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Russell Mariott, Mahesh S. Raisinghani

A CMM Assessment of Information Systems Maturity Levels in Botswana
Faith-Michael E. Uzoka

The Analysis of MIS Collaboration Research Networks and Research Issues Structure – The Example of *MIS Quarterly* Journal
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airiti press

GPN 2007800019
ISSN 1018-1393
9 771018 139006 09

MIS REVIEW Volume 16 Number 1 September 2010

MIS REVIEW
An International Journal

Vol.16 No. 1 September 2010

MIS Review **Vol. 16, No. 1** Published in September 2010

Publisher: Eugenia Y. Huang

Published by: Airiti Press Inc. & National Chengchi University, Department of Management Information Systems

Editor-in-Chief: Eldon Y. Li

Executive Editor: Tsang-Hsiung Lee

Assistant Editor: Chia-Jen Ting, Liang-Chun Chen

Printed by: Sincere Digital Printing, Co.

Cover Designer: Thomes Chen

Typesetting: Wen-Ling Liu

Publication Office:

National Chengchi University, Department of Management Information Systems
No. 64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City 116, Taiwan

Airiti Press Inc.
18F., No. 80, Sec. 1, Chenggong Rd., Yonghe City, Taipei 234, Taiwan

Order Information:

Airiti Press Inc.
18F., No. 80, Sec. 1, Chenggong Rd., Yonghe City, Taipei 234, Taiwan
Tel: +886-2-29266006
Fax: +886-2-22317711
E-mail: press@airiti.com

Price: NT$ 400

e-Journal: http://www.airitilibary.com

ISSN: 1018-1393

GPN: 2007800019

Printed in Taiwan

Editorial Board

Editor's Introduction

This issue marks the sixteenth year of operation of MIS Review. The journal will be listed in the next edition of Cabell's Directory in May 2010. As stated on the Cabell's web site (see http://www.cabells.com/), Cabell's Directory of Publishing Opportunities provides such information as valuable contact information, review process data, manuscript specifications and guidelines, and publication information for each journal. If you are interested in submitting journal papers, please check our website http://www.icebnet.org/misr/ or contact us for detailed submission information. We sincerely welcome your contribution and support.

In this *MISR* issue we are proud to present four research papers. The summaries of the four papers are as follows. Russell Mariott and Mahesh S. Raisinghani in their paper "Perceptions of Information Privacy in Outsourcing among Healthcare Executives: An Empirical Analysis" provides an in-depth discussion of the various issues, incidents, and next/best-practice models regarding privacy in the outsourcing of services requiring the usage of Protected Health Information (PHI). A survey of 33 hospital executives within the United States at the Vice-President level and above was conducted. These executives were asked to relate their individual attitudes and perceptions of privacy in outsourcing to the actual policies and practices of their organizations. Responses indicate that a link exists between the perceptions of hospital executives and the hospital's policies and procedures. The study extends a number of best practice models and reveals a need for executives to stay informed regarding potential issues in choosing outsourcing partners.

Faith-Michael E. Uzoka in his paper "A CMM Assessment of Information Systems Maturity Levels in Botswana" examines the maturity levels of IS in corporate organizations in a developing country, using the capability maturity model (CMM). The results show that most parastatal and large organizations reside in the high echelon of IS maturity, while public and small organizations are still in the lower levels of maturity. Majority of the organizations do not utilize the CMM practices mainly due to lack of such knowledge. The study shows that the effectiveness and control of an organization's software processes and services improve as organizations having moved up to the higher maturity levels.

Jyun-Cheng Wang, Chui-Chen Chiu, and Ching-Hui Chang in their paper "The Analysis of MIS Collaboration Research Networks and Research Issues Structure -- The Example of *MIS Quarterly* Journal" collect sampled data such as names of the authors and keywords from *MISQ*, one of the most prestigious journals in MIS research field, from 1977 to 2007. They apply social network analysis to mapping out the journal

authors' collaboration network over time and classifying each article through its keyword-hierarchical structure. This paper provides a new way to visualize and understand the development of various MIS subjects, and exemplifies the development of research communities and referenced domains.

Yee-Ming Chen and Cheng-Wei Wei in their paper "Using Multiagent Based on Fuzzy Reasoning Approach to Solve Project Team Work Allocation Problems" proposes an Agent-based Project Management System (AbPMS) to simulate interaction among team members and with those tasks being involved in a project. The system is based on the software BDI (Belief, Desire, and Intention). Agents are used to simulate social human behavior at work, where human characteristics are represented by a set of fuzzy values. Further, they model by applying fuzzy rules the interaction among agents relating to performances of a work team. This paper presents the analysis of a sample case by deploying techniques found in AbPMS for critical issues involving configuration, initialization, and human resource management. It uses AbPMS platform to perform scenarios of stimulus/response agents solving specific problems, such as project durations, task quality and adaptive allocation, in the projects under a state of urgency.

We would like to thank all the authors and reviewers for their collaborative efforts to make this issue possible. We hope this new bilingual format of the journal would open an attractive knowledge exchange platform for both Chinese and non-Chinese authors. Please render us your continuous support and submit your papers to *MISR*. Finally, to our loyal readers around the world, we hope you find the contents of the papers useful to your work or research.

Dr. Eldon Y. Li
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Fall 2010

MIS Review

September 2010 Vol.16 No.1

Content

Research Articles

MIS Review Vol. 16, No. 1, September (2010), pp. 1-51

Perceptions of Information Privacy in Outsourcing among Healthcare Executives: An Empirical Analysis

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ABSTRACT: *This study provides an in-depth discussion of the various issues, incidents, and next/best-practice models regarding privacy in the outsourcing of services requiring the usage of Protected Health Information (PHI). In addition, a survey of 33 hospital executives within the United States at the Vice-President level and above was conducted, relating their individual attitudes and perceptions of privacy in outsourcing to the actual policies and practices of their organization. Convenience sampling was utilized to identify respondents, who were referred to an electronic version of a 23 question survey. Responses indicate that a link exists between the perceptions of hospital executives and the hospital's policies and procedures. The study also reinforces a number of best practice models and implies a need for executives to stay informed regarding potential issues in choosing outsourcing partners.*

KEYWORDS: *Healthcare, Offshore Outsourcing, Information Privacy, Health Insurance Portability and Accountability Act (HIPAA), Protected Health Information (PHI).*

1. Introduction

As in other industries, outsourcing has become a powerful tool for many healthcare executives looking to reduce costs or address a myriad of organizational pressures (Davino, 2004). However, the dynamic nature of this industry and the highly sensitive nature of personal health information create a number of issues that should be considered prior to engaging in outsourcing activities. To better understand these issues, background information will be provided regarding the nature of outsourcing in the healthcare industry.

1.1 What is outsourcing?

Outsourcing, the contracting of traditionally internally provided goods and services to outside third party contractors, has quickly become a $4 trillion-a-year business. Healthcare providers, along with many businesses, have utilized outsourcing to reduce their bottom line and address a number of operational issues within their organizations. Initially, outsourcing was only utilized to provide noncore hospital services such as food

services, housekeeping, and security. These functions have expanded, however, to include core service areas such as top executive positions, clinical areas (e.g. nurse and physician staffing), medical transcription, and a number of business functions, including coding and billing. Degrees of outsourcing may vary, from contracting a single function such as medical transcription, to outsourcing whole hospital divisions, such as human resources (Hazelwood, Hazelwood and Cook, 2005).

1.2 Why do healthcare providers outsource?

While there are a number of different reasons why managers may choose to outsource a particular business function, the decision almost always comes back to the question of cost reduction. In the healthcare industry, human capital accounts for one of the largest operating expenses. The cost of recruiting, training, and retaining qualified employees is often a very expensive and time consuming task. Transferring some of these functions off-site may enable the healthcare provider to eliminate some of the costs associated with supporting a full-time staff, including the reduction of physical space requirements and expenses (Forsman, 2003). This has become especially important considering the limited labor market for some professions that are typically candidates for outsourcing, such as medical transcription. Further justification is offered due to the fact that many outsourcing firms are also specialists in their given field and may be able to offer more reliable and efficient services at a lower price than is possible with an in-house operation.

Outsourcing certain functions can also help in-house staff concentrate on core-competencies important to the healthcare provider, such as providing quality healthcare. Easing heavy or irregular workloads (Hazelwood et al., 2005), providing predictable annual costs, and decreasing internal management's responsibilities allow hospital employees to concentrate on providing for their patients (Forsman, 2003).

1.3 Are benefits really benefits?

Despite the apparent benefits of outsourcing, many still argue that it is not a cure-all and might actually end up costing the hospital more than doing the job themselves. Executives may be lured in by the promise of a quick fix and reassured by the low costs that outsourcing offers, especially if it is done overseas where labor is cheap. This low price, however, may conceal a number of hidden costs that could make outsourcing just as expensive as providing the service in-house (Rhodes, Dennis, and Roach, 2004). In their article about outsourcing medical transcription, Rhodes et al. (2004) state that "When you consider the investment in technology, the cost of telephone and internet communications, staff training, management staff, travel, and proofreading costs, it is probably not less expensive to outsource medical transcription overseas." Providers that seek outsourcing

partners solely on the basis of cost may in turn threaten quality. Correcting mistakes and verifying the quality of the service/product provided creates an additional burden on the provider's staff, which may indirectly increase costs associated with outsourcing (Forsman, 2003). Other inefficiencies that may have similar effects on the actual costs of outsourcing include reduced provider control over information and increased turnaround times (Forsman, 2003). In addition to this, outsourcing firms add a profit margin to their fees to earn a profit off of the services they provide.

1.4 Privacy in outsourcing and the law

One of the most important ethical concerns regarding outsourcing is the privacy of patient health information. There are a large number of rules and regulations that apply to healthcare providers that outsource services. These laws, however, are far from conclusive, so it is important to be informed about their stipulations, how they are able to protect patient health information, and also what limitations might exist.

The most notable U.S. law regarding privacy in the health industry is the Health Insurance Portability and Accountability Act (HIPAA) of 1996. This act was put into place to help "improve the productivity of the American healthcare system and to provide federal regulations for the security and confidentiality of health information (Hazelwood et al., 2005)." While these laws only directly apply to healthcare providers, payers, and clearinghouses, HIPAA does require that these entities undergo certain actions when entrusting their health information to outside parties (Davino, 2004). As mentioned by Davino (2004), HIPAA requires that business associates who have access to protected health information maintain the information's confidentiality. Certain provisions must be included in contracts with business associates that have access to medical information, such as specifications for the permitted uses and disclosures of information by the business associate. Appropriate safeguards, such as guidelines for the release of information to subcontractors, provisions for contract termination (Davino, 2004), and a means to comply with current and prospective legislation that deals with notifying individuals about possible breaches of privacy, should also be included. These obligations are the same whether the business associate is a foreign or domestic entity (Rhodes et al., 2004), even though the ability to enforce the contract in a foreign country may create complications.

It is also important to take international legislation regarding privacy into account when dealing with foreign companies. Policies such as the European Union Data Protection Directive may limit the transfer of personally identifying information outside certain economic areas. Other emerging legislation, such as India's Information Technology Act, may also bring the privacy policies of lesser developed nations into line with their foreign outsourcing clients. Many of these policies, however, have not been fully implemented. In the interim, Rhodes et al. (2004) suggest that "US healthcare

organizations wishing to outsource functions to India that involve individually identifiable health information should be blending their security and privacy requirements into their outsourcing contracts and business associate agreements."

1.5 Incidents and legislation

While privacy has long been a concern in the healthcare industry, its importance in the outsourcing of patient information was brought into the public eye after a 2003 incident with the University of California at San Francisco Medical Center (UCSF) and a Pakistani subcontractor, Lubna Baloch. This incident occurred when a UCSF contractor subcontracted a portion of its medical transcription caseload, after which a chain of subcontracting ended with the information going overseas to Ms. Baloch. After a dispute over payment for the subcontracted work, Ms. Baloch sent UCSF an email threatening the release of a number of patient files if she was not paid. Luckily, one of the subcontractors eventually paid Ms. Baloch and disaster was avoided, but it does serve as a lesson regarding the risks assumed when patient information is outsourced (Lazarus, 2003).

Since some degree of risk to privacy exists when healthcare providers choose to outsource services that involve patient information, a key ethical consideration that the provider should consider is whether they should inform patients that their information is being outsourced. Despite current trends in other industries, few healthcare providers inform their patients if their information is outsourced (Hazelwood et al., 2005). State and National lawmakers are currently proposing legislation to address these issues, even though there is considerable debate about whether such laws are logical or tenable for the healthcare industry (AHIMA [American Health Information Management Association], 2004).

1.6 Identifying and minimizing risk

While there are no fail-safe ways to ensure privacy during outsourcing, there are a number of considerations that should be made to identify and minimize risk in an outsourcing environment. These considerations are used to construct the basis of our survey instrument, discussed later.

1. The first step that should be taken before outsourcing is a self-audit. This is basically a research step in which you document, summarize, and ensure accessibility and understanding of all applicable laws and regulations under which the provider and its business associates operate. This should be followed by an analysis of current policies and procedures that are in place at the hospital. Areas of improvement should be identified, as should any disparities between existing laws and current policies. Steps should then be taken to align policies with legal requirements for privacy (Rhodes et al., 2004).

2. Ensure that contracts with any outside vendors obligate not only the vendor to maintain confidentiality of information, but also require that any party to whom the vendor sends information maintains the privacy and security of information. While the HIPAA (The Health Insurance Portability and Accountability Act) law does extend to business associates and make them responsible for the privacy and security of the provider's health information, complications may arise if the information finds its way overseas. According to Margaret Davino (2004), "Entities not domiciled in the US may not be subject to, or even aware of, US laws." Rhodes et al. (2004) also address this subject in their article "Overseas Outsourcing." They explain that obtaining a judgment against a foreign party is difficult in and of itself, but in most situations involving the inappropriate release of information, the goal of legal action is to stop or prevent a behavior, not to seek judgment for damages or breach of contract. If such an injunction could be obtained from a US court for an individual outside the country, it would be nearly impossible to enforce the injunction in a timely fashion. Thus, Rhodes et al. suggest including contractual provisions with business associates that allow the provider to obtain an injunction if contractual terms are violated. Including a provision of this nature would speed court proceedings allowing an injunction against the business associate to be made in an expedited manner (Rhodes et al., 2004).

3. Require indemnification both from vendors and their subcontractors for any breach of contract, including confidentiality and privacy of information. This will ensure that vendors and their subcontractors will be held wholly liable for their actions which will hopefully dissuade them from handling provider information in an unsafe manner (Davino, 2004).

4. If sending patient information overseas is not a risk worth taking, placing stipulations and requirements on current business associates may be a viable solution. Including contractual provisions with business associates that explicitly prohibits them, or their subcontractors, from sending provider information overseas may not necessarily stop contractors or subcontractors from releasing patient information, but it will ensure that they are privy to American privacy laws (Davino, 2004). Other options may include requiring the disclosure of subcontracts. Based on the UCSF case, however, keeping track of information once it is outsourced can sometimes be a difficult task.

5. Another option that would eliminate the risks associated with overseas outsourcing is to use business associates that do not subcontract any work at all. Many companies have full time domestic staffs that may offer many of the same benefits as in-house departments. For example, employees may be offered hourly wages and other performance incentives that increase their productivity. Some business associates

even assign employees to single contracts, which allow them to build familiarity with the provider's needs and requirements. This service, however, is likely to come at a premium, so providers must weigh the benefits and costs associated with choosing domestic outsourcing firms that do not subcontract work (Davino, 2004).

6. Another consideration to keep in mind is whether business partners are making investments to obtain and retain the healthcare provider as a customer. A company that is willing to make investments into a relationship with their customer is clearly communicating the importance of maintaining the terms of the relationship. For example, the company may purchase new computers or invest in new technology to help retain or obtain the customer's business (Davino, 2004).

7. Including specific performance standards in the contract, such as turnaround time or error rate, may help protect the provider by allowing them to terminate the contract if standards are not met. These standards may also help the provider identify hidden costs associated with vendor inefficiency. Many companies may appear to be less expensive because they charge lower fees, but may actually create other expenses to the provider. For example, if the contractor has a high error rate, employees for the healthcare provider may have to dedicate time to review, edit, and correct the contractor's work (Davino, 2004).

8. Weighing the costs of training staff with regards to privacy is also an important step in analyzing the feasibility of outsourcing. HIPAA requires that individuals with access to personal health information receive training on the requirements of the law. In addition, some states require additional training in other areas of confidentiality, such as the New York AIDS confidentiality law. The burden associated with training employees, in addition to recruiting, hiring, and retaining qualified workers, may be easier and more cost-effective to place in the hands of a contractor (Davino, 2004).

9. It is also important to include standard protection terms in any contract with outside vendors. These terms include provisions required by HIPAA, the ability of both parties to terminate the contract with or without cause, an appropriate length of time for the contract, the inability of the vendor to assign the contract without the provider's permission, and a requirement that any claim be brought in the state in which the provider is located (Davino, 2004).

10. Verify the security practices of any vendors with which personal health information will be exchanged. Partners should be able to assure that they are able to meet the demanding requirements and regulations within the healthcare industry, most notably, how their practices comply with the new HIPAA laws. For example, vendors may be required to complete a security audit or verify current practices with regards to industry regulations (Zeile, 2005).

1.7 Questions to ask prospective outsourcing partners

According to the AHIMA, there are a number of questions that providers should answer when considering possible outsourcing partners. These questions are listed below (Hazelwood et al., 2005).

1. How and where will the work be done and will any portion of the work be subcontracted?
2. Who will be performing the work and at what pay?
3. What policies, procedures, and training programs are in place at all of the contractor's sites, and are they compliant with industry standards for privacy and security?
4. What laws govern the protection of personal health information in the countries where services are being performed?
5. How will the information be securely transported to and from the healthcare facility?
6. How and when will physician and patient demographic information be provided to the contractor?
7. How long will information reside on the contractor's database?
8. How will information retained on the contractor's database be destroyed?
9. How will the service ensure and measure quality?
10. What language exists in your contracts to assign responsibility for breaches of privacy and security?

2. Premise for the hypothesis

Based on the discussion above, it is evident that many healthcare executives believe significant cost savings are possible for organizations interested in outsourcing various components of their operations. However, the question is whether executives are placing too great of an emphasis on creating cost savings, while neglecting the safety of their patient's personal information. This research will seek to identify relationships between the personal attitudes and perceptions of privacy in outsourcing among executives and the actual policies and practices of the organization. It is hypothesized that while individual executives may place a strong personal emphasis on the privacy of health information, these attitudes will not be reflected in the outsourcing policies and practices of the organization.

3. Research methodology

Participants were asked to complete a 23-question online survey assessing organizational policies and procedures regarding privacy in outsourcing, personal perceptions of privacy, and demographics. Survey questions were developed based on current literature, as well as best practices within the industry for privacy in outsourcing (see Appendix A for full survey). Survey responses were compared and statistically analyzed to identify significant relationships between the organization's policies/practices and the perceptions of the individual respondents. All participants are current employees in hospital or hospital systems throughout the United States. Individuals at the Vice-President level and above, as well as individuals at the director level serving in a health information management role, were invited to participate in the survey. Information was collected over a two month period in the following manner.

3.1 Partnership with Health Data Management

The research team worked closely with the professional journal *Health Data Management* to identify prospective participants for the survey. Subscribers to this journal who met the criteria listed above were sent an email inviting them to take the online survey. A follow-up email was then sent out two weeks after the initial email.

3.2 Convenience sampling

The research team also utilized personal contacts, primarily within the Dallas/Ft. Worth and Houston markets, to identify participants for the survey. These individuals were sent a personal email inviting them to take the online survey, as well as a reminder email approximately two weeks after the initial contact.

All participants were instructed to access the survey using a URL that was provided to them in each email contact. This URL led the participant to a secure site where responses were collected and tabulated. Participants were not required to provide personally-identifiable information, but had the option of including their email address to receive information regarding the results of the survey.

4. Measures

A total of 33 individuals, approximately half from each sampling measure, completed the survey in its entirety. An additional 10 surveys were unusable due to incomplete responses. Inadequate sample size restricted the research team from conducting Pearson's Product Moment Correlations between survey responses, so its nonparametric equivalent

(Spearman's Rho Correlation) was used to assess the statistical significance of our findings (Results from the survey can be found in Appendix B, while the statistical analysis can be found in Appendix C).

5. Results

1. Q1. The majority (60.6%) of participants were from the state of Texas. There were not enough participants from any other state to make comparisons with.
2. Q2. There was no significant correlation between hospital size and the eight perceptions of privacy in outsourcing.
3. Q3. No significant differences were found regarding the eight perceptions of privacy in outsourcing between urban and suburban participants. (Only 3 rural, thus these were not included in the analysis.)
4. Q4. No comparison could be made between CEO (n = 1), COO (n = 4), CIO (n = 3) and Other (n = 25) because the majority listed other as their position.
5. Q6. Participants who said that patients are notified if their health info is released to contractors had significantly greater agreement than participants who said that patients are not notified if their health info is released to contractors regarding the question "authorization should be required before contractors may share patient health info with subcontractors."
6. Q7. Participants who said that contractors are required to notify their organization if patient health information is released to subcontractors had significantly less agreement than participants who said that contractors are not required to notify their organization if patient health information is released to subcontractors on the item "the benefits of outsourcing outweigh its possible risks to privacy."

Participants who said that contractors are required to notify your organization if patient health information is released to subcontractors had significantly greater agreement than participants who said that contractors are not required to notify your organization if patient health information is released to subcontractors on the item "companies should never share personal information with other companies unless it has been authorized by the individual who provided the information."

Of those who said yes, to Q7. Sixteen of them said that the contractors are required to submit the information of the subcontractors (Q8).

7. Q9. There were no differences on the eight perceptions of privacy in outsourcing between participants who did and did not have contractors restricted from sending patients health information outside the US.
8. Q10. Only 2 respondents reported that indemnification is not required, compared to 16 who said yes it is required. Thus no stats were conducted.
9. Q11. Only 1 respondent reported that all contracts do not obligate business partners, compared to 31 who said yes. Thus, no stats were conducted.
10. Q12. There were no differences on the eight perceptions of privacy in outsourcing between participants who did and did not specific performance standards present in contracts with businesses
11. Q14. There is a significant moderate positive correlation between Q14 and Q17. Participants who agreed that contractors used by their organization make adequate investments of time and money to obtain and retain their organization as a customer also agreed that they can trust outsourcing partners to maintain the integrity of patient health information and vice versa.
12. Q13, 14, and 15 are all significantly moderately positively correlated to one another. Participants who agreed on one, agreed on the other two and vice versa.

6. Discussion

While the relatively low response rate inhibited this survey from providing the most statistically viable results, it did provide interesting insight into the relationship between organizational policies regarding privacy in outsourcing and the individual executive's personal views of the topic. The majority of the information gathered in this research negates the hypothesis that executives within the healthcare field may place a strong personal emphasis on the privacy of health information, but that these attitudes are not reflected in the outsourcing policies and practices of the organization.

Significant agreement can be seen between the perceptions of executives and the practices of their organization in a number of different areas. The following list outlines these relationships:

1. Executives that felt authorization should be required before contractors are able to share patient health information with subcontractors typically indicated that their organization did indeed notify patients if health information was released to contractors.

2. Respondents who felt that companies should not release personal health information without prior authorization typically required contractors to notify their organizations if personal information was released to subcontractors.

This relationship implies that the values of the individual tend to align with the policies and practices of their organization. The cause of this alignment, however, is unclear.

Other important discoveries focused around the respondent's knowledge and approach towards the safekeeping of their organization's protected health information. In an article written by Joanne Wojcik, many problems with privacy arise from the fact that companies do not know what's being outsourced offshore (Wojcik, 2004) and often do not find out unless there is a problem. This can be a significant issue, however, since most security incidents go unreported. According to a study conducted by the Government Accountability Office, as many as 80% of such incidents go unreported because managers do not realize a problem exists (Robeznieks and Conn, 2006).

Based on our research, less than half of respondents were fully aware of who had access to their organization's protected health information. Approximately 42% of respondents did not know whether their PHI was restricted from going overseas, while 21.2% of respondents had no such restrictions in place. These are very interesting statistics, especially when you consider that 51.6% of respondents did not require indemnification of contractors and subcontractors regarding breaches in privacy. Since HIPAA regulations are largely unenforceable internationally, organizations that are not diligent in protecting their patient's information may face legal recourse if a breach should occur. This threat has been highlighted by organizations such as the American Medical Association, who has recently issued a statement encouraging U.S. physicians to be wary of outsourcing services overseas without first verifying the security practices of contractors and subcontractors (Robeznieks, 2005), as well as incorporating language in all contracts that protects the customer.

Another discrepancy could be seen based on certain responses to the survey. Approximately 90% of respondents indicated that the protection of privacy should be maintained at any cost, yet they also overwhelmingly indicated that they do not feel U.S. HIPAA laws or foreign privacy laws adequately protect PHI abroad. At the same time, 63.6% of respondents either had no restrictions regarding overseas outsourcing or did not know if such policies were in place. Despite this, 70% of respondents maintained that they trusted their outsourcing partners. This information seems to imply that many managers are unaware of the threats that face their PHI or have done little to "put their money where their mouth is" in regards to protecting their organization's information.

Results from the survey were also able to reinforce a number of measures identified by related literature as key methods to minimizing privacy risk in outsourcing. For example, individuals who indicated that they verify the security practices of business partners (Zeile, 2005) and felt that their partners make adequate investments of time and money to retain their business were more aware of who had access to their patients' information after it is released to contractors. The survey also reinforced the idea that business partners who invest time and money into their relationships with healthcare providers are typically better trusted to ensure the integrity of personal health information (Davino, 2004).

7. Implications

While a number of key findings from this survey proved to be very interesting, the survey will need to be replicated and conducted on a much larger scale to provide any conclusive information. In addition, a more randomized approach to identifying survey recipients is needed to improve the validity of the survey instrument.

As stated previously, this research seems to imply that the values of the individual tend to align with the policies and practices of their organization, even though a clear cause of this alignment is not apparent. Further research is needed to determine whether executives exert influence over policies and practices based on their personal views, whether the executive chooses to join an institution because its policies closely mirror their personal values, or whether the executive assimilates the values of the organization's corporate culture into their own values. Additional research is also needed to establish a more viable relationship between the executive's personal values and the policies and practices of their organization. However, establishing a better defined link between these two factors may help managers involved in the hiring process better understand what types of individuals may thrive in positions whose responsibilities involve privacy and outsourcing.

Despite a lack of knowledge regarding who is handling an organization's information, more than 70% of respondents still felt that they could trust their outsourcing partners. Upon consideration of the number of incidents that go largely unreported, managers may need to take a closer look at the organizations that are handling their information to truly understand what privacy risks they may be facing. Contracts may also need to be reevaluated to provide secure terms in the case of a legal challenge, or possibly prohibit the overseas outsourcing of PHI altogether. In addition, future research may seek to address questions regarding how often privacy issues go unnoticed and what can be done to improve awareness and prevention of such problems.

Other future research may also seek to address issues within a wide range of outsourcing areas. While most current research focuses on issues surrounding the outsourcing of medical transcription, other services such as radiology, payroll, and customer services are also increasingly being sent overseas.

8. Conclusion

The major contribution of this research stems from its ability to provide an initial link between the perceptions of privacy among hospital executives regarding outsourcing and the actual policies and practices exhibited by their organization. Such a link may be important in developing an organization focused around privacy, as well as choosing administrators that are compatible with the hospital's culture and goals.

While outsourcing may provide numerous benefits to an organization, hospital executives must be careful in choosing partners whose processes are focused around security and privacy. Numerous regulations in the U.S. and abroad have attempted to address the issue of privacy, but the responsibility in protecting this information is largely in the hands of the organization which it originates. Remaining knowledgeable about the risks faced by the organization, as well as how to adequately address them while still capitalizing on the benefits offered by outsourcing will enable organizations to significantly decrease potential violations of protected health information.

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About the authors

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Appendix A: Survey Instrument

The return of your completed questionnaire constitutes your informed consent to act as a participant in this research.

Survey Instrument

Demographic Information

1. State where hospital is located. (Pull down menu with states listed)
2. Size of Hospital
   _____ Beds
3. Hospital Setting
   a. Urban
   b. Suburban
   c. Rural
4. Position at Hospital
   a. Chief Executive Officer
   b. Chief Operations Officer
   c. Chief Information Officer
   d. Other (Please Specify): _____
5. Email Address (This information will be used only to send you an executive summary of this research. Please leave this field blank if you do not wish to receive such information.)
   _____

Privacy Practices in Outsourcing

Please indicate the most appropriate response in regards to the current practices of your hospital.

For the purposes of this survey, the term "contractor" is defined as any business partner that your organization enters into contract with to perform services for your organization. "Subcontractors" are business partners used by contractors to help perform services for your organization.

6. Are patients notified if their health information is released to contractors?
   a. Yes
   b. No
   c. I don't know

7. Are contractors required to notify your organization if patient health information is released to subcontractors?
   a. Yes
   b. No
   c. I don't know

8. If yes, are the contractors required to submit the information of the subcontractors to you?
   a. Yes
   b. No
   c. I don't know

9. Are contractors for your organization restricted from sending patient health information outside the United States?
   a. Yes
   b. No
   c. I don't know

10. Is indemnification required from contractors for any breach of contract, as well as from any subcontractors that they may send information to?
    a. Yes
    b. No
    c. I don't know

11. Do all contracts with business partners obligate them, as well as any other person or entity to which the information is sent, to maintain the confidentiality and security of patient health information?
    a. Yes
    b. No
    c. I don't know

12. Are specific performance standards present in contracts with businesses that will have access to patient health information (ex. Turnaround time, error rate, template consistency, etc.)?
    a. Yes
       If yes, please specify some key performance standard/s used by your organization: _____
    b. No
    c. I don't know

Indicate the degree to which you, as an employee, agree with the following statements by selecting the appropriate number.

1=Strongly Disagree; 2=Disagree; 3=Somewhat Disagree; 4=Neutral; 5= Somewhat Agree; 6=Agree; 7=Strongly Agree.

13. The security practices of business partners are verified before entering into a contractual agreement where patient health information will be exchanged.
14. I feel that the contractors used by my organization make adequate investments of time and money to obtain and retain my organization as a customer.
15. I am aware of who has access to the personal health information of my organization's patients after it has been released to contractors.

Perceptions of Privacy in Outsourcing

Indicate the degree to which you, as an individual, agree with the following statements by selecting the appropriate number.

1=Strongly Disagree; 2=Disagree; 3=Somewhat Disagree; 4=Neutral; 5= Somewhat Agree; 6=Agree; 7=Strongly Agree.

16. The benefits of outsourcing outweigh its possible risks to privacy.
17. I can trust outsourcing partners to maintain the integrity of patient health information.
18. The privacy of patient health information should be protected no matter how much it costs.
19. Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.
20. Authorization should be required before contractors may share patient health information with subcontractors.
21. The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.
22. Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.
23. I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.

Appendix B: Survey Results

Section 1: Demographic Information

1. State where hospital is located

State	Response Percent	Response Total
Alabama	3	1
California	6.1	2
Florida	3	1
Michigan	3	1
North Carolina	6.1	2
Ohio	3	1
South Dakota	3	1
Tennessee	3	1
Texas	60.6	20
Utah	3	1
Virginia	3	1
Wyoming	3	1
Total Respondents		33
Skipped Question		0

2. Size of hospital (number of beds)

Mean	361
Median	245
Mode	216

3. Hospital setting

	Response Percent	Response Total
Urban	45.5	15
Suburban	45.5	15
Rural	9.1	3
Total Respondents		33
Skipped Question		0

4. Position at hospital

	Response Percent	Response Total
CEO	3	1
COO	12.1	4
CIO	9.1	3
Other	75.8	25
Total Respondents		33
Skipped Question		0

5. Email Address (confidential)

Section 2: Privacy Practices in Outsourcing

6. Are patients notified if their health information is released to contractors?

	Response Percent	Response Total
Yes	36.4	12
No	42.4	14
I don't know	21.2	7
Total Respondents		33
Skipped Question		0

7. Are contractors required to notify your organization if patient health information is released to subcontractors?

	Response Percent	Response Total
Yes	66.7	22
No	18.2	6
I don't know	15.2	5
Total Respondents		33
Skipped Question		0

8. If yes, are the contractors required to submit the information of the subcontractors to you?

	Response Percent	Response Total
Yes	55.2	16
No	24.1	7
I don't know	20.7	6
Total Respondents		29
Skipped Question		4

9. Are contractors for your organization restricted from sending patient health information outside the United States?

	Response Percent	Response Total
Yes	36.4	12
No	21.2	7
I don't know	42.4	14
Total Respondents		33
Skipped Question		0

10. Is indemnification required from contractors for and breach of contract, as well as from any subcontractors that they may send information to?

	Response Percent	Response Total
Yes	48.5	16
No	6.1	2
I don't know	45.5	15
Total Respondents		33
Skipped Question		0

11. Do all contracts with business partners obligate them, as well as any other person or entity which the informationis sent, to maintain the confidentiality and security of patient health information?

	Response Percent	Response Total
Yes	93.9	31
No	3	1
I don't know	3	1
Total Respondents		33
Skipped Question		0

12. Are specific performance standards present in contracts with businesses that will have access to patient health information?

	Response Percent	Response Total
Yes	45.5	15
No	24.2	8
I don't know	30.3	10
Total Respondents		33
Skipped Question		0

13. If yes, please specify some key performance standard/s used by your organization (open ended).

14. The security practices of business partners are verified before entering into a contractual agreement where patient health information will be exchanged.

	Response Percent	**Response Total**
1 = Strongly Disagree	0	0
2 = Disagree	3	1
3 = Somewhat Disagree	9.1	3
4 = Neutral	12.1	4
5 = Somewhat Agree	21.2	7
6 = Agree	30.3	10
7 = Strongly Agree	24.2	8
Total Respondents		33
Skipped Question		0

15. I feel that contractors used by my organization make adequate investments of time and money to obtain and retain my organization as a customer.

