

## Interaction with Interconnected Data in Participatory Processes

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### 1 ABSTRACT

This paper proposes a conceptual graphical user interface for the interaction with interconnected data in participatory processes that play an important role for future smart cities. The presented idea is based on identifying important tasks for data exploration and data editing. The data to consider is structured, semi-structured or unstructured and of different facets. For example, participatory processes like planning and decision processes involve text, time and spatial data. In other words, the handling of the data is a complex endeavor in terms of representation and interaction. In this respect, we utilize and describe a graph-based data model that properly reflects the connected data.

### 2 INTRODUCTION

Online civic participation is one major element of future smart cities. Even now, people engage individually or together in participatory processes, e. g., formal and informal planning and decision processes (cf. DANIELZYK 2005), and social communities, e. g., groups in different social media applications (BBSR 2015). People want to characterize their social environment and make contributions to the public. People develop ideas and discuss past or future events. In this regard, they use different information and communication channels. Any smart city can benefit from the knowledge of the masses and continuously adjust its future development, if it provides the proper software tools tailored to their own specific needs. These services must enable different user groups to participate independently from space and time constraints while lowering the barriers for getting started (SCHÜTZ et al. 2015). Although this thought is very promising, it immediately leads to three main challenges.

Firstly, participatory processes produce data of various data types, e. g., text, image, time and geographical data. Consequently, future software applications and services of smart cities in the area of e-participation need to deal with structured, semi-structured and unstructured data. This is a complex undertaking in terms of storing and processing the heterogeneous data that is additionally interconnected on multiple hierarchy levels, e. g., consider comments of comments. Secondly, we must understand the users' needs during participation in order to design and implement interaction methods. We need to allow the users to accomplish their tasks. But for this purpose, typical and clearly distinguishable tasks have to be identified at first. Thirdly, the user requires an interface to participate. Thereby, the collected data needs to be visualized properly without suffering from information overload. Furthermore, the user interface must provide ways to work with the data, e. g., for adding new content or searching existing information.

This paper briefly examines related work (see Section 3) and proposes a system to interact with the interconnected data of participatory processes. Thus, it addresses the aforementioned challenges by presenting 1) a graph-based data model, 2) main tasks from a user's point of view and 3) a graphical user interface (GUI) for exploring and creating content during participation. Firstly, the graph-based data model (see Section 4) best reflects the data's nature in terms of interconnected and multi-faceted entities. It easily represents the relations between participatory contributions while storing several related data attributes of various data types. Secondly, it is important to understand the users' needs. In general terms and from a user's perspective, participatory processes are all about finding, understanding and providing information. Thus, common and fine-grained tasks for working with the data are identified as well as categorized (see Section 5). These tasks build the foundation for the design of specific interaction mechanisms. Thirdly, the collected information, e. g., documents, comments and geographical data, is visualized in a two-panel-based main view that allows interactions. Therefore, a user can keep track of different content, compare it or relate

it to each other at the same time. In contrast to many visualization techniques that display the graph's structure, i. e., its nodes and edges, in combination with multiple facets (cf. HADLAK et al. 2015), we propose a user interface (see Section 6) for exploring paths of the graph, i. e., the relations between entities, without explicitly displaying the graph's components in a main view. The overall goal is to display the sophisticated data in a clear and simple interface that also provides ways for creating new content based on related and already existing data. In this regard, corresponding conclusions and possible future work (see Section 7) are explained as well.

