On Visualizing Negotiation Communication Networks

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Abstract

SCENS, the Secure Content Exchange Negotiation System, is an ongoing project in the Dartmouth Experimental Visualization Laboratory (DEVLAB) that aims to build a web-based platform for sharing sensitive data among distributed parties. In this paper, we describe the interface for SCENS that facilitates parties to conduct their negotiations through our system. We will also introduce our visualization functionalities to track and analyze *Negotiation Communication Network (NCN)* between negotiation parties in SCENS. And finally I will demo our visualizations based on sample records of negotiation transactions among students in DEVLAB.

Keywords: NCN (negotiation communication network), Negotiation, Visualization, SNA (Social Network Analysis)

1. Introduction

Data sharing of sensitive or highly valuable informational resources requires new models of negotiation to promote communication with built-in incentives, secure authentication, and new metrics of evaluation.

Negotiations can be characterized by a set of common properties:

- There are two or more parties and a conflict of interest among these parties.
- The conflict can be resolved by an agreement, which is accepted by all parties.

- There is a mutual dependency between the parties, one needs the other and vice versa.
- The parties communicate because they want a better agreement instead of simply accepting what the other side will voluntarily give them.

This definition clarifies that a negotiation is a communication process, and that this process can be distinguished from a decision process, where no communication might occur.

The Secure Content Exchange Negotiation System (SCENS) [1] has as goal facilitating on-line negotiations among distributed parties or organizations. The basic interface in SCENS is a traditional web-based platform, which allows human beings to interact with the system in order to conduct negotiations and get feedback on negotiation activities.

Having tools to visualize and analyze inter-party negotiation logs is very important in providing us the knowledge on
1) discovering the collaborative relationships between these parties, especially the way it evolves over time in order to promote healthy resource sharing for SCENS;
2) identifing the most active resource contributors or requestors in order to giving right recommendations for new parties;
3) finding out the popularity of specific resource in order to predict the marketing potential for it;

In this paper we will address the above three points and we will propose some key components we have in SCENS to solve these problems.

2. Related Work

Several Web-based negotiation support systems are in use. WebNS[2] is a prototype Web-based system designed to facilitate remote negotiations on the Internet. SmartSettle [3] attempts to find quantitative and qualitative preferences for all parties, and uses a

central server to arrive at agreements without exposing confidential data. INSPIRE[4] and INSS[5] are Web-based systems containing facilities for specification and assessment of preferences, a messaging system, a scoring function to aid in the construction of offers, graphical displays of the negotiation progress, and a facility for constructing compromises. Most existing negotiation systems do not focus on security and privacy concerns, which make them inappropriate in a security-sensitive environment. Since they are designed primarily for use in online markets, they also lack efficient support for representing the exchange of complex information, such as sharing of scientific data, tools and services, and neither of them offers the visualizations for tracking negotiation communication networks.

Data sharing of sensitive or highly valuable informational resources requires new models of negotiation to promote communication with built-in incentives, secure authentication, and new metrics of evaluation. SCENS's goal is to facilitate electronic negotiations among distributed parties or organizations. The basic interface in SCENS is a traditional web-based platform, which allows human beings to interact with the system in order to conduct negotiations and get feedback on negotiation activities. SCENS also provides negotiation web services to support semi-automated and fully automated negotiation. This paper will focus on web-based SCENS.

In order to analyze communications of negotiations conducted through SCENS, we have derived some basic knowledge from *Social Network Analysis (SNA)*[6]. SNA studies and measures the relationships and flows between people, groups, and organizations. Here we treat inter-party negotiations as social ties from resource providers to resource requestors and they will form a collaboration network for resource sharing. Hence, SNA research results can help us analyze and monitor the communication pattern in online negotiation activities.

3. Design and Implementation of SCENS Online

In our web-based negotiation system[1], we have designed most important components for an end user to conduct negotiations with others. And the system also enables administrators to track negotiation activities going through SCENS. Figure 1 introduces the architecture of our SCENS system[7]. It is also sitemap showing the components a user will meet when he uses our system. Each component is denoted as a rectangle with name inside it and the arrows show the relationship between them.

