SMS-based Mobile Recommendation System for Campus Recruitment in China

Xiangpei Hu, Lirong Wu, Chao Li
School of Management
Dalian University of Technology
Dalian, China
drhxp@dlut.edu.cn; wulirong915@163.com

Minfang Huang
School of Economics and Management
North China Electric Power University
Beijing, China
hmf1006@126.com

***Abstract*- This paper presents a SMS-based recommendation system for campus recruitment in China, which can help college placement office to match the companies and students with higher precision and lower cost. We are mainly focusing on profile matching and preference-list-based two-sided matching for further recommendation. With regard to profile matching, three kinds of matching methods (i.e., semantic matching, tree-based knowledge matching and SMS-based query matching) are integrated according to representations of attributes of students and companies, and then the profile similarity degree is acquired. Another focus is to provide two-sided matching from the perspective of central bureau (college placement office). Based on profile similarity degree, the preference lists of companies and students are calculated, which serves as the input of two-sided matching. With the loop matching triggered by the information of SMS-based query&interaction, the matching results would be further optimized and provide more effective guidance for recommendation. The new system embedding SMS-based interaction can raise the matching degree, shorten recruiting period and reduce cost. Furthermore, this recommendation service not only is applicable in the field of campus recruitment, but also can provide a framework for the field of mobile business with the extension to other domains such as hospital-intern and college-student matching and recommendation.**

Keywords- recommendation system; two-sided matching; SMS; campus recruitment; mobile business

I. INTRODUCTION

With the development of modern information and communication technology, mobile business grows fast in various forms and it focuses on attracting new customers in the mobile web markets. Examples of these services include mobile tourist guides, shopping guides for consumers, emergency service for disabled people, etc. The mature market environment provides a great opportunity for mobile business development. Taking China for example, China Mobile and China Unicom have set up the largest mobile communication networks in the world, and the total number of mobile subscribers in China has reached 726 million by the end of 2010[1].

At the same time, the Chinese Short Message Service user group has been increasing rapidly in recent 10 years. As an advanced technology, SMS provides an agile communication measure with lower price, and is popular among Chinese people, especially young people. Besides technologies, many external factors such as economic development level, market competition, cultural difference, etc., together lead to a successful SMS user group in the world. This huge customer infrastructure means great potential market. New opportunities are likely to occur on both users and providers of mobile business basing on SMS. More and more SMS-based services have been developed and put into practice.

The SMS-based mobile recommendation system for campus recruitment is one of such services with potential market in China. According to our survey and interview with college placement offices, current campus recruiting systems have often been criticized because of their relatively lower matching degree (e.g. information overload or ambiguity), longer recruiting period and higher cost. Briefly speaking, four reasons lead to those problems. Firstly, the requirement descriptions the HR launched were not clear and definite, which resulted in the wider range of requirement and led to job seekers' misunderstanding. Secondly, job seekers who lack essential career planning or can't understand the requirement description thoroughly may apply for the inappropriate positions. Thirdly, the phenomenon that job seekers under greater employment pressure apply for various positions massively and aimlessly would increase the cost of candidate selecting. In addition, most China campus recruitments are hold during October and November; this results in staff overwork. In such situation, the candidates might be selected randomly which leads to worse matching.

In order to deal with those actually practical issues, we are trying to design a campus recruitment recommendation system for college placement office by making use of SMS strengths with the purpose of providing the most suitable students (companies) information for companies (students). Compared with email system, SMS has the advantages of real-time response, lower cost for user interaction, mobility and prevalence. Compared with phone calls, SMS can be used to interact with several users simultaneously, enquire private information, and also be convenient for students who are having classes or meeting. So the SMS-based mobile recommendation system can enhance the matching accuracy, shorten recruiting period for companies and reduce costs.

However, there are special difficulties to develop a SMS-based mobile recommendation system for campus recruiting. The first one is how to generate profiles for company requirement and student requirement according to real-world campus recruitment environment. Secondly, profile matching and preference-list matching are complicated because the attributes are represented in different formats. The third one is how to make use of strengths of SMS in order to provide more precise matching results.

To solve these problems, we are focusing on three detailed questions. 1) Profile representation for company and student. 2) Profile matching methods. 3) Two-side

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matching for further recommendation, which are illustrated in Figure.1.

