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Future of International Collaborative Work

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Abstract

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Topic: Future of International Collaborative Work

Content: Thanks to constant improvements in technology, the world has become more interconnected, fast-paced and trends change rapidly in potentially every field. Thus, things we were used to and that worked perfectly 10 years ago can quickly become obsolete. In fields like business or technology, unless you are innovating or improving on your systems, you are very likely to fall behind competition and eventually disappear from the market. And as it is in every working environment, cooperating with people is a daily issue and managing it well is an important task. Therefore in collaborative work, as well as in other fields, one needs to constantly innovate and introduce more advanced and efficient solutions. Today's globalized environment also gives us a possibility to work across the world, surpassing the need of having working teams co-located in one place, which, however, brings more challenges and issues that have to be dealt with.

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Introduction

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Future of international collaborative work is a complex domain, which we are going to study in the following paragraphs. Firstly, we will talk about collaborative work in general to understand basic concepts and challenges within the field. With theoretical knowledge acquired and a practical basis to start from, we will direct our efforts towards identifying collaboration work on an international scale, along with discussing its current state, problems, technological solutions and potential future development and innovations. Afterwards, we will glimpse into some challenges and advantages, that collaborative work disciplines present us with. Later, we will look at some projects in Germany concerned with those issues. Lastly, I will give my own perspective on the topic, discussing it and supporting my statements with what I have learned.

Collaborative work

Generally speaking about collaborative work, stripping away terms “future” and “international”, we get to a point where it's easier to identify what kind of ideas we are to be concerned with. Researching further, what that term might imply and what's been already researched in this field, we come across various disciplines concerning with collaboration at our workplaces and jobs.

Thus, I decided not to reinvent a wheel in this field of study and instead of trying coming up with my own classification of ideas or technologies, I'd prefer sticking to a few already existing ones and possible elaborate on those further. Once we look at the matter of subject more in detail, we will actually get to the core idea of the paper, which is a collaborative work on an international scale along with its future prospects.

One of the most-renown of the terms, summarizing collaboration efforts, is CSCW (Computer-supported cooperative work). From now on, most of the paper's ideas will originate or will be inspired by it. In the further chapters, we will look more into meaning of this expression and into many other related disciplines, which will provide us with a broader perspective on the topic, eventually leading into more detailed ideas giving us insight on we set the aim to.

Terminology

Let us explain the most important terms, so we can use them later without a need for clarification.

CSCW

Computer-supported cooperative work (CSCW) consists of software tools and technology that supports a group of individuals working on projects at different sites. It is based on the principle of group coordination and collaborative activities supported through computer systems (Techopedia). It's a design-oriented interdisciplinary academic field, which brings together economists, organizational theorists, social psychologists, sociologists, anthropologists and computer scientists, among others. Many claim that groupware and CSCW are basically the same. However, the difference can be found in the aforementioned extensions CSCW provides, whereas groupware refers to real computer-based systems.

The term CSCW was coined in 1984 by Irene Greif and Paul M. Cashman at a workshop dealing with technology in work and how could it support people. Since then, the disciple has grown into an identifiable research field, even though there already exists a great variety of disciplines branching off from the core idea. This complexity also contributes to the fact, that finding unified resources (theory-wise) might be quite problematic, forcing us to use sources of information such as e.g. Wikipedia, that seems to be providing accurate information on the matter of subject. I dare to make this decision, because the website provides a lot of empathy on the minor (or sometimes possibly no) differences between the various terms and disciplines. Also, as we will later see, systems such as Wikipedia resonate to a great extent with CSCW endeavours.

CSCW is truly a constantly evolving research field, however, it gives us some goals we can hold to. It identifies core-dimensions of collaborative work as following:

- *Awareness*: individuals working together need to be able to gain some level of shared knowledge about each other's activities.
- *Articulation work*: cooperating individuals must somehow be able to partition work into units, divide it amongst themselves and, after the work is performed, reintegrate it.
- *Appropriation* (or tailorability): how an individual or group adapts a technology to their own particular situation; the technology may be appropriated in a manner completely unintended by the designers (Wikipedia, 2017).

