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資訊管理與財務金融學系

資訊管理碩士論文

社群評鑑機制之求職推薦應用

A Social Referral Mechanism for Job Reference  
Recommendation



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中華民國 103 年 6 月

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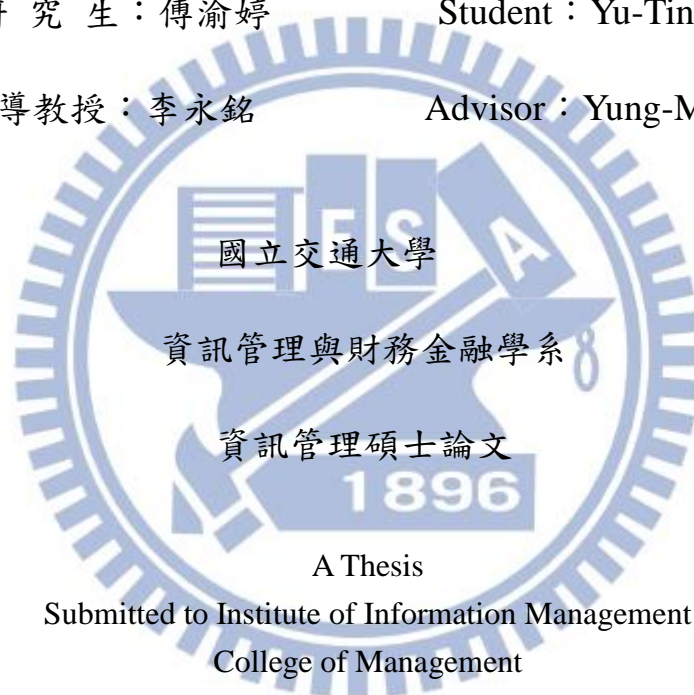
for Job Reference Recommendation

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Student：Yu-Ting Fu

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Advisor：Yung-Ming Li



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# 社群評鑑機制之求職推薦應用

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## 摘要

近年來，隨著社群平台使用者的大量增加，這類新科技的趨勢對現在人們的生活形成巨大衝擊，也重新定義我們和他人的互動行為、增進不同社群團體的互動機會、也讓人更容易利用群眾力量進行搜尋或尋求評價。在本次研究中，我們根據社會學家的研究，利用新科技加速資訊的交換和傳播流程，並以求職活動當作研究的範疇。本研究即以求職活動為例，依據協助意願和工作相關的影響力，為求職者的理想工作推薦出合適的諮詢對象，以提供更多工作相關資訊或是進行引薦。整合了人力資源學說的研究，藉著社群平台的技術，我們建置社群工作引薦平台，讓求職者從被動的職缺搜尋到主動的資訊獲得，也讓社交平台的服務更加多元豐富。

**關鍵詞：**社群搜尋、商務社群平台、求職工作、社群推薦、社群評價

# A Social Referral Mechanism for Job Reference Recommendation

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## ABSTRACT

Recently, with the popularity of various social media, this new trend of information technologies has impacted our lives, redefined the way we interact with each other, and facilitated the communication and influence cross different social groups, such as enhancing the power of social search and appraisal.

In this research, we mainly focus on this mystery process of information exchanges existing long ago on the base of sociology and apply this power in the field of job seeking. Considering the factors of both willingness and influence, we generate the list of proper reference candidates to desired job for job seekers to provide more job-related information or to be referrals. Integrating the knowledge of human resources management, we implement this social referral application with the support of information technologies and strive to enrich the service of social media, turning the passively searching for job seeking to actively consulting for exclusively job information.

**Keywords:** Social Search, Business Social Platform, Job-seeking, Social Referral, Social Appraisal

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一下子就畢業了，這兩年的時間過得真的很快，在我尚未熟悉交大的一切之前，我又要離開這個美麗的校園了。在這兩年的時間內，第一個要感謝的人就是指導教授李永銘老師。每當我在研究中遇到困惑的時候，老師總以自己獨特的見解指點我，給我許多創新的觀點和解法，幫助我順利地進行一個創新服務的開發。同時也感謝口試委員劉敦仁老師、陳柏安老師和翁頌舜老師，老師們都給予我許多建議和指教，也讓我的研究更完整。

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# CHAPTER 1 INTRODUCTION

## 1.1 Background

Recent years, Internet has played a vital role. According to the report of International Telecommunication Union, the number of people using Internet is going to reach 2.7 billion in the end of October 2013. Almost 40% of the world's population is using the Internet.

Internet now has become irreplaceable in our daily lives and widely applied in many ways.

For business companies, Internet has replaced the classifieds advertisement in the newspapers and turned out to be the main channels for recruitment. According to the study in 2001 by iLogos, it showed that 88% of the global 500 companies had a company Internet recruitment site [1]. By 2005, 96% of all companies will use the Internet for their recruitment needs [2].

For job seekers who just graduated from colleges and feel eager to find their jobs, the job websites are also their first choice for job-hunting by 72.7%. [3]

While most of jobs are filled through online recruitments, the human resources also noticed that there is another effective channel, which already existed for thousands of years to locate a job; that is by personal relationship, or we called it social network nowadays. The survey conducted by the society for human resource management and Wall Street Journal in 2001 showed that 95% of human resources managers or job-seekers find the desired employees or ideal jobs through the personal relationship. 61% of job recruiters and 78% of job applicators consider it as the most effective way [4].



As contacting as many people as possible is a highly effective way to find a job, the social scientists precisely analyze the relationship and interaction between the job-finders and the job information providers. Those people who are belonged to distinct social circles and meet occasionally would bring us novel information, which includes new job offerings and opportunities. This acquaintance relationship, which is labeled as weak tie, becomes crucial and remarkable while considering mobility opportunities. The nature of weak ties, which travel through different social circles, could assist job-seeker to exposes to all the information traffic [5].

While considering the strength of weak ties, the popularity and prevalence of social media sites nowadays can offer a perfect opportunity to practice the social theory. There are 1.26 billion people using Facebook by October 2013, which are almost half of total Internet users, and the daily active users on average are 757 million by December 2013[6]. Social media could gather the power of social networking and come out to be the perfect platform to initiate social search. Social search, defined as people search or search for people via social networks as human intermediary search, combines the basic ideas of web search mainly based on huge amounts of database and extends it to the people (or should label as users) involved situations[7]. It can support people to obtain information or connect people who might help through various social circles, which can also apply in the job hunting field. The intersection of recruitment and social media thus become a new platform for both recruiters

and job-seekers as promotional and advertising channels. Among all the social media platforms for job search, LinkedIn has become one of the most typical social networking websites for people in professional occupations. As of Jun 2013, LinkedIn reports more than 259 million users across more than 200 countries [8][9]. The convenience of Internet has conquered the boundaries of time and space constraint, which enables LinkedIn to transfer information about occupations through distinct social circles and becomes a global company. To sum all, since the large amount of users on the social networking sites and abundant information generated along within those social medias, the trend of social support for job-seeking is surging.

## **1.2 Motivation and Research Problems**

Actually, with the convenience of various current job websites and business social platform, there is something to be improved. First, as for the job websites, which are the main recourses for job seekers, although they have listed lots of job openings on the websites, most job seekers can only see the job name and very little information about that job. For example, like Figure 1, all users can see it from that kind of websites is only the job title, the location of that job, how many people have already applied it, and official job description.

Job users have to spend a lot of time to survey more about the job itself, such as the working hour, real workload, and company culture about that company on the Internet randomly.

There would be a big challenge and also time-consuming task for job-seekers to gather more

true information about that position or even harder to actually connect to someone working in that company or relevant industry.

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Figure 1. Job Information on 104 Human Resource Banking

On the other hand, recently, with service supported by the famous business social platform, LinkedIn, the job seekers could see through all the company as well as some workers in that company. However, since LinkedIn is only for the purpose of social networking, it lacks the consideration of real, frequent and timely interaction among people compared to other social platforms, such as Facebook. According to the survey conducted by The Buntin Group and Survey Sampling International, while 76% of Twitter and Facebook users log in at least once each day, only 40% of LinkedIn user have the same habit, and even 48% of LinkedIn users only access to the website once to several times a week[10].

Undoubtedly, the less frequent users stay, the less the requests distributed on that platform could be seen and fulfilled. Besides, it is not easy for job seekers to initiate conversation to someone who is totally a stranger or even consul some very confidential information about concerning job position and company. With the social relation as the mediation, in the end, job seekers can only see the name of those employers about their dreaming companies displaying on the website but do not have that opportunity to get closer. We may wait the

reply from someone we want to connect in the LinkedIn for days while this person may already spend three hours lingering on the Facebook each day. Though the job seekers can surely try to connect to anyone on LinkedIn, however it lacks of consideration the social interactions happened in the real world.

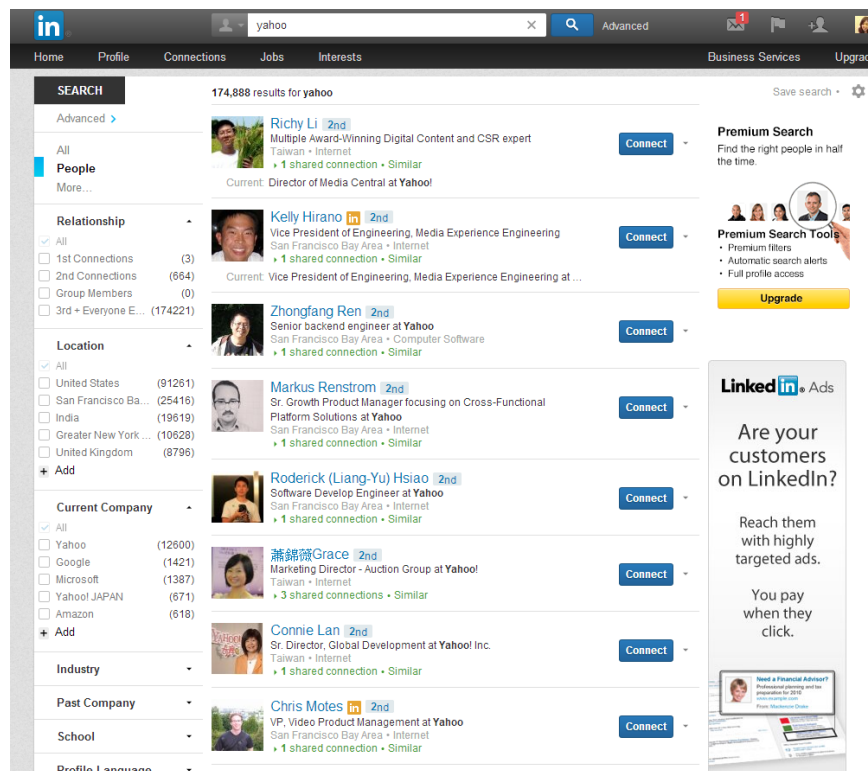


Figure 2. The LinkedIn searching result of certain company

To exploit the power of social networking in supporting job seeking, there are two problems we should solve:

1. *How to benefit the job hunting activates by providing extra information about the job description through locating reference people from the social network?*

First, considering the previous services provided by job websites and social platforms, what we could find through the synergy of these information is only about the job opening and some people who worked in that company. However, what we cannot obtain from those

combination is the social link, which here is the real social connections, happening in user's daily live and private live, from the job seekers to someone he or she wants to contact to. Therefore, we wish to provide with more information to increase the availability through taking more factors into account.

2. *How to combine the current database from the job websites and from the social network platform to discover the best consulting candidate for the job seeker?*

Here we see our problem from the view of social computing. As we mentioned before, since social media is widely used among people, using this platform is perfect to start a social search. The problem we have to think about is that how to distribute the request of social search and how to find out the best candidate through all involvers. Moreover, based on what kind of information should we index and thus categorize people in order to calculate the score for ranking the candidate list on the probability to help. To resolve the problem, we need to integrate and analyze the database of both job websites and social platform.

### **1.3 Research Goal and Contributions**

In this paper, we aim to exploit the power of social networks in improving job search. Specifically, we develop a social referral mechanism applied in the job-searching field and improve the job-matching with the power of social ties. Unlike the existing social recruiting services, which mainly focus the benefits for the recruiters and companies, we will commit to construct a social search and appraisal engine striving for the convenience of job seekers.

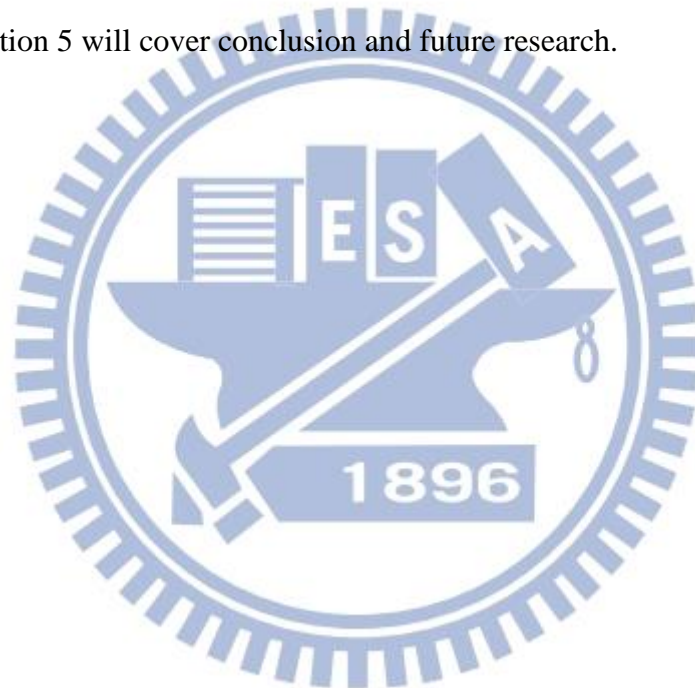
In this research, the main components of the proposed system include personal preference, social search and social appraisal analysis modules. First, we will first analyze what kinds of jobs users are looking for and the personal information about users as the input query. Secondly, we will ask users to distribute those requests to their own social network to collect the information we need to estimate if there are some people existing in the social circle who are related to their desired jobs. Finally, after gathering all information, we use the



interaction data in the social network to measure the willingness how specific person will help users or not. After those three analysis steps, users can gain a list of people they might consult about their desired job positions.

