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ANALYSIS OF INFORMATION BEHAVIOUR IN PRODUCT DEVELOPMENT CONTEXT

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1. Introduction

Product development activities are nowadays conducted by team rather than mere individual, emphasizing socio-technical aspect of the product development processes. In product development team, each team member communicates, interacts and makes decisions based on his prior knowledge, competences, motivation etc. [Ensici et al. 2013]. Different individual behaviours influence the way team members collaborate and work together. In terms of their individual information behaviour, there are significant differences in patterns of information acquisition, exchange and usage in various engineering development environments [Tenopir and King 2004]. As a consequence, the analysis and interpretation of information flows within organizations and teams becomes crucial for management [Eppinger and Browning 2012].
According to Wilson [1981], information behaviour can be defined as "totality of human behaviour in relation to sources and channels of information". Translating this concept into product development domain, information behaviour embraces all activities related to generation, editing or sharing of information. The information, as a basic concept, is considered as multidisciplinary (different contexts) and embraces any data or knowledge that participants perceive as information [Shooter et al. 2003], [Ensici and Badke-Schaub 2011].
Using information-centered perspective more understanding can be gained about structure of product development activities, that are reflection of product itself and social interaction as a part of teamwork [Eckert et al. 2001]. Therefore, information-related activities such as information seeking, requesting or processing are important for description and characterization of teamwork [Ensici and Badke-Schaub 2011]. Since only few research attempts were made to analyse information behaviour patterns within teams in product development context, main aim of this study is to explore different aspects of information-related activities in product development teams. In presented research, the work sampling approach was used as the method for collection of the data about different aspects of team and individual information activities within two different product development teams. By analysing diversity and frequency of information activities within these two teams, new insights were obtained that could aid management of product development processes.

2. Related work

Studies of information activities in product development projects were conducted for various purposes and from different perspectives (information science, CSCW, organizational studies). However, according to Karunakaran et al. [2013] these research studies were not complementary. Existing studies of information activities in product development context are often related to creation of information

flows graphs (e.g. [Hickethier et al. 2013]), analysis of specific information activity (e.g. information seeking [Hertzum and Pejtersen 2000], [Cash et al. 2013]), analysis of usage of design information [Court et al. 1996] or their main concern is identification of information needs during the process. In addition, studies are mostly conducted at organizational level indicating communication patterns and issues (e.g. [Zwijze-Koning et al. 2013], [Parraguez et al. 2015]), however focused only on one aspect of information behaviour – information sharing, not taking into account others.
Only few researchers tried to holistically embrace information behaviour in product development teams. Ensici and Badke-Schaub [2011] analysed information activities in two student design teams, taking into account content of the activity. Cash and Kreye [2013] applied IPT (Information Processing Theory) in early design phases exploring relations between uncertainty perception, information seeking and knowledge exchange, while Robinson [2013] studied engineers' information behaviour in product development organization on a higher level.
Information behaviour research in engineering design context was mostly conducted by using widely accepted protocol analysis method [Ensici and Badke-Schaub 2011]. Research studies like [Cross et al. 1996], [Stempfle and Badke Schaub 2002] were focused on cognitive processes of individuals and teams which were inferred from their verbal records [Ensici and Badke-Schaub 2011]. For the purpose of collecting data about information behaviour in engineering companies, researchers also used naturalistic observation (e.g. [Fidel et al. 2004]) followed by structured interviews to acquire feedback on the observed session [Allard et al. 2009]. As an alternative, Robinson [2010, 2012] proposed usage of work sampling approach to collect the data about information intensive activities in real organizational environment.

3. Research approach

In order to enable analysis of information behaviour at required lower level of process granularity and allow longitudinal data collection with several participants, we selected work sampling self-reporting approach as an appropriate one for gathering data. Work sampling is an approach for estimation of time participant spends on certain activity. In concrete terms, it enables collecting data about ongoing process at fixed or randomized time intervals. Afterwards, statistical background enables straight-forward analysis of collected data. To bypass some of the limitations of paper based templates used previously for this type of study (e.g. work diaries [Pedgley 2007]), the participants were provided with work sampling application for smartphones which allows data collection in real time and significantly speeds up data entry [Škec et al. 2016]. Mobile application was designed as a series of menus that were related to different aspects of information activities within product development context. Since work sampling approach requires usage of predefined menus, classification of information activities had to be done beforehand. In this study, we used classification that was based on previous work done by Robinson [2010] and Cash [2012]: information processing, information seeking, giving information (unidirectional), receiving information (unidirectional) and information exchange (bidirectional).
Application emitted alarms randomly during working hours and participants were asked to respond by selecting items on proposed menus about work at that point. For more information about the app, please consult [Škec et al. 2015, 2016].
Analysis of the information activities was divided in two phases. First part of analysis was related to overall information behaviour in a team whose members sampled their activities. Using calculations made on whole dataset, general understanding of information behaviours in observed team can be established. However, to focus on information behaviour within technical context of product development process, data related to individual administrative work was disregarded in this analysis.
Second part of analysis consists of mapping information activities to the most dominant product (or process) context during session period. In comparison to classical network representations of information flows within teams and organizations, additional qualitative data was added to nodes (team members) and links (information flow). To each team member, data about specific information activities are assigned. Information activities that are part of individual technical work are tagged within circle of a node, while information activities as a part of teamwork are presented as links between team members. Different colors were used to differentiate between various information activities and arrowheads indicate direction of an information activity.

