Emerging personal intelligence in collective goals: data analysis on the bottom-up approach from PKM to OKM

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Abstract

Purpose – *A pattern of personal intelligence is seen emerging from the concept of agent-mediated personal knowledge management (PKM) in achieving collective organisational goals. The purpose of this paper is to present the results of surveys undertaken to prove this emergence.*

Design/methodology/approach – *A quantitative analysis supported by a qualitative analysis was conducted across three main industries in Malaysia, namely manufacturing, service and education. The triangulation of analysis is based on the four proposed hypotheses.*

Findings – *From these analyses, it was discovered that the emergence of personal intelligence is embedded within the collaborative interactions amongst software agents, and between agents and human knowledge workers. All the hypotheses are supported by the results of the surveys which manifest organisational knowledge management (OKM) practices as a consequence of the agent-mediated PKM processes.*

Research limitations/implications – *This research focused on the PKM in Malaysia, where the level of KM implementation varies among the organisations. The results may not reflect other developing countries due to the socio-cultural differences amongst the knowledge workers.*

Practical implications – *The results from this paper can be used either to relook and reanalyse the existing organisational KM system or to plan and design a KM system for organisations that have not implemented any.*

Originality/value – *The focus on personal intelligence and agent-mediated PKM contribute to further development of agent-based system that animates these theories in the real working environment.*

Keywords *Personal knowledge management, Organisational knowledge management, Personal intelligence, Software agent*

Paper type *Research paper*

1. Introduction

With the shift of focus from organisational knowledge management (OKM) to personal knowledge management (PKM), recent studies have looked at it from the perspective of bottom-up instead of the traditional top-down approach to OKM. PKM focuses on helping individuals to be more effective in personal, organisational and social environments (Pauleen, 2009). Compared with the traditional view of knowledge management (KM), PKM focuses more on increasing individual effectiveness in work environments such as teams and organisations (Pauleen, 2009), whereas KM is concerned primarily on managing organisational knowledge, or commonly termed as OKM.

Studies in this area do not end in terms of social sciences alone, but also in terms of technical and agent intelligence. Apart from the common KM system that is widely proposed since the beginning of the second millennium, more tools and technologies are introduced to assist and mediate individual knowledge workers in managing their personal knowledge. Amongst the few latest introductions of PKM tools in agent intelligence domain include an agent-based PKM system supported by mobile technology cross-platform solution (Osis and Grundspenkis, 2012) and a PKM system on social software agent technologies called

> **"The agent-mediated PKM processes of individual knowledge workers contribute to the emergence of personal intelligence in achieving the collective organisational goals, demonstrating the bottom-up approach from PKM to OKM."**

WANT (Kim *et al.*, 2007). However, in the context of the worldwide application of tools and technologies, there is still some doubt in their possible implementation to fit the purposes and styles of managing personal knowledge in the eastern side of the world since most of these technicalities are proposed based on research conducted in the western world. As such, the proposed tools and technologies somehow lack of ''reach'' particularly in the south-eastern part of Asia, where the culture and environment could be totally different from the rest, leading to the difficulty of the proposed tools and technologies being accepted and implemented. With this reason in mind, this research starts off by understanding the ''people factor'' before the technical intelligence aspect is introduced.

It is against this backdrop that this study focuses on agent-mediated PKM processes which results in the emergence of personal intelligence in terms of the tasks delegated to software agents by human knowledge workers. Accordingly, this paper discusses the emergence of personal intelligence, justified by the quantitative and qualitative data gathered across three main industries based on the following hypotheses:

H1. Agent-mediated PKM can be replicated.

H2. The replicated agent-mediated PKM represents a function of the intelligence of an individual knowledge worker in an organisation.

H3. The replicated agent-mediated PKMs overlap to reveal tasks for a common goal.

H4. The GUSC framework also emerges in agent interactions.

These hypotheses are developed to guide the research investigation which is derived from the preliminary research conducted in early 2011 (Ismail and Ahmad, 2011a). The preliminary research provided information and details that assisted the researchers in developing the research methodology. The background literature and rationale that made up the hypotheses are included in the next section.

2. Related works

2.1 PKM and OKM

Myint (2004) and Zhang (2008) believe that individual knowledge workers are important to an organisation and hence there is a need to investigate the bottom-up approach of OKM, with PKM supporting the processes of OKM. Despite the gap between PKM and OKM, researchers in the fields of Internet technologies attempt to fill this gap by exploring the essential skills for PKM. For instance, Pettenati *et al.* (2007) and Razmerita *et al.* (2009) investigated the Web 2.0 technologies and tools used by knowledge workers in managing personal knowledge and suggested that these tools should be used not only at the individual level but also at the organisational level.

The important aspect argued by researchers across the literature in this domain is the ''people factor''. The PKM processes are defined in terms of networking, e.g. finding people who share the same social interest, sharing knowledge, collaborating, extending and extrapolating, and joining community of practice, since the core focus of PKM is ''personal inquiry'', which is a quest to find, connect, learn and explore (Verma, 2009). Nonetheless, individual knowledge workers still perform different processes of PKM and often with different approaches at different times depending on the situations. Yet, there are still

similarities in the patterns of the processes, since the goals of performing the processes would eventually lead to the common collective goal. Even though PKM supports individual knowledge workers rather than establishing an organisational approach (Razmerita *et al.*, 2009), the PKM environment integrates individual work environments and the facilitating infrastructure to support joint creation, distribution, sharing and application of knowledge (Martin, 2000). In other words, PKM can collectively contribute to OKM because knowledge is a source of competitive advantage at organisational level as well as at the individual level (Razmerita *et al.*, 2009).

Regardless of its potential in being the basis of OKM, little significant conceptual work around PKM has been undertaken especially in terms of PKM models supported by strong theoretical framework, leading to difficulties in having the models being more widely understood and adopted (Chatti, 2012). Further, the existing PKM models do not address the relationship between PKM and OKM (Gorman and Pauleen, 2011), leaving organisations with abstracts that sound impressive but lack of implementation capability. In most cases, research tends to fill this gap by proposing tools and technologies since these are the tangible aspects that can help organisations realise their bottom-up KM strategies. As an example, a recent work looks at the PKM processes and how personal knowledge network plays an important role in successfully enabling PKM of the knowledge workers because in the personal knowledge network model, personal and organisational KM converge around a knowledge worker-centric work and learning environment (Chatti, 2012). The concept of personal knowledge network is often revisited in this paper in the concept of ''locations'' of knowledge sources.

Throughout the evolution of PKM research, the perspective of PKM-OKM approach changes from theory to technical, where these two worlds are expected to meet in some forms that can be implementable in real organisations. One of the technologies proposed in recent works includes the software agents under artificial intelligence.

