# Tele-Board: Follow the Traces of Your Design Process History

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**Abstract** Introducing digital tools to creative work settings is challenging; capturing creative work and conveying design ideas to absent team-members is even harder. In this article we show a new way of saving and presenting creative work data that enables users to browse through past design activities. We extended our existing Tele-Board system – previously intended for real-time design work at different locations – with functionalities for time-delayed interaction. The "Tele-Board history browser" is a web-based user interface offering functionality to go back and forth in the timeline of a whiteboard. Additionally, it is possible to view the whiteboard's usage statistics to gain insights on creative work. With our tool we can support design teams in fulfilling their common tasks more efficiently in dispersed teams and we can also assist design researchers to understand how designers work in an all-digital setting.

## 1 Collaborative Design Across Distance and Time

Design Thinking and creativity methods make use of analog, tangible tools, artifacts and methods [1].

The extensive use of sticky notes, whiteboards, walls, pens, all imaginable handicraft objects, role-play and storytelling is substantial. Bringing together the insights on research and different perspectives of a diverse team are key factors of successful design work.

Being sure to incorporate different cultural aspects as well, such as input sure to incorporate different cultural aspects as well, input from international team members is important.

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But how can teams reasonably utilize the above-mentioned analog tools if people are geographically dispersed and time zones separate them by several hours?

Can digital equipment support Design Thinking teams when they are not located at the same place?

To answer these questions, we developed the *Tele-Board* system, which provides the possibility to work creatively over distances and all the same retains the feeling and working modes of traditional tools [4]. People can work with whiteboards and sticky notes as they are used to and additionally have the advantage of digital functions that don't exist in the analog world. For remote settings, all whiteboard actions are synchronized automatically and are assigned to every connected partner. To facilitate a really interactive session we included a video-conference between the distributed team: the translucent whiteboard is an overlay on top of the full screen video of the other team members. This setup lets everyone see what the others are doing and where they are pointing. Additionally, you can see their gestures and facial expressions (see Fig. 1).

But as we learned from feedback on this prototype, it is not only important to enable synchronous working modes for distributed design teams, but asynchronous collaborative work as well. To address the problems of Design Thinking teams who are working asynchronously over distances, we developed the *Tele-Board history browser*: a web-based interface that provides the opportunity to go back and forth in the timeline of a whiteboard. It enables designers to view the collected data from different perspectives and thereby gain a deeper understanding of the project context. Additionally, it supports the team to analyze the overall project progress

**Fig. 1** Working remotely with the Tele-Board system

and decision paths taken by the respective distributed sub team or by the team itself in an earlier project phase. The team can also continue at any past state by duplicating the whiteboard content, i.e. starting a parallel session. All data is persisted implicitly, meaning that the user has the freedom not to think about saving data. Furthermore, it is possible to view the whiteboard's usage statistic to gain insights on how the designers work. Important areas on the whiteboard (hot spots), time periods with a lot of interaction or different project phases can be detected when analyzing the collected data.

In this article, we describe the general architecture and setup of the Tele-Board system and how it can be used for synchronous work as well as for asynchronous work. We present a novel way of capturing creative work data and thus enabling others to understand the evolution of a design team's work. Furthermore, Tele-Board and its new history function give unlimited possibilities in easily analyzing and evaluating how creative teams manage their work and how innovations arise.

## 2 Translating Creative Work to the Digital World

The Tele-Board system is an electronic whiteboard software suite, which works like a traditional whiteboard: you can write and draw on the whiteboard surface and – if you are not really satisfied with your work – erase all of your scribbles afterwards. Additionally you can write digital sticky notes: on tablet PCs, an iPad, smartphones or directly on a whiteboard, just as you prefer. You can move the created sticky notes, edit and resize them or group several sticky notes in a cluster. All of the mentioned actions are synchronized automatically and propagated to every connected whiteboard. Every user can manipulate all sticky notes and drawings, no matter who created them. This is a major advantage compared to *Clearboard* [5] and *VideoWhiteboard* [8] where you can only edit your own whiteboard marks.

To facilitate a real interactive session, we included a video-conference feature for distributed team members. The whiteboard can be displayed as a translucent overlay on top of the full screen video of the other team members (see Fig. 2). This setup gives the opportunities to see what the others are doing, where they are pointing and what gestures and facial expressions they are making. The flexible architecture of the Tele-Board system makes it possible to start the whiteboard software on every computer. Thus you can use it with all kinds of pointer input hardware – such as interactive whiteboards, interactive projectors or tablet PCs.