These concepts stem from various analysis conducted by many researchers in the field, both from a theoretical background as well as from studies of existing systems like Wikipedia.

What also makes CSCW goals and any making any sort of conclusions rather difficult is the complexity of the domain. With various projects aiming at solving different needs in diverse teams, any slight dissimilarities between expectations, aims and the real adaptation of the final system will lead to uncertain results. Simply put, so many variables in the play make it very difficult to get us anything so convincing and tangible as we'd wish.

Other terms and disciplines

As mentioned before, CSCW can sometimes overlap with various other disciplines, or branches off, creating an entire sub-division of many other, identified as separate, domains. We won't go through all of them and we won't even go deeper into explaining them, because in my opinion, it

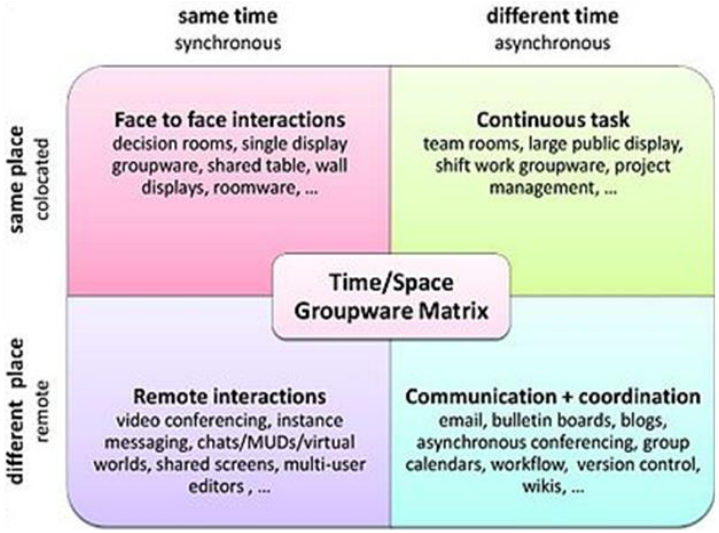
doesn't really benefit us now if we'd do so. The various disciplines, among others are: collaborative software, groupware, collaborative working environment (CWE), collaborative working system (CWS), collaborative innovation network (CWI). All of them somehow relate with CSCW, focusing on different aspects of the collaborative work.

CSCW more in depth

In the next paragraphs, we solely focus on CSCW and explain some if its core ideas applicable to building real systems, thus leading us towards existing projects, understanding them and how they relate to CSCW.

CSCW matrix

Conceptualizing CSCW systems can be done in many different ways. One of the most common ones is to consider use of the system. The CSCW matrix was first introduced in the late 90's. We will use this division in the next chapters to help us identify the "international" and "future" elements of collaboration.



CSCW matrix

The matrix works with 2 dimensions: x-axis representing weather collaboration takes place at the same time, or asynchronously. Y-axis decides if collaboration is co-located, or geographically distributed.

Following the matrix, we get 4 main divisions of collaborative systems:

- same time/same place
- different time/same place
- same time/different place
- different time/different place

(Wikipedia, 2017)

We will focus more on the 2 bottom parts of the matrix (different place/same time and different place/different time). One would argue that funneling our efforts into looking only there would

suffice. It's very tempting to interpret international work as something happening at different places, completely ignoring the upper part of the matrix concerning with geographically co-located sites. But what about language dissimilarities or culture differences?

With the matrix explained and clarification of possible misunderstandings, we will take a look at each of the parts separately and see what technology/system/solutions they offer. Along with that, we will also expand that matrix. Adding a third dimension – time, which will depict the future of the collaboration in regards with that particular matrix part. The last criteria is a focus on the international domain, precisely how each of the innovative technologies relate with it and how can they benefit it.