2.2 Agent-mediated PKM processes

On the technical side, researchers are turning to software agents in mediating the processes of PKM because agents are claimed to have the ability to carry out all the actions and exhibit all the behaviours within a knowledge flow (Newman and Conrad, 2000). As claimed by Ismail and Ahmad (2011b, 2012) and supported by Apshvalka and Wendorff (2005), the four processes of PKM that can be mediated by software agents are: get/retrieve, understand/analyse, share, and connect. These processes are aligned with the PKM processes suggested by previous authors (Martin, 2000; Avery *et al.*, 2001; Grundspenkis, 2007; Pettenati *et al.*, 2007; Razmerita *et al.*, 2009), but with more focus on PKM over computer and Internet technologies.

Looking at these PKM processes of get-understand-share-connect or also known as the GUSC model (Ismail and Ahmad, 2012), Figure 1 is tabulated to show the cross-reference amongst related literature on PKM processes with indication of where the GUSC can be applied or categorised based on the processes defined by the authors. The figure displays a wide coverage of G (i.e. get knowledge) and U (i.e. understand knowledge), but quite less on S (i.e. share knowledge). The least covered area by previous authors is on C (i.e. connect to other knowledge), which is quite questionable since the ''people factor'' in PKM processes cannot avoid socialisation and interaction amongst the individual knowledge workers, especially when getting, understanding and sharing tacit knowledge are of great concern.

"Instinctively, knowledge workers perform their individual tasks to achieve their vocational goals which are normally connected to the organizational goals."

Figure 1 Comparison of PKM processes by authors across the GUSC concept

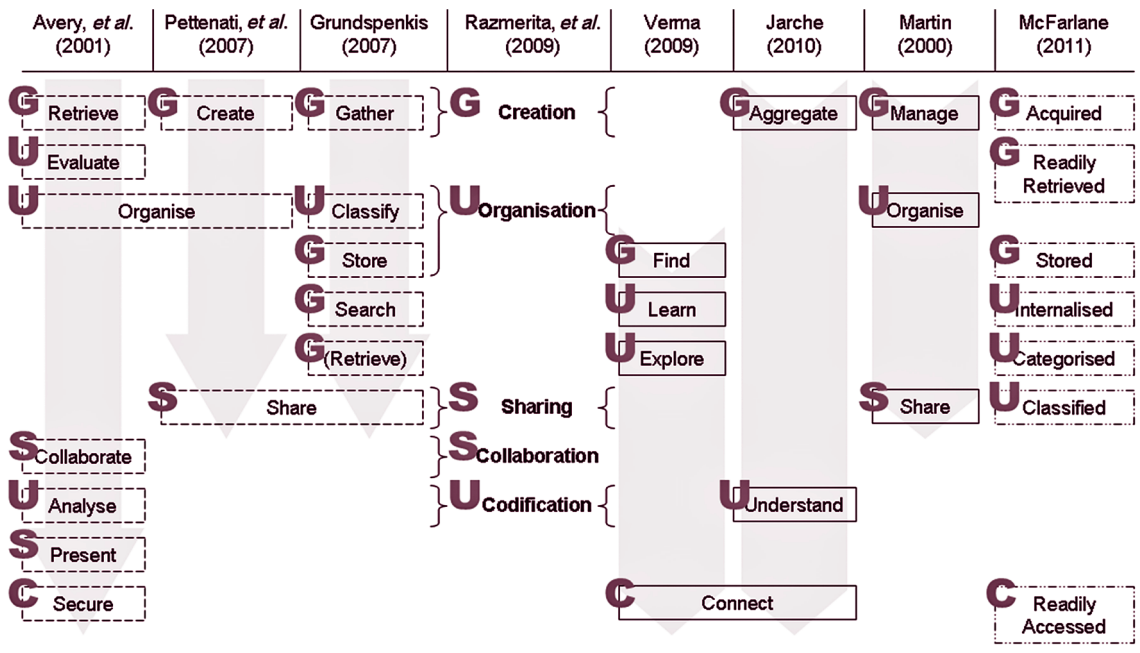


Figure 1 also shows the process flows mentioned by the related authors (Avery *et al.*, 2001; Grundspenkis, 2007; Pettenati *et al.*, 2007). The flows look rigid, rendering their proposed frameworks less flexible. When compared across the table, a questionable terminology is found where ''retrieve'' is used in different stages in Grundspenkis (2007) instead of the initial process in Avery *et al.* (2001). The process flows defined by Verma (2009), Jarche (2010) and Martin (2000) are slightly different in that they offer more of a macro view instead of separate and discrete processes proposed by the former three authors. Razmerita *et al.* (2009) did not define their PKM processes as a rigid flow, whereas McFarlane (2011) did not determine clearly the processes to be in a certain flow since they are defined as what the PKM processes should be.

On top of that, the four processes of PKM depend on cognitive enablers, such as the method of performing tasks (i.e. method), how knowledge sources are identified (i.e. identify), how decision is made on the approach to take in ''seeking knowledge experts'' (i.e. decide) and the drive for knowledge workers to seek knowledge experts (i.e. drive) (Ismail and Ahmad, 2011b, 2012). These enablers are derived at from Agnihotri and Troutt (2009) and Schwarz (2006). For the purpose of this research, the cognitive enablers are not meant to be looked at in detail but to understand the need of such enablers in defining the characteristics of the software agents for future development and simulation.

This research also takes into account the development of software agent in nodal approach, especially with the related works done on mediating the human knowledge workers in multi-agent systems. The relation between KM as an application and software agents as a basic technology for supporting KM can be outlined since the basic features of agents (i.e. social ability, autonomy, re- and pro-activeness) can alleviate several drawbacks of KM technology (van Elst *et al.*, 2003). In supporting this argument, Zafeiris *et al.* (2005) presented an agent-mediated KM approach that enables the discovery of distributed and heterogeneous knowledge resources through an infrastructure of knowledge repositories by means of software agents. These works has led to the work on nodal approach by looking at the agent-mediation processes as an entire system revolving around the human knowledge counterpart in a nodal view.

According to the nodal approach proposed by Ahmed *et al.* (2009), a human entity can work cooperatively with a software agent in a virtual workspace called a node. A node consists of a knowledge worker, and one or more agents, also known as role agents, to perform some roles of the knowledge worker. The knowledge worker has a set of functions, some of which could be delegated to the agents. In supporting the needs of realising the PKM processes, two types of functions of knowledge worker are identified: common functions (e.g. open document, create/edit document, upload/download document, delegate role, request, and request response); and unique functions based on knowledge held (e.g. analyse problem, propose solutions, and response-to-request) (Ahmed *et al.* 2009). These common and unique functions can be further distinguished into online and offline modes, with offline modes consist of mostly physical tasks such as attending a meeting to make a crucial decision which the knowledge worker needs to do to complete a current online work cycle (Ahmed *et al.*, 2009).

