Designing Visual Systems for Social Data Analysis in Open Government Applications

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Abstract. In this paper we discuss our preliminary experiences in designing a visual system for social data analysis in collaboration between citizens and municipal authorities through a web-based open government system. Based on the integration of theoretical models with findings from formative evaluations and stakeholder workshops with a prototype system, we present a multi-perspective visualization model and user interface designs addressing specific requirements of social data analysis in heterogeneous stakeholder settings.

Keywords: Social Data Analysis, Information Visualization, Multi-Perspective Visualization, Collaborative Sensemaking, Open Data, Open Government

1 Introduction: From Visualization to Collaborative Sensemaking

The use of information visualization for facilitating the discovery of insights in large or complex data collections has been extensively researched. Common approaches consider the use of visualization techniques for augmenting cognitive capabilities of individual users in recognizing contexts, patterns or relationships in a data collection as a means of constructing new knowledge [2]. More recently, there has been a growing interest in supporting the interpretation of large or complex information sets through collaborative use of shared visualizations in asynchronous distributed scenarios. Systems such as Many Eyes [9] or SenseUs [4] provide web-based platforms allowing users to create interactive visualizations of own or shared data collections and to share them with others. Besides creating customized visualizations from predefined templates (e.g. pie charts, stacked graphs) such systems allow the saving and recall of specific visualization states (e.g. zoom, filter or time scale parameters) which can then be accessed by others (application state bookmarking [10]). Collaborative analysis is supported by textual comments and graphical annotations that link user contributions to the related views and vice-versa (double-lined discussions [4]). Most recent solutions allow existing visualization systems to be extended with user comments and discussions [11].

The basic idea of such „social data analysis“ [10] is that by coupling visualization with asynchronous social interaction, the process of individual sensemaking in which people create new knowledge by collecting, organizing and interpreting information [6] can be made more effective [4]. The associated notion of collaborative sensemaking emphasises that sensemaking is often a social process in which the meaning of data and information is negotiated against specific social contexts involving shared backgrounds, frames of reference, goals and perspectives [1],[5]. While these questions may not play a critical role in the above examples of general-purpose platforms, they become of central importance when designing for purposeful collaboration with shared goals, such as in collaborative decision-making in organizations [4] or in heterogeneous stakeholder networks with conflicting perspectives on the meaning of information [5].

Previous research suggests that such contexts require considering specific requirements in order to support effective sensemaking through exploratory information access and analysis [5]. In particular, this refers to the need and potential of providing visual views of heterogeneous information collections from clearly defined multiple perspectives reflecting personal points of view of individual users or shared perspectives of specific user groups. This raises both questions of how such personal and shared perspectives can be defined as well as how they can be effectively visualised and made useful for social discovery transfer in heterogeneous data collections [5]. Aforementioned approaches do not consider these requirements and offer only incidental support corresponding to this need (e.g. the possibility of bookmarking and sharing specific views of the *same* visualization [10][11]

In this paper we discuss our preliminary experiences in designing a visual system for social data analysis in collaboration between citizens and municipal authorities through a web-based open government system. In particular, we discuss the requirements and design principles for designing visual systems for this specific class of applications and present one possible solution for turning them into practice. This is based on the integration of theoretical underpinnings with findings from formative evaluations and stakeholder workshops with a prototype system. The developed solution presents a multi-perspective visualization model and user interface designs incorporating well-known visualization techniques (tree maps, geo-visualisation) applied in a novel way to satisfy the requirements of social data analysis in heterogeneous stakeholder settings. In this way, the paper provides an application-oriented contribution to this emerging area of research.

2 Application Setting: Social Data Analysis for Open Government

The underlying idea of open government approaches is that through open publishing and public analysis of data collections concerning public services better government and satisfaction of citizen needs can be achieved. Different web portals make various forms of data collections related to citizen life (e.g. city budgets, transportation statistics) available online. While such open data collections are being provided by an increasing number of local and national authorities or citizen initiatives (e.g. Germany’s Open Data Network), the provision of systems and tools for easy

collection, organization and analysis of this data is still at its beginnings. The few existing visual tools in this domain typically provide straightforward applications of well-known visualization techniques (e.g. tree maps of country budgets [15]) without considering specific use cases or application settings and their requirements. The more sophisticated current visual systems for social data analysis (such as [4], [9] or [11]) are designed as general-purpose tools and could in principle be applied to such contexts, but this has not yet been the case (to the best of our knowledge). Similarly, none of these approaches consider the existing body of knowledge on supporting collaboration in heterogeneous settings or the use of visual information interfaces in such settings [5].

