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Analysis of Users’ Social Roles in Cyberspace and Application to Information Behavior Support

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サイバースペースにおけるユーザのソーシャルロール解析と情報行動支援への適用

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Abstract

With the increasing popularity of social network services (SNS), a tremendous amount of information has been produced. And with more and more users involving in the SNS environment, their relationships may be built in cyberspace the same as in real-world. Therefore, their relationships become more complex. In these relationships, users may have different positions such as the opinion leader and follower. By this mean, the users' social roles exist and exert an important influence. According to Leyssen et al.'s study, social roles are defined as the part people play as members of a social group. Therefore, social roles have become crucial to better understand users and further support their information behaviors. Especially in the group activities it becomes easier if their social roles can be identified.

Previous research works have been tried to analyze and identify the users' social roles, but most of them only focused on the roles in cyberspace without considering the roles in real-world. With the development of related technologies, the identification of social roles can be more accurate by combining the data from real-world, such as the GPS data and users' profiles.

In this study, to facilitate the construction of relationship networks and further benefit information behavior support, we concentrate on the computational approaches to modeling and analyzing of users' social roles not only in cyberspace,

but also in real-world. Users' social roles are systematically analyzed, identified and classified to form the related information for the descriptions of users' relationships. In addition, the influence factors are analyzed to facilitate the social roles identification process. We use the identified social roles data to support a variety of information behaviors varying from participatory information search, recommendation, and collective decision-making support. Moreover, we propose a framework of participatory information search and recommendation based on the analysis and identification of users' social roles and their connection networks. We further propose a hierarchical model of social roles, and develop a mechanism to utilize the identification of social roles to support the collective decision-making process.

In this thesis, firstly, a model of social roles with a set of role attributes, including the profile data, context data, location data and situation data, etc., is proposed. Then, a set of factors including the location factors, situation factors and context factors, etc., is proposed to describe and detect the dynamical switching of social roles. Based on these, a basic model of social role identification is introduced, and a mechanism is developed for real-world situations mapping and synthesizing and role attributes analyzing as well.

Based on these basic models and methods, the user connection networks which can be built by using the social roles are discussed. Furthermore, by using the social roles and connection networks, a framework of participatory information search and recommendation is proposed, and the design and implementation issues of the system's functional modules are addressed. Simulation result based on the prototyping of core functional modules an application scenario shows our proposed approach can support the participatory search and recommendation process in a more efficient way.

Moreover, a model of collective decision-making processes corresponding to functional modules that take into account social roles is presented based on the social choice theory. Then, a three-layer model of social roles is introduced and the issues of collective decision-making support are discussed. Based on these, an integrated mechanism is proposed and developed to support the collective decision-making process by analyzing users' social roles in both real-world and cyberspace. As a case study, we apply our proposed models to the Course Offering Determination (COD) system, which is practically used in a Canadian university. A NetLogo based tool is developed to demonstrate the negotiation process, which is a core process for collective decision-making, using our proposed method and the Delphi method respectively. The evaluation experiments show the effectiveness of our method comparing with the traditional baseline.

This study has focused on analysis identification and utilization of users' social roles not only in cyberspace but also in real-world. Comparing to the traditional methods with considering users' social roles in cyberspace only, the important factors in real-world are also considered in our model. We model the social roles with a set of attributes and factors to represent the time-changing dynamics in different situations and contexts. The mechanism that we develop to identify the roles is twofold: mapping of real-world situations to cyberspace, and analyzing social role attributes based on the mapping and synthesizing. Furthermore, based on the proposed framework and developed mechanisms, we introduce and build a relationship schema to represent users' roles and connections, and further confirm users' positions, which can support the search and recommendation process in a more efficient way. On the other hand, with a three-layer model and integrated mechanism to analyze users' social roles in a hierarchical way, our proposed approach has been demonstrated to help users achieve the decision consensus in a more efficient way.

The modeling and analyzing approach presented in this study can facilitate the precision rate of information selection from chaotic data, and support users' information search and decision-making in an effective way.

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Chapter 1 Introduction

In this chapter, we introduce the background of this study at first, and discuss the motivation and purpose secondly. After then, we present the major contributions. The organization of this thesis is addressed in the end.

1.1 Background

With the development of social media such as SNS, blog and micro blog, the number of users and the volume of related information are becoming larger and larger than ever before. Users themselves, as well as their relationships in cyberspace (such as the social media), have become more complex than real-world. In these relationships, users may have different positions such as the opinion leader and follower. By this mean, the users' social roles exist and exert an important influence. The social roles, not only referring to the roles played by individuals in cyberspace, but also the roles in real-world, have become crucial to better understand the users and further support their information behaviors.

"Social roles are the part people play as members of a social group" [1]. For instance, users begin to play their social roles when they join a discussing group in social networks. Since the complexness of individual relationships, the users will be benefited in many ways when the social roles they play can be identified in a distinct way. However, because of the multitudinous influence factors and the unique characteristics of social roles, it is still difficult to build a model in regard to the roles that users play in a user relationship network. Therefore, it is essential to model and analyze the social roles in different situations and further find out the relevant attributes and influence factors to identify the roles.

The analysis and identification of social roles can be viewed as the effective means to help people understand the characteristics of the network [2]. It means that according to the analysis of social roles, users' connection and relationship networks (e.g. a relationship schema) can be organized and confirmed, which can efficiently assist the related utilization part such as the identification process of useful information sources in the information search and recommendation services. However, the social roles that users play may change dynamically in different situations [3], and the varying influence factors which cause the changing of social roles may come from both real-world and cyberspace. It means that the connection and relationship networks may also change and lead to different results of information behaviors along with the changing of factors. Therefore, it is important to find an efficient method to analyze the social roles from both real-world and cyberspace in a dynamical way.

Moreover, with the increasing volume of users and the transmission of messages (e.g. the messages forwarded by users) in a social network service system, the big data era has come. Information overload has become a common phenomenon, and we need to filter out the irrelevant information [4], especially in the services of information search and recommendation. However, for a normal user, it is hard to pick up the valuable information he or she is interested in from the big data environment. Since the social roles have drawn increasing attentions in information recommendation field, as the utilization of social roles analysis, a dynamically method to filter the redundant information is essential to help dynamically information search and recommendation.

On the other hand, with the rapid development of emerging computing paradigms [5] and high accessibility of SNS (Social Networking Service), which leads to an increasing complexity of social-economic environment [6], it has become increasingly necessary to find an effective way to provide support for the social facets of collaborative works. The collective decision-making process, which can be defined as a process that a group of individuals try to achieve a common solution of a decision problem with several alternatives, considering their own opinions or preferences [7], is considered as an important part in lots of conceivable human tasks [8]. It indicates that the study of decision making is necessary and important in many groupware or collaboration systems along with the high development of Internet, electronic communication, and knowledge-based economy [9]. Especially, the social issues [9], such as the user roles, relationships and communities [10], have been emphasized in these systems. Thus, as utilization of social roles analysis, based on the analysis and identification of users' different social roles, a support method for the collective decision-making process is necessary.

1.2 Purpose of This Study

As discussed above, since users' messages are spread by other users, the information volume for user role analysis will become larger. Thus, it has become an increasing important issue to analyze and utilize the social role related data. In order to find a way to better utilize the valuable information to provide individuals with the personalized service and support. In details, to take advantage of the considerable size of data for individualized social roles utilization, a well- structured social roles model for an individual, and related utilization programs are requisite.

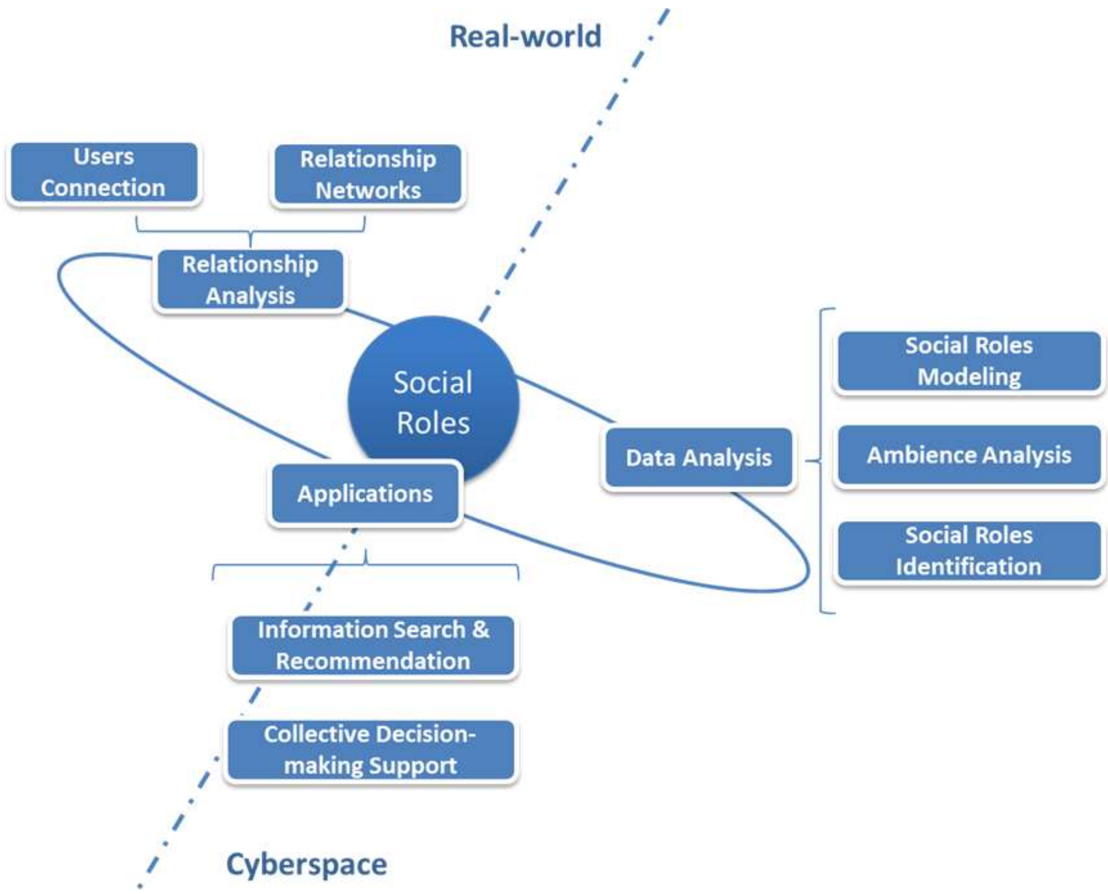

Figure 1-1 Basic structure of this study

Therefore, in this study, we delve into modeling and analyzing the social roles and the related utilization methods. As shown in Fig. 1-1, the key point of this study is the social roles. In order to capture the users' current needs and further benefit the information recommendation process, after the social roles modeling [11], we try to find a way to identify the social roles under different environments in both real-world and cyberspace considered. Based on this, in order to benefit utilization， we try to describe the user's connection and relationship networks as the relationship schema part to organize the identified social roles [12]. At last, to utilize the analyzed social roles, we try to support the information behaviors which include the information search & recommendation and collective decision-making [13]. On one hand, we take users also as the information sources, and propose a participatory system for information search and recommendation by analyzing their social roles and connection networks in cyberspace. On the other hand, based on the analysis of social roles in a hierarchical model, an integrated mechanism is developed to support the collective decision-making process, which can efficiently help users achieve the decision consensus in negotiation.

1.3 Contributions of This Study

Three major outcomes or contributions can be expected in this study, which are summarized as follows.

1) A model of social roles based on the analysis of social roles' influence factors (ambience) and related attributes

A model of social roles is introduced with a set of role attributes, and the concept of ambience is proposed with a set of factors, in order to describe and detect the dynamical switching of social roles under different ambiences. Based on these, a mechanism is then developed to map the ambiences from real-world into cyberspace for the identification of social roles.

2) A framework of participatory information search and recommendation system based on social roles analysis and connection networks

According to the identification and analysis of users' social roles and connections, an application system framework is proposed to identify and confirm the most relevant and useful users and their messages through the dynamical information filtering. Comparing with the traditional methods of information search or recommendation, we consider more about the users' roles both in cyberspace and real-world. Moreover, a relationship schema is introduced and built to store users' roles and connections, and confirm users' positions, which can support the search and recommendation process in a more efficient way.

3) **An integrated mechanism to support the collective decision-making process based on the hierarchically analyzing and modeling of social roles**

A three-layer model of social roles is proposed, which can provide a methodology to categorize the social roles in both real-world and cyberspace for the collective decision-making support. Based on this, an integrated mechanism is developed to utilize the analyzing and modeling of social roles in the collective decision-making, which can improve the efficiency in negotiation process. Finally, a NetLogo based tool is applied to simulate the negotiation process, which can be utilized to demonstrate and compare different decision-making methods.

1.4 Thesis Organization

As the basic structure shown in Figure 1-1, this thesis is organized in six chapters. In

Chapter 1, we introduce the background and existing problems and issues, and discuss the motivation and purpose. We conclude our major contributions of this study at the end of the chapter,

In Chapter 2, we summary related work, and discuss the main issues related to this study, including issues of user relationship modeling and analysis, social roles identification, information search and recommendation and collective decision making support.

In Chapter 3, the basic concepts in terms of social roles and the ambience are introduced with discussion of the related attributes and factors. Bases on the elemental notions, a basic model of social role identification is proposed. In addition, both the mechanism for ambiences synthesizing and the role attributes analysis are discussed in detail. At last, an application scenario is showed to explain how to identify the social roles in the SNS environment using the proposed model.

In Chapter 4, based on the identified social roles, we discuss how to utilize these roles to build users' connections in the SNS system. Then, the design and implementation issues of our proposed participatory system are presented, and the functional modules which utilize the social roles and connections are described to support and empower information search and recommendation. Finally, an application scenario is showed with the simulation result to verify our proposed methods.

In Chapter 5, the social choice theory and a collective decision-making model are described at first. Then, a three-layer model is presented to analyze users' social roles in a hierarchical way, and an integrated mechanism is proposed to support the collective decision-making process. Based on this, we design and implement a simulation tool to demonstrate the comparison between our proposed method and the Delphi method. An application scenario is discussed to show how to utilize individuals' social roles to support the collective decision-making process finally.

Finally, in Chapter 6, we give a brief summary of the thesis, and conclude the features of this study. The expected challenging issues and the future work directions are also presented.

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Chapter 2 Related Work

In this chapter, three main issues relate to this study are walked through. That is, issues of studies on identification and analysis of user social roles, user relationship modeling and analysis, information behaviors support.