3.1 Data collection sessions - case of two companies

Data were collected in two different companies that work in different product and production process development contexts. Research and development activities of the first company are related to the systems for production, distribution and transformation of electrical energy. Second study was conducted in the Tier 1 development and manufacturing supplier for the automotive industry. Their activities include the establishment and improvement of production processes, logistics and procurement. In both companies one team was selected whose main preoccupation was product and production process design. Further on in the paper we will use Team 1 and Team 2 as a designation for teams from Company 1 and Company 2, respectively.

To observe information behaviour in these two development teams, using the already mentioned work sampling application, experiment was set up in real organizational settings. In both companies, work activities of 15 team members were sampled for two weeks. During that period, alarms were emitted 6-8 times per day and per person via work sampling application. To enable randomness within data sample, alarms were emitted randomly with minimum time distance between two alams of 30 minutes and maximum time distance of 90 minutes. Participants were asked to respond on each alarm by selecting options on the application menus [Škec et al. 2016] about present work activity. Therefore, although it is possible to obtain quite detailed insights into information behaviour of participants, not all information-related activities (e.g. all interactions between team members and between team members and corporate information systems) can be captured because of the level of sampling (approximately they answered on a hourly basis). Sampled projects in both companies were in different product development phases and all involved team members participated in more than one project during sampling period.

4. Results

4.1 Analysis - Team 1

During sampling session in Team 1 1357 alarms were emitted, out of which team members inserted data for 1193 alarms (response rate - 87,9%). Overall number of responses per each team member varied between 57 and 100 as a consequence of individual response rate and randomized number of alarms per day. To enhance understanding of analyzed product development process and give wider perspective on analyzed session, it is important to provide brief overview of the session summary data.

Within given two-week period team members spent most time on individual technical work (67,9%). Percentage of teamwork was 14,8% and for the rest of time team members reported individual administrative work and breaks. Therefore, number of relevant responses (related to individual technical and teamwork) for this study was 934 (78,3 % of collected responses).

Analyzing individually, team member 10 reported highest number of team activities (29 team activities; 34,5% of time), followed by team members 8 (27; 36,5%) and 3 (15; 25,9%). On the other side, team members 11 (92,2%) and 2 (94,1%) reported highest share of individual work.

In terms of product development activities (input menues were tailored after taxonomy proposed by Sim and Duffy [2003]), team members mostly reported conceptualization and detailing activities as a part of individual work, while they stated that planning, analysis and conceptualization were most frequent teamwork activites.

For the purpose of this study, information activities were analyzed separately on individual and team level. Information processing on individual level by far has the highest share (65,3%) among all other information activity types. This is probably due to the later stages of the product development projects (detailing) which were dominant during that period. Giving and receiving information activities on individual level had lower shares (3,3% and 4,7%) during sampled period, implying team members interacted less with computer information systems. Team members spent 8,3% on information seeking at the individual level, although only 5 team members reported that type of activity.

During teamwork team members mostly spent time on information exchange (bi-directional). Second most frequent team information activity was uni-directional receiving information. Information seeking activities were almost insignificant at team level. These results indicate that exchange of information was mostly mutual and in both directions what means that various team members were involved in decision making and problem solving on a team level.

Besides analyzing overall dataset in terms of time spent on certain information activity type, on Figure 1 information activities were shown based on their occurrence within different product and process contexts. Overall, information activities of Team 1 were mostly related to product aspect (electronics, software and mechanical/hardware).

