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A Conceptual Model for Enterprise Adoption of Open Source Software

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Abstract: *While IT researchers have long focused on achieving strategic benefits provided by IT investments, recently some have claimed "IT doesn't matter." We believe that most large organizations have both highly strategic and highly commoditized IT investments, and that differences in the strategic importance of information systems help explain where firms will adopt new technologies. We develop a framework that considers the tradeoffs between features, risk, and cost in IT adoption, and show how it can be applied to explain the adoption of open source software in large firms. We discuss a planned survey to provide empirical support linking the framework to enterprise deployment of open source software.*

The two decades from 1980-2000 marked tremendous growth in the organizational adoption of information technologies, through new users, new uses, and new technologies. Some (mainly smaller) firms adopted their first computers with the availability of desktop computing, while at larger enterprises, computing shifted from being a back office data processing system to become an integral part of daily operations and even used as a competitive weapon.

Much of the growth came from innovations leading to new technologies such as RDBMS,[1] RISC-based computing, local area networks, and web-based intranets. However, this huge growth in technology adoption masked a contrary trend in the declining real cost of computing, by more than 50% *per annum* during the post World War II era (Nordhaus 2001).

The end of the technology bubble in 2000 accelerated the cost reductions sought by IT management, which in turn fueled increasing commoditization of the IT industry. This commoditization of IT — along with the widespread adoption of IT by most sizable firms — prompted Carr (2003) to assert "IT doesn't matter" in terms of providing competitive advantage. Even those that disagree with Carr concede that many previously "strategic" information systems are no longer a source of differentiation.

Based on interviews, industry accounts, and prior IT research, we offer a framework to explain how enterprises make IT investments of varying strategic importance within the firm, each with a corresponding value for features, risk, and cost. We show how differences in the relative importance of these broad categories explain how, when, and where firms adopt new technologies.

We use this to consider the initial adoption of open source software in large organizations — customarily referred to as the "enterprise." We predict that such adoption will tend towards replacing systems of the lowest strategic importance and highest cost sensitivity, and offer a causal model explaining this adoption. Finally, we show how the model has implications for buyers and sellers of information technologies and the likely impact open source software will have on existing vendor-client relationships.

Strategic Value of IT Investments

Research on information systems over the past 20 years has sought to identify how a firm's IT spending provides it with strategic advantage. Among the earliest such work was that of McFarlan (1981, 1984; McFarlan et al, 1983), who provided managerial tools to help firms identify and maximize the strategic value of IT investments. More recently, researchers have sought to provide empirical evidence of how IT spending provides business value (for a summary, see Melville et al, 2004).

Varying Degrees of IT Importance

While firms differ in the level of strategic benefit they achieve from IT investments, usually such variation has been ascribed to differences between industries and a firm's position within an industry. McFarlan et al (1983) developed a "strategic grid" model that classifies firms (or divisions) into four categories — strategic, factory, support or turnaround — based on how strategically valuable IT is to the firm's (division's) performance. In their "strategic alignment" model, Henderson and Venkatraman (1983) contend that strategic benefit is contingent upon the alignment of IT function to the business strategy, and also the alignment of internal systems and processes to the external context.

Such research describes the variability of IT strategic importance on a firm-by-firm basis: some firms create advantage over competitors through their IT spending, while others have more routine IT needs in which IT plays an important but supporting role. However, most large firms today have a range of information systems, and this earlier research assumes that all systems within a given firm (or division) have similar strategic importance.

If all systems are of equal strategic importance, how would a firm ever adopt a new, highly strategic technology? Does this mean that any new technology must be adopted firm wide — an approach that reduces some management difficulties, but makes the initial deployment more risky (and thus requires more complex steps to mitigate risk)? These same questions also apply to cost-reducing innovations. For example, in their interviews with firms adopting open source software, Dedrick and West (2004) found that many firms adopting Linux viewed it as riskier (although cheaper) than other alternatives, and thus tended to initially deploy Linux systems for uses that were of lower strategic importance — such as displaying web pages or providing file and printer services.

