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Cloud Computing Based Visual Backchannel for Web Based Events

Santhosh.kola, Sanjib.k

Department of computer science & Engineering, jyothishmathi institute of technology & science (JNTU), INDIA

Abstract—The cloud computing based Visual Backchannel for web based events as a novel way of following and exploring online conversations about events. Micro blogging communities, such as Twitter, are increasingly used as digital backchannels for timely exchange of brief comments and impressions during political speeches, sport competitions, natural disasters, and other large events. Currently shared updates are typically displayed in the form of a simple list, making it difficult to get an overview of the fast-paced discussions as it happens in the moment and how it evolves over time. In contrast, our Visual Backchannel design provides an evolving, interactive, and multi-faceted visual overview of large-scale ongoing conversations on Twitter. To visualize a continuously updating information stream, we include visual saliency for what is happening now and what has just happened, set in the context of the evolving conversation. As part of a fully web-based coordinated-view system we introduce Topic Streams, a temporally adjustable stacked graph visualizing topics over time, a People Spiral representing participants and their activity, and an Image Cloud encoding the popularity of event photos by size. Together with a post listing, these mutually linked views support cross-filtering along topics, participants, and time ranges. We discuss our design considerations, in particular with respect to evolving visualizations of dynamically changing data. Initial feedback indicates significant interest and suggests several unanticipated uses.

Index Terms— Backchannel, information visualization, events, multiple views, micro blogging, information retrieval, World Wide Web.

1 INTRODUCTION

Digital backchannels are an emerging social phenomenon. As people are watching political debates, attending educational events, or even coping with natural disasters, they increasingly share brief and timely pieces of information in digital backchannels, which create persistent conversations about events of social significance. Digital backchannels have become an intriguing communication medium, over which more and more people exchange impressions, suggestions, and comments during events. Such backchannels not only enable participants to share their experience and shape how observers perceive an event, they are also used to help participants influence the unfolding of an event and its outcome.

As these digital backchannels rise in importance as social information spaces, in which people complement and co-create large-scale events,there some significant limitations with current methods of displayed information. The widespread chronologically ordered lists uniquely are not sufficient for large-scale backchannels in that they are not able to perfectly represent the scale and dynamics of real-time conversations. This has the unintended but well-known consequence that participants get distracted from the main event, have difficulties focusing, and lack an overview of what the backchannel contains.

Fig. 1. The Visual Backchannel—here shown for Twitter posts about the event Park(ing) Day—consists of a) Topic Streams: a visualization representing topical development, b) controls for filtering and searching, c) People Spiral indicating the activity of participants, d) chronologically ordered list of posts, and e) Image Cloud displaying shared photos

To overcome these issues, here introduce the Visual Backchannel, an evolving, interactive, and multi-faceted interface that integrates three visualizations with a list of backchannel posts via linking; brushing and filtering (see Figure 1). In order to give new perspectives on backchannel conversations, we introduce Topic Streams, a temporally and topically adjustable stacked graph that visualizes topics extracted from digital backchannel conversations. This is accompanied by two compact visualizations, People Spiral and an Image Cloud, presenting visual aggregates of active participants and shared images. These visualizations offer a visual sense of the conversation at the moment, using visual accentuations that make the present visible, in the context of the topical development. This way Visual Backchannel provides saliency and visual evidence of what is happening now, and what is recent within the ongoing temporal context of how backchannel conversations unfold over time. The four views, which are linked via highlighting, brushing, and filtering are designed to provide organically evolving representations of a constantly changing data set, and interactive access to the temporal distribution of topics, the most active participants, and salient photographic impressions. with this work, we make two main contributions:

- We propose the notion of evolving visualizations that integrate representations of current activity and recent development in continuous information streams, such as digital backchannels.

- We introduce three novel interactive visualizations that summarize the main facets of large-scale backchannels and provide exploratory interactivity along time, topics, and people in the context of a Visual Backchannel interface.

2 DESIGNING A VISUAL BACKCHANNEL

The design and implementation of a Visual Backchannel as a coordinated-view interface that provides interactive and visual access to the current activity and ongoing development of backchannel conversations. Besides featuring a conventional list of backchannel posts, the Visual Backchannel interface consists of three novel visualizations that are linked in order to support cross-filtering and brushing. The primary visualization using the most screen real estate is Topic Streams, a stacked graph visualization of conversation topics, below which there is a People Spiral, a helical view of the most active participants, and an Image Cloud featuring photographs taken during an event (see Figure 2).