2.3 Personal intelligence and software agents

Being the domain under artificial intelligence, software agents are expected to be ''intelligent'' with the capabilities to re-act and pro-act on given situations. Amongst the capabilities and features of software agents expected in this study of personal intelligence are autonomy, reactive, proactive, able to communicate, adaptive, goal-oriented, capable to co-operate, reason and flexible (Paprzycki and Abraham, 2003). In a separate case, personal intelligence is seen as one of the five layers that constitute collective intelligence where the layer deals with enabling users (Solachidis *et al.*, 2010). Similar to the software agent conceptual framework, Solachidis *et al.* (2010) stated that personal intelligence exists within a restricted ''environment'' such as event, user, content capture, terminal and network.

Personal intelligence also involves the abilities to recognise personally-relevant information from introspection and from observing oneself and others; form that information into accurate models of personality; guide one's choices by using personality information where relevant; and systematise one's goals, plans and life stories for good outcomes (Mayer, 2008). In relating this concept with software agents, the intelligence of the agents depends on the rationality of the agents. Mayer (2008) also elucidated that personal intelligence as having ''cumulative decisions'' that helps in the well-being of that person, which is exploited in this study whilst focusing on the collective goals in manifesting the OKM.

The characteristics of software agents are usually stated in the definitions across the literature. On top of that, the definitions can be analysed in terms of the PKM processes (i.e. get-understand-share-connect) in order to further determine if there is a possibility of applying the GUSC model on the roles expected to be performed by the intelligent agents. Table I shows this tabulated GUSC application based on the definitions of software agents by renowned authors, with the highlighted phrases and words that ascertain the applicability of the GUSC concept.

3. Methodology

In order to prove the hypotheses, two surveys were conducted in 2011 to understand the pattern of PKM processes and how the PKM amongst knowledge workers could overlap in achieving organisational goals. In general, a total of 118 questionnaire surveys were answered and returned within three months out of the 501 questionnaires distributed (i.e. a response rate of 24 per cent), whereas eight respondents were interviewed within six months. The respondents are from three main industries in Malaysia, namely manufacturing, service and education. They work in organisations that are equipped with proper IT infrastructure to support their organisational KM efforts. The organisations include higher education institutions, oil and gas producer, a telecommunication company, a financial institution, government agencies and a business project investment company.

From the triangulation of data and results of these surveys, a framework is conceptualised to further understand how an agent-based system can be developed in mediating human PKM processes and how personal intelligence can be animated from the agent-based framework to prove the proposed hypotheses.

Table I Software agents characteristics and capabilities applicable to GUSC Model

Authors	*Definitions of software agents*	*Get*	*Understand*	*Share*	*Connect*
Coen (1991)	Programmes that engage in dialogues and negotiate and coordinate the transfer of information			✓	✓
Russel and Norvig (1995)	Anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors	✓	✓		
Gilbert *et al.* (1995)	Software entities that carry out some set of operations on behalf of a user or another programme with some degrees of independence or autonomy, and in so doing, employ some knowledge or representation of the user's goals or desires		✓	✓	
Maes (1995)	Autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in this environment, and by doing so realise a set of goals or tasks for which they are designed	✓	✓		✓
Jennings *et al.* (2000)	An encapsulated computer system that is situated in some environment and that is capable of flexible action in that environment in order to meet its design objectives	✓	✓		✓
Ali *et al.* (2010)	Computational systems that inhabit some complex dynamic environment; sense and act autonomously in this environment and by doing so realise set of goals or task for which they are designed	✓	✓		✓

3.1 Questionnaire survey

A questionnaire survey was conducted based on theoretical sampling according to a random non-probabilistic purposive sampling procedure suggested by Wiedemann (1995) in view that the features and the extension of the basic population were not known in advance. The objective of the questionnaire survey is to identify the approaches used by knowledge workers in managing their personal knowledge. A pilot test was implemented to get feedback on the questionnaire design from a sample of five experts.

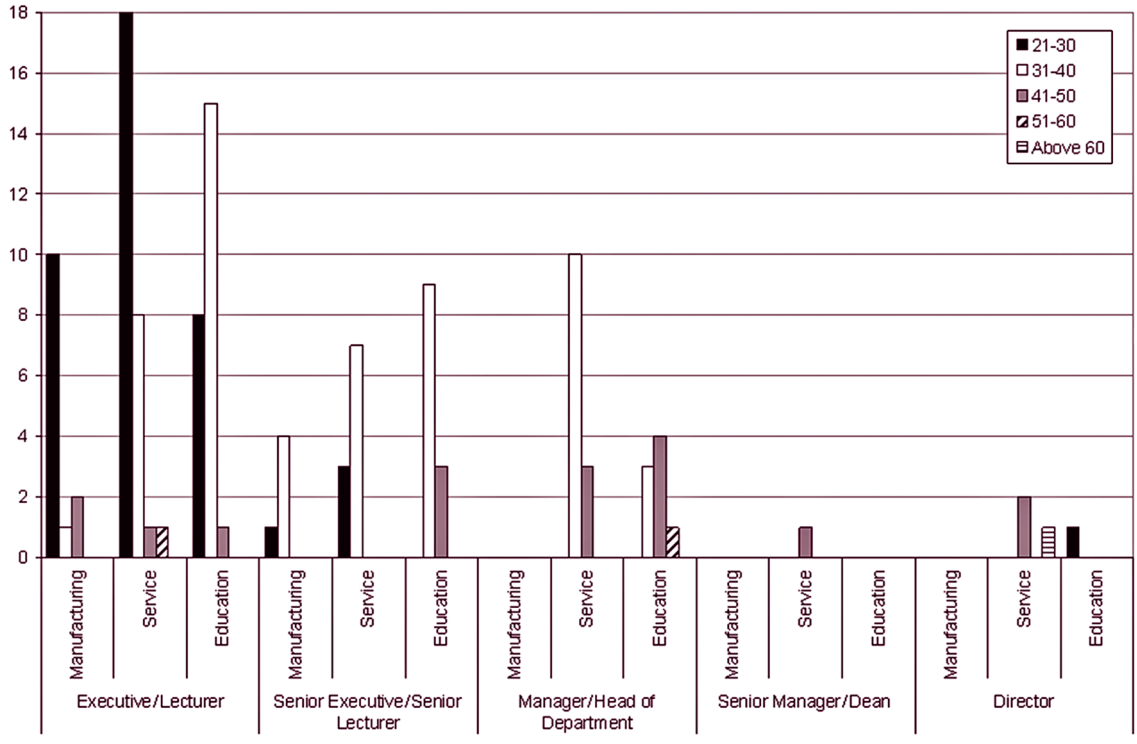
Figure 2 shows the demographic information of the respondents. Most of them are from the service industry (46.41 per cent), followed by the education industry (38.14 per cent) and the manufacturing industry (15.25 per cent). The majority of respondents are between the age of 21 to 30 (34.75 per cent) and most of the respondents hold positions as executives or lecturers (55.08 per cent). These respondents represent the fundamental strength in common organisations, which is the group of knowledge workers who relies on their effectiveness in managing personal knowledge, especially in understanding new knowledge by referring to knowledge experts.

