CrystalChat: Visualizing Personal Chat History

Annie Tat & Sheelagh Carpendale
Department of Computer Science
University of Calgary
{annie, sheelagh}@cpsc.ucalgary.ca

Abstract

As more people take part in online conversations, awareness of the varying conversational styles and social mores afforded by different software is growing. However, this awareness is largely built on personal impressions as varying styles of social interactions are hard to discover in text-based presentations. Through visualization we explore social and temporal interactions in instant messaging. CrystalChat visualizes personal chat history. Rather than showing online social networks that indicate merely who talks to who, CrystalChat reveals the patterns in an individual's communications with those people who are part of their personal chat history. The patterns revealed come from instant messaging data that includes information about temporal clustering, conversation initiation, conversation termination, length of conversations, length of postings, patterns of repetitive or alternating postings, and emotional tone as represented by emoticons.

1. Introduction

While casual conversations are typically fleeting and traditionally leave no record, they have been and continue to be a significant part of our day to day interactions. Some varieties of online communication tools, such as instant messaging (IM), seem particularly well suited for casual conversations where people use single words, sentences snippets and complete each other's phrases. Unlike the spoken variety of these communications, the online version leaves a digital trace. We present CrystalChat, a visualization of the trace information left by instant messaging.

Online communication continues to grow in the number of people who use it, in the number of messages sent, and in the new varieties and styles of software that support it. Online communication now includes not only email but also such things as chatrooms, bulletinboards, text messaging, conferencing software, newsgroups, and instant messaging. This is changing the way we communicate with each other and affecting the way we maintain our social groupings [2,3,6]. Accompanying visuals have arisen to support these tools. One reason for visualizing this data arises from the recognition is that simple text

communication is less rich than face-to-face conversations, thus, visuals are added to augment the communication itself [11,15,18]. Another reason to use visuals is to provide ways to better understand people's interactions and the social networks that develop around them [7,10,11,21]. CrystalChat, an interactive visual representation of instant messaging data, falls into this latter category.
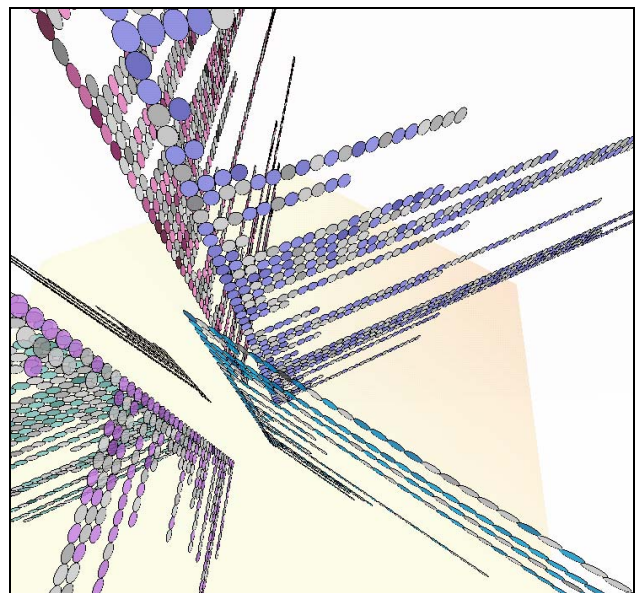

Figure 1: A view looking down at the structure of conversations in CrystalChat.

Text data from IM chat is typically displayed as a temporally ordered list and quickly fills available screen space. As a result we can only view a small segment at a time and the text list itself does not make interaction patterns easy to discern. A considerable number of social visualizations have arisen in response. These often focus on a particular type of online communication such as email [10, 19] and newsgroups [2] or a particular aspect of the data such as the social network [5-7,13] and conversation initiation and response [10,17]. These social visualizations are created to enrich text and to visually capture social patterns that are not easily visible through plain text [2-8,13,15,17-21]. CrystalChat focuses on the social interaction centered around one person, supporting self exploration of one's own chat history (Figure 1). This program creates an interactive visualization that incorporates the actual text messages in a structure that

integrates one's chat interaction patterns with a temporal history trace. Our design is based on combining the social network and the temporal aspect into one 3D representational structure.

In the next section we outline the related work. In Section 3, we describe the concepts and design goals behind CrystalChat. In section 4, we explain the visual representation and in Section 5 discuss interaction possibilities. In Section 6, we describe some of the patterns revealed by this visualization. In Section 7, we discuss response from people who have used CrystalChat. In Section 8 we discuss and list future work. We conclude in Section 9.

2. Related Work

Visualizing online conversations has been approached from many perspectives. These include visually augmenting the chat itself, visualizing the social networks formed by chat activities, and providing some trace of activities through time.

Most chat spaces are primarily text-based, though some graphic symbols that represent each person are often included. Comic Chat [11] augments text space by providing tools to support the use of some aspects of comics such as word balloons and comic characters. Each person is represented by a comic character allowing for the use of simple expressions and gestures. This augmentation requires effort on the part of the user and, while this presentation is charming, most people still opt for the simplicity and speed of text entry.

Chat Circles [19] provide an abstract visual system in which the chat takes place. Each individual is represented as a circle which expands to hold a message's text. In order to 'hear' or see the words of another's posting, your circle must be close to theirs. Your next posting replaces the previous one. Social groupings form and adjust spatially, indicating who is listening to whom. Similarly, there are many other systems developed in the MIT Lab that also visualize the social patterns of a group of people [2,3,21]. Here, the social information from one person is present but gets lost in many cases when the visualization is based on and/or focuses on the entire social community.

Visualizations of the social network of online communication often use some form of graph structure in which the nodes represent the people and edges represent the relationships between people. Mutton [14] describes a system that uses a bot to infer a social network which is then displayed as a node and weighted edge diagram. The edge weights represent the relative strength of the relationships and a spring layout is used to display the graph. Our previous work [16] showed the social network

with translucent directed edges. The relative weight of an edge builds with repeated communications. Both of these works show the communication network between people. In contrast, Thread Arcs [10] shows the relations between email messages for one person. PostHistory and Social Network Fragments (SNF) [20] are two visualizations that also focus on one person. PostHistory displays one person's direct interactions with their email contacts. SNF represents people by their name. The type of relationship they have with the central person is indicated by color and the strength of their relationship is indicated by font size. Again, a spring layout is used. While both visualizations report that the central person found meaning in these representations, they can become complex and cluttered thus, hard to decipher. In CrystalChat, however, we focus on the social network revolving around one person, but support selective display of chosen subsets of this network.