While being designed to create aesthetic aggregations that summarize topical, social, and pictorial aspects of a backchannel over a given time period, these visualizations also accentuate current activity in on-going backchannels using 'half-lived' highlights in the context of recent developments. The visualizations provide ways for interactive and responsive cross-filtering along time, topics, and participants. Further more, the interface features interactive representations of currently set filters, including text search, and a conventional list of backchannel posts giving rapid access to the data being visualized.

2.1 Topic Streams

The primary view of our Visual Backchannel is used by Topic Streams, an interactive stacked graph that visualizes live-changing textual data across time and supports interactive exploration by temporal zooming and panning, and topical filtering. In contrast to previous stacked graph techniques that relied on fixed time intervals and predefined categories, such as news topics, movie titles, and artist names, our Topic Streams support multiple levels of temporal zoom and are based on the changing textual contents of tweets.

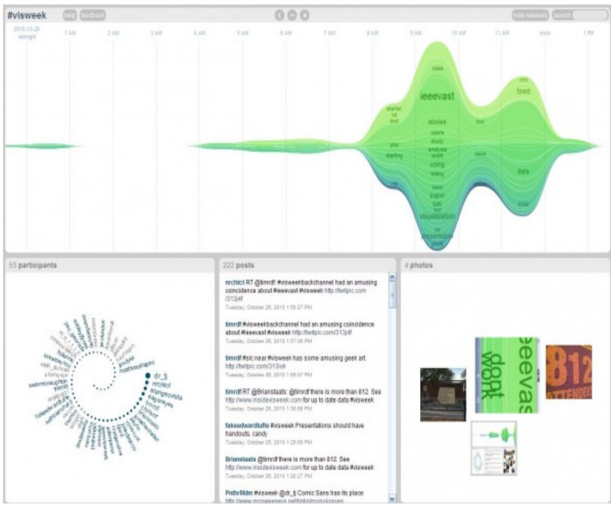

Fig.2 Visualbackchannel for visweek2010

2.1.1 Representing Conversation Development

The visualization uses an integrated set of visual variables and arrangements to encode topical development:

Ordering. Recent work on stacked graphs suggested novel methods for finding ideal stream orderings in order to reduce 'wiggle' between time intervals. One of the suggestions is to arrange arriving streams on the outside (both top and bottom) and streams that have arrived earlier close to the inside of the stacked graph. We experimented with many ordering techniques, however, we experienced very unstable orderings of streams for different time spans leading to abrupt re-orderings when zooming or panning along the time dimension. To avoid excessive visual activity through reordering, yet still use the order of streams in a meaningful but more stable way, we decided to order by general newness of a topic from top to bottom of the streams. The choice of newness as an ordering measure over time of first occurrence is based on the observation that the first occurrence of a word in an individual tweet alone does not make it a conversation topic, but only when it is picked up by multiple participants.

Colour. We double-encode the newness of topics with their stream colours, as the stream ordering only represents a ranking and not a distribution of values. The mapping from newness to colour is done in the HSV (hue, saturation, value) colour space. We choose a subset of the hue spectrum between blue and green, with the newest topics rep- resented by green and the oldest in blue. To make the streams of newer topics appear brighter and more saturated we map greater newness tom higher saturation and higher value (see Figure 3).

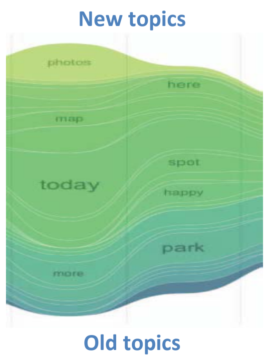

fig.3 representing the topics

The Topic Streams are stacked in order to give the impression of a conversation river consisting of multiple topic lines. While earlier techniques used exclusive categories for stacked graph visualizations, we use words coinciding with other words in tweets as the basis for the Topic Streams. This has the effect that tweets with more words ultimately have a greater impact on the resulting visualization. We find that this is acceptable as longer backchannel posts also contribute more to a conversation. Alternatively, a normalization step could take into account the length of a tweet and scale the contribution of a word to the visualization accordingly. We decided not to count multiple instances of the same word per tweet to reduce the influence that individual tweets can have on the visualization of topics

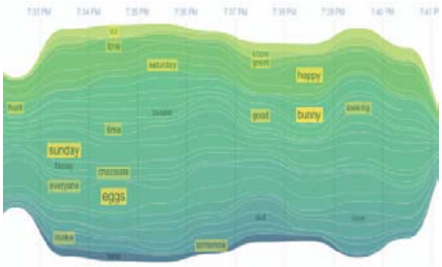

Fig.4 The Topic Streams represent Twitter topics during Easter 2010 with yellow highlights indicating current activity in the backchannel

.**Scaling.** While the vertical width of an individual stream at a specific time interval is determined by the relative number of topic occurrences in tweets during this time bin, the overall sum of the stream widths per time interval corresponds to the sum of occurrences of these most popular topics. We scale the topic visualization so that the time
bin with the most topics uses the full height of the topic view in the interface. This has the effect that the Topic Streams are rescaled between filter explorations. While this carries the danger of impeding comparability.