### 3 RELATED WORK

Plenty of individual software applications for the realization of participatory processes in the digital space do exist. This applies likewise to informal and formal planning and decision processes. So, information and communications technologies play a growing important role (MEDAGLIA 2011). There are systems that mainly present and deliver information like city-related information portals, e. g., of the city of Köthen<sup>1</sup> in Saxony-Anhalt, Germany. Their interfaces focus on displaying texts and lists of downloadable documents that can be explored only in an incoherent fashion. There are also more interactive applications for exploring the planning material and participation contents like "BOB-SH"<sup>2</sup>, a platform listing current planning procedures of the state Schleswig-Holstein, Germany, or "Rechne mit Halle"<sup>3</sup>, a platform for discussing the budget of the city of Halle, Saxony-Anhalt, Germany. Their interfaces support the exploration by search and filter elements and integrate possibilities to participate via online forms or by the integration of discussion boards. But overall, it is difficult to understand the relations and connections within the data, because the included information is presented separately. Often, transparency and insight are hard to acquire. To the best of our knowledge, there is no description or concept available of how a Web-based GUI for the exploration and editing of data in participatory processes can look like that focuses on the interconnections.

Graph visualization and interaction is an interesting and promising research area when it comes to the representation of the interconnected data. This field incorporates a lot of methods and interactive systems for the data exploration (cf. BECK et al. 2014, HADLAK et al. 2015, VEHLLOW et al. 2015). But these systems and their GUIs commonly deal with different abstract graph representations, typically affect experts only and neglect the data editing. There are also many text visualization techniques (cf. KUCHER et al. 2015) for the deduction of insights from multi-faceted data with the focus on natural language text that plays a major role in participatory processes. These methods are promising as well but normally show results of analytical tasks only, e. g. topic modeling. Such methods do not support the user during the participation process itself.

### 4 GRAPH-BASED DATA MODEL

Online participatory processes deal with data of different types. In the case of formal and informal planning and decision processes we need to consider a wide spectrum. In formal processes, involved participants, e. g., citizens or public agencies, typically produce natural language text data, e. g., when they write official statements in relation to specific parts of the planning material like binding site plans. These materials themselves comprise of text data but can additionally contain more useful information on a deeper level. In this respect, we noticeably point to textual references, e. g., references to external legislative texts or references within a document itself. In informal processes, the situation is similar to the already described one but often allows more degrees of freedom regarding the communication among each other, i. e., users are encouraged to discuss and develop ideas or opinions collaboratively, so that we might gain a deeper and denser net of interconnected data. Additionally, there is no restriction to natural language text. Each online contribution might contain other data like images or videos. More importantly, we need to consider more facets like time-oriented and spatial data, because all participatory contributions are made at a specific point in time and planning and decision processes involve geographic information systems (GIS) for further interactions, e. g., placing markers or defining regions on a map. Generally, details about the described data depend on the specific application, i. e., not every participatory process needs to consider all possible kinds of data. But in relation to multiple data facets the challenges for software systems in the area of e-participation stay the same: How can we represent and obtain the interconnected data?

<sup>1</sup> See [www.koethen-anhalt.de/de/stadtplanung.html](http://www.koethen-anhalt.de/de/stadtplanung.html), last access: March 31th, 2016

<sup>2</sup> See [www.bob-sh.de](http://www.bob-sh.de), last access: March 31th, 2016

<sup>3</sup> <http://www.rechne-mit-halle.de>, last access: March 31th, 2016

## 4.1 Data Representation

The previously described situation leads to a complex endeavor regarding data representation. We consider a mathematical graph for describing the data. A graph  $G = (N, E)$  basically comprises of a set of nodes  $N$  and a set of edges  $E$ . In our approach, each node  $n \in N$  represents a specific entity or contribution, e. g., a comment referring to a text passage or a marker on a map. Such an entity is described by a number of attributes, e. g., the author's name or the date of submission. Each node of our graph model is able to store a different number of attributes. This flexibility is motivated by the fact that online civic participation can not only involve one but various types of participatory entities as previously described. Consequently, we have a single graph that is allowed to contain different types of nodes. Furthermore, an edge  $e = (n_1, n_2) \in E$  is a directed connection between two nodes  $n_1$  and  $n_2$ , i. e.,  $n_1$  refers to  $n_2$ , while  $n_1, n_2 \in N$ . Hence, an edge represents a relationship. It is additionally possible to weight an edge, e. g., to emphasize its importance in comparison to other edges, but we currently do not consider any special edge weighting, i. e., each relationship is equally important. But generally, this aspect depends on the use case in practice and needs further investigation.