2.1 Social Roles Identification and Utilization

Two main issues related to this study are walked through in this section. That is, issues of social role identification and studies on social roles analysis and related utilization in social media are addressed respectively.

2.1.1 Social Roles Identification

Recently, in order to preserve and improve the effectiveness of social networks, a lot of studies have been done. Especially on the topic of user roles, research works have been tried to identify the user's roles in the social networks [14-19]. With the aim of identifying the leaders and filtering high-volume members at a deeper level in Usenet groups, based on the approach of combining TF*IDF weighting with social computing, Nolker et al. tried to confirm key members' roles by discovering implicit knowledge from online communities [14]. In order to give users the possibility to define the roles interactively during a search session and retrieve the users for that role, Trabado et al. described a search engine for detecting roles in a social network

[15]. Sankar proposed a framework called "Information Wheel" which is made of data base management systems and information resources management to identify the roles in information systems, which was similar to a physical wheel consisting of a hub, a rim a tire, and spokes [16]. Moreover, in order to refine role definitions, Gleave et al. provided two examples of how researchers can move between interpretive and structural measures and analyzed the strategies for identifying social roles in the online community based on a conceptual definition of social roles [17]. Based on the identification of potential structural signatures by name space edit distributions and user talk network features in Wikipedia, Welser et al. improved a method for expansion and refinement of the role signatures, and identified other important social roles [18]. Sarcevic et al. suggest technological ways of identifying roles to help coordination in the trauma bay, which examined a particular feature of team interaction in time-critical situations. [19].

2.1.2 Social Roles Utilization

On the other hand, many researchers focus on the analysis and utilization of the social roles [20-23]. Nair et al. presented a practical analysis to quantitatively evaluate different algorithms in terms of role allocation and reallocation approaches [20]. Takabi and Joshi formally defined the problem of mining a role hierarchy with minimal perturbation and developed a heuristic solution called *StateMiner* to find an

RBAC (a role based authorization model) state to close the optimal state [21]. Molloy et al. advocated a two-step process of role mining with noisy data, and proposed the nonbinary matrix decomposition as a solution to cleaning the user-permission relation [22]. Moreover, in the application of user roles, Fukazawa et al. implemented a task-based service navigation system based on the constructed role-ontology [23].

2.2 User Relationship Modeling and Utilization

Two important aspects, including user relationship modeling and related utilization, are introduced to address the issues of analysis of user relationships.

2.2.1 User Relationship Modeling

Researchers recently focused more on the aspect of user relationship modeling [24-27], which can benefit not only the data organization but also the attributes analysis. Zhou et al. have developed a mechanism to build a Dynamical Socialized User Networking (DSUN) model, which can discover and represent users' current profiling and dynamical correlations [24]. Xiang et al. have formulated a link-based latent variable model, which is an unsupervised model to estimate relationship strength from interaction activity and user similarity [25]. Based on formal concept analysis, Zhi et al. have proposed an event description model which concerns the relationship between event and its occur-time [26]. Based on the analyzing of main workflow and the intercommunion way in the group, Wang et al. have provided an empirical social network model which correctly describes the group personnel relationship by using the dyad method [27].

2.2.2 User Relationship Utilization

User relationship analysis and utilization, as well as their applications, have also drawn lots of researchers [28-34]. Based the examination of characteristics and patterns that emerge from the collective dynamics of large numbers of people, Leskovec et al. have constructed a communication graph to examine characteristics and patterns [28]. Based the inspection of the interplay between individual user features and social interaction, Aiello et al. have built a user similarity network in order to perform the prediction of friendships, and modeled different recommendation tasks as weighted random walks in the relational graph [29]. Boris et al. have adopted a multi-relational framework to integrate different entity types available in the social media system and relations between the entities [30]. Based on the analyzing of user's important contexts, real location and time, Arakawa et al. have proposed a method to evaluate effectiveness of our proposed context-aware text entry by using Twitter [31]. Liu et al. have proposed a regression test case design method based on the analysis of the relationship and developed a test case generation tool [32]. With the analysis of soft information and relationship banking theory, Tao has proposed a typical dynamic game model with incomplete information to study the relationship of mico-loan company with loan clients [33]. Based on the complexity analyzing of SoS (System of Systems) relationships, Lu et al. have proposed a double layer CP modeling framework and discussed the key modeling technique [34].

2.3 Information Behavior Support

In order to support and improve the effectiveness of information behaviors, a lot of studies have been done, including information search and recommendation, issues of collective decision-making analysis and modeling and studies on multi-agent collective decision-making systems are addressed respectively in this section.

2.3.1 Information Search

Research works have also been tried on information search and recommendation in SNS environments. In the research of information and user search [35-37], based on a review of the social network, information processing, and organizational learning literatures, Borgatti et al. proposed a formal model of information seeking, in which the probability of seeking information from another person was calculated and applied [35]. Based on the utilization of relevance feedback from users, Roman et al. proposed a human-centric integrated approach for web information search and sharing [4]. In order to offer an explanation of social network search ability in terms of recognizable personal identities, Watts et al. presented a model that defines a class of searchable networks and a method for searching personal identities [36]. In order to find a way to seek the information related to users' current interests and needs among these data streams and provide users with other more relevant information, Zhou et al. proposed the concept of associative ripples to provide users with more related information for the assistance of information seeking and discovery [37].

2.3.2 Information Recommendation

On the other hand, in the research of information recommendation in the SNS, Chen et al. proposed a gradual adaption model for information recommendation based on a set of concept classes which are extracted from Wikipedia categories and pages [38]. Gallego et al. presented a context-aware mobile recommender system based on the real banking data [39]. Based on the utilization of current technologies (i.e. Android, Mahout, etc.), Pan et al. proposed a collaborative approach to effectively filter out irrelevant tag neighbors, and thus obtain more appropriate recommendations for the users [40]. By utilizing the trust mechanism to augment recommendation's accuracy and privacy, Elmisery et al. introduced a framework for private recommender service based on Enhanced Middleware for Collaborative Privacy (EMCP) [41]. Jeong et al. have provided a process of filtering customer information for the preparation of profiles and making recommendations, and suggested a movie recommendation system based on the selection of optimal personal propensity variables and the utilization of a secure collaborating filtering system [42]. Walter et al. presented a model of the trust-based recommendation system that combines the concepts of social networking and trust relationships in a social network [43].

2.3.3 Collective Decision-Making Support

Recently, in order to analyze the collective decision-making process, a lot of studies have been conducted [44-49]. Li et al. introduced a distributed protocol for the collective decision-making [44]. Hamann et al. proposed a generalized approach to analyzing the symmetry breaking in the collective decision-making process [45]. Nurmi described the straightforward generalizations of the solution concepts in terms of the fuzzy social or individual preference relations [46]. Gaudin et al. presented the analysis of collective processes in command and control activities [47]. Sánchez-Anguix et al. analyzed how environmental conditions affect different intra-team strategies in order to provide teams with the knowledge to select the proper intra-team strategy [48]. Cui et al. presented a multi-criteria group decision making approach which employed the fuzzy theory and the entropy-based method [49].

The modeling of collective decision-making process has also been widely discussed. Zhukovskayaa and Fainzil'berg proposed a constructive interval model to make a collective decision by an independent group of experts [50]. Valentini et al. presented a weighted voter model which implemented a self-organized collective decision making process [51].

As for the studies on multi-agent collective decision-making, several models and applications have been developed to solve the existing problems and issues [52-59]. Li et al. studied the problem of collective decision-making in the case where the agents' preferences were represented by CP-nets (conditional preference networks) [52]. Bosse et al. presented a computational model which can not only enable the individual intentions to converge to an emerging common decision, but also achieve the sharing of underlying individual beliefs and emotions at the same time [53]. O'Connell and Stearns investigated the problem of designing the mechanisms to control the collective decisions made by self-interested autonomous agents [54]. Sharpanskykh and Treur addressed how internal agent models and behavioral agent models for collective decision-making can be related to each other [55]. Yu et al. presented an implicit leadership algorithm based on a simple, purely local control law which allows all agents to follow a single rule and efficiently reach a common group decision without complex coordination mechanisms [56]. Reina et al. derived CDP (Cognitive Design Patterns) for collective decision making inspired by the nest-site selection behavior of honeybee swarms [57]. Fan and Su introduced the concept of "diffusion" into the multi-agent system, and investigated the impacts of using diffusion distances on the performance of solution synthesis in the experience-based multi-agent decision making [58]. Yu et al. described a demonstration of a multi-agent game for training students in the practice of Agile software engineering [59].

In addition, many research works have concentrated on the studies of system framework to process the multi-agent collective decision-making [60-63]. Saffre and Simaitis presented a collective decision-making framework inspired by biological swarms, which was capable of supporting the emergence of a consensus within a population of agents in the absence of environment-mediated communication [60]. Sá provided a group decision making framework in which the agents were able to employ abductive reasoning and discuss the options towards consensus [61]. Fan and Su took a two dimensional perspectives to explore the use of diffusion distance and Euclidean distance in identifying 'similar' experiences which can be viewed as a key activity in the process of recognition-primed decision making [62]. Vo and Li provided a generic and flexible framework to allow the concepts and results of game theory to be more readily mapped to the reasoning and decision making mechanisms in multi-agent systems by making agents' expectations explicit [63].

2.4 Summary

Research works showed the trends of social roles analysis not only in the models and identification, but also in the design of systems and related utilization services, which can provide us with more information and knowledge in various aspects using the social roles and analyzing methods. The modeling of user relationships and related analysis can promote the organized and collaborative works. And the studies of information search and recommendation, as well as the support models and methods of collective decision-making, can also help enhance the social roles utilization process. In these studies, the users play an important role in social networks, and their relationships have also been considered.

In this study, we concentrate on the unified modeling and analysis of social roles, and the related utilizations to support information behaviors. Comparing with the traditional methods, we focus more on capturing users' varying position information in cyberspace, and further integrate and organize the related information in order to support the related utilizations. Differing from other role analysis models which classified users' social roles based on their characteristics in a given network environment such as an online system, we also pay attention to considering their social roles in real-world. In addition to the user-to-user relationship, we highlight the analysis of user connections such as a social group in the SNS system, which could be considered to assist the search and recommendation services.

Furthermore, comparing with the traditional studies which mostly focus on the optimization of decision-making process, we focuses more on an integrated approach to utilizing the users' dynamical social roles to support and facilitate the decision-making process. Through the social roles analysis, especially the analysis of social roles in real-world, the collective decision-making process in the social networking environments is expected to be more reasonable and efficient.

Chapter 3 Social Roles: Attributes, Modeling and Identification

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The individual social roles are the categorized response to the expectation from an organization or society [3], which are complex and unstable because of the switching situation. It contains enormous amount of potential worth and value not only for the confirmation of people's position in a social group, but also for the enhancement of collaborative works from all walks of life. In this chapter, the modeling and attributes of social roles are discussed, along with the dynamical switching of social roles with considering the influence factors. We also discuss the design of the model and mechanism of dynamical role identification. Finally, an application scenario is showed on how to identify the social roles in cyberspace.

3.1 Social Roles

Individual social roles are the part people play as members of a social group [1], which means in different situations, individuals will have different social roles. Therefore, in order to identify the dynamical social roles, in this section, we model the social roles by a set of attributes, and consider a series of factors which we call ambience, a concept from Ambient Intelligent to correspond different situations.

3.1.1 Definition of Social Role

In this study, our main idea is to identify and utilize the social roles to assist and support information behaviors in the social network environment, which include information search, information recommend and collective decision-making support. As the first step, before the social roles utilization in the SNS system, we need to identify user's roles in the social network. Differing with the traditional studies which only identify the user roles in cyberspace, we also focus on the social roles which users play in real-world.

"Social roles are the part people play as members of a social group" [1]. The purpose that users would like to play different roles in different groups is to meet the expectation of the corresponding group [6], which means users will dynamically change their roles due to different groups. As shown in Fig. 3-1, in real-world, in order to let a group play its function, its members need to play their pre-defined roles to maintain the group's operations. In this situation, the environment of the role is the social group. Similarly, in cyberspace, such as in an SNS system, the environment of the role is the SNS groups which the users participate in. When the members in the SNS group are similar to the members in the social group, it means that the role of users in this environment will not change.

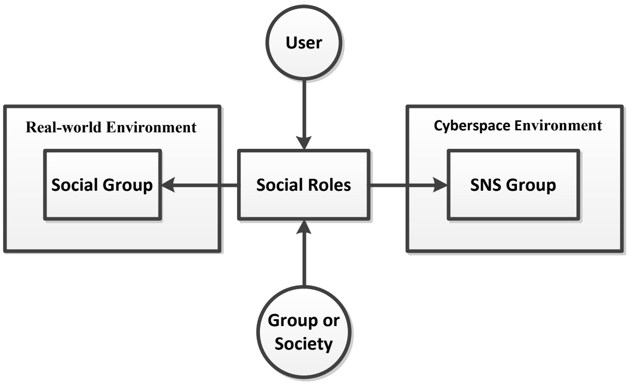

Figure 3-1 Social roles in real-world and cyberspace [12]

There are many attributes of a social role, such as age, gender, duty and so on. According to different environments, people may play plural roles at the same time [6]. Normally, in a given environment, each user will have a main or leading role to play. The main role which the users play will be our aim to identify and further help the determination of the users' positions.

Therefore, in order to describe the social roles, we need to model the social roles by a set of attributes. Specifically, to identify the members' role means to identify their positions in a certain group, which may also benefit related services such as the information filtering process for a user to find more suitable information.

3.1.2 Attributes of Social Role

By reference to the basic thinking and classification of social roles in social science [3], we classify the social roles' attributes into four types which are shown in Table 3-1.

Table 3-1 Classification of social role attributes [11]

Type	Characteristics	Example
Individual-based attributes	Basic attributes Belong to the individuals themselves Relatively stable	Gender Age Title Profession
Relation-based attributes	Main attributes Depend on the relations and situations Not unaltered	Family: Father - Son Position: Superintendent -Subordinate, Professor – Student, Opinion Leader - Follower
Temporal attributes	Auxiliary attributes Change with time Temporal	Staff - Customer Resident – Visitor
Other attributes	Composite attributes Based on situations Occasional	Session chair in an academic meeting

(A) Individual-based Attributes

The individual-based attributes indicate the attributes which belong to the individuals themselves. In details, the individual-based attributes include an individual's gender, age, title and profession, which are the basic attributes to describe the personal information for an individual. Moreover, take the gender attribute for example, it is stable. According to different individual-based attributes, individuals can be divided into several groups, for instance, man and woman, adult and child, which can benefit the social role identification process in different situations.

