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**COLLABORATIVE SOFTWARE FOR SUPPORTING
COMMUNICATION AND COOPERATION
IN PROJECT TEAMS**

Abstract: Communication and collaboration are processes which strongly influence the course and outcome of a project. Although not all aspects concerning these processes can be fully managed and structured, there are various tools whose appropriate appliance can aid effectiveness, transparency and efficiency of communication and collaboration processes. The aim of the paper is to specify and depict features and functionalities of different collaborative tools and software supporting communication and collaboration among project team members. This review aims at apprehending which features of available software and hardware can be utilized to develop a communication model in a project team, which could provide effective information and knowledge transfer among project team members and support communication process.

Keywords: project communication, telecommunication tools, groupware, unified communications.

1. Introduction

Communication is one of the most important processes in project management. It is crucial for successful project completion but difficult to master, as effective communication requires team members to select the most appropriate medium for the information transfer and to communicate the optimal amount of information in order to achieve top performance. It has been proven that both too scarce information and information overload hinder project performance [Patrashkova, McComb 2004]. It is therefore essential to use available software and hardware supporting collaboration and communication in a studied and deliberate way, apply appropriate tools depending on communication channel, information content and recipient. In order to achieve this goal one of the prerequisites is to recognize the features and functionalities of available software and hardware that can support project teams in communicating and collaborating on a project.

Many projects, especially in the electronic economy, are realized by virtual enterprises, in which managing and operation teams work in virtual reality. In order to enable efficient work and collaboration of such teams it is essential to apply the whole spectrum of methods and group-work technologies, especially for the communication, document and workflow management [Dyczkowski 2002].

The paper is structured as follows: section two describes issues connected with the communication process, communication types and most common communication problems encountered during project realization. In sections three and four two categories of information and telecommunication tools are described: asynchronous and synchronous. Section five is devoted to hybrid communication and workgroup systems which combine different kinds of asynchronous and synchronous software to deliver a set of communication and collaboration tools for project-driven organizations. The last section summarizes the paper and suggests further areas of study.

2. Communication in project management

Good communication, during all phases of a project lifecycle, is an important success factor which completes all other factors of project success. It is decisive for the outcome of the projects, particularly for mega-projects. The larger and the more complex project, the more significant communication is for the results, because communication is the coordinating social mechanism which most strongly influences the results [Johannessen, Olsen 2011]. Communication should start from the moment a project is assigned, and continue on a daily basis, or even hourly basis, throughout the life cycle of a project. It is vital to realize that communication is not simply saying or writing messages but it is a two-way process to build a common understanding. Without that understanding it is impossible to agree, disagree or resolve anything.

Effective communication management assures that each project team member is fully informed about the project status at all times. Some detailed information may not be shared with all team members but the big picture should always be shared among the entire team. In order to make communication within a project team efficient it is important to maintain open, regular and accurate channels of communication with all levels of project staff and stakeholders, which ensures smooth flow of instructions and sufficient warning of risks and changes to enable early assessment and preparation.

Successful communication needs to be focus-oriented rather than of general nature and timing is of crucial importance. Used effectively, it can reduce non-productive effort, avoid duplication and help to eliminate mistakes. It can help to manage uncertainty, may lead to problems being identified sooner or may generate ideas that lead to better solutions. Furthermore, it will encourage team-work, increase motivation and ensure the involvement of all key players. The end result will be

a project which is more likely to meet its objectives within the allocated time and resources [Clarke 1999].

Communication on projects presents a number of growing challenges. One of the well-known barriers to communication is distance. It restricts both the type and amount of communication possible, and reduces informal interaction considerably. As project teams become global, time differences also interfere with communication. Special delivery methods, communication devices and tools need to be utilized to overcome this challenge.

Different languages and cultures are another growing communication challenge for technical projects. Global work involves people who speak different languages and who have different ways of working and communicating. Sharing complicated technical project information in this sort of environment is never easy, and misunderstandings are common. Cross-functional or inter-organizational project teams involve people from very different educational and work backgrounds which causes additional obstacles [Kendrick 2003].

