SILVERVIZ: Extending SILVER for coordination in distributed collaborative modeling

Yudi Xue, Nathaniel Osgood and Carl Gutwin
Department of Computer Science, University of Saskatchewan
{*yudi.xue@usask.ca, osgood@cs.usask.ca, gutwin@cs.usask.ca*}

0. ABSTRACT
System Dynamics modeling projects commonly involve distributed team collaboration. Remote Collaboration can impose substantial burden of extra work for team project coordination, and research suggest that the difficulties of distance coordination have been a major contributing factor in shaping the success or failure of teams in some domains. (Gary M. Olson and Judith S. Olson. 2000). It is currently difficult for modelers to keep track of what changes fellow collaborators have made as a modeling project evolves. While proper information technology support is known to lessen the difficulties of remote collaborations, there is limited software support available for collaboration across System Dynamics modeling projects. The use of general technology such as email systems and wikis can lead to much needless effort to establish common understanding regarding the current status of work and in communicating recent changes. This paper describes the design of an extension to the open source SILVER system that provides a visual workspace that reduces such effort by keeping modelers notified on fellow modelers' past activities and changes within modeling project, and to identify commonalities shared by multiple elements of a model.

1. INTRODUCTION
System Dynamics modeling projects frequently involve the collaboration of a medium- or large- group of interdisciplinary stakeholders. Specific phases of modeling -- such as model conceptualization, formulation, testing, calibration and policy exploration -- often require ongoing cooperation and coordination between teams of modelers and other stakeholders. In this paper, we term such such processes "collaborative modeling".

Often, collaborative modeling is project-based and is spatially distributed, with collaborators being located remotely from one another. In the context of such a remote context, modelers and stakeholders' workspace may be located as close as in different offices or floors of the same building, or scattered in different locations across the globe.

During modeling, modelers manually bookkeep consecutive changes to models, document supporting assumptions in scenarios for simulation, and establish logically interconnected sets of scenarios motivated by a similar purpose (e.g. investigation of the sensitivity of the model to exogenous shocks, study of intervention trade-offs). The information and artifacts associated with such interlinked structures are commonly either not shared, or are shared with collaborators through emails and downloads from websites or wikis. To coordinate the model construction process, it is common for a modeler to need to meet frequently in person with fellow modelers or other stakeholders to adapt changes and to discuss shared contributions and documentation. Even when close inter-modeler communication are facilitated by shared virtual spaces such as websites or wikis, a modeler may make several changes to a shared model before a remotely located fellow modeler looks up for updates and seeks to understand them. In this situation, high-efficiency modeling collaboration is difficult to maintain without collaborators being collocated or frequently traveling to meet.

Past computer science research has highlighted the importance of awareness information during collaboration and sought to understand and support remote scientific collaboration (Olson et al. 2008). Partly motivated by such considerations, we designed and implemented the software system SILVER. SILVER (Osgood 2009) supports collaborative modeling by providing storage mechanisms for individual model version control and for scenario bookkeeping. Such mechanisms can be used as a version of a "lab notebook" for modelers to record changes and refinements to models in greater detail, and to maintain the integrity of the (traditionally implicit) links between multiple modeling artifacts. The first version of SILVER addressed a focused set of collaborative modeling problems that receive little or no support from current modeling software. However, the initial incarnation of SILVER provided limited support for coordinating *distributed* modeling collaboration.

Our proposed solution to this shortcoming is to extend SILVER and to add a modeling workspace that supports workspace awareness in asynchronous collaborative modeling. In particular, we seek to address several problems during distributed modeling coordination:

- Modelers are unaware of recent collaborators' activities
- Modelers are unaware of the recent current state of the project
- Tightly coupled model construction tasks are hard to carry out remotely

Such problems were identified as collaboration awareness problems in the areas of Human Computer Interaction (HCI) and Computer Supported Collaborative Workspaces (CSCW).

Our main contribution in this work are: Identification of user requirements for maintaining workspace awareness for remote collaborative modeling, improvements in the specification and construction of a visual workspace that supports modeling collaboration, and the evaluation of the effectiveness of our system in different collaboration scenarios.

Within this paper, we first introduce terminology and provide background information on SILVER. The paper then discusses the design of the visual workspace in a SILVER extension (termed SILVERVIZ), and a describe how the SILVERVIZ design supports a number of important extensions and refinements to SILVER's user interface. Subsequent sections discuss the collaborative use within the SILVERVIZ design, and the state of the system implementation. We conclude with some remarks on limitations and directions for future work.

2. BACKGROUND

Terminological Conventions

In SILVER, (Osgood 2009) proposed terminology used to describe aspects of the System Dynamics modeling process. This terminology described associated versions of models, assumptions, collections of conceptually related but alternative assumptions, and external documentation related to a modeling project. It also provided a guideline for implementation of SILVER. In SILVER, the location that stores all modeling projects and their associated information is defined as a repository. The repository is displayed in a tree-view browser. Each model project in the view is the root of an independent tree structure.