The questionnaire design was based on the conceptual analysis made in a preliminary study which models the PKM as processes which a common knowledge worker would perform which involve locating knowledge experts (Ismail and Ahmad, 2011a). It is focused on gathering the information on how respondents manage their personal knowledge according to the four identified processes (i.e. get/retrieve knowledge, understand/analyse knowledge, share knowledge and connect to other knowledge or knowledge experts) and the cognitive enablers of the PKM processes that the respondents could verify (i.e. method, identify, decide and drive). The data gathered are analysed using the Statistical Package for Social Science (SPSS) software, with which the reliability and validity of the data are tested as well.

3.2 Interview survey

An interview survey was conducted based on expert sampling in which the respondents were identified and selected from a preliminary questionnaire survey ($n = 118$) conducted prior to this interview. Expert sampling was chosen because it is the best way for this study to elicit the views of persons who have specific expertise and to provide evidence for the

Figure 2 Demographic information of questionnaire survey respondents



validity of another sampling approach used in the previous surveys (Trochim, 2006). The experts interviewed in this study are the people who could clarify certain information retrieved from the previous survey such as definition of ''personal knowledge'', identification of knowledge sources and such.

Eight interviews were conducted from July 2011 to January 2012. Only eight ''experts'' were interviewed out of ten who were approached due to some complications in getting through to the right people to be interviewed. Since this interview survey is purposively added on to clarify certain information gathered in the previous questionnaire survey, the number of respondents for the interview is not crucial.

The interview is designed based on the conceptual analysis made in a preliminary study which models the PKM as processes common to knowledge workers and includes the necessity of using personal knowledge network to support it. It consists of semi-structured questions that revolve around the same topics as the questionnaire survey but with additional questions that help validate the overlapping of tasks for a common goal which would lead to the manifestation of OKM. The interview questions also consider the gap in the quantitative analysis found in the questionnaire survey conducted earlier.

In relation to the related works, this study evaluates the qualitative data according to selected themes. Content analysis is conducted according to these themes, justifying the needs and processes involved in PKM especially in terms of personal knowledge networks across the knowledge sources. Table II summarises the background information of each interviewee.

4. Results and findings

The responses received from the questionnaire survey show that knowledge workers generally perform the four processes of get/retrieve, understand/analyse, share and connect. Yet, the technological tools used for all these processes are not clearly identified

Table II Demographic information of interviewed respondents

Respondent	*Industry*	*Type of organisation*	*Type of job*
R01	Education	Tertiary education	Education management
R02	Education	Tertiary education	Academic
R03	Service	Project-based investment	General management
R04	Service	Telecommunication	Risk management
R05	Service	Financial institution	Project management
R06	Manufacturing	Oil and gas	Facilities management
R07	Service	Ministry	Event management
R08	Education	Tertiary education	Research and development

Notes: The job positions of the respondents are not included in this table, to respect their wish not to have them disclosed; n=8

except for e-mail. The e-mail system is highly relied upon as the main tool for communication and knowledge sharing since most organisations require knowledge workers to use office email for official tasks. Figure 3 shows the chosen options for each PKM process, highlighting the highest percentages of ''general search'' for get/retrieve process, ''summarise'' for understand/analyse process, ''e-mail'' for share process, and ''e-mail and online message'' for connect process.

In order to get or retrieve knowledge from the right source, knowledge workers need to identify and know who or where the sources are. The interview results provide some elaboration on this which justifies the responses of the questionnaire survey. Table III shows the top list of knowledge sources identified from the interview survey and this result guides the modelling of software agent in demonstrating personal intelligence.

In terms of understanding or analysing knowledge, the results varies across industries such as based on past experience or previous knowledge, information, recommendation or reference by others that lead to a knowledge expert. Looking into the details of ''learning from past experience or previous knowledge'', two interviewees mentioned different approaches: learn

Figure 3 Knowledge workers' PKM processes

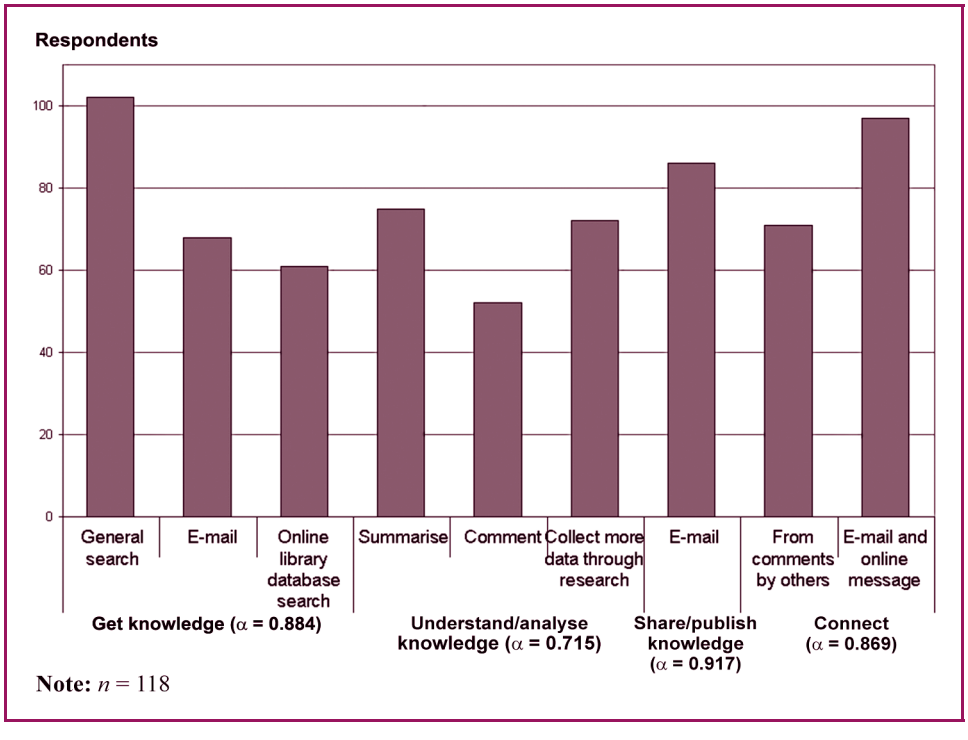


Table III Knowledge sources

Knowledge sources	*Education*	*Service*	*Manufacturing*
Other human knowledge workers			
People (in general)	Y	Y	Y
Professional (people)	Y	Y	Y
Organisational people (within organisation)	N	Y	N
Knowledge repositories and databases			
Personal database	N	Y	N
Organisational database	N	Y	Y
Organisational documents	N	Y	Y
Internet or worldwide/semantic web			
Internet	Y	Y	N
Online forums, blogs	Y	N	N
Journals, textbooks, articles, magazines	Y	N	N

Notes: Y = Yes; N = No; $n = 8$

by observation and reviews from others (e.g. audience and people who listen to knowledge experts); and learn from documents (e.g. error logs and workflow documented in previous projects). However, the concept of referring to the recommendations of others, whether ''they'' are ''tacitly informative'' or ''explicitly documented'', still applies. These processes are part of the method and the way of identifying the right knowledge entity or source.