(B) Relation-based Attributes

The relation-based attributes indicate the attributes based on the relationships, such as the kinships in a family or the positions in an organization, which are the main attributes to describe the relations among individuals. Comparing with the individual-based attributes, these attributes are not unaltered. They change by different situations. Note that since most of roles depend on the relation-based attributes, we should pay more attention to them. Besides, for a pair of relation-based attributes, each of them will result in the relative positions. For instance, the position of father is generally higher than son in the oriental culture society, and the position of opinion leader is higher than his follower, which can be used to identify the social roles.

(C) Temporal Attributes

Example, a man who is a staff of shop at noon, but when he enters into others' shop at night, he may become a customer. Similarly, when a men living in an area for a short period, he may be a visitor of this area, but he will become a resident when he lives here for a long time. Therefore, the temporal attributes indicate these attributes based on the time and the frequency factor, which are auxiliary attributes that cannot determine a social role without other attributes.

(D) Others Attributes

In addition to the attributes discussed above, there may be many other attributes which can describe the social roles, such as the session chair in an academic meeting. However, this kind of attributes is occasional but can be useful.

3.2 Modeling of Social Roles

Based on the introduction of social roles attributes above, in this section we will describe the ambience with a series of influence factors, and then based on the analysis of switching ambience, we will further introduce the model of social roles and discuss the relationship between role attributes and influence factors.

3.2.1 Influence Factors

In addition to the main role which we mentioned, as another point which we should consider in practice, the secondary roles which the user plays are also important when the user has plural roles in the group. Due to the communication among the users, the main role and secondary roles which the user plays may exchange [6]. Therefore, we need to analyze the environment with some influence factors and identify the user's roles in a dynamic way.

As we discussed above, the social roles will switch or change according to the changes of a series of factors such as locations, situations, contexts and many others.

In this study, we refer all of these influence factors as ambience factors.

Table 3-2 Ambience factors

Category	Description
Location	a geographical place, or a physical site
Situation	a variety or a combination of circumstances or happenings, not necessarily depending on a geographical physical location
Context	the part, inferred from a variety of clues surrounding a situation, that helps to understand the situation
Other	other factors not in the above categories

Life log is the record for people who want to capture their entire lives in both cyberspace and real-world, which include the data of video, audio, acceleration sensor, gyro, GPS, annotations, documents, web pages, and emails [45]. The life log could be viewed as a link between real-world and cyberspace, and contains a lot of information that can be employed for the ambience detection.

We divide these factors into four categories as shown in Table 3-2.

(A) Location Factors

The location data is one of the basic data among life logs. Since people are increasingly accustomed to sharing their personal information across social networks, especially checking in with their locations only if they can get into Internet, the location data has become an important factor to determine the basic ambience. Moreover, with the development of positioning technology, the location data can be recorded more accurately with more detailed information in a more efficient way. For instance, based on the network map service, such as “Google map”, we can recognize the detailed description for the place, such as restaurant and university, and further reduce the scope of possible social roles.

(B) Situation Factors

The situation factors may relate with location factors. With the same location, individuals may be in multiple situations. The situation factor is the main factor which can identify the individuals’ relationship and further affect the ambience.

The situation factors can be collected from both real-world and cyberspace. For example, the situation factors may be sensed, analyzed and inferred from the logs in an SNS system. Within the same group, all the situation data can be used to identify the relation-based attributes for social roles.

(C) Context Factors

In addition to the current location or situation, the user context, not only for the individual, but also for the group, should also be taken into account as the complement to the ambience factors, due to the complexity of the ambiences for individuals.

The context data can be extracted from life logs collected from the social media and real-world life if available, which may give many clues about individuals' ambiences in a certain location and situation. Therefore, by analyzing the user context in both the real-world and cyberspace, it is possible to grasp an individual's detailed ambience. For instance, due to different sequences of locations which users have checked in, the weight of social roles may change.

(D) Others Factors

Besides these three major factors discussed above, other factors, such as an individual's like, dislike, emotion and character, can also determine the ambience, and further influence individuals' social roles.

3.2.2 Social Roles Modeling

The social roles can be modeled into the structure of "other person – I - relationship" [3]. It means in a group with a certain number of members, in order to analyze the role attributes and further identify the social roles, three important factors, the individual, other related members and the relationships among them should be considered. As shown in Fig. 3-2, the data from individuals can influence the individual-based attributes, while the temporal attributes are influenced by the ambiences, and the relation-based attributes are influenced by both ambiences and groups. That is, the ambience factor is the most important factor to identify the individuals' social roles.

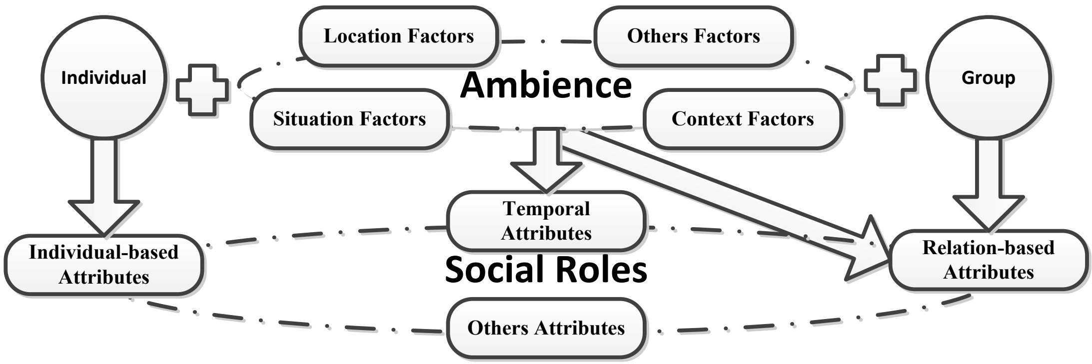

Figure 3-2 The social roles model with role attributes and factors [11]

Thus, based on the factors discussed above, we will detect the current ambience by mapping the corresponding ambiences in both real-world and cyberspace, and finally identify the dynamically switched social roles in different ambiences.

3.3 Dynamical Social Roles Identification

3.3.1 Constructing of Social Role Identification Model

The physical world can be classified into two different parts, real-world where we live, and cyberspace such as the Internet and SNS environments. As shown in Fig. 3-3, data in both real-world and cyberspace can contribute to the extraction of the ambience factors, in order to identify the social roles in cyberspace. In details, factors such as situation and context factors can be sensed or inferred from both real-world and cyberspace, while the location factors can be obtained and analyzed only from real-world.

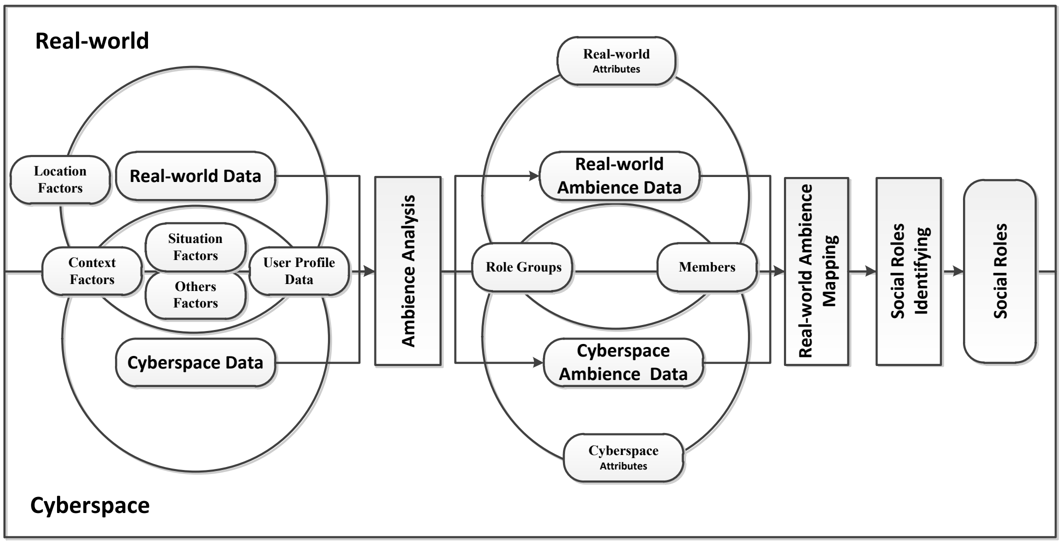

Figure 3-3 Basic model of social role identification [11]

Using these extracted factors, we can analyze and detect ambiences in both the real-world and cyberspace, and obtain the related role attributes for a number of individuals in a set of optional role groups (e.g., the "professor-student" role group which can be obtained by analyzing the ambience factors). We further map the ambiences from real-world into the cyberspace, in order to consider all these factors and attributes together in a synthesized way. Finally, based on the analysis of the related role attributes, we can identify the appropriate social roles for each individual.

3.3.2 Procedure of Social Role Identification

Five major steps to identify the social roles are described as follows.

Step 1 Identification of the individual groups

The Dynamically Socialized User Networking (DSUN) model [24] proposed in our previous study is employed to select a group of related individuals. Based on this model, algorithm and mechanism are developed to describe and analyze the users' relationships based on their interactional behaviors. Thus, it can help us assign the individuals into a variety of groups, and analyze the social roles among different individual groups in regard to their different interests or needs.

Step 2 Ambience factor analyses

The second step is to analyze the ambiences which include inferring the optional role groups by analyzing the real-world location data and detecting the group positions in cyberspace. By analyzing the ambience factors which we collect in both real-world and cyberspace, we can obtain the past ambiences first. And we can further identify the optional role groups based on these ambiences. Meanwhile, by analyzing the factors such as the contexts and situations in cyberspace, the relativeness among individuals can also be figured out. On the other hand, by analyzing the current selected data within the same group, we can get the current ambience factors, such as the user context and situation.

Step 3 Mapping ambience from real-world to cyberspace

For the ambiences that are detected in real-world, we combine them together with the ambiences in cyberspace by mapping the factors of ambiences from social space into cyberspace, in order to consider all the factors and attributes in a synthesized way.

Step 4 Attributes analysis in both real-world and cyberspace

Based on all the related factors and attributes in cyberspace and mapped from real-world, we compare the factors of current ambience with the factors in each past ambience, in order to find the suitable ambience, including the corresponding role attributes and the suitable role groups.

Step 5 Social role identifying

Finally, based on the role group selecting and relative position analyzing, we identify the social roles for each individual.

3.3.3 Application Scenario

Take a specific user John for instance, we assume that he and his friends have the habits to check their location information in the SNS, which can be recorded as their life logs. Usually, the system cannot obtain the real-world-based social roles which John plays in a user group, unless he updates them into the system to determine the relationships. Therefore, through our proposed approach, the system can identify John and other related users' real-world-based social roles by mapping their past ambiences which can be further used to assist information recommendation to John.

In details, for example, we may extract users' data of last month for analysis. Firstly, according to analyzing of the related data using the DSUN model, we can obtain the basic individual groups which can be further used to construct the real-world-based user relationship network.

For instance, one of the groups consists of users John, Lucy and Jack, and our purpose is to identify their social roles. Based on the analysis of these three users' past data, their past ambiences can be described by several factors such as the locations and situations. The similar process will also be used in the current ambience analysis. Since the current ambience is mostly based on the factors in cyberspace, such as the context factor that is influenced by users' time-changing behaviors, in order to identify the social roles in cyberspace, we need to use these factors to find the suitable past ambience. In this case, after analyzing the ambience, one past ambience based on "Mikajima", with some more additional information such as where one campus of Waseda University is located, can be mapped to John and his friends' current ambience.

As discussed above, the ambience based on the location factor "University" may also have many optional role groups such as "professor-student", "resident- visitor". Since the social roles in each ambience can be described by several role attributes such as the individual-based and situation-based attributes, in order to finally identify the social roles, we need to use the users' profile and cyberspace-based position data to identify the role attributes. That is, by analyzing these three users' role attributes such as their ages, titles and positions, we can finally identify that they are in the “professor-student” role group because of the high frequency of location record “Mikajima” and time record beginning around 9:00 am, and ending around 6:00 pm. Moreover, Lucy may play the role of professor because her elder age and high-level of position, and John and Jack may play the student role because of the younger age and low-level position.

Therefore, for John, after the process of ambience mapping and role attribute analysis, we may finally identify his social role which can further be used to describe the real-world-based user relationship network for information search and recommendation support. Comparing with the general role identifying process in an SNS system, in this study, we consider more on the users’ social roles in real-world, which means by this approach, users can find out the real-world relations in cyberspace rather than only the relations in the social media.

3.4 Summary

Since the individual social roles are complex and changing in different situations, in order to identify the dynamical social roles, in this chapter, based on the introduction of basic concept and related analysis, we have modeled the social roles by a set of attributes first, which include the individual-based attributes, the relation-based attributes, the temporal attributes and other related attributes, in order to better understand the characteristics of social roles and further support the individualized information utilization.

Following the analysis of a series of influence factors to correspond the switching situations, a concept of ambience has been introduced and defined as an important factor to identify the social roles. Based on these, we have further built a model to describe the relationship between the social role attributes and ambience influence factors, which can integrate the attributes and influence factors together to support the social roles' identification process as well.

We have also proposed and presented a basic model of social role identification, and described the detailed procedure for ambience mapping and role attribute analysis from both real-world and cyberspace. At the end, we have described a scenario to show how to identify the individuals' social roles by mapping and synthesizing the ambiences and analyzing the role attributes, which can also show the main characteristics different to the general roles identifying process.

Chapter 4 Participatory Information Search and Recommendation Based on Social Roles Analysis

In this chapter, based on the identified social roles, we discuss how to utilize these roles to build users' connections in the SNS system. We also discuss the design and implementation issues of our proposed participatory system, and then describe the functional modules which utilize the social roles and connections to support and empower information search and recommendation. At last, an application scenario is presented with the simulation result of our proposed methods. .

4.1 Framework of Participatory Information Search and Recommendation Based on Social Roles and User Connections

4.1.1 User Connection Network

In a given SNS environment, in order to provide the information search and recommendation service efficiently, after confirming the user roles, the information about users' relationships becomes important. There are already many studies about the representation of users' profiling and relationships, such as the model of Dynamical Socialized User Networking based on the activity streams [67]. In this study, we call these kinds of relationships the user connection network, which can be further used to adjust the search and recommendation modules. Therefore, after identifying the users' social roles, we need to confirm the user connections by analyzing the user roles data.