Previous contributions

SILVER lacked support for collaborative modeling in two broad ways. Firstly, the depiction of the repository lacked visual elements to show where the modeling project is located. As a result, users could not effectively distinguish between projects that are stored locally on a user's computer from projects that are stored remotely on a web server. When a user started to work on a project that existed in multiple repositories, it was difficult to locate the correct model project with which to work.

Secondly, user activity was not logged in the workspace, and information on that activity was not available for feedback to the user. In a remote SILVER repository, a user has access to all available model projects and is acknowledged as the author of the project and associated sub-components. However, while SILVER supports editing activities such as updating project names, duplicating scenarios or removing model versions, information on the occurrence of such activities is not recorded or maintained in SILVER. While it is important for a modeler to know what has been changed since the last time they worked within the system, the modeler also needs to know where the changes are located, and who performed those changes.

Awareness

When working in a group collaboration environment, it is important to be aware of what others in the group are doing. In many modeling tasks, such awareness is important to the success of that task because it provides an individual with the necessary context on which to base a modeler's action. (Dourish and Bellotti 1992) have defined *group awareness* as an understanding of the activities of others, which provides a context for your own activity. Such context ensures that individual contributions are aligned with group goals and are coordinated to group activity as a whole. The information also allows a group to manage the collaborative work process.

The challenge of maintaining awareness information in group collaboration has been a topic of research area in the field of CSCW. An overview of the awareness concept is found in (Gutwin and Greenberg 2008), which discusses a conceptual framework for groupware awareness and provides guidance for designing workspace awareness support in SILVERVIZ. General workspace awareness provides information to help the user find collaborative information during interaction between the user and the workspace. Such information reflects both present state and historical information. In our paper, we focus on supporting workspace awareness for asynchronous collaborative modeling -- cases in which the work performed by a different parties are loosely coupled, and can proceed without awaiting each others' work. The elements of workspace awareness related to modeling often describe the past state of a workspace. It provides historical information regarding that history, including 'who', 'what', 'where', 'when' and 'how' changes were made. These categories of awareness for the past focus on particular elements of interaction and are shown in Table 1:

Table 1: Elements of workspace awareness relating to the past

Category	**Element**	**Specific questions**
How	Action history	How did that change happen?
	Artifact history	How did this model version come to be in this state?
When	Event history	When did that change to the model happen?
Who (past)	Presence history	Who was working in this project, and when?
Where (past)	Location history	Where has a person been?
What (past)	Action history	What has this person been doing?

In our framing, the elements of workspace awareness of the past describe the history of an associated repository, which includes the history of a set of modeling projects. The workspace awareness is then bounded by the associated repository. In particular, workspace awareness information will be different between local and remote associated repositories.

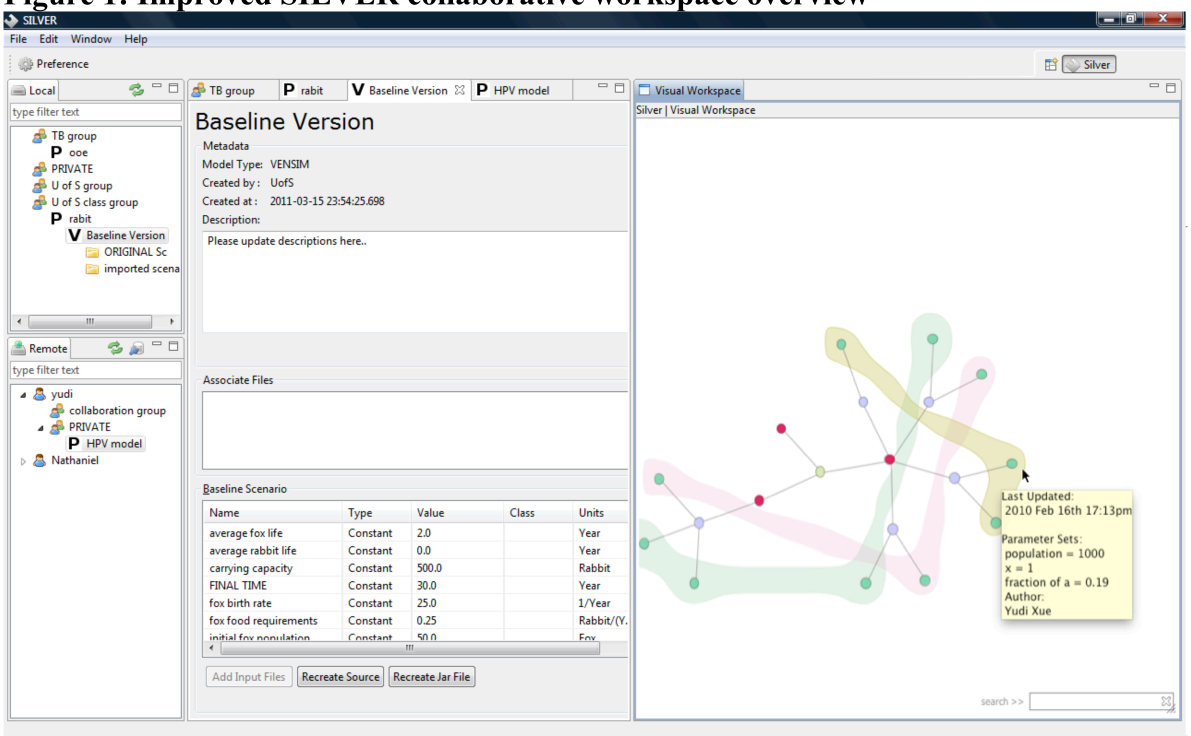
Within an associated repository, the workspace awareness elements for 'who', 'what' and 'where' are related to activities of a particular modeler in that workspace. The 'when' element is the event history, which describes when a change in the workspace occurred. The 'how' element is either an action history or an artifact history, which describes one or a series of change actions performed in the past and through what series of states an artifact came to take on its current state.