	Response Percent	**Response Total**
1 = Strongly Disagree	0	0
2 = Disagree	0	0
3 = Somewhat Disagree	3	1
4 = Neutral	6.1	2
5 = Somewhat Agree	15.2	5
6 = Agree	63.6	21
7 = Strongly Agree	12.1	4
Total Respondents		33
Skipped Question		0

Section 3: Perceptions of Privacy in Outsourcing

16. I am aware of who has access to the personal health information of my organization's patients after it has been released to contractors.

	Response Percent	Response Total
1 = Strongly Disagree	9.1	3
2 = Disagree	18.2	6
3 = Somewhat Disagree	12.1	4
4 = Neutral	12.1	4
5 = Somewhat Agree	15.2	5
6 = Agree	27.3	9
7 = Strongly Agree	6.1	2
Total Respondents		33
Skipped Question		0

17. The benefits of outsourcing outweigh its possible risks to privacy.

	Response Percent	Response Total
1 = Strongly Disagree	3.2	1
2 = Disagree	9.7	3
3 = Somewhat Disagree	6.5	2
4 = Neutral	16.1	5
5 = Somewhat Agree	22.6	7
6 = Agree	38.7	12
7 = Strongly Agree	3.2	1
Total Respondents		31
Skipped Question		2

18. I can trust outsourcing partners to maintain the integrity of patient health information.

	Response Percent	Response Total
1 = Strongly Disagree	3.2	1
2 = Disagree	6.5	2
3 = Somewhat Disagree	6.5	2
4 = Neutral	12.9	4
5 = Somewhat Agree	12.9	4
6 = Agree	45.2	14
7 = Strongly Agree	12.9	4
Total Respondents		31
Skipped Question		2

19. The privacy of patient health information should be protected no matter how much it costs.

	Response Percent	Response Total
1 = Strongly Disagree	0	0
2 = Disagree	0	0
3 = Somewhat Disagree	3.2	1
4 = Neutral	6.5	2
5 = Somewhat Agree	12.9	4
6 = Agree	35.5	11
7 = Strongly Agree	41.9	13
Total Respondents		31
Skipped Question		2

20. Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.

	Response Percent	Response Total
1 = Strongly Disagree	3.2	1
2 = Disagree	0	0
3 = Somewhat Disagree	6.5	2
4 = Neutral	9.7	3
5 = Somewhat Agree	6.5	2
6 = Agree	32.3	10
7 = Strongly Agree	41.9	13
Total Respondents		31
Skipped Question		2

21. Authorization should be required before contractors may share patient health information with subcontractors.

	Response Percent	Response Total
1 = Strongly Disagree	9.7	3
2 = Disagree	0	0
3 = Somewhat Disagree	3.2	1
4 = Neutral	16.1	5
5 = Somewhat Agree	3.2	1
6 = Agree	41.9	13
7 = Strongly Agree	25.8	8
Total Respondents		31
Skipped Question		2

22. The Health Insurance Portability and Accountibility Act (HIPAA) adequately protects health information that is exchanged during outsourcing to companies outside of the United States.

	Response Percent	**Response Total**
1 = Strongly Disagree	6.5	2
2 = Disagree	16.1	5
3 = Somewhat Disagree	6.5	2
4 = Neutral	38.7	12
5 = Somewhat Agree	9.7	3
6 = Agree	12.9	4
7 = Strongly Agree	9.7	3
Total Respondents		31
Skipped Question		2

23. Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.

	Response Percent	**Response Total**
1 = Strongly Disagree	9.7	3
2 = Disagree	25.8	8
3 = Somewhat Disagree	6.5	2
4 = Neutral	51.6	16
5 = Somewhat Agree	0	0
6 = Agree	3.2	1
7 = Strongly Agree	3.2	1
Total Respondents		31
Skipped Question		2

24. I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.

	Response Percent	**Response Total**
1 = S trongly Disagree	3.2	1
2 = Disagree	3.2	1
3 = Somewhat Disagree	0	0
4 = Neutral	51.6	16
5 = Somewhat Agree	12.9	4
6 = Agree	19.4	6
7 = Strongly Agree	9.7	3
Total Respondents		31
Skipped Question		2

Appendix C: Statistical Analysis

Correlations

			X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Spearman's rho	The security practices of business partners are verified before entering into a contractual agreement where patient health information will be exchanged.	Correlation Coefficient	1.000	.647(**)	.501(**)	-.279	-.173	-.022	-.038	.146	.231	.253	.161	.222
		Sig. (2-tailed)	.	.000	.003	.116	.353	.907	.838	.434	.212	.170	.386	.230
		N	33	33	33	33	31	31	31	31	31	31	31	31
	I feel that the contractors used by my organization make adequate investments of time and money to obtain and retain my organization as a customer.	Correlation Coefficient	.647(**)	1.000	.508(**)	-.017	.026	.405(*)	.036	.195	.131	.223	-.048	.215
		Sig. (2-tailed)	.000	.	.003	.925	.889	.024	.847	.293	.483	.228	.797	.247
		N	33	33	33	33	31	31	31	31	31	31	31	31
	I am aware of who has access to the personal health information of my organization's patients after it has been released to contractors.	Correlation Coefficient	.501(**)	.508(**)	1.000	-.155	-.032	.216	.100	.227	.120	.158	.021	.270
		Sig. (2-tailed)	.003	.003	.	.390	.864	.244	.591	.220	.522	.397	.910	.141
		N	33	33	33	33	31	31	31	31	31	31	31	31

Correlations (conti.)

	Size of Hospital (Number of beds)	Correlation Coefficient	-.279	-.017	-.155	1.000	-.151	.022	-.160	.052	.104	-.176	-.101	.194
		Sig. (2-tailed)	.116	.925	.390	.	.416	.908	.390	.781	.577	.342	.587	.295
		N	33	33	33	33	31	31	31	31	31	31	31	31
	The benefits of outsourcing outweigh its possible risks to privacy.	Correlation Coefficient	-.173	.026	-.032	-.151	1.000	.582(**)	-.313	-.413(*)	-.215	.186	.063	.319
		Sig. (2-tailed)	.353	.889	.864	.416	.	.001	.087	.021	.245	.316	.735	.080
		N	31	31	31	31	31	31	31	31	31	31	31	31
	I can trust outsourcing partners to maintain the integrity of patient health information.	Correlation Coefficient	-.022	.405(*)	.216	.022	.582(**)	1.000	-.203	-.267	-.368(*)	.423(*)	.346	.089
		Sig. (2-tailed)	.907	.024	.244	.908	.001	.	.273	.147	.042	.018	.057	.632
		N	31	31	31	31	31	31	31	31	31	31	31	31
	The privacy of patient health information should be protected no matter how much it costs.	Correlation Coefficient	-.038	.036	.100	-.160	-.313	-.203	1.000	.515(**)	.291	.044	.005	-.281
		Sig. (2-tailed)	.838	.847	.591	.390	.087	.273	.	.003	.112	.813	.979	.125
		N	31	31	31	31	31	31	31	31	31	31	31	31
	Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Correlation Coefficient	.146	.195	.227	.052	-.413(*)	-.267	.515(**)	1.000	.639(**)	-.053	-.122	-.119

Correlations (conti.)

	Sig. (2-tailed)	.434	.293	.220	.781	.021	.147	.003	.	.000	.777	.512	.523
	N	31	31	31	31	31	31	31	31	31	31	31	31
Authorization should be required before contractors may share patient health information with subcontractors.	Correlation Coefficient	.231	.131	.120	.104	-.215	-.368(*)	.291	.639(**)	1.000	-.081	-.211	.082
	Sig. (2-tailed)	.212	.483	.522	.577	.245	.042	.112	.000	.	.665	.255	.663
	N	31	31	31	31	31	31	31	31	31	31	31	31
The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.	Correlation Coefficient	.253	.223	.158	-.176	.186	.423(*)	.044	-.053	-.081	1.000	.717(**)	.031
	Sig. (2-tailed)	.170	.228	.397	.342	.316	.018	.813	.777	.665	.	.000	.867
	N	31	31	31	31	31	31	31	31	31	31	31	31
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	Correlation Coefficient	.161	-.048	.021	-.101	.063	.346	.005	-.122	-.211	.717(**)	1.000	-.086
	Sig. (2-tailed)	.386	.797	.910	.587	.735	.057	.979	.512	.255	.000	.	.646
	N	31	31	31	31	31	31	31	31	31	31	31	31

Correlations (conti.)

	I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.	Correlation Coefficient	.222	.215	.270	.194	.319	.089	-.281	-.119	.082	.031	-.086	1.000
		Sig. (2-tailed)	.230	.247	.141	.295	.080	.632	.125	.523	.663	.867	.646	.
		N	31	31	31	31	31	31	31	31	31	31	31	31

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Footnote (Legend for Column Name):

X1: The security practices of business partners are verified before entering into a contractual agreement where patient health information will be exchanged.

X2: I feel that the contractors used by my organization make adequate investments of time and money to obtain and retain my organization as a customer.

X3: I am aware of who has access to the personal health information of my organization's patients after it has been released to contractors.

X4: Size of Hospital (Number of beds)

X5: The benefits of outsourcing outweigh its possible risks to privacy.

X6: I can trust outsourcing partners to maintain the integrity of patient health information.

X7: I can trust outsourcing partners to maintain the integrity of patient health information.

X8: I can trust outsourcing partners to maintain the integrity of patient health information.

X9: Authorization should be required before contractors may share patient health information with subcontractors.

X10: The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.

X11: Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.

X12: I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.

T-Test

Group Statistics

	Hospital Setting	N	Mean	Std. Deviation	Std. Error Mean
The benefits of outsourcing outweigh its possible risks to privacy.	Urban	14	4.71	1.729	.462
	Suburban	14	5.00	1.301	.348
I can trust outsourcing partners to maintain the integrity of patient health information.	Urban	14	5.14	1.916	.512
	Suburban	14	5.29	1.383	.370
The privacy of patient health information should be protected no matter how much it costs.	Urban	14	6.07	1.141	.305
	Suburban	14	6.00	1.038	.277
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Urban	14	5.50	1.951	.522
	Suburban	14	6.07	.917	.245
Authorization should be required before contractors may share patient health information with subcontractors.	Urban	14	5.21	1.805	.482
	Suburban	14	5.36	1.985	.530
The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	Urban	14	4.00	1.569	.419
	Suburban	14	4.21	1.672	.447
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	Urban	14	3.29	1.590	.425
	Suburban	14	3.29	1.326	.354
I feel that patient health information shared with domestic business partners is more secure.	Urban	14	4.71	1.541	.412
	Suburban	14	4.57	1.284	.343

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
The benefits of outsourcing outweigh its possible risks to privacy.	Equal variances assumed	1.187	.286	-.494	26	.625	-.286	.578	-1.474	.903
	Equal variances not assumed			-.494	24.147	.626	-.286	.578	-1.479	.907
I can trust outsourcing partners to maintain the integrity of patient health information.	Equal variances assumed	1.670	.208	-.226	26	.823	-.143	.631	-1.441	1.155
	Equal variances not assumed			-.226	23.654	.823	-.143	.631	-1.447	1.161
The privacy of patient health information should be protected no matter how much it costs.	Equal variances assumed	.081	.778	.173	26	.864	.071	.412	-.776	.919
	Equal variances not assumed			.173	25.769	.864	.071	.412	-.776	.919
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Equal variances assumed	7.620	.010	-.992	26	.330	-.571	.576	-1.756	.613
	Equal variances not assumed			-.992	18.473	.334	-.571	.576	-1.780	.637
Authorization should be required before contractors may share patient health information with subcontractors.	Equal variances assumed	.005	.944	-.199	26	.844	-.143	.717	-1.617	1.331
	Equal variances not assumed			-.199	25.769	.844	-.143	.717	-1.617	1.332

Independent Samples Test (conti.)

The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	Equal variances assumed	.437	.514	-.350	26	.729	-.214	.613	-1.474	1.045
	Equal variances not assumed			-.350	25.895	.729	-.214	.613	-1.474	1.046
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	Equal variances assumed	.218	.644	.000	26	1.000	.000	.553	-1.137	1.137
	Equal variances not assumed			.000	25.189	1.000	.000	.553	-1.139	1.139
I feel that patient health information shared with domestic business partners is more secure.	Equal variances assumed	.140	.711	.267	26	.792	.143	.536	-.959	1.245
	Equal variances not assumed			.267	25.181	.792	.143	.536	-.961	1.246

Frequencies

State where hospital is located.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Alabama	1	3.0	3.0	3.0
	California	2	6.1	6.1	9.1
	Florida	1	3.0	3.0	12.1
	Michigan	1	3.0	3.0	15.2
	North Carolina	2	6.1	6.1	21.2
	Ohio	1	3.0	3.0	24.2
	South Dakota	1	3.0	3.0	27.3
	Tennessee	1	3.0	3.0	30.3
	Texas	20	60.6	60.6	90.9
	Utah	1	3.0	3.0	93.9
	Virginia	1	3.0	3.0	97.0
	Wyoming	1	3.0	3.0	100.0
	Total	33	100.0	100.0	

Hospital Setting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Urban	15	45.5	45.5	45.5
	Suburban	15	45.5	45.5	90.9
	Rural	3	9.1	9.1	100.0
	Total	33	100.0	100.0	

Position at Hospital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	CEO	1	3.0	3.0	3.0
	COO	4	12.1	12.1	15.2
	CIO	3	9.1	9.1	24.2
	Other	25	75.8	75.8	100.0
	Total	33	100.0	100.0	

Are patients notified if their health information is released to contractors?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	14	42.4	42.4	42.4
	Yes	12	36.4	36.4	78.8
	I don't know	7	21.2	21.2	100.0
	Total	33	100.0	100.0	

Are contractors required to notify your organization if patient health information is released to subcontractors?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	6	18.2	18.2	18.2
	Yes	22	66.7	66.7	84.8
	I don't know	5	15.2	15.2	100.0
	Total	33	100.0	100.0	

If yes, are the contractors required to submit the information of the subcontractors to you?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	7	21.2	24.1	24.1
	Yes	16	48.5	55.2	79.3
	I don't know	6	18.2	20.7	100.0
	Total	29	87.9	100.0	
Missing	9999	4	12.1		
Total		33	100.0		

Are contractors for your organization restricted from sending patient health information outside the United States?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	7	21.2	21.2	21.2
	Yes	12	36.4	36.4	57.6
	I don't know	14	42.4	42.4	100.0
	Total	33	100.0	100.0	

Is indemnification required from contractors for any breach of contract, as well as from any subcontractors that they may send information to?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	2	6.1	6.1	6.1
	Yes	16	48.5	48.5	54.5
	I don't know	15	45.5	45.5	100.0
	Total	33	1000.0	100.0	

Do all contracts with business partners obligate them, as well as any other person or entity to which the information is sent, to maintain the confidentiality and security of patient health information?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1	3.0	3.0	3.0
	Yes	31	93.9	93.9	97.0
	I don't know	1	3.0	3.0	100.0
	Total	33	100.0	100.0	

Are specific performance standards present in contracts with businesses that will have access to patient health information (ex. Turnaround time, error rate, template consistency, etc.)?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	8	24.2	24.2	24.2
	Yes	15	45.5	45.5	69.7
	I don't know	10	30.3	30.3	100.0
	Total	33	100.0	100.0	

The security practices of business partners are verified before entering into a contractual agreement where patient health information will be exchanged.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	D	1	3.0	3.0	3.0
	SWD	3	9.1	9.1	12.1
	Neutral	4	12.1	12.1	24.2
	SWA	7	21.2	21.2	45.5
	A	10	30.3	30.3	75.8
	SA	8	24.2	24.2	100.0
	Total	33	100.0	100.0	

I feel that the contractors used by my organization make adequate investments of time and money to obtain and retain my organization as a customer.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SWD	1	3.0	3.0	3.0
	Neutral	2	6.1	6.1	9.1
	SWA	5	15.2	15.2	24.2
	A	21	63.6	63.6	87.9
	SA	4	12.1	12.1	100.0
	Total	33	100.0	100.0	

I am aware of who has access to the personal health information of my organization's patients after it has been released to contractors.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	3	9.1	9.1	9.1
	D	6	18.2	18.2	27.3
	SWD	4	12.1	12.1	39.4
	Neutral	4	12.1	12.1	51.5
	SWA	5	15.2	15.2	66.7
	A	9	27.3	27.3	93.9
	SA	2	6.1	6.1	100.0
	Total	33	100.0	100.0	

The benefits of outsourcing outweigh its possible risks to privacy.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	1	3.0	3.2	3.2
	D	3	9.1	9.7	12.9
	SWD	3	6.1	6.5	19.4
	Neutral	5	15.2	16.1	35.5
	SWA	7	21.2	22.6	58.1
	A	12	36.4	28.7	96.8
	SA	1	3.0	3.2	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

I can trust outsourcing partners to maintain the integrity of patient health information.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	1	3.0	3.2	3.2
	D	2	6.1	6.5	9.7
	SWD	2	6.1	6.5	16.1
	Neutral	4	12.1	12.9	29.0
	SWA	4	42.4	12.9	41.9
	A	14	12.1	45.2	87.1
	SA	4	12.1	12.9	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

The privacy of patient health information should be protected no matter how much it costs.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SWD	1	3.0	3.2	3.2
	Neutral	2	6.1	6.5	9.7
	SWA	4	12.1	12.9	22.6
	A	11	33.3	35.5	58.1
	SA	13	39.4	41.9	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	1	3.0	3.2	3.2
	SWD	2	6.1	6.5	9.7
	Neutral	3	9.1	9.7	19.4
	SWA	2	6.1	6.5	25.8
	A	10	30.3	32.3	58.1
	SA	13	39.4	41.9	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

Authorization should be required before contractors may share patient health information with subcontractors.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	3	9.1	9.7	9.7
	SWD	1	3.0	3.2	12.9
	Neutral	5	15.2	16.1	29.0
	SWA	1	3.0	3.2	32.3
	A	13	39.4	41.9	74.2
	SA	8	24.2	25.8	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	2	6.1	6.5	6.5
	D	5	15.2	16.1	22.6
	SWD	2	6.1	6.5	29.0
	Neutral	12	36.4	38.7	67.7
	SWA	3	9.1	9.7	77.4
	A	4	12.1	12.9	90.3
	SA	3	9.1	9.7	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	3	9.1	9.7	9.7
	D	8	24.2	25.8	35.5
	SWD	2	6.1	6.5	41.9
	Neutral	16	48.5	51.6	93.5
	A	1	3.0	3.2	96.8
	SA	1	3.0	3.2	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	1	3.0	3.2	3.2
	D	1	3.0	3.2	6.5
	Neutral	16	48.5	51.6	58.1
	SWA	4	12.1	12.9	71.0
	A	6	18.2	19.4	90.3
	SA	3	9.1	9.7	100.0
	Total	31	93.9	100.0	
Missing	9999	2	6.1		
Total		33	100.0		

Descriptives

	N	Minimum	Maximum	Mean	Std. Deviation
The security practices of business partners are verified before entering into a contractual agreement where patient health information will be exchanged.	33	2	7	5.39	1.391
I feel that the contractors used by my organization make adequate investments of time and money to obtain and retain my organization as a customer.	33	3	7	5.76	.867
I am aware of who has access to the personal health information of my organization's patients after it has been released to contractors.	33	1	7	4.12	1.883
The benefits of outsourcing outweigh its possible risks to privacy.	31	1	7	4.74	1.527
I can trust outsourcing partners to maintain the integrity of patient health information.	31	1	7	5.13	1.586
The privacy of patient health information should be protected no matter how much it costs.	31	3	7	6.06	1.063
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	31	1	7	5.81	1.515
Authorization should be required before contractors may share patient health information with subcontractors.	31	1	7	5.32	1.815
The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.	31	1	7	4.06	1.692
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	31	1	7	3.29	1.395
I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.	31	1	7	4.65	1.355
Valid N (listwise)	31				

T-Test

Group Statistics

	Are patients notified if their health information is	N	Mean	Std. Deviation	Std. Error Mean
Size of Hospital (Number of beds)	No	14	283.14	256.333	68.508
	Yes	12	390.08	251.406	72.575
The benefits of outsourcing outweigh its possible risks to privacy.	No	12	5.00	1.595	.461
	Yes	12	4.42	1.782	.514
I can trust outsourcing partners to maintain the integrity of patient health information.	No	12	5.50	1.508	.435
	Yes	12	4.67	1.923	.555
The privacy of patient health information should be protected no matter how much it costs.	No	12	6.17	.835	.241
	Yes	12	6.25	.866	.250
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	No	12	5.33	1.875	.541
	Yes	12	6.50	.522	.151
Authorization should be required before contractors may share patient health information with subcontractors.	No	12	4.25	2.261	.653
	Yes	12	6.17	.835	.241
The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	No	12	4.00	1.907	.550
	Yes	12	3.92	1.832	.529
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	No	12	3.25	1.485	.429
	Yes	12	3.08	1.621	.468
I feel that patient health information shared with domestic business partners is more secure.	No	12	4.75	1.357	.392
	Yes	12	4.92	1.676	.484

NPar Tests
Mann-Whitney Test
Ranks

	Are patients notified if	N	Mean Ranks	Sum of Ranks
Size of Hospital (Number of beds)	No	14	11.61	162.50
	Yes	12	15.71	188.50
	Total	26		
The benefits of outsourcing outweigh its possible risks to privacy.	No	12	13.58	163.00
	Yes	12	11.42	137.00
	Total	24		
I can trust outsourcing partners to maintain the integrity of patient health information.	No	12	14.13	169.50
	Yes	12	10.88	130.50
	Total	24		
The privacy of patient health information should be protected no matter how much it costs.	No	12	12.04	144.50
	Yes	12	12.96	155.50
	Total	24		
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	No	12	10.25	123.00
	Yes	12	14.75	177.00
	Total	24		
Authorization should be required before contractors may share patient health information with subcontractors.	No	12	9.29	111.50
	Yes	12	15.71	188.50
	Total	24		
The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	No	12	12.54	150.50
	Yes	12	12.46	149.50
	Total	24		
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	No	12	12.67	152.00
	Yes	12	12.33	148.00
	Total	24		
I feel that patient health information shared with domestic business partners is more secure.	No	12	11.88	142.50
	Yes	12	13.13	157.50
	Total	24		

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Size of Hospital (Number of beds)	Equal variances assumed	.021	.887	-1.070	24	.295	-106.940	99.957	-313.242	99.361
	Equal variances not assumed			-1.072	23.529	.295	-106.940	99.802	-313.140	99.259
The benefits of outsourcing outweigh its possible risks to privacy.	Equal variances assumed	.834	.371	.845	22	.407	.583	.690	-.848	2.015
	Equal variances not assumed			.845	21.737	.407	.583	.690	-.849	2.016
I can trust outsourcing partners to maintain the integrity of patient health information.	Equal variances assumed	1.434	.244	1.181	22	.250	.833	.705	-.629	2.296
	Equal variances not assumed			1.181	20.815	.251	.833	.705	-.634	2.301
The privacy of patient health information should be protected no matter how much it costs.	Equal variances assumed	.117	.736	-.240	22	.813	-.083	.347	-.803	.637
	Equal variances not assumed			-.240	21.970	.813	-.083	.347	-.804	.637
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Equal variances assumed	8.639	.008	-2.077	22	.050	-1.167	.562	-2.332	-.001
	Equal variances not assumed			-2.077	12.697	.059	-1.167	.562	-2.383	.050
Authorization should be required before contractors may share patient health information with subcontractors.	Equal variances assumed	15.161	.001	-2.754	22	.012	-1.917	.696	-3.360	-.474
	Equal variances not assumed			-2.754	13.944	.016	-1.917	.696	-3.410	-.424

Independent Samples Test (conti.)

The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	Equal variances assumed	.016	.899	.109	22	.914	.083	.763	-1.500	1.666
	Equal variances not assumed			.109	21.965	.914	.083	.763	-1.500	1.667
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	Equal variances assumed	.709	.409	.263	22	.795	.167	.635	-1.150	1.483
	Equal variances not assumed			.263	21.832	.795	.167	.635	-1.150	1.483
I feel that patient health information shared with domestic business partners is more secure.	Equal variances assumed	.240	.629	.268	22	.791	.167	.623	-1.458	1.125
	Equal variances not assumed			.268	21.084	.792	.167	.623	-1.461	1.125

NPar Tests
Mann-Whitney Test

Ranks

	Are patients notified if	N	Mean Ranks	Sum of Ranks
Size of Hospital (Number of beds)	No	6	10.67	64.00
	Yes	22	15.55	342.00
	Total	28		
The benefits of outsourcing outweigh its possible risks to privacy.	No	6	20.50	123.00
	Yes	21	12.14	255.00
	Total	27		
I can trust outsourcing partners to maintain the integrity of patient health information.	No	6	17.83	107.00
	Yes	21	12.90	271.00
	Total	27		
The privacy of patient health information should be protected no matter how much it costs.	No	6	12.33	74.00
	Yes	21	14.48	304.00
	Total	27		
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	No	6	7.58	45.50
	Yes	21	15.83	332.50
	Total	27		
Authorization should be required before contractors may share patient health information with subcontractors.	No	6	8.92	53.50
	Yes	21	15.45	324.50
	Total	27		
The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	No	6	13.33	80.00
	Yes	21	14.19	298.00
	Total	27		
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	No	6	11.50	69.00
	Yes	21	14.71	309.00
	Total	27		
I feel that patient health information shared with domestic business partners is more secure.	No	6	13.33	80.00
	Yes	21	14.19	298.00
	Total	27		

Test Statistics[b]

	Size of Hospital (Number of beds)	The benefits of outsourcing outweigh its possible risks to privacy.	I can trust outsourcing partners to maintain the integrity of patient health information.	The privacy of patient health information should be protected no matter how much it costs.	Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Authorization should be required before contractors may share patient health information with subcontractors.	The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.	Foreign laws are as effective as U. S. HIPAA laws in protecting the privacy of patient health information.	I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.
Mann-Whitney U	57.500	59.000	52.500	66.500	45.000	33.500	71.500	70.000	64.500
Wilcoxon W	162.500	137.000	130.500	144.500	123.000	111.500	149.500	148.000	142.500
Z	-1.363	-.784	-1.173	-.343	-1.666	-2.392	-.029	-.122	-.450
Asymp. Sig. (2-tailed)	.173	.433	-.241	.731	.096	.017	.977	.903	.653
Exact Sig. [2*(1-tailed Sig.)]	.176[a]	.478[a]	2.66[a]	.755[a]	.128[a]	.024[a]	.977[a]	.932[a]	.671[a]

a. Not corrected for ties.

b. Grouping Variable: Are patients notified if their health information is released to contractors?

T-Test

Group Statistics

	Are patients notified if their health information is	N	Mean	Std. Deviation	Std. Error Mean
Size of Hospital (Number of beds)	No	6	306.83	368.254	150.339
	Yes	22	395.73	336.832	71.813
The benefits of outsourcing outweigh its possible risks to privacy.	No	6	6.00	.632	.258
	Yes	21	4.43	1.630	.356
I can trust outsourcing partners to maintain the integrity of patient health information.	No	6	5.83	1.602	.654
	Yes	21	5.00	1.673	.365
The privacy of patient health information should be protected no matter how much it costs.	No	6	5.83	.983	.401
	Yes	21	6.00	1.140	.249
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	No	6	4.33	2.160	.882
	Yes	21	6.33	.966	.211
Authorization should be required before contractors may share patient health information with subcontractors.	No	6	3.67	2.503	1.022
	Yes	21	5.71	1.454	.317
The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	No	6	3.83	2.229	.910
	Yes	21	3.90	1.546	.337
Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	No	6	2.67	1.033	.422
	Yes	21	3.33	1.560	.340
I feel that patient health information shared with domestic business partners is more secure.	No	6	4.67	.816	.333
	Yes	21	4.76	1.578	.344

Test Statistics[b]

	Size of Hospital (Number of beds)	The benefits of outsourcing outweigh its possible risks to privacy.	I can trust outsourcing partners to maintain the integrity of patient health information.	The privacy of patient health information should be protected no matter how much it costs.	Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Authorization should be required before contractors may share patient health information with subcontractors.	The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.	Foreign laws are as effective as U. S. HIPAA laws in protecting the privacy of patient health information.	I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.
Mann-Whitney U	43.000	24.000	40.000	53.000	24.500	32.500	32.500	48.000	59.000
Wilcoxon W	64.000	255.000	271.000	74.000	45.500	53.500	53.500	69.000	80.000
Z	-1.288	-2.379	-1.427	-.616	-2.400	-2.400	-1.863	-.930	-.246
Asymp. Sig. (2-tailed)	.198	.017	.154	.538	.016	.016	.062	.353	.806
Exact Sig. [2*(1-tailed Sig.)]	.214[a]	.022[a]	.195[a]	.589[a]	.022[a]	.022[a]	.075[a]	.408[a]	.842[a]

a. Not corrected for ties.

b. Grouping Variable: Are patients notified if their health information is released to contractors?

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Size of Hospital (Number of beds)	Equal variances assumed	.580	.453	-.563	26	.579	-88.894	158.019	-413.708	235.920
	Equal variances not assumed			-.534	7.450	.609	-88.894	166.610	-478.094	300.306
The benefits of outsourcing outweigh its possible risks to privacy.	Equal variances assumed	8.527	.007	2.286	25	.031	1.571	.687	.156	2.987
	Equal variances not assumed			3.575	22.094	.002	1.571	.440	.660	2.483
I can trust outsourcing partners to maintain the integrity of patient health information.	Equal variances assumed	.064	.802	1.085	25	.288	.833	.768	-.749	2.415
	Equal variances not assumed			1.112	8.399	.297	.833	.749	-.880	2.547
The privacy of patient health information should be protected no matter how much it costs.	Equal variances assumed	.041	.841	-.324	25	.748	-.167	.514	-1.225	.892
	Equal variances not assumed			-.353	9.240	.732	-.167	.472	-1.231	.897
Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Equal variances assumed	7.248	.012	-3.333	25	.003	-2.000	.600	-3.236	-.764
	Equal variances not assumed			-2.206	5.583	.073	-2.000	.907	-4.260	.260
Authorization should be re-quired before contractors may share patient health information with subcontractors.	Equal variances assumed	4.062	.055	-2.578	25	.016	-2.048	.794	-3.684	-.412
	Equal variances not assumed			-1.913	5.996	.104	-2.048	1.070	-4.666	.571

Independent Samples Test (conti.)

The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies.	Equal variances assumed	2.346	.138	-.091	25	.929	-.071	.789	-1.697	1.554
	Equal variances not assumed			-.074	6.439	.944	-.071	.970	-2.407	2.264
Foreign laws are as effective as U.S. HIPAA laws in prot-ecting the privacy of patient health information.	Equal variances assumed	.834	.370	-.980	25	.337	-.667	.680	-2.068	.735
	Equal variances not assumed			-1.230	12.332	.242	-.667	.542	-1.844	.511
I feel that patient health information shared with domestic business partners is more secure.	Equal variances assumed	2.632	.117	-.141	25	.889	-.095	.675	-1.485	1.295
	Equal variances not assumed			-.199	16.633	.845	-.095	.479	-1.108	.918

Correlations

			Size of Hospital (Number of beds)	The benefits of outsourcing outweigh its possible risks to privacy.	I can trust outsourcing partners to maintain the integrity of patient health information.	The privacy of patient health information should be protected no matter how much it costs.	Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Authorization should be required before contractors may share patient health information with subcontractors.	The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.	Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.
Spearman's rho	Size of Hospital (Number of beds)	Correlation Coefficient	1.000	-.151	.022	-.160	.052	.104	-.176	-.101	.194
		Sig. (2-tailed)		.416	.908	.390	.781	.577	.342	.587	.295
		N	33	31	31	31	31	31	31	31	31
	The benefits of outsourcing outweigh its possible risks to privacy.	Correlation Coefficient	-.151	1.000	.582(**)	-.313	-.413(*)	-.215	.186	.063	.319
		Sig. (2-tailed)	.416	.	.001	.087	.021	.245	.316	.735	.080
		N	31	31	31	31	31	31	31	31	31
	I can trust outsourcing partners to maintain the integrity of patient health information.	Correlation Coefficient	.022	.582(**)	1.000	-.203	-.267	-.368(*)	.423(*)	.346	.089
		Sig. (2-tailed)	.908	.001	.	.273	.147	.042	.018	.057	.632
		N	31	31	31	31	31	31	31	31	31
	The privacy of patient health information should be protected no matter how much it costs.	Correlation Coefficient	-.160	-.313	-.203	1.000	.515(**)	.291	.044	.005	-.281
		Sig. (2-tailed)	.390	.087	.273	.	.003	.112	.813	.979	.125
		N	31	31	31	31	31	31	31	31	31

Correlations (conti.)

