Technical Document: TeacherBRIDGE Activity Visualization Tool

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Abstract

I present a multi-purpose visualization tool (Teacher BRIDGE Activity Visualization Tool) associated with Virginia Tech's Teacher BRIDGE synchronous online work and chat environment. I have developed this tool independently over the course of my participation in the CRA-W Distributed Mentorship Project based on research performed in the areas of activity-centered design, computer-supported collaborative work, user interface design and knowledge management. I introduce, through the development of this tool, new considerations for the visualization of temporal and network data types in the context of specific computer-supported collaboration tasks.

1. Introduction

Teacher BRIDGE (**B**asic **R**esources for **I**ntegrated **D**istributed **G**roup **E**nvironments) is a graphical "network developed for supporting online resources and collaboration among local teachers", which supports live chats, distributed creating and editing of material, and more complex tasks such as online discussion, classroom materials management, and virtual exhibits and events [Isenhour, et. al.]. Teacher BRIDGE relies on the CORK architecture [Isenhour, et al.] which provides synchronous activity and manipulation of objects in the system. It allows users to view who is online at the current time and to request chat sessions with those users as well as view, edit, and use sharable (permission-based) work objects that reside in various participant's directories in the network. Given this description, Teacher BRIDGE admirable meets the criteria for a Computer Supported Collaborative Work environment that facilitates group work and development of social capital through a network. However, while Teacher BRIDGE provides notification tools for current online users and access to shared objects, the task of collaboration can be enhanced by providing a context of work via a viewable activity history to improve ongoing awareness of the contributions to

the system and the objects that users interacts with [Rosson, 2003]. Other types of systems share the goal of knowledge acquisition through generation of activity-based context. For example, Knowledge Management (KM) has been defined as the capturing, organizing, and retrieving of information, and employs several database tools, data mining techniques, and search functions to retrieve desired information about human-computer productivity. Recent KM tools have been said to lack "consideration of human and social factors" when viewed from the perspective of CSCW and don't generally operate on social levels.

Social network visualization tools, including IBM's Babble, provide heightened awareness of past and present participating (remote) users by providing visualizations of conversations or group visitation to a site of interest [Thomas,J.C., et. al.] and promote shared knowledge through conversation structure by allowing users to search through structured views of conversational material. However, most social network visualization tools don't address goals typical to knowledge management to actually show multiple objects of focused activity in the system or view generalized user relationships to these multiple work objects over time to provide a context for shared knowledge. While the conversation flow and content contains within it references to work objects and activity on those objects, comprehension of system activity and user interaction must be grounded in the conversational discourse to be conveyed to the user seeking this information. Current research looks at bridging a gap between social awareness and activity awareness by demonstrating the ways in which social networks and activity are related [Fisher, D].

In my own attempt to bridge a gap between social awareness and activity awareness I used system-generated logs of Teacher BRIDGE object use as a corpora for activity queries, which generate a situated common ground for users of Teacher BRIDGE. I seek to provide user awareness through a structured, searchable, comprehensible presentation of the activity in Teacher BRIDGE network by demonstrating drawing the relationships of object use to users of those objects and times of use. Objects are defined as Teacher BRIDGE entities which may be shared (chat sessions, shared records).

In a way similar to that of Danyel Fischer in *Developing the Social Workscape,* I consider ties between people, events, and time to manage interpersonal information as well as inform users about their own activity, thus facilitating their own goals [Fisher, D.] Unlike Fisher, I do not attempt to consider

roles of users in the activity networks with respect to other users, only to the objects upon which they act, relying on the data visualizations and user induction for knowledge of what users might be directly "connected". For example, a user might infer that users are connected if they are both working on the same chat object at the same time. I developed a data visualization tool to examine previously unexplored log data to address two goals:

1. Evaluation of Teacher BRIDGE through quantitative examination of use patterns (e.g. how many users stopped using the system altogether and when, what percentage of initial users remained active throughout a given period of time, what was the drop-off rate or increase in use throughout a given period of time? What times of the day do most users require the most resources?).

2. Provision of a means of knowledge acquisition for users of Teacher BRIDGE through log-based visual query results that display both work activity *and* social activity in the Teacher BRIDGE collaborative environment. In particular, query results should enhance the user's knowledge of:

- the different kinds of activity in the system
- how that activity relates to the user's own activity
- how the user can proceed in the system to accomplish a task they wish to perform, especially when this task is connected to or dependent on other users of the system

In this work, I do not consider issues of privacy, and make the assumption (as is the case with Teacher BRIDGE) that cooperation is voluntary and history of activity a non-invasion of privacy. I also do not compare productivity of users in social versus isolated environments or make claims that productivity is correlated to particular social practices or awareness, only that users of collaborative tools, who rely on knowledge of each other's work activity, presence, intentions, and goals, may benefit from access to searchable histories and viewable patterns of activity, presence, intentions and goals. Although "tool", "environment" and "system" have meanings very distinct from one another, I use all three interchangeably when referring to Teacher BRIDGE in this paper.