### *2.1 Projects and Panels*

All activities in the Tele-Board software are centered around *projects*. A project can comprise different phases in a design process and can last several months. Applying design thinking methodology in a project often involves a fixed set of analog whiteboards that will be filled with sticky notes and handwriting over

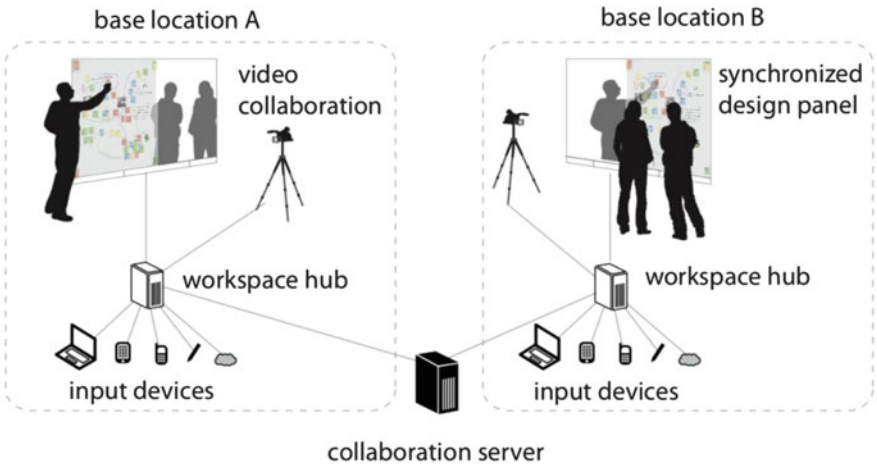


**Fig. 2** General setup of the Tele-Board system

several hours or days. Later, these whiteboards will be photo-documented, cleaned, and used for new content. The digital pendants of these physical whiteboards are called *panels* in the Tele-Board system. Panels do not have to be cleaned after being used, but can be archived and restored. Moreover, an unlimited number of empty panels can be requested.

In an ideal setup, panels are viewed and modified with the help of interactive whiteboard hardware, which can be connected to any computer. Decoupling whiteboard hardware and the whiteboard's content adds flexibility, as fewer – potentially only one – electronic whiteboard is needed to replace a traditional setup with analog whiteboards. In addition to direct manipulation of a panel displayed on an electronic whiteboard, Tele-Board allows for indirect user input from different devices, such as mobile phones or laptops, preferably with touch or pen input (Fig. 3).

## *2.2 Tele-Board Components*

The mapping of the Tele-Board data model on different hardware devices is achieved by using the Tele-Board software system, which consists of four components: a *Web application,* a *whiteboard client*, a *sticky note pad*, and a *server component*.

### 2.2.1 Web Application

The *Web application*[1] serves as the entry point to the Tele-Board system: users can browse and manage projects and associated panels. Here they can also start the

[1] http://tele-board.de/


**Fig. 3** Tele-Board and its components (from *top-left* to *bottom-right*): StickyPad on iPod touch, whiteboard interaction, StickyPad on tablet PC, web application, screenshot of the whiteboard client, editing with a laptop computer

whiteboard client and work on the panel's content. Users only need to click the "START" button and the whiteboard client software is started from the browser. It is not necessary to install the software, which makes it easily accessible from any computer.

### 2.2.2 Whiteboard Client

The Tele-Board *Whiteboard Client* is developed in Java, as we were looking for a platform independent solution. Its main functions comply with standard whiteboard interaction: writing on the whiteboard surface with pens of different colors, erasing, writing sticky notes. Additional functions as panning the whiteboard surface, cut and paste, clustering and deleting elements enhance the working experience.

If no special devices are connected, the client takes the mouse input of the computer. For an optimal performance of interactive whiteboard equipment or tablet PCs we created an abstraction layer that can be the connection with programming interfaces (APIs) of different devices as e.g. the SMARTBoard API or the tablet PC API.

### 2.2.3 Sticky Note Pad

As an equivalent to paper sticky note pads we created different applications for writing sticky notes. The Java application is ideal for tablet PCs and other pen input devices. For fast finger input you can use the dedicated App on an iPad, iPhone or iPod Touch.