Strategic Differences within a Firm

To explain technology adoption, we focus on the differences of strategic importance between systems. Our unit of analysis is the information system: we consider differences in importance of systems between firms, within firms, and how the importance of a given system changes over time.

To help explain how such importance explains IS department decisions to buy and operate systems, we classify production systems into three broad categories of strategic importance: strategic, mission critical, and support. We also posit a fourth type of system (laboratory) that is used for experimental evaluation and deployment.

We call these categories "stages";[2] the characteristics of each are as follows:

- *strategic.* These are systems that provide actual (not imagined) competitive advantage over rivals. To achieve such advantage, they tend to require the greatest resources and top management "mindshare" (McFarlan et al, 1983; Venkatraman, 1994).
- *mission critical.* The smooth and reliable operations of the systems in this stage are critical to the fulfillment of the mission of the enterprise, and their failure (however temporary) can subject the enterprise to loss of sales, profits, and customer loyalty. Thus, reliability is paramount for such systems, and they also require significant resources.

- *support.* These "routine systems" (to use the phrase of Saarinen & Vepsäläinen 1994) provide business value by improving the enterprise's internal efficiency; as such, decisions about these systems are usually driven by cost-efficiency. For a typical enterprise, these might included desktop, productivity, communications, and much of the IT infrastructure; however, the classification of a system by any given firm is based on the business value to that firm, not the technology employed.
- *laboratory.* These non-production systems are developed in response to demands for pilot studies and experimentation with new technology.[3] This stage is a temporary stop for systems that are being evaluated for a permanent operational role, although not all systems will "graduate." As Dedrick and West (2004) found, the evaluation of new technologies often depends on the availability of "slack" human capital within the organization.

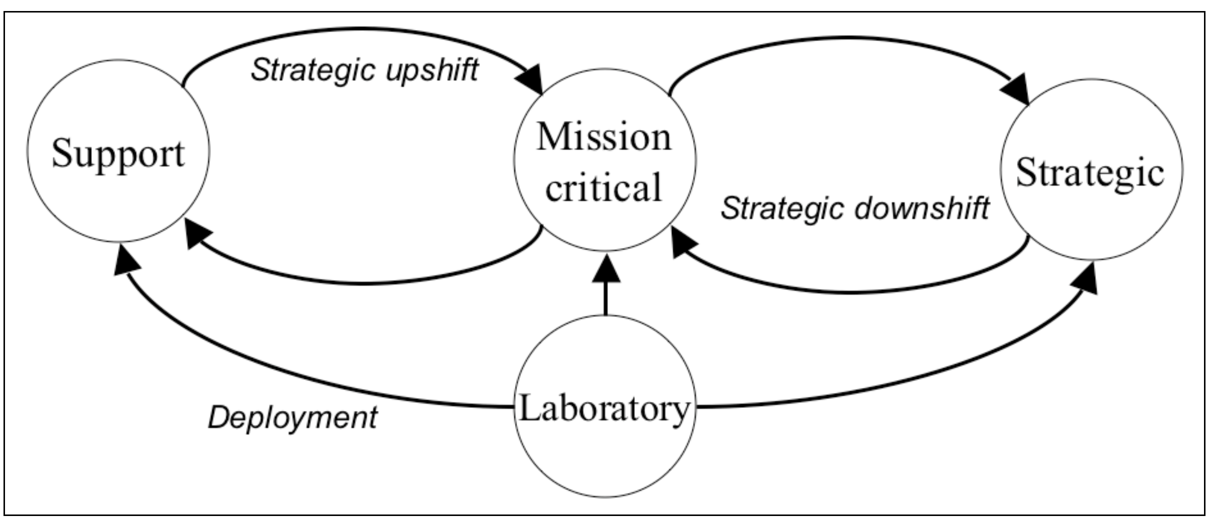
The differences among stages are summarized in Table 1.