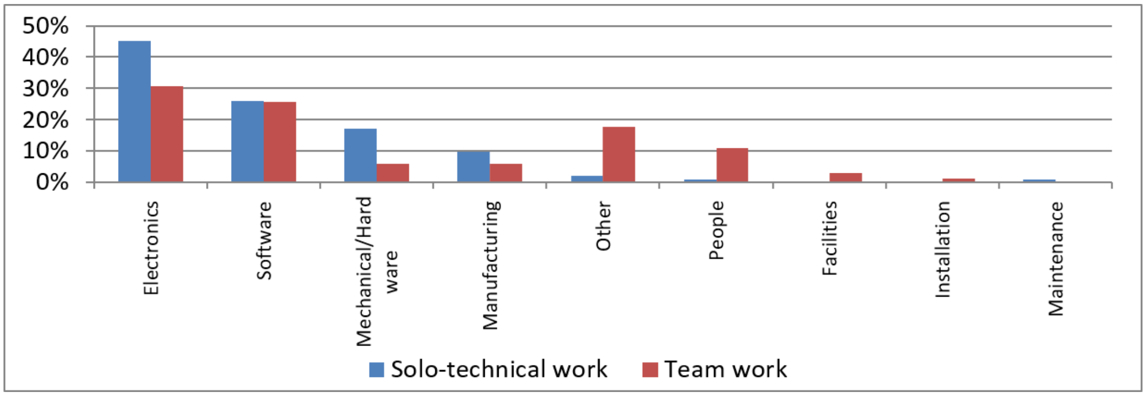

Figure 1. Share of information activties within different contexts (Team 1)

The highest number of information activities was conducted in the context "electronics", and therefore it was selected for more detailed analysis (Figure 2). Within context "electronics" team members reported 419 information activities (42,5% of overall time), out of which 365 (37,0%) were related to individual technical work. The rest of information activities were reported as a part of teamwork.

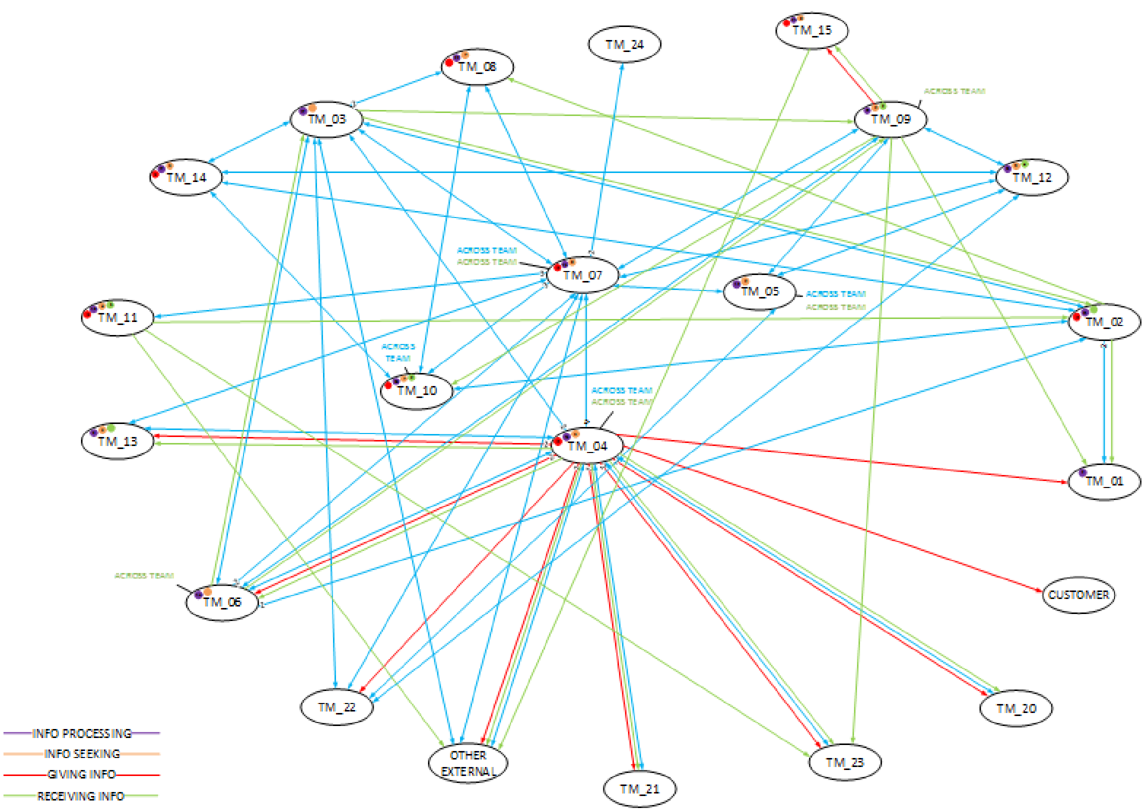

Figure 2. Information flow graph for "Electronics" context (Team 1)

