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THE CAPABILITY MATURITY MODEL: A VALID ARCHITECTURE TO SUPPORT A BASELINE ENVIRONMENTAL MANAGEMENT MATURITY MODEL

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ABSTRACT

Because of the necessity of organizations to compete in a global economy, industrial management is increasingly becoming of paramount importance to strategic pursuits, competitive advantage, and corporate function. Although various management methodologies favor process improvement activities to pursue and sustain corporate activities, they do not uniquely address environmental process improvement through a standardized framework. Further, no single baseline framework exists to uniquely address process improvement issues with respect to environmental management considerations from an evolutionary and process maturation perspective. As a method of addressing this shortcoming, this paper considers the issue of whether the Capability Maturity Model (CMM) architecture may be modified to create a baseline framework capable of addressing environmental process improvement initiatives. Further, an introductory proposal to outline a framework for an Environmental Maturity Model (EMM), derived from the CMM architecture is presented as a management tool to enhance process improvement initiative within management settings.

ENVIRONMENTAL MANAGEMENT

Numerous environmental hazards and disasters occurred during the last century. Such events include both natural and unnatural disasters include forest fires; floods and storms; earthquakes; wars; oil spills; and aviation accidents. The 20th century witnessed two world wars and numerous regional conflicts. During 1999, the Marma region of Turkey suffered from an earthquake (Akinci, 2004). Extreme weather events devastated the region of Barrow, Alaska during 1963 (Brunner, Lynch, Pardikes, Cassano, Lestak & Vogel, 2004). The Chernobyl accident occurred during 1986 (Marples, 2004). The Exxon Valdez was grounded during 1989 (Kurtz, 2004). Hurricane Camille devastated the U.S. Gulf Coast during 1969 (Otvos, 2004). Arkansas suffered from the flooding of the Mississippi River during 1927 (Bearden, 2003).

Saha and Darnton (2005) discuss the tensions between corporations and environmental factions. These considerations permeate firms from both domestic and international perspectives. Similar observations are given by Seldman (2005) from the perspectives of “clean operations.” Bonazountas, Killidromitou, Kassomenos and Passas (2005) discuss forest fire management and risk analysis, and introduce modeling concepts of mapping fires and managing risk. Gerald (2005) discusses water management during periods of disaster. The U.S. experienced an oil embargo during 1973 (Roeder, 2005). Porter, Blett, Potter and Huber (2005) examine the atmospheric considerations associated with environmental practices. Wagner (2005) considers whether environmental protection programs have the potential of saving lives and reducing the impact of disasters. Each of these considerations may affect political policy and legislation. These arguments indicate that environmental management philosophies are of paramount concern among governmental agencies and political parties; the common citizenry; and businesses.

CAPABILITY MATURITY MODEL

The capability maturity model (CMM) facilitates continual process improvement through "evolutionary steps rather than revolutionary innovations" within a framework of "five maturity levels that lay successive foundations for continuous process improvement (Kan, 1995; The capability, 1994)." These maturity levels encompass the following stages: 1. initial (random); 2. repeatable; 3. defined; 4. managed; and 5. optimizing. Each CMM level increases visibility into "processes for both managers and engineering staff," and focuses upon "processes that are of value across the organization." In essence, the CMM becomes an evolutionary achievement of mature processes. Within maturity levels two through five are key process area (KPA) requirements for the outlining of maturity goals.

Each KPA has key practices that describe the "activities and infrastructure that contribute to the most effective implementation and institutionalization of the key process area (The capability, 1994)." Each succeeding level of maturity introduces additional KPAs while retaining and building upon KPA tenets of each previous maturity level as a method of generating process maturation (based upon levels two through five of the CMM). Ordering is determined by common attributes that judge the effectiveness, repeatability, and durability of KPAs. Five common KPA areas are manifested, and are given by the SEI as follows:

Table 1: KPA Areas

Area	Description
Commitment	Organizational actions that establish durable processes, policies, and leadership.
Ability	Existing preconditions (e.g., resources, organizational structures, etc.) for process implementation.
Activities	Events, roles, and procedures for KPA implementation. Project planning, tracking, procedures, and contingencies.
Metrics	Status related to processes via measurements and analysis.
Implementation	Verification of implementation (e.g., reviews and audits) in accordance with established processes.

Given this basis of the CMM, organizations may improve their environmental processes through evolution from an *ad hoc* to an optimized setting. Reliance upon the "individual heroics of personnel" may evolve to manifest a "strong sense of teamwork that exists across the organization" (Paulk, 1995; The capability, 1994). Finally, environments that employ "risky technological environments" and "*ad hoc* data collection" methodologies may evolve into settings where "proactive technological embellishment" and "defined data analysis" are manifested to generate process improvements (Paulk, 1995; The capability, 1994).

CMM DERIVATION

Evidence exists to suggest that the baseline CMM architecture is portable across unrelated application areas and settings. Turetken and Demiroros (2004) indicate that the CMM philosophy may be applied within human resources management functions. Nightingale and Mize (2002) investigate applications within the realm of lean enterprise transformation. Gilllies and Howard (2003) examine applications within respect to organizational processes and human resources. Given these examples, the CMM framework may be applicable across a myriad of domains.

ENVIRONMENTAL MATURITY MODEL

The CMM is not directly concerned with environmental management philosophies or methodologies, but it is concerned with the overall improvement of processes within organizational software environments. The CMM suffers shortcomings when applied to organizational functions that are unassociated with software development because KPA requirements do not exist to directly address unrelated issues. As a method of applying the CMM concept to additional organizational functions, one may consider developing a CMM-based derivative framework that facilitates process improvement efforts with respect to environmental management issues. Thus, an EMM could be crafted using the CMM architecture and environmental KPAs as its basis.

The proposed EMM employs similar maturity levels found within the CMM (i.e., initial through optimizing), and employs a unique set of KPA requirements within each maturity level. The EMM KPA requirements address environmental management issues. As a result of introducing the proposed EMM into corporate structures, organizations would gain an additional tool through which improved environmental management functions could be facilitated.

Similar to the CMM, each proposed EMM level increases visibility into processes for supervisors and staff, and focuses on the organizational value of processes. Within levels two through five of the proposed EMM are key process area (KPA) requirements that outline process goals with respect to environmental management functions.