Looking at the situation across industries through these two surveys, it is discovered that PKM processes are applicable and practiced by knowledge workers. With this justification, a framework for human knowledge worker and an agent-based environment in which human works are represented as a conceptualised nodal form is shown in Figures 4 and 5. A

Figure 4 Overview of agent-mediated PKM

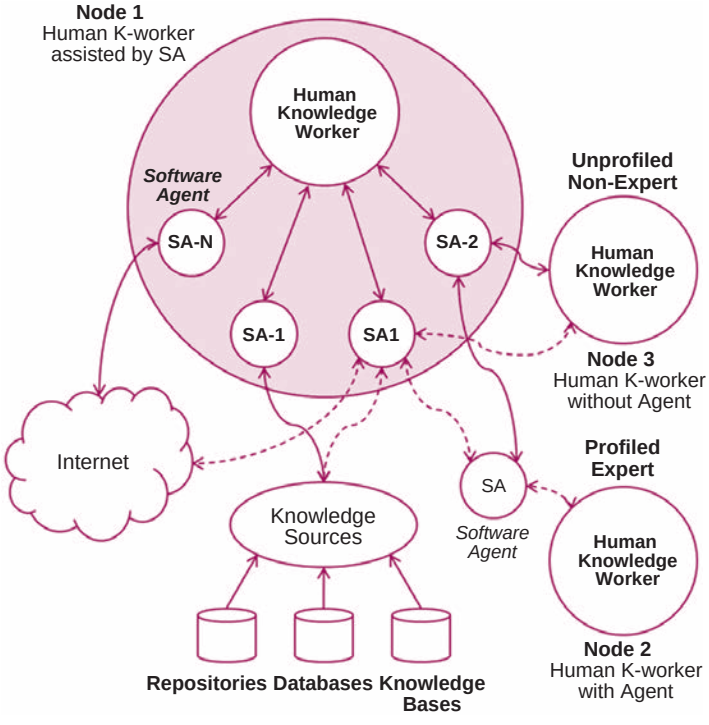
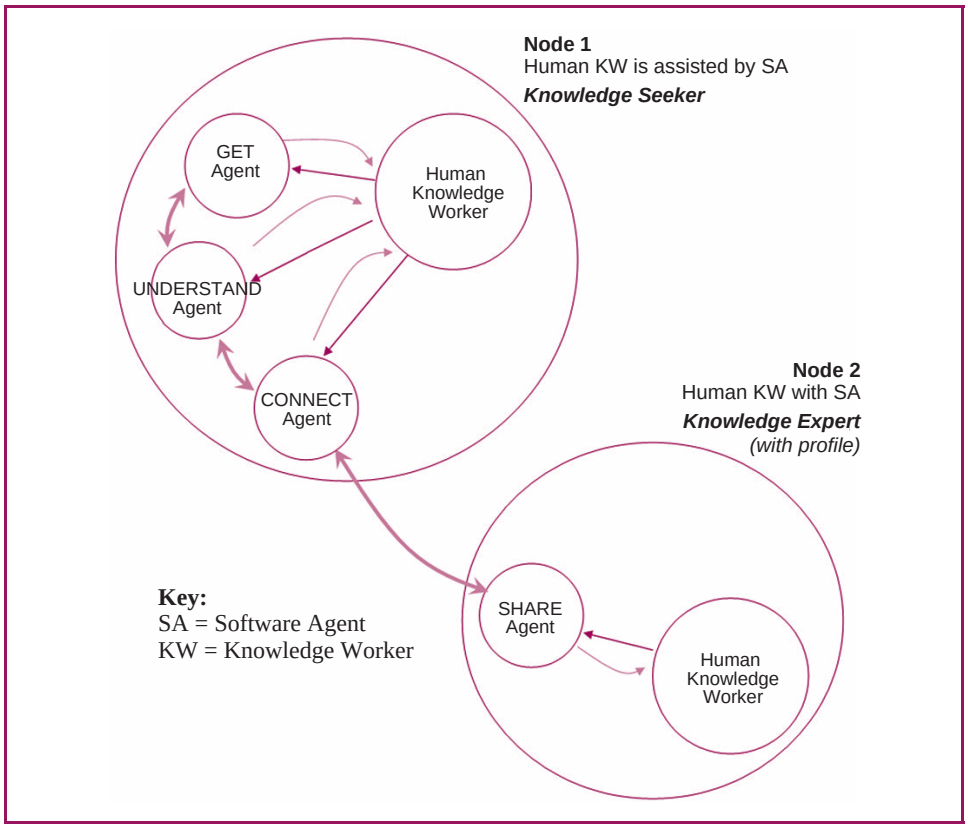


Figure 5 Overview of agents' roles in mediating PKM processes



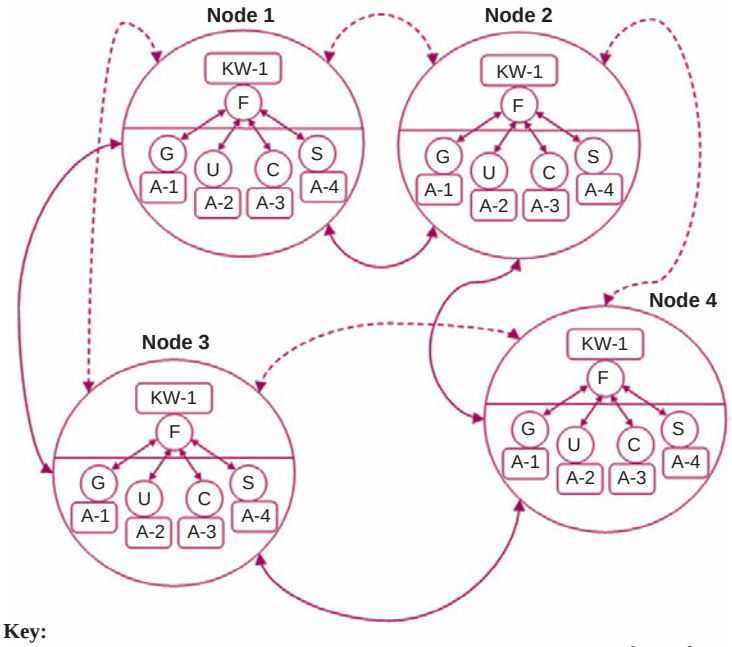
personal model of agent-mediated PKM can be designed in a nodal approach (Figure 4), where the knowledge worker connects to three other nodes, also referred to as ''locations'' (shown in Table III) with the help of a software agent (SA). One of these locations is a node that consists of another knowledge worker (identified as ''other human knowledge workers'' in Table III) who could be construed as a profile of another individual in a social network and could be the knowledge expert the agent is seeking for and on behalf of its human seeker.