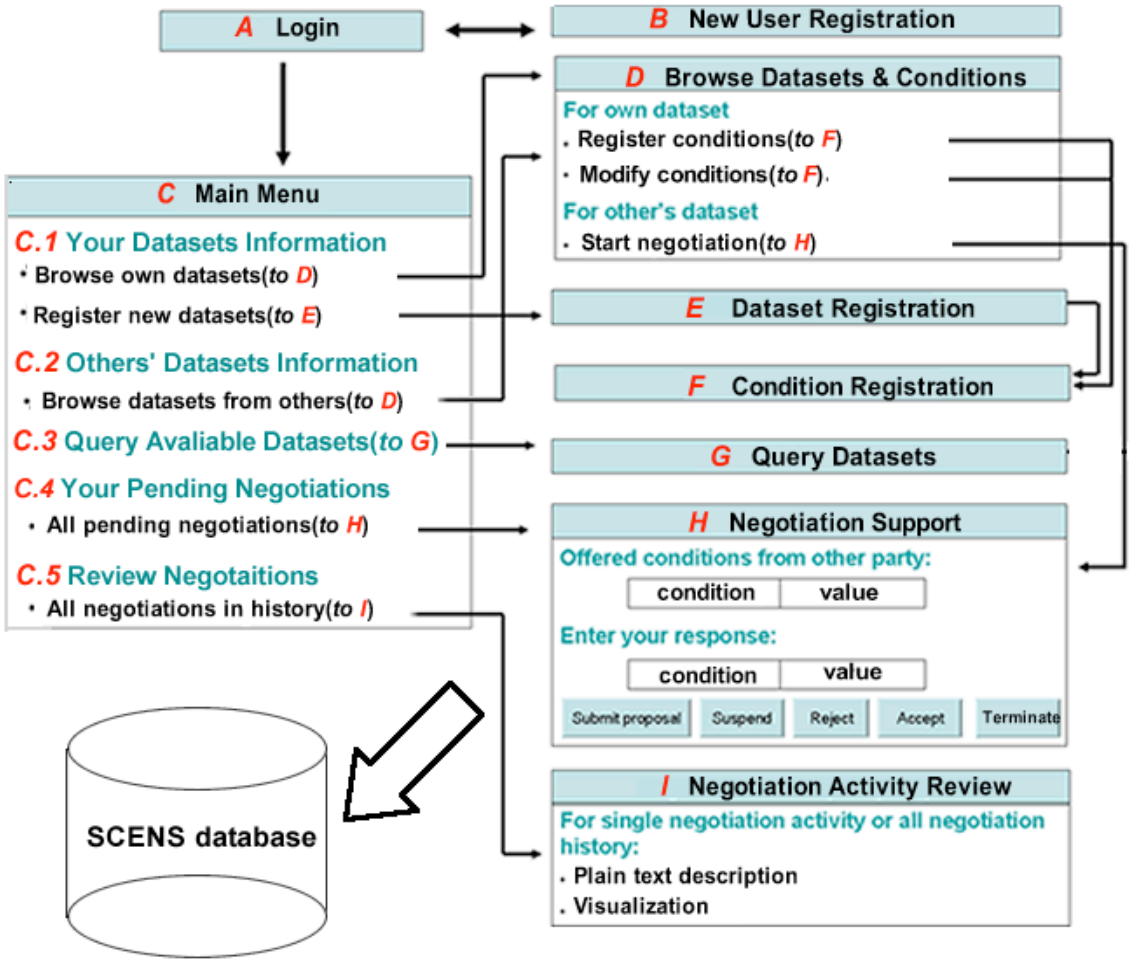

Figure 1 SCENS online architecture. It is a web-based system with key components (marked as *A*, *B*, *C*, to *I* in order) and working with a central database. The arrows show

[1] URL of online SCENS is http://scens.cs.dartmouth.edu:8080/SCENS/login.jsp or https://scens.cs.dartmouth.edu:8443/SCENS/ (you need a browser that supports 128-bit encryption to use this secure connection)

the relationship between these components. Database records information of users, datasets and negotiations.