Time lines are used to represent patterns in data sets that have been produced for periods of time [5,9,15,20]. These timelines make intervals, patterns, and repetitions of series of events more visible. For example, LifeLines [15] is a time line that visualizes personal histories. This interface begins with one screen overview and then allows user to focus on details upon request with rescaling and filtering tools provided.

There are many visual systems that have considered social activity, social network, and the temporal aspect in one system. However, these components are either shown in separate screens or in two visualizations. For example, both Chat Circles [19] and Babble [5,8] have included visualizations of social activity and timeline, but in two separate visualizations. In another example, Newsgroup Crowds and AuthorLines [18] visualize the social group and the individual, yet, these are presented separately. The work that is most related to CrystalChat is a user-centric social interaction system, the side by side visualizations of PostHistory and SNF [20]. Their studies reveal that visualizing personal email habits supports personal narration and recall. However, people and time are again presented in the division of two panels and on separate screens. With multiple screens, the user would have to learn to relate the two graphical representations to see a pattern. One can lose one's point of reference when switching from one visualization interface to another.

Mutton [14] provides minimal evidence of temporality by fading his graph layout as time passes. As time progresses eventually old parts of the graph will disappear. On the other hand, CrystalChat is a visualization that combines the social network and the temporal aspect one 3D structure together. All the social information remains and does not disappear with time, so that people can go back in time to view the conversations history.

3. CrystalChat

The intention behind CrystalChat is to visualize one's personal chat history. Online social networks are complex structures often forming general graphs as the number of interconnections between people grows. In contrast, one's connections to those people who are part of one's personal chat history can be represented simply as a hub and spoke diagram. This hub and spoke diagram can be seen in Figure 2, where the hub – here a void in the centre – represents oneself and each spoke represents each person one chats with. However, there is more data in chat history than is evident in this view. This includes data about temporal clustering, conversation initiation, conversation termination, length of conversations, length of postings, patterns of repetitive or alternating postings, and emotional tone as represented by emoticons.
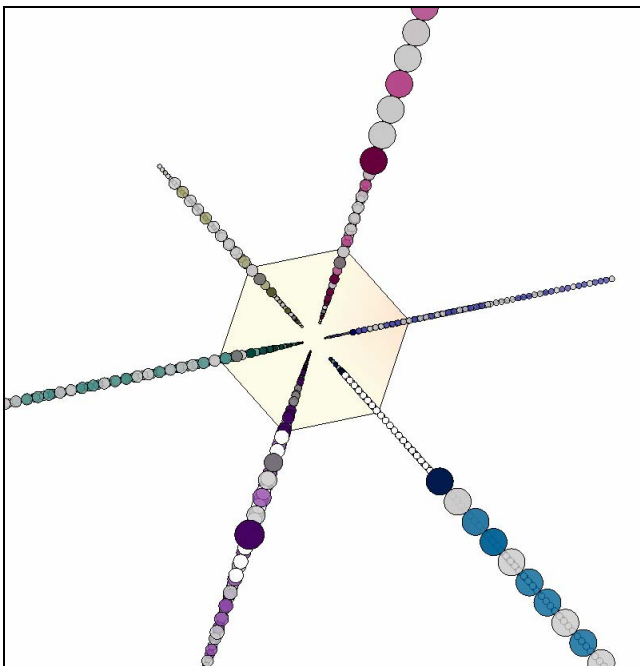

Figure 2: Top view showing the void central hub and six spokes that each represents conversations with a given person.

One approach might be to assign as much of this data as possible to different visual variables [1] and draw the spoke edges accordingly. This approach involves making use of the visual variables that have not been used in the basic diagram to characterize the spokes. Since location and orientation create the hub and spoke diagram this leaves visual variables such as colour, size, shape, (light and dark) value, and texture. For instance, characterizing the spokes according to some aspect such as posting frequency is of interest.

To include as many details as possible about temporal patterning and to incorporate the actual text of the posting

within the visualization, we extend these spokes into the third dimension. Figure 1 shows an aerial view (slightly offset from the top as seen in Figure 2) to reveal how the spokes representing the conversations with one person have become facets in which the temporal patterns can be revealed.

3.1. The design goals

In order to visualize one's personal chat history in a single structure capable of revealing temporal patterns, we developed the following design goals:

- To reveal one person's chat activities using data available from chat log history.
- To make individual messages apparent and maintain the link between the message's visual symbol and its text contents.
- To indicate the beginning and ending of a 'conversation' as defined by the opening and closing of a chat dialog box.
- To represent one's interactions with each person as a distinct visual grouping in one's chat network.
- To provide a structure linking the interactions with all people in one's chat network.
- To be able to show temporality, including both ordinallity which indicates sequencing as in which message is followed by which message, and frequency, to indicate the comparative length of time between messages.
- To provide an indication of the emotional content of the chat dialog as indicated by the emoticons used.

3.2. The data

While CrystalChat currently uses history log data from MSN Messenger, the visualization structure can easily be applied to other instant messaging systems. The history log data develops as follows. Chat messages are received in real time and these text messages are then stored in history log files that are ordered consecutively according to when the text message was received and written. The log files are formatted as an xml ordered list (see Figure 3). This file contains data about the time the message was posted, the person who posted it, the person receiving it and the contents. There is a file like this one for every different person with whom one chats. This data format lends itself to revealing chat patterns between oneself and one other person. Viewing two separate files makes comparing conversations with more than one person difficult. Each message has a time stamp with the time, day, month and year. Each message also includes a "To" and "From", which shows the users friendly (nick) name. The colour and type of fonts used in the original message are also included in this xml file. The end of an individual message is indicated when a person hits the enter key or presses send. The xml file also includes information on when the

user closes the message dialogue window which determines when a conversation ends.

