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CONTINUOUS AUDITING:
THEORY AND APPLICATION

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CONTINUOUS AUDITING: THEORY AND APPLICATION

Editors

David Y. Chan
St. John's University, NY, USA

Victoria Chiu
State University of New York at Oswego, NY, USA

Miklos A. Vasarhelyi
Rutgers, The State University of New Jersey, NJ, USA

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List of Contributors

Abdullah Al-Awadhi	Rutgers University, The State University of New Jersey, NJ, USA
Michael G. Alles	Rutgers, The State University of New Jersey, NJ, USA
Gerard Brennan	Siemens Corporation, NJ, USA
Helen Brown-Liburd	Rutgers University, The State University of New Jersey, NJ, USA
Nancy Bumgarner	KPMG LLP, NY, USA
Paul Eric Byrnes	Rutgers University, The State University of New Jersey, NJ, USA
David Y. Chan	St. John's University, NY, USA
Victoria Chiu	State University of New York at Oswego, NY, USA and State University of New York at New Paltz, NY, USA
Rick Elam	University of Mississippi, MS, USA
S. Michael Groomer (1942−2012)	Indiana University, IN, USA
Benita Gullvist	Hanken School of Economics, Vasa, Finland
Fern B. Halper	AT&T Bell Laboratories, NJ, USA
Alexander Kogan	Rutgers University, The State University of New Jersey, NJ, USA
Stephen Kozlowski	Eastern Illinois University, IL, USA
Qi Liu	Rutgers, The State University of New Jersey, NJ, USA
Peter L. McMickle	The University of Memphis, TN, USA
Uday S. Murthy	Indiana University, IN, USA
Zabihollah Rezaee	The University of Memphis, TN, USA
Ahmad Sharbatoghlie	Independent Systems Consultant, Boston, MA, USA

Ephraim F. Sudit	Rutgers, The State University of New Jersey, NJ, USA
Ryan Teeter	Rutgers, The State University of New Jersey, NJ, USA
Miklos A. Vasarhelyi	Rutgers, The State University of New Jersey, NJ, USA
J. Donald Warren	University of Hartford, CT, USA

Introduction

Victoria Chiu, David Y. Chan and Miklos A. Vasarhelyi

Modern auditing dates back to 1844 when the British required management of companies to issue audited financial statements to shareholders.[1] Beginning in the 1900s, regulation delegated the audit profession with a prominent corporate governance role in the United States. The Securities Exchange Act of 1934 required the financial statements of public companies to be independently audited by external auditors. Furthermore, regulatory requirements of the Sarbanes Oxley Act of 2002 increased the role of auditing in corporate governance within an organization. While the audit profession is over a century old, it has surprisingly underutilized advanced technologies in the audit process (Chan & Vasarhelyi, 2011). Auditors have slowly embraced the use of technology like other business functions (e.g., marketing, human resources, supply chain management, etc.). Except for the use of spreadsheets and computerized aided audit tools (CAATs), auditors have only scratched the surface in utilizing advanced audit technology to enhance their fiduciary role. Chan and Vasarhelyi (2011) emphasized that the incorporation and effective use of advanced audit technology is critical for the profession to remain relevant in the real-time economy and to support the emerging and evolving need for real-time assurance. Researchers and practitioners have both commonly agreed that the next paradigm in auditing is the use of the advanced auditing technology called continuous auditing (CA). Academic researchers have made great strides in the development of theories and the application of CA through experiments in practice.

Tracing the school of thought of CA, research propositions on the use of online technology to automate audit processes and research frameworks conceptualizing audit tasks performed on a continuous basis were first introduced to the literature in the late 1980s. Groomer and Murthy (1989) developed an approach that allows auditors to capture information of audit significance continuously within a database environment for compliance and substantive testing. Two years later, Vasarhelyi and Halper (1991) argued that the importance of the CA model under the trend of

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[1] http://highered.mcgraw-hill.com/sites/dl/free/0070968292/436879/Smieliauskas4e_App1B.pdf

real time and electronic financial reporting and compared it against the traditional audit model. The notion of performing audits on a continuous basis was a breakthrough in the accounting information systems fields. However, the definition and boundaries of "continuous auditing" had been discussed and debated in the literature. CA is a type of auditing that produces audit results simultaneously with, or a short period of time after, the occurrence of relevant events (Kogan, Sudit, & Vasarhelyi, 1999; AICPA, 1999). Rezaee, Sharbatoghlie, Elam, and McMickle (2002) viewed and defined CA as slightly more conservative: CA is a comprehensive electronic audit process that enables auditors to provide some degree of assurance on continuous information simultaneously with, or shortly after, the disclosure of the information.

CA systems are commonly implemented and operated by external and internal auditors.[2] However, the role of CA has evolved primarily into an internal audit function (Byrnes, Al-Awadhi, et al., 2012; Byrnes, Ames, et al., 2012; Malaescu & Sutton, 2015; Vasarhelyi & Kuenkaikaew, 2010). The ability of CA technology to produce a more effective and efficient audit to support real-time assurance lies in the approach to performing an audit. In the CA environment, the traditional audit procedures are automated using computer programs, and the analytical procedures and substantive testing are carried out using computer algorithms. Audit procedures that cannot be automated will ultimately be reengineered (Alles, Brennan, Kogan, & Vasarhelyi, 2006). The audit programs can be either embedded into applications in an accounting information system (Groomer & Murthy, 1989) or can be operated as a standalone system (Chan & Vasarhelyi, 2011). Under either methods, the CA programs tap into the accounting information system on a continuous basis or regular basis (Du & Roohani, 2007) or after a number of transactions/batch (Du & Roohani, 2007; Pathak, Chaouch, & Sriram, 2004) to perform the automated audit procedures.

Although never empirically studied yet, financial reporting and audit quality should improve under the CA paradigm. Under a CA, the whole population is considered and thus offering a more comprehensive and robust audit (Bumgarner & Vasarhelyi, 2015). Utilizing analytics, each and every single economic transaction can be analyzed and evaluated against a benchmark (Vasarhelyi, Alles, & Kogan, 2004). Theses benchmarks are based on rules or developed by modeling historical transactional data using learning algorithms. For modeling data, there is the assumption that unaudited transactions should look like previously audited transactions. The computer algorithms are derived from the statistical, data mining, and machine learning domain. Those transactions that deviate from expectations or are considered anomalous and deemed material are identified as exceptions by the CA system and require the attention of auditors. A CA is often considered an audit by exception. If the CA system does not generate an exception then there is the

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[2]Based on feedback from participants of the annual World Continuous Auditing & Reporting Symposium at Rutgers University.
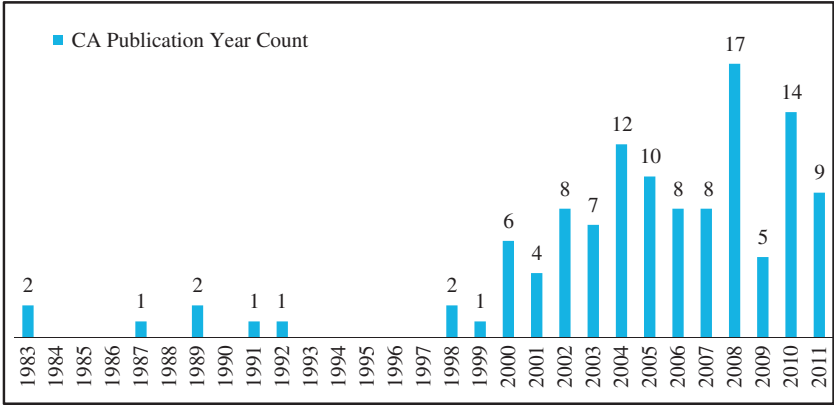
assumption that the controls are working as intended and there are no material anomalous transactions.

The theoretical benefits of utilizing CA technology in the audit process are clear but the adoption of the CA paradigm in practice has been nominal to date (Vasarhelyi & Kuenkaikaew, 2010). However, there is momentum in the novel application of CA within individual business processes (e.g., accounts payable, accounts receivables, treasury transactions, etc.) at larger companies. Companies such as AT&T Corp., Siemens, P&G, Computer Associates, IBM, MetLife, and HP are all exploring piecemeal opportunities in CA. Furthermore, many of these organizations include academic researchers into the process of developing their in house CA systems (Alles et al., 2006; Kim & Kogan, 2014; Thiprungsri & Vasarhelyi, 2011; Vasarhelyi & Issa, 2011a, 2011b). The interest of companies and the active involvement of academic researchers in the development of CA systems evidence that perhaps we are at a crossroad and practitioners are beginning to realize that the traditional auditing methodologies are outdated to support current and future business needs.

As we progress into an all-digital economy where business transactions are completely processed online electronically, the CA paradigm will become more relevant and feasible (Alles et al., 2006). Although the application of CA reduces the latency of detecting control violations or anomalous transaction, the CA of today is functioning from a continual perspective because typically a short period of time passes before the CA system engages an audit. We envision that the second wave of the CA paradigm will entail analyzing transactions as they occur instead of immediately or shortly after occurrence. This type of audit is synonymous with the coined term "predictive audit" (Vasarhelyi & Kuenkaikaew, 2013). A predictive audit is similar to how credit card companies analyze transactions in real time in order to accept or deny a charge. Ultimately, a predictive audit will transform the auditing paradigm from a reactive audit into a proactive audit (Chan & Vasarhelyi, 2011). As researchers and practitioners gain from their experiences, the development of CA methodology and technology will advance further to a point where CA can become a full viable alternative or replacement of the traditional audit. At that point, real-time assurance on information can truly become a reality.

The CA literature has been published in a number of top academic publications of multiple disciplines, accounting, accounting information systems, management information systems, and computer science (Chiu, Liu, & Vasarhelyi, 2014). The amount of research in CA has become more pervasive over the past 10 years (Table 1). The top five journals that were found to publish the most CA studies are *International Journal of Accounting Information Systems*, *Journal of Information System*, *Auditing: A Journal of Practice and Theory*, *The International Journal of Digital Accounting Research*, and *Decision Support Systems* (Table 2). This book consists of selected CA articles reprinted from top journals in the accounting information systems field. The articles present concepts, techniques, frameworks, methodologies, and technologies in the CA paradigm.

