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Principles of Analytic Monitoring for Continuous Assurance

Miklos A. Vasarhelyi
Michael G. Alles
Alexander Kogan
Rutgers, The State University of New Jersey

ABSTRACT: The advent of new enabling technologies and the surge in corporate scandals has combined to increase the supply, the demand, and the development of enabling technologies for a new system of continuous assurance and measurement. This paper positions continuous assurance (CA) as a methodology for the analytic monitoring of corporate business processes, taking advantage of the automation and integration of business processes brought about by information technologies. Continuous analytic monitoring-based assurance will change the objectives, timing, processes, tools, and outcomes of the assurance process.

The objectives of assurance will expand to encompass a wide set of qualitative and quantitative management reports. The nature of this assurance will be closer to supervisory activities and will involve intensive interchange with more of the firm's stakeholders than just its shareholders. The timing of the audit process will be very close to the event, automated, and will conform to the natural life cycle of the underlying business processes. The processes of assurance will change dramatically to being meta-supervisory in nature, intrusive with the potential of process interruption, and focusing on very different forms of evidential matter than the traditional audit. The tools of the audit will expand considerably with the emergence of major forms of new auditing methods relying heavily on an integrated set of automated information technology (IT) and analytical tools. These will include automatic confirmations (confirmatory extranets), control tags (transparent tagging) tools, continuity equations, and time-series cross-sectional analytics. Finally, the outcomes of the continuous assurance process will entail an expanded set of assurances, evergreen opinions, some future assurances, some improvement on control processes (through incorporating CA tests), and some improved data integrity.

A continuous audit is a methodology that enables independent auditors to provide written assurance on a subject matter, for which an entity's management is responsible, using a series of auditors' reports issued virtually simultaneously with, or a short period of time after, the occurrence of events underlying the subject matter.

—CICA/AICPA Research Study on Continuous Auditing (1999)

Companies must disclose certain information on a current basis.

—Corporate and Auditing Accountability, Responsibility, and Transparency (Sarbanes-Oxley) Act (2002)

Please address comments to Miklos Vasarhelyi at miklosv@andromeda.rutgers.edu.

The Guest Editor for this article was Professor Dan O'Leary of the University of Southern California.

Corresponding author: Miklos Vasarhelyi
Email: miklosv@andromeda.rutgers.edu

INTRODUCTION

With the post-Enron support of *continuous assurance* (CA) by the SEC, the AICPA, and Congress, interest in CA has finally reached critical mass. Several years of academic research and conferences culminated in the simultaneous establishment of centers for continuous audit research in the United States and the European Union in September 2002. Three papers in a special issue on CA in the March 2002 volume of *Auditing: a Journal of Practice & Theory* (Alles et al. 2002; Elliott 2001; Rezaee et al. 2002), focused on clarifying the distinction between CA and current audit practices and describing the potential for new assurance products. With CA having been firmly established as the future of auditing, it is now time to shift the focus of the discussion from the potential and promise of CA to a systematic examination of the emerging CA-enabled audit environment.

Vasarhelyi and Halper (1991) predicted that "[Continuous Process Auditing] will change the nature of evidence, timing, procedures, and effort involved in audit work." This paper will first examine the reasons for continuous assurance and then delineate the changes in the nature of assurance encompassing its: (1) objectives, (2) levels and hierarchy, (3) timing, (4) process, (5) tools, and (6) outcomes. The object of this paper is to analyze these changes and the resulting new continuous assurance-enabled audit environment.

This new continuous analytic monitoring-based assurance environment is an outcome of a fundamental transformation in business operations and control: the electronization of the firm through the continued used of legacy systems and the progressive widespread use of Enterprise Resource Planning (ERP) systems. The unique and unprecedented characteristic of ERP is that it seamlessly integrates and automates business processes to achieve real-time information flows. Since CA is progressively being built upon the firm's underlying ERP system, CA inherits these characteristics. However, CA only achieves its full power when it takes full advantage of this ability to automate business processes and integrate information flows. On the other hand, analytic monitoring allows for the increased understanding and monitoring of the integrated and nonintegrated portions of the IT environment. We argue in this paper that the full scope of the capability that automation and integration provides CA has not been fully appreciated and utilized, and show how it provides auditors with an unprecedented toolset that transforms auditing into continuous analytic monitoring of business processes.