### 2.2.4 Server Component

The *Server Component* coordinates all communication between the remote partners. All interactions are transferred in the form of XMPP messages to keep the connected whiteboards synchronized. For advanced saving and resuming possibilities we extended the Server Component with additional functions (see Sect. 3 for details).

## *2.3 Video and a Translucent Whiteboard Surface*

Remote collaboration on electronic whiteboards benefits from an accompanying videoconference showing the remote team interacting with their whiteboard. Without video, whiteboard interactions by remote team members appear as if made by a "ghost hand". For the current implementation we decided to use Skype because of its popularity, proven reliability and ease of use. However, Tele-Board can be used with any third-party video conferencing software. Instead of separating video transmission screen areas from whiteboard content, the Tele-Board whiteboard client can act as a translucent overlay on the video conferencing software to give the impression that the remote party is directly interacting with local whiteboard content.

The video cameras should be positioned next to the electronic whiteboards, capturing the foreshortened whiteboard and the people in front of it (see Fig. 4, angular position). Using this configuration, people can face the whiteboard and the camera at the same time. However, this introduces the trade-off that due to the camera angle on the electronic whiteboard the screen area of the whiteboard client is roughly reduced by half. Another possible setup uses a camera position directly in front of the whiteboard, capturing the whole whiteboard surface almost without any skewing and no loss of whiteboard space (see Fig. 4, orthogonal position). The person standing in front of the board is shown from behind. Eye-contact is

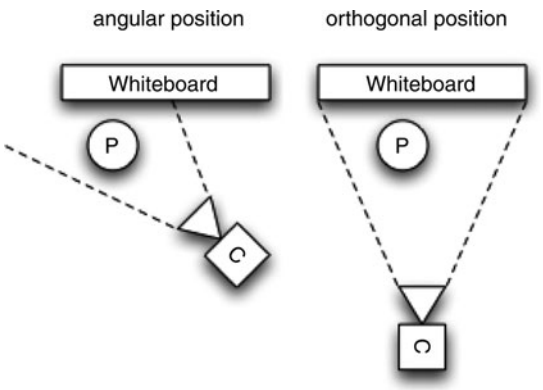


**Fig. 4** Different camera setups; *left*: split-screen setup, *right*: full screen setup

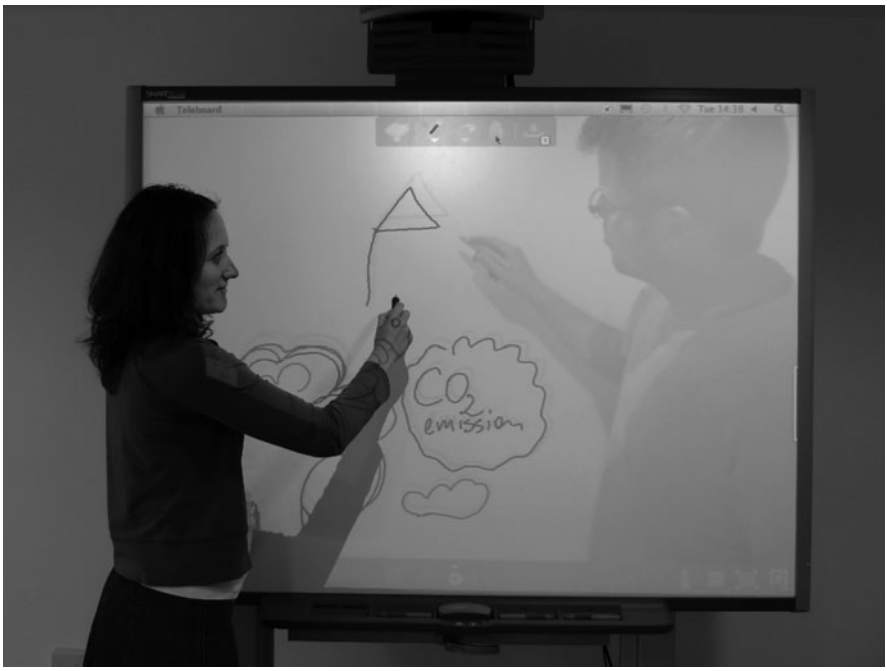


**Fig. 5** Full screen video overlay setup (orthogonal position)

limited with this setup, but for the perception of pointing gestures, this setup is ideal (see Fig. 5).

