Chapter 12
A Design Language for Knowledge Management Systems (KMS)

Imagination is more important that knowledge. For while knowledge defines all we currently know and understand, imagination points to all we might yet discover and create.

– Albert Einstein

12.1 Problem Statement

As with all species, humans spend their life in competition. Unlike other organisms, we carry this competitive drive past mere survival and reproduction into the structures of our social and business life. The structures of our business environment revolve around the ability of an organization to obtain long-term competitiveness through the control of rare and valuable resources that have limited substitutability, mobility, and imitability (Barney, 1991, Peteraf, 1993). Knowledge is precisely such a rare and valuable resource and does add greatly to an organization's ability to sustain competitiveness (Alavi and Leidner, 2001, Kogut and Zander, 1992, Argote and Ingram, 2000). The problem all organizations have is to efficiently discover knowledge, create new knowledge, capture it, share it, and use it to gain competitive advantage. They need to develop a system to manage their knowledge: a knowledge management system (KMS).

There is a need for a comprehensive model and a tool that can build on previous research and provide organizations with a better understanding of their unique knowledge flows and how best to leverage the organization's capital to create an efficient and effective KMS. This model needs to consider external inputs, the internal flows of knowledge, and the value of the outputs.

In response to the recognition of knowledge as a resource providing sustainable competitive advantage, there has been extensive research into and development of the nascent discipline of knowledge management. Research efforts have produced conceptualizations of the internal flows of knowledge creation, capture, sharing, and

Robert Judge

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use (Nonaka and Takeuchi, 1995, Rubenstein-Montano et al., 2001, Wiig, 1993, Choo, 1998, Firestone and McElroy, 2003). Several of these models qualify as a white box, connecting enough of the gears to provide some understanding of how knowledge flows through a generic organization.

However, the white box is far from complete. It does not yet help us understand how knowledge flows vary among specific organizations. These models help us understand at a high level how knowledge flows and how we might best manage it. But they fail to provide a means for individual organizations to customize the model of flow to fit their organization as it currently exists and then predict how the flows might change as they grow over time. Each organization faces a unique external environment and scans it for new inputs. Each organization has a unique organizational structure, set of personnel, and information systems infrastructure. And each organization has various forms of barriers to knowledge flow and use. Organizations are also rarely static; they evolve constantly. These factors all affect how efficiently knowledge is used to improve the quality, timeliness, and throughput of solved problems and responses to opportunities. Organizations must be able to strategically determine where and when to invest in an evolving knowledge management system (KMS).

Entrepreneurial and small- to mid-sized enterprises (SMEs) often experience a rapid growth in the need for internally generated knowledge and the external acquisition of knowledge. They experience rapid changes to their organizational structure, growth in the numbers of personnel, and the need for improved information systems infrastructure. They also may have limited access to capital forcing a critical selection process of where to invest for long-term competitiveness. This makes them good candidates for a tool that can help them understand their knowledge flows and how they might be altered over time due to the changes in their internal or external environment.

This research describes and validates a versatile simulation system designed to provide small- to mid-sized enterprises (SMEs) with a means to understand the impact that various barriers and facilitators have on the flow of knowledge given the organization's existing business environment. The initial model of the organization can subsequently be modified and its parameters changed to reflect proposed KMS changes to improve knowledge flows or to reflect the future growth of the company. These subsequent simulations are relevant to an organization's efforts to determine the appropriate strategy (timing and investment) for current and future KMS efforts.

There is no one way to implement a knowledge flow simulation – every company is different. However, this research will use kernel theories (organizational memory (OM), input–process–output (I–P–O), decision execution cycles (DEC), barriers to knowledge, and the cycle of knowledge creation: socialization, externalization, combination, and internalization (SECI)) to establish the requirements for the basic core model needed to represent the primary knowledge flows of a company. The core model will contain constructs representing a process flow concept of knowledge flows (Newman, 2003). The constructs to represent knowledge flows in organizations will be indentified – from competing and complementary theories (Nonaka and Takeuchi, 1995, Firestone and McElroy, 2003, Choo, 1998, Wiig, 1993). Each construct will then be rigorously defined by theory and characterized computationally by distributions. Simulation will be used to determine how the complexity and turbulence of external inputs to an organization and the configuration of the organization's knowledge processes affect its level of quality, timeliness, and throughput for outputs (solved problems, products, and services).

The research question pursued by this chapter is does the extent and value of knowledge, its linkage, and structural barriers to knowledge flow change as an SME grows? The value in this research is in providing a mechanism for the SME business community to use in evaluating potential strategies when considering or moving forward with the implementation of a KMS. A company that knows the volume, linkage, and structural barriers to knowledge flow can then understand the timing of investments in resources to support an evolving KMS. This research may also prove valuable to those involved in the design of future KMS simulation tools: to create a more effective interface to allow users to capture their corporate knowledge structure and the parameters for factors affecting the flow through that structure. This research and model could also be employed to understand large companies as well. However, SMEs provide an advantage in the simulation because they experience the point where the flow of knowledge through personal contact becomes impacted by growth.