Table 1: CA Research Distribution by Year.

■ CA Publication Year Count

Source: Adapted from Chiu et al. (2014).

Table 2: CA Research Distribution by Journal.

Journal	■ Total
Accounting and Finance	1
Accounting Forum	2
Accounting Horizon	3
Advances in Accounting	1
Advances in International Accounting	1
Auditing: A Journal of Practice and Theory	8
Computer Fraud and Security	1
Computer Standards and Interfaces	1
Computers and Security	1
Critical Perspectives on Accounting	1
Decision Support Systems	5
Design Studies	1
Expert Systems with Applications	1
Information Management & Computer Security	1
International Journal of Accounting Information Systems	22
International Journal of Auditing	3
International Journal of Computer Integrated Manufacturing	1
International Journal of Disclosure and Governance	1
International Journal of Industrial Organization	1
International Journal of Information Management	2
International Journal of Intelligent Systems in Accounting, Finance & Management	2
Issues in Accounting Education	2
Journal of Accounting and Public Policy	2
Journal of Accounting Education	1
Journal of Accounting Research	2
Journal of Accounting, Auditing and Finance	1
Journal of Business Finance & Accounting	1
Journal of Computer Information Systems	2
Journal of Emerging Technologies in Accounting	3
Journal of Information Systems	21
Journal of Information Systems and Technology Management	1
Journal of Information Technology Theory and Application	1
Knowledge Bases Systems	1
Managerial Auditing Journal	1
MIS Quarterly	1
Public Administration Quarterly	1
The Accounting Forum	1
The Accounting Review	3
The International Journal of Accounting	1
The International Journal of Digital Accounting Research	8
The Journal of Corporate Accounting & Finance	1
Total Quality Management	1
WSeas Transactions on Computers	1
WSeas Transactions on Information Science and Applications	1

Source: Adapted from Chiu et al. (2014).

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Continuous Auditing—A New View[1]

Nancy Bumgarner, CPA and Miklos A. Vasarhelyi, PhD[2]

1. INTRODUCTION—CONTINUOUS ASSURANCE THE THEORY[3]

This volume is intended as an update on the report Continuous Audit (also called Red Book) published by the CICA and AICPA in 1999. In that volume, some basic principles and a vision were presented that served as a basis for additional guidance work by the Institute of Internal Auditors (IIA) in 2005 and the Information Systems Audit and Control Association (ISACA) in 2010. Fifteen years after that 1999 report, this volume presents a much different state-of-the-art, and this essay proposes an expanded set of concepts largely adding to Vasarhelyi and Halper (1991) and joining it with an increasing set of experiences and literature from practice and academia. The evolution of IT, the emergence of big data, and the increasing use of analytics have rapidly changed the landscape and profile of continuous assurance and auditing.[4] Many of the current audit standards were initially instituted by legislation based on the Securities Act of 1933 and the Securities Exchange Act of 1934 and progressively developed into the current, ever-evolving set of generally accepted auditing standards, or GAAS. This formalization of "generally accepted" has had an enormous effect on business practices and consequently large effects on the social ecosystem.

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[1]From *Audit Analytics and Continuous Audit − Looking Toward the Future* (2015) Reprinted by permission of the AICPA.

[2]The suggestions and contributions of professors Michael Alles and Mr. Shrikant Despante are gratefully acknowledged. This essay also substantively benefited from the suggestions of Messrs. Bob Dohrer, Chris Kradjan, Dorothy McQuilken, and Beth Schneider.

[3]The authors are appreciative for advice and guidance from Professor Michael Alles, the comments of Mr. Shrikant Deshpande, and the research assistance of Ms. Qiao Li.

[4]In general the field of assurance incorporates both the traditional audit as well other types of assurance such as SysTrust, WebTrust or assurance on cybersecurity. In this essay *continuous assurance* is also taken as potentially a larger set of topics than providing traditional auditing services but on a more frequent basis. On the other hand, the terms *continuous audit* and *continuous auditing* are used interchangeably.

Within this context, in addition to the external verification of financial statements, many contexts in need of third-party verification have risen. Consequently, organizations developed internal audit departments, consulting firms introduced auditing services, and some of these needs are being satisfied on an ad hoc basis mainly by external audit firms. Vasarhelyi and Alles (2006), in a study for the AICPA's Enhanced Business Reporting (EBR) project, characterized the umbrella of verification services as "assurance," under which falls a set of services such as the "traditional (external) audit," internal audit, and much of what we later in this paper call "audit-like services." Several data analytic and monitoring functions of the expanded set of activities that we hereby call continuous assurance have dual or multiple functions serving assurance, management, and other parties. Guidance on materiality, independence, and required procedures will eventually be needed to adapt to the new tools as the environment evolves. This essay illustrates some of these needs.

Groomer and Murthy (1989) and Vasarhelyi and Halper (1991) have respectively argued for and demonstrated the desirability and possibility of "closer to the event" assurance processes. This approach, reflecting the evolution of technology to online, real-time systems, has had slow but progressive adoption both in practice (Vasarhelyi et al, 2012; ACL 2006; PWC 2006)[5] and in professional guidance (CICA/AICPA, 1999; IIA, 2005; ISACA, 2010).

1.1.   *Continuous Process Auditing*

Motivating the need for continuous assurance, Vasarhelyi and Halper (1991) state: "There are some key problems in auditing large database systems that traditional auditing (level 1) cannot solve. For example, given that traditional audits are performed only once a year, audit data may be gathered long after economic events are recorded." To deal with these problems, the AICPA/CICA's Red Book (1999) introduced the current definition of continuous auditing:

> 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 auditor's reports issued virtually simultaneously with, or a short period of time after, the occurrence of events underlying the subject matter. (CICA/ AICPA, 1999)

Research studies have provided a much broader perspective on how technology is changing auditing. Alles, Kogan, and Vasarhelyi (2002) questioned whether there was an economic demand for continuously provided assurance and suggested that the more likely outcome is audit on demand. Alles, Brennan, Kogan, and

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[5]PricewaterhouseCoopers, Internal Audit Survey; Continuous Audit Gains Momentum, 2006.

Vasarhelyi (2006) expanded the scope of the continuous audit by dividing it into continuous control monitoring (CCM) and continuous data assurance (CDA). It has also been shown that many internal audit procedures can be automated, thus saving costs, allowing for more frequent audits and freeing up the audit staff for tasks that require human judgment (Vasarhelyi, 1983, Vasarhelyi, 1985; Alles, Kogan, and Vasarhelyi, 2002).

In the last decade of the 20th century, many large companies, prompted in part by the Y2K concern, replaced their legacy IT systems with new enterprise resource planning (ERP) systems. These ERP systems are controlled by extensive control settings while data is organized into relational databases that are composed of complex, multi-dimensional tables that are "related" to each other for the creation of reports by common fields. Users, for highly justifiable business reasons, are allowed to override control settings. Consequently, new assurance needs have emerged due to the ever increasing difficulty of direct observation of (1) control structures, (2) control compliance, and (3) data.

Control Structure

The ubiquitous usage of ERPs diminished concerns with the adequacy of control structures as the systems are typically based on best of class implementation and widely used even though each company will determine how the ERP control structure will be adopted for company-specific circumstances. Many questions remain, as the actual control structure does not only involve the ERP systems but also the entire manual and IT set of processes (that include many elements aside from the ERP systems) and their integration. Controls can be overridden or bypassed by the users, or may not exist at the upstream of the process, and transactions will be received as legitimate.

Control Compliance

Control compliance, on the other hand, became a much larger problem as established flexible and widely applicable control structures often entail a very large number of controls and for operational reasons these controls may have to be temporarily re-parameterized. For example, a particular checking account may be allowed to go over its credit limit for operational reasons. The need to monitor and assure control settings and the nature of overrides generated a new type of audit objective and process.

Data

Data is in general stored in ERPs, in files for legacy systems, or in more recent times in large repositories external to the organization that are called big data (Vasarhelyi, Kogan, and Tuttle; 2015). The access to these data for observation, monitoring, or mass retrieval requires the auditor's knowledge and extensive use of software tools. This access is not only technically challenging but also organizationally difficult (Vasarhelyi, Romero, Kuenkaikaew, and Littley; 2012).

1.2.   Conceptualizing Various Elements of CA

Table 1-1 illustrates the uses, purposes, and approach of the expanded model of continuous assurance differentiating between internal and external usage and further differentiating between diagnostic, predictive, and historic usage.

Each of these elements is discussed in the following sections.

Continuous assurance (CA) has the potential to benefit a wide variety of users. Management will be interested in all aspects, from data assurance to monitoring operations. Investors may primarily be interested in data assurance though, depending on the industry, compliance and risk monitoring may be equally as important.

CA is well suited for historic analyses, particularly given the speed with which CA provides information on attributes such as accuracy. Auditors that provide assurance on historic information will likely be primarily interested in the ability of CA to be used for such purpose. Access to sophisticated ERPs and complex data sets create an opportunity for CA to be used for diagnostic purposes. Where an error or anomaly has been identified, CA may perform a retrospective diagnostic of the situation—providing insight and analyses to management. Diagnostically, CA could also be tied to effectively assessing operational and structural strengths and weaknesses of an organization—enabling strategic decisions to be made in a timely manner and with sufficient context.

Automation is an essential element to CA, though manual involvement remains important particularly in situations where extensive judgment is required and where anomalies, exceptions, and outliers are identified.

Table 1-1: Users, Purpose, and Approach of the Elements of Continuous Assurance.

