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Supporting Workspace Awareness by Visualizing the Story Graph Evolution in Non-Linear Collaborative Storytelling

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“Thought is impossible without an image.”

Aristotle, 350 BC

“The understanding can intuit nothing, the senses can think nothing.
Only through their union can knowledge arise.”

Immanuel Kant, 1781

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Abstract

The art of telling stories has a long and venerable history, dating back for centuries. Stories have been shared in every culture. Storytelling is a traditional way to refer experience and is mostly oral. Today, there also exists an oral culture in organizations, face-to-face and via telephone. Due to this, there is an increased demand for audio books and podcasting, which indicate an increasing demand of listening.

Telling stories is not only a human way to share knowledge and experiences, but is also used as a method in different areas of application under the designation *storytelling*. Collaborative storytelling aims at the development of a common understanding within a group through coordinated narrating activities, in order to make implicit knowledge explicit. On this basis, audio-based collaborative storytelling functions as the act of telling stories in groups in a digital manner.

This thesis was developed in the framework of CASTing, a group support system which supports processes for audio-based collaborative storytelling. A concept was developed to enhance the awareness of groups within the CASTing web portal. With this concept in mind, a prototype for a visualization of story graph evolution was designed. The visualization supports the understanding of group members by showing who has modified the story graph, what exactly was modified and when it was modified. This knowledge is important for people who just joined the project or want to help another group member during the work process. At last different awareness and interface factors were tested in experiments with the visualization.

The concept of a visualization of using story graph evolution is addressed to researchers of computer supported cooperating work areas, researchers who deal with storytelling and groups wanting to increase awareness in their workspace. The developed story graph visualization can be used to enhance the awareness of group members and their workspace within a storytelling web portal, especially CASTing.

The experiment proved that the visualization prototype enables users to get information about the previous work in the story graph and that the users are more aware of other group members within a project. It also proved that there is still room to improve the prototype.

The prototype can be used as a basis for more exact visualizations of events during the time the group members work on a project. Improvements can be achieved in the accuracy of the evolution controls, as well as the audio nodes and the connection between them. The evolution controls could be more exact to get an even better source of information for the CASTing community. This approach is interesting for other storytelling software to enhance the workspace awareness at the point where a community comes together.

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Acronyms

CSCW	Computer Supported Cooperative Work
DB	Database
e. g.	exempli gratia (for example)
FABridge	Flex Ajax Bridge
SQL	Structured Query Language
RIA	Rich Internet Application
UI	User Interface
XP	eXtreme Programming

1 Introduction

1.1 Storytelling in Connection with CASTing

The art of telling stories has a long and venerable history, dating back for centuries. Stories have been shared in every culture. Storytelling is a traditional way to refer experience and is mostly oral [40]. Today, there also exists an oral culture in organizations, face-to-face and via telephone. Due to this, there is an increased demand for audio books [28, 12] and podcasting [19, 24], which indicate an increasing demand of listening. The spoken language is an essential and natural part of human communication. The act of telling stories in groups ties to everyday experience of discussing collectively remembered episodes. Narrative structures do not develop exclusively as a creation of an autonomous narrating person, but are formed by the demands, additions, references, interpretation and much more from listening persons, who later become co-storytellers [26].

Telling stories is not only a human way to share knowledge and experiences, but is also used as a method in different areas of application under the designation *storytelling*. Collaborative storytelling aims at the development of a common understanding within a group through coordinated narrating activities, in order to make implicit knowledge explicit [23]. On this basis, audio-based collaborative storytelling functions as the act of telling stories in groups and in this way it enables the exchange of experiences and knowledge within a group. Thus storytelling can be used as an alternative to mainly textual techniques, e.g. wikis [42]. Three approaches for collaborative storytelling can be differentiated: “peer-to-peer”, “top-down” and “bottom-up”.

Peer-to-peer approaches are predominantly found where collaborative storytelling is used pedagogically. These forms of discourse exist when students tell stories in order to acquire knowledge in the learning process. This is also visible in areas of knowledge management, e.g. in narrative reflection on completed projects [27].

Top-down approaches addressing knowledge transfer are found in educational contexts as well. This happens when stories are told for learners, and not by the learners. This presupposes an asymmetric relationship between the tellers of stories and their recipients, because the storytellers have to define knowledge [36] [37].

Bottom-up approaches targeting qualification for participation are promoted by grassroots media [13], e.g. by the concept of community radio [39, 11]. Even forms of communication between experts and laymen do not serve exclusively for the dissemination of knowledge. Alleged laymen, e.g. future users of a technical product, are experts for the area of application. As such their narrations contribute to a deepened understanding of knowledge in the targeted domain. The use of storycards in eXtreme Programming (XP), for instance, benefits from this fact [4].

This thesis is developed within the enhancement of CASTing, a groupware system which supports audio-based collaborative storytelling. CASTing consists of a storytelling client application (Figure 1.1) which supports the following process steps: creating a project team, adding audio recordings, segmenting audio recordings, linking audio recordings and publishing a story [6].

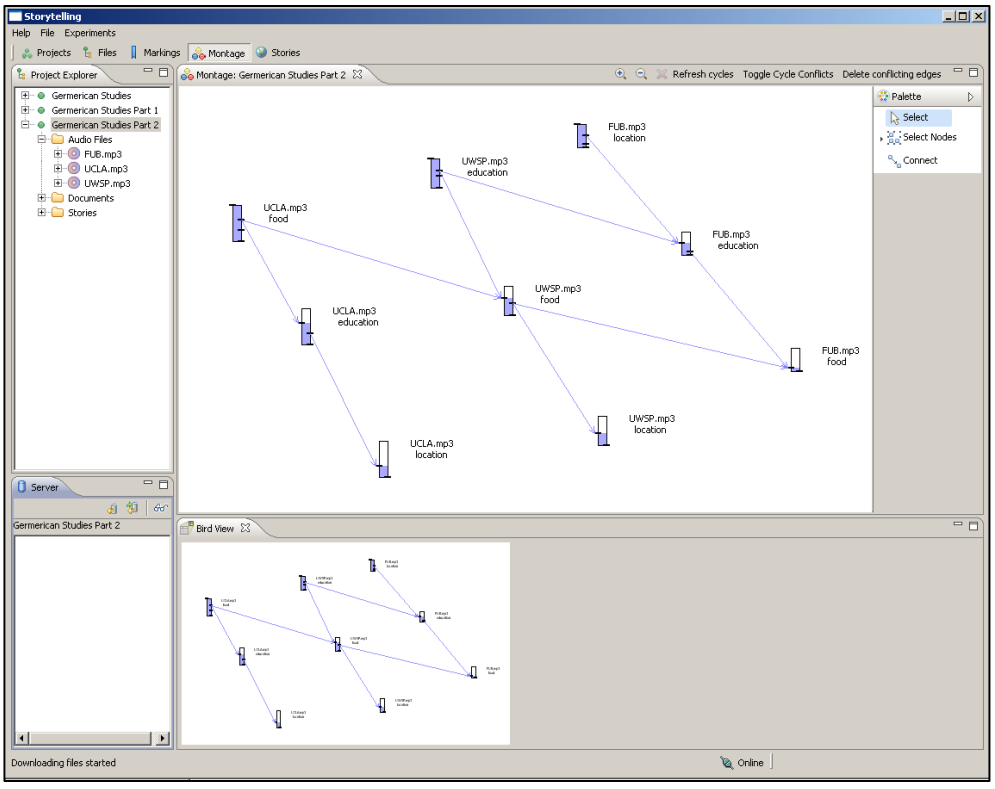


Figure 1.1. The story graph perspective (montage).

For this work the steps *linking audio recordings* and *publishing* are the center of attention. Before linking the audio recordings, the audio recordings were segmented by creating markings in the used audio files. In the *linking audio recordings* step these markings are used to connect different audio contributions. The result of these connections is called the *montage* in the CASTing client [6]. In non-

linear stories, the connections between different audio recordings represent a directed graph. The nodes (displayed as rectangles) in the story graph represent parts of audio recordings. The edges (displayed as arrows) in the graph represent the connections between these parts. Figure 1.1 shows the story graph perspective of the storytelling client application. The upper left corner contains the project explorer with the audio recordings and their marks. The lower section shows a bird's eye view of the current story graph. The upper middle section contains the current story graph. Each rectangle represents one audio recording. The colored part within the rectangle indicates the part of the audio recording which is used in the story. The starting mark is highlighted by a black line on the left side of the rectangle. Marks which are used to link to other audio recordings are shown as black lines on the right side of the rectangle [23].

The CASTing client application supports the users in collaboratively creating such a story graph. Users can retrieve the most current version of the story graph or synchronize their local changes. By adding nodes and connecting nodes, users can create a story graph.

Furthermore, CASTing consists of a web portal [32] which offers the functionality to publish podcasts and discuss, comment, vote and reuse audio stories. CASTing also uses a server which offers the functionality to manage and maintain the shared data [23].

1.2 CASTing Web Portal and its Limitations

The Liferay-based [22] web portal (Figure 1.2) allows users to register, create a project, invite project members, join ongoing projects, upload and share audio recordings, communicate via chat or message board, view who else is currently online and review project-related information. The accessible information is the project description, the project members, tags of projects, used audio files and the project changes since last login of the user. All of this information is displayed textually. The web portal also supports users to comment and vote on stories [23]. To sum up, the web portal supports communication, coordination and cooperation for distributed groups that want to create podcasts [32].

The main limitation of the CASTing web portal is, as mentioned above, that information is displayed textually. Tests of shape recognition show that image recognition is significantly faster than word recognition. While 25-50 ms may be required for the recognition of simple images, 65-100 ms are required for simple words. Picture recall is so superior to that of word recall that the concrete picture processing system is mnemonically superior to the abstract symbolic system (words and numbers) [7]. This implies that visualizations can be explicitly used as distinction between automatic and controlled processing. For instance, color and

size are typical features for coding data capable of automatic processing, opposed to text [8]. A visualization of the textual information would at the least enhance the recognition of information processing.

Figure 1.2. The web portal.

Another limitation is that the information displayed as text is limited and doesn't help users to understand the activities of other project members in the story graph. If an activity happened in the past, it won't be displayed in the web portal. Only the changes after the last login are displayed. So the users cannot reconstruct the work steps that other group members have made and they are unavailable to help or be asked questions related to them. Due to this and limited recognition of textual information, the feeling of working in a group is limited in the CASTing web portal.

Therefore, a lack of awareness is recognizable. Gutwin and Greenberg [17] define workspace awareness as an understanding how another person interacts with the shared workspace until now. In this way workspace awareness is the consciousness that other people exist and how they interact with the workspace. This information is important for successful collaboration, especially in groupware systems [10] and for people who just joined the project and need an overview of the project or who need to know what another project member has done up to a certain point in time.

1.3 Motivation

The need of more awareness for group members within a project of the CASTing web portal is the basis for this thesis.

The workspace awareness within the web portal of CASTing can be improved by a visualization of the user's activities during the process of a project. The user's activities can be visualized by showing the evolution of the story graph of the CASTing client. It should display how the result of the CASTing process (the story graph) was modified over time. Due to the visualized information, the activities of every member are able to be viewed by the entire group. The workspace awareness should be improved by showing who worked on the project last and which parts of the project were modified over time. The knowledge will help the project members to recognize, understand and trace the activities of other project members and in this way advance the workspace awareness in the web portal.

This bachelor thesis is focused on the development of visualization of such a story graph evolution, in the research topic of Computer Supported Cooperative Work (CSCW). The concept of the visualization of the story graph evolution is addressed to researchers of computer supported cooperating work areas, researchers who deal with storytelling, as well as awareness relating to groups and their workspace. The developed story graph visualization can be used to enhance the awareness of group members and their workspace within storytelling web portals, especially CASTing.

1.4 Hypotheses and Goals of this Thesis

According to Dourish & Belotti [10] workspace awareness can be used for:

- Management of collaboration,
- Coordination of actions in collaborative activities,
- Simplification of communication and
- Traceability of work results provided by other project members.

Consistently this guides to more effective collaborative interactions. This leads to the following hypotheses:

- **Hypothesis 1:** The visualization advances workspace awareness in group projects in the community portal.

- **Hypothesis 2:** The visualization empowers project members to question and understand the results of other project members.

The main task to prove the hypotheses is to develop a visualization of the story graph evolution to support workspace awareness in group projects in the web portal of CASTing. That main task can be divided into subtasks via ISO 13407 (Human-centered design process [41]), which defines a general process for including human-centered activities throughout a development life-cycle. In this model, once the need to use a human centered design process has been identified, four activities form the main cycle of work:

- **Understand and specify the context of use:** Identify the people who will use the product, what they will use it for, and under what conditions they will use it.

- **Specify the user and organizational requirements:** Determine the success criteria of usability for the product in terms of user tasks. Identify business requirements or user goals that must be met for the product to be successful. Determine the design guidelines and constraints.