The above mentioned functions of the Tele-Board system enable people – especially designers in a d.school-like environment – to work synchronously in a way they are often used to. However, we learned from user feedback and interview that people in remote teams are working asynchronously most of the time. To support these working modes as well, we developed a solution that helps teams members who cannot be connected at the same time to understand what the others were doing and easily hand over their work. The next section gives a detailed description of the "history" part of the Tele-Board system.

## 3 Tele-Board History

Many digital whiteboard tools already exist. Most of them are designed for being edited locally, some of them support synchronous settings over distances, but hardly any of these tools is able to support asynchronous working modes. However, the asynchronous scenario is one of the most crucial elements of collaboration within companies. Teams are often distributed over several time zones.

Collaboration starts with understanding and retracing work that has been done by the other team members in order to come to a common understanding within the team. Many solutions offer save and load of a whiteboard state, but only the latest state is kept and no history stays within the system. As one of the few exceptions, Klemmer et al. implemented the possibility to go back to different states and even try out parallel interactions from a certain (decision) point within the whiteboard's timeline [6]. However, the authors point out, it is sometimes problematic to reconstruct certain whiteboard states as their system is based on paper sticky notes (which are partly digitalized) and degenerated states can occur.

Often users bypass this problem by manually creating a file archive and use a conceived numbering scheme to keep track of crucial changes. If a solution kept all changes- which were made for an artifact and the whole document- instantly, this could help understanding what has happened and to better build upon the team members' insights and ideas. This behavior also includes the freedom of not having to worry about explicitly storing and loading the content and thinking about the "right" moment – without saving too frequently or too infrequently.

It is crucial for team interaction to understand what colleagues are doing and when they make certain decisions. Navigation through different whiteboard states and continuation of work at any previous point in time must be easy. A digital whiteboard solution can also offer the possibility of extensive and partly automated documentation. In traditional whiteboard settings it is time-consuming and troublesome to take detailed photographs after work is done. Written documentation for stakeholders and customers has to be prepared additionally. Another argument for the importance of an implicit documentation is the statistical relevance for people researching on teams and how they design over distances and time differences. Various questions could be answered using the history data: What is the main working time of the employees? How can the output become measurable? Not only design researchers could be interested in this information, but also the designers themselves would profit from gaining insights into key factors of their creative work.

## *3.1 Message Capturing*

To address the mentioned challenges and realize the necessary functionality we extended the Tele-Board system with three main functional units:

- Interception of message flow
- Storage of communication data
- Enabling interaction with the history data in an appropriate user interface

The communication data should be captured on the fly, which has influenced our selection of technology insofar as it must be possible to analyze packets separated from the message routing [3]. The message server and its plug-in architecture, the

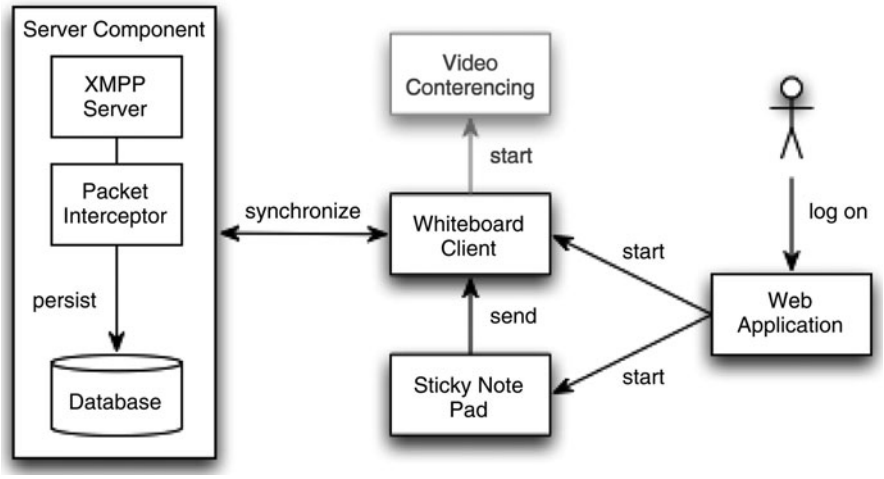


**Fig. 6** Conceptual component model of the Tele-Board system

web-based management system, and the database management system represent central roles in the overall system (see Fig. 6).

The history functionality is a concept that is implemented as a crosscutting concern in all parts of the system. It cannot be realized as one single component. A central history archive is used to keep all data together in order to analyze it conveniently and enable asynchronous work. An interceptor was realized as a plug-in within the communication server. This so-called *Server-Buddy* plug-in thereby captures all incoming packets and stores them in a database. This allows the immediate analysis of the communication flow.