To study more closely information activities, information flow graph was created for given context. Representation of the information flow in context "electronics" indicates active behaviour of many team members. This type of behaviour is expected considering background and expertise of team members in Team 1. In terms of frequency of information activities, team member 7 was the most active, while e.g. team member 1 reported information activity only once for this context (Figure 3). As a part of teamwork team member 4 reported highest number of information exchange activities, followed by team member 7 and 6. Overall, these three team members stood out in terms of their information exchange with others, while other team members had significantly less information exchange activities.
Analyzing information activities in terms of diversity, it can be noticed that 6 team members reported only one type of information exchange, 5 of them two types and only 3 team members reported all three types of information exchange (bi-directional, uni-directional - giving and receiving). One team member didn't report neither one information activity within given context.
Intense information exchange in terms of its quantity and diversity could be especially highlighted for team member 4. A deeper analysis of his activities showed that he participated in two team meetings in which he gave information to other team members. Very high share of activities giving and receiving infomation (uni-directional) may be due to the higher number of formal meetings.
Based on quantity and quality (in terms of information activity type) of links between different team members, roles and responsibilities could be deduced within certain context. Results suggest that there are significant differences between team members related to specific contexts. However, for brevity we presented results only for one context.

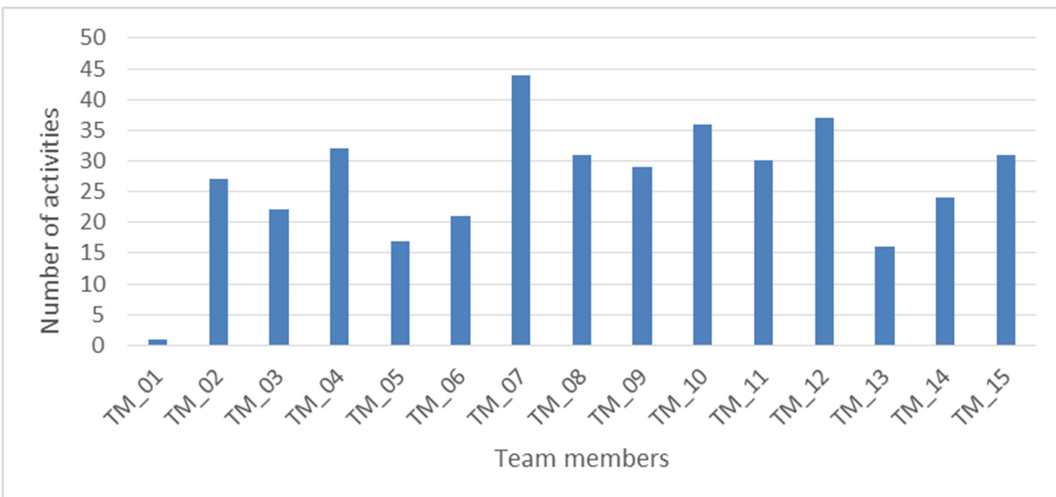

Figure 3. Number of information activities for different team members (Team 1)

4.2 Analysis - Team 2

Within two weeks of sampling session, team members answered on 1127 alarms (response rate is 82,6%). Number of responses for individual team members oscillated between 42 and 96, and average number of responses per each team member was 75,1.
By analyzing how much time team members spent on different work types, interesting results were obtained. Individual administrative activities were dominating with 38,4% time spent what was probably related to revision activities during sampling period. By ignoring responses which were related to individual administrative work and breaks, number of relevant responses decreased to 471 (41,8% of collected responses).
Team members mostly reported conceptualization and planning activities as a part of individual technical work, while planning and sale/procurement were were the most frequent teamwork activities.
After brief introduction of the sampling context, analysis of the information activities can be presented. Information processing activity had the highest share among all information activities (34,0%). Higher share of teamwork activities reflected on almost equal percentage of time spent on information exchange

(33,6%). To be more specific, analysis of individual information activity categories showed that team members spent most time on information exchange on a team level (28,5%) among all information activities. On sending and receiving information team members spent 14,5% and 11,2% respectively, while on information seeking less than 7% of working time. These percentages point to more even distribution of information activities' time percentages in comparison to Team 1. Four team members reported usage of all information activity types. Hence, it can be concluded that all enlisted information activity types were considered relevant and important.

Teamwork activities accounted for 24% of time, indicating more interaction between team members in comparison to Team 1. Only analyzing information activities which were part of teamwork, information exchange had the highest time share of 50,8%, followed by information processing (group thinking) with 17,8% and giving/receiving information (both around 14%). All involved team members reported at least using two different information activities when working in teams, while 9 of them specified using 4 or more information activities.