In Figure 4, SA-2 refers to ''Software Agent 2'' that connects the knowledge worker to another knowledge worker who is either an unprofiled non-expert or a profiled expert who may or may not be assisted by a software agent. Similarly, SA-1 is another software agent that mediates the searching, connecting to the knowledge sources and retrieving the required knowledge. This model proposes the possibility of having multiple software agents to mediate the PKM processes with other nodes.

This nodal approach can further manifest the GUSC framework by assigning roles to agents that mediate the whole process, resulting in the extension of the personal model in Figure 4 into a role-based model in Figure 5. Figure 5 shows how the human knowledge worker delegates and interacts with software agents that execute the roles according to the PKM processes: GET, UNDERSTAND, and CONNECT. In order for the knowledge seeker to find the knowledge expert, the knowledge expert should be willing to share, hence the existence of an agent role called SHARE.

Considering that the knowledge seeker may often be a person who shares knowledge with others, or in other words is also a knowledge expert to others, then all the agent roles of GET, UNDERSTAND, CONNECT and SHARE can be the mediating processes for the knowledge seeker. The interview survey results lend support to this, with respondents from middle management level admitting being the point of reference to others on certain subject matters

Figure 6 Multiple nodes replicated from a single multi-agent environment for PKM processes



and being the persons who seek others regarding subject matters which are not within their field of expertise. The significant findings include the capability to ''connect'' to the one who has the expertise, provided that the expert is willing to ''share''.

Having said this, the single node of human knowledge worker shown in Figure 5 can be easily replicated into multiple nodes that would eventually form a network of connecting, and possibly socialising, nodes. Figure 6 shows this concept of ''social network'' of nodes, with mediating PKM role agents from each node connecting to each other. In addition to this, the concept of personal intelligence can be seen emerging from the functions of the PKM role agents, with multiple nodes forming a group of human knowledge workers interacting within and across organisations.

With the support from the survey data analysis, Figures 4-6 confirm the first two hypotheses, that ''agent-mediated PKM can be replicated'' (*H1*) and ''the replicated agent-mediated PKM represents a function of intelligence of an individual knowledge worker in an organisation'' (*H2*).

The interview survey reveals the overlapping of tasks and PKM patterns amongst knowledge workers in organisations. A respondent from manufacturing industry verified that it is a norm to have at least two knowledge workers involved in the same project or task to ensure that one will cover the other if the latter is not available when certain information is needed regarding the project/task. These overlapping tasks are meant to achieve a common goal of the department, which will further ensure the achievement of the collective goal of the organisation. This is supported by other respondents from the service and education industries who observed the same pattern of overlapping tasks for a common goal. The questionnaire survey results support this in terms of having higher agreement on ''collaborate'' task (38 per cent) compared to ''delegate'' task (36 per cent) in response to the question on how the respondents perform a task.

The responses received from the interview survey also lead to the verification of overlapping personal goals in fulfilling personal key performance indicators (KPIs), which leads to collective goals measurable through departmental KPIs followed by the organisational goals and KPIs. This is the result from having the performed tasks replicated amongst the knowledge workers where common tasks are performed in order to achieve a common departmental goal (which is determined by a KPI) and also to back each other up in terms of job responsibilities and knowledge know-how. This indicates that KPI is a way to perceive the overlapping of tasks within a department and the integrated KPI (whether within or across departments) which would lead to the manifestation of the organisational KPI.

The integration of all common tasks leading to the achievement of each KPI can be manifested as an OKM process. For example, common tasks performed by knowledge worker KW_1 overlaps with those performed by knowledge worker KW_2, resulting in an intersection of common organisational tasks represented as $KW_1 \cap KW_2$. If the intersection of the common tasks of KW_1 and KW_2 is represented by KPI_1, then the intersection of the common tasks of KW_2 and KW_3 is represented by KPI_2, and so on. For the total of N knowledge workers, the total number of intersections is N-1, represented by KPI_{N-1}. Putting in equations, if the intersection of common organisational tasks of knowledge workers:

$$KW_1 \cap KW_2 \cap KW_3 \cap \ldots \cap KW_{N-1} \cap KW_N \quad (1)$$

can be measured by their individual KPIs:

$$KPI_1 + KPI_2 + KPI_3 + \ldots + KPI_{N-1} \quad (2)$$

then the collective processes of achieving an organisational KPI, KPI_0, can be construed as the OKM process.

$$KPI_0 = KPI_1 + KPI_2 + \ldots + KPI_{N-1} \quad (3)$$

$$KPI_0 = KW_1 \cap KW_2 \cap \ldots \cap KW_{N-1} \cap KW_N \quad (4)$$

In higher education institutions, lecturers perform common organisational tasks, for example they are loaded with certain number of teaching, research and supervision hours by their departments. Each of them contributes to the KPI of the department depending on their individual achievements in teaching, research and supervision, which is clearly represented by equation (4). In the context of KM, the personal goal derived from the personal tasks is achievable through effective PKM processes, which manifests the organisational KM processes if the PKM processes overlap the personal goals of other knowledge workers. Based on these arguments, ''the replicated agent-mediated PKMs overlap to reveal tasks for a common goal'' (*H3*) is verified.

The findings from the interview survey also extends into the realm of personal knowledge network, where the ''other human knowledge workers'' are considered as knowledge sources and received the highest number of agreement by the respondents (as shown in Table III). Table IV is tabulated from the gist of the interview data analysis that shows the significance of personal knowledge network in the PKM processes of a knowledge worker. It is shown that there are three areas or environments in which software agents are expected to be located and moved around in order to perform the task of connecting a knowledge seeker (i.e. a human knowledge worker) to knowledge experts (i.e. other human knowledge workers).