#### **1.4 Thesis Outline**

The outline of the paper is organized as follows. We'll refer to some literature review and basic concepts in Section 2. In Section 3, we present the social referral mechanism combined with social relationship analysis, personal preference analysis and job analysis. After the system framework, Section 4 describes the experiment processes and discusses the empirical results. Lastly Section 5 will cover conclusion and future research.



# CHAPTER 2 LITERATURE REVIEW

## 2.1 Online Recruitment

Generally speaking, there are two channels for the company to identify and attract the potential employee: formal and informal [42]. Formal channels refer to that there are other organizations and agencies involved in the process of connecting the employees and job-seekers, such as job fairs, ads in the newspapers, personnel consultancies, online links among government centers, education institutes and online human resources agencies. The informal channels indicate it is the personal recommendation from internal employers, friends, or relatives that facilitate the process of recruiters and potential employers.

Considering so various channels with respect of recruitment, the difference and the effectiveness of them have been a main issue in the study of human resources and could be measured and estimated in distinct ways [43]. While the company enjoyed the convenience and cost-effectiveness brought by the internet recruitment sites, 33% of European companies indicates the employers recruited through online websites are more liable to leave their jobs and 44% think that it not easy to find out the very good-fit employers with the internet tools [44]. On the other hand, the employers who entered the company with personal referral would significantly work longer and also tend to accept the job offer [45]. In this research, we try to improve the effectiveness of online recruitment by integrating the idea of informal referral into the online web sites.

## 2.2 Social Media

With the prevalence of mobile devises and social network platform, the involvement of social media has become daily routine for people around the world. Facebook, Youtube and Baidu are the second, third and the fifth most popular websites by Feb 2014. While the activities of social actions are unveiled, many applications have been developed, no matter in the form of web applications or app, and apply in distinct fields [46], such as online dating

websites, knowledge transmission, finding experts [47], and fund-raising.

For the study of computer science, the vast population using the social media is an excellent opportunity to examine large-scale social theories. For example, Gilbert and Karahalios predict the tie strength and verify the completeness of dimension [48]. Choudhury, Counts and Horvitz focus on the changes of activities and emotions as to childbirth with social media interfering [49]. Burke and Kraut verify the premise that the strong ties offer better emotional support and the weak ties enable people to find a new job under the situation of unemployment [50]. Recently, there are lots of application about recruiting, as well as providing job information based on social network sharing, such as the popular business social network sites LinkedIn and Glassdoor, which has over 10 million users by 2012 [51]. The aim of this paper is to utilize the abundant data of individual's social ties from the social media platform as well as the convenience and amount of users in order to generate a social referral application with the purpose of facilitating the job-hunting process.

### **2.3 Social Ties Analysis**

Social network analysis has played a key role in modern research of sociology, which illustrates the connection between two individuals as “tie”. [33] Considering the concept of relationship, the intuitive notions of the “strength” of those ties would appear and thus could be calculated by different elements. Granovetter defines tie strength as a “combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie” [34]. Furthermore, he indicates there are two different social ties, which vary on the strength scores. The one is the “Strong Tie”, which usually occurs between trusted friends and families. The other is the “Weak Tie”, which often happens among acquaintances. [35]

Those ties impacts people's daily lives in different ways. Reliable friends and close families can affect emotional health [36], help people suffer from stress [37], and often join

together to lead the groups while facing the crisis [38]. Loose friends can help a friend inspire new ideas [39], a perfect place to launch the diffusion of information, or find a job through reference [40] [41]. In this research, we utilize the function and properties of weak ties as a perfect tool to locate a social referral for job-seekers.

## 2.4 Social Search

For decades, while the search engine generating from the concept of digital library project dominates the world of information retrieval [11], there are another ancient way to acquire knowledge-“the village diagram”. Compared with the latter web search only focuses on the individual’s seeking, the village way of query put more emphasizes on the context-finding the right person to answer the question and also find the people connecting to those answers [12].

Actually, this kind of concept is widely used to optimize the results of searches, such as using collaborative social interactions [13] or social recommendation for collaborative filtering [14] by leveraging the data in the user’s social network. Since the social acts and social interactions could benefit the search process [15], this type of search can even be applied in the wall of decentralized search [16]. In this search model, how to route the queries over a social network becomes the main issues to break through [17], including considering the factors, such as how a specific node on that node responds or not, or how relevant this node is to the question we are searching for [18]. Although this paradigm of decentralized search, or so-called, peer-to-peer has been the main issue with regard to small-world related

experiment a few years ago [19], they are all bounded by the limitation that the only source of interpersonal data collection could only be generated from the email system.[20][21]

Recently, besides the elaboration of application on the expert-finding area [22], social search has extended to various field, such as social discover ([23]), finding new web services ([24]), people search ([25]), and etc. In this study, we further use the concept of people search to find the reference candidates for our desired jobs.

## **2.5 Social Support and Appraisal**

The provision of social appraisal can be regarded as one of the important features for social support, which is the combination of psychological and behavior functions. S. Wasserman and K. Faust have proved that with more connections, whether in link of friendship or interaction, it is more likely for people to influence to each other. [26] Actually, this kind of influence play an important role when talking about social support, which is defined as a mediating construct providing help from other people in the social network.[27] With the help or support, or here we can say, the information from others in the social network could be offered as the source of social appraisal to help the decision making process.[28]

Recently, social appraisal has been widely used due to the popularity of social network analysis. For example, a lot of researches have been conducted in the field of electronic commerce, such as information filtering [29] and spreading [30]. Besides, the social appraisal



is also used in knowledge management, such as expert-finding ([31] [32]). In this research, we use the social network relationship as the sources of social support to do the social appraisal for the evaluating how people are willing to help you and also how people could affect others.



## **CHAPTER 3 THE SYSTEM FRAMEWORK**

When it comes to job hunting, it means the processes or actions of searching for employment and the main purpose is to gain the opportunities to be interviewed by a hiring manager. Those people who seek jobs would first browse through all available sources of job information, such as job websites or newspapers, and choose those jobs which interest them. Then those job-seekers would contact their desired companies by submitting resumes or related required documents for further chances to get an interview.

Technically speaking, the whole process of job searching would be divided into five

steps: locating a job, researching employees, networking, applying, and interviewing. In this paper, we mainly pay the attention on the first three steps and design the whole mechanism to increase the possibilities to attain the interview for job seekers. Especially, for the first step to locate the job opening, we emphasize the enhancement of current job websites, which have been the main channels for job searching.

For current job websites, it can provide the job-seekers with lots of job offerings stored in the huge database collected from all kinds of companies, which improves the efficiency of doing job search as well as the variety of job opportunities and facilitates the process of locating a job. However, bounded by the base of search engine, the job websites still hold some constraints. First, in the view of the mechanism of the job websites itself, the preciseness of keyword input affects the quality of result. The misuse of searching keyword may disturb the operation of the searching process and cause less useful job information for users. Secondly, even though job sites could search all the possible job offers quickly, there is no sufficient job-related information for job-seekers to evaluate and learn more about each positions or the companies. After locating jobs, the uses still have to spend time to go through the Internet and search for any detail with regard to their desired job. Then, following by locating a job and researching, the third step mentioned above would be decisive and also be a challenge for most of job seekers; that is networking. How to discover the right reference that can affect the opportunities by considering the willingness of all the candidates within one's social network is important for the job seekers.

In the framework of social referral mechanism, we are dedicated to resolve this problem by combining the social network of job-seekers and the current job openings of desired industries. Figure 3 depicts the processes involved in our mechanism:

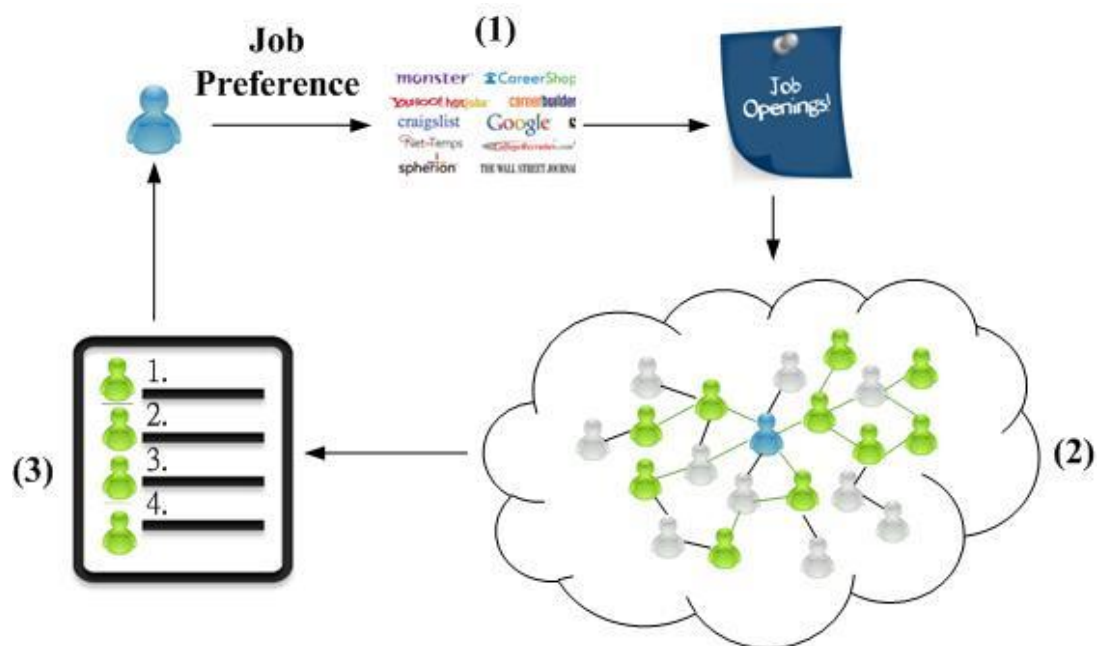


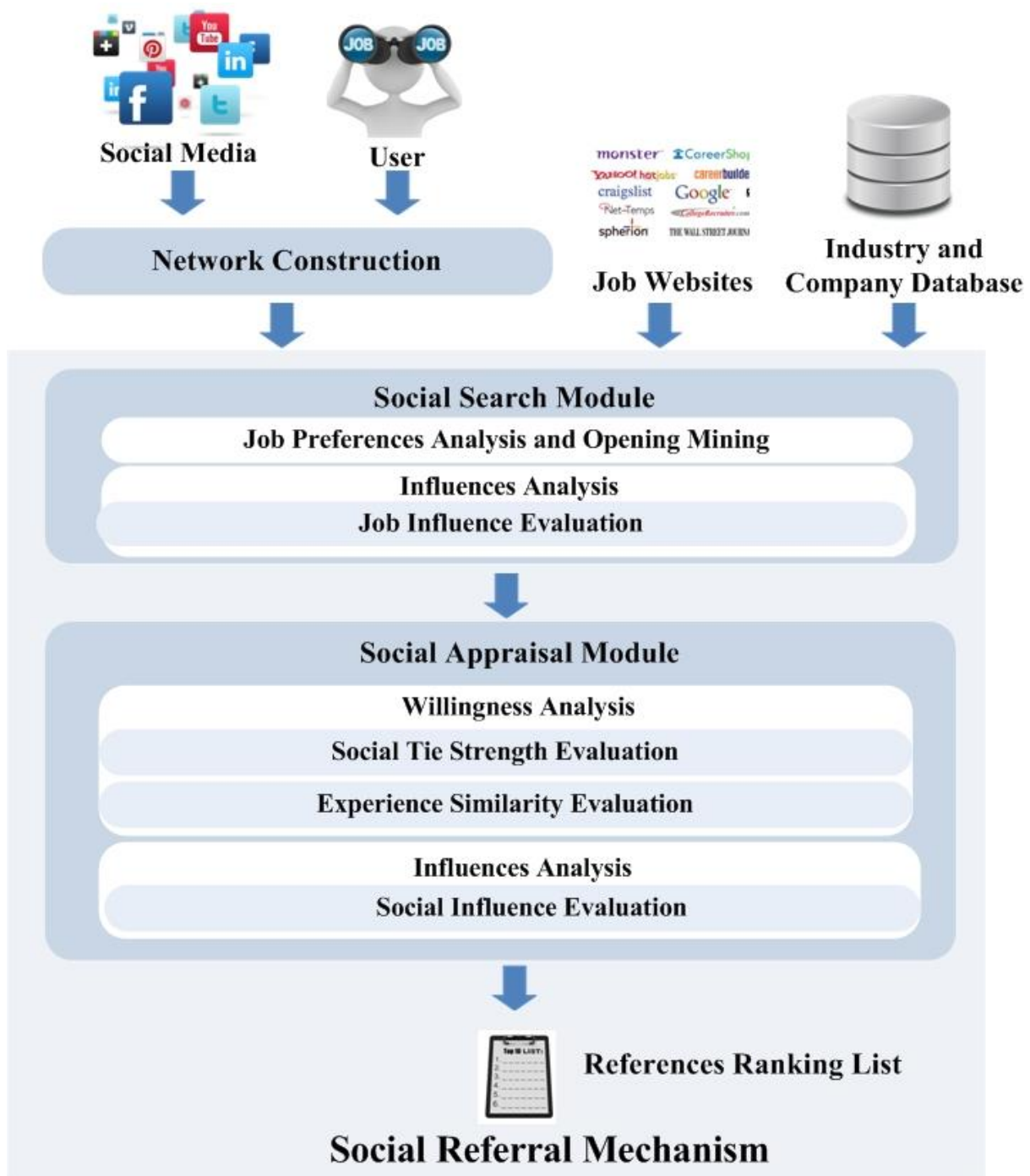
Figure 3. The process flow of social referral mechanism

1. The social search engine is triggered when job seeker enters their job preferences. By this information, then we would mine the current job offerings from job websites and use the properties of job offerings as the condition of job query.
2. We could search users who are related to the job query recursively in the social network and include and update those users to the possible candidate set. Besides the candidate, the social links between those people are recorded too.
3. After locating all the possible candidates, the system will use social appraisal module to evaluate and rank all the possible referrals. The output of our system would be a list of current job openings, a ranking list of possible referral candidates about those job openings as well as the social path link to those candidates.