12.2 Concept

The artifact is based on the concept that knowledge is created or acquired and then must flow to others who can apply it in the same or new ways or combine it with other knowledge to create new knowledge. Nonaka (1994) identified four forms of knowledge capture, which in the context of this chapter can be conceptualized as knowledge flows: socialization, externalization, combination, and internalization. This knowledge flow is the key to the artifact model (see Fig. 12.1). The knowledge flows along these pathways as information packets of tacit or explicit information. Socialization is the pathway for tacit information to flow between people. Sometimes this tacit information can be converted to explicit information and flow through the pathway of externalization. Combination occurs when someone is able to take explicit information and add more explicit information to it. Lastly, information that is received as explicit and converted into tacit occurs through internalization. Thus there are several ways that information packets can

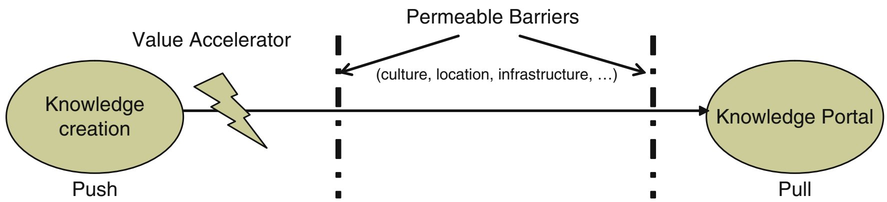


Fig. 12.1 Conceptual model

flow from someone motivated to exchange that knowledge to someone motivated to receive it. Something must induce the flow of knowledge. This chapter assumes a push-pull concept. Push represents the input and capture of created knowledge and the willingness to share it. If there is someone who has the desire for that knowledge, they will pull it toward themselves. The model also represents the fact that there are barriers to the ease with which knowledge flows from those who create and capture it to those who desire it. Examples of barriers that may exist in an organization's flow of knowledge are as follows:

1. Physical: Employees less likely to interact frequently because they are separated by walls, buildings, geography.
2. Too few employees: Few packets of explicit information being entered in a KMS.
3. Employee density: As a company grows, it becomes less likely that each employee will have equal opportunity to interact with every other employee – this in turn will slow the flow of tacit knowledge in the company.
4. Culture and language: Communication of information may be limited by poor ability to understand one another or for cultural reasons that do not encourage sharing for reasons such as loss of power.
5. Lack of motivation to share or use knowledge.
6. Perceived "usefulness": When the users do not receive an adequate amount of relevant information, they will use the system less. When more information packets are present in the system, the users will find it more useful.
7. Information systems infrastructure: Lack of proper KM mechanisms and technologies.
8. Security, and others.

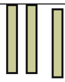
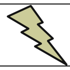
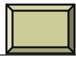
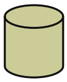
There may also exist "value accelerators" that will improve the ability of an information packet to move through the barrier more readily. Examples of value accelerators are as follows:

1. Linking of packets to other packets: Improving context or broadening to other contexts.
2. Knowledge repositories: Storage of explicit information packets in a readily searchable form.
3. E-mail: It will increase the flow of knowledge among those employees who may not have the chance of meeting face-to-face.
4. Brown bag lunches: Open discussions and storytelling to socialize tacit information.
5. Linking of competence to packets: Providing links to experts who can provide additional details and context related to particular information packets.
6. Expert systems and A.I.: Sophisticated systems that aid the search for key information.
7. Data warehousing and data mining: Providing the tools necessary to consolidate key information and look for unexpected relationships in the information.
8. Communities of practice: Online discussion with others interested and dealing with similar issues – provides for give and take of explicit information.

The permeability of the barriers and the value of the knowledge will determine how effectively the knowledge flows from creator to user. These barriers and value accelerators will vary from organization to organization. The model must allow for the selective inclusion of the relevant barriers and value accelerators and adjustment of their respective parameters.

This research develops a simulation system using the above concepts. The system includes a set of graphical constructs representing the structural characteristics that influence knowledge flow in an organization (see Table 12.1), the capability to simulate the knowledge flows of that structure, and the means to evaluate alternative structures and strategies. The graphical constructs serve a purpose analogous to objects in object-oriented programming and contain methods and parameters. In a given instantiation, the methods determine the context of the construct (object) in the organization's knowledge flows and determine which parameters will be necessary to properly represent it in the simulation.

Table 12.1 Graphical constructs

Permeable Barriers (Physical separation, Cultural, Language, Incentives, Management support, Security, Information infrastructure, etc.)	
Value Accelerators (Linking of packets, Linking of expertise, Communities of practice)	
Portals (Capturing, Adding value,Accessing)	
Knowledge Management Technology Modules (Information packets, Directory of competencies, KB, AI, Expert Systems, OLAP, Data mining, etc.)	
Knowledge Flows (Socialization, Externalization, Combination, and Internalization)	→

The process proposed for using such a simulation system entails working with an SME to understand the knowledge flows, barriers, value accelerators, and portals that exist in the company. These constructs will determine the parameters necessary to configure the system's algorithms (percent of tacit versus explicit packets, number of employees, number of packets generated by employees, etc.) and distributions (probability of a useful packet of information being found, impact of the number of employees on socialization, etc.) to properly model the SMEs KMS structural characteristics. A discrete-stochastic simulation, using the model and parameters, will simulate the flow of information packets throughout the organizational structure as modeled. A representative baseline will be developed by adjusting the construct parameters until the flows and usage rates approximate those measured by the organization. This baseline will be stored for comparison to models representing changes to the organizational structure (KM infrastructure, technology and mechanisms, and processes). The comparison of simulations will allow for an understanding of sensitivity of the knowledge flows to changes in the organizational structure and the associated costs/benefits. The organization may then develop a better informed knowledge management strategy.