Same time/same place

This kind of collaboration can be understood as a "face to face interaction". The collaborating teams are located at the same time at the same workplace such as an office, room or specialized workspace. Technologies that can be used for better support and performance are roomware, shared tables, wall displays, digital whiteboards, electronic meeting systems, single display groupware and group decision support system, among others. We are not going to challenge each of those solutions, let us rather look what could be done on the international field and its future. I identified a couple of problems one needs to deal with.

Language dissimilarities

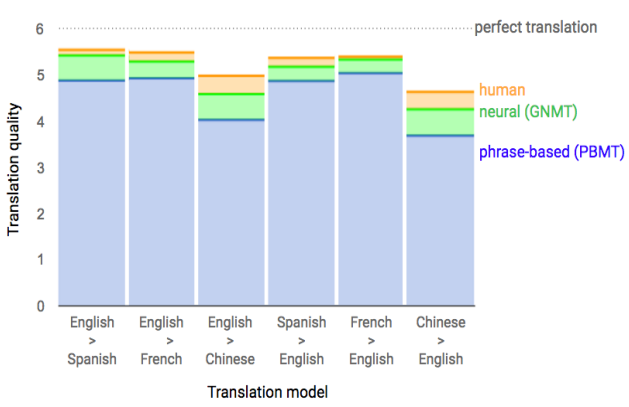
Having hundreds of languages spoken around the world, the people collaborating together may sometimes run into the barrier of language dissimilarities. Surely, most of the times, if we have heterogeneous teams (nationality-wise) working together for a longer time, they choose a mutual communication language, which is most commonly English. But in other cases, there could be exceptions. Then we need a real-time language translator with speech recognition to help us out. Examples of currently existing software solutions are Google's Google Translate or iTranslate Voice developed by Apple. Those applications can be used on various handheld or desktop devices, iTranslate Voice limited to the Apple's iOS. The results are promising enough to support basic interactions. However, there needs to be a lot of work done on the field of recognizing multiple voices and improvement of quality of the translation.

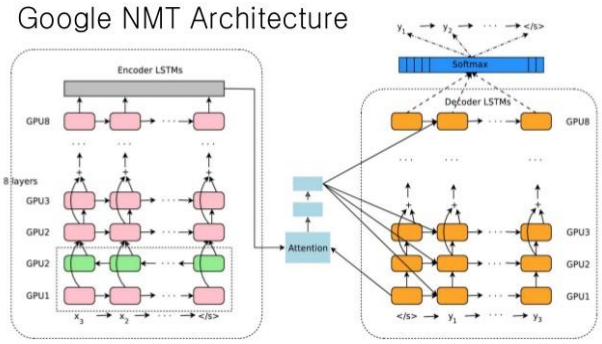
Regarding the quality of translation, there is a big issue with semantics. Every single language has its own specifics that cannot be translated by a trivial set of rules applied to them, unless the set is completed with special cases, such as idioms, that help the translation to have the very same or as indifferent meaning as possible. This would require massive expansion of the translator's vocabulary, very difficult to be accomplished by one subject. Luckily enough, thanks to the Internet, we can take advantage of 2 major tools: machine learning and crowdsourcing. We will look at each of those at an example of Google Translate, which is in the lead of innovation in the field.

Machine learning

In November 2016, Google changed its engine to the Google Neural Machine Translation (GNMT). The former phrase-based engine (PBMT) translated sentenced piece by piece, which resulted in often mismatches in translations and a quite insufficient accuracy. The new engine uses a large neural network and translates the sentence as a whole. The neural machine translation (NMT) uses deep learning and representational learning. GNMT improves quality of the translation by applying example based machine translation (EBMT) – basically meaning, it

learns from other examples, de facto from millions of documents on the Internet. As the neural network processes more and more data, its quality gradually improves. Also compared to the former engine, GNMT is now able to do a zero-shot translation. This means the source language can be directly translated into a target language (formerly it was necessary to translate the source language into English and from there to the target language). Nowadays, it seems that deep learning is the number application, especially after the breakthrough in the real use of deep learning and artificial neural networks (solving the vanishing gradient problem) and subsequent development in the field. As speed of the neural networks improves and engines will have had time to learn more, quality of translations is expected to reach at least human level translation. The next challenge will be to reach a level of translation surpassing an average human being proficient in the field.