Other communication challenges result from the temporary nature of projects. In short-term projects the communication among team members is temporary, which means that communication systems need to be established quickly in shorter periods of time.

The most common reasons for communication problems are connected with one of the following situations: miscommunication, lack of communication or overload of communication. All of these states can cause project failure. These aspects must be therefore taken into account when selecting tools and methods for project communication within a project team.

Even though electronic communication or collaboration software is becoming increasingly effective and supports project communication in many ways, it has been proven that interpersonal communication is the basis for almost any type of cooperation. That is why organizations strongly relying on communication and collaboration tools should consider support for both planned and informal means as compensation for reduced communication. Some applications like, for example, groupware systems are explicitly designed to substitute face-to-face communication with electronically mediated communication, which may result in loss of certain social and tacit benefits [Gloria, Volker 1999].

3. Asynchronous collaboration software

Asynchronous collaboration software is a kind of communication tools which support non-real-time communication. Some of these tools encourage interaction and others are rather passive suppliers of information. One of the greatest benefits of asynchronous interaction is its flexibility. And from the technical point of view access to asynchronous environments and tools can often be made with a low hardware and network specification, which is of use to remote participants and accounts for

lower costs to organizations [Karsenti 2007]. The most popular asynchronous tools are: e-mail, discussion boards, shared calendars, project websites, newsgroups and mailing lists.

E-mail is one of the most common collaborative software applications. The basic idea behind the tool is to pass simple messages between two or more people, but even relatively basic e-mail systems today typically include interesting features for forwarding messages, filing messages, creating mailing groups, attaching files, automatic sorting and processing of messages. The main advantages of e-mail are: short delivery time, possible expedited information transfer, possible multimedia attachments, selectivity and personalization (adjustment of the message depending on the recipient), high efficiency, measurability and low cost. The most important drawbacks, on the other hand, include: necessity to wait for the response, lack of certainty of reception of the message, possible anonymity which may cause undesirable behaviour of some of the users, overload of e-mail messages, which may cause the user to become reluctant to read them (in a flow of many unwanted mails important information may be overlooked) [Gracz 2007].

Discussion board is a virtual place in which its members can post messages on a particular site, read each other's messages, and reply to messages. Such a forum is often designed for a specific purpose, for example: a forum to discuss project outcomes. It is useful for reporting on the status of work activities, posting questions, setting deadlines, and holding general conversations for all to see. Group discussion spaces, in particular, allow relatively easy review of group knowledge. Participants with language differences, or those with less expertise relative to others, can take time to develop their postings and review those of others. In this way, teams can build a base of common knowledge [DeSanctis et al. 2001]. Many studies have highlighted that on-going asynchronous interactions – such as those possible in electronic discussion groups as well as forums – are preferable to synchronous computer-mediated communication groups in that they help participants to build a better context of the discussion. Moreover, those who have trouble communicating because of language shortcomings or shyness can take their time writing a reply [Karsenti 2007].

Shared or group calendars allow scheduling, project management, and coordination among many people. Typical features detect when schedules conflict or find meeting times that will work for everyone. Group calendars also help to locate people. The most obvious advantage of group calendars are that they can be used to efficiently set up meetings ensuring that the right people, as well as other necessary resources, are available for the scheduled meetings. Additional features enable sending invitations and reminders via e-mail, which can be enriched with data files [Edwards, Wilson 2004]. Shared calendars enable tracking one's own tasks and schedule and grant other users access to them. However, to make group calendars effective, a "critical mass" of users has to be reached. To achieve this goal it is crucial for the group leaders and peers to encourage other team members to use the

shared calendars by, for example, refusing to accept any bookings through any other media [Lee 2003]. Typical concerns of group calendars are: privacy (users may feel that certain activities are not public matters), completeness, and accuracy (users may feel that the time it takes to enter schedule information is not justified by the benefits of the calendar).