According to related studies in the field of sociology, in a given environment, the social roles played by people and the expectation from their group which people participate in are bound together [1]. It means that with the same expectation from the same group, other people in the same position play the same roles. Therefore, in cyberspace, according to the main social roles the user plays, it is possible that there are other users who play the same roles

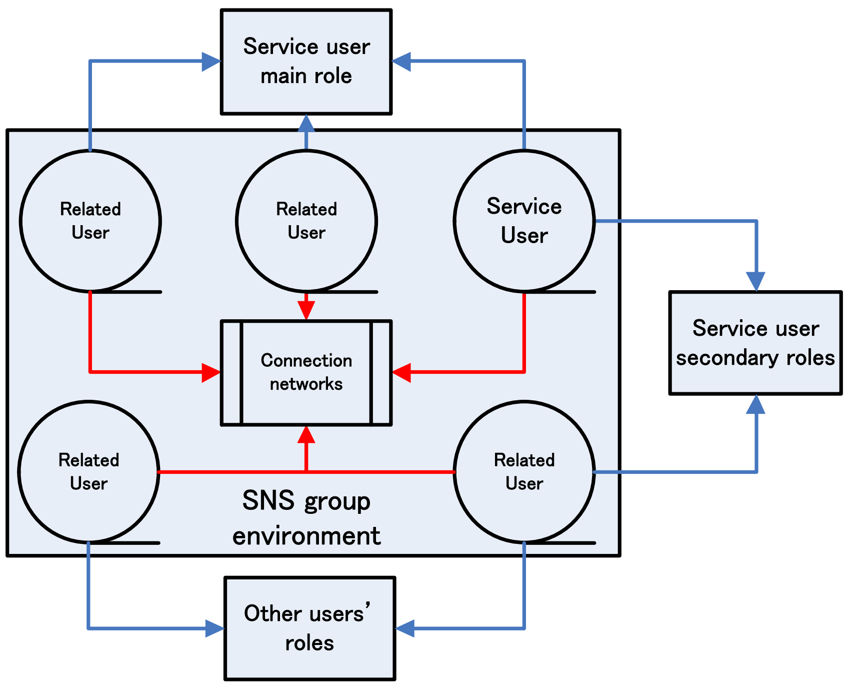

Figure 4-1 The user connection networks in an SNS system [12]

As shown in Figure 4-1, according to their different roles, users can be classified into different groups, in which we refer to the user who is using our system as the service user, and refer the user who connects to the service user as the related user.

And the relationships among these groups may have many types such as cooperation or competition. In this case, the roles will be the key to define the relationships of users even if these users may not know each other. However, the main role is not the only element to decide the relations, according to the situation, even if the users are in the different groups which are classified by their main roles, they can be in the same group which are classified by their secondary roles.

As a result, we can have a list of users who are in the similar position of the service user by analyzing their main role and secondary roles. On the other hand, in addition to the list which we get, with the classification of the users we can draw the relationship schema based on the users' connection networks. The relation schema includes the users' roles and connections, which can be used to identify and confirm the users' positions in a certain group. It means that we confirm not only the users who have the same position, but also the opposite or other types of position of users to support the search and recommendation.

4.1.2 Participatory Search and Recommendation

In order to provide the personalized information services efficiently, the main part of our system will be the participatory search and recommendation. As a participatory system in our approach, the information sources include other users who are in the same SNS system. However, in the SNS system there may be many users, so that at first we need to confirm who are the suitable users. In the research field of information recommendation, there are many ways to filter the users such as to analyze their interests. But the traditional methods did not consider about the position of users in the given group. With the complex relationships among the users, only considering the user interest becomes not enough anymore. Therefore, in this study we conduct the filtering process by analyzing the service user's social roles and connection networks in the information environment.

The main point of our approach is the keyword "participatory", which means the users will work together to build an efficient system [68]. There are two types of participation ways: the initiative way and the passive way. The initiative way is the one which is considered as a type of search engine that operates based on the principle of the convergence of information technology and human power [69]. With the users joining in the search spontaneously, this kind of search method can get more information which cannot be collected in the traditional ways. However, the human user involved method is not stable, and it is hard to judge the quality of user participation. Oppositely, by analyzing the roles which the users play, we can classify the users into different levels that can help us decide the weight of their information. Therefore, in our system, after confirming the suitable users, we collect and analyze their feedback information according to their social roles and connections, and then use them to adjust the results in a dynamic way.

On the other hand, the initiative methods have a defect that the users may not have time to provide feedback which we need. Therefore, the passive participation way will be more important for us, which uses the positions and relationships among the users to help us filter the information for the further search and recommendation process based on the confirming of suitable users who will be the information sources. Thus, following this way, users do not need to update their information initiatively, when the social roles and connections change with the change of time and environment. Besides, in order to capture the dynamical change of user roles as well as their connections, we also need to collect the feedback information from the users who participate in. Differing to the collection of feedback which has been mentioned in the initiative method, the feedback data is also collected in a passive way such as using the user tracking technology.

In our study, we use both of the methods to design our search and recommendation services based on the data of user roles and connections. The framework and architecture will be discussed in the next section.

4.2 System Architecture

The system, as shown in Figure 4-2, consists of three components: the preparation module, the participatory search module, and the dynamically personalized recommendation module. In this framework, the search and recommendation modules receive the data from the preparation module. The preparation module also receives the data from the other two modules as the feedback information. Therefore, the system will run in a dynamical way which can adapt to the change of users' roles and relations.

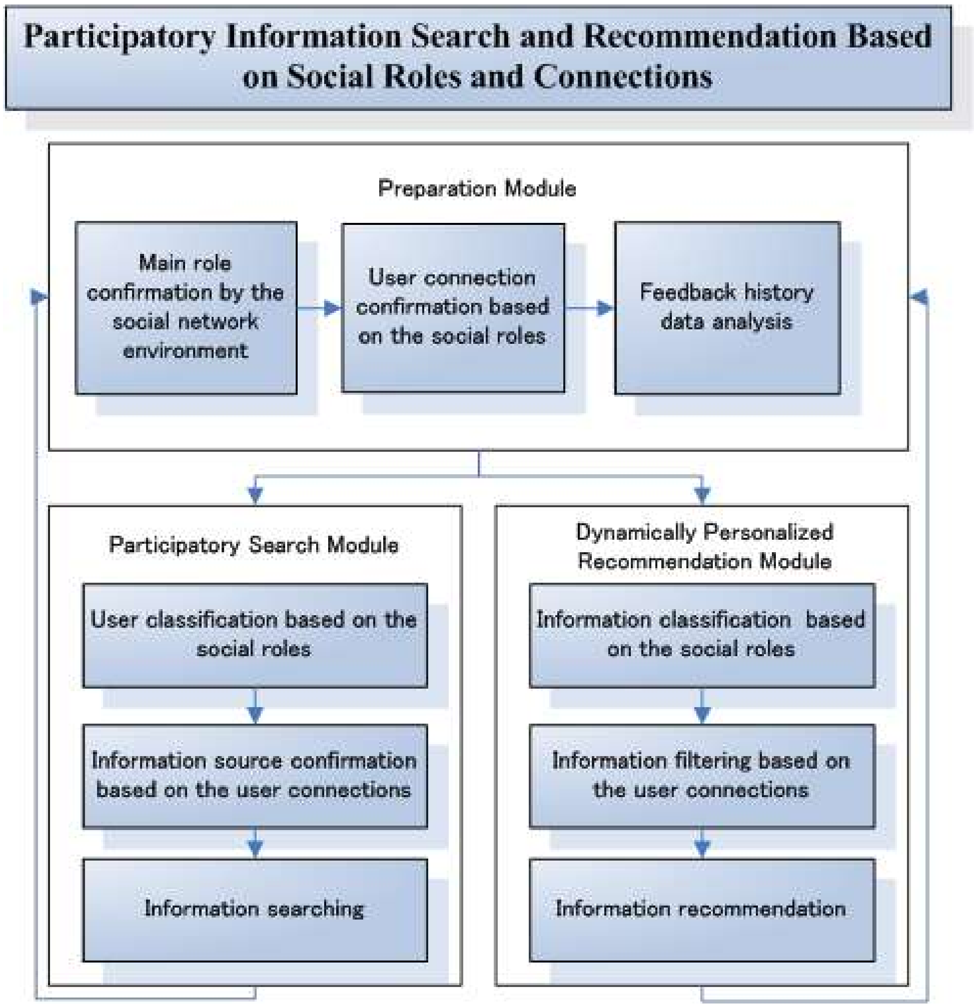

Figure 4-2 The basic framework of system [12]

4.2.1 Preparation Module

In order to save the computing and users' time, we need to process the data which can be analyzed offline before providing to the service users. Therefore, the purpose of this module is to collect the preparation data which will be used in other modules. In our system, the preparation data includes two types of data: the user roles and the user connections, and each of the data needs to be worked out by analyzing of users' registration information but not the instant information from the users.

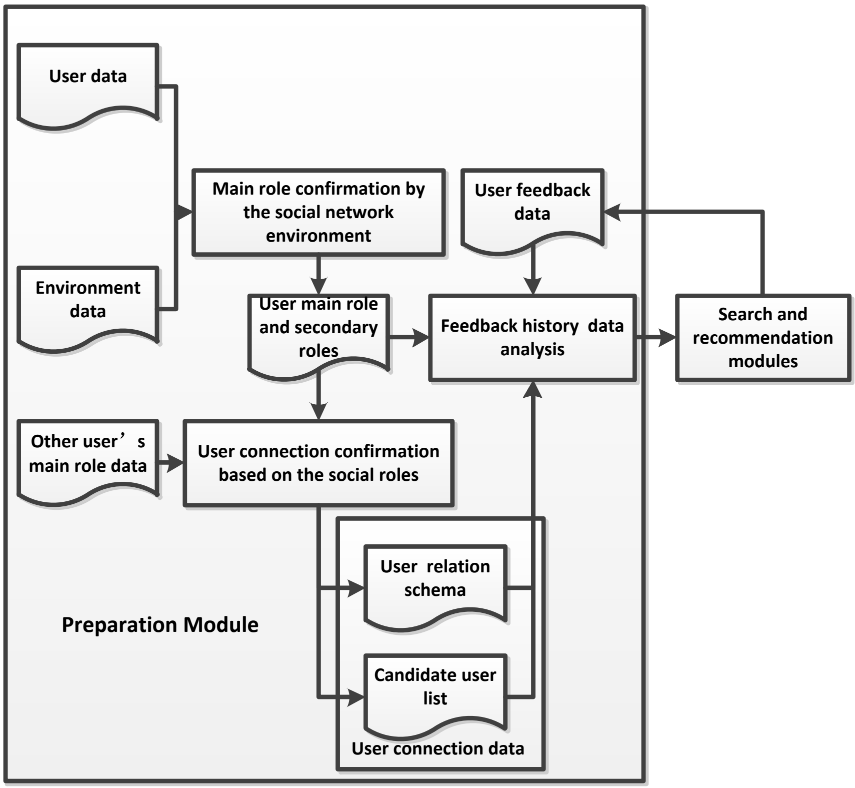

Figure 4-3 Preparation module [12]

As shown in Fig. 4-3, according to the basic data of users, we can identify and confirm the users' roles including the main role and the secondary roles. The main role is important to classify the user groups, while the secondary roles are necessary to analyze the user relations. The second step of the preparation module is the confirming of users' connection networks. In a given information environment, based on the analyzing of main role data which belongs to the service user and other users, we can confirm the users' positions and finally have the user relation schema and the candidate user list.

4.2.2 Participatory Search Module

Such as in Wikipedia and other Web 2.0 based websites, in order to provide the information service efficiently, the users' power could not be ignored. On the other hand, in a given environment, the importance of search results for the service user depends on users' different positions. Therefore, in this study, we propose a participatory method which takes the users as the information sources to search the useful information based on the users' social roles and their connections.

The purpose of this module is to identify and confirm the suitable users based on the searcher's keywords in the SNS system, and then take them as the main search sources, even if they may not in the searcher's friend list. As shown in Fig. 4-4, in order to confirm the suitable users and then retrieve the suitable information, this module consists of three main parts to search information based on the service user's social roles and connection networks.

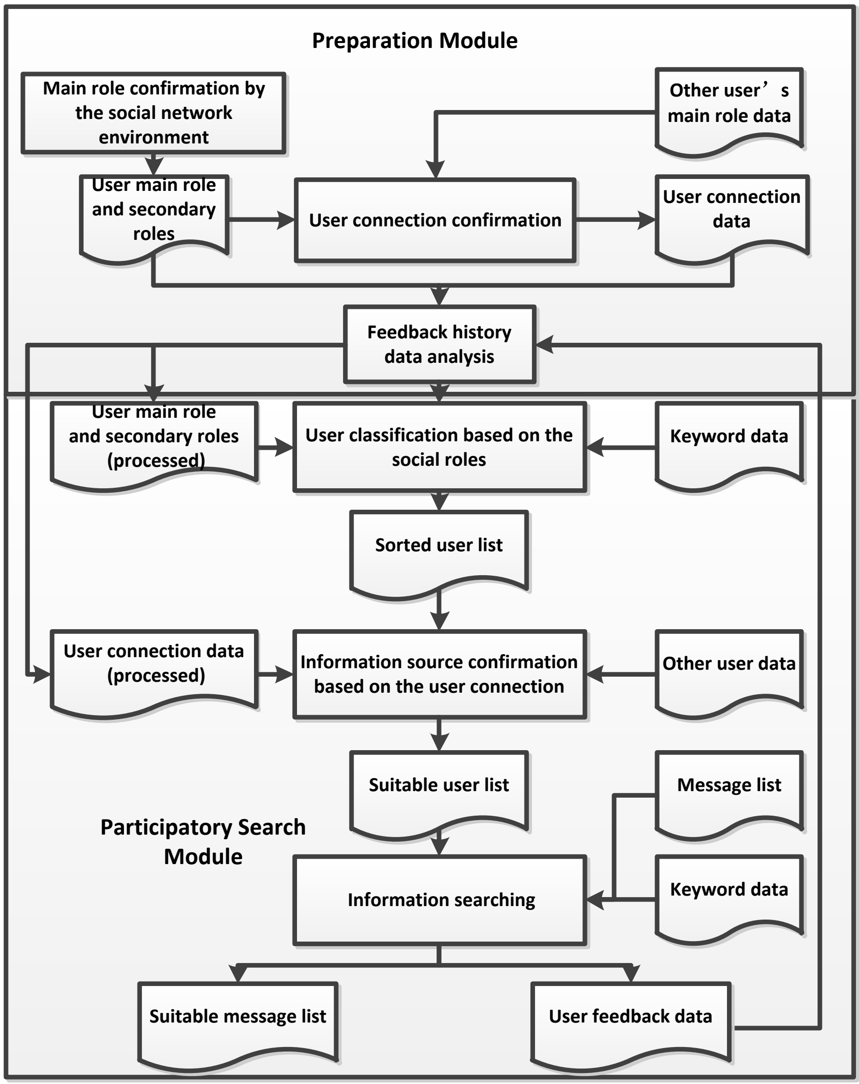

Figure 4-4 Participatory search module [12]

After receiving the preparation data which includes the processed user roles and connections from the preparation module, the first part of this module is the user classification based on the social roles which users play. According to the search keywords, we can classify the users into different importance levels by analyzing the social roles. We can have a user list which includes the users who are suitable to participate in the information search work, and the list will be sorted by their importance levels. However, in this part of the module, only the users who have the direct connections with the service user can be selected.