To meet the objective of searching for the proper candidates for reference from the social network and rank them considering the possibility, several techniques are required. We implement these processes by two main components in our proposed system. The system

architect is displayed as Figure 4.

1. Network Construction: In this stage, we will collect the personal and working information about users and record the interaction data between each users.
2. Social Search Module: First we will ask user to enter their job preference and the system will discover current available offerings as the query condition. Furthermore, the system will search all the users in the social network and find out possible candidates by evaluation of job relevance.
  - (1) Job Preference Analysis and Opening Mining: The system will provide selections for user to choose their preference and then the system will list those job openings that match their requirement.
  - (2) Job Influence Analysis: The system will analyze the job information about each user to measure how relevant the user is to the job query.
3. Social Appraisal Module: Based on all the needed information, we will rank those candidates by considering both willingness and influence. Analyses about social tie strength and experience similarity are both involved. As for influence, besides the job influence, here the social influence is also considered.
  - (1) Referral Willingness Analysis: The system will take the social interaction and common experience between each pair of friends as the index to compute how a friend is willing to help each other.
  - (2) Social Influence Analysis: The system will check the social network data to know how certain use can affect his or her social network.



**3.1 Social Search Module** Figure 4. Architecture of Social Referral

The social search module measures the job relevance of each user in the social network as the job influence to help the job seeker. Due to the nature of social network, the system will go through the job checking process recursively.



### 3.1.1 Job Preference Analysis and Offer Mining

The purpose of this analysis is to search all possible job offerings in the desired industries, companies or functions that users may be interested in. Before actually going to the search phase, first we have to carefully describe our query condition. In this research, we refer the common job description shown on the job website and use four properties to describe the job shown as Figure 5. They are industry categories, company name, function name and job grade, and each of those variables all belong to their individual set. The job could be denoted as:

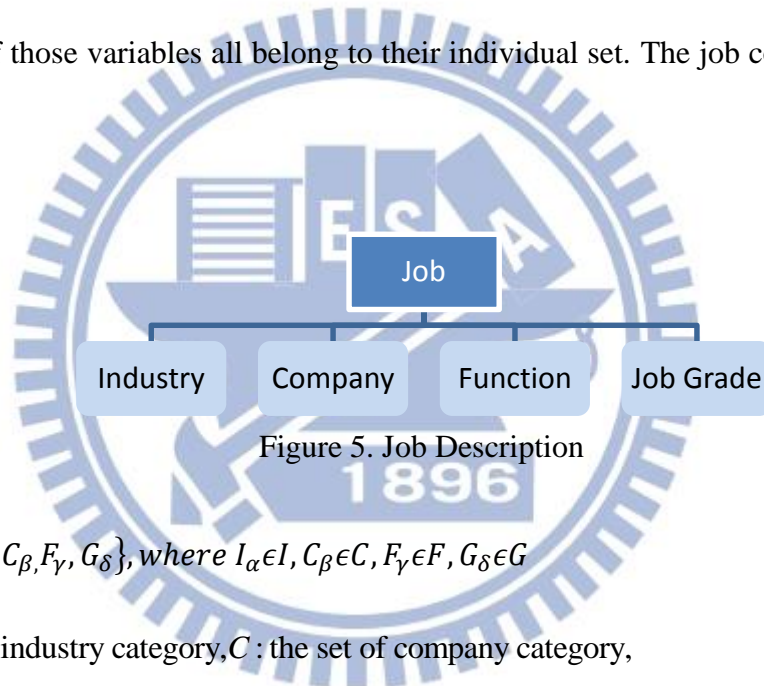


Figure 5. Job Description

$$\bullet \text{ Job} = \{I_{\alpha}, C_{\beta}, F_{\gamma}, G_{\delta}\}, \text{ where } I_{\alpha} \in I, C_{\beta} \in C, F_{\gamma} \in F, G_{\delta} \in G \quad (1)$$

$I$ : the set of industry category,  $C$ : the set of company category,

$F$ : the set of function category,  $G$ : the set of distinct job grade

For example, we will describe the job shown in Figure 1 in chapter 1 as this set:

$$\text{Job} = \{I_1, C_3, F_5, G_3\},$$

$I_1$  = Information Technology,  $C_3$  = TSMC,  $F_5$  = Information Technology,  $G_3$  = Employee.

The stage is conducted by the following two processes:

**Job Preference Analysis.** The system will ask users to choose their desired job by the

input of the four variables. We will design the options of those variables by the reference of job websites.

**Opening Mining.** After understanding the job seeker's preference, the search will be executed through all the online web sites as the database to mine the available job offerings by the tools of web crawlers. The system will store the list of job openings in the job set for users. For example, the job offerings which are suitable for job seeker  $u$  are:

$$Openings(u) = \{Job_{u1}, Job_{u2}, \dots, Job_{un}\} \quad (2)$$

### 3.1.2 Job Influence Evaluation

In this process, our goal is to search and construct the candidate network expanded from the job seeker, or called initiator in our model. We calculate the job influence score by comparing the four indexes describing the job offering and the information of working experiences about each user in the social network. In other word, the job influence is measured as the similarity. We consider one suitable job offer at a time, denote as the  $J_u$ . The similarity between the job offer  $J_u$  and the job to search  $J_v$  can be estimated as:

$$Sim_{Industry}(J_u, J_v) = \begin{cases} 1, & \text{if } Industry(J_u) = Industry(J_v) \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

$$Sim_{Company}(J_u, J_v) = \begin{cases} 1, & \text{if } Company(J_u) = Company(J_v) \\ 0, & \text{otherwise} \end{cases} \quad (4)$$

$$Sim_{Function}(J_u, J_v) = \begin{cases} 1, & \text{if } Function(J_u) = Function(J_v) \\ 0, & \text{otherwise} \end{cases} \quad (5)$$

$$Score_{JobGrade}(J_v) = \left. \begin{cases} 0.2 & , \text{if } J_v \text{ is associate} \\ 0.5 & , \text{if } J_v \text{ is staff} \\ 0.7 & , \text{if } J_v \text{ is middle-level manager} \\ 1 & , \text{if } J_v \text{ is high-level manager} \end{cases} \right\} \quad (6)$$

The values of  $Sim_{Industry}(J_a, J_b)$ ,  $Sim_{Company}(J_a, J_b)$ , and  $Sim_{Function}(J_a, J_b)$  present the similarity between Job  $a$  and Job  $b$  respectively. The function  $Industry(J_u)$ ,  $Company(J_u)$ ,  $Function(J_u)$  will return the property of the  $J_u$  respectively. If the person works in exactly the same industry, the same company or the same function that is the same as the job user  $u$  is searching for, we mark 1. Otherwise is zero. Since we only consider how the user  $v$  influence the job offer, we only use the job grade of user  $v$ .

The job influence between job of user  $v$  and  $J_u$  :

$$JI(J_u, J_v) = \alpha * Sim_{Industry}(J_u, J_v) + \beta * Sim_{Company}(J_u, J_v) + \gamma * Sim_{Function}(J_u, J_v) + \gamma * Score_{JobGrade}(J_v), \text{ where } \alpha + \beta + \gamma + \delta = 1$$

### 3.1.3 Job Discovery

After measuring the job influence of each user in the social network, then the network of referral candidates will be expanded continuously from the job seeker. Specially, we denote as the social network which is constructed by nodes expanding for  $l$  layers,  $\Theta_{SN}$  as the set of users of social network and the function  $Friends$  to express the friend set of certain user. Following by this definition,  $SN(0) = u$ , the job seeker, and  $\Theta_{SN}(0) = u$ .  $\Theta_{SN}(1) = Friends(u)$  and  $\Theta_{SN}(2) = Friends(Friends(u))$  too.

Along by the  $SN(l)$  definition, we also use  $ECN(l)$  as the set of users included in the referral candidate network for  $l$  layers expanding, and  $\Theta_R$  as the set of referral candidates. The network expanding process in this stage can be described as:

$$\Theta_R(l+1) = \Theta_R(l) \cup \{v | v \in \Theta_{SN}(l+1), JI(J_u, J_v) > \varepsilon_R\} \quad (8)$$

where  $\Theta_R(0) = \phi$  and  $\varepsilon_R$  is the threshold of job influence level. In this research, we construct the network of referral candidate network after expanding three layers ( $l=3$ ). To record the link from job seeker  $u$  to certain candidate  $v$  in the  $ECN$ , we will use the set

$SocialPaths(u, v)$  to record all the social paths from user  $u$  to user  $v$ :

$$SocialPaths(u, v) = \{SocialPath_1(u, v), SocialPath_2(u, v), \dots, SocialPath_n(u, v)\} \quad (9)$$

For single path  $i$ , we denote as  $SocialPath_i(u, v)$  and store all the nodes along this path. The notation will be

$$SocialPath_i(u, v) = \{sp_1, sp_2, \dots, sp_n\} \text{ where } sp_1 = u \text{ and } sp_n = v. \quad (10)$$

## 3.2 Social Appraisal Module

The objective in this stage is to evaluate and rank the best candidate as the reference of desired job. The model consists of two major components: willingness analysis and influence analysis. The former emphasizes how personal relationships affect the mission of reference; the latter stresses the relevance between the searching goal and the current resources, whether in personal side or the job side, which we have already computed before. We will discuss further about the details of each component in the following chapters and talk about the formula to measure each candidate in the end of 3.2.

### 3.2.1 Referral Willingness Analysis

We take a single link as the unit of referral willingness calculation. Among single link, there are two components of referral willingness score: social tie strength and the similarity of experience. We will mention how to accumulate the total willingness in the end of section.

#### 3.2.1.1 Social Tie Strength Evaluation

In this study, the factors we considered about social tie strength includes, mutual friends, interaction duration (day since the last communication), and status comment (the frequency of like or comment in the status wall). The three factors represent three different dimension concerning the willingness respectively, the structure, the intimacy, and the intensity. We will

discuss the details of each calculation in the following description.

From the structure view, the more mutual friends we have, the more possible there would be a certain social link between us and then we are more likely to help each other.

From the intimacy view, since in this case we focus on the help of taking real referral action, private messages exchanging will be a perfect index to reflect the actual interaction of intimacy. Last, as for the intensity, we use the comment and like rate of status update to consider how friends interact with each other.

**Mutual Friends:** The number of mutual friends between two people intuitively indicates how close these people are in the view of social circle. Deduction from the concept of social tie triangle, the stronger tie exists between two people, the more possible they would be friends and get quite familiar with each other. Here we use the function  $MF(u, v)$  to record of

$$MF(u, v) = \frac{|Friends(u) \cap Friends(v)|}{|Friends(u) \cup Friends(v)|}, \quad MF(u, v) \geq 0 \quad (11)$$

the number of mutual friends of user  $u$  and user  $v$  in order to compare the closeness between these two people.

**Interaction duration:** According to the previous research, the social tie strength differs a lot for the people talked once and for those who never talk [48]. By this finding, we record the day since first communication and last communication of every pair as the index of duration.

The function  $FirstDay(u, v)$  is defined as the function which returns the time intervals from



the first conversation to now. The function  $LastDay(u, v)$  means from the last conversation to now. If the conversation just happened today, the value will be zero. If the conversation never happens, both the function will return the infinite value  $\infty$ .

$$Duration(u, v) = \alpha * \frac{1}{FirstDay(u, v)} + (1 - \alpha) * \frac{1}{LastDay(u, v)}, \quad (12)$$

$$FirstDay(u, v) \geq 0, LastDay(u, v) \geq 0,$$

**Status comment:** There is another crucial element to affect the decision that whether we would like to assist other or not. That is how we feel about others, the emotional aspect. If we have good feelings about the other person, we are liable to give him or her hand. In

case of affection  $n$  dimension, we accumulated the number of like or comment a user  $v$  have made on the status of person  $u$  during the two months to figure out how user  $v$  thinks about person  $u$  compared with his or her other friends. We use  $Friend_{like}$  and  $Friend_{comment}$  function to summarize how many times the user  $v$  has clicked like on the post of user  $u$  and how many times user  $v$  has left comment on the post of user  $u$ .

$$Friend_{Comment}(u, v) = \sum_{p \in Post(u)} Post_{Comment}(v, p), \quad (14)$$

$$Friend_{Like}(u, v) = \sum_{p \in Post(u)} Post_{Like}(v, p).$$

The set  $Post(u)$  is used to record the all the status post of user  $u$  and function

$Post_{Like}(v, p) = 1$  if user  $v$  clicks like for the post  $p$  or  $Post_{Like}(v, p) = 0$  otherwise. The rule works the same on  $Post_{Comment}$  function. If user  $v$  left comment on post  $p$ , then

$Post_{Comment}(v, p) = 1$ , otherwise  $Post_{Comment}(v, p) = 0$ . We also conduct the linear normalization

as below after calculating the score above:

$$\begin{aligned}
 Like_{given}(u, v) &= \frac{Friend_{like}(u, v) - \underset{f \in Friends(u)}{Min} Friend_{like}(u, f)}{\underset{f \in Friends(u)}{Max} Friend_{like}(u, f) - \underset{f \in Friends(u)}{Min} Friend_{like}(u, f)} \\
 Comment_{given}(u, v) &= \frac{Friend_{comment}(u, v) - \underset{f \in Friends(u)}{Min} Friend_{comment}(u, f)}{\underset{f \in Friends(u)}{Max} Friend_{comment}(u, f) - \underset{f \in Friends(u)}{Min} Friend_{comment}(u, f)} \\
 Status(u, v) &= \alpha * Like_{given}(u, v) + (1 - \alpha) * Comment_{given}(u, v). \tag{17}
 \end{aligned}$$

Because the range of the value in  $MF(u, v)$ ,  $Duration(u, v)$  and  $Status(u, v)$  does not between zero to one, in order to decrease the error we apply the min-max normalization to normalize those value in as shown in the equation (18), where  $value$  is the original value,  $value'$  is the new value after normalization,  $min$  is the minimum value of the population and the  $max$  is the maximum value of the population.

$$value' = \frac{value - min}{max - min} \tag{18}$$

The social tie strength of user  $u$  and  $v$  is computed as:

$$ST(u, v) = \alpha * MF(u, v) + \beta * Duration(u, v) + \gamma * Status(u, v), \tag{19}$$

where  $\alpha + \beta + \gamma = 1$

### 3.2.1.2 Experience Similarity Evaluation

Apart from the social tie strength, there is another similarity exerting in the real situation. If the social tie means the private, personal and subjective side of willingness, the similarity experience points the objective side. It is very common to see the job reference from the help of alumni although the senior managers may not directly interact with the younger student. In experience evaluation, two elements are considered: Living location and Education

background. The experience of user  $u$  and user  $v$  is computed as:

$$ES(u, v) = \alpha * Sim_{Education}(u, v) + (1 - \alpha) * Sim_{Location}(u, v) \quad (20)$$

The elements included in the evaluation are detailed as follows.