	Companies should never share personal information with other companies unless it has been authorized by the individual who provided the information.	Correlation Coefficient	.052	-.413(*)	-.267	.515(**)	1.000	.639(**)	-.053	-.122	-.119
		Sig. (2-tailed)	.781	.021	.147	.003	.	.000	.777	.512	.523
		N	31	31	31	31	31	31	31	31	31
	Authorization should be required before contractors may share patient health information with subcontractors.	Correlation Coefficient	.104	-.215	-.368(*)	.291	.639(**)	1.000	-.081	-.211	.082
		Sig. (2-tailed)	.577	.245	.042	.112	.000	.	.665	.255	.663
		N	31	31	31	31	31	31	31	31	31
	The Health Insurance Portability and Accountability Act (HIPAA) adequately protects patient health information that is exchanged during outsourcing to companies outside of the United States.	Correlation Coefficient	-.176	.186	.423(*)	.044	-.053	-.081	1.000	.717(**)	.031
		Sig. (2-tailed)	.342	.316	.018	.813	.777	.665	.	.000	.867
		N	31	31	31	31	31	31	31	31	31
	Foreign laws are as effective as U.S. HIPAA laws in protecting the privacy of patient health information.	Correlation Coefficient	-.101	.063	.346	.005	-.122	-.211	.717(**)	1.000	-.086
		Sig. (2-tailed)	.587	.735	.057	.979	.512	.255	.000	.	.646
		N	31	31	31	31	31	31	31	31	31
	I feel that patient health information shared with domestic business partners is more secure than patient health information shared with foreign business partners.	Correlation Coefficient	.194	.319	.089	-.281	-.119	.082	.031	-.086	1.000
		Sig. (2-tailed)	.295	.080	.632	.125	.523	.663	.867	.646	.
		N	31	31	31	31	31	31	31	31	31

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

MIS Review Vol. 16, No. 1, September (2010), pp. 53-84

A CMM Assessment of Information Systems Maturity Levels in Botswana

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ABSTRACT: *The maturity of information systems (IS) in corporate organizations has become crucial in influencing the maturity and effectiveness of other functional programs such as marketing, finance, production, and human resources. This study examines the maturity levels of IS in corporate organizations in a developing country, using the Capability Maturity Model (CMM). The results show that most parastatal and large organizations reside in the high echelon of IS maturity, while public and small organizations are still in the low levels of maturity. Majority of the organizations do not utilize the CMM software principally due to lack of knowledge of its existence. Furthermore, the study shows that the effectiveness and control of an organization's software processes and services improve as organizations move up the maturity levels.*

KEYWORDS: *Information Systems, Capability Maturity Model, Software, Key Process Areas, Software Process Improvement.*

1. Introduction

The information systems (IS) field is experiencing a tremendous rate of growth and divergence simultaneously. Our current information society is based on the premise that the use of electronic information will bring improvement in the quality of life of people. Information technologies (IT) pervade almost every aspect of daily life, necessitating constant assessment and evaluation of the impacts of technology on the society. Despite the popular association of information technology with business process improvement (BPI) and business process re-engineering (BPR), little research appears to have been done on how IT actually co-operates with business processes to improve their process capability (Hinks, 1998).

It is a fact that different types of information systems are developed for different purposes and the organizations differ in size and their information systems development capabilities; therefore there is no silver bullet universally true for any information systems development task. Progress has been made in developing participative approaches in which different stakeholders can raise issues related to the value that they attribute to information systems (Remenyi, White and Sherwood-Smith 1997). However, little has been said about the importance of understanding the context of relations in which

information systems are implemented and evaluated as an enabler or facilitator of change. Many organizations know that they need to improve their IT-related development processes in order to successfully manage change, but often don't know how. Such organizations typically either spend very little time/capital on process improvements because they are unsure of how best to proceed; or focus on a number of parallel and unfocussed efforts, to little or no avail.

The Software Capability Maturity Models (SW-CMMs) are able to address these problems by providing effective, proven practices and methods for organization's to gradually gain control over and improve their IT-related development processes. SW-CMM is basically a framework that describes the key elements of an effective software process. They provide a conceptual structure for improving the management and development of information systems products in a disciplined and consistent way. CMMs describe an evolutionary improvement path from an ad hoc, immature process to mature disciplined process (Olson, Reizer and Oyer, 1994). The various practices are typically organized into five levels, each level representing an increased ability to control and manage the development environment. An evaluation of the organization's practices against the model -- called an assessment -- determines the level at which the organization's information systems currently stands. It indicates the organization's maturity in the area concerned, and the practices on which the organization needs to focus on in order to realize the greatest improvement and the highest return on investment. The benefits of capability maturity models are well documented for software engineering. Their application to enterprise architecture has been a recent development, stimulated by the increasing interest in enterprise architecture in recent years, combined with the lack of maturity in this discipline. In assessing IS, participation and involvement of stakeholders has become an interesting if not essential feature of formative approaches to evaluation (Doherty and McAulay, 2001). The CMM model has gained a wide-scale acceptance over the last decade in supporting process improvement. Some of the current business drivers that continue to influence the development of information systems include: globalization of the economy, electronic-commerce, security and privacy issues, collaboration and partnership, knowledge asset management, continuous improvement and total quality management, as well as business process redesign (Muhammad, 2006).

The CMM was originally formulated as a tool to evaluate the ability of government contractors to perform a contracted software project. Though it comes from the area of software development, it has been, and it continues to be widely applied as a general model of the maturity of processes. Currently, the CMM is used for evaluating IS quality and maturity in both public and private organizations, large and small organizations, organizations especially in developed countries. The aim of this study is to discover the maturity levels of information systems of organizations in Botswana, be it a small or large

corporation, private or government organization. Botswana is a developing country that has a high level of technological advancement and global competitiveness [rated 8th in Africa] (Blanke, 2007). An attempt is made to assess the maturity levels through the Capability Maturity Model, which acts as a guide or framework for software process improvement. The study addresses the key process areas (KPAs) defined by the SW-CMM to evaluate the IS maturity levels of organizations. These KPAs address the organizations' IS planning, system quality, information quality, user awareness, IS performance evaluation, and organizational impact of IS. In specific terms, the study attempts to: (1) determine the level of utilization of the CMM by organizations in Botswana for process improvement; (2) determine if effectiveness, and control of an organization's software processes improve as the organization moves up these five levels of the CMM; (3) compare the maturity levels in terms of size and nature of organization.

2. Background

Information technology (IT) had been one of the fastest growing industrial sectors in developed countries in the last four decades. Through declining hardware costs and increasing benefits, IT has achieved varying intensities of diffusion in less-developed countries, many of which have joined the race to become "information rich" (Sackman, 1981). Being aware that computers are the most important factor in this process, some countries have developed or adopted robust information policies to realize their goals. Botswana is one those countries that have incorporated IT growth into its national strategy, named Vision 2016 (BV2016C [Botswana Vision 2016 Council], 2004), and aims to propel its socio-economic and political development into a competitive, winning and prosperous nation. In one of the seven key goals towards achieving this strategy, Botswana will be abreast of other nations in information technology and will become a regional powerhouse in the field (WITF [World Information Technology Forum], 2005). It further indicates that most people will be computer literate as most schools and workplaces will be equipped with computers. This enables Botswana to become an informed nation in which a culture of transparency and accountability will flourish. However, as a latecomer to the IT scene like most developing countries, it will face enormous difficulties such as becoming users of IT without the required infrastructure and manpower to support it.

The diffusion rate of IT in Botswana is currently relatively low. Internet subscription rates are less than 1% of the population with Internet access charges being relatively high in Botswana compared to most other South African Development Corporation (SADC) countries (Heeks, 2001). Currently, IT resources are limited and affordable to those fortunate to have access to them or extremely rich, thus creating what is nowadays called the "digital divide" (Venson, 2005). The effect of this digital divide is that those

without access to technology are likely to remain poor and isolated from developments nationally and internationally. The Internet in Botswana, for example, is accessed in three major locations: the Internet Cafes, schools and universities, businesses and research institutions (Mutula, 2004). In 1996, while most organizations in Botswana were aware of the Internet, few actually had access to IT and those that did made long-distance phone calls to Internet Service Providers in South Africa. At that time there was confusion about when the Internet would be readily available in Botswana. Today, it is said that most of the Internet market is fully liberalized, and that most of the users are currently corporate institutions and government organizations. Most organizations in Botswana have gradually resorted to the use of information systems in their daily processing of information and the provision of their services. Botswana ranks fourth after Mauritius, South Africa and Namibia in IT infrastructure development within SADC region (Mutula, 2004).

E-readiness is fundamental to the adoption of information systems especially in a networked global economy. It represents the capability of nations to create, diffuse, adopt and use various components of the networked economy. The rankings of e-readiness survey have become an established benchmark for countries seeking to harness the information system's potential to drive business efficiency, improve the provision of public services and encourage the integration of local economies with the global economy (Lane et al., 2004). The e-readiness rankings for 2006 shows that European countries took six of the ten top spots and Nordics occupy three of the spots with Denmark in the first position. According to McKenna (2006), virtually all countries included in the 2006 rankings improved their scores over the 2005 figures, with the improvements being more significant at the lower tiers of the ranking (consisting of developing nations) than at the top (developed nations). This implies that the digital divide is fast narrowing. Irrespective of the reduction in the digital gap, it is noted in Mutula and Brakel (2006) that e-readiness in developing countries especially in Africa is low when compared with those of developed nations.

Historical stimulus for growth of IT in Botswana has been a combination of curiosity and research as most access originated primarily in learning institutions. Current stimulus for IT growth and diffusion is the desire to become a contributing member to the regional and global communities as well as to further develop Botswana as an information society. Some internet cafe's in Gaborone report an average of 150 customers a day. Some potential reasons for this low usage include: low penetration of electrical services in the home, high cost of internet connectivity, high cost of basic computing hardware and little local content creation. Most businesses use the Internet primarily for collaboration purposes, while government use of IT is particularly visible through the central government site (Sairosse and Mutula, 2004).

The challenges above were addressed at the World IT Forum (WITF, 2005), which was held in Botswana and addressed the challenges of IT usage. The Government of Botswana has also introduced a draft national Information Communication Technology (ICT) policy, as well as a number of initiatives. Its e-government initiative will bring services closer to the people, and hopefully also act as a catalyst for the public as well as the private sectors to embrace IT and ICT. In addition, efforts are being made to reduce communication costs in Botswana, mainly through further liberalization of the telecommunications industry. This should create more competition and ultimately result in lower tariffs for consumers.

3. Research foundation

Information systems have become very important in the functioning of corporate organizations through the support for business processes, management decision making and strategic advantage (O'Brien and Marakas, 2007). Ultimately, information system has changed role from being a tool to being a driver of other functional areas in corporate organizations. However, there is a high level of concern regarding the quality of information systems (especially software components) utilized by corporate organizations (Ahern, Clouse and Turner, 2001). Smith (2004) observes that almost 70% of software projects are not completed, majority exceed budget estimates while running short on meeting requirements specifications.

In 1984, the Software Engineering Institute (SEI) led by Humphrey Watts began to work on a development framework that could address the problems stated above from the software developers' point of view (Humphrey, 1988). The result was the Capability Maturity Model (CMM). The CMM assists organizations in improving the quality of their software development and implementation processes towards "maturity"; that is, developing processes that have high predictability of results and low risk of encountering unknown variables or situations (Smith, 2004). The CMM development has been enhanced by lots of academic research in the field of process engineering. These research activities have led to the constant improvement of the CMM by SEI, and the creation of maturity models for different information systems components such as software acquisition (Kind and Ferguson, 1997), network development (Capone et al., 1998), system security management (Murine and Carpenter, 1984; Stacey, 1996), and project management (Fincher and Ginger, 1997; Hartman and Skulmoski, 1998; Remy, 1997). All these models were founded on the underlying principles of the CMM. The existence of several models caused organizations to incur additional training costs in inter-model transitions, and also created confusion on the part of practitioners regarding the model of choice. The SEI subsequently developed the "Integrated CMM" (CMMI) to eliminate

the conflicts by codifying the tenets of model-based process improvement engineering practices in organizations that span several disciplines (Ahern, Clouse and Turner, 2001).

3.1 Basics of capability maturity model

The Capability Maturity Model is a representation of a "common sense engineering" approach to software process improvement. The maturity levels, key process areas, common features, and key practices have been extensively discussed and reviewed within the software community with a consensus regarding software development and process improvement efforts. The CMM provides a conceptual structure for improving the management and development of information systems products in a disciplined and consistent way. The model characterizes the maturity of the organizations processes or information systems to establish the "as is" system; that is the current conditions and operations of the existing system specification. It then establishes goals for process improvements to define the "to be" system, which is the expected outcome of the system after its development/maturity phase. It then sets priorities for immediate actions as a process of transition from the "as is" to "to be" system. Stability then becomes effective through the management and sustainability of organizational changes. Changes in software process and components are then incrementally introduced to avoid the disruption of current systems. When an organization moves up these steps, it also moves up the maturity levels defined by the model.

In evaluating an information system component using the CMM, the following are considered (Wikipedia, n.d.; Figure 1):

1. Maturity Levels: A five layered framework that provides a progression to the discipline needed to engage in continuous improvement. The uppermost level (level 5) is the notional ideal state, where processes are managed by a systematic combination of processes optimization and process improvement.

2. Key Process Areas (KPAs): A key process area identifies a cluster of related activities, which when collectively performed, achieve a set of goals that are deemed to be important. The KPAs represent the stages that the organization must go through on the way to becoming mature, as each KPA identifies an organization goals, commitment, stability, measurements and verification.

3. Goals: The goals of a KPA provide a summary of the states that must be attained for that KPA to have been implemented in an effective and lasting manner. They signify the boundary, scope and intent of a KPA, and indicate how much of capability the organization has attained at a given maturity level.

4. Common Features: These include practices that assist in the implementation and institutionalization of a KPA. The common features include: commitment to

perform, ability to perform, activities performed, measurement and analysis, and implementation verification.

5. Key Practices: These describe the elements of infrastructure and practice that provides the most contribution to performance and institutionalization of the KPAs.

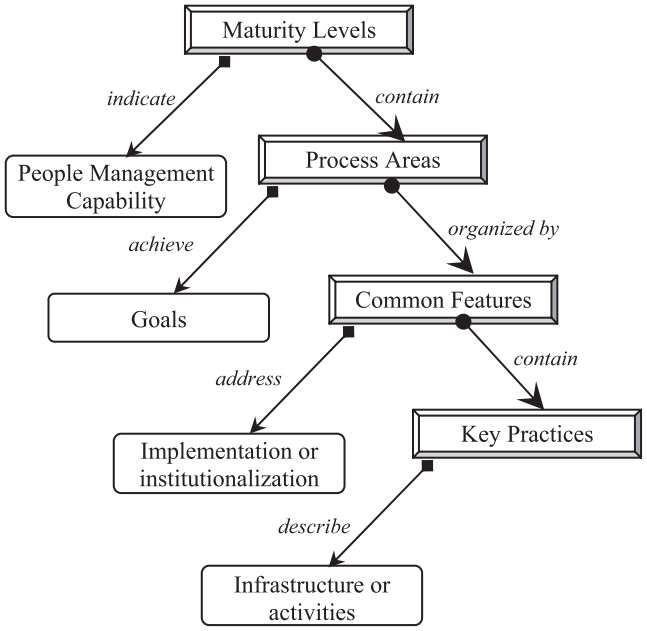

Figure 1 CMM Components

The five maturity levels of the CMM and their KPAs are explained below (Paulk et al., 1993):

3.2 Level 1: Initial

This is the base level whereby application development practices and results are inconsistent. Development processes are not properly defined and developers perform their assignments through individualized methods that show little consistency across the information systems of an organization. Project management is weak and protect developers are susceptible to disruption created by unreasonable commitments or excessive requirements changes. The Level 1 IS organization lacks the ability to consistently meet commitments. With no Key Process Areas prescribed for it, an organization is said to reside in level 1 maturity if its IS has been evaluated not to have achieved the KPAs mentioned below for the rest of the four levels of maturity.

3.3 Level 2: Repeatable

Level 2 focuses on requirements management, which is developing the capabilities of project managers to plan achievable commitments and establish control of requirement baselines and product configurations. Project management principles are established to track project costs, schedules and functionality, and applications are delivered on schedule. Although projects may use different methods or practices, the environment must be stabilized to support their performance. A concerted effort is made to repeat earlier project successes though skill and experience of the project team are crucial in project success. Effective project management practices lay the foundation for standardized processes in the next level. The following KPAs characterize level 2 maturity: requirements management, project planning, software project tracking and oversight, quality assurance, and software configuration management.

3.4 Level 3: Defined

At this level, a standardized system development process or methodology is purchased or developed. This is after projects can repeat successful or best practices, which are identified from different projects. These procedures are then integrated into a common process and deployed across the organization. A strong organizational culture emerges at Level 3 based on a common process that covers all the important elements of the organization's information systems. All projects use a tailored version of the common process to develop and maintain IS, and the organization can begin comparing results, sharing lessons learned and transferring people more easily among projects. Each project results in consistent and high-quality documentation and deliverables, and it is much easier to achieve targets for cost, functionality and scheduling. The process is then stable, predictable and repeatable. The third level maturity includes the following KPAs: organization process focus, organization process definition, training program, integrated software and service management, software product engineering, inter-group coordination, and peer reviews.

3.5 Level 4: Quantitatively managed

Organizations residing in this level of maturity have established measurable goals and productivity yardsticks. Having established a common process, an organization can then develop statistical capability baselines that characterize the expected results from performing these procedures. The baselines provide a quantitative understanding of the capability of development processes and the causes of variation in their performance. By statistically managing performance of the development processes, an organization is able to predict and control project outcomes much earlier in the course of a project. Thus systems development problems such as cost overruns, scope creep and schedule delays are tackled more proactively. Quantitative management enhances greater empowerment of

project teams and increased predictability of project results. The process can be adjusted or 'crashed' when the need arises based on predictable and measurable impacts. Its KPAs are; quantitative process management and software quality management.

3.6 Level 5: Optimizing

At this level, the system development process is continually monitored and improved based on measures and data analysis established at level 4. At this level of maturity, the organization continuously evaluates the capability of its processes to identify areas requiring the greatest improvement. Continuous improvements can be achieved by evaluating the results of lessons learned, or they can be accomplished proactively by evaluating new development methods, processes or technologies for potential adoption. A Level 5 organization ultimately establishes a facility for supporting continuous change management as a crucial component of its overall development process.

Each process of a given level becomes the new foundation for more sophisticated processes at the next level. Consequently, as an IS organization achieves the next level of maturity, the culture moves one step further away from the initial state toward an environment of professionalism and continuous improvement. Thus it is very important to recognize that each level is a prerequisite for the next level. Seeking formal assessment and improvement under this model can be time consuming and expensive, but the rewards in the quality of the software product and predictability of quality in future products are very real. Some organizations are so preoccupied with market and daily demands that serious process improvement initiatives are ignored. Additionally, many smaller organizations rightly view the CMM as designed for large shops or organizations, thus they cannot see its direct value (Gainer, 1998). While the CMM is neither perfect nor comprehensive, it does represent a broad consensus of the information systems and software community and it is a useful tool for guiding improvement efforts, and it can be used to equally help small organizations improve their processes. The CMM framework is shown in Figure 2.

The model indicates that with the exception of level 1 all maturity levels contain KPAs. The result of an appraisal is a capability maturity level and the maturity levels indicate process capability as well as contain KPAs which are organized by common features to achieve goals which are generic and specific. The common features simply address implementation and institutionalization. They contain specific practices that describe infrastructure and activities such as organizational factors and business factors. Organizational factors (culture, size, structure) and business factors influence the specific practices of an organization. In turn, those specific practices of an organization help it to define specific goals focusing on line of business, current process capability, and technology support. The specific and generic goals help in achieving the necessary KPAs that result in higher maturity levels of an organization's IS.

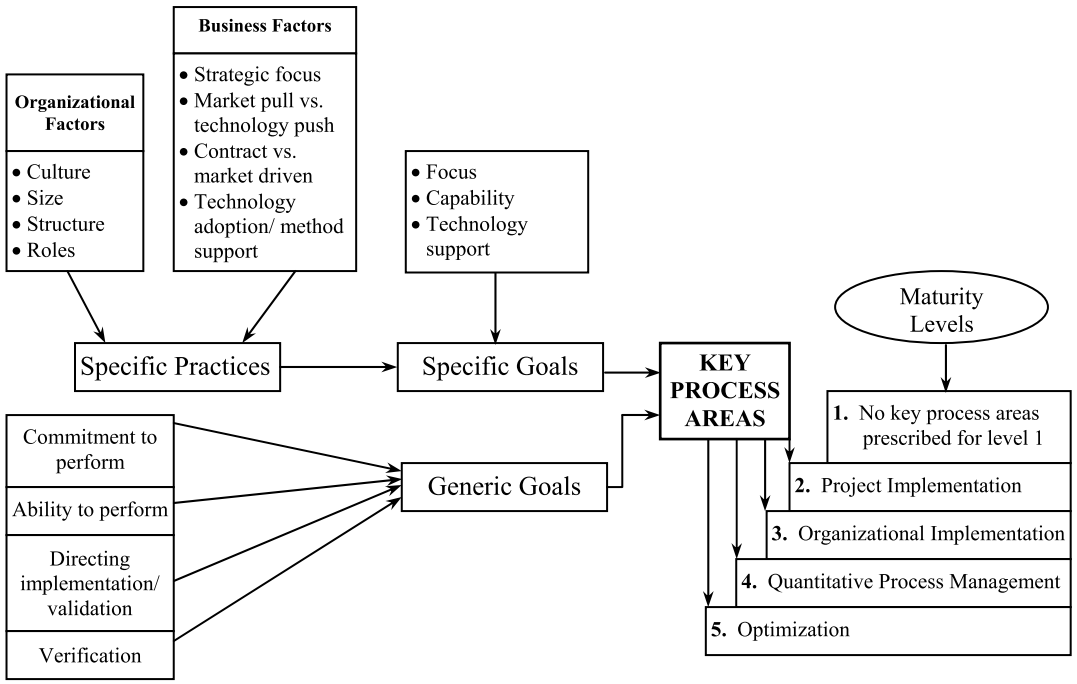

Figure 2 The Research Model

The following hypotheses were tested in this study:

H^1: Effectiveness and control of an organizations software processes and services improve as organizations move up the maturity levels.

H^2: Maturity Levels are not influenced by the nature of the organization.

H^3: There is a no significant correlation between size of an organization and its maturity level.

4. Research design

4.1 Survey procedure

The population of this research included both product and service providing organizations that were in the private, public or parastatal sectors of Botswana. Enterprises of different sizes were surveyed. The parastatal organizations are organizations that are partly owned and financed by government, but maintain some entrepreneurial independence. A total of 100 questionnaires were distributed to staff of fifty organizations, with an average of two questionnaires distributed to individuals who were either directly involved or aware of the information systems development and its impact on the organization. It is assumed that employees involved in IT/IS services

have a relatively greater understanding of the questionnaire and therefore provide useful information for the research, thus IT/IS specialists were the target respondents. A total of eighty-one people responded to the questionnaire (81%).

4.2 Measures

The data collection instrument used for this research was the questionnaire (Appendix), which consisted of three parts. The first part captures the sample characteristics such as respondents' job classification, age of organization, nature of organization, and size of organization. The second part of the questionnaire uses organizational variables relating to IS maturity to assess the maturity levels of an organization's IS. The variables used are known as Key Process Areas (KPAs), and they are defined for the Software Capability Maturity Model (SW-CMM). According to (Paulk et al., 1993) SW-CMM is a three-dimensional construct. The first construct is "Project Implementation", representing the maturity level 2 KPAs as; requirement management, software project planning, software project tracking & oversight, software quality assurance and software configuration management. Organizational Implementation is the second construct representing the maturity level 3 KPAs; organization process focus, organization process definition, training program, integrated software management, software product engineering, peer review, and inter-group coordination. The third construct is "Quantitative Process Management" representing the KPAs at both maturity level 4 and 5. At level 4, the KPAs are; quantitative process management and software quality management, while at maturity level 5 the KPAs are; problem prevention, process change management and technology change management. For an organization to achieve maturity in a particular maturity level it has to accomplish most of the KPAs in that maturity level as well as in the previous maturity levels. The third part of the questionnaire measures the use of the Capability Maturity Model (CMM) as a framework for process improvement and it minimally looks into different organizational reasons for the adoption of CMM. The data covers the following aspects: management of Information Systems, the efficiency and effectiveness of Information Systems and training programs.

4.3 Analysis procedure

The statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) Version 14.0. The initial component of the analysis involves the use of descriptive statistics in capturing respondents and organization's characteristics, and the levels maturity of the organizations. Regression analysis was utilized in determining the factors influencing the levels of IS maturity. The hypothesis relating to the nature of organization and level of maturity was tested using the one factor analysis of variance (ANOVA). The ANOVA table provides a formal F test for the factor effect. The F-statistic is the mean square for the factor divided by the mean square for the error. This statistic follows an

F distribution with (k-1) and (N-k) degrees of freedom. The decision rule is to reject the null hypothesis if $F_{calculated} > F_{critical}$. Multiple regression analysis was further carried out in order to test the hypothesis that the effectiveness and control of an organization's software process improves as organizations move up the maturity levels. A correlation analysis was run to determine the relationship between organizational size and maturity levels.

5. Results and discussions

5.1 Sample characteristics

Table 1 shows the respondents' characteristics as well characteristics of the organizations they work in. There were a total of 81 respondents coming from private, parastatal and public organizations. A total of 29 respondents represented the Parastatal sector at a percentage of 35.8%; Majority (49.4%) were from the Private sector, while 14.8% represented the public sector. 82.8% of the parastatal organizations were 21 years and above, while only 10.3% were between 15 and 20 years, and 6.9% were between 5 to 10 years. 39.4% of the organizations were either small or medium sized, while the rest were large or very large. Majority of the large and very large organizations were parastatals, while majority of the small organizations were private. The respondents were from diverse industries, with the majority being general services-non-profit (27.2%), general services-for-profit (16.0%), and business/professional services (16.0%). Financial services occupied 13.6%, education 9.9%, wholesale and retail were 6.2%, while mining was 4.9%. The majority of the respondents were non-management staff and they constituted 82.8% of the parastatal sector, and 73% of the private sector and 58% of the public sector. On the other hand, 17.2% of the respondents from the parastatal organizations were management staff, as well as 28% of the private sector and 42% of the public sector respondents.

5.2 Determining maturity

The second section of the questionnaire addressed the key process areas of the CMM, which were used as the indicators for assessing the maturity levels in this research. Maturity Levels 2 through 5 can be characterized by three things: the activities performed by the organization to establish or improve the software process, activities performed on each project and the resulting process capability across projects. A behavioral characterization of Level 1 is included to establish a base of comparison for process improvements at higher maturity levels. Each maturity level has its own set of key process areas except for the Initial level. The following SW-CMM key process areas stated in Section 3.0 were used to help determine maturity levels.

Table 1 Sample Characteristics

	Nature Organization							
Size of Organization	**Parastatal**	**Valid%**	**Private**	**valid%**	**Public**	**valid%**	**Grand Total**	**Cumulative%**
Very Small	0	0	3	7.5	0	0	3	3.7
Small	0	0	10	25	3	25	13	16.0
Medium	5	17.2	8	20	6	50	19	23.4
Large	4	13.8	18	45	3	25	25	30.9
Very Large	20	69	1	2.5	0	0	21	26.0
Grand Total (%)	29 (38.5%)	100	40 (49.4%)	100	12 (14.8%)	100	81	100
Years in Operation								
<5 years	0	0	8	20	2	17	10	12.4
5-10 years	2	6.9	24	60	6	50	32	39.5
11-15 years	0	0	0	0	0	0	0	0.0
15-20 years	3	10.3	0	0	0	0	3	3.7
21 years and above	24	82.8	8	20	4	33	36	44.4
Grand Total	29	100	40	100	12	100	81	100
Industry of Organization								
Business/ Professional Services	2	6.9	11	28	0	0	13	16.0
Education	4	13.8	4	10	0	0	8	9.9
Financial Services	7	24.1	4	10	0	0	11	13.6
General Services-For Profit	1	3.44	12	30	0	0	13	16.0
General Services-Nonprofit	11	37.9	2	5	9	75	22	27.2
Health Care	0	0	2	5	3	25	5	6.2
Mining	4	13.8	0	0	0	0	4	4.9
Wholesale/ Retail	0	0	5	13	0	0	5	6.2
Grand Total	29	100	40	100	12	100	81	100
Respondents Position in Organization								
Management Staff	5	17.2	11	28	5	42	21	26.0
Non-Management Staff	24	82.8	29	73	7	58	60	74.0
Grand Total	29	100	40	100	12	100	81	100

80% of the data from the respondents for the KPAs were recorded on a 5 point scale, which were coded from 1 to 5, while the other 17% were recorded on a 4 point scale coded from 1 up to 4. 1 was the most significant option and 5 the least significant option, in all questions. This made it easy to integrate the data from each respondent, for each level of maturity and find their average. This average was then used to determine the maturity levels of the organizations from each respondent and then compared to the nature of the organization. It is important to understand that for an organization to reside in a particular level of maturity it must have accomplished or fully achieved all KPAs in that level and KPAs of the level below that one, if any. Thus, the averages of the total scale points were used to assess maturity level, also considering that some variables were satisfied by more than one option.

In relation to the 5 point scale, the following criteria were used to establish maturity levels from the averages of the key process areas.

(1-2.5): indicates that all KPAs were fully satisfied in that level and that the organization resides in that level and possibly more levels ahead of it, if any. But it must have also achieved all previous levels as well.

(2.5-3.5): indicates that the KPAs were partially achieved and that the organization resides in that level but not in any levels after that one. Also, it must have achieved all the other levels before it.

(3.5-5+): indicates that most of the KPAs were not achieved, therefore, the organization does not reside in that level nor can it reside in levels after that one. Instead, if it had achieved any level before that one then it will be said to be in such a level, otherwise it will reside in level 1.

Table 2 and Figure 3 show the distribution of maturity levels against the nature of organizations. This research shows that 49.4% of the organizations reside in level 5, and according to this table, 21 of them were the parastatal organizations, and 12 were private while 16 of them were public organizations. Level 1 organizations occupied 23.5% with the most being private organizations then public organizations. Level 2 organizations occupied 11.1% also by only private and public organizations. Level 3 was 8.6% from all types of organizations, as well as Level 4 with 7.4%.

While this study indicated that several organizations had gone up on the maturity grid, a sizable percentage of organizations were on levels 1 or 2 (33.6%). Majority of these organizations were private firms, which may not have elaborate/efficient information systems project management structure. Herbsleb et al. (1997) noted that planning and tracking of projects is an area that seems to be holding many level 1 organizations from achieving level 2. Active monitoring, staffing, and efficient resource allocation are management controls that appear critical in movement from the lower to upper levels of the maturity grid.

Table 2 Established Maturity Levels

	Nature of Organization				
Maturity Levels	**Parastatal**	**Private**	**Public**	**Grand Total**	**Percent**
Initial	0	13	6	19	23.5
Repeatable	0	8	1	9	11.1
Defined	4	2	1	7	8.6
Managed	4	1	1	6	7.4
Optimizing	21	16	3	40	49.4
Grand Total	29	40	12	81	100

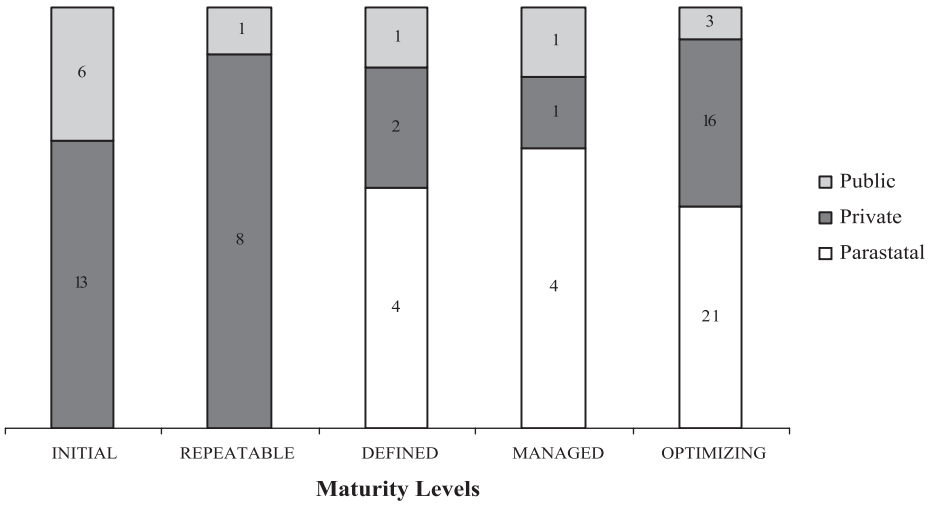

Figure 3 Maturity Levels and Nature of Organizations

5.3 Organizations' usage of the capability maturity model

The third section of the questionnaire focused on the adoption of the capability maturity model as a tool for process improvement. 100% of the respondents do not use the capability maturity model for process improvement. It was pertinent to find out the reasons why this model was not being used in Botswana. Table 3 shows that most people are unaware of the CMM. 81.4% of the respondents indicated lack of knowledge of the tool. Another factor most people strongly agreed to was that they had other preferences to invest in other ventures instead of purchasing the CMM (88.8%). Other factors are: high

purchase cost of the CMM, the risk of associated failure, and the lack of realization of benefits of the CMM to the organization.

Table 3 Factors influencing lack of use of the CMM

Factor	SA	A	N	D	SD	Total
Lack of Knowledge about CMM	50	16	5	8	2	81
Never seen CMM in use by other organizations	26	11	10	20	14	81
Preference to invest in other ventures	50	22	2	1	6	81
High purchase cost of the model	23	16	16	18	8	81
Associated failure	12	9	20	25	15	81
No realization of benefits of CMM	35	21	8	8	9	81

Note: SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly Disagree

The results obtained with respect to non-utilization of CMM tools for software process improvement (SPI) are in consonance with previous findings (Staples et al., 2006) that identified the following reasons for organizations' inability to purchase CMM tools: small size of organization, lack of time for consideration of CMM software tools, utilization of alternative SPI approach, cost of implementing CMM, and a notion that CMM implementation was infeasible.

5.4 Hypothesis testing

The following hypotheses relating to the attainment of IS maturities were tested:

H^1: Effectiveness and control of an organizations software processes and services improve as organizations move up the maturity levels

A statistical linear model was estimated in order to make inferences that can be made about the linear relationship that exists between the maturity levels and the improvement of the effectiveness and control of an organization's software process. The dependent (Y) variables are improvement of service, software improvement, and productivity improvement, generated from the section B of the questionnaire; while the independent variable (X) is maturity levels, which were established by key process areas. The purpose of this hypothesis was to determine if the independent variable (maturity levels) had an impact on the improvement of the dependent variables. Table 4 presents model summary, while Table 5 shows the results of the linear regression.

