JOURNAL OF INFORMATION SCIENCE AND ENGINEERING 33, 1501-1517 (2017)
DOI: 10.6688/JISE.2017.33.6.7

Communication and Coordination Using Facebook: A Case Study of Distributed Software Development

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Distributed Software Development (DSD) is becoming a norm in the software industry. Today, more software projects are being developed using geographically distributed teams. The team members in DSD must communicate and coordinate with each other to successfully develop software. This study explores Facebook as a mean for communication and coordination in DSD projects. We conducted an exploratory study to explore 1) how does informal communication take place among developers using various channels of Facebook? 2) Which channels are used for what type of communication? 3) How do team members use different features of Facebook to achieve coordination? We found that Chat and Comments were the most frequently used channels for formal and informal communication. Informal communication constituted one-fifth of the communication among team members. The socio-technical congruence score indicated a high degree of coordination among team members using Facebook. We, based on the results of the study, propose a usage model for DSD using Facebook as mean for communication and coordination.

Keywords: distributed software development (DSD), communication and coordination, communication channels, socio technical congruence, social media, Facebook

1. INTRODUCTION

Software development is a complex and a rapidly changing activity in which multiple individuals, teams, and organizations are involved to build a common project [1] over a specific period [2]. In DSD, team members are placed at various distant locations during the software project development. They form a network of virtual teams working on the similar projects. These teams might belong to different organizations or from same organizations [3]. Communication and coordination play an important role for successful DSD projects. Communication is a two-way process that involves receiving information as well as sending it [4]. Formal as well as informal communication is needed for distributed groups to accomplish their tasks [5]. Informal communication positively impacts software development. It is a casual form of information sharing. It might be detected during phone calls, conversations, text messages and electronic mails between peers in an organization [6]. Informalism in communication is created using smileys and slang words [7]. Emoticons have been used for many years to increase informalism in chat sessions and emails [8]. Emoticons have playful, informal and expressive

Received January 8, 2017; revised February 9, 2017; accepted February 14, 2017.
Communicated by Kashif Saleem.

inferences [10]. Lack of informal communication results in low levels of trust and awareness of work at remote sites [9]. Emoticons are frequently used especially in informal communication as compared to formal communication [10]. Formal communication is a form of spoken demonstration or document intended to share information. It does not involve any slang words or jargons [11]. Communication takes place via certain communication channels, whether it is formal or informal. A medium over which a message is transferred to its envisioned spectators is termed as Communication channel [12]. Information can be conveyed to others by the exchange of messages and thoughts. It can be in the form of speech, writing, signals, visuals, and behavior [13]. In DSD team members need to communicate and coordinate project activities. Coordination is the process of managing dependencies between project activities [14] via information sharing and netting project activities [28]. In DSD, team knowledge impacts coordination. Physical distance negatively impacts coordination, but it can be reduced through shared knowledge of team [15]. Knowledge sharing is essential for teamwork. Teams may share the knowledge using files, documents, messages, work plans, collaboration agenda and discussions [16]. Social media can play an important role in supporting Communication and coordination. Social media are computer-mediated tools which enable individuals to share, create and exchange ideas, information, videos and pictures among communities. Facebook is an important social networking service that aids people to communicate effectively with their family, friends, and co-workers [4]. It was launched in February 2004 [4, 17, 18]. Facebook is a multi-channel social networking tool as it provides many ways of communication *e.g.* Wall posts, Status updates, Photo uploading, Video uploads, sharing content from other sources, Messaging, Chat, Groups, Comments, Liking, Apps, *etc.* [4]. It has great potential and usability [17]. People use Facebook because of its user uptake, familiarity, response to postings and timely notification service [22]. Few features of Facebook for example wall post, private message and comments are very effective for Communication [19]. It has appeared as one of the major collaborative tool for on-task as well as for informal interaction [20]. The main goal of this research is to explore usage pattern of Facebook by team members for achieving Communication and coordination in DSD.

2. RELATED WORK

We performed a thorough literature review to have an understanding and current knowledge related to social media usage for supporting software development in DSD. We classified the existing studies into specific and generic social networking software/ tool categories.