	Data assurance	Controls	Compliance	Risk monitoring and assessment	Operations (monitoring)
Who uses					
• Management	X	X	X	X	X
• Audit (internal or external)	X	X	X		
• Investors	X				
• Regulators	X	X	X		
Purpose					
• Diagnostic		X	X	X	X
• Predictive				X	X
• Historic	X	X	X	X	X
Primarily performed by					
• Automation	X	X	X	X	X
• Manual		X		X	X

Continuous Data Audit CDA

Vasarhelyi and Halper called the process of monitoring and constantly assuring AT&T's RCAM system continuous audit. The architecture of the system described in figure 1-1 shows data being (1) extracted from pre-existing reports, (2) sent to the business units through the remote job entry network, (3) transferred to an email system, and (4) extracted through individual text mining programs. This technique, analogous to what is called today "screen scrapping," was chosen to avoid interference in the long and complex system process development protocol. All information was collected from existing reports and placed in a relational database. This database drove hypertext graphs that were given to auditors to interact with the system. The several layers of the RCAM system were represented as flowcharts respecting the internal auditors' documentation practices and experience in data analysis. Many of the analytics impounded into the system were drawn from knowledge engineering (Halper, Snively, and Vasarhelyi, 1989) internal auditors and capturing the calculations they made with paper reports. The formalization of these processes allowed for their repetition at repeated frequency, and often reliance on these tests up to the moment that alerts were generated. Although internal auditors started relying on these exception reports, they also requested that the source reports be retained mainly for their traditional audit reports.

Although the idea of a continuous audit was conceptualized initially as a data monitoring and exception system (Vasarhelyi, 1996), its concept was expanded in an implementation at Siemens (Alles et al, 2006) as a reaction to Sarbanes Oxley and
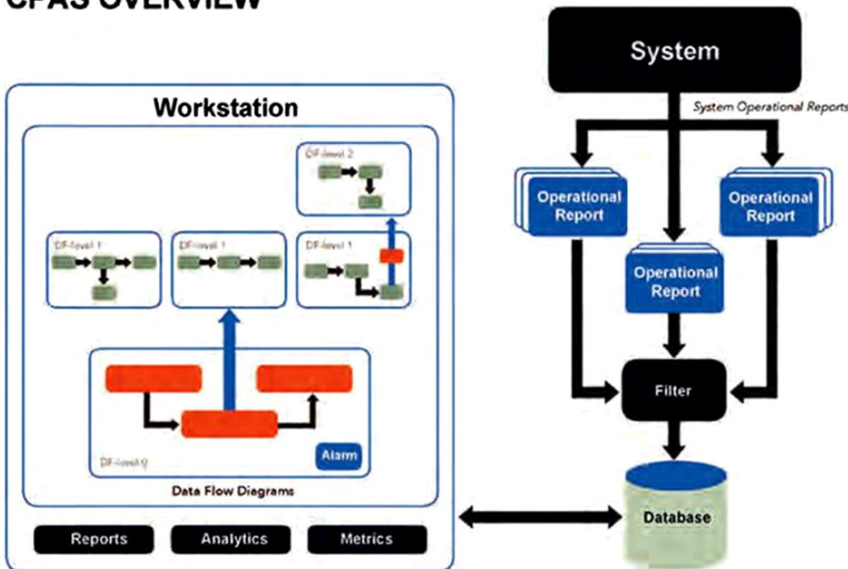

Figure 1-1: CPAS as Continuous Data Audit (from Vasarhelyi & Halper, 1991).

the need to issue opinions on the adequacy of internal controls. This expansion was entitled continuous control monitoring (CCM).

Continuous Control Monitoring (CCM)
Siemens had over 150 instances of SAP that were reviewed by technical experts using that narrow guidance of a standardized set of audit action sheets. These were a formalization of the audit plan to review controls and features of a particular SAP implementation and were adapted to each audit instance. Alles et al. (2006) developed a proof of concept tool where a baseline of control settings would be compared with the actual configurable control setting every night and auditors would be alerted of variations. Teeter (2014) extended the original work examining the potential for automation of not only the deterministic settings of SAP but a wider set of controls and parameters in the SAP system.

> The...essay...investigates the implementation of a comprehensive continuous controls monitoring (CCM) platform for evaluating internal controls within a highly formalized and well-controlled enterprise resource planning environment. Utilizing the IT audit plan as a template, auditor expertise as a guide, and manual audit output as a validation tool, this field study examines the process of audit formalization and implementation of CCM at a software division of a large, multinational corporation. (Teeter, 2014)

The results of the applied effort[6] indicated that 62 percent of the controls arguably could be formalized, creating the possibility of a control certification or assurance layer on top of the SAP instance. Conceptually, this layer could be a part of SAP or an add-on, could be generic in configuration or tailored to the instance, and could be re-thought as a way to increase audit coverage as the original audit plan was applied in an 18- to 24-month cycle, and under this design this layer would be executed every day. Furthermore, the audit plan contained many qualitative questions such as "Is there documentation for XYZ system?"

> Elder et al. (2013) narrate a continuous monitoring effort at a large South American bank in which internal audit monitored 18 different key performance indicators (KPIs) for over 1400 branches of a bank. Daily extracts of variances were obtained and, on a selective basis, followed up by emails to the regional managers for the branches. These KPIs looked to control overrides such as credit above allowable level or reversal of certain types of transactions.

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[6]Private notes Teeter, R.A., Warren, J.D., Brennan, R., and Vasarhelyi, M.A. 2007.

These examples illustrate (1) situations where auditors were in positions of control over operational controls, which could result in a conflict to the auditor's objectivity or independence and (2) that technology has changed the needs, capabilities, and roles of the assurance function. As suggested earlier, a more flexible set of conceptualizations must evolve, concerning auditor independence in particular. These examples are focused on internal auditors, but a similar monitoring role could be developed for external auditors and an ongoing monitoring opinion could potentially be issued as a new CPA product.

Figure 1-2 describes the vision developed for multi-instances of ERPs and an analytic engine supporting a set of functions. This view, however, could be immediately after the event based on the two experiences described above and would be an ex-post-facto overnight process, which we would describe as retroactive close to the event meta-control or assurance process.

Incorporating the concept of CCM into the original CA conceptualization led to the renaming of the original CA to Continuous Data Audit (CDA) where CA = CDA + CCM.

Continuous Risk Monitoring and Assessment (CRMA)
Vasarhelyi, Alles, and Williams (2010) suggested the addition of Continuous Risk Monitoring and Assessment (CRMA) into the CA schema where: CA = CDA + CCM + CRMA. CRMA is discussed in more detail in essay 6, "Managing Risk and
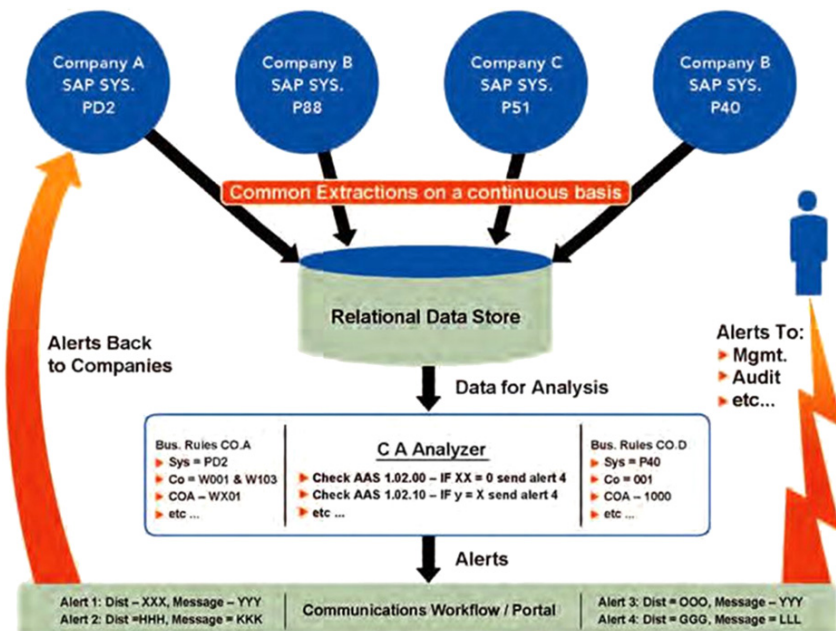
Figure 1-2: Pilot Continuous Monitoring of Business Processes at Siemens, Rutgers CAR-Lab & Siemens Adding Intelligence (from Alles et al, 2006).

the Audit Process in a World of Instantaneous Change" of this book. The essence of the CRMA concept is displayed in figure 1-3 where risks are divided into three areas: (1) operational, (2) environmental, and (3) black swans (Taleb, 2010). Black swans are very remote risks with strong consequences that could arise, as Taleb predicted the crisis of 2008. Risks are chosen judgmentally by the audit team or management, and key risk indicators (KRIs) are associated with the most important risks in each of the categories. The same basic variance and acceptable variance model can be adapted to detecting significant changes of risk. The model can be parameterized at the initial audit planning stage with heuristic or otherwise developed weights and optimization procedures applied to determine an audit program. When substantive changes in risk are perceived by the risk monitoring procedures, the algorithm can be rerun, but management must also be informed and joint action by assurance and management must follow. This risk variance activation procedure also confounds the classical audit theory, as many organizations have independent risk management areas often broken down by type of risk or product. New conceptualization of coordinated auditing or coordinated management, audit, and risk areas must follow.