Table 4 Model Summary

Model	R	R Square	Adjusted R Square
1-Service improvement	.567	.322	.313
2-Software quality improvement	.737	.543	.537
3-Productivity improvement	.605	.366	.358

Table 5 Regression Statistics

	Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
Model	**B**	**Std. Error**	**Beta**		
1-Service improvement	-.130	.021	-.567	-6.123	.000
2-Software quality improvement	-.237	.024	-.737	-9.684	.000
3-Productivity improvement	-.151	.022	-.605	-6.750	.000

In all cases, $|t| \geq 2$, which implies that the level of maturity has a significant impact on service improvement, software quality improvement, and productivity improvement. Table 4 shows a better model fit (Adjusted R square = 0.537) for software quality improvement. Also, the t-values indicate that the software quality is mostly affected by the level of capability maturity ($t = -9.683$), followed by productivity improvement ($t = -6.750$) and service improvement ($t = -6.123$).

The results are consistent with previous results reported in (Herbsleb et al., 1997), which indicated that maturity level tends to affect quality, and productivity. It is also noted in Ravichandram and Lertwongsatien (2005) that variation in firm performance is explained by the extent to which IT processes support and enhance firm's core competences.

H^2: Maturity Levels are not influenced by the nature of the organization.

Table 6 utilizes an analysis of variance test to determine if the maturity level is significantly affected by the nature of the organization. The ANOVA table shows that F_{calc} (54.74) > F_{crit} (3.90). Therefore, the relationship between maturity levels and the nature of

organizations is statistically significant. With the p-value between groups less than alpha = 0.05, we say that there is a statistical relationship between the two variables, and the hypothesis is rejected. Therefore, the maturity level of an organization is influenced by the nature of an organization. Figure 2 indicates that higher maturity levels (level 4 and 5) were attained mostly by the parastatal organizations.

Table 6 ANOVA: Single Factor

Source of Variation	SS	Df	MS	F	P-value	F_{crit}
Between Groups	102.7222	1	102.7222	54.74463	7.32E-12	3.900236
Within Groups	300.2222	160	1.876389			
Total	402.9444	161				

Lee and Xia (2006) examined nature of organizations as a moderator influencing the relationship between size of organization and process innovation, and found nature of organization to be a significant moderator. Their results indicate that organization size may not be an advantage in process innovations for non-for-profit organizations. This study indicates that public organizations (non-for-profit) did not perform well on the maturity model. The parastatals on the other hand, occupy a significant amount in the *Optimizing* maturity level. The parastatals are made up of 82% large and very large organizations, which might add reason for the attainment of higher maturity levels. Most public organizations are at the initial levels of the CMM. This could be attributed to poor work attitude and *laissez faire* management style that is associated with public organizations (ROB, 2006) especially in Botswana with a good level of dissatisfaction among workers in public organizations. Recently, the government introduced scarcity and retention allowances (ranging from 15% to 40% of basic salary) for public service workers. The parastatals are considered private corporations that work under government regulations and financial support. It is noted that parastatals in Botswana were previously public organizations, and there is exodus of high skilled professionals from the public service to the parastatals. This may have warranted the introduction of retention allowances for public workers. Moving up the CMM levels by parastatals is not a surprise because these organizations tend to show world class standards by adopting the best management, service, and other organizational processes and practices.

H^3: There is a no significant Correlation between size of an organization and its maturity level.

Table 6 shows organization size against level of maturity. A correlation analysis was carried out between size of organization and maturity level. The results show a correlation of 0.669942, which is indicative of a good correlation between the size of the organization and maturity level. We accept the hypothesis that there is a significant correlation between size of an organization and its maturity level. Table 7 shows that 87.5% of the small and very small organizations reside in lower levels of maturity (level 1 and 2).

Table 7 Size of Organization Against Level of Maturity

Count of Size of Organization	Size of Organization					
Maturity Levels	**Very Small**	**Small**	**Medium**	**Large**	**Very Large**	**Grand Total**
1	3	8	7	1	0	19
2	0	3	4	2	0	9
3	0	0	1	4	2	7
4	0	0	1	3	2	6
5	0	2	6	15	17	40
Grand Total	3	13	19	25	21	81

According to the results, most maturity levels were found at level 5 (Optimizing). However, most small and medium sized enterprises (SMEs) have not yet fully established their IS departments in order to achieve the best in process development and delivery. The adoption of the CMM is relatively low in Botswana as most organizations fail to employ tools that help with process improvement and requirements. The study shows that service improvement, software quality and increasing productivity are being affected positively with upward movement on the CMM ladder. Though most of small and medium sized organizations do spend a lot on IT infrastructure, they lack good implementation strategies. Another factor was the poor work culture and negative attitudes, which tend to impact negatively upon the maturity of these organizations.

This study agrees with previous studies that established a positive relationship between firm size and IS maturity. McBride, Henderson-Sellers and Zowghi (2004) found a correlation between system maturity and organizational size in a study conducted in

Australia. In another study, Jung and Hunter (2001) found that the average capability level for organizations with large IT staff is greater than the capability level for organizations with small IT staff. Lee and Xia (2006) examined the relationship between organization size and IT process innovation. They concluded that though there is a positive correlation between organization size and process innovation, the following moderators affected the relationship: type of innovation, type of organization, stage of innovation adoption, and scope of size.

6. Conclusion and limitations

Information systems development is a complex process comprising not only technological expertise, and analytical and designing methodology, but also issues of process improvement and project management. It is the reality that different types of information systems are developed for different purposes and the organizations differ in size and their information systems development capabilities. Many people and generally organizations are unaware of the Capability Maturity Model and its potential benefits. Instead, they continue to spend a lot on Information Technologies without a strategy. This study shows that 77% of organizations spend highly on developing their IT services but some of them continue to remain in low levels according to the CMM assessment. The capability maturity model is rarely used in Botswana by all sectors and sizes of organizations. This research supports the assertion by Dillion (2001) that even if a technology is engineered to be highly usable, and shown to be so through formal testing, there exists no guarantee that this will lead to acceptance. Continuous process improvement is based on many small, evolutionary steps rather than revolutionary innovations. The staged structure of the CMM, which was used in this research is based on principles of product quality espoused by Shewart and Deming (1939). Organizations find the model costly, and would rather invest in other business ventures. Despite the non utilization of the CMM, many organizations had reached a high level of maturity. A significant 49.4% of the organizations have reached maturity level 5 and 7.4% are at maturity level 4. The results indicate that a total of 56.8% of organizations reside in the higher levels of maturity.

This research has shown that public organizations are lagging behind in information systems developments, indicated by the amount of public organizations that attained only lower levels of maturity. Some of the reasons for low maturity include low level of training and skills of workers, poor working conditions and incentives for staff members, poor documentation of software requirements and architecture, and the integration of software components. Low usage of the appropriate technology as well as poor management culture and negative attitudes are also factors that hinder full development

of information systems in the public sector. It is recommended that public sectors should concentrate more on process improvement; through assessing their current IS situation, and exposing themselves to more information systems innovations, which include process tracking, and documentation for efficiency and effectiveness.

It was also discovered that all sectors find it costly to manage information systems. A proper management system is therefore suggested. According to Barati and Berg (2003), a good management system is the key behind the success of many IS implementations. This also helps in purchasing technologies that are appropriate for the organizations.

While this study utilized the CMM constructs in assessing IS maturity of public, parastatal and private organizations in Botswana, it is pertinent to note that the CMM was utilized because of the belief that it captures the organization's IS program as an integral whole. Future studies could utilize the CMMI especially when considering the IS as consisting of several interrelated programs such as security, network management, project management, e-commerce, etc. Furthermore, the maturity of organizations across industries could be considered.

The Assessment Requirements for CMMI [ARC] (SEI, 2006) stipulate that the ratings of organizations' maturity level be performed by a qualified software evaluation professional. In this study, a sampling of software experts was done *apriori*. This stems from the fact that their levels of expertise in software process evaluation was assumed based on their job positions in the organizations. The self reporting data collection mechanism that utilized professionals from within the organization could create some level of bias that may have skewed the results towards higher maturity levels.

In this study, the dataset representing maturity levels 2-4 represent a small percentage of the survey (27.1%). This shows a significant kink in the expected gradient of maturity levels. Level 1 constituted 35%, while level 5 constituted 49.1% of the respondents. One explanation for this low number of respondents at the lower levels maturity could be that a high percentage of the organizations had passed through levels 2, 3, and 4 to level 5, while the other majority (level 1 and mainly small organizations) are not making efforts towards software process improvement. Another explanation could be in terms of the non-response bias of the survey. It is probable that a high percentage of non-respondents are from organizations that operate within maturity levels 2-4. Though the non response rate was statistically low (19%) according to Armstrong and Overton (1977) evaluations, it could affect the results of the survey.

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Appendix: Questionnaire

SECTION A. BACKGROUND QUESTION

1. Please give your company details.
Please tick the most appropriate option.

a) How do you classify your organization in terms of size?
Very Small ☐ Small ☐ Medium ☐ Large ☐ Very Large ☐

b) State the nature of your organization.
Private Organization ☐ Parastatal Organization ☐ Public Organisation ☐

c) Number of years your organization has been in operation.
< 5 years ☐ 5-10 years ☐ 11-15 years ☐ 15-20 years ☐ 21 years and over ☐

d) Which of the following best describes the industry of your organization?
Mining ☐ Manufacturing ☐ Education ☐ Business/Professional Services ☐
Financial Services ☐ Health Care ☐ Public Administration ☐
General Services-NonProfit ☐ Wholesale/ Retail ☐ General Services-For Profit ☐

e) How would you classify your position within the organization?
Management staff ☐ Non management staff ☐

SECTION B. KEY PROCESS AREAS FOR ACHIEVING CAPABILITY

2. Are you aware of any documented procedures within your work place that are meant to capture, refine, prioritize and track the development of customer requirements?
Yes ☐ No ☐ Unsure ☐ Not Applicable ☐

3. How do you feel about the management of Information Systems in your organizations?
Very Satisfactory ☐ Satisfactory ☐ Neutral ☐ Dissatisfactory ☐ Very Dissatisfactory

4. How effective do you think your organizations' Information Technologies and Information Services are, with regards to achieving customer satisfaction?
Very Effective ☐ Effective ☐ Neutral ☐ Ineffective ☐ Not at all ☐

5. Has your company's Information Systems delivery ever been evaluated against either the company's documented expected performance, or the level of expected performance within its industry?
Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐

6. Has your organization established a website that people can access to gain information about it?
Yes ☐ No ☐ Unsure ☐ Not Applicable ☐

7. Do you often use email/ telephone to communicate with your customers?
Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐

8. How easily accessible is email/Internet at your work place?
Excellent ☐ Good ☐ Average ☐ Poor ☐ Not Applicable ☐

9. Has the existence of email/internet in your work place enhanced the communication between yourself and other staff members?
Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐

10. Do you think your organization has adopted all necessary technologies to help it achieve the following?

	SA	A	B	D	SD
Its business goals					
Achieve customer satisfaction					

11. Would you agree that your organization conducts regular activities that assess, develop and help to maintain the service delivery of your Information Systems?
Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐

12. How often is information collected from within the organization about the efficiency of your Information Services / Information Technology delivery?
Never ☐ Once ☐ Occasionally ☐ Frequently ☐

13. Is there any standard or common Software /methodology being used within your organization in its daily service delivery activities, to help achieve its goals?
Yes ☐ No ☐ Unsure ☐

14. Please indicate by a tick if you agree or disagree to each of the following, where; SA= strongly agree, A= agree, N= neutral, D= disagree and SD= strongly disagree.

	SA	A	N	D	SD
The organizations standard software process is developed and maintained according to a documented procedure					
The organizations standard software process is documented according to established organization standards					
The organization has established and maintained a software process database					
The organization has documentation of all software related processes					

15. Please indicate the percentage you think, of staff that might have access to any if not all of your IT facilities. *Tick where appropriate*.

0	
Less than 20	
21-40	
41-60	
61-80	
81+	

16. Indicate the approximate percentage of those staff members that have rights/ privileges to using the common/standardized software that has been adopted by the organization.

0	
Less than 20	
21-40	
41-60	
61-80	
81+	

17. Does your organization offer any training programs to its staff members, on how to use the standardized software?

Never ☐ Once ☐ Occasionally ☐ Frequently ☐

18. Please indicate by a tick if you agree or disagree to each of the following, statements; SA= strongly agree, A= agree, N= neutral, D= disagree and SD= strongly disagree.

	SA	A	N	D	SD
Different departments are able to share processed data and lessons learned from different on going projects					
There is Maintained consistency in Information Service delivery					
The Software in use is in performance with relation to the organizational requirements					
The organization does Software testing (according to the Projects' defined Software Process)					
There is documentation of Software Engineering tasks, such as through Requirement documents and Test Plans					

19. Are there regular Technical Review interventions and Interchanges being conducted between the Information Services group and other departments/groups?

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐

20. How effective do you think the Information Systems team is, with addressing the Organizations System Requirements, objectives and issues?

Very Effective ☐ Effective ☐ Neutral ☐ Ineffective ☐ Not at all ☐

21. How often has your organization had external people to audit the implementation of its Information systems?

Never ☐ Once ☐ Occasionally ☐ Frequently ☐

22. To what extent has the use of Information Systems changed your organizations performance looking back at the past 5 years?

Extremely ☐ Moderately ☐ Slightly ☐ Has Not Changed at all ☐

23. What has this change brought to your organization?

Please rank each statement by significance, circling either the most significant number as 1, the second most significant 2…5 the least significant.

Improved productivity	1	2	3	4	5
Increased profits	1	2	3	4	5
Improved services	1	2	3	4	5
Improved Employee and customer relations	1	2	3	4	5
Increased performance against competitors	1	2	3	4	5
Offered uniqueness to the market	1	2	3	4	5
Reduced employee turnover	1	2	3	4	5

24. Where do you think the Costs of managing your Information Systems lies?
High ☐ Average ☐ Low ☐
25. How effective do you think your organizations Information Services department is in response to solving user problems?
Very Effective ☐ Effective ☐ Slightly Effective ☐ Ineffective ☐ Not at all ☐

26. How would you rate the type of technology in use within your organization?
Excellent ☐ Good ☐ Average ☐ Poor ☐ Not Applicable ☐

27. How effective do you think the injection of these technologies into the organization is?
Very Effective ☐ Effective ☐ Slightly Effective ☐ Ineffective ☐ Not at all ☐

28. How well is the response towards the use of these technologies by staff members?
Very positive ☐ Positive ☐ Neutral ☐ Negative ☐ Very Negative ☐

29. How would you assess the improvement of the following looking in the past year: *Tick where appropriate*.

	Improved	Remained Constant	Deteriorated
Service Improvement			
Software Quality			
Increasing Productivity			

30. To what extent would you assess the following factors to have contributed to the low improvement of the above: (*service delivery, software quality & productivity*) *(Tick appropriately.)*

Factors influencing service, software & productivity improvement

Factors	Very Much	Much	Not Much	Very Little	Not at all
Low Level of training and skill of workers					
Poor Working conditions and incentives					
Poor documentation of software requirements, architectures & integration of software components					
Low Usage of appropriate technology					
Low Management calibre					
Poor work culture and negative attitudes					
Poor Work method and work design					
Unmotivated workers					

SECTION C. THE USE OF CMM FOR PROCESS IMPROVEMENT

31. Does your organization use the Capability Maturity Model or any other model/ tool/ framework/program, for Process & Quality Improvement in their Information Systems?

Yes ☐ No ☐ Other (Specify) _____

32. If you answered Yes above or mentioned another model or tool please identify the reasons for using it. Where: SA= strongly agree, A= agree, N= neutral, D= disagree and SD= strongly disagree. *(You can select more than one option.)*

Reasons for adopting the CMM	SA	A	N	D	SD
Persuasion from various sources					
Perceived competitive advantage in the market					
From observing beneficial results by other organizations					
Government funding					
Perceived ease of use of the model					
Quality in Software development and implementation of processes					

33. If you answered No in part (a) above, please identify the reasons for using it. *(You can select more than one option.)*

Reasons for not adopting a model/ tool for Process Improvement	SA	A	N	D	SD
Lack of technical Knowledge about the tool					
From observing lack of use of the CMM by other organizations					
Preference to invest or upgrade other business ventures					
The high purchase cost of the model/tool					
The risk of associated failure					
Lack of realization of value/benefits of the CMM to the organization					

MIS Review Vol. 16, No. 1, September (2010), pp. 85-126

The Analysis of MIS Collaboration Research Networks and Research Issues Structure: The Example of *MIS Quarterly* Journal

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ABSTRACT: *The development of theoretical diversities within management information systems (MIS) discipline has been a constant focus and a frequently discussed issue. Those studies provide a developing pattern for the readers and researchers to track and understand the evolution of information technology and management subjects. Furthermore, the results can be a guidebook for future trends of information management researches.*

In this research, we collected the authors and keywords from the most prestigious journal in MIS research domain, MISQ, from 1977 to 2007, as the source of data sample. Using social network analysis (SNA) for mapping out the Journal's author collaboration network over time and classifying each article through their keyword-hierarchical structure, we exemplified the development of research communities and referenced domains.

While limited by the sampled data, the results of our findings indicated that the structure of co-author research communities fits a scale-free distribution model, a preferential attachment process, in the first decade of these research collaborations. And the research communities developed a stable small-world structures/ communities over time, and many distinct clusters are connected to each other by a rather small number of links, since 1997. We conclude by applying the trends of co-author relationship in each MIS sub-domain to provide a new aspect to observe and understand the development of various MIS subjects.

KEYWORDS: *Small-World Network, Scale-Free Distribution, Social Network Analysis, Research Co-Author Community, Research Keywords, Community Structure Variation.*

1. Introduction

This study made innovative contribution to information management domain by advocating an idea of applying social network analysis and theoretical basis into research on development of information management domain from the perspective of co-research in knowledge community. Innovations constantly taking place in information

management issues and research trends was caused by sustainable development of information technology and enterprise operation, which becomes one important issue attracting attentions of many scholars into discussion. Since 1982, similar studies by citing other authors' analysis statements into articles (Culnan and Swanson, 1986; Culnan, 1987; Grover et al., 2006; Wade, Biehl and Kim, 2006) or summarizing keywords research issues (Hamilton and Ives, 1982; Barki, Rivard and Talbot, 1988, 1993; Alavi and Carlson, 1992; Swanson and Ramiller, 1993; Benbasat and Weber, 1996; Lee, Gosain and Im, 1999; Claver, Gonzalez and Llopis, 2000; Vessey, Ramesh and Glass, 2002; Liang and Chen, 2005; Prasad and Tata, 2005) by scholars had been published every several years, in the hope of depicting history and development background of information management, to assist scholars within this domain to know about research achievements and foundations set up in the past and understand possible development directions concerning this domain in future. Past research approaches took issues/subjects as major objects and classified articles previously published in MIS research into different categories from aspects of essential domains and scholars over time and discussed co-discipline/co-author citation quoted by such articles (Hamilton and Ives, 1982; Culnan and Swanson, 1986; Culnan, 1987; Barki et al., 1988; Alavi and Carlson, 1992; Barki et al., 1993; Swanson and Ramiller, 1993; Benbasat and Weber, 1996; Lee et al., 1999; Claver et al., 2000; Vessey et al., 2002; Liang and Chen, 2005; Prasad and Tata, 2005; Grover et al., 2006; Wade et al., 2006). However, there was not any analysis related to co-author and structural changes of keywords domains/issues by adopting social network analysis methods. Regarding this, this article managed to analyze the scholars' articles and keywords that are cited most frequently in MIS domain in *MIS Quarterly* (*MISQ*) to generate a broad overview of structural depth and achievements that never touched before.

This study took all articles published previously in *MISQ* as objects of data collection, disposal and analysis. Totally 738 articles were collected from 1977 to 2007, including 1,012 authors (for the narration purpose, sometimes it is called as research community) and 3,607 keywords (2,275 for non-repeated words). The keyword coding framework consisting of nine categories issued by Barki et al. (1993) in *MISQ* was adapted to the classification and hierarchical divisions of codes for all keywords in combination with triangulation, totally classified into 710 codes of different categories in *MISQ*. Finally, it analyzed characteristics of network structures formed by measurement indices produced by social network relation matrix data constructed by these authors and keywords.

This study classified research data collected within 31 years into three phases, first phase 11 years, middle phase 10 years and last phase 10 years, compared first phase with subsequent 2 phases respectively (For the convenience of description, "three phases period" represents comparison among these three phases.) It found out that co-research

network relationship among authors within three decades continuously grew up, being consistent with the development trends of other disciplines (Newman, 2001; Moody, 2004). Later on, when analyzing the distribution of articles published by authors, the percentage of authors in each article and the number of co-authors, it found that co-research in articles was dominated by collaboration between two authors and collaboration among more than three authors appeared less; next, discussed possible implication of such results for research on development and diffusion of knowledge domains. Analyzing co-research trends, we further advocated the development progress of each sub-domain in nine categories of keywords, and provided reference for discussion on possible development trends in future.

For development of published articles in later period, when the number of authors publishing more articles (9 articles above) increased, this study verified network structures accumulated in each phase by using measurement indices in Small World and power law distribution network. Findings included: Small World network structure was formed in research community structure before the end of early phase, and in much earlier phase, network structure was evolved into power law distribution model that highlighted preferential attachment.

Section two was the description of relevant research literatures. Section three was the detailed introduction of data collection and disposal processes. Section four was the discussion of analyzed results of this study. Finally, section five discussed contribution, future direction and limitation of this study.

2. Literature Review

2.1 Discussion on MIS study issues and discipline domains

Management information issues and research trends had been constant focus and frequently discussed issue in this domain. Due to continual development of information technology and endless innovation of enterprise operation, many scholars had issued articles concerning this domain on prestigious journals, attempting to depict history and development background of information management and further discuss trends and direction of research development, provide subsequent scholars the directions that they could strive for. Relevant studies organized by this study were seen in the following table.

Based on the data in Table 1, research articles could be roughly divided into two categories: One category took issues/subjects as main analysis objects, adopted classification and worked with time axis to depict the classification of research subjects in information management domain and changes over times. Among articles of this category, they discussed used research methods, provided history development and

Table 1 Summary Researches on MIS Research Issues and Domain Subjects

No	Literature	Research Object	Analysis Methods	Data Time	Major Conclusion
1	Hamilton & Ives (1982)	Study Method	Citation analysis	1970-1979	A majority of articles adopted non-empirical research method with only one variable studied.
2	Culnan & Swanson (1986)	Reference and Citation Discipline	Citation analysis	1980-1984	MIS was a new-born and different domain from other domains and obviously tended to develop toward cumulative tradition.
3	Culnan (1987)	Author Citation	Co-citation analysis	1980-1985	Information management study obviously tended to develop toward cumulative tradition.
4	Barki et al. (1988, , 1993)	Keywords	Content descriptors	Since 1977	IS keywords classification framework was developed.
5	Alavi & Carlson (1992)	Research Theme and Research Methods	Descriptive Statistics	1968-1988	The number of empirical studies had exceeded total number of non-empirical studies.
6	Swanson & Ramiller (1993)	Research Theme and Keywords	Descriptive Statistics	1987-1992	It found that, if each issue was regarded as independent one, the first three issues cumulated at most within 6 years were computer-supported cooperative work (CSCW), information system strategy management (ISSM) & enterprise and information system. If put relevant issues into bigger issues, the first three issues cumulated at most within 6 years were system program, economy & strategy issue and user factors.
7	Benbasat & Weber (1996)	Research Theme, Theoretical Basis and Research Method	Review Relevant Literatures		In past development, information management study was too loose, without establishing theoretical basis on its own, and continuously borrowed theories and methods from other disciplines to solve information management problems, leading to the increase of diversities in this domain. Furthermore, with information management becoming more important in enterprises application, researchers from different backgrounds being attracted to actively join into study was also another reason why diversities in information management study expanded. Diversity characteristics also showed that information management study domain will encounter more diverse pressures from inside and outside. The variation of whole dynamics could be faster and stronger than other disciplines.

Table 1 Summary Researches on MIS Research Issues and Domain Subjects (conti.)

No	Literature	Research Object	Analysis Methods	Data Time	Major Conclusion
8	Lee et al. (1999)	Research Subjects	Descriptive Statistics	1991-1995	Academic cycle gave big concern on issues such as development method of information system, advanced technology, computer-supported cooperative work, information system application, user acceptability, expert system and artificial intelligence, decision support system and information system study. In practice cycle, more concerns were given to information technology marketing, information system strategy, information system application, client-server framework technology, standardization system, commercial products, new tools and technologies. Therefore, there was a great gap on highlighted issues between academic cycle and practice cycle.
9	Claver et al. (2000)	Research Subjects, Research Method and Author	Descriptive Statistics	1981-1997	It is found that information system development, decision support system, information system evaluation, information system practice, expert system and artificial intelligence are issues occurring most frequently in research subjects. As to research strategy, empirical study is dominant, followed by field study, theoretical study and case study.
10	Vessey et al. (2002)	Research Subjects, Research Method and Reference Discipline	Descriptive Statistics	1995-1999	Diversifies of information management studies increased.
11	Prasad and Tata (2005)	Keywords and Inner Text	Descriptive Statistics	1990-1999	Compared article categorys and analyzed issue information presented by the number of articles.
12	Liang and Chen (2005)	Article Title Classification	Descriptive Statistics and multi-dimension analysis	1980-2001	Information management study was divided into four phases in the past 20 years. Introduction of new information technology and application demands constituted the major driving factors of its development.
13	Grover et al. (2006)	Reference and Citation Discipline	Citation analysis	1990-2003	Information management study had a certain degree of cumulative tradition and affected other disciplines positively.
14	Wade et al. (2006)	Reference and Citation Discipline	Citation analysis	1990-2001	Currently, information management study is only a sub-domain in management discipline and doesn't become one independent reference discipline. However, it has potential to realize.

motives of information management research subjects through statistical analysis, and provided guides in research direction of future by making possible predictions of trends. There were a lot of such articles, e.g. ten articles listed in column 1, 4, 5, 6, 7, 8, 9, 10, 11 and 12; articles in column 1, 5, 7, 9 and 10 discussing research methods. In the review of MIS study and discipline development by Alavi and Carlson (1992), they analyzed issues related to classification, subjects and research methods in MIS articles; Prasad and Tata (2005) analyzed publication categories of MIS articles, compared article categories and analyzed issue information presented by the number of articles. In the ninth article written by Claver et al. (2000), they focused on key issues and research methods, though covering studies about author material, only gave a basic statistics about the number of articles published by authors.

Another category of article took co-citation among disciplines and authors as main analysis approach, mainly discussing important domains and scholars in MIS study. Four articles in column 2, 3, 13 and 14 in above table covered researches related to these aspects. For example, Culnan (1987) attempted to develop MIS intellectual mapping by using citation as analysis method, collecting data from 1972 to 1982 as analysis objects. His results showed that MIS obviously tended to develop toward cumulative tradition. Also, Grover et al. (2006) also studied similar issues by citation method, showing MIS had a certain cumulative tradition and exerted positive influence on other disciplines. However, in articles written by Wade et al. (2006), they also used citation analysis and proposed the opposite conclusions compared with citation analysis in other domains. Notwithstanding, currently, MIS was only a sub-domain in management discipline, because its cumulative experience can't make it one independent reference discipline.

Similar study discussions from above aspects were also seen in other disciplines, e.g. mathematics (Grossman, 2002), biology (Weitz, Benfey and Wingreen, 2007), physics (Yeung, Liu and Ng, 2005), particularly when Moody (2004) studied sociology domain by integrative comparison and analysis of co-author community published in articles and specialties of corresponding issues. His article explained the relationship between history course and knowledge community in sociology domain from the view of knowledge diffusion. Based on Moody and White (2003) and Whitley (2000), if two authors co-published articles, inference could be given that two authors shared relevant knowledge, cooperated and co-developed in similar research domain. Furthermore, based on social influence opinion held by Friedkin (1998), research scholars could form structural cohesion through opinion exchange, issue research, method, execution and discussion in reality. Therefore, understanding structural models of co-publish articles in research domain could benefit understanding formed structures and development course of different knowledge domains in specific discipline, or possiblly producing theoretical framework in such discipline (Moody, 2004).

2.2 Network structural analysis integrating authors/subjects/keywords

2.2.1 Social network analysis

Social Network Analysis (SNA) studied the relationship amid research actors. Social network analysis tried to know about interpersonal relationship among actors and observe the influences exerted on individuals or organizations by this relationship (Wellman, 1996). Analysis of all characteristics in social network analysis mainly developed together with graphic theory, to generate relevant characteristic properties to represent roles and significance of actors playing in social network, meanwhile, applied graphic drawing to function as auxiliary analysis. However, due to graphic drawing is too random or flexible, incurring difficulty in conducting strict analysis on math model, social network analysis graph needs a kind of drawing principles defined in more strict way. Firstly, nodes had to define the number of used modes and link clearly described categories to be used. Nodes or links must be clearly defined in their weights with colors matching the definitions, so as to realize the goal of assisting in analysis and identification.

Many different hierarchy and concepts were derived from graphic theory, summarized as follows:

Social network method was applied into analyzing application of network dynamics and field evolution. Abel, Bryan and Norman (2000) pushes the analysis hierarchy from simple histogram into dynamic image that helps readers intuitively understand analysis method compared with only demonstrating statistical figures. Since sociogram is introduced by Moreno for the first time, social network had been expanded into visible use (Brandes, Raab and Wagner, 2001, Moody, Mcfarland and Bender-Demoll, 2005). More articles started focusing on social network analysis to discuss development process and pattern of communities. For example, Powell et al. (2005) applied social network analysis to discuss collaboration network dynamics inside life science organization and

Table 2 Levels and Concepts of Social Network Analysis Methodology

Concepts/Levels	Whole Network	Sub-network	Ego (Individual) Measures
Links	Cohesion: → Density → Average Distance → Centralization	Group → Clique → n-clique → k-plex → k-core (cohesive group)	Ccentrality → Degree centrality → Closeness centrality → Betweenness centrality → Structural hole constraint
Equivalency	Structural equivalence Regular equivalence	Structural equivalence Regular equivalence	Structural equivalence Regular equivalence

such domain evolution. Moody (2004) applied social network indices into the observation of framework of social and scientific collaboration network. Newman (2001, 2004) also applied social network into analysis of framework of scientific collaboration framework. All literatures mentioned above adopt social network analysis to discuss development patterns of communities. By inheriting this concept and method, this article will use social analysis to analyze MIS research community and its knowledge evolution process.

2.2.2 Small-world network structures

Watts and Strogatz (1998) proposed a Small-World theory, indicating its structure was neither a completely routine-based nor fully random one, but a balance mode mixing chaos among one of two routines. Many networks often seen were small world networks, e.g. global information network, food chain in ecological system, business connection network in economic activities, connection network in human brain neurons and molecular interaction inside cells (Watts, 1999). In studies on small world network, cluster coefficient (CC) and average path length (APL) were two indices measuring small world phenomenon in network. For single author, CC was used to calculate the percentage of his attachment accounting for all possible connected authors. When discussing network cluster characteristics in paragraph 4.2 in this article, CC value in whole network was used to calculate the mean of CC for all authors in the network. APL in whole network calculated the sum of route lengths linking any two authors in network being relative to that of route lengths linking all authors. These two indices were used to compare closeness/intimacy of this network structure.

Based on the studies by Collins (2001) and Davis (2001), if the studied discipline developed fast, researchers had disperse specialty, research methods and expense resources were diverse, the mode of collaboration study should be highly and regionally clustered. It meant that if collaboration research acted so, the mean route length between two authors could be small; the studied community could form a small world network (Milgram, 1969; Watts and Strogatz, 1998, Watts, 1999). This typical collaboration research structure incorporated many separated cluster networks. Because there was a high cohesion in research basis (theory) inside community, and a close linkage among authors inside networks, total APL in cross-fields could be larger, leading to difficulty in integration of researches among different clusters (Moody, 2004). In studies by Moody, small world network was used to describe development structure characteristics in sociology research field.

2.2.3 Power-law network structures

Verifying collaboration network being a link network following scale-free power law distribution or not is another approach to describe structural characteristic of collaboration study (Barabasi, Albert and Jeong, 1999; Newman, 2000). Based on power

law distribution discovered by Barabasi et al. (1999, 2002), they found its link is centrally skewed. That is to say, a highly linked hub will generate in network structure. If referring to collaboration network study, this hub author was a star author who directly or indirectly worked with a majority of people. If referring to keywords, the hub meant a key term or concept used in each article.

Previous literatures pointed out that few famous scientists may become cores of expert collaboration network, other scientists could connect with networks through active individuals in communities (Crane, 1972). Preferential attachment inclination can explain modes of appearing in heterogeneous network framework and attachment distribution of power law (Dorogovtsev and Mendes, 2000). Central position can explain why core scientists spread information in communities rapidly. Newman (2001) strongly asserted himself that collaboration could turn into status creator, and further calculated who was a scientist with optimal attachment. If network distribution linking co-authors was attached to few active researchers (star researchers, who may cohere a lot of research expenditure and resources due to his popularity and academic reputation, and gathered many following students and co-scholars), his expertise and knowledge could affect the development of specific discipline within a short time, presenting it in article structures of co-research. This collaboration network could generate an unevenly distributed collaboration network pattern centralizing star scholars (Merton, 1968; Crane, 1972; Cole and Cole, 1973; Zuckerman, 1977; Allison, Long and Krauze, 1982).