Table 1. Hypothesized Tradeoffs between Stages

Stage	Goal	Driver	Contemporary Example
Strategic	Competitive Advantage	Differentiation	Customer Relationship Management (CRM)
Mission critical	Reliability	Risk	Transaction Processing
Support	Efficiency	Cost	Office Automation
Laboratory	Evaluation	Future Advantage	Radio Frequency Identification (RFID)

Over time, the strategic importance of a given system may increase or decrease, and thus shift between stages (Figure 1). One common example is systems that were once unique and provided strategic advantage that are now common among rivals; such systems neither provide advantage, nor can they be discontinued without creating a competitive disadvantage; Neumann (1994) says such systems have become a "strategic necessity". Another example is for laboratory systems, which, once deployed, shift to one of the three operational stages.

Figure 1: Shifts between stages of strategic importance



Tradeoffs Based on Strategic Importance

While enterprises procure systems of differing levels of strategic importance, there are other differences as well. In allocating resources for each system, firms must decide the relative importance of competing product attributes. When analyzing attributes of various products — in academic research, trade journals, and product promotional materials, we classify these attributes into three categories:

- *F: features.* These are the attributes commonly used to measure what is new or valuable about a given technology, and used by vendors to differentiate their products. Because anything could be tautologically classified as a "feature," we define feature as the residual of the two remaining categories.
- *R: risk.* Risk for a system is often thought of in terms of reliability — the comparative scarcity of crashes, failures, or data loss. However, risk-lowering measures might also include efforts to mitigate the effect of inevitable if rare failures (such as redundant data or 7/24 support). Firms may also consider the risks of their investments over time, such as the risk that the technology may be orphaned by the vendor (either deliberately or with the vendor's bankruptcy), or that for some other reason the investment is rendered obsolete.
- *C: cost.* These may include both the initial purchase price, and the ongoing usage costs such as support contracts and upgrade fees. An attempt to calculate total cost of ownership would also include personnel cost, and (for large data centers) related equipment costs such as power, air conditioning, security, etc.

The interpretation of all of these attributes will depend on the firm and system context. Features that matter to one buyer may be irrelevant to another. For psychological (or accounting) reasons a firm may only consider the initial acquisition cost, while staff costs are treated as quasi-fixed costs.

All things being equal, firms would prefer to have the greatest number of features at the lowest risk and cost. However, the feasible region of the tradeoff space is determined by the availability of products. In particular, we would expect cost to be inversely related to the other attributes, because vendors will seek to maximize profits by increasing prices based on customer perceived value, such as provided by more features or lower risks (Shapiro & Varian, 1999).

So how do firms trade off the F, R, and C attributes? We would expect that the only systems that justify the highest costs are those that generate the greatest strategic value, so such systems (i.e., in the strategic stage) and enterprises would seek the most advanced features and capabilities. At the other extreme, Dedrick and West (2003, 2004) found in their interviews with MIS buyers two important motivations driving many buying decisions in the post-dot com era:

- a desire for lower costs that motivated the adoption of lower cost solutions to existing problems;
- a recognition that achieving lower costs requires either giving up features or accepting higher risk.

Thus, we would expect the trade-offs between features, risk, and cost made by IS managers to vary based on the strategic importance of the systems.

From this framework, we make three types of predictions:

- within systems of similar strategic importance, the relative importance between features, risk, and costs are similar (see Table 2);
- between systems of different strategic importance, the differences in the importance of these three attributes are based on differences in strategic importance; and
- within the same system, the relationship for features, risks, and costs is among different layers of the systems stack.

