Work Processes in Virtual Teams: A Matching Algorithm for Their Technological Facilitation

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Abstract: Virtual teams have almost become normality, especially in larger organizations. Often globally dispersed project teams work together in a virtual setting, but we also find organizations that are fully organized following a virtual design. New technology facilitates the implementation of virtual teamwork into the organization. However, new technology steadily evolves and adaptations by organizations are not always considered as successful. We therefore propose an algorithm for matching technology to work processes of virtual teams. The results are evaluated through interviews and derived on a generalizable level, making them transferrable to changing work environments and also to technologies yet to be innovated.

1 VIRTUAL TEAMS IN THE CONTEXT OF NEW WORK

“New work” as a buzzword and manifestation of various concepts has been discussed since the early 80s (Väth, 2016). The discourse predominantly approached organizational development from a philosophical perspective and focused on individual freedom regarding goals and means of work. Discussions in the context of new work shifted over the years and nowadays mainly address “the three Ds”: democratization, decentralization and digitalization (Väth, 2016). Whereas democratization reflects, e.g., the ways work conditions are negotiated, decentralization and digitalization impact the ways people work and their organizational integration.

We focus on the second and third “Ds” for this study addressing knowledge work. Working in a decentralized way is manifested in, e.g., virtual teamwork. Digitalization of organizations and people’s private lives is facilitated by innovative technologies and by the intensity and ways these technologies are demanded and used.

Organizations adapt to the requirements of new work in order to acquire and retain workforce, to be competitive on their market, and based on ethical motivations (Gajendran and Harrison, 2007). Implementing virtual teamwork is one eligible way for focusing these goals. Most virtual teams work decentralized in various ways, e.g. geographically, and work digitally, relying on technological support for work processes. This technological support and the facilitated work processes are elements of the organization’s knowledge system (Fang, Kwok and Schroeder, 2014). Innovative technologies for communication and management, e.g. three-dimensional virtual environments (3DVE), can thus be crucial for serving the goals of new work and support virtual teams in their business goals (Powell, Piccoli and Ives, 2004).

3DVE are considered a popular research object, whereas other new technologies in the context of virtual teamwork are not as intensely analyzed (Gilson et al., 2015). Yet, established and partly already replaced technologies, e.g. email, are still researched regarding the use and benefit for virtual teams (Gilson et al., 2015; Dubé and Robey, 2009). Furthermore, insights on technology choice and performance are contradictive. The endeavor to categorize and analyze new technologies serving as reference for future technology design and technology choice is thus relevant for research, even more, as the development of technological solutions and of society are not static but keep evolving dynamically.

The goal of this study is thus to present an algorithm that serves as reference for matching technological solutions to work processes. This allows enhancing technological innovations that meet current and future requirements. The algorithm is

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designed on an abstract level supporting the analysis of new technologies that are already in use and those yet to come. The proposed algorithm does not replace decisions of tech-savvy humans or individual choices. But the algorithm can serve as guidance for a more objective technology choice as well as tool for analyzing technology choice and its link to work performance. The results also provide guidance for technology choice in practice and furthermore serve as a link for subsequent research in this area. The following research questions (RQ) direct the process of this study in order to achieve these goals.

RQ1: What are the requirements of work processes by virtual teams with respect to technological facilitation?

RQ2: Which technological capabilities support specific work processes for virtual teams?

The study is divided into three main sections. The conceptual design presents the fundamental ideas regarding, e.g., the applied media synchronicity theory (MST) (section 2). Matching capabilities and requirements is then performed in three steps (section 3). The proposed results are validated by performing expert interviews (section 4). Main contributions and links for future research are presented (section 5).

2 CONCEPTUAL DESIGN

Conceptualizations for new technology, for current types of workplaces and for virtual teams are proposed subsequently. The MST is introduced serving as main theoretical approach for the subsequent analysis of new technology. MST supports a structured decomposition of technology for specific work processes (DeLuca and Valacich, 2006; Hassell and Limayem, 2011) and allows insights into how technology can support team processes (Maruping and Agarwal, 2004). It is thus used as theoretical lens for this study and introduced in the following (section 2.1). An overview of related work shows how to embed this study into current research (section 2.2).