2. Technical Grounding

a. Data Types and Tasks definitions

The "Data type by task" taxonomy is often used to identify visualization data types and the corresponding tasks required by visualization systems [Schneiderman, B. Plaisant, C.]. Data types include: 1D linear, 2D map, 3D world, multi-dimensional, temporal, tree, and network and tasks include overview, zoom, filtering, details-on-demand, relating, history, and extraction of the data types considered in a visualization. [Schneiderman, B. Plaisant, C.]The Teacher BRIDGE Activity Visualization Tool handles temporal and network data types and addresses the tasks of providing a visual overview of queried information, zooming in on that information, filtering information, relating information, and providing a history of information.

b. Sought Awareness

Exchanges among collaborators in a group are influenced by the situational factors of the workgroup. Groups are situated in contexts of varying organizational strategies, goals and responsibilities, interpersonal relationships, tasks and interdependencies and resources [Carrol, et al.]. Contexts are domains of activities—often seen as joint endeavors directed at long-term goals [Bodker]. The situation in which users of a system collaborate provides an overarching framework for setting goals, coordinating efforts, and understanding evaluation progress as well as receiving feedback about individual work [Carrol, et al.]. Activity awareness encompasses situation awareness, or "knowing what is going on around you" [Endsley, 2000].

3. Design / Prototype

To enhance knowledge acquisition of activity patterns and the objects thereof in the Teacher BRIDGE Activity Visualization Tool, I considered each task that visualization systems seek to address: overview, zoom, filtering, details-on-demand, relate history, and extraction to compile a design document of the Teacher BRIDGE Activity Visualization Tool. I mention some design choices that fell outside of the time and resources of my development of the initial prototype, further elaborating in the "Future Work" section concluding this paper.

Many previously created activity visualization tools informed the design phase of the Teacher BRIDGE Activity Visualization Tool. Some interfaces, such as Pad++, accomplish these tasks rather seamlessly by providing an overview of data, allowing the user to search the overview and focus in semantically on an area of interest. Zooming in consequently filters information outside of the user's interest range. Pad++ "records on objects the interaction events that comprise their use", making it possible to view histories of the objects as inseparable from the objects themselves [Bederson, Hollan]. To contextualize navigation through information-rich environments, Pad++ structures information based on metrics such as relevance to a task or relation of a certain type of information to other data in the system [Bederson, Hollan]. Particularly relevant to the Teacher BRIDGE Activity Visualization Tool is the use of "semantic zooming", which models information exploration based on a human processing model, allowing an overview of information to take precedence over detailed information, which is not initially displayed until the user iteratively seeks out and defines a new range of focus. Since the Teacher BRIDGE Activity Visualization Tool will seek to provide information about user interactivity over varying periods of time for many users, this paradigm was adopted in the design phase, to be implemented by providing a means of zooming in on particular visual objects by selecting an object and performing context-dependent queries based on that object, generating a new graphical field of view. For example, after inquiring about the times of day a particular object was used, the user might click on that time of day and ask "what users were logged in at that time?" Performing this query would generate a new visualization, which can be compared to the first, or placed in a sequentially meaningful position in the tool.

To facilitate details-on-demand tasks, I adopt a slider model, which demonstrates work done on a particular object by giving the user the ability to drag the work object through a dimension of time to generate information about the size of the object and who has contributed to the object over a (user-defined) period of time (explored with the sliding gesture).
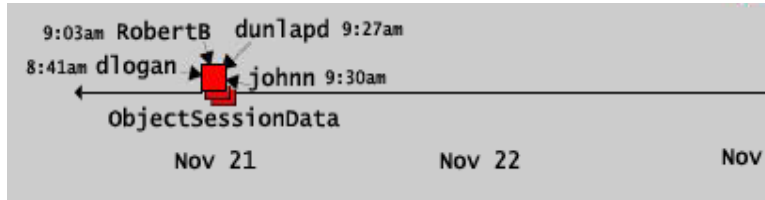
Before user slides red object of focus: query is "who worked on the ObjectSessionData object between the dates of November 21st and November 23, 2002?" (starting time is shown rather than each second that a change was made to an object)
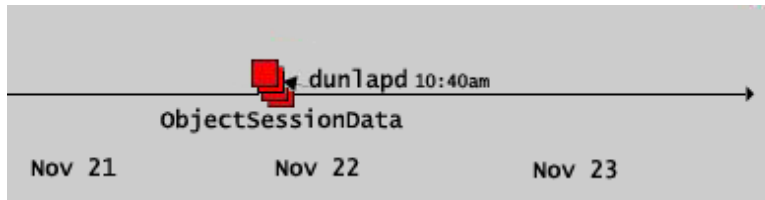
After the user slides the red object of focus: object size change shows contribution was made and user contribution is adjusted to show the active user for the given day slid to

The Teacher BRIDGE Activity Visualization Tool makes use of sequential information to exhibit causal and dependency relationships [Fisher, C. Sanderson, P.]. Since the context I consider is one of collaborative work practices, I explore whether one person's actions depend upon another's actions in a cause-and effect manner.