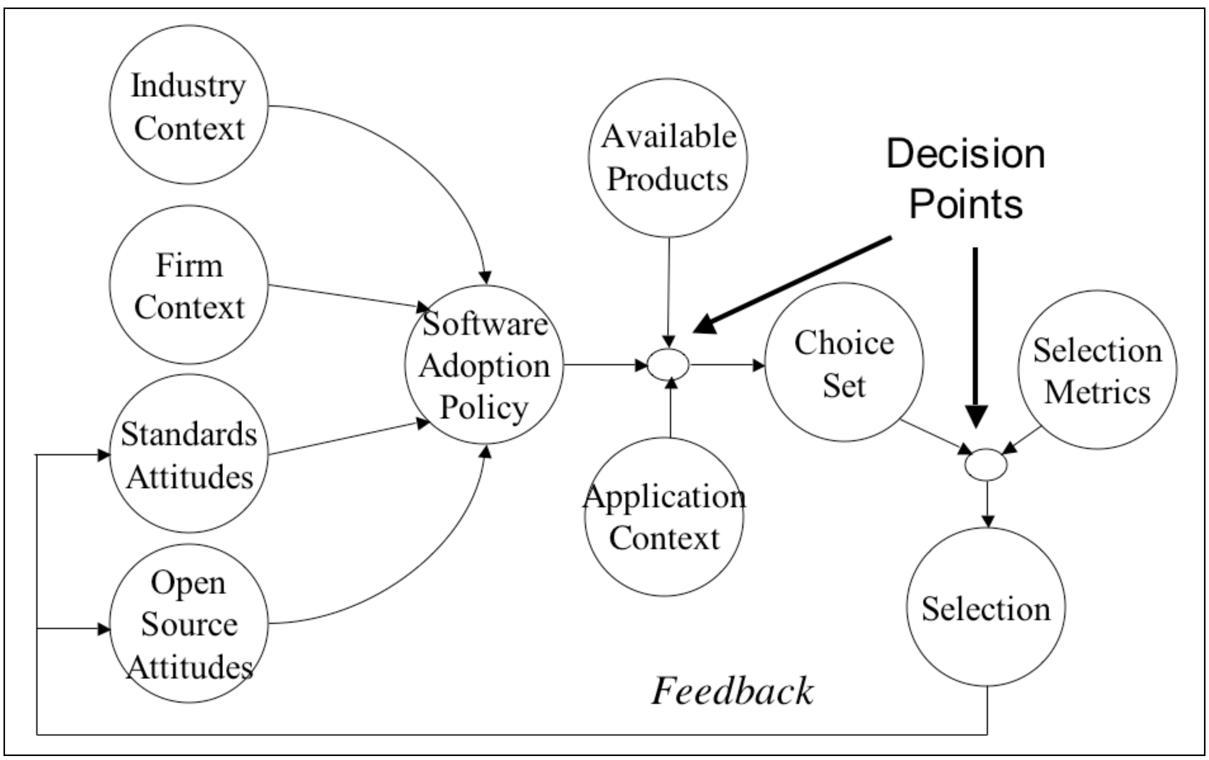
Table 2. Hypothesized tradeoffs between Stages

Stage	Features	Risk	Cost
Support	Minimal	Moderate	Low
Mission Critical	Standard	Little or none	Moderate
Strategic	High	Low	High
Laboratory	Varies	High	Medium

A Model for Open Source Adoption

From the stages framework, and our interviews with vendors and IS managers, we developed a conceptual model of how enterprises would evaluate open source software (in competition with commercial software) for inclusion in their information systems (Figure 2).

Figure 2: Model for open source adoption



The model assumes a three phase process:

- *policies.* The firm establishes a series of policies (formal or informal) that guide its procurement decisions.

- *choice set.* From the range of available options, at the first decision point the firm identifies those acceptable alternatives that meet minimum requirements.
- *selection.* From the range of acceptable alternatives, at the second decision point, the firm makes its final selection decision.[4]

Software Adoption Policies

Not all enterprises have formal policies for software adoption, but most have a pattern of attitudes and decisions that constitute a *de facto* policy about how open source software will be considered. The "Software Adoption Policy" included in the model subsumes both the formal and informal policies of the organization. The policy not only determines the preferences for buying decisions (e.g., 7/24 vendor support vs. self-support), but also those areas for which there is a consistent companywide policy. For example, the organization may have a strategic relationship with a single hardware vendor, but procure database software or integration services from multiple competing vendors.