Based on the CMM, the proposed EMM contains key practices for describing the “activities and infrastructure that contribute to the most effective implementation and institutionalization of the key process area” (The capability, 1994). Each succeeding EMM maturity level introduces additional KPAs while retaining and building upon KPA tenets of each previous maturity level as a method of generating process maturation (based upon levels two through five of the proposed EMM. Thus, similar to the CMM framework, order is determined by common attributes that judge KPA effectiveness, repeatability, and durability.

Given this basis for the EMM, organizations may greatly improve their environmental initiatives and processes through evolution from a setting where “few processes exist” to becoming a setting in which processes are “continuously monitored and systematically improved” in a fashion that parallels CMM implementation (Kan, 1995; The capability, 1994). Further, through implementation of the EMM architecture, organizations that employ risky and chaotic methodologies may evolve into settings where “proactive technological embellishment” and “defined data analysis” are manifested to generate environmental management process improvements similar those required by the CMM framework (Kan, 1995; The capability, 1994).

CONCLUSION

As organizations progress toward higher levels of global competitiveness, they must remain aware of environmentally sound management practices. When competing within a global arena, corporations must also remain aware of the relationships among their operating practices with respect to various forms of domestic and international legislation; ISO requirements; and industry dictates. Each corporation, regardless of its industry or physical location, must examine its processes to ensure that they are optimal and environmentally sound. Given these notions, coupled with information previously discussed, one may derive the following concepts regarding such attributes of environmental management process improvement initiatives:

1. Because the CMM is primarily concerned with software process improvement instead of high-level organizational quality issues, it suffers shortcomings when applied to unrelated areas because necessary KPA requirements do not exist.

2. Many methods of developing sound environmental management practices exist (e.g., legislation; ISO requirements; etc.), but do not directly address discrete issues related directly to process improvement maturity.
3. As a method of addressing the environmental management tenet of process improvement within organizational functions unrelated to software environments, derivatives of the CMM may be generated (e.g., an EMM; etc.) via development of necessary KPA requirements.
4. Based upon CMM architecture, an EMM framework may be generated to address the unique requirements challenging sound environmental management practices. Within the EMM are maturity levels and KPAs associated with environmental management issues.

Through use of the CMM as a basis, organizations may develop EMM activities through which the maturity of environmental management processes may be improved. Given the EMM flexibility, environmental management activities may evolve their separate set of objectives, maturity levels, and KPA requirements necessary to address issues of environmental management process improvement. The proposed EMM represents a protocol through which an environmental process maturity framework may be crafted, matured, monitored, and maintained.

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IMPLEMENTATION OF THE CAPABILITY MATURITY MODEL TO SUPPORT CONTINUOUS PROCESS IMPROVEMENT TENETS OF THE TQM PHILOSOPHY

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ABSTRACT

Because of the necessity of organizations to compete in a global economy, quality management within the organizational environment is of paramount importance to strategic pursuits, competitive advantage, and corporate survival. Although the philosophy of Total Quality Management (TQM) advocates continual process improvement activities to facilitate achievement of corporate objectives and goals, it does not uniquely address process improvement in a discrete fashion. As a method of addressing this shortcoming, the Capability Maturity Model (CMM) may be implemented as a tool through which the process improvement efforts of an organization may be matured to facilitate effective corporate TQM implementation and pursuits.

INTRODUCTION

Given the proliferation and growth of global business during the last century, both organizations and individuals have been affected with numerous challenges with respect to quality management. Despite recent introduction of TQM philosophies to improve quality within organizations, services, and products, there is a component shared by each philosophy: the manifestation of organizational and individual human processes and procedures within the corporate environment that contribute to improving the overall effectiveness, efficiency, and performance of an organization (Kendall & Kendall, 1995; Paulk, 1995). Although TQM is a product of human ingenuity, it remains that not all organizations and individuals associated with the implementation of TQM achieve the potential maximum benefit derived from its continuous process improvement tenet.

As a method of alleviating difficulties encountered with initial implementation of TQM initiatives, both organizations and individuals are responsible for devising efficient, effective tools through which TQM may be fostered. Thus, through introducing the CMM as being a valid mechanism through which continual process improvement may be generated within TQM, both individuals and corporations may experience greater benefit of TQM implementation. Given this concept, this paper shall address the issue of whether CMM implementation is a valid supportive measure for TQM, suggest recommendations, and shall delineate conclusions based upon the presented information.

TOTAL QUALITY MANAGEMENT OVERVIEW

According to Kan (1995), TQM may be defined as a philosophy that represents a “style of management aimed at achieving long-term success by linking quality with customer satisfaction” through the “creation of a culture in which all members of the organization participate in the improvement of processes, products, and services.” Thus, TQM becomes a strategic philosophy that permeates all levels and facets of organizational structure and personnel to improve overall organizational quality and generate customer satisfaction. According to Hunt (1993; 1992), the four primary philosophical tenets of TQM may be listed as follows:

1. Customer Focus: TQM advocates total customer satisfaction.
2. Process: TQM advocates reduced process variations and continuous process improvement.
3. Cultural: TQM advocates an enterprise-wide corporate culture awareness of quality pursuits.
4. Analytical: TQM advocates continuous improvements in all quality parameters via measurement systems.

Because TQM is a philosophy instead of a static procedure, both Hunt (1993; 1992) and Kan (1995) indicate that dynamic implementation of TQM may be manifested within organizations using theoretical models (e.g., Deming, Crosby, Juran, and Feigenbaum). Thus, single models, multiple models, or a combination of models may be implemented within a corporate environment to facilitate overall quality strategy. However, such philosophies are merely models; they do not contain static guidelines and instructions regarding process improvement activities because the myriad of requirements and implementation specifications for such activities is unique and varied with respect to individual corporate environments.

As a result, organizations that implement TQM philosophies do not discover explicit tools to facilitate process improvement within the selected TQM philosophy itself. Instead, they must adopt variations of existing tools or create internal tools to fulfill the TQM tenet of continual process improvement with respect to processes and procedures. Because TQM does not dictate specific process improvement guidelines, organizations may consider models, such as the CMM, as tools through which continual process improvement tenets of TQM may be facilitated.