Figure 4 illustrates percentage breakdown of information activities within different contexts. Analysis indicated that team members mostly reported category "Other". This could be either due to limited number of categories which didn't enable them straightforward category selection or because they had very diverse set of activities during sampling period (more than usual). Based on the number of information activities related to different product/process development contexts, "Manufacturing/Deployment" was selected for more thorough analysis.

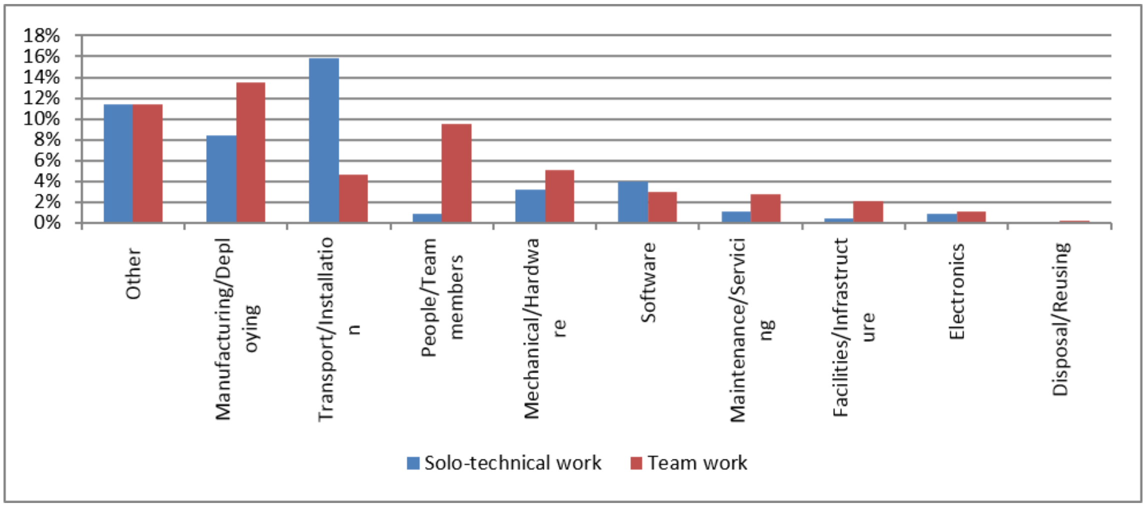

Figure 4. Share of information activties within different contexts (Team 2)

Overall, team members reported 94 information activities within this context (36 - individual technical work; 58 - teamwork). Ten team members participated in information activities (team members 2 and 15 were reported by others) in this context (Figure 5 and Figure 6). When working individually information processing accounted for majority of time, while on a team level team members devoted the greatest proportion of time to information exchange (bi-directional).

In terms of frequency of information activities team member 8 was by far the most active with more than 40 information activities (Figure 5 and Figure 6). He was followed by team member 7 with 27 information activity inputs, while all the others were less active within the context "Manufacturing/Deployment". Since this was multidisciplinary team, it is easy to distinguish 2 experts whose main preoccupation was this aspect of product development process, while others provided support.

It is necessary to emphasize interaction of team members 8, 11 and 12 with experts which were not part of the team or company, meaning that team members were responsible for direct contact with external asscociates (supplier, customer, other external).

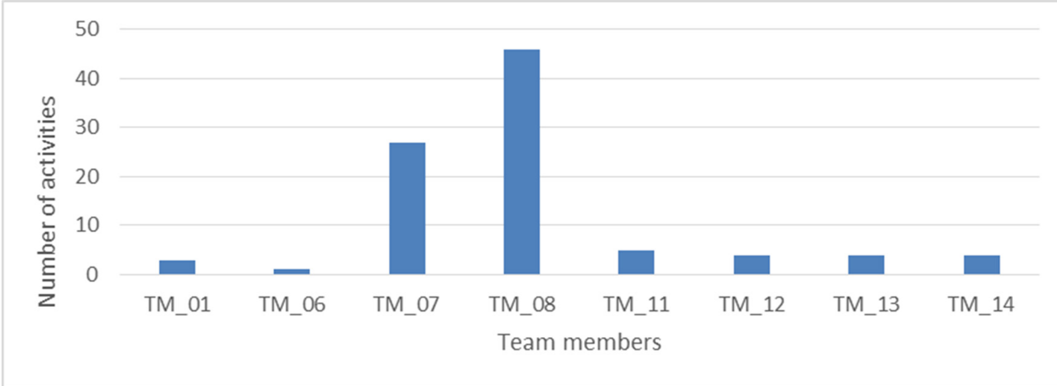

Figure 5. Number of information activities for different team members (Team 2)

