ConVis: A Visual Text Analytic System for Exploring Blog Conversations

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Abstract

Today it is quite common for people to exchange hundreds of comments in online conversations (e.g., blogs). Often, it can be very difficult to analyze and gain insights from such long conversations. To address this problem, we present a visual text analytic system that tightly integrates interactive visualization with novel text mining and summarization techniques to fulfill information needs of users in exploring conversations. At first, we perform a user requirement analysis for the domain of blog conversations to derive a set of design principles. Following these principles, we present an interface that visualizes a combination of various metadata and textual analysis results, supporting the user to interactively explore the blog conversations. We conclude with an informal user evaluation, which provides anecdotal evidence about the effectiveness of our system and directions for further design.

Categories and Subject Descriptors (according to ACM CCS): H.5.2 [Information Systems]: Information Interfaces and Presentation—User Interfaces I.2.7 [Natural Language Processing]: Text analysis—

1. Introduction

Since the internet revolution and the subsequent rise of social media, an ever-increasing amount of human conversations are generated in many different modalities. These conversations are primarily asynchronous in nature, where the participants communicate with each other at different times (e.g., emails, blogs, forums, Twitter, Facebook) [JCN13]. Often many people contribute to the discussion, which can quickly become very long with hundreds of comments and replies. Traditional social media sites present the original posts and subsequent replies as a paginated indented list. Thus the reader needs to go through a long list of comments sequentially, until her information needs are fulfilled. Going through such an overwhelming amount of textual data in this way often leads to information overload, i.e., the user finds it very difficult to get insights about the ongoing (or past) discussion. The end result is that the readers start to skip comments, generate simpler responses and leave the conversation without satisfying their intent [JRR04].

To illustrate the problem, consider a scenario where Sarah is interested in technology-related blogs. She opens a blog discussion about a news article of hacking in US army servers. She is curious to know what are the different opinions about the US cyber security lapses. She finds that the

top few posts blame the 'shoddy work' done by the contractor companies, while others believe that the incident was merely 'a honeypot for hacker'. Sarah wants to know more about what other people are saying about the security collapses, but soon realizes that the topic of discussion is shifted to 'US involvement in the Vietnam war', which she is not interested in. So Sarah keeps on skimming comments and notices that some others are discussing the technical details of hacking. At this point, Sarah is quite exhausted; she does not know whether the long list of remaining comments are relevant to the reasons for cyber security lapses; but she decides to end the reading without fulfilling her information needs.

To support the readers in dealing with similar situations, we present ConVis: a visual exploratory text analytic system for blogs that tightly integrates interactive visualization with text mining techniques that are especially devised to deal with conversational data. Motivated by the nested design model [Mun09], we started by characterizing the domain. While asynchronous conversations comprise emails, blogs, microblogs (e.g., Twitter), and messaging; in this paper we focus on the domain of blogs. In fact, blog conversations often have complex thread structure with large number of participants and comments [JCN13], making it a more challenging problem from the visualization perspective. Once we

have characterized our domain, we derive a set of design principles, which then guide the visual encoding and interaction techniques of ConVis. The primary contributions of this work are as follows:

1) We performed a user requirements analysis based on extensive literature review in the domain of blogs (Section 2). The analysis includes data and task abstractions for the problem domain and a set of design principles to support the user requirements.

2) To the best of our knowledge, ConVis is the first visual text analytic system for blog conversations that visualizes both *topic* and *opinion* mining results along with a set of metadata (e.g., authors, position of the comments), which were identified as primary means for browsing and navigation from the user requirement analysis. Existing systems either visualize some metadata or only one type of content information from the conversations (e.g., the topics covered but not opinions), thus limiting the ability of the user to explore and analyze the conversation.

3) We present the design, implementation, and an informal evaluation of ConVis. ConVis visually represents the overview of a blog and then allows the user to explore this conversation based on multiple facets (e.g., topics and authors). This is a major shift from traditional blog reading interfaces which provide a long list of paginated comments, thus only supporting a linear way of navigation.

2. From User Requirements to Design Principles

Blog reading has been extensively studied in the fields of computer mediated communications (CMC) [Zin11, DKV99, Kay05], social media [HHD08, FMO*07], human computer interaction (HCI) [BST08, DWM04, MR10], and information retrieval [JRR04, KJ12, MSOS10, Mis06, SSM10]. This literature provides a detailed analysis of the motivations and goals for readings blogs, along with the unique behaviour of blog reading. Based on this analysis, we characterize the data and tasks in the domain of blogs and then identify the user requirements (*UR*), which are finally translated into a set of design principles.