2.1 Relevant Elements

Technologies in general are “manufactured objects” that “enhance human capabilities” or “enable humans to perform tasks they could not perform otherwise” (Grübler, 2003). This basic definition suits the context of virtual teamwork as it stresses the relevance of technology for virtual teams to be able to exist. Evolving technology is usually described as “new” at a certain moment in time. Technology is regarded as “new” for this study if it is still emerging or is already diffused for established use throughout recent years. New technologies analyzed in this study include soft- and hardware (Grübler, 2003) that facilitate virtual teamwork through remote access but also allow performing individual work processes that do not require communication. We exclude technologies that are either replaced by current solutions or have been used and analyzed for decades, e.g. offline mail services, email, fax and phone calls. We propose five categories of new technologies for our study that are used in practice by virtual teams and analyzed in the context of teamwork in literature (Gilson et al., 2015). Technologies are discussed in scientific literature on different levels of abstraction. We focus on technological core functions instead of taking combined features and specific tools, such as Skype or Trello, into account, resulting in five categories. This level of abstraction allows for the proposed algorithm to be still applicable for upcoming technological solutions instead of solely addressing technologies that are currently in use. The categories for our analysis are video conferencing, 3DVE, chat, document sharing tools and management systems.

Video conferences are video calls with two or more participants. Spoken words and facial expressions are transmitted (Dennis, Fuller and Valacich, 2008). Some video conference systems also support parallel written chat and document sharing. For our study we address these features separately as described above. *3DVE* can be deployed for conferencing through avatars, for observation, e.g. for customers during the planning phase of architectural ideas as well as for design (Gilson et al., 2015). 3DVE differ from augmented reality by not requiring physical representations of objects. *Chat* tools for written messages have been in use for several decades. As they have not been replaced and new chat software solutions on new devices still emerge, they are categorized as new technology. *Document sharing tools*, also referred to as virtual file systems, are often integrated into work platforms among other functionalities, e.g. calendars. Still, several tools exist and are deployed that provide the core function of document sharing. These tools often provide standard folder structures facilitating consistent storing of work artefacts. With that virtual teams are not required to, e.g., send updated artefacts per email but can store and access them in a central database, either hosted by their organizations or as cloud service (Gilson et al., 2015). *Management systems* support the organizational aspects of teamwork and include tools for project management (Seerat, Samad and

Abbas, 2013), process management and workflow automation (Dustdar, 2004).

We deploy the concept of *capabilities* from the MST in order to structure the observed technologies and allow a precise matching to the requirements of work processes in section 3. Any technology can be classified regarding the five capabilities: feedback, parallelism, rehearsability, reprocessability and symbol set (Dennis and Valacich, 1999; Dennis, Fuller and Valacich, 2008; Powell, Piccoli and Ives, 2004). The facilitation of *feedback*, in terms of immediate response, also referred to as transmission velocity (Dennis, Fuller and Valacich, 2008), is a capability that highly distinguishes technological solutions. Most new technologies allow feedback to some extent, but the velocity of feedback varies significantly. 3DVE and conference tools support real-time feedback and thus synchronous communication. *Parallelism* describes if and to what extent a technology supports processing several tasks simultaneously. Asynchronous technologies, e.g. chat tools, provide more support for parallelism than, e.g. video calls. *Rehearsability* characterizes if technologies allow checking and reworking content before sharing it with team members. Most features in management and document sharing tools support repeated rehearsability. If technologies support *reprocessability* the produced content can be re-used. E.g. 3DVE applications are enriched with content that is persistent and is updated for re-use. The *symbol set* refers to the repertoire a technology offers. E.g. spoken words combined with facial expressions in video calls provide a richer symbol set than chat tools and thus serve different work process requirements. The manifestations of these capabilities indicate which processes a certain technology supports through synchronous or asynchronous features. The building of a shared mental model, e.g., requires convergence of the team members' ideas and is supported by technology that allows synchronous communication (Dennis and Valacich, 1999), like video conferences. Transferring information to team members and storing it for mutual use, e.g., is supported by asynchronous technology (Dennis and Valacich, 1999), like document sharing tools. The manifestations of the five capabilities for synchronous and asynchronous technologies are shown in table 1.