Date	Time	From	To	Message
10/7/2003	10:52:09 AM	Disc Girl (Kristen)	Annie	hi
10/7/2003	10:52:12 AM	Annie	Disc Girl (Kristen)	hey
10/7/2003	10:52:18 AM	Disc Girl (Kristen)	Annie	we going for lunch?
10/7/2003	10:52:31 AM	Annie	Disc Girl (Kristen)	yes do you want to go at 11:15?
10/7/2003	10:52:34 AM	Annie	Disc Girl (Kristen)	instead
10/7/2003	10:52:47 AM	Annie	Disc Girl (Kristen)	nice pic
10/7/2003	10:54:08 AM	Disc Girl (Kristen)	Annie	ok
10/7/2003	10:54:11 AM	Disc Girl (Kristen)	Annie	11:15 is fine
10/7/2003	10:54:19 AM	Disc Girl (Kristen)	Annie	thanks. I got it take for work
10/7/2003	10:54:32 AM	Disc Girl (Kristen)	Annie	I'm supposed to have it on msn so I look professional
10/7/2003	10:54:38 AM	Annie	Disc Girl (Kristen)	haha
10/7/2003	10:54:39 AM	Disc Girl (Kristen)	Annie	how did you know about this hotmail account?
10/7/2003	10:54:48 AM	Annie	Disc Girl (Kristen)	i just guessed
10/7/2003	10:54:52 AM	Disc Girl (Kristen)	Annie	oh wow
10/7/2003	10:54:54 AM	Disc Girl (Kristen)	Annie	you're smart!
10/7/2003	10:54:58 AM	Annie	Disc Girl (Kristen)	i thought it would be easier
10/7/2003	10:55:05 AM	Disc Girl (Kristen)	Annie	yes. this is great
10/7/2003	10:55:12 AM	Disc Girl (Kristen)	Annie	now we can communicate properly
10/7/2003	10:55:17 AM	Annie	Disc Girl (Kristen)	no kidding
10/7/2003	10:55:25 AM	Annie	Disc Girl (Kristen)	now we can be real cpsc geeks!
10/7/2003	10:55:29 AM	Disc Girl (Kristen)	Annie	haha
10/7/2003	10:55:36 AM	Annie	Disc Girl (Kristen)	yeah.. hardy har har
10/7/2003	10:55:55 AM	Disc Girl (Kristen)	Annie	I'll meet you on 1st floor math science at 11:15
10/7/2003	10:56:05 AM	Annie	Disc Girl (Kristen)	ok. sounds good!

Figure 3: The data contains a time stamp, the person sending, the person receiving and the text contents.

4. CrystalChat: the Approach

In this section we use illustrations to build up a description of the CrystalChat visual representation.

4.1. Building a conversation from a sequence of messages

When viewed from above each spoke represents all the conversations with one person. When viewed from the side, these spokes are revealed as flat facets containing all the details of the conversations with a single person. As shown in Figure 4, the conversations are temporally sequenced starting from the bottom so that the most recent conversation is always at the top. This order makes more sense when viewing from the top, since the most recent conversation is in front.

Each person in one's chat community has a facet in the crystal. The number of facets represents the number of people that were chosen to be displayed. All figures used for this explanation display six different people. Figures 1 and 4 show some evidence of these multiple facets along the left hand side. Each facet starts from the empty central hub and points outward like spokes in a wheel. Figure 2 shows the top view of the six spokes. The central open region is small but important for the readability of the individual facets. Starting the facets too close to each other can interfere with people's ability to maintain visual distinctions between the facets and, as a result, to comprehend where they are in their explorations.
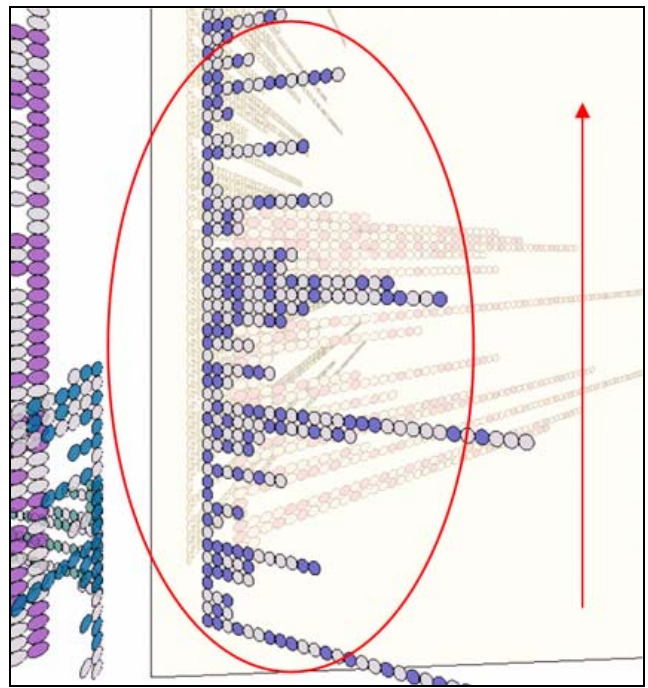

Figure 4: Temporal ordering of a facet. Conversation reads starting from the bottom, upwards.
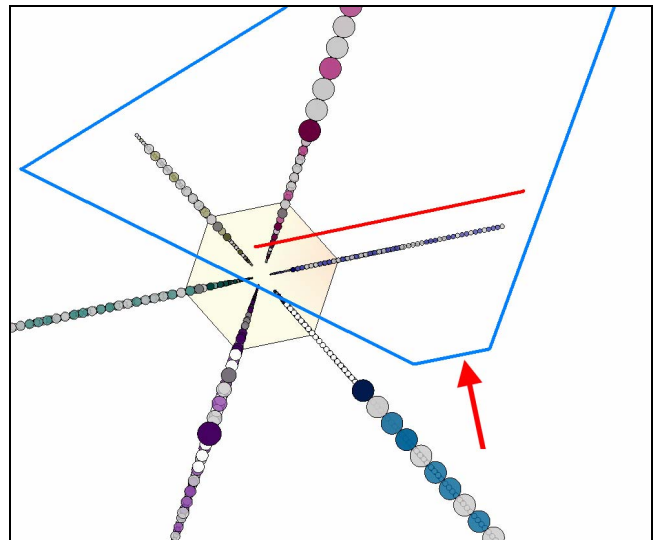

Figure 5: The red arrow indicates the viewpoint, the blue triangle indicates the field of view and the red line indicates the transparent shield. The facet in front of the transparent shield is the facet viewed in Figure 4.