2.1 Specific Social Networking Software/Tool

Few organizations designed their specialized tools which they used only inside their companies. An organization developed a collaborative tool called “Entzonet” for increasing communication and collaboration among employees. This platform positively impacts employees. It enhanced trust, happiness, engagement, information sharing, social comfort, collaboration and speed of feedback among employees [21]. Kukreja [22] conducted an experimental study for collaborative requirements elicitation and manage-

ment of requirements by WinWin negotiation. To achieve this objective, researcher established a social networking based framework Winbook. This framework positively affected requirement management. It was easy to use. It bridges the gap between requirements and system architecture [22]. To explore what was happening inside the organization a web-based service "WaterCooler" was designed and deployed in HP. This service also facilitated people to share knowledge among themselves. They became aware of each other as well as current happening inside the organization. It brought the world very close inside HP [23]. DiMicco *et al.* [24] installed a social networking site named "Beehive" at IBM to connect people and allow them to share professional activities among themselves via Beehive. The researchers examined that relationship building among employees increased. The IBM employees got awareness about each other as well as about company's current happenings. The Beehive was also used to explore the pattern of employee's communication with their coworkers [25]. A company "Mega" launched their internal blogging engine named as "BlogSite." It was a blog hosting platform within the company's Intranet environment. It was proposed for knowledge sharing and forming informal interaction within the community. That can assist others in the successful completion of the project. It helped employees to know about current happenings within the company as well as aided them in knowledge sharing [26, 27].

These studies [21-27] designed and deployed their specific tools, frameworks, and websites to collaborate with their team members in the respective firms. They did not specify study context. They are not generic. Moreover, none of these studies addressed informal communication and how coordination is achieved using these tools. They have not investigated the channels used for different types of communication.

2.2 Generic Social Networking Software/Tool

The researchers have used social media tools such as Twitter, Facebook [2], YouTube [34], microblogging [26-29] and instant messaging (IM) [30, 31], *etc.* for communication and coordination, and knowledge sharing in DSD. Uptake in the usage of Social media tools is seen and is currently growing extremely fast. Facebook has over 400 million users [32]. Physically disseminated developers used numerous communication tools to part technical information, discussed issues related to design and technical snags. They coordinated via email, discussion forum tools and IM [30]. Many organizations used freely available Social media tools and websites to fulfill their communication needs. In DSD people used more than one tool to communicate with each other. Social media tools play an important role in the improvement of communication among different teams [32]. Facebook is a faster and an effective communication tool [17]. Ramirez *et al.* used Facebook as a tool to support software projects for monitoring them and to solve problems related to communication, coordination, and knowledge sharing in DSD. They used Facebook, G+, Skype, and Dropbox collectively to study what kind of issues related to Communication and coordination can be implemented via Facebook. They got positive results of the study because of Facebook's fame amongst young developers and its huge storage capacity for maintaining an online repository of project activities on a daily basis. It has several other important features which motivated team members to stay online for facilitating just in time communication. The researcher presented a metrics to assess how knowledge sharing, Communication, and Coordination could be implemented

in DSD [2]. Wu *et al.* [33] Examined social values of Wikipedia to discover its impact on knowledge sharing [33]. MacLeod [34] used YouTube to share knowledge related to programming by creating videos. The researcher investigated that how developers produced and shared knowledge via screencasts. Developers used multiple tools for creating video-based documentation for other developers and then they launched and shared those videos on YouTube. Screen caster showed frustration to their available tool support. They also have not specified the study context as collated or distributed [34]. Alqhtani *et al.* [31] used WebEx meetings and TeamViewer to resolve problems of DSD. They also used group-email and IM to send a message to multiple people to improve communication [31]. Cataldo *et al.* [30] used email, teleconference, IM, and discussion forums in DSD to examine how and for what purpose software developers used various communication media. Results showed that these media were used to communicate technical information; discussion of design issues and technical problems as well as for coordinating project activities [30]. Cao *et al.* [26] Used blogs and social networking sites in software engineering to investigate the influence of Social Media on work performance of the employee. Researchers proposed a model to assess this impact. Results revealed that social media promoted work performance of employees by strengthening trust among them and by providing a channel for knowledge sharing [26]. Jackson *et al.* [27] Examined company's internal blog to know why people used blogs for communication, building social relation, information sharing, and knowing trends of the company [27]. Wu *et al.* [33] Used blogs for sharing knowledge [33]. Reinhardt [28] used microblogging to share knowledge and support communication [28]. Guzzi [29] used microblogging to record comprehensive knowledge of project [29]. Wang *et al.* [35] Used microblogging to know how it supported DSD projects in sharing knowledge, motivating other members and for crowdsourcing [35].