Thus, co-research link network that fits power law distribution developed in mode of preferential attachment, leading to the emergence of "the Rich Richer." When one author had many attachments, new attachments were easily produced. If network was distributed conforming to preferential attachment, collected data could be used to observe distribution curve of power law, thus after the power was converted properly, the power distribution map could turn into data distribution in linear way. Moody (2004) also adopted the preferential attachment mode to discuss whether co-author had star author attached to it or not in research of sociology field. However, verification conducted on power law distribution curve tended to convert the curve actually distributed into log-log, and check conformity of the distribution with straight lines by means of regression analysis. The number of power in power law reflected convergent-skewed degree, namely, straight slope of straight lines after conversion.

Making use of structural characteristics in two networks mentioned above, this study aimed to understand different opinions and visions concerning MIS development modes. Firstly, this study described the changes of co-author community structures in MIS articles, tried to know about development mode in MIS research in past 31 years. Because when nodes and links exceeded 100 in network, difference in network complexity in

reality was unable to be identified by structural graph. Structural indices mentioned above could be used for easy identification.

Moreover, this study shifted knowledge about co-author network into a wider scope of analyzing MIS research issues, through analyzing network structural characteristics, to discuss issue/keyword network formed in keyword categories in articles, thus, provided dimensions of research issues generated by keywords categories, understood structural forms and structural changes of MIS research subjects appearing in different domains/subjects within 31 years, with the expectation to provide holistic and integrative understanding of knowledge development about MIS research community.

This study discussed whether information management field had small world network clustered phenomenon. Compared with disciplines with long history that already completed similar research, was there a significant difference on structures? Thus, these two structural indices were used to discuss the structural difference of author community in whole discipline and structural differences among different categories within such discipline that was specifically referred to information management in the past 30 years. Through structural comparison and description, it did not only provide a broadened understanding of structures and veins in whole disciplines, but also provided other scholars in different disciplines understanding of information management research development and a map of collaboration modes.

3. Research methods

To understand MIS collaboration network and knowledge development, this study took information management literatures published previously as analysis objects, and conducted social network analysis on these literatures. In this section, research steps and methods, including data collection, data construction and keyword classification, were introduced.

3.1 Data collection

Due to rapid development of IT industry and demands for IT industry, as well as rapid growth of information management research, this study believed there is a necessity to discuss development patterns of MIS research, thus, chosen journals in MIS field as research objects. According to ranking survey made on information management journals in the past (Gillenson and Stutz, 1991; Katerattanakul et al., 2003; Peffers and Ya, 2003; Lowry et al., 2004; Saunders, 2005), it found some representative journals in information management discipline such as *MIS Quarterly* (*MISQ*), *Journal of Management Information Systems* (*JMIS*), *Journal of the Association for Information*

Systems (*JAIS*), *Information Systems Research* (*ISR*) and *Decision Support Systems* (*DSS*). Due to our limited resources, we only picked up *MISQ* journal as research object. We collected articles published in *MISQ* from 1977 to 2007, totally covering 738 articles and 1012 authors. Collected data included article title, author, keyword, publication date and abstract. Though only *MISQ* journal taken as research object, as a leading role in MIS research journals, its application into this explorative research to discuss patterns of MIS literatures should be representative.

3.2 Classification of keywords

To create consistent keywords from resembled ones, this study was based on one keyword classification table issued by Barki et al. (1988) in *MIS Quarterly* as classification framework. In their study, keywords in information management study were classified into reference discipline (A), external environment (B), information technology (C), organizational environment (D), information system (IS) management (E), IS development and operations (F), IS Usage (G), information systems (H) and IS education and research (I), many sub-domains divided under these nine categories. Later on, Barki et al. (1993) modified this framework but there was basically the same. In recent years, research about information management issues classification also adopted this classification framework, e.g. Alavi and Carlson's (1992) analysis was based on this framework.

Among 738 articles published in *MISQ* journal from 1977 to December, 2007, 29 articles didn't involve keyword codes, mainly discussing responses of published papers. Regarding to collected keywords, for 29 articles providing no keywords by the author, the coders didn't add any keyword for these articles by themselves. Considering the number of such articles should not affect analysis of overall tendency, among 709 articles deducted, it acquired totally 3,670 keywords involving authors, 2,275 for non-repeated keywords.

Among organizing captured keywords, if deducted keywords in singular and plural forms that obviously repeated, e.g. impact and impacts; semicolon(-), e.g. Decision Making and Decision-Making; phases using adjective and noun meaning the same, e.g. Organizational change and Organization change and abbreviations like IS and Information System(s), such repeated keywords were identified as 93, thus 2,182 non-repeated keywords were left. Among these keywords, 461 phases were totally conforming to code phases in *MISQ* journal, after deduction, 1,721 phases were left, requiring manual identification and classification. Furthermore, among 188 articles collected from issue 3, volume 8 in 1994 to issue 3, volume 27 in 2003 of published articles in *MISQ* journal, original coders provided 786 codes corresponding to *MISQ* codes among 848 keywords contained in 153 articles; it also included 374 different codes. In the rest 35 articles, 5 articles didn't have keywords, so 156 keywords provided in 30 articles together with keywords of articles issued in other date adopt were coded manually.

This article made keywords in *MISQ* articles coded manually by following triangulation coding. Firstly, invited experts in information management discipline to conduct coding work independently, to classify each keyword into one code in the classification framework. One article may be classified into several categories. Sometimes, if the same keyword was applied into different articles, it may be presented in different domains, e.g. database design may represent CB06 in software category in C category under computer science issue. However, the same keyword may appear as FB0401 in system design category in F category under IS development issue. At this time, classification operators must read abstract and even text to identify which category keyword was belonged to. During classification, if coders can't find suitable codes in the lowest category, they will use code in upper class in order, finally may choose one class from A to I in nine categories.

In order to ensure the reliability of classification work, this research used the inter-rater reliability to test the reliability of classification work and used the Kohen's Kappa coefficient as an index for reliability measurement. Kohen's Kappa coefficient could avoid the coincidence caused by probability factor to evaluate the reliability of two independent coders' coding result (Krippendorff, 1980; Weber, 1985; Liang and Chen, 2005). If the Kappa coefficient is more than 0.8, it means almost perfect agreement, indicating that the two coders' coding results are almost completely the same; if the Kappa coefficient is 0.6-0.8, it means substantial agreement; if the Kappa coefficient is more than 0.5, it means moderate agreement (Landis and Koch, 1977). In this research, the code reliability is 0.520 and the significance level is .000, indicating that the code reliability is within an acceptable range. After confirming that the code reliability is all right, invite a third researcher to reconfirm the keywords of the two coders' different codes, and finally establish the network analysis data based on the codes confirmed by such third researcher.

Codes of original coders in *MISQ* and results of manual coding were combined for use. 3,607 keywords were classified into 710 codes under *MISQ* nine categories. The nine categories in coding list were seen in Table 3. After non-parametric Wilcoxon Signed Ranks Test finishes, Z-value is -2.666 and significance is 0.008 at 2-tailed, indicating there is no significant difference between classification produced by this article and that given by *MISQ*.

With respect to authors collection, though they published articles in only one journal within 30 years, confusion was still incurred because the name of same author was written with middle name initial or not in articles sometimes. In this case, one solution often adopted was to identify the article list of this author to confirm he was the same author by searching his website. Totally 1,012 different authors were covered among 738 articles.

Table 3 *MISQ* Journal Keyword Classification Scheme Summary

Keyword Classification Scheme	MISQ Original Coded Keywords	Keywords Coded by this study	Sub-total
A. Reference Disciplines	248	638	886
B. External Environment	29	95	124
C. Information Technology	14	103	117
D. Organizational Environment	79	212	291
E. IS Management	174	667	841
F. IS Development and Operations	59	438	497
G. IS Usage	60	165	225
H. Information Systems	80	414	494
I. IS Education and Research	43	89	132
Total	786	2821	3607

3.3 Construct analysis network data

This study took social network analysis as analysis tool. Firstly, we analyzed structures of collaboration network and keywords from standpoint of 1-mode, described interactive actions in communities and compare structural changes by social network indices constructed, SNA research and data analysis. After data were collected from *MISQ* journals, this journal was regarded as one social community network. Communities were interconnected with each other due to nodes and ties. Each author was regarded as node in communities. If two authors kept collaboration relationship, a tie will appear in collaboration relationship. Construction of keywords applied the same principle.

Because collected data has spanned 31 years (1977-2007), considering the thorough investigation of co-author statistics and comparison in different keyword domains, this study imitated Moody (2004) to divide data collection into three phases; first phase is 11 years, 10 years for each phase in subsequent two phases. Comparison was made in three phases. Regarding analysis of structural indices, because network structure experiences a cumulative process, to effectively observe change trends of structural indices, we measured network indices accumulated every three years, so as to investigate the structural changes of network structures over time. Because the data quantity was accumulated till 31st year, a network structure cumulated in 31 years rather than in 30 years was applied into measurement of last structure index. As to analysis of network structure, firstly,

	1	2	3	4	5	…
1		1	2	1	1	
2			0	0	0	
3				0	1	
4					3	
5						
…						

Co-Author Linked Matrix

	1	2	3	4	5	…
A	0	1	2	1	1	
B	1	0	0	0	2	
C	1	0	1	0	1	
D	0	0	2	1	1	
E	1	0	1	1	1	
…	1	0	1	1	1	

Author-Keyword Scheme Linked Matrix

Figure 1 Example of Network Relation Matrix Construction

convert co-publication relationship of authors into matrix in network relation, seen in map in left side of following table. Codes of authors were written on titles of different rows and lines, recording the times of co-publication within statistical period in middle table. Because collaboration was direction-free, only triangle data in right upper side of matrix is recorded. When convert authors and keywords into network relation matrix, the title on first line was modified as matrix, in the same way, the times of using keywords in the same class to publish articles by the authors was recorded into data grid.

4. Research results and findings

4.1 Co-MIS research trends

Collaboration network forming was limited by the distribution of articles published by authors and the distribution of number of co-authors in one article. Figure 2 showed the distribution of all articles published in any pattern in *MISQ* from 1977 to 2007 (including articles having single author). In holistic view, with the prolongation of research development, trends of co-publication gradually increased year by year, e.g. its average is 57% in earliest 11 years (1977-1978), and reached 79.6% between 1988 to 1997, and even achieved 88.3% in recent decade (1998-2007). Furthermore, the average percentage of co-publication (excludes single author) within 31 years was 75.1% and the number of authors in each article was averaged 2.13. Within three ten-year's phases, the average is 1.69 in earliest 11 years, 2.27 in next decade, and 2.39 in recent decade, which was equivalent to 2.2 in computer science field. However, it was still lower compared with the average of 2.7 in sociology field from 1989 to 1999 (Moody, 2004) and 8.9 in high-energy physics (Newman, 2001). Seen from the lower number of co-authors in one article, it may reduce the size of clusters possibly formed through collaboration. Therefore, inference may be made that MIS research is still at developing stage in terms of

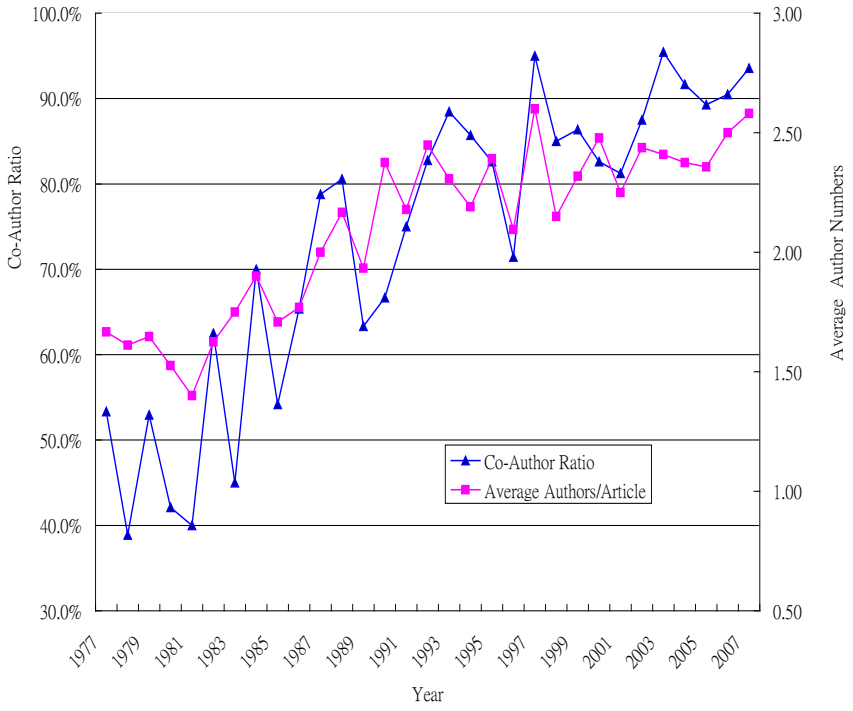

Figure 2 Yearly Average Authors and Co-author Ratio of *MISQ* Journal

integration knowledge; however, collaboration trends and diffusion of domain knowledge were continuously rising.

In Figure 2, "Collaboration Percentage" meant the percentage of articles with two or above authors accounting for overall articles within the year, which was used to calculate the percentage of co-author quantity in C item in Table 4. "Mean Author Quantity" meant average co-author quantity in all articles within the year. Based on data in Figure 2, item statistics was organized in Table 4, which integrated three items trends and their comparisons within three phases' period, with data accumulated 31 years being underlined. Three trends included "Percentage of Article Quantity Published by Authors", "Percentage of Authors in Each Article" and "Percentage of Co-Author Quantity." To benefit indication and description, three items were marked as A, B and C respectively in front side.

Based on results shown in Table 4, for A-Percentage of Article Quantity Published by Authors, 75.1% authors only published one article in *MISQ*, 12.85% authors published two articles. With the increase of article quantity issued by each author, the author quantity sharply reduced. The above trend was also seen similar case in each phase within three decades. It may expect that authors with more articles accumulated within 31 years.

Table 4 Distributions of Author and Co-Author in *MISQ* Journal

	A- Ratio of each author's article counts				B- Ratio of each article's author counts				C- Ratio of Co-Author articles			
Period/ Count	1977-1987	1988-1997	1998-2007	1977-2007	1977-1987	1988-1997	1998-2007	1977-2007	1977-1987	1988-1997	1998-2007	1977-2007
0	-	-	-	-	-	-	-	-	24.12%	7.69%	4.18%	9.78%
1	82.32%	78.55%	78.42%	75.10%	43.22%	21.32%	11.07%	24.93%	41.48%	34.97%	33.41%	34.09%
2	11.25%	12.59%	14.62%	12.85%	54.66%	70.54%	77.46%	67.75%	20.58%	25.87%	28.54%	25.79%
3	4.18%	5.59%	4.18%	5.73%	1.27%	6.20%	9.43%	5.69%	6.75%	12.59%	16.71%	13.34%
4	0.96%	1.63%	1.16%	2.57%	0.42%	1.55%	2.05%	1.36%	3.86%	9.09%	7.42%	8.60%
5	0.32%	1.40%	0.46%	1.68%	0.42%	0.39%	0.00%	0.27%	2.57%	3.50%	4.18%	3.06%
6	0.32%	0.00%	0.70%	0.99%	0.00%	0.00%	0.00%	0.00%	0.00%	3.03%	1.62%	1.09%
7	0.00%	0.23%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	1.39%	1.09%
8	0.64%	0.00%	0.00%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.93%	0.79%
9+	0.00%	0.00%	**0.46%**	0.79%	0.00%	0.00%	0.00%	0.00%	0.64%	1.40%	1.62%	2.37%
N	311	429	431	1012	236	258	244	738	311	429	431	1012

However, in recent decade (1997-2007), the percentage of authors publishing more than 9 articles greatly rose, so an inclination that start authors gather and cooperate into study may appear. This trend can be validated by conforming to network structure of power law distribution.

As to B-Percentage of Authors in Each Article, 25% articles only had one author, 68% articles had two authors, showing that co-publication by two authors was dominant in *MISQ* articles published and gradually rose over time. The same trend was also seen in co-publication by more than three authors, which gradually increased with knowledge accumulation and development of study. If compared with C-Percentage of Co-Author Quantity, at initial stage of MIS development (1977-1987), the percentage of single author (24.1%) plus two authors (41.48%) in co-publication had exceeds 65%; in next decade (1988), the trend that author worked with others starts growing, collaboration team by two authors maintains 1/3 at most. However, the publication of single author obviously decreased and spread into other fields where the number of co-authors was large. It showed collaboration research and discipline knowledge were constantly developing and diffusing.

4.2 Research keywords classification/development of theme sub-domains and analysis of collaboration research

The list of co-author statistical distribution under keywords of articles and second tier of *MISQ* keywords classification within three decades was seen in Table 5. First and second row symbolized classification code and representative keyword in second tier of MISQ keywords; 64 sub-domains were listed totally under (AZ), (BZ), (CZ), (DZ),(EZ), (FZ), (GZ), (HZ) and (IZ). Because when keyword classification was coded, no corresponding classification codes were found in categories below second tier in original *MISQ* classification codes. So, we classified keyword into first tier in (A-I) according to abstract of articles. For example, "Online Use" had no proper sub-domain in original code (G, Computer Usage), so it was classified into code (G). However, to avoid calculation problem of upper-hierarchy and subordinate-hierarchy in below table, code (#Z) was uniformly applied to each problematical case. Thus, keywords below #Z code may be keywords depending on overall sub-domains at initial stage or those in need of adding sub-domain codes under #Z code or represent the quantity of articles possibly applied to develop into new sub-domains.

Third line in the table showed articles within 31 years that are described by three phrases and summed according to keywords listed by authors, listing figure and percentage in each sub-domain. The times of a certain keyword occurring in specific category were braced, with the percentage of such keyword in relative to total keywords within one decade next to it. Because this table took keywords in second tier as statistical

basis, if multiple keywords belonging to third tier appeared in second tier for one article, it was limited by calculating once keywords codes in second tier in the article, avoiding repeated calculation of times article appearing in the classification, thus benchmark in sum was 2720, lower than original keyword quantity. Because limitations by table size and convenience for demonstration, three phases were shown by P1 (77-87), P2 (88-97) and P3 (98-07) respectively.

Forth line calculated percentage changes of specific keyword within three ten-year period, indicating that the percentage of such keyword accounting for overall keywords from P1 to P2 and from P2 to P3 increases or decreases. Fifth line showed the percentage of articles with more than two authors who used specific keyword within 31 years, calculating in current category, the percentage of articles with two or above authors using such keyword. Sixth line compared trends of co-publication article from P1 to P2 and from P2 to P3. Furthermore, categories and figures mentioned in following paragraphs were marked in bold in the table for the convenience of comparative reading. Discussion of development trends in each category are described as follows.

4.2.1 Development of reference domain

Firstly, (A) class was the code of discipline in reference domain of research, appearing at highest percentage among overall articles. As to sub-domains under (A) class, Research (AI) was definitely listed on top, because a majority of authors often marked research methods, framework, mode and statistical methods as keywords. The ranks following by management theory (AF), behavior science (AA) and decision science far ahead from information theory were listed on fifth position. Only 4 keywords involved development of new sub-domain.

When analyzing growth of the number of published articles within three ten-year period, the articles occupying fastest growth in each phase (in relative to total number in the same phase) were classified into research class. Subsequent rankings showed focus shifts in research sub-domains. From P1 to P2, the second highest in growth ratio is information theory (AD), followed by artificial intelligence (AL); from P2 to P3, the second highest in growth ratio is decision science (AC) followed by behavior science (AA). But management theory (AF) shows negative growth in each phase.

Regardless of the quantity of articles published or co-author trends, more efforts should be paid to develop application and discussion on relevant theory in more complex environment, e.g. politics, sociology and ecology. Additionally, there were 4 keywords in AZ in total, indicating that reference discipline domains add in limited way or codes in original domain are already complete. As for ratio of co-authors, deleting the ratio involving too few authors, it was evenly distributed in the whole. Within three phases, collaboration study growth is conforming to quantity growth.

4.2.2 Domains with steady growth

After understanding the trends and changes of theoretical framework of reference disciplines used, we reviewed the subjects in sustainable and steady domains in whole study. Firstly, (E) category in IS management issues was close to (A) category, with keywords used at most. There were 13 sub-domains in (E) category, making it become second largest domain next to (A) category. Under (E) category, the top three sub-domains were sequenced as: IS evaluation (EI), IS plan (EF), IS management issue (EL). IS evaluation (EI) issues grew steadily in first two decades, though fallen down in recent decade, and still ranked on top in sub-domains. The development trends of this issue should be gradually convergent whereas have continuously outputs in some periods. IS plan (EF) issue dropt down in terms of article quantity and collaboration research trend, indicating relevant issues had limited space in development. In the opposite, IS management issue (EL) showed steady growth in terms of article quantity and collaboration research trend.

Category (H) involved study on information system categories and object-related issues, second only to category (E) and category (F). Due to increase of system application category, relevant issues and collaboration research trend in category (H) show constant growth. Sub-domain (HA) categories of Information system took priority over other sub-domains under category (H), e.g. transaction system, Email system, MIS system and DSS system. Almost keywords were derived from MIS system and DSS system from 1977 to 1987, whereas, tended to be evenly distributed in recent decade. Though research in such sub-domain tends to decrease, its productivity was substantial in recent decade. Under application system (HB) sub-domain being industry-specific, the second largest in (H), e.g. financial system, marketing system and production system, showed gradual rise in terms of article quantity and collaboration research tend in each decade. It should attribute to increase and development of profound application issues following specialization of application characteristics in information system industry, meanwhile, call for professional talents introduced for the purpose of collaboration.

4.2.3 Domains with gradual slow-down

As the second largest domain in aspect of research quantity in the past, category (F) surrounded software and application system development issues. In holistic view, system development issue (F) showed decrease both in article growth and co-author research trend. Its research articles were accumulated in first decade, and the number of overall application system development (FZ) was cumulative in early period by applying keywords, thus the same for IS management (EZ). That is to say, development methods and methodologies research in information system development domain have been matured.

Category (G) was the forth research issue, discussing categories of computer application. There is a small gap between organizational use of IS (GA) and IS user (GB). When correspond these two sub-domains to those under A category-reference citation fields, it can reflect theoretical basis sources and issue directions discussed in the past research. However, the growth tend of article quantity and the ratio of knowledge diffusion under co-author research both develops slowly within three phases, among them, decrease of organizational use of IS (GA) is higher than IS user (GB), particularly shown in trend of author collaboration.

Under category (C) -- computer science (technology), its ratio in relative to overall ratio is only about 3.4%, listed in the last three sub-domains together with BZ (external environment) and information education and research (IZ) among all sub-domains. Category (C) grows negatively in three phases. The ratio of co-author slows down in hardware (CA) and decreases in software (CB), showing that information management issues are gradually separated from information technology development issue.

4.2.4 Domains with gradual growth

Under category (G), computer usage (GZ) adds new categories of usages, particularly in recent decade, the development of new issues and author collaboration grew more significantly, which indicated that computer usage will pose new research issue direction and space.

Category (I) was related to information education and information management research issues. Research issues organized in this study into Table 1 were classified into sub-domain information research (IB), covering most keywords under articles in this category. Information management research framework and mode belong to this sub-domain. Though the research ratio decreased from phase1 to phase 2 in relative to that in whole phases, in recent decade, the number and phase ratio in this research issue multiplies greatly; the ratio of co-author research was higher than that in whole MIS ratio. In different phases, compared with that of first two phases, co-author research grew slightly in recent decade. When MIS research accumulated up to a certain level, research issue, field category, strict narration and modes of research methods and discipline orientation could come to the surface.

Category (D) involved environmental issues inside organization, its number second only to the three domains above. Discussion was mainly made on sub-domain organizational dynamics (DD) that grew significantly within one decade. Similarly, collaboration research also increased with historical accumulation. Next to it is Organizational characteristics (DA) sub-domain that increased in its number whereas the increasing tend of co-author research slowed down. Summarizing the growth of keywords

in sub-domains mentioned above that seldom discussed by main-streams, in combination with growth inclination of co-author research, it is expected that issues related to organizational dynamics (DD) and social environment (BD) couldhave constant growth.

4.2.5 Others

Category (B) mainly involved outer environment with a small number, including four sub-domains, among which, studies on social environment (BD) and economic environment (BA) were listed on first and second regardless of sum in whole phases or number in each phase and co-author research ratio, however, growth ratio in social environment studies gradually rose, for economic environment, it gradually slowed down; collaboration research ratio also increased in both sub-domains. There was only 1 keyword in BZ, its research quantity and growth tends smaller than those of other sub-domains.

Another issue field worthy of discussion was IS management (EZ), its quantity equivalent to that of IS plan (EF), mainly appears in early phase. After investigation one by one, the number of keywords in EZ mainly appeared in early phase of study, differing from other domains that are classified with keywords due to emergence of new issues. In early phase of study, because many articles directly applied MIS and IS management as keywords equivalent to those under category (E), they were classified into domain (E). Therefore, in early phase of study, MIS was regarded as one keyword in holistic concept, and gradually produced depth and width of discipline through development and diffusion.

4.3 Clustering characteristics in collaboration research network structures

4.3.1. Investigation of Small-World network

This study applied cluster coefficient and average path distance proposed by Watts (1999) to measure Small-World network as two indices and identify whether small-world exists in collaboration network.

Because dimensions of network world was a relativity comparison, this study imitated Moody (2004) and Newman (2001) to compare randomized network produced by nodes and links equivalent to those in network in each phase in *MISQ*. Following procedures advocated by Pajek 1.24 version (Batagelj and Mrvar, 2006), this study input identical nodes and links into system that produces link network (if the number of authors is cumulative up to 231 in 1985, the number of collaboration links will be 148). Then measured CC and APL value in random network and compared such values with measurement indices produced in *MISQ* author network in reality. Comparing differences on cluster coefficient and average route distance with randomized control network, the degree of small-world in *MISQ* author network could be demonstrated, results shown in Table 6. Table 6 divided 31 years into 10 phases (1977-2007), three years taken as one

Table 5 The Growth Rate of Co-Author by the Second Level Keyword Scheme

2nd Key-word Scheme	Domain of the Keyword Scheme	(Counts) Ratio of 2nd level keyword scheme				Among periods Growth Ratio		Co-author ratio	Co-author growth ratio	
		77-87(P1)	88-97(P2)	98-07(P3)	77-07	P1-P2	P2-P3		P1-P2	P2-P3
Subtotal of each period		**846**	**907**	**967**	**2720**	-		**75.48**	-	
AA	Behavioral science	(25) 2.96%	(30) 3.31%	(58) 6.00%	**(113) 4.15%**	**0.35%**	**2.69%**	**80.53%**	N/A*	**8.40%**
AB	Computer science	(0) 0.00%	(1) 0.11%	(1) 0.10%	(2) 0.07%	0.11%	-0.01%	100.00%	0.27%	0.00%
AC	Decision sciences	(16) 1.89%	(18) 1.98%	(47) 4.86%	**(81) 2.98%**	**0.09%**	**2.88%**	**81.48%**	1.36%	**7.05%**
AD	Information theory	(8) 0.95%	(18) 1.98%	(20) 2.07%	(46) 1.69%	**1.04%**	**0.08%**	**67.39%**	**2.45%**	0.27%
AE	Organizational environment	(3) 0.35%	(1) 0.11%	(7) 0.72%	(11) 0.40%	-0.24%	0.61%	81.82%	0.00%	1.63%
AF	Management theory	(57) 6.74%	(41) 4.52%	(43) 4.45%	**(141) 5.18%**	**-2.22%**	**-0.07%**	**80.85%**	-1.63%	0.81%
AG	Language theories	(1) 0.12%	(0) 0.00%	(0) 0.00%	(1) 0.04%	-0.12%	0.00%	0.00%	0.00%	0.00%
AH	Systems theory	(4) 0.47%	(2) 0.22%	(5) 0.52%	(11) 0.40%	-0.25%	0.30%	72.73%	-0.27%	1.08%
AI	Research	(16) 1.89%	(48) 5.29%	(81) 8.38%	**(145) 5.33%**	**3.40%**	**3.08%**	**83.45%**	**6.52%**	**9.21%**
AJ	Social science	(1) 0.12%	(6) 0.66%	(14) 1.45%	(21) 0.77%	0.54%	0.79%	80.95%	1.63%	1.36%
AK	Management science	(8) 0.95%	(3) 0.33%	(5) 0.52%	(16) 0.59%	-0.61%	0.19%	81.25%	-1.09%	0.81%
AL	Artificial intelligence	(2) 0.24%	(9) 0.99%	(9) 0.93%	(20) 0.74%	**0.76%**	-0.06%	80.00%	1.36%	0.00%
AM	Economic theory	(2) 0.24%	(5) 0.55%	(15) 1.55%	(22) 0.81%	0.31%	1.00%	86.36%	1.09%	2.17%
AN	Ergonomics	(0) 0.00%	(1) 0.11%	(0) 0.00%	(1) 0.04%	0.11%	-0.11%	100.00%	0.27%	-0.27%
AO	Political environment	(0) 0.00%	(3) 0.33%	(1) 0.10%	(4) 0.15%	0.33%	-0.23%	75.00%	0.54%	-0.27%
AP	Psychology	(0) 0.00%	(5) 0.55%	(4) 0.41%	(9) 0.33%	0.55%	-0.14%	77.78%	1.09%	-0.27%

* The code is added at the succeed period, so no ratio is available.

Table 5 The Growth Rate of Co-Author by the Second Level Keyword Scheme (conti.)

2nd Keyword Scheme	Domain of the Keyword Scheme	(Counts) Ratio of 2nd level keyword scheme				Among periods Growth Ratio		Co-author ratio	Co-author growth ratio	
		77-87(P1)	88-97(P2)	98-07(P3)	77-07	P1-P2	P2-P3		P1-P2	P2-P3
Subtotal of each period		**846**	**907**	**967**	**2720**	**-**		**75.48**	**-**	
AZ	Reference disciplines	(1) 0.12%	(0) 0.00%	(3) 0.31%	(4) 0.15%	-0.12%	0.31%	75.00%	-0.27%	0.54%
BA	Economic environment	(4) 0.47%	(14) 1.54%	(15) 1.55%	(33) 1.21%	1.07%	0.01%	78.79%	2.17%	1.08%
BB	Legal environment	(0) 0.00%	(4) 0.44%	(5) 0.52%	(9) 0.33%	0.44%	0.08%	100.00%	1.09%	0.27%
BC	Political environment	(2) 0.24%	(5) 0.55%	(3) 0.31%	(10) 0.37%	0.31%	-0.24%	80.00%	1.36%	-0.54%
BD	Social environment	(5) 0.59%	(11) 1.21%	(26) 2.69%	(42) 1.54%	0.62%	1.48%	76.19%	1.90%	4.07%
BZ	External environment	(0) 0.00%	(1) 0.11%	(0) 0.00%	(1) 0.04%	0.11%	-0.11%	0.00%	0.00%	0.00%
CA	Computer systems (Hardware)	(15) 1.77%	(14) 1.54%	(13) 1.34%	(42) 1.54%	-0.23%	-0.20%	69.05%	1.36%	0.27%
CB	Software	(15) 1.77%	(13) 1.43%	(10) 1.03%	(38) 1.40%	-0.34%	-0.40%	71.05%	1.09%	-0.54%
CZ	Computer science	(4) 0.47%	(6) 0.66%	(3) 0.31%	(13) 0.48%	0.19%	-0.35%	84.62%	0.54%	-0.54%
DA	Organizational characteristics	(11) 1.30%	(24) 2.65%	(28) 2.90%	(63) 2.32%	1.35%	0.25%	77.78%	3.26%	1.90%
DB	Organizational departments	(10) 1.18%	(15) 1.65%	(12) 1.24%	(37) 1.36%	0.47%	-0.41%	67.57%	1.63%	0.27%
DC	Job characteristics	(10) 1.18%	(3) 0.33%	(19) 1.96%	(32) 1.18%	-0.85%	1.63%	78.13%	-1.09%	4.07%
DD	Organizational dynamics	(16) 1.89%	(26) 2.87%	(48) 4.96%	(90) 3.31%	0.98%	2.10%	74.44%	3.53%	6.23%

Table 5 The Growth Rate of Co-Author by the Second Level Keyword Scheme (conti.)

2nd Key-word Scheme	Domain of the Keyword Scheme	(Counts) Ratio of 2nd level keyword scheme				Among periods Growth Ratio		Co-author ratio	Co-author growth ratio	
		77-87(P1)	88-97(P2)	98-07(P3)	77-07	P1-P2	P2-P3		P1-P2	P2-P3
Subtotal of each period		**846**	**907**	**967**	**2720**	**-**		**75.48**	**-**	
DZ	Office environment	(4) 0.47%	(2) 0.22%	(1) 0.10%	(7) 0.26%	-0.25%	-0.12%	57.14%	-0.27%	0.00%
EA	Data administration	(6) 0.71%	(3) 0.33%	(2) 0.21%	(11) 0.40%	-0.38%	-0.12%	54.55%	0.00%	0.00%
EB	Human resource management	(1) 0.12%	(4) 0.44%	(2) 0.21%	(7) 0.26%	0.32%	-0.23%	85.71%	1.09%	-0.54%
EC	Computer management	(0) 0.00%	(2) 0.22%	(2) 0.21%	(4) 0.15%	0.22%	-0.01%	100.00%	0.54%	0.00%
ED	Software management	(1) 0.12%	(3) 0.33%	(3) 0.31%	(7) 0.26%	0.21%	-0.02%	57.14%	0.54%	0.00%
EE	IS project management	(16) 1.89%	(17) 1.87%	(16) 1.65%	(49) 1.80%	-0.02%	-0.22%	75.51%	1.09%	0.54%
EF	IS planning	(32) 3.78%	(31) 3.42%	(28) 2.90%	**(91) 3.35%**	-0.36%	-0.52%	69.23%	1.63%	0.00%
EG	Information infrastr-ucture	(25) 2.96%	(14) 1.54%	(12) 1.24%	(51) 1.88%	-1.41%	-0.30%	74.51%	-1.09%	-0.54%
EH	IS staffing	(18) 2.13%	(23) 2.54%	(14) 1.45%	(55) 2.02%	0.41%	-1.09%	80.00%	2.45%	-2.71%
EI	IS evaluation	(52) 6.15%	(62) 6.84%	(55) 5.69%	**(169) 6.21%**	0.69%	-1.15%	72.78%	4.62%	1.36%
EJ	IS control	(12) 1.42%	(6) 0.66%	(4) 0.41%	(22) 0.81%	-0.76%	-0.25%	63.64%	-0.54%	0.00%
EK	IS security	(4) 0.47%	(4) 0.44%	(3) 0.31%	(11) 0.40%	-0.03%	-0.13%	81.82%	0.54%	-0.27%
EL	IS management issues	(14) 1.65%	(25) 2.76%	(37) 3.83%	**(76) 2.79%**	1.10%	1.07%	75.00%	2.99%	2.17%
EZ	Administration of IS	(37) 4.37%	(31) 3.42%	(8) 0.83%	**(76) 2.79%**	-0.96%	-2.59%	72.37%	1.09%	-5.15%

Table 5 The Growth Rate of Co-Author by the Second Level Keyword Scheme (conti.)