12.3 Artifact Construction

The simulation constructed to represent the above model concepts was accomplished using iGrafx simulation software and is composed of the following components:

1. Knowledge packet generator
   a. Poisson random number generator
   b. Percent of tacit versus explicit packets
   c. Prioritization of packets (determination of packet value)
2. Barriers
   a. Employee density (socialization pathway)
   b. KMS usefulness (externalization pathway)
3. Value accelerators
   a. Scheduled brown bag meeting (socialization pathway)
   b. E-mail (externalization pathway)
   c. Knowledge repository (externalization pathway)
4. Receiver of knowledge packets

12.4 Knowledge Packet Generator

The knowledge packet generator controls the time between the creation of information packets produced each day. The interarrival time is based on the exponential distribution and adjusted to account for the number of employees. The exponential distribution has repeatedly been found to be a good approximation of the time between arrivals (information packets being generated) (Render et al., 2003). The key assumption associated with the use of an exponential distribution is that the arrivals are independent of one another. Although there may be circumstances where two people generate information packets at the same time because of collaborated content, this is probably rare and not a serious constraint in the use of the exponential distribution. The exponential probability function is

$$P(x) = \frac{1}{\beta} e^{-x/\beta}$$

Table 12.2 The value for β given the number of company employees

Number of employees	Value for β
5	0.5
10	0.3
20	0.2
50	0.15

The mean interarrival time is β (in days) and x is the given service time (in days). β is adjusted each simulation according to the number of employees. Table 12.2 lists the values of β per number of employees in the company for the simulation.

This table is based on the observation that a small company has frequent interactions among its members and with that stimulation of ideas and knowledge. Also, a small company is generally composed of founders who have considerable expertise and inventiveness. Thus a company of five may generate information packets twice per day on average. As the company grows, other employees are brought in for support functions and may not contribute new information as frequently. The time between new packets will decrease because there are more employees; however, the rate of new information generated per person will be less. This reduction in the rate of generating new information per person may also be driven by the new employees being less informed in the technology or having less cognitive capacity to generate knowledge than the initial founding team. The values provided in Table 12.2, and all subsequent tables, are based on limited personal observations and would need to be adjusted based on expert opinion and empirical observations for any specific company to be simulated.

Each information packet is randomly determined to be tacit or explicit and will, respectively, be directed to either the socialization pathway or the externalization pathway of the model. Since there are only two options, the Bernoulli distribution was selected for random assignment. The Bernoulli distribution will assign a given percent of the information packets as either tacit or explicit based on a provided probability of one of these occurring. This probability will change over time as the number of previously generated explicit packets increases. As more explicit packets enter and reside in the KMS, the usefulness of the system will increase because the users will have a greater likelihood of locating valuable packets of information. The percent of tacit and explicit packets will be adjusted in the simulation to increase the probability of explicit packets being created as the volume of existing explicit packets grows. This is accomplished by adjusting the Bernoulli distribution based on Table 12.3.

The last function of the knowledge packet generator is to assign a priority to represent the value of a particular packet just created. Not all packets are created equal. Some have more valuable content that will be desired by one or more people in the company. The normal distribution is used to represent the assignment of priority which has a range of 1–127. It is not unreasonable to assume that in any company, there are some low value and some high value packets, but in general

Table 12.3 Distribution of explicit packets given the number of employees

Number of explicit packets	Percent explicit packets to generate
0–250	0.2
251–500	0.3
501–1000	0.4
1001–2000	0.5
2001+	0.6

most will be somewhere in between in value. The normal distribution should reflect this condition reasonably well.

12.5 Barriers

There are several barriers in this model, two of which will be implemented in the evaluation instantiations described below. One barrier will be placed on the socialization pathway and represents a barrier to information flow caused by employee density. It will be found in all four instantiations. The other barrier, KMS usefulness, will be placed on the externalization pathway in the last two instantiations. The employee density barrier addresses the observation that the communication of ideas flows unimpeded in a small company but less so as the company grows. Although there are many reasons for this, the employee density barrier is concerned with the decrease in flow of tacit packets due to more people. As the employee population increases, there are too many people to meet on a daily basis, which, therefore, decreases the probability of running into the person with the right packet of information. The priority of a packet also plays a role in this barrier. A high priority packet will stimulate a person to tell it to more employees and thus increase the likelihood of the packet getting to the right person. The impact of the barrier in the model represents a delay in the transfer of a packet, which depending on its priority may range from a portion of a day to its never reaching another company employee. This barrier is simulated by the following function:

Delay due to employee density = packet priority $\times$ (normally distributed random number selected from between the numbers X and Y) $\times$ employee multiplier function

The numbers X and Y are equal to 1 and 3, respectively, in the instantiations evaluated in this chapter, but can be adjusted depending on the variability of desired delays. The employee multiplier function is used to provide a value to calibrate the packet wait time based on the number of employees and is represented in Table 12.4.

The KMS usefulness barrier will be implemented in the externalization pathway. The function used to simulate this barrier has parameters representing the packet

Table 12.4 Employee multiplier table

Number of employees	Multiplier
0–5	0.5
6–10	1.5
11–20	1.5
21–50	2.5
51+	4.0

priority, number of employees, number of explicit packets in the system, and a random generator. The result of this function is a delay attributed to an explicit packet:

KMS barrier delay = priority × (5/#employees) × delay based on number of employees × (normally distributed random number selected from between the numbers X and Y)

Although the priority can range between 1 and 127, for purposes of this function, it is normalized to a range of 1–12 with 12 being the highest priority. The numbers X and Y are equal to 1 and 3, respectively, in the instantiations evaluated in this chapter, but can be adjusted depending on the variability of desired delays. The delay based on the number of employees is represented in Table 12.5. The table is used to increase the delay when there are fewer packets in the system. The users will perceive the KMS to be of low value to them when there are few packets and use it infrequently. This is because the probability of there being a packet the user needs is very low when there are few packets. Therefore, the explicit packets initially entered into the system may be unused for a long period of time until the users see an adequate base of packets to search through and find useful.