Project websites or generally content, which can be accessed by a web browser, can be used to publish all kind of information concerning on-going projects. The web portal can be either a passive, one-way communication channel or an interactive wiki portal, which enables the users not only to read the content but also to create and edit it. The static websites are mostly used for providing general information concerning projects to the stakeholders, while wikis may be used by team members for day-to-day collaboration on project tasks. The main advantages of wikis is that they enable creation of a central portal used as a source of project information, and let the desired information be easily found, foster knowledge sharing and, due to no rigid initial structure, can be used in many different ways and tailored to organization's needs [Mader 2008].

Newsgroups and mailing lists are similar to e-mail systems except that they are intended for messages among large groups of people. The main difference between newsgroups and mailing lists is that newsgroups only show messages to a user when they are explicitly requested ("on-demand"), while mailing lists deliver messages as they become available (an "interrupt-driven" interface). A similar service providing information immediately after it has been published is the RSS (Really Simple Syndication) although instead of e-mail message it appears in a form of an entry in a web browser.

The main advantages of newsgroups are: possibility to find and contact people who have expertise in a requested field, possibility to monitor discussions on a given topic and also to gain and contribute knowledge, moreover newsgroups are usually structured and likely to have a moderator, which helps in maintaining subject integrity and focus. The disadvantages may be: problems in finding answers to one's questions, having to wait for the response. Mailing lists have similar advantages although they have no organizational scheme or structure like newsgroups. They have also one additional disadvantage: belonging to a very active mailing list or to many lists may easily overload one's mail-box and make it impossible to track all updates [Fielden 2001].

Considering asynchronous communication tools it is worth noticing that time-related information, such as "time available to work" on a specific task, queries about "how much time" one or another team member can devote to an activity, or "possible times" to hold calls or chats, account for significant part of information that is transferred. A survey conducted among highly dispersed project teams showed that nearly half of the postings to group discussion boards included some sort of time-related reference [DeSanctis et al. 2001]. This would indicate that project team members should be encouraged by group leaders or project manager to make

better use of shared group calendars which support much of that kind of information. Table 1 summarizes and supplements the advantages and disadvantages of the above-mentioned asynchronous collaboration and communication tools.

Table 1. Advantages and disadvantages of asynchronous communication software

Category of software	Advantages	Disadvantages
E-mail	<ul style="list-style-type: none"> – short delivery time – possible expedited information transfer – possible multimedia attachments – selectivity and personalization – high efficiency – measurability – low cost 	<ul style="list-style-type: none"> – necessity to wait for the response – lack of certainty of reception of the message – possible anonymity – overload of e-mail messages – lack of non-verbal communication
Discussion boards	<ul style="list-style-type: none"> – useful for reporting project info for all to see – allow review of group knowledge – provide time for studied response – build sense of virtual community 	<ul style="list-style-type: none"> – discussion thread can go off topic, become argumentative instead of collaborative – lack of non-verbal communication
Group calendars	<ul style="list-style-type: none"> – efficient setting up meetings – help to locate people – tracking tasks and schedules of the whole team 	<ul style="list-style-type: none"> – threaten privacy – effective only if widely used – not effective if lacking accuracy and completeness
Project websites (wikis)	<ul style="list-style-type: none"> – enable joint creation of a project portal content by all team members – desired information easy to find – foster knowledge sharing – no rigid initial structure enables tailoring to organization's needs – built-in version control – low costs 	<ul style="list-style-type: none"> – require professional implementation and trainings to be successful – need maintenance not to become a mess – low security level
Newsgroups and mailing lists	<ul style="list-style-type: none"> – access to expertise in a requested field – possibility to monitor discussions, gain and contribute knowledge 	<ul style="list-style-type: none"> – problems in finding specific answers – necessity to wait for the response – possible e-mail overload when belonging to many mailing lists