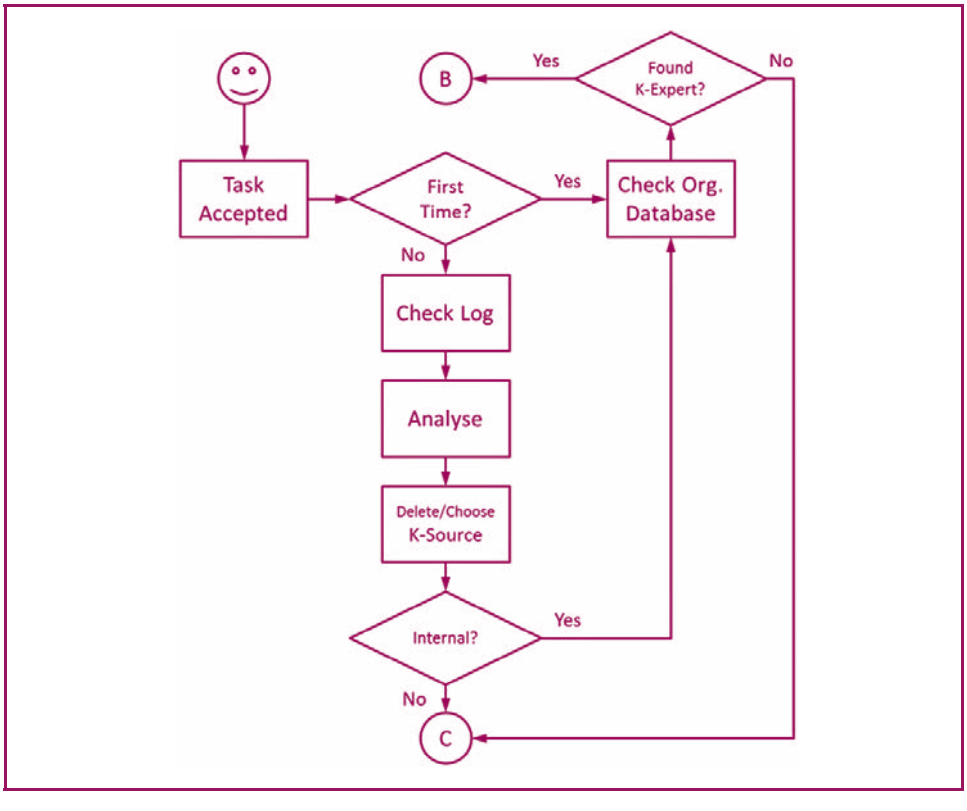
The findings from Table IV are further extended to design the multi-agent system framework where the tasks are separated to ease the modelling of the multi-agent system, i.e. identify knowledge source, roam the Internet and merit reputation point and initiate connection to knowledge source (as shown in Figures 7-9). Relating the concept to related works on personal knowledge network, the terminology of ''gatekeeper'' and ''point of reference'' are translated to ''other people within organisation'' and ''people's recommendation'' as shown in Table IV. The findings from the interview show that there are similarities in the methods of identifying, ascertaining and connecting to the required expertise across industries in Malaysia, supporting the need to find the right and reliable knowledge experts online.

Table IV Interview results on tasks performed in finding knowledge experts

Task to perform	*Findings from respondents*
Identify knowledge source	i. personal knowledge directory [R01, R02, R03, R07, R08] ii. knowledge directory in firm KM system [R04, R05, R06, R07, R08] iii. identified by a unit within department [R04, R06] iv. identified from other people within organisation [R01, R04, R06, R08] v. identified from other people outside of organisation [R01, R02, R03, R07] vi. identified from experts' profile or documentations over social media or Internet [R01, R02, R07]
Initiate connection to knowledge source	i. by e-mail [All] ii. by social media [R01, R02] iii. by telephone call (offline) [All]
Roam the internet to review the reputation of suitable knowledge experts	i. general search [R01, R02, R04, R07] ii. database search [R05, R06, R07, R08] iii. from people's recommendation (offline) [R01, R02, R03, R04, R05, R07] iv. from expert's reputation and people's recommendation (online) [R01, R02, R07, R08]

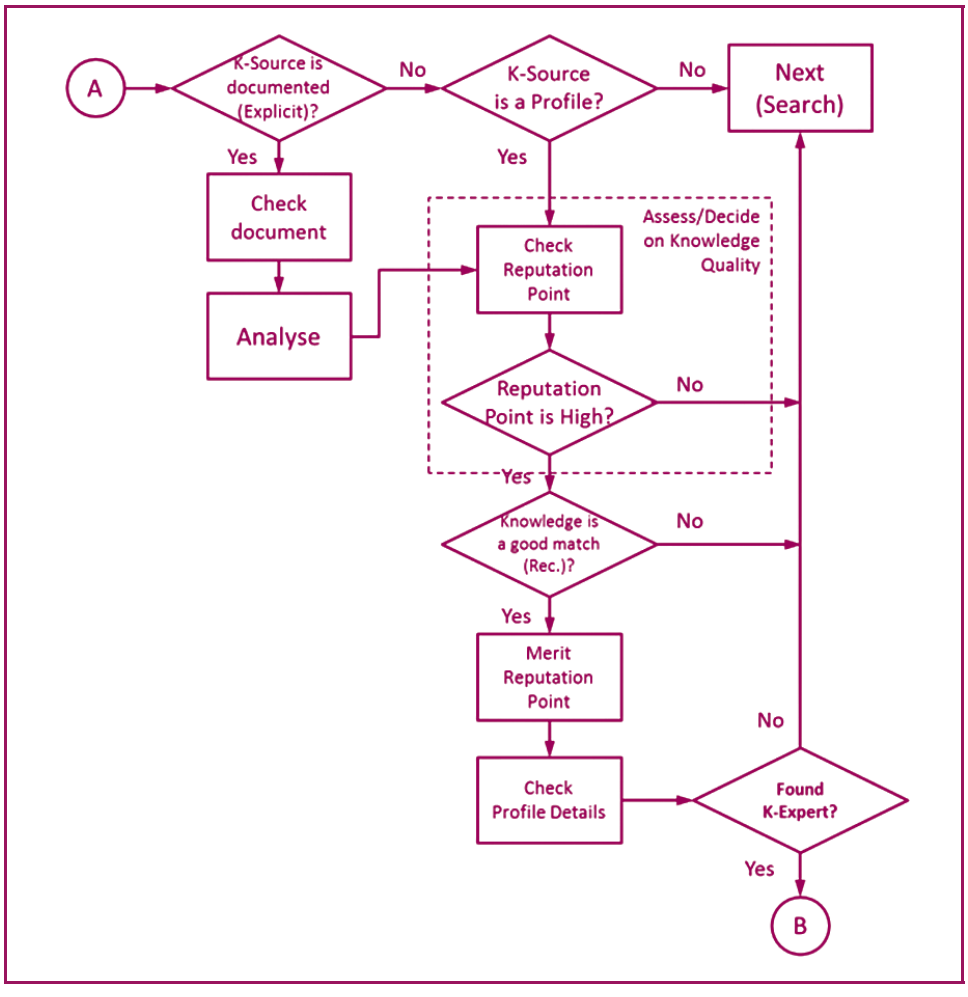
Notes: $n = 8$; Respondents' background are as follows: R01 – Education management of tertiary education (education); R02 – Academic of tertiary education (education); R03 – General management of project-based investment (service); R04 – Risk management of telecommunication (service); R05 – Project management of financial institution (service); R06 – Facilities management of oil and gas (manufacturing); R07 – Event management of ministry (service); R08 – Research and development of tertiary education (education)