The default view is to have a single facet approximately centered on the screen (Figure 4). The view in Figure 4 shows one facet when viewed from between two facets. This is shown diagrammatically as a top view in Figure 5 where the red arrow indicates the viewpoint and the blue triangle shows the field of view. From the diagram, one can see that several other facets would also be in the field

of view. To clarify the view of the facet that is being examined, a translucent shield is placed directly behind it. This is shown in Figure 5 by the red line. This translucent plane placed behind the current facet increases readability and makes it possible to expand the number of facets displayed. The translucent plane can also be used for the subtle display of additional information for the top down view. This is described in section 4.5.

4.2. Building a facet from a sequence of conversations

Each facet is composed of a series of conversations which are constructed as follows. A colored disc represents a single message (Figure 6) and each colour indicates a different person (Figure 7). In these images, the person whose chat network is displayed is represented by a neutral colour grey so that all colour choices for other people will show well in contrast. Left to right reading sequencing is used to order these messages. That is, the messages are arranged so that the first message in the conversation starts on the left. A conversation is defined, as in the data, by the opening and closing of the chat window. One row of message discs represents a conversation (Figure 8).
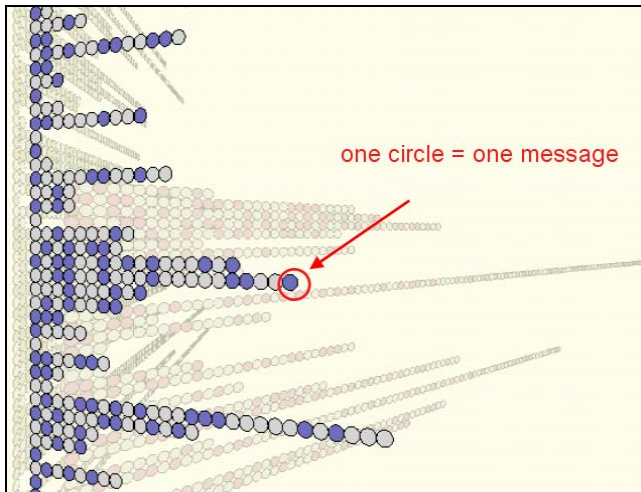

Figure 6: As indicated in red, one circle represents one message in CrystalChat.
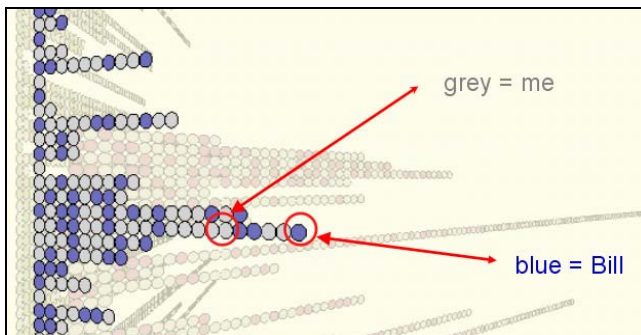

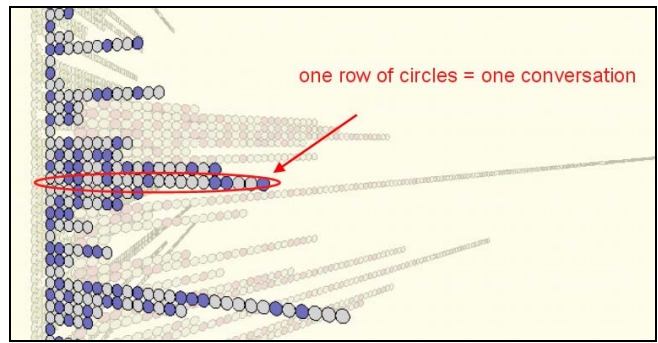
Figure 7: Colour is used to identify individual people.

Figure 8: The row in CrystalChat represents the conversation that occurred within a given message window.

4.3. Including the text data in the visualization

As declared in our design goals, all the text details are still connected with each message disc. One can explore each of the conversations in detail by selecting it. The conversation will open diagonally to maintain both the temporal ordering and to provide space for the text of each message to be displayed (Figure 9). The colour of the text corresponds to the colour used to represent the person who sent the message.
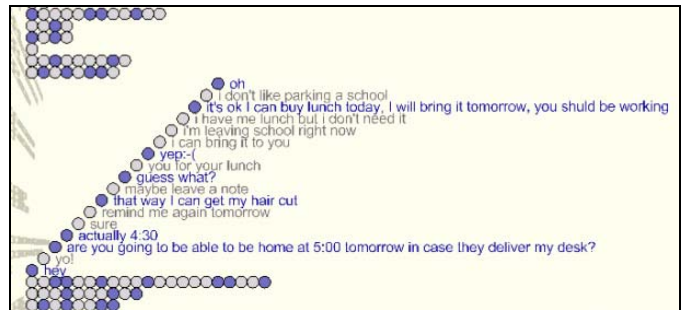

Figure 9: The text of one conversation displayed.

4.4. Augmenting the basic structure

CrystalChat is a fully interactive 3D hub and spoke structure. The spokes extend into 3D as planes that we refer to as facets. With the structure as described at this point, the simple view from the top (Figure 10) does not provide much in the way of additional information. It simply shows the number of facets available and is helpful in supporting the creation of a mental model of the structure as it is rotated. When viewing from the top, the discs automatically rotate, showing their flat side and thus making their colour visible (Figure 10). Within a facet, every time a conversation occurs, the conversation row is placed on top of the previous row like a stack. Thus, the varying sizes of the message circles in the perspective view from the top indicate the relative number of conversations in each facet.

