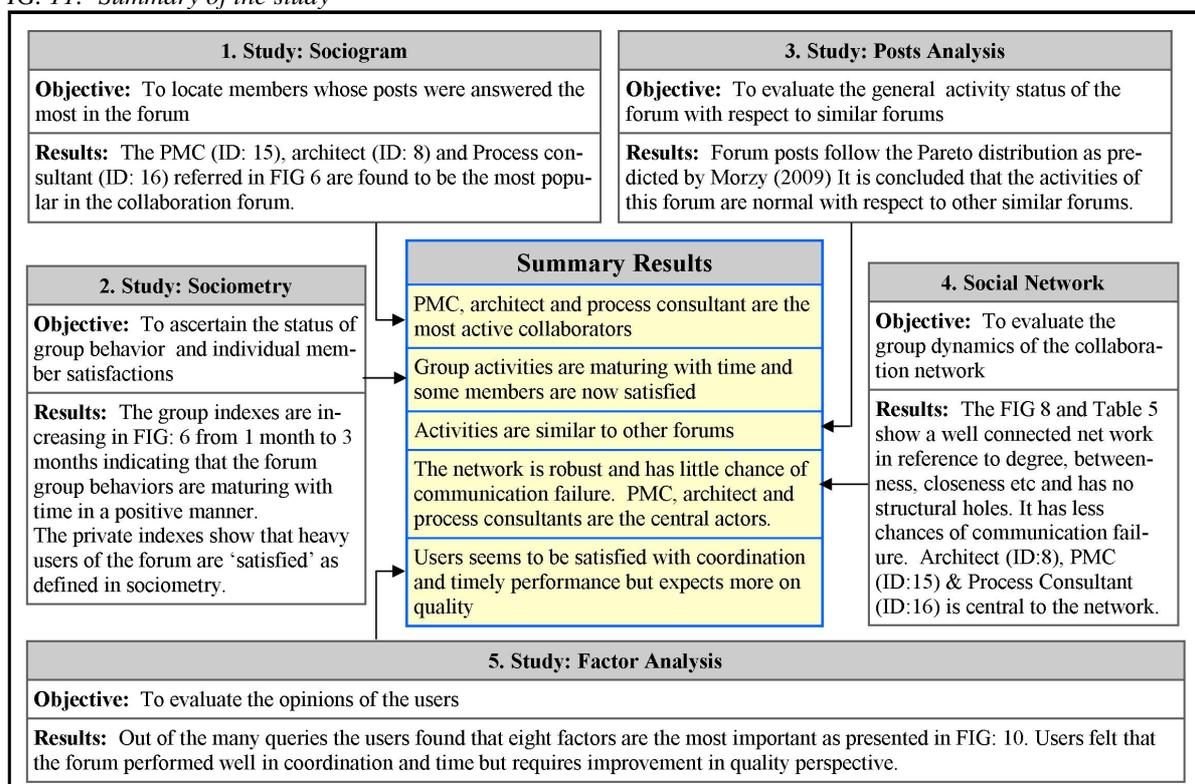
## 7. DISCUSSION

The study provides an insight about the means of improvement of the design collaboration system in a developing economy like India. Project specific website is not yet a common practice in India as evidenced from Ahuja et al (2009). They did not find any web based comprehensive project management solution in small and medium enterprises in a country wide survey. The sample survey conducted in Kolkata in 2006 and presented in Table 1 could not locate any project specific web address maintained from Kolkata. It further reinforced the findings of Ahuja et al (2009) on the local level. The findings are also in conformity with FIG 1 which is an extrapolation of US experience about the adoption cycle of IT in construction (Becerik 2004). The FIG 1 seems to predict that such forums in CPE might appear in Indian business environment after 2010.

None of the consultants participating in collaboration forum had any prior experience which was similar to a case study in Brazil (Scheer et al 2007). They used questionnaire survey among participants for evaluation. Hjelt and Björk (2007) also used questionnaire survey for end users response. In line with these studies, the analysis of the stakeholders' responses simultaneously in several ways reveals substantial information about the collaboration performances.

Brief results of the five studies executed on the collaboration forum are reported in FIG 11 and the key finding of each is transferred to 'Summary Result'. Reviews of summary results in FIG 11 reveal a wealth of information about the performance of this collaboration operation. Individual member activities and group behaviors can be estimated from sociogram and sociometry respectively. Operation of the forum with respect to standard can be judged from post analysis and with other forums can be quantitatively compared with the help of SNA. The risk of failure of the collaboration system can also be judged from further analysis of SNA. Collaborators' self assessment can be derived from factor analysis. The information would help the designer for improvement of the collaboration tools. It will also help PM consultants to compare similar collaboration systems quantitatively, gain insight about collaboration activities, correct weak aspects and manage projects efficiently.

FIG. 11: Summary of the study



## 8. CONCLUSION

The study provides a method for evaluation of collaboration facilities in a project web site in a developing country like India. Related literature indicates that a simple system is desirable in a nascent market and therefore the web space is designed in a simple manner. A web enabled project management system at the very core is a customer oriented system. Unless the stakeholders find it convenient the system is doomed to failure. Several analyses have been therefore made about the responses of the participants. A sociogram has been presented for investigating about the relative importance of the participants. The role of architect and the PMC have been found to be the most prominent in the sociogram which is expected for a design development stage. A number of indexes in line with Moreno's methods of sociometric analysis have been reported. These indexes provide a relative idea about the group dynamics in collaboration. The indexes can be compared with that of a similar web site or with this site in future to ascertain the level of collaboration.

A statistical analysis of the posts is conducted. The posts seem to follow Pareto distributions which are in conformity with the literature. A social network diagram and quantitative attributes of the participants have been reported for investigating the network activities. The results could be compared with similar data in future for

comparing the network activity of this or similar project management forums. Finally, the opinion of the participants about the web space is investigated with factor analysis and the opinion of the users is mapped. It seems that users approve the coordination and benefit perspective of the web space but desire quality improvement and expects more satisfaction out of the system.

Simultaneous evaluations of the users' responses in different manners reveal substantial knowledge about the forum as outlined in FIG 11. The project web site designers could improve the facility with this feedback. A reanalysis of the same in future would reveal the evolution of the forum with progress of the project. Quantitative analysis of collaboration systems of a project web site in the context of a developing country like India is not yet common in the technical literature. The study could be used as a benchmark for investigating the performance of similar cases in other collaborative web sites for project management. The quantitative nature of the study makes it easy to compare internet forums of different projects.

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