A Workflow-supported Social Networking Knowledge Visualization System

Hyeonil Jeong¹, Sungjoo Park¹, Hyunah Kim¹, Sungwoo Park², Jihyun Lee³, Hyeongnyeon Kim² and Kwanghoon Pio Kim¹*

¹ Collaboration Technology Research Laboratory
Department of Computer Science
KYONGGI UNIVERSITY
154-42 Kwangkyosanro Youngtongku Suwonsi Kyonggido, 443-760, South Korea
1 e-Mail: {hijeong, npk1234, kwang}@kgu.ac.kr
http://ctrl.kgu.ac.kr
2 e-Mail: {swpark, jhlee, buddah}@kgu.ac.kr
http://designbiz.ac.kr/xe/
3 Workflow Intelligence Research Center
WoToWiTo, Inc.
e-Mail: hakim@wotowito.com
http://www.wotowito.com
*Corresponding author: Kwanghoon Pio Kim

Abstract

The purpose of this paper is to implement a knowledge visualization system designated for workflow-supported social networking knowledge that can be discovered from a workflow model or a group of workflow models in a workflow-supported organization. The implemented system is pipelining from the XPDL⁴-formatted workflow model to the GraphML⁵-formatted workflow-supported social network, and adopting the open-sources information visualization toolkits, such as Prefuse, JFreeChart, and Log4j. Additionally, the system is able to visualize the degree-centrality measurements for each of the workflow performers making up a workflow-supported social network.

Keywords: workflow-supported social networking knowledge, XPDL, SocioMatrix, GraphML, knowledge discovery, analysis, and visualization

1. Introduction

Recently, the workflow literature just started being focused on “People.” That begins from the strong belief that social relationships and collaborative behaviors among people who are involved in enacting workflow models affect the overall performance and being crowned with great successes in real businesses and working productivity as well. Consequently, research and development issues of adapting the social network concept into the workflow model have been emerging in the literature, and the title of the adaptation result is dubbed “workflow-supported social networks.” There

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⁴XPDL stands for XML Process Definition Language.
⁵GraphML stands for Graph Markup Language

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have been existing two main branches of research approaches in adopting social network techniques onto workflow-supported organizations; One is the discovery approach, and the other is the rediscovery approach. The latter is concerned with mining social networking knowledge from workflow enactment event logs, which was firstly issued by Aalst [10]. The former is to discover social networking knowledge through exploring the human perspective of the workflow model, which was issued at first by Song [4].

More specifically we have differentiated the discovery approach from the rediscovery approach in exploring workflow-supported social networking knowledge in the workflow literature. The discovery implies to explore planned (or defined) social networking knowledge from a workflow model itself, whereas the rediscovery is to explore enacted social networking knowledge from the execution event logs of a workflow model. In terms of visualizing the workflow-supported social networking knowledge, we try to differentiate the planned one from the enacted one, too. In this paper, we develop a systematic way of visualizing the planned workflow-supported social networking knowledge from a workflow model. That is, we implement a knowledge visualization system that is able to effectively visualize and beautifully display the planned social networking knowledge.

In terms of making up the paper, the next section gives the literature survey focusing on discovering and visualizing workflow-supported social networking knowledge. And the next consecutive section describes details of the implemented knowledge visualization system with a couple of screen-captures. Finally, we give some concluding remarks including future works.

2. Related Work and Scope

In recent, we have been interested in social and collaborative work analysis among employees in a workflow-driven organization. Our work of workflow-supported social networking knowledge is directly related with a converged issue of workflow model-log comparison issue [1] and social networks generation and analysis issue [2]. This converged issue stems from the actor-oriented workflow model [5], in which the authors suggested an algorithm transforming an ICN-based workflow model [19] into an actor-oriented workflow model. Unfortunately, it was interpreted not as social or collaborative behaviors among actors but as control flows among actor-objects in implementing an actor-oriented workflow engine. Also, there have been several research approaches, so far, that can be classified into the social network discovery issue [4][7][17] and the social network rediscovery issue [3][10], as stated in the previous section.