While continuous assurance is clearly still an emerging field, the broad forces that will shape its evolution and the nature of the assurance that it will provide are now coming into focus. By identifying the underlying principles of the analytic processes of continuous assurance, and the automation and integration of business processes that give CA its power, our objective in this paper is to provide researchers and practitioners with a clearer roadmap as to how CA is to be implemented, what its capabilities are, and how they are brought about.

We first turn to an examination of the supply and demand for CA services, showing that both have now reached critical mass, driving the recent endorsement of CA by the SEC and the AICPA. Then, in the ensuing sections, we examine the changes in the objectives, timing, processes, tools, and outcomes of the continuous assurance process. The last section provides some concluding remarks.

SUPPLY AND DEMAND FOR CONTINUOUS ASSURANCE

Alles et al. (2002) examined the role of demand in the emergence of CA, and suggested that the major constraint on its adoption was from the demand side, not the supply of the necessary technology. The recent corporate scandals and the passage of the Sarbanes-Oxley Act have only enhanced the demand side effects on CA, removing some of the doubts about its widespread adoption. Elliot (2002), Vasarhelyi (2002), and others have discussed the enabling technologies of CA, such as the use of embedded audit modules (Groomer and Murthy 1989). The new CA-enabled audit environment will emerge from the intersection of these changes in demand, supply, and technology.

The relative speed of expansion or change of each of the three co-determinants affects the feasible set of deployment. Examining these forces in detail, we take the demand-side first. The basic reasons for the need of assurance have only been exacerbated in the new economy, with organizations that are more complex, with more rapid and integrated business processes, and a wider set of legislation and regulations. Many types of management and control information needs exist apart from those served by the traditional financial statement audit, and in the real-time economy these needs can only be satisfied by continuous assurance. In particular, the current series of crises as well as the increasing reliance on technologically enabled business processes suggest new needs for assurance concerning (1) changes in the environment and industry, (2) the existence and effectiveness of controls, (3) increased human resource risks, (4) increased use of outsourced processes, (5) process continuity and integrity, and (6) coherence between endogenous and exogenous factors:

Environment and industry: Over the years, defaults epidemics had plagued particular industries, usually caused by basic economic changes in their environment and by the lack of ability of their management to cope with these changes. This phenomenon has happened in the savings and loans industry and more recently in the telecom industry. After the ensuing wave of defaults and bankruptcies, an intensive set of legal procedures and accusations of improprieties followed. These dramatic changes in the environment are often preceded or occur simultaneously with an increase in the number of mentions in the press and other forms of exogenous indicators. Vasarhelyi and Peng (1999) developed a methodology of semantic parsing and analysis that can serve as an early-warning system for auditors that major environmental changes are occurring with particular clients and more intensive scrutiny is required.

Controls: A key paradigm change in modern business systems concerns the nature of controls. While traditional systems have over the years relied extensively on controls (Vasarhelyi 1980), the intrinsic nature of controls is rapidly changing with automation and the prevalence of IT-based systems often based on ERP systems. Controls in modern systems are typically computer based and entail complex sets of analytics. This requires assurance concerning the existence of controls: that these controls are operational, that their warnings are properly observed and distributed, and that the controls are comprehensive, covering all relevant aspects of operational risk.

Human resources: Major corporate personnel changes serve as a red flag for potential problems and system instability. Templates can be used to look for fraudulent patterns and HR databases can be scrutinized for unorthodox changes. Patterns in personnel changes can indicate problem areas and increased risks.

Outsourcing: The increased outsourcing of business processes is creating virtual parts of businesses that do not naturally flow through the corporation's value chain. New methodologies such as along and across the value-chain analytic monitoring, as well as transaction control tag monitoring, must be used to preserve and evaluate process integrity.