With the sorted user list, the second part of the module is employed to confirm the final suitable user list by analyzing the service user's connections. According to other users' data, we can confirm the users who play the same roles in the given environment. Therefore, the final list includes not only the friend of users but also the users who are playing the similar roles in the SNS group.

Table 4-1 Procedure of participatory search [12]

Input: The user set U: $\{u_1, u_2, \ldots, u_n\}$

Service user u_i with Keyword K_i

Output: The suitable message list $Mps_i\{m_{i1}, m_{i2}, \ldots, m_{is}\}$

Step 1: For each user u_j, calculate the role r_{jk} and the connection c_{jk} in each group g_l, where $g_l \in G = \{g_1, g_2, \ldots, g_m\}$, which are classified by users' relationships

Step 2: For service user u_i, based on keyword K_i and users' relations, filter the related users from each group g_l, and further sort them by the importance of User u_i's role to form the group set G'

Step 3: For user u_j in each group g_l', based on the connection c_{jk}, confirm their related levels to service user u_i and then identify and select the suitable users in each g_l' to form the suitable user list L_{ip}, as well as the list set $\{L_{i1}, L_{i2}, \ldots, L_{im}\}$

Step 4: Based on the suitable user list set $\{L_{i1}, L_{i2}, \ldots, L_{im}\}$ and keyword K_i, find the useful message list $Mps_i\{m_{i1}, m_{i2}, \ldots, m_{is}\}$ and send to user u_i

With the final suitable users and their messages, the last part is to search and output the suitable message list to the service user based on the keywords. In addition, the system also records the feedback data which belongs to the searcher and the users in the list, and further sends them to the preparation module in order to adjust the next search process. The detailed procedure is shown in Table 4-1.

4.2.3 Dynamically Personalized Recommendation Module

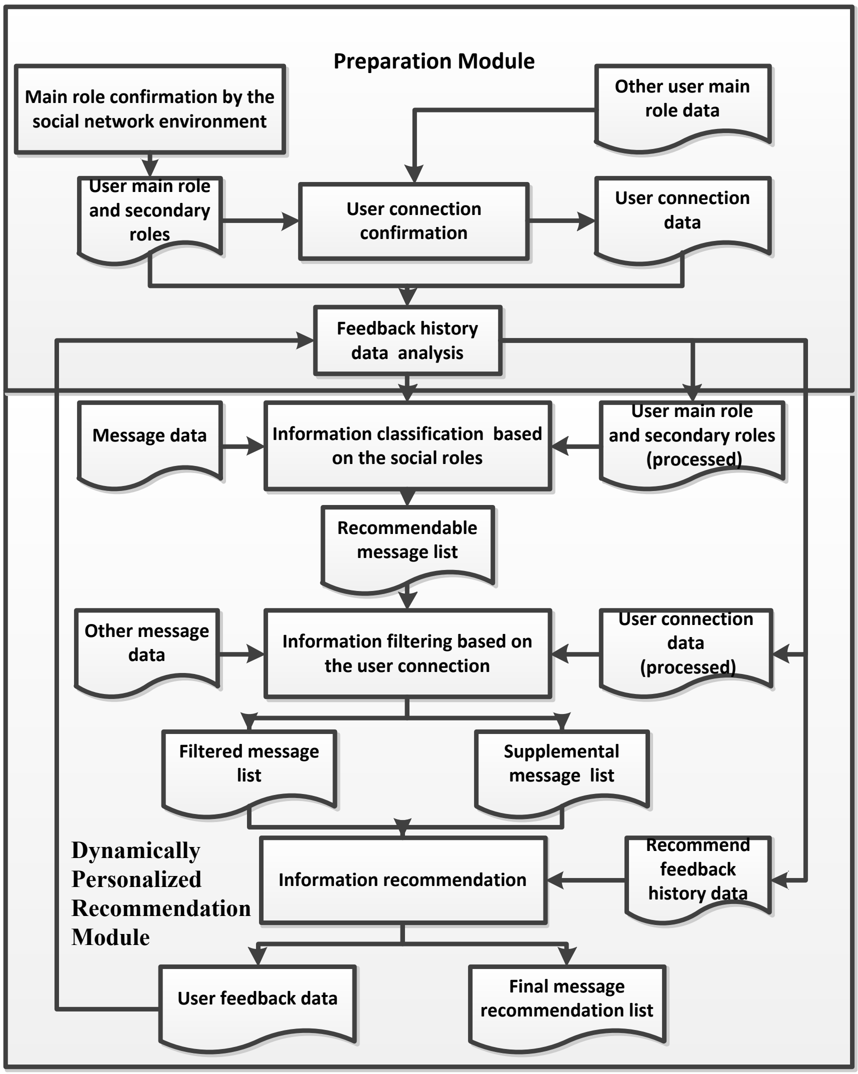

Figure 4-5 Dynamically personalized recommendation module [12]

In addition to the information search service which uses the users as the information sources, in order to provide information more efficiently and timely, information recommendation service is conceived. Differing to the searching module, the recommendation module doesn't have a keyword. Therefore, in this module we need to filter the recommendable information from the huge number of user messages.

When the users participate in many SNS groups in the system, it is hard to confirm which group’s messages are more important than others. Therefore, in this module, our main purpose is to filer the messages in order to improve the quality of information based on the analyzing of the social roles and their connections. As shown in Fig. 4-5, the recommendation module has three main parts described as follows.

After receiving the processed data of user roles and connections from the preparation module, differing to the search module, the first part aims to use the processed social roles data to classify the messages sent by the users. Different roles have their different weights for the service user. Therefore, by analyzing the different social roles which a user played in the different group, we can know which group’s messages are more important to the service user and then classify and output them as the recommendable message list.

However, according to the group which the service user participates in, the message list may be huge and hard to be used for recommendation. Therefore, the second part of this module is to filter the messages with the user connections. Based on the other users’ messages, this part is of two purposes: to filter the redundant information and to merge the supplemental information. After the processing, the messages will be sorted and ready to be recommended.

Table 4-2 Procedure of dynamically personalized recommendation [12]

Input: The user set U: $\{u_1, u_2, \ldots, u_n\}$

Service user u_i

Output: The recommended message list $Mpr_i\{m_{i1}, m_{i2}, \ldots, m_{ir}\}$

Step 1: For each user u_j, calculate the role r_{jk} and the connection c_{jk} in each group g_l, where $g_l \in G = \{g_1, g_2, \ldots, g_m\}$, which are classified by users' relationships

Step 2: For service user u_i, based on his/her role r_{ik} , classify the messages into different groups and record as set $MG_i = \{mg_{i1}, mg_{i2}, \ldots, mg_{im}\}$ which are sorted by the importance of user u_i's role

Step 3: For messages in each sorted group mg_{it}, according to the connection c_{ik}, delete the redundant information and merge the supplemental information generated from different users, and return the message group set MG_i'

Step 4: Return the recommended message list m_{iq} from each mg_{it}' and form the recommended message list $Mpr_i\{m_{i1}, m_{i2}, \ldots, m_{ir}\}$

Based on the message list which has been filtered, the final part is to recommend the suitable information to the user. Differing to the search module which has a certain keyword, the suitable messages recommended to the user will change with the user's interest. Thus we need to consider about the feedback history data as the parameter to provide the recommendation service dynamically. The recommendation services are based on the users' social roles and connections, and for different service users, the user roles and connections may be different even the users are in the same group. Therefore, with this module, we can provide personalized recommendations to the different service users. The detailed procedure is shown in Table 4-2.

4.3 Application Scenario and Simulation Result

In this session, firstly, we describe a scenario which shows how analyzing of social roles and networks in the SNS group can enrich user communication experience by providing users the relationship schema in each given information environment. Based on these, we further show a simulation to demonstrate how our framework can provide users with personalized recommendation services by analyzing their social roles and connections.

4.3.1 Application Scenario

Take a specific user John for instance, we assume that he logs in the SNS system (such as Twitter) one day, but even John himself doesn't know what information he really needs. He only types a tweet like "This video is good. Everybody should have a watch!" into the system. Usually, before other users reply or retweet this message, this message will not be involved into a communication process, and John does not know who will be interested in this topic. We assume John's information behavior history can be recorded, such as his log of communication with other users. After selecting a specific keyword (e.g., "video") in this message, the related users will be classified into a certain group. By analyzing John's social roles in these groups, we can finally obtain his group-based relationship schema. For instance, we can extract messages of last one month for analysis. The result may show that in that month John joined in some discussions related to the topic "video". Based on this, we can firstly create a list of groups which refer to this keyword "video", and the list may be sorted by the importance of social roles which John played in these groups. Furthermore, based on his relationship schema in each groups, we can also provide a user list which is sorted by their position levels. Moreover, further analysis may also help us to find John's dynamically changing roles or positions in these discussion groups.

Therefore, for John, after the analysis of the suitable groups and users with the keyword "video", we may finally provide the recommended messages which are related to this keyword first, and then show him the recommended users based on his relationship schema. In other words, John can receive the useful information, which can further guide his future information behaviors in order to achieve his goals. All these discussed above can contribute to enriching the user's communication experience.

Comparing with the general communication process in an SNS system, in this study, we focus more on the users' social roles, which means that by using our approach, users can find out the suitable users and their messages according to their social roles and positions. In addition, users can also be recommended the information from other users who are determined by their social roles and positions (such as the messages from users who play the same roles in a group). Furthermore, this social role based communication may not only provide users with enriched experience, but also help them to recognize their own positions, which can go further to guide their behaviors in the further communication within this group. For example, when using our methods in the SNS such as Twitter, by analyzing a user' social roles, when the user logs in to the system, he/she can receive more useful messages with the detailed explanations including which group the messages come from, so that the user can select the interesting ones as the feedback information to the system, which will make the recommendation process in a dynamical way. On the other hand, by using the keywords which are typed by users or collected from their messages, our approach can guide the user to search related users and messages according to the role-based relationship schema.

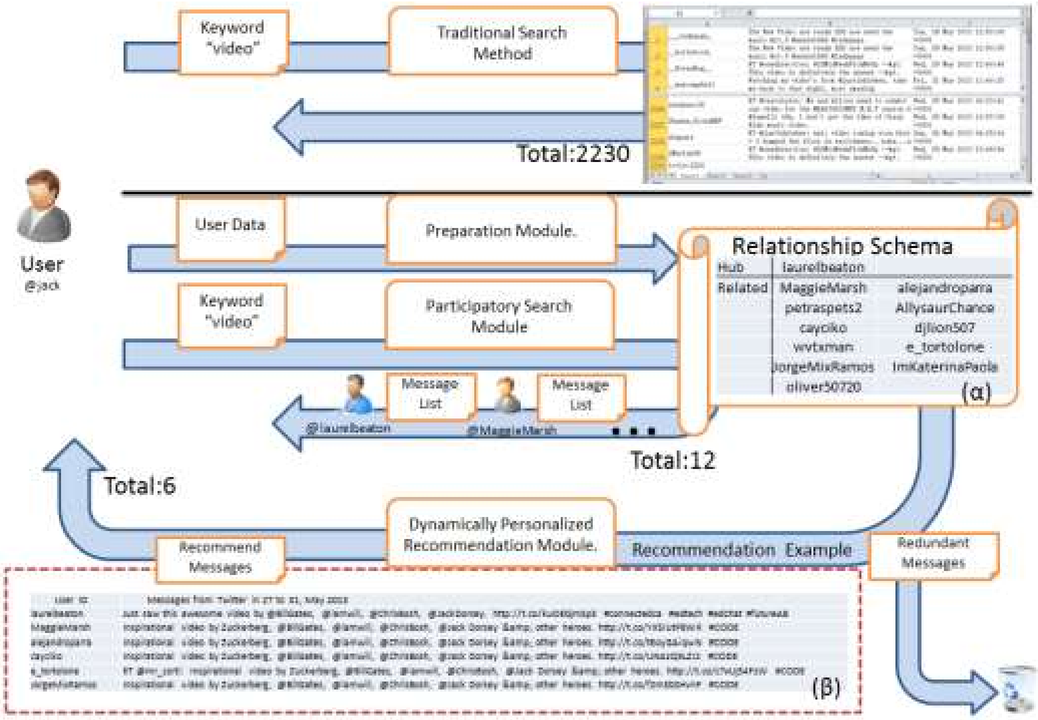

Figure 4-6 Snapshot of scenario based simulation [12]

4.3.2 Scenario Based Simulation

For a specific user @jack who and his friends send mass of messages in Twitter, we analyzed a data set of 400,122 tweets collected from Twitter from May 27 to 31, 2013. With user @jack and a specific keyword such as "video", the result of traditional search methods will be a set of related messages (total 2,230), it is hardly to judge which one will be more important. We further optimize the results using our methods,

At first, in the preparation module of our system, based on the analysis of users' related information, as well as their feedback history information, we identify and confirm user @jack's main role and connections in each group which are classified by their relationships. Furthermore, with these roles and connections, we create the group-based relationship schemas which can be shown to @jack so that he can know his positions in these groups. For example, in a specific group for him, after the role and connection analysis, we may finally construct a relationship schema with 12 users (α in Fig. 4-6 and Table 4-3) including one hub user (the most active and initiating user in the group) and other ranked related users.

Table 4-3 Users extracted from twitter based on keyword “video” [12]

Hub User	**laurelbeaton**			
Related User	**MaggieMarsh**	**alejandroparra**	**petraspets2**	**AllysaurChance**
	cayciko	**djlion507**	**wvtxman**	**e_tortolone**
	JorgeMixRamos	**ImKaterinaPaola**	**oliver50720**	***jack***

Comparing with the traditional methods, when user *@jack* uses our participatory search system to find useful messages with the keyword *“video”*, according to the relationship schema from preparation module, the result will be a list of users with their messages which have been ranked by their group positions. For example, according to the different levels of roles, hub user *@laurelbeaton* in the group will have a high position in the group-based user list. Finally, user *@jack* will have a list of refined messages which is sorted by their related degree.