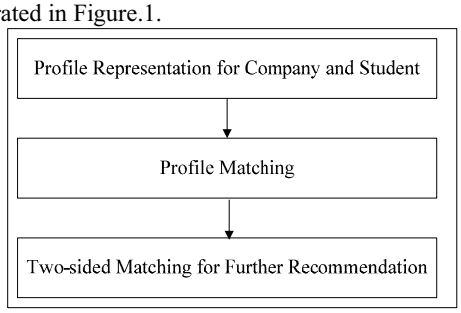

Figure.1 Research structure

The remaining parts of the paper are organized as follows. In section II, we discuss related work including SMS-based service, campus recruitment system, and matching methods. In section III, we focus on the profile representation, profile matching and two-sided matching of preference lists generated from the profile similarity degree, and then present an example to illustrate the recommendation system in section IV. Finally, we draw our conclusions in section V.

II. RELATED WORK

As the exploding of E-business revolution, online recruiting is one of the most successful E-business applications as a method for quickly reaching a large amount of potential jobs or job seekers [2]. Since the late 1990s, it has enjoyed explosive growth as the strong economy produced a high demand for qualified employees [3]. Job boards and resume scanning were the first stage of online recruiting. Job boards were simple websites where employers posted available jobs and job seekers posted resumes [4]. Then, to access the information that the employers are interested in from the resumes, the keyword strategy was introduced. Once employers entered the search parameters, resumes in the database would be marked as a "hit" if it is matched. And some more sophisticated recruiting systems are capable of ranking resumes based on the number of "hits". However, employers quickly realized that keyword searches did not differentiate good applicants from mediocre ones. There have been several other attempts to automate matching between the job seekers' resumes and the demand of employers. Reference [5] suggested using techniques like collaborative filtering to recommend candidates matching a job and [6] proposed content-based measures combined with collaborative filtering for better ranking. Reference [7] introduced a method using relevance models to bridge the divide of vocabulary used in job descriptions and resumes. Major advantages cited for the rapid and successful adoption of E-recruiting methods include cost savings, efficiency, and convenience for both recruiters and job seekers [8, 9]. Even with these e-recruiting systems, employers and job seekers are not satisfied. Many job seekers reported that posing a resume online was the equivalent of sending it into a black hole [10, 11]. Both job seekers and recruiters are not able to keep up with the thousands of new information appearing every day. Besides that, automatic information extraction is not always correct. Especially, it cannot deal with the issues referring to tacit knowledge, such as what kind of information can indicate the candidate has good ability of learning, organizing and so on. So during the informatin age, how to deal with information overload and how to extract the required information become very important.

Nowadays, the rapid proliferation of wireless devices has made mobile commerce (M-commerce) a major driving force for the next wave of electronic commerce (E-commerce). Although there is as yet no standard definition, the term "M-commerce" generally refers to the use of wireless devices (particularly mobile phones) to conduct electronic business transactions, such as product ordering, fund transfers, and stock trading [12, 13]. The power of M-commerce is primarily due to the anytime-anywhere connectivity of wireless devices, which provides enormous opportunities for business process innovation and location-sensitive services [14]. Its applications vary from personal e-payment services and intra-business operations to inter-business supply-chain integration [12, 13, 15].

Many believe that M-commerce is going to substantially extend current operations in E-commerce. Unfortunately, many attempts in M-commerce have so far failed to meet expectations. Especially disappointing was the failure of WAP (Wireless Application Protocol) as a platform for Web access from wireless devices. The primary reason for it is the high cost. Nonetheless, some M-commerce systems combined with Short Messaging Service (SMS) have been successful. Tae-seok Lee and Yuan Yang propose a SMS-based ubiquitous home care system [16]. Susanto introduces SMS-based government in Philippines [17]. Curtin University in Adelaide, Australia has conducted a trial of Library and Information Service integrating SMS [18]. There have been many SMS-based implemented applications and here we are trying to make use of SMS in Campus Recruitment System.