All these studies were conducted to achieve different goals using multiple tools. There is no tool available which have multiple channels in it to support communication, coordination and knowledge sharing. If multiple channels are not available in one tool, then people have to switch among tools to achieve their desired goal. Switching from one to another tool results in the wastage of time as well as frustration among people. Switching tools are not user-friendly, thus do not provide a productive environment to work. When all features and channels are available at one place in one tool then people don't need to switch among tools, this thing may facilitate them and enhance their productivity. There is no such work that has been done to study how informal communication takes place and how coordination is achieved using different channels and features of Facebook. They haven't investigated which channel of Facebook is used for what type of communication and how Facebook can be utilized to achieve the basic needs of communication, coordination, and knowledge sharing in DSD. So there is a need to bridge this gap. There is a need to present a usage model or guidelines which can help software developers and practitioners in future projects from the perspective of Communication and coordination using Social media particularly Facebook in DSD.

3. RESEARCH DESIGN

We conducted an exploratory case study to answer intended research questions. We designed study process according to the criteria given in [36]. We took a single case hav-

ing a single unit of analysis from Pakistan. We selected three universities which were located in three different cities, exhibiting characteristics of DSD settings. We selected a web-based project. A team comprised of 9 members/students developed this project. These teams were located at remote sites having no face to face communication. They completed project in 11 weeks.

3.1 Research Setting

We created a Facebook closed group, and all team members joined that group. We set group settings as a closed group due to privacy concerns of members. They were restricted to use only "Facebook" for communication among themselves during project development. They were not allowed to use any other communication medium *i.e.* Skype, email, phone call or physical meetings (across the site). We monitored communication of team on a daily basis. They were directed to add researcher in their chat conversation to have access to their chat content for data collection and analysis purpose. We advised them that: (1) all their posts and activities related to project development should be visible to other team members; (2) upload project artifacts in group to make a repository; (3) each of the members who worked on a specific artifact must have to mention his/her name at the end of their work in project deliverable and (4) must assign a version number to the document. Scheduled as well as Unscheduled meetings should also be notified on the Facebook group. They were free to work at any time on any day and were not restricted to work for/on specific working hours.

3.2 Team Composition

We selected undergraduate students of the software engineering department at random from 3rd and 4th year of the degree. We selected students at random, but according to predefined criteria *i.e.* each of the students should have 3.00 and above CGPA, having sound knowledge of web designing and development, web languages, software testing techniques and strategies, documentation of the project and Facebook usage. Any student who has enrolled in 3rd and 4th year can take part, but they should meet defined criteria as mentioned above. We selected three students from each university, hence comprising a team of 9 members (both male and female). Table 1 describes the team composition.

Table 1. Team composition.

Team ID	University	Number of Students	Gender	Year of Degree
Team 1	University A	3	All Females	3rd Year
Team 2	University B	3	All Females	4th Year
Team 3	University C	3	All Males	4th Year