Process integrity: Traditional audit technology has not been able to provide logical links among the pieces of business to define its logical functioning. Intrinsic relationships exist between the parts of business that can be analytically examined, relationally modeled, to give assurance of macro-process integrity.[1]

Internal and external process coherence (integrity): Most organizations operating in a particular industry tend to have a coherent set of operating statistics with operating ratios falling within a predictable range. This allows auditors to define outliers that require examination. The real-time economy now offers a much larger set of dynamic reference points, measurements, and standards. These are obtained through relentless measurement, exponential increase in sensors, intensive collection of statistics, and the progressive adoption of mutually accepted methods of measurements and standards.

[1] See the "Continuity Equations" section later in the paper.

OBJECTIVES OF CONTINUOUS ASSURANCE AND ANALYTIC MONITORING

The basic objective of the traditional audit focuses on providing assurance on the accuracy of the financial statement. Trade-offs between the benefits of this assurance, and the then current information technology led to the development of a materiality threshold of acceptable error. The modern audit, with great improvements in information technology, has changed these trade-offs in the direction of a much finer and timely assurance effort. Eventually, with the increased granularity of data distribution, through the distribution of tagged XML elements, data-level assurance will become necessary. The continuous audit will aim at providing prompter, and more accurate assurance on more granular data for a much wider set of financial and nonfinancial variables.

Levels of Assurance and Audit Objectives

The *audit objectives*—the specific assertions whose verification is the intent of the audit tasks—vary in a continuum, from well-defined issues such as transaction verification, to tasks that are of much higher order of complexity, relying extensively on human judgment, such as the estimation of contingent liabilities. Tasks that are routine and mechanical in nature can be readily transferred from a manual to a CA system and done more comprehensively and cost effectively, taking advantage of the automation and integration of the firm's ERP systems. The question is whether the effectiveness of CA declines monotonically from one end of the audit objective continuum to the other. If that is indeed the case, then the impact of CA on auditing and its ability to create a new audit environment is lessened, as it essentially does not do much more than automate existing audit methods. CA still adds a great deal of value by freeing auditors from mechanical tasks that are better handled by automated systems, thereby giving them more time to focus on matters that require pure human judgment. However, that is still a second- rather than first-order effect on the audit process.

To examine this matter, we propose to distinguish between four levels on the audit objective continuum and examine the role of CA on each one. These four levels of continuous auditing are hard to define in mutually exclusive or exhaustive ways, but they do serve to illustrate the necessary functional dependence of CA on the audit objective. Our four levels of analysis are:

Level 1: Verifying atomic elements of transactions (e.g., movement of money, information, at the data level).

Level 2: Assuring the appropriateness of the measurement rules used in transaction processing (i.e., GAAP).

Level 3: Verifying the adequacy of estimates and their assumptions, as well as the consistency of high-level measurements.

Level 4: Auditing and questioning high-level judgments and facts about the organization.

Exhibit 1 displays in a summary form the four levels of continuous audit, their objectives, procedures, level of automation, and changing paradigms.

While the automation of the first level seems sufficiently straightforward, the really surprising effect of the CA methodology is in its applicability to the other (higher levels). While the extent of application of CA decreases with the increase in the complexity of the audit objective, we argue that certain audit procedures can still be applied, sometimes formalized, and automated even at the high end of the continuum of audit objectives. The key is to undertake formal process mapping, analysis, and reengineering of audit processes. Analogous to the reengineering preceding ERP, it is likely to be the case that a good proportion of audit tasks currently thought to be matters of pure human judgment can, in fact, be systematized to a far greater extent than is currently imagined. The move toward CA

EXHIBIT 1
Levels and Characteristics of Analytic Monitoring

	Level 1 Transactional Verification	Level 2 Compliance Verification	Level 3 Estimate Verification	Level 4 Judgment Verification
Procedures	Rule/waterfall review of data	Formalization of standard relationship with XML derivative	Upstream/down-stream verification	
	Process interruption	Continuity equations	Continuity equations	Continuity equations
	Value chain transaction tracking	Structural knowledge	Value chain relationships	Expert systems
Degree of automation	High	Mixed	Mixed	Low
New paradigms procs., techns.	Continuous reconciliations	Continuity equations	Continuity equations	Continuity equations
	Invisible tracking/ transparent markers		Extensive use of exogenous data	Use of exogenous data
	Automatic confirmations			
	Rule-based trans. evaluation			
		Time-series/cross-sectional analysis	Time-series/cross-sectional analysis	Time-series/cross-sectional analysis

will require auditors to explicitly state the assumptions underlying their estimates and judgments, which is the first step toward bringing these tasks to within the capability of automated CA systems.