*Panels* and *Projects* in the Tele-Board portal are mapped to the corresponding concepts in the Tele-Board history, which have been described earlier. A Panel describes the sequence of events executed on a whiteboard in the temporal order of these events. Therefore, an event is a set of attributes describing which action has been undertaken and where, by whom, and when. Each event has an operation code, which can be NEW, CHANGE or DELETE to describe the event type. A Project is the collection of multiple Panels that can be configured to require certain access permissions to edit/view/delete.

## *3.2 User Interaction Points*

Basically there are three major groups of users interacting with the developed system: the designer working on the whiteboard content, a manager tracing the design activity of the designers, and a design researcher who seeks to gather insights on how the designers worked. Designers and managers care more about what has happened, design researchers are more interested how the interaction took

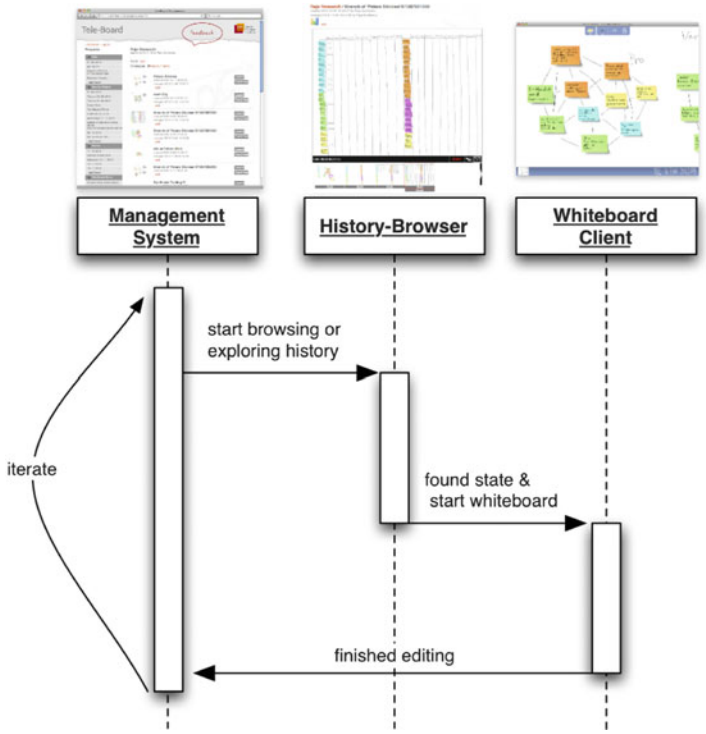


**Fig. 7** User interaction points with the Tele-Board components

place. Indeed, there are large overlapping areas between these three activity categories.

Figure 7 shows the components that are interesting for understanding the interaction process. There are three main points, where users can interact with the system. The first one is the web-based management system. The user logs in at the web portal and browses through Projects and Panels in order to get an understanding of past design sessions. Embedded in the web-interface is the History-Browser. It is a user interface enabling people to go back into the history of a Panel. A user can immediately see changes between points in time by switching between the screenshot images of the whiteboard content. By scanning through days, hours, minutes or even seconds, differences can be found immediately. While searching for a certain series of events you can drill-down into the history of the Panel. At each level users only see time intervals when action took place.

The third component is the earlier described Whiteboard Client. This is the main component for synchronous whiteboard use, as design teams will spend a lot of their time creating content with this interface.

Every single component has very special needs in terms of user interface development, data structures, and communication methods. So it was an important decision to use the Extensible Messaging and Presence Protocol (XMPP) as a

communication protocol, because a variety of input devices and different platforms should be supported. XMPP is an open standard and is typically used as a chat and instant messaging protocol. Over time it has been extended to support voice, video, and file transfer. Authorization, session and roster handling is managed by the server. People can connect with every possible client without transferring any configuration data from client to client except for username and password.

Technically, all communication is routed over the XMPP server. In terms of XMPP, the whiteboards "chat" with each other. All XMPP-Clients producing text-based sticky notes or other whiteboard content (including whiteboard clients) direct their messages to a chat room, which reflects a specific whiteboard. From there, messages are distributed automatically to all connected whiteboards.