An example for a very simple model is depicted in Figure 1. It shows various types of nodes (map, map marker, document, comment, image and rating information in form of a “heart”, “like” or “thumbs up”) indicated by different symbols. The example includes three text documents (nodes 3, 4, 5) and a map (node 2) of a GIS. Some markers (nodes 1, 6, 7, 8) are present on the map. There are also some comments (nodes 9, 11) on text documents as well as a comment (node 14) on a map marker. And even comments (nodes 10, 13) on comments exist. One comment (node 9) refers to a text document and to the map at the same time. Even an image (node 16) is attached to one specific comment. Last but not least, some comments and the image are liked or rated (nodes 12, 15, 17) by some participants. In the end, we see different levels of complexity. Table 1 shows typical attributes and some values corresponding to the presented node types of the previously described graph-based data model.

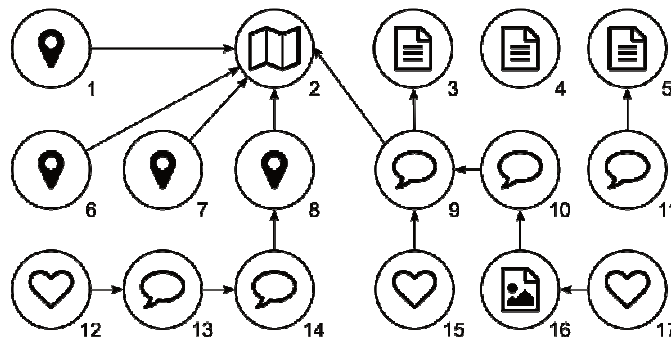


Fig. 1: Exemplary graph-based data model showing different node types and some interconnections.

Type	Attribute	Value
Document 📄	Author	John Doe
	Name	goals.pdf
	Title	Planning Goals
Map 🗺	Dataset name	saxony_anhalt12
Map marker 📍	Label	M3
	(x, y)	(51.746071, 11.983459)
Comment 💬	Author	Jana Doe
	Content	I don't agree with the idea! That would be too expensive.
	Timestamp	20160308 T 07:59:01 UTC
Image 🖼	Size	88 KB
	Dimensions	1363 × 667
	Name	sketch_3.png
Rating ❤	Author	Joe Blow

Table 1: Exemplary attributes and their values for different types of nodes.

## 4.2 Graph Creation

There are two main mechanisms that create the data graph of a participatory process. As a starting point, an initial graph is needed that describes the available material given through the planning or decision process itself. This is done through a (semi-)automated approach. Secondly, each contribution made during participation is added to the graph by a manual, interface-supported interaction. This means the graph grows over time during the whole process.

A (semi-)automated method creates the initial graph, because it is not always possible to manually maintain all conceivable references. Otherwise, this would lead to an extra amount of work that might not be desirable. Therefore, we need automated methods that extract the interconnected information and create nodes and edges. For example, planning material like expert reports might contain textual references to legislative texts, e. g., “§ 437 BGB (German Civil Code)”, commonly prefaced by the section sign “§” or by the strings “Sec.” or “Section”. Such information can be extracted computationally via specific rules, e. g., by the integration of a set of regular expressions. But natural language text is more complex when we generally consider its unstructured form and the information contained within. In this context, a different example is the mention of other available documents in phrasings like “I received your letter from last Monday”. Algorithms in information extraction (cf. JIANG 2012) and specifically named entity recognition (cf. GRISHMAN et al. 1996, RATINOV et al. 2009) or coreference resolution (cf. DURRETT et al. 2013) deal with these problems. However, this is out of the scope of this paper and will be described elsewhere. For this paper, we assume the availability of a suitable algorithm. On the downside, these approaches are prone to errors. Absolute correctness and completeness are sophisticated goals and commonly utopistic. Because of that, a user-driven control mechanism to check and modify computed suggestions is added, bringing the manual effort to a minimum.