2.1. Why and How People Read Blogs?

Kaye performed a web survey among active bloggers to find the reasons why they access blogs [Kay05]. These reasons were grouped into 10 general motivational blocks, including information seeking, fact checking, guidance/opinion seeking, and political surveillance. In particular, the users reported that often they read blogs to seek information about their area of interests (e.g., education, technology, politics) [Kay05, DWM04]. Blogs also help users to quickly verify and compare accounts of news and information and check the accuracy of traditional media (fact checking)

[Kay05, KJ12]. Frequently, users read blogs to seek a wide variety of opinions and to help them make up their minds about important issues [Kay05, DWM04, Mis06, KJ12]. Mishne noted that the information in blogs is often subjective or opinionated [Mis06]. In fact, it has been found that readers consider blogs with a mixture of positive and negative posts more credible [AGSS12]. Overall, this suggests that the interface should facilitate a visual overview of the diverse range of opinions covering positive and negative sentiments about important topics, allowing the user to understand various viewpoints (UR-1).

The people-centric nature of the domain of blogs was reported in various studies [DWM04, Mis06]. Dave et al. reported that Blog readers are looking to find ideas or information, take the pulse of a community, and meet people [DWM04]. In other words, blogging can promote a sense of belonging in the blogosphere among others who try to publicly express their opinions and to affiliate with like-minded individuals ("find people who think like I do") [Kay05, KJ12]. This indicates the importance of identifying the key participants and their opinions (*UR-2*).

In reality, users do not always look for important information or opinions, they may read blogs simply for enjoyment or personal fulfillment [BST08, Kay05]. An ethnographic study reveals that "the participants visit blogs for information, inspiration, entertainment, and to a certain extent because it is just what they have always done " [BST08]. Kaye suggests that blogs bring more novelty and thus users find blogs to be more fun and interesting than formal media content [Kay05]. This aspiration for novelty and fun should be encouraged by the interface by promoting exploration and serendipitous discoveries (*UR-3*).

Previous studies suggest that many blog readers are inherently *variety-seekers* [SSM10, MR10], i.e., they are often looking for variety of opinions and discussion themes. Singh et al. found the individual's tendency to switch from one set of topics to another [SSM10]. Even in the case when a reader may read on the same topic, she essentially reads distinct posts leading to some variety within a topic. Thus, being able to browse the conversations based on different possible topics and sub-topics can effectively support this variety seeking behaviour (*UR-4*). Many users also exhibit *skimming* tendency [Zin11, NC10], i.e., they seek to quickly scan through a set of posts to understand what the authors are saying. This behaviour might be explained by the exploratory nature of blog reading. It has been found that readers remain in an *exploratory state* (intermediate state) before entering into a *focused state* from another *focused state* [SSM10]. The reading in this exploratory state provides clues of what the reader may expect to find if she focused on the comments she is currently skimming. In other words, the reader needs to quickly skim through (i.e., explore) a few posts about a topic before delving deeper into its details (i.e., entering into a focused state). Therefore, the interface should facilitate open-ended

No	Questions (Q)	Topic	Author	Opinion	Thread	Comment	UR
1	What this conversation is about?	X				X	1,4
2	Which topics are generating more discussions?	X					1,4
3	What do people say about topic X?	X		X	X	X	1
4	How controversial was the conversation? Were there substantial differences in opinion?	X	X	X	X	X	1
5	How other people's viewpoints differ from my current viewpoint on topic X?	X		X	X	X	1
6	Why are people supporting/ opposing an opinion?			X	X	X	1
7	Who was the most dominant participant in the conversation?		X		X	X	2
8	Who are the sources of most negative/positive comments on a topic?	X	X	X	X	X	1,2
9	Who has similar opinions to mine?		X	X		X	1,2
10	What are some interesting/funny comments to read?	X	X	X		X	3,5

Table 1: *A set of tasks (phrased as questions) that a user may likely have to perform/answer while exploring a blog conversation to satisfy her information needs.*

exploration within the conversation space, by providing navigational cues that helps the user to seek interesting comments and to quickly decide whether they are worthwhile to read (*UR-5*).

2.2. Data and Tasks Abstraction

From the analysis of primary goals of blog reading, we compile a list of tasks and the associated data variables that one would wish to visualize for these tasks. In addition, we analyze the Blog track in the Text REtrieval Conference (TREC), which defines a set of tasks on opinion finding (e.g., *What do people think about X?*) and blog distillation (e.g., *Find me a blog with a principle interest in X*) [MSOS10]. Based on these analyses, we create a list of tasks (phrased as questions) that the blog reader might ask, along with the possible associated variables (listed in Table 1). Most of these questions involve *topics* and the *sentiment* expressed in the conversation, which are relevant to some of the key goals of the users, including information seeking, fact checking, and guidance seeking. Q1 and Q2 are related to finding topics, while Q3 through Q6 can involve both topic and sentiment information. Q7 through Q9 may additionally require to know the people-centric information and relate such information with other data such as topics and sentiment (extending *UR-2*). The last question (Q10) reflects the motivations for personal fulfillment/ enjoyment. Finally, to reflect the exploratory behaviour associated with most of the tasks listed here, both thread (to support *exploratory state*) and comments (to support *focused state*) are included as data variables.