What factors influence the makeup of the policy? We identify four broad categories:

- *industry context.* As Porter (1980) observes, different industries have different levels of competitive intensity, profitability, buyer power, and (over time) a different series of environmental shocks. Thus, the context of the U.S. electric utility industry in October 2001 would be far different than that for the commercial airline industry. And as McFarlan et al (1983) note, a common industry context can lead to a similar strategic IT importance across multiple firms in that industry.
- *firm context.* Despite a common context between firms in an industry, various firms will have different competitive positions and role for IT; one of the key variables is the level of IT intensity in a firm compared to its peers. For example, IT spending has historically been more important for Wal-Mart than for most other U.S. retailers. We would expect that (compared to industry peers) the high IT intensity firms would be more knowledgeable about IT, spend more time evaluating new technologies, and be more likely to deploy systems of strategic importance.
- *standards attitudes.* For decades, firms have long had differing opinions about the value of tight integration provided by proprietary vendors compared to the choices provided by open standards. For example, Chau & Tam (1997) concluded that differences in attitudes towards standards explained the likelihood of firms adopting open systems.
- *open source attitudes.* Based on the work of Dedrick and West (2004), other research, and our own interviews, we would expect attitudes towards open source to roughly parallel those towards open standards — some are favorably disposed towards open source, some are antagonistic, and others make software adoption decisions without regard to whether the solution is open source or commercial.

The attitudes may originate as top-down mandates, or bottom-up technology initiatives led by the rank-and-file IT workers most knowledgeable about new technologies. We do not hypothesize that the originating direction predicts the policy decision, although we observe that with open source software (as with other disruptive innovations such as personal computers and open systems), the firms that adopt a pro-innovation policy are often pushed by a bottom-up initiative.

Personal Motivations for Adopting Open Source Software

Companies have many rational, objectively measurable reasons for adopting open source software. However, at the same time, it is hard to ignore that decisions are made by individuals, who have a combination of personal and professional motivations. This is particularly applicable to open source, the passion of advocates has often been compared to religious zealotry (Wikipedia 2004).

Much of the early discussion of open source motivations was written by open source advocates, who emphasized factors such as "free as in freedom" (ability to modify source code) as reasons for users selecting open source (or "free") software (e.g. Stallman, 1999). Implicitly or explicitly, a second key motivation was reducing the power of dominant proprietary vendors such as Microsoft. Later on, some of the early academic studies were openly sympathetic to such goals.

In contrast to these earlier studies and advocacy, in their interviews with Linux adopters Dedrick and West (2003, 2004) found little evidence of source code modifiability being an important motivator for open source adoption. They explained the discrepancy in terms of adopter characteristics, in which the earliest 2.5% of adopters (termed "innovators" by Rogers 2003) have different motivations and priorities than the broader market of subsequent potential adopters.

What did explain adoption in their study? They found two factors: compatibility and cost. Linux adopters came from organizations with strong Unix skills; programmers and managers in these "Unix shops" saw the Linux operating system as a natural outgrowth of Unix, both technically and philosophically. At the same time, the organizations that switched from Unix to Linux were facing major cost pressures, and were willing to accept increased risk in exchange for reducing costs (primarily due to using commodity Intel-compatible hardware).

Choice Set and Selection Processes

We model a two-step selection process: the first step establishes a choice set of acceptable products and the second step selects from among those products.

In our model, we focus on the first decision point to establish the choice set, where we expect the decision will be guided by three factors:

- *software adoption policy,* which in turn reflects the industry and firm context, and attitudes towards standards and open source;
- *application context,* which reflects the strategic importance of the specified system and thus the corresponding importance (and choice set limits) for features, risk, and cost; and
- *available products,* where the preferences of the buyer for a particular policy or set of FRC trade-offs may be constrained by a limited number of available choices.

These factors will influence both the minimum (or maximum) acceptable attribute value as well as the relative importance of each attribute. For example, a firm may have a policy to only buy systems that include 7/24 support from a Fortune 500 company; or, it may require such support for systems at the mission critical stage, but not for less strategic support stage systems. These minimum requirements would be incorporated in the bidding constraints for the systems procurement, and systems that fail to meet these minimums are disqualified (cf. Timmerack 1973).