Table 1: Manifestations of technological capabilities.

	synchronous	asynchronous
feedback	+ immediate	- slow
parallelism	- less	+ more
rehearsability	- no	+ yes
reprocessability	- low	+ high
symbol set	+ rich	- narrow

MST does not support instant technology choice but provides the necessary analytical foundations by focusing communication performance (Dennis, Fuller and Valacich, 2008). We therefore build our matching of work process requirements and technology as additional step based on the introduced capabilities.

The use of technology by virtual teams for work processes allows new alternatives of *workplaces*, with a workplace being a physical place for value creation. Regular offices and working hours, even with flexible hours, do not cover the whole reality of today's workplace structures and demands (Gilson et al., 2015). Some professions require humans or machines to be at a certain workplace, e.g. for garbage collection service. Our focus is on professions that are traditionally associated with offices and working hours and thus on knowledge work, e.g. researchers and programmers. Offices in buildings have been regarded as standard workplace for a long time. Remote work at home emerged as alternative workplace. Beyond that, considering work by digital nomads (Nash et al., 2018) leads to a manifold image of today's workplaces. Synthesizing technological characteristics of these workplaces shows that the common grounds are a computer and internet connection. Depending on the tasks that are involved in the work processes, workers add hardware devices, e.g. microphones and virtual reality devices. Office space, desks, nearby colleagues and regular hours are not generally required amenities.

Organizations adapt to new work requirements and market conditions in order to remain competitive by approaching specific customer segments and by acquiring a qualified workforce (Gajendran and Harrison, 2007). One way to meet these goals is to deploy virtual teams as workforce. Costs can be lowered by saving on real estate and travel expenses (Gajendran and Harrison, 2007). New customers are approached and qualified employees are acquired and retained by creating a work environment that suits their cultures and choices of how to live (Kane et al., 2015). Yet, integrating virtual teams also introduces challenges to the organization, e.g. regarding building trust (Dubé and Robey, 2009). Thus, the deployment of virtual teams is a strategic decision that is enabled by new technology but mainly triggered by market conditions and cultural shifts. *Virtual teams* can be defined as group of people working together remotely or asynchronously with technological support in an organizational context (Schweitzer and Duxbury, 2010). Virtual teams often include people in various time zones speaking different native languages. But even teams that are working in the same city but remotely or asynchronously require technological facilitation and can be considered virtual teams. Currently common implementations of virtual teams are mainly related to knowledge work. Online and consulting service providers are well suited areas for virtual teamwork. Therefore, several companies in this field even consist solely of virtual teams, e.g. Zapier and Basecamp (https://zapier.com/about/, https://base camp.com/about). Taking a look at job offerings for remote and virtual work (e.g. at https://www.flexjobs.com/ and https://remote.co/) supports this assumption, as most careers are in the fields of knowledge work and online services in particular. Besides the virtual work in a knowledge work context, virtual teamwork also emerges in areas that have been known to require manual operations, e.g. medical surgeries and manufacturing. Not only trainings for surgeries are carried out in virtual environments (Satava, 1993) but also actual surgeries can be performed with members of the team working remotely via virtual technologies (Pessa et al., 2015). Applications for virtual environments and appropriate hardware, e.g. head-mounted displays, are used for work processes in manufacturing for planning, designing and decision making, as another prominent example of technologically facilitated virtual teamwork (Berg and Vance, 2017).

Work processes in general include all activities carried out by humans in a work context in order to enable or perform value creation (Gilson et al., 2015). They can be differentiated from business processes regarding their affiliation to human actors. Actors can be employees, executives, and also freelance workers. We focus on team members and team leaders of virtual teams for our study. Thus, all work processes performed by them are taken into account.