Upon identifying the data involved in the list of tasks, we abstract them in terms of scale and type. Table 2 lists a comprehensive set of conversational data to be visualized and their abstract types. We also compute average and maximum counts for different types of data to better understand what scale the visualization needs to deal with. These values are computed based on a set of 20 Slashdot blogs which comes with human generated topic annotations [JCN13]. Here, the

Attributes from data	Abstract type	Counts	
		Avg.	Max.
Thread structure	Tree	Depth: 4.3 nodes: 60.3	Depth: 5 nodes: 101
Topic	Categorical	10.77	23
Author	Categorical	57.71	92
Derived Attributes	**Abstract type**	**Range**	
Topic length	Quantitative	[0.0,1.0] (normalized)	
Comment length	Quantitative	[0.0,1.0] (normalized)	
Position of the comment	Ordinal	[1,101]	
Sentiment	Ordinal	[-2,-1,0,+1,+2]	

Table 2: *Set of conversational data to be visualized and their abstract types. The avg. and max. counts for different types of data are provided based on the Slashdot dataset.*

topics and the *sentiment* are added, since they can be useful for performing almost all of the tasks in Table 1. The position of the comment in the discussion space, and comment length are added since they have been found to be useful cues for navigation [NC10, BST08] (*UR-6*).

Another study suggests that the exact timestamp of a comment is much less important to users than its chronological position with respect to the other comments [BST08] (*UR-7*). Therefore, we wanted to encode the *position of the comments* (ordinal) as opposed to their timestamps (quantitative).

2.3. Design Principles

Based on the user and tasks analysis, we have identified the following key design principles (*DP*) that form the basis of our visualization system. Each design principle is derived from one or more of the User Requirements, as follows:

1. **Show comprehensive set of relevant data:** The vi-

sual interface should display a comprehensive set of user/system generated metadata (comment length, position of the comment, and moderation score) *(UR-6, UR-7)*, as well as the results of text analysis *(UR-1)* as listed in Table 2.

2. **Provide faceted exploration:** Considering the exploratory nature of blog reading, the interface should provide various facets (e.g., topics and authors) as a means for navigation and browsing. Once these primary facets are effectively presented, users will arguably take a more active role in exploring conversations in a non-linear fashion, by quickly navigating through comments of a particular facet (addressing *UR-3, UR-4,UR-5*).

3. **See relationship between multiple facets:** Many of the common tasks for browsing conversation require the user to perceive the relations between multiple facets and comments. For example, to perform the task in Q8, the user needs to know how author, opinion, and topic facets are related to each other. Thus, we aim to effectively reveal the relation between multi-facets to the user, to better support the critical tasks identified in Table 1 (*UR-2*).

4. **Provide overview at multiple granularity:** We aim to integrate the high level summarized view of the conversation (e.g., topics), the visual overview of the thread (showing sentiment information of all the comments), and the actual comments (detailed content) in a seamless way, so that the user can easily switch between the different levels of overview and the actual conversation (*UR-1, UR-5*).

5. **Lightweight interactions:** To enhance learnability, the interface should facilitate the open-ended exploration of conversations through a set of low cost interactions [Lam08], that can be easily triggered and reversed without requiring much cognitive overload (*UR-5*). Low cost interactions, along with interface metaphors that are easily understood, can make the exploration process more enjoyable (*UR-3*).

3. Related Work

Previous work on visualizing asynchronous conversations can be classified into two categories: metadata-based and content-based visualization; depending on whether the focus of the research was more on visualizing system and user generated metadata (e.g., thread structure), vs. the results of some text analysis (e.g., finding topical clusters).

Metadata-based Visualization: Earlier works for visualizing asynchronous conversations primarily focused on revealing the structural and temporal patterns of a conversation [WM03, PCK09]. Typically, the goal was to effectively represent the thread structure of a conversation using tree visualization techniques, such as thumbnail metaphor (a sequence of rectangles) [WM03] and radial tree layout [PCK09]. Various interaction techniques, such as highlighting user-specified search terms [WM03] and zooming into

an area of the thread overview [PCK09] were proposed to deal with space constraints for larger threads. Other works visualize various system and user generated metadata such as timestamp [Don02]; comment length and moderation score [NC10]. Metadata-based visualization has also been applied to blog archives [VG*08], as opposed to a single blog conversation, which shows the history of social interactions to help users identify potentially useful blog entries.

Even though metadata-based visualizations help to understand the social interaction patterns or the quality of the comments in a conversation, they may be inadequate to support users in most of the tasks shown in Table 1. For example, if the user is reading a political blog to know *"what do people think about Obama's recent healthcare policy?"*, knowing how nested the thread structure is or how many replies are made to a particular post would be insufficient.