Continuous Compliance Monitoring
Very closely related to risk evaluation, and closely linked to the increasingly regulated modern business world, is the area of compliance. Although much of the traditional world of compliance is qualitative, it is progressively being implemented by automated systems. Frequent upgrades in ERPs, for example, at banks and
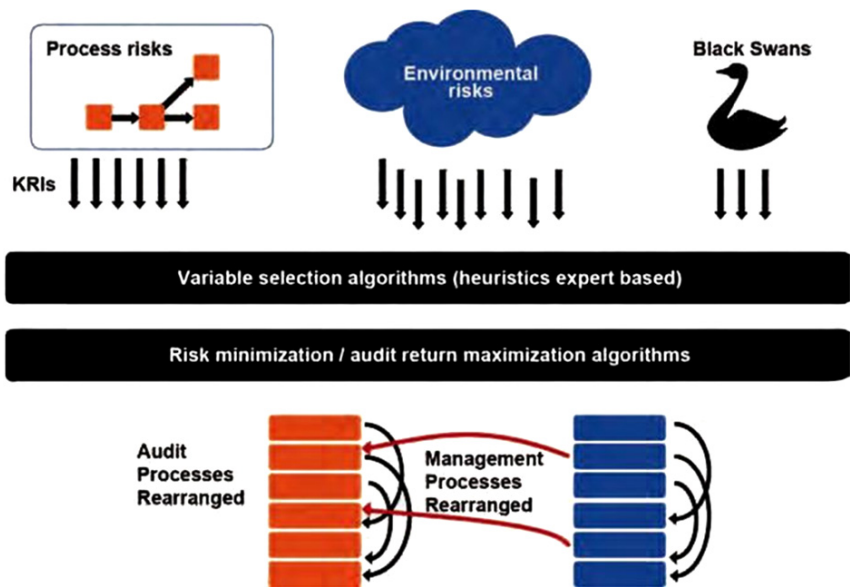

Figure 1-3: Structure for CRMA Effort.

insurance companies reflect the increased regulation, the need to reduce costs of compliance, and the need to obey hundreds of regulations. In this essay, the development of a compliance monitoring (COMO) approach to complement CA is proposed.

The COMO approach would create comprehensive taxonomies of compliance issues and progressive updates for regulatory changes acknowledged by geography, area of activity, and the nature of compliance rule (qualitative, quantitative, mixed, or other). It would restate the CA equation to:

$$CA = CDA + CCM + CRMA + COMO$$

The integration of these views into a closer-to-the-event framework has the advantage of improving assurance coordination, working towards avoiding task repetition, and the potential usage of a conceptual and IT platform. Table 1-2 illustrates one type of (quantitative) compliance objective in relation to the topic of money laundering. As a caveat, if the above functions are united into a joint conceptual view and one platform implementation, the risks of their failure are much larger as a certain degree of redundancy decreases risk but also increases costs.

Compliance requirements can be largely qualitative, interpretive especially of legal, regulatory requirements, but its fulfilment (for example, fulfilment of the obligations) needs a degree of formalization in measurement of supporting information, monitoring, and reporting.

Compliance fulfilment data is processed in the complex corporate legacy, ERP, and other sources of big data where the company operates. Traditional methods of extracting and evaluating an assertion of fulfilment of compliance obligations to stakeholders and regulators are anachronistic. Therefore the argument for continuous auditing applies to compliance. Compliance management needs to be design-driven (for example, formal structure for requirement definition, data capture, single view of data bases, data visualization and interpretation from analytics based representation). Continuous assurance and continuous compliance assurance are

Table 1-2: Example of Compliance Monitoring Table.

Anti-money laundering
1. Compliance Topic: AML
2. Obligation or Compliance issue (for example, not to let over $10,000 through bank teller deposit without regulatory reporting)
3. Method of compliance: All transactions for a given deposit rule have been captured and reported
4. Frequency capture daily, report quarterly
5. Importance: H M L HIGH

complementary and can leverage many common design, analytics, and technology components. Their integration is aimed to alleviate the multiple problems generated by the proliferation of audit-like organizations.

1.3.   *Guidance on Continuous Auditing*

The first guidance on continuous auditing was published jointly by the CICA and AICPA (1999) and is often called the Red Book. This current volume attempts to update the Red Book along several dimensions. Since the publication of the Red Book, the Institute of Internal Auditors published its *GTAG 3 Continuous Auditing: Implications for Assurance, Monitoring, and Risk Assessment* (IIA, 2005) *and ISACA its IT Audit and Assurance Guidelines, G42, Continuous Assurance,* (2010). In 2010, the Australian Institute of Chartered Accountants also published its *Continuous Assurance for the Now Economy*.

   Leveraging this statutory work, continuous auditing literature reviews (Brown et al, 2007; Chiu, Liu, & Vasarhelyi, 2014), and literature from practice, this essay will summarize some basic theory postulates for continuous assurance. *Assurance*, for purposes of this essay, is defined as *an umbrella of services that include the traditional audit and other services of a similar or complementary nature that are emerging or being facilitated by new technologies and business needs.* (Vasarhelyi & Alles, 2006)

   Considering the new assurance needs in control structure, control compliance, data, and the existing guidance on continuous auditing, a reconsideration and expansion of the elements in the concepts of continuous assurance is needed.

2.   THE ELEMENTS OF CONTINUOUS ASSURANCE REVISITED

The advent of new information and analytic technologies has brought about new products as well as new ways to perform business processes. Since the early years of continuous auditing, business has substantially evolved the continuous monitoring processes of production into many other areas of activity including accounting and finance.

2.1.   *Continuous Auditing Versus Continuous Monitoring*

Considerable thought has been given to the problem of overlap between management and assurance processes when they progress in the automation route. KPMG (Littley and Costello, 2012) described it in operational terms, as shown in table 1-3. Another approach would be to consider some new type of conceptualization based on the new economics of information, control, and risk.

Table 1-3: CA Versus CM.

Continuous Auditing Performed by Internal Audit	**Continuous Monitoring Responsibility of Management**
• Gain audit evidence more effectively and efficiently • React more timely to business risks • Leverage technology to perform more efficient internal audits • Focus audits more specifically • Help monitor compliance with policies, procedures, and regulations	• Improve governance—aligning business/compliance risk to internal controls and remediation • Improve transparency and react more timely to make better day-to-day decisions • Strive to reduce cost of controls and cost of testing/monitoring • Leverage technology to create efficiencies and opportunities for performance improvements

Littley and Costello (2012), as shown in table 1-1 and the AT&T Bell Laboratories development of Continuous Process Audit System (CPAS) (Vasarhelyi and Halper, 1991) in parallel to management's Prometheus system (table 4) show a substantive overlap of management and assurance analytics and the potential of the usage of similar systems to support infrastructure. IBM's[7] internal audit approach was to commission three monitoring systems for auditees and progressively obtain their agreement to use the system for monitoring by management. Traditional audit thinking argues that if the auditor acts as a "monitorer," in one sense, he or she becomes part of the control system and loses independence. On the other hand, the traditional audit can be viewed as a form of tertiary control acting both as a deterrent as well as an after-the-fact detective control. The progressively increasing set of layers between the auditor and the data, as well as the massive nature of data being used by large corporations, forces the existence of monitoring and reporting layers, not to mention ERP software, web interfaces, legacy systems, and outsourced processes.

Vasarhelyi and Halper (1991) initially developed the CPAS project aimed at creating a meta-understanding of the system being audited and making this system auditor-monitored. It became clear after a certain amount of time that similar monitoring insight and analytics would be also of interest to management and of benefit in the utilization of the system being monitored. Consequently AT&T developed the Prometheus system (Vasarhelyi, Halper, & Esawa, 1995), which used the same technological undercarriage of CPAS but with some unique analytics for both management and auditing, as well as a larger common base of analytics and monitoring controls.

Table 1-4 illustrates a series of reports, screens, and data monitoring procedures based on AT&T's RCAM system where there is examination of data at multiple

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[7]As described in annual presentations at the World Continuous Auditing Symposium in Newark (2011, 2012), that can be seen in http://raw.rutgers.edu/

Table 1-4: CA and CM at AT&T[8].

Analytic number	Process	CPAS (Continuous Audit)	Prometheus (Continuous Monitoring)
1	Bill Completion Monitoring	Percentage of bills generated that were completed	Percentage of bills generated that were completed
2	Calls recorded	Long-term count of calls adjusted for cycle	Switch billing integrity comparisons
3	Bills missing	Process integrity reconciliation	Process integrity reconciliation
4	Job sequencing in the data center		Examination of CA-7 and CA-11 reports
5	Discrimination of reasons bills not printed		Staged counts
6	Specific Bill content examination	Bill images—content extraction summaries	For accuracy verification
7	Bill sequencing controls	For fictitious bill detection	For production monitoring
8	Continuity Equations	For predictive Auditing (Kogan et al., 2014; Kuenkaikaew, 2013)	For error detection and process monitoring

levels. While analytic 1 examines the overall completion rate of the billing process, analytic 2 works at a much lower and earlier level examining the data collected by the switches. Some analytics are only provided to the audit functions, others are only of interest to management monitoring, while others are to be supplied to both. The CPAS conceptualization involved 4 major elements: (1) actuals, (2) standards (models), (3) analytics and (4) alarms (alerts) in addition to the method of measurement (direct data access or secondary capture). Analytics in CPAS were provided in the form of formulae, rules, and, in most of the instances, with graphic visualization.

Kogan et al. (2014) applied the concept of continuity equations expanding the original suggestion of Vasarhelyi and Halper (1991) including the following:

- Distinguishing exceptions from anomalies
- Introducing time-lagged process measurements that reflected better the actual information flow in the system

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[8]This table is illustrative in nature. It is loosely based on the actual experience of the monitoring and assurance of the RCAM system in the 1986–1991 period.

- Focusing on transaction-level monitoring with clarification of the different levels of activities
- Introducing the concept of automatic transaction correction into the audit literature

Recent continuous auditing literature (Chiu, Liu, and Vasarhelyi, 2014) has tried to improve the quality of the models that serve as the basic elements of comparison for exception detection.

Table 1-5 compares and expands the original conceptualization of the CPAS effort (Vasarhelyi & Halper, 1991; Halper, Snively, & Vasarhelyi 1988; Vasarhelyi, Halper & Esawa, 1995) with several research efforts performed over the years.

Table 1-5: Expanding Conceptualization in CA/CM[9].