As for how to extract the required information and provide for company (student) with suitable student (company) information, there exist many related research about matching methods to solve this. Fausto Giunchiglia and Pavel Shvaiko [19] proposed a new matching method called semantic matching. This approach is based on two key ideas. The first is that calculating mappings between schema elements by computing semantic relations, instead of computing coefficients rating match quality in the (0, 1) range, as it is the case in the most previous approaches [20, 21, 22]. The second idea is that it determines semantic relations by analyzing the meaning which is codified in the elements and the structures of schemas. Reference [23] expanded and updated the semantic matching method reported in [24] by integrating word sense disambiguation techniques. Besides that, it also gave an in-depth discussion of the optimization techniques that improve the efficiency of the matching algorithm. College admissions face the same problem and [25] provides a fairly complete characterization of ordinal equilibria, that is every ordinal equilibrium yields a degenerate probability distribution, and then relates equilibrium behavior in random and in deterministic mechanisms. Two-sided matching [26] provides a model of search processes such as those

between firms and workers in labor markets or between buyers and sellers in auctions and discusses two many-to-one matching algorithms and matching stability taking hospital-intern for instance.

In summary, based on those three research aspects, we propose a new Mobile Campus Recruitment System which integrates three matching methods together considering the real recruitment situation. The new approach can overcome the weaknesses of single matching method and make great use of SMS for more effective recommendations.

III. RECOMMENDATION PROCESS

In this part, we present the SMS-based recommendation process which mainly focuses on the issues of profile matching and two-sided matching of preference lists. At the very beginning, we represent the attributes of both companies and students with database according to our investigation. Then the database filtering, semantic matching, tree-based knowledge matching and SMS-based query are adopted to match profiles of companies and students. Based on the rank order of similarity degree, the company preference lists and student preference lists are generated. For recommendation stage, two-sided matching is applied for further matching. During this stage, SMS-based query&interaction is incorporated to update matching result for preciser result. The details of recommendation process are shown in Figure. 2.

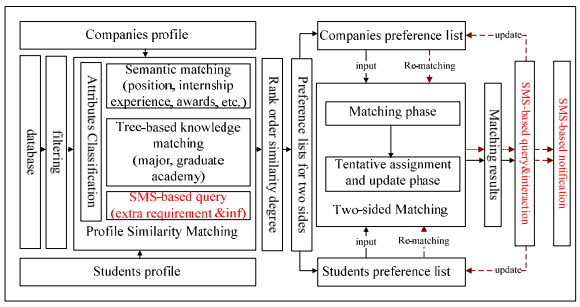

Figure.2 Framework of recommendation process

A. Profiles of companies and students

How the profiles of companies and students are represented plays an important role in the further matching and recommendation process. According to the investigation, we summarize 13 important attributes both company and student concern respectively, and the requirements are represented differently according to their features. The 13 attributes are listed as follows (C_a is the set of company attributes and S_a is that of student):

C_a=P(city, property, gender, education, foreign language, position, major, Graduating Academy, internship experience, foreign language level, awards, personality, extra requirement&inf)

S_a= P(city, property, gender, education, foreign language, position, major, Graduating Academy, internship experience, foreign language level, awards, personality, extra requirement&inf)

According to their features, the 13 attributes are classified into four groups, based on which different matching methods are applied. The details how the profiles are represented are shown in Figure.3

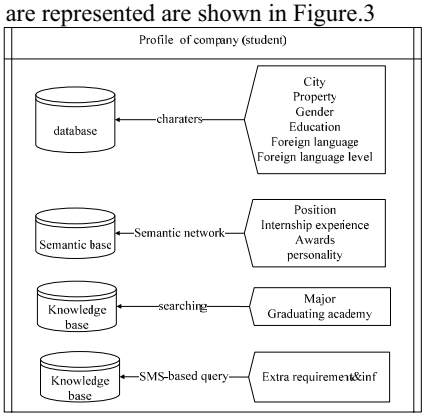

Figure.3 Profile representation

B. Profile matching

In order to narrow the range of profile matching and provide more precise matching results, we will firstly filter the inappropriate profiles according to the value of attributes (city, property, gender, education, foreign language and foreign language level), and then match the profile according to the representation of other attributes. Considering different representation should be matched in different ways, here we employ three kinds of matching methods which are proposed for semantic matching, tree-based knowledge matching, and SMS-based query&interaction.