Content-based Visualization: Some early works aimed to identify and visualize the primary themes or topical clusters within conversations [Sac00, DWM04]. In contrast, [YH05] focused more on the organization of the discussion by creating a tree layout, where the parent comment is placed on top as a text block, while the space below the parent node is divided between supporting and opposing statements. In general, the main limitation of these approaches is that they rely on simple, generic text analysis methods, which do not consider the structure of the conversation. More recently, the TIARA system proposes an enhanced Latent Dirichlet Allocation (LDA)-based topic modeling technique, which automatically derives a set of topics to summarize a collection of documents and their content evolution over time [WLS*10]. Each layer in the graphical representation represents a topic, where the keywords of each topic are distributed along time. From the height of each topic and its content distributed over time, the user can see the topic evolution. In contrast to visualizing topics, Opinion Space visualizes the differences in opinions in an online conversation [FBRG10] by projecting users on a two-dimensional map based on (PCA), where the participants with similar opinions are positioned near to each other. The expectation is that by exploring the map, users can better understand a broad range of viewpoints.

While there has been a clear trend of moving beyond using only metadata to an increasing use of text analysis within the interactive visualization process, current systems generally suffer from two fundamental limitations. First, they use generic text analysis techniques. Secondly, current systems only convey one type of mined information (e.g., either topic or opinion), thus limiting the user's ability to perform most of the tasks in Table 1. In this work, we aim to address both limitations.

Faceted exploration: SolarMap arranges entities of the topic facet as cluster nodes and interactively highlights the relations with other facets located in the surrounding circular ring to this cluster region [CGS*11]. FacetLens introduces linear facets (e.g., year) and integrates richer faceted naviga-

tion techniques to expose trends and relationships between attribute values within a facet [LSR*09]. PivotSlice allows the user to construct a series of dynamic queries using facet values to divide the entire dataset into different subsets in a tabular layout, while directed edges are drawn between related items upon selection [ZCCB13]. In general, the above methods require the user to apply some interactive techniques (e.g., dynamic queries [ZCCB13], context switching [CGS*11]) in order to explore the relationships between facets. In contrast, our work is more similar to [DRRD12], where all relationships between facets are permanently displayed and are directly accessible to the user.

4. Mining and Summarizing Conversations

4.1. Topic Modeling

In topic modeling the sentences of a blog conversation are first grouped into a set of topical clusters/segments (segmentation). Then, representative key phrases are assigned to each of these segments (labeling). We adopt a novel topic modeling approach that captures finer level conversation structure in the form of a graph called Fragment Quotation Graph (FQG) [JCN13]. All the distinct fragments (both new and quoted) within a conversation are extracted as the nodes of the FQG. Then the edges are created to represent the replying relationship between fragments. If a comment does not contain any quotation, then its fragments are linked to the fragments of the comment to which it replies, capturing the original 'reply-to' relation.

The FQG is exploited in both topic segmentation and labeling. In segmentation each path of the FQG is considered as a separate conversation that is independently segmented [MH91]. Then, all the resulting segmentation decisions are consolidated in a final segmentation for the whole conversation. After that, topic labeling generates keyphrases to describe each topic segment in the conversation. A novel graph based ranking model is applied that intuitively boosts the rank of keyphrases that appear in the initial sentences of the segment, and/or also appear in text fragments that are central in the FQG (see [JCN13] for details).

4.2. Sentiment Analysis

For sentiment analysis, we applied the Semantic Orientation CALculator (SO-CAL) [TBT*11], which is a lexicon-based approach for determining whether a text expresses a positive vs. negative opinion. SO-CAL computes polarity as numeric values. Its performance is consistent across various domains and on completely unseen data, thus making a suitable tool for our purpose. At first, we apply So-CAL to generate the polarity for each sentence of the conversation. We define 5 different polarity intervals, and for each comment in the conversation we count how many sentences fall in any of these polarity intervals. Then, we normalize the value in each po-

larity interval by the total number of sentences in the comment to compute the polarity distribution for that comment.

While designing and implementing ConVis, we have been mainly working with two quite different blog sources: Slashdot [sla] (a technology-news related blog site) and Daily Kos [dai] (a political analysis blog site). We applied topic modeling and sentiment analysis on each conversation. The results of this analysis along with different metadata are mapped to the abstract data type as shown in Table 2.

## 5. ConVis Design and Implementation

5.1. Visual Encoding

ConVis is designed to support multi-faceted exploration of blog conversations. The visual encoding was guided by the design principles presented in Section 2, and the information to be presented is generated by the text mining techniques described in Section 4. A high level design decision for the interface was to follow an overview+detail approach to deal with the space constraints. The rationale is that several studies have found the overview+detail approach to be more effective for text comprehension tasks than other approaches such as zooming and focus+context [CKB08]. Overview+detail also allows us to provide information at multiple granularities *(DP-4)* by displaying a high level overview of what was discussed by whom (i.e., topics and authors), a visual summary of the whole conversation (in the Thread Overview) and the most detailed view representing the actual conversation (see Figure 1). The interactions between these views are performed in a coordinated way. Below, we describe the design of each component along with careful justification of crucial design decisions.