We argue that the effective application of such approaches to the application domain of open government requires considering specific aspects and requirements of this particular application context and developing domain-specific solutions. On one hand, this concerns the inherently problematic nature of the underlying collaborative scenario. Use cases of social data analysis specifically discussed in previous work point either to relatively homogeneous user groups with implicit shared interests (e.g. a group of analysts analyzing a shared data set in [9]), or encompass a heterogeneous population of general users sharing and commenting on personal visualizations [9], or they refer to a general audience who may become aware of a shared interest defined by using the visualization (e.g. baby names or job statistics [4]).

In contrast, the open government applications are characterized by a collaboration setting formed around specific goals and conflicting interests of different user groups (e.g. citizens, local authorities). Previous research has shown that using visual information tools to support such contexts requires considering very specific requirements. This includes the need for providing visual overviews of information collections from clearly defined perspectives reflecting personal points of view of individual users or shared perspectives of specific groups of users [5]. This raises both questions of how such personal and shared perspectives can be effectively elicited, visualised and made useful for social discovery transfer in open data collections [5]. Such concerns are also grounded in theoretical frameworks of collaboration in heterogeneous settings. The notion of "boundary objects" emphasises the importance of artefacts which allow perspectives of different user groups to be used independently while at the same put in relation to each other [8][7]. Similar requirements form the basis of the well-known "perspective making – perspective taking" model of knowledge transfer [1]. Finally, a number of current practical initiatives aiming at supporting citizen participation in local government through easy-to-use tools for collaborative elicitation of citizen needs [13][14][16], reflect an existing practical need for capturing a shared perspective of a specific stakeholder group (citizens) and communicating and visualizing it for others (municipal officials).

This raises the following questions: How can we effectively design visual tools for social data analysis in such heterogeneous application contexts? Which design principles from literature on collaboration support and from recent general-purpose visualization platforms can be successfully transferred? What specific requirements characterize this application context? And can we identify conceptual and design elements of a specific visualization model that could satisfy such classes of applications and thus further current practice in this emerging field?

3 E-Local: A Web Platform for Participatory City Management

We have been investigating these questions within the E-Local project for participatory city management [12]. The E-Local project develops a Web2.0 platform for stimulating active citizen participation in local government through collaborative elicitation of citizen needs, their interactive visualization and online dialogue between the citizens and the local administration. A central element of its design is the data-centric interaction around a shared visualization facilitating online discussion.

3.1 Use Case Scenario

The basic use case of the E-Local project is depicted in Fig. 1. Citizens enter need requests (e.g. "Please fix the road holes in Wins street") through the E-Local web interface or a mobile app. The requests are stored in the E-Local database and displayed in a geographic visualization based on Google Maps (GPS-data is captured by the phone app or the user can pinpoint the location). Once the request enters the E-Local system it can be edited online and forwarded to one's social network to collect supporters (via Email, the E-Local network or one's Facebook account). During this "mobilization phase" the request can be discussed and commented upon by all users. After a determined time this phase ends and the request (with corresponding supporter votes and comments) is forwarded to the municipal administration. This starts the online dialogue ("feedback and discussion phase") in which municipal officials can accept the request and propose a solution or refute it (with an explanation).

Figure 1. Typical Use Case and Visual Design of the E-Local Prototype

In both cases the citizens can vote for accepting or refuting the administration's decision. In case of refutal, they can start a citizen initiative for solving the request and raising the required funding on their own[1]. All requests accepted by the local authorities enter the "implementation phase" in which their progress is monitored and communicated by the local administration. In this way, a model for pro-active citizen participation in the management of local municipal affairs in a collaborative process with local authorities is realized (which distinguishes E-Local from other citizen platforms, such as [13], [14], [16]). Through the described workflow a data set of citizen needs and corresponding discussions is created, visualized to different parties and made available for collaborative analysis and social interaction around the shared visualization. The basis for the visualization is provided by collaborative user-generated data sets (citizen needs in the first-iteration prototype), which are then integrated with external open data sets (municipal data in the second system design).