4. Synchronous computer-mediated communication

Synchronous communication takes place in real-time (same time mode) when the participants of the communication process communicate directly (face to face meetings) or indirectly through various communication software and hardware. The most common tools supporting indirect synchronous communication are: telephone and VoIP (Voice over IP), shared whiteboards, instant messaging and chat systems, video conferencing applications and devices. The most apparent advantage of real-

time communication is instant feedback and possibility to immediately explain any ambiguities. Additionally, tools which support live audio or video communication provide extra non-verbal communication content in the form of body language, tone of voice, etc. The weaknesses of synchronous communication are connected with a problem of arranging one convenient time for everyone to meet, whether personally or virtually, especially among team members dispersed across different time zones. The dynamics of real-time communication gives the participants less time to respond and analyze each other's messages and sometimes makes it impossible for the timid attendees to give their contribution. The high costs and network technical requirements may also be a drawback for using synchronous computer-mediated communication.

Telephone is the basic equipment for carrying out distant conversations. The phone device itself is only a terminal connected with a telephone network, which can be either ground-based, cellular or satellite. Telephone networks operators offer many useful functions, like waiting calls, voice mail, teleconferences [Potocki et al. 2003]. There is also the **VoIP** technology (Skype, Net2Phone, Yahoo! Messenger, Google Talk, etc.) which enables phone-like conversations, with possible video extension, through Internet. Both these solutions are very useful when quick response to an issue is needed. VoIP is much cheaper than traditional phone and offers many interesting and useful features, like transferring images, video, texts and files along with the voice. But on the other hand it requires broadband connection, high quality hardware and is dependent on Internet service provider. The possible drawback of using voice communicators is that such conversations foster social discussions, which can distract team members from their work.

Shared whiteboards allow two or more users at various distributed workstations to view, write or draw on a shared drawing surface and to work on shared documents. This can be used, for instance, during a phone call, where each person can take notes or to work collaboratively on a visual problem. Most shared whiteboards are designed for informal conversation, but they may also serve structured communications or more sophisticated drawing tasks, such as collaborative graphic design, publishing, or engineering applications. Shared whiteboards can indicate where each person is drawing or pointing by showing telepointers, which are colour-coded or labelled to identify each person [*The Internet Encyclopedia* 2004]. The main use for shared whiteboards, in conjunction with real-time audio tools, is for aiding presentations and brainstorming sessions [Kouki, Wright 1999].

Chat systems or **instant messaging systems** permit many people to write messages in real-time in a public or local space. Localized chat systems are typically used in corporate environments as they allow to chat with anyone on the same network. Chat systems can allow either "one on one" (chat with only one user) or multiphase (chat with many users simultaneously) communication. One of the interesting features of chat systems is having a direct transcript of the conversation, which not only has long-term value, but allows for backward reference during conversation.

This feature makes it easier for people to drop into a conversation and still pick up on the ongoing discussion. It is even possible to generate a knowledge-base by extracting topic threads, assorting and filing them and relating them to participants [Ogura et al. 2004].

Video conferencing systems allow two-way or multi-way calling with live video. High costs, low Internet speed and compatibility issues limited early use of video systems to scheduled video conference meeting rooms. Nowadays video conferencing may be performed using some of the more advanced VoIP tools [Gough, Rosenfeld 2006]. The costs of using such tools are rather low and savings on organizing face-to-face meetings can be significant. Video is advantageous when visual information is being discussed but may not provide substantial benefit in most cases where audio communication is adequate.