Each of team members was assigned a role based on their expertise after mutual discussion and agreement. For example; students having roles of developer, tester, designer, team leader and database manager are skillful in programming, testing, designing, team leading and database development and management respectively. Team member of one university was familiar with each other, but they were unfamiliar and a stranger to

students of another university. They added each other on Facebook and became Facebook friends (Having no prior social bindings among cross-site members). They did not have any knowledge about each other before the project has started. We have assigned them a project in collaboration with their course instructors. They developed a project during their current semester as a course project. We assigned the role of Team Leader to one of the team member in order to compile the whole work at end, for arranging meetings (scheduling of meetings, and notify on group) when needed during project development, monitoring team members' involvement in project development to ensure that they were working according to prescribed project plan, listening to their views and feedback. The project was "web-based online course registration system for students." We selected this project because it is a system related to education sector and universities. Students have domain knowledge of it. This project has certain key requirements which they have to implement. Members of one team communicated with members of the onsite team, as well as cross-site teams because their tasks were dependent upon each other.

3.3 Data Collection

We collected data by different data collection methods. We designed data collection forms. We collected data and then stored that data in those data collection forms (http://drive.google.com/file/d/0B3w1kI71xt7gdUZtTUd6Qmhkb00/view?usp=sharing).They were qualitative as well as quantitative. We used to fill these forms on a daily basis by analyzing Facebook. We collected data from multiple data sources through multiple data collection methods to ensure triangulation. Multiple data sources included Facebook chat, Facebook group posts, shared links, Facebook comments, shared files and shared photos. Whereas multiple data collection methods involved observations, documents/ artifacts analysis, and Facebook communication archives. Data collected by the researcher was comprised of; chat messages, emoticons, group posts, comments on posts, files uploaded, shared photos, shared links, time of all activities and meetings. The researcher collected all messages along with their contents to have an insight of their conversation. Researcher considered triangulation during data collection.

(A) Why did we choose this data set?

We have selected this case as our study case due to two important reasons. On the one hand, this project setting was mirroring an industrial software development environment. On the other hand, the data can be collected easily, on a daily basis (more than one time per day) and we validated data in time.

(B) Validating the accuracy of the data

To ensure the data consistency, we used to check Facebook at least three times (morning, evening, night) in a single day and each activity was kept recorded in data collections forms. We have validated the data by monitoring it frequently and by matching it with entered data. So, that if someone deleted a post or edited the content, or deleted a chat message or deleted a file which was uploaded previously *etc.*, can be kept recorded. Once we have found any modification in data, we contacted the intended member instantly to root out the cause, and updated data forms accordingly. We read and reread the data many times to ensure its validity, accuracy, and consistency.

3.4 Validity Threats

(A) Construct validity

Construct validity is concerned with the evidence of concepts and theories behind the research study [36, 40]. We designed data collection forms to collect intended data to answer research questions. We have not taken data collection forms from any published source. Therefore error may exist in them. We designed our data collection forms through proper discussions with experts and identified that they were accurate for collecting required data.

(B) External validity

External validity is concerned with, to what extent the findings of the study could be generalized [36, 40]. Findings of our study may not be generalized to form a theoretical background for further studies because our study was limited regarding one case (single project) and it was not from industry. It was an exploratory case study which provided new research insights. Our study was the basis, and in future, such studies can be replicated, and results can be generalized.

(C) Reliability

This aspect is concerned with to what extent the data and the analysis are dependent on the specific researcher [36, 40]. A single researcher collected data manually during case study, which can results in a human error during data collection. To ensure data accuracy and consistency, we checked Facebook many times in a single day and kept a record of each activity in data collection forms. We validated data by monitoring it frequently and by matching it with entered data. So, that if someone deleted a post or edited the content, or deleted a chat message or deleted a file which was uploaded previously, *etc.*, can be kept recorded. Once we found any modification in data, we contacted the intended member instantly to root out the cause and updated data forms accordingly. The data was read and reread multiple times to ensure its validity, accuracy, and consistency. We collected data from multiple sources by using multiple data collection methods to eliminate biases which can result due to the single data collector.

3.5 Data Analysis Methods

We used both qualitative as well as quantitative data analysis methods to analyze the transcribed data. We performed social (Facebook) network analysis to check the connection among team members (Fig. 1).