XMPP as a communication language between the clients turned out to be very appropriate. The development of the whiteboard clients can rely on a sophisticated infrastructure e.g. for user handling and message routing, as part of the existing protocol. The chat messages between the Whiteboard Clients contain an XML-encoded text representation of a single whiteboard element.

The History-Browser is the tool, which enables users to browse in the archived whiteboard data. It is possible to go back in the timeline of interaction and reproduce every point in time of a collaborative session. This application is visually part of the portal interface, but logically separated from it. The aim of this application is to show users how a Panel has developed over time. It offers a read only view on the whiteboard content and offers an entry point into existing whiteboard sessions.

The current version of the History-Browser is the result of an iterative development process. The first versions used a time-synchronous approach to display the history data. It turned out to not always meet the user expectations, e.g. when working on a Panel for an hour on one day and a week later for another hour, the timeframe with no interaction at all took most of the screen area in the user interface. We decided to only show those periods with available interaction data to make navigation more convenient and leave out unnecessary parts without losing the information of a longer gap between two sequences. There are several temporal zoom levels for adjusting the amount of detail that is shown. The user can switch between units of days, hours, 10 min, 10 s, and even single seconds.

When the user has navigated to an interesting state, currently two options are offered: to resume or branch a Panel and comment or email an interesting point.

From a technical viewpoint, resuming is only possible at the end of a whiteboard session, because everything that is recorded lies in the past and cannot be modified without changing the ongoing events. In the user interface this limitation does not exist anymore. Users can resume virtually every whiteboard state by branching from any point and resuming the created branch.

The History-Browser is a very valuable tool, when finding certain points in time and retracing activity on a very detailed level. This is especially useful when a user – who was already participating in the design session – browses the history. Besides this interactive History-Browser, we developed an additional application that renders a movie from a series of screenshots. The still images are taken from every point in time when action took place. Thereby, every interaction can be

seen in the video. This movie playback is a more passive way of exploring the history towards an overall understanding of an unknown session. The user can later explore the history more detailed and with a better temporal classification of the content by using the History-Browser.

### *3.3 Statistics*

"How do designers work?" is a typical design research question. To be able to answer this question, continuous observation is needed towards a deeper understanding of how designers carry out their activities. Previous approaches such as iLoft [7] or the Design Observatory [2] use elaborated techniques and tools to capture the behavior in the room where the observed designers work. A reported disadvantage is the fact that these observation instruments can lead to distraction of the design activity. By implementing the observation instruments as a part of the tools designers actually use, this distraction will be eliminated and they can even benefit from the digital enhancements, such as resuming existing sessions.

A major drawback of the previously mentioned approaches is that they often only capture an image stream of the interactions. There is only little context information available and large effort has to be spent on the manual analysis of raw material. With an all-digital solution, this process can be automated for the most part. It also offers the possibility for immediate feedback loops because analyses take less time. This can lead to faster iteration cycles for experiment setups and better results in the end.

Designers can also benefit from statistics of their work. With a distant view to past work, they can replay what has happened and come to further insights for their future work. It also enables the participants in asynchronous settings to better evaluate their personal contribution to the design task and also better value the work of colleagues (Fig. 8).

First analysis of the history data visually revealed structural connections between certain Panels. To fulfill strong statistical criteria, the categorization algorithms have to be refined. Preliminary results therefore outline what kind of

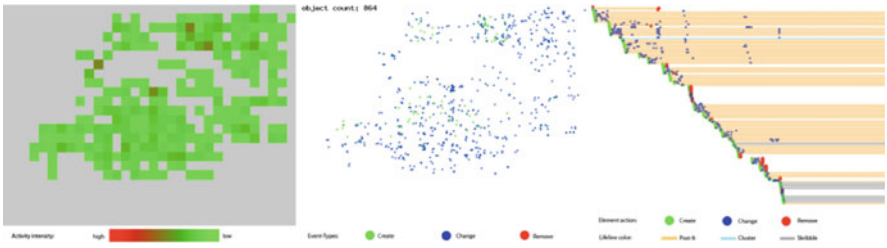

**Fig. 8** Example analyses of the history data on different parts of the system: whiteboard usage areas (*left*), whiteboard events (*middle*), whiteboard elements (*right*)

statistics will be possible in the future. The data can be used for several applications such as an overall search function or recommendations within the portal. By analyzing the processes, important points of the whiteboard content could be made easily accessible in order to highlight the most important points. The definition and extraction of outstanding phases in the sessions could also lead to a compact report for an asynchronously working colleague by automatically giving hints on which points in time would be more valuable than others.

