Decision Support Systems 48 (2009) 237–245

Contents lists available at ScienceDirect

Decision Support Systems

journal homepage: www.elsevier.com/locate/dss

Recommender system based on workflow

Lu Zhen [a,*], George Q. Huang [b], Zuhua Jiang [c]

[a] Department of Industrial and Systems Engineering, National University of Singapore, Singapore
[b] Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, PR China
[c] Department of Industrial Engineering and Management, Shanghai Jiao Tong University, Shanghai, PR China

ARTICLE INFO

Article history:
Received 14 December 2008
Received in revised form 29 July 2009
Accepted 23 August 2009
Available online 29 August 2009

Keywords:
Recommender system
Workflow
Collaborative filtering
Knowledge management

ABSTRACT

This paper proposes a workflow-based recommender system model on supplying proper knowledge to proper members in collaborative team contexts rather than daily life scenarios, e.g., recommending commodities, films, news, etc. Within collaborative team contexts, more information could be utilized by recommender systems than ordinary daily life contexts. The workflow in collaborative team contains information about relationships among members, roles and tasks, which could be combined with collaborative filtering to obtain members' demands for knowledge. In addition, the work schedule information contained in the workflow could also be employed to determine the proper volume of knowledge that should be recommended to each member. In this paper, we investigate the mechanism of the workflow-based recommender system, and conduct a series of experiments referring to several real-world collaborative teams to validate the effectiveness and efficiency of the proposed methods.

1. Introduction

This study concerns knowledge recommender systems for collaborative team contexts, rather than general situations in daily life, e.g., recommending commodities, news, films to customers. Among a collaborative team, members usually come from diverse disciplines, each with particular expertise and contribution from their relevant areas. Thus, their demands for knowledge are also different from each other. Recommender system provides a platform to deliver right knowledge in the right context to the right person in the right volume [27,34,36].

This paper proposes a workflow-based recommender system model, which is oriented to the collaborative team environment. Within this context, more information could be utilized by recommender systems, comparing to ordinary daily life situations. Workflow is one type of collaborative processes and it virtually exists behind every collaborative team [37,38]. The workflow in the collaborative team environment contains members-roles-tasks reference information that describes which member plays which roles or fulfills which tasks. This reference information could be combined with collaborative filtering to obtain members' demands for knowledge. It ensures that knowledge resources in proper domains will be recommended to proper members in collaborative team. Moreover, the volume of those recommended knowledge resources should also be proper for each member. Otherwise, too much knowledge is recommended to some busy members, which will cause information overload and interruption to them. In our study, the work schedule information contained in the workflow is utilized to determine the proper volume of recommended knowledge for each member.

This paper investigates the mechanism of the workflow-based recommender system, and conducts a series of experiments referring to several real-world collaborative teams so as to validate the effectiveness and efficiency of the proposed methods. The rest of this paper is organized as follows. Some related works done by other scholars are briefly introduced in the next section. In Section 3, we introduce the application background: collaborative environment, which is the basis for our proposed method. Then, Section 4 addresses the general framework of the workflow-based recommender system, and analyzes two key technical issues. Sections 5 and 6 investigate those issues in detail respectively: workflow-based collaborative filtering, and recommendation volume control by using the schedule information in workflow. For performances evaluation, several experiments are conducted to validate the proposed model and methods in Section 7. Closing remark and summary are then outlined in the last section.

2. Related works

The recommendation technology has become a promising and hot area in both academia and industries; numerous recommender systems (RS) have been developed [2]. Tapestry [7] is one of the earliest RSs. Based on this work, several automated RSs were designed and implemented. A RS for news and movie recommendations was developed by Konstan et al. [13]. For book recommendation, Mooney and Roy proposed a content-based RS [23]. McNee et al. designed a RS

* Corresponding author. Tel.: +65 6516 4608.
E-mail address: zhen_lu@yahoo.cn (L. Zhen).