We shall now examine in more detail the characteristics of each of the four prescribed levels.

Level 1: Transaction Evaluation

As transactions flow through corporate systems they will be examined, classified, and aggregated, and records of these tasks will be stored by the system at varying points, locations, and degrees of detail. Different types of analysis can be used for different kinds of transactions depending on the type of data they contain. The traditional differentiation between master and transaction data is being progressively refined into a hierarchy of data and storage types depending on factors such as the nature and frequency of the data usage, the geography of the data flow, the location of the activity, the nature of their security and privacy, and existing best practices captured in ERP systems.

Detecting transaction irregularities will range in methods from traditional transaction edits to rule-based evaluations. Basic entry edits include validation of account numbers, checks against lists of clients, regions, products and departments, plausible validity ranges, time validity ranges, and so forth. The validity of these tests depends on the accuracy of various thresholds and other parameters used. The setting of such parameters will typically be done as configuration of a CA system, which has to be reexamined and updated on a regular basis.

Additional verification procedures have to validate the flow of a transaction to make sure that the sequence of processing corresponds to the process specifications defined in the system. Examples of process-flow verifications include checking if the sale corresponds to an inventory movement, to a

bill issued, or to purchase queries received through the website. Real-time process-flow verification becomes possible in CA due to the automation and integration of audit procedures. These verification procedures cannot be done in real time during conventional audits, and very often are not done at all since there is no tight integration of audit processes such as with the audits of accounts receivable and of finished goods inventory.

The continuity and completeness of transactions can be verified in CA using the formal specification of workflow of business processes stored in corporate ERP systems. Automated CA procedures can verify that the transaction has been processed at all the previous steps as required by the process specification. Moreover, structural knowledge of workflow, captured in continuity equations, allows the prediction, to some degree, of transaction flow and whether transactions are missing or have been tampered with. For example, Hume et al. (2000) tapped a very large AT&T biller at many points and succeeded in tracking hundreds of millions of transactions and reconciling their transaction flow. Structural workflow knowledge adds to this reconciliation by allowing flow prediction and loss diagnostics. Note that manual verification of continuity and completeness of a significant number of individual transaction flows presents an insurmountable challenge.

Transaction flow verification within the boundaries of the enterprise, as described above, can be extended beyond these boundaries across the supply chain links if CA is implemented at both ends of a value chain link. This is implemented as a real-time automated confirmation process that creates a certain level of integration between CA systems that are implemented and operated by different assurance providers. Both CA systems will benefit since they can confirm in real time that a receivable booked by Company A matches a payable booked by Company B.

Modern security technology such as encryption and digital signatures can be incorporated in the CA system to prevent or detect transaction tampering. Furthermore, certain types of fraudulent activities have distinct formal patterns and can be detected by matching transactions against fraudulent pattern templates or by using other artificial intelligence techniques such as neural networks (which are currently successfully used for identifying fraudulent credit card transactions).

Level 2: Measurement Rule Assurance (Compliance)

A major task in any audit is to verify that the measurement rules (such as GAAP) are properly applied to the business transactions verified at the first level. Examples of verifying proper rule application include establishing that a certain transaction is properly recorded as revenues, that another transaction is indeed a loan and not a forward contract, or that an expense is properly classified as a capital expense—all examples that have arisen in the current crop of corporate scandals. The problem with automating the verification of such rules in a CA system stems from the fact that while automated rules are strictly formal, the existing rules have a significant amount of imprecision in their formulations. On one hand, if the measurement rules are fuzzy, then they give too much manipulation leeway to the management and cannot be verified. On the other hand, the complexity and variety of modern business transactions make the creation of an exhaustive set of specific measurement rules impractical. The difficulty of finding an appropriate trade-off currently manifests itself in the ongoing extensive debate about principle- versus rule-based accounting standards. Depending on the outcome of this debate, the degree of automation of Level 2 CA procedures will differ.