Google NMT architecture

Crowdsourcing

The second option for improvement of the system's accuracy is crowdsourcing: the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers (Merriam-Webster). As an example, Google Translate allows you to add your version of the translation, if you think yours is better or more accurate than the provided one. In that way, since the application is being used by millions of people on a daily basis, the amount of data acquired is sufficient enough to have a great impact on the improvement of the usability of the tool.

What does it help to our case? When that kind of translation precision is achieved, effectiveness of collaboration is improved massively, leveling with a pure human to human interaction where homogeneous language is used.

Cultural differences

Conducting any kind of subsequent collaboration requires people to understand each other as much as possible, both on a human and a problem domain level. Regarding the human level, cultural dissimilarities can play a huge role and elimination of any sort of problems can have a huge payoff.

Therefore, future tools dealing with quality of human interactions (interpersonal skills) can be added to other systems and technologies such as optical head-mounted displays. These will help us dealing with differences in manners, ethical questions or communication in general.

Different time/same place

These are scenarios covering working on any kind of continuous task. Technologies used for effective collaborative work here are: team rooms, large displays, post-it, warrooms.

Regarding international collaborative work, it is very similar to the same time/same place instance. Change of the time dimension of the matrix doesn't give us anything new to work with. We need only small adjustments to cover possible problems and reach some improvements. Language-wise, our translations need to be stored somewhere in a form of text or a translated voice record. The aforementioned tools already incorporate those needs. Apart from this, there is nothing major I can think of, that would be relevant discussing.

Same time/different place

Electronic meeting systems, videoconferencing, real-time groupware, messaging (instant messaging, email, chat) and telephoning are the prominent means of a remote interaction. The change in the location dimension gives us many more ideas to work with, that we can elaborate on, especially in a context of international collaborative work.

With improved networks over the past 15 years, this kind of collaboration became more efficient than ever before and enabled teams to take advantage of new technologies like instant messaging and videoconferencing that are nowadays considered to be de facto status quo.

If we talk innovation here, let us focus on more exotic ideas, rather than on improving Internet speed to deliver higher-resolution image or discussing increase in use of video-calling in general. In my opinion, it is inevitable technologies like augmented reality, virtual reality or later brain-computer interfaces will become the new standards. My statement is partially influenced by the Gartner company, which every year releases a prediction of future technologies. They estimate how long it will take the technology to become de facto standard and how successful it may be. Augmented and virtual realities have already been part of their predictions since a couple of years.

Gartner hype cycle 2016

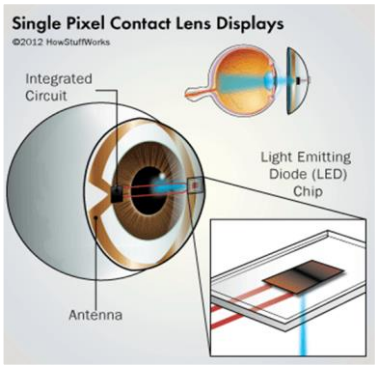
Augmented reality

Augmented reality has started peeking out a few years ago and during the last 2 years it has started to find a real use in cooperative environments. I think it will still take approximately a decade until it becomes as common as the current technologies. It will enable teams to increase their work productivity and will introduce a new set of possibilities of collaboration, for instance augmented working spaces or new ways of prototyping. It will also improve creativity, as more complex ideas will be easier to translate to something tangible.