**Living location:** by observation and actual cases in the real world, it is possible for people to take care of those who come from the same living areas in most referral cases. So in this case, we take this factor into consideration.

$$Sim_{Location}(u, v) = \begin{cases} 1, & \text{if } Location(u)=Location(v) \\ 0 & \text{otherwise} \end{cases} \quad (21)$$

**Education background:** In the real world, it is common to find that the seniors who are graduated are willing to share their own working experiences and even want to recruit some talented juniors to join their companies. Proved by this fact, we are going to exam if the same education background influences the effective of willing of referring. For the job reference case, the collage, the graduated school and the major are the three information sources about education experience we consider.

$$Sim_U(u, v) = \begin{cases} 1, & \text{if } University(u) = University(v) \\ 0, & \text{otherwise} \end{cases} \quad (22)$$

$$Sim_G(u, v) = \begin{cases} 1, & \text{if } Graduate(u) = Graduate(v) \\ 0, & \text{otherwise} \end{cases} \quad (23)$$

$$Sim_M(u, v) = \begin{cases} 1, & \text{if } Major(u) = Major(v) \\ 0, & \text{otherwise} \end{cases} \quad (24)$$

Summing up all the three factors, the similarity of experience will be computed as :

$$Sim_{Education}(u, v) = \alpha * Sim_U(u, v) + \beta * Sim_G(u, v) + \gamma * Sim_M(u, v) \quad (25)$$

where  $\alpha + \beta + \gamma = 1$ .

After going through all the process of social tie strength evaluation and experience similarity evaluation, now for a single link which connects user  $u$  and user  $v$  we can get the score of willingness:

$$W(u, v) = \alpha * ST(u, v) + (1 - \alpha) * ES(u, v) \quad (26)$$

The variable  $\alpha$  and  $1-\alpha$  present the linear combination of the measurement.

### 3.2.1.3 Calculation of Referral willingness

After computing the willingness score among each social link, here we strive for finding the willingness along the social path from job seeker  $u$  to certain candidate  $v$ . Combing the result of each social link score and the social path we record in the 3.1.3, the calculation process is depicted as:

$$W(u, v) = \underset{SocialPath_i(u,v) \in SocialPaths(u,v)}{Max} W(sp_1, sp_n) = \underset{SocialPath_i(u,v) \in SocialPaths(u,v)}{Max} \prod_{i=1}^{n-1} W(sp_i, sp_{i+1}) \quad (27)$$

Besides locating the possible candidates in the second model of social search, here we also strive for finding the best routing path, or the closest path to each possible candidate in the goal of maximizing willingness in order to increase the possibility for those candidates to help the job seekers.

The example of calculating process is described as follow Figure 6. After finding the candidate Amy, the system has recorded that there are two social paths between from job

seeker John and Amy in the search stage. In this appraisal stage, the system will process willingness score computing.

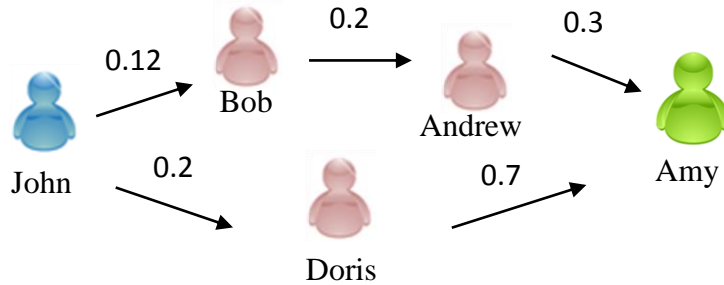


Figure 6. The example of calculating willingness

The willingness score between John and Amy will be computed as:

$$w(John, Amy) = w(John, Bob) * w(Bob, Andrew) * w(Andrew, Amy) = 0.12 * 0.2 * 0.3 = 0.0072.$$

$$w(John, Amy) = w(John, Doris) * w(Doris, Amy) = 0.2 * 0.7 = 0.14$$

After processing this two social path from John to Amy, the system will automatically update the highest score of social path, in this example, the path through Doris, for the willingness of  $w(John, Amy)$ .

### 3.2.2 Social Influence Analysis

In this stage, we mainly focus on analyzing the social influence. In the analysis of social influence, we use three elements, total friends, social popularity and social engagement to evaluate the status of certain user in the social circle. The first element is to measure the possible social circle a person can impact on, and the second one is to measure the actual attention a person can gain, or how popular he or she is in the social network. The last one is to measure how this person becomes involved in the communities of social network. The



formula of social influence is described at the end of 3.2.2 and the details will be discussed further in the following paragraph.

**Total Friends:** The concept of total friend is just to measure how many friends the user has on the social network platform in order to know the scope he or she may influence and how many people that user can help distribute the job query. We use the  $tf(u)$  function to get the number of friends of certain user  $u$ . Considering the diversity of different social circle, the normalization formula would be described as:

$$TF(u) = \frac{tf(u) - \underset{v \in Friends(u)}{Min}(tf(v))}{\underset{v \in Friends(u)}{Max}(tf(v)) - \underset{v \in Friends(u)}{Min}(tf(v))} \quad (28)$$

**Social Popularity:** We expressed this kind of social power in the way of gaining attention. Imagine that, maybe the person is not directly relevant with your desired job, neither the company nor the industry. However, this popular person may publish your job hunting news in his or her own social network and directs you to his or her friend as result, which occurs a lot in the real world. In this evaluation, the average number of like and comment from friends per status update are used to measure how much attention a user would get through their personal social network. The definition is shown as:

$$Like_{received}(u) = \frac{\sum_{p \in Post(u), f \in Friends(u)} Post_{like}(f,p)}{n(Post(u))} \quad (29)$$

$$Comment_{received}(u) = \frac{\sum_{p \in Post(u), f \in Friends(u)} Post_{comment}(f,p)}{n(Post(u))} \quad (30)$$

The score of social popularity is generated as below:

$$SP(u) = \alpha * Like_{received}(u) + (1 - \alpha) * Comment_{received}(u) \quad (31)$$

**Social Engagement:** Here we talk about how a person participates the community in order to know personal status in the social network. With the popularity of low-cost and often-asynchronous social network on the Internet, social involvements turned from the local and group-based to the internet-based. In this research, we consider the status in the way of participating group. We use the function  $group(u)$  to denote the number of group user  $u$  joins and the compare this involvement degree with user's friends to conduct the normalization from the view of social scope.

$$SE(u) = \frac{group(u) - \underset{v \in Friends(u)}{Min}(group(v))}{\underset{v \in Friends(u)}{Max}(group(v)) - \underset{v \in Friends(u)}{Min}(group(v))} \quad (32)$$

To sum up, the score of social influence will be defined as:

$$SI(u) = \alpha * TF(u) + \beta * SP(u) + \gamma * SE(u), \text{ where } \alpha + \beta + \gamma = 1 \quad (33)$$

Integrating the score of job influence in 3.1.2, here we could sum up and estimate the final influence as the following formula:

$$I(u, v) = \alpha * JI(u, v) + (1 - \alpha) * SI(u, v) \quad (34)$$

Note that because the social influence only considers personal power, so only the candidate user  $v$  will be involved.

### 3.3 Weight Calculation

In this section we apply one of the most widely used approaches, the Analytic Network Process (ANP) to solve our weighting problems in all above modules.[52]

**Step1:** we design the hierarchy by identifying the goal, criterion, and alternatives like Figure 7. Our goal is to find the most proper referral for job seeker, and four elements in our model would be our criteria, and the candidate set would be our alternatives. Level-1 weights are the edges between criteria and goal, level-2 weights are the edges between alternatives and criteria.

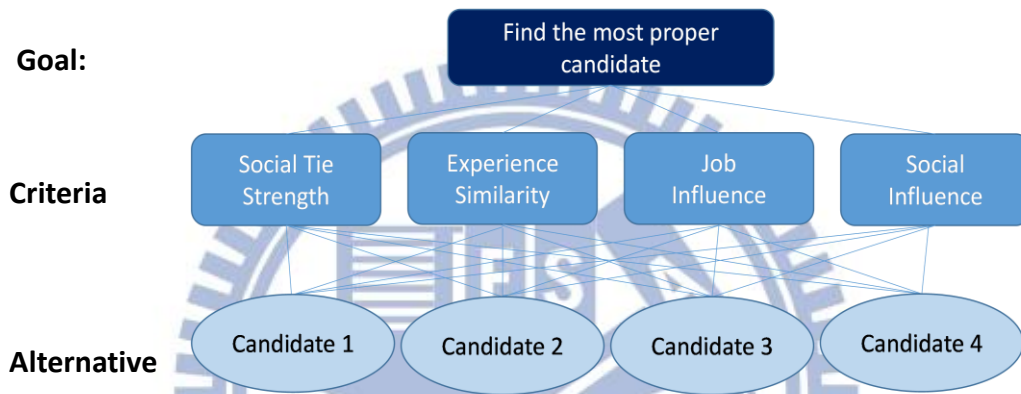


Figure 7. ANP Structure

**Step 2:** In order to calculate the relative weight between each component, we collect the user feedback and the criteria score from pervious criteria computing section as the data source, and then we use pairwise comparison to compute the priority weight in level-1. First, we form the pairwise comparison matrix shown at Formula 35:

$$M_{TEJS} = \begin{bmatrix} 1 & E_{TE} & E_{TJ} & E_{TS} \\ \frac{1}{E_{TE}} & 1 & E_{EJ} & E_{ES} \\ \frac{1}{E_{TJ}} & \frac{1}{E_{EJ}} & 1 & E_{JS} \\ \frac{1}{E_{TS}} & \frac{1}{E_{ES}} & \frac{1}{E_{JS}} & 1 \end{bmatrix} \quad (35)$$

where  $E_{TE}$  means relative weight ratio between social tie strength and experience

similarity,  $E_{TJ}$  means relative weight ratio between social tie strength and job influence,  $E_{TS}$

means relative weight ratio between social tie strength and social influence,  $E_{EJ}$  means relative weight ratio between experience similarity and job influence,  $E_{ES}$  means relative weight ratio between experience similarity and social influence,  $E_{JS}$  means relative weight ratio between job influence and social influence. Then we use a mean method which shown at Formula 36 to calculate the relative weight for each criteria:

$$W_i = \frac{1}{4} \frac{\sum_{j=1}^4 E_{ij}}{\sum_{i=1}^4 E_{ij}} \quad (36)$$

where  $W_i$  means the relative weight of criteria  $i$ . By this formula then we can know how these four components affect the final score to rank the proper candidate.

Back to the process of evaluating the proper candidate, after long processing each component, we could finally generate the score of each candidate as well as the ranking list of users in the candidate set  $\Theta_R$ . The score of certain possible candidate  $v$  could be a proper reference for user  $u$  to hunting a desire job is defined as follows:

$$R(u, v) = W(u, v) * I(u, v) \quad (37)$$

$W(u, v)$  stands for the willingness for user  $v$  to help user  $u$ , and  $I(u, v)$  means how user  $v$  could influence the job user  $u$  wants as we mentioned previously. We will rank the candidate set by this score and eventually output the job opening as well as a list of ranking candidate and the social links to those people.

In order to better explain all of the factors we mention in our model, we illustrate them

in Figure 8.