Labels. The topic visualization is also accompanied by textual labels. For each topic there is a label positioned at its widest section of the corresponding stream. The label that is used is the most used word instance of the particular stem. The font size of the label is correlated with the overall number of occurrences of the topic in this time window and its colour is a darker tone of the colour of the stream. There are date and time labels at the top of the visualization for temporal intervals. Faint vertical lines demarcate the different time bins.

2.1.2 Representing Current Activity

Complementing the visualization of topics changing over time, we see a need for representing current activity in the backchannel in the context of recent developments. We want to represent data change in ways that are comprehensible and not lost when following the visualization only peripherally or sporadically, which is likely during events.

To encode current activity we are focusing on three main visual variables: colour, position, and motion. These variables are not in conflict when used for representing topical development, as they can be seen as extensions from the present into the recent past.

Colour. We accentuate the topics and authors of incoming posts by adding temporary yellow-coloured backgrounds to the corresponding labels in the visualizations (see Figure 4). The opacity of a highlight depends on the relative frequency that a topic was mentioned. These visual accentuations can be seen as 'half-lived' highlights of current activity whose immediate presence in the interface is always temporary. However, we seek to connect the representation of the now with the representation of recent developments in the data stream. Therefore, we choose yellow as it is the natural extension of the colour scale used to indicate newness in the streams. One could argue that the newest or most recent time point is the present.

Position. We position the present at a clear location, namely the far right of the topic visualization. This way the viewer can expect the most change in a particular region of the interface. Similar to the temporary use of colour, the position of the now gradually slides to the left of the visualization as the previous now becomes the recent.

Motion. Data change leads to animated transitions in the visualizations. The Topic Streams grow or shrink relatively with current activity. The extent of the animations represents the extent of the change in the backchannel conversation. When the animated transitions terminate, the result of the previous now becomes the shape of the recent.

2.1.3 Interactivity

The Topic Streams support three basic filter interactions: temporal zoom, temporal sliding, and topical selection. All these interactions result in animated transitions of the Topic Streams and the other views, reducing the cognitive cost of following the change.

Temporal zooming. The zoom level specifies the basic unit for each time interval. A range between ten seconds and a month per interval, with seven steps in between, was chosen to represent a wide spectrum of events and allowing viewers to set their time span of choice. The viewer can change the level of temporal zoom by scrolling with the mouse wheel, similar to how zooming works in web-based mapping services, or clicking on the corresponding button above the Topic Streams. This zoom event is acknowledged by an animation of the grid representing the time intervals. As soon as the data for the new time window of the topic visualization has been transmitted to the browser, the Topic Streams are updated through animated transitions.

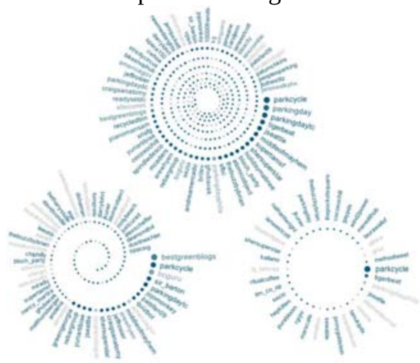

Fig. 5. Representing the activity and originality of Twitter members with posts about Park(ing) Day 2009. The People Spiral accommodates a range of participant numbers and adjusts its layout accordingly.

Temporal sliding. The viewer can also change the current time window by sliding it to an earlier or later period. Also similar to web based mapping tools, the viewer can simply drag the topic view either to the left or to the right or select corresponding buttons to move the time window to a later or earlier time point. By dragging with the mouse pointer, the streams, time grid, and time labels will follow its movement, and after releasing the mouse button they will snap into the chosen place. When the viewer drags the topic visualizations, there will be pre-rendered parts of the streams with the length of the current time window in each direction.

This technique is known in computer graphics as off-screen rendering, and here it allows us to provide a smoother user experience.