During participation, each new contribution is added to the graph as a new node, e. g., when a user submits an official statement. Often, a contribution relates to a specific part of the available data and hence a specific part of the graph, like a specific chapter of a planning document, a specific region on the map or a specific participation contribution of someone. To improve follow up work with the contribution, like the analysis of all made contributions or the exploration of contributions by other participants, it is important to connect the new node to the most related nodes in the graph, either manually through the contributor, or automatically supported by the interface or the same analysis methods mentioned above. This is described in Section 6.3.

## 5 TASKS

Each participant of participatory processes has certain goals and wants to accomplish specific tasks respectively. Here, we want to characterize basic tasks for users of an online e-participation system. We distinguish between two main perspectives: tasks for data exploration and tasks for data editing. Therefore, we cover two major objectives from a user’s point of view, which are exploring the space of available process information and contributions made by every participant as well as taking part in the participatory process by making own contributions. These tasks build the foundation for the software system and are based on an established task categorization for interaction in information visualization (YI et al. 2007) and for graph exploration and graph editing (GLADISCH et al. 2015).

### 5.1 Data Exploration

In the following, we describe basic tasks for exploring the complex and interconnected data of participatory processes. They allow interaction with the underlying components of the data model, i. e., the nodes, the nodes’ attributes and the edges.

**Explore tasks:** Exploration tasks allow a user to examine different parts of the given data.

- *Inspect online:* This task allows a user to read or view the provided information material in an online and direct way without the need of additional software.
- *Scroll content:* Scrolling changes the view and shows previous or subsequent content of the current view. For example, a user scrolls documents in order to read different sections or scrolls a list of comments in order to browse their contents that relate to one specific posted idea.
- *Directly navigate:* Performing this task, the user can directly jump to another view of the current content or exchange the displayed content at all. Considering the table of contents of a document,

clicking on a hyperlink that links to the related section is one imaginable example as well as the selection of a document in a list of downloadable or online readable files.

- *Pan view in GIS:* Geographical map data plays an important role for self-positioning in the environment of interest. Panning allows to move the current view. Panning also extends scrolling by allowing not only one- but two-dimensional translations of the related view at the same time.
- *Zoom view in GIS:* This task enables a user to zoom in or out of the current content shown in the view in order to reveal different information.
- *Download data:* Performing this task, a user wants to consume parts of the data later or in a different context. For example, participants might want to download individual chapters of planning documents for offline use.

**Select tasks:** These tasks focus on marking data items as interesting and keeping track of them.

- *Select / deselect content:* When selecting / deselecting content, the user marks the affected data item as interesting / uninteresting. This task is often a starting point in a chain of further tasks.
- *Select / deselect multiple content:* This task is similarly performed to the previous one but takes multiple concurrent selections into account.

**Reconfigure tasks:** Reconfigure tasks lead users to a different perspective on the data.

- *Sort items:* This task changes the spatial arrangement of the data representation. For example, a user sorts all comments that relate to one specific text paragraph by their date of submission.
- *Enable / disable layers in GIS:* GIS incorporate several layers of data. By performing this task, users can toggle the list of displayed layers. This might show different relationships between geographical data facets.

**Abstract & elaborate tasks:** These tasks enable the user to adjust the level of abstraction of data representation and consequently provide more or less detail.

- *Examine details:* This task can represent further details of one or more data items on demand. Hovering special content that reveals further information is an example.
- *Hide details:* When hiding details, the user suppresses a specific amount of information, e. g., in order to overcome information overload. For example, this task might undo a previous request for more details but can also be independent.

**Connect tasks:** These tasks highlight relationships that are already presented and show previously hidden data items that are relevant to a given data item.

- *Combine information:* This task aims at visually connecting data from different contexts. For example, a user wants to write a comment to a specific document section and at the same time see the related or involved geographical area highlighted on the provided map in a GIS.