However, almost all of those approaches are concerning about how to represent [8], discover [4][10], and analyze [4][7][9][17] workflow-supported social networking knowledge, whereas they are rarely interested in how to effectively, efficiently, and even beautifully visualize the corresponding knowledge. The only one emphasizing visualization of the knowledge is Jeon [9], in which the authors developed a display function to visualize workload-centrality measurements of performers engaged in enacting a specific workflow model. However, because the display function is visualizing the graphical objects on a fixed-size window and it doesn’t adopt any graphical toolkits or libraries, it always needs a certain amount of additional manual-operations, such as re-positioning, resizing, or rearranging operations, to gracefully and properly visualize graphical objects making up the displayed workflow-supported social network. As an upgraded version of Jeon [9], this paper proposes a systematic approach to dramatically improve the quality of beautification as well as the quality of efficiency in visualizing workflow-supported social networking knowledge. The systematic approach is pipelining from XPDL [14][15]-based workflow model to GraphML [11][12][13]-based workflow social networking knowledge, which is designated for the planned workflow-supported social networking knowledge, and adopts the famous information visualization toolkits like Prefuse, JFreeChart, and Log4j.

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6 The planned and enacted workflow-supported social networking knowledge is abbreviated and referred to as pWSSN and eWSSN Knowledge, respectively, in the paper.
3. The pWSSN Knowledge Visualization System

We implement a pWSSN knowledge visualization system that is able to explore, visualize, and analyze the planned workflow-supported social networking knowledge discovered from a workflow model or a group of workflow models (or packages) formatted in the visual of XPDL. In this section, we illustrate a series of systemic components through describing the detailed functionalities and their captured-screens.

System Architecture. The essential functional components composing of the implemented system are corresponding to the visual-transformation phases as summarized in the following:

- XPDL-to-SocioMatrix visual-transformation phase: SocioMatrix Generation Functionality
  - XPDL-to-Binary SocioMatrix: Binary SocioMatrix Generation Function
  - XPDL-to-Valued SocioMatrix: Valued SocioMatrix Generation Function
- SocioMatrix-to-GraphML visual-transformation phase: pWSSN Knowledge Visualization Functionality
- SocioMatrix-to-Discovery GraphML: pWSSN Knowledge Discovery& Visualization Functionality
  - Binary pWSSN Knowledge GraphML Generation Function
  - Valued pWSSN Knowledge GraphML Generation Function

- SocioMatrix-to-Analysis GraphML: pWSSN Knowledge Analysis & Visualization Functionality
  - Centrality Analysis Functionality of the Binary or Valued pWSSN Knowledge
    - Degree Centrality Analysis Function
    - Closeness Centrality Analysis Function
    - Betweenness Centrality Analysis Function
    - Eigen-value Centrality Analysis Function
  - Prestige Analysis Functionality of the Binary or Valued pWSSN Knowledge

Fig. 2 depicts the system architecture of the pWSSN knowledge visualization system that is implemented by using the Java programming language, and it is made up of seven architectural components—Window-panel controller, XPDL parser, SocioMatrix Generator, GraphML generator, Social Network Analyzer, Charts generator, and Statistical Data Analyzer—that are functionally associated with the XPDL-to-SocioMatrix, SocioMatrix-to-GraphML, and SocioMatrix-to-Chart visual-transformation phases.

The XPDL parser using the Xpdl-parser supports the XPDL 1.0 version of WfMC, and the SocioMatrix generator takes charge of generating the binary and valued SocioMatrices from an XPDL-based workflow package. The social network analyzer and the GraphML generator are able to visualize discovered pWSSN knowledge as well as analyzed pWSSN knowledge as non-directed graphs that are transformed from binary and valued...
SocioMatrices and graphically displayed by the Prefuse graphic library. In terms of the pWSSN knowledge analysis aspect, the system is theoretically backed up by the extended versions of the workload-centrality analysis equations [2][18], such as actor-degree centrality analysis equations, group-degree centrality analysis equations, closeness centrality analysis equations, betweenness centrality analysis equations, and so on. Finally, the statistical data analyzer and the Charts generator are able to visualize a variety of charts to the pWSSN knowledge by using the JFreeChart library.

### Table 2. The ICN-based Hiring Workflow Model[6] and Its Social Networking Knowledge by the Theoretical Discovery Algorithm[4]

<table>
<thead>
<tr>
<th>Workflow Model</th>
<th>Workflow Activity</th>
<th>Workflow Role</th>
<th>Workflow Performer</th>
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<tbody>
<tr>
<td>Hiring-Workflow-Model</td>
<td>18 Activities</td>
<td>16 Roles</td>
<td>17 Actors</td>
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The Planned Hiring Workflow Model