3.2 Visual System Design and Protoype Implementation

The main hypothesis of the system concept is that centering the interaction around a shared visualization can further collaboration between the two stakeholder groups. For this reason a central element of the user interface both for citizens and municipal officials is a visual map of the citizen needs dataset contextualized by geographic location (Google Maps). The map is practically permanently present and accompanies the vast part of information access, interaction and discussion (e.g. see request input, overview and detail pages in Fig 1). While citizens and the municipal officials are likely to use the map for different purposes (e.g. entering requests, finding out what is going in one's neighbourhood for citizens vs. monitoring areas with intense citizen activity or comparing needs with planned municipal actions), the map represents a shared context of reference around which the communication between their different perspectives can occur. Thus, the map implements a kind of a "boundary object", providing an important mechanism for collaboration in heterogeneous settings [8][7].

At the same time, to cater for the distinctive needs of the two very different groups of users the E-Local system has been designed as a multi-perspective information system from its outset. The system design involves two different views on the user data and the corresponding user interfaces: one for the citizens and one for the municipal officials. While the basic functionalities and the GoogleMaps visualization are available to both groups, the municipal officials have access to an additional instrument, the CityCockpit. The primary means of visual exploration and information access for the citizens is provided by the Google Maps visualization that allows them to quickly spot and get information about relevant citizen requests in their neighborhood. The main design assumption here has been that "locality" is the primary measure of relevance for the citizen's perspective. In contrast, based on requirements interviews with municipal representatives, the primary means of access for the municipal officials has been conceived in terms of a monitoring and control center with an event ticker, statistical reports and visual charts for aggregated analysis of citizen requests in addition to the GoogleMaps visualization. The described

[1] To this end the E-Local platform interfaces with the online donation platform betterplace.org.

delineation of perspectives in the user interface implements the second important and theoretically grounded requirement for supporting collaboration between heterogeneous groups of users: the availability of means for the users to work within their own distinctive perspective corresponding to their own terms, interests and frames of reference (perspective making) [1]. Such a combination of separate user interfaces with distinctive perspectives and a shared visualization (Google Maps) used by both groups implements the model of perspective making and perspective taking: while working in own interfaces allows the expression of distinctive perspective of each group (perspective making), the map as a boundary object connects the two perspectives thus supporting the discovery of relationships between them (perspective taking), without forcing any group to abandon their own perspective.

To implement the described model in practice, the system architecture allows easy implementation and linking between different views on available data sets through a MVC-like architecture and considers the conceptual multi-perspective visualization model proposed in [5]. The prototype system implements the described use case and functionalities based on the Django web application framework with a mysql database. The frontend application is realized with Ajax and the mobile application is an Android App. The system architecture is designed in a modular way with APIs allowing easy integration of new data sets. In order to quickly realise a functioning version of the system that can be tested and iteratively extended in practice, the first-iteration protoype system implements a basic version with the communication and data collection module alongside with the basic visualization mode (geo-localization view) and basic social analysis functions (comments and discussions). The preliminary CityCockpit has been provided at the level of a visual mockup, illustrating basic reporting and analysis functionalities for municipal officials (Google Maps visualization, new requests ticker, filtering of requests by topic, requests pending answers, chart of citizen requests distribution by topic). Such implementation allowed us to elicit feedback from target users in early formative tests and stakeholder workshops with a cooperating municipality in order to verify the described design decisions and assumptions before proceeding to final realization.

3.3 Lessons from Formative Evaluation and Stakeholder Workshops

A formative evaluation of a first-iteration E-Local prototype has been undertaken with 5 participants representing the citizen users. The participants were roughly equally spread by age and sex within two demographic groups (two aged 24-26, three aged 50-56; two male and three female participants) and within a range of professional backgrounds (fashion design, public administration, consulting, electric technician). Most of them were regular Internet users (four participants between 0,5-7 h/day) and highly proficient in computer use (three out of five) with three of them using one of the well-known social networks. The participants were provided with access to the web application with the basic functionalities implementing the typical E-Local use case as depicted in Fig. 1 (submitting a request, extending the request, displaying requests on a map, searching for requests, setting up user profiles, submitting comments, going through the 3-phase cycle of the online discussion). They were asked to complete a set of typical tasks corresponding to this use case and received no

prior training with the prototype. User feedback was collected through a Likert-scale questionnaire. Table 1 depicts the main results of relevance for this paper.