Table 2. Advantages and disadvantages of synchronous communication software

Category of software	Advantages	Disadvantages
Telephone	<ul style="list-style-type: none"> – commonness – ease of use – some need no power supply – no additional equipment is needed – instant response 	<ul style="list-style-type: none"> – high costs – encourage long “social” talks disrupting work
VoIP	<ul style="list-style-type: none"> – possible simultaneous image, video and file transfer – low costs – instant response 	<ul style="list-style-type: none"> – broadband connection and high quality hardware needed – dependent on Internet service provider
Shared whiteboards	<ul style="list-style-type: none"> – useful for collaborative graphic design, publishing, or engineering applications – helpful in brainstorming sessions and presentations – possibility to share applications 	<ul style="list-style-type: none"> – need for similar software among all participants – need for scheduling an interaction in advance – limited number of participants
Chat and instant messaging systems	<ul style="list-style-type: none"> – possible simultaneous files transfer – makes direct transcript of the conversation available – and allows for backward reference during conversation – possibility to generate a knowledge-base by extracting topic threads – low costs 	<ul style="list-style-type: none"> – inconvenient for the “slow typists” – lack of non-verbal communication – encourage “social” chats disrupting work
Video conferencing	<ul style="list-style-type: none"> – savings on face-to-face meetings of large teams – increase probability of meeting with “busy” experts – integration with other collaborative tools (shared whiteboards, shared applications) 	<ul style="list-style-type: none"> – high costs of professional software and equipment – need for scheduling an interaction in advance – danger of disruptions due to technical difficulties

Generally synchronous communication tools are good for solving certain kind of problems, which involve processing ideas and knowledge of different project team members. Also to have an opportunity to see or at least hear other team members, if they are in distant locations, provides social benefits. But for the day-to-day realization of project tasks the asynchronous collaboration applications prove to be the most appropriate and efficient, mainly because of the problem of scheduling meetings, even these on-line ones. It is however important not to underestimate synchronous communication in project teams and use it to ensure faster feedback cycles and better project understanding. Even though there is a variety of information and telecommunication tools to replace face-to-face meetings project teams should bear in mind that personal meetings have the highest informational richness [Christiansen 2007]. Table 2 summarizes and supplements the advantages and disadvantages of the before-mentioned synchronous collaboration and communication tools.

5. Groupware, hybrid communication and project collaboration systems

To achieve best results in collaboration and communication, project teams utilize a mix of different asynchronous and synchronous software [Otter, Emmitt 2007]. Different sets of such tools are available in many offered groupware and project collaboration systems. Some of them, called hybrid (unified) communications, are a combination of different features and forms of communication, integrating various transmission media in order to support users with seamless and diverse communication tools. Unified communication allows the user to send messages by one kind of medium and receive it by another, which means, for example, that a voicemail message can be accessed through e-mail. One of the most important features of unified communication is presence feature, which informs about the availability status or even physical location of users. Unified communication aims at eliminating device and media dependence and optimizing team performance and business processes by providing mobility, presence and contact capabilities. Although available Unified Communications packages offer a variety of features, usually only some of them are used by companies, depending on their profile and needs [Rash 2010; Nash 2009]. It is also worth mentioning that in order to gain full benefits of these solutions a high-performance network infrastructure is crucial.

Groupware systems are computer-based applications which support communication, collaboration, and coordination among a group of people working towards a common goal; much of the time these people are geographically distributed. A groupware system usually has a very diverse set of tools such as: e-mail, audio and video conferencing, calendar, content management, workflow management, electronic meetings, etc. that complement each other. Groupware systems have proven effective in reducing the time and resources required to complete a project by minimizing the inter-activity intervals and delays. Researchers have shown that

teams using groupware systems can reduce their labour costs by up to 50% and project cycle times by up to 90%. Groupware systems also have the potential to effectively support meeting processes involving large groups and to increase the number and quality of the ideas generated. Groupware systems also provide a set of tools which can efficiently process large amount of information consumed or generated during meetings. Other notable attributes of such systems include anonymity, simultaneity, process structuring, process support, and task support [Babar et al. 2006].

The features of such groupware systems can be considered in four functional categories: communication, information sharing, electronic calendar and project management. Within the **communication** category the most common features are e-mail, announcement, chat room and instant messaging. Those basic features often include additional possibilities, like application sharing or document presentation. There are also tools offering the possibility of parsing e-mail messages for phone numbers, addresses, time and name and linking them to instant messaging tools, maps, calendar and address book. **Information sharing** features include file/document sharing, database sharing, address book sharing, discussion boards, Wikis. One of the most important issues connected with information sharing is synchronization which is essential for information cohesion. **Group calendar** features, described earlier in this paper, are often integrated with other collaboration tools like e-mail or pop-up message box for reminding about upcoming events. Some of the groupware systems offer also basic **project management** features, like tasks, milestones, time sheet, Gantt chart, which can prove quite sufficient for less complicated projects [Xu et al. 2008]. There are also features combining synchronous and asynchronous communication forms like for example the asynchronous videoconferencing system which enables its users to record discussion comments into audio/video files and to browse through materials recorded by other users [Watt et al. 2002]. Such features facilitate and enhance communication possibilities of users, e.g., project team members.