- **Produce design solutions:** Develop a visualization design which allows the user to reconstruct the events during the story graph evolution. This part of the process may be done in stages by building from a rough concept to a complete design and in the end to a prototype of the visualization embedded in the CASTing web portal.

- **Evaluate designs against requirements:** The most important part of this process is the evaluation, ideally through usability testing with actual users. The designs are evaluated against user use requirements.

To accomplish the tasks and goals of this thesis, the required basics are examined in the following chapter.

2 Fundamentals and earlier Work

This chapter introduces important concepts for this thesis. It is about basic concepts of the main research field and introduces a framework of awareness developed by Gutwin and Greenberg.

2.1 Computer Supported Cooperative Work

This thesis is based on Computer Supported Cooperative Work (CSCW) in the groupware system CASTing. According to Grudin [15] CSCW can be defined as "how collaborative activities and their coordination can be supported by means of computer systems." Different authors claim that while groupware refers to real computer-based systems, CSCW focuses on the study of tools and techniques of groupware as well as their psychological, social, and organizational effects. The definition of Root [31] differentiates these two concepts as follows: "CSCW [is] a generic term, which combines the understanding of the way people work in groups with the enabling technologies of computer networking, and associated hardware, software, services and techniques."

The mandatory attributes [14] for a CSCW system are:

- Support of communication.
- Support of cooperation.
- Support of decision-making process.
- Support of awareness.

These factors are very important for the development of a group support system. The first three factors are covered adequately in the CASTing web portal at that time. The goal of this thesis is to support the fourth factor, awareness, as mentioned in the motivation in Chapter 1.

2.2 A Framework of Awareness

This part reviews the theory of awareness developed by Gutwin and Greenberg [17]. A brief summary of their work is described below to introduce the concept of awareness.

2.2.1 Introduction

Whenever people work together in a shared environment (virtual or face-to-face) they need information about the activities and intentions of their co-workers. This information is important for a successful collaboration, especially in groupware systems [10]. The knowledge of others, as a result of the interaction of the participants and their environment, is called *awareness*.

Referring to Dourish and Belotti [10] awareness is "an understanding of the activities of others, which provides a context for your own activity". They emphasize the importance of awareness by writing, "…awareness information is always required to coordinate group activities, whatever the task domain".

More precisely, Gutwin and Greenberg [17] state that awareness:

- Is knowledge about a state of the work environment in a limited portion of time and space.
- Provides knowledge about changes in that environment.
- Is maintained by all the interactions between the team-mates and the environment.
- Is a part of an activity (completing a task, working on something…). Maintaining awareness is not the purpose of an activity. Awareness is used to complete a task.

Therefore, awareness sums up the knowledge extracted from an environment and updates knowledge thanks to the interaction between the participants and their environments.

In conformity with Gutwin et al. [16] researchers of CSCW make a distinction between four types of overlapping awareness, relating to group work. These are shown in Figure 2.1.

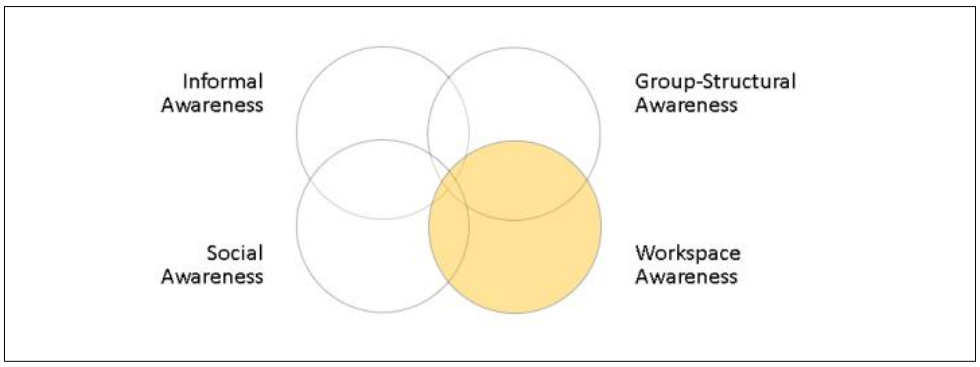


Figure 2.1. Types of awareness in group work. [16]

- **Group-structural awareness:** is all the information about the roles and responsibilities of the people, their positions on an issue, status, and group processes.

- **Social awareness:** is the information that a person maintains about others in a social or conversational context. It can indicate whether a partner is paying attention or being interested.

- **Informal awareness:** of a work community is the information of who is where and what kind of activity they are up to.

- **Workspace awareness:** Gutwin and Greenberg [17] define it as "the up-to-the-moment understanding of another person's interaction with the shared workspace […]". It is awareness of people and how they interact with the workspace, rather than awareness of the workspace itself.

The first kind of awareness, the group-structural awareness, is already covered adequately in the CASTing web portal. For that purpose the web portal offers a user profile where all the useful information can be stored and is visible to other project members. Thus, the user can access information about the roles and responsibilities of people who work on the same project. These parts are not considered in this thesis. Social awareness as well as the informal awareness is also not considered. It is not necessary to consider who is where and what they are doing at the moment, because this work deals with the activities, which were already done in the past.

This thesis focuses on workspace awareness, because it advances awareness with the help of a visualization of the story graph evolution. The visualization shows when a project member changed something in the story graph and what has been changed. These changes are stored, so that every point in time of the story graph evolution can be reconstructed.

In the following section a conceptual framework of workspace awareness is introduced, which will specify workspace awareness and their effect on the design of this approach.

2.2.2 Awareness Information

Gutwin et al. built a conceptual framework of workspace awareness that structures thinking about groupware interface support. The framework consists of

two parts: the elements that make up people's workspace awareness and the mechanisms that are used to gather awareness information.

According to Gutwin and Greenberg [17], elements of workspace awareness can be divided into two parts: those related to the present (Table 2.1) and those related to the past (Table 2.2).

Category	**Element**	**Specific questions**
Who	Presence	Is anyone in the workspace?
	Identity	Who is participating?
What	Authorship	Who is doing that?
	Action	What are they doing?
	Intention	What goal is that action part of?
	Artefact	What object are they working on?
Where	Location	Where are they working?
	Gaze	Where are they looking?
	View	Where can they see?
	Reach	Where can they reach?

Table 2.1. Elements of workspace awareness relating to the present. [17]

Category	**Element**	**Specific questions**
How	Action history	How did that action happen?
	Artifact history	How did this artifact come to be in this state?
When	Event history	When did that event happen?
Who (past)	Presence history	Who was here, and when?
Where (past)	Location history	Where has a person been?
What (past)	Action history	What has a person been doing?

Table 2.2. Elements of workspace awareness relating to the past. [17]

The most important awareness information is the elements that answer "who, what, when and how". In groupware systems people can keep track of these elements.

In the CASTing web portal the *"who"*-question is already answered. In the project overview the user is able to see who else is working at the project. But this question in connection with other questions, like *"what"* and *"when"* is still unanswered. So the user is not able to recognize who changed what, who changed

something when and how. At this time the user is only partially able to track the *"what"*-category. He is able to see when a story was published in the web portal. Additionally he can see what changes in the story graph were made since his last login. But this information disappears after the next login, because only the changes since the last login are displayed. In this way the information can easily get lost and cannot be reconstructed in the CASTing web portal. The *"how"*-category refers to the *"what"*-category. In the case of the story graph evolution it is not necessary to consider the *"where"*-category, because it refers to the *montage* step and partially to the *publish story* step (see Section 1.1).

2.2.3 Gathering Awareness Information

To get the needed awareness information, it has to be gathered in some way. In this section the information-gathering mechanisms according to Gutwin et al. [16] are described.

- **Direct Communication:** People explicitly communicate information about their interaction with the workspace: this communication is primarily verbal. This mechanism is not considered in this thesis, because it already exists in the CASTing web portal in form of a chat. This means that the people are able to communicate directly with each other.

- **Indirect Productions:** People commonly communicate through actions, expressions, or speech that is not explicitly directed at the other members of the group. This mechanism is very important in the following section of this thesis, because the visualization of the story graph evolution shows such actions of users. So the necessary awareness information is gathered by seeing the actions of other users within the story graph visualization.

- **Consequential Communication:** Watching or listening to others as they work provides people with a great deal of information about their interaction with the workspace. In the context of story graph evolution this mechanism refers to indirect productions. The user sees what other users have changed at a specific point in time, so they get information about the activities of others.

- **Feedthrough:** Information can also be gathered by observing the effects of someone's actions on the artifacts in the workspace. This mechanism strongly refers to the prior mechanism. The user can keep track of the activities of other users in the story graph. In this way they can gather information with the help of observing what happened in the past.

- **Environmental Feedback:** People also perceive higher-levels of feed-through from the indirect effects of another's actions in the larger work-space. This mechanism is not considered in this thesis because the user activities in the visualization of the story graph evolution will not have an effect on other parts of the web portal, outside of a project.

2.2.4 Use of Workspace Awareness

Workspace awareness can be used collaboratively in many different ways. Gutwin and Greenberg [17] state five types of activities. In addition to these, the activities used in the CASTing web portal are described below.

- **Management of coupling:** Coupling is the degree to which people are working together. By allowing people to know what a team-mate is doing with the appropriate awareness information, they can recognize when collaboration is possible. That kind of use of workspace awareness is partially possible in the CASTing web portal. The users are able to see what other users have changed in the story graph. In this way they can recognize which group members work on a topic within a project that they would like to join. In this sense the visualization might advance the degree to which people work together.

- **Simplification of communication:** is a way to employ awareness information by simplifying verbal communication and making it more efficient. This type of use can be achieved indirectly by the visualization, because the displayed information may simplify the understanding of what another person has done and therefore simplify the verbal communication with that person.

- **Coordinate actions:** By informing partners about the current focus of the team-mates, what they have already done or what they intend to do, it allows people to know when they can collaborate. This use of workspace awareness is related to "management of coupling" in the CASTing web portal.

- **Anticipation and predictions:** are based on predicting the future from the present. By seeing that a partner is picking an object, one can infer that this artifact is going to be used. This use of workspace cannot be achieved by the visualization of the story graph evolution. A user might be able to guess what artifact is going to be used in the story graph, but this is not ensured. So it is not considered in this thesis.

- **Assisting others:** can be employed to know if a team member needs help and in which way. Knowing what he has done, where his focus is and what he intends to do is useful to other team mates. This use of workspace awareness is related to Hypothesis 2 in this thesis, so it will be considered how to display other group members' activities.

Figure 2.2 shows the summary of the theory of awareness developed by Gutwin and Greenberg.

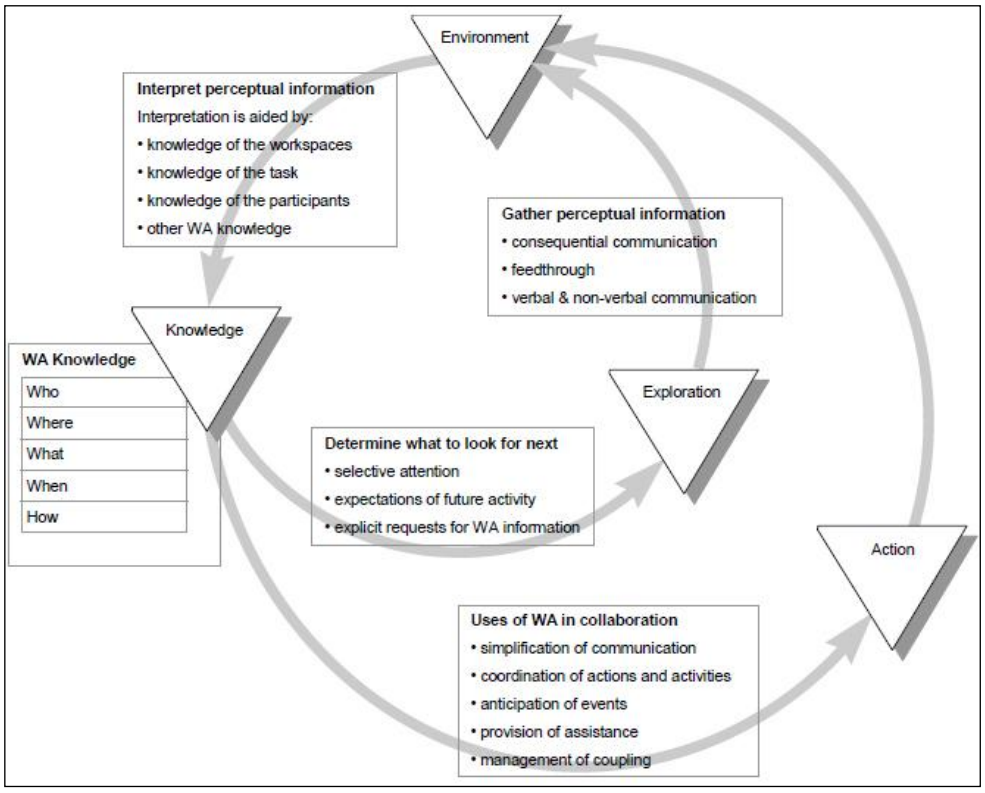


Figure 2.2. The workspace awareness framework. [17]

The basic information regarded in this chapter is important to analyze the requirements for the visualization of the story graph evolution in the next chapter.