The dotted line represented one-way communication among team members whereas solid line represented two-way communication. Arrowheads represented the direction of flow of communication among the peers. We checked out the frequency of Facebook feature's (group, comments, chat, *etc.*) utilization. We have also performed emotion analysis to find out frequently used emoticons as well as the overall frequency of emoticons in communication, which decided the type of communication. We checked coordination among team members by Socio-technical congruence (STC) [37], delay [38] and status meetings occurrence [15].

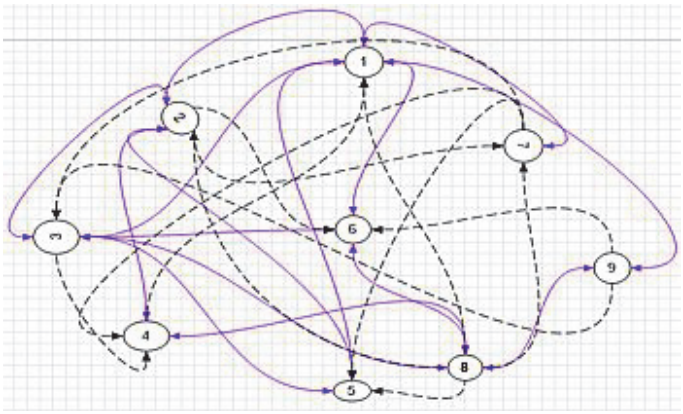

Fig. 1. Connection among team members.

4. STUDY RESULTS AND ANALYSIS

4.1 Communication among Developers Using Facebook

Formal communication as well as informal communication (communication having emoticons and slangs) occurred during the project development. We have calculated the number of emoticons, and slang words used per chat message and comment. Communication among team members took place in English. The ratio of formal communication and informal communication was different. The ratio of formal communication was high (81%) as compared to informal communication (19%) (Fig. 2).

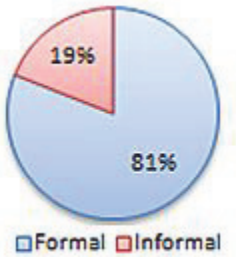

Fig. 2. Ratio of overall formal/informal communication.

Moreover, if we look in more detail, then the ratio of formal chat (31.29%) and formal comments (53.63%) is high as compared to informal chat (4.24%) and informal comments (7.27%) (Fig. 3).

Emoticons and slang words were used only in chat messages and comments, as these two channels involved textual communication. If we generate a comparison between informal chat and informal comments, then it can be concluded that more informal communication was done via comments as compared to chat as the ratio depicts (7:4). Table 2 represents the ratio of emoticons used by developers during their communication.

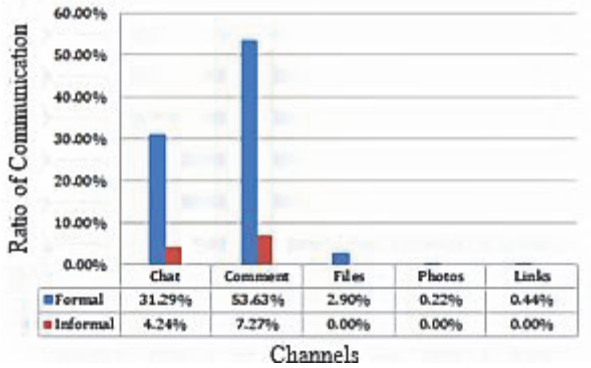

Fig. 3. Channel wise formal/informal communication.

Table 2. Ratio of emoticons.

Emoticon Name	Emoticon Symbol	Ratio
Tongue		43.8%
Smile		31.5%
Grin		7.5%
Unsure		5.6%
Like		3.4%
Squint		2.9%
Gasp		1.9%
Frown		1.2%
Wink		1.2%
Confused		0.5%
Devil		0.2%
Cry		0.2%

"Tongue" and "Smiley" were used more frequently as compared to other emoticons. Whereas ratio of "Cry" and "Devil" was very low. It depicts good communication environment among developers in DSD. Fig. 4 represents the frequency of multiple emoticons used in chat and comments separately. The frequency of emoticons in comments is high as compared to chat. It depicts that chat was more towards formal while comments were informal.