The automation of CA procedures at this level will utilize a formalization of many measurement rules using knowledge representation methods and the use of automated reasoning techniques. The appropriate technology has been developed in the domain of artificial intelligence and expert systems. Fisher (2003) has demonstrated the feasibility of increased formalization of accounting standards and the benefits of this process. Without going into details of knowledge representation schemes, we can say that a measurement rule is formalized as a special template (whether this

template is a sentence in a first-order language, a Horn clause, or a frame is a matter for another discussion). The hierarchical structure of the accounting standards will be reflected in the formalization so that the templates representing more specific rules override the templates representing more general rules.

The Level 2 procedures will use pattern matching and other techniques to verify an application of rules and either will automatically conclude that this application is justified or will identify this case as unresolved and submit it for the consideration by the human auditors. While the latter cases cannot be guaranteed to be assured in real time, the selectivity of the process will make sure that the scarce resource of human judgment is utilized in the most efficient way. Thus, the participation of human auditors in this type of CA processes is effectively an application of "audit by exception."

Level 3: Estimate Assurance and Consistency of Aggregate Measures

Many estimates are utilized in business measurement and reporting for various reasons. Certain accounting numbers have to be estimated because the underlying information technology made their direct measurement either impossible or too expensive. For example, percentage of work completion used to be difficult to measure, and therefore had to be estimated. However, modern ERP systems and cost accounting techniques allow sufficiently precise measurement of the percentage of work completion in many cases. Note that the fuzziness of accounting standards discussed above may have a direct implication on the difficulty of direct measurement of the percentage of work completion.

A more substantial reason for using accounting estimates is due to the impossibility of knowing the future. Clearly not every account receivable will be collected and not every loan will be paid off. It is usually implicitly assumed that only a human expert can estimate, say, a bad debt allowance. However, many such estimates do not have to be based on intuition. Very often, the intuition of human experts can be captured and formalized in a model that utilizes both internal parameters (like past experience with collecting accounts receivable) as well as external parameters (such as market interest rates, unemployment levels, various economic growth indicators, etc.). The ubiquity of Internet connections to external sources of relevant data and the high level of automation and integration of the firm's own ERP systems make such automatic estimates feasible. Formal models providing such estimates can be incorporated into both ERP and CA systems. Even if a company does not generate an estimate automatically, the CA system can still utilize its own formal model of an estimate to assure in real time that the estimate used by the company is acceptable. Of course, creating a formal model of an accounting estimate is not a simple proposition and may add significant costs to the development of a CA system. A cheaper alternative will be if a company utilizes a formal model for automatically deriving an estimate.[2] Then auditor's task will be reduced to verifying the acceptability of this model, which has to be done only once, and can be done offline, on the basis of whether the parameter values used in the model are reasonable. This is a much simpler task and one that can be automated more readily. While not every estimate can be derived in a formal way, even partial implementation of estimate assurance in the CA system will greatly expand the scope of real-time assurance and reduce the workload on human auditors.

The spectrum of procedures applied at this level of CA includes automatic versions of various analytical review procedures, which will be based not only on internal but also external parameters, which the CA system can receive as an online feed. For example, the distribution representing the aging of accounts receivable can be automatically compared with the distribution derived from the experience of other companies in the industry. If there is a significant discrepancy between the two distributions, or the company has significantly changed the parameters of its estimates, then the CA system can generate an alarm to draw the attention of human auditors. The wide use of automatic

[2] An extreme view of this suggestion may entail that GAAP contain a series of "approved" estimate models, placed in a web library, and corporations use these models disclosing the parameters applied.

managing the pension portfolio. Some of these judgments may be relevant for a wider set of assurance and management services that may eventually arise.