4. Implementation

The Teacher BRIDGE Activity Visualization Tool was implemented using Java with Swing GUI libraries and the Java Universal Network /Graph Framework (JUNG) libraries. It connects to a remote server via a JDBC driver to query an SQL (in my case PostGRES) database. The database construction, which includes table formulation based on meaningful relations in the data, is an integral part of the design and implementation processes as well as the tool's success as it must support and anticipate user inquiries that help to generate a common-ground within the collaborative environment.

Log data representing chat-related objects was captured by the developers of Teacher BRIDGE, who then ran a script to remove actual chat content from the data files for privacy. Beginning with these logs, I used Perl, shell scripts, and Java to parse the different fields into meaningful entities and attributes for inclusion in a freely obtained SQL database. After setting up connection to the database, I developed the Swing-based Java application for viewing the query results textually and used the JUNG libraries to draw the graphical query results. Future implementation of visual representations of information will be done with Java2D.

A list of all log data tables, each contain fields describing username, IP address, object modified, time of modification and date of modification

```
TBlogs=# \d
              List of relations
 Schema |    Name    | Type  |  Owner
--------+-----------+-------+---------
 public | action    | table | lwilcox
 public | activity  | table | lwilcox
 public | address   | table | lwilcox
 public | baseclass | table | lwilcox
 public | date      | table | lwilcox
 public | date2     | table | lwilcox
 public | duration  | table | lwilcox
 public | object    | table | lwilcox
 public | parsed    | table | lwilcox
 public | tbuser    | table | lwilcox
 public | time      | table | lwilcox
 public | username  | table | lwilcox
(12 rows)

TBlogs=#
```
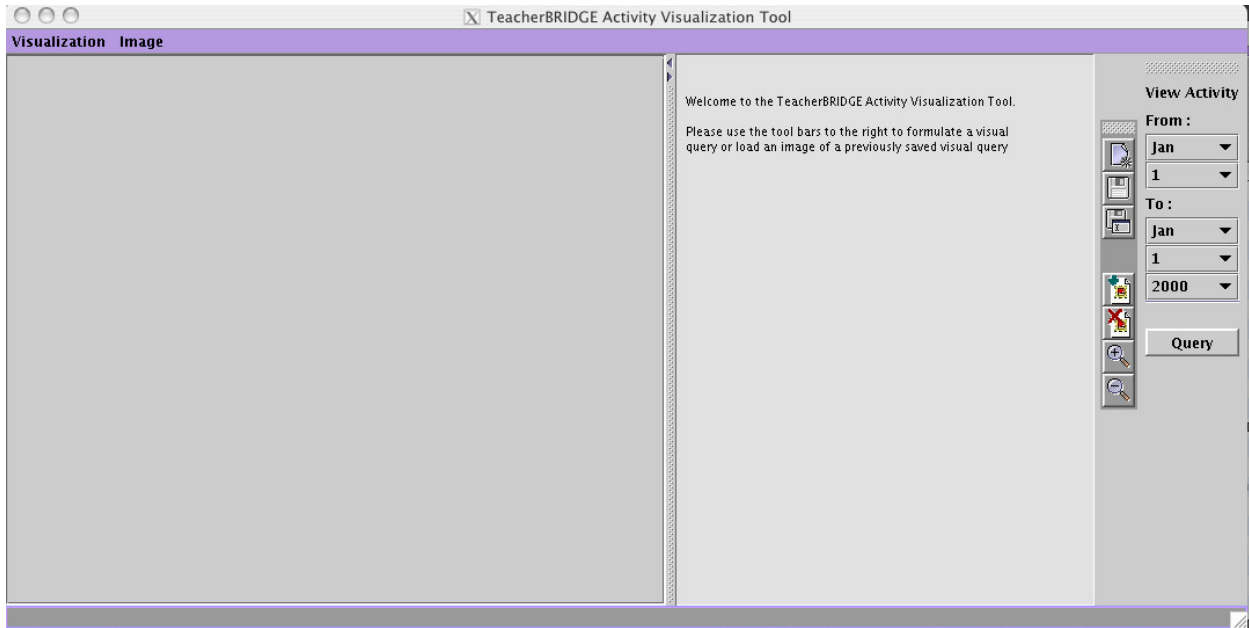
5. Results