Similarly, a firm may have a maximum acceptable cost or a minimum acceptable feature list, but improvements beyond these limits would make one product more attractive than another — where cost improvements would be most valued for support stage systems and features valued for strategic stage systems.

Case Study: Strategic Downshift at Sabre Holdings

In the early 1960s, American Airlines and IBM developed SABRE, the first online airline reservations system. The system built upon much of what IBM and MIT had pioneered during the 1950s (notably in real-time computing) by designing computer systems to support the SAGE air defense radar system.[5]

During the 1970s and 1980s, Sabre was often cited as an exemplar of a strategic IT system (e.g., Hopper 1990). To provide competitive advantage for American, Sabre employed an expensive proprietary architecture incorporating custom applications, IBM's Transaction Processing Facility (TPF) applications platform, and IBM-compatible mainframes. American eventually concluded that selling services to its competitors would generate more value than any advantage provided by vertical integration. In 1996, it spun out The Sabre Group (later Sabre Holdings) as a partly-owned subsidiary, which was fully divested in 2000.

In the mid-1990s, the Sabre division had concluded that it needed to migrate applications off its mainframe to lower cost open systems while maintaining the reliability, scalability and performance of the mainframe environment. One problem was that its web-based shopping service Travelocity.com allowed potential customers to browse for possible flights without necessarily buying; any rise in the "look to book" ratio increased Sabre's data processing costs without increasing revenues.

In response, Sabre developed a new three-level IT architecture. For the lowest-revenue, most-compute intensive activity — air travel shopping — the new system uses Itanium and Opteron servers running two open source packages: the Linux operating system and the MySQL database. The new architecture delivers adequate data synchronization and reliability at a lower cost, while the use of commodity processors improves scalability and upgradeability.

When it comes time for Sabre to book the customer's flight — creating a contractual obligation to provide air carrier service at the quoted price — Sabre needs higher reliability and data integrity than with its shopping system. It reduced costs by shifting the final pricing from the mainframe to fault-tolerant, open standards HP NonStop Servers, while retaining the mainframe (at least temporarily) for executing the booking transaction. A single customer sale would thus involve three separate architectures, each one optimized by Sabre for the particular risk vs. cost trade-offs of that part of the shopper's visit — and integrated so that the handover is transparent to the buyer.

The entire Sabre system demonstrates the concept of strategic downshift, as the once highly strategic system faced increasing cost pressures. Part of the architecture migrated to *support* stage systems, using commodity hardware and open source software to provide "good enough" solutions; the remainder of the architecture was supported by *mission critical* stage systems that deliver high reliability at the lowest possible cost.

Sources: National Research Council 1999; Stafford, 2003; Anthes 2004, Burt, 2004; AA.com, IBM.com and Sabre-Holdings.com websites

The choice set is determined once the firm has identified the set of products that are "good enough to be considered." After this, firms will apply their own selection metrics to the choice set to determine the actual product to be selected. This process has been studied by many researchers and the problem and methodology is well understood by IT managers (e.g., Timmreck 1973; Klein & Beck, 1987; Tam & Hui, 2001; Stehman, 2004), although we would expect that many of the particulars of this second decision process will be specific to each firm.

Discussion

We believe that the stages framework and the enterprise software adoption model have the potential to better explain the differences in firm adoption decisions by considering the differences both between firms, within firms, and over time.

Managerial Implications

The model and framework have implications for both buyers and sellers of information technologies. For enterprise IT buyers, both the model and framework make explicit trade-offs between features, risk, and cost and how these trade-offs vary for different systems across the IT portfolio. IT managers can use the framework to identify those support applications where the goal is a “good enough” solution at the lowest possible cost, and the strategic applications where true competitive advantage must be realized to justify the higher level of associated funding.