0167-9236/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.dss.2009.08.002

to help recommend research papers' citation [19]. Citeseer [3], Webpersonalizer [22], GroupLens [13], SiteSeer [25] filter and recommend web information according to the similarities between web resources and users' interests. For improving sales on e-commerce websites, a taxonomy RS was developed by Schafer et al. [26]. Ontology technologies were also brought into RS researches. Middleton et al. explored a novel ontological approach for user profiling within RS, which could recommend on-line academic research papers [20,21]. Li and Zhong presented an abstract Web mining model for extracting approximate concepts hidden in user profiles, which could make recommendation much more efficient [14,15]. Godoy and Amandi designed a document clustering algorithm that carried out incremental, unsupervised concept learning over Web documents for acquiring user profiles to support recommendation of web information [6]. Yu et al. suggested a hybrid collaborative filtering method for multiple-interests and multiple-content recommendation in e-commerce [31]. By analyzing customer behaviors (navigational patterns), Yong et al. designed a collaborative filtering based RS for e-commerce sites [30]. Yeong et al. proposed a new methodology in which customer purchase sequences were used to improve the quality of collaborative filtering based recommendation [29]. Liang et al. developed a knowledge recommender that allows customized content to be suggested based on the user's browsing profile. The method adopts a semantic-expansion approach to build the user profile by analyzing documents previously read by the person [16]. Malinowski et al. developed a relational recommendation approach for providing an automated pre-selection of candidates that fit best with future team members [18]. Garfinkel et al. designed a recommender system which extends the one-product-at-a-time search approach used in current 'Shopbot' implementations to consider purchasing plans for a bundle of items [4]. They also developed 'Shopbot 2.0' to integrate recommendations and promotions with comparison shopping [5]. Jiang et al. studied how to maximize customer satisfaction through an online recommender system, and proposed a novel associative classification model. Products could be recommended to the potential buyer if the model predicts his/her satisfaction level will be high [9]. Kagie et al. designed a graphical shopping interface based on product attributes. It represents the mutual similarities of the recommended products in a two dimensional map, where similar products are located close to each other and dissimilar products far apart [11]. Wang et al. developed a navigation graph-based recommender system, in which the navigation patterns of previous website visitors are utilized to provide recommendations for newcomers [28].

To adapt recommendation technologies to large scale peer-to-peer (P2P) environment, Han et al. suggested a distributed collaborative filtering algorithm to construct a scalable distributed RS [8]. Kim et al. implemented an image content recommender in P2P architecture [12]. Olsson developed a headline recommender system in P2P environment without centralized control [24]. As to multi-dimensional RS [1], a workflow space based collaborative filtering method was proposed in [35]. However, those systems mainly concern personalized recommendations in ordinary daily life situations, e.g., recommending commodities, news, films to customers. They have not considered specific applications of knowledge recommendation in collaborative team context, or about some specific business processes. Jung proposed blog context overlay network architecture for context matching between blogs, so as to realize knowledge recommendation and distribution among members in community [10]. Liu and Wu developed a novel task-based knowledge recommender. A modified relevance feedback technique, which is integrated with the task-relevance assessment method, could be enabled to provide knowledge workers with task-relevant information based on task profiles [17]. Based on knowledge grid environment, some conceptual models of proactive knowledge recommender system and reactive knowledge query platform were proposed in [32,33].

3. Workflow-centric collaborative environment

The recommender system model proposed in this paper is mainly oriented to the workflow-centric collaborative environment, and one example is illustrated in Fig. 1. This collaborative environment consists of three key concepts: members, roles and tasks. Members are the core factor in collaborative environment. All the knowledge is produced and also used by members while performing their tasks. Each member in a collaborative organization may have one or more roles, e.g., product engineer, design engineer, test engineer, mechanic designer, etc. Moreover, there are up-low relationships between those various roles, all of which constitute a role hierarchy, denoted by 'role tree'. The role tree reflects the organization architecture of a collaborative team. Besides the mapping with the member list, the role tree also has the mapping with the task model. As shown in Fig. 1, Mapping_1 deploys the roles onto tasks in workflow; Mapping_2 deploys the roles onto members in member list.

The workflow-centric collaborative environment is the application context for our proposed recommender model, while traditional recommender systems are oriented to general situations in daily life. The collaborative environment contains some potentially useful relationships among the collaborative members, which could be utilized to support collaborative filtering in recommender systems.

4. The framework of recommender system based on workflow

As for the implementation of recommender systems in collaborative environment, there exist two core issues. Firstly, as to the recommended knowledge, which domains are suitable for each member? Secondly, what is the suitable volume of recommended knowledge for each member? Once the above two questions are answered, the proper knowledge could be delivered to the proper persons in the proper volume. Fig. 2 illustrates the general framework of the recommender system based on workflow. There are two core modules in the model, which are marked in the figure.

For the first issue, a novel collaborative filtering based on task (or role) relationships from workflow is proposed to obtain the 'members-to-knowledge domains' relation table, which reflects the members' demands for suitable domain knowledge.

For the second issue, a statistic analysis method is proposed to obtain the occupancy scale from the schedule in workflow, so as to determine the suitable volume of the recommended knowledge.

The following two sections will give details to the above two key issues respectively.

5. Collaborative filtering based on workflow

This section investigates the first key issue: as to the recommended knowledge for each member, how to determine suitable domain that may be potentially useful for him (or her). We proposed a novel collaborative filtering method based on workflow to reach the above target.

Workflow realizes work cooperation between team members through a definite logical process, and it is used to integrate distributed and heterogeneous tasks (activities) into a unified process. Abundant information is contained in workflow, e.g., the logical dependence order relationships between team members' tasks (activities), and member-roles–tasks reference information that describes which member plays which roles or fulfills which tasks. The above information could be combined with collaborative filtering so as to obtain members' demands for knowledge from their correlative colleagues. It guarantees that knowledge resources in proper domains could be recommended to proper members in the collaborative team.