2nd Keyword Scheme	Domain of the Keyword Scheme	(Counts) Ratio of 2nd level keyword scheme				Among periods Growth Ratio		Co-author ratio	Co-author growth ratio	
		77-87(P1)	88-97(P2)	98-07(P3)	77-07	P1-P2	P2-P3		P1-P2	P2-P3
Subtotal of each period		**846**	**907**	**967**	**2720**	-		**75.48**	-	
FA	IS development approaches	(15) 1.77%	(12) 1.32%	(6) 0.62%	(33) 1.21%	-0.45%	-0.70%	72.73%	0.27%	-1.36%
FB	Development process life cycle	(76) 8.98%	(32) 3.53%	(22) 2.28%	**(130) 4.78%**	-5.46%	-1.25%	67.69%	-4.08%	-2.17%
FC	Analysis techniques	(19) 2.25%	(11) 1.21%	(8) 0.83%	(38) 1.40%	-1.03%	-0.39%	68.42%	0.00%	-0.27%
FD	Computer systems implementation	(28) 3.31%	(45) 4.96%	(19) 1.96%	**(92) 3.38%**	1.65%	-3.00%	71.74%	6.52%	-6.50%
FE	IS operations	(10) 1.18%	(2) 0.22%	(4) 0.41%	(16) 0.59%	-0.96%	0.19%	62.50%	-1.63%	1.08%
FZ	Applications development	(39) 4.61%	(18) 1.98%	(10) 1.03%	(67) 2.46%	-2.63%	-0.95%	67.16%	-2.72%	-1.08%
GA	Organizational use of IS	(26) 3.07%	(37) 4.08%	(19) 1.96%	(82) 3.01%	1.01%	-2.11%	81.71%	3.53%	-3.52%
GB	Users	(16) 1.89%	(33) 3.64%	(31) 3.21%	(80) 2.94%	1.75%	-0.43%	80.00%	5.43%	0.00%
GC	Type of IS support	(2) 0.24%	(4) 0.44%	(3) 0.31%	(9) 0.33%	0.20%	-0.13%	77.78%	0.82%	-0.54%
GE	Type of processing	(3) 0.35%	(0) 0.00%	(3) 0.31%	(6) 0.22%	-0.35%	0.31%	83.33%	-0.54%	0.81%
GZ	Computer usage	(1) 0.12%	(2) 0.22%	(9) 0.93%	(12) 0.44%	0.10%	0.71%	75.00%	0.27%	1.90%
HA	Types of Information Systems	(71) 8.39%	(76) 8.38%	(59) 6.10%	**(206) 7.57%**	-0.01%	-2.28%	71.84%	4.62%	-2.44%
HB	Applications programs	(17) 2.01%	(20) 2.21%	(30) 3.10%	**(67) 2.46%**	0.20%	0.90%	73.13%	2.17%	2.44%

Table 5 The Growth Rate of Co-Author by the Second Level Keyword Scheme (conti.)

2nd Keyword Scheme	Domain of the Keyword Scheme	(Counts) Ratio of 2nd level keyword scheme				Among periods Growth Ratio		Co-author ratio	Co-author growth ratio	
		77-87(P1)	88-97(P2)	98-07(P3)	77-07	P1-P2	P2-P3		P1-P2	P2-P3
Subtotal of each period		**846**	**907**	**967**	**2720**	-		**75.48**	-	
HC	Components of IS	(12) 1.42%	(11) 1.21%	(10) 1.03%	**(33) 1.21%**	-0.21%	-0.18%	87.88%	0.82%	-0.27%
HD	IS characteristics	(8) 0.95%	(9) 0.99%	(13) 1.34%	(30) 1.10%	0.05%	0.35%	80.00%	0.27%	1.08%
HZ	Information systems	(23) 2.72%	(6) 0.66%	(5) 0.52%	(34) 1.25%	-2.06%	-0.14%	67.65%	-2.99%	0.00%
IA	IS education	(1) 0.12%	(11) 1.21%	(2) 0.21%	(14) 0.51%	1.09%	-1.01%	92.86%	2.45%	-2.17%
IB	IS research	(15) 1.77%	(15) 1.65%	(28) 2.90%	(58) 2.13%	-0.12%	1.24%	84.48%	-0.54%	3.79%
IC	IS professional societies	(1) 0.12%	(1) 0.11%	(1) 0.10%	(3) 0.11%	-0.01%	-0.01%	100.00%	0.00%	0.00%
ID	History of IS	(5) 0.59%	(7) 0.77%	(3) 0.31%	(15) 0.55%	0.18%	-0.46%	66.67%	1.09%	-1.08%
IZ	IS Education and Research	(0) 0.00%	(1) 0.11%	(0) 0.00%	(1) 0.04%	0.11%	-0.11%	100.00%	0.27%	-0.27%

phase, four years in last phase, to understand development process of network structures from beginning to 2007 in whole network.

Development of author collaboration structures in *MISQ* articles were divided into three periods, being consistent with that described in section 4.1; first period extended 9 years from 1977 to 1985 covering three phases. In the first phase, APL (Average Route Length) in author collaboration network was far lower than structural value in random network, showing that the number of author collaboration is small (refer to Table 4) and the collaboration link is limited by small fragmented clusters detached to each other with few core authors connected with different collaboration clusters, thus it is different from ordinary small-world. In Figure 3, author collaboration structural graph in 1985 showed that collaboration was possibly based on original author relationship network, may appear at beginning of specific discipline or field development. Second period is next 9 years and collaboration structure was cumulative from 1977 to 1988, from 1988 to1991 and from 1991 to 1994, matching the increase of collaboration ratio in Table 4 in section 4.1. CC and APL values in network structures showed significant rise, indicating that except the number of collaboration authors and the ratio of collaboration network increase, the scope of collaboration clusters appears wide extension. In Figure 4, author collaboration structural graph in 1994 showed that numerous medium and small-scale collaboration networks were produced in network structures and one large-scale core collaboration network forms. Structures in this period demonstrated relationship of research authors starts diversified. Third period referred to the last four phases, with collaboration structures cumulated starting from 1995 and ending in 2007. In this period, compared with last period, CC value in network collaboration structure rose slightly. After 1997, network structures inclined to robust growth. In 1997, APL was close to that of randomized network and equals to CC, showing steady and non-significant changes. Therefore, in each phase of this period, though a large amount of new authors constantly participated in collaboration, its affect on APL and CC is small. Community network researched subsequently strengthened and grew up constantly under original network structures. In Figure 5, it is seen from author collaboration structural graph in 2007 that the large-scale collaboration network forming through accumulation was composed of numerous small and medium cluster networks that are linked by several author points. Collaboration structure in this period was conforming to judgment criteria of Small-World network structures (CC value in network structure is significantly higher than that of random structure whereas APL is larger or closer to that of random structure.) The formation of small-world phenomenon may symbolize gradual cohesion of different domains in concerned discipline.

4.3.2 Power law distribution structure analysis

This study demonstrated graphic distribution by mapping out the relationship

Table 6 Small-World Indices of Authors in MISQ Journal

Year Range		1977-1979	1977-1982	1977-1985	1977-1988	1977-1991	1977-1994	1977-1997	1977-2000	1977-2003	1977-2007
Cumulated Authors		73	140	231	356	483	590	670	751	817	1012
Ratio of Authors increased		-	91%	65%	54%	36%	22%	14%	12%	9%	24%
Cluster Coefficient	MISQ Author Network	.237	.160	.222	.267	.341	.368	.384	.393	.398	.419
	Random Author Network	.0000	.0000	.0000	.0000	.0029	.0011	.0000	.0005	.0000	.0004
Avg. Path Length	MISQ Author Network	1.167	1.420	1.502	2.065	2.988	4.047	7.701	7.833	7.074	7.144
	Random Author Network	5.431	4.962	11.665	9.562	10.819	8.932	9.062	8.308	8.023	8.146

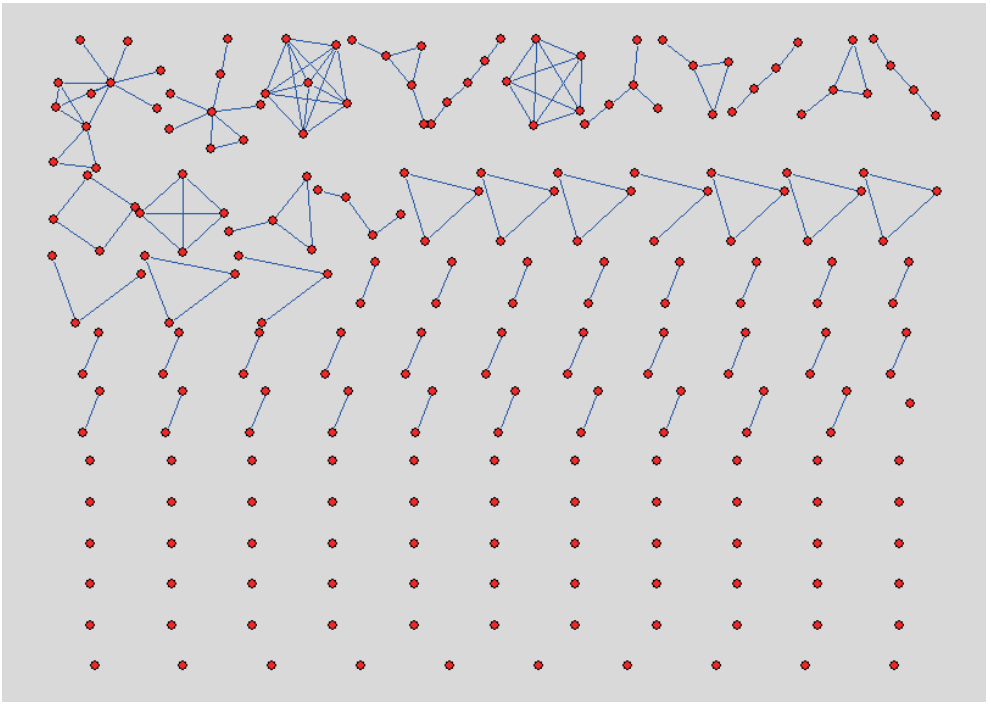

Figure 3 1977-1985 Cumulated Co-Author Network Structure of *MISQ* Journal

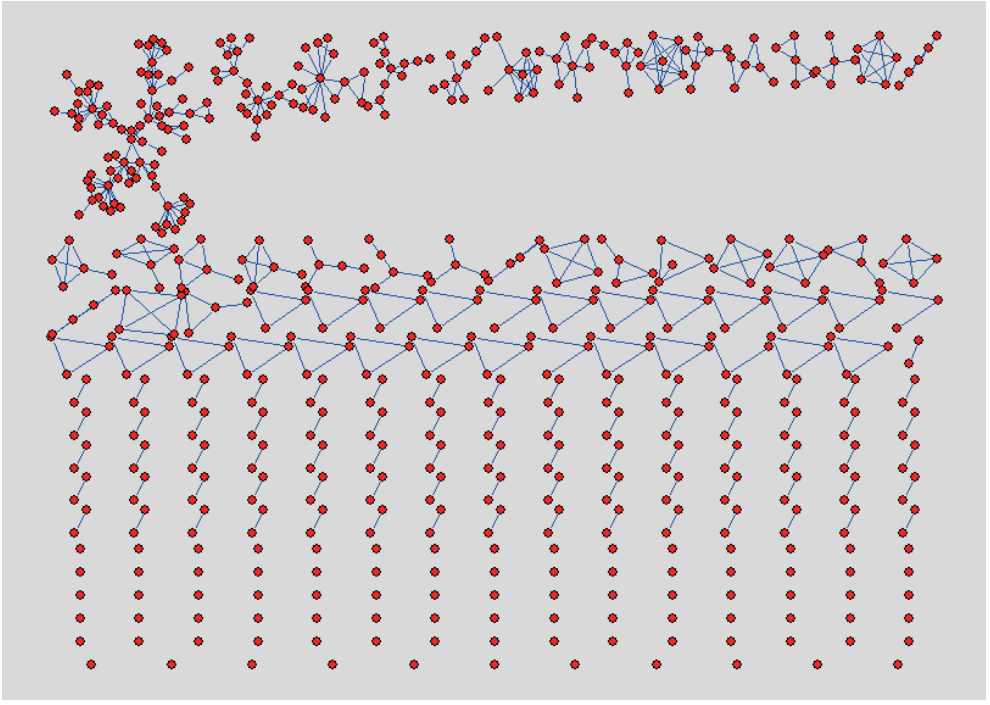

Figure 4 1977-1994 Cumulated Co-Author Network Structure of *MISQ* Journal

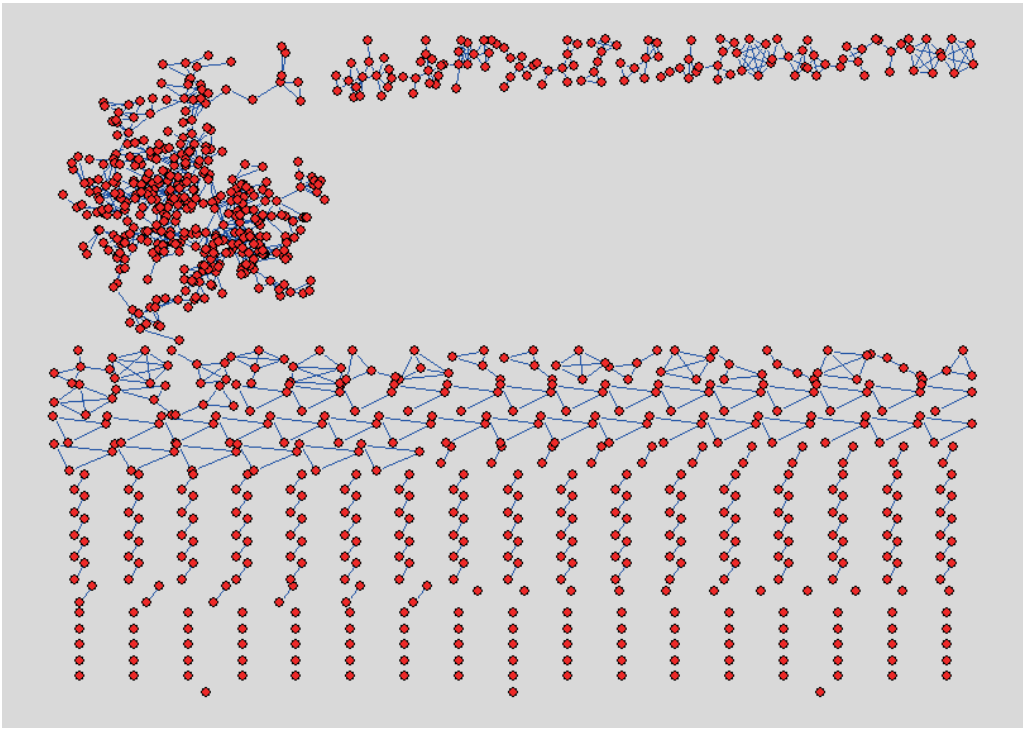

Figure 5 1977-2007 Cumulated Co-Author Network Structure of *MISQ* Journal

between author collaboration quantity and author collaboration ratio, after log-log conversion, verified whether the distribution conforms to linear distribution by adopting regression analysis, and checked whether collaboration research distribution in each phase fits power law distribution or not. That is to say, small-world network structure in *MISQ* authors was formed depending on whether the links of preferential attachment mode to start authors exist or not.

Distribution of *MISQ* author collaboration link networks in reality was seen in Figure 6, where horizontal axis represented the number of collaboration link authors, called the degree in network analysis, and vertical axis referred to the number of authors owning such degree. Because the degree of authors without collaboration is 0, when verifying power law, it needed to conduct log conversion for avoiding mathematical problem. Therefore, all degrees were added with 1 to avoid errors of log conversion. The coordinate used degree+1 to show displacement. Data were demonstrated in the same manner used in small-world network: draw a cumulative distribution map in every three years until 2007, 10 phases in total. Figure 6 showed ten phases developed over time and gradually inclined to curve map of power law distribution. Seen from graphic changes, the inclination to power law distribution was significant after 1985, that is to say, with time accumulation, more and more core link points were produced in networks and these

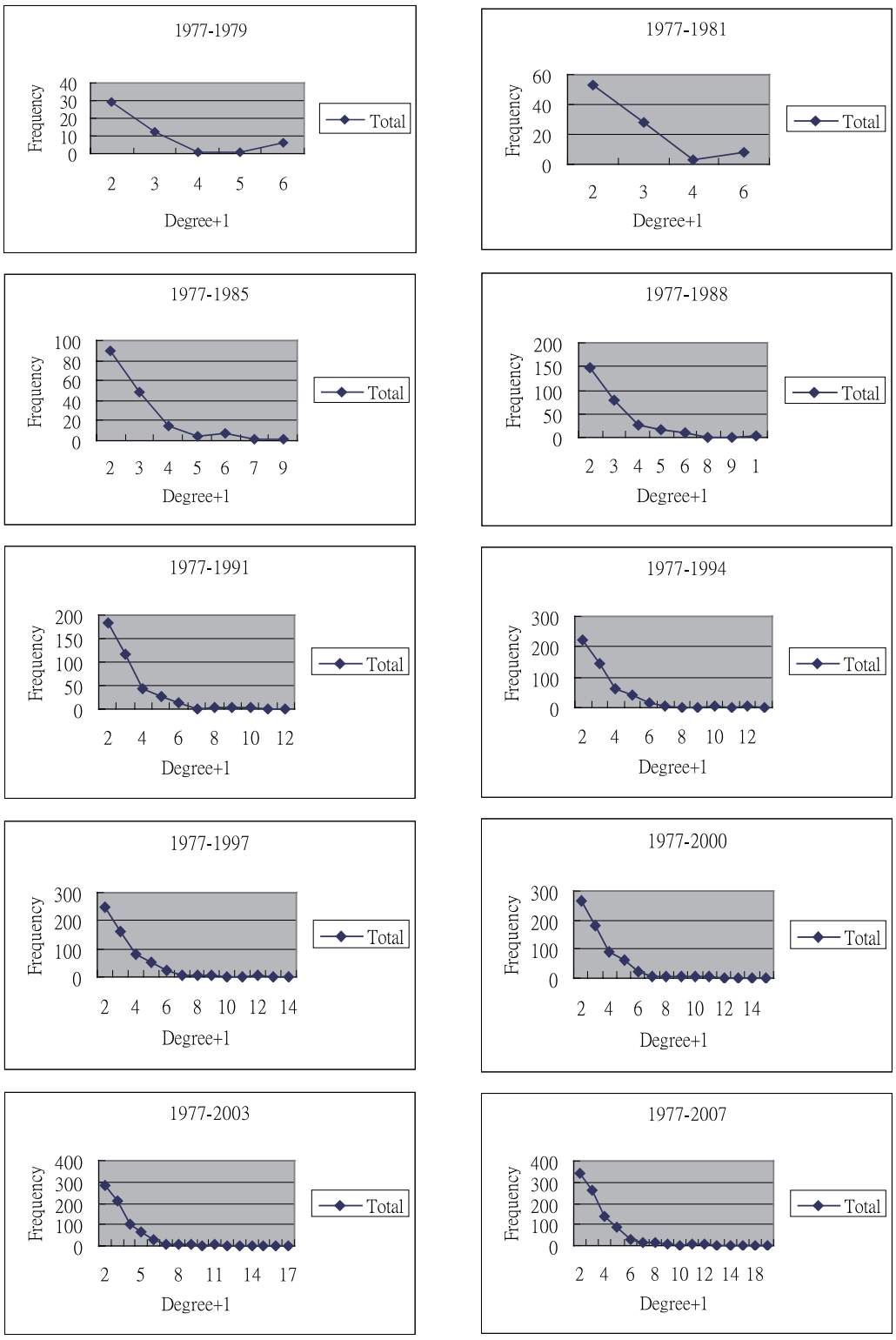

Figure 6 Co-Author Distribution of *MISQ* Journal

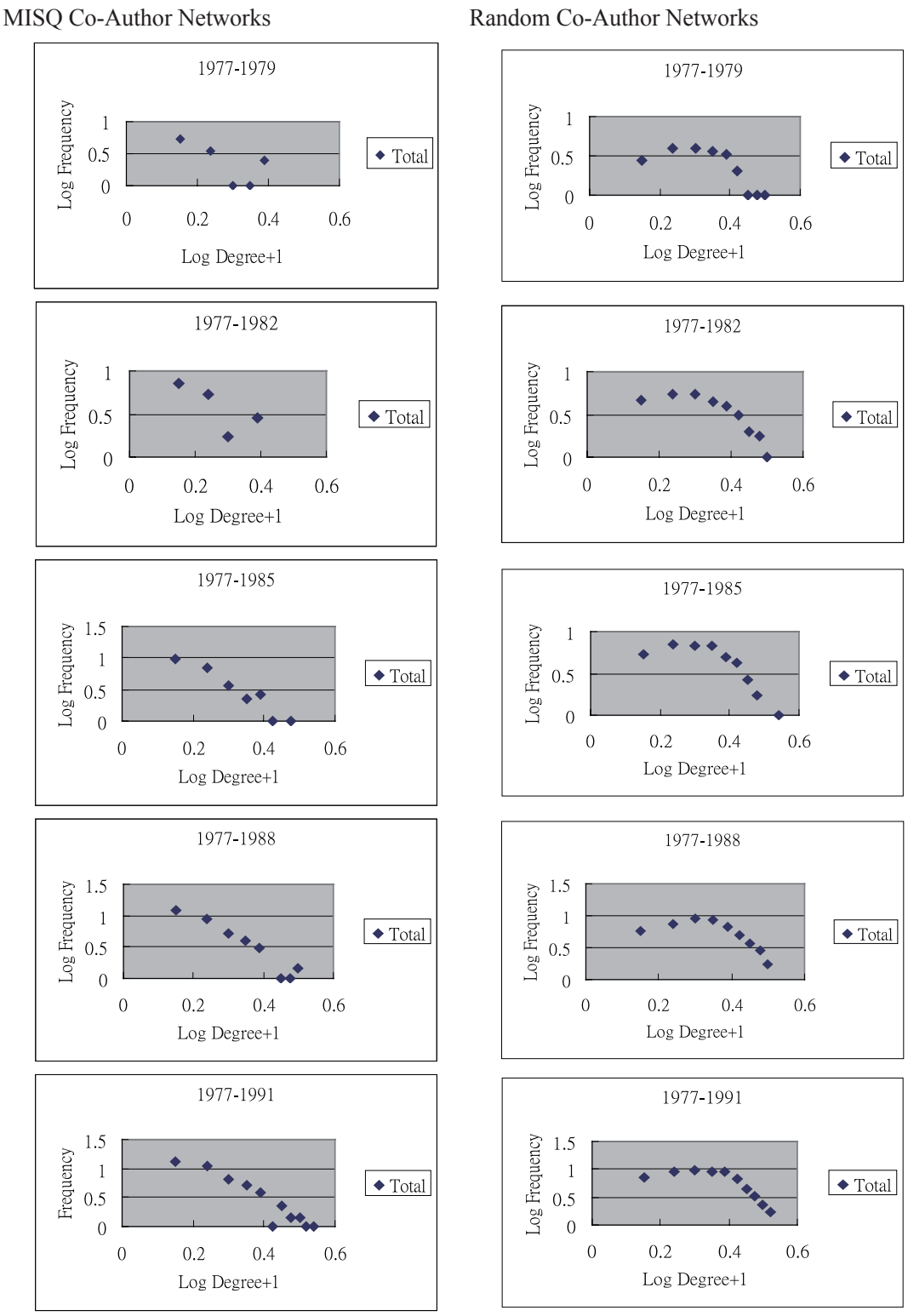

Figure 7 Log-Log (Frequency vs. Degree) Scale of *MISQ* Co-Author Distribution

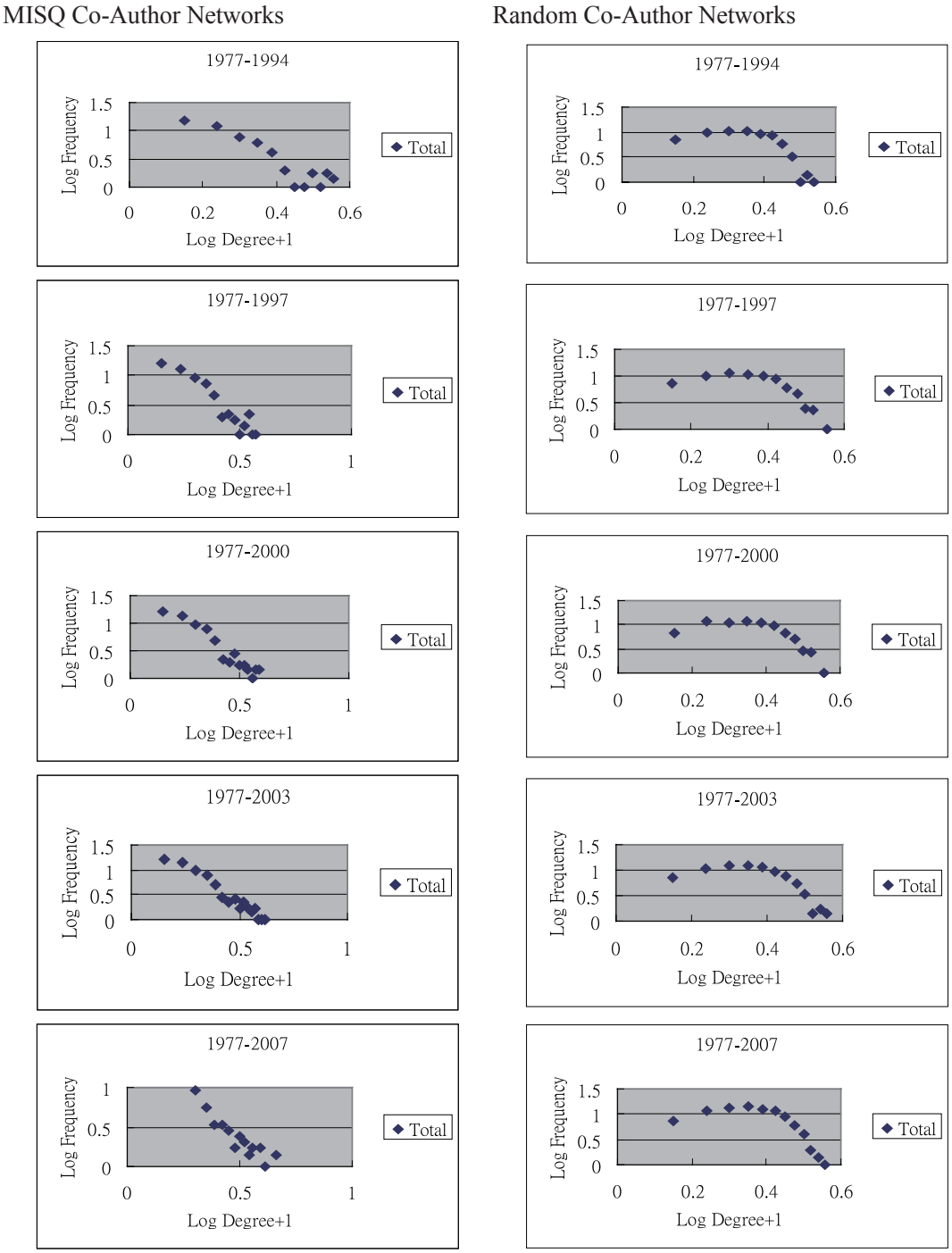

Figure 7 Log-Log (Frequency vs. Degree) Scale of *MISQ* Co-Author Distribution (conti.)

points referred to start authors. Because star authors highly connecting with each other was essential for whole structures of research network, these authors played un-ignorant influence on the development direction of whole research field.

In Figure 7, it drawn and compared log-log size distribution map between actual author collaboration link network and randomized network. Randomized network produced convex curve distribution, far from conforming to linear distribution. In actual author collation network, in second phase at the beginning, from 1977-1979 and from 1979-1982, linear regression verification was of no significance, however, when being cumulative, after 1985 significance of linear regression conformity was 0.001, and maintained 0.000 from 1998 to 2007, and finally in 2007 power formula was seen as follows:

$$\text{Log}(P(k)) = -2.1661\text{Log}(k) + 1.444 \quad (7)$$

Distribution index is -2.166, showing that the concentration of representing power law distribution can be used as comparison benchmark in power law distribution for other journals or disciplines in future. Linear regression in randomized network always didn't reach acceptable significant level.

Known from the above data collected, at the beginning of development, this research field naturally produced preferential attachment network structure. After accumulation for 9 years in *MISQ*, star author network that fits power law was formed, and continued in subsequent development of collaboration research network.

5. Conclusion and discussion

5.1 Contributions

After discussing changes of collaboration structures in scholar community within 31 years, though there is a gap between MIS and other disciplines with long history in terms of collaboration research ratio, the community collaboration development, knowledge diffusion and field development in MIS were constantly moving forward. Through further analysis, this study discovered that the ratio of author collaboration research in MIS communities is increasing, whereas publication of single author significantly dropt down. Collaboration in this concerned research communities were dominant by two authors, but collaboration research by multiple authors was increasing, slower than collaboration research by two authors. Furthermore, analysis results of data demonstrated the development status of networks in whole research communities, showing an inclination attaching to star scholars preferential network development mode. This result appeared more apparently in research distribution in recent decade. Due to an obvious increase of

authors with high productivity, the structure in whole network kept developing in power law distribution form.

Through further analysis on each sub-domain adopting author collaboration development trends produced, this study found that reference disciplines in information management research field converts from information theory and artificial intelligence system and technology at initial period into science application and behavior influence based on decision science and behavior theory in recent days; more attention should be paid to development of relevant theories in more complex environment, e.g. politics, sociology and ecology. In relation to the application trends of reference theories into studying classification on different theme objects in concerned field, this study was based on different development trends and frequency published in articles, analyzed key points in each research theme: In theme of information management classification, system evaluation, system program plan were taken as key issues in past research, applied into system development and application system. Regarding technical modes subjects applied into system development, because relevant system development methods and methodology were gradually matured, many issues tend to decrease year by year. However, due to the popularity of information system application and its influence as well as the significance of information system management and information system in organization influence, concerned subjects were developing. Application system development theme gradually changed from functional system into whole industrial system. Seen in this study, other subjects, e.g. computer application, outer environment influence, computer science technology, organizational environment, information research and education, were developing slowly. Results in this research showed some fields with author collaboration research rising include: issues relevant to social environment, organizational change and impact and information management research. Because information application deeply permeated into all aspects of society, its research also expanded complex issues focusing on completeness, sociology and strategies.

Holistically speaking, there is a consistent and apparent trends in reference discipline or development of each theme that research direction in whole shifts from technical, special issue with single and special function into those combining complexity, width, integrity and integration together. Information management research had already spanned issues related to sociology, politics and ecology emphasizing integrity and complexity. Through 30 years' accumulation, information management had evolved into one of formal subject matter fields that can't be neglected.

Through investigating changes of author collaboration structures in each phase, this study found that a small-world collaboration study mode that is highly and regionally clustered exists in collaboration network in research community by using cluster coefficient and average path distance as measurement indices in small-world. After 1997, small-world network cohesion structure tended to be stable, though new members enter into, they are incapable of impacting this structure and only developed gradually within scope of network in this structure (average route length). Further verification on power law distribution indicated that clustering characteristics of collaboration research structures had being intensifying preferential attachment mode in power law distribution since 1985 and until now. That is to say, entry of subsequent authors was under existing network structure in this most prestigious journal in information management research, and maintains close cohesive relationship. In opinions of some literatures (Merton, 1968; Crane, 1972; Cole and Cole, 1973; Zuckerman, 1977; Allison et al., 1982), this structure may be affected by research expenditure, resource preference, specialty of academic institution and knowledge cluster. Other social relationship network other than collaboration network like education degree and teaching should be further investigated.

Research on authors and issues in information management articles can assist in understanding achievements and basis established previously in this field and possible development direction in future; therefore, since 1982, every several years, scholars were contributing to provision of organized results and suggestions. However, a majority of research concerning this field seldom applies community structure changes and knowledge diffusion into analysis from the perspective of knowledge community. This study provided a new angle to explain the issue by social network analysis, moreover, in combination with changes of knowledge community structures, to provide possible trends changes, in the hope of providing useful references in terms of collaboration research in each MIS domain in future.