The **Thread Overview** hierarchically represents a visual summary of the whole conversation, and allows the user to navigate through the comments (see Figure 1, middle). It displays each comment as a horizontal stacked bar. Each stacked bar encodes three different metadata (comment length, position in the thread, and depth of the comment within the thread) and the text analysis results (i.e., sentiment) for a comment, which are identified to be potentially useful navigational cues *(DP-1)*. The stacked bars are vertically ordered according to their positions in the thread starting from top with indentation indicating thread depth, allowing the user to see the whole thread structure at a glance. The height of each bar encodes the normalized comment length, while the width of all the bars remain equal. Thus one could easily notice the differences in length among comments. The current implementation can reasonably show up to 200 comments when the visualization is used on a 1920 × 1080 screen. This scale was sufficient for all the conversations we have examined (see Table 2) and is plausibly adequate for the vast majority of blog conversations.

The distribution of sentiment orientation of a comment is encoded using color within each stacked bar, where width of
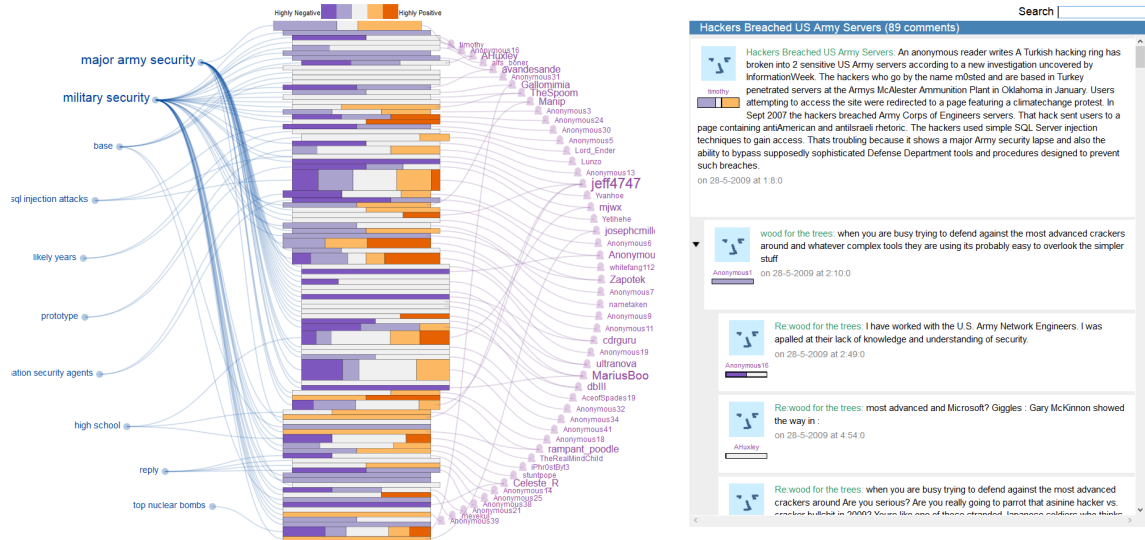
Figure 1: *A snapshot of ConVis for exploring blog conversation: The Thread Overview visually represents the whole conversation encoding the thread structure and how the sentiment is expressed for each comment(middle); The Facet Overview presents topics and authors circularly around the Thread Overview; and the Conversation View presents the actual conversation in a scrollable list (right). Here, topics and authors are connected to their related comments via curved links.*

each cell of a stacked bar indicates the number of sentences that belongs to a particular sentiment orientation. A set of five diverging colors was chosen from ColorBrewer [col] to visualize this distribution in a perceptually meaningful order, ranging from purple (highly negative, -2) to orange (highly positive, $+2$). Thus, the distribution of colors in the Thread Overview can help the user to perceive whether this conversation is mainly neutral /positive /negative, or very controversial. For example, if the Thread Overview is mostly in strong purple color, then the conversation has many negative comments.

Facet Overview: To support multifaceted exploration of the conversation *(DP-2)*, the primary facets, namely topics and authors are presented in a circular layout around the Thread Overview (see Figure 1). Topics and authors are presented to the left and right side of the Thread Overview respectively, creating a symmetric view. Both topics and authors are positioned according to their chronological order in the conversation starting from top, allowing the user to understand how the conversation evolves as the discussion progresses. Two distinctive qualitative colors are used to encode the facet links and the facet elements. The font size of a *topic* encodes how much it has been discussed when compared to the other topics within the whole conversation. Likewise, the font size of an *author* encodes how many times a participant has posted in a conversation. Thus, the font size of both facets helps the user to quickly identify what are the mostly discussed themes and who are the most dominant participants within a conversation.