These components are,

- User Login (component *A*), where the user can login SCENS with valid user name and password;

- New User Registration (component *B*), where the user registers his personal information to SCENS in order to be authorized as a valid user;

- Main Menu (component *C*), which is the main interface in SCENS. It directs the user to different components for different task purpose;

- Browse Datasets & Conditions (component *D*) lists all the datasets the user is interested (they could be the results from Dataset Query, or complete list of datasets belong to others, or list of his own datasets). And it also shows the negotiation conditions of these datasets registered by their owner. From here, the user could start negotiation on the dataset he chosen;

- Dataset Registration (component *E*), where the user registers his dataset for sell through SCENS;

- Negotiation Conditions Registration (component *F*) is used to register conditions (such as price, usage time, etc.) for a dataset by the owner. This are the conditions that this owner willing to archive through negotiation;

- Dataset Query (component *G*) supports user to flexibly set search conditions to find out datasets he fells interested;

- Negotiation Support (component *H*) allows two parties[2] to propose the offers or

[2] Currently, we only support two parties negotiating at the same time.

response to counterparties in order to process their negotiations. There are several options for a user to choose the way to continue a current negotiation he is involved. These options are “Submit proposal”, “Reject”, “Accept” and “Terminate”.

- “Submit proposal” enables a party to submit his proposal to the other party he is negotiating with.
- “Reject” enables a party to reject offer proposed by the other party, thus this negotiation is ended as a failure.
- “Accept” enables a party to accept offer proposed by the other party, thus this negotiation ends as a success.
- “Terminate” enables a party to terminate or give up a negotiation for any reasons. This will causes negotiation end by the reason of “termination”.

- Negotiation Activity Visualization (component *I*) offers users the option to review the details of any his previous negotiation. The detailed information is described as text in a table (such as condition value in each round, etc.). And we also visualize the change of each condition separately by the means of plotting.

4 NCN Visualizations

In this section we introduce NCN visualization functionality in SCENS. The purpose of it is to uncover patterns of collaboration structure in the context of negotiations for data sharing and exchanging.

4.1 Methodology

We have derived some techniques from Social Network Analysis (SNA) research. There are two popular approaches in current SNA study: one is formal theory organized in mathematical terms (like adjacency matrix, network measures[8]), the other is graphical network visualization with nodes and edges[9]. Although graphs and matrices are equivalent in its functionality to represent communication networks, we choose graphs as main way to represent negotiation communication network for two reasons. First of all, it

allows the viewer to understand nodes and relationships between nodes more rapidly than examining the raw mathematical model. Second, visualization is more intuitive and easier for end users not from mathematics background.

To differentiate the resource owner and requestor in each negotiation transaction, we represent network in our visualizations as a *directed graph*. In such a graph, a node is a user of SCENS, and an edge is a negotiation communication from the dataset owner to the dataset requester and these nodes are layout by a specific layout algorithm.

We base our graph on the Fruchterman-Reingold graph drawing algorithm[10] for force-directed placement which has some attractive features. This method compares a graph to a mechanical collection of electrically charged rings (the vertices) and connecting springs (the edges). Every two vertices reject each other with a repulsive force, and adjacent vertices (connected by an edge) are pulled together by an attractive force. Over a number of iterations, the vertices are moved to a final place where the whole graph reaches into a balanced force status. This kind of layout algorithm generates a consistent graph with the relationships in that the distance between vertices in the graph is negatively proportional to the communication frequency between them (more communications between party A and B, much closer they are placed in the graph). And it will place the most active parties in the center of the graph. Based on these features, we can easily identify the most active providers or requesters since they have frequent negotiations with other parties. It can also help us find out the most popular dataset, since it attracts larger scale of parties and it will form a big cluster in the center of the graph.

4.2 Demo Visualizations

We have collected 11 sample negotiation transactions happened in the interval of day 2005-1-12 to day 2005-1-19 between users in DEVLAB [Table 1] and we use them to demonstrate how we visualize negotiation communication networks between these parties.

dataset	owner	requester	timestamp
0000000010	yurong	jford	1/12/2005 3:48:30 AM
0000000007	yan	fei_xiong	1/12/2005 6:01:02 AM
0000000009	shadows	clap	1/12/2005 7:11:48 AM
0000000005	bob	bobagain	1/12/2005 9:02:56 AM
0000000001	alice	bob	1/12/2005 11:03:56 AM
0000000007	yan	yesong	1/18/2005 2:33 PM
0000000008	yan	yesong	1/18/2005 4:13 PM
0000000001	alice	yan	1/18/2005 4:14 PM
0000000001	alice	zhifeng	1/18/2005 4:46 PM
0000000001	alice	haha	1/19/2005 1:29 PM
0000000001	alice	yan	1/19/2005 4:43 PM

Table 1 Sample negotiation communication data we use in visualization. There are 11 negotiations happened in the time interval from day 1/12/2005 to day 1/19/2005.