3 Requirements Analysis and Design of the Visualization

The goal of this thesis is to develop a concept to enhance the awareness of groups within the CASTing web portal with the help of a visualization of the story graph evolution. A design is required which advances the awareness of the web portal, which is described in this chapter. To aid in designing the prototype, a scenario has been developed which supports the determination of the basic functions of the prototype. The scenario has been created on the basis of the hypotheses in Chapter 1. It also specifies the *context of use* (see Chapter 1, the four activities from the main cycle of work) for the development of the visualization of the story graph evolution. In this context the scenario identifies the people who will use the product, what they will use it for, and under what conditions they will use it. Furthermore this chapter specifies *the user and organizational requirements* (see Chapter 1, the four activities from the main cycle of work). In this way the design guidelines and constraints are determined.

3.1 Scenario

There is a group of students at different universities in Germany and USA. This group made it their business to collect the differences between the educational establishments. For that they want to use CASTing as a tool for audio-based collaborative storytelling. The group worked successfully for a few weeks on the project, but now they want to widen their circle and sent an invitation over the web portal to another person in Germany. That person is a newcomer to the storytelling technique, so he is not accustomed to the terms and the use of the storytelling technique as the group is. The newcomer decided to join the project anyway and now needs an overview of the events from the last few weeks. He needs to know who is working on the project and how the current story graph has developed over time. To help him he needs a visualization of the story graph from the CASTing client (see Section 1.1), as well as additional information related to the graph.

3.2 Basic Requirements regarding to Workspace Awareness

The approach of this thesis is based on the elements and mechanisms of workspace awareness. Fundamentally the prototype should fulfill three conditions. It should show:

- What happened in the story graph over time,
- When exactly occurred the events and
- Who caused the events.

All three conditions are responsible for workspace awareness related to present and past (see Table 2.1 and Table 2.2). The first condition is essential to serve the *"what"*-category of workspace awareness related to the past and the present. The second condition serves the *"when"*-category of workspace awareness related to the past. The third condition serves the *"who"*-category related to the present and the past. This knowledge is important for people who just joined the project or want to help another group member.

To fulfill these conditions the visualization should enable the mechanisms for gathering awareness information (see Section 2.2.3), such as:

- Indirect productions,
- Consequential communication and
- Feedthrough.

The first mechanism, indirect productions, should be provided by the visualization by displaying the actions of people within the story graph. The second mechanism, consequential communication, can be provided by the visualization by showing the changes a person made within the story graph. This also refers to "indirect productions". The last mechanism is feedthrough, which refers also to the first two mechanisms, "indirect productions" and consequential communication". The users should be able to keep track of the activities of other project users in the story graph. In this way they can gather information with the help of observation what happened in the past.

The visualization of the story graph visualization should also enable some of the activity types of Gutwin and Greenberg (see Section 2.2.4), such as:

- Management of coupling,
- Simplification of communication,
- Coordinate actions and
- Assisting others.

The first activity type, management of coupling, can be enabled indirectly by the visualization. The users are able to see what other group members have changed in the story graph. In this way they can recognize what other group members are working on a topic inside of a project they would like to join, thus possibly advancing the degree to which people work together.

The second activity type, simplification of communication, can also be achieved indirectly by the visualization, because the displayed information may simplify the understanding of what another person has done and in this way simplify the verbal communication with that person.

The third activity type, coordinate actions, is related to management of coupling. The last activity type, assisting others, is related to Hypothesis 2 (see Chapter 1) in this work. So the visualization should display what users have done over the time.

3.3 Presentation of the Story Graph Visualization

The visualization of the story graph evolution has to have similarities to the *"montage"* step in the CASTing client (Figure 3.1, see Section 1.1). Thus it has to be a simple and direct graph without loops and the possibility to display single nodes. The similarity between the graph in the *"montage"* step and the graph in the web portal is necessary, because the users are usually working with the CASTing client to create the story graph and they need to recognize that it is essentially the same.

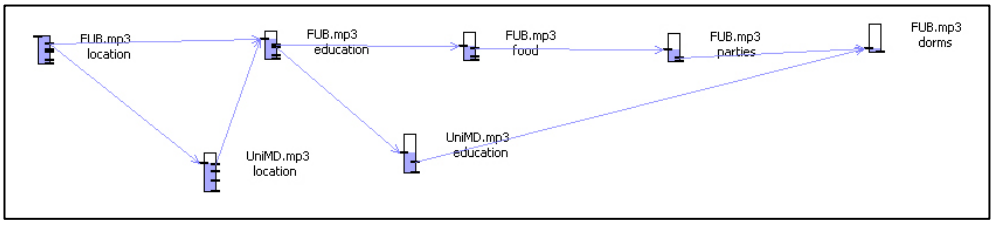


Figure 3.1. Story graph in the CASTing client.

3.3.1 Presentation of the Nodes in the Story Graph

As mentioned in Section 1.1 a rectangle represents a *node* (Figure 3.1) in the story graph of the CASTing client application a part of an audio recording. The height of the rectangle displays the length of the used audio recording. The colored part within the rectangle indicates the part of the audio recording which is

used in the story. The starting mark is highlighted by a black line on the left side of the rectangle and marks which are used to link to other audio recordings are shown as black lines on the right side of the rectangle. For simplification reasons the marks will only be displayed as text and not as a graphical object.

The disadvantage of this node design is that the rectangles get longer and longer depending on the length of the used audio recording. Due to that a lot of screen space is wasted. Therefore advancement in the visualization of the story graph in the CASTing web portal can be achieved.

A possible solution for that is to display the nodes as circles so that all of the nodes have the same size. Then the colored background changes depending on the real length of the audio recording (Figure 3.2) and the used part of the audio recording. Doing so helps to save screen space, which is very important for the limited size of the CASTing web portal.

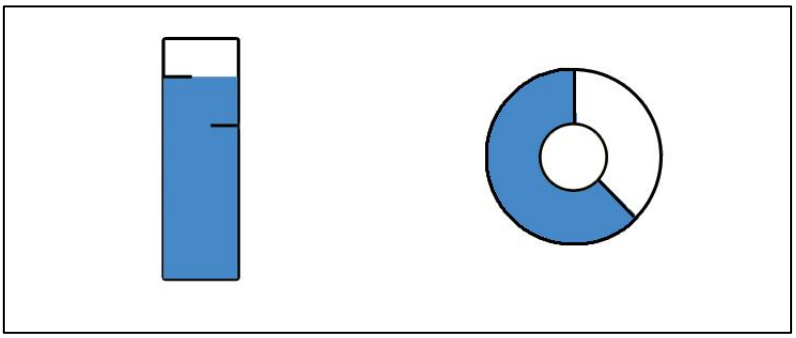


Figure 3.2. Change of node design; old (left), new (right).

Additionally, another difference will appear in the visualization of the story graph in the CASTing web portal. This refers to the way the human visual system analyses images, with regards to the displaying of the story graph evolution as effective as possible at this point in time. There is a limited set of visual properties that are detected very rapidly and accurately by the low-level visual system. These properties are called *preattentive* [18]. Typically tasks that can be performed on large multi-element displays in less than 200-250 ms are considered preattentive. Eye movements take at least 200 ms to initiate, and random locations of the elements in the display ensure that attention cannot be prefocused on any particular location, yet viewers report that these tasks can be completed with very little effort. This suggests that certain information in the display is processed in parallel by the low-level visual system. A simple example of a preattentive task is the detection of a red circle in a group of blue circles. The target object has a visual property "red" that the blue distractor objects do not (all non-target objects are considered distractors). A viewer can tell at a glance whether the target is present or absent [18].

Considering this fact the nodes in the CASTing web portal will get a colored inner circle, which enables the users to recognize the age of a node preattentively (Figure 3.3). In this way a white inner circle is used to represent nodes which were created in the last year, a yellow inner circle is used to represent nodes which were created in the last month, and an orange inner circles is used to represent nodes which were created on the current day. The more intense a color is, the more recent the node is.

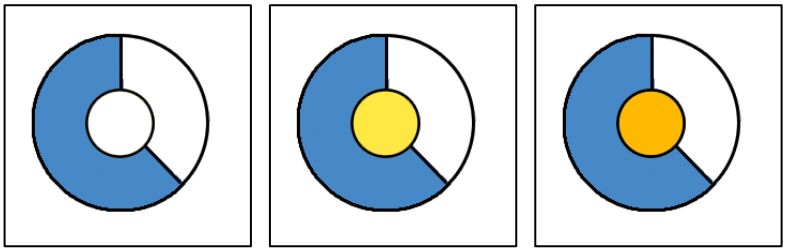


Figure 3.3. Age of audio nodes.

3.3.2 Presentation of the Edges in the Story Graph

As mentioned in Section 1.1 an arrow represents an *edge* (displayed as arrow in Figure 3.1) in the story graph of the CASTing client application, and is the connection between the parts of audio recordings. The edges are drawn between marks which are used to link to other audio recordings and starting marks. The display of the edges will be slightly changed in the CASTing web portal. For simplification reasons it will not be displayed from which mark to which mark the edge goes.

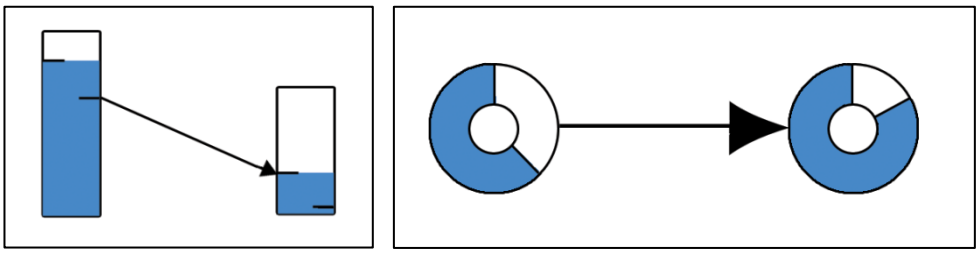


Figure 3.4. Representation of nodes; old (left) and new (right).

Additionally the visualization of the story graph evolution should have the possibility to filter certain information. In regards to the main goal of this thesis,

the question to ask is: *How could the filter functionality of the prototype advance the workspace awareness in the CASTing web portal?*

In the following section design patterns are used to identify possible solutions to this question. Christopher Alexander described patterns as the following: „Each pattern is a three-part rule, which expresses a relation between a certain context, a problem, and a solution [3]". Design patterns are suggested because they contain experience and knowledge of experts, are reusable and offer an adaptable solution for different problems. Therefore they can provide the most auspicious solutions to the question above. For that, patterns for computer-mediated interaction [33] were determined. Three chosen design patterns are described in the following section.

3.4 Activity Log

To reconstruct the user events the prototype has to have an activity log ([33], pp. 371-376). It is essential to store some information about the user's activities in a log to provide a history of their activities and the artifacts' evolution. The activity log is the basis for the filter functions.

The CASTing client saves the data of all current nodes, edges and marks in a database. To enable an activity history much more data has to be stored. For that reason three new database tables are necessary: *NodeHistory*, *EdgeHistory* and *MarkHistory*. In these tables the user actions are stored. The only actions stored for the user are creating, deleting and modifying a node, edge or mark. Additionally the time and person who edited the story graph should be stored. In this way the activity log represents the basis for the *feedthrough* mechanism for gathering awareness in the CASTing web portal, as well as the indirect *productions* mechanism and the *consequential communication* mechanism. So the "what"-category, "when"-category and "who"-category of workspace awareness by Gutwin and Greenberg (see Table 2.1 and Table 2.2) are indirectly supported by such an activity log, because the database tables represent the basis for all other functions.

3.5 Timeline

The prototype needs a timeline ([33], pp. 377-382). The user should know who has done what at a specific point in time, as this knowledge advances workspace awareness. In the visualization two kinds of timelines are possible.

The first one is to color code the nodes and display in that way the general age of a node. Doing so allows the user to see preattentively when the nodes were created (see Section 3.3.1).

The second way is a slider for the evolution. Such a timeline should display from when to when the story graph was modified. The user should be able to limit the beginning and end time of the timeline. In that way it should be possible to reconstruct the evolution of a specific time span.

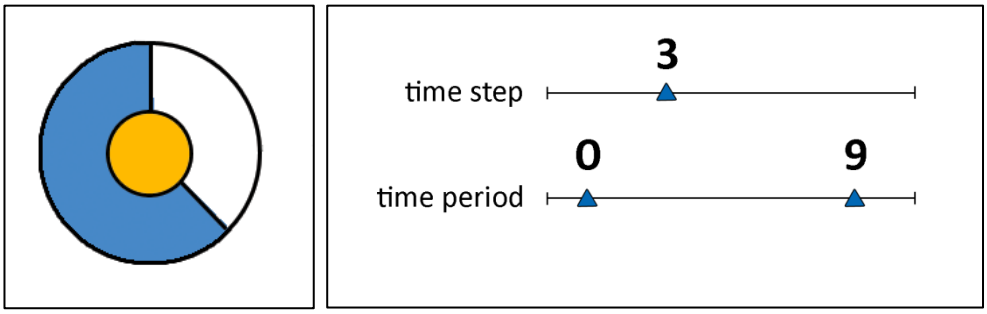


Figure 3.5. Representation of timeline; color coding (left) and slider (right).