	Vasarhelyi and Halper (1991), Red Book (1999)	Expanded Conceptualization (1999−2014)	Notes
	CPAS/ Prometheus effort	Several corporate experimental Experiences	Work with P&G, Siemens, Itau Unibanco, and so forth
Measuring	Metrics	Extractions from many different systems and drawing from the Big Data environment	Great potential for increased validation of values including database to database confirmations
Creating a model	Standards	Of comparison	
		Of variance	
Relating	Analytics	Representational equations	
		Continuity equations	Kogan et al., 2015
		Visualization	
		Clustering and transaction level continuity equations	For automatic fraud detection and transaction correction
	Alarms (4 levels)		
	Measurement Versus Monitoring	Measurement (indirect data acquisition)	
		Direct data access	

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[9]Highlighted items are expansions to the Vasarhelyi and Halper (1991) initial conceptualization.

Table 1-5: (*Continued*)

	Vasarhelyi and Halper (1991), Red Book (1999)	Expanded Conceptualization (1999−2014)	Notes
		Introducing external comparative benchmarks	
		Probabilistic data relationships	Linking corporate ERP data to big data in the fringes
Dimension	Data	Continuous data Auditing (CDA)	Vasarhelyi and Halper, 1991
	Control	Continuous Control Monitoring (CCM)	Vasarhelyi, Halper & Esawa, 1995; Alles et al, 2006
	Risk	Risks (CRMA)	Vasarhelyi, Alles, & Williams, 2010; Essay 6
	Compliance	Compliance (CM)	Essay 1

2.2.   *The Elements of Continuous Audit*

Vasarhelyi, Alles, and Williams (2010) have argued for the inclusion of continuous risk monitoring and assessment (CRMA) in the CA schema: "The audit planning process provides a template for how to make the Continuous Assurance system dynamic: by formally incorporating into it a risk assessment system that encompasses assessment of auditor perceptions of risks and allocation of audit resources to risky areas of the audit."

Vasarhelyi, et al. (2012) examined the continuous audit efforts of nine large organizations. It was noteworthy that organizations had a series of "audit-like" organizations (ALO) that competed for resources and presented very different levels of technology use. In its principle 3.5, the King report (Institute of Directors in Southern Africa, 1994, 2009) in South Africa states that "The audit committee should ensure that a combined assurance model is applied to provide a coordinated approach to all assurance activities." A control and assurance automated ecosystem can evolve the audit to create a more reliable and efficient corporation.

> All of the interviewed companies have a number of audit-like organizations which perform assurance-like functions in different areas. However, some of the audit areas overlap, and the results of the review are not efficiently shared among them as one manager declared,

> *"Let me start with my administrative boss. He is the director of risk management for the organization. Underneath is internal audit. Credit examination and our risk management/Sarbanes-Oxley...there is another group that does testing that reports to Chief Legal Counsel. Fraud is handled in our securities group, which is in our service company. They perform investigations on internal and external fraud...We do [received feedback], but not as much as we should."*

One of the interviewed companies had up to seven ALOs, which resulted in substantive differences in the quality of reviews, substantial redundancy, lack of depth in the reviews, and what they called "audit fatigue" where auditees would not cooperate due to the multiplicity of assurance efforts. If the companies had continuous audit in stage 4, a full continuous audit in stage 4, these problems could be eliminated as the monitoring systems would be centralized and integrated. All ALOs could share the systems and information, and their works would not overlap. ALOs in this study included (1) internal audit, (2) compliance, (3) fraud, (4) SOX, and (5) Basel, in most situations, although several other nomenclatures and subdivisions existed. (Vasarhelyi et al, 2012).

The original framework of continuous assurance can be expanded into four elements: data, control, risk, or compliance. Figure 1-4 expands Vasarhelyi, Alles, and Williams (2010) components to add an element of compliance monitoring, expanding the scope of the CA and CM effort. The same considerations of opacity of the data processing environment and the difficulty of access to its information apply to all elements of the auditing framework that evolved since the AT&T CPAS effort.
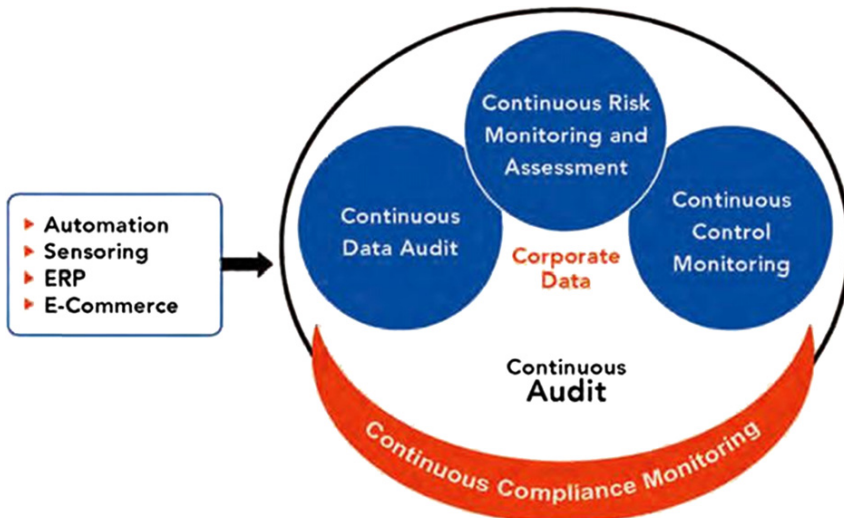

Figure 1-4: Expanded Scope of CA including Compliance Monitoring: An evolving continuous auditing framework.

3.   INFORMATION TECHNOLOGY AND THE AUDITOR

Traditional auditing has changed considerably as a result of changes in IT, including more advanced ERP systems, increasing the use of on-line transactions with both customers and suppliers, use of the cloud, and the rapid expansion of data available for use by management and auditors. The continuously evolving IT landscape leads to a variety of audit challenges that compound over time, as summarized in table 1-6 (Adapted from Vasarhelyi and Halper, 1991).

Table 1-6: The Evolution of IT and Associated Audit Challenges (Adapted from Vasarhelyi & Halper, 1991)[10].

Phase	Period	Evolution of IT	Examples	Audit Challenges
1	1945−1955	Input (I) Output (O) Processing (P)	Scientific and military applications	Data transcription Repetitive processing
2	1955−1965	I, O, P Storage (S)	Magnetic tapes Natural applications	Data not visually readable Data that may be changed without trace
3	1965−1975	I, O, P, S Communication (C)	Time-sharing systems Disk storage Expanded operations support	Access to data without physical access
4	1975−1985	I, O, P, S, C Database (D)	Integrated databases Decision support systems (decision aides) Across-area applications	Different physical and logical data layouts New complexity layer Decisions impounded into software
5	1986−1991	I, O, P, S, C, D Workstations (W)	Networks Decision support systems (non-expert) Mass optical storage	Data distributed among sites Large quantities of data Distributed processing entities Paperless data sources

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[10]Highlighted items are expansions to the Vasarhelyi & Halper (1991) initial conceptualization.

Table 1-6: (*Continued*)

Phase	Period	Evolution of IT	Examples	Audit Challenges
6	1991−2000	I, O, P, S, C, D, W Decisions (De)	Decision support systems (expert)	Interconnected systems Stochastic decisions impounded into IT systems
7	2000−2010	I, O, P, S, C, D, W, De, Distributed (Di),	Distributed systems Internet based Cloud	Data stored in the cloud and replicated Virtual IT software
8	2010−2020	I, O, P, S, C, D, W, De, Di, Big Data (BD)	Preponderance of data that is applicable in wide array of business, accounting, accounting, and auditing areas	Big data Multiple sources of automatic data capture
9	2020 +	I, O, P, S, C, D, W, De, Di, BD, Artificial Intelligence	Self-improving systems Embedded intelligent modules	Audit activities and reporting are slow and occur too late

For example, the challenges that emerged in phase 5 with the decentralization and distribution of data were aggravated with the advent of cloud computing in phase 7. The emergence in phase 8 of big data (Vasarhelyi and Kogan, 2015; Moffitt and Vasarhelyi; 2013) creates a hybrid environment where systems must monitor the boundaries of the broad external data environment, which is too voluminous to be contained within the organization's stores or its outsourced environment (Krahel and Vasarhelyi, 2014). Organizations already scan and extract from big data receptacles (for example, Twitter) and only retain selected pieces or summaries. Although many systems exist that present some degree of decision intelligence and even predictive behavior (Kuenkaikaew, 2013), artificial intelligence applications in business are not yet so prevalent to create an audit challenge.

The evolution of IT also creates opportunities for the introduction of further audit tools and methodologies especially as financial systems have moved towards decentralization, distribution, online posting, continuous (or at least daily) closing of the books, and paperlessness (Vasarhelyi and Yang, 1988).

The CCM application Alles, Brennan, Kogan, and Vasarhelyi (2006) developed is much broader in scope than the Red Book definition, and indeed, subverts its

focus on only more timely audits. The point of CCM is to exploit the very structure of the ERP system in order to bring about automation, as opposed to simply doing the same audit procedures more often. In their words, they were reengineering the audit process, not just speeding it up.

Alles, Kogan, and Vasarhelyi (2003) proposed something similar when they used the ability of ERP systems to propose the development of an auditing "black box" that would enable the tertiary monitoring of the audit itself. A decade later, a similar philosophy underlies the use by Jans, Alles, and Vasarhelyi (2014) of event logs to audit business processes.

Alles and Gray (2012) state: "When analyzing the role of big data in auditing it is critical to differentiate between whether what is meant is more of the same kind of data that auditors are already using, or more data of a different kind than what auditors have traditionally relied on to give an audit opinion." The former approach would lead, for example, to continuous auditing where the scope of data is not necessarily expanded, but measurements are taken more frequently in time (Kogan, Alles, Vasarhelyi, and Wu, 2014). By contrast, big data as it is defined below pushes the domain of data far outwards from financial data to non-financial data, from structured to unstructured data, and from inside the organization to outside it.