Topical selection. Besides changing the temporal granularity or position of the Topic Streams, the viewer can also change their topical composition by selecting a topic itself as a filter. This has the effect that only those Topic Streams that coincide with the selected topic will be shown. The selected topic will be removed from the Topic Streams, as it is implicitly present in all selected tweets and thus will not change the visual representation of the Topic Streams. Instead the topic filter will be represented as an interactive button above the topic visualization that allows its cancellation by simply clicking it.

2.2 Compact Visualizations for Participants and Photos

Besides the rich and sophisticated visualization provided by the Topic Streams, we decided to choose more compact views representing the people participating in a backchannel and the shared photos. Together these views can only use about one third of the screen area of the backchannel interface to have sufficient screen space for the post listing. Particularly guided by the goals of designing for an organic appearance and making efficient use of the screen space, we came up with two aesthetic, yet compact views that summarize the activity of backchannel participants and their pictorial impressions.

2.2.1 People Spiral

With the goal to display participants in an aesthetic representation, we designed the People Spiral layout consisting of dots and labels representing backchannel participants and their activity (see Figure 6). Each dot in the spiral stands for a participant using the dot size to represent their activity in the backchannel, based on the relative number of tweets within the current time window and topic selection. The colour of a dot indicates the originality of the person's posts. The more tweets were quotes, or re-tweets, the less saturated the dot is. The base colour is a tone of blue.

N=100

Fig.6 The Image Cloud arranges photos shared by Twitter members during the Burning Man 2009 desert festival. Image sizes correspond to relative differences in image sharing and reposting. With fewer images in a selection (left), the displayed images can assume larger areas

S=1.5 r=25·

Fig.7 Different visual arrangements for an Image Cloud representing 100 photos shared during the SXSW 2010 festival on Twitter. Layouts differ by margins between images, adjusted by the spacing constant *s*, and the image orientations, specified by the rotations range *r*.

Another goal for the design of the People Spiral is to visually represent as many people as possible, and give precedence to more active participants. An early design included an icon list of participants, which did not indicate activity and could only display a few people without having to scroll. Slightly compromising the readability of some labels, we chose a spiral layout for its organic shape and the ability to represent many participants in a compact area. The People Spiral is ordered by activity and represents up to 300 participants. The most active participant is positioned at the outer end of the spiral on the right side with its label straight and easily readable. A label's font size is relative to the dot size and has the same colour. Further along the spiral, the labels are rotated perpendicular to the tangent of the spiral at a given point, however, on the left side they are flipped to avoid labels being rendered upside down. Depending on the current temporal and topical selection, the number of participants displayed varies.

In order to represent large numbers of participants, we omit the labels for less active participants whose dots are positioned in the inside of the spiral. Hovering over these dots reveals the name of the participant as a tooltip. If the number of participants is below a certain threshold, currently set to 40, the layout reverts to a full circle displaying the labels for all represented participants (see Figure 6, bottom right). The labels allow interactive filtering by participant. Selecting one will change the colour of the label and dot to orange and add a participant filter on the top right of the interface. Clicking again on the label or on the filter button will withdraw the filter. Selecting another participant will change the filter. In combination with other views, filtering by participant allows us to quickly see what individual people have been talking about in the backchannel. We have experimented with selecting only the posts by the selected participant and also including those that mention them. We find both cases to be useful.

2.2.2 Image Cloud

The Image Cloud is a lightweight view for socially shared images, inspired by the widespread use of tag clouds on the Web. Similar to how tag clouds typically use font size to encode how often a tag has been associated with resources in web communities, we can adjust the area an image uses in the visual display to indicate how often it has been shared in relation to other displayed images. As posts on Twitter can contain links to images, it can be observed that images and, in the context of events, photos assume social significance based on the re-postings by participants. With the Image Cloud, we harness these social frequency measures by displaying more frequently posted images larger than
those that have been posted only once (see Figure 5). In our current design, we focused on the presentation of at most 100 image thumbnails with a square aspect ratio, however, this technique can be easily extended to arbitrary rectangles and larger displays. The positioning of images is based on an iterative force-directed layout algorithm that is seeded by initial positions with larger images positioned closer to the centre and smaller ones further at the periphery of the view. In order to make efficient use of the space devoted to the Image Cloud we need to adjust the maximum image size on the basis of the image frequencies and quantity. In our prototype, we set the maximum length of image thumbnails using the following formula: $lmax = \sqrt{\frac{A}{s\sum_{i=1}^{n}\frac{ci}{cmax}}}$ (1)

with *A* for the screen area, *n* for number of images, ci for occurrences of a particular image, cmax for maximum occurrences among all images, and *s* as a spacing constant ranging between 1 and 2.5.