PROJECT DEVELOPMENT CONSIDERATIONS

The lack of specific methodologies with respect to process improvement within the TQM philosophy allows corporations the dynamic perspective of either designing unique process mechanisms or adopting process improvement philosophies as a method of ensuring timely project progression. However, without an organizational emphasis with respect to the TQM tenet of process improvement, many projects may suffer dire consequences resulting from the "implementation of immature and inefficient" processes within organizational environments (Paulk, 1995). Examples of such consequences may be given as follows:

1. "In some organizations, the typical software project is a year late and double the budget" (Paulk, 1995).
2. With respect to the federal government, a "Department of Defense organization's average 28-month schedule was missed by 20 months, and a four-year project was not delivered for seven years. No project was on time" (Paulk, 1995).
3. "Being on time, but 50% over budget loses about 3% of total potential profit over the product's lifetime" and "meeting budget while being six months late loses 32% of total potential profit" (Frailey, 2000).
4. "The inability to hit deadlines," or 25% to 75% of organizational resources being "spent on rework" (Potter, 1999).

Paulk (1995) indicates that such situations pose "chronic" and "severe" problems for organizations, and that "the understanding of software as a product and of software development as a process is not keeping pace with the growing complexity and software dependence of existing and emerging mission-critical systems. Arveson (1998) indicates that understanding of environmental managerial approaches allows organizations to address the "changing demands" of the organizational setting, and indicates that it is critical to selecting a "management approach that is most appropriate to the desired need or goal." Therefore, organizations must enhance their understanding of software development methodologies and their underlying processes to cope with systems complexity, and must have an understanding of the management approach being considered.

To achieve this goal, organizations that implement a TQM philosophy must understand their continual process improvement methodology and related managerial concerns. As a result, sound management of continual process improvement allows corporations to "proactively determine improvement opportunities" to avoid or minimize the problematic situations described by Paulk, Frailey, and Potter (Hunt, 1993). Given the nature of problematic situations with respect to continual process improvement, organizations may consider the CMM structure as a tool within TQM activities to facilitate continual process improvement within software environments.

In essence, the CMM is deliberately concerned with factors related to software processes with emphasis upon the content of individual process issues instead of dictating individual, procedural implementation methodologies (Somerville, 1994b). Thus, the CMM is an "application of the process management concepts of Total Quality Management" whereas TQM is considered as being "the application of quantitative methods and human resources" for improving "all of the processes within the organization" (Hunt, 1993; 1992; Somerville, 1994b). Hence, the CMM becomes a tool through which TQM organizations may fulfill both the current and future requirements and needs of their process improvement and quality improvement initiatives.

SOFTWARE PROCESS IMPROVEMENT WITHIN TQM

Through use of the CMM as a tool for facilitating quality improvement efforts of TQM, one may note associated considerations within an organizational context. From a managerial perspective, Crosby (1985) indicates that organizational groups (both management and work groups) must present "quality improvement on a continual basis." This notion is supported by Paulk (1995) through which he prescribes continual "guidance and quantifiable data where possible" and "learning individually and organizationally" as methods of facilitating improved management functions resulting from the ways humans "think and organize themselves." Through such actions, organizations may begin to develop various corporate standards to facilitate process improvement efforts that contribute to TQM implementation.

Such actions may produce continuous, effective process improvement activities that contribute to TQM corporate pursuits with respect to a situational basis. Holmes (2000) supports this notion through her observations that the "complexity and duration" of organizational quality efforts are "unique to each situation," and that the "most successful" software improvement processes involve: (1) describing issues; (2) determining causes; (3) issue resolution; and (4) following-up on issues. Through crafting of such a process, then tailoring it to suit individual organizational software environments, and implementing it as a corporate standard, the CMM requirements for software process improvement may be fulfilled and corporate TQM tenets regarding continual process improvement may be satisfied.

Somerville (1994a) indicates that the "quality of the software process directly affects the quality of delivered software products," and asserts that "a well-planned, managed process is more likely to lead to high quality products." Zahran (1998) confirms this notion through examination of CMM-based models employed within the Raytheon Corporation to facilitate continual software process improvement. These models provide a continuous basis for software process improvement activities to occur while "applying the principles of quality improvement and process management" in conformance to "the principles of Deming and Juran."

CONCLUSION

As organizations progress toward higher levels of quality, they must consciously make a decision to instigate change, select a TQM philosophy, and instigate activities that facilitate philosophy implementation (Hunt, 1993; 1992). However, within TQM pursuits, organizations must remain aware of the tenet regarding continual process improvement. Given these notions, coupled with information previously discussed, one may derive the following concepts regarding quality improvement and CMM efforts:

1. without an organizational emphasis with respect to the TQM tenet of process improvement, many projects may suffer dire consequences resulting from the "implementation of immature and inefficient" processes within organizational environments (Paulk, 1995).
2. TQM is a philosophy that advocates continual process improvement, but does not uniquely prescribe a given methodology for implementing process improvement activities.
3. The CMM is a model that advocates continuous process improvement, primarily within organizational software environments, but is not directly concerned with overall TQM philosophy.
4. The lack of specific methodologies with respect to process improvement within the TQM philosophy allows corporations the dynamic perspective of either designing unique process mechanisms or adopting process improvement philosophies (e.g., CMM).
5. Because the CMM is primarily concerned with software process improvement instead of high-level organizational quality issues, it suffers shortcomings when applied to unrelated areas.
6. As a method of addressing the TQM tenet of continual process improvement within organizational functions unrelated to software environments, derivatives of the CMM may be generated (e.g., testing maturity models, communications maturity models, etc.).

During implementation of TQM activities, organizations must address the tenet of continual process improvement. Through use of the CMM, organizations may instigate activities through which processes within software environments may be improved continually to achieve higher levels of maturity, and functions unrelated to software environments may benefit from CMM-based derivative models in which separate, unique maturity models are presented. Given the Raytheon three-tier process improvement model and recommended CMM derivatives, evidence is provided that advocates implementation of the CMM as a mechanism through which continual process improvement tenets of the TQM philosophy may be facilitated. Therefore, one may conclude that the CMM is a valid tool to support continuous process improvement tenets of the TQM philosophy.