5.2 Future development

This study attempted to analyze research development in information management field by using social network analysis and theoretical basis from the perspective of knowledge cluster in collaboration research. After analyzing authors and keywords in most prestigious *MIS Quarterly*, it can preliminary observe structural depth and outstanding achievements that never touched before. Therefore, research concerning information management can develop toward two directions: (1) Increase data collection and expand scope of knowledge community coverage to other key journals. On the one hand, it helped to understand structural changes of communities and development of knowledge field in specific field more completely; on the other hand, it also benefits similar comparison with research communities in domestic; (2) Conduct profound

discussion, increase reference data for collaboration community and structures in knowledge field, which doesn't only describe mode and development process of specific knowledge field, enhances depth of historical cognition, and also provides reference for collaboration modes and field fusion when new fields are developed and combined in future.

Other issues extending from this research, e.g. further understanding and explanation of reasons of collaboration network forming that fits power law distribution and its influence on MIS research field, changes and development of original structures in collaboration research communities after research field transfers, were capable of revealing more profound knowledge drawing on the concepts and codes in this study. Except providing reference for information management research communities, this study could compare with development of other disciplines and demonstrate differences between one newly integrative discipline with traditional foundational disciplines in terms of exemplars.

5.3 Research limitation

Due to limitations on time and resources, this study only conducted analysis by taking *MIS Quarterly* as example. As the most prestigious journal in information management field and may affect the results of community structure development, this journal's inference on effectiveness of whole research community is in need of further analysis and comparison.

Because *MISQ* keyword classification comparison list used in data classification is the last version in 1993, some keywords in new issues were only classified into the nearest sub-domain without changing original code structures; if this code structure was properly upgraded, the development and exploration of new sub-domain could be more clearly identified. In keyword classification, inter-rater reliability is only 0.52, meaning moderate agreement, it may be caused by different individual understandings on keywords arising from different background and intensive collaboration with other different disciplines in later period within 30 years. Agreement degree could be improved by adding experts of sub-domains in subsequent research.

Moody (2004) also proposed the third structural index (structure cohesion) when discussing structure of sociology research articles, to measure the robustness of network structure together with cohesive blocking issued by Moody and White (2003). Compared with the shortages that power structure may appear hub and make network collapsed, cohesive blocking could find nodes embedded in multiple block networks, so as to find the number of nodes accepted by network if attack appears, also represent the balance of network structure. This method should assist in cores of level 2 and even level 3 structures

in existing sample structures, and further help us understand secondary structures of development for concerned study. However, because this index in structure calculation had recursive nature, if nodes of network were above 250 (in second phase), convergent results of this index could be not obtained. Therefore, the inability in verification and exploration of close stability of structures occurs in this study, which needs extension in subsequent study.

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MIS Review Vol. 16, No. 1, September (2010), pp. 127-154

Using Multiagent Based on Fuzzy Reasoning Approach to Solve Project Team Work Allocation Problems

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ABSTRACT: *When a new project starts, the right selection of people integrates into a work team in order to carry on the project is of very importance. The success of a project is greatly due to the personal responsibility of each team member, and to an adequate communication, collaboration and co-operation among the team members. Nowadays, the project team formation process is typically performed by a manager based on past experience and available information (though frequently uncertain and dynamic) about the cognitive characteristics of the potential team members. The dynamic and continuously changing nature of construction project team justifies the need for decision support tools with high adaptability and handling of uncertainty which is featured by multi-agent techniques for human resource allocation. An Agent-based Project Management System (AbPMS) is proposed to simulate the interaction of a team member with other team members and with the tasks of a project. Meanwhile, the system is based on the software (Belief, Desire, Intention [BDI]) agents which are used for modeling social human behavior at work, where human characteristics are represented by a set of fuzzy values, model the interaction between the agents to generate the possible performance of a work team are modeled by fuzzy rules. This paper presents the project team agents and techniques in AbPMS and discusses a sample case applying these techniques for the project allocation initialization and human resource management in the urgent state. We use AbPMS platform to perform scenarios of stimulus/response agents in order to solve specific problems, such as project durations, task quality and adaptive allocation emergency response.*

KEYWORDS: *Multiagent systems, BDI, Fuzzy, Project Management.*

1. Introduction

1.1 Research motives

Any project is in need of participation by members within a group and successfully executing jobs to finish one project is of very importance. Making a well-organized team is no easy, because many factors need consideration and evaluation. Factors that are necessarily considered during project running are given as follows:

1. Personal characteristics: Knowing about professional degree and education experience of each person is essential. These characteristics define the patterns of jobs this person is qualified for. Selecting person having relevant experience to finish time-pressing jobs need to consider personal characteristics from objective and subjective views. Thus, how to choose suitable person to join in project team is virtually a key for execution proficiency of project.
2. Social characteristics: Communication and coordination among group members are valued highly concerning whether project team runs smoothly or not, thus social characteristics among team members is one important indicator for selecting staff.
3. Duration and task quality: Project leader often wishes his working team can finish project by using pre-planned schedule. Generally speaking, difficulty and easiness of task executed by each member combines with resources, leading to a possibility that duration is often advanced or delayed. Due to influence of its relation with task quality, selection of project in middle phase is also an important and influential factor.

Thus, before starting project plan, selection of staff and even dispatch and allocation of staff during plan execution are important issues for human resource allocation in project management. Effective integration and utilization of various resources inside company comes to a key determining success and failure of project; additionally, human resource takes priority over all other essential resources. Human resource management is divided into four parts: selection, utilization, cultivation and retention, interrelated with each other. As a new product project launches and forms, project host (manager) pays deliberate attention to selection and utilization of talents. At the start of project, professional talents will join into the project, thus allocating them into tasks which they are most suitable and push project forward smoothly becomes the most important issue. In addition, it must allow for monitoring progress of project at any time in order to solve problems at the first time upon occurrence of emergencies or progress lagging.

In Figure 1, initial allocation of project management is the most important issue in undertaking any project. During project running, the problem of emergent allocation often takes place (Belout and Gauvreau, 2004), thus this study conducts deeper discussion and empirical analysis on two important issues described below:

1. Human resource problem in initial allocation of project management: In order to make project run smoothly during project management, human resource must be configured properly in its initial allocation, otherwise, it affects duration and task quality of project execution.

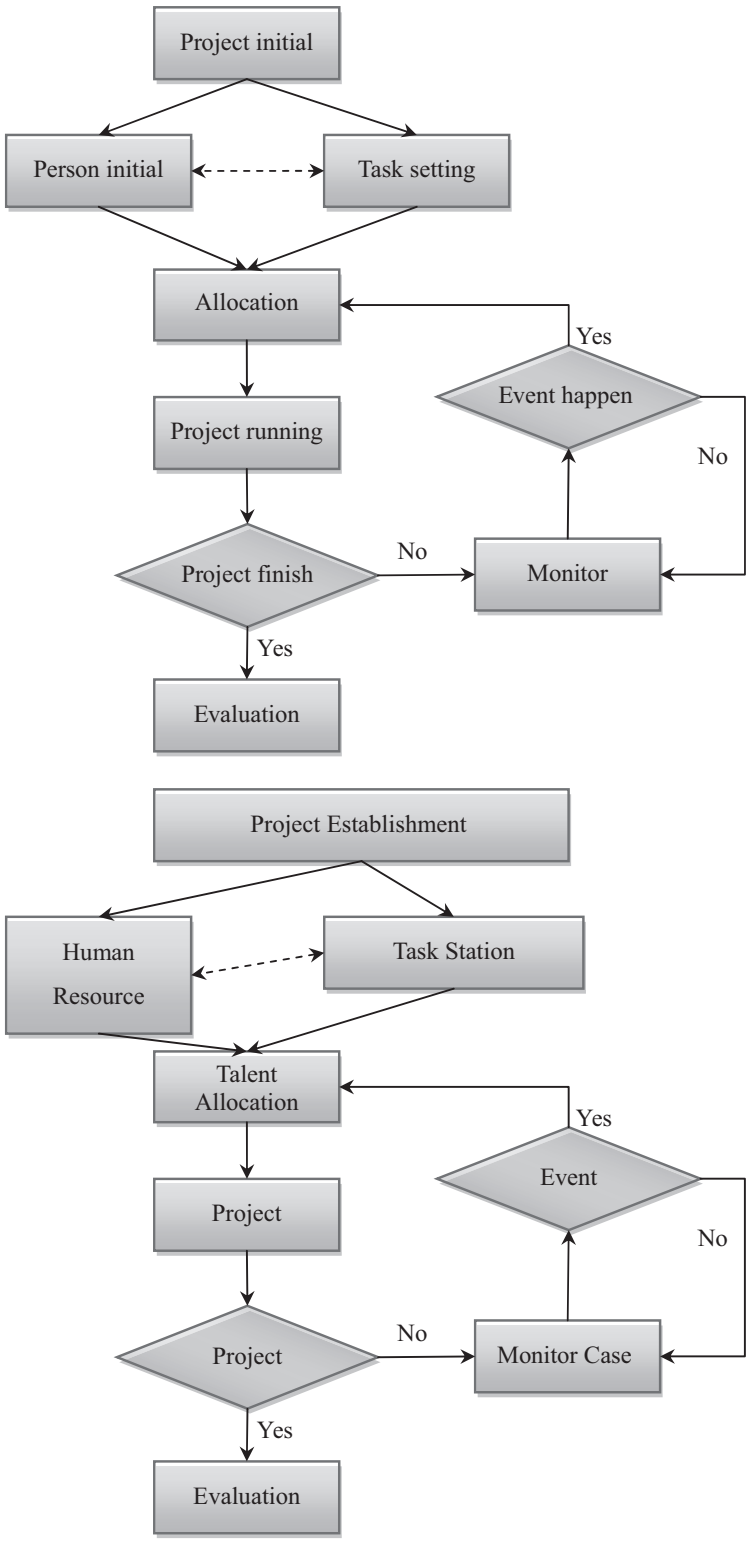

Figure 1 Project Flow Chart

2. Urgent human allocation problem: This essay proposes one function of monitoring project with the aim of monitoring various changes in execution environment at any time and taking responsive actions. Thus, it is supposed that as project management is under way, if sudden event happens to one executor, the task must stop execution. At this time, monitor project will start and select appropriate substitutes who continue executing subsequent tasks.

1.2 Research purpose

In recent years, multiagent system (MAS; Iglesias et al., 1998) helps completion of many complex and routine jobs. To simplify its repeatability, multiagent system doesn't truly represent unique behavior properties of individual decision members but also has its own behavior decision mode, thus it is very suitable to treat human resource allocation problem in project management, handles with many complex and routine jobs, leading to talents problem in human resource of project management are properly configured and solved instead of always considering allocation optimization as the only factor. Much emphasis is paid to agent who owns his unique characteristics and speciality and develops his autonomy to undertake project management. Agent roles established in multiagent system include:

1. Project manager agent: Such agent role must have the capability of managing project and fully understanding and mastering tasks.
2. Engineer agent: Such agent role has expertise and knowledge in particular task.
3. Technician agent: Such agent role has professional knowledge about task in certain field.
4. Assistant agent: Such agent role is good at handling with routine affairs in tasks.

Because agents can't handle with project during project management alone and must interact with each task station (T_i, i = 1, 2,……, n), with respect to description of task station, its definition will be given in combination with agent parameters. T1 parameters include: number of participating people, duration, difficulty and easiness, task pattern and task quality. Agents of all kinds will join in the calculus of properties of task station, configuring each agent to task station properly to execute tasks. Allocation of talent selection is a process that involves autonomous coordination and communication from multiple aspects, with the purpose of realizing suitability of human resource allocation in project management. The purposes of this study are described as follows: (1) regarding talent utilization, an agent-based project management system will be designed by using individual behavior model of agents and timeliness and role analysis and interactive model in GAIA methodology (Wooldridge, Jennings and Kinny, 2000). (2) Agents are introduced into BDI model, and established with their BDI models according to fuzzy

integration of social characteristics, emotion attribution and task characteristics of member roles in project, and configured to determine its duration and quality in project task by means of fuzzy allocation system (FAS).

2. Literature review

2.1 BDI agent theory

2.1.1 Introduction of BDI agent

Philosopher Michael Bratman firstly proposes BDI theory on the basis of actual reasoning inference process of human beings in 1987 (Bratman, 1987). This model describes logically three mental properties and their relations with each other including belief, desire and intention (shortly named as BDI hereunder) based on philosophy and logic theory.

BDI framework is an empirical inference framework that means inference process is similar to decision process in daily lives. The concepts of this framework are seen in Figure 2 and detailed as follows:

1. Belief of revision function: This function is in charge of sensing input from outer cycle and current belief of agents, in this case, produces and integrates new belief in belief database to indicate information sensed by agents under current environment.
2. Option of generation function: This function is used to decide whether agents make proper judgment. The choice judgment is decided by current belief and intention.
3. Filter function: This function represents the deliberation process agent goes through, determines intention of agent and represents what is currently highlighted by agent. It is also the goal that agent tries to realize and finish.
4. Action of selection function: This function is used to decide which action is taken to achieve goal with current intention.

2.1.2 BDI agent framework -- Procedural reasoning system (PRS)

There are two famous frameworks in BDI framework -- IRMA (Intelligent Resource-Bounded Machine Architecture) and PRS. IRMA is mainly proposed by Bratman, Israel and Pollack, including four abstract data structures: plan library, beliefs, desires and intentions. Also, reasoner, means-ends analyzer, opportunity analyzer, filtering process and deliberation process are also used to construct IRMA.

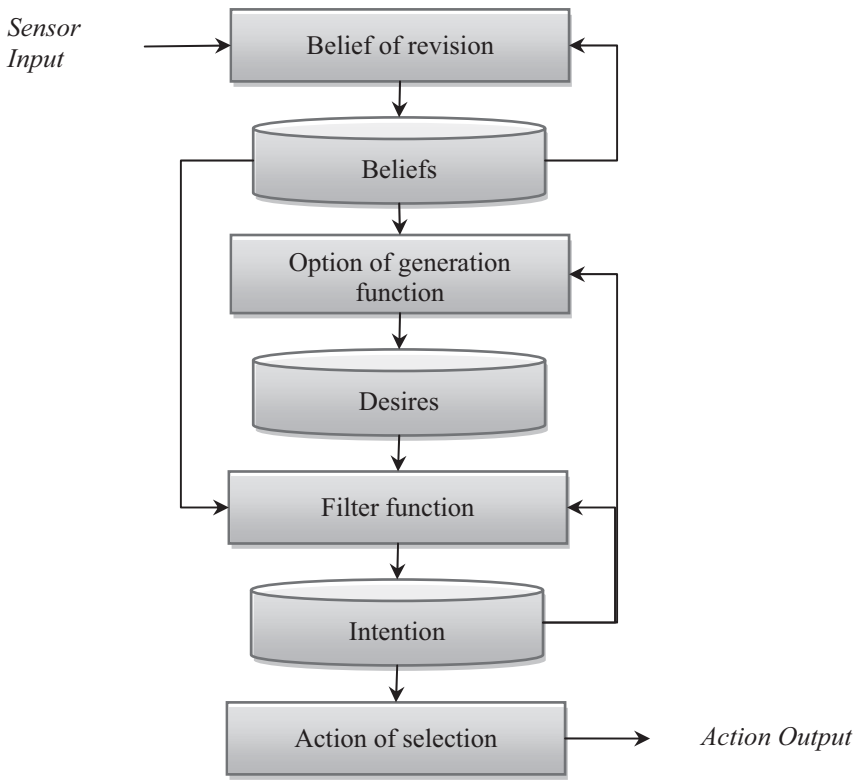

Figure 2 BDI Framework Chart (Wooldridge and Jennings, 1995)

PRS is an agent framework created by practicing BDI agent theory by scholars Georgeff and Lansky (1987), its framework seen in Figure 3. It includes database, knowledge library, goals and intention structure and interpreter. Description is given as follows:

1. Database: It represents information owned by one agent in the world he lives in. It provides agent with beliefs related to current status of the area agent stays.
2. Goals: It arises from environment stimulus or self-monitoring after agent understands demands by him and stipulates goals.
3. Knowledge library: Once the agent stipulates goals, the goal will be developed into the plan of realizing such goals that are expressed by rule forms and produce intention action by linking with database.
4. Intention structure: It represents the request of agent who promises to finish. The task accepted by agent upon his decision is intention of agent, including goal, motivation and evaluation.

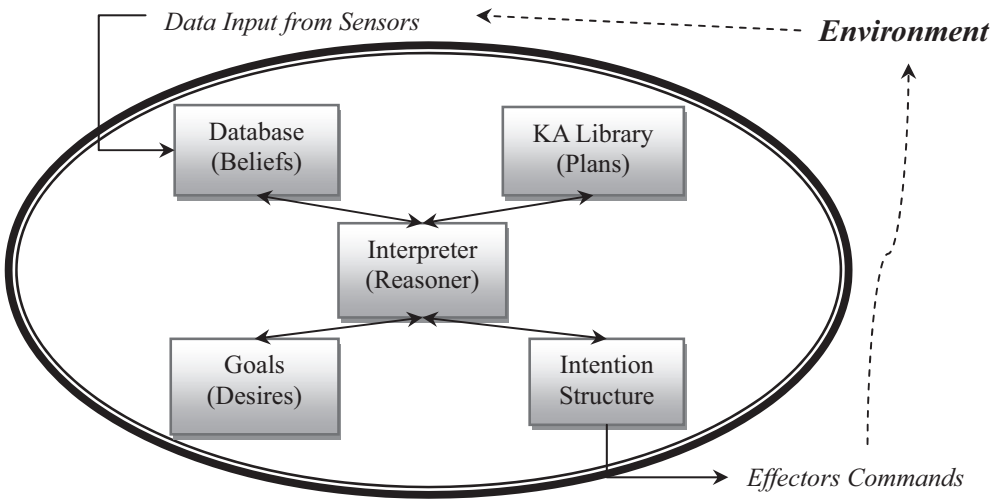

Figure 3 PRS of agent framework chart (Georgeff and Lansky, 1987)

5. Interpreter: As an important factor in BDI agent, interpreter is used to correct beliefs by environmental observation, produce new desires based on new beliefs to choose an acceptable plan, and then forms intention in combination with selected plans and goals. After continually periodical running and environment interaction, finally, the goal is realized.

2.1.3 Realization of BDI agent

In 1995, scholars Rao and Georgeff take the initiative to apply this BDI framework into intelligent agent field. Later on, BDI develops into one of models widely used for reasoning agent. Realization model Map of BDI agent is seen in Figure 4 (Rao and Georgeff, 1995).

Each execution made by interpreter will decide which each goal or event takes place. Therefore, it will select and add one plan from planned candidate list into intention framework to execute; after intention is executed every time, it will be classified into inner event and change inner information or goal and intention. The whole steps are composed of deliberate calculus mechanism based on PRS framework established at initial period and makes BDI theory evolve into an empirical framework and applied into practice.

2.2 GAIA methodology

Wooldridge, Jennings and Kinny (1999) propose a methodology of agent-based analysis and design in 1999 -- GAIA, that regards construction of agent system as one design process of organization to display system framework by means of multi-layer technology conforming to popularization in terms of maintenance and understandability.

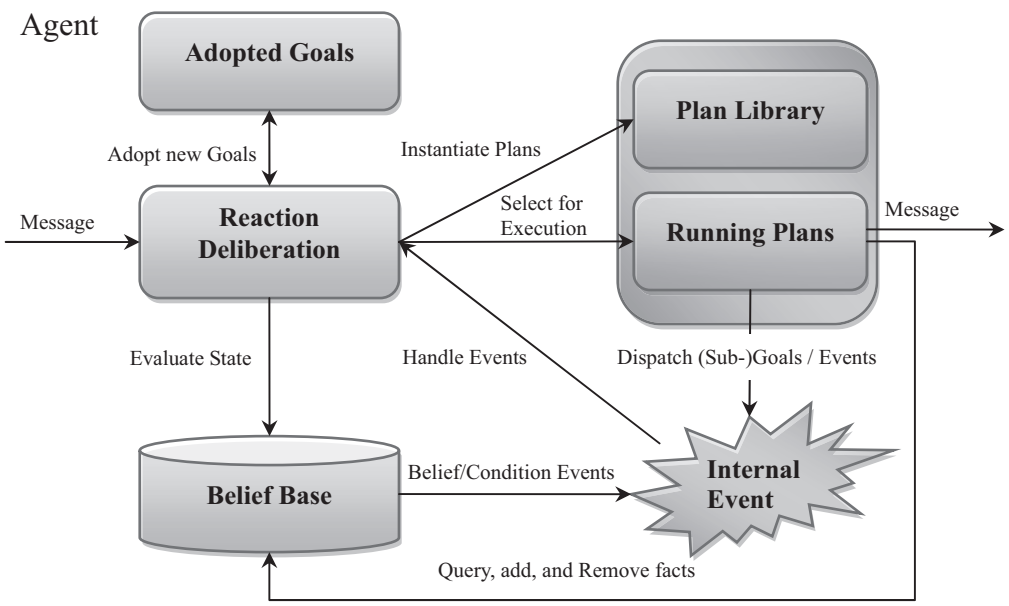

Figure 4 BDI Model Chart (Rao and Georgeff, 1995)

This system model to be analyzed and designed will develop into one framework Map. To develop research framework, this study summarizes model relation map of GAIA methodology into Figure 5. After demands are submitted, what is required by system will be analyzed in role model and interaction model, and relevant role properties are defined as: responsibilities, permissions, activities and protocols. Based on definition and properties of role demands, the object-oriented concept is converted into agent model; service model is defined and designed by protocol, activity and liveness in role model and interactive model; acquaintance model is designed by activity in role model and interactive model.

Concepts to be analyzed and designed are divided into two types: abstract and concrete, seen in Table 1. Abstract entity is to conceptualize the system during analysis without directly involving realization of system; concrete entity is related to running and execution of system during design.

Social model patterns are used into analysis in view of agent-based analysis. In 1999, Wooldridge, Jennings and Kinny refer to roles as functional classification of agents in society, each role having its unique functional property and responsibility. Roles have four properties in concept of agent-based analysis, including responsibility, permissions, activities and protocols. Responsibility property defines the function of the role that must be done. Responsibility has two properties: safety property and liveness property. Safety property is described as "something good happens" meaning a status of thing carried by agent in given environment condition. Liveness property is described as "nothing

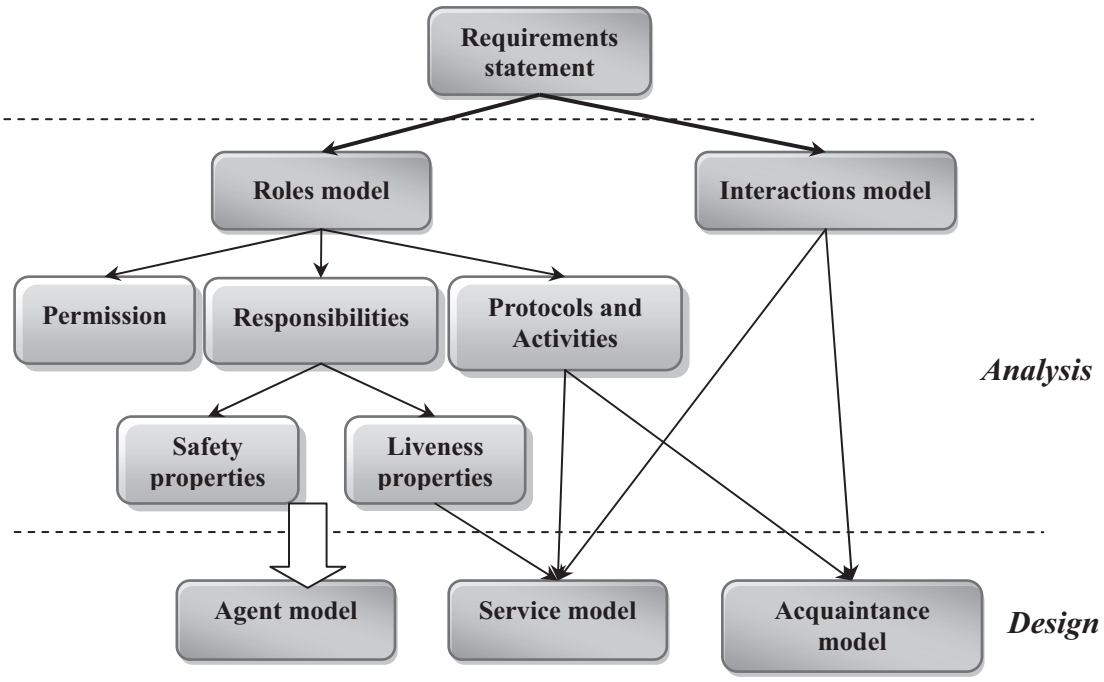

Figure 5 Method Relation Chart

Table 1 Abstract and Concrete Concepts

Abstract concepts	Concrete concepts
Roles	Agent Types
Permissions	Services
Responsibilities	Acquaintances
Protocols	
Activities	
Liveness properties	
Safety properties	

bad happens," meaning a status of acceptable thing is maintained during execution. Permission property is right limit of roles, defines information resources that are stored, corrected or produced by roles. Activity property represents execution force of role itself. Protocol property defines interaction approach among roles.

Role model is composed of a group of role outlines. Each role in system has its role outline. In this outline, role name, role description, protocol and activity property, permission property and responsibility property (incorporating liveness property and safety property) are included. Role models are seen in Figure 6.

Role Schema	Name of Role
Description	short English description of the role
Protocols and Activities	protocols and activities in which the role plays a part
Permissions	"rights" associated with the role
Responsibilities	
Liveness	liveness responsibilities
Safety	safety responsibilities

Figure 6 Role Model

Interactions Model defines interactive relation amid roles and consists of a group of protocols. Interaction for each role is endowed with one protocol. This protocol has the following properties:

1. Purpose: Brief description of the nature of interaction.
2. Initiator: Which role is responsible for initiating interaction.
3. Responder: Role object which interacts with initiator.
4. Inputs: Information applied by initiator when protocol is adopted.
5. Outputs: Information delivered by responder during interaction.
6. Processing: Brief description of the procedures of interaction made by initiator.

Agent-based design program produces three models in view of agent-based design, including agent model, service model and acquaintances model. Agent model confirms agent pattern constituting the system and agent instance of realizing such agent pattern during execution period. Service model confirms major service in each agent pattern, namely, confirms agent function. In view of object-oriented terms, service is similar with method. One object method is called by other objects, whereas agent service is one kind of service uniquely owned and participated in by single agent, not able to be called by other agents. Acquaintances model defines communication and linkage among agents of all kinds. By means of graph indication, this model neither defines message delivered by each communication and linkage nor when such message is delivered, instead, simply indicates communication routes among agents of all kinds.

2.3 Fuzzy allocation system (FAS)

This paper proposes basic framework of FAS consisting of control rule database and fuzzy decision logic, with its basic framework map seen in Figure 7. In principle, design steps of this framework are described as follows:

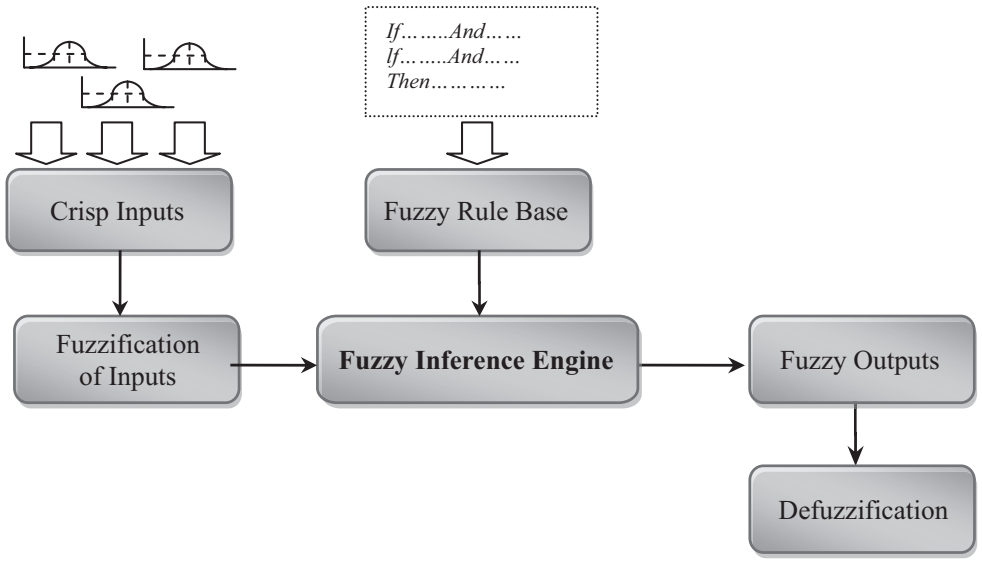

Figure 7 FAS Flow Chart

Agents are introduced into BDI model, and established with their BDI models according to fuzzy integration of social characteristics, emotion attribution and task characteristics of member roles in project, and configured to determine its duration and quality in project task by means of fuzzy allocation system (FAS).

1. Factor input: Firstly, social characteristic, emotion attribution and task property related to agent in BDI model and membership function categories are determined.
2. Fuzzy input: In order to decide universe of discourse for each variable, measurement and operation scope of output and input variables are decided on actual status. And then language presentation matters and corresponding membership function of each variable are arranged.
3. Fuzzy engine and fuzzy rule: enerally, convert it into fuzzy rule base explained by language with experience of operator and expert knowledge. Conditional rules narrating linguistic meanings like If-Then are usually used.

Fuzzy inference engine conducts inference when concepts narrated in judgment sentence are not clear to make composition calculus in fuzzy theory under existing logic rules (Mamdami and Assilina, 1975). Generally use max-min product composition, max-product composition, max-bounded product composition, max-drastic product composition, etc. This essay utilizes Mamdani inference method (namely, max-min composition).

4. Fuzzification output and defuzzification: Defuzzification means to convert duration and task quality in fuzzy output of project task inferred into real crisp values, adopting three methods, e.g. center of gravity, center of maximum and mean of maximum. In this essay, use center of gravity to make defuzzification. Because it is suitable to continual output value, its principle is the same as acquiring center of gravity location of objects, namely, acquiring center value of fuzzy integration to represent the whole fuzzy integration. It is supposed that membership function of fuzzy integration is u_i, when inferred value y_i (refer to duration and task quality) is continual under I rule, center of gravity method is shown in formula(1) as:

$$y'_{COG} = \frac{\int y_i u_i(y_i) dy_i}{\int u_i(y_i) dy_i} \tag{1}$$

3. Agent-based project management system (AbPMS)

This essay studies analysis and design of the core parts in this framework by means of milt-level technique (Nwana and Woddridge, 1996), analyzing roles modules to analyze demands of project management layers for role analysis and defining role characteristics. It further extends to agent module to design communication and interaction of roles and actions in agent-based system (Wood and DeLoach, 2001), and establishes inner actions in agent model by using object modules and add group organization and calculus of fuzzy allocation system to develop agent-based project management system (AbPMS). Finally, it designs exemplars by using UML object-oriented to practice exemplars and simulate results by JAVA language and medium software platform (JadeX, 2007). Figure 8 shows the study framework map in this essay.

3.1 Project management of group organization

This essay advances the allocation principle of applying group organization concept in the human resource allocation, which makes trans-department manpower selection, not depending on the experience or technology, but more widely considering social characteristic and emotion attribution to select the task executor, and reflecting such two characteristics in the system as variables. Group organization will show an interaction between the organization and the group during the process of human resource allocation; at this time, the project management leader will make negotiation and coordination with leaders of different departments, thus to produce an harmonious effect among the project management leader, department leader, and candidate, and improve the system flexibility and feasibility. The group organization concept map is shown as Figure 9. It is supposed

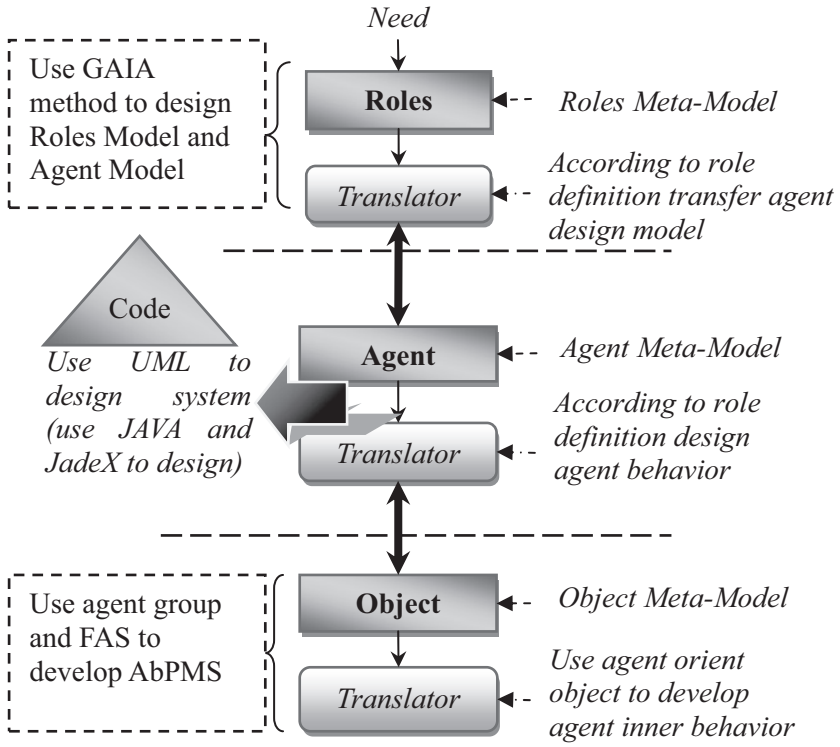

Figure 8 Research Framework Chart

that there are three members in Department_1: PA11, PA12, and PA13 and three members in Department_2: PA21, PA22, and PA23. Based on the group organization concept, use the BDI mode of the candidates to present their autonomy and use FAS to allocate the attributive group; the result shows that they are divided into three groups: Group 1, Group 2, and Group 3. Therefore, the department leader, project management leader, and the candidate will form an interactive relationship involving mutual communication and influence. Through such communication and coordination, there can arrange allocation processes for different requirements.