4.2.1 Static Visualization

The static visualization is a traditional visualization. It renders overall communications by the means of directed graph. Since Fruchterman-Reingold layout is used to place the nodes in the graph, we can gain a fundamental impression of the relationship between parties in SCENS at the first sight.

Figure 2 is the overall negotiation collaborative structure for these 11 negotiations. We can find 3 clusters from the graph and each of them are negotiating for different dataset. So, if a new user feels interested in the dataset belongs to party *yan*, we could recommend him to negotiate directly with *yan* or with *yesong and fei_xiong* instead, since *yesong* and *fei_xiong* were partners with *yan* before (they all requested dataset from *yan*). And especially *yesong*, since he has more frequent communications with *yan* (he is closer to *yan* than *fei_xiong* in the graph). This kind of information is very useful for the new user, since it may help user to achieve more chances of success or gain more benefit because he has other negotiation choices.

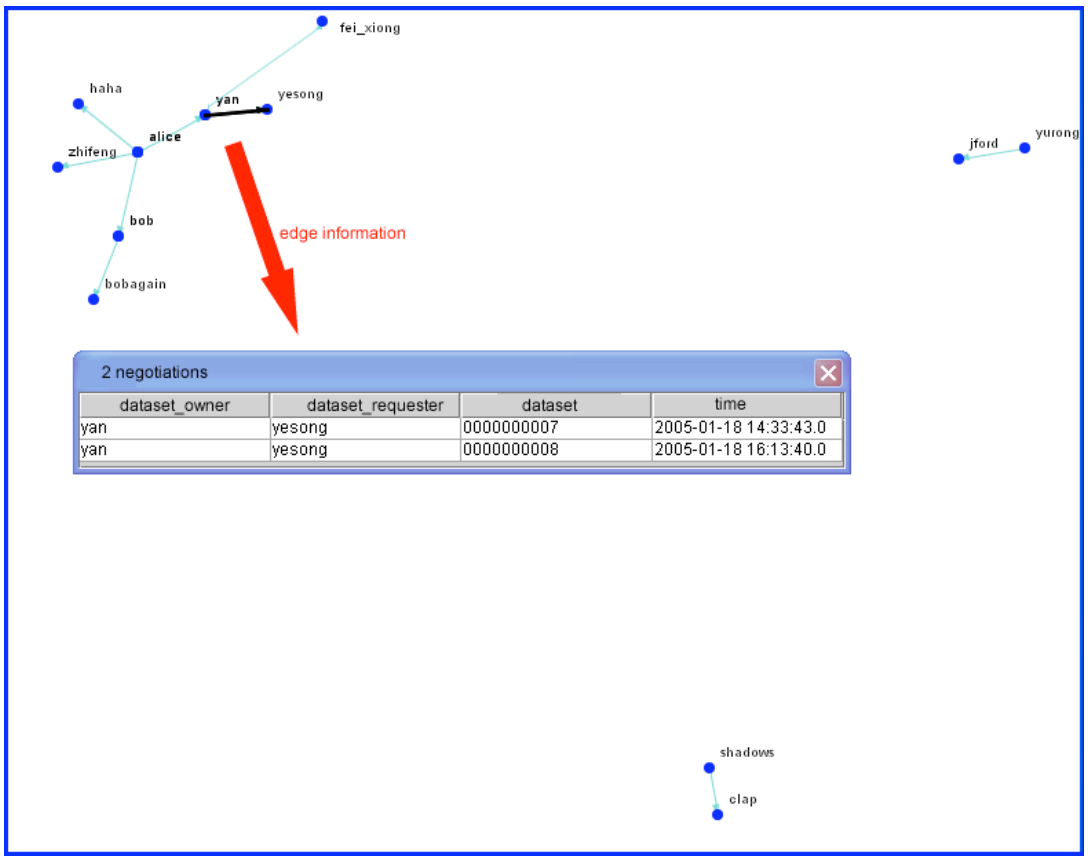

Figure 2 Visualization of overall negotiation collaborative network for 11 sample negotiation transactions between parties in DEVLAB. A small window shows negotiation information between selected parties. And there are 3 separate clusters. E.g. parties *jford* and *yurong* are only negotiating with each other.