SILVER's current workspace tracks partial elements of workspace awareness information such as showing the current participating modelers in the remote model repository. Our approach to providing workspace awareness in SILVERVIZ has proceeded by improving user interface interaction and by adding collaboration support to the associated repository in SILVER's workspace.

COLLABORATIVE WORKSPACE

Based on SILVER's original workspace, we followed Gutwin's framework with respect to workspace awareness to integrate a collaborative workspace that aids modelers in finding useful information in an asynchronous collaborative modeling context. An overview of the design SILVERVIZ's interface (which integrates the existing SILVER user interface with the new collaborative workspace) is shown in Figure 1 below:

Figure 1: Improved SILVER collaborative workspace overview



Separated by its vertical boundaries, the screenshot has three separate display panels. The panel to the left contains model browser views, which include data from different associated repositories, with local repositories located on the top and remote repositories on the bottom. The views display associated repositories in a tree-view structure, which allows user to browse the repository according to the hierarchy.

Next to the model browser panel, the middle panel contains detailed editor views for a particular repository element. Multiple editors are allowed to display information related to different elements, with those editors being arranged and accessed by tabs. When the user chooses to open an element from the model browser, SILVERVIZ will open an editor associated with the element under a new tab. Until the point where the user closes the tab, the user can browse back to a tab by the name of the represented element.

The panel that contains a diagram amidst white space to the right is a visual workspace. The visual workspace includes an interactive, reconfigurable visual representation of a model project accompanied by a set of colored visual embodiments denoting shared characteristics between entities. The interaction techniques and diversely colored visual embodiments associated with this visual workspace will be discussed in a later section.

In short, our work in building a collaborative workspace for SILVERVIZ consists primarily of two contributions. First, we extended the terminologies used to help standardize the modeling work flow in SILVERVIZ by introducing the 'user' and 'group' elements to current associated repository. Second, we designed and implemented the visual workspace to help display workspace awareness information.

Improvements in Associated Repository

The SILVER implementation in current use supports a 'Model Project' at the top of its hierarchy. In an addition with diverse ramifications, the SILVERVIZ design described here added a 'User' category at the top level of the repository hierarchy. We added it because SILVER previously lacked user information, which is important to identify a user so as to support attribution of activities, information ownership and changes. The new 'User' construct in SILVERVIZ retains all basic information necessary for identification. Such information includes the user's name, email, password and description.

Distinct repositories within SILVER can be used to support different sets of users. In extent versions of SILVER, all users are considered to share all resources within the same model repository. To support user specification of desired privacy levels for projects within a given SILVERVIZ repository, we also added the concept of a group in the (top-level) 'User' classification. Specifically, under 'User', we added a 'Group' classification that includes one or more model projects. The user that creates a group beneath their 'User' tag may designate whether all work within the group is 'private' or 'public'. The owner of a 'private' group has access to all work within the group, but that work is hidden from fellow modelers that share the same associated repository. The concept of a group is not intended to enforce information security within a collaborative workspace so much as to offer a convenient mechanism to organize information that is not of broader concern to the group. By contrast, all work within a 'public' group can be edited by other users collaborating within the same associated repository.

In a further change to SILVER, SILVERVIZ has introduced 'changesets' to log user activities. Specifically, when an editing action has occurred (e.g. the description of a project is changed, a new scenario is added, the name of a model version is modified, or a document is associated with an existing model version), the changeset records the character of the change, the user who performed the change and the time at which change occurred. The SILVERVIZ design supports browsing of the information stored within the changeset by using an interactive search field included in the visual workspace.

The SILVERVIZ design adds Tagging to SILVER to help facilitate user communication. We use tags to indicate data sharing identical characteristics -- for example, scenarios that use identical parameter sets, and model versions that were created by the same modeler. Tags on top of the associated repository can provide useful categorical information related to particular sets of entities.