We analyzed slang words used by team members in their chat conversation and comments. We also calculated their ratio as shown in Table 3.

The contents of files, photos, and links which were shared by team members were viewed and analyzed in detail and were found to be formal. "Chat" and "Comment" appeared to be the two most important channels of Facebook which supported informal communication.

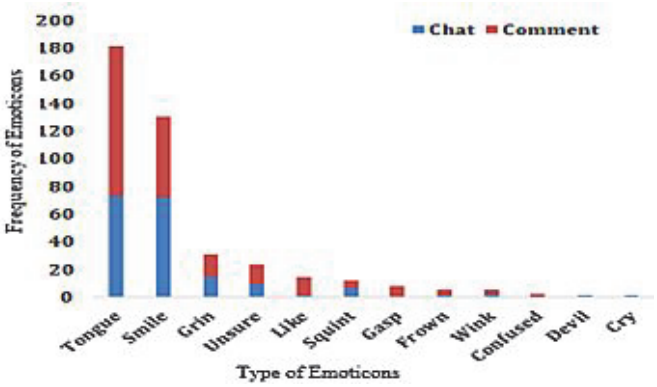

Fig. 4. Frequency of emoticons in chat and comments.

Table 3. Ratio of slang words.

Slang Words	Ratio
Hahaha	38.3%
Lol	33.7%
Hmm	24.0%
W8	2.7%
Wana	1.3%

(A) Overall channel usage frequency

We analyzed the Facebook network to check the frequency of Facebook channels usage (Fig. 5). Comments were used most frequently among all channels of Facebook and chat was used at 2nd level. Results revealed that team members did not use other channels of the Facebook *i.e.* timeline, audio call, video call, pokes, events, news feed and Facebook pages.

(B) Frequency of Channel usage with respect to time

Fig. 6 represents channel usage pattern with respect to the time frame. Results revealed that channel usage pattern of team members slightly changed from start of the project to the end.

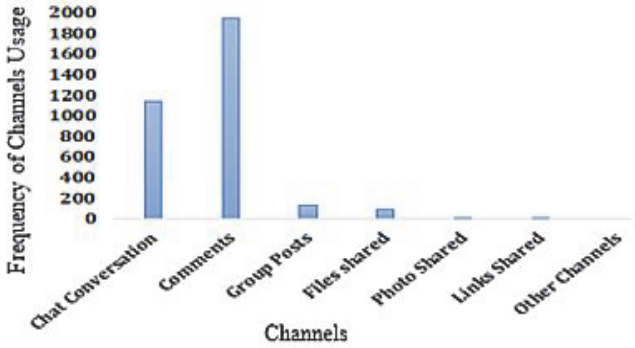

Fig. 5. Frequency of channel usage.

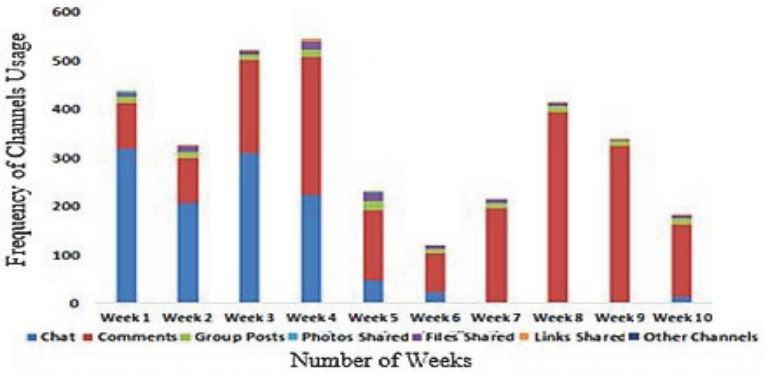

Fig. 6. Week wise frequency of channel usage.