Over the last two decades, many new analytic and information technologies have become ubiquitous. These technologies also have been progressively applied to accounting and auditing. There have been studies looking at the role of visualizations, exploratory data analysis, process mining, tagging, the remote audit, predictive audits, and so forth.[11]

3.1.   *Evolving Database Audit Conceptualization*

The core of traditional systems evolving from the early file-oriented systems to hierarchical and today's relational databases is the structured nature of its data. Vasarhelyi and Halper (1991) pointed out levels of audit complexity in their usage. Table 1-7, "Evolving Database Structures and Their Audit" (expanded from Vasarhelyi and Halper, 1991), expands their view with some of the new considerations of storage and data provenance. Hierarchical data structures of the COBOL days were by and large replaced by the relational databases that are the core of the modern ERPs. With the ubiquity of the internet, there is the emergence of large corpuses of unstructured data from which to draw expanded information. A few facilitating axioms may be useful to introduce:

- There are no reasonable limits of sources of data, but there are great limits on what data an organization can actually store and make useful.

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[11]See http://raw.rutgers.edu/pcaob

Table 1-7: Evolving Database Structures and Their Audit (expanded from Vasarhelyi & Halper, 1991)[12].

System Characteristic	Audit Complexity (level 1)	Audit Complexity (level 2)
Database	Documentation	Data dictionary query
Database size	User query	Auditor query
Transaction flows	Examine levels	Capture sample transactions
Duplicates	Sorting and listing	Logical analysis and indexes
Field analysis	Paper oriented	Software based
Security issues	Physical	Access hierarchies
Restart & Recovery	Plan analysis	Direct access
Database interfaces	Reconciliation	Reconciliation and transaction follow-through
Unstructured data	Linkage to know Database elements	Establishment of stochastic relationships between data elements and unstructured data
Cloud storage	Access and privacy evaluation	Tests of system integrity and business continuity
Big Data	Selection of validating parameters	Linkage to data streams and extraction of meaning
		Creation of new forms of evidence Integration of new evidence into the traditional audit theory (Hoogduin, Yoon, and Zhang, 2015)

- In general data will tend to exist to support particular decisions or processes, but the great challenge is to anticipate such needs and create software and processes for its examination.
- The costs of system development, improvement, and overlay obey much different rules than the traditional fixed and variable cost managerial accounting model.
- Many IT provisioning economic models are charged on an incremental basis proportional to usage (Siegele, 2014).

Table 1-7 expands the table in Vasarhelyi and Halper (1991) with additional system characteristics and presents the aforementioned opportunities for the introduction of new tools and methodologies.

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[12]Highlighted items are expansions to the Vasarhelyi & Halper (1991) initial conceptualization.

3.2. Incremental Technological Change

The costs of more frequent assurance and its benefits have substantively changed with IT. In the 21st century information technology environment (21CITE), the costs of performing processes has greatly changed with advents in IT and networking as well as the reduction of the human labor component. In essence the following has been noted:

1. Information storage and retrieval is being progressively automated.
2. The cost of creating a report that previously required incremental labor per report now, once established, costs nothing to repeat and is typically developed by the ERP developers.
3. With the modern systems, automatic data collection is changing the schemata of data collection. Data from e-commerce transactions, GPS[13], and RFID[14] can be captured at defined time intervals contingent on the business need being satisfied. (Moffitt and Vasarhelyi, 2013)
4. Cloud distribution and storage of created/sensed files creates ubiquitous access and much more robust backup. Third party sourcing creates several challenges on assurance but also some degree of professionalism and competence in the data custody function. (Mendelson et al. 2012)
5. A progressive incorporation of some forms of artificial intelligence into several business functions is creating a more stochastic and judgment based set of decision rules. It cannot be assumed any more that a well validated business procedure will respond "correctly" as the rationale in the computer logic is a mix of heuristic rules and complex analytics.
6. Robots are taking a larger and larger role in business processes (Brynjolfsson and McAfee, 2014) and progressively systems with artificial intelligence will be integrated into the manual performance of tasks.
7. The ubiquitous access to information and devices will also be of great import. Two additional sources of internet connection—"The Internet of Things" (Kopetz, 2011) and "Wearables" (Wei, 2014)—will provide further substantive data of particular value for detective and preventive assurance.

These and many other considerations relative to technology and, most importantly, to the economics of business processes are the drivers of evolution on the continuous audit conceptualization.

3.3. The Audit Data Standard

Zhang et al. (2012) discuss the fact the audits are at risk of becoming less relevant if they do not change to meet stakeholder needs, especially for timeliness and scope

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[13]www8.garmin.com/learningcenter/training/Oregon/
[14]www.aimglobal.org/?page=rfid_faq&hhSearchTerms=%22rfid%22

(for example, process assurance, data-level assurance). Furthermore, they state that audit standards tend to lag behind advances in technology, and many basic audit procedures have not been updated to complement these developments. It also mentioned that the Center for Audit Quality (CAQ) (2011) held roundtable discussions that suggest that investors must act on timely and continuous financial information and it should be explored whether auditor assurance should be provided for financial information disclosed by managers throughout the year.

Furthermore Zhang et al. (2012) argue that "auditors face a challenge in accessing data as there are no standard requirements in place for data availability. Auditors do not have ready access to their clients' accounting data, even when the clients' business operations have become almost entirely digitized. As technology is the major driver of the evolution of the audit process, the AICPA Assurance Services Executive Committee (ASEC) Emerging Assurance Technologies Task Force is trying to pave the way for enhanced use of technology and advanced data analytics in the audit process. The audit data standards, including data standards, data access, audit applications and continuous audit, are formulated to facilitate data acquisition in a standardized fashion and advance the process of audit automation" (Vasarhelyi et al. 2011).

The CAQ initiated an effort to guide the profession towards a set of audit data standards that would guide organizations to make data available to auditors in a standardized format allowing for the homogenization of utilization of data using common auditor oriented applications ("apps"). The AICPA's ASEC took this effort over[15] and is progressively issuing this guidance. Figure 1-5 displays a symbolic view of an automated audit architecture that links: 1) existing corporate IT systems (including outsourced ones and Big Data Links, 2) extractor routines, 3) ADS standards, 4) automatic audit plan generation, 5) apps, 6) app selection routines, and 7) continuous assurance.

Zhang et al. (2012) stress that the Audit Data Standard project is an effort to bridge the gap (Kaplan, 2011) between accounting scholarship and practice. "Kaplan (2011) argues that accounting faculty, as scholars in professional schools, have conducted studies that are mostly reactive and put overemphasis on the existing practice instead of advancing the practice. He suggests that accounting scholars should fill the void in academic research and focus on developing knowledge for leading edge practice. The emergence of data standards and audit applications (Apps) is the fruit of academic and practice cooperation."

The AICPA issued initial guidance on the Audit Data Standard in 2013, which included the creation of the following audit data standards: (1) base standard, (2) general ledger standard, and (3) accounts receivable subledger standard. The work continues in extending the standard to other cycles and directions. Currently underway are order-to-cash and procure-to-pay subledger standards.

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[15]www.aicpa.org/InterestAreas/FRC/AssuranceAdvisoryServices/Pages/AuditDataStandard WorkingGroup.aspx
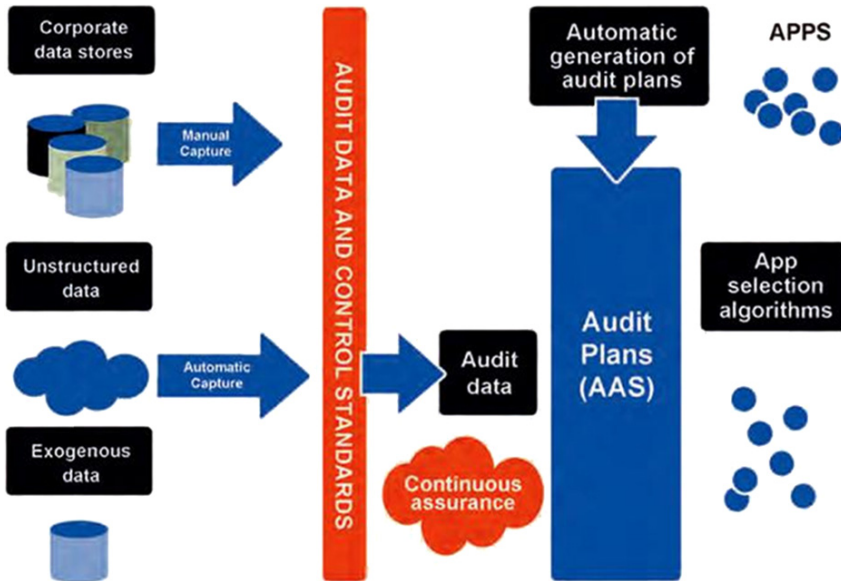
Figure 1-5: ADS Ecosystem Architecture.

4. THE NEW CONTINUOUS AUDIT

New considerations in continuous audit tie closely to the evolution of information and analytic technologies that grandly expanded the feasible set of monitoring and assurance activities. Many of these activities that could be extremely beneficial are not performed either because of ignorance of their availability, misconception of their nature, misunderstanding of the costs, or mainly because of the serious costs that may occur in such a litigious society as the United States if substantive corporate reporting problems are detected. Many of the instances where a "material error" was detected, the problem had existed for years in an increasing scope. The problem tends to explode when the adverse business economics that usually causes misrepresentation is too large to be unnoticeable.

Figure 1-6 lists the dimensions of the assurance process that are evolving in the new continuous audit: (1) assurance level, (2) time focus, (3) time interval, (4) data source, (5) chosen procedure, (6) choice of assertion, (7) analytic methods, and (8) assurance entity. Other dimensions may also be of importance in the progressive evolution of audit theory over time.