TIMING OF CONTINUOUS ASSURANCE

Online/real-time systems provide the opportunity of immediate assurance processes either simultaneously or just after a particular economic event. This form of verification is different from the pure *ex post facto* nature of the traditional audit process. It provides the opportunity of controlling a process simultaneously or just after the event and in certain cases the ability to interfere with the conclusion of the event correcting its nature. These factors are very different from the traditional audit and should be stated objectively and eventually carefully researched.

A continuous audit procedure, that in CA for example implies day-to-day repetition of an audit step (say reconciliation) becomes a type of meta-control and will eventually become part of a corporation's internal controls. The continuous auditor will then assume the role of secondary verifier by checking if the procedure is really being performed.

A continuous audit procedure that points out an erroneous transaction, and an auditor who acts to correct this error, becomes a proactive actor in corporate information processing. New methods must be developed to maintain his/her independence.

The continuous audit is distributed across the year, performed mainly automatically, and will be a form of "audit-by-exception" where the system is considered materially correct (has an evergreen opinion) until an alarm states it otherwise. The conceptualization of the time frame of a "clean opinion," the meaning of an alarm in the impairment of an opinion, and its usage as audit evidence are further issues for research and the development of standards and principles of practice.

Furthermore, corporate processes have a time cycle of their own. There are instantaneous, hourly, daily, and monthly processes. Each will have a different frame of time for the calculation of their analytics and for the determination of the meaning of an audit alarm.

THE NEW PROCESSES OF CONTINUOUS ASSURANCE

CA will fundamentally change the process of assurance and will consist of an overlay of analytic control processes on top of a monitoring architecture. This section discusses the process, hierarchies, the MC layer, and the steps to be followed confronted with traditional methods.

The Process of Analytic Monitoring

Continuous assurance requires two key components: an IT structure for data gathering and an analytic monitoring methodology to support monitoring, control, and assurance. Since a CA system is an overlay on top of a set of existing systems, the CA IT architecture has to utilize a middleware layer to provide integration between loosely coupled applications such as the firm's ERP system, their legacy systems, and the new web-facing systems. Exhibit 2 shows the proposed architecture of the corporate enterprise systems, where the CA system is shown as an instantiation of the monitoring and control (MC) system.

The system of analytic monitoring uses the MC layer with Key Performance Indicators (KPIs) and formal inter-process relationship models for measurements of flows and levels and to detect variances through metrics and to generate alarms when the standard for discrepancy is reached. This level of analytic monitoring lays on top of a level of actual direct measurement of systems that can be tapped and monitored, as well as processes that still do not have automation and have to rely on pure, high-level analytic monitoring. Clearly, if there are too many discontinuities without direct process monitoring the job of high-level monitoring becomes close to untenable.

TOOLS FOR ANALYTIC MONITORING IN CONTINUOUS ASSURANCE

Each CA level has its own requirements to achieve assurance and, hence, uses different tools and methodologies. As discussed in the first part of this paper, demand is likely to drive CA away from *ex post* evaluation to a closer-to-the-event review. Further, software, people, and analytic thresholds may, at a certain point, intervene into processes and cause their interruption prior to completion. This is a paradigm shift in the nature of auditing that will cause major behavioral resistance and potentially require changes both in the view of independence as well as in many regulations of the professional conduct of accountants. In this more active role, the auditor is part of a meta-control and this intervention process will have to be understood and regulated. To distinguish from the traditional auditor role we call this *analytic monitoring* whereby the functions of performance evaluation, review, assurance, and intervention are rebalanced between auditors, managers, and operational staff.

Understanding both the new demands for assurance and, on the supply side, the automation and integration that underlies CA systems, enables the construction of new audit tools and processes that provide the unique analytic monitoring capability of CA. These new assurance technologies, which are discussed in greater detail by Vasarhelyi et al. (2003), will create an entirely new audit environment. These new technologies facilitate new objectives, processes, and tests, with modern IT systems facilitating a series of intrusive and increasingly transparent activities by analytic monitors:

- Observing events when they happen
- Alarming when exceptions occur
- Drilling down to finer degree of aggregation
- Integrating data across multiple and distinct processes
- Performing repeated tests with low variable cost

We next examine some of the tools that will underlie analytic monitoring in CA and the forces that will shape those tools.