The adoption model we described incorporates the influence of IT buying policies, and points to the role of such policies in realizing a given firm’s IT strategy. Our preliminary research suggests that many firms have adopted open source first, and then sought to make a consistent policy after that decision to ratify and codify the initial decision. This is consistent with the earlier research of Nolan (1973; Nolan & Gibson, 1974), who showed that after new technologies were adopted, IT managers developed policies and guidelines as a means of control.

While the model is intended to test the behavior of large organizations, it also has potential applications to small and medium size enterprises (SMEs) that lack the formal processes of their larger brethren. Such SMEs rarely have the scale necessary to either hire integration or consulting firms to help them make software adoption decisions, or to perform a thorough internal evaluation. The process outlined here could provide a practical template for systematizing the IT adoption process, and establishing the policies necessary to guide that process.

Finally, the model and framework offer insights for IT vendors, particularly the name-brand vendors whose previous differentiation-driven margins are threatened by the commoditization associated with strategic downshift. Recognizing which stages value features, risk, and cost enable vendors to concentrate their value-creation effort on those product segments where that value will be recognized by buyers.

Conversely, open source vendors seeking to promote commoditization can identify segments of greatest existing opportunity, as well as factors (such as risk and advanced features) that delay adoption of their products for more strategic applications. Some examples:

- MySQL has been adding more advanced features to its database product by acquiring technology and merging with other products (Krill 2003; Salkever 2004).
- Established vendors such as HP and Novell have mitigated the risks buyers face in adopting open source by offering indemnifications and warranties for open source software such as JBOSS or Linux.
- On the service and maintenance side, it is now commonplace for vendors and integrators to offer “one-stop” shopping for professional level-of-service agreements.

Theoretical Implications and Future Research

Both the stages framework and the enterprise software adoption model provide a richer view of how firms differentially apply requirements and resources to the systems in their IT portfolio. We hope that future researchers will move past the conception of a firm's IT strategy as a monolithic attempt at strategic alignment, and instead consider the complexities of differences within a firm's IT portfolio and strategy.

To test and validate both the model and the framework, we are now designing a large scale survey of enterprise IT users. In particular, we plan to focus on two key implications of the model for open source adoption:

- How does the strategic importance of a given application relate to the features, risks, and costs of the system chosen to implement that application?
- Is adoption of open source driven more by the requirements for a specific application, or by general attitudes towards the suitability of open source for their organization?

To test our hypotheses we plan on sampling a stratified sample of large organizations (such as the *Fortune 1000*). We hope to report preliminary results in Q2 2005.

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Notes

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[1] RDBMS: Relational Database Management System

[2] The term "stage" (or the similar "phase") has brought complaints from those who object to the implication that all systems will of necessity pass through each stage; terms such as "category" or "mode" have been suggested. Our classification system explicitly allows for such shifts over time, but does not require them.

[3] We are not aware of previous Information Systems (IS) research that explicitly identifies the importance of such pre-deployment systems as part of the IS portfolio, even though the use of this approach is widely accepted as the norm for large scale deployment of new complex systems.

[4] To simplify the later discussion, we assume that the process leads to a single adoption decision for each application (system) in the company's portfolio. However, we recognize that in some cases multiple systems may be deployed, or that a production "bake-off" extends the competition past evaluation into deployment, or that the losing vendor/product may be kept in reserve as a backup choice should the customer become dissatisfied with its first choice.

[5] The common heritage is illustrated by the acronyms SAGE (Semi-Automatic Ground Environment) and SABRE (Semi-Automated Booking and Reservation Environment).

Biographies

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Stephen K. Kwan is professor and chair of the Management Information Systems department at the College of Business, San José State University. He is the Principal Investigator of the Silicon Valley Open Source Research Project. Kwan is also working on research projects looking into the critical factors that contribute to the success of location commerce and the application of new technology in hospital administration systems. He received a B.S. and M.S. in Computer Science from the University of Oregon, and a Ph.D. in Management from UCLA. His research has been published in *European Management Journal*, *Information Systems*, *Data Base*, *Queueing Systems: Theory and Applications*, and *ACM Transactions on Office Information Systems*.

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