3.2 Analysis of GAIA methodology

Known from literature review, GAIA method is divided into two parts: analysis and design. Analysis has two phases including role analysis and interaction analysis. They are used in role analysis to define role characteristics and communication and interaction of roles and actions respectively.

As requirements of founded project generate, proposal person (PP) will receive project requirements and analyze resources required by project, including number of task station required, relevant task information, and delivery of talent recruitment message.

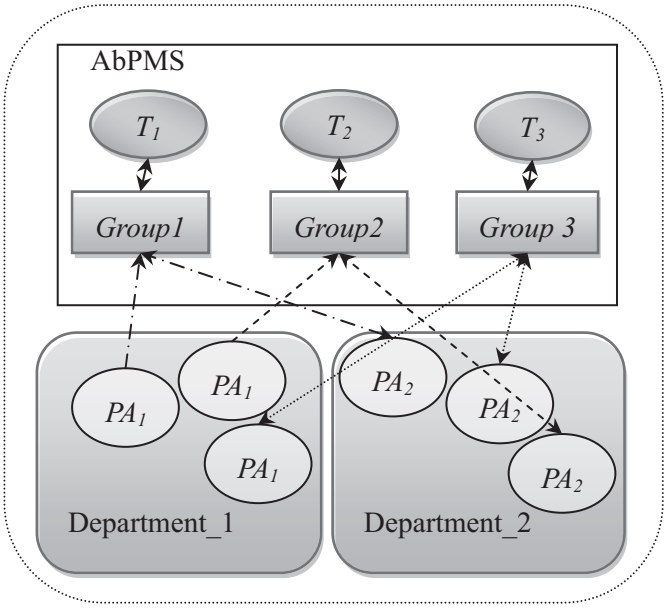

Figure 9 Group Concept Chart

For example: as one project is founded, PP will propose how many task stations should be produced on the basis of project requirements; meanwhile, deliver messages to relevant selected talents and inform them such requirements. Therefore, from above description, it is known that PP has two protocol properties and one activity property: Get Project Requirements is to receive and analyze project requirements; Produce Analysis is to analyze resources required by project; Send Project Requirement Messages is to deliver requirement messages to relevant roles. PP is the only role who has the right of reading required resources and producing talent recruitment messages in permission properties. As to responsibility property, when requirements exist, he will continuously undertake tasks in protocol property and activity properties and deliver requirement messages to other roles. Role model map of proposal person is seen in Figure 10. Furthermore, this essay proposes six role models to construct role analysis process, including task generator (TG), project person (ProP), fuzzy allocation system (FAS), task manager (TM), project leader (PL) and monitor inspector (MI).

In GAIA methodology, interaction analysis narrates protocol property relations among roles. Thus, protocol property during role analysis is considered as important point in interaction analysis. In project management, interaction protocol is divided into four parts: PP gets project requirement notice and generates project requirements, task generator gets project requirement message, task manager gets task details, proposal person gets task target, all of which finish human resource allocation procedures in fuzzy allocation system; as task station manager (TM) gets allocation result delivered

Role Schema: Proposal Person (PP)

Description:
Analysis

Protocols and Activities:
GetProjectRequirements, ProduceAnalysis,
SendProjectRequirementMessages

Permissions:
reads supplied requirements
generates requirementmessages

Responsibilities
Liveness:
Proposal Person=(GetProjectRequirements . GenerateAnalysis)$^{\omega}$
GenerateAnalysis =(ProduceAnaiysis . SendProjectRequirementMessages)$^{+}$
Safety:
Requirements exit.

Figure 10 Proposal Person (PP) Model

by proposal person, three different exemplars will occur (send task executor, send task progress and send negotiation message). Therefore, four protocol exemplars will take place, including human resource allocation protocol process, project monitor protocol process, protocol process negotiated between task manger and proposal person and selection protocol of project leader. Project monitor protocol process is seen as in Figure 11.

3.3 Design of GAIA methodology

In this section, three models in design of GAIA methodology include: agent model, service model and acquaintance model. They are used to design inner action of agent module.

Agent module confirms agent patterns constituting system, agent instance of realizing such agent patterns during execution period, and put such instances into practice into system. Generally speaking, each agent is usually one substantiated role in role analysis, designed and practiced in system. Thus, this essay regards roles with different patterns as agent model to construct one system. List of role converting into agent is seen in Table 2. Figure 12 is agent model.

Service module confirms major service of each agent pattern, namely, function of agent. In view of object-oriented terms, service is similar with method. One object method is called by other objects, whereas agent service is one kind of service uniquely

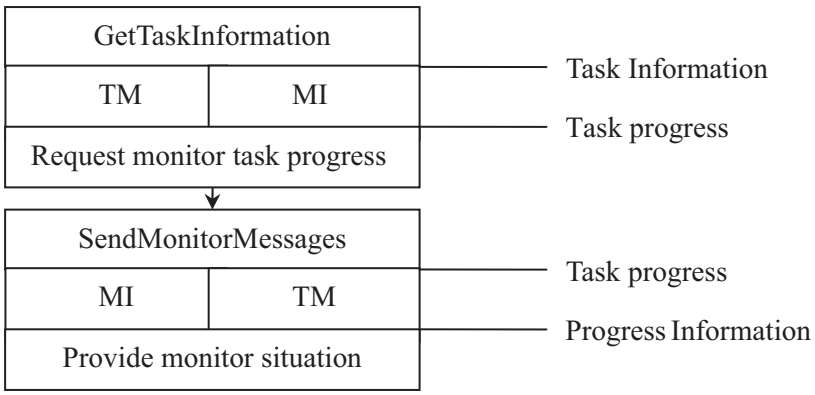

Figure 11 Project Monitor Process

Table 2 Role-Agent Transformation

Role	Agent
Proposal Person (PP)	Proposal Agent (ProA)
Task Generator (TG)	Task Generator Agent (TGA)
Task Manager (TM)	Task (T_i)
Project person (ProP)	Project Agent (PA_j; j = 1, 2,....., m)
Fuzzy Allocation System (FAS)	Fuzzy Allocation System (FAS)
Project Leader (PL)	Project Manager Agent (PMA)
Monitor Inspector (MI)	Graphics Agent (GraA)

owned and participated in by single agent, not able to be called by other agents. In GAIA methodology, service model can get designed module from analyzed activity and liveness of responsibility property in GAIA methodology. Service module consists of inputs, outputs, pre-condition and post-condition. Inputs and outputs can be designed in interaction analysis; pre-condition and post-condition are designed in security property in responsibility property. Service item establishment list of service model is seen in Table 3.

Acquaintances model defines communication and linkage amid various agents. By means of graph indication, this model neither defines message delivered by each communication and linkage nor when such message is delivered, instead, simply indicates communication routes among agents of all kinds. Acquaintance model map is seen in Figure 13.

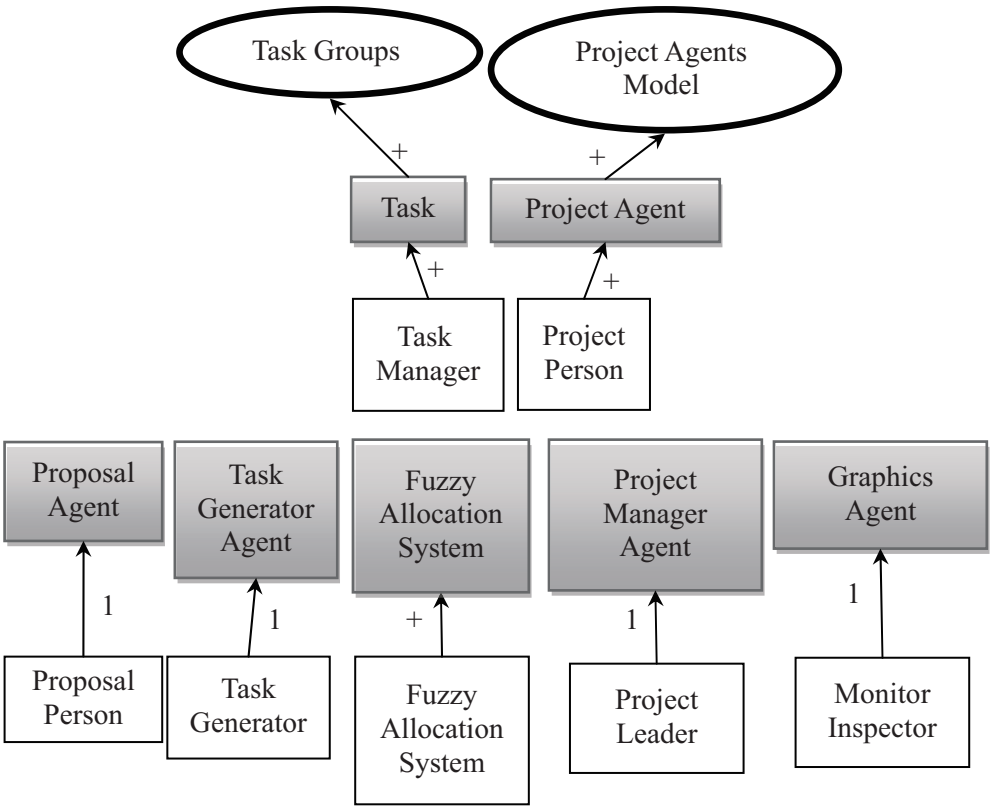

Figure 12 Agent Model

Table 3 Service Model

Service	Inputs	Outputs	Pre-condition	Post-condition
Get Project Requirements	Requirements	Requirements details	True	True
Produce Analysis	Requirements details	Requirement messages	True	True
Produce Tasks	Requirement messages	Task details	True	True
Alter Tasks	Requirement messages	Task details	True	True
Compare Fuzzy Allocation	Fuzzy allocation outputs	Allocation information	True	True
Send Messages	Allocation information	Allocation information messages	True	True
Computer Fuzzy Allocation	Fuzzy allocation inputs	Fuzzy allocation outputs	True	True
Update Task Data	Task details	Task information	True	True
Find Task Executor	Allocation result	Task executor	True	True

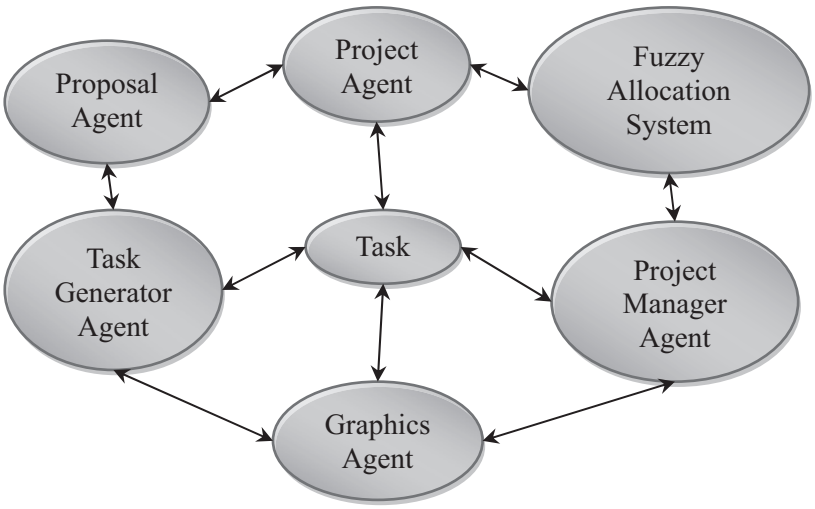

Figure 13 Association Model

After analyzing and designing overall requirements by using GAIA methodology, this essay proposes an agent-based project management system (AbPMS) framework according to relevant analysis to understand what role each agent plays during the whole project management and their tasks. This agent-based project management system framework is seen as Figure 14. Task station is shortly named as T_i (i = 1, 2,……, n); project agent is shortly named as PA_j (j = 1, 2,……, m); i, j, k refers *to* task station, project agent and department number respectively.

3.4 Process of human resource allocation

This essay proposes human resource allocation process involving group organization concept, BDI module of project agent and fuzzy allocation system (FAS). Therefore, project agent will actively configure task station. As requirements generate, project management will initiate structures. ProA in system framework who participate in this process will receive requirements and send proposal to TGA to set up relevant task station, which is called as initiation; as initiation finishes, project agent (PA_j) notified will make inner BDI module calculus, conduct fuzzy inference and calculus on each inner parameter and variable in FAS, interact with task station groups and conduct proper allocation. After allocation, verify whether repeated executor exists during allocation of task station. At this time, each T_i is put into verification. In case repeated executor exists, a new allocation principle will be sent to project agent to conduct partial fuzzy inference calculation and allocation in FAS until task station is configured; finally, *GraA* is in charge of monitoring project and urgent treatment. ProA continues to receive changes of tasks from outside. Human resource allocation process of project agent is seen as Figure 15.

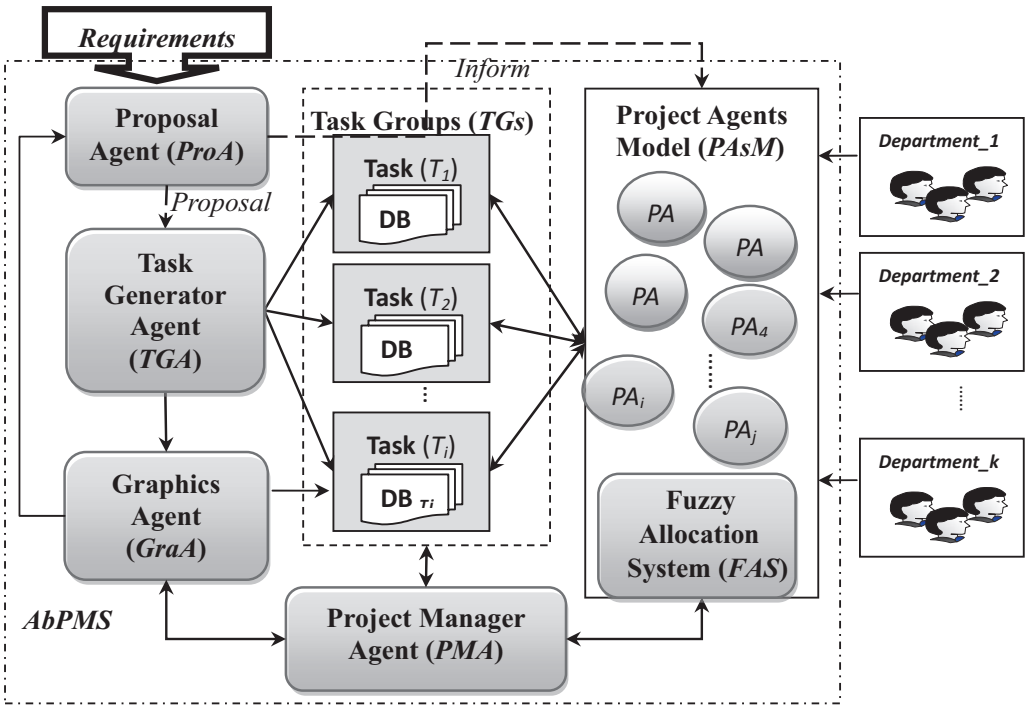

Figure 14 AbPMS

i: Numbers of Task
j: Numbers of project agent
k: Number of departments

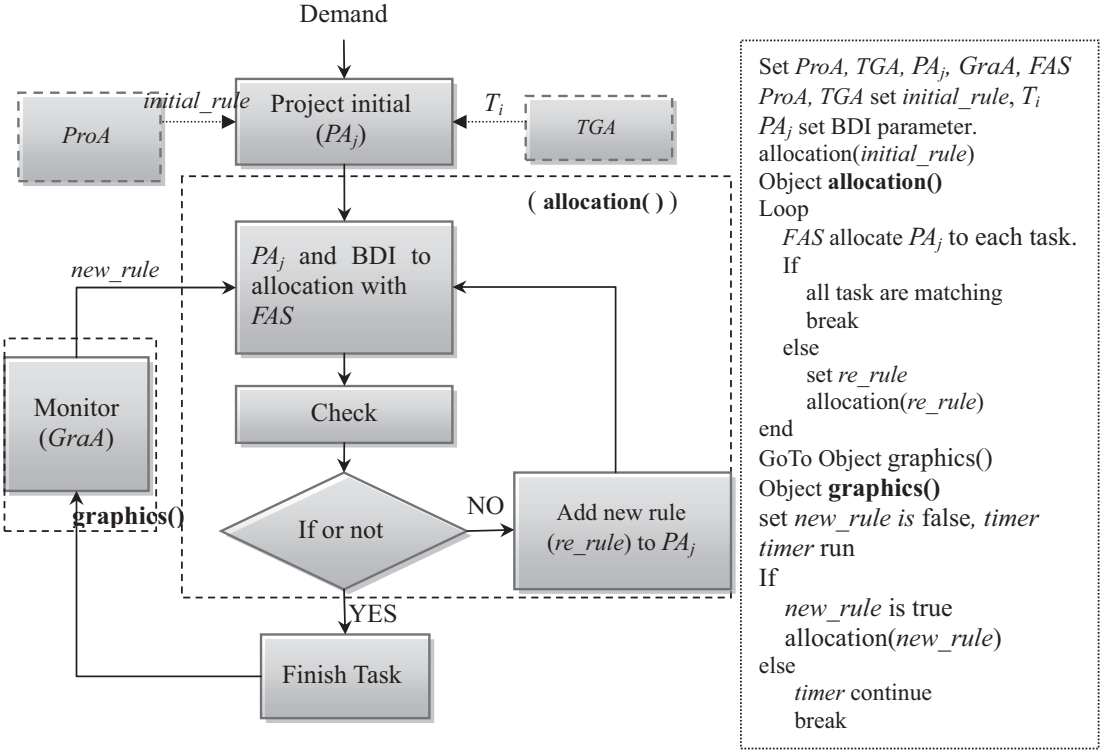

Figure 15 Project Allocation Process

4. Performance of agent-based project management system

This essay puts two questions mentioned in foreword into practice in system, constructs FAS and performs project agent (PA_j) by using project agent model in AbPMS. Use JadeX medium platform, make agent communicate with other agents through ACL message, and construct task groups (TGs) in AbPMS by using GUI interface developed by JAVA. Finally, in simulation tests, two exemplars including human resource allocation and urgent human allocation are supposed to conduct simulation process for validating feasibility and applicability of this system in terms of performance.

4.1 FAS performance

FAS plays an important role in exemplars mentioned by this essay, utilizes fuzzy inference to conduct calculus of different parameters and also combines results with project monitor. Its performance process is described as follows:

4.1.1 Step 1 -- define its variables

This essay makes calculus on variables selected from exemplars. Variables include: *Creativity*, *Experience*, *Desire*, *Interest*, *Stress*, *Difficulty*, *Type*, *duration* and *quality*. Variables are defined by fuzzification. Stress is defined to include three linguistic variables: *Low* (0~25), *Medium* (20~80) and *High* (65~100). *Duration* is defined as five linguistic variables: *Excellent* (-30~-10), *High* (-15~0), *Acceptable* (-5~5), *Regular* (0~15) and *Low* (10~30). *Quality* is defined as five linguistic variables: *Very Low* (0~30), *Low* (25~65), *Minimum* (45~75), *Acceptable* (65~95) and *Satisfactory* (90~100). Other variables are defined as three linguistic variables: *Low* (0~35), *Medium* (25~75) and *High* (65~100).

4.1.2 Step 2 -- decide its fuzzy sets

Each fuzzy sets is presented by each membership function graph. This essay uses Gaussian-type membership function to show membership function of each variable, make each variable value in linguistics overlap and interact with each other and meet the requirements of continual calculus.

4.1.3 Step 3 -- construct fuzzy rules

This essay constructs fuzzy rules for different variables, setting up 180 rules through linguistic matching, and conducts inference. Finally, parameters are acquired in defuzzification. Exemplar rules are described as follows:

RULE: IF (Difficulty IS low) AND (Experience IS low) AND (Interest IS low) AND (Stress IS low) THEN (duration IS regular).

4.1.4 Step 4 -- de-fuzzificate output variables of duration and task quality in project task

Finally, calculus is made. This essay will use UML in JAVA language and jFuzzyLogic to develop FAS.

4.2 Project agent performance

After FAS is constructed, this essay will continue to perform project agent (PA_j, description is made by taking PA_j as example hereunder). This essay will use XML to generate single PA_j, conforming to object provided by JadeX, allow agent to inherit category provided by JadeX during practice undertaking. These categories include beliefs, goals, plans, events and properties. Practicing is described as follows:

1. Beliefs: Receive events given from outer environment and deliver them to inner properties to generate new goals, record agent properties in map gathering, allow agent to make calculus on T_i property value according to property value contained in map.
2. Goals: Mainly record results acquired from calculating FAS and execution goals each time, allow agent to find suitable goals from selecting goals to execute such goals. Variables contained are seen in Table 4.

Table 4 FAS Goals

Variable	Type	Define
Difficulty	String	Record T_i parameter: *Difficulty*
Type	String	Record T_i parameter: *Type*
Result	String	Record FAS result: (duration, quality)

3. Plans: Mainly execute methods. In this practicing, there are three methods established: agent execution procedure, allocation procedure and message delivery procedure. In agent execution procedure, agent will judge pattern generated by new beliefs to judge which method is adopted, and respond to outer environment by executing such method; allocation procedure will make calculus on inner properties and parameter values delivered by T_i in FAS system and receive results; message delivery procedure is to communicate received results with project leader and T_i.
4. Events: Mainly define format setting delivered by message, communicate and deliver messages by following ACL Message standard (FIPA, 2007). In this practicing, ACLMessage.REQUEST and ACLMessage.INFORM are incorporated to receive

request and parameter of T_i respectively. INFORM has two functions: notify results by using messages delivered back after allocation; as T_i selects a certain agent to execute task, deliver a message related to whether participate in or not.

5. Properties: Mainly record all activities of agents undertaking in JadeX platform, for the convenience of record and request in the future.

5. Application examples

This essay uses situational description to construct simulated environment to describe AbPMS proposed by this essay, including role description of agent, description of task station and description of simulation conditions, and then describes the procedures by means of two supposed examples. The involved party configures PA_j by using property values given by different T_i and configures PA_j into proper task station for executing task and solving human resource allocation problem in project management. Furthermore, when project management is under way, if urgency occurs when PA_j is executing task, he must stop executing task. At this time, AbPMS monitor system will send messages and inform other PA_j and configure new executors to implement unfinished tasks.

Supposed conditions are described as follows: (1) Suppose that task station in human resource allocation has single task and single executor, however, human resource takes priority over other resources in allocation. Suppose if urgency occurs, other relevant human resources will be given preference to execute tasks. (2) Suppose when urgency occurs, schedules arrangement amid task stations will be not affected and cost limitation and calculation are not considered.

5.1 Human resource problem in initial allocation of project management

Suppose there are 12 T_i and 10 PA_j in project management, including 1 project management agent, 3 engineer agents, 3 technician agents and 3 assistant agents, to participate in allocation process. Each parameter is produced by using normal distribution method, to render uncertain change of variables, with simulation executed for 30 times. This essay develops agent allocation interface (see Figure 16) and task station allocation interface (see Figure 17) allowing users to access parameters setting.

It is known that menu of agent allocation interface includes agent allocation, task allocation and monitor interface. In agent allocation, agent sets up its parameters on interface. As setting finishes, press “Show” to check in lower window. If errorless, press “Create Agent” to generate ADF file in XML and agent appears in right side of “Created Agent” window. If setting is wrong, press “Clear” to set up parameters again.

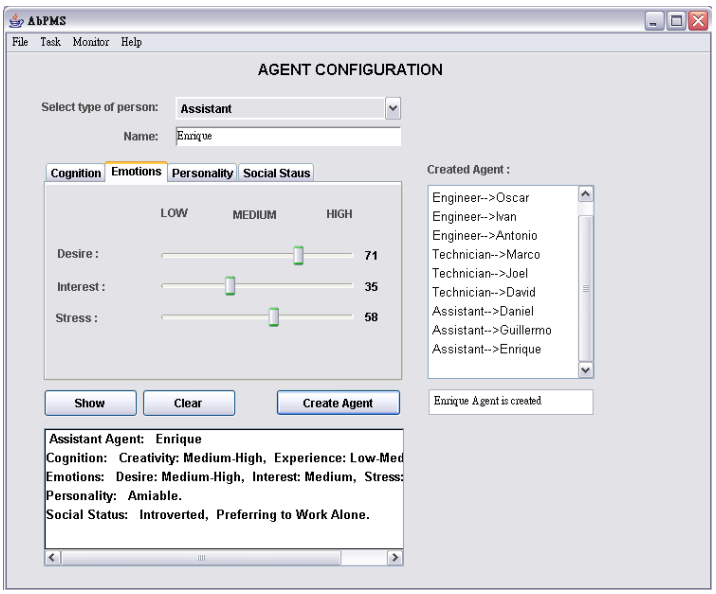

Figure 16 Agent Configuration

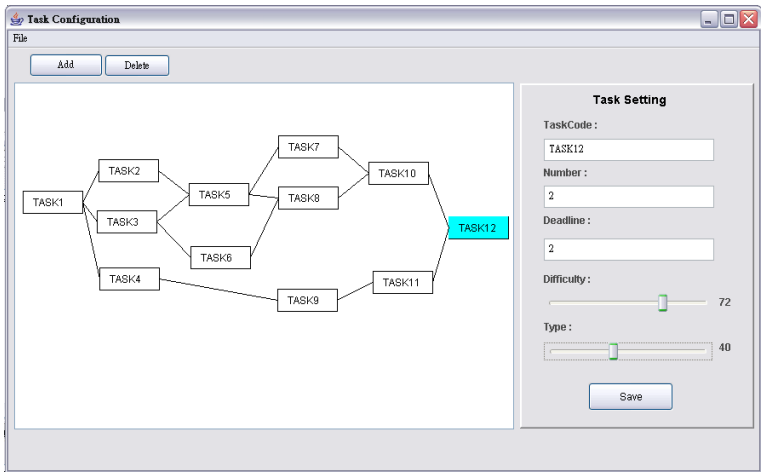

Figure 17 Task Configuration

Task station allocation user interface is seen in Figure 17. On this interface, it can add task station, set up the order of priority of task station. If clicking task station, parameters can be set up on "Task Setting" window in right side, including: number of participated people, duration, task difficulty and task pattern. Finally, press "Save" to store information of task station and enter into monitor state.

Finally, after PA_j and T_i complete setting, with JadeX platform combined and used, status and allocation result of each PA_j are understood. During allocation, *PMA* will participate in coordination of repeated use problem of human resource, meanwhile,

evaluate composites with higher benefits. Simulated results of duration and task quality outputs in this essay are seen in Figure 18 and Figure 19 respectively. Known from results, in task stations of T_1, T_2, T_3, T_9 and T_{10}, their agents will complete tasks as scheduled, other agents are under delay state; Regarding performance of task quality, agents in task stations of T_1 and T_2 will provide tasks with higher quality. These two statistics maps are demonstrated to make users and project leaders clearly acquire relevant utility messages and analysis results.

5.2 Urgent human resource allocation problem

This essay also proposes a function of monitoring project with the aim of monitoring changes of environment at any time for giving responses. Therefore, suppose when project management is under way and one PA_j is executing task, if urgency occurs, he must stop

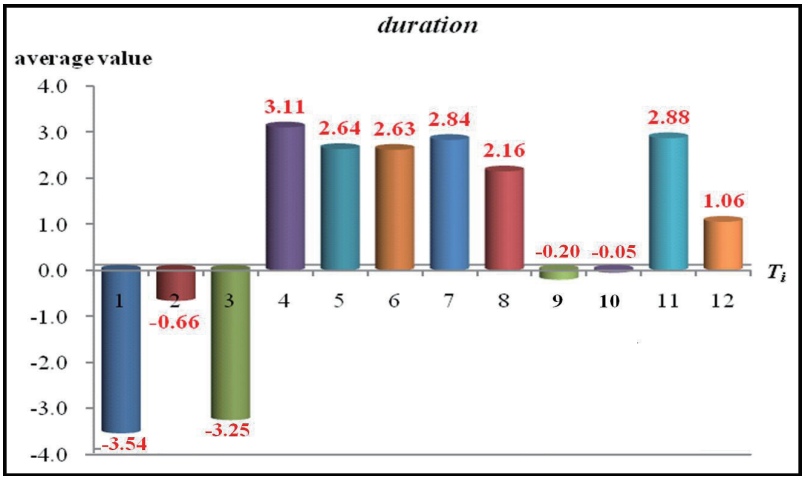

Figure 18 Duration Output

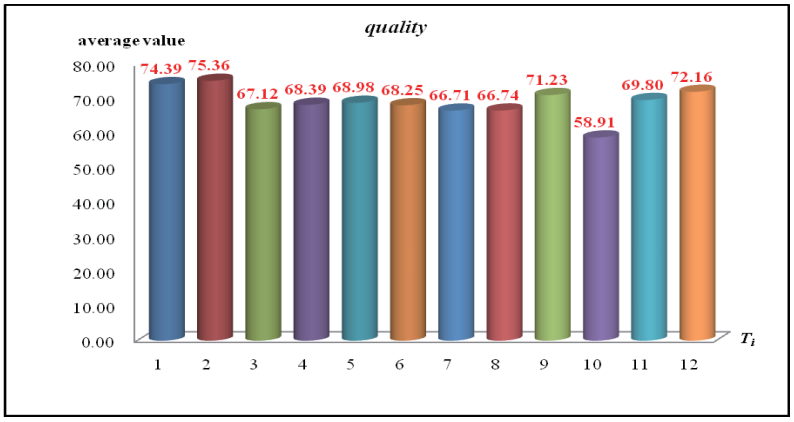

Figure 19 Quality Output

executing task. At this time, AbPMS monitor system will send messages to inform other PA_j to configure new executor for executing subsequent tasks. Its monitor interface is seen in Figure 20.

Simulated results are described as follows: Suppose during project monitoring, monitor interface moves until T_5, Graphics Agent (GraA) will know about lagging events and send messages to Project Manager Agent (PMA) to execute the task of picking up substitutes: PMA will enter into project and execute tasks through FAS allocation calculus and send request concerning whether working with allocation calculus. Sending request will not stop until new project agent is found. Message delivery process is seen in Figure 21. It is known from communication messages that agent Joel will take over task 5.

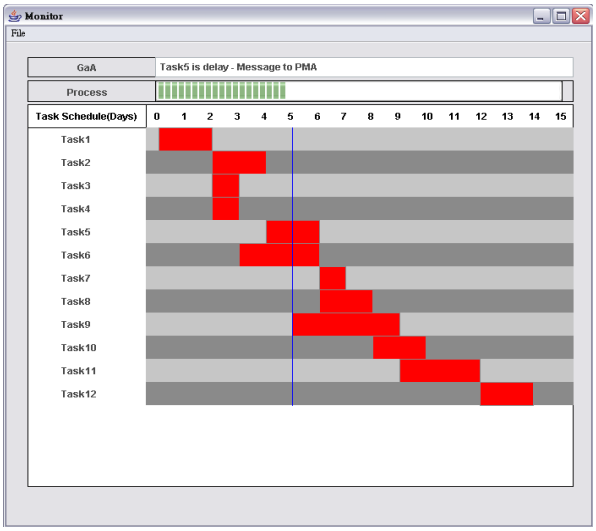

Figure 20 Progress Monitor

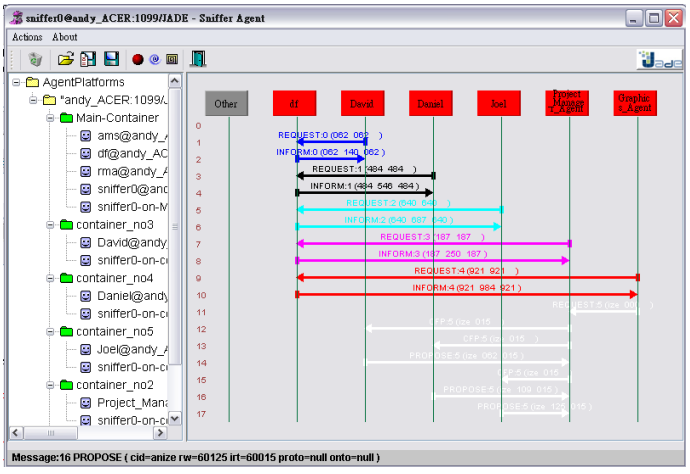

Figure 21 Rush Allocation Message Transfer Each Other

6. Conclusion and subsequent research direction

This essay mainly discusses and practices human resource allocation and urgent human allocation in project management. In the process of study, it is able to rapidly understand, perform and construct AbPMS by means of GAIA methodology and a whole set of system framework theory, allowing project management to finish project plan based on this system. Agent technique is applied into project management through application of PA_j and T_i allocation constructed by this essay and monitor interface. Meanwhile, construction of BDI agent permits agent roles to allocate themselves in task stations in combination with FAS system according to methods and parameters used during participating in project, and adjust change of inner parameters depending on beliefs provided in different environment, which truly demonstrates characteristics of agents and function of real-time project monitor.

Because project management involves wide issues for discussion, subsequently, it can be extended from existing AbPMS model to other discussion topics as follows:

1. Resource conflict problem: When a project is undertaken, task delay problem often occurs, causing project in need of great change, and even progress of overall project to be affected, thus, how to control human resource and adjust project progress to solve resource conflict in project needs further discussion.
2. Multi-project problem: In enterprises, projects are undertaken in multiple ways. Only undertaking single project never happens. Thus, how to allocate human resource and develop function of monitoring multiple projects to allocate project with suitable human resources for the goal of completing tasks will become another issue worthy of investigation.

In conclusion, this essay focuses on practicing human resource allocation problem and urgent human resource allocation problem, constructs AbPMS to develop BDI multi-agent system function on the basis of GAIA methodology. This system has an opened framework, thus to incorporate different project management issues and provide for project managers in terms of practice application.

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