In this process the *timeline* picks up the *feedthrough* mechanism for gathering awareness in the CASTing web portal, so the users should be able to keep track of the activities of other project members in the story graph. Thus they can gather information by observing the event history. This results in the “when”-category of workspace awareness by Gutwin and Greenberg (see Table 2.2) is being supported.

3.6 Replay

The prototype also needs a replay function ([33], pp. 425-430). This would allow the user to get all information over some time period and not only at a specific point in time. The replay function goes hand in hand with the timeline (see Figure 3.5). The user should be able to go step by step through the timeline to reconstruct the story graph at every point in time in the event history. Therefore this function also supports the “*when”*-category of workspace awareness.

Based on these requirements and design solutions it is possible to develop an adequate user interface and graph visualization. So the basis for the implementation is created.

4 Development of the Visualization

In the previous chapter the requirements of the story graph evolution are listed. The basis for the technical implementation is created. This chapter describes the development of the visualization and the produced *design solutions* (see Chapter 1, third activity) of the story graph evolution.

4.1 Framework and Visualization Toolkit

The basic requirement to the visualization of the story graph evolution is that it could be embedded in the CASTing web portal [32]. The outcome of this is that the visualization has to be adapted to that framework. Figure 4.1 shows the components of the system architecture. The web portal and the server are based on Liferay [22]. The storytelling client application accesses the shared resources on the server via Tunnel Servlet, whereas the web portal accesses these via a Struts [38] Servlet. At the server, both servlets can access the Liferay portal logic as well as the Storytelling Kernel which encapsulates the process functionality via an embedded Spring [39] layer. Finally, the Liferay portal logic and the Storytelling kernel provide access to the shared resources which are stored in a Java content repository and a MySQL database. The Java Content Repository is used to store and manage the shared files, i.e. audio clips and documents, whereas the MySQL database is used to manage application specific shared data [23].

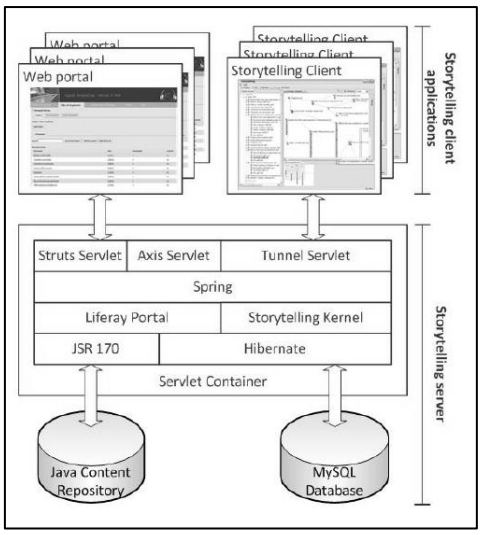


Figure 4.1. Overall system architecture. [23]

In this way research for adequate graph visualization toolkits is limited to Java-, JavaScript- and ActionScript-based visualization toolkits. In regards to this framework several visualization toolkits are considered in the following section. In Table 4.1 an overview of the toolkits is provided.

Toolkit	**Language**	**Pro**	**Con**
JUNG	Java	Support a variety of representations of entities and their relations	Doesn't fulfill the graphical requirements of the prototype
Prefuse	Java ActionScript	Supports a rich set of features for data modeling, visualization and interaction	Too powerful and complex for the requirement of the prototype
ProcessingJS	JavaScript	Open source programming language and environment for programming images, animation and interactions	Too weak for the requirement of the prototype
Birdeye	ActionScript MXML	This library for Adobe Flex enables the creation of multi-dimensional data visualization interfaces for the analysis and presentation of information	Still in development phase (possibly no solutions for very concrete requirements)

Table 4.1. Overview of the visualization toolkits.

JUNG [21], the Java Universal Network/Graph Framework, was the first possible visualization toolkit. It is a software library that provides a common and extendible language for the modeling, analysis, and visualization of data that can be represented as a graph or network. The JUNG architecture is designed to support a variety of representations of entities and their relations. It provides a mechanism for annotating graphs, entities, and relations with metadata. Besides that JUNG doesn't seem to be the right toolkit for the prototype, because the examples did not fulfill the graphical requirements of the prototype.

A second considered toolkit was **Prefuse** [29]. Prefuse is a set of software tools for creating rich interactive data visualizations. The original Prefuse toolkit provides a visualization framework for the Java programming language. The Prefuse flare toolkit provides visualization and animation tools for ActionScript and

the Adobe Flash Player. Prefuse supports a rich set of features for data modeling, visualization and interaction. It provides optimized data structures for tables, graphs, trees, a host of layout and visual encoding techniques, support for animation, dynamic queries, integrated search and database connectivity. Prefuse seemed to be a very powerful tool, but it is also a little bit too powerful and in this way too complex for the requirement of the visualization of the story graph evolution in the CASTing web portal.

Then **ProcessingJS** [30] was taken into consideration. ProcessingJS is an open source programming language and environment for programming images, animation, and interactions for the web without using Flash or Java applets. It is created to teach fundamentals of computer programming within a visual context and to serve as a software sketchbook and professional production tool. In this case the tool was too weak for the requirements of the visualization of the story graph evolution in the CASTing web portal.

The last and final visualization toolkit which was chosen is **Birdeye** [5]. BirdEye is a community project to advance the design and development of a comprehensive open source information visualization and visual analytics library for Adobe Flex [1]. The actionscript-based library enables the creation of multi-dimensional data visualization interfaces for the analysis and presentation of information. Adobe Flex is a free, open source framework for building interactive web applications that deploy consistently on all major browsers. MXML, a declarative XML-based language, is used to describe User Interface (UI) layout and behaviors, and ActionScript 3 is used to create client logic. Flex also includes a rich component library with extensible UI components for creating rich Internet applications (RIAs). RIAs created with Flex can run in the browser using Adobe Flash Player software. Adobe Flex in connection with Birdeye was chosen, because it has a very pleasing graphical representation, is not too complex, but also fulfills the requirements of the visualization prototype.

For the communication between the existing Liferay framework and the Flex RIA, the Adobe Flex Ajax Bridge (FABridge) [2] was used. This is a code library that can be inserted into a Flex application, a Flex component, or an empty SWF file to expose it to scripting in the web browser. With that, the FABridge ActionScript classes can be made available to JavaScript without additional coding. This means that anything you can do with ActionScript, you can do with JavaScript. Adobe Flash Player has the native ability, through the External API (the External Interface class), to call JavaScript from ActionScript, and vice versa. This enables the transfer of data between Liferay and the Flex RIA. Consequently an adequate visualization toolkit and framework was found for the visualization of the story graph evolution in the CASTing web portal.

4.2 Development of the Prototype

The visualization was developed with the method of *evolutionary prototyping* [9]. The main goal when using evolutionary prototyping is to build a robust prototype in a structured manner and to constantly refine it. This technique allows to add features and to make changes that could not be conceived during the requirements and design phase.

At first a basic prototype was designed (Figure 4.2). That design helped to illustrate the main functionalities of the prototype and to integrate the application in the Liferay portal. The first prototype consisted of three main parts: the story graph visualization panel, the story graph view panel and the story graph control panel. In the story graph visualization panel the graph itself was displayed. In the story graph view panel the user was able to change the view of the story graph, like zoom and data input, in case the story graph changes in the time of observation. The last part, the story graph control panel, enabled the user to change the displayed information of the graph such as, created stories, at which point in time an artifact was created and which user created the artifact.

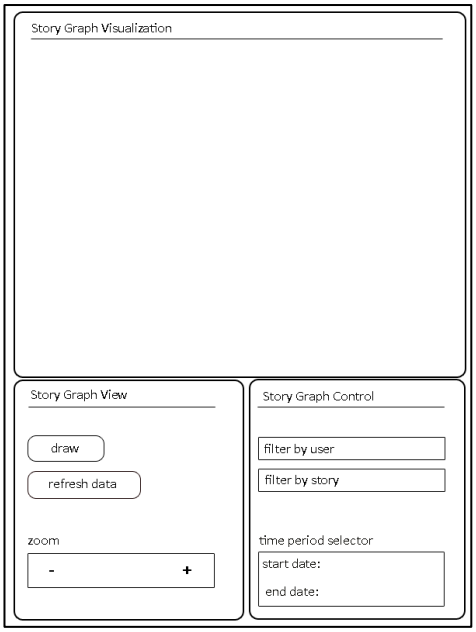


Figure 4.2. Sketch of interface version 1.

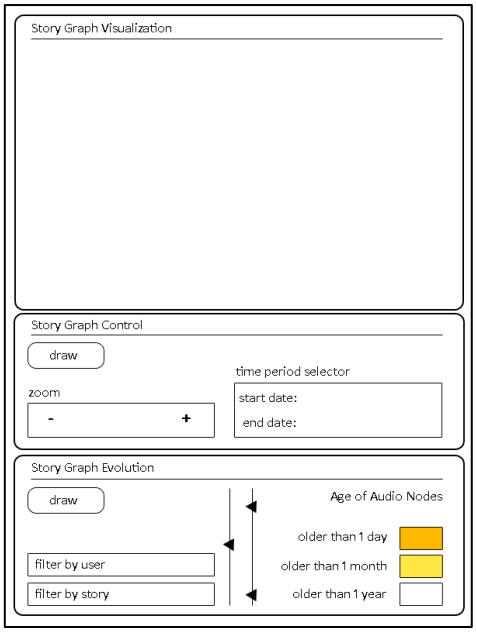


Figure 4.3. Sketch of interface version 2.

After that the first version of the user interface was designed to be embedded in the Liferay-based CASTing web portal. This part of the development was the most complex, because a connection for the data transfer between Liferay and the Flex application had to be created. As mentioned in Section 4.1 that problem

was solved with the help of Flex Ajax Bridge. That enabled the transfer of data between Liferay and the Adobe Flex application. Liferay fetches the needed data from the database. This data is provided to the Flex Ajax Bridge via Java and JavaScript. At last the Flex Ajax Bridge transfers the data into the Adobe Flex application. The data transfer is illustrated in Figure 4.4.

Figure 4.4. Data transfer in the prototype.

Then a formative evaluation [34] with storytelling experts was accomplished. Formative evaluation means that before the prototype is tested in reality or in experiments, during the development, it is tested for quality and user friendliness. In this way the storytelling experts had the chance to bring in their own ideas and demands, how the visualization prototype should look like and which functionalities it definitely should have, besides the very basic requirements.

After the first formative evaluation, the functionality was adapted to the demand of the storytelling experts (Figure 4.3). Also the user interface was changed slightly. The second prototype consisted also of three main parts: the story graph visualization panel, the story graph control panel and the story graph evolution panel. In the story graph visualization panel the graph itself was displayed. That aspect did not change. In the story graph control panel the user was able to change the view of the story graph with the help of the zoom technique and also to filter the graph data by time. The third part, the story graph evolution panel, enabled the user to filter the displayed information of the graph, like created stories and which artifact was created by which user. The second prototype also added visible features to help the user, which explains several colors in the story graph and a primitive replay function.

Following development of the second prototype, a second formative evaluation was accomplished by the storytelling experts. The result was that the basic requirements were already fulfilled, but the user interface of the second interface design was still confusing for the experts and needed improvement. So a third prototype with improved interface was designed (Figure 4.5). The results of this final version are explained in detail in the next section.

Figure 4.5. Sketch of interface version 3.

4.3 Presentation of the Visualization Prototype

The prototype is divided into two main parts. The upper part displays the actual story graph visualization and the lower part displays the control functions to filter the displayed information in the story graph (Figure 4.6).

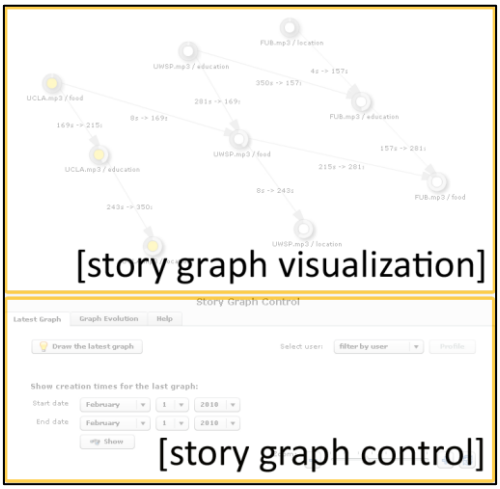


Figure 4.6. Build-up of the visualization prototype.

The story graph control is divided into three parts: Latest Graph, Graph Evolution and Help (Figure 4.7). The **Latest Graph section** provides several filter functions for the graph, which the user would see in the *"montage"* section in the CASTing client (see Chapter 1).