Depending on aesthetic intentions for creating customized backchannel displays, one could, for example, decrease *s* creating larger overlaps and images. Exploring these aesthetic considerations a little further, we have experimented with adding small, random rotations to images around the z-axis as a simple way of creating a more 'natural' appeal similar to the aesthetic of photo collages. By setting the range of rotation *r* and adjusting the spacing constant *s*, one gets a spectrum of visual layouts for an Image Cloud that ranges between a clean mosaic-like layout and a messy collage view with many overlaps. A relatively high spacing constant leads to open unused areas in the layout and relatively small images (see Figure 7, left). Reducing the spacing and adding rotation both increased the area used by shared images and also added an interesting visual pattern (right). The spacing and rotation constants provide the designer of a backchannel interface with more control over its visual appearance. While image spacing and rotation for aesthetic purposes may appear like visual clutter, we think that an appropriate balance between order and deviation in the layout can make the presentation both appealing and useful.

Allows filtering by a participant of interest. Topic and participant filters become interactive controls displayed in the top right of the interface accompanying a search box and a button for filtering out re-tweets. In addition to these positive filters, we envision negative filters to hide particular participants or topics, for example, due to spam or different interests. The search box already allows negative filtering by preceding a search term with a minus sign.

3 DISCUSSION

In the following, we critically assess the Visual Backchannel idea with regard to open questions regarding scalability, distraction, participation, and potential uses beyond events.

Scalability. The two main bottleneck areas for the Visual Backchannel are analyzing the data and generating visualizations. Running the Visual Backchannel as a web-based system on state of the art computers10 allows the processing of about 5 posts per second. While preparing and rendering the Visual Backchannel interface and subsequent for a medium sized event (1400 posts) takes about one second to render, it takes about 7 seconds for a large event (180,000 posts). Generating views for an exceptionally large conversation of one million posts by 325,000 participants over a times pan of 25 days, takes about 45 seconds to generate admittedly not interactive response times. As the system had not gone through any rigorous optimization, these preliminary measures are promising. However, to support exceptionally large events more research on scalability and performance is necessary. Distraction. Besides the scalability of the Visual Backchannel, there is the cognitive load for the participant to consider. One of our design goals is to provide visual overviews to reduce distraction from the main event by the backchannel conversation. While the competition for attention between the back and the front channel is already occurring, we need to investigate more closely what effect our design decisions regarding the representation of the now and the recent have on the participants and their event experience. The jury is out whether the visualizations that we introduced can quickly satisfy high-level information needs or whether they captivate or confuse the viewer to explore the backchannel communication instead of following or engaging with the main event.

Participation. The initial motivation for this work arose from a desire to use electronic means to increase the level of meaningful participation during meetings and events. This then grew into a more ambitious goal: supporting truly large-scale events and discussions involving hundreds of thousands and potentially millions of participants, such as national "town hall" meetings or truly global topical discussions. While the work that we present here can be seen as one step toward that goal, the Visual Backchannel in its current state does not provide ways of actually participating in a large backchannel. The challenge here is to design new ways to engage in an event or backchannel by allowing the participant to be heard among "too many people" and creating new relationships.

We designed the Visual Backchannel interface with the goal of representing current backchannel activity in its immediate temporal context. Providing this context also enables seamless transitioning to viewing past activity. we received during a trade show was particularity positive about this dual capability and encourages us to further explore the notion of visualizing the 'now' together with the 'recent'. There was significant interest in our Visual Backchannel from both event organizers and event participants that suggests uses for backchannel interfaces after as well as during the event. We have since observed the use of our tool by colleagues who asked to use it to monitor events they were not able to attend. These initial results promise further research opportunities for the visualization of both live and archival backchannel activity.

Beyond events. While we have approached backchannel communication from the perspective of event support, we believe that the Visual Backchannel can be extended into a general-purpose interface for any type of data that has at least topical and temporal characteristics. For example, server logs for web site navigation and search terms could

be visualized across time and in real-time to anonymously represent a sense of what web surfers have been recently and are currently interested in. The question is whether the resulting visualizations, in particular the Topic Streams, can provide meaningful and interesting information without the shared experience of an event. The common ground that is typically provided by an event may be necessary for shaping and punctuating the visualization.