To convey how facets and comments of the conversations are inter-related *(DP-3)*, the facet elements are connected to their corresponding comments in the Thread Overview via subtle curved links indicating topic-comment-author relationships (the relation between topic and comments can be many-to-many). While a common way to relate various elements in multiple views is synchronized visual highlighting, we choose visual links because it has been found that users can locate visually linked elements in complex visualizations faster and with greater satisfaction than plain highlighting [SWS*11]. By default, these visual links are drawn in the de-saturated tone of the corresponding facet's color.

The design decision of arranging facet elements in a circular layout is motivated by two primary reasons. First, more elements can be accommodated in this way than in a linear fashion. In fact, the current implementation can reasonably show up to 100 topics /authors when the visualization is used on a 1920×1080 screen. Second, a circular layout helps encode the curved links between facets and comments without much visual clutter.

The **Conversation View** displays the actual text of the comments as a scrollable list (see Figure 1, right). Like in the Thread Overview, comments are indented according to their depth in the thread hierarchy, thus revealing the reply-to relationships. At the left side of each comment, the following metadata are presented: title, author name, photo, and a stacked bar representing the sentiment distribution (mirrored from Thread Overview). Overall, the Conversation View provides a familiar web discussion interface to the user, thus potentially enhancing the learnability for those who are accustomed to the current blog interfaces *(DP-5)*.
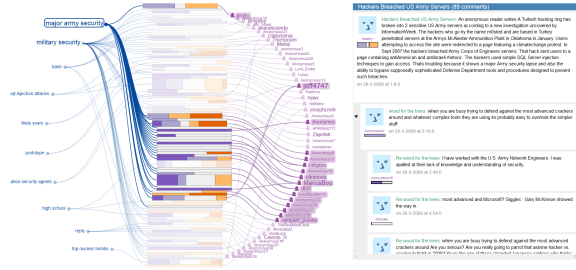
Figure 2: *Hovering the mouse over a topic element ('major army security') causes highlighting the connecting visual links, brushing the related* authors*, and providing visual prominence to the related comments in the Thread Overview.*

5.2. User Interactions

ConVis provides a set of lightweight interactions [Lam08]. These interactions are designed so that they can be easily triggered without causing drastic modifications to the visual encoding, thus allowing the user to comprehend their effect without much cognitive overload *(DP-5)*.

Both overviews and the Conversation View interact in a coordinated way. Hovering the mouse over a facet element causes a rectangular border to be drawn around that element and subsequently highlights the connecting curved links by changing their color to a darker tone. This also causes brushing the elements in the other facet, and provides visual prominence to the related comments in the Thread Overview by de-saturating the rest of the stacked bars (see Figure 2). As such, the user can perceive relations between multiple facets *(DP-3)*. If the user becomes further interested in a facet element (e.g., a specific topic), she can subsequently select that item by clicking on it, resulting in drawing a thick vertical outline next to the corresponding stacked bars in the Thread Overview (see Figure 3). As a result, the comments of a particular topic/author remain persistently selected. The color of the vertical outlines is the same color as its facet, thus distinguishing between the selections of different types of facets. This encoding is also mirrored in the Conversation View (see Figure 3, right). Moreover, the user can select multiple facet items so that the comments shared among them become more apparent.

Highlighting and selection is also possible for each individual comment both from the Thread Overview and the Conversation View. Hovering the mouse over the stacked bar representing a comment causes it to be highlighted by drawing horizontal outlines on the top and bottom of the bar. It also causes the related topic(s) and author to be brushed along with the visual links connecting the comment to be highlighted. This highlighting is also mirrored in the Conversation View. Conversely, hovering the mouse over a comment in the Conversation View highlights the corresponding stacked bar in the Thread Overview. The user can subsequently select a comment either in the Thread Overview (see Figure 4) or in the Conversation View, so that this high-
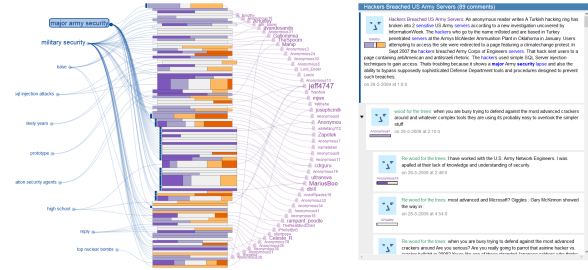
Figure 3: *Clicking on a topic results in drawing a thick vertical outline next to each of the related comments.*

(a)   (b)
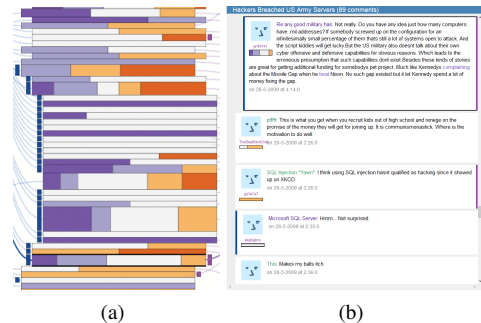
Figure 4: *An example showing: (a) The user clicked on a comment (the one with horizontal outlines) in the Thread Overview. (b) As a result, the system automatic scrolled to the actual comment in the Conversation View.*

lighting remains persistent unless the user toggle the state by clicking on it again.