Table 1. Results of the formative user evaluation of the E-Local Prototype (citizen group).

E-Local structure and functionalities							
		---	--	-/+	++	+++	
Resolving a problem with the municipal authorities through Elocal...	is time consuming	0	0	2	2	1	is uncomplicted and direct
	is untransparent	0	0	3	1	1	is transparent
The 3-phases model...	is not clear	0	0	3	1	1	is logical and understandable
	is too cumbersome	0	2	3	0	0	is expeditious enough
The permanent presence of the map...	is unnecessary	0	0	0	1	4	is meaningful
	distracts me from the task	0	0	0	2	3	provides me continuously with an overview
The navigation with the map...	is not helpful for searching	0	0	0	0	5	helpful for searching
The overal construction of the Website...	is confusing	0	0	2	2	1	is clear
	is inapropriate for the given contents	0	0	1	3	1	is apropriate for the given contents
Creating a citizen request...	was complicated	0	0	0	2	3	was simple
	was not personalizable enough	0	0	0	4	1	was sufficiently personalizable

Statement of attitude						**Expectations**					
Elocal...	---	--	-/+	++	+++	How would you primarily use E-Local?	---	--	-/+	++	+++
...is fun to use	0	1	2	2	0						
...interaction is clear and understandable	0	0	3	2	0	...would primarily keep looking for what is happening in my area and participate accordingly	0	0	1	1	3
...would strengthen the feeling of community within a neighbourhood	0	1	1	3	0						
...would help to improve the relationship between citizens and the municipality	0	0	0	3	2	...would try to publish all problems that I become aware of as citizens requests	0	1	2	2	0
...would try to bring as many of my friends and acquaintances as possible to Elocal	1	2	1	1	0	...would use Elocal to let the town authorities know what i really think of them	2	0	1	2	0

On one hand, the results suggest the suitability of the overall concept and the E-Local prototype with largely positive to very positive responses to the individual functionalities[2]. They are likely to be partially biased due to the fact that most participants were highly proficient in using computers and the Internet on a daily basis. However, this bias is partly offset by the fact that such users tend to represent a typical core group of users in community-based portals. On the other hand, positive to very positive responses to the overall construction of the web prototype, the clarity of interaction design and the central role of visualization suggest that the described principles of the system design and the central role of visualization resonate positively with the target users. In particular this relates to the use and permanent presence of the map as a central element for structuring navigation, interaction and collaboration. All test participants rated the usefulness and importance of the map as a central interaction element high or very high (Table 1, upper center, rows three and four). In addition, four out of five users confirmed that their primary mode of use would be to continuously monitor the activities in their local area and participate accordingly (Table 1, bottom right, row three). This supports the design decisions of choosing "locality" as the primary concept for modeling the citizen's perspective (citizen requests dataset) and choosing the map as a central element for mediating interaction.

[2] The only exception is the 3-phases workflow model that hasn't quite convinced and was perceived neutrally (three users) or as cumbersome (two users; Table 1, row two). This requires further investigation into the exact reasons for such perception.

The results thus indicate that the described requirements and design assumptions for a multi-perspective visualization interface and data-centred visual interaction model could be well suited for such a user group.

As none of these test users provided free comments on the questionnaire, we undertook an additional informal focus group with five additional participants to get more contextual feedback. These participants were recruited among trainees and employees of the Humboldt-Viadrina School of Governance who were not directly associated with the project. They undertook the same tasks as the previous group but provided only informal feedback. While the general feedback on the overall concept and usability of the prototype largely corresponded to the above results, several remarks provided a more differentiated picture. In particular, this includes a more critical stance towards the explicit 3-phase model with automatic transition constraints ("What if I would want to finish a phase earlier, because I feel to have enough supporters for my issue?") and the use of the number of supporters as representative for the importance of an issue (incidentally, the same issue was raised later on by the municipal officials). With respect to the visualization model, the most interesting observation was the request to provide the same kind of analysis and reporting tools foreseen for the municipal officials also to the citizens ("Why is the CityCockpit intended only for the municipal administration and not for citizens? I would like to be able to see the statistics and visual charts too. Especially, if they tell me how the money spent by the administration is related to my needs.") Another participant inquired about the possibility to provide information about already planned actions of the municipal administration for a given area so as to avoid duplicate requests ("I would like to know what the municipal administration has already planned to do in my area so I don't need to waste time on entering requests which will be resolved anyway".). This feedback suggests that the visualization of the municipal perspective should not be considered only in its own right but in relation to the citizen's perspective as well. Incidentally, this is a nice illustration of how the theoretical requirements of the "perspective making – perspective taking" model [1], are confirmed in practice: while the voicing of the citizen perspective (perspective making) is important in its own right, there is also a need to put this in relation to a visible municipality perspective, which needs to be understood by the citizens as an orientation for their action (perspective taking).