Figure 7 Identify knowledge source



In designing the tasks for software agents to mediate the human knowledge workers, it is found that the required model challenges the agents in fulfilling the expected criteria which is basically ''intelligent''. This is seen in the processes of analysing and deciding, during the identification of knowledge source (as shown in Figure 7) and the search over the internet and awarding reputation point (as shown in Figure 8). The agents are expected to be sociable as well in fulfilling the task of initiating connection to knowledge sources (as shown in Figure 9)

Figure 8 Search the internet and merit reputation point

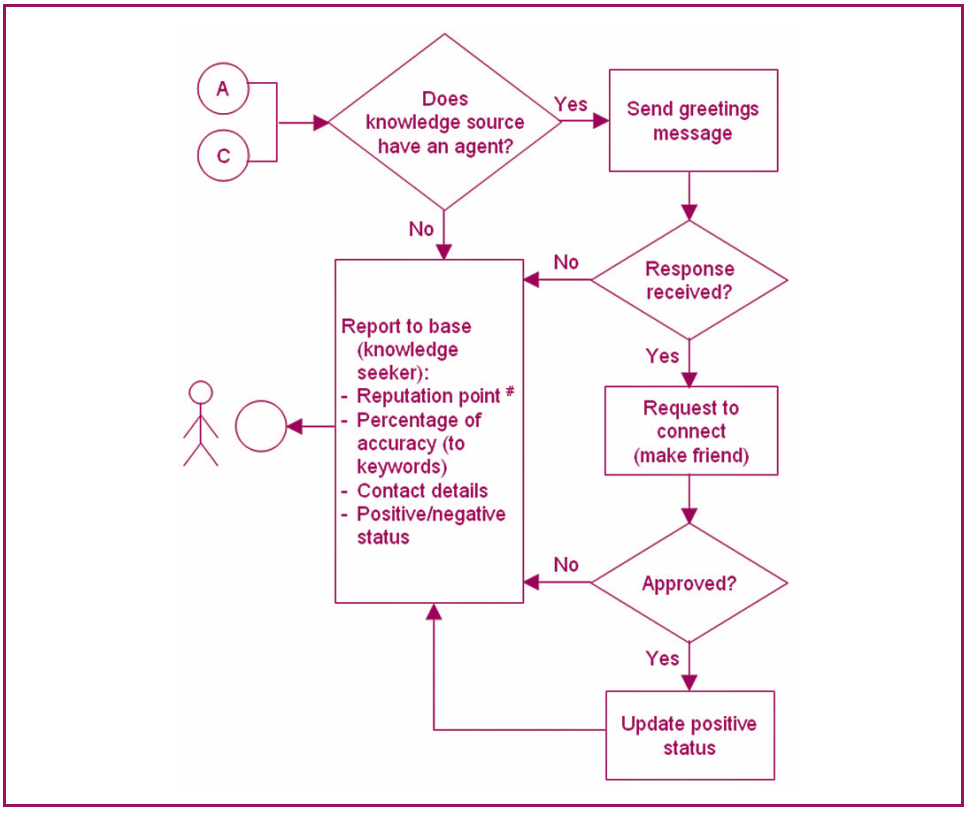


before reporting back to the ''base'' or the human knowledge seeker. In these aspects, the agent technology coupled with the advancement of the Semantic Web could be implemented and integrated to manifest a true ''intelligent'' behaviour required by these agents, hence animating the PKM processes more efficiently and effectively for their human counterparts.

Without diverting from the original concept of PKM processes, this multi-agent reputation point system proposed in Figures 7-9 shows how agents can simulate the intelligence behind the PKM processes of a human. For instance, the agents ''get'' knowledge (or in the explicit form, information) by checking the log (in Figure 7) and referring to the reputation point as how others review the knowledge source (in Figure 8). Agents also ''understand'' knowledge by analysing what they ''get'', before deciding if the knowledge is what they are looking for or need (in Figure 7 and Figure 8). The ''connect'' part is expected before any of the sources can be further used by the human knowledge seeker, and agents are expected to initiate this connection to ensure that the knowledge experts are willing to ''share'' (in Figure 9). If the knowledge expert has a profile with an agent that fulfils the task of ''share'' knowledge, then it would ease the process of ''connect''.

The GUSC framework of PKM processes shown as the roles of agents in Figure 5 are clearly detailed out in Figures 7-9 through agents interaction amongst each other according to tasks, embedding the concept of GET, UNDERSTAND, SHARE and CONNECT within the modelled system. With these findings, it confirms that ''the GUSC framework also emerges in agent interactions'' (*H4*).

Figure 9 Initiate connection to knowledge source



5. Conclusion and further work

Instinctively, knowledge workers perform their individual tasks to achieve their vocational goals which are normally connected to the organisational goals. However, given the variations of work problems, each of them implements the processes of achieving his/her own goals in many different ways. Such differences, whilst appear to be disconnected, follows a common pattern of get/retrieve, understand/analyse, share and connect processes.

This paper presents the emergence of individual knowledge workers' personal intelligence in collectively achieving the organisational goals with the analysis of data to prove this fact. The findings from the survey analyses also indicate that there are overlapping tasks which knowledge workers perform in achieving their own goals. Such overlaps hold true for many work processes that contributes to the achievement of organisational KPIs, thus manifesting the OKM processes. While data obtained from the study could contribute to other emerging markets, it is left to the practitioners and researchers to analyse the significance of the data and information and judge the applicability of the results to suit their regional peculiarities.

This paper also proposes an agent-based framework to implement the PKM processes in which a human knowledge worker works in symbiosis with his/her agent in a node. Many such nodes can be replicated, the interactions of which manifest the emergence of personal intelligence that implements the PKM processes of knowledge workers. Hence, the agent-mediated PKM processes of individual knowledge workers contribute to the emergence of personal intelligence in achieving the collective organisational goals, demonstrating the bottom-up approach from PKM to OKM. This leads to other areas of KM intelligence, including social intelligence and collaborative intelligence amongst knowledge workers in achieving organisational goals.

In our future work, we shall implement the emergence of personal intelligence in human-agent coupling as well as the manifestation of OKM as a consequence of many PKMs in an agent-based platform. The personal intelligence aspect offers opportunities for more research on the granularity of PKM, when agents' intelligence could also manifest patterns of personal intelligence at the finest granular level of KM.

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