Continuity Equations

The CA environment facilitates bringing an entirely new set of data into assurance processes, with consequently expanded new analytic methods and insights. One category of such analytic methods is what we call *Continuity Equations*, which incorporates structural knowledge into business assurance processes. The objective is to add context to financial data by relating business processes and their ensuing measurements. Structural information about business processes is used to model how data varies with management decisions and how it migrates from process to process throughout the value chain.

The first application of continuity equations was in a tool that was prototyped at Bell Labs in the early 1990s. Exhibit 3 displays a set of sequential processes that entailed bill preparation in the former Bell system (now AT&T).

Transactional data were received from the operating telephone companies in the form of magnetic tapes, which were then extracted into datasets and segmented into other types of datasets that separated types of transactions, which were then rated (priced) and accumulated into 20 different billing cycles. At the end of the cycle at bill pull time, these were rated again now with the optional calling plans that depended on monthly usage for establishing the rates. Finally the bill was prepared, printed, distributed (mailed), and consequently payments started coming in, followed by accounts receivable management, collection actions, customer support, secondary sales, etc. These processes are structurally and logically linked and structural equations provide the model and methodology to use this knowledge in assurance (and management). For example, the effect of a new advertising campaign can be traced through to its impact on usage, billing, and cash receipts. In examining transactions, understanding of knowledge structures serves to identify major breaks in control and

Organizations, when opening bank accounts, signing supplier contracts, or adding vendors to their list of approved vendors, will enclose a mutual confirmation clause and potentially some standard confirmation protocol that will be used by both parties in their mutual transactions. This protocol will present some form of security and code for the type of confirmation obtained (e.g., data-level confirmation, account aggregate confirmation) and this information will be added as a label in the data's XML derivative representation. Automatic procedures in the data flow will review the existence (or lack thereof) of the automatic confirmation and provide summaries and exceptions for the assurance process summaries.

The usage of automatic confirmations will substantially change the nature, procedures, scope, and weight attributed to audit evidence. Confirmations, obtained automatically and highly complemented by self-correcting procedures, will eventually be the most important form of audit evidence. Automatic confirmations, provisioned by extranet agreements, will substantively resolve the audit objectives of existence, completeness, and, to a certain degree, accuracy at the transaction level and account aggregation levels.

Control Tags

Tagging also allows for the inclusion of *control* tags, of which users may or may not be aware, and that can contain sequential numbers, confirmatory information, structural information, data-level assurance measures, and path markings. These tags, aimed at providing auditor information, will also substantially change the weighting of audit evidence, allowing for physical validation of audit objectives. For example, a transaction may have tags with the time of its inception, the time of its passage through key control points, an intelligent sequence number, a prevision of a processing path, and conditions for transaction acceptance and rejection. A control tag may link an order to its payment or other transaction it generated along the value chain. Furthermore, the transaction may leave behind *trailing tags* at the process structural points for transaction validation, alternate path routing, or bot-based verification.

These tools of analytic monitoring, all of which are built upon and take advantage of the automation and integration of the underling IT-enabled business processes, will fundamentally change the way in which auditing will be carried out. The audit environment within which the tools will be used will depend on the changes that CA will also drive on the levels, hierarchy, and process of auditing.

OUTCOMES OF THE CONTINUOUS ASSURANCE PROCESS

Finally, the outcomes of the continuous assurance process will entail an expanded set of assurances, evergreen opinions, some future assurances, some improvement on control processes (though incorporating CA tests), and some improved data integrity.

An Expanded Set of Assurances

The CA module in the MC layer can be programmed to issue both periodic audit opinions as well as current audit opinions, which are updated in real time whenever a change in the situation requires an update. Moreover, opinions of different nature, and alarms of different type, can be issued to different stakeholders such as banks, insurers, federal authorities, state authorities, employee unions, and environmental protection organizations. Such reports (with financial and nonfinancial information) can be tailored to the needs of the stakeholder in question (e.g., asset reports for insurers, environmental reports for OSHA, traditional reports for individual shareholders, etc.). Assurance reports with estimated levels of data reliability can be issued to the stakeholders upon the payment of a fully disclosed fee, set in advance, and open to all entities of that category.