**Filter tasks:** When performing filter tasks, the set of displayed data items is changed based on conditions. So, this generic task reduces or extends the set of visible data, but the perspective on the data persists. Direct search queries, e. g., for document titles, that alter the number of displayed items are an example. We do not subdivide tasks of this category any further.

**Encode tasks:** Encode tasks alter the visual representation or encoding of the data in terms of visual appearance. In participatory processes, we currently do not consider encoding tasks for exploratory purposes.

## 5.2 Data Editing

This section is about the basic tasks for data editing in participatory processes.

**Compose:** Composing is about the creation of new own data.

- *Write text:* This basic task allows a user to write text which is a fundamental part in participatory processes.
- *Style text:* This task allows to emphasize specific parts of the text, e. g., by changing the color of a word or by setting the font of a sentence in “bold”.

- **Attach data:** This task focuses on the data source that originates from outside of the system, i. e., the data usually comes from other applications. For example, a user might want to attach photos or scanned documents from hard disk.

**Add:** These tasks allow the graph-based model to evolve by adding new data.

- **Send data:** Submitting data describes the process of transferring and storing the composed data as a contribution to the related participatory process.
- **Save draft:** This task temporarily adds new contributions to the graph-based model. This new information can be interpreted as a preliminary version of a final submitted version of the data.

## 6 GRAPHICAL USER INTERFACE

In this section, we propose a conceptual idea of a GUI for data exploration and data editing in the environment of participatory processes. The GUI reflects the previously described tasks. The concept is currently optimized for the use on large screens with keyboard and mouse interactions. The interface basically comprises of three main components: direct navigation area, two-panel view area and editor area (see Figure 2). They are arranged vertically from top to bottom.

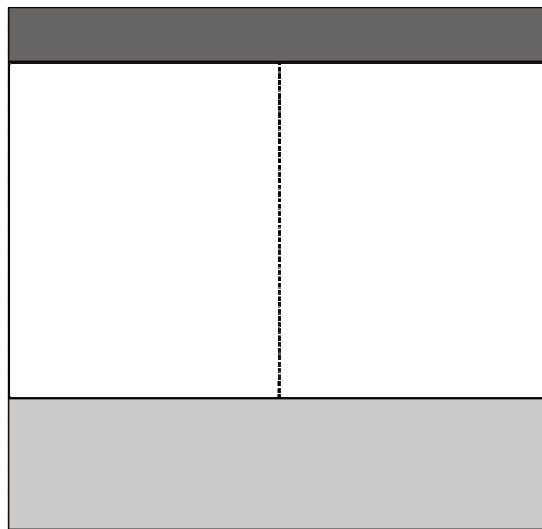


Fig 2: Main components: direct navigation area (top), two-panel view area (center) and editor area (bottom).

### 6.1 Two-panel View Area

We start with the two-panel view area that features a side-by-side arrangement as the name might already suggest. The simple layout is motivated by dual-pane file managers of operating systems, e. g., Vifm or Midnight Commander, as well as centuries-old printed books. With this choice, we enable the exploration of maximal two different contexts simultaneously.

Each panel can hold different content reflecting certain nodes in the data graph during exploration. For example, a document can be displayed on the left side for further reading (*inspect online task*), while the map is displayed on the right side. Therefore, at least two distinct types of data can be mentally combined and viewed in context (*combine task*) which can lead to more transparency and insight. Depending on the shown data, further interactions with the content are possible. For example, when we consider text documents, scrolling (*scroll content task*) can be achieved, text can be selected (*select / deselect content task*) and tooltips that explain technical terms can be shown (*examine details task*) or hidden (*hide details task*). In case of a geographical map, panning (*pan view in GIS task*), zooming (*zoom view in GIS task*) as well as selecting different map layers (*enable / disable layers in GIS task*) is allowed. In this regard, we understand that GIS can be complex systems and provide their own individual interaction methods possibly based on different and more advanced tasks. Therefore, map data will be displayed through an integrated GIS client inside the panels.

In case people want to inspect planning material at a later time and maybe in an offline scenario, they can download data via a button (*download data task*), e. g., by downloading a whole document or a screenshot of the current map's viewport.