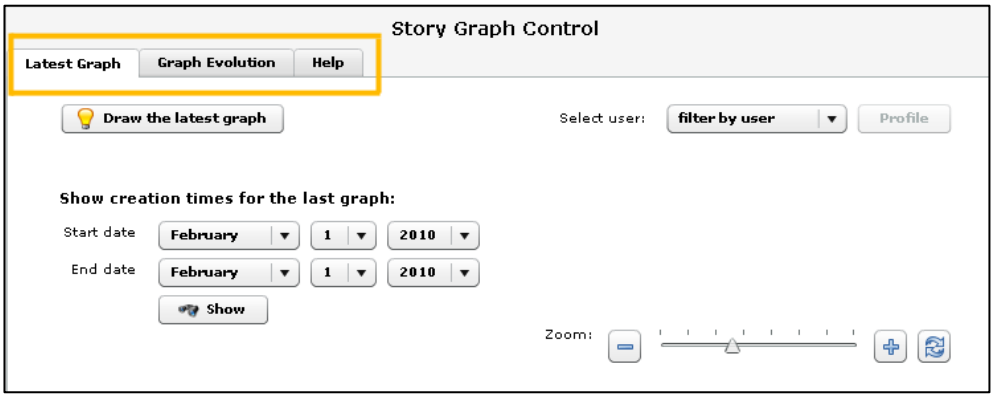


Figure 4.7. Latest graph section.

The function **Select user** (Figure 4.8) allows filtering of the latest story graph according to the user in the project. If a node or an edge is created by the selected user, then these nodes and edges are highlighted. That function offers the ability to see which person created what artifact in the most current graph view. It uses the *activity log* and supports the *"who"*-category and the *"what"*-category of workspace awareness by Gutwin and Greenberg. So by using this function the questions *"Who is participating?"* and *"What are they doing?"* are answered for the group member. Additionally this function offers the possibility to get further information about the user by pushing the **Profile** button, which is a link to the profile page of each user.

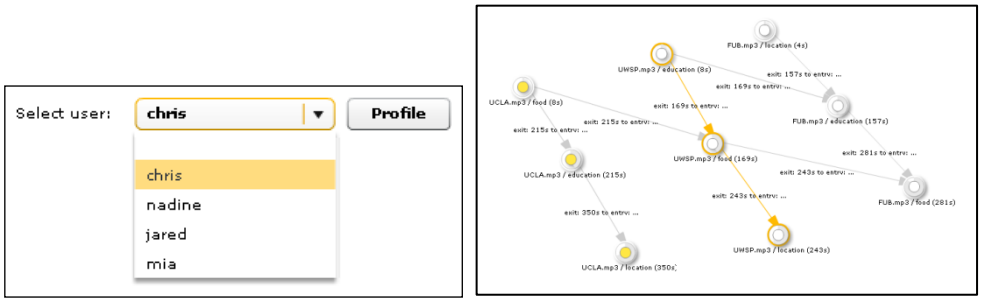


Figure 4.8. Select user function.

The function **Show creation times** (Figure 4.9) allows filtering of the latest story graph according to the creation date of nodes and edges in the project. If a

node or an edge was created in the selected time period, then these nodes and edges are highlighted. That function offers the ability to see when an artifact was created in the latest graph view. It also uses the *activity log* and supports the "*when"*-category of workspace awareness. So by using this function the question "*When did that event happen?"* is answered to the users.

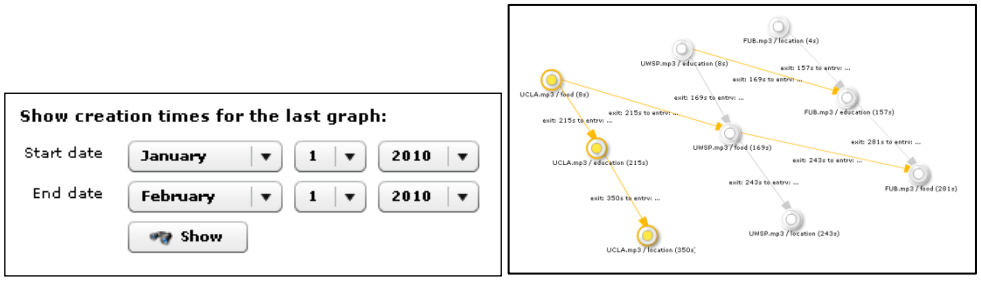


Figure 4.9. Creation times function.

The function **Zoom** (Figure 4.10) allows zooming in and out of the latest story graph. This was implemented for the case of the story graph being larger than the panel on which it is displayed. In this way the user can take a look at the full graph or have a closer look to specific details. The same function is provided for the *Graph Evolution* section. This function was additionally implemented to improve the usability of the story graph. It is not related to the categories of workspace awareness.

Figure 4.10. Zoom function.

The second part of the story graph control is the Graph Evolution (Figure 4.11). The **Graph Evolution section** provides several filter functions for all graph artifacts, which were created, modified or deleted over the time.

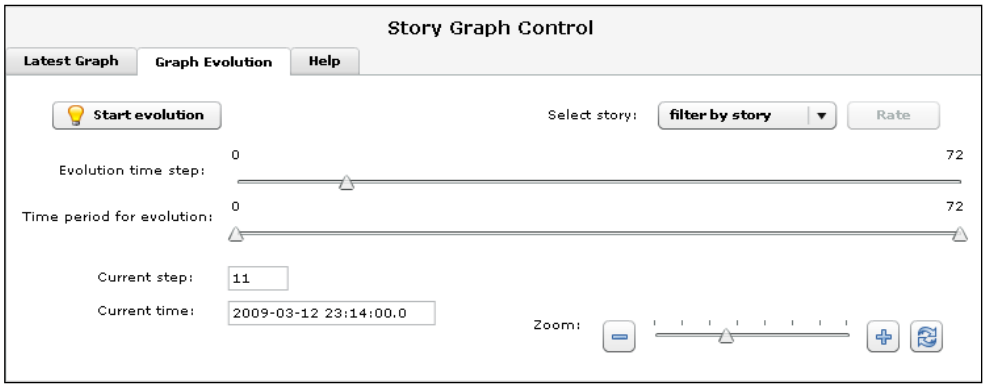


Figure 4.11. Graph evolution section.

The function **Select story** (Figure 4.12) allows filtering of the story graph evolution according to the created stories in the project. If a node or an edge is part of a story, then these nodes and edges are highlighted in the panel. This function is related to the past and offers the ability to see how the stories in the project were created. It uses the design pattern *activity log* and supports the *"what"*-category of workspace awareness. So by using this function the question *"What has a person been doing?"* is answered for the group member. Additionally this function offers the possibility to get to the rating page of the story by pushing the **Rate** button, which is a link to the rating system in the CASTing web portal.

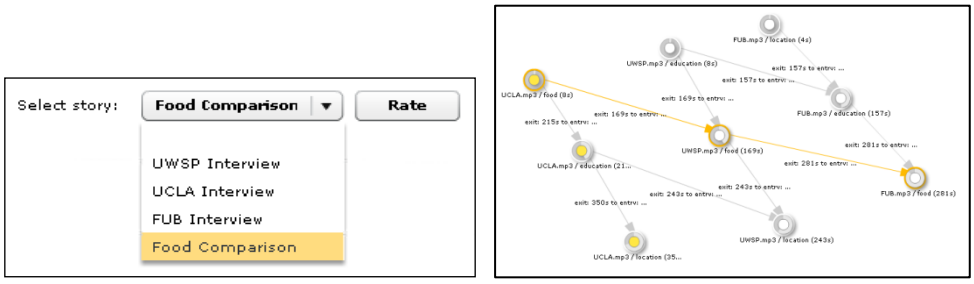


Figure 4.12. Select story function.

The function **evolution** (Figure 4.13) allows viewing the story graph evolution at a specific point in time and a time period. To change these settings there are two sliders. The lower slider is for selecting a time period in which the evolution should be displayed and the upper slider enables the user to slide through the evolution. The current slide step and time are displayed in the lower part of the evolution function. The function uses two design patterns. The first pattern is *timeline* (lower slider) and the second pattern is the *replay* (upper slider).

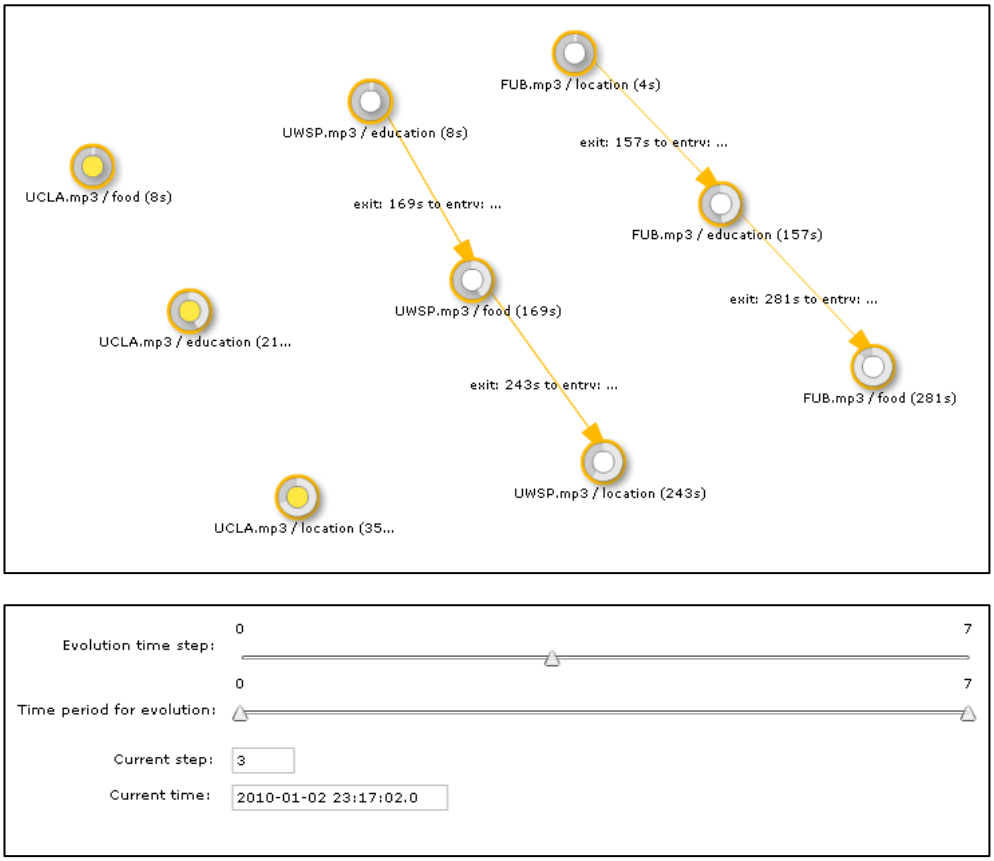


Figure 4.13. Evolution function.

That function is related to the past and allows the ability to see how the story graph was developed over time. It also supports the *"when"*-category, the *"how"*-category and the *"what"*-category of workspace awareness. So by using this function the questions "*What has a person been doing?*", *"When did that event happen?"* and *"How did this artifact come to be in this state?"* are answered.

The third and last part of the story graph control is the **Help section** (Figure 4.14). The Help section provides graphical descriptions of the meaning of the colors and displays of a node or an edge. This section was implemented additionally to improve the understanding of the story graph by users. It is not related to the categories of workspace awareness.

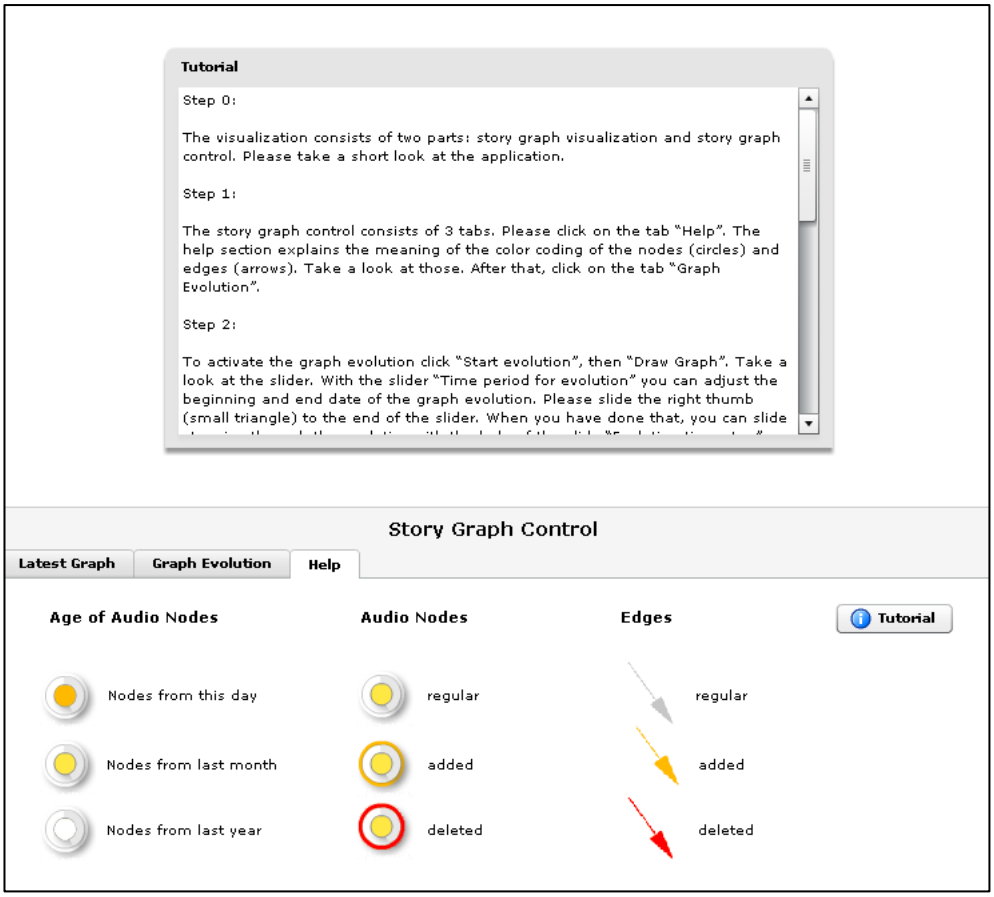


Figure 4.14. Help section.