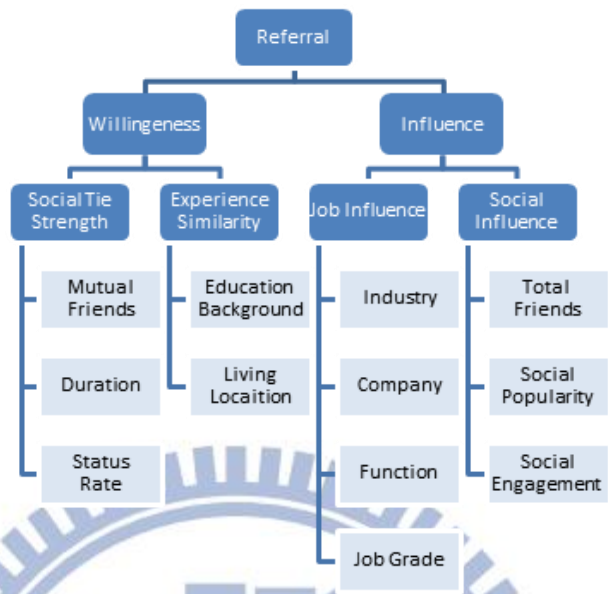
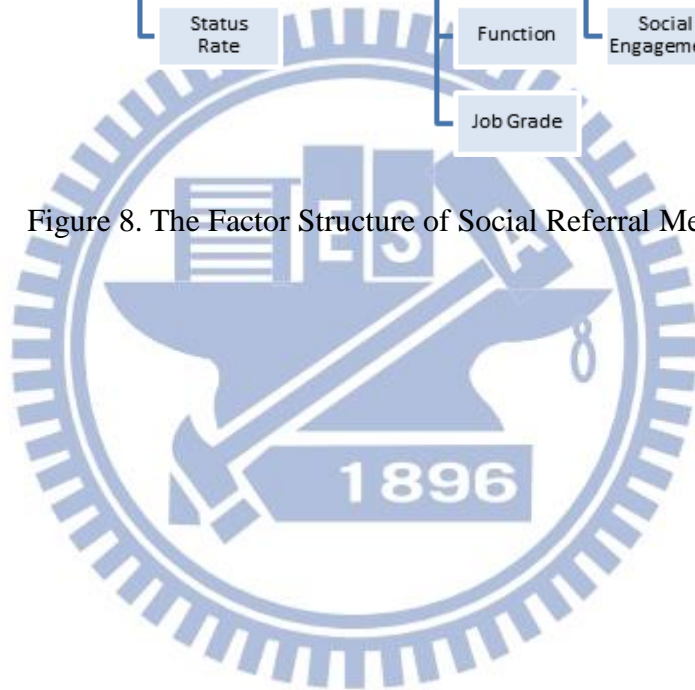


Figure 8. The Factor Structure of Social Referral Mechanism





## CHAPTER 4 EXPERIMENTS

After planning the whole framework of social referral mechanism, in this chapter, we conduct an experimental study and verify the effectiveness and efficiency of this proposed project. Generally speaking, the process of social referral is to request some information from social network, which expands by the connection of real social interactions, and the result is a list of people who may have the high possibility to help by the rank of recommendation calculation.

As for the input of this referral mechanism, since the experiment environment and the using habits of participants, we choose the most popular job website in Taiwan, 104 human resources bank and the most popular social services websites, Facebook, to execute the job-seeking process and observe the interaction process among people. The information of job openings is collected from the 104 human resources bank and the social interaction data is collected from Facebook. We use web crawler to analyze the job openings in the 104 websites and index some properties in advance in order to optimize the request process later happened in the social search among Facebook. As for each one who helps spread the job seeking request, we use the our own web-based app to gain more detailed personal information in order to index every user among the social circle of job seekers.

For technical side, we use Facebook API, such as the FQL and Graph API, to gather the real interactions among specific relationship to estimate the intimacy between friends or the popularity of certain people among his or her own social network. Furthermore, we implement our web-based app on the host of Bitbucket and platform of Heroku, which are both Git server and store our data in the Postgres database server. We utilize the analytical software, SPSS, as our tool to the factor analysis.

In the following sections, we will describe each procedure of data collection, storage and process as well as the calculation of how we actually use those collecting data to compute the recommendation results.

#### 4.1 Experiment Process

The whole experiment is composed of four steps as Figure 4 illustration: network construction, social search for job query, social appraisal to rank candidates, output the final ranking list and request for feedback.

**Step one:** We will help the job seeker to distribute our web-based app to friends of his or her social network on Facebook to construct the network. Besides providing personal information, we will also ask his or her friends, or called “participants” in our study, to help distribute the app to their friends as many as possible to maximize the social circle to collect more data. In this stage, considering the power of weak-tie in the issue of providing new job information as we mention in chapter 1, we could support this kind of distribution with a recommended list of people mixed of both strong-tie and weak-tie friends in their social network. Those two kinds of friends would be identified from the analysis of social tie strength in chapter 3.3.1. The interface of web-based app displays as Figure 8 and the recommended list is shown as Figure 9. Both personal information about each user and the information about each link are recorded in this stage.

**Step two:** The job seeker, in this case we call “initiators” will choose preferred industry or company as the keywords of the job request query and provide other personal information. A list of predefined industry, company and major categories will be provided to help the initiators to best describe the terms. The input interface shows as Figure 10.

Hello, thank you for support this questionnaire.

Your feedback will greatly benefit my research.

There are four steps to finish this questionnaire.

### click log in->click authorize->fullfil questionnaire->click summit

1. Click the bellow blue button **Facebook Log-in Button** .
2. Please click the right Facebook button  
If the pop-up window appears and asks to authorize, please click "I agree".  
Please allow the pop-up window in this webpages if you dont' see the pop-up windows.  
If you log-in successfully, **your name** will show up besides the blue log-in button.
3. Please continue fulfilling the following questionnaire.
4. After finishing, click the below blue button and submit it, you're done!

About this questionnaire :

- This research aims to study the relationship between the Facebook data and job-seeking.
- The data we collect in this questionnaire will be definitely confidential.

Welcome to contact [cat3067@gmail.com](mailto:cat3067@gmail.com) if any advise or comment.

Wish you a good day.^^

Please click the right Facebook button  
(If the pop-up window appears and asks to authorize,  
please click "I agree".)

**Facebook Log-in**

Who do you get this questionnaire?

Your gender?  Male  Female

What's your age?

Where are your living region?

How many days on average do you spent on Facebook?

How long have you been used the Facebook?

Please select your highest education degree

What's your major?

What's your industry?

What's your company name?

Which function you're working at?

What's your job grade?

Figure 8. The interface of web-based app for participants

您好，歡迎使用social\_referral系統。

本系統將收集您的Facebook資訊和您個人對理想工作的偏好，為您推薦合適的求職諮詢對象。  
除了諮詢對象外，本系統也依您的工作偏好，為您列出目前104上相關的工作職缺。  
祝您求職順利~

## Congrate that you have finished your query!

Help you and us to build our platform together!

Please pass this app to your friends on the following list:

Get more information from them! Invite your friends to join our app!

- 謝欣辰 
- Fu-Hsun Hsieh 
- Wan-Chi Wang 
- 張光宇 
- 林奕杉 
- Samuel Chang 

Figure 9. The suggestion list of distribution people

Hello, Welcome to use to the social referral system beta version.

We will recommend the best candidates as your career consultants and also referrals by understaging your social network and job preferences. Besides the candidate list, we will also provide the public available offers on the job websites in 104 human resource bank. Wish you to get your desired job!

**What's your major ?**

**What's your preferred industries?(multiple choices)**

**What's your preferred company ?**

**Which function your are interested?(multiple choices)**

**Where you wan to work at?(multiple choices)**

Please click the right Facebook button  
If the pop-up window appears and asks to authorize,  
please click "I agree".

[Facebook Login](#)

Figure 10. The interface for job query

**Step three:** After collecting the data, we start processing those data and calculating the score of our four major modules explained in chapter 3. In this stage, we use the ANP questions collected from the app to decide the weight of our formula and compute the score of each component from the data we have collect.

**Step four:** Following calculating the score, we will demonstrate our result of ranking list to job seeker, shown as Figure 11, and ask them to help evaluate the effective of our system by knowing how he or she think the candidates ranked by the score on the result list are willing to help him or her and in what percentage it is possible.

#### 4.2 Data collection

We start our data collection by asking what kinds of jobs users prefer and index the job with predefined variable, such as industry, company, function. Here user can either enter the job query by his or her own preference or by the current available job openings listed on the job websites. Here we refer the categories of 104 job banking websites as our variable. Users also have to input their personal information, such as living location and education background

Hello, Welcome to use to the social referral system beta version.

We will recommend the best candidates as your career consultants and also referrals by understaging your social network and job preferences. Besides the candidate list, we will also provide the public available offers on the job websites in 104 human resource bank. Wish you to get your desired job!

Based on your job preference and information on the social network, the following is our recommendation list:

Date	Job Title	Region
03/06	<b>資訊工程類 - 資訊安全工程師 IT Security Engineer</b> 1. Positions open for Engineer/Senior Engineer/Principal Engineer. 2. Responsible or support assessme...	新竹市

[我要應徵](#)  
11~30人應徵

Those are people who may help you...

- 林致緯
- Fred Lin 透過共同朋友 Alice Sung
- 賴宜廷
- 李柔 透過共同朋友 王善捷
- Jessie Chu 透過共同朋友 黃雅慧 或 Jerry Chu

Figure 11. The result of possible consulting candidate generates from the social referral system

After figuring out the description about the ideal jobs, or we could call the “query condition” of our social search, then we collect the data by passing the webpage link we designed to gather all information we need in the further calculation. We use this web form to get both personal information concerning job and education and the records of social interaction happened in the Facebook. By the way, the automation of sending request can be done by the support of FQL.

There are 35 users as initiator involved, and for each of initiators we ask them to pick up three kinds of different types of jobs and spend approximately one week long to distribute and gather information from their social network. At the end of our experiment, we have 4,445 participants involved and collect 1,877,995 social links. On average, there are 127 participants of each the social network (the amount of people who fulfilled the web form from certain initiator) and 53657 social links among per social network. The details about the dataset summary show as follows:

Title	Value
The Number of Initial Users	35 people
The Total Amount of Participants	4,445 participants
The Total Amount of Social Links	1,877,995 social links
The Number of Participants On Average Per User	127 participants
The Number of Social Links On Average Per User	53657 social links

Table 1. The summary of dataset

#### 4.2.1 User Profile

In order to make sure the sampling is fair and unified, we further analyze the information about 35 users and 4,445 participants. Their gender distribution and age distribution are shown respectively in Figure 11, Figure 12, Figure 13 and Figure 14.

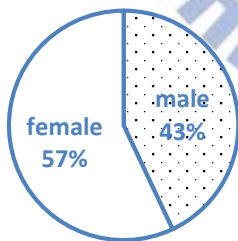


Figure 11. Gender Distribution of Users

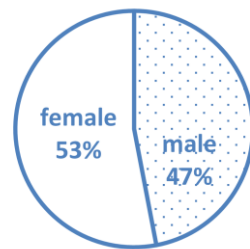


Figure 12. Gender Distribution of Participants

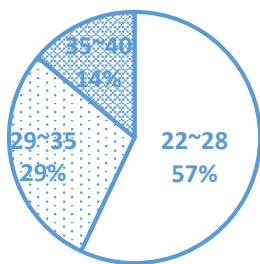


Figure 13. Age Distribution of Users

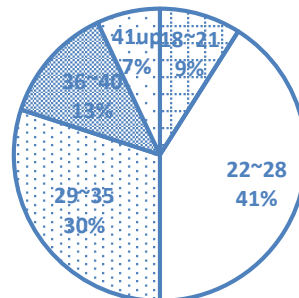


Figure 14. Age Distribution of Users



Furthermore, we also do some statistics data about the occupation distribution of participants and users 'job queries as the following Figure 15 and Figure 16.