As an example, we can think of an improved videoconferencing using groupware such as eyeglasses or optical head-mounted displays. In fact, at the Hochschule Furtwangen in the research department, it's possible to use Microsoft HoloLens for video-calling. With the HoloLenses mounted on one's head, the other person can see via the video the exact image the other person can see. This offers many improvements for collaboration in manufacturing and repairs. For example, consider a scenario when a person in China doesn't know how to fix a chainsaw. With the HMD (head-mounted display), he can provide an engineer in Germany with a real-time view of the broken chainsaw. The engineer can clearly see what's happening, can instruct the person and help him fix the problem, without the need of him being physically present thousands of kilometers away. However, this was just one simple example of what augmented reality can bring us in the international collaboration work field.

Later in the future, instead of HMDs, we can expect devices such as bionic contact lenses. Using infrared lights, they can provide an augmented reality. A micro lens (fresnel lenses) have to be applied to enable the digital image to reach retina. Apart from this challenge, there are many others (thickness of the lenses, chip width, safety, antenna size etc.), that complicate the development process. So far, this technology is being researched and developed in labs. Its safety and harmlessness has been successfully tested on animals.

Microsoft HoloLens



Bionic contact lenses

Virtual reality

One step forward is virtual reality. In this way, considering a fully-immersive experience, for instance engineers will be able to virtually see complex 3D maps or operate in them with their co-workers. The set of possibilities seems to be endless here, once we realize we can basically generate anything we want – workspaces, employees, technology, situations and scenarios etc. Tasks like virtual prototyping that utilizes computer-aided design (CAD) will become widely-available.

The first attempts to create a virtual reality device dates back to 1950's, but it only became a buzzword after the release of Oculus Rift in 2010, created by Palmer Luckey. After then companies such as Samsung, Sony, Google or Facebook started vehemently investing into the virtual reality technology. Nowadays, there are hundreds of businesses developing it. Facebook has recently released a beta version of Facebook Spaces, which allows users on Facebook to connect in a virtual reality, with a possibility of creating virtual workspaces and interacting within them not only with the environment, but also with other users. This allows teams to set up their offices anywhere they want, with members geographically dispersed around the world, thus significantly improving on the current videoconferencing tools.

Technology-wise, most of the produced devices now support a built-it dynamic binaural audio system that enhances the audio experience by placing sound sources anywhere in 3D space. It's also nowadays relatively expensive for companies to acquire the technology on a bigger scale. Therefore, due to all the technical and economic challenges, I think we should expect the technology to become standard in work environments within the next 10-15 years.

VR glasses

Facebook Spaces

Other real-time groupware

This would include various other technologies that can improve collaborative work in the future. We can consider advanced motion-tracking devices, enabling for instance hand-gestures to be used for more complicated tasks than nowadays possible. There are being developed many tools with different technologies, but they are mostly to be found only in research labs. Their accuracy as well as usability is lacking the precision and ease-to-use to become widely used. All of this is closely related to virtual reality, as some of the tools can be used with it together.

Looking more in the future, brain-computer interfaces will probably start emerging in the next 50 years. This kind of technology would allow us to translate our ideas even more efficiently, making any barriers in geographically dispersed collaboration almost non-existent.

Different time/different place

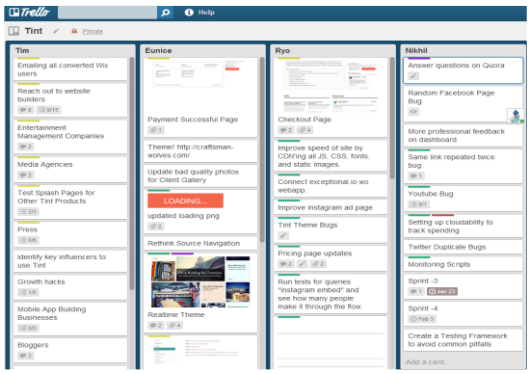
The last type of collaborations takes place asynchronously and is distributed geographically. We are talking about communication and coordination. Concurrent technologies representing this situation are electronic meeting systems, blogs, workflows and version controls.