Table 4-4 Example of recommended messages [12]

User ID	Messages
laurelbeaton	Just saw this awesome video by @BillGates, @iamwill, @ChrisBosh, @JackDorsey. http://t.co/kuOE0jmSp3 #connectedca #edtech #edchat #futureAB
MaggieMarsh	Inspirational video by Zuckerberg, @BillGates, @iamwill, @ChrisBosh, @Jack Dorsey & other heroes. http://t.co/YXSIUtP8WR #CODE
alejandroparra	Inspirational video by Zuckerberg, @BillGates, @iamwill, @ChrisBosh, @Jack Dorsey & other heroes. http://t.co/tEoyGAiqwN #CODE
cayciko	Inspirational video by Zuckerberg, @BillGates, @iamwill, @ChrisBosh, @Jack Dorsey & other heroes. http://t.co/UNAzQ5LZI2 #CODE
e_tortolone	RT @mr_corti: Inspirational video by Zuckerberg, @BillGates, @iamwill, @ChrisBosh, @Jack Dorsey & other heroes. http://t.co/c7xUj54FzW #CODE
JorgeMixRamos	Inspirational video by Zuckerberg, @BillGates, @iamwill, @ChrisBosh, @Jack Dorsey & other heroes. http://t.co/f2mSbSHvnF #CODE

Table 4-5 Example of less useful messages [12]

User ID	Messages
AllysaurChance	@florentdechard @CodySimpson what better place to make a video than my cinematic arts department at my school in jacksonville?????
djlion507	#BAILALONAMA #VIDEO #ESTRENO http://t.co/sZ5VFKSYae l @duboskyMusica y @bcapanama By @JAHIREVENTMUSIC @oliver50720
ImKaterinaPaola	RT @djlion507: #BAILALONAMA #VIDEO #ESTRENO http://t.co/sZ5VFKSYae l @duboskyMusica y @bcapanama By @JAHIREVENTMUSIC @oliver50720 @Jacke_D11 @D11Artz
oliver50720	RT @djlion507: #BAILALONAMA #VIDEO #ESTRENO http://t.co/sZ5VFKSYae l @duboskyMusica y @bcapanama By @JAHIREVENTMUSIC @oliver50720

Table 4-6 Example of redundant messages [12]

User ID	Messages
petraspets2	RT Inspirational video by Zuckerberg, @BillGates, @iamwill, @ChrisBosh, @Jack Dorsey & other heroes. http://t.co/tEoyGAiqwN #CODE
wvtxman	RT Inspirational video by Zuckerberg, @BillGates, @iamwill, @ChrisBosh, @Jack Dorsey & other heroes. http://t.co/tEoyGAiqwN #CODE

In addition to the user list from the search module, our system can also recommend messages to users using the dynamically personalized recommendation module according to different keywords. For example, as shown in Tables 4-4, 4-5 and 4-6, based on the keyword "video" and the identified relationship schema, the specific user @*jack* will finally receive six most relevant and useful messages (Table 4-4) from the hub user @*laurelbeaton* and other users such as @*MaggieMarsh,* while other six messages which may be viewed as less useful or redundant messages for him will be dropped (β in Fig. 4-6, Table 4-5 and Table 4-6). Comparing to 2,230 messages selected by traditional methods, for the same keyword, the numbers of messages which the user @*jack* received from our system can be reduced to six most relevant messages.

4.4 Summary

In this chapter, we have proposed a framework of participatory information search and recommendation based on the analysis of users' social roles played in different communications within a social group, in order to recommend users with more related information that best fits their requirements, which can further facilitate the information seeking process in the SNS environment.

We firstly discussed the user connection networks which can be identified by using the social roles. Then, by using the two types of information, user social roles and connection networks, we proposed the framework of participatory information search and recommendation system, and discussed the design and implementation issues of the system's functional modules. Finally, we have shown and discussed an application scenario with the simulation of our proposed system.

Our approach has focused more on the utilization of users' participation. According to confirmation and analysis of users' social roles and connections, the system can identify and confirm the most relevant and useful users and their messages in a dynamical way. Comparing with the traditional methods of information search or recommendation, we considered more about the users' roles both in cyberspace and real-world. Moreover, we have introduced and built a relationship schema to store users' roles and connections, and further confirm users' positions, which can support the search and recommendation process in a more efficient way.

Chapter 5 Collective Decision-Making Support Based on Social Roles Analysis

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In this chapter, the social choice theory and the corresponding processes are introduced, and a hierarchical model of social roles is proposed to support collective decision-making. Then, a mechanism is developed to facilitate the opinion collecting, voting, and negotiation processes based on the analysis and identification of social roles. Furthermore, a Netlogo-based tool is developed to simulate the collective decision-making processes in a Course Offering Determination (COD) system.

5.1 Social Choice Theory and Collective Decision-Making Model

5.1.1 Six Processes Based on Social Choice Theory

The social choice theory is concerned with the design and analysis of methods for collective decision-making [70]. There are six topics based on the theory: preference aggregation, voting theory, resource allocation and fair division, coalition formation, judgment aggregation and belief merging, and ranking system [71].

Thus, according to the theory, in a decision-making system, such as the COD system, six main processes should be considered. The first process is to obtain users' original opinions, which aims to collect users' first decisions without other users' influence. The second one is the voting process, which lets every user evaluate other users' decisions. The third process is to calculate the weight of each user's voting, which will be utilized to calculate the voting results of all the decisions in the second process. Specifically, considering the different importance and contribution of each user in the collective decision-making processes, in this study, the weight of each user's voting will be calculated based on the analysis results of users' social roles during this process. The fourth one is the user grouping process, in which users will be assigned into different groups based on their voting results. The fifth one is the negotiation process, in which users will discuss on the voting results of decisions within each group or among groups. Finally, the sixth process is to re-rank the voting results based on the discussing results. These processes will be repeated in a circle until a consensus decision of all the users is made.

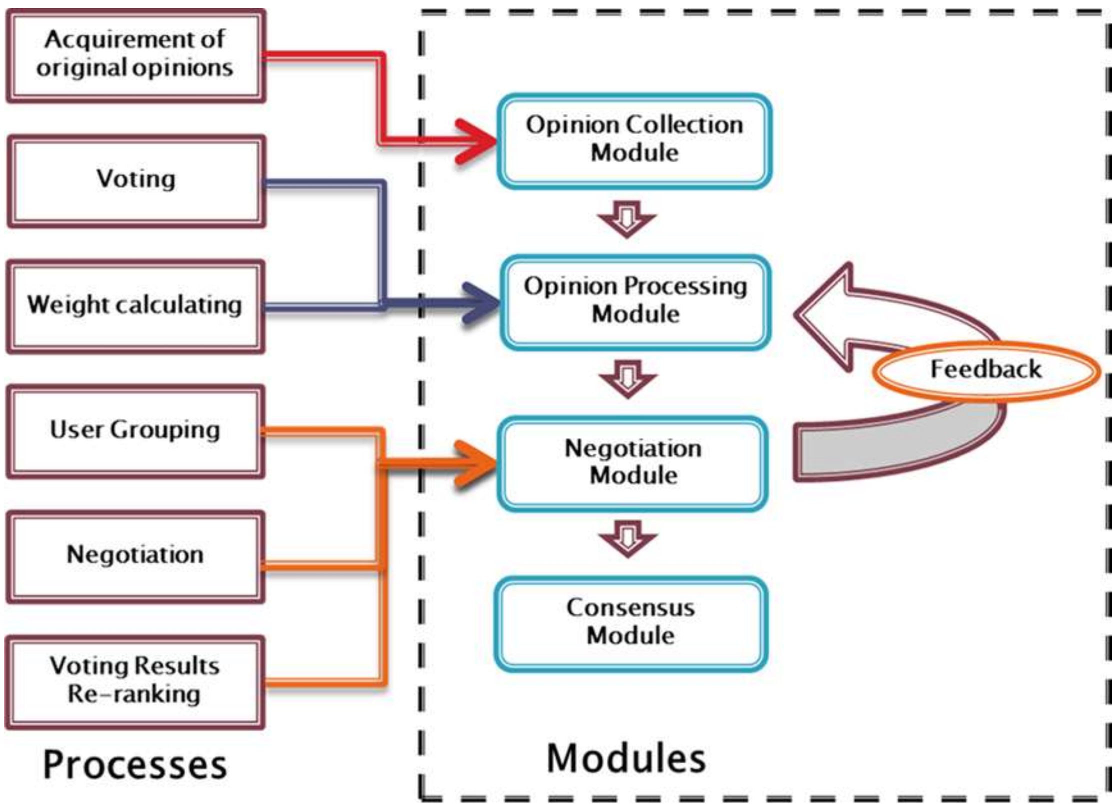


Figure 5-1 Collective decision-making support model [13]

5.1.2 Collective Decision-Making Model

Based on the six processes discussed above and multi-agent technologies [72], the collective decision-making support model is conceived to consist of four major modules as shown in Fig.5-1.

(A) Opinion Collecting Module

At first, we need to know all users' direct opinions and preferences as the basic data, which can be collected through the questionnaire. This module includes one process: the acquirement of original opinions.

(B) Opinion Processing Module

Users' opinions may be changed by others' influence. Therefore, after obtaining users' direct opinions, the second module is to share the information among all individuals and then help them make the new decisions after being possibly influenced by other users. Many methods can be used for it, such as voting and auction. Moreover, different decisions from different individuals will be assigned with different voting weights. Therefore, this module includes two processes: the voting process and the weight calculating process. In this study, factors, such as the social roles, are taken into account in this module. After the discussions are made among the users, their opinions may be changed based on the feedback data. In order to obtain the final decision, these processes may be conducted many times.

(C) Negotiation Module

In order to support the collective decision-making processes, we need to consider not only the individual's opinion, but also the whole social community's. Therefore, users are classified into different groups by analyzing their opinions. And then they will discuss together and re-rank the results. This module includes the rest three processes: the user grouping, negotiation, and voting results re-ranking processes. After the discussion, we need to find a balance point to reach the final decision. Therefore, the negotiation process also needs to be repeated many times and send feedback of the related data to the opinion processing module. And the analysis of social roles is expected to observably improve the efficiency in this process.

(D) Consensus Module

The last step is to achieve the consensus. After the discussions in the negotiation process, the weights of the voting results should be re-calculated and re-ranked. If the top one opinion's weight is higher than the threshold, it can be considered as the final collective decision.

5.2 Hierarchical Social Roles Model

In this section, to facilitate the collective decision-making processes, a three-layer model is presented to analyze users' social roles which can be viewed as an important element for the acceleration of achieving the consensus. After discussing the identification of social roles in different layers, an integrated mechanism is developed to utilize the analysis results of social roles for the collective decision-making process support.

As shown in Fig. 5-2, based on our discussion for social role analysis and identification in Chapter 3, a hierarchical model is proposed to categorize the social roles in both real-world and cyberspace into three layers: the content layer, individual profile layer, and relation layer, which can be employed to assist the different modules discussed above, corresponding to the collective decision-making processes.

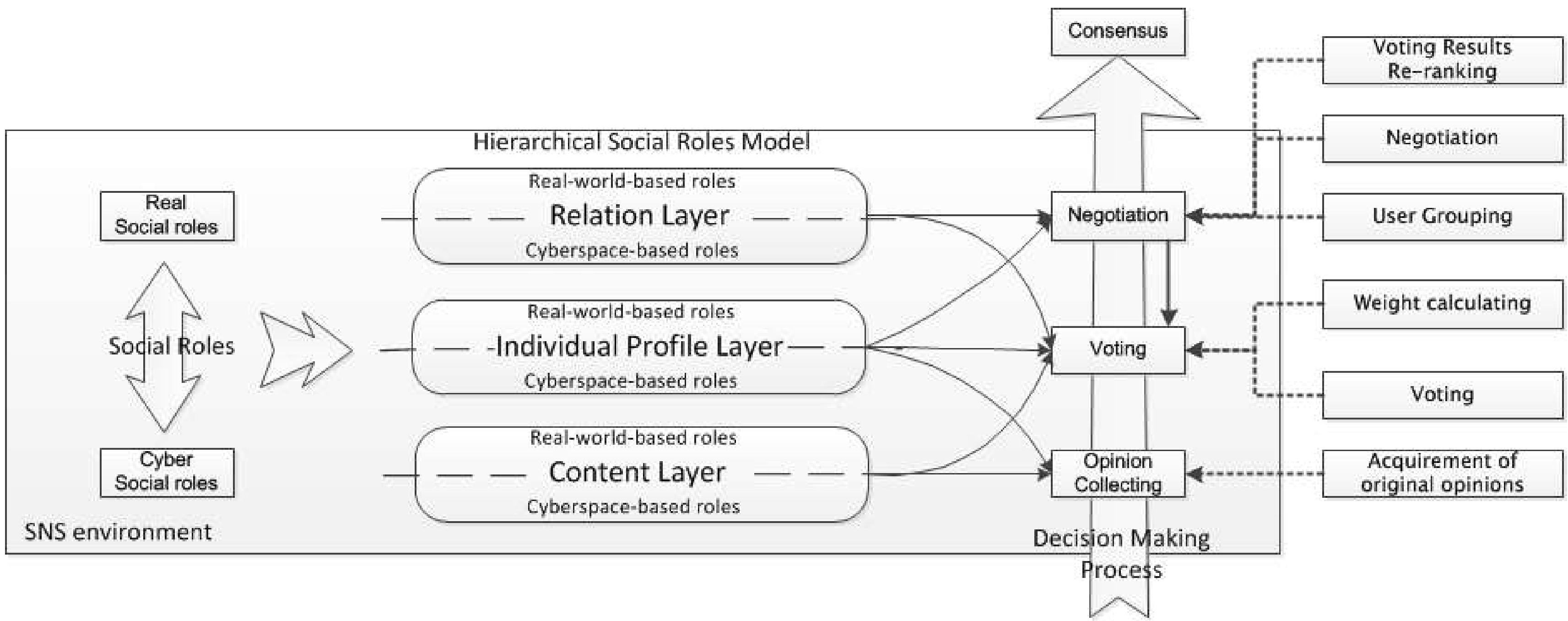


Figure 5 2 Three-layer model for social roles analysis corresponding to collective decision-making processes [13]

5.2.1 Content Layer

This layer includes the social roles which are decided by the contents along with the actions in both real-world and cyberspace, such as the roles (e.g., the commissary in charge of studies) decided by the academic record in real-world, or the roles (e.g., active/non-active user) decided by the frequency of information behaviors in cyberspace. By analyzing these roles, individuals' history actions will be extracted and recorded as reference information, which may help individuals confirm their opinions finally. For example, in a COD system, before a specific user selects the courses, a course-offering history record data from the commissary in charge of studies who has high academic scores, or other users who continuously keep active in the system, may provide good examples for the references. Besides, the analysis of the roles in this layer can also be used to assist the calculation of voting weight in the decision-making processes.