2.2 Related Work on Technology Analysis

Researchers are looking for reasons of failed and successful teamwork processes since teamwork became a prominent way of organizing tasks. Especially interrelations of technology choice and performance are of interest since collaborative technologies have emerged (Dennis and Valacich, 1999). Models and theories are derived through these insights, e.g. in the field of collaborative engineering (Randrup and Briggs, 2017). E.g. the media richness theory has been established for explaining technology-task-fit and technology use in teamwork and was evaluated in many studies (Dennis and Valacich, 1999). Dennis et al. proposed the MST based on the media richness theory by focusing on process outcomes instead of the formally discussed technology-task-fit (Dennis and Valacich, 1999; Dennis, Fuller and Valacich, 2008). Supporting a more dynamic view, adaptive structuration theory takes a longitude perspective by providing an approach for analyzing technology use over time and focus on the actual ways technology is used instead of how it is intended to be used (Dennis and Valacich, 1999; DeSanctis and Poole, 1994). Today, technology design, choice and use are analyzed from various scientific perspectives, e.g. engineering and psychology, and often prototypes or guidance are provided for practice. Due to these practical approaches, the studies are less aimed at proposing theoretical foundations but shed light on topics on an application level. Insights provided on an application level address, e.g., the implementation of avatars for cultural translation in conferencing (Hasler et al., 2017) and the use of collaboration systems (Dustdar, 2004).

In order to contribute to this intensely researched field and also offer benefits for practice, we position our work as abstract model that delivers an adaptive algorithm, also deployable for future reference. An algorithm presents a qualified measure to solve a problem based on precisely described steps with a finite amount of time and data (Dale and Lewis, 2007). We therefore conceptualize virtual teams through their work processes without explicitly including cultural and behavioristic approaches that would regard, e.g., motivation in teams and evolution of technology use during team lifespan. In order to support future referencing across different industries, the model abstracts from specific branches and is built on the equally abstract MST.

3 MATCHING ALGORITHM

In the following sections we derive technological requirements of work processes by virtual teams (RQ1) and match these requirements to the capabilities of new technologies (RQ2). We therefore derive work processes for virtual teams and their technological requirements (section 3.1), break down technologies to the level of capabilities (section 3.2) and match the requirements to the capabilities (section 3.3). The results of this matching algorithm can serve virtual teams to optimize their technology choice and also reveal shortcomings regarding technology design.

3.1 Work Processes in Virtual Teamwork

We suggest structuring work processes into two perspectives, in order to facilitate the allocation of processes. The administrative view includes processes that are not directly bound to the content of work objects. Work processes from a value creation view present the generation of work results. As in any team, even more importantly in the context of virtuality, communication is considered as vital for successful collaboration on any organizational and team level (Powell, Piccoli and Ives, 2004). Two fundamental communication processes exist based on MST. These are the transfer of information, called *conveyance* and the communicative activity to achieve a shared mental model or to come to an agreement, the *convergence* of information (Dennis, Fuller and Valacich, 2008; Ramesh and Dennis, 2002). Conveyance presents the administrative aspect of communication, whereas convergence is bound to the content of information. *Coordination*, being another essential administrative work process for virtual teams can be operationalized through a team leader, self-coordinating teams or a hybrid coordination approach (Piccoli, Powell and Ives, 2004; Powell, Piccoli and Ives, 2004). Team members carry out *individual tasks* that usually depend on a certain profession and role. As these individual tasks are highly diverse across professional fields, e.g. coding and research, we do not further specify requirements of individual professions. When the members carry out tasks together as a team, these tasks include individual input which is intertwined due to interdependencies, e.g. in the partly remote surgery situation described above. *Team task performance* is hence regarded as work process which requires team interaction for achieving mutual goals. An overview of the described work processes is displayed in figure 1.

These work processes require certain technological support in order to be practicable by virtual teams. These requirements are analyzed based on the capabilities proposed by MST (Dennis and Valacich, 1999; Dennis, Fuller and Valacich, 2008). The requirements of derived work processes are shown in table 2.

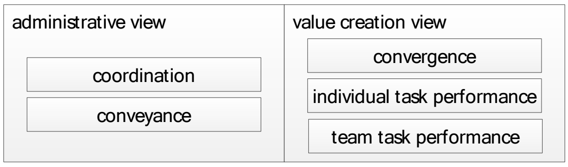

Figure 1: Work processes in virtual teams.