Current solutions

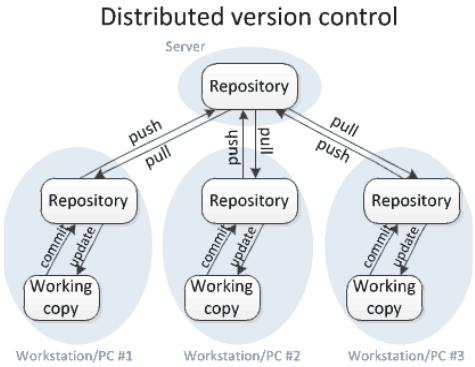
Online version control systems have lately become very popular, especially in the field of computer science and programming. However, there has also been an increase in optionality

those tool offer – companies got quite comfortable working with them due to their easy adaptation as well as efficiency. An instance of a very popular version control application is Git.

Among others, project management applications such as Trello or Slack provide a powerful control over projects and improve team collaboration. They can host various kind of multimedia data, provide history of changes, voting, profiles, multi-threading, etc.



Trello dashboard



Version control flow chart

Innovative solutions

I don't see that much of an improvement regarding structure of the applications. Project boards and version control systems are intuitive, straight-forward and well thought-out. Where I see possible improvements or disruption is in the way those solutions are available for the teams via innovative groupware such as augmented reality or virtual reality devices, discussed in the previous part.

Challenges and advantages

CSCW if used in the right way can bring us a lot of value. However, that's the problem – "used in the right way". As we said in the beginning, there have been a lot of problems with results quantification and solution usefulness due to the complexity of the domain.

Challenges

Any kind of CSCW tool or environment brings up many challenges both for users as well as for developers.

Users

From the users' perspective, one of the issues is adaption of the tools. As many solutions improve our work, one needs to consider, that it takes time and effort to adapt something new. Designing a too complex tool (time adaptation-wise) with just a little payoff will generate more work than without implementing it. Also, there is a requisite critical mass for the groupware to be of any use. Other problem for the user is a decrease in creativity. Some software might help us to ease collaboration, au contraire it can be too restrictive/lacking appropriate tools to allow a user fully express her ideas. And what about intergenerational groups? Solving cross-generation gaps in virtual teams is another difficulty we have to deal with.

Developers

Therefore, developers and researchers have many tasks to do to overcome the aforementioned issues. Firstly, I would say the most important one, is to understand the users and identify their problems and needs clearly with as much empathy on the cause as it's humanly possible. If this step is not executed properly, the rest of the work is pretty much useless. Closely in relation to understanding those basics is creating a well thought-out interface. Interface here in its essence defines how users interact and how they collaborate. As CSCW is an interdisciplinary field, there are many other factors coming into play. That's the reason why many of created groupware fail. There are simply many pitfalls developers can step into. What also makes development of such tools very difficult is the strenuousness of data quantification in the domain.

Advantages

While CSCW field brings a lot of challenges, it certainly provides many advantages, as well. Teams working together don't have to be location dependent. They can work asynchronously and communicate via more threads simultaneously, which increases work efficiency. Companies save costs, for instance with virtual teams, renting offices, parking and electricity becomes irrelevant. Commuting time for employees is also saved.

Projects in Germany

Since this paper is written in Germany, let me mention a couple of projects that have been developed here. All of them account to Fraunhofer FIT, an institute for applied information technology. Their research department of cooperation systems is a world-leading department on the matter of subject and has developed a lot of successful projects.

BSCW (Basic Support for Cooperative Work)

The goal of the project is the development and enhancement of the BSCW Shared Workspace System which provides facilities for collaboration over the Internet and the WWW in particular. A primary goal of the project is to achieve cross-platform interoperability (at least across various Microsoft Windows versions, Macintosh OS and various Unix flavors) to enable cross-platform and cross-organisational cooperation, e.g., in locally dispersed communities.

The BSCW system is based on the notation of a shared workspace, a joint storage facility that may contain various kinds of objects such as documents, tables, graphics, spreadsheets or links to other Web pages. A workspace can be set up and objects stored, managed, edited or downloaded with any Web browser. The BSCW system will keep the members of a group informed about each others' relevant activities in a shared workspace (Fraunhofer FIT, 2017).