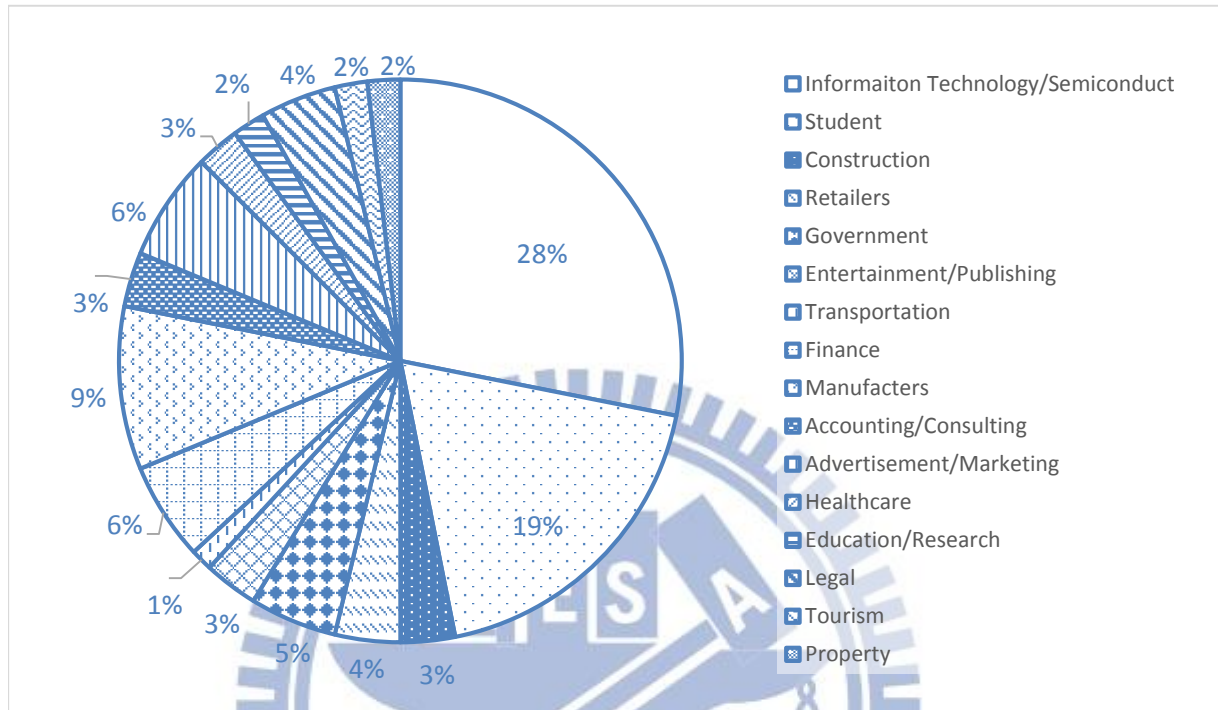


Figure 15. Occupation distribution of participants

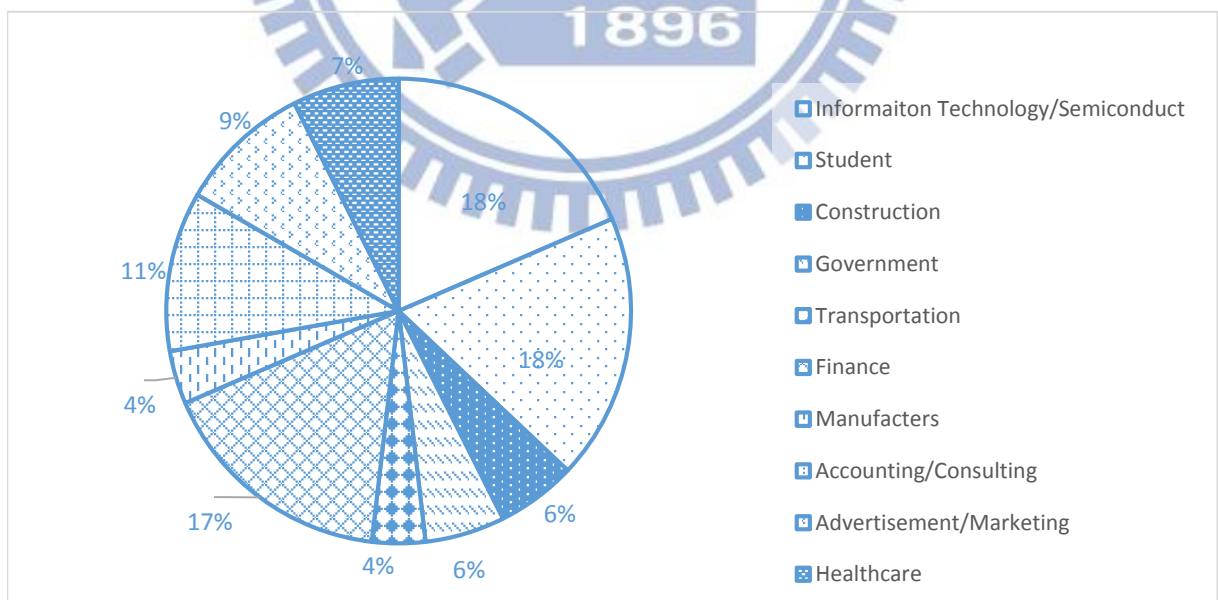


Figure 16. Occupation distribution of users 'job queries

### 4.3 Weight Generation

In this research, we adapt ANP model to solve the weighting problem among all kinds of combination. Actually, we can tear down the whole model into 13 different variables in Figure 8. As we mentioned before, we use our app to know the relationship of weighting between the different factors from our participants. In order to ask more conveniently, we use the example questions like Table 2 to figure out the correlation between each pair of variables and convert it to the original calculation in Table 3.

<b>Question</b>	<b>I think when it comes to asking someone to help me find a job, with the support from the one who is willing to help me has higher possibility to successful referral than the one who has the influence to help me.</b>					
	5	4	3	2	1	
<b>Strongly Agree</b>						<b>Strongly Disagree</b>

Table 2. Question for estimating weighting

	Left side is important								Right side is important								B											
	Important								Degree																			
	Extremely	Very	Slightly	Generally	Equal	Generally	Slightly	Very	Extremely	9:1	8:1	7:1	6:1	5:1	4:1	3:1		2:1	1:1	1:2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	
<b>A</b>																												

Table 3. ANP table for weighting

After carefully analyzing, finally we can get the result from the collaborative opinions from all participants and thus use this to further recommend people of possible candidate lists with the method in chapter 3.4.

## CHAPTER 5 RESULTS AND EVALUATION

In order to evaluate the accuracy of this proposed mechanism about recommendation referral candidate, we use the web-based app to keep tracking the following distribution process. After collecting data, we will use our system to execute the candidate processing and inform our users the candidate list. Furthermore, we ask them to rate the result of candidate and to see what's their opinion about it as the feedback to enhance the mechanism.

### 5.1 Accuracy of Social Referral Information

In this experiment, top ten candidates are selected from the ANP result and ranked by the score in the candidate list. The reason why we choose top ten people is because it's the reasonable number for job seeker to actually contact in person for specific job position. After recommendation, we ask job seeker to review that list and pick up those people who job seeker think are actually helpful as our evaluation. In this part of evaluation, we measure the accuracy of the referral recommendation mechanism by the equation (38), where

$\Phi_{recommended\ referrals}$  is the set of referrals on the recommendation list and

$\Phi_{recommended\ referrals} \cap helpful\ referrals$  is the set of referrals who job seeker thinks are truly useful in our recommended list.

$$Accuracy = \frac{|\Phi_{recommended\ referrals} \cap helpful\ referrals|}{|\Phi_{recommended\ referrals}|} \quad (38)$$

In this chapter, we mainly use this accuracy to measure the performance of our system.

## 5.2 Components Weighting Determination

We let the participants determine the weight of each component by asking them the ratio between each two as we mentioned in 4.4. After applying the ANP method, we illustrate the general results from all participants in our study in the following graph.

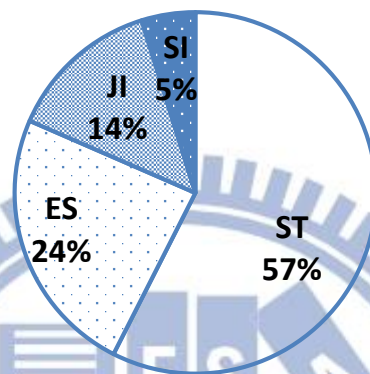


Figure 18. Average Weight for each component

As the result shows, most of users think the social relationship matters the most while talking about job hunting activities. Surprisingly, the weight for social capital is really insignificant.

In order to determine the weighting approach to provide better recommendation result, we perform three different combinations of weighting and to see the evaluation of each method from users: (1) equally weighting, (2) group weighing approach and (3) personal weighting approach. Equally weighting assigns each component as 25%. Group weighting approach assign the average weighting. Personal weighting use the personal preference as the weighting. We use those different approaches to output the ranking result and ask uses to

evaluate the accuracy. The users' evaluation is show as Figure 19.

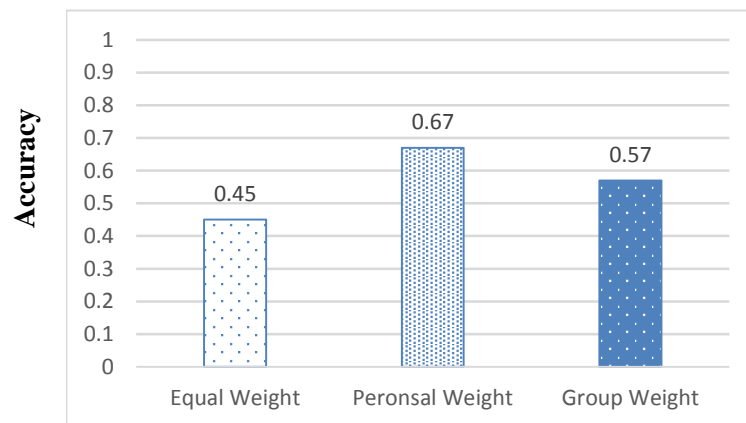


Figure 19. Weighting Approaches

As we can see from the above figure, users are satisfied with the recommendation result the most from the group weight approach, surprisingly. We think it is because the weighting approaches of group and personal weight are quite similar.

We also conduct the t-test to confirm the result. According to Table 4, the results shows that all the pair tests is significant under 0.05 at 95% significant level which provided that group weight is statistically better than the other two weighting approaches.

Paired Group		Mean	Std. Deviation	Std. Error Mean	t	Sig. (2-tailed)
Group	Equal Weight	1.06780	1.40030	0.18230	5.857	0.000
	Personal Weight	0.49153	1.20877	0.15737	3.123	0.003

Table 4 .Statistical verification results of weighting

### 5.3 Recommendation Performance

In this sector, we analyze the accuracy for our recommendation results of different types of jobs. We classify the job query from users in different industries and calculate the user's satisfaction for each categories. The result is displayed as Figure 20. What we can figure out from the figure is that obviously the users who are still student think the outcome of this mechanism benefit their job hunting the most. Besides those group of people, those users who works in the information technology or semi conduct related also regard this mechanism is helpful. The reason may be obvious since we can see that in our sample, both in our participants or users, the population whose jobs is about information technologies and semi conduct are the largest group from Figure 15 and Figure 16. With more possible candidate as the selection base, the more people we can recommend and of course the better result we might reach and deliver.

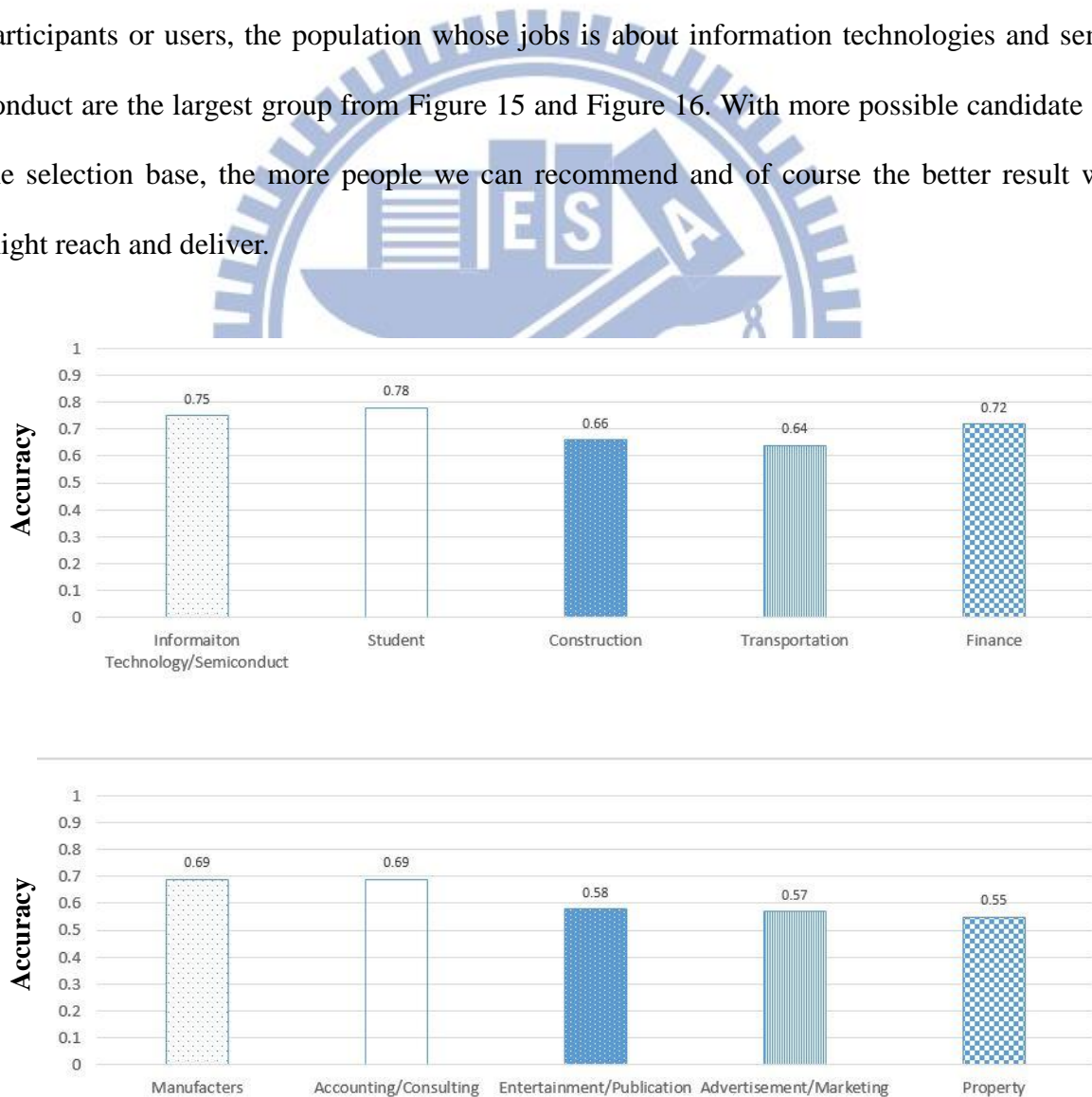


Figure 20. The Performance of different kinds of job



## 5.4 Factors Performance

We compare the distinct candidate list generated from different approaches by comparing the accuracy. Here we use ST, ES, JI and SI stands for social tie strength, experience similarity, job influence and social influence correspondingly in the following description. We ask user to evaluate how they think the outcome results generated from the combination of four factors are really helpful or not. Then we respectively look deep into the influence on result for each factor.

First we exam these factors respectively with the candidate lists produced by single components and random pick-up. The result is displayed as below Figure 21:

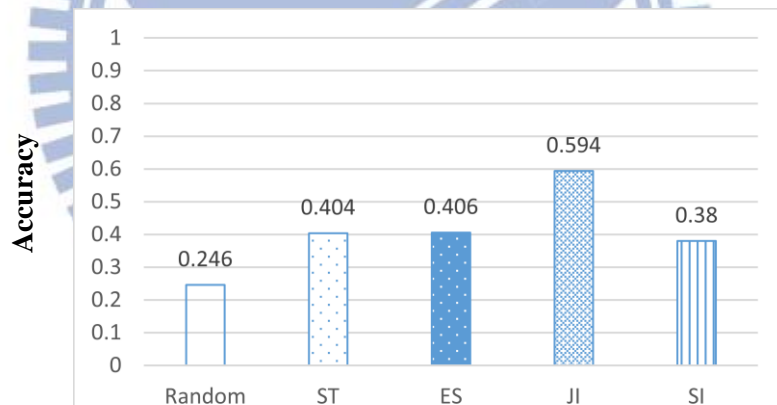


Figure 21. Comparison for single components

Surprisingly, this figure shows that the factor of job relevance plays the best among all the results from single factors, instead of the social tie, which most users consider the most important in the questionnaire showed at 5.2. The other finding we can see from this Figure 22 is the satisfaction that only generated by one factors is far below the expectation compared with the result from all of four factors.