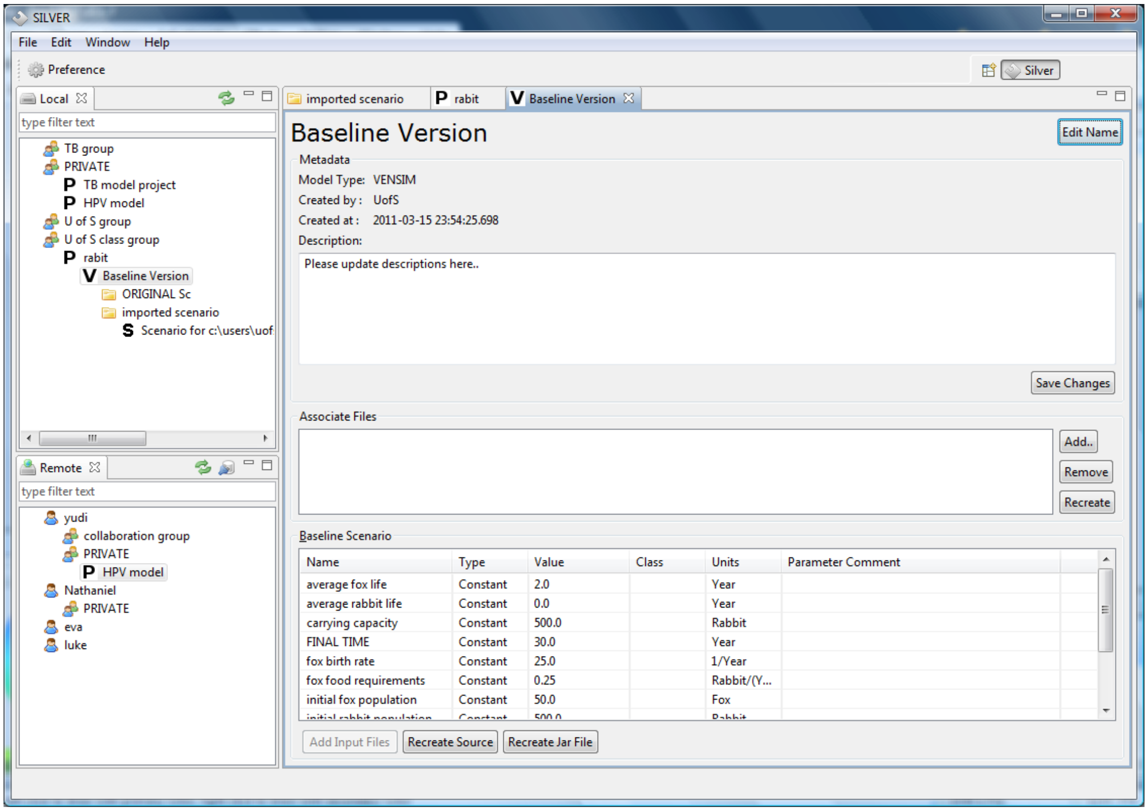
Information captured by tags and in changesets generally represents descriptive data which exists in a different dimension. It is challenging to represent such information on top of the original visual representations of modeling project elements. In our collaborative workspace, we chose to represent such information by particular visual embodiments in the visual workspace. Such embodiments are discussed in the following section.

User Interface Improvements

The SILVERVIZ design introduces two categories of enhancements to the SILVER user interface. The first category relates to improvements we added to the model repository browser. In particular, while the original design displayed local and remote repositories in the same model browser view, we decided to visually separate such repositories. The original model browser view now displays the local associated repository which is located on the user's computer. We added a further additional remote repository model browser, located beneath the local repository model browser. The remote repository browser will connect to a remote database that stores a valid model repository. Figure 2 shows a screenshot of the browsers (but with the visual workspace hidden).

The second category of enhancements introduced by the SILVERVIZ design involves the integration of an interactive visual workspace. Specifically, the visual workspace contains an interactive visualization which represents a selected modeling project from the repository within the model browser. The visual workspace allows us to display additional information that is poorly communicated through the user interface widgets in SILVER. We will describe how it supports workspace awareness in later sections.

Figure 2: Details of model browsers with the visual workspace hidden



Remote Repository Browser

As depicted in Figure 2, the remote repository browser is connected to a remote database server and displays work by all users in a hierarchical tree view. It starts at the level of a user and follows the convention of the local repository browser in displaying all containing available work in a hierarchical "tree view" structure in a visual representation. The user may double-click on any elements within the remote model repository to display detailed information in the editor view to the right.

The user may also specify an alternative database connection by which to re-connect to a different remote model repository.