The manifestations of technological capabilities are adopted as work process requirements in order to apply an analytical level similar to MST. “x” marks a mainly positive and “-“ a mainly negative manifestation. Cases that are volatile are marked with “x-“. All five work processes are examined similarly to the following description for convergence processes: A virtual team seeks to achieve consensus regarding an unclear goal description of a new project. In that case convergence presents the work process on a value creation level. In order to achieve consensus, immediate feedback is required in discussions, parallel tasks impair the focus and thus the results of convergence. As convergence is supported by synchronous communication, input is not rehearsable but happens immediately. As convergence can be regarded as frequently required process, arguments as well as resources can be reprocessed for similar work processes to a certain extent, e.g. by recording. A rich symbol set is regarded to facilitate convergence (Dennis, Fuller and Valacich, 2008) and may include spoken words, tone, facial expressions and shared written documents and models in that case.

3.2 Capabilities of New Technologies

The five proposed new technologies are analyzed regarding their capabilities based on MST in order to match these technologies to the work processes. The selected technologies can be positioned along a continuum between synchronous and asynchronous, regarding their manifestations of the described capabilities. The results are displayed in table 3, based on the cited literature and judgment by the two authors, corresponding to inter-code-reliability.

Video conferencing is only convenient when the participants’ internet connections are good enough to tolerate steady and synchronous communication. Therefore, the transmission velocity needs to be high allowing immediate feedback. Parallel conduct of video conferences is not viable and content once transmitted via spoken words and mimic cannot be rehearsed. Video conferences can be recorded and their content thus be reprocessed, e.g. for protocols. This process could be enhanced by implementing

Table 2: Technological work process requirements.

requirement \ work process	coordination	conveyance	convergence	indiv. task performance	team task performance
feedback	-	-	x	-	x
parallelism	x	x	-	x	-
rehearsability	x	x	-	x	x-
reprocessability	x	x	x-	x	x
symbol set	-	x	x	x-	x-

Table 3: Capabilities of analyzed technologies.

capability \ technology	vid. conf.	3DVE	chat	doc. shar. tools	manag. systems
feedback	x	x	x-	-	-
parallelism	-	-	X	x	x
rehearsability	-	x	X	x	x
reprocessability	x-	x-	x-	x	x
symbol set	x	x-	-	x-	-
	synchronous		← →		asynchronous

automated transcription. Video conferencing tools provide a rich symbol set (e.g. speech and mimic).

3DVE facilitate synchronous communication (Schouten, Hooff and Feldberg, 2016). Analogous to video conferencing, immediate feedback is supported and parallel process performance unfavorable. 3DVE support the rehearsing of interaction. The set-up of 3DVE can be reprocessed and optional recordings of interactions stored for documentation or re-use. 3DVE can include individualized avatars for communication that translate cultural differences or provide images of objects that require discussion (Hasler et al., 2017). Therefore, the richness of the symbol set strongly depends on the maturity and features of the deployed 3DVE.

Feedback in *chat* systems can be delivered immediately or slowly. The tool's velocity does not only depend on the technology itself but on the way team members are using it. This use can differ between teams and between individuals and is related to organizational culture and communication habits. Chats support parallel communication tasks which negatively influences the velocity of feedback. This as well as the amount of parallel threads is limited due to human information processing. In cases where chat bots are implemented, this limitation is softened up to technological processability. Chat content is rehearsable and reprocessable due to delayed transmission until ordered and due to automated documentation of conversations. Chat tools are most commonly limited to written and voice messages presenting a narrow symbol set.

Some *document sharing tools* integrate feedback features. Yet, most document sharing tools are only convenient for up- and downloading documents, with limited comment areas. Document sharing tools are not restricted regarding parallelism and rehearsability. Reprocessability is a core function of document sharing tools. The symbol set of document sharing tools is as rich as the shared documents, e.g. if only pictures or written documents are shared.