The following images represent key portions of the Teacher BRIDGE Activity Visualization Tool. Formulating queries to check for particular values, group by particular fields, count instances of a query, or only show distinct relations is one way to achieve the visualization task of filtering information.

```
TBlogs=# SELECT DISTINCT P.m, P.hour, P. mon, P.day, P.ip FROM parsed P WHERE P.mon='Mar' AND day=20 AND P.ip='128.173.54.22' GROUP
 BY P.ip, P.m, P.hour, P.mon, P.day;
 m  | hour | mon | day |      ip
----+------+-----+-----+---------------
 AM |    1 | Mar |  20 | 128.173.54.22
 AM |    5 | Mar |  20 | 128.173.54.22
 AM |    8 | Mar |  20 | 128.173.54.22
 AM |    9 | Mar |  20 | 128.173.54.22
 AM |   10 | Mar |  20 | 128.173.54.22
 AM |   11 | Mar |  20 | 128.173.54.22
 PM |    1 | Mar |  20 | 128.173.54.22
 PM |    2 | Mar |  20 | 128.173.54.22
 PM |   11 | Mar |  20 | 128.173.54.22
(9 rows)

TBlogs=#
```

The above image demonstrates a simple example query supported by the Teacher BRIDGE log database. In English, this query is: "show me the hours of the day that a particular IP address (this might be substituted with username or computer name) has connected to Teacher BRIDGE on March 20th".

Nested queries and joins with other tables allow more for greater depth in information, such as "show times of day that are most popular among (user-defined set of) other users interacting with (user-defined set of) objects" and "show how many times a particular (user-defined) user edited a (user-defined) object".

The following screen shots demonstrate the current implementation of the Teacher BRIDGE Activity Visualization Tool in action. The resulting GUI application shown below demonstrates its capabilities through the query "*which users used what objects over a given (user-defined) period of time?*".
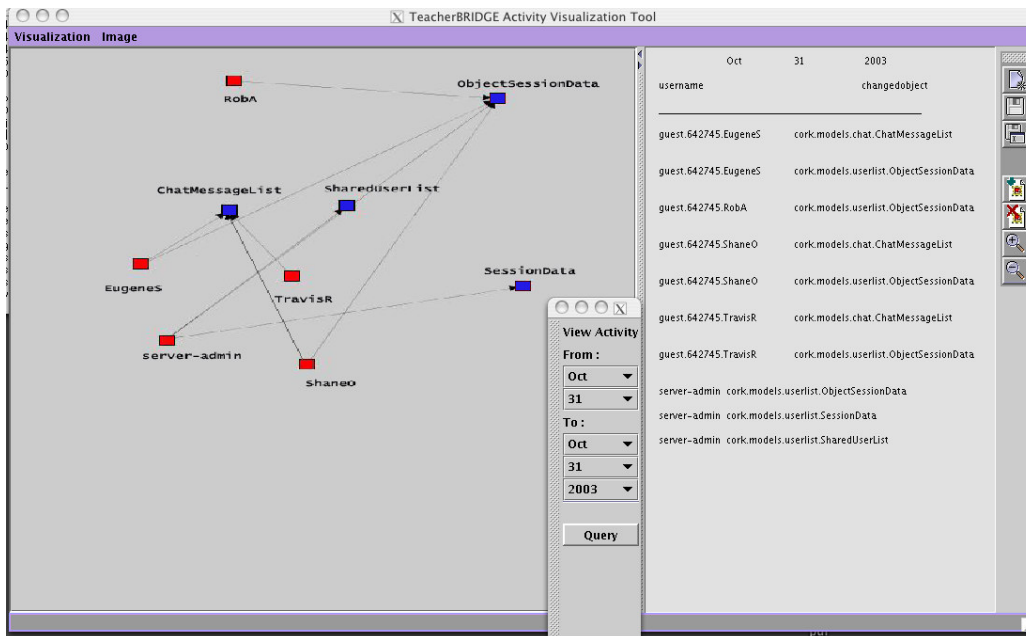
Welcome screen with instructions for system use. Toolbars facilitate querying the log data, clearing and loading and clearing an image of previously generated visualization of query results, zooming in visually on a visualization, and saving a visualization.
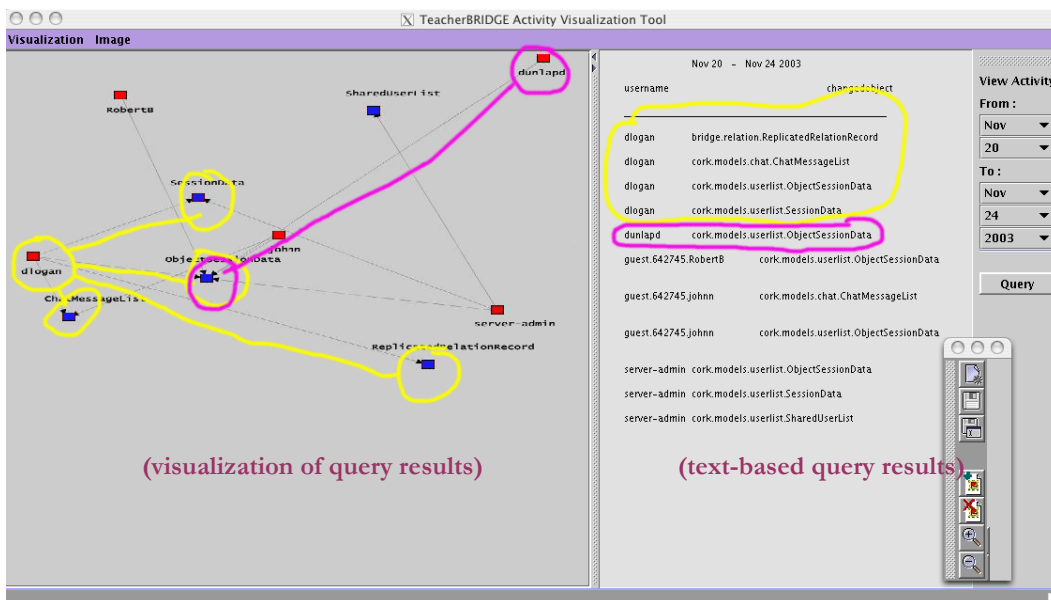
Queries are performed using the menu options in the *View Activity* toolbar. Both toolbars can be removed from their initial position to aid viewing the visual and textual query results. Clicking the "Query" button assigns menu items currently selected on the interface to tokens of an SQL query. The results are retrieved over TCP/IP and displayed both textually and graphically for the user.