If the inner ring of a node is colored in orange it was created on that day. If it is yellow then it is at least one month old, and if it is white it is at least one year old. With that color, the user is enabled to see the approximate age of a node at a glance. Otherwise if the outer ring of the node is highlighted in orange, the node was created at the chosen point in time. If it is red it was deleted at the chosen point in time. The same is true for edges. The help section is meant to be a legend for the user. This section also offers a tutorial for new users, which give them a better understanding of the application.

After the story graph control was described in the last section, the graph visualization (Figure 4.15) is taken into consideration. The visualization itself fulfills the first three basic requirements regarding to workspace awareness (see Chapter 3). It shows:

- What happened in the story graph over time,
- When exactly occurred the events and
- Who caused the events.

It displays the nodes in the new design, connected by edges and the mark times. The artifacts displayed in the panel depend on the functions being used in the story graph control.

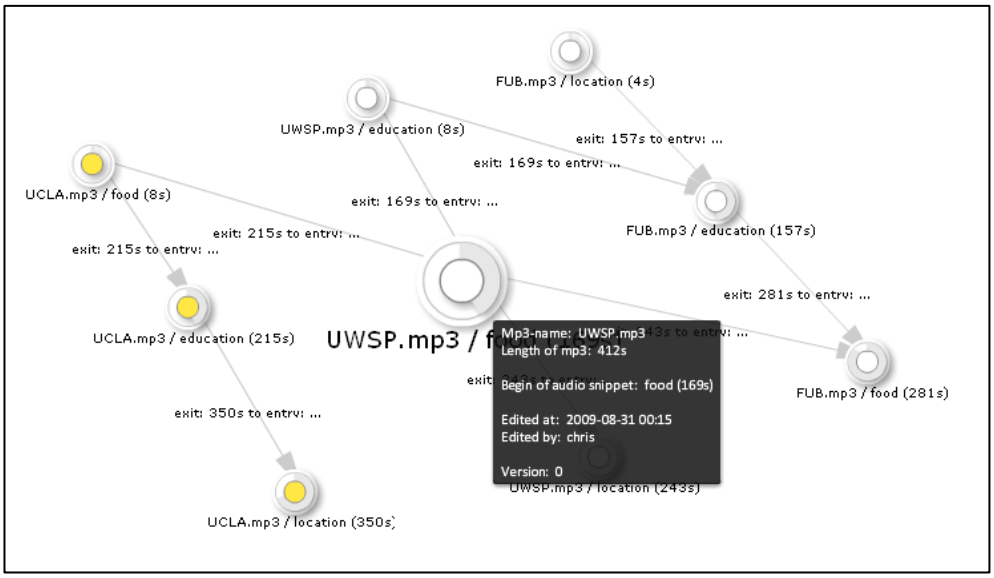


Figure 4.15. Graph visualization.

In Figure 4.15 the latest story graph is displayed. The inner rings of the nodes point out the approximate time the nodes were created at. In this screenshot the user can see preattentively that six of the nodes were created last year and three of them were created in the last month. Furthermore, the used audio recordings and audio snippets are displayed under every node. When the user points at a node with the cursor, the node gets bigger and a tooltip appears which contains more detailed information about the node. In Figure 4.15 the tooltip is displayed in a darker grey and contains the mp3 title, the length of this mp3 file, the beginning of the used audio snippet, when this node was edited, by whom this node was edited and in what edited version the node is at the moment.

The outer ring of the node is white because it is the latest graph and not the graph evolution. It is only colored when the user is in the graph evolution section.

The edges display the connections made by the project member. They also have a tooltip function which displays the user who edited the edge. The exit mark of the node from which the edge comes is also displayed.

5 Evaluation of the Visualization

The goal of this thesis was to advance the workspace awareness of groups within the CASTing web portal with the help of a visualization of the story graph evolution. To achieve this goal a visualization prototype was developed in the earlier chapters. This chapter is about evaluating the design of the visualization prototype, and showing whether or not the goals of this thesis were achieved. For that purpose the prototype has to be validated.

5.1 Validation of the Prototype

In order to use the prototype for further experiments it has to be validated. The validation makes sure that the functions of the prototype are implemented correctly. In this way the results of the experiments enable conclusions related to the goals of this thesis to be made.

In the last chapter a formative evaluation of storytelling experts related to the design, the requirements and the functionalities of the prototype were described. This means that the prototype was already evaluated of quality and user friendliness by experts. In the following section the prototype will be tested by the target group, that is, people who are new to storytelling. So the fourth activity of the main cycle of work is considered [41]. As mentioned in Chapter 1, the evaluation is completed through usability testing with actual users. The designs shall be evaluated against user use requirements. In this way the user use requirements are the following:

- Integration of the visualization prototype in the CASTing web portal.
- Correct implementation of the functions of the visualization prototype.
- The visualization enables the user to get all workspace awareness related information he needs to complete the experiment.

The requirements arise from the hypotheses of this work. Regarding those requirements the prototype was tested by two participants. The number of participants who work at the same time was not a relevant factor for the validation phase, because the prototype is embedded in the Liferay-based CASTing web portal, which implies the availability of it to many users at the same time. Both parti-

cipants had the task to login in the CASTing web portal and complete tasks related to the visualization. Those tasks were the same tasks the users of the real experiment will have to do (see Section 5.3). The result of this test was that both participants were able to login and complete the tasks. The ability to login shows that the visualization prototype was integrated in the CASTing web portal. Thus the first user use requirement was fulfilled. This means that the user could complete the tasks, which showed that the functions of the visualization prototype were implemented correctly. This ability also showed that the user was able to get all workspace awareness related information he needs for completing the experiment. This implies that all three requirements were fulfilled.

Therefore all requirements were tested during the validation and the results showed that the prototype is a solid basis for further experiments. This is not a guarantee for a successful accomplishment of the goals of this thesis. For that further experiments are necessary to see if the results have a strong variance or not. Such experiments are determined and accomplished in the next section.

5.2 Subjects of Evaluation

As described in Chapter 1, the following hypotheses have to be proven:

Hypothesis 1: The visualization advances workspace awareness in group projects in the web portal.

Hypothesis 2: The visualization empowers project members to question and understand the results of other project members.

In regards to these hypotheses, the following questions should be explored with the experiment:

I. Does the visualization make it clear who changed what in the story graph?

   This question is related to Hypothesis 1 and 2. On the one hand it supports the *"what"*-category and the *"who"*-category of workspace awareness defined by Gutwin and Greenberg and in this way advances the workspace awareness in group projects in the web portal. On the other hand it will empower project members to question what another group member has changed in the story graph.

II. Does the visualization make it clear when something was changed in the story graph?

This question is also related to Hypothesis 1 and 2. On the one hand it supports the *"when"*-category and the *"what"*-category of workspace awareness and in this way advances the workspace awareness in group projects in the web portal. On the other hand it will empower project members to question when an artifact of the story graph was changed by another group member.

III. Does the visualization make it clear who in general is working in the story graph? Are the user aware of other user in the project?

This question is, like the two before, related to Hypothesis 1 and 2. It supports the *"who"*-category and the *"where"*-category of workspace awareness and in this way advances the workspace awareness in group projects in the web portal. Additionally it will empower project members to be aware of other project members.

IV. Is the user interface easy to handle?

This question makes sure that the user interface is easy to handle for the project members. If it is easy then the users are able to get all the information they need. So the workspace awareness is advanced in an indirect way. It is not related to the hypotheses directly.

To explore these questions an experiment is necessary, which shows the truth of the statements describing the purpose of the above questions. The experiment should make it possible to prove the two hypotheses in this work.

5.3 Settings and Execution of the Experiment „Newcomer"

To explore the above questions an experiment was created. The experiment was accomplished by ten participants independently. It took on average 30 minutes to complete. The experiment was based on the scenario in Chapter 3 (see Appendix A.1). In order to do this a story graph was created in the CASTing client. Four dummy users were applied to the project, from which three were active during the process of the story graph evolution. The graph consisted of nine nodes and ten edges and had seven different edit times of the nodes and edges. This equates to a small, but not too complicated storytelling project. It should not be

too complex, because a more complex story graph would just expand the time span of the experiment.

The execution of the experiment was divided into three phases. At first the participants had to read basic information about storytelling and what they expect to see in the visualization prototype. Doing so should give them basic knowledge for completing the experiment.

After that, the participants had to put themselves in the position of the following scenario:

> *"There is a group of students at different universities in Germany and USA. This group made it their business to collect the differences between the educational establishments. For that they want to use CASTing as a tool for audio-based collaborative storytelling. The group worked successfully for a few weeks on the project, but now they want to widen their circle and sent an invitation over the web portal to another person. That person decided to join the project and needs an overview of the events from the last few weeks. He wants to know who is working on the project and how the current story graph has developed over the time."*

This scenario goes along with the scenario in Chapter 3 and describes the situation in which the visualization prototype will be used in real future projects. The visualization will be important for a user who is new to the project or wants to track the actions of another user, to help that user solve a problem.

Then the participants had to accomplish a tutorial to get to know the visualization prototype. This tutorial relates to the tutorial in the help section of the application. After that they had to answer questions related to the visualization. These questions should help to explore the statements of Section 5.2 and in this way prove the hypotheses of this work. The questions and the expectations that go along with them regarding to the experiment are listed in the following.

1 Which persons work on the story graph?

This question should support statement III of Section 5.2 (Does the visualization make it clear who in general is working in the story graph? Are the user aware of other user in the project?), because it shows that the participants know which people worked on the story graph and which people are only registered to the project. It should be shown whether or not the participants are aware of other project members by using the application.

2 What is Nadine's last name?

This question should not support any of the statements above. It just shows the connection between the visualization and the web portal. In this way it proves that the prototype is embedded in the web portal.

3 Which person is the most active in regards to the story graph?

This question should support statement I of Section 5.2 (Does the visualization make it clear who changed what in the story graph?). It underlines the *"who"*-category and the *"what"-category of workspace awareness.* Therefore it shows that the participants are able to track what a user edited in the story graph and that the participant is able to distinguish between the user activities.

4 Which person is the most inactive in regards to the story graph?

This question should also support statement I of Section 5.2. It is related to question 3 and ensures that the answer of the participant to question 3 was not incidentally.

5 What did Jared do on January, 27th 2010?

This question should support statement I and II of Section 5.2 (Does the visualization make it clear when something was changed in the story graph?). It underlines the elements "*identity"*, "*action history"* and "*event history"* of workspace awareness. Therefore the participants should be able to use the correct function of the prototype to get the answer to this question.

6 Which stories were created in the story graph?

This question should support statement I of Section 5.2. It underlines the *"what"*-category of workspace awareness, making sure that the element *"action history"* is taken into consideration. Therefore the participant should be able to see which stories were created in the past and which nodes and edges are related to these stories.

7 Which audio files were used in the project?

This question should also support statement I of Section 5.2. It is also a part of the *"action history"* of workspace awareness. In this way the participants should know of which audio recordings the story graph consists.

8 Which person was the last working on the project?

This question should support statement I and III of Section 5.2. It underlines the *"who"*-category of workspace awareness. The participants should be able to track the *"identity"*-element and therefore know who was the last to work on the projekt.

9 At which point in time was „UCLA.mp3 / location → UWSP.mp3 / location" deleted?

This question should support statement II of Section 5.2. It emphasizes the *"when"*-category of workspace awareness. Therefore the participants should be able to track the *"event history"* of the story graph.

10 When was node (circle) „UWSP / education" created and by whom?

This question should support statement I and II of Section 5.2, because it shows the *"who"*-category and the *"when"*-category of workspace awareness, so the participants should be able to track the elements *"identity"* and *"event history"* in the story graph.