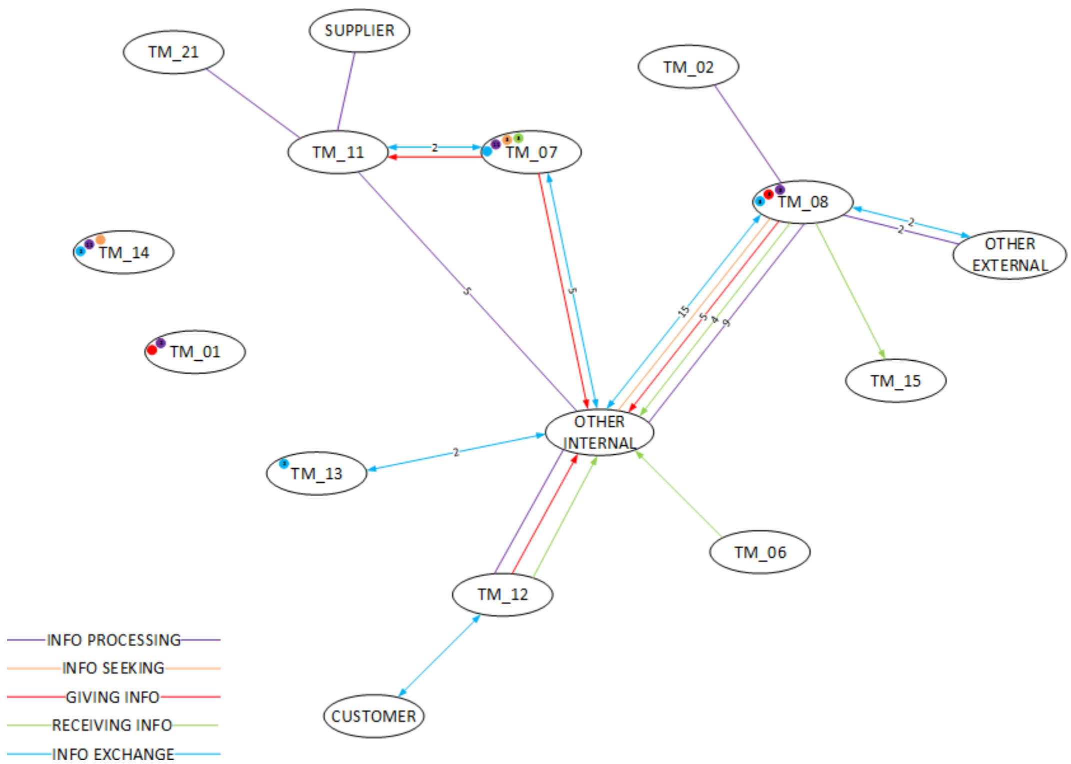

Figure 6. Information flow graph for "Manufacturing/Deploying" context (Team 2)

4.3 Comparison of two product development teams

To enable comparison between information activities in these two teams, differences between company contexts have to be highlighted. To start with, it is necessary to emphasize difference between organization-based teams which are often monodisciplinary (Team 1) and project-based teams which consists of experts with different professional backgrounds (Team 2). This results in the similarity of team members' competences in Team 1 (mainly electrical and mechanical engineers) and the diversity of team members' competences in Team 2 (besides engineers there are experts in procurement, logistics, production, etc.). In addition, Team 1 members are working on more projects in parralel than in Team 2. Also, according to the information activities which were related to particular context predominant ones can be inferred - the product (Team 1) and the process (Team 2). These organizational settings significantly influenced the obtained information behaviour findings.

In terms of work type, team members from Team 1 are more working individiually (81,8%) than team members from Team 2 (43,0%), what refers to different shares of teamwork and information exchange activities. However, almost all Team 1 members are participating in information exchange related to different product development contexts. Interpretation for these findings could be that Team 1 members reported regular team meetings which were associated with different contexts. Although Team 2 members reported more teamwork activities, significantly less team members were involved in information exchange related to different contexts (on average 8 per context). More specific, in Team 2 there was neither one product development context for which all 15 team members participated in information exchange. This could imply more specialized information exchange for which is not needed more than few team members, but could be again related to different approach to team profiling and composition.

In both teams, when working individually, team members devoted significantly more time on information processing activity. During team activities, team members from both teams spent most of the time on information exchange (bi-directional) activities. Also, there were no records of information seeking as a part of teamwork.

Analyzing information exchange with participants across team, it could be noticed that in Team 1 communication is the more frequent with external (out of company) associates, while in Team 2 with other employees within same company. This could be due to higher needs of Team 1 for direct and immediate contact with externals, while in Team 2 this can be achieved through intermediaries from the same company.

Regarding the number of information activity types that was reported by team members during sampling session, all enlisted information activity types were reported by members of Team 2, unlike in Team 1. The possible explanation could be that some Team 1 members reported only uni-directional information exchange (giving or sharing) because of their team role and team hierarchy in general.