5.2.2 Individual Profile Layer

This layer includes the social roles which are decided by the individuals' profile. For instance, in real-world, the roles can be identified based on the gender or occupation. And in cyberspace, the roles can be identified based on the user experience in the system (e.g., the time of using the system). Note that the social roles in this layer can be used in all the modules in the decision-making processes. For example, for a course of dance, the vote from a female dancing teacher who has much experience may become more important.

5.2.3 Relation Layer

This layer includes the social roles which are decided by the relations among individuals, such as the roles based on the positions in both real-world (e.g., teacher and student) and cyberspace (e.g., opinion leader and following user). Due to the characteristics of relation-based roles, in addition to supporting the calculation of voting weight, the roles in this layer are of special importance in the negation module. For example, in the negotiation process, a professor or system administrator's opinion could be considered as more important.

5.3 Support Mechanism for Collective Decision-Making Processes

As we discussed above, the social roles are classified into six different types within the three layers. To assist the dynamical identification process of various social roles in different situations, we mine and analyze the personal and social data related to a group of individuals in the social networking environment. Specifically, users' different positions are utilized to identify their alternative roles.

Usually, in a certain group of people, someone may be in the "strong/high" position, while others in the "weak/low" positions, such as the roles of professor and student in a laboratory in real-world. Individuals who are in the "strong" position may result in the roles (e.g., professor) which will have more influence for negotiation. Therefore, based on the analysis of the personal and social data from the SNS system, we can obtain data on the individuals' positions, which can be utilized to identify the social roles and further help decide the voting weight in the negotiation process.

In details, in the content layer, in order to analyze individuals' positions to identify the social roles, the related personal stream data [73] of each user is extracted and organized from the SNS system. For example, with the mining of individuals' academic record data, we can obtain the individuals' positions within all students, which can help identify the roles in terms of their academic records in this layer.

In the individual layer, we analyze individuals' dynamical profiling built based on the behavioral data mining to analyze their different positions. For instance, the identification of the hub user [74] can be employed to analyze individuals' different positions regarding to some specific issues. Specifically, the hub user is defined as the user who continuously shares and delivers information, and has influenced a lot of other users. Therefore, we can use the identification of hub user to obtain individuals' higher positions, which will lead to the powerful roles in the collective decision-making processes.

In the relation layer, the DSUN (Dynamically Socialized User Networking) model, which is built in accordance with the analysis of organized social streams [75], is used to identify individuals' different social roles. For two users i and j, the weight w_{ij} can be calculated by:

$$w_{ij} = \varphi\ (ImR_{ij},\ ExR_{ij}) \tag{5.1}$$

where, ImR_{ij} denotes the implicit relationship, while ExR_{ij} denotes the explicit relationship. The implicit relationship means those relations that cannot be perceived directly from the SNS, and the explicit relationship means those relations that can be detected directly from the SNS. Thus, we analyze individuals' different positions based on the mining of their dynamical and potential correlations within a certain group, and further identify their different roles.

The Delphi method, which is a consensus-building tool that allows, promotes, and encourages the involvement of all stakeholders during the evaluation framing process [76], is widely employed in the collective decision-making processes. In this study, the analysis of six types of social roles is utilized to improve the Delphi method, in order to facilitate the collective decision-making processes.

According to the Delphi technique, the final decision is determined by multi-times of negotiations. In this study, based on the hierarchical model we discussed above, individuals' opinions may be influenced by the social roles categorized in these three layers, including the real-world-based role δ_r and the cyberspace-based role δ_c in the content layer, the real-world-based role θ_r and the cyberspace-based role θ_c in the individual profile layer, and the real-world-based role ϑ_r and the cyberspace-based role ϑ_c in the relation layer.

Using the COD system as a case study, let $C = \{c_1, c_2, c_3 \dots, c_n\}$ be a set of courses in the system, where *n* is the number of the courses. Our main purpose is to gather individuals' decisions in order to confirm the preference degree list *P* for all the courses. The number of users is *m*. The procedure of the support mechanism is shown as follows.

Step 1: For each course *i*, considering each user *k*'s social role influence S_{R1}, which is based on the roles in the content layer and individual profile layer, the evaluation value can be calculated as follows.

$$d_{ik} = F(S_{R1}, e_{ik}) \tag{5.2}$$

where, $k = 1, 2, \dots, \text{m}$. e_{ik} is defined as the user's evaluation and it can be calculated as follows.

$$e_{ik} = \begin{cases} (0,1] & if\ the\ user\ has\ given\ evaluation \\ 0 & else \end{cases} \tag{5.3}$$

The social role influence parameter $\mathrm{S_{R1}}$ can be calculated as follows.

$$S_{R1} = \alpha(\delta_r + \delta_c) + (1-\alpha)(\theta_r + \theta_c) \tag{5.4}$$

where, $\alpha \leq 1$. The evaluation results can be recorded in a matrix as follows.

$$\begin{bmatrix} d_{11} & d_{12} & d_{13} & \dots & d_{1m} \\ d_{21} & d_{22} & d_{23} & \dots & d_{2m} \\ d_{n1} & d_{n2} & d_{n3} & \dots & d_{nm} \end{bmatrix}$$

For each course i, in each line of the matrix, calculate the average value $\bar{d}_i$ and variance value v_i as follows.

$$\bar{d}_i = {}^{1}/_{m} \sum_{k=1}^{m} d_{ik} \qquad i = 1,2,\dots,n \tag{5.5}$$

$$v_i = \sqrt{{}^{1}/_{m} \sum_{k=1}^{m} (d_{ik} - \bar{d}_i)^2} \quad i = 1,2,\dots,n \tag{5.6}$$

Step 2: Feedback the results in *Step 1* to all users. After the negotiation, in the new round of evaluation, for each course i, considering the social role influence S_{R2} , which is based on the roles in the individual profile layer and relation layer, the evaluation value can be calculated as follows.

$$d_{ik}' = F(S_{R2}, e_{ik}') \tag{5.7}$$

The social role influence parameter S_{R2} can be calculated as follows.

$$S_{R2} = \beta(\theta_r + \theta_c) + (1-\beta)(\vartheta_r + \vartheta_c) \tag{5.8}$$

where, $\beta \le 1$. The evaluation results in the new round can be recorded in a matrix as follows.

$$\begin{bmatrix} d_{11}' & d_{12}' & d_{13}' & \dots & d_{1m}' \\ d_{21}' & d_{22}' & d_{23}' & \dots & d_{2m}' \\ d_{n1}' & d_{n2}' & d_{n3}' & \dots & d_{nm}' \end{bmatrix}$$

For each course i, in each line of the matrix, calculate the average value $\bar{d}_i'$ and variance value v_i as follows.

$$\bar{d}_i' = {}^{1}/_{m} \sum_{k=1}^{m} d_{ik}' \qquad i = 1,2,\dots,n \tag{5.9}$$

$$v_i' = \sqrt{{}^{1}/_{m} \sum_{k=1}^{m} (d_{ik}' - \bar{d}_i')^2} \quad i = 1,2,\dots,n \tag{5.10}$$

Step 3: We assume that after l times of loops, it achieves that the variance value $v_i^{\,l} \le \epsilon$, where ϵ is the threshold given in advance. That is, repeat ***Step 2*** until the variance value $v_i^l \leq \epsilon$. The final matrix of the evaluation results is:

$$\begin{bmatrix} d_{11}{}^l & d_{12}{}^l & d_{13}{}^l & \dots & d_{1m}{}^l \\ d_{21}{}^l & d_{22}{}^l & d_{23}{}^l & \dots & d_{2m}{}^l \\ d_{n1}{}^l & d_{n2}{}^l & d_{n3}{}^l & \dots & d_{nm}{}^l \end{bmatrix}$$

Step 4: Calculate the average value $\overline{d_\iota}^l$ for each course as follows.

$$\overline{d_\iota}^l = {}^1\!/_m \sum_{k=1}^{m} d_{ik}{}^l \qquad (5.11)$$

Finally, we can have the results list *P* as follows.

$$P = \{ \overline{d_1}^l, \overline{d_2}^l, \overline{d_3}^l \dots, \overline{d_n}^l \} \qquad (5.12)$$

5.4 Application to COD and Simulation Experiment

In this section, we introduce a case study of the COD (Course-Offering Determination) system [77], and discuss the simulation experiment which demonstrates a comparison between our proposed method and the Delphi method.

5.4.1 Course-Offering Determination

We assume the COD system integrated with a social network application (such as a Twitter-like system, e.g. Status-Net [78]) to allow the students to publish comments, discuss with the professor and/or other students, and vote/negotiate about the courses which may be offered in the coming semester. This will assist students to choose the courses, and help the professors and university staff to make the teaching plans.

Having lots of different courses to choose, students may feel difficult about how to select. Therefore, any reference information or chance to discuss with other students will be helpful to them. Because of the different characteristics among the system users, when making the final decision, it is not possible for all students, professors and staff to have the same voting weights. We try to use our method to benefit all students, professors, and staff for the facilitation of decision-making processes in this course-offering determination process.

Based on the discussion above, considering the influence of social roles, two major functions are implemented into the system.

(A) Providing Reference Information

Since it is sometimes difficult for people to know their own needs clearly when they face making decisions. Through this function, our system will provide an interface for users to collect their direct opinions. And then, according to filtering of the social role based historical data, our system will provide the users with the useful information (such as the historical decisions data in the previous semester) as the reference to help them to determine their opinions.

On the other hand, in the negotiation process, since the number of users is large, it is difficult to check all of their opinions. Therefore, this function can also provide the users with the related information from other users by analyzing their social roles.

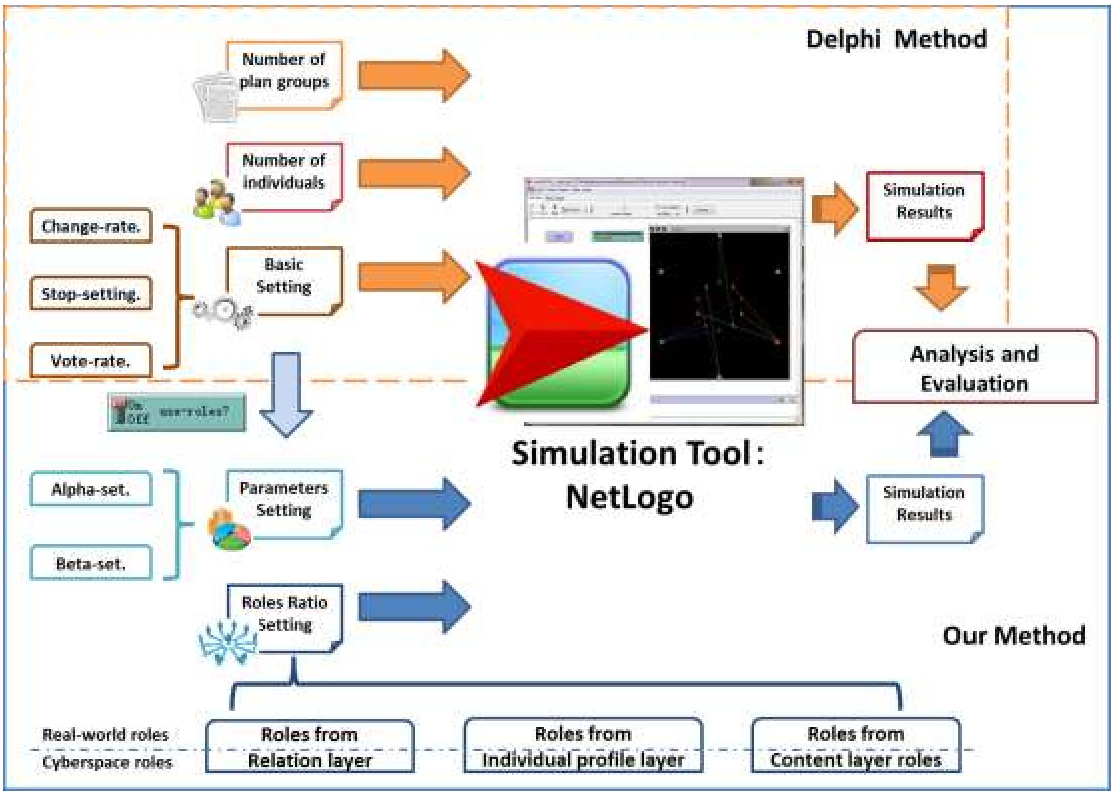


Figure 5-2 Simulation workflow [13]

(B) Collecting Opinion

Since people may sometimes have different positions in real-world and cyberspace, by this function, based on the social roles analysis, the users will be assigned with different voting weights, in order to make the voting process more effective and efficient.

In this system, in addition to the voting process, since it is often difficult to reach the consensus when people have different opinions, the negotiation process is needed. Therefore, when a negotiation process begins or becomes complex, we can use the voting weight in this function to support the negotiation process.

In order to test the system with our methods, we used Netlogo [79], which is a multi-agent programmable modeling environment, to integrate and implement these functions.

5.4.2 System Simulation with NetLogo

We simulate a course-offering process with two different decision-making methods, namely, our proposed method and the Delphi method, as shown in Fig. 5-3.

(A) Simulation Setting

According to the mechanism and the COD system environment we discussed above, at first, as the general setting, we set up two basic parameters: num-groups (the number of plan groups) and num-individuals (the number of users who are involved in a specific decision making process). In this case study, the plan groups represent a set of courses, and the individuals include the students, professors and administers, etc.

In order to control the simulation, we set up other three parameters, the change-rate, vote-rate and stop-setting. Since the individuals may not change their decisions in each negotiation, we set the change-rate to decide the probability of decision change. Similarly, we set up the vote-rate to adjust the probability whether the individuals change their opinions. At last, the stop-setting is used for setting the threshold to stop the simulation. In this case study, the variance value is employed as the threshold to reach the consensus.