11 Which person would you contact, if you had questions regarding the UWSP Interview?

This question should support statement I of Section 5.2. It also shows the *"identity"*-element of workspace awareness. The participant should be able to know who created specific nodes and edges of the story.

12 With which person would you cooperate, if you want to do something with the story "Food Comparison"?

This question should also support statement I of Section 5.2. It is related to question 11 and ensures that the answer of the participant to question 11 was not incidentally.

13 The handling of the story graph visualization was easy to learn.

This should support statement IV of Section 5.2 (Is the user interface easy to handle?). The participant should not have problems to learn the handling of the interface. If he does, then it will be very difficult for him to get the needed information.

14 I always knew where I am and what to do.

This should also support statement IV of Section 5.2. The participant should always be aware of his current position and therefore know what he has to do to get specific information.

5.4 Results and Conclusions of the Experiment

In this section the results of the experiment are introduced and compared to the expectations from Section 5.3. For that purpose the experiment and the results of the questionnaires are analyzed.

Altogether ten participants from four countries took the experiment. In Figure 5.1 and Figure 5.2 statistical information about the distribution of the age and the location of the participants can be seen. All of the participants had no experience with the storytelling technique which goes with the basis of the experiment; the scenario *newcomer*.

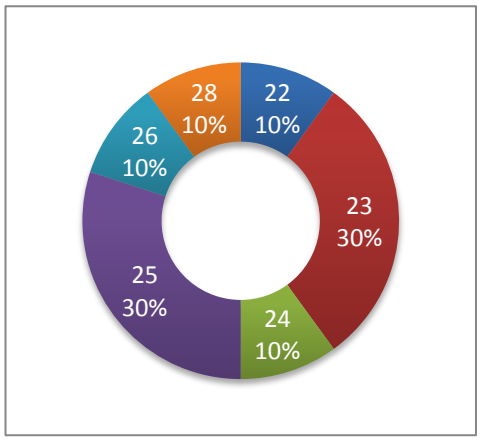


Figure 5.1. Participant ages.

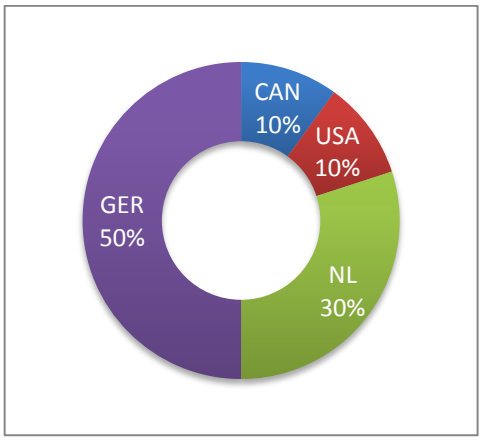


Figure 5.2. Participant locations.

As mentioned in Section 5.3 the participants had to fill out a digital questionnaire. They were able to complete the experiment independently from each other. The questionnaire consisted of two different sections of questions and a total number of 14 questions to the experiment. Every question had different answers that the participants were able to choose. The first 12 questions are closed questions [25] and the last two questions used an ordinal rating scale [25]. The first 12 questions were used to answer the questions in Section 5.2 and the last two questions were used to create a ranking.

With the help of the experiments the following four questions should be answered. To answer the following questions, several other questions related to the prototype were explored during the experiment. This context is shown in the following section, where the questions and the results of the experiment are compared with each other.

I. Does the visualization make it clear who changed what in the story graph?

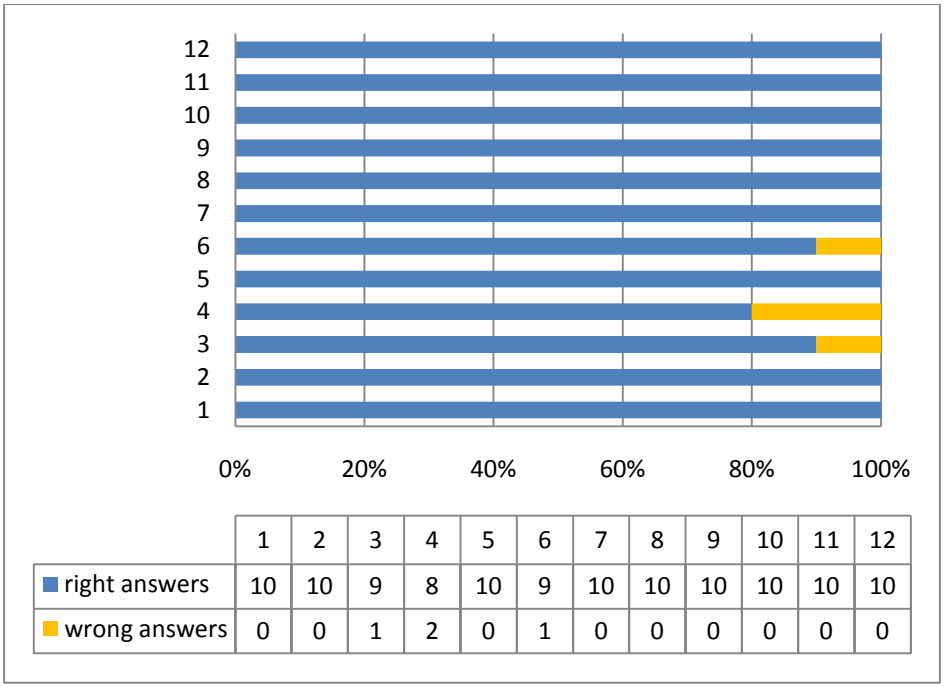
The first 12 questions, besides question 1 and 9, support statement I. All questions were answered 100% correct, besides question 3, 4 and 6 (Figure 5.4). Some participants had trouble answering which of the project applied persons are the most active or inactive related to the story graph. Another one did not know which stories were created in the project. The issue here might lie in the way the questions were asked. It is possible that there were too many ways to interpret the question. Besides that most participants were able to solve the tasks in the right manner. This implies that the visualization prototype provides the needed functionality to emphasize the *"what"*-category and the *"who"*-category of workspace awareness defined by Gutwin and Greenberg. This proves that statement II supports Hypothesis 1 and 2 of this thesis.

II. Does the visualization make it clear when something was changed in the story graph?

Question 5, 9 and 10 were answered 100% right by the participants (Figure 5.4). This implies that the participants were able to get the workspace awareness related information of the *"when"*-category of workspace awareness. So statement II is correct and in this way the workspace awareness in group projects in the community portal is advanced regarding to the *"when"*-category. This also supports Hypothesis 1 and 2.

III. Does the visualization make it clear who in general works in the story graph? Are the users aware of other users in the project?

Question 1 was answered 100% correct by the participants (Figure 5.4). This implies that the participants know which people worked on the story graph and in this way they are aware of the other project members. So statement III is correct and in this way the workspace awareness in group projects in the web portal is advanced. Additionally it empowers project members to be aware of other project members. This, like the two prior results, supports Hypothesis 1 and 2.



	1	2	3	4	5	6	7	8	9	10	11	12
right answers	10	10	9	8	10	9	10	10	10	10	10	10
wrong answers	0	0	1	2	0	1	0	0	0	0	0	0

Figure 5.4. Answers of the participants to question 1-12.

IV. Is the user interface easy to handle?

The result of the last two questions of the questionnaire is shown in Figure 5.5. The participants rated both questions on average “agree”, which means that the interface and the usability is good, but that there is still room to improve. Possible improvements for the future are described in Chapter 6. A possible explanation for the scattering of the rating is the usage of participants to such applications. The people who had no computer science background rated on average lower than the participants with computer science background. Another explanation could be that different people perceive a user interface different. That means that some aspects of the visualization prototype might be reasonable for some users and not for others.

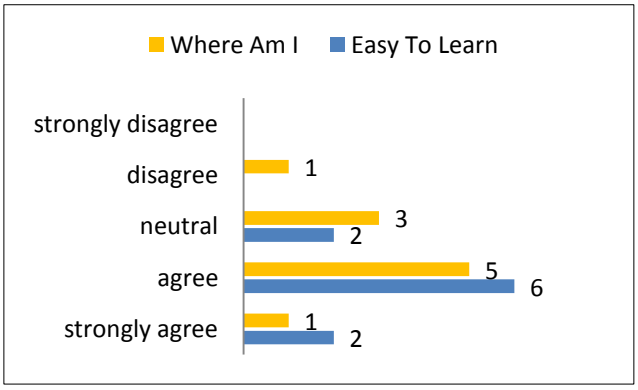


Figure 5.5. Answers of the participants to question 13 and 14.

In general it was shown that the visualization prototype provides the functionality to show the user all workspace related information he needs to get an overview about what happened in the past. The application advances the workspace awareness within the CASTing web portal by showing who edited what artifact in the story graph and when it was edited. It was also shown that the visualization makes users aware of other users within the story graph and the project. This fact and the easy learning of the story graph handling enables users to track the activities of other users and empower users to question and understand the work results of other users. The experiment also proved that the visualization displays all information which was only displayed textually before. Thus the main goal of the experiment has been achieved.

During the experiment limitations of the prototype were also discovered, which is the basis for improvements in the future. Prospect improvements and extensions for the visualization prototype are discussed in the next chapter.

6 Conclusions and Future Work

In this thesis the design and development of the visualization of a story graph evolution for non-linear collaborative storytelling for advancing workspace awareness in the CASTing web portal is described. This chapter is a summary of the thesis and their results. It also offers further thoughts about future research prospects and extensions of the visualization of the story graph evolution.

6.1 Summary of this Thesis

Telling stories is not only a human way to share knowledge and experiences, but is also used as a method in different areas of application under the designation *storytelling*. Collaborative storytelling aims at the development of a common understanding within a group by coordinated narrating activities, in order to make implicit knowledge explicit. On this basis audio-based collaborative storytelling functions as the act of telling stories in groups in a digital way.

This thesis was developed in the framework of CASTing, a group support system which supports processes for audio-based collaborative storytelling. The functionality of the CASTing system to create stories was described in this thesis to create a basic understanding of the storytelling technique and how CASTing uses it. Limitations of the CASTing web portal were discovered, which contribute to the initial point of the main goal of this thesis. Those limitations are related to the workspace awareness within the web portal.

Furthermore a concept was developed to enhance the awareness of groups within a project of the CASTing web portal with the help of a visualization of the story graph evolution. Requirements for such a visualization were listed and a basic design for necessary functions was created.

On this basis a prototype related to the requirements and design concept was created. It was developed with formative evaluation of storytelling experts.

In conclusion the prototype was validated and different awareness and interface factors were tested in experiments with the visualization. The experiments showed that the prototype supports the workspace awareness by showing who has modified the story graph, what exactly was modified and when was it modified. This knowledge is important for people who just joined the project or want to help another group member. They also showed limitations of the prototype, which are discussed in the following section.

6.2 Comparison of Results and Thesis Goals

The goal of this thesis was to advance the workspace awareness of groups within the CASTing web portal with the help of a visualization of the story graph evolution. The following hypotheses had to be proven:

- **Hypothesis 1:** The visualization advances workspace awareness in group projects in the community portal.

- **Hypothesis 2:** The visualization empowers project members to question and understand the results of other project members.

To prove the hypotheses a visualization prototype was developed in this work. The prototype visualizes the story graph evolution and offers several functionalities to filter the displayed information.

In general it was shown that the visualization prototype shows the user all workspace related information he needs to get an overview about what happened in the past within the story graph. The application advances the workspace awareness within the CASTing web portal by showing who edited what artifact in the story graph and when it was edited.

It was also shown that the visualization makes users aware of other users within the story graph and the project. This fact and the easy learning of the story graph handling empower users to track the activities of other users and empower users to question and understand the work results of other users. The experiment also proved that the visualization displays all information, which was only displayed textually before.

So the main goal of the prototype could be achieved. Consequently the hypotheses of this work could be proved.

6.3 Future Work

This thesis and the developed visualization are the basis for many possibilities in using and extending the prototype. During the experiments limitations of the visualization were discovered, which can be solved in the future.

The first topic to be discussed is possible extensions of the prototype. In the experiments it was discovered that the fixed size of the web portal where the

visualization is embedded is disadvantageous, because when the size of the story graph gets really big, the user has to scroll a lot and might lose the overall picture of the story graph. Thus advancement can be made in configuring an expanded web portal and a resizable flash application for the prototype. In this way the user is enabled to see more parts of the story graph at once. The black arrows in Figure 6.1 show the current size of the application, the CASTing web portal and the browser. The bright arrows represent the possible enlargement of the visualization and the web portal if they were resizable.