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NONPARAMETRIC METHODS IN EXCEL

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ABSTRACT

Textbooks on statistics increasingly emphasize the integration of spreadsheets into their presentation of statistical concepts and applications. Since Microsoft Excel is the most widely used spreadsheet in business as well as in colleges and universities, more and more texts present Excel as the sole or primary method of calculation of statistical procedures. Many researchers have noted that certain Excel statistical capabilities contain flaws and provide incorrect results. Excel 2003 includes 18 data analysis tools and 80 statistical functions and purports to correct many of the known anomalies in Excel.

In cases when one has a small sample size and the population is not normally distributed, it is appropriate to employ a nonparametric procedure based on ranks. Applications including the Wilcoxon signed ranks test, the Mann-Whitney-Wilcoxon rank sum test, and the Kruskal-Wallis test all would use the RANK function in Excel, since Excel does not provide any tools specifically designed for non-parametric tests.

Some of the problems encountered using this EXCEL procedure function are illustrated

ADJUSTING BUSINESS STATISTICS GRADES FOR ANXIETY

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ABSTRACT

The teaching of Business Statistics continues to garner the attention of academia as evidenced by the large number of studies available for discussion and use. One area of focus is the level of anxiety for students taking a Business Statistics class. Several studies have utilized the Statistics Anxiety Rating Scale (STARS) as the instrument to measure the Business Statistics anxiety. These studies identify various class and student characteristics which may contribute to the level of Business

Statistics anxiety. Another component contributing to the student's anxiety level may be associated with the professor assigned to teach a Business Statistics class. The Student Evaluation of Teachers (SET) score is used as a proxy to determine a student's anxiety level for the professor.

The purpose of this study is to develop an anxiety index, consisting of selected characteristics for students, classes and professors, which will represent a composite measure of anxiety for the Business Statistics class. The index could be applied to a student's numerical class score for determination of the final class grade. Adjusting for the anxiety associated with Business Statistics would allow for a more level playing field when assessing student grades and perhaps improve the professor's SET scores.

USING DISTRIBUTED PROCESSING TO CHECK FOR VULNERABILITES IN PASSWORD FILES

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ABSTRACT

The recent explosion in hacking has necessitated that security managers understand how hackers are able to break passwords and operationally have superior versions of the tools used by hackers so that they can run proactive tests on the vulnerability of their resources. A resource that is especially vulnerable is the password file even though it is encrypted.

This paper uses a modular approach to offer improvements to a commonly used password attack tool called "John the Ripper" and evaluates its potential for distributed processing. Through distributed processing and improved software logic the authors were able to improve performance in both time to solve and number of passwords guessed. These results, if implemented properly, could offer security managers a competitive advantage over hackers in identifying vulnerable passwords quicker than the hackers can exploit them.

A DESIGN OF SELF-QUESTIONING MECHANISM FOR INFORMATION REQUIREMENT SPECIFICATION

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ABSTRACT

Incorrect requirement specifications are widely recognized as the major cause of information system failures. In order to improve the correctness of requirement specifications, various requirement specification techniques such as Data Flow Diagram, and Object model, have been invented to help information analysts capture, understand, and represent information requirements. However, information analysts' cognitive abilities are still the most important determinant for the correctness of requirement specifications. Self-questioning has long been recognized in the field of learning research as a strategy that can improve students' cognitive abilities on reading comprehension and problem solving. In order to improve the cognitive abilities of novice information analysts, this research argued that novice information analysts should be trained to incorporate self-questioning mechanism into their requirement specification process. On the basis of the theories on human cognition, this research also proposed several design strategies for self-asking questions that can guide novice information analysts to make more effective model-based reasoning and hence to achieve a higher correctness of requirement specifications.

INTRODUCTION

In order to improve the correctness of requirement specifications, various requirement specification techniques such as Data Flow Diagram, and Object Model, have been invented to help information analysts capture, understand, and represent information requirements (Couger, Colter, and Knapp, 1982; Davis, 1988; Wieringa, 1998). However, the cognitive abilities of information analysts are still the most important determinant for the correctness of requirement specifications (Schenk, Vitalari, and Davis, 1998). The inadequacy of cognitive abilities makes novice information analysts unable to perform model-based reasoning effectively, and therefore leads to more errors in requirement specifications (Batra and Davis, 1992; Batra and Sein; 1994; Sutcliffe and Maiden, 1992).

In the field of learning research, self-questioning is regarded as a cognitive strategy that can help students focus attention, organize the new material, and finally integrate the new information with existing knowledge (Doerr, and Tripp, 1999; Glaubman, and Ofir, 1997; King, 1989, 1992; Wong, 1985). Therefore, this research argued that novice information analysts should be trained to incorporate self-questioning mechanism into their cognitive process of information requirement specification. When novice information analysts can ask right questions to themselves during requirement specification, they will be able to learn how to think like an expert, organize their knowledge like an expert, and finally specify information requirements like an expert.

Currently, the common practice of requirement specification is focused on deriving information requirements from the answers of the generic questions for the constructs of requirement specification techniques. However, the generic questions do not fit the cognitive behavior of novice information analysts naturally. Consequently, the generic questions may induce from novice information analysts the answers that lead to incorrect requirement specifications. Therefore, on the basis of the theories in human cognition (Gernsbacher, 1990; Graesser, 1995;

Kintsch, 1988; Ortony, 1978), this research proposed that basic objects, coherence, and systematicity are the three cognitive principles that should be the guides for designing effective self-asking questions. For demonstration, a set of self-asking questions deriving from the three cognitive principles were designed to help specify information requirements by Data Flow Diagram.

The rest of this article will be organized into two sections. First, basic objects, coherence, and systematicity as guides for designing self-asking questions will be elaborated. In addition, Data Flow Diagram will be used to demonstrate the design of self-asking questions. Then the conclusion will be made in the final section.

A DESIGN STRATEGY FOR SELF-QUESTIONING MECHANISM

This section will discuss the four design strategies for self-asking questions including the generic question approach, and the three approaches based on the principles of basic concepts, coherence, and systematicity. In this research, Data Flow Diagram is used as an example of requirement specification techniques for demonstrating the design of self-asking questions.

Generic Questions

Generic questions are the questions that directly map the constructs of the intended requirement specification technique onto the concepts in the problem statement. For example, Data Flow Diagram is a requirement specification technique with four constructs: external entity, data flow, process, and data store. The generic questions for specifying information requirements on the basis of Data Flow Diagram are like those in table 1.