Although sampling session lasted for only two weeks, comparison of these two teams revealed certain information behaviour patterns. Diversity and frequency of information activities in these two teams offered some new insights and enhanced understanding of team members' behaviour in organizational environment. Company contexts, team and individual characteristics were quite different, therefore conducting analysis of information behaviour in each of these two teams brought some new results. Analysis of this type can provide evidence for existing individual and team information behaviour and point to communication issues at individual and team level.

5. Discussion and conclusions

Presented research results could be discussed from several different points of view and few conclusions can be drawn from this work. Initially, work sampling approach offered some new possibilities for analysis of information-related activities resulting in new insights for project managers and decision makers and aiding management process of the product development projects. Used work sampling approach allows continuous data collection significantly reducing retrospectivity bias and providing more realistic "snapshots" of information flow. In addition, this embracive approach allows data collection on formal and informal meetings, email exchange, video conferences etc. which means it can encompass various communication and information exchange manners. However, the most important feature of used work sampling application is that it offers data collection about different aspects of each sampling point. The multidimensional aspect of work sampling enables coupling of different perspectives and collection of contextual data for each point.

Several aspects of the information behaviour were analysed:

- Diversity and frequency of information activities as part of individual technical and team work
- Identification of team preoccupation within given period
- Characterization of information behaviour within different product development contexts
- Analysis of individual information behaviour in general and for certain context (e.g. team member 4 – "Electronics" (Team 1))

Overall analysis of information-related activities in organizational environment provided new point of view on real product development processes. According to results obtained for each team member and team in general, management of product development teams is also supported using individual approach. Although aggregated results for individual and team information activities can provide additional insights into team information behaviour, assigning results to each team member facilitates understanding even more. Team and individual perspectives complement each other and could help project manager to better understand how product development projects are actually conducted.

The high amount of collected data enabled creation of information flow graphs for different contexts within product development process. Complementing traditional information flow networks with data about individual information behaviour (information activity types, intensity of information exchange, time/date of certain activity, context of the activity) allows deeper understanding of information processes in product development context. Still, even though it is possible to automatically generate information flow graphs with proposed additional qualitative data, interpretation relies on expertise and understanding of the project manager. Presented results showed that visualization of this type can significantly increase understanding of the communication and information behaviour in development teams. By combining findings from different information flow graphs, team roles and responsibilities could be inferred. In addition, by adding date and time to links it is possbile to track information (as an output of activity) routes during the product development process. For example, early information activities within context "electronics" involved team members 2, 1 and 8, and then team member 8 transferred information to others.

In terms of session results, direct comparisons with some of the previous studies conducted in product development settings (e.g. [Ensici and Badke-Schaub 2011]) are not possible because of different classifications of the information activities, but also different purposes of the study. In this study, focus was put more on information sharing activities (whether they were uni-directional or bi-directional) than on information evaluation or elaboration [Ensici and Badke-Schaub 2011] which we encompassed under information processing category (but did not analyse any further). Also, many studies on information sharing are often conducted by analysing merely email corpus (e.g. [Parraguez et al. 2015]) or exchange through corporate information systems [Gopsill et al. 2011]. Robinson's [2012] study of information activities in blue-chip manufacturing organization can be compared in terms of time ratios that were spend on certain information activity, but taking into account aforementioned differences between studies. Overall, his results indicate more uniform time percentage breakdown of information activities than in both of our teams. This could be again associated with higher percentages of teamwork (40,4%), changing significantly ratios of recorded information activities.

Although here presented results provide several new insights, this study is also subject to few limitations. For the purpose of this study only two teams were sampled with fifteen team members each. In addition, experiments were conducted for two weeks. This is reflected on insufficient number of data points for analysing wider context of activites during sampling period. Because of the potential of proposed approach, longer studies have to be conducted in order to fully explore information activities and their change during different phases of the product development projects and within various contexts. Longer studies would allow more in-depth analysis on which we could draw firm conclusions about team and individual information activities. Further investigations are needed to understand reasons and potential causes for certain information activities.

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References

Allard, S., Levine, K. J., Tenopir, C., "Design Engineers and Technical Professionals at Work : Observing Information Usage in the Workplace", Journal of the American Society for Information Science and Technology, Vol.60, No.3, 2009, pp. 443-454.

Dorst, K., "Editorial Analysing design activity : new directions in protocol analysis", Design Studies, Vol.16, No.2, 1995, pp. 139-142.

Cash, P., "Characterising the relationship between practice and laboratory-based studies of designers for critical design situations", PhD Thesis, University of Bath, 2012.