4.2.2 Dynamic Visualization

Besides the overall structure visualization, we also generate time-based dynamic visualization to study the evolvement of negotiation collaborative network over time. This kind of dynamic visualization consists of an interactive movie showing the evolution over time of the communication network. Day is treated as the basic time unit in our visualization. A dragging time slider (each tick stands for one day in the time interval) is added to enable users to look at the network graph on the day where he puts the cursor down.

Figure 3 and Figure 4 are snapshots of collaboration structure among parties up to day

2005-1-17 and 2005-1-18 respectively (use 11 sample negotiation transactions between parties in DEVLAB in Figure 2 and Table 1). From these two pictures, we could identify a structural change up to day 2005-1-18, which is a formation of a denser cluster based on two separate clusters before day 2005-1-18. On Figure 3, there is no connection between parties *alice* and *yan*, they are isolated to each other, same as members in their own group. And *alice* is the owner of dataset 0000000001 and *yan* is the owner of datasets 0000000007 and 0000000008. Parties like *bob*, *bobagain* are requesters *alice*'s dataset and *fei_xiong* is the requester of *yan*'s dataset. But on Figure 4 because of a negotiation on dataset 0000000001 going between *alice* and *yan* (*yan* requested this dataset from *alice*) , these two clusters for different datasets became connected with each other and it became possible for parties in the same cluster as *yan* (e.g. *fei_xiong*) to have higher chances of success when he wants dataset 0000000001 since he is aware of the fact that he could negotiate with any party inside the whole cluster since all the them have requested dataset 0000000001 from *alice* before. And there are two new parties join in the negotiation group on that day, they are *yesong* and *zhifeng*. Thus we could predict that dataset 0000000001, 0000000007 and 0000000008 have higher market potential than other datasets.