All the illustrations thus far have shown the messages as temporally ordered and the conversations as ordered by start time. Time has been considered as an ordered variable. To display more precise relative sequence information, the actual times of conversation posting can be included. This is shown in Figure 11 where the gaps between messages represent the amount of time that occurred between the conversations. This mode of representation takes more space but does reveal the temporal interspacing of conversations between different people, thus providing relative time spacing. The timeline is still vertical and increases upwards. In this view, when temporal data is used explicitly, each row of messages corresponds to the conversations in one day. A greater distance occurring between two conversation rows means that more days have occurred in between those two conversations.

In the temporal spacing mode, there can be more than one conversation occurring in one day causing conversation rows to overlap. From both the side and top view, these overlapped conversation rows that occur in the same day can be fanned out like playing cards in a dealt hand (Figure 12). Using this feature, one can determine the amount of conversations that occurred during one particular day by seeing number of conversation lines as they are fanned out.
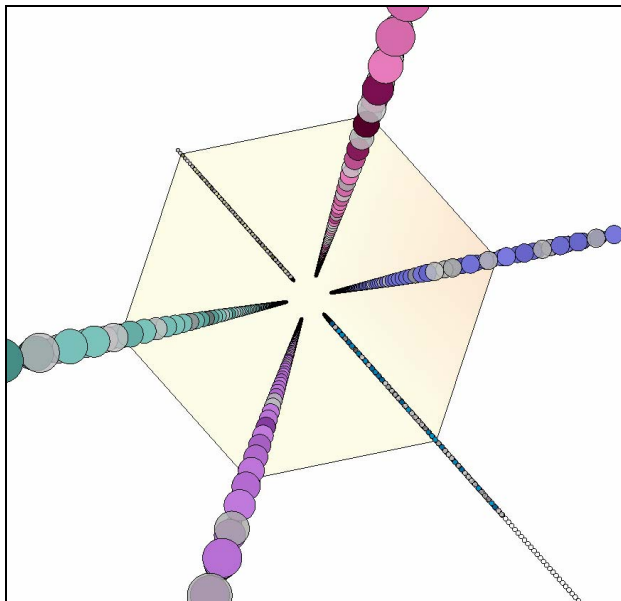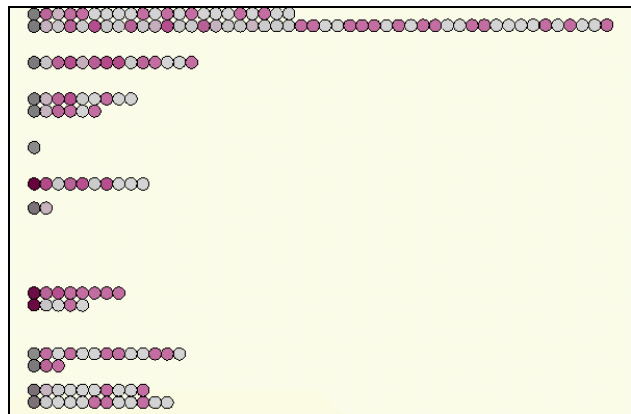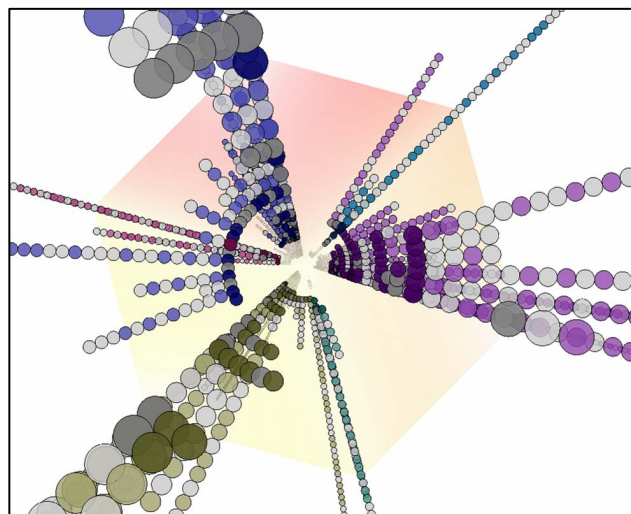

Figure 11: Temporal spacing.

Figure 12: Top view with temporal spacing - each facet is spread in a fan to see more than one conversation occurring in one day.

4.5. Showing emoticon content

We mentioned earlier that translucent planes were added for readability for the side view. These planes slightly obscure the rest of the structure without removing one's awareness of it. Still using a subtle colour, the plane can be used to display information about conversational tone. With the color change of the plane, one can see evidence of use in existing and non-existing of emoticons and repetitive use of punctuation.

Consider the view from the top (Figure 13). Here each corner of the translucent plane corresponds to one's conversations with a given person. The hexagonal shape results from the choice to display one's conversations with six people. One can also move the translucent plane towards the viewer or away from the viewer, which has the effect of bringing into focus what is above and subduing what is below the plane. This interactive repositioning of the translucent plane moves through one's chat history. The neutral colour of the plane is pale yellow. Moving the

Figure 10: Top view – one can approximate number of conversations that occurred with one person by comparing the sizes of the circle.

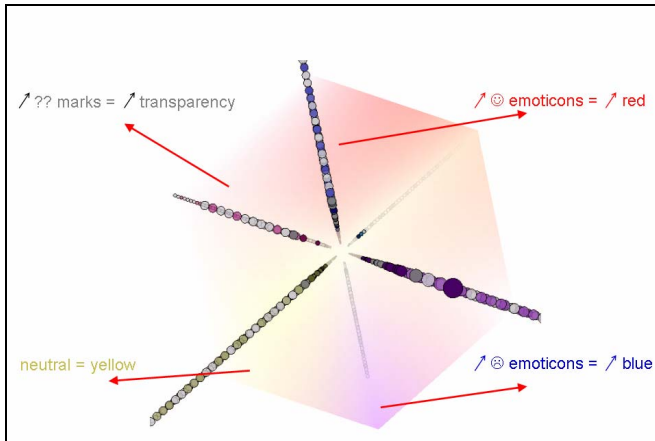screen up or down to a different level will also cause colour changes as the use of emoticons changes.