Table 12.5 Usefulness delay based on number of packets in the system

Number of packets in the system	Usefulness delay factor
0–100	20
101–250	18
251–600	15
601–1000	12
1001–1500	8
1501–2000	6
2001–5000	3
5001+	1

12.6 Value Accelerators

Just as both the socialization and externalization pathways may have barriers, they may also have various value accelerators. The value accelerators perform the function of increasing an information packets priority. The higher the priority, the more rapidly the packet will pass through any barrier it encounters. There are three value accelerators used in the evaluation section of this chapter: brown bag meetings, e-mail, and knowledge repositories. The brown bag meetings serve as a value accelerator in the socialization pathway by providing a time and place for employees to exchange ideas and build on each others knowledge. This is accomplished in the simulation by a function that increases an existing tacit packet's priority. The brown bag meeting value accelerator is represented by a function which takes into account the existing priority of the packet as well as a randomization component.

Brown bag value accelerator = existing priority × (Normally distributed random number selected from between the numbers X and Y)

The numbers X and Y are equal to 10 and 50, respectively, in the instantiations evaluated in this chapter, but can be adjusted depending on the duration and variability of desired delays.

The e-mail value accelerator increases the value of explicit packets in the externalization pathway by increasing their priority. This has the subsequent effect on movement through barriers as seen above in the brown bag value accelerator. The increase in priority is based on a randomness component plus the number of information packets being sent and viewed. The accelerator assumes that as the email system is used more frequently, the probability of receiving a valuable packet will increase. The e-mail value accelerator is represented in the simulation by the following function:

E-mail value accelerator = existing priority + ((normally distributed random number selected from between the numbers X *and* Y) × probability of finding a good packet)

The numbers X and Y are equal to 10 and 50, respectively, in the instantiations evaluated in this chapter, but can be adjusted depending on the duration and variability of desired delays. The values used in the simulation of this chapter are found in Table 12.6.

Table 12.6 Probability of receiving a good packet

Number of explicit packets	Probability of receiving a good packet
0–100	0.05
101–250	0.1
251–600	0.2
601–1000	0.3
1001–1500	0.55
1501–2000	0.65
2001–5000	0.85
5001+	0.90

The last value accelerator is the knowledge repository. This value accelerator also operates by increasing the priority of explicit packets. A knowledge repository allows for packets of information to be stored and easily searched. This in turn allows packets to pass from the point and time of creation to an end user more rapidly than by e-mail alone. This effect of the knowledge repository is simulated by the following function:

Knowledge repository value accelerator = existing priority + ((normally distributed random number selected from between the numbers X and Y) × probability of finding a good packet)

The numbers X and Y are equal to 50 and 100, respectively, in the instantiations evaluated in this chapter, but can be adjusted depending on the duration and variability of desired delays. As is the e-mail value accelerator, the probability of finding a good packet is captured in Table 12.6.

12.7 Receiver of Good Packets

This last function in the simulation gathers statistics on how many packets, either tacit or explicit, were selected and the average length of time they were in the system prior to selection. This function only counts those packets that have a priority higher than 60. This gate can be adjusted for any given simulation. The packets as initially generated receive priorities normally distributed between 1 and 127, so a value of 60 establishes that about 50% of the packets will make it through at some point in time. The percent that ultimately make it through will vary depending on the length of the simulation and more importantly on the number of value accelerators each packet encounters. This follows from the logic that as you add value to your KMS (value accelerators), it will be used more often and thus more packets will be located and used for multiple purposes.

12.8 Evaluation Methodology: SME Model Instantiation Comparisons

The concepts and simulation model developed above will be applied to a theoretical SME environment for the purpose of evaluation. A basic model (see Fig. 12.2) will be developed that can be modified to represent alternative configurations of KMS infrastructure for the SME. The model will be adapted by addition of barriers, value accelerators, and parameter changes to reflect four alternative KM infrastructures for the SME. The artifact will be evaluated by comparing simulations of these separate SME organizational structures of barriers and value accelerators. The four instantiations evaluated in this study are as follows:

(1) *Instantiation #1 – baseline SME organizational structure:* This instantiation will consist of the socialization pathway (tacit packets) with a barrier (employee density) and an externalization pathway (explicit packets) with one value

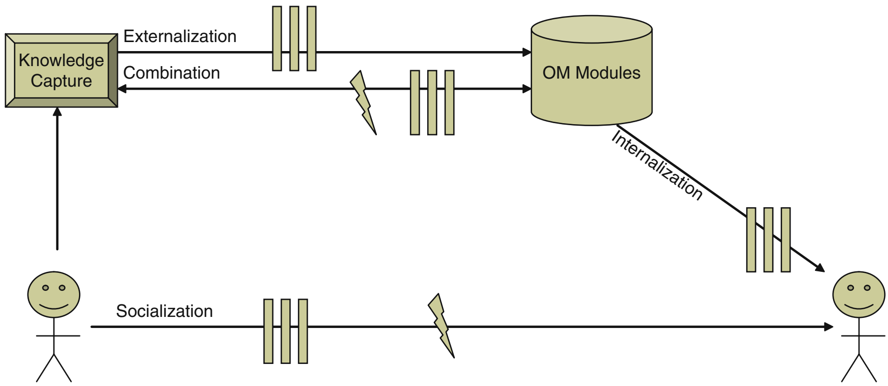


Fig. 12.2 Basic model

accelerator (e-mail). This organizational instantiation represents one of an organization with few initial personnel and a poor KM infrastructure and technologies. It is reflective of a small startup company with few employees and little infrastructure.