During the stage of filtering, we use SQL to reduce the number of irrelevant items from the database. For instance, if the company requires male students, the items of female students will be omitted. This is called exact matching. Following steps should be realized in the similarity-based matching component. Table.1 shows the relationship between attributes and matching methods.

TABLE.1 Matching Methods for Grouped Attributes

Attributes	**Matching Methods**		
	Semantic matching	***Tree-based knowledge matching***	***SMS-based Interaction& Query matching***
Position	√		
Internship experience	√		
Awards condition	√		
Personality	√		
Major		√	
Graduate academy		√	
Extra requirement&inf			√

Position, internship experience, awards condition and personality are four important aspects that companies concern, however, those attributes are traditionally matched manually. Unsuitable matching occurs frequently due to misunderstanding or incomprehension of specific content. In our paper, from the profile, we have got the concepts of those attributes, which provide great convenience for us to use concepts similarity to match them.

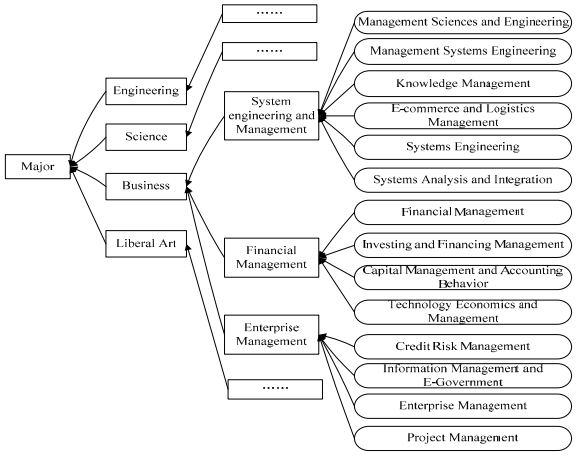

Figure.4 Tree-based knowledge of major

Providing proper matching for attributes of major and graduate academy is also main concern of companies. In this part, we generate a knowledge tree for representing major and graduate academy knowledge (see example of major in Figure.4).

We use $L_i(i=1,2,3,4)$ to represent for every layer, and L_{if} (f=1,2, ⋯ ,6) for *f*th node of *i*th layer relative to previous layer. Accordingly, we set the similarity degree between two layers and within the same layer based on investigation of campus recruitment experience. Taking the *business* for example, similarity degrees are demonstrated below:

$$S(L_i, L_j) = w\frac{1}{|i-j|} \quad (i \neq j, w \subset (0,1)) \qquad (1)$$

$$S(L_{im}, L_{in}) = \begin{cases} 0 & i = 1,2 \\ 1/k & i = 3,4 \end{cases} \qquad (2)$$

Where, *k* is the number of facets with the same father node.

What's more, in current campus recruitment situation, there are often some special information or requirement which both company and student want to know or provide, so here we add an additional attribute *extra requirement&inf* in profile to satisfy this need. However, this attribute might be represented in various forms and we can't employ the same matching method to deal with it. Because of this, we will make use of the strength of SMS to get the similarity degree of *extra requirement&inf*.

In this part, the content of *extra requirement&inf* is automatically sent to the other side, requiring a value of matching degree. This step is applied to avoid invalid matchings. When receiving the kind of short message, the student or company will reply with a value of similarity degree or matching degree. Because this value may be not accurate or trustful, but very important, we need to reevaluate the value according to other attributes based on the reactive value.

After three kinds of matching, we get all the similarity degrees of all the attributes, which are expressed by $A_i(S_m, C_n)$. Then we give every attribute a weight value W_i. So the similarity degree for every pair of student and company is calculated by:

$$Sd(S_m, C_n) = \frac{\sum_{i=1}^{n} W_i A_i(S_m, C_n)}{N} \qquad (3)$$

C. Two-sided matching

According to (3), we get Table.2 to show all the similarity degrees between companies and students. Then by ranking every row and every column, we can get the preference lists of both companies and students, which are as follows:

TABLE.2 Similarity Degrees between Companies and Students

	C_1	C_2	C_3	……	C_n
S_1	$Sd(S_1, C_1)$	$Sd(S_1, C_2)$	$Sd(S_1, C_3)$	$Sd(S_i, C_i)$	$Sd(S_1, C_n)$
S_2	$Sd(S_2, C_1)$	$Sd(S_2, C_2)$	$Sd(S_2, C_3)$	Sd(Si, Ci)	$Sd(S_2, C_n)$
S_3	$Sd(S_3, C_1)$	$Sd(S_3, C_2)$	$Sd(S_3, C_3)$	Sd(Si, Ci)	$Sd(S_3, C_n)$
⋯	$Sd(S_i, C_1)$	Sd(Si, C_2)	$Sd(S_i, C_3)$	Sd(Si, Ci)	$Sd(S_i, C_n)$
S_m	$Sd(S_m, C_1)$	$Sd(S_m, C_2)$	$Sd(S_m, C_3)$	Sd(Si, Ci)	$Sd(S_m, C_n)$

$P(C_n)$ = Student List [Rank order ($Sd(S_1, C_n)$, $Sd(S_2, C_n)$, $Sd(S_3, C_n)$ … $Sd(S_m, C_n)$)]

$P(S_m)$ = Companey List [Rank order ($Sd(S_m, C_1)$, $Sd(S_m, C_2)$, $Sd(S_m, C_3)$ … $Sd(S_m, C_n)$)]

Here $P(C_n)$ denotes preference list of company *n* and $P(S_m)$ denotes prefernce list of student *m*.

For example, suppose that student number *m* is 6, and

$Sd(S_1, C_1) = 0.8$
$Sd(S_2, C_1) = 0.5$
$Sd(S_3, C_1) = 0.2$
$Sd(S_4, C_1) = 0.4$
$Sd(S_5, C_1) = 0.7$
$Sd(S_6, C_1) = 0.9$

Then,

$P(C_1)$=Student List[Rank order (0.8,0.5,0.2,0.4,0.7,0.9)]
=Student List(0.9, 0.8, 0.7, 0.5, 0.4, 0.2)
=[S_6, S_1, S_5, S_2, S_4, S_3]

The results of $P(C_1)$ indicates that company *1* prefer student *6* than student *1*, and prefers student *1* than student *5*, and so forth.

With the reference to NIMP [26], these lists are entered into what may be thought of as a preference-list-processing algorithm consisting of a matching phase and a tentative-recommendation-and-update phase. The first step of the matching phase (the 1:1 step) checks to see if there are any students and companies which are top-ranked in one another's ranking. If no such matches are found, the matching phase proceeds to the 2:1 step, at which the second ranked company on each student's ranking is compared with the top-ranked students on that company's ranking. At any step when no matches are found, the algorithm proceeds to the next step, so the generic *k*:1 step of the matching phase seeks to find student-company pairs such that the student is top-ranked on the company's ranking and the company is *k*th ranked by the student. At any step where such matches are found, the algorithm proceeds to the tentative-recommendation-and-update phase.

When the algorithm enters the tentative-assignment-and-update phase from the *k*:1 step of the matching phase, the *k*:1 matches are tentatively made; i.e., each student who is a top-ranked choice of his *k*th choice company is tentatively recommended to that company. The rankings of the students and companies are then updated in the following way. Any company which a student S_i ranks lower than his tentative recommendation is deleted from his ranking and student S_i is deleted from the ranking of any company which was deleted from S_i ranking. Note that, if one of a company's top-ranked candidates is deleted from its ranking, then a lower-ranked choice moves into the top-ranked category, since the company's updated ranking has fewer students, but the same quota, as its original ranking. When the rankings have been updated in this way, the algorithm returns to the start of the matching phase, which examines the updated rankings for new matches. Any new tentative matches found in the matching phase replace prior tentative matches involving the same student. The algorithm terminates when no new tentative matches are found, at which point tentative matches become final. That is, the algorithm matches students with the companies to which they are tentatively matched when the algorithm terminates. Any student or company position which was not tentatively matched during the algorithm is left un-recommended, and must make subsequent arrangements by directly negotiating with other unmatched students or companies. The two-sided matching process is shown in Figure.5.