Management systems allow immediate conveyance of, e.g., performance indicators or work instructions. However, most management systems do not provide bidirectional feedback features. Content can be rehearsed and reprocessed and parallel projects and processes be monitored. The symbol set is usually limited to written text as well as displaying models and figures.

3.3 Matching Procedure

The matching algorithm of work process requirements and technological capabilities is processed by synthesizing tables 1, 2 and 3 and the results are presented in table 4 below. E.g. coordination processes require parallelism,

Table 4: Matching of new technologies and work processes in virtual teams.

technology / work process	vid. conf.	3DVE	chat	doc. shar. tools	manag. systems
coordination			2	2	1
conveyance		3	3	1	3
convergence	1	2	3	3	
indiv. task performance		3	3	1	3
team task performance	3	1	3	3	

rehearsability and reprocessability. Technologies are scanned and the ones selected that meet these three requirements, e.g. management systems (labeled as choice 1). Technologies which provide additional not required capabilities are mentioned as second-best choices (labeled as choice 2). Even though this might seem counterintuitive, richer technology is not regarded as better choice than the ones with specific fit (Dennis, Fuller and Valacich, 2008). Technologies that lack one required capability are labeled as choice 3. Technology that lacks more than one required capability is not marked as choice. The matching results of specific technologies are transferred to five propositions throughout the matching procedure generalizing towards synchronous and asynchronous technology.

The requirements of coordination work processes are met by management systems (1). Besides this exact match in all three capabilities (parallelism, rehearsability, and reprocessability), document sharing tools (richer symbol set) and chats (more immediate feedback) are also possible matches (2).

Proposition 1. Asynchronous Technology Facilitates the Requirements of Coordination Processes for Virtual Teams.

Conveyance processes can be performed using asynchronous technology and are facilitated by document sharing tools (1). 3DVE, chats and management systems (3) all lack one capability and thus support conveyance to a certain degree.

Proposition 2. Asynchronous Technology with Rich Symbol Set Facilitates Conveyance of Information in Virtual Teams.

Convergence processes require highly synchronous communication potential. The best match is to deploy video conferencing (1). 3DVE adds the capability of rehearsability and varies in symbol set and is therefore regarded as second best match (2). Chat and document sharing tools lack at least one capability and thus serve as third choice for supporting convergence processes (3).

Proposition 3. Convergence Processes in Virtual Teams are Facilitated by (Reprocessable) Synchronous Technology.

Work processes included in individual task performance have highly unique requirements. The technological requirements depend on the field of work, e.g. coding programs, exercising surgery, training or planning interior design. The common ground regarding teamwork is that the work results need to be transmitted, shared or provided for subsequent tasks. Thus, the matching of individual task performance requirements and technology shows an equal result as conveyance processes.

Proposition 4. The Integration of Individual Task Performance and Derived Results into Teamwork Processes is Facilitated by Asynchronous Technology.

The best technological match for team task performance is 3DVE as all requirements are met (1). No second choice exists providing additional capabilities. The three third choices, video conferencing, chat and document sharing tools (3), support team task performance to a certain extent.

Proposition 5. Unison Team Task Performance is Facilitated by Highly Synchronous Technologies that Additionally Provide Rehearsability and Reprocessability.

The results are summarized in table 4 above. The matching shows which technology is assumed to support which work process best based on the presented insights following MST. Combining technologies, even ones that are not considered to fully support the process requirements, can still facilitate process performance to a certain extent (Dennis, Fuller and Valacich, 2008). E.g. using a document sharing tool to open documents, protocol results and update content during a meeting in a 3DVE can enhance team task performance compared to an exclusive deployment of synchronous 3DVE.

4 EVALUATION AND DISCUSSION OF RESULTS

We conducted a field study using interviews in order to evaluate, possibly validate and amplify the insights regarding the matching of technologies and processes (Yin, 2014). Interviews were chosen for data collection as they allow assessing actual implementations of technology with taking individual interpretations of the actors into account (Schultze and Avital, 2011). The field study includes five semi-structured interviews (Myers and Newman, 2007) with experts from practice (section 4.1). The experts' judgment on the proposed assumptions and results are analyzed for potential consensus and discussed (section 4.2) in order to evaluate and improve our findings (Frank, 2007). The evaluated matching algorithm is finally presented as model (section 4.3).