Example of remote back end results

GUI Figure 1: Results are generated for a particular day

GUI Figure 2: text-based query results are displayed adjacent to a visual representation of the queried information. Users are represented as nodes or vertices as are objects that the users use. Edges between vertices are directed and represent use and modification of an object by a user. Information about two users is highlighted to demonstrate the relationship from the text to the graph.
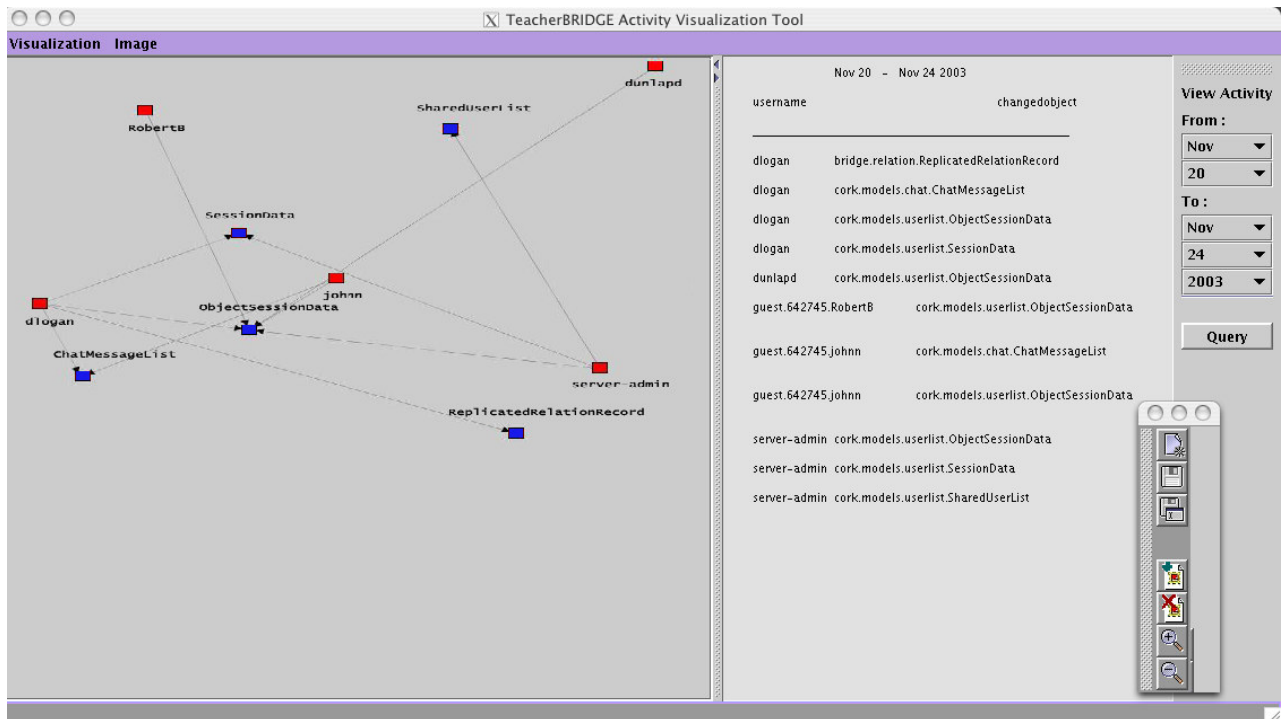
**GUI Figure 3: Results are generated for the duration of four days**