In addition to these parameters to control the simulation process of the Delphi method, as for the social roles setting, two other sets of parameters are utilized to control our social role based method. One set of parameters is the alpha-set and beta-set. These two parameters are used to adjust the impact factors α and β which we mentioned in ***Step 1*** and ***Step 2*** in Section 5.3. According to the social analysis which we discussed in Chapter 3 and Section 5.3, another important set of parameters is the roles ratio setting, which represents the composition of social roles in terms of the six types. For instance, the "Rlayer-R-high-scale" indicates the ratio of individuals who have a "strong/high" position in the relation layer of real-world. Based on our methods, the ratio of the roles can be identified among totally six types (including each layers' real-world/cyberspace roles) within the three layers.

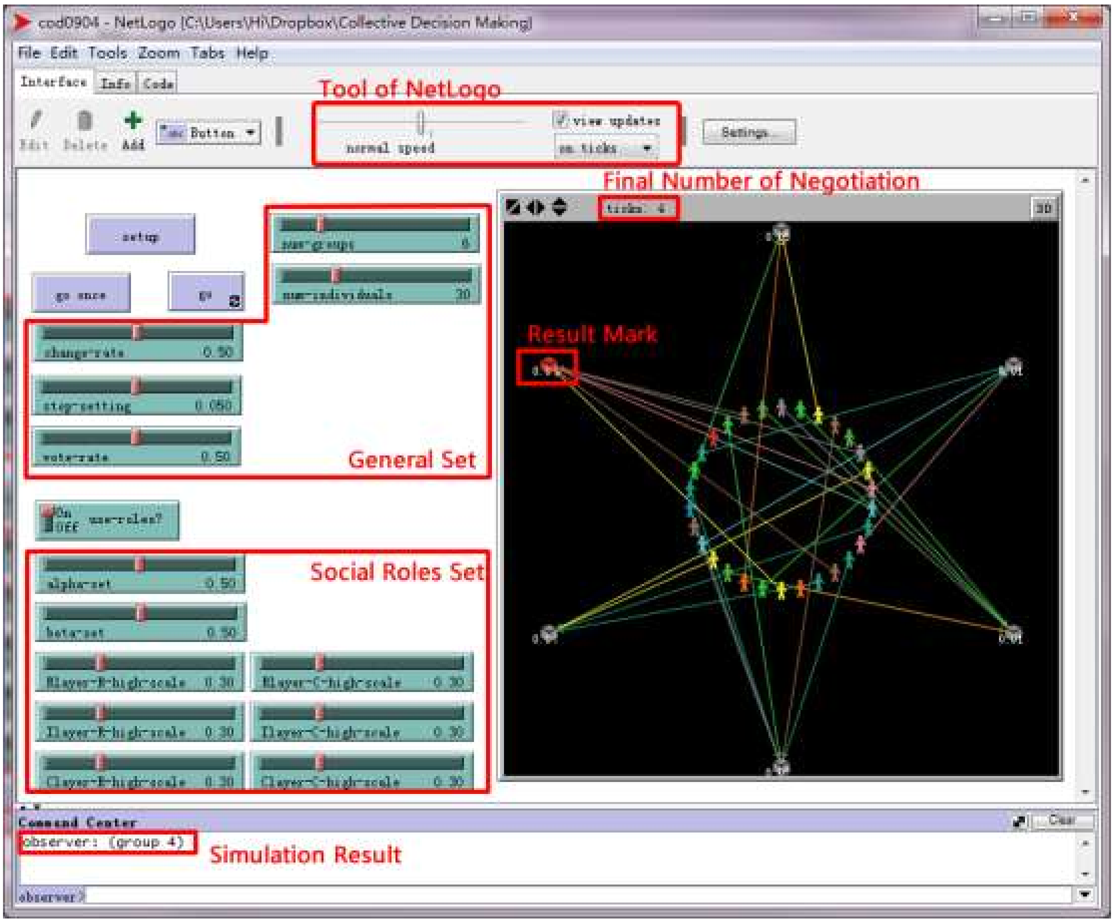


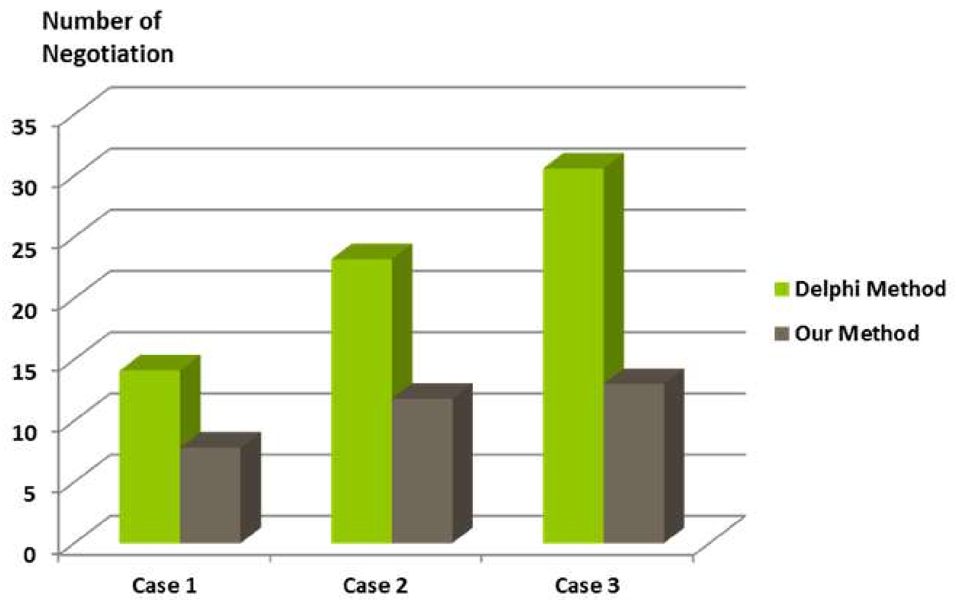
Figure 5-3 Simulation snapshot [13]

(B) Simulation Process

After setting up all the parameters and choosing the running mode (e.g., the Delphi method mode or the social role based mode), the simulation begins from Step 1 by pressing the button "setup", after which all the users get into the initial state that they have finished their first round voting. Then, we click the button "go once" to run the negotiation process. That is, every time the button "go once" is clicked, one new round of negotiation will be conducted, and the result will be demonstrated in the screen. We use the icons of "person" and "box" to simulate the individuals and the plan groups. As shown in Fig. 5-4, after one round of negotiation, each user will have a tendency to each plan group, and the average score of each plan group will be shown under each “box”. For a specific user, the line connected him/her to one group indicates his/her highest tendency among all the groups. This process will be repeatedly conducted, until the final consensus is achieved, and the total negotiation times will be shown on the top of the screen.

(C) Comparison and Evaluation

Using the simulation results, we conduct the evaluations to compare our social role based method with the Delphi method in two experiments.



Case 1	6 groups, 60 users	vote-rate	0.5
Case 2	12 groups, 60 users	change-rate	0.5
Case 3	6 groups, 30 users	stop-setting	0.05

Figure 5-4 Simulation results with different case settings [13]

Firstly, we conduct the comparison experiment to evaluate the performances under different numbers of plan groups and users. In details, three cases: (1) six plan groups with 60 users; (2) 12 plan groups with 60 users; and (3) six plan groups with 30 users, which simulate three different situations, namely, few plan groups to many users, many plan groups to many users, and few plan groups to few users, are utilized to evaluate the performances of both two methods. Each case was repeated for ten times for the negotiation using each method. The results are shown in Fig. 5-5.

On the other hand, we evaluate the performances of both methods under different thresholds to reach the consensus. In details, based on a large number of experiments using our developed tool, three thresholds of 0.04, 0.45 and 0.05, are selected for the comparison experiment. Likewise, we conducted ten times under each threshold for both two methods respectively. The results are shown in Fig. 5-6.

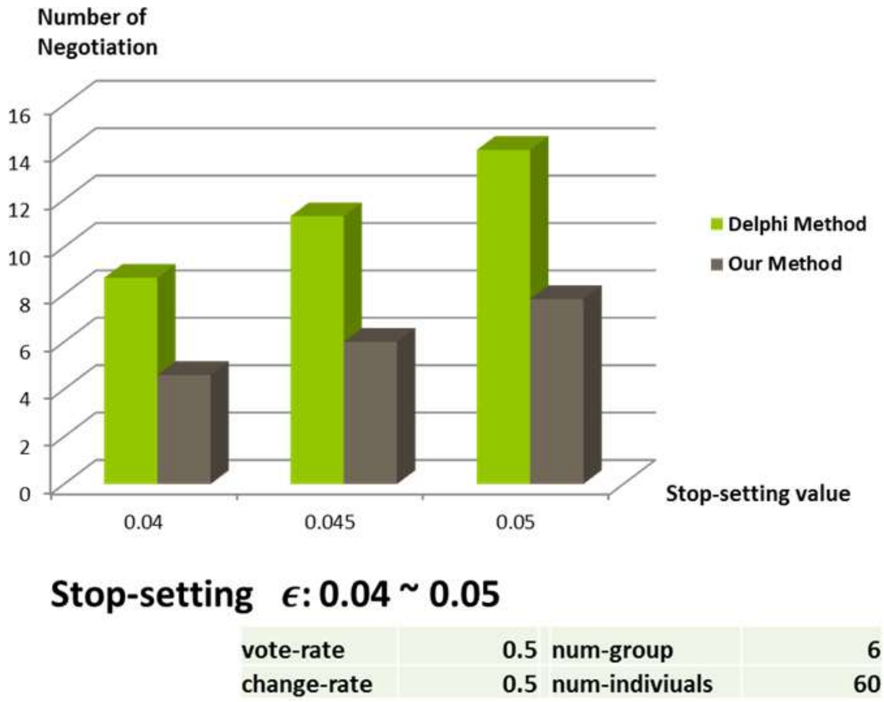


Figure 5-5 Simulation results with different stop-settings [13]

5.5 Discussion

According to the two experimental results shown in Fig. 5-5 and Fig. 5-6, our method averagely has fewer negotiation times (nearly half) comparing with the Delphi method, which indicates that people may reach the consensus more quickly when using our social roles based method in a collective decision-making processes. As shown in Fig.5-5, under the same setting (vote-rate = 0.5, change-rate = 0.5, stop-setting = 0.05), our method performs much better in Case 1 comparing with other two cases. It indicates that our method would lead to better results in the situation when many users face to a few of plan groups.

On the other hand, as the comparing results shown in Fig. 5-6, a smaller stop-setting value will lead to a better result, which means in our method the stricter the consensus requires, the better result we may obtain.

5.6 Summary

In this chapter, following the introduction of the social choice theory and a collective decision-making model, we have proposed an integrated method to support the collective decision-making process based on the analysis of individuals' social roles.

Firstly, we have proposed a collective decision-making support model based on the social choice theory. Then, we have presented a three-layer model of social roles for the collective decision-making support and described the identification of social roles in these three different layers respectively. Based on these, an integrated mechanism was proposed and developed to support the collective decision-making process aided by analyzing users' social roles in both real-world and cyberspace.

As a case study, we applied our proposed approach to the COD system, and developed a NetLogo based tool to demonstrate the negotiation process using our proposed social role based method and the Delphi method respectively. The evaluation experiments showed the effectiveness comparing with the traditional method. Finally, an application scenario was presented to show how the enhanced system can support the collective decision-making process based on social roles analysis.

Chapter 6 Conclusion

In this chapter, after a brief summary of this study, we discuss the features of our proposed models and approaches and their limitations. Finally, we give some promising perspectives on future work.

6.1 Summary of This Study

In this study, we have made effort to develop a computational approach to modeling and analyzing the social roles, and apply our proposed models and approaches to information behavior support.

Firstly, we have overviewed previous research work on analyzing and identifying users' social roles, building of user relationships, and their utilizations. We have further surveyed related work on information behavior support, such as information search and recommendation, and decision-making process support.

We have proposed a model of social roles analysis and identification by introducing a set of basic attributes, such as individual-based, relation-based and temporal attributes, and a set of influence factors, which we called ambience, such as location, situation and context. We have further presented a basic model for social roles identification by mapping of the real-world influence factors and synthesizing with these factors in cyberspace toward an integrated analysis.

Moreover, we have presented a framework of participatory information search and recommendation system based on analysis of users' social roles and their connection networks, in which users are also taken as information sources. We have developed necessary algorithms and supporting mechanisms, and discussed the design and implementation issues for such a system utilizing users' social roles and their connection networks. We have showed the evaluation result with a scenario-based simulation using Twitter data set, which demonstrated an efficient recommendation of more relevant messages could be made by our proposed model and method.

In addition, we have applied the concept and approach to support collective decision-making process. We have proposed a collective decision-making support model and a three-layer model of social roles analysis corresponding to the collective decision-making processes, and developed an integrated support mechanism based on DSUN, which was proposed in our previous work. A NetLogo based tool has been developed to simulate the negotiation process, which can be utilized to demonstrate and compare different decision-making methods. Experiment results have shown that our proposed methods and systems are useful and effective.

Finally, major features of this study can be summarized as follows.

- Modeling and analyzing of users' social roles in terms of basic attributes and influence factors (ambience factors) in both real-world and cyberspace

- Mapping the ambience factors from real-world into cyberspace so as to analyze and identify the social roles in an integrated way
- Information filtering based on users' social roles and connections for participatory information search and recommendation, in which users are taken as information sources
- Collective decision-making processes support based on the social choice theory and a hierarchical model of social roles

We highly expect the outcome of this study can support and facilitate a wide variety of human information behaviors, from information search and recommendation to collective decision-making, and promote individualized information utilization and sharing among larger group of individual users in both cyberspace and real-world and across cyberspace and real-world.

6.2 Limitations

However, there are some limitations and unsolved issues left in this study.

- For participatory information search and recommendation presented in Chapter 4,
    - As for the experiment, the data set from Twitter was limited, which resulted in a limited simulation result.
    - Comparison experiments with other related works should be conducted to

evaluate our proposed framework and method.

- For collective decision-making support presented in Chapter 5,
  - In the simulation, the weights of coefficients were set in an empirical way, which should be improved with a systematic method or optimized with more experiments.
  - Comparison experiment of our social role based method has only been conducted with a baseline method, i.e., the Delphi method. More comparison experiments with other improved methods should be conducted for a better evaluation.

6.3 Future Work

As for future work, we will improve the design and implementation of our proposed methods and related algorithms, in addition to overcome the limitations discussed in Section 6.2. Furthermore, Performance evaluation experiment shall be conducted to improve our proposed mechanisms and functional models.

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