Visual Workspace

The Visual Workspace in SILVERVIZ combines information related to user activity with the visual representation of selected modeling projects in a model repository. Our goal in designing the visual workspace was to build a visualization system that supports the exploration of a model project and its sub-components during modeling. This involves designing a different visual representation of the modeling project in the associated repository, additional visual embodiments, and control widgets.

Design and Motivation

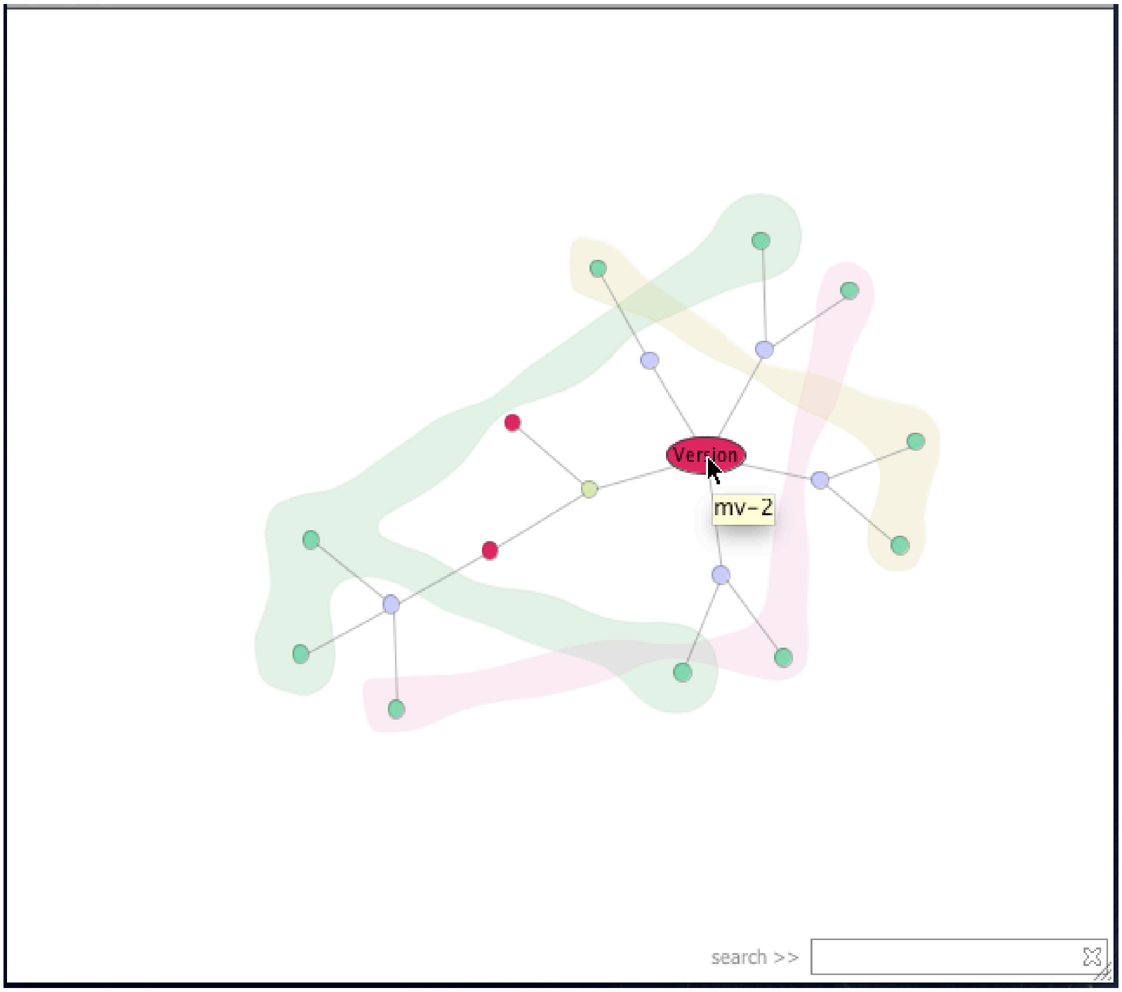
During interviews with modelers, we learned that imagery aids a user in familiarizing themselves with the resources associated with a model and with the model itself. We also learned that the activity of exploring and collecting information from an established or a work-in-progress model demands much effort from modelers.

Our goal in designing the visual workspace is to deliver a concise and memorable presentation of an existing modeling project. To support the workspace awareness information, we need to allow a user to access representations of action history, presence history, event history and artifact history by interacting with the model browser, the editor pane and the visual workspace as a whole.

Among the awareness support requirements, the artifact history is already shown in the recording of model versions and scenarios in an associated repository. The user presence information at a given point in time can be found in the remote model browser. In the visual workspace, we chose to display event history and user activity information through visual embodiments and use of search fields.

Layout

Figure 3: The name for an entity remains hidden in the workspace until a mouse is hovering over it



As shown in Figure 3, the visual workspace in SILVERVIZ represents a modeling project using a familiar graph representation, where nodes represent sub-components of the project and links represent associations between those sub-components. In this rendering of the space, network members are presented using both their names and a color indicating the type of member involved.