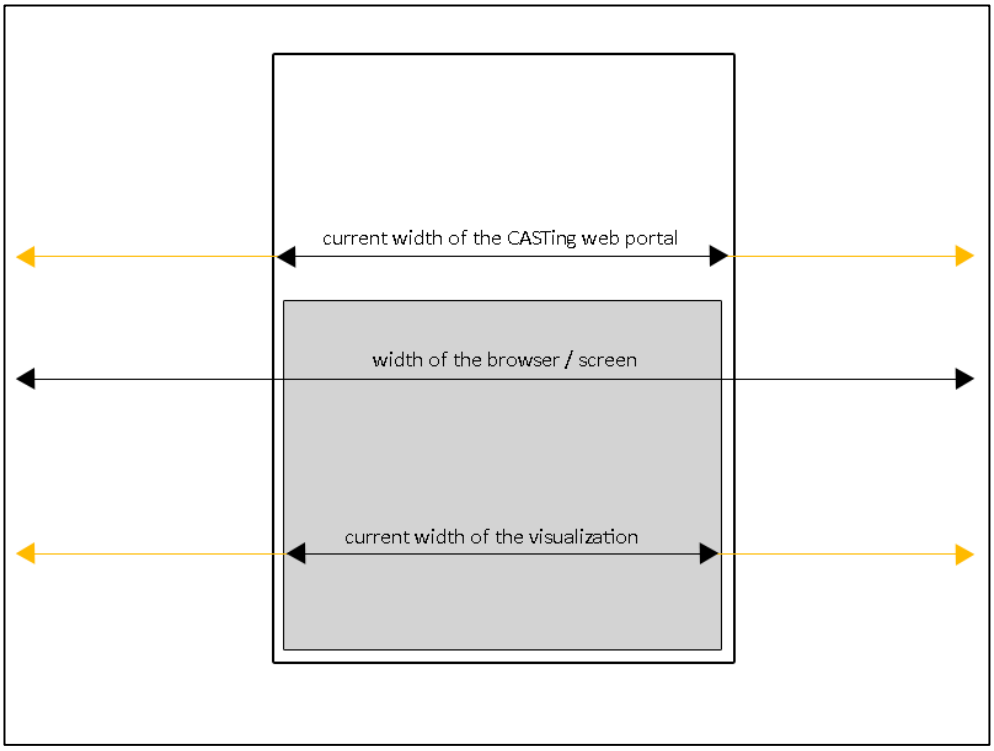


Figure 6.1. Resizable web portal and flash application.

Another way to avoid the user from losing their location is to implement an overview map in the story graph, so that the user knows where in the story graph he is at the moment. An overview map can be seen in Figure 6.2. The black lines represent the web portal and the blue square is the panel of the story graph visualization. A part of a story graph is displayed in the top panel, but since the coordinates of some of the story graph is outside of the panel, the entire story graph isn't visible. The overview map, in Figure 6.2 displayed as an orange square, makes sure that the user always has an overview of the entire graph, even if it is just a small picture. This addition makes sure the user always knows where he is in the story graph at any given point in time.

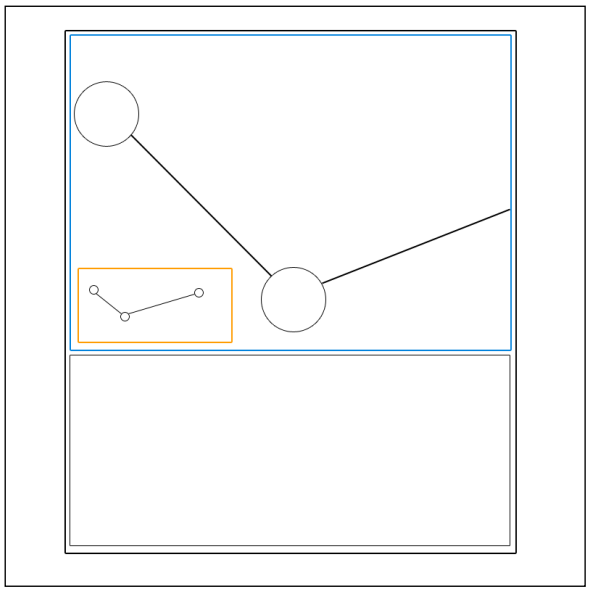


Figure 6.2 Overview map.

Another limitation of the prototype is the design of the marks. The current graph visualization algorithm does not support the edges being drawn from an exit mark to an entry mark like in the original montage graph. That limits the understanding of the marks and how they are connected with each other. In the current version the marks are displayed textually, but this is a point which needs advancement in the future to improve the visualization.

Additionally listening to the audio recordings within the story graph visualization could be a beneficial feature in future development. When a user points with the mouse at a specific node, the specific part of the audio recording could be replayed on request. This could help the user track the development of the story graph in an even more interactive and informative way.

It was determined in the experiment that, in general, the visualization of the development of a collaborative process was created. It was shown that the users are able to follow that process. In this way the idea of visualizing a collaborative process can be applied to any kind of other group support systems. On the one hand it would be interesting to determine different kinds of visualization for collaborative processes and on the other hand it is necessary to prove the advantages of these visualizations for such systems. This also implies possible research questions for awareness. One of which is, which visualizations provide adequate awareness for users?

Furthermore, in the experiment it was determined that the empowering of users to question and understand the work results of other users was achieved. It was shown that the users are able to keep track of the actions of other users. With that knowledge it is possible to manage coupling in a project indirectly. The

users are able to see what other group members have changed in the story graph. In this way they can recognize what other group members work on a topic inside of a project they would like to join. This allows for the visualization to possibly advance the degree to which people work together.

So it is also thinkable, that a company benefits from such a visualization by shortening the time a user needs to introduce himself to the project. It is also an improvement for the user himself, because he can track the actions of the other and maybe in this way can learn from them or reconstruct what they have done until now. In this way it is easier for him to understand the whole project, without the need to have somebody to tell him all about it.

The experiment has shown that the visualization prototype advances the workspace awareness in the CASTing web portal. Because of the results of this work multiple approaches for further research exist within the CASTing web portal and especially the visualization prototype. Some unanswered research questions are:

- How big is the difference of workspace awareness in a storytelling web portal with and without the visualization of the story graph evolution?
- How many nodes and edges can be displayed, until the visualization becomes too confusing?
- Does the visualization lead to a better coordination and communication between project members?
- Can a simplification of communication be achieved?

All these questions can be answered with the help of the prototype. This work also provides further research possibilities for other storytelling software. In this case the visualization prototype has to be adapted to the particular storytelling system. It would be interesting to determine if this kind of visualization could be an advancement for other storytelling systems.

As listed in this section there are a lot of possibilities to use and extend the prototype. The goal of this thesis, to develop a visualization of the story graph evaluation to advance the workspace awareness in the CASTing web portal, therefore has been achieved.

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Appendix

A.1 Experiment and Questionnaire

Basic Information – Storytelling

The purpose of the story graph visualization is to display snippets of audio files (circles) and their connections (arrows). For that, audio files were recorded of a group previously and separately.

Every node (circle) is a piece of an audio file. In this case the audio files are interviews about different universities. A piece of an audio file (for example “UCLA.mp3”) can be an interview part about the local “food”. In this case the snippet (circle) has the title “UCLA.mp3 / food”.

The pieces can be connected and those pieces and their connections can be converted into new audio files (“stories”). In that case the new audio flie can be the story “Food Comparison”. Multiple stories can exist within the story graph visualization.

Scenario

There is a group of students at different universities in Germany and USA. This group made it their business to collect the differences between the educational establishments. The group worked a few weeks successfully on that project, but now they want to widen their circle and they sent you an invitation over the web portal. You decided to join the project and now you need an overview about what has actually happened the last weeks.

For that please complete the following tutorial first.

Tutorial

Step 0: The visualization consists of two parts: **story graph visualization** and **story graph control**. Please take a short look at the application.

Step 1: The story graph control consists of 3 tabs. Please click on the tab "**Help**". The help section explains the meaning of the color coding of the nodes (circles) and edges (arrows). Take a look at those. After that, click on the tab "**Graph Evolution**".

Step 2: To activate the graph evolution click "**Start evolution**", then "**Draw Graph**". Take a look at the slider. With the slider "**Time period for evolution**" you can adjust the beginning and end date of the graph evolution. Please slide the right thumb (small triangle) to the end of the slider. When you have done that, you can slide stepwise through the evolution with the help of the slider "**Evolution time step**". Now you should see, how the story graph was developed over the chosen time period. Under the sliders are displayed the current step and time. From the help section you still should know, that orange nodes and edges were add at the current time and red nodes and edges were deleted at the current time.

Step 3: In the lower right corner, you can zoom in and out of the graph with the "**Zoom**". In the upper right corner there is the "**Select story"** function. Those stories were created within the story graph. If you choose a story name, the used nodes and edges are highlighted in orange. After you have done that click on the tab "**Latest Graph**". That tab shows the story graph in the latest condition.

Step 4: Click "**Draw the latest graph"** and then **"Draw Graph**" to activate the latest graph. In the upper right corner there is a function "**Select user**". If you choose a user name, the nodes and edges that user has created are highlighted in orange. In the lower right corner, you can zoom in and out of the graph with the "**Zoom**". In the lower left corner there is the function "**Show creation times**". You can choose a time period and if some nodes and edges were created in that time period, they are highlighted in orange.

Step 5: Please point with your mouse at a node and at the text of an edge. Now you should see some more information about that node or edge.

Now you can begin to answer the questions on the next page with the help of the story graph visualization.

0 – Statistical Information

Age: [ ]

Gender:

[ ] Female

[ ] Male

Current location (country):

[ ] USA

[ ] Canada

[ ] Germany

[ ] Netherlands

Experience with storytelling:

[ ] I've no experience at all.

[ ] I've heard of it before.

[ ] I've already used the storytelling technique.

[ ] I'm a storytelling expert.

I – Tasks (Check any that apply.)

Which persons are applied to the story graph?

[ ] Jane

[ ] Chris

[ ] Kenneth

[ ] Mia

[ ] Nadine

[ ] Jared

What is Nadine's last name?

[ ] Jefferson

[ ] Herzog

[ ] Pfefferkorn

[ ] Regan

Which person is the most active regarding to the story graph? (Which person created the most nodes and edges?)

[ ] Chris

[ ] Nadine

[ ] Jared

[ ] Mia

Which person is the most inactive regarding to the story graph? (Which person created the fewest nodes and edges?)

[ ] Chris

[ ] Nadine

[ ] Jared

[ ] Mia

What did Jared do on January, 27th 2010?

[ ] He deleted a node.

[ ] He added an edge.

[ ] He added a node.

Which stories were created within the story graph?

[ ] UMD Interview

[ ] UCLA Interview

[ ] FUB Interview

[ ] Education Comparison

[ ] Food Comparison

[ ] UWSP Interview

Which audio files were used in the story graph?

[ ] UCLA.mp3

[ ] UMD.mp3

[ ] UWSP.mp3

[ ] TUB.mp3

[ ] FUB.mp3

Which person was the last working on the story graph?

[ ] Mia

[ ] Jared

[ ] Chris

[ ] Nadine

At which point in time was deleted „UCLA.mp3 / education → UWSP.mp3 / location“?

[ ] 2009-08-31

[ ] 2009-03-12

[ ] 2010-01-31

When was node (circle) „UWSP / education“ created and by whom?

[ ] 2009-08-31 by Chris

[ ] 2009-08-31 by Jane

[ ] 2010-01-02 by Jared

II – Tasks Part 2 (Choose one of the following answers.)

Which person would you contact, if you had questions regarding the UWSP Interview?

[ ] Chris

[ ] Nadine

[ ] Jared

[ ] Mia

With which person would you cooperate, if you want to do something with the story "Food Comparison"?

[ ] Chris

[ ] Nadine

[ ] Jared

[ ] Mia

III – User Interface (Choose one of the following answers.)

The handling of the story graph visualization was easy to learn.

[ ] strongly agree

[ ] agree

[ ] neutral

[ ] disagree

[ ] strongly disagree

I always knew where I am and what to do.

[ ] strongly agree

[ ] agree

[ ] neutral

[ ] disagree

[ ] strongly disagree

A.2 Experiment Results

Statistical Information	Nr. 1	Nr. 2	Nr. 3	Nr. 4	Nr. 5	Nr. 6	Nr. 7	Nr. 8	Nr. 9	Nr. 10
Age	25	22	28	23	23	24	26	25	23	25
Gender	male	male	male	female	male	male	male	male	female	female
Location	Germany	USA	Germany	Netherlands	Netherlands	Canada	Germany	Germany	Germany	Netherlands
Experience	no	no	no	no	no	no	no	no	no	no
I - Tasks										
1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	0	1	1	1
4	1	1	1	1	1	0	0	1	1	1
5	1	1	1	1	1	1	1	1	1	1
6	1	1	0	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1
II - Tasks Part 2										
1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1
III - User Interface										
Easy to learn	strongly agree	agree	agree	strongly agree	neutral	agree	neutral	agree	agree	agree
Where I am	agree	disagree	neutral	strongly agree	agree	agree	neutral	neutral	agree	agree

Declaration

I declare that this thesis has been created by myself, that the work contained herein is my own except where explicitly stated otherwise in the text and that this work has not been submitted for any other degree or professional qualification except as specified.

Otto von Guericke University Magdeburg, March 9th 2010

Jana Schumann