An interesting and useful feature of this technology is the possibility to store the outcome of the work of project teams and instantly access the archival resources. The technology itself cannot, however, assure success. The foundation of a well functioning groupware system is to consider the work specificity of the teams which are going to use it. It is crucial to adopt groupware tools to the requirements of the users. A well conducted implementation of a groupware system should be therefore preceded with a precise definition and design of business processes, which reflect the way the team members fulfil their tasks and communicate throughout the project [Frössler 2008].

The whole set of synchronous and asynchronous communication and collaboration applications gives the users a combined list of advantages:

- economy in time and space, which translates into reduction of costs,
- centralization of data storage, which supports access of all team members to coherent and complete data set concerning realized projects; thanks to this feature

the communication can be reduced only to the exchange of information, which cannot be found in the shared repository, and such a repository enables knowledge transfer from project to project [Belanger, Allport 2008],

- monitoring of information flow and tracking issues together with assigned accountabilities for carrying out certain project tasks,
- integrity of information derived from different sources and media,
- safety and confidentiality.

Examples of the most popular groupware systems include: IBM Lotus Notes and Domino, Microsoft Exchange Server and Outlook, Microsoft SharePoint, Novell GroupWise, Atmail, eGroupWare, Zimbra and many other, both commercial and freeware, applications. Some of the more common unified communication products include: Microsoft Live Communication Server, Avaya Integrated Web Conferencing or IBM Lotus Sametime.

6. Conclusions

The fact that, despite availability of a whole range of different software and hardware supporting communication and collaboration, still quite many project fail, due to the lack of proper and efficient communication, indicates that the problem lies in adequate and efficient management of those technologies. There is a need for integration and adoption of different communication and collaboration tools to create an efficient communication model in a project team. Without that any significant improvement will not be possible. Unified communication could be considered as an idea for increasing efficiency of collaboration within project teams, although it is also important to choose the right combination of available tools and features.

This review of the most frequently used synchronous and asynchronous types of tools supporting communication and collaboration in project teams aimed at revealing what technologies can and should be utilized, in what situations certain applications are mostly welcome and where pitfalls await.

In my further research I intend to conduct a survey among project managers, managing IT projects, in order to find out which communication channels within project teams are the most important, what types of communication are most commonly used within these channels and what project managers consider the most important factors improving communication. This knowledge together with the review of available communication and collaboration tools and their characteristics will enable to formulate a communication model for the project teams.

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OPROGRAMOWANIE KOMUNIKACYJNE WSPOMAGAJĄCE KOMUNIKACJĘ I WSPÓŁPRACĘ W ZESPOŁACH PROJEKTOWYCH

Streszczenie: Komunikacja i współpraca są procesami mającymi duży wpływ na przebieg i wyniki projektu. Mimo iż nie można w pełni ustrukturalizować wszystkich aspektów składających się na te procesy, dostępne są różnego rodzaju narzędzia, których właściwe użycie może zwiększyć efektywność, przejrzystość i wydajność procesów komunikacji i współpracy. Celem niniejszego referatu jest opis oraz wyszczególnienie cech i funkcjonalności różnych narzędzi oraz programów wspomagających komunikację i współpracę w zespołach projektowych. Przegląd ten ma pomóc w zrozumieniu, które cechy dostępnych programów i urządzeń mogą być wykorzystane do stworzenia modelu komunikacji w zespole projektowym, który zapewniłby efektywną wymianę informacji i wiedzy pomiędzy członkami zespołu projektowego i wspomagałby proces komunikacji.