Cash, P., Stanković, T., Štorga, M., "An Analysis of Engineers Information Seeking Activity", ASME 2013 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, American Society of Mechanical Engineers, 2013.

Court, A. W., Culley, S. J., McMahon, C. A., "Information access diagrams: a technique for analyzing the usage of design information", Journal of Engeering Design, Vol.7, No.1, 1996, pp.55-75.
Eckert, C., Clarkson, P. J., Stacey, M., "Information flow in engineering companies: problems and their causes", In Proceedings of the International Conference on Engineering Design (ICED 2001), Design Society, 2001, pp. 43-50.
Ensici, A., Badke-Schaub, P., "Information Behavior in Multidisciplinary Design Teams", Proceedings of the 18th International Conference on Engineering Design (ICED11), Design Society, 2011.
Ensici, A., Badke-Schaub, P., Bayazıt, N., Lauche, K., Ensici, A., Badke-schaub, P., Bayazıt, N., Lauche, K., "Used and rejected decisions in design teamwork", International Journal of CoCreation in Design and the Arts, Vol.9, No.2, 2013, pp. 113-131.
Eppinger, S. D., Browning, T. R., "Design structure matrix methods and applications", Cambridge: The MIT Press, 2012.
Gopsill, J. A., Mcalpine, H. C., Hicks, B. J., "Learning from the lifecycle: The Capabilities and limitations of current product lifecycle practice and systems", In: DS 68-6: Proceedings of the 18th International Conference on Engineering Design (ICED 11), Impacting Society through Engineering Design, Vol. 6: Design Information and Knowledge, Lyngby/Copenhagen, Denmark, 15.-19.08., 2011.
Hertzum, M., Pejtersen, A. M., "The information-seeking practices of engineers: searching for documents as well as for people", Information Processing & Management, Vol.36, No.5, 2000, pp. 761-778.
Hickethier, G., Tommelein, I. D., Lostuvali, B., "Social network analysis of information flow in an ipd-project design organization", 21st International Group for Lean Construction Conference Proceedings (IGLC-21), 2013, pp. 319-328.
Karunakaran, A., Reddy, M. C., Spence, P. R., "Toward a model of collaborative information i in organizations", Journal of the American Society for Information Science and Technology, Vol.64, No.12, 2013, pp. 2437–2451.
Molenkamp, L. E., "Making Communication Visible : Using Network Analysis To Diagnose Communication Problems", 2014.
Parraguez, P., Eppinger, S. D., Maier, A. M., "Information Flow through Stages of Complex Engineering Design Projects: A Dynamic Network Analysis Approach", IEEE Transactions on Engineering Management, Vol.62, No.4, 2014, pp. 604-617.
Pedgley, O., "Capturing and analysing own design activity", Design Studies, Vol.28, No.5, 2007, pp. 463-483.
Poltrock, S., Grudin, J., Dumais, S., Fidel, R., Bruce, H., Pejtersen, A. M., "Information seeking and sharing in design teams", Proceedings of the 2003 International ACM SIG GROUP Conference on Supporting Group Work - GROUP '03, 2003, pp. 239.
Robinson, M. A., "How design engineers spend their time: Job content and task satisfaction", Design Studies, Vol.33, No.4, 2012, pp. 391-425.
Robinson, M. A., "An empirical analysis of engineers' information behaviors", Journal of the American Society for Information Science and Technology, Vol.61, No.4, 2010, pp. 640-658.
Stempfle, J., Badke-Schaub, P., "Thinking in design teams - An analysis of team communication", Design Studies, Vol.23, No.5, 2002, pp. 473-496.
Škec, S., Štorga, M., Tečec Ribarić, Z., Marjanović, D., "Work sampling approach for measuring intellectual capital elements in product development context", In: DS 80-3 Proceedings of the 20th International Conference on Engineering Design (ICED 15) Vol 3: Organisation and Management, Milan, Italy, 2015.
Škec, S., Štorga, M., Tečec Ribarić, Z., "Work sampling of product development activities", Technical Gazette, Vol.23, No.6, 2016, (forthcoming).
Tenopir, C., King, D. W., "Engineers' Information Seeking and Use", In: Communication Patterns of Engineers, Hoboken, NJ: Wiley-IEEE Press, 2004, pp. 57-70.
Wilson, T. D., "On user studies and information needs", Journal of Documentation, Vol.62, No.6, 2006, pp. 658-670.
Zwijze-Koning, K. H., de Jong, M. D. T., "Network Analysis as a Communication Audit Instrument: Uncovering Communicative Strengths and Weaknesses Within Organizations", Journal of Business and Technical Communication, Vol.29, No.1, 2014, pp. 36-60.

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