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\[ \sigma_0 = \{ o_1 \}; \]
\[ \sigma_1 = \{ o_2, o_3 \}; \]
\[ \sigma_2 = \{ o_4, o_5 \}; \]
\[ \sigma_3 = \{ o_6, o_7, o_8 \}; \]
\[ \sigma_4 = \{ o_9, o_{10}, o_{11}, o_{12}, o_{13} \}; \]
\[ \sigma_5 = \{ o_{14}, o_{15}, o_{16} \}; \]
\[ \sigma_6 = \{ o_{17} \}; \]
\[ \sigma_r = \{ o_1, o_2, o_3 \}; \]
\[ \sigma_s = \{ o_4, o_5, o_6 \}; \]
\[ \sigma_t = \{ o_7, o_8, o_9 \}; \]
\[ \sigma_u = \{ o_{10}, o_{11}, o_{12}, o_{13}, o_{14}, o_{15}, o_{16}, o_{17} \}; \]

The Planned Workflow-supported Social Networking Knowledge

\[ \sigma_S \text{SocialPredecessors} \]
\[ \sigma_A \text{SocialSuccessors} \]

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Summarily, the system’s development and operation environments are listed in the following. Note that the input XPDL workflow package’s release version is XPDL 1.0, as mentioned before, and so, it is necessary to be extended to support the recently released version of XPDL 2.0 or more, which reflects the BPMN\(^9\) graphical constructs.

- Display: NVIDIA GeForce GTS 450
Fig. 3. The Hiring pWSSN Knowledge Visualization from the Binary SocioMatrix-to-Discovery GraphML Visual-transformation Phase

Fig. 4. The Degree-centrality Visualization of The Hiring pWSSN Knowledge from the Binary SocioMatrix-to-Analysis GraphML Visual-transformation Phase

An Operational Example. As an operational example, we try to visualize pWSSN knowledge from a typical ICN-based workflow model arranged in Table 1, which is the Hiring workflow model rigorously described by Kim & Ellis [6]. The specification and the performers’ assignments of the Hiring workflow model are formally described in the first and the second rows, respectively. Also, we theoretically apply the pWSSN knowledge discovery algorithm
introduced in Song [4] to the Hiring workflow model, and the result of which is formally described in the third row of the table.

Likewise, we apply the XPDL-formatted Hiring workflow model to the implemented system, and the visualized results from the system are Fig. 3 and Fig. 4. Fig. 3 is to visualize the Hiring pWSSN knowledge discovered through the binary SocioMatrix-to-Discovery GraphML visual-transformation phase of the system [16], and Fig. 4 shows the Degree-centrality measurements of the performers, who are planned to be involved in enacting the Hiring workflow model, through the binary SocioMatrix-to-Analysis GraphML visual-transformation phase of the system, too. In Fig. 4, the sizes of the circles imply the normalized values (between 0 and 1) of the degree-centrality of each performer, and the bigger the circle is, the larger number of in/out connections with others it has. Furthermore, in the case of the valued SocioMatrix, the different values can be visualized by the different levels of weights (thickness) of the corresponding edges in the graphical visual of the pWSSN knowledge, and otherwise the values themselves may be directly put on the corresponding edges. Eventually, Fig. 3 and Fig. 4 show the graphical view of the Hiring pWSSN knowledge, and the graphical visual of the pWSSN knowledge, and the graphical view of the Hiring pWSSN knowledge, and the graphical visual of the pWSSN knowledge, that effectively exhibiting work-sharing relationships and collaborative behaviors among workflow performers. Finally, we have verified the applicability and operational correctness of the implemented system through an operational example.

As future works, we need to extend the pWSSN knowledge visualization system not only to develop much more advanced functionalities but also to visualize enacted workflow-supported social networking knowledge, which is abbreviated as eWSSN knowledge, rediscovered from the workflow enactment event logs, and accordingly we have a plan to implement an eWSSN knowledge visualization system in the similar way of this paper.

5. Conclusions

The recent big-trends in working environments are undoubtedly large-scale workflow management systems with increasingly large and complex workflow applications. The large-scale workflow management systems ought to be reflecting the typical organization-wide perspectives like behavioral, social, informational, collaborative, and historical perspectives, and accordingly the visualization capability of the large-scale information ought to become a much more important feature in those large-scale systems. In this paper, we suggested a tangible way of discovering and visualizing a special type of social networking knowledge, planned workflow-supported social networking knowledge that is effectively exhibiting work-sharing relationships and collaborative behaviors among workflow performers. Finally, we have verified the applicability and operational correctness of the implemented system through an operational example.

As future works, we need to extend the pWSSN knowledge visualization system not only to develop much more advanced functionalities but also to visualize enacted workflow-supported social networking knowledge, which is abbreviated as eWSSN knowledge, rediscovered from the workflow enactment event logs, and accordingly we have a plan to implement an eWSSN knowledge visualization system in the similar way of this paper.

References