4.1 Interview Method

The field study was intended to evaluate the theory-based propositions through insights from practice and interviews were selected as methodical approach. Interviews are an appropriate approach for deriving insight for how and why something is done (Yin, 2014). The interviews consisted of open questions. The questions were based on the assumptions regarding work processes (section 3.1) and technological capabilities (section 3.2) as well as the results of the matching (section 3.3). The interview script consisted of three blocks. The first block addressed personal characteristics (see table 5) and individual hardware use. Questions of the second block inquired, what technologies are used for which processes. E.g.: "Coordination: You want to communicate a planned schedule to your team members and monitor the compliance with deadlines. Which technology do you use?". The third block addressed technological capabilities based on the five selected technologies. E.g.: "Chat: Do you use chat tools? For which processes and tasks are chat tools convenient? What are, in your opinion, advantages and disadvantages of chat tools?". If the interviewees did not cover all capabilities in their answers for the third block, these capabilities were explicitly addressed. E.g. regarding rehearsability: "How important is it for you to be able to proof-read, structure and edit content before you transmit the content using a chat tool?". The interviewees were informed about confidentiality of the interviews and asked to abstain from personal and organizational data during the interview, before the recording of the interviews was started. All interviewees were shortly and equally briefed in order to achieve a mutual understanding of technology and work processes. All interviews took about 30 minutes and were recorded. The answers where analyzed and insights extracted that are summarized in section 4.2. The interviewer followed the questions prepared in the script but also improvised by referring to answers already given to questions and by asking for more detail, especially when statements did not adhere to the theoretical foundation (Myers and Newman, 2007).

Table 5 shows the characteristics of the five interviewees, regarding the kind of organization they represent and what role they hold in that organization. The interviews and the interviewees present the user perspective as they report on how and what technologies they actually use or would find applicable for certain work processes.

The interviewees were selected due to their different roles in organizations and as they are working across several industries. This selection was made in order to provide a certain degree of transferability of the results and also not limit the insights to one group of employees which might bias the results (Myers and Newman, 2007).

Table 5: Characteristics of interviewees.

#	organization	interviewee
1	market research and product development	senior consultant
2	digitalization assessment and consulting	consultant
3	online marketing	senior campaign manager
4	virtual power plant operator	software coder
5	health consulting and software systems	CEO

4.2 Analysis of Interview Results

The interviews were analyzed regarding their support and dissent of the propositions. The results of the interviews support the five propositions (section 3.3) to a certain extent as described subsequently.

Ref. prop. 1: The interviewees use a variety of asynchronous technology for coordination processes. Spread sheets are used for project and process management despite their lack of integrability. In most cases, the solutions are not integrated but consist of organization-wide project and process management systems, personal calendars and to-do applications redundantly combined with email reminders for delegated tasks.

Ref. prop 2: Document sharing via online tools and in local databases is a standard procedure for the interviewees for conveying information. Still, emails with individual transmissions are widely used in one international company that does not provide any internal document sharing platform accessible across locations. This interviewee stated that he has expected email use would be obsolete by now, considering all the available tools. Two other interviewees stated and approved that email was banned for transmitting content for security and efficiency reasons by their organization. Especially the factor "efficiency" validates our theoretical assumptions.

Ref. prop. 3: Asking about convergence processes confirmed that a rich symbol set is required and the interviewees often referred to the need of seeing facial expressions as they are used to from face to face meetings. Immediate feedback presents another reason to choose video conferencing above other technology. Lack of technology use skills and insufficient connection were mentioned as main downsides impairing video conferencing. Most interviewees use reprocessability of recorded video conferences for documentation and sharing with other team members. This confirms the findings that reprocessability is, to some extent, relevant in synchronous technology and provides insights on actual use and ideas for future design and implementation of conferencing technology. The statements regarding video transfer in conferencing are divergent. Most interviewees mentioned an urge to see the person they communicate with. Most statements did not include specific reasons but rather an emotional drive to see who they are working with, even if the other person carries out tasks that do not require interaction. Opposing statements considered seeing a person as unnecessary for communication and video transfer even as inconvenient regarding privacy of workspace.