Table 1: Generic self-asking questions for Data Flow Diagram
What are the external entities in the problem statement?
What are the data flows in the problem statement?
What are the processes in the problem statement?
What are the data stores in the problem statement?

Without rich experience and knowledge in requirement specification, novice information analysts basically use the definition of the constructs to guide them in identifying and mapping relevant concepts in the problem statement. Although this approach can focus novice information analysts on the relevant concepts, incorrect requirements or missing mappings may happen very often due to the inadequacy of novices' reasoning processes and knowledge organizations.

Basic Concepts

According to the research in concept formation (Komatsu, 1992; Rosch, et al., 1976), humans can recognize objects at different levels of abstraction. However, there is one level of abstraction at which the basic concepts of the objects are made. From the perspective of human cognition, the basic concepts are the concepts that carry the most information for human reasoning and are easiest to understand. According to Komatsu (1992), the basic concepts are the most useful concepts for us because they are those formed during perception of the environment, those formed during our childhood, and those to be most codable, most coded, and most necessary in language.

For analyzing business information systems, business concepts like order clerks are the basic concepts of users and hence easier to identify and understand than the information concepts such as objects, and processes used by requirement analysis techniques. Therefore, on the basis of the theories on concept formation, the self-asking questions that are focused on business concepts are easier to answer correctly by novice information analysts than those on the information concepts that are used as constructs for requirement specification techniques.

Assume that an information analyst is reading a problem statement and feeling that the information requirements are concerned with order processing. And if the information analyst has the domain knowledge about order processing, she or he may ask questions during requirement specification as in table 2.

Table 2: Self-asking questions based on the basic concepts from order processing system
Are there people performing an activity of processing order?
Is there an order file?
Is there a customer file?
Are there customers out of this system?
Are there orders flowing in the system from the customers?

It is obvious that the above questions about business concepts are easier to answer than those about information concepts. However, business concepts are domain-specific and will become difficult to identify and model if there is no pre-exist template of requirement specifications, or if the information analysts have little or no background knowledge.

Coherence

Coherence is well accepted as the goal of human cognition on reading comprehension. Specifically, reading comprehension is a process of building a coherent situation model of the problem statement being comprehended (Gernsbacher, 1990; Graesser, 1995; Kintsch, 1988; Ortony, 1978). A situation model is a mental representation of the concepts that are explicitly mentioned in the problem statement and that are derived by the knowledge of the reader (Graesser, Singer, and Trabasso, 1994; Kintsch, 1988; Mckoon and Ratcliff, 1992). Coherence is “a state or situation in which all the parts or ideas fit together well so that they form a united whole” (Collins Cobuild English Dictionary; 1995). The coherence of a situation model for a problem statement determines how well the reader can answer questions about the problem statement, and remember, summarize, or verify the statement (Kintsch, 1988; Trabasso, 1989). In general, the more coherent the situation model of a problem statement, the better the comprehension and usage of the problem statement (Trabasso, 1989).

From the perspective of coherence, the purpose of self-questioning is to derive answers that can provide a coherent structure for a concept. Coherence structures can be at least divided into two levels: local coherence and global coherence (Long, Oppy, and Seely, 1997; Mckoon and Ratcliff, 1992). First, local coherence can be defined as “a small set of adjacent sentences that makes sense on its own or in combination with easily available general knowledge” (Mckoon and Ratcliff, 1992, p.444). From the perspective of local coherence, the coherent structures in Data Flow Diagram are the acceptable connections through data flows . Derived from the coherent structures, a list of the possible questions that can be used to derive the locally coherent connection is thus shown in table 3.

Table 3: Local coherence-driven questions for data flow diagram modeling

Concept	Question
External Entity	A-structure: (external entity---request---process) What is the request of the external entity? To what process? B-structure: (process---report---external entity) What is the report for the external entity? Provided by what process?
Process	A-structure: (external entity---request---process) What initiates the process? From which external entity? B-structure: (process-report—external entity) What report is generated by this process? To what external entity? C-structure: (process---intermediate---process) What immediate result is generated by this process? To what process? D-structure: (process---save---data store) What data store save the result of the process? E-structure: (data store---retrieve---process) What data store provides information for the process? What data are provided?
Data store	D-structure: (process---save---data store) What data in the data store are saved ? from what process? E-structure: (data store---retrieve---process) What data in this data store are retrieved? By what process?
data flow	A-structure: (external entity---request---process) What external entity is the sender of the request? To what process? B-structure: (process---report---external entity) What external entity is the receiver of the report? From what process? C-structure: (process---intermediate result---process) What process generates the immediate result? What process will do the further processing? D-structure: (process---save---data store) What is the data store saving the data? What is the process generating the data? E-structure: (data store---retrieve---process) What is the process retrieving the data? From which data store?

Second, global coherence involves constructing a requirement model that reflects a bigger unit of problem statement like a paragraph, or even the whole problem statement (Long, Oppy, and Seely, 1997). Two examples of the generic coherent structures defined at the global level are process decomposition structure (Martin, 1989), and event partition structure (McMenamin, and Palmer, 1984). The questions that can drive the concepts in the event partition structure are shown in table 4.

Table 4: Global coherence-driven questions for event partition structure

Construct	Question
Event	What is the event?
Source	What is the source?
Destination	What are the destinations?
Trigger	What is the trigger?
Response	What are the responses?
Process	What is the process?
Data Store	What are the data stores?

Table 4: Global coherence-driven questions for event partition structure	
Construct	Question
Update	Does the process update any data stores?
Use	Does the process use any data stores?