The most important innovation of an audit opinion generated by CA is its explicit futurity, i.e., the promise to continue monitoring and evaluating the operations of the firm, informing the (registered/paying) users/stakeholders if any substantive exceptions occur. The general nature of the evaluative analytics and the magnitude of the limiting variances can be disclosed online, while the auditor could reserve the right to utilize undisclosed models and analytical procedures. The new types of audit opinions provided by CA will result in substantive changes in the timing and role played by assurance in society.

Improvement on Control Processes

The Sarbanes-Oxley Act through its Section 404 requires an auditor's opinion on the quality of corporate internal controls. While the profession is interpreting the law as the requirement to document controls, and their consideration under COSO, the issue of measurement, monitoring, and evaluation of controls in a heterogeneous integrated computer environment is far from being resolved. CA and analytic monitoring can: (1) provide data evidence that controls are functioning without their direct measurement through the understanding of the data consequences of ineffective/nonoperational controls, (2) can repeat computer operation tests (e.g., the test for duplicate payments) activated by auditors to assure that those controls are working, and (3) can "ping" (query) specially designed controls about their operating or pick data from this control on the nature of its functioning.

Improved Data Integrity

The third outcome of analytic monitoring is bringing increased assurance to a lower level of aggregation, in particular the transaction level, providing evidence/inputs for the aforementioned data-level assurance focusing on the tools of Level 1 of analytic monitoring. Automatic confirmations and control tags will provide direct evidence of data-level reliability on particular transactions while high-level monitoring will assure that these are not systematically wrong.

CONCLUSIONS

The progressive electronization of all but the smallest firms has revolutionized the management of business processes and the flow of information within firms. The implementation of ERP results in processes that are automated and integrated to an unprecedented degree, especially since it necessitates that business processes be first reengineered, so bringing them up-to-date and eliminating redundancies and inefficiencies. Continuous assurance systems are built upon a firm's underlying IT systems and so they inherit the ability to rapidly access information from anywhere in the firm's automated and integrated value chain. This will result in fundamental changes in auditing across all its dimensions: objectives, levels and hierarchy, timing, process, tools, and outcomes.

The experience with the evolution of new technologies and business processes suggests that CA will initially be used to do no more than automate existing audit procedures and thereby take full advantage of the capabilities that it has in the new ERP-based environment. This paper describes the tools that will come forward once CA moves to the second stage of its evolution when audit processes are reengineered to exploit the underlying technological capabilities to the fullest. This will lead to the creation of a new system of continuous analytic monitoring that will completely transform the audit environment, in much the same way that ERP systems themselves revolutionized firms' internal monitoring and control systems.

However, to reach that stage will require more than technology implementation. For one thing, it will necessitate auditors actually examining their processes to see if they are susceptible to process mapping and reengineering. This is particularly important if CA is to achieve its full potential, by being progressively extended to higher levels of audit objects, rather than being restricted to the most

mechanical of audit task at the transaction level. However, systematizing processes, once thought to be exclusively in the pure human judgment domain, will take a paradigm shift by auditors. At the same time, continuous analytic monitoring will intrude into the internal control arena, especially since it is built on the firm's own ERP systems. This will create concerns with independence and the relationship between internal and external auditing, analogous to the current debate on the boundary between auditing and consulting.

These implementation issues, the specification of the analytic monitoring toolset and the nature of continuous auditing at each level of audit object all require an intensive research effort, extending from establishing solid theoretical foundations to rigorous laboratory testing. The research agenda put forward by Kogan et al. (1999) needs to be expanded from CA alone to the nature of the entire CA-enabled analytic monitoring environment. While the theoretical work in CA has made progress, the field has been hindered by the lack of a proper set of experimental and empirical research. Consequently, establishing viable data laboratories with large quantity of real (not necessarily but preferably current) data emulating corporate ERP systems, legacy systems, web-facing systems, and real economic circumstances including accounting malfeasance is a priority for the continued development of CA.

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