The overview and relation tasks are shown in the initial query results with the ability to view both text-based and image-based results via a directed graph. Additional query panes or criteria widgets would allow further filtering by allowing more user-defined complex queries.
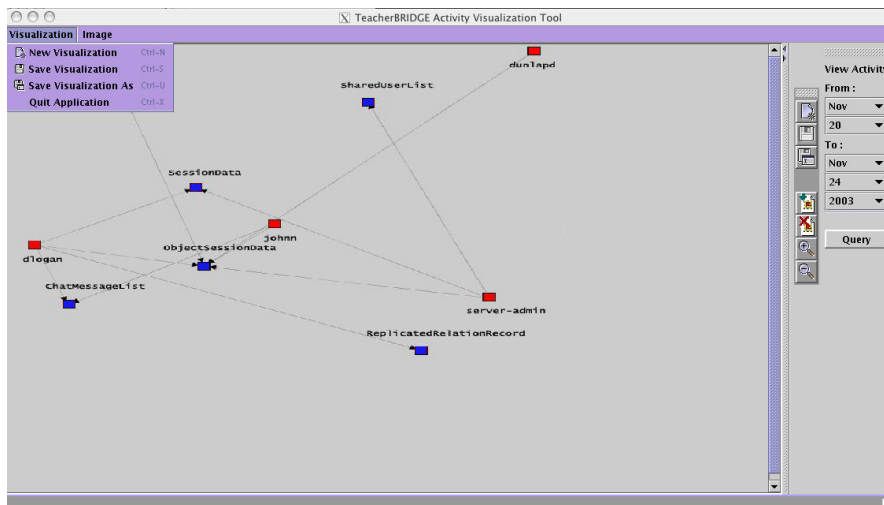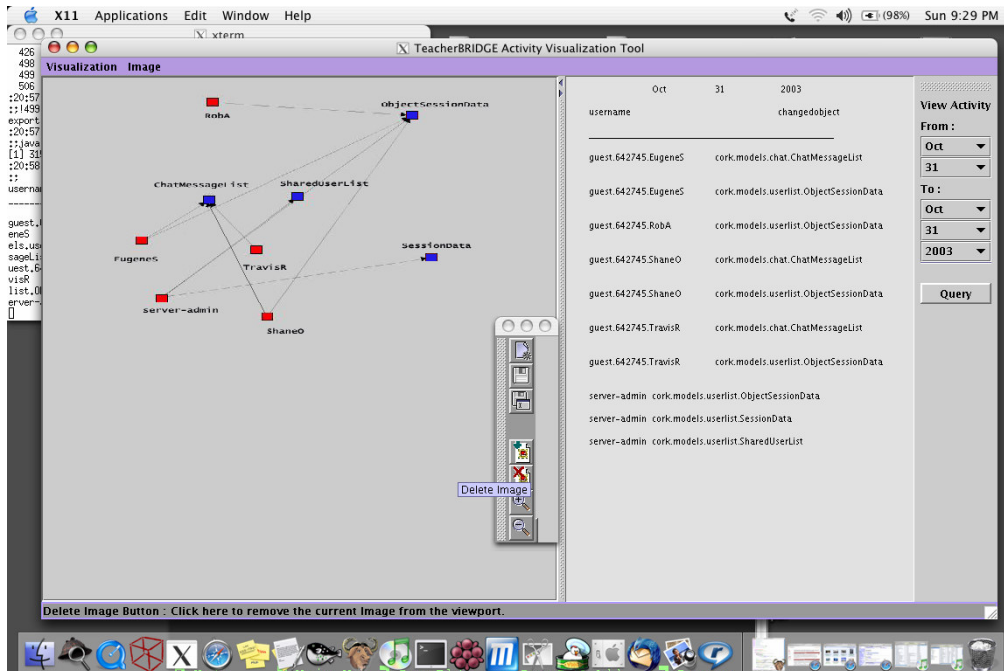