A selection of a comment in the Thread Overview or of a facet in the Facet Overview causes scrolling to the relevant comment in the Conversation View via a smooth animation. In this way, the user can easily locate the comments that belong to a particular topic and/or author. Moreover, the keyphrases of the relevant topic and sentiments are highlighted in the Conversation View upon selection, providing more details on demand about what makes a particular comment positive/ negative or how it is related to a particular topic. The user can also scroll through the comments with traditional interactions using mouse wheel, or standard arrow and page keys. Finally, any branch of the conversation can be expanded/collapsed by clicking the up/down arrow to the left side of parent posts.

Implementation: A server-side component (in php) retrieves conversations annotated with topics and sentiment information. The visualization component, on the other hand, is implemented in Javascript (using D3 and JQuery library), which is sufficiently fast to respond in real time to the user actions. A live demo of ConVis is available at [Con].

6. Informal Evaluation

During the design and implementation of ConVis, we conducted formative evaluations to identify potential usability
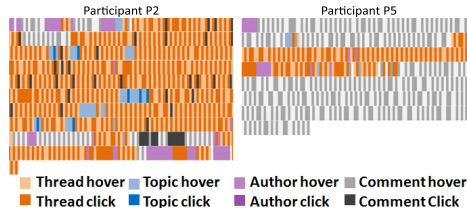
Figure 5: *Comparison of uses patterns between two participants using the two different strategies on the conversation titled "Music Streaming to Overtake Downloads".*

issues and to iteratively refine the prototype. Once the prototype was completed, we ran an informal evaluation [LBI*12] with a different set of target users to evaluate the higher levels of the nested model [Mun09]. In this evaluation, we aimed to: 1) understand to what extent the overall visualization and its specific components are perceived to be useful by the potential users; 2) identify differences among users in how they performed the tasks; and 3) solicit ideas for improvements and enhancements.

6.1. Procedure and Participants

A pre-study questionnaire was administered to capture demographic information and prior experience of participants with blog reading. Then the ConVis interface was demonstrated to the participants. After that, they were allowed to choose three conversations of their interest from a set of six blogs from Slashdot, all of them having similar length (avg. number of comments is 91.33). Instead of asking some abstract questions (such as the ones in Table 1), we provided an open-ended task to reflect the exploratory nature of blog reading. We asked the user to explore the conversations according to their own interests and write down a summary of the key insights gained while exploring each conversation. During the study, we primarily focused on gathering qualitative data such as observations, user-generated summaries, and semi-structured interviews. The recorded interviews were transcribed and coded to facilitate analysis. In addition, we logged interface actions to better understand the usage patterns of ConVis.

We conducted the study with five participants (age range 18 to 24, 2 female), who are frequent blog readers (four of them reported to read blogs at least several times a day and one reported several times a week). The three most common reasons for them to read blogs are information seeking, guidance/opinion seeking, and enjoyment. They are primarily interested in blogs about technology, politics, and education.

6.2. Results and Analysis

Browsing strategies: From the interaction log data and semi-structured interviews, we identified two main strategies for reading comments: exploring by topic facets, and skimming through detailed comments. Figure 5 shows the

sequence of interface actions made by participant P2, who followed the former strategy, and P5 who followed the latter, on the same conversation. Overall, of the five participants, two followed the exploration by topic strategy, while the other three followed the skimming comments one. The two participants, who followed the former strategy, reported that they would begun by quickly scanning the topics and selecting either the most discussed topic first or the ones that were interesting to them, and then reading the comments linked to that topic. We also observed that to find the comments of interest in the selected topic, they often relied on the sentiment and comment length encoded in the Thread Overview. After going through the comments of a specific topic, they either went on reading the next topic that appeared in the conversation, or went back to scan the topic list to find the next topic of interest. This navigational behaviour can be observed from the sequence of actions made by Participant P2 (see Figure 5(left)). The other three participants followed the traditional way of blog reading, primarily skimming through the comments in the Conversation View. This is illustrated in Figure 5 (right), where P5 mainly hovered over different comments. However, at the same time these participants acknowledged that they tended to coordinate with the topics and Thread Overview where the related items were highlighted, so that they could get a sense of what part of the conversation they were reading and when the topic was about to change. Supporting evidence came from interaction log data, where those who followed the first strategy, on average clicked on different topics 13 times and hovered 68 times for each conversation. On the contrary, those who followed the second strategy hovered only 11 times on average per conversation and never clicked on a topic.