Based on the described node-link representation, we make use of the network layout implemented in the Prefuse toolkit (Heer et al. 2005) to maintain the relative display location between each nodes. The network layout is computed using a spring-embedding (force-directed) algorithm, in which the nodes repel each other and edges act as springs.

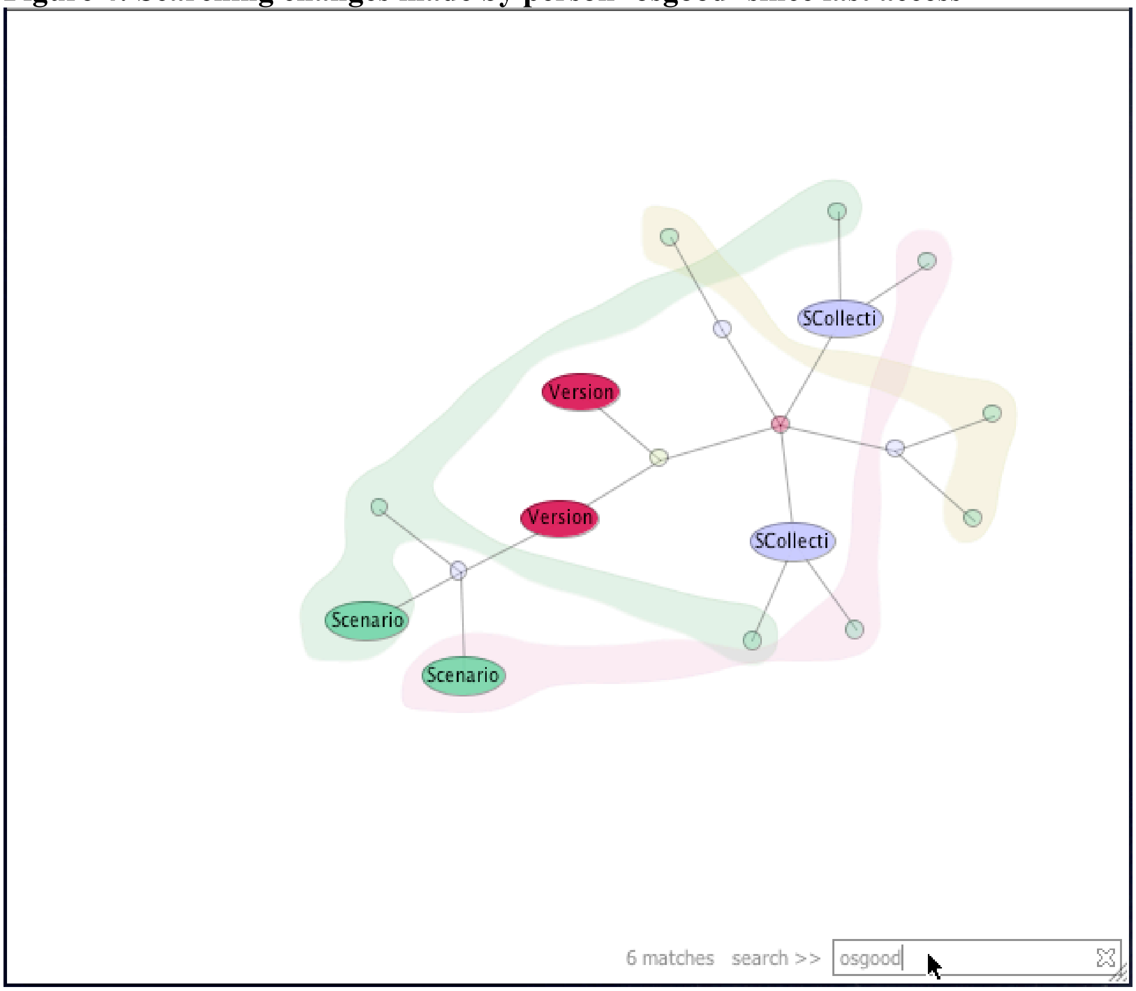
The network layout of the representation is computed in real time. When a node has been moved by a modeler, the displacement of the node will exert a force on its neighbouring nodes. The edges in the network will react to the deflection and trigger (dissipative) readjustment until the system re-establishes a static equilibrium. Such simulated movement is aesthetically enjoyable, and offers a familiar "feel" because of its similarity to the movement of mechanical systems. This approach, grants modelers the freedom to move the structure into a convenient, memorable, and aesthetically pleasing configuration.

Displaying changeset information

In the SILVERVIZ workspace, a 'changeset' is an important piece of awareness information used to notify modelers of changes in a selected modeling project since the most recent point at which the user accessed the project.