GUI Figure 4: Menu options as well as toolbars allow the user to save the visualization as an image file (in this case .jpg) to retrieve later or compare with other query-generated visualizations.
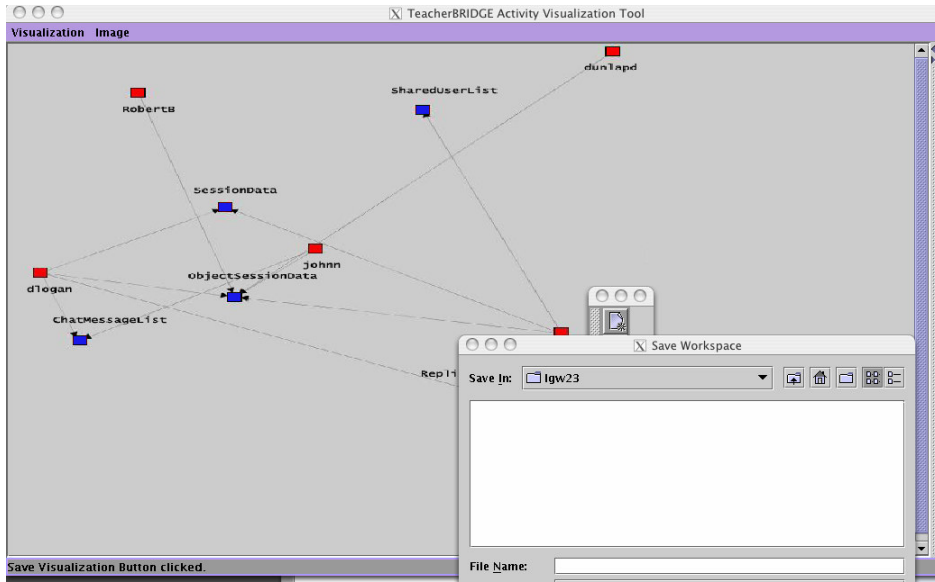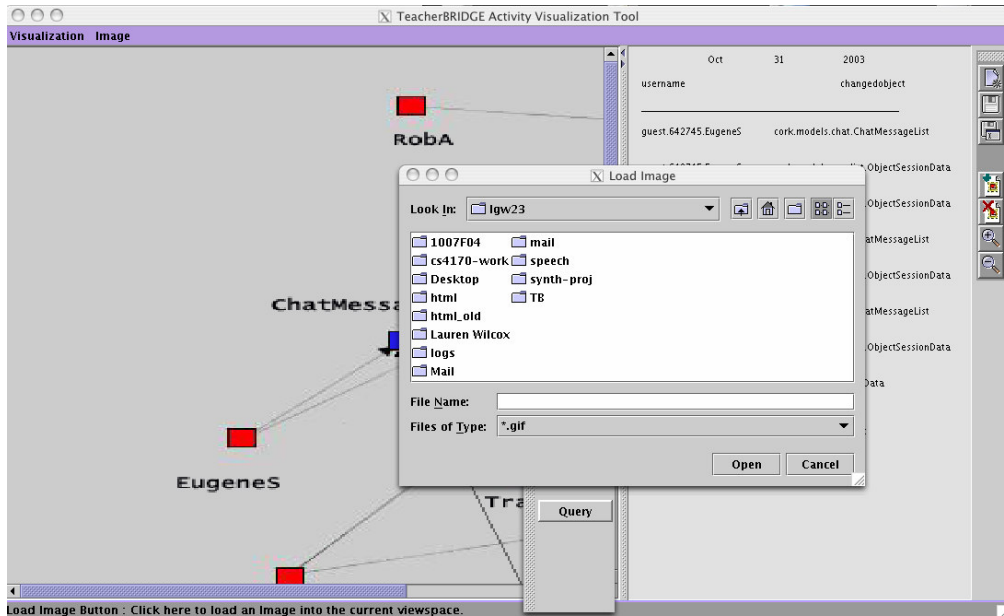
GUI Figure 5: Saved images can be loaded into the viewing space to provide additional history for users, addressing the history visualization task.


Any loaded image can be deleted to clear the view space.