At the start, team members used multiple channels for Communication and coordination. But with the passage of time their channel usage got a slight difference. They started using commenting feature more as compared to other. The chat was frequently used during initial days while commenting was used throughout project development. This behavior depicted that commenting is more interactive as compared to other channels. It was best suited to express and share one's views openly as comments were easily accessible for all team members to view. Commenting feature provided more area for interaction. Threads of comments are very efficiently organized on Facebook as compared to chat messages. In the case of chat messages, a lot of scrolling of mouse pointer is needed to view previous conversations, and it involves extensive load time for previous messages. If a huge archive of chat messages is present, then it's very difficult and frustrating thing to view previous messages as load time of archived messages is high. Whereas in comments very less scrolling and loading of threads are required.

(C) Purpose of Communication

Team members communicated with each other on different topics. Their purpose of the communication was numerous throughout project development. Fig. 7 represents the purpose of communication-based on the type of communication and channels.

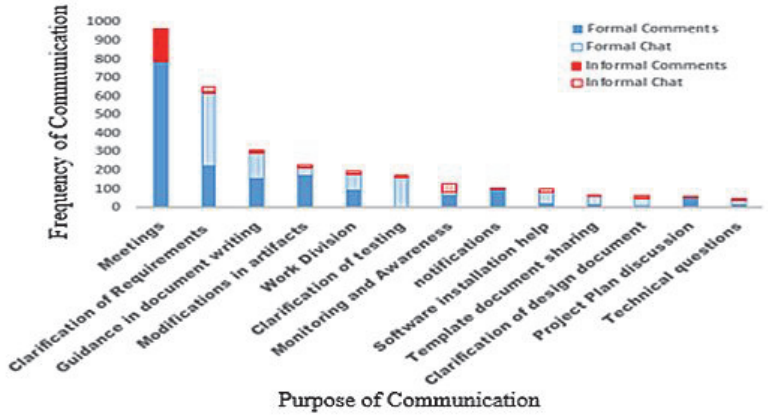

Fig. 7. Classification of purpose w.r.t communication type and channels.

Graph of meetings was highest which showed most of the communication occurred during meetings via commenting. Clarification of requirements came at a second level which was supported by both chat and comments.

4.2 Coordination among Team Members Using Facebook

Team members used various channels of Facebook to coordinate project activities to complete the project successfully. We analyzed and measured coordination by socio-technical congruence (STC), delay and number of status meetings. We quantified STC by a technique proposed in [39]. The value of congruence in the case of arc mirroring is 0.861702. Whereas the value of congruence in the case of node tie is 0.80434. A value nearer to 1 shows high congruence whereas value nearer to 0 specifies low congruence [39]. Delay was another parameter to measure coordination. It's additional time it takes to resolve an issue when more than one site is involved. We assessed it by equating the actual submission date of the project deliverables with the dates mentioned in project plan by utilizing the Facebook features. 80% artifacts were delivered on time whereas only 20% were submitted delayed (Fig. 8). Only one member submitted the artifact with a delay of 3 days. Team members established a centralized repository on the Facebook group for submission of artifacts. All team members have submitted their artifacts in that repository. These artifacts comprised of code documents, project design documents, testing documents, *etc.*

Fig. 8. Artifact status.

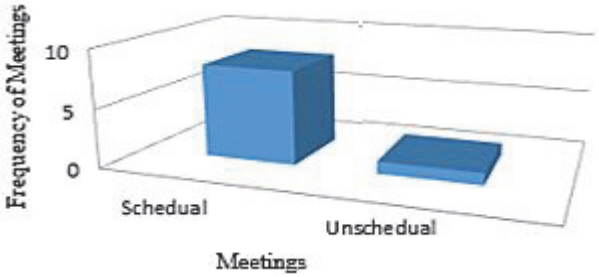

Fig. 9. Frequency of meetings.

Increased number of status meetings show coordination issue or bad coordination [15]. We have matched the frequency of actual meetings held during project development with meetings planned in project plan document. Fig. 9 shows that there were eight scheduled meeting and only one unscheduled meeting. The very low frequency of un-

scheduled meetings is a sign of good coordination. All of the nine members were part of these status meetings to be aware of current status of project development. All of these meetings took place on the Facebook group. There was no meeting which held via chat.