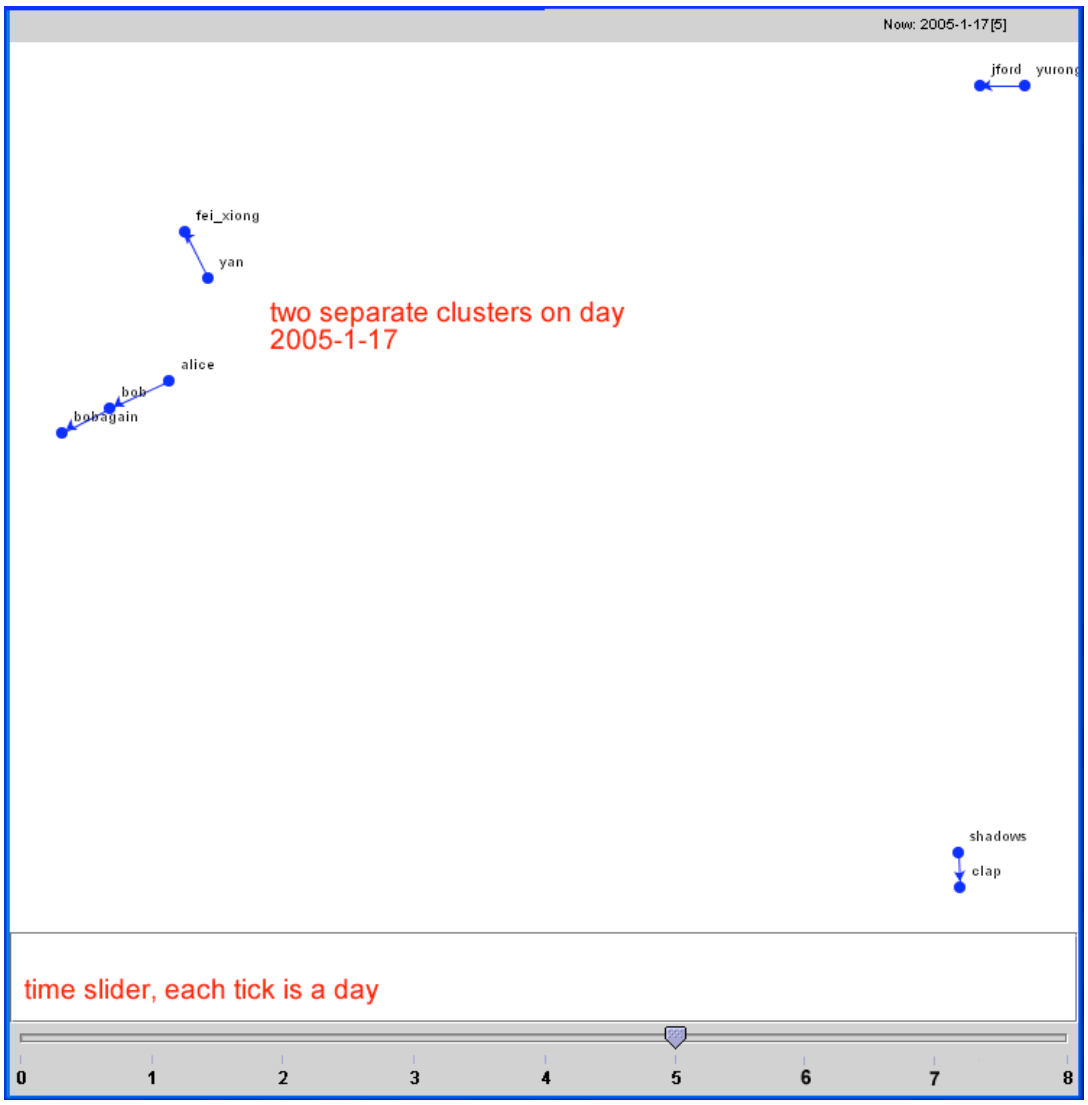

Figure 3 Visualization of negotiation collaborative network on day 2005-1-17. Nodes denote parties in the negotiation and edge denote dataset exchange from its owner to its requester. The structure is formed by all the negotiation activities up to day 2005-1-17. And there are 4 separate small scale clusters for different datasets isolated from each other.

Figure 4 Visualization of negotiation collaborative network on day 2005-1-18. Thanks to a negotiation between party alice and party yan (yan requested dataset from alice), these two clusters became connected with each other, thus to form a bigger cluster. And there appears more potential for parties inside this cluster to conduct negotiations with each other than before day 2005-1-18. And two new parties yesong and zhifeng joined in the negotiations on that day.

In conclusion, these kinds of NCN visualizations could help us to find some subtle collaborative patterns between negotiation parties, which are not evident in the raw data. And it can recommend negotiation counterparties for new users to achieve more changes of successful negotiations for a specific resource.

5 Conclusion and Future Work

Current implementation of web-based SCENS can efficiently support two party online and offline negotiations. It provides plenty of functionalities including dataset registration, interactive negotiation, and negotiation history review and visualization. Negotiation Communication Network visualization has significance in that they can be used to reveal obstacles in communications during negotiations, as well as to promote the collaborative structure in resource exchanges or collaboration.

However, to make SCENS a practical negotiation system that can be widely deployed, we are planning to continue the development of SCENS in the following directions:

We want to implement the negotiation web services, which enable negotiation agents to communicate with SCENS server through web services. We have implemented several negotiation related web services.

We want to support multiparty negotiation. Current SCENS supports only two party negotiations. To support multiparty negotiation, we will have to redesign the user interface and provide more negotiation functionalities to support both online and offline multiparty negotiations.

We want to support personalized negotiation services. For example, SCENS should allow users to define their dataset properties and negotiation conditions; users can create and/or choose their own user interface. Current SCENS online is implemented as a demonstration system and it does not provide enough flexibility to support personalized functionalities.

We need to find the way to help users to intuitively analyze their negotiation transactions through visualizing negotiation process. Thus, users can get experience from past negotiations, including both successful and failed ones, to revise their negotiation strategies and identify their negotiation partners in the future.

We are also going to advertise our system and attract more users.[3] The system could be used as a testbed for negotiation strategy study. Since SCENS is an open negotiation system, researchers can implement their own negotiation agents and improve their negotiation qualities.

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[3] We have started to give out surveys to collect feedbacks from students in our school.