SAGE

SAGE is another project from the Fraunhofer institute. It's been coordinated by Wolfgang Gräther, who is one of the leading figures in Germany in the collaborative systems field.

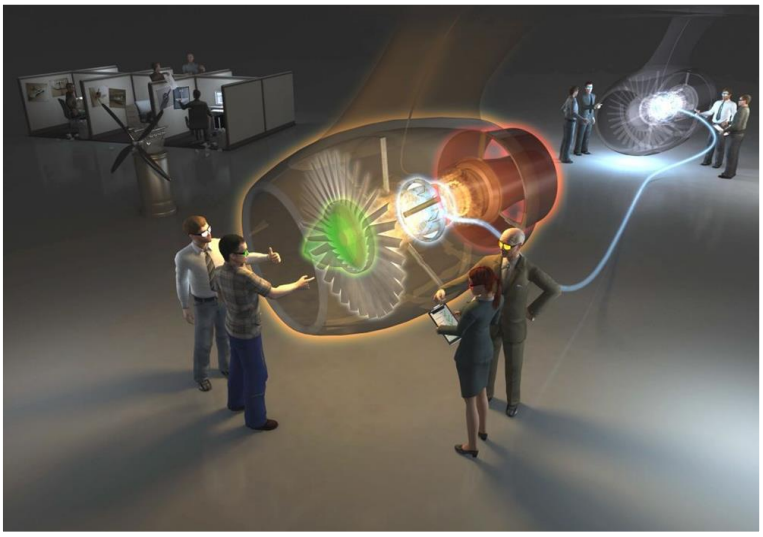
The SAGE platform provides efficient web-based functionality for self-organized cooperative task management.... In SAGE, a task is the basic element in coordinating design and development processes. A task provides a rich context that includes working materials,

communications functions and collaboration functions. Team members may create task objects, add necessary descriptions and related information, set up a discussion or poll the team members. Tasks may be combined in flexible networks and defined as elements of a higher-level process.

Coordination is assisted by the traffic light model, flexible time management and automatic detection of work progress. In addition to personal task lists, services at the team level keep the teams up-to-date on current and past activities, help to keep an eye on critical tasks and let the team react immediately to the requirements of their work processes. Team membership - and thus access rights to the information of the task objects - can be re-assigned dynamically, should the need arise (Fraunhofer FIT, 2017).

Other projects

Fraunhofer FIT has been working on many other projects solving various collaboration issues, for instance CoSpaces coordinated by Dr. Leif Oppermann (Fraunhofer FIT, 2017). The whole list can be found here: https://www.fit.fraunhofer.de/en/fb/cscw/projects.html.
Another successful trace the institute has is ICIDO, which is a German company developing virtual reality solutions in manufacturing, whose origin tracks back to Fraunhofer FIT http://virtualreality.esi-group.com/.



ICIDO virtual reality solutions

Conclusion

International collaborative work is a very complex domain, which will have an interesting future, as we have seen. In the beginning, we explained what a collaborative work is and how can we categorize it. Later, we defined four various fields, a sub-division allowing us to study real examples of different technologies concerning the matter of subject, especially cooperation of teams on an international scale. We also hinted at a few innovative solutions, along with projects, that are being worked on in Germany. Lastly, we looked at some challenges and advantages collaborative work presents us with.

Goal of this research paper was to present to the reader innovation in international collaborative work. Due to the complexity of the field, I introduced the topic on a more general scale and only then started elaborating on single solutions. As the domain is quite large, covering any kind of the examples would exceed the paper limit. Therefore, it serves more like an overview in regards to the status quo as well as to the innovative technologies. I focused on discussing ideas translatable into real tangible results in the near future, limited by approximately 50 years overhead. Super-advanced brain-computer interfaces or AI were not discussed, as they go beyond the topic of the paper. None-the-less, the field of international collaborative work can expect a very promising future full of improved systems and devices helping us to cooperate more effectively and efficiently.

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