Halper and Vasarhelyi (1991) recognized the evolving nature of information technology table 1-6, "The Evolution of IT and Associated Audit Challenges" (Adapted from Vasarhelyi and Halper, 1991), and its opportunities in relation to assurance. Here the discussion is expanded to look at several of the evolving dimensions transforming the panorama of audit (internal and external), control, and management.
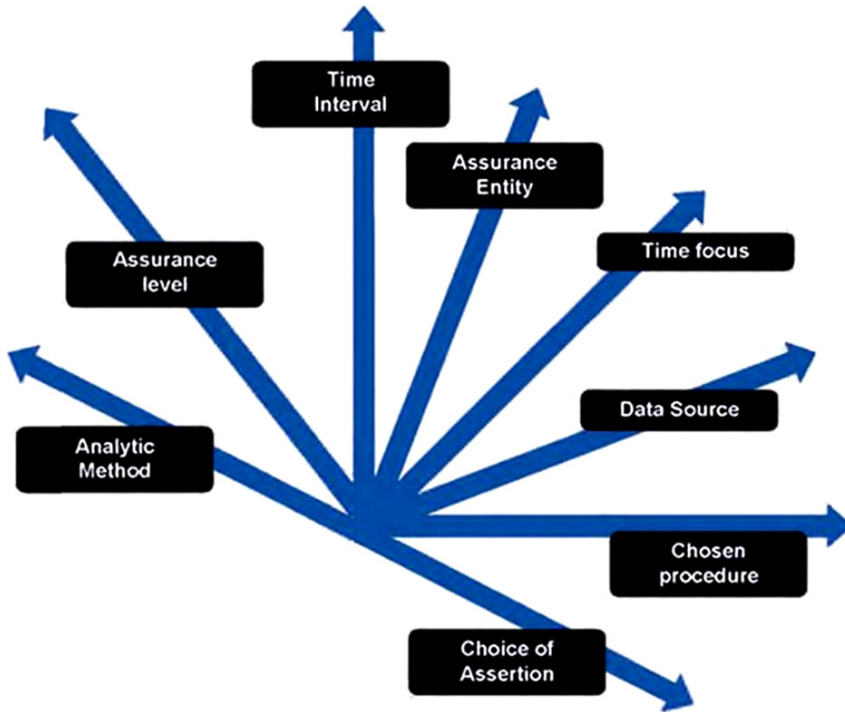
Figure 1-6: Dimensions of the New Continuous Audit.

The concept and practice of internal control evaluation (design and compliance) has been in the literature for many decades. Sarbanes Oxley expanded its formalization by requiring auditor assurance on management assertions about internal controls. Although the literature of data audits and its methods have evolved for many decades, research on internal control representation formalization (Cash, Bailey, and Whinstone, 1977; Bailey and Meservy, 1986; Bailey et al., 1985) has been sparse. The issues of control representation, assessment, configurable controls, compliance, and verification are to emerge as a major need for professional work and research. The monitoring of controls, the effect of their modification by tailored ERPs or overrides in configurations, and the existence of tens of thousands of controls plus compliance requirements creates a very complex environment both for management and assurers.

4.1. Assurance Level

Kogan et al. (2014) focus on transaction level assurance whereby continuity equations are used to monitor transactions through the stages of a hospital supply chain. It utilizes the patterns of delay between processes to improve predictions and to

perform automatic transaction correction. It improves the basic quality of data and allows for preventive auditing and automatic transaction correction.

Control level assurance (CCM) has partially replaced the traditional process of internal control evaluation and compliance testing. The ERP environments with pre-set controls have already demonstrated a reliable information structure, but new issues such as configurable controls have appeared to concern management and assurers.

Account level accuracy can be supported and assured at many low, intermediate, and high levels of accuracy. Dashboards (Moharram, 2014) and visualizations (Alawadhi, 2014) are improved with new technology which combines analytic transformation and takes advantage of the attributes of human information process. With the evolution of technology, it is possible to develop and test assertions at a much finer and directed manner.

Statement level assurance allows for combined assessment of accuracy, taking into consideration transaction accuracy, control climate, and all levels of account level accuracy. Each level of assurance actually serves different purposes for both management and auditors.

4.2. *Time Focus*

Auditing has been retroactive since its inception. Auditors examined past accounts for accuracy and reported perceived discrepancies. Figure 1-7 illustrates that
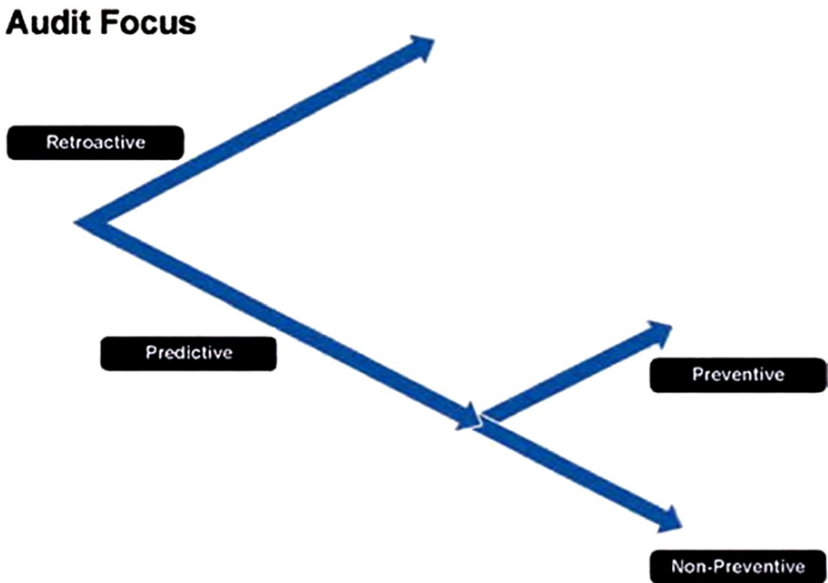

Figure 1-7: Time Focus of the Audit Methodology.

auditing can both be reactive and predictive (Kuenkaikaew, 2013). When predictive, the auditor (Vasarhelyi and Halper, 1991; Vasarhelyi, Alles & Williams, 2010) will rely on models (standards) to predict results (performance) in an account (transaction) (Kogan, et al., 2014). This prediction is compared with actuals in near-real time to detect substantive variances in monitored processes. Much of the recent research on CA has recently focused on developing better models for actual comparisons (Chiu, Liu, and Vasarhelyi, 2014; Brown et al., 2007). These variances, from improved models, are treated either as an alert to the management and audit function or, if the system has reliable filters, to prevent faults from progressing toward execution. Modern systems combine management action and assurance. Much conceptual work is needed in the re-definition of concepts such as auditor skepticism, independence, materiality, auditor role, audit objectives, and so on. Many of these needs are motivated by the ever-increasing level of automation in corporate business systems and the correspondingly automated nature of tools used by individuals. The advent of a progressively bring-your-own-device (BYOD) environment (Loras et al., 2014) is affecting the locus of the control and assurance. Some of the BYOD tools like smart phones already incorporate predictive algorithms to perform a set of integrative functions for the user. These functions associate typical behavior with data integration to decrease keystrokes by the user. For example if the device detects a request for contact and a telephone number or an address, it may immediately prompt a call or a map to the location.

Auditors will eventually have predictive procedures to drive them to data level prediction (Kuenkaikaew, 2013), procedural prediction (based on the experience of other auditors using the tools and maybe the guidance of the audit plan), and control prediction (where weaknesses in controls or process changes drive the activation or re-parameterization of controls.)

Intelligent *preventive* controls are progressively permeating the corporate IT eco-system and personal devices. The relationships between processes that have always existed may now be explored analytically and visually for management and assurance purposes. If the predictive ability of models is high and processes modularized and discrete, it may be possible to prevent an error, automatically correct an error, or correct a control deficiency prior to its occurrence. For example an insurance company develops a forensic model to determine if a particular claim payment is inaccurate (fraudulent or in error). This model is very accurate in generating a number of false positives and false negatives. It can develop a process that once a transaction is ready to order a wire transfer, it is subjected to the same forensic model and, if the level of confidence of accuracy of the transaction (the loading function for the transaction to be further discussed later in this essay) is below a certain threshold, the transaction is blocked and a group of auditors (Elder et al., 2013) proceeds to examine it and release it or not. The economics for this preventive behavior depends on the amounts of the electronic fund transfers, the incidence of erroneous transactions, the losses/costs historically incurred in these (detected and undetected but estimated) errors, and the cost for an auditor or manager to perform this supervisory and assurance action.

4.3.   Time Interval

The original CA work aimed at using the evolution of technology to replace the work on the annual audits, but the client organization was internal audit. It rapidly became clear that external audit firms do not use CA techniques but consult with internal audit departments on the matter. (Please refer to Chapter 2 of *Audit Analytics and Continuous Audit - Looking Toward the Future*, AICPA https://www.aicpa.org/interestareas/frc/assuranceadvisoryservices/downloadabledocuments/auditanalytics_lookingtowardfuture.pdf)

> As the technological drivers of Continuous Assurance continue to rapidly progress, it has proven difficult to reach consensus on what Continuous Assurance actually encompasses. There is the need to update the AICPA and CICA definition of continuous assurance to do away with written audit reports, which are redundant in today's world of electronic communication. Even more importantly, the word 'continuous' undoubtedly would not be used today, because it implies a frequency of auditing that is both difficult to achieve technically without impacting the operations of the entity's IT systems, and probably beyond the needs of most users. The different elements of a corporate information system have different pulses and natural rhythms. The assurance process must be coherent with these rhythms to be useful and effective. (Adapted from Vasarhelyi, Alles, and Williams; 2010.)

This new view of CA, encompassed in this essay, disagrees with the above statement that the "frequency of auditing that is both difficult to achieve technically without impacting the operations of the entity's IT systems, and probably beyond the needs of most users." Technology is already present to achieve "close to real time assurance." Corporate business ecosystems will be by nature distributed, real-time, and most of all very opaque to the naked eye. Consequently there will be many systems that will be difficult to audit unless a transaction is monitored frequently, predicted in value, prevented if deemed probably erroneous, and so forth. The nomenclature (is this management, control, or auditing?) given to the meta-control and assurance function is of less import than its progression over time and the integrated systems need.

Assurance close to the event allows for inter-process fault blocking and rapid management/auditor intervention into incorrect or unexpected events, which is one factor that was not to be considered in the traditional audit approach.