A panel can also show a group of information items of same type that might be hierarchically structured like lists or trees of comments and subcomments. Additionally, such structures can be filtered via text queries (*filter task*) and sorted by different aspects (*sort items task*), e. g., date or author of the contribution. Each item itself can be visualized by using a short form respectively snippet of the item's content. This whole idea is shown by Figure 3.

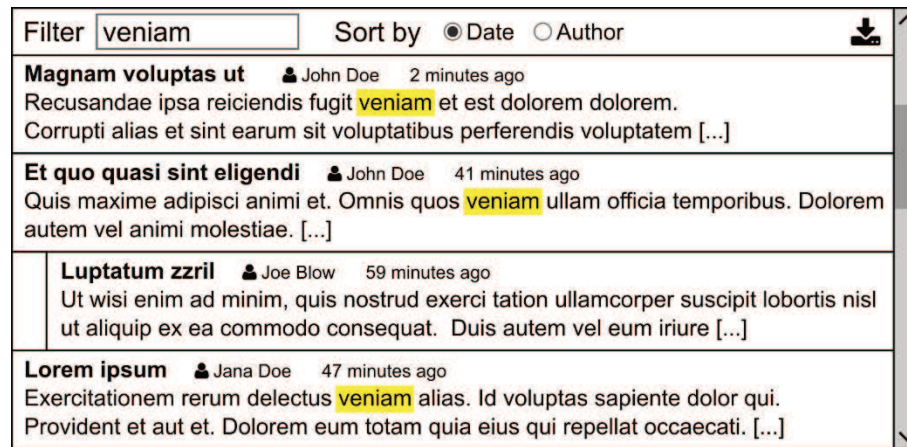


Fig. 3: List of comments including one sub-comment in one panel with filter and sorting functionalities.

In addition to showing any two information items simultaneously, a two-panel-based view is nicely suited for exploring paths of the graph in context. For this purpose, the graph edges are visualized as part of the content visualization like hyperlinks are visualized in a Web document. Clicking such a visualized edge or reference will then show the original content in the left panel and the related content in the right panel. For example, if the user is reading an expert report which refers to a specific section of the planning document, this reference is highlighted in the report on the left side. Clicking on the reference, i. e., following a graph's edge, will then show the section of the planning document on the right side. Such a visualized edge can also summarize several edges at once, e. g., all comments to a section of a document, that will be displayed in the previously described list view.

## 6.2 Direct Navigation Area

Reflecting different cases of application, we allow different methods for changing the content of each panel (*directly navigate task*). Most important for the exploration in context is the previously described following of edges that is directly realized in the panel view. This can lead to a navigation sequence, in which the user explores several edges. To trace back such a route and for getting back to the original starting point, the navigation area provides back navigation through the panels' history similar to back navigation on the Web.

Additionally, the navigation area also allows for direct selection of content to be displayed in each panel via single selection dropdown boxes with maximally two navigation levels. The first level distinguishes between available main entities like planning documents, maps or the collection of participation content. The optional second level dynamically adjusts its content based on the first level. For example, if a document contains several sections, typically listed in the document's table of contents, the second navigation level lists these direct links to the sections. Figure 4 shows the navigation area.

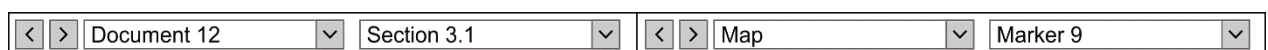


Fig. 4: Dropdown boxes for direct navigation and buttons to browse each panel's history.

## 6.3 Editor Area

An interface is needed to compose the ideas and opinions of the participants (see Figure 5). An important part is the possibility to create text with at least minimal features known from operating system text editors or online forms (*write text task*). We consider basic methods for highlighting text like setting font in "bold" or "italic" in order to allow each user to emphasize specific content (*style text task*). Also, we allow the user to upload data that gets attached to or directly integrated into the written content (*attach data task*). The last part of the editor area enables a user to save the composed content as a preliminary version (*save draft task*). People can be interrupted or run out of ideas while they participate. Consequently, it is necessary to come

back to the current state of the contribution. Draft versions can be managed separately in the personal user area of the system. Of course, the composed content can finally be submitted (*send data task*), too.