There are different perspectives on how the history can be analyzed; three of them are shown in the following.

### 3.3.1 Spatial Analysis

One of the most intuitive ways of analyzing the whiteboard content distribution is a map of the content. Hotspot analysis of activity on the whiteboard surface shows high activity regions, e.g. caused by creating and moving sticky notes or the creation of sketches. Another aspect of interaction that can be evaluated with our system is the panning interaction on the whiteboard. Patterns in whiteboard content distribution lead to a deeper understanding of how users use the panning capabilities and affect future developments of the software.

### 3.3.2 Temporal Analysis

The temporal activity distribution is also a very important dimension of analysis. It can give insights about the project lifecycle and when participants were active. The working time distribution can be analyzed – not only in general but also for every participant separately. Profiles can identify personal preferences.

### 3.3.3 Key Figures

Besides the mentioned visual ways of analyzing the whiteboard content, there can be a variety of other key figures describing the interaction process. One example is reasoning on resizing actions of sticky notes by counting actions to enlarge or shrink. From these numbers an argumentation can lead to optimized sticky note default sizes for different tasks. Very important is also to study the contribution of activities by each team member in a distributed setting. Significant differences can reveal certain team characteristics and their influence on team performance.

To sum up, the history can be a very efficient tool leading to a deeper understanding of people interacting with the Tele-Board system. Results can be made traceable and the implications for team performance become measurable in a way that the history infrastructure can be a valuable tool for design researchers as well as designers.

We are also elaborating on structural analysis of the history data in order to provide search applications or make meaningful recommendations to the user. The key challenge of this automatic learning from history data is how to find important points in time. Therefore we have to ask the question: What makes an episode in the history important for the person who wants to understand past design activity? Ongoing user observations and tests will give us more insights on this problem domain.

## 4 Outlook and Future Work

In this article we presented the possibilities and advantages of the Tele-Board system which supports creative work in synchronous and asynchronous settings. Tele-Board automatically captures whiteboard interactions and offers a history view to the minute. Users can browse through whiteboard screenshots at different time levels or generate a video of the history data. Thereby, we reduce the amount of time users need to view the whiteboard interaction as they do not need to watch several hours of standard video. Still, a lot of data is generated while working for hours, days or even months. For team members who want to understand what their partners did, it would be an enormous help if the system found important phases during their work. In the future, Tele-board should recognize the most important phases and present them in the history browser. A prerequisite for suggesting important points of a design session history is an analysis of the stored history data and identifying situations with high information value. Such moments can be, for example, when a team came to certain decisions or had seminal ideas. During the past project year we collected several hours of test data, which will be the basis for our research. The obvious commonalities in these processes can be transferred to the computational analysis. Usage pattern analysis is an approach that can lead towards a computational understanding of the interaction processes. Indicators for these usage patterns are: transitions between working modes, writing/sketching/clustering phases, count of new sticky notes and scribbles etc. In summary, user-generated feedback can be even more valuable and an indication for these reasoning methods. Users can comment on the history of a design process, but also during the sessions they can give direct feedback with certain devices, e.g. a multi-button buzzer.

Furthermore, we will evaluate the importance of additional audio or video recordings. We want to know if it is sufficient to only view whiteboard interactions of important points in time or if it makes a significant difference to add the related audio or video recordings as well.

Another feature that can support design teams during their work is the simplified generation of documentation. Designers could select history artifacts that would be directly inserted into text documents, presentations or any other kind of documentation. As an analysis of this automatically derived information, we want to find out how helpful this semi-automatic documentation can be.

### *4.1 Evaluating Our Ideas and Designs*

In the upcoming year we also plan to set up the Tele-Board system in a team's design space for a longer time period to investigate whether or not people would utilize the system and how satisfied they are with its use. Students of the ME310[2] course will use it for working in distributed setups. We want to identify factors and project phases where the system is helpful and in which situations people prefer other tools and why. This will give us valuable research data on usage behavior and the practical and social influences of the system.

Overall we want to determine that a digital system can be used as comfortably and intuitively as traditional tools for creative work settings and, furthermore, even augment the analog experience. The added value of a whiteboard history, highlighting of important project phases and automatic documentation can make the Tele-Board an essential tool for geographically distributed teams.

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[2] http://me310.stanford.edu/