Zooming: the Teacher BRIDGE Activity Visualization Tool supports narrowing a focus to a specific range of the display with respect to images of history loaded in the viewing space. Future work would implement a semantic zoom function, where focusing in on particular work objects or contributors would be supported and new queries generated based on the new context provided by the zoomed perspective [Bederson, Hollan].
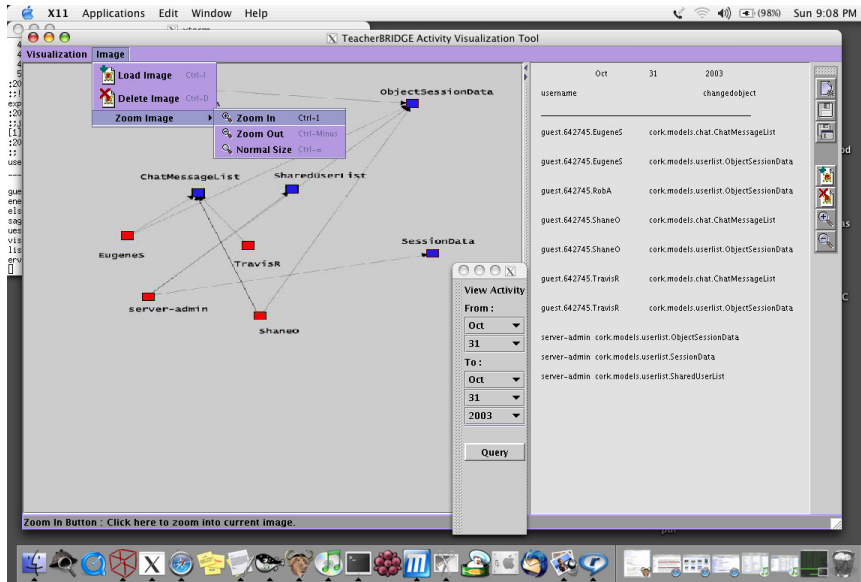
Before zoom
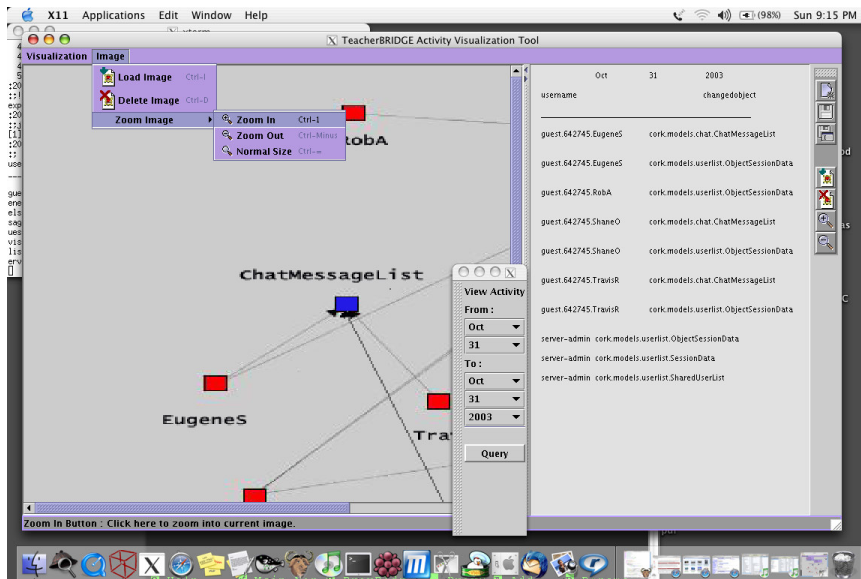
After zoom

6.Evaluation / Future Work

The Teacher BRIDGE Activity Visualization tool is evaluated in this paper with respect to the ways in which it addresses the aforementioned data type by task taxonomy and it's compliance with the design document (ways in which is does not comply point to future work on the tool). Future evaluation would make use of formal expert-based evaluation methods including heuristic evaluation, consistency inspections, and multi-user cognitive walkthroughs.

1. Improved interaction style: the Teacher BRIDGE Activity Visualization Tool interaction style is currently based on menu selection. I chose this interaction style for the initial prototype to support short learning time, reduced number of keystrokes needed, structured decision making, and minimization of input errors [Schneiderman, B., Plaisant, C.]. Some clear disadvantages of the menu driven application include interface clutter, and a need for a high refresh rate [Schneiderman, B., Plaisant, C.]. Future work on the Teacher BRIDGE Activity Visualization Tool includes implementation of direct manipulation objects as described in the prototyping/design section that allow for exploitation of dimensional space to exhibit and navigate through the realm of time, progress of an object, and user participation with respect to the Teacher BRIDGE tool.

2. Dynamic query support: the Teacher BRIDGE Activity Visualization Tool might benefit users by offering prompt feedback about user changes to objects out of their current foreground in Teacher BRIDGE [Schneiderman, B. Plaisant, C.].

3. Implementation of semantic zooming (as described in previous sections)

4. Implementation of multiple query menus and flexible widgets that allow the user to make complex queries though the interface while minimizing error: while complex queries are currently supported in the log database, these queries cannot currently be performed without entering long lines of text into the system. A future interface might account for this by offering the user example visualizations of queries to choose from (e.g. a graph of user activity over a certain period of time

versus a social network at a particular time) and allowing the user to choose the query structure according to these visual cues. Based on that structure, the system would prompt the user for the needed field to perform the query (e.g. if time duration is in question, the user would be prompted for a starting time or date and ending time or date).

5. Improved temporal-spatial visual mappings: currently the graphs are drawn without respect to the temporal information retrieved by the query. As the prototype section describes, "timeline" approach would be a necessary consideration as a backdrop to improved interaction techniques that are based on exploitation of dimensions of time or work progress.

6. Improved visualization comparison methods: currently the Teacher BRIDGE Activity Visualization Tool only supports comparing visualizations through manual comparison of saved images. Future menu options would allow for multiple image panes and query result panes to support comparison of differently categorized activity visualizations.

7. Integration of data-mining techniques for exploration of system recognized patterns: future work might explore the integration of statistical and machine-learning based approaches to generate automated queries and render the results to the user of the system [Schneiderman, B. Plaisant, C.]

8. Implementation of a web-based version of the visualization tool: this would accommodate the actual online system more than a stand-alone application. Since the database queries are performed over TCP/IP, a web-based application would be conducive to ease of use of the system. Drawbacks of a web-based approach include a shift to a browser for GUI support, which introduces navigation issues, latency issues due to the primarily thin-client web model, and browser compatibility considerations.

6. Acknowledgements

7. References

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