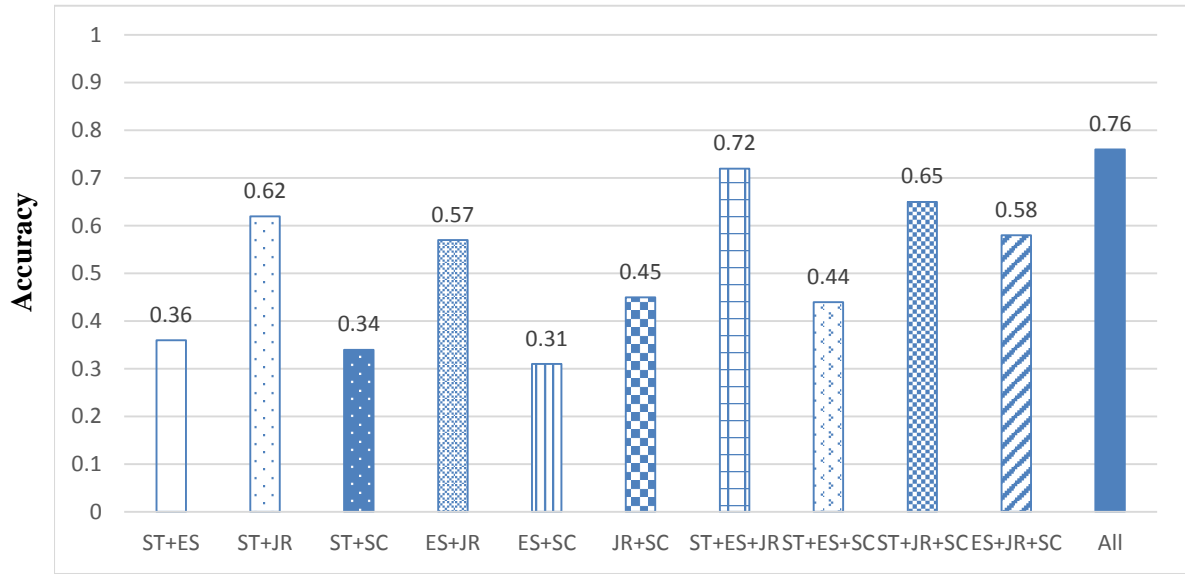


Figure 22. Components Combinations

The result shows that in two components scenarios, users are more satisfied with the result from the combination of experience similarity and job relevance. We can also conclude from this figure that even though with more factors considered the better the performance is, the factor of social capital here contributes little to the improvement of results. Finally, a statistical test is conducted using the paired sample t-test as Table 5.

Paired Group	Mean	Std. Deviation	Std. Error Mean	t	Sig. (2-tailed)	
All	ST+ES	2.11429	1.04317	0.12468	16.957	0
	ST+JR	0.88571	0.86045	0.10284	8.612	0
Four Factors	ST+SC	2.17143	0.9776	0.11685	18.584	0
	ES+JR	0.8000	1.07137	0.12805	6.247	0

ES+SC	2.48571	0.94398	0.11283	22.031	0
JR+SC	1.42857	1.001013	0.11965	11.940	0
ST+ES+JR	0.14286	0.87287	0.10433	1.369	0.175
ST+ES+SC	1.74286	0.73594	0.08796	19.814	0
ST+JR+SC	0.85714	0.96738	0.11562	7.413	0
ES+JR+SC	0.8000	0.86141	0.10296	7.770	0
JR+SC	1.42857	1.001013	0.11965	11.940	0

Table 5 .Statistical verification results of factor combinations

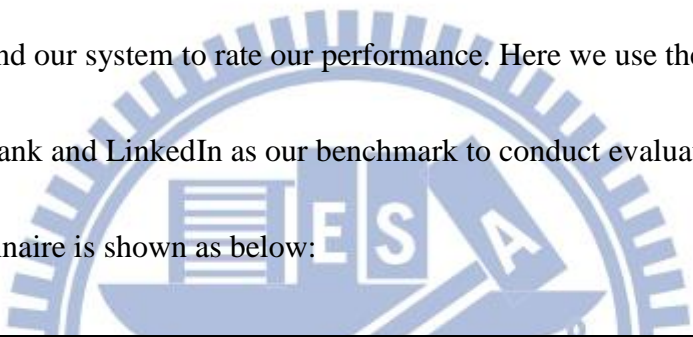
As shown in Table 5, we can see except for the combination of ST+ES+JR, all the other pair are significant under 0.05, which we can conclude that our proposed model is better than the other listed model. However, we find out something interesting in the combination of ST+ES+JR, which we do not have enough evidence that the result of four-factor model is significant better than that. In other words, we may consider only use this combination enough applied in our model.

### 5.5 User's rating

In this section, we measure how our referral mechanism improves the new services by comparing to well-known web services representing the traditional job websites and business social network websites as our benchmark. Since the output of our system is totally different from those two benchmark websites, here we measure this difference by the user's

satisfaction in the way of Likert scale questionnaire. There are two aspects of evaluation we consider in the questionnaire: (1) providing more information (2) facilitating for the job hunting activities.

We measure above questions by the questionnaire, asking how those job seekers think about the result of candidate list and how they think this platform is going to support their job-hunting works. In order to fairly compare, we invite the users who have used LinkedIn, 104 job websites and our system to rate our performance. Here we use the job website of 104 human resources bank and LinkedIn as our benchmark to conduct evaluation. The partial content of questionnaire is shown as below:



Question 1: Do you think this social referral service benefits your job-hunting activities?				
1	2	3	4	5
Equal	Weak	Essential	Very Strong	Absolute
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Question 2: Do you think the service provide by 104 human resource bank benefits your job-hunting activities?				
1	2	3	4	5
Equal	Weak	Essential	Very Strong	Absolute
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table 6. User evaluation Questionnaire

The questionnaire is composed of two different aspects. Maybe it is easier to depict as the 3x2 matrix to understand this kind of evaluation. The rows are our benchmark and our proposed system, and the columns are the two aspects we planned to compare. Here we use the Likert scale of five points to do the quantitative analysis. The higher value represents the more satisfied users feel about certain services. We summarized the result from the users' questionnaires are displayed as following Figure 23:

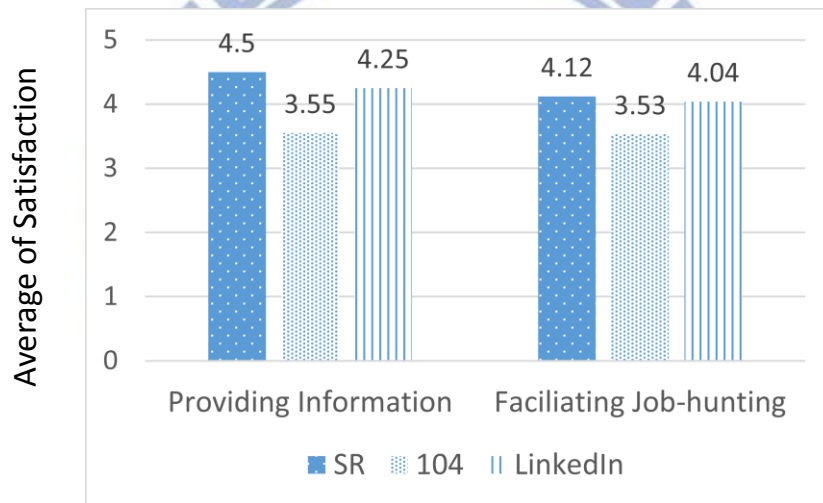


Figure 23. Comparison for Useful Information Dimension

From the previous figures, we can observe that our system performs well in every aspect, whether being informative and help the job hunting, compared with other current job related information websites. Another interesting findings from the survey is that though LinkedIn is very popular in the United States and other countries, it is not that prevalent in Taiwan due to lacking of adverting and also the limitation of languages. 104 human resource bank, on the

other side, is still the first choice for most users when they think about finding jobs.

## 5.6 Recommendation list

As we mentioned in section 4.1, we will recommend the distribution list which is composed of mixture of both strong-tie and weak-tie friends to the job seeker. Here we further analyze the effectiveness of network construction by different ranking of the list.

There are three different types of ranking list: ranked from the strongest to the weakest, ranked from the weakest to the strongest, the random ranked. We use the definition the same as Granovetter[5]: for those people who directly contact at least twice a week, we define as strong tie, others are weak tie. We will choose the strong-tie and weak-tie friend by this concept. As for random, we will randomly select people from the friend list of user to from the recommended list. Sincere in our experiment this list only works in the period of network construction, we use the size of network as the measurement of those three methods. The result shows as Figure 24.

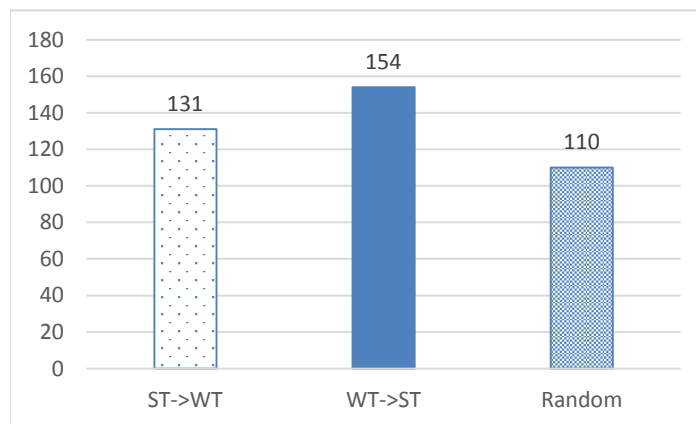
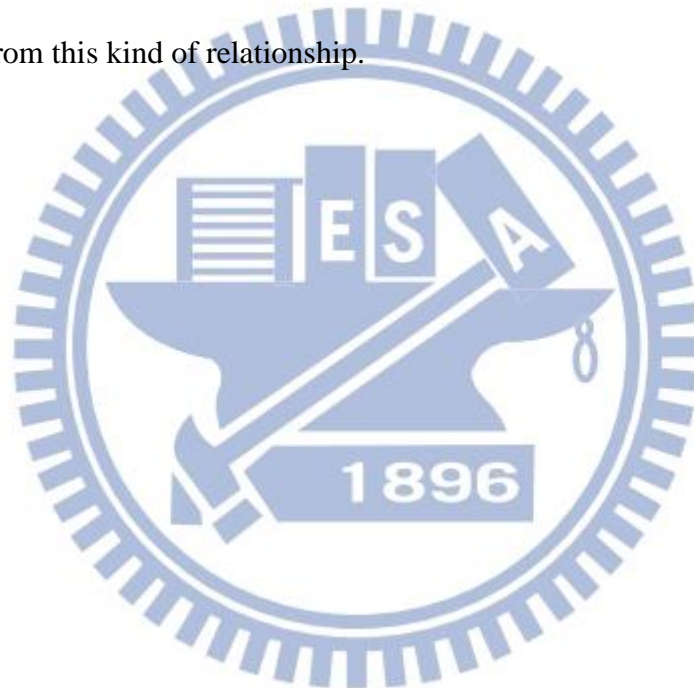


Figure 24. The average number of participant network



From the above figure we can see the real result matches the sociological theory. Though strong-tie friends are definitely willing to help the job seeker more, there would be more possible to have people overlapped in the scope of social network. On the other hand, weak-tie friends might be less directly interact, though, somehow they are still happy to give a hand when some occasion, like job hunting, happens. Thus, we would larger distribution result benefiting from this kind of relationship.



## CHAPTER 6 DISCUSSION AND CONCLUSION

Social power has long been comprehensively used in various activities in the life of people, especially in the field of diffusion the request or asking for someone help. With the popularity of social media, people tend to utilize this huge digital media to publicize their needs, such as job seeking or consulting information. On the other side, from the view of business companies, they has already started to implement their recruiting activities by the support of internet and websites, and even use the social platform as the new channel to promote their own companies and their job, and even an abundant source to find and search the data of candidates to do further evaluation. Combining those trends from the recruiters and job seeker, this mechanism perfectly solves this problem by the matching platform for both job providers and job seekers. The result of the experiment shows that this proposed platform has better performance than other previous benchmark approaches. Moreover, according to our experimental results and evaluations, this new mechanism can effectively mine the potential referral from their social network on the base of social search and appraisal as well as the best efficient social path to reach to referrals.

### 6.1 Research Contributions

This study makes several significant contributions as follows. At first, from the methodological aspect, our research propose the concept of using the power of social search to find out referral candidates from the social network to provide more job information more than the official description in the job websites. With this key element, a searching mechanism that utilized the power of social network is proposed to find all the possible candidates on the base of willingness and influence. In order to calculate the result with these elements, a classical ANP method is used to generate the final recommendation result.

Secondly, from the empirical aspect, we discover that not all the factors are equally important in the performance of social referral. Actually, the social tie strength, experience

similarity and job relevance are the three factors that truly matters for the result. Among those three factors, job relevance is the most important, which is surprisingly against what users think. Besides, according to the users' feedback, we can see the recommendation performance of different job industries would be largely dependent on the occupation distribution of participants.

Thirdly, from the practical aspect, for most users joined our test, they all amazingly find out that actually they can reach those one who owns the information they long for concerning certain job openings or are worked in their dreaming companies by the support of our social platform, which does not show on any job websites so far. People can gain more information other than the job information itself but with the real people who they can ask or interact with. Furthermore, they can even easily search and access those targeted people by the “social path”, the people connection through his or her own friends and the extended social network. By consideration the real-time and daily interaction occurred on Facebook, our social path is more feasible and practical for those users, which is different from the function LinkedIn has already provided.

## **6.2 Research Limitations**

Though this application has supported the recruiting activities for recruiters and job-hunting for job seekers, there are some limitations we encountered while conducting this research. First, due to the basic assumption and core concept of this mechanism, we need to ensure all the participants are linked by the real existing social links. All of links between every pair of people are tractable and measurable. The web-based app can only be distributed and filled by the people who really know each other. The job seekers have to request all of his or her friends to provide their information and even ask them to send out the same request to their friends (friends of friends) to maximize the distribution and information gathering in order to locate the best referral candidates. This process is very critical in our

system but also very challenging and definitely faced lots of troubles about practical implementation, such as the amount of involving users and the time it takes to gather all of that information.