Figure 13: The colors of the translucent plane change according to the amount of emoticons used.

5. Interacting with CrystalChat

There are several significant views for this 3D structure. Camera paths and smooth animation are applied to move through different views of this wheel-like structure. In creating navigation interactions with CrystalChat, our purpose is not to limit the navigation power but to provide 3D interaction paths that give freedom without causing the viewer to lose themselves in 3D screen space.

Setting camera paths is similar to setting pan, scroll and zoom paths in 2D spaces. For the side views, our 3D camera paths are set so that one can rotate forward or backward viewing the different facets in the structure. Further navigations include panning upwards, downwards, and side-to-side and zooming in and out. From the top view, the user can zoom in and zoom out, shifting forward and backwards through time. This provides a rich 3D structure that contains possibilities of visual comparisons between several conversations, within an easy to use navigation scheme that is a simple extension to 2D navigation.

Switching from the side view to the top view or vice versa, the camera is animated automatically along a smooth camera path, guiding the viewing's eye to understand what is being done. How this camera path is shaped and how fast the camera moves is also important. In general, we are familiar with the idea of moving through 3D space via camera paths through our experiences in movies. This idea has been successfully used in interfaces such as a 3D desktop [12]. While we have not formally studied this, people (including the authors) outright refused to use a version with total 3D freedom and happily use the camera path navigation without mentioning it as an issue. In this

structure the camera paths allow the freedom wanted and provide the user with the feeling of simple control and understandable view transitions.
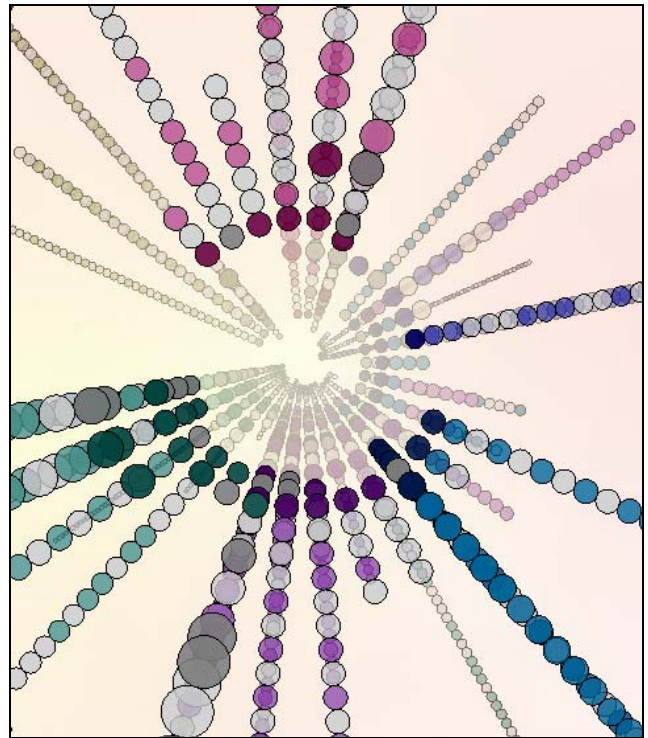

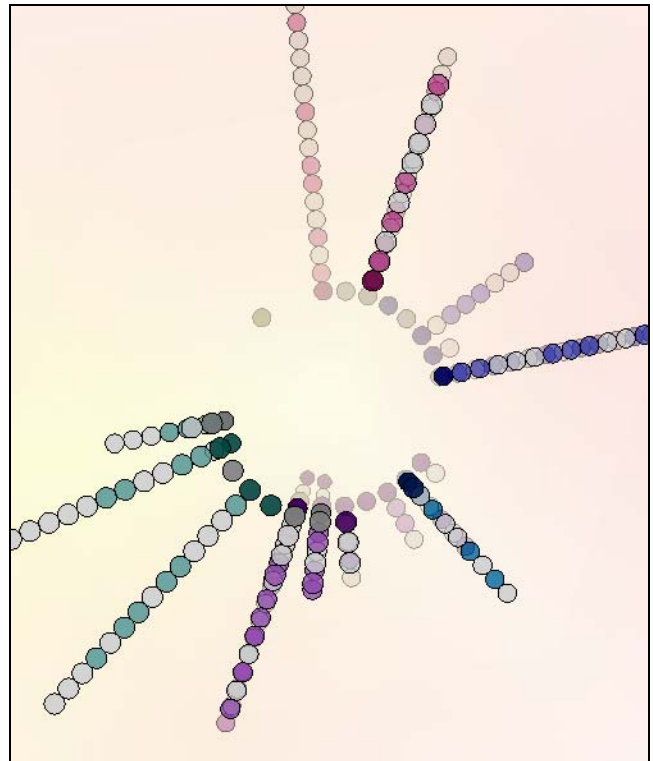Figure 14: Top view with no time filters applied.

Figure 15: A time filtered selection.

There are also filtering features available. More occlusion problems start occurring when looking from top view. The filters allow users to filter conversations by selecting a certain time frame. Figure 14 has no filters applied and Figure 15 is filtered for a specific time period. This way, different conversations from different people can be identified by their colours more easily.