Shown in figure 4, the design allows a user to browse for user activity by interactively searching through a search field at bottom of the window. As the user types the name of the modeler whose activity is sought within the modeling project, all nodes that were updated by that modeler since their last access to the project will be highlighted.

Figure 4: Searching changes made by person 'osgood' since last access



Displaying tagging information

Tagging is a useful technique to associate information or categorical data with nodes across types. Within the design of SILVERVIZ, we have adopted the idea of BubbleSet

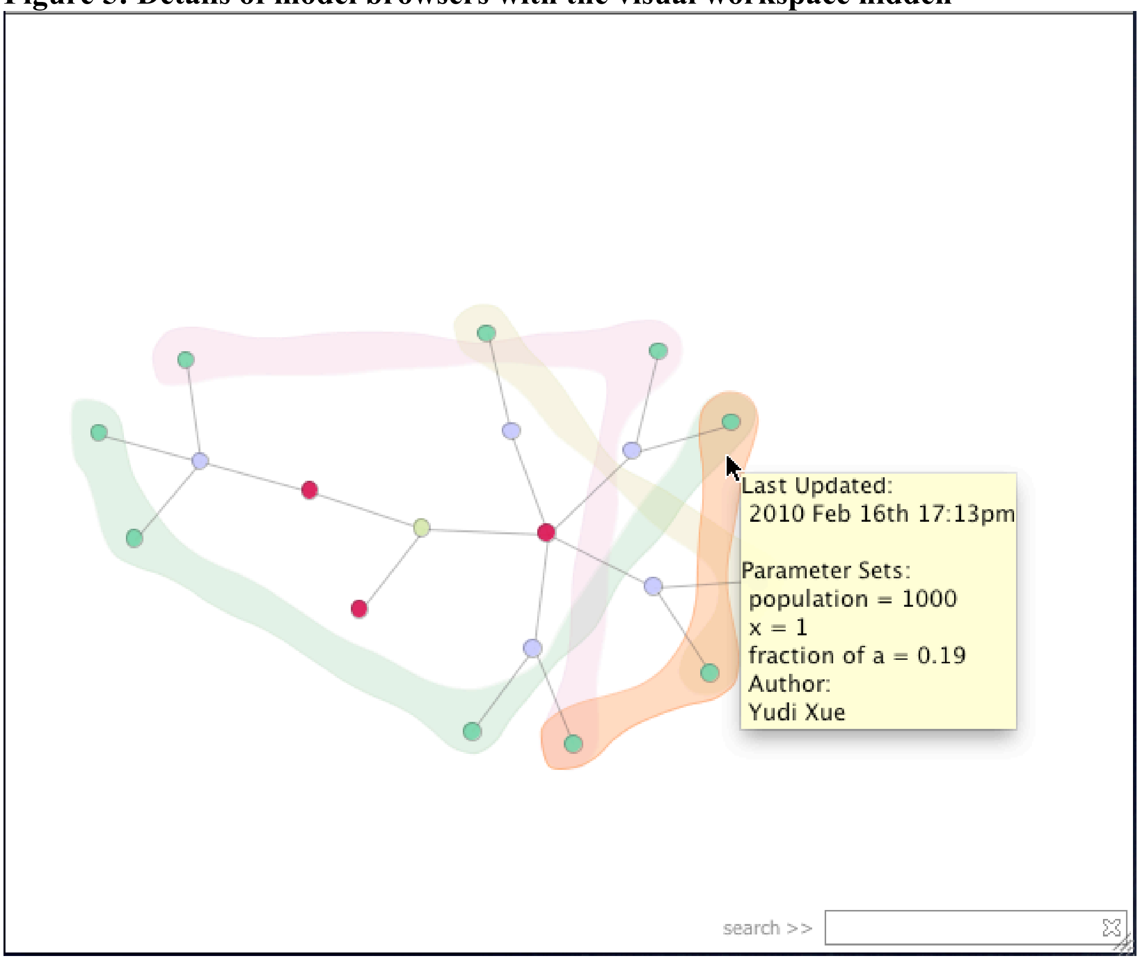
(Collins et al. 2009) of displaying nodes that are grouped by categorical data.

BubbleSet is a visualization algorithm used to help group set based data by drawing a convex hull surrounding particular points. In the context of a dynamic environment, this hull is constantly updated to avoid overlapping blocking nodes that do not belong to the set of interest. For example, in Figure 4, the "green tags" successfully detoured around an intruding node that is likely to be included by a naive convex hull connecting the associated points.

By nature of storage, there are two types of tags associated with a modeling project. While the initially displayed tags are 'permanent' in the database, we also allow modelers to create 'temporary' tags and add a node by selecting it from the visual workspace while pressing the 'Ctrl' key on keyboard. To remove a node that is already included in the tag, the user may select it again while pressing the 'Ctrl' key on keyboard.

As shown in figure 5, a newly created tag is always assigned with the same color ('orange') before a user chooses to save it to the repository and to share it with the remainder of the collaborators.