4.3 Facebook Usage Model for Distributed Software Development

We proposed a model to demonstrate the use of Facebook for software development specifically for distributed projects (Fig. 10). This model is proposed based upon the results obtained from the study. Results showed that basic usage of Facebook consisted of communication and coordination via multiple channels of Facebook. Communication purpose included clarification related to software requirement specification (SRS), clarification related to project design, clarification related to project testing, modifications, monitoring and awareness, discussion and knowledge sharing, work division, notifications, and software installation guidance.

Team members coordinated project activities through meetings, resource sharing, and artifact submission. Both of these major usages of Facebook came under the umbrella of formal and informal communication via multiple channels of Facebook. Facebook provided various channels for communicating and coordinating project activities. These channels are; chat (text messaging, audio call, video call), comment, group, page, event, timeline, file sharing, photo sharing and link sharing.

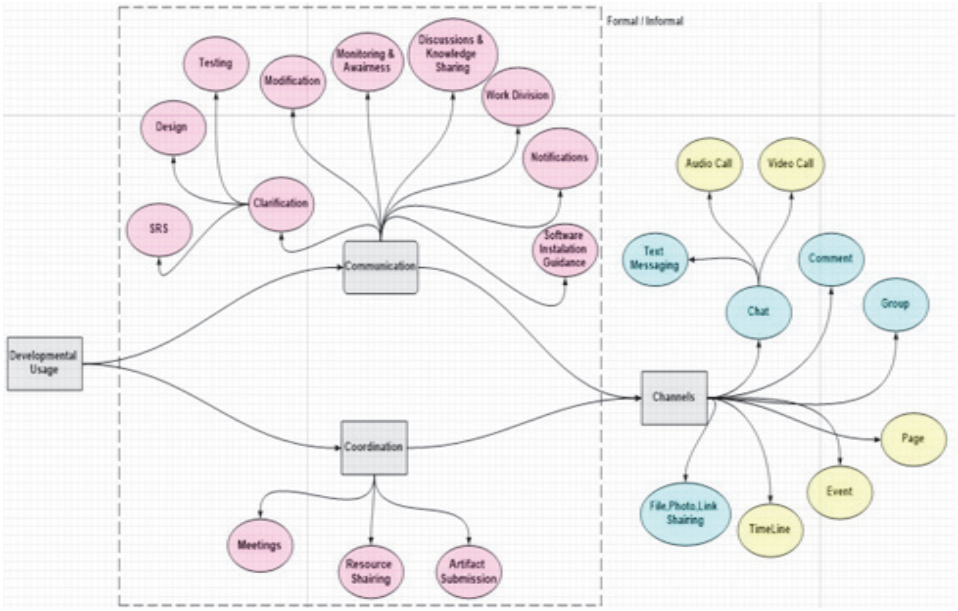

Fig. 10. Facebook developmental usage model.

5. CONCLUSION AND FUTURE WORK

This study gave a deep understanding of social media particularly Facebook usage in distributed software development. Facebook is multichannel as well as it supported

informal communication, so we choose it. Formal as well as informal communication took place via multiple channels of Facebook. Chat and Comments were the most frequently used channels for supporting meetings, requirement clarification, and various other activities. The teams were from the same culture and from same time zone, so our study does not measure the impact on the communication and coordination due to time and cultural difference. Facebook made possible understanding, knowledge sharing, and building of social relationships necessary to overcome the distance between collocated teams in DSD settings. Mostly small companies of underdeveloped countries do not have enough financial resources to purchase specialized and professional tools to support DSD projects. Our study provides direction for such companies to develop software projects with freely available social networking site Facebook to support communication and coordination needed in DSD settings. Facebook is most popular social networking site among young developers as well as in all age groups. Although there can be some confidentiality and privacy concerns, which can be overcome by Facebook security features implementation. This study was conducted with a single case and with university students. Both male and female students took part in our study. However, we have not studied the impact of gender on our study results. The impact may be studied in future. The possible direction for the future work of this research leads to conduct multiple case studies with industry projects using Facebook to evaluate the effectiveness of the proposed model in DSD projects.

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