6. Emerging Patterns

With this visualization there are several patterns that became more visible in comparison to a simple text list. In Figure 16, one can see that the person with the green disc initializes the conversation more often. The number and frequency of message posting varies for different people. From the visual pattern in Figure 17, we can see at a glance that the number of messages sent between the two people varies in that the person in grey sends more messages than the person in pink. Note that the person in grey often sends a series of consecutive messages.
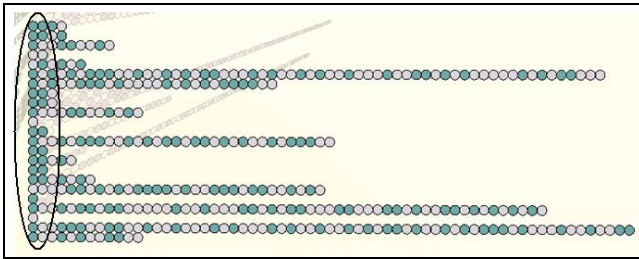

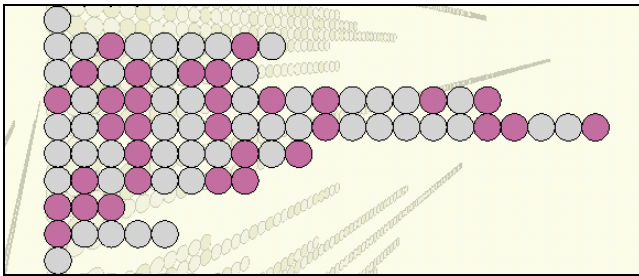Figure 16: The person in green has started the majority of the conversations.

Figure 17: The number and frequency of message posting varies for different people.

When the text view is expanded, colour coded letters show which person has sent longer postings (Figure 9). In addition, the light and dark value of the colour changes to represent the length of the messages. For example, the darker the value means the longer the messages. We use this term value to mean the relative lightness or darkness of a given hue by increasing or decreasing the RGB values. As shown in Figure 18, one can spot at a glance the more verbose conversations from those that consist of quicker word responses.
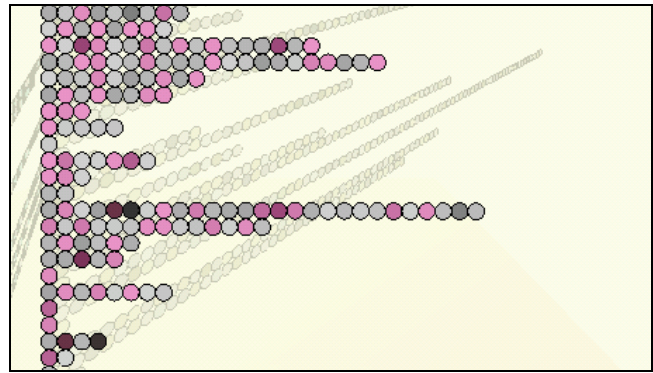

Figure 18: The darker the color value of the message circle, the more characters that are typed for that message.

7. Personal Response

While CrystalChat has not been formally studied, this visualization has been distributed to several people and we received both positive and negative feedback.

On the positive side, use of this tool prompts people to reminisce, telling stories about their personal history. For example some people mentioned why they were talking a lot during a period of time and what they were talking about. As mentioned in [20] this use is parallel to common use of photo albums. People enjoy gathering around a set of pictures and hearing about the events that occurred when those pictures were taken. Similarly, viewing previous IM conversations triggered this type of story telling. This is an interesting use for this type of tool. Previously, conversations were fleeting and often only hashed over in case of a disagreement. In contrast, this type of story telling was clearly pleasurable.

Also, patterns confirm people's relationship with others. For instance, one person reflected how his personal relationship has changed in the past months as he was able to see the social pattern through the visualization that he did not have as many conversations with his friend any more. Even though the program so far does not show the name of the person they are talking to, people were able to identify who the person was by reading the conversation. From this a person realized that she had longer conversations with women than she did with her male friends.

This program not only allowed people to discover their own personal patterns but also allowed them to reflect upon themselves and influenced them to change their social behavior in the future. A person uttered, "I don't have as many conversations with this person anymore, and this is probably something I should do more often". Another person realized the majority of the conversations that she initialized were mainly because she had a question about

something. This gave her pause to consider whether this social pattern was something she would change.

On the negative side, while people really did like the camera paths implemented, they wanted to do more navigation outside of these paths. For instance, zoom out further while still rotating the 3D structure. In this situation because people could still navigate for themselves in 3D space, they often got confused and at times lost in 3D space. We are currently working on extending the work with camera paths to provide all the 3D navigation that the structure requires. We need to study for this 3D structure, whether a set of camera paths is sufficient or whether a good set of paths plus free navigation with a method for easily returning to the path set may be preferred.

With real-time chat conversations, graphical representations can be overwhelming and can cause distractions when people are trying to pay more attention to typing and reading responses. However, viewing chat history is not a distraction as it is a tool intended for after-conversation use.

8. Discussion and Future Work

There are certainly advantages and disadvantages to archiving conversations such as instant messaging. Lovejoy and Grudin [13] mention that ephemeral conversations, such as instant messaging, encourage casual and informal exchanges. However, once conversations are archived people tend to write more formally and less casually. This may be an issue, but if chat histories are used in an informal setting or if the system is set in a way where only the authors have viewing permission, it may not be a large problem. As mentioned earlier, CrystalChat is a user-centric system where only one's own conversations can be viewed.

The general design structure of CrystalChat can be used with other types of messaging applications, but there are some limitations. Cell phone text messaging might be appropriate because exchanged messages are generally short. This could be applied to email but some decisions would have to be made. For instance a facet could represent an email thread or a facet could represent one person, each row representing one email and each circle representing a sentence or a word. However, the limitations would arise because the text in emails tends to be longer.

Theoretically this 3D structure can support a considerable amount of information. Each conversation from a new day can be stacked on top of the ones from the day before. Conversations also can be very long as there is no limit for the length of conversation rows. Technically speaking, however, computers can only store so much information before runtime response becomes unbearable. Interaction

with the system can be more tedious as panning from the bottom to the top will take longer as the years of conversations increases. Similarly, reading long conversations by panning left and right might also be frustrating.