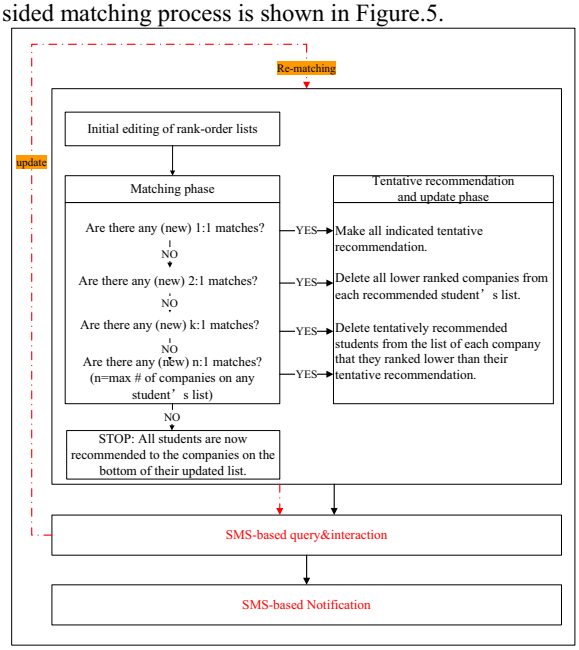

Figure.5 Two-sided matching process

At this step, we get the preliminary matching results, and then proceed to SMS-based query & interaction. Because every company has a quota for desired students, in the matching results we provide more students than the required quota. However, the situation that valid recommendation is higher than quota still can't be guaranteed due to dynamic information and uncertainty of students. In order to deal with this issue, we employ SMS to interact with students about their intentions for interview. According to the reactive information, some preference lists are updated if the system gets negative reaction information, or the preference lists are still valid. The update loop stops when the system receives all the positive reactive information (i.e., the two-sided matching result is optimal and there is no need for updating), and then proceeds to the phase of SMS-based notification.

IV. AN EXAMPLE

In this section, we will demonstrate the mobile campus recruitment system (MCRS) by an example. There are three banks (C_1,C_2,C_3) who want to employ students with the quota of two, three and five respectively, and twenty students (S_1,S_2, ⋯ ,S_{20}) in the database waiting to be matched.

STAGE ONE

Use SQL to filter unmatched students (the number is *x*) based on attributes of city, property, gender, education, foreign language, and foreign language level.

STAGE TWO

Calculate all left $A_i(S_{20-x}, C_3)$ (see profile matching in section 3.2) except for the similarity degree of extra requirement, which is acquired by SMS shown in Figure.6. Then we get the results as shown in Table.2.

STAGE THREE

Generate the preference lists, and get pre-matching result after two-sided matching as below:

$$M = \begin{matrix} C_1 & C_2 & C_3 \\ S_1\ S_3\ S_5 & S_2\ S_4\ S_8\ S_{10} & S_6\ S_7\ S_9\ S_{11}\ S_{15}\ S_{17}\ S_{18} \end{matrix}$$

Then use MCRS to interact with students for further confirmation or rejection, the message is shown in Figure.7. For example, if the answer of S_2 and S_9 are REJECTION, then update the preference lists by deleting S_2 and S_9. Initiate the MCRS once more after we get the re-matching results until all the reactive answers are YES. Then we get the final matching result, for example:

$$M = \begin{matrix} C_1 & C_2 & C_3 \\ S_1\ S_3\ S_5 & S_{12}\ S_4\ S_8\ S_{10} & S_6\ S_7\ S_{19}\ S_{11}\ S_{15}\ S_{17}\ S_{18} \end{matrix}$$

According to this final matching result, MCRS could send messages to every matched student automatically, see Figure.8.

Figure.6 Figure.7 Figure.8

V. CONCLUSION

In this paper, we integrate three matching methods and apply them into the Mobile Campus Recruitment System.

The MCRS presented by the research has a great potential market, as China is becoming one of the largest mobile business markets for its great amount of mobile devices and users. In our paper, the strengths of SMS are used in three aspects. In the stage of profile matching, SMS provides as new tool to acquire similarity degree directly. And in the stage of two-sided matching for further recommendation, SMS-based query&interaction plays the role of initiating multi-matching in order to get preciser recommendation list, and also of notification tool.

Furthermore, this recommendation service not only is applicable to the field of campus recruitment, but also provides a framework for the field of mobile commerce with the extension to other domains such as hospital-intern and college-student matching and recommendation. Our future work will focus on the more precise matching methods for various attributes representations and extending the application domains.

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