Ref. prop. 4: The choice of technology for carrying out individual tasks is as diverse as expected. This also concerns remote accessibility and mobility of technology. Interviewees mostly stated that they hardly ever use mobile devices besides laptops and only sometimes require remote access to the organizations databases for their individual tasks.

Re. prop. 5: The selected interviewees stated to be interested in 3DVE for either direct interaction or for observing locations without traveling. Rehearsability and reprocessability are not seen as relevant for team task performance, thus not confirming the proposition.

The interview questions did not require any adaptation of the work processes and technologies. All interviewees were able to find their own work processes and tasks as well as technologies they use in the suggested structure. The overall use of synchronous and asynchronous technology for processes proves to be as recommended by the matching. Yet, the individual manifestations of technology use vary significantly. The two extremes are one company with centralized, highly structured and lean technology use and the other company with a variety of technologies that are used or not used based on each employee's liking.

4.3 Validity of the Proposed Matching Algorithm

The matching results and derived propositions are mainly supported by the interviews as described above. We therefore consider the proposed matching algorithm as valid method for analyzing and planning appropriate technology choice and development. The granularity and structure of work processes as well as the proposed classes of technologies were confirmed to model reality throughout the interviews. The algorithm consists of two initial steps and one synthesizing step. The two initial steps are (1) analyzing work process requirements and (2) analyzing technologies, both on the level of capabilities. Finally, (3) the manifestations are matched and the results assessed regarding their accuracy of fit. The proposed algorithm is modeled for our use case in figure 2.

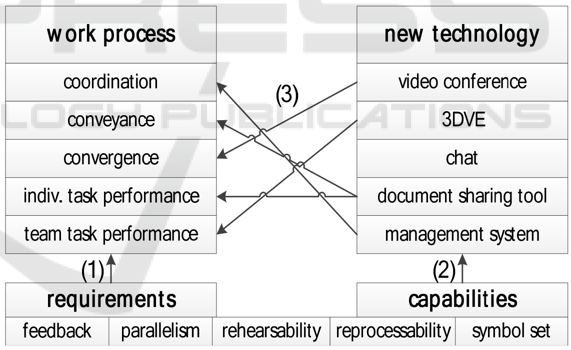

Figure 2: Modeled matching algorithm.

5 CONCLUSION

The matching results as well as the insights from interviews are mostly in line with the hypotheses from MST regarding the capabilities of synchronous and asynchronous technologies. Email applications were not taken into account; still, most interviewees used email as benchmark for other technologies. This phenomenon could be interpreted as a transition from the email era as former main communication tool and could be an issue for further investigation.

The matching algorithm presents the main contribution of this study. The foundations are closely based on MST and the proposed results are evaluated through interviews. The algorithm allows for an adaption for varieties of technological solutions, e.g. management systems with discussion sections, due to its high level of abstraction and with generalizability. Future research could focus on matching technological solutions with the needs of certain professional fields, e.g. for researchers or legal consultants, as we did not specify the requirements of certain professions. We assessed the insights of the evaluation cautiously because of the following weak points. The number of interviewed experts was relatively small and thus provides only indicative results. Insights by expert interviews are known to tend to rather validate whatever is assumed beforehand (Kromrey, Roose and Strübing, 2016). Subsequent studies could provide further insights for enhancing the matching algorithm, also including longitude studies analyzing changes of technology use over time (DeSanctis and Poole, 1994) or focusing on specific industries or requirements by diverse user groups. The proposed results of the matching algorithm can serve virtual teams by optimizing their technology choice and support future decisions in technology design.

The current revival of “the three Ds” - the trends and visions of new work - manifests in deploying virtual teams, and it is enabled through new technology and requested by the current and future workforce. Scientific research is encouraged to further develop an understanding and moreover provide guidance for these and upcoming trends and visions of new work.

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