Figure 5: Details of model browsers with the visual workspace hidden



COLLABORATIVE USE

From the previous section we explained how to access workspace awareness information by using the remote model browser and the visual workspace. All components work as a whole to provide workspace awareness support in SILVERVIZ.

At the moment, we are able to show limited event history and action history associated with a person using changeset information from the visual workspace. A user may start to examine user activities and associated changes within a modeling project by opening up both detailed information in the editor pane and a visual representation in the visual workspace. The user also may notice changes indicated by the structure of the representation and examine related changes undertaken by particular collaborators. If the user has any comments to offer that cut across multiple artifacts in the workspace, the user may choose to create a tag which groups related items and communicate the idea with the rest of collaborators. For example, the user might group scenarios -- spanning multiple model versions -- that exhibit a surprising and counter-intuitive behavior. An alternative tag whose support we anticipate building into the software might group together scenarios across multiple versions of the model that share an identical mapping of parameters to values. Finally two additional tags might highlight model versions that have been publically released to a client, or scenario collections that serve the same general theme (e.g. compare response to different types of intervention options).

SOFTWARE IMPLEMENTATION

This software used in implementing SILVERVIZ is a cross-platform desktop software under development at the Department of Computer Science at the University of Saskatchewan. The software follows component-based design principles (Aoyama 1998) and is implemented with Equinox OSGi (Equinox OSGi 2011) technology. In this software system, each component is a plug-in that contributes different mechanisms within the system and is supported by lower level plug-ins specified via dependencies.

The collaborative workspace is built as a plug-in on top of SILVER, along with a few improvements within the implementation of original SILVER software. The visual workspace of SILVERVIZ is prototyped for early feedback from our modeling group. It is currently being built and anticipated to be integrated into SILVER in summer, 2011. The current beta-release of SILVER (without the visual workspace support) is under evaluation by modelers for its stability in managing associated model repository. The software development for this project is currently maintained as an open-source project housed at google code. (GoogleCode, 2011)

DISCUSSION AND FUTURE WORK

In this paper, we provided background literature in asynchronous collaboration and explored design requirements for supporting workspace awareness in SILVER. We presented a design solution for integrating a collaborative workspace into SILVER and explained how modeling collaboration awareness support user interaction within the proposed workspace.

Our early prototypes of the collaborative workspace attracting modellers' attentions were able to explore implicit relationships between assumptions across versions of models, as well as to maintain awareness of changes made by other collaborators. In the near future we will compare and evaluate how well the collaborative workspace in SILVERVIZ supports distributed collaborative modeling in the real world. Our results from evaluation will also aid in providing knowledge for designing future collaborative system in collaborative modeling. We hope that completing implementation of the design in a way that accomodates user feedback will help provide a tool that can broadly leverage group collaboration across System Dynamics modeling projects.

REFERENCES

Osgood, N. 2009. "SILVER: Software in Support of the System Dynamics Modeling Process". *Proceedings, The 27th International Conference of the System Dynamics Society*, July 2009, Albuquerque. 12pp.

Olson, J. S., Hofer, E., Bos, N., Zimmerman, A., Olson, G. M., Cooney, D., and Faniel, I. (2008). A theory of remote scientific collaboration. in G. M. Olson, A. Zimmerman, and N. Bos (Eds.) *Scientific Collaboration on the Internet.*Cambridge, MA: MIT Press.

Collins, C. , Penn, G., and Carpendale, S**.** 2009. Bubble Sets: Revealing Set Relations with Isocontours over Existing Visualizations. *IEEE Transactions on Visualization and Computer Graphics* 15, 6 (November 2009), 1009-1016

Olson, G. M.and Olson, J. S. 2000. Distance matters. *Hum.-Comput. Interact.* 15, 2 (September 2000), 139-178.

Aoyama, M. (1998). "New Age of Software Development: How Component-Based Software Engineering Changes the Way of Software Development." Department of Information and Electronics Engineering , Niigata Institute of Technology, 1719 Fujihashi, Kashiwazaki 945-11, Japan.

SILVER Project Website on GoogleCode. 2011. Retrieved March 21st, 2011, from http://code.google.com/p/uofs-silver-hg/

Heer, J., Card, S. K., and Landay, J. A. 2005. prefuse: a toolkit for interactive information visualization. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (CHI '05). ACM, New York, NY, USA, 421-430.

Gutwin, C., and Greenberg, S. (2001) A Descriptive Framework of Workspace Awareness for Real-Time Groupware. Computer Supported Cooperative Work, Kluwer Academic Press.

Dourish, P. and Bellotti, V. 1992. Awareness and coordination in shared workspaces. In*Proceedings of the 1992 ACM conference on Computer-supported cooperative work* (CSCW '92). ACM, New York, NY, USA, 107-114.

Equinox osgi project. 2011. Retrieved March 21st, 2011, from http://www.eclipse.org/equinox/