(2) *Instantiation #2 – enhanced socialization pathway:* This instantiation builds directly on the preceding one by adding one value accelerator to the socialization pathway. In this situation, the additional value accelerator (brown bag lunches) will represent a means to increase the flow of tacit knowledge by regular open exchanges of knowledge that might not happen by simple meetings in the hallway. This communication helps to promote the flow of knowledge through the employee density barrier found in this instantiation and instantiation #1.

(3) *Instantiation #3 – initial externalization pathway*: This instantiation builds directly on the second instantiation by adding a barrier to the externalization pathway. The barrier is titled "usefulness" and represents that a KM system provides little "usefulness" when the number of explicit information packets available for searching is low. As the number of packets in the system increases, so does the probability of finding a useful packet. The barrier's permeability increases as the number of packets increase.

(4) *Instantiation #4 – enhanced externalization pathway*: This instantiation will build on the third instantiation by adding a value accelerator (knowledge repository) to the externalization pathway. The value accelerator will improve throughput of knowledge packets by allowing for storage and future use. It also adds value by allowing for better categorization to aid in the search for specific information.

Each of the above four instantiations will be simulated 20 times: four categories of company size (5, 10, 20, or 50 employees) times five categories of the number of days (50, 100, 250, 500, and 1000). The results collected by each simulation will be the average time each packet spends in the system and the average number of packets received per person per day for both tacit and explicit packets. These key indicators of the efficiency and usefulness of the system will be plotted to evaluate the effectiveness of the model.

The four instantiations represent a sequential improvement that one might expect to see in an SME over time. The first instantiation represents the baseline and perhaps could be considered a very early stage startup. The second instantiation represents an improvement to the socialization pathway. This difference can be addressed by the following hypotheses:

H1a: The value accelerator implemented in instantiation #2 will significantly reduce the average time tacit packets spend in the system over that of instantiation #1.

H1b: The value accelerator implemented in instantiation #2 will significantly increase the number of tacit packets received per person per day in the system over that of instantiation #1.

Instantiation #3 represents the inclusion of a barrier on the externalization pathway to account for low usefulness of a KMS until a critical mass of packets are available for searching and finding valuable information. The fourth instantiation installs a knowledge repository to improve the usefulness of the KMS. This leads to the following hypotheses:

H2a: The value accelerator implemented in instantiation #4 will significantly reduce the average time explicit packets spend in the system over that of instantiation #3.

H2b: The value accelerator implemented in instantiation #4 will significantly increase the number of explicit packets received per person per day in the system over that of instantiation #3.

12.9 Results

The data from each simulation was collected in a spreadsheet for analysis and graphing. The data collected for each of the four instantiations was associated with their simulation-specific parameters of the number of employees and the number of days simulated. The key statistics collected for each were (1) the average time until a “tacit” packet reached a user of that packet, (2) the average time until an “explicit” packet reached a user of that packet, (3) the average number of “tacit” packets received by a user each day, and (4) the average number of “explicit” packets received by a user each day. The following figures report this data and are used to validate that the model is operating as instantiated.

The first set of figures (Figs. 12.3, 12.4, 12.5, 12.6, and 12.7) look at the baseline instantiation. This first instantiation, as detailed in the above evaluation section, incorporates an employee density barrier and an e-mail accelerator. The expectation