The feedback of the municipal administration was elicited in a stakeholder workshop with municipal officials of the cooperating municipality (a town of approx. 60,000 inhabitants). The workshop involved 10 participants: the heads of the administrative departments ("Dezernenten") and their senior staff, the coordinator for interdepartmental projects, the communications officer (also in charge of the internet strategy) and the head of IT. As the basis for the discussion, after an introductory presentation the prototype system was presented in a live-demo by replaying a scenario for a typical use flow on the citizen-side and on the administration-side. This included the CityCockpit in form of a visual mockup (features as stated in Section 3.2). The main findings of this workshop are summarized in Table 2.

Table 2. Main results from the stakeholder workshop with municipal officials.

Feedback	Requirement
Increase the system usefulness by making visible what the administration already does for the citizens.	Provide a clear visualization of the administration perspective.
Support the discovery of relationships between citizen requests and current municipal actions (e.g. repairing street holes in winter; planning construction measures) – for the officials *and* for the citizens (!)	Support discovery of relations between visualizations of different perspectives.
Provide mechanisms for assessing the relevance of citizen needs by criteria other than number of supporters.	Support interactive parameterization of visualizations
Tools for monitoring and analysis must make existing work easier, not adding additional workload ("Who will analyse all this data?", "We have enough to do").	Integrate visualization and analysis closes with existing tasks and processes.

Overall the results can be summarized as follows: while gathering and visualizing citizen needs was considered useful by some participants (e.g. the department of construction), the majority of municipal officials felt that in order to become useful for them, the system needs to more actively support the communication of actions that the administration performs for its citizens (see Table 2). The CityCockpit should also provide an easy analysis of the relative importance of citizen needs in comparison to each other and to existing (or planned) budgetary actions as well as to the available budget for specific areas or topics. Moreover, it should make clear these relations to the citizens, not only the administration (with the expected effect of reducing the number of generated citizen requests). Finally, all participants shared the concern that functions for activity monitoring and data analysis must make existing work easier instead of adding additional workload (reflecting the basic worry regarding the introduction of the system in practice). In terms of requirements, this points to the need to support the visualization of their own perspective for each group of users (citizens vs. officials) while at the same time making it perceivable for the other and providing easy-to-use ways for discovering relationships between them. Such results (alongside with previously discussed citizen evaluation) led to a complete redesign of the CityCockpit mockup and the associated multi-perspective visualization model for social data analysis that are presented in the next section.

4 The Open City Cockpit

The results of formative user evaluation and workshops led to a complete redesign of the City Cockpit. The main focus has been the development of a multi-perspective visualization model, which would satisfy both the needs of the municipal officials and the citizens while supporting collaborative data analysis between the two groups. This resulted in a visualization design that extends existing approaches to social data analysis and is grounded both in theory and in requirements elicited from practice.

4.1 Visualising Multiple Perspectives

The new design of the Open City Cockpit is depicted in Fig. 3. One shared user interface provides a unique point of access for all users, regardless of affiliation (citizens vs. officials). Within this interface any user can choose any of the available perspectives to be displayed in one of the available visualization types. The current design includes two main visualization types: a geographic map based on Google Maps (Fig. 3, left) and a tree map visualization (Fig. 3 right). A perspective is now represented by the corresponding data set (citizen needs dataset vs. municipal budget dataset) and a selected visualization type. To satisfy the need of both supporting working within one's own perspective as well as facilitating the discovery of relationships between the perspectives, the user can choose between three different modalities of display: a one monitor view, a two monitor view and a mixed monitor view. One monitor view displays only one perspective of the selected visualization type. In the two monitors view (Fig. 3, right) the selected perspectives are displayed next to each other (each in a selected visualization type) and are independently controlled (e.g. zoom, filter, select). In the mixed monitor view, the two selected perspectives are superimposed upon each other, whereby the portion of the space occupied by each and the transparency of the superposition can be interactively adjusted through movable sliders (Fig. 3, left). The visualization of both perspectives is manipulated with a single control (e.g. zooming in on one, is automatically followed in the other). For all visualizations, the data sets corresponding to a given perspective are colour coded: green for citizen data, blue for the municipal data set.