Systematicity

When selecting a base structure (e.g. a conceptual structure from a particular requirement specification technique) to be mapped onto a target structure (e.g. a conceptual structures from a problem statement), the base structure with higher-order relation will be more likely to be imported into the target structure than is that with an isolated relation or object-attribute. It is called the principle of systematicity (Gentner and Markman, 1997). The principle of systematicity is not a principle for deriving self-asking question, but rather a principle for selecting the best set of questions among several sets of answerable questions. When there are several sets of self-asking questions can be raised to induce answers for information requirements, systematicity will select the set of self-asking questions that can induce answers to lead to the most coherent requirement specifications. On the basis of systematicity, the self-asking questions in table 2 will have the highest priority because they are derived from the principle of basic objects and provide a mapping on the basis of literal similarity. The self-asking questions in table 4 will receive the second highest priority because they are derived from the principle of (global) coherence and provide mappings on the basis of abstractions. The self-asking questions in table 3 also provide mappings on the basis of abstraction. However, they will have lower priority than those in table 4 because the questions in table 3 are derived from local coherence with lower order relations. Finally, the questions in table 1 can get only the lowest priority because they are generic questions and provide only the mapping on the basis of surface similarity.

CONCLUSION

Traditionally, the research studies for improving the modeling performance of novice information analysts have focused on providing access to domain and modeling knowledge through computer-aided software engineering (CASE) tools. However, this research is concerned with how to improve novices' cognitive abilities for requirement specification. On the basis of the principles of basic concepts, coherence, and systematicity, this research has proposed design strategies for effective self-asking questions. Guided by the effective self-asking questions, novice information analysts can build a more correct requirement specification.

References available upon request from the author I-Lin Huang.

AN ALGORITHM FOR DERIVING MIXED SAMPLING DISTRIBUTIONS WITH DISCRETE CONTAMINANTS

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ABSTRACT

Statistical distributions generated from any J- or U-shaped random variables are cumbersome to derive. Analytically they have singularity problems, and they do not fit the classical probability distributions which makes them illusive for analytical manipulation. In this proposal we are advocating a computational method and algorithm for providing a numerical sampling distribution derived from a basic U-shaped random variable composed of a continuous part mixed with (or contaminated by) a discrete part at the tails as indicated by the vertical lines in the U-shape. The J-shaped sampling distribution case is implied as a special case. Such distributions will open up an area of sampling distributions of mixed random variables that are not elaborately covered, if at all, in textbooks dealing with the theory of distributions.

A RAPID SUPPLIER SELECTION METHODOLOGY

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ABSTRACT

This manuscript reports the rapid growth of a small business and its desire to respond to the needs of a major customer. While growth is desirable, growing too fast without planning and preparation can impact response time and product quality. Although the firm had expanded its warehouse capabilities, the new warehouse had begun to resemble the old warehouse [i.e., materials were crowded and handling of the materials was difficult and time consuming]. Two MBA students were assigned to study the warehouse management processes and make recommendations. They identified the firm's equipment needs and developed a methodology for selecting vendors.

INTRODUCTION

A small business firm (SB) located in Texas initially began offering printing and copying services in the early 1990s. While small firms account for almost 98 percent of the U.S. business organizations, and small business is the fastest growing segment of the U.S. economy, these firms face many obstacles on their road to success (e.g., limited resources, experience, etc.). To overcome these obstacles, it is not unusual for small firms to develop strategic alliances with larger companies (Miles, Preece & Baetz, 1999). About five years ago SB formed just such a relationship with a large technology company (LTC) that provided SB with several advantages. This alliance served as a catalyst for increased production efficiencies and income stability, both of which allowed SB to expand and pursue opportunities with other potential customers.

SB's Transition

Although SB started as a reproduction business that produced custom printed materials and instruction manuals, the alliance with LTC provided an opportunity to develop other core competencies. Because of LTC's immediate needs and the alliance, SB became a materials handler for the technology company in addition to supplying its reproduction requirements. The needs of LTC focused on rapid response time because of its own desire to respond rapidly to its customers' personalized orders without carrying large inventories.

LTC required SB to meet a lead-time of 2 to 4 hours. The maximum time of 4 hours was crucial in order for LTC to keep its promises to its clients. SB immediately recognized the importance of meeting LTC's needs, and one of its first steps was to promptly place a technical representative at LTC's site to ensure fast response. Because of SB's strong market-orientation, LTC engaged the firm to handle other materials for them (e.g., CDs, diskettes, and other electronic components). While SB may not have realized that it was implementing the marketing concept and may not have intended to change the focus of the company, SB began developing activities in the supply chain management arena.

Nevertheless, this change in SB's core competency underscored its need to transform itself from strictly a product-oriented company to a service provider. Although SB recognized that having a good product was still important, it quickly became apparent that their service capabilities eclipsed their product-orientation. Their service capabilities had become their primary competitive advantage in acquiring new customers in addition to satisfying and maintaining current customers.

SB's Growth and Its Impact

Success triggered rapid growth. However, the rapid growth the firm was experiencing was affecting their operations in the form of operating deficiencies. These deficiencies were impacting the firm's ability to maintain the optimum responsiveness and service capability it was touting. Fortunately, SB had already recognized that the rapid growth it had experienced called for warehouse expansion, and it had just completed a new warehouse. Completing the new expanded warehouse was just the first step in improving its material handling capabilities. Prior to moving all of the equipment and materials to the new warehouse, management was already concerned that the space was inadequate. Two MBA students were engaged to study their warehouse management processes and provide recommendations to SB.

Immediate Challenges

Almost immediately after occupying the new warehouse space, the warehouse resembled the old warehouse in that it was literally overflowing with inventory stacked in the aisles. Clearly, the warehouse management practices needed to be modified. The first complaints that SB received involved customers receiving quantities that exceeded their order requirements. One cause of the over fulfillment was the use of a variety of different sized boxes but with no applied standard as to the number of items in each box. Since the orders were not filled properly, the problem of missing inventory surfaced in the warehouse. These losses not only increased costs, but also reduced customer service level. Changes in its warehouse distribution system needed to be made immediately.

Improvements Needed

Initially, the plan to improve materials handling focused on procedures and work processes, but it quickly became apparent that appropriate equipment was needed to support these new processes. One of the most time-consuming and complex activity in any warehouse is order picking, packaging, and shipping, commonly called pick/pack/ship. SB had no workstations to facilitate this process. To provide warehouse personnel with appropriate work tools, several pieces of equipment were identified as being essential to the pick/pack/ship system at SB. A conveyor system, flow racks, carton shelving, an automated box taper, and floor matting were the primary equipment components for the pick/pack/ship system. The system and equipment that the MBA students recommended were flexible and expandable without being too expensive.