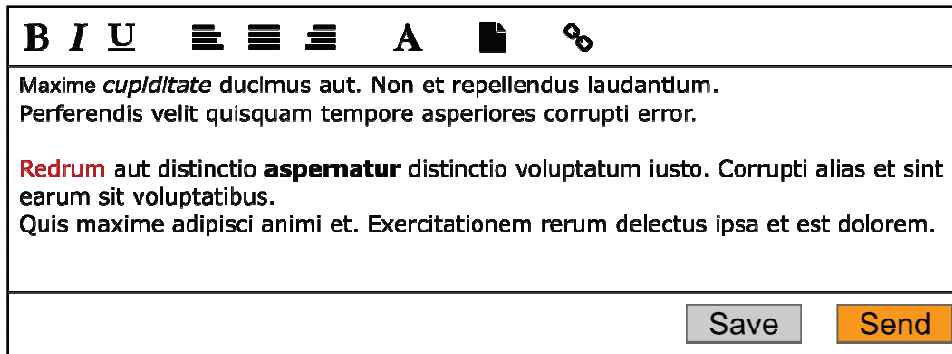


Fig. 5: Editor area for composing, saving and submitting content.

But the pure content composing is only one necessary part. Another important aspect is the creation of connections that originate from the new content and relate to other nodes of the graph. In this regard, we look at two basic approaches. On the one hand, we use (semi-)automated methods of information extraction and coreference resolution for adding new parts to the graph as described earlier. In the contribution submission process, an automated procedure searches for possible new connections which the user must refuse or accept before submitting. This idea can even possibly be realized during content composing, i. e., in realtime. On the other hand, a manual, user-controlled method is provided. It can start from two different areas:

- The first way starts from the contents of the panels and ends in the editor. As an example, let us consider documents. A context-aware menu can be displayed after a user successfully selected a text of interest (*select / deselect content task*) (see Figure 6). By clicking the displayed chain symbol of the menu, the user links the current content of the editor window to the selected text or can start composing new content. So, while the user is reading the document, he can start making his contribution.
- The second way starts from the editor and ends in a panel's content. By clicking the chain symbol in the editor window, already shown by Figure 5, the user enables a selection mode. During this mode, the user can select single items, e. g., text paragraph, or even a set of items, e. g., several comments, in both panels at once (*select / deselect multiple content task*). This mode is left when the chain symbol is clicked again. Figure 7 shows these steps in the complete concept of the GUI as an example.

These ways can be repeated and chained individually so that multiple targets might got specified in the end. Existing interconnections are highlighted by a specific background color similar to the visualization of text selections as shown in Figure 6. By clicking this existing connection, the context-aware menu pops up and contains an additional icon that might trigger the deletion of the selected connection.

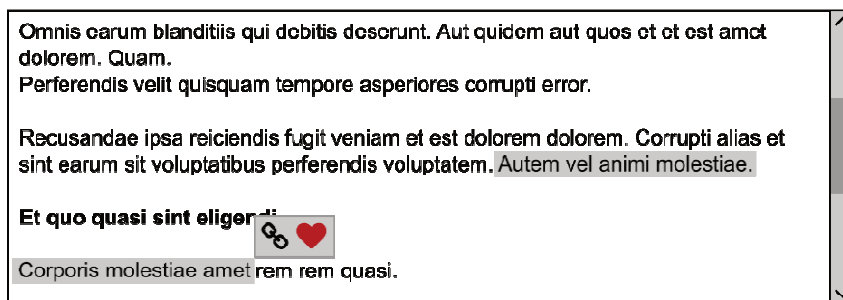


Fig. 6: Selected text and context-aware popup menu for adding another comment or rating.