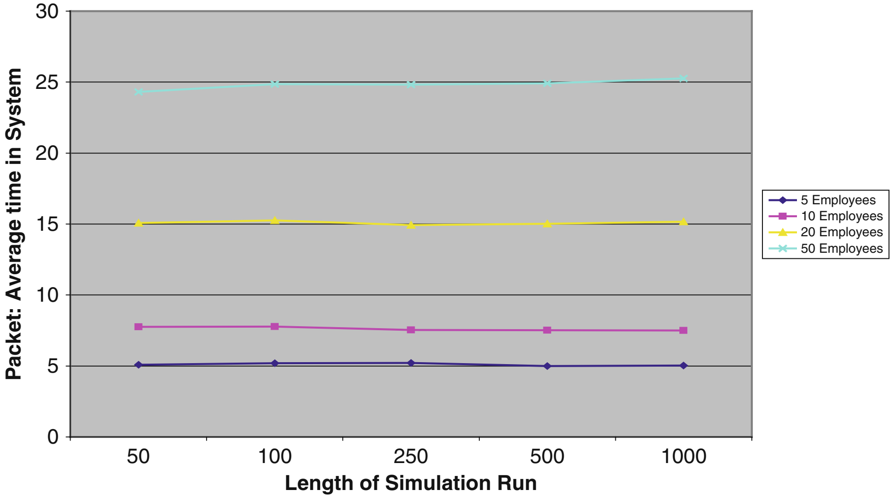


Fig. 12.3 Instantiation #1 – tacit packet average time (days) in system

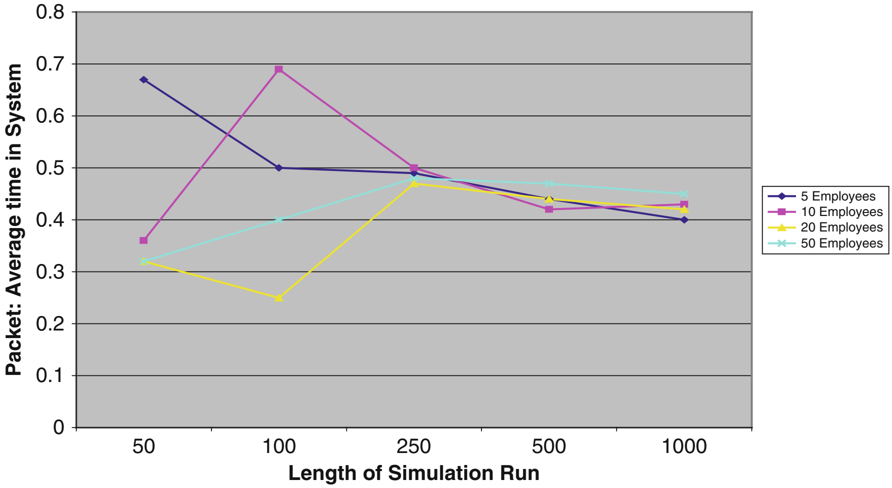


Fig. 12.4 Instantiation #1 – explicit packet average time (days) in system

for such an instantiation is that we would see evidence that the larger the employee population is, the longer the average time a tacit packet takes getting to the user of that packet. This might occur for two primary reasons: (1) as a company brings on more employees, some will be in support roles and not likely to be large contributors of new knowledge, and (2) the original small team, which had a relatively rapid exchange of that sharing, now are spending time managing and working with the new employees and less time exchanging new information. Figure 12.3 shows us

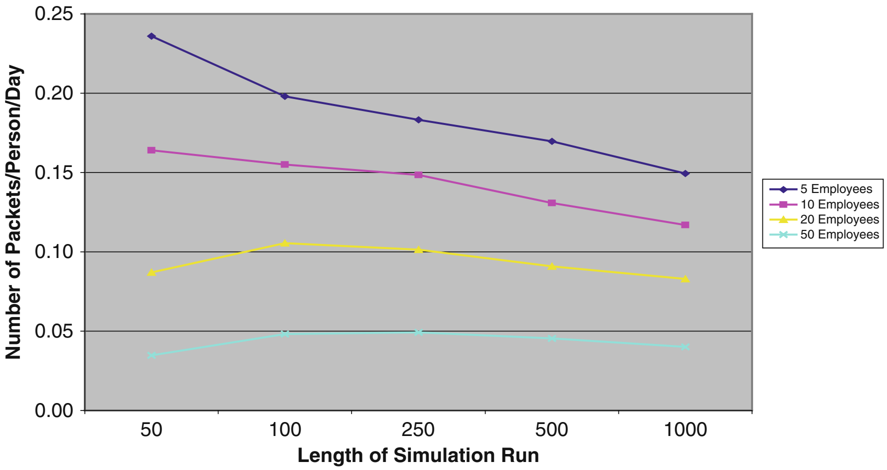


Fig. 12.5 Instantiation # 1 – tacit packets/person/day

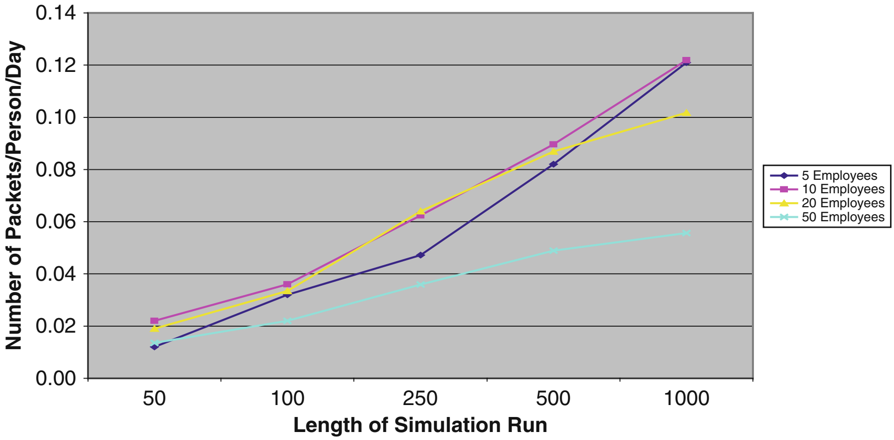


Fig. 12.6 Instantiation #1 – explicit packets/person/day

that our expectations are met. The line for 50 employees shows an average increase of 20 days per packet in the system – about a 400% increase from when there were only 5 employees. The expectation of a longer time through the system was met, but is the difference seen here too excessive or maybe not excessive enough? I believe this may be excessive because as a company grows larger, subgroups form around job responsibilities and the need for similar information. So perhaps a less drastic difference might be more realistic.

Figure 12.4 looks at the impact of this baseline instantiation on the flow of explicit packets. Since this instantiation does not have any barriers to explicit packets flowing through the externalization pathway, we would expect the time spent in the system to be invariant to the number of employees and the number of days simulated. Other than initial random noise, which disappears after about 250 days, this expectation seems to be met.

The next two figures look at the number of packets per person per day received. Figure 12.5 shows this for the tacit packets and Fig. 12.6 for the explicit packets. The expectations are that the number of tacit packets per person per day should be highest with a small employee population and lowest with the larger population. This is because in a smaller group there is more interaction and opportunity for exchange of information. As the group grows, the odds of a person with a valuable packet of information running into the right person who should receive that packet decreases. This is what the figure validates. What is also apparent in this figure is a downward slope for all lines. This is also expected. The downward slope is due to the transition over time from primarily tacit information flow to one of an increasing proportion of explicit packets. Initially there are few explicit packets generated, but as the number of days of simulation increases, more explicit packets enter the system. The more explicit packets in the system, the more interest the users have in looking for those packets, which further encourages the production of explicit packets as all members see this value.