Once the necessary equipment was determined, acquisition became the focus. Thus, the students began identifying dependable sources from whom to purchase the equipment and developing selection criteria. Lambert and Stock (1993) suggest that selecting the best supplier from among a number of vendors is the most important activity in the acquisition process. Since the buying process is complex and usually includes both decision makers and decision influencers, it was considered important that SB's management group strongly support the equipment and supplier selection. Unfortunately, the management team was overwhelmed with daily operational issues and was unable to commit to a group meeting for several weeks. The MBA students devised a method for obtaining management's input unobtrusively , quantitatively assessing potential suppliers, and communicating the selection in a way that was easily understandable and fully acceptable to the management team. They began with a review of the firm's Pick/Pack/Ship process.

Pick/Pack/Ship

In today's rapidly changing business and technological environment, customers are ordering smaller quantities more frequently and demanding increased quality and service (Rider 1999). To meet these demands pick/pack/ship operations must be flexible, immediate, and accurate. The system must be routine, easy to understand, and predictable to provide the required levels of customer service and cost control necessary for businesses to survive in the global marketplace.

Although "picking" is formally defined in the *APICS Dictionary* as "the process of withdrawing from stock the components to make assemblies or finished goods," in SB's situation, it refers to the warehouse personnel selecting and placing those items identified by customers orders in a packing area. The packing and marking of products typically includes placing the ordered items in appropriate containers for safe shipment and marking and labeling the containers with customer information (e.g., shipping designation). The final element, shipping, naturally provides for ensuring that the items are correctly prepared for shipping (e.g., weighed, loaded, etc.). Thus, a well-designed pick/pack/ship operation combines these three functions into a seamless work process in which the items to complete an order are removed from stock, packaged per customer specifications, labeled appropriately, and shipped to their intended destination. The complete work process must also consider the sequence that orders are processed and the information requirements of the warehouse management and enterprise requirements planning systems (Wing, 2000). These issues and requirements were considered in developing the layout and equipment specifications.

Equipment Requirements

The new warehouse was essential, but now SB needed equipment to package orders quickly and effectively. While an area had been planned in the layout of this new space for equipment, no equipment had been ordered. It was a typical catch-22 issue. The firm needed the equipment so they could process shipments faster, but no one had time to determine the equipment needs and place orders because they were too busy shipping out orders using manual processes. The MBA students followed a process to assist in defining the hardware needs and making recommendations as to which equipment was needed and which supplier best met pick/pack/ship needs.

Process

The MBA students defined their process as follows: (1) work with the warehouse and customer service personnel to define the needs the packaging equipment must fulfill; (2) determine the financial boundaries; (3) clarify the supplier selection criteria, communicating it to both SB and the potential suppliers; and (4) collect bids. Although it was imperative to include major selection criteria such as quality, price, and delivery terms, other criteria (e.g., technical capability, reputation, experience, and design capability of each supplier) were identified (Hirakubo & Kublin, 1998). By identifying the selection criteria before requesting bids, the potential suppliers as well as the members of the decision making unit (DMU) will have a clearer understanding of what is expected (Vonerembse & Tracey, 1999). The final selection of the appropriate equipment to meet SB's packaging needs kept in mind the objective of every supplier selection decision: minimize the total cost of ownership (Degraeve & Roodhootf, 1999).

Equipment Needs Identified

Several pieces of equipment were identified as being essential to the pick/pack/ship system. This type of system can be as manual or automated as the company wants. In this situation, flexibility of the equipment was considered to be essential in order to meet the changing needs of the company without being overly costly. The individual equipment components and their specifications were identified and submitted to each vendor under consideration. The components included:

Conveyor System (Automatic conveyor with rollers that extend for 30 feet)
Flow Rack Bays (Gravity flow racks for fast moving material)
Carton Shelving (Racks for holding various box sizes for shipping)

Conveyor Scale (Scale with ability to connect to computer for printing labels)
Automated Box Taper (Machine tapes box as it flows down the conveyor)
Ergonomic Matting (Mats for employee safety and comfort)

The conveyor, scale, matting, flow racks and carton shelving are fairly standard in setting up a pick/pack/ship system, but SB also identified the automatic taper as an essential part of their system. They currently have at least five box sizes that must be sealed upon packaging. This automatic taper will ease the process by reading the size of the box and taping it appropriately. The choice of this equipment provides flexibility available for expansion and rearrangement. Moreover, several sources should be able to supply this type of equipment.

Supplier Selection Methodology

Prior to submitting the equipment needs to vendors, a decision as to whether to use a single source or multiple sources for the various components was made. SB's desire for rapid implementation favored choosing a single source that would provide a "turn-key" job versus selecting multiple sources that would require careful coordination in the installation phase. Thus, the equipment was combined in one request for bid package. The focus then shifted to seeking that single supplier that would give SB the best overall value and fastest response to complete the pick/pack/ship project.

To evaluate the vendors, a trade-off analysis methodology was developed that was simplistic and straightforward. Cooperation and long-term satisfaction is more likely to occur if all members of the DMU understand the process and contribute to the selection of the final vendor. The MBA team followed the steps suggested by Hunger (1995) in setting up the evaluation process, and at each step explanations were provided to the participants. The steps included: (1) determine the criteria for supplier selection; (2) determine the ranking for each criteria; (3) calculate a weighting factor each criterion, and (4) complete a decision chart.

Criteria for Supplier Selection

After several discussions and a review of the purchasing literature, the criteria list for selecting a supplier was determined. The final list of twelve criteria included:

Purchase cost	Advertised reliability	Ease of Use	Location of supplier
Installation cost	Safety	Warranties	Reputation of supplier
Maintenance cost	Aesthetics	Technical support	Existing relationship with supplier

Ranking Criteria

SB's President, the Manager of Account Services, the Warehouse Manager, the Sales Manager, the Director of Operations, and the MBA team reviewed the criteria, and each individual indicated the level of importance of each criterion. Importance weights for each criterion were determined by averaging the importance assigned to each criterion across all of the responses. All of the averages were totaled, and in order to see the relative relationship, each criterion's average was divided by the total. The results are shown in Table 1.