4 ADVANCED TECHNOLOGY

We introduce EdgeMaps as a new method for integrating the visualization of explicit and implicit data relations. Explicit relations are specific connections between entities already present in a given dataset, while implicit relations are derived from multidimensional data based on shared properties and similarity measures. Many datasets include both types of relations, which are often difficult to represent together in information visualizations. we explore how both explicit and implicit relations can be visualized as EdgeMaps.

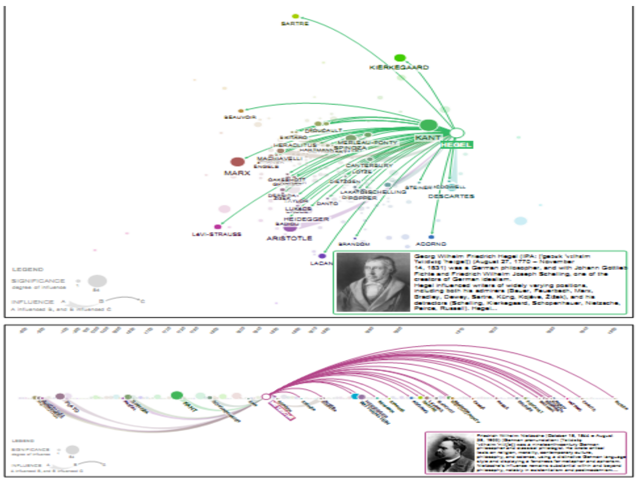

Figure 1. Visualizing influence relations between philosophers using an interest map (top) and a timeline (bottom).

For example, visualizing influences between philosophers as edges may indicate which philosophers had more impact, yet, it is not possible with these links alone to see the extent of the impact a philosopher had across time and interests. However, positioning philosophers based on birthdates or interests can make the extent of influence much clearer (see Figure 1).

VISUALIZING EXPLICIT AND IMPLICIT RELATIONS

To develop a way of representing both explicit and implicit relations, we introduce EdgeMaps as a visualization method that integrates spatialization and graph drawing techniques. EdgeMaps encode explicit relations as curved edges and implicit relations as node position. Other visual variables are used to double-encode these data relations and introduce additional information such as directionality and distinctness.

4.1Implicit Relations

To represent the implicit relations, we designed two general layouts: an interest map and a timeline. While both visualization layouts represent philosophers as nodes and influences as links, as we will describe in more detail later, the layouts differ in the way the positions on the plane are utilized. The interest map represents the similarity of philosophers based on their philosophical interests and professional occupations. The timeline uses birthdates as an ordering criteria to arrange philosophers along a temporal axis.

4.2 Explicit Relations

The layouts for topical and temporal similarities interest map and timeline represent only the implicit relations between philosophers. In order to represent influences between philosophers as explicit relationships, edges are drawn between the nodes. If all influence edges were to be shown for all philosophers, there would be far too many edges to be actually readable, let alone interpretable

5 CONCLUSION

We have presented the Visual Backchannel, a novel medium for exploring large-scale conversations around events, making it possible to:1) get a visual sense of large backchannel conversations over time,2) follow evolving representations of a live, continually changing data set, and 3) explore its temporal, topical, social, and pictorial facets. In order to visually summarize what a backchannel conversation is about and how it changes, we have introduced Topic Streams, as temporally adjustable stacked graphs, and two lightweight visualizations, People Spiral and Image Cloud, that represent the authors and images of a backchannel. These three visualizations provide context for the continually updated post listing and are themselves continually updating and evolving. The viewer can engage in different types of interactive explorations to focus on the subset of a backchannel conversation by selecting a time span, participant, and/or topic of interest.

In a continual stream of information, there are interesting nuances in the temporal experience. For instance, the current moment or 'the now' is caught up in what is actively taking place in the posts. However, to understand the topics in the now, one needs the context of the immediately preceding, or 'the recent'. Further, both the now and

the recent need the context of the on-going but slightly longer term focus of the event. By integrating decaying highlights that progress form the incoming yellow through the hue gradient of yellow through green to blue, the Visual Backchannel combines information about the now together with information about the recent into one visualization.

Providing this temporarily fading highlight raises the possibility that one might be able to keep one's awareness of the backchannel in one's periphery. This possibility is certainly worth further exploration.

We see this research in a larger context of exploring emerging social information streams that have considerable value for both observers and participants of backchannels. While we have addressed challenges of data change and development in the context of backchannels for events, we feel that there is a need for much more research on representing both the 'now' and 'recent' in changing information spaces.

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