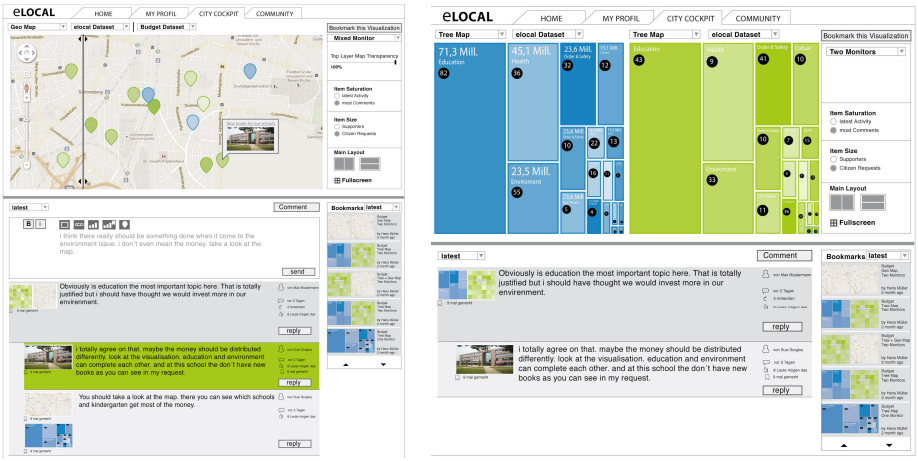

Figure 3. Multi-Perspective Visualization and Interface Design of the Open City Cockpit

By choosing a geographic visualization of the citizen data and of the municipal budget in a mixed monitor view, both the citizens and the officials can easily determine which budgetary actions are planned in their area (blue icons) and compare this to related citizen requests (green icons). Similarly, by selecting a tree map visualization of the municipal budget and of the citizen needs in a two monitor view it

is easy to compare the relations between expenditures in the budget (blue squares) to relations between the number of citizen requests in related topics (green squares).

4.2 Interfacing visualization and discussion

The social analysis of the visualizations follows the principle of doubly-linked discussions proposed in recent work [4][11]. A currently displayed visualization state can be saved in form of a visual bookmark that can be recalled from the bookmarks panel at any given time (Fig 3., rightmost column in both interface designs). User comments are linked to the current state of the displayed visualization, unless the user manually overrides this and specifies it more precisely: by assigning a specific item (citizen request, budgetary action) to the comment or selecting an already saved visual bookmark as its point of reference. In this way, a more precise and natural referencing between comments and visualizations can be realized (e.g. a user may inspect several visualizations or different zoom levels before reaching a conclusion which may relate to one of the previous visualizations or a specific citizen request which spurred his interest in the first place). Selecting a comment then displays a pop-up with the corresponding visualization state and upon user confirmation switches the current view to this particular visualization. In case a single item has been referenced, then the corresponding visualization state highlighting this specific item is displayed. The same holds in reverse, selecting a visualization state displays a list of comments referencing it, while selecting an item highlights the referencing comments (Fig. 3, comments panel).

4.3 Implementation

We are currently working on implementing the main elements of the described visualization model and interface design in form of interactive prototypes that can be used for the next user evaluation cycle. For the implementation of the tree map visualization we are using an open source library from the javascript information visualization toolkit [17]. The data sets for the municipal budget at this stage are based on open data sources adhering to the JSON standard. The implementation of the application state bookmarking (visual bookmarks) will follow the model of URL-based state vectors proposed in [11]. In a further stage the data from the cooperating municipality will be integrated into the prototype.

5 Conclusions

The presented analysis and first experiences in designing a visual system for social data analysis in open government applications suggest that the heterogeneity of this setting requires considering and integrating specific requirements and design principles from collaboration theory and empirical practice. The first experiences in the development and formative evaluation of a possible solution based on multi-

perspective visualization point to the need for further investigation of application-oriented design principles in this emerging field of research.

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