Table 1: Criteria and Weights Assigned

Criteria	Weight	Criteria	Weight
Technical Support	0.1171	Advertised Reliability	0.0856
Ease of Use	0.1126	Warranties	0.0856
Purchase Cost	0.1036	Maintenance Cost	0.0811
Safety	0.0991	Aesthetics	0.0495
Installation Cost	0.0946	Location of Supplier	0.0405
Reputation of Supplier	0.0946	Existing Relationship with Supplier	0.036

Supplier Information

It was decided to submit the equipment specifications for the pick/pack/ship system to five vendors. Two of the vendors selected had previously been in contact with SB, but the other three were selected from a search of vendors on the Internet. After reviewing the background of each vendor, each was provided a layout draft depicting the type of system SB needed. In addition, they were given an overview of the company's previous and current needs together with plans for future development and SB's expectations for the pick/pack/ship system.

Initial Screening of Potential Suppliers

Although the procurement team had identified equipment and made a preliminary layout, it was still seeking additional insights or suggestions for improving the warehouse distribution system. Thus, the team conducted interviews with each potential vendor. One of the companies with which SB had previous contact was Supplier A. However, the interview with Supplier A left much to be desired. The sales representative offered few suggestions to the selection team, did not offer to visit the current facilities, and merely faxed a quote for the items that the team had provided on a rough diagram. Upon further research and discussions with other individuals, it was learned that Supplier A was known for making hasty contacts and charging high prices.

Supplier B, a company selected from the Internet sources, also had little to offer. Its sales representative knew very little about pick/pack/ship systems, and merely provided the team with a notebook full of catalogs with numerous types of equipment, but no set-up ideas. This vendor was relatively inexpensive, but it could offer no insight on how the system could be expanded as the company's needs grew. In addition, they were unable to offer any suggestions on how to set up the inventory or flow.

A third vendor, Supplier C, had provided equipment to SB in the past. Supplier C had been accommodating in the past, but it had trouble getting the product to SB on time. Although this vendor did not have any experience with pick/pack/ship systems, the sales representative was helpful and consulted with Supplier C's vendors for additional assistance. Although Supplier C provided the lowest purchase cost, the lack of experience with the system was a concern.

Another vendor from the Internet search, Supplier D, had experience with pick/pack/ship systems. The sales representative was knowledgeable and offered an array of alternatives. Supplier D made several suggestions to improve the original layout and provided information as to the amount of work that could be sent through the line. The sales representative suggested the "U" shaped conveyor system would not be needed initially. This would keep the costs down in the beginning, but would allow for expansion as the volume increased.

The final vendor interviewed was Vendor E. This vendor was known to have a good reputation in setting up pick/pack/ship systems. The sales representative had experience in manufacturing and specifically in the efficiency and flow or production. Vendor E began with a review of SB's objectives and requirements, and then compared SB's needs with the customer profile and market objectives that they had developed. Finally, they determine if SB's needs and

Vendor E's capabilities matched. In addition, Vendor E offered suggestions for current and future needs.

Decision Chart

After meeting with each supplier and reviewing the information and costs each provided, the team rated each supplier against the twelve criteria using a four-point scale. The rating scales are summarized in Table 2.

Table 2: Rating Scales

Cost Related Criteria		Subjective Value Criteria	
Very Inexpensive	4	Very Good Fit	4
Somewhat Inexpensive	3	Somewhat Good Fit	3
Somewhat Expensive	2	Somewhat Poor Fit	2
Very Expensive	1	Very Poor Fit	1

The ratings of each criterion for each vendor were recorded, and the results are shown in Table 3. In addition, the weights of each criterion were multiplied times the rating scales to produce a weighted total for each vendor. Vendor E had the highest weighted value of 3.29. Thus, the team recommended purchasing the equipment from Vendor E.

Table 3: Criteria, Weights, and Ratings of Vendors

		Rating of Vendor by Criterion				
Criteria	**Weight**	**A**	**B**	**C**	**D**	**E**
Technical Support	.1171	3	2	4	2	2
Ease of Use	.1126	4	2	4	3	3
Purchase Cost	.1036	2	3	2	4	1
Safety	.0991	3	3	4	4	3
Installation Cost	.0946	2	3	2	2	1
Reputation of Supplier	.0946	3	2	4	1	1
Advertised Reliability	.0856	3	2	4	2	2
Warranties	.0856	3	3	3	3	2
Maintenance Cost	.0811	2	3	3	3	3
Aesthetics	.0495	3	2	4	4	3
Location of Supplier	.0405	4	4	3	4	4
Existing Relationship with Supplier	.0360	1	1	1	2	1
WEIGHTED TOTAL		2.80	2.51	3.29	2.77	2.09

The total cost of the equipment (powered conveyor system, low rack bays, carton shelving, an integrated conveyor scale, and automated taper and box former) and installation was approximately $25,000 which was neither the most expensive nor the least expensive of the five suppliers. Nevertheless Vendor E's willingness to help with determining future needs and forecasts (criterion: technical support), was an important consideration.

It is expected that SB and Vendor E may develop a strong and long-lasting relationship. As SB grows not only in their warehouse needs, but also in their assembly facility, the representatives of both companies can work together to determine the most efficient layouts and automated processes. This partnership will directly influence SB's ability to meet its customer time constraints and quality demands.

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NEW APPROACHES IN SUPPLY CHAIN MANAGEMENT

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ABSTRACT

Supply chain management (SCM) is the process of synchronizing the flow of physical goods/services, and associated information from the production line of low level component suppliers to the end-consumer. This results in the provision of early notice of demand fluctuations and synchronization of business processes among all the cooperating organizations in the supply chain.

Supply Chain Management is not a new concept; however, the techniques for doing so, and the ultimate goal of this process itself have evolved quite significantly in the past few years. A modern organization can use effective supply chain management to gain significant competitive advantage, and position itself well with its customers. Modern supply chains are in the process of migrating from a "push" model (build-to-stock) to a "pull model" (build-to-demand).

The purpose of this paper is to study the newer approaches in supply chain management systems. It will identify the characteristics of successful supply chain managers, and will also describe the top industry leaders in SCM. The paper will be very educational for supply chain or procurement managers as it describes modern supply chain practices. It will also be beneficial to academic researchers and faculty in the business or information technology disciplines as it will allow them to become more knowledgeable in the supply chain management field. The enhanced knowledge can be used to conduct further research in SCM and/or educate their students about modern management practices.

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