Moreover, the social interactions we can gather by Facebook are just limited on the online interaction. Although we do all know actually the real face-to-face interaction matters more than virtual ones, little information we can gain from that due to the limitation of the nature of social digital media. For example, user A may click like on the Facebook wall of his friend B frequently and seldom do the same of the Facebook wall of friend C. Based on the data we can collect, we thus assume the social tie strength between A and B is closer than A and C. However, maybe the true reason is A meets C everyday and C seldom updates his wall while A never meets B in the real life. Besides, the privacy issues about social media also troubles the process of evaluation the social tie strength happened between every two people. This mechanism needs the information such as education experiences and current job description about each person involving in the social network of job seekers.

Thirdly, for the picture of the whole benefit of this mechanism, the more users use this system, the larger the database we have, and thus the more candidates we can select and recommend. It is predicted that this system must encounter the problems lacking of enough users at first. But with the network effect, there would be more alternatives to choose and calculate after more users contributed their social network data to the mechanism.

Lastly, though plenty of sociology researches have proved that weak tie could provide more new information and would be better resources to consult when searching for a new job, how to fully apply to strength to the process of job seeking in a proper way is something worth considering. In this research, we support a list of strong-tie and weak-tie friends and wish users to get information from those people as they could, however in real world in most cases friends in social-tie are more likely to help the query mission. How to conquer this gap

between

### 6.3 Future Works

There are several related issues, which could be further studied to facilitate the analysis process to best recommend the proper candidates for referrals.

We will check those issues from three different dimensions, the mechanism itself, the job seekers and the purpose of this application.

First, in order to enhance the recommendation mechanism, there are some strategies we could apply to do more accurate analysis and try to stimulate the real decision process. We may take the relationship between different companies into considered and constantly update those correlations by the latest news. For example, take TSMC, HP, and MediaTek for consideration. Though it looks like there are totally different companies, actually HP is the vendor for TSMC IT department and MediaTek is the client side that assigns TSMC to complete their weaver producing. The calculation model will be precise if we consider all of those complicated and dynamic relationship between different companies and the collaboration between those departments in the companies in the advanced version of this application.

Secondly, we could also free the limitation of online media in the further use. We could ask our users to provide more detailed descriptions in the offline interaction among his or her own social network and even the context or scenario happened in the interaction. After calculation the list of possible candidates, the user may provide the real interaction information about the relationship of that social link to further optimize the process based on the true situations in the real world. For example, candidate A may be the classmate who meets three days a week and candidate B just someone meet in the party once.

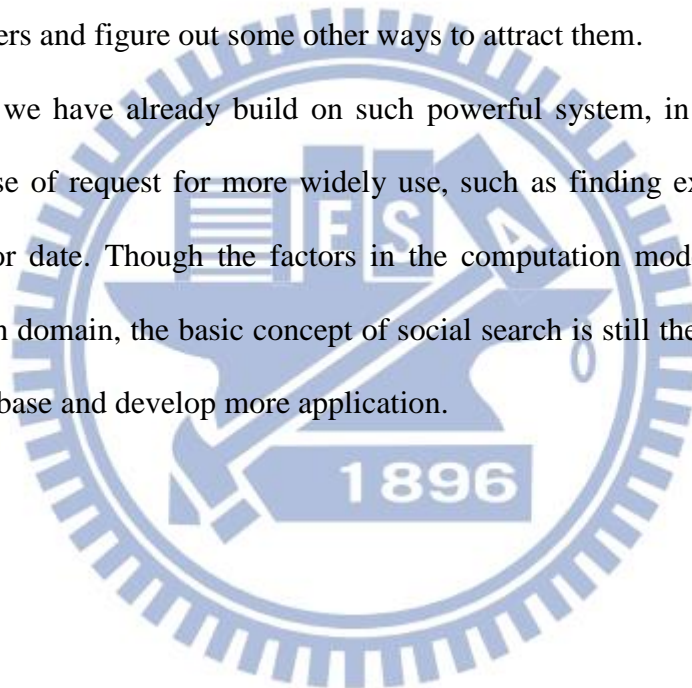
Thirdly, as we mentioned in the limitation part, we need more users to be involved and willing to provide the information about their own working, education experiences as well as



their social interaction records. For the future, we could design mechanism to encourage more users engaged, like the membership and point system. For example, user can get some extra points while one of his or her friends decide to provide their information for the recommendation process.

Fourthly, we also focus on the distribution of users. From our experiment, we can see due to the users of Facebook, most users of our application are younger generation, like the student just graduated or the employers whose working experience is less than three years. Maybe for the future we could pay more attention on the users of different ages, such as 40~50 year-old users and figure out some other ways to attract them.

Lastly, since we have already build on such powerful system, in the future we might expand the purpose of request for more widely use, such as finding experts or recommend male or female for date. Though the factors in the computation model may be vary with distinct application domain, the basic concept of social search is still the same. We might use this system as the base and develop more application.





## REFERENCE

- [1] iLogos Study Research, Global 500 Web Site Recruiting 2001 Survey, Available at:[<http://www.thefreelibrary.com/iLogos+Research+Study+Shows+Global+500+Increase+Web+Site+Recruiting...-a075511718>], Accessed: 13/05/2014.
- [2] Forrester Research Institute, e-Recruitment, Available at [<http://en.wikipedia.org/wiki/E-recruitment>], Accessed: 13/05/2014.
- [3] Wang, I.Z, (2000). Companies focus on the professional skills while students focus on the package and interest, Young, 20-24.
- [4] Society of Human Resource Management, (2001), Society for Human Resource Management Research. Available at:[<http://www.shrm.org/Research/SurveyFindings/Documents/Search%20Tactic%20Poll.pdf>] Accessed at:13/05/2014
- [5] Granovetter, M. (1983). "The Strength of Weak Ties: A Network Theory Revisited". *Sociological Theory* 1: 201~233.
- [6] facebook. Facebook Reports Fourth Quarter and Full Year 2013 Results Available at: [<http://investor.fb.com/releasedetail.cfm?ReleaseID=821954>] Accessed at 13/05/2014
- [7] Mark-Shane, S., (2008).Facebook as a social search engine and the implications for libraries in the twenty-first century. *Emerald*,. 26(0): p. 540 - 556.
- [8] Hempel, Jessi,(2013).”LinkedIn: How Its’ Changing Business.”. *Fortune*. pp. 69-74.
- [9] Nishar,Deep.(2013).”200 Million Members!” LinkedIn Blog. LinkedIn. Available at:[ <http://blog.linkedin.com/2013/01/09/linkedin-200-million/>]. Accessed at: 14/05/2014
- [10] The Buntin Group and Survey Sampling International, (2013), the Lost Art of Getting Together: Quantitative Exploration of Consumer Attitudes and Behavior”. Available at:[ <http://www.mychinet.com/uploads/lostart/Results.pdf> ] Accessed at:14/05/2014
- [11] S. Brin and L. Page. (1998). The anatomy of a large-scale hyper textual Web search engine, WWW.
- [12] M.R. Morris, J.Teevan, K.Panovich.(2010). What do people ask their social networks, and why?: a survey study of status message Q&A behavior. CHI.
- [13] B. Smyth, (2007). A Community-Based Approach to Personalizing Web Search, in *IEEE Computer*, 40(8), pp.42-50.
- [14] Glance, N.S. (2001). Community search assistant. In *Proc. intelligent user interfaces* (pp. 91–96).
- [15] Amershi, S., Morris, M.R., (2008). CoSearch: A system for collocated collaborative web search. In *Proc. CHI’ 08* (pp. 1647 – 1656). ACM Press.
- [16] J. Kleinberg. (2006). Complex networks and decentralized search.In *Proc. of*

the Intl. Congress of Mathematicians (ICM).

- [17] A.Trias,I. Mansilla,(2013), Question Waves: A multicast query routing algorithm for social search, *Information Sciences*,253,pp.1-25.
- [18] A. Banerjee and S. Basu, (2008), “A social query model for decentralized search,” in *SNAKDD*.
- [19] J. Kleinberg. (2000).The small-world phenomenon: An algorithmic perspective. *Proc. 32nd ACM Symposium on Theory of Computing*.
- [20] C. Lin, N. Cao, S.X. Liu, S. Papadimitriou, J. Sun, X. Yan. (2009),*SmallBlue: Social Network Analysis for Expertise Search and Collective Intelligence*, *International Conference On Data Engineering*, Shanghai, IEEE, pp. 1483 – 1486.
- [21] H.Fang.,C.X.Zhai.,(2007), Probabilistic models for expert finding, *ECIR*, pp.418-430.
- [22] Zhang, Z., et al., (2013), User community discovery from multi-relational networks. *Decision Support Systems*, 54(2): p. 870-879.
- [23] L. A. Adamic and E. Adar. (2005).How to search a social network. *Social Networks*, 27(3):187–203.
- [24] Maamar, Z., et al.,(2011), Using Social Networks for Web Services Discovery. *Internet Computing*, IEEE. 15(4): p. 48-54.
- [25] C.T.Li,M.K.Shan,&S.D.Lin,(2011), Context-based People Search in Labeled Social Networks,*ACM International Conference on Information and Knowledge Management (CIKM'11)*.
- [26] S. Wasserman, K. Faust, (1994),*Social Network Analysis: Methods and Applications*,*Cambridge University Press*, Cambridge,.
- Hall, B. Wellman, (1985),*Social networks and social support*, in: S. Cohen,
- [27] S.L.Syme (Eds.), *Social Support and Health*, *Academic Press*, Orlando, Florida, , pp. 23–41
- [28] Y.M.Li, C.Y.Lai,(2014), “A Social Appraisal Mechanism for Online Purchase Decision Support in the Micro-.Blogosphere” with C.-Y., Lai, *Decision Support Systems*, Vol. 59, pp190-205.\
- [29] C.N. Ziegler, J. Golbeck, (2007) Investigating interactions of trust an interest similarity, *Decision Support Systems* 43 (2) 460–475.
- [30] D. Zhao, M.B. Rosson, (2009)How and why people Twitter: the role that micro-blogging plays in informal communication at work*Proceedings of the ACM 2009 International Conference on Supporting Group Work*, pp. 243 – 252
- [31] A.Trias,I. Mansilla,(2012),Asknext: An agent protocol for social search, *Information Sciences*,190,pp.144-191.
- [32] J,Zhang,J.Tang,J.Z.Li,(2007), Expert Finding in a Social Network, *Advances in Databases: Concepts, Systems and Applications Lecture Notes in Computer Science Volume*

4443, , pp 1066-1069

- [33] Rapoport A (1954), Spread of information through a population with socio-structural bias: Iii.suggested experimental procedures. *Bull Math Biol* 16: 75-81
- [34] MS Granovetter, (1973), The Strength of Weak Ties, *American Journal of Sociology*, Volume 78, Issue 6 (May, 1973), 1360-1380
- [35] David Easley and Jon Kleinberg, (2010), *Networks, Crowds, and Markets*, "Strong and Weak Ties," (New York: Cambridge University Press, ), 46.
- [36] Schaefer, C., Coyne, J. C., Lazarus, R. S. (1981). The health related functions of social support. *Journal of Behavioral Medicine*, 4, 381-406.
- [37] House, J., Landis, K., and Umberson, D. (1988). Social relationships and health. *Science*, 241, 540–545.
- [38] Krackhardt, D and Stern, R.N.(1988) Informal networks and organizational crises: an experimental simulation. *Social Psychology Quarterly*, 51[2]:123-140.
- [39] AX Cui, (2012), Roles of Ties In Spreading, University of Electronic Science And Technology of China, Chengdu.
- [40] Ronald S. Burt, in B. Silverman: (2008), "Industry Performance and Indirect Access to Structural Holes," *Network Strategy (Advances in Strategic Management*, 25). Bingly: Emerald JAI, 2008, pp. 315-60
- [41] Granovetter, M. (1974), "Getting a Job: A Study of Contacts and Careers". University of Chicago Press.
- [42] Kirnan, J.P., Farley, J. A., & Geisinger, K. F., (1989), "The relationship between recruiting source, application quality, and hire performance: and analysis by sex, ethnicity, and age ", *Personnel Psychology*, Vol.42, po.293-308.
- [43] Y.S.Hadass,(2004), The effect of internet recruiting on the matching of workers and employers, *Social Science Research Network*,p.43
- [44] JÖ RGEN SUNDBERG, Kuhlen (2014) How Social Recruiting Is Used In Europe [Study].
- [45] C.H.Tsai,(2010), A study of semantic web-based specialist recommendation & trust inference mechanism — a case of EMBA database,NCCU.
- [46] Alex Internet, (2014), "Alexa Top 500 Global Sites".
- [47] Horowitz, D. & Kamvar, S.D. (2010), The Anatomy of a Large-Scale Social Search Engine, *Proceedings of the 19th international conference on World Wide Web — WWW'10*, ACM Press, New York, NY (p.431)
- [48] Gilbert, E., Karahalios, K. (2009), "Predicting tie strength with social media", 27th International Conference on Human Factors in Computing Systems – CHI, pp., pp.211-220.
- [49] Choudhury, M,D. & Counts, S.& Horvitz, E, (2013) Major Life Changes and Behavioral Markers in Social Media: Case of Childbirth, CSCW'13.

- [50] Burke, M. & Kraut, R. (2013) Using Facebook after Losing a Job: Differential Benefits of Strong and Weak Ties, CSCW'13.
- [51] Glassdoor Team, Glassdoor Blog, Available at: [<http://www.glassdoor.com/blog/for-infographic-glassdoor-sky-rockets-10-million-users/>], Accessed at: 22/05/2014
- [52] Saaty, T. L. (2004). Decision making—the analytic hierarchy and network processes (AHP/ANP). *Journal of systems science and systems engineering*, 13(1), 1-35.
17. Goodman, L.A. (1961). "Snowball sampling". *Annals of Mathematical Statistics* 32 (1): 148–170.
- B.M.Evans, E.H.Chi,(2010), An elaborated model of social search, *Information Processing & Management*, 46,(6), p.p. 656-678.