The externalization pathway carries the explicit packets and in instantiation #1 there are no barriers in this pathway. We would expect to see an increase in explicit packets over time. As more explicit packets are accumulated, the "usefulness" of the KMS increases and proportionately more explicit than tacit packets are generated by users. This is validated in Fig. 12.6. This figure also highlights the effects of adding new personnel as the company grows: (1) as a company brings on more employees, some will be in support roles and not likely to be large contributors of new knowledge, and (2) the original small team, which had a given level of sharing and relatively rapid exchange of that sharing, now are spending time managing and working with the new employees and less time exchanging new information. The figure illustrates this effect as a distinctly lower increase in packets per person per day for a company with 50 employees relative to that of the smaller companies.

The next figure looks at the second instantiation, which adds in a value accelerator: brown bag lunches. This accelerator offers a means for a company to improve the flow of tacit packets, which will become more crucial as the company grows. When Fig. 12.3 is compared with Fig. 12.7, it can be seen that the number of days a tacit packet spends in the organization decreases. This comparison validates the expectations of the impact of the value generator in terms of both its effect on the time spent in the system and also on the greater value to a larger company.

Figure 12.8 can be compared with Fig. 12.5 to understand the effect of the brown bag value accelerator on the number of packets received per person per day. This comparison validates, that as expected, the average number packets per person per day increases due to the beneficial impact of the brown bag lunches on facilitating tacit information exchange.

The third instantiation adds the barrier: KMS usefulness. The purpose of this barrier is to reflect the impact perceived usefulness has on actual use of the system. If the users do not perceive the system as useful, because the information desired is

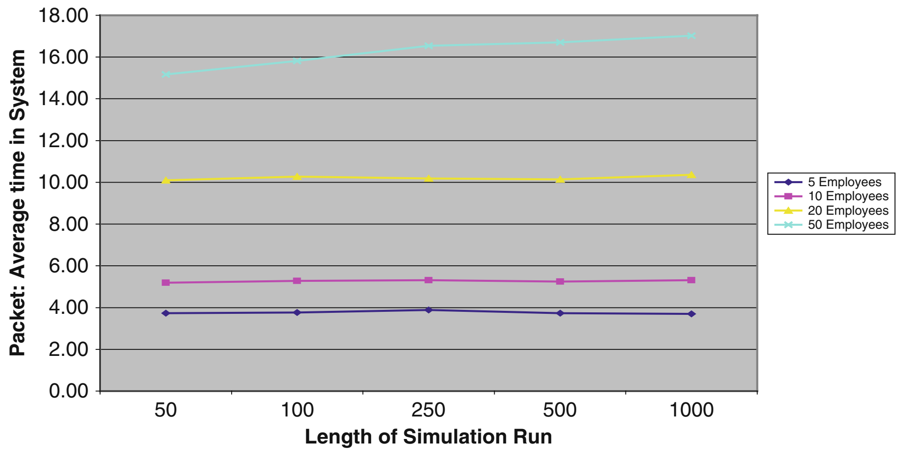


Fig. 12.7 Instantiation #2 – tacit packet average time (days) in system

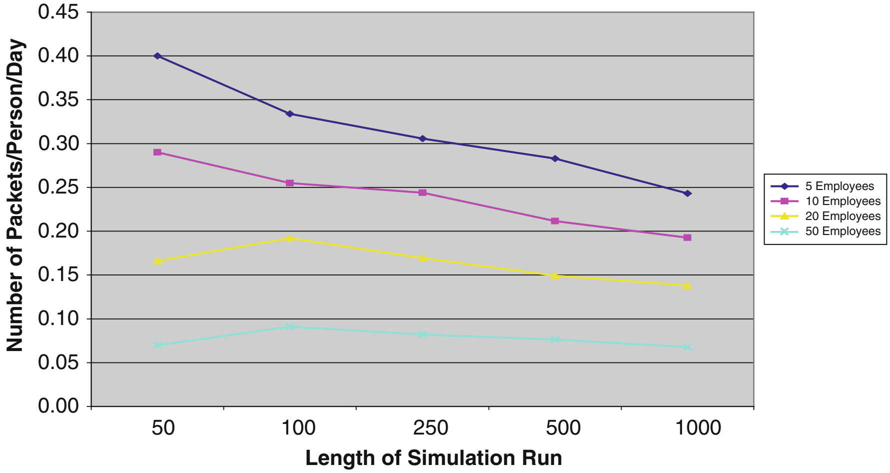


Fig. 12.8 Instantiation #2 – tacit packets/person/day

not available, then they will not use it. The premise of this barrier is that as more explicit packets enter the externalization pathway and build up, the perceived and actual usefulness will increase. Users will have a greater likelihood of locating the information they require in a bigger pool of packets. By adding this barrier, the expectation is that the average time an explicit packet spends in the organization will increase to a point (critical mass) and then begin decreasing as more use of the system occurs. This is validated in Fig. 12.9.