Interface features: In general, all participants, independently from their preferred browsing strategy, agreed that showing the set of topics and then visually linking them to the comments in the Thread Overview helped them to quickly understand what a conversation is about and to focus on its most interesting parts. P2 said: *"I just try to find topics that are interesting to me which is really useful. I could look into a comment of that topic and then look at other comments replying to that comment, so this navigation feature was really good."* Another useful feature according to the participants is the Thread overview displaying the comments and sentiment. P1 said: *"In the visualization it is very clear to see what kind of article I am going to dealing with... the last conversation has lot of purple, indicating its something going to have many negative comments"*; however P3 reported that the sentiment classification was incorrect in some cases, making it less reliable. Encoding the comment length was found to be useful to P4: *"The height of the bar was really useful, cz the thicker comments were generally more interesting and insightful than the shorter ones."*.

Users were also interested in seeing how much an author contribute to a specific topic. According to one participant *"My primary interest with the author would be to see how*

much they have participated back into the topic and that happens in various occasions, so I found the linking between topics and authors quite useful'. P2 also found some utility of the author facet: '*"If I find someone's comment interesting, then I wanna know what other comments she made, and how people reacted to that."* In such scenario, linking the comments to the corresponding author is valuable. But participants also emphasized that if they would have been part of the community, the author facet would have been much more useful: *"If I would know some people, I would be really interested in what they are saying. But since these are random people, I don't know if I would inclined to care"* (P1). The participants also acknowledged that if they had been participants in the conversation, they would have been interested to know who is replying to their posts.

Preference: When the participants were asked to compare their experience using ConVis with their regular blog reading interface, the answers were generally in favour of ConVis, due to its ability to show a visual overview of the whole conversation and allowing the user to explore through facets. Moreover, the visualization tool was found to be easy to learn by the participants. According to P1: *"Seeing the sort of pagination in current interfaces, you don't get the overall. I have to read through all of them."* On the contrary, *"Using ConVis I would read more important parts of the conversation as opposed to just people talking. I can navigate through the comments without actually reading them, which is really helpful."* P5 who followed the strategy of skimming through the conversation mentioned: *"I am so much used to scroll up and down in the list of comments, but using this additional visual overview, I had a sense of where I am reading right now and what topic I am currently reading"*. P2 said that ConVis provides a quicker way to explore comments: *"It allows me to navigate through the most insightful stuffs out of five minutes which could take say 15 minutes otherwise. Actually I found many comments to be interesting towards the end of conversations, which I probably wouldn't notice if I would use my blog interface."*

Revisiting task abstraction: Analyzing the user generated summaries from the evaluation (see section 6.1) helps us to reflect on the task abstraction in Section 2. After mapping each sentence of the summaries to one or more possible tasks in Table 1, we find that some of the tasks were performed more frequently than others. All of the participants answered Q1 and Q2 in their summaries, suggesting that understanding the *topics* is a fundamental task. A substantial portion of each summary answers questions Q3 through Q6, which are related to the *opinion* variable. We also realize that the exploratory behaviour can be largely influenced by participant's own viewpoints (Q5) and what they perceive as interesting/funny (Q10). However, the summaries reveal very little interest of the participant in looking for questions specific to *authors* (Q7 through Q9), suggesting that being a part of the community might be highly relevant for these tasks as mentioned by a participant. Thus, it is important to consider

the characteristics of the target blog community into the design process.

7. Conclusions and Future Work

We have presented ConVis, a visual text analytic system designed to support the exploration and analysis of blog conversations. Our approach incorporates novel mining methods that take advantage of conversational features, with interactive visualization that supports multifaceted exploration. The participants' feedback from our informal evaluation suggests that ConVis can help the user to identify the topics and opinions expressed in the conversation; supporting the user in finding comments of interest, even if they are buried near the end of the thread. Remarkably, ConVis is beneficial also to users who followed the traditional strategy of scrolling through the Conversation View, because the other views provided situational awareness (e.g., what topic was expected next).

We envision extending ConVis in several ways. An important aspect of our visualization was to explicitly depict the relations between multiple facets of the conversation with the related comments. However, depending on the tasks additional facets can become more useful to the participants (e.g., moderation scores, named entities), while an existing facet being less useful (e.g., author). We plan to devise an interactive visualization technique that allows the user to dynamically change the facets of interest and reveal relations between them. On scalability, while ConVis can deal with conversations with hundreds of comments, additional techniques are needed for longer conversations. We intend to apply additional computational methods such as detecting high quality comments [FCMJ07] to guide the way of filtering and aggregating comments, as well as to apply focus+context techniques to the Thread Overview.

In general, the utility of visual text analytic systems can be substantially improved if more accurate natural language processing techniques are adopted. Even though the text analytic methods used here achieve significantly higher accuracy than traditional methods [JCN13], the informal evaluation reveals that still in few cases the extracted topics and opinions are incorrect. In such cases, a promising approach could be to incorporate users feedback in the text mining loop, so that the underlying models can be iteratively refined. Finally, we plan to conduct summative evaluations [LBI*12] to study the effectiveness of our approach compared to traditional blog reading interfaces, in a more ecologically valid way over an extended period of time. Such longitudinal studies may provide valuable insights regarding the utility of the interface compared to more traditional interfaces.

Acknowledgement

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