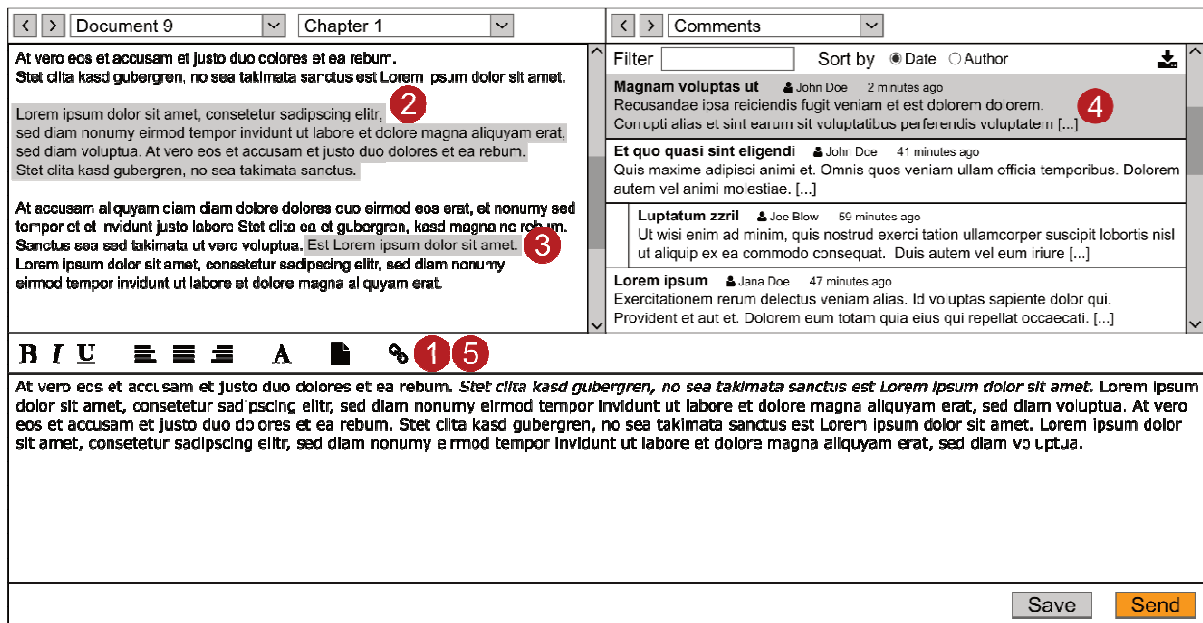


Fig. 7: Exemplary steps for creating interconnections: (1) Start process by clicking the chain symbol, (2, 3) select some text targets by clicking, holding, dragging and leaving the mouse, (4) select a comment by clicking the mouse and (5) click to end the process.

## 7 CONCLUSION AND FUTURE WORK

E-participation is one major aspect of smart cities. Complex and potentially a lot of data arise during the progress of participatory processes depending on the number of participants and their activities. If more and more people participate, a flexible and expendable data model is needed. Our described graph-based model is able to represent data of different types with a varying number of attributes. Especially when it comes to the relationships between several data items, the graph easily describes the interconnections due to its inherent incorporation of edges.

We described basic tasks for data exploration and data editing. It is sometimes not easy to identify the matching category of a task and the boundaries seem to blur. But this approach helps in finding the needed and atomic tasks. Therefore, redundant complexity can be avoided before it comes to mapping these tasks to interaction elements in a GUI.

The presented conceptual idea for a GUI of an interactive software system for data exploration and data editing picks up on the described tasks. We currently implement and integrate this idea in a Web-based software prototype for formal or informal planning and decision processes. In a next step, we will conduct user studies to evaluate the presented concept. A key challenge is the achievement of simplicity, i. e., different user groups of various ages need to be able to efficiently work with the system. This concerns experts as well as amateurs. Another challenge for the future is the adaptation of our concept to different devices, especially tablets and smartphones with smaller screens and other interaction mechanisms.

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