The effect of adding a value generator (knowledge repository) to the externalization pathway occurs in the simulation of the fourth instantiation and is seen in Fig. 12.10. The figure looks similar to Fig. 12.9, but the scale is shifted downward

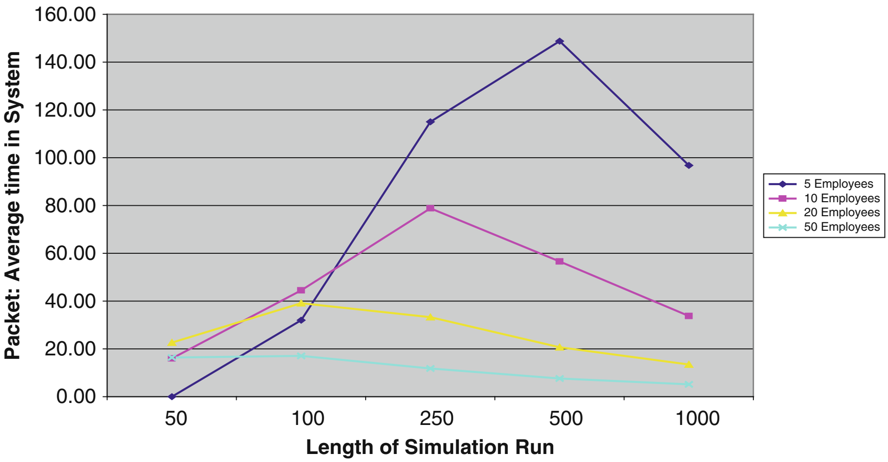


Fig. 12.9 Instantiation #3 – explicit packet average time (days) in system

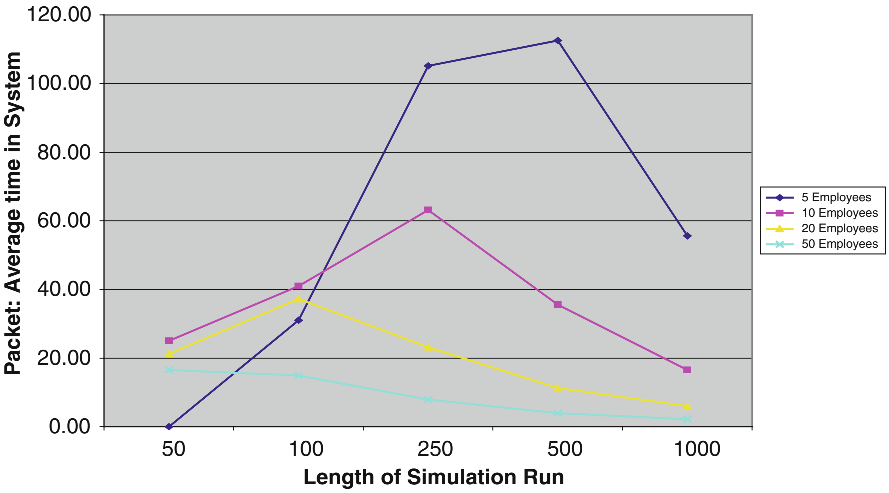


Fig. 12.10 Instantiation # 4 – explicit packet average time (days) in system

representing a faster throughput of packets in the organization. This was expected and validates the externalization pathway for barriers and accelerators (Table 12.7).

12.10 Contribution to Research

The process of developing and validating this artifact identified numerous areas where future research is required:

Table 12.7 Summary of results

Hypothesis	Supported/not supported
H1a: The value accelerator implemented in instantiation #2 will significantly reduce the average time tacit packets spend in the system over that of instantiation #1	Supported
H1b: The value accelerator implemented in instantiation #2 will significantly increase the number of tacit packets received per person per day in the system over that of instantiation #1	Supported
H2a: The value accelerator implemented in instantiation #4 will significantly reduce the average time explicit packets spend in the system over that of instantiation #3	Supported
H2b: The value accelerator implemented in instantiation #4 will significantly increase the number of explicit packets received per person per day in the system over that of instantiation #3	Supported

- How does one measure the number of tacit packets?
- What is the ratio of tacit to explicit packets?
- What factors establish the explicit/tacit ratio or cause it to change?
- What are the real barriers to flow of information and knowledge and what factors define them?
- What are the means to improve the flow of information through barriers and how are these means defined?
- How are all these questions affected by size, age, and industry of the company?

The design itself is an iterative process and as new theory or data on parameters become available the design will be improved. Using the knowledge gained from this study will provide insight into what researchers might look for and what they might see when studying knowledge flows in situ.

This research also provides some support that the organizational structure, number of employees, the type of information packet, and time can be modeled to understand how these variables interact. Future research may provide additional insight into how organizational structure, KM infrastructure, motivators, physical workspace, organizational climate, and actual behaviors work together to produce "usefulness" in a KMS for an SME.

12.11 Conclusion

This model with its four instantiations is an initial attempt to demonstrate that a simplified model of knowledge flows in a company is possible and provides valuable understanding. It points out a means of representing the flow through the use of barriers and value accelerators. Future development of the model needs to address the following:

- Sensitivity analysis of all parameter inputs.
- Validation of distributions used to simulate packet creation, barrier-induced wait time, and probability of finding good packets.
- How cost information can be combined with the model to better analyze strategies for implementation of value accelerators (relevance to the business community).
- Looking at how value accelerators not only alter priority for faster movement through barriers but may also generate new packets themselves (i.e., brown bag lunches provide opportunities to exchange knowledge – but they may also stimulate new knowledge).
- Use of ANOVA to understand the statistical significance of treatments associated with employee population size, time, and other factors on
  - average time for packets moving through the organization and
  - average number of packets received per person per day.

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