There are still many changes that need to be made to make this visualization more effective. This visualization is structured such that new features can be added. We also collected many suggestions for changes that people would like to have incorporated into the structure.
- Improve the general interactive capabilities to allow one to always focus on the 3D form rather than having to switch and look elsewhere.
- Include date labels for timeline integrated into the structure in a similar manner to which the text contents now are integrated.
- Add more camera paths to have a complete interaction set so that sorting out 3D navigation would be simple.
- Incorporate more visual information into the size or shape of the message circles to represent word complexity, number of emoticons, number of punctuations, etc.
- Allow spokes of people to be rearranged around the hub

10. Conclusion

CrystalChat visualizes one's personal social network, focusing on providing a single visual structure that is capable of revealing temporal interactivity and providing information about the quantity and frequency of message posting. It reveals one person's chat activities using data available from chat log history. With CrystalChat, individual messages are apparent and still linked to their textual content. A given conversation can be opened at will. Messages within a conversation are grouped and conversations are associated according to the person involved. This structure also provides an indication of the emotional content of the chat dialog as indicated by the emoticons and punctuations used.

Providing a graphical interface that represents conversation through an interesting graphical environment can encourage people to view their past conversations and examine their own social behavior. While existing patterns emerge visually through effective social visualization, peoples' memories of the past can surface and storytelling can occur. Furthermore, personal social habits can be realized and can influence one's future social interaction.

11. Acknowledgements

12. References

[1] J. Bertin, Semiology of Graphics: Diagrams, Networks, Maps. W. J. Berg (Translator). University of Wisconsin Press, Madison, WI, 1983.

[2] Judith Donath. A Semantic Approach to Visualizing Online Conversations. *Communications of the ACM*. Volume 45, Issue 4, ACM Press, New York, pages 45-49, 2002.

[3] Judith S. Donath, Karrie Karahalios and Fernanda B. Viégas. Visualizing Conversations. In *Proceedings of the 32nd Hawaii International Conference on Systems*, IEEE Computer Society Press, Los Alamitos, CA, 1998.

[4] Judith S. Donath. Visual Who: Animating the Affinities and Activities of an Electronic Community. In *Proceedings of the third ACM international conference on Multimedia*, ACM Press, New York, pages 99-107, 1995.

[5] Thomas Erickson and Mark R. Laff. The Design of the 'Babble' Timeline: A Social Proxy for Visualizing Group Activity over Time. In *Proceedings of CHI 2001, Extended Abstracts*, ACM Press, New York, pages 329-330, 2001.

[6] Thomas Erickson. Designing Visualizations of Social Activity: Six Claims. In *Proceedings of CHI 2003, extended abstracts*, ACM Press, New York, pages 846-847, 2003.

[7] Thomas Erickson, Smith, D. N., Kellogg, W. A., Social Translucence: Designing Social Infrastructures That Make Collective Activity Visible. *Communications of the ACM. Vol. 45, Issue 4*, ACM Press, New York, pages 40-44, 2002.

[8] Thomas Erickson, David N. Smith, Wendy A Kellogg, Mark Laff, John T. Richards and Erin Bradner. Socially Translucent Systems: Social Proxies, Persistent Conversation, and the Design of "Babble". In *Proceedings of CHI 1999*, ACM Press, New York, pages 72-79, 1999.

[9] Susan Havre, Beth Hetzler, and Lucy Nowell. ThemeRiver: Visualizing theme changes over time. In *Proceedings of IEEE Information Visualization*, IEEE Computer Society Press, Los Alamitos, CA, pages 115-123, 2000.

[10] Bernard Kerr. Thread Arcs: An Email Thread Visualization. In *Proceedings of the 2003 IEEE Symposium on Information Visualization*, IEEE Computer Science Press, Los Alamitos, CA, pp. 477-482, 2003.

[11] David Kurlander, Tim Skelly, and David Salesin. Comic Chat. In *ACM SIGGRAPH*, ACM Press, New York, pages 225-236, 1996.

[12] John Light and J.D. Miller. Miramar: A 3D Workplace. In *Proceedings of IEEE Intl. Prof. Communication Conf. IPPC'02*, IEEE Computer Society Press, Los Alamitos, CA, pp.271-282, 2002

[13] Tracey Lovejoy and Jonathan Grudin, Messaging and Formality: Will IM Follow in the Footsteps of Email? Interact 2003, IOS Press, IFIP, pp. 817-820, 2003.

[14] Paul Mutton. Inferring and Visualizing Social Networks on Internet Relay Chat. In *Proceedings of Conference on Information Visualization*. IEEE Computer Society, Los Alamitos, CA, page 35-43, 2004.

[15] Catherine Plaisant, Brett Milash, Anne Rose, Seth Widoff, Ben Shneiderman. LifeLines: Visualizing Personal Histories. In *Proceedings of CHI 1996*. ACM Press, New York, pages 221-227, 1996.

[16] Annie Tat and Sheelagh Carpendale. Visualizing Human Dialog. In *Proceedings of Conference on Information Visualization*. IEEE Computer Society, Los Alamitos, CA, pages 16-21, 2002.

[17] Edward Tufte. Envisioning Information, Graphics Press, Cheshire, Connecticut, 1990.

[18] Fernanda B. Viégas and Mark Smith. Newsgroup Crowds and AuthorLines: Visualizing the Activity of Individuals in Conversational Cyberspaces. In *Proceedings of the 37th Hawaii International Conference on System Sciences*. IEEE Computer Society, Los Alamitos, CA, 2004.

[19] Fernanda B. Viégas and Judith S. Donath. Chat Circles, In *Proceedings of CHI 1999*, ACM Press, New York, pages 9-16, 1999.

[20] Fernanda B. Viégas and Judith S. Donath. Digital Artifacts for Remembering and Storytelling: PostHistory and Social Network Fragments. In *Proceedings of the 37th Hawaii International Conference of System Science*, IEEE Computer Society, Los Alamitos, CA, 2004.

[21] Marc Weber, Marc Alexa and Wolfgang Muller. Visualizing time-series on spirals. *In Proceedings of IEEE Symposium on Information Visualization*, IEEE Computer Society Press, Los Alamitos, CA, pages 7-13, 2001.

[22] Rebecca Xiong and Judith Donath. PeopleGarden: Creating Data Portraits for Users. In *Proceedings of the ACM Symposium on User Interface Software and Technology*, ACM Press, New York, pages 37-44, 1999.