4.4.   Data Source

The new corporate data presents a wider scenario of data sources (Krahel and Vasarhelyi, 2014) internal (endogenous) from ERPs, legacy systems, web-facing systems, and middleware. This data is complemented by associated (outsourced) systems and by bridges to external (exogenous) data of several origins. Data can come
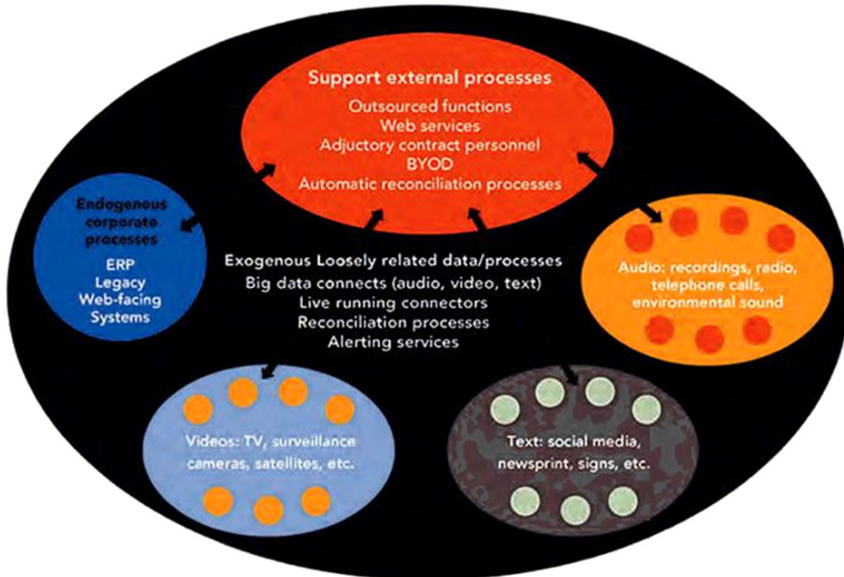
Figure 1-8: Sources of Data (adapted from Qi and Vasarhelyi, 2014).

from public databases (for example, macroeconomic data, market data such as Compustat and CRSP), from bridges to the larger data environments of video, text, and audio (Moffitt and Vasarhelyi, 2013), and from the many automatic data collection devices that are emerging for multiple purposes. See figure 1-8 for further examples.

4.5.　*Chosen Procedure*

Audit procedures have been frequently formalized under GAAS in order to create guidelines for verification of financial statements. Unfortunately the standards have not yet explicitly embraced more advanced technological methods that can deal with the emerging challenges of big data, cloud computing, embedded decision making, and the like. In general the audit standards allow for evolution of procedures but do not necessarily facilitate or require such an effort. See table 1-8 for procedures and their evolution.

4.6.　*Choice of Assertion*

International auditing standards and U.S. GAAS classify assertions into three categories:

- Assertions about classes of transactions and events for the period under audit
- Assertions about account balances at period end
- Assertions about presentation and disclosure

Table 1-8: Procedures and Their Evolution.

	Traditional procedures	**Modern procedure**
Client acceptance and investigation	Multiple mainly manual methods including investigators	Identical plus extensive text mining of sources like newsprint and social media
Client monitoring		Extensive text mining of sources like newsprint and social media
Population estimate	Statistical or judgmental sampling	Big data population estimation
		Full population measurement
Confirmation	Manual confirmations or confirmation.com	Close to full population confirmation with database to database confirmatory pings/handshakes
Substantive testing	Manual examination of documents	Electronic documents, process mining
Analytical review	Comparison of end of the month ratios and their trends	A wide selection of analytics procedures at most stages of the audit
Internal control valuation and compliance testing	Manual tracing, observation, structural evaluation	Reliance on ERP design, CCM

To which we add the following:

- Assertions about emerging issues of less traditional nature

An assertion basically represents the concern of auditors of particular system faults. Exploratory Data Analysis (EDA) (Liu, 2014) allows for preliminary data examination leading to choice of assertions to be considered in a particular audit. By looking at the data characteristics and distributions and contingencies, the auditor will start with basic assertions and choose additional ones to be considered. EDA will allow for the creation of assertions and the transformation of EDA into confirmatory data analysis.

4.7.   *Analytic Method*

The development of new IT infrastructure, analytic methods, and the expansion of ALOs is changing the potential of continuous audit to a new dimension described in table 1-5: Expanding Conceptualization in CA and CM. The essence of audit automation and the progressive evolution of an audit ecosystem entails synergistic integration of its elements. As has repeatedly been discussed in this essay, systems that

support business processes have become too complex to be efficiently addressed through pure human assurance. Layers of data, software, and the interconnection with upstream and downstream systems (and processes) make observation and evaluation very complex.

In general an entirely new family of audit analytics is emerging[16] that can affect all parts of the audit engagement and can allow the use of an expanded data framework that includes external big data to support audit assertions in an unorthodox manner. Table 1-9 illustrates the number of potential changes and improvements to assurance methodologies. It should be considered together with table 1-10 in which the emphasis is more on procedures.

Table 1-9: Audit Phases and Analytic Methods (modified schema of Cushing and Loebbecke, 1986).

Audit phase	Applicable analytic methods	Observations
Client examination	• News media monitoring • Social media monitoring	A large set of sources allows for environmental scanning of events with directors, their reputation, the behavior of competitors, and events in the industry
Audit Planning	• Ex-ante risk assessment a la CRMA • Ratio analysis	Peer industry group evaluation for performance
Audit risk assessment	• CRMA	The "material" change in the risksituation requires changes in continuous monitoring, management action, and in continuous audit parameters
Internal Control evaluation	• Process mining • Analytical modeling	Much reliance on the "best of class" nature of designed ERP systems but hampered by the fact that most large organizations' data is a mix of ERP based and many other sources
Compliance testing	• Process mining • CCM	Concern about user configurable controls requires monitoring these settings through a CCM methodology

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[16]http://raw.rutgers.edu/audit_analytics_certificate

Table 1-9: (*Continued*)

Audit phase	Applicable analytic methods	Observations
Substantive testing	• Cluster analysis • Database-to-database confirmations • Continuity equations	The emergence of very large number of transactions, the ability to store them online, the reliance on electronic documents and records, and the usage of XML derivative languages to exchange data from upstream and to downstream systems changed drastically the items to be tested and requires new audit tests that are not yet in the vernacular
Opinion formation	Formal expert systems for the evaluation of new forms of audit evidence Systems for estimating potential for audit failure based on internal evidence and exogenous variables	With the multitude of data forms and volume, and the lack of direct observability of data, audit systems will have to be substantially automated with a symbiotic process of opinion formulation partially relying on machine observation and opinion formulation

4.8.   *Assurance Entity*

Different ALOs have a mix of complementary, independent, and overlapping objectives. Assurance coordination, as recommended to be implemented in the King report, must take into consideration the evolving variables discussed in this section: (1) assurance level, (2) time focus, (3) data source, (4) chosen procedure, (5) chosen assertion, (6) analytic method, and (7) the specific issues and objectives of the different assurance entities. Organizing a matrix of the above variables, ALOs, and technology platforms can help to create a more efficient assurance function.

5.   QUESTIONS REGARDING SOME AUDITING CONCEPTS IN THE MODERN ENVIRONMENT

The speed of technological change is overtaking the ability of business to change and of the multiple lines of defense. The inherent opacity of the layers of technology opens exposures at the same time that it creates capabilities for business. The same technology that allowed data to be processed rapidly and consistently also allows

Table 1-10: Expanded Opinion Conceptualization.

We have	The	For the period	And we found
Examined	Financial statements	Year	Materially correct
Monitored	Account	Month	Reliable to the 99% level
Analyzed	Transactions	Continuously or close to the event or in the appropriate frequency	The enclosed exceptions for the period
Prepared	Controls		The following alerts in the attached URL
Reported	Process		Correct with an acceptable error rate of 1%
Reported and verified	Outsourced process		
Shared examinations	Automated decision settings		The settings to be adequate to perform the continuous assurance function
	Security of user information such as social security numbers and passwords		The system vulnerable to serious attack

for consistent errors and their distribution without human observation. The same technology that allows for remote access of computers allows for foreign intrusion and virus diffusion. The same technology that facilitates electronic transactions with credit card magnetic information also allows massive and intrusive capture and leakage of credit card information at reputable organizations such as Target[17] and Home Depot[18]. As earlier discussed, the roles of management, internal audit, and external audit are overlapping and use the same tools. Figure 1-10 attempts to integrate some high-level functions that will compose some of the elements of future management and assurance. Prior to its discussion some basic issues in modern assurance are discussed including: (1) progressive implementation of assurance systems, (2) functional migration of roles and tasks, (3) concepts to be evolved in the new audit conceptualization.

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[17] www.businessweek.com/articles/2014-03-13/target-missed-alarms-in-epic-hack-of-credit-card-data
[18] www.reuters.com/article/2014/09/09/us-usa-home-depot-databreach-idUSKBN0H327E20140909

5.1.   *Stochastic Opinion Rendering in a World of Statistics*

The nearly "yes" or "no" nature of external audit reporting doesn't provide the types of insights or commentary that stakeholders may find informative. The audit literature has proposed over the years several forms of probabilistic reporting and more explanatory audit opinions. These would give more information to stakeholders, but in general the proposed methods are limited.

Associated with the concept of probabilistic reporting, the modern audit could benefit from a real-time auditor dashboard. The issues related to legal liability, stakeholder needs, and the natural reticence to change will tend to make this evolution challenging. However several commercial products and research efforts are developing these dashboards in internal audit organizations responding to real needs of system monitoring. Internal audits would provide additional value with the issuance of probabilistic reporting.

In general, materiality estimates relate to dollar value in relation to a value on a financial statement. For example, 5 percent of net income is compared with the total value of the account on an account-by-account basis. The audit literature has been linked to the concept of materiality for a long time. Clearly there are decreasing returns in the economics of data evaluation and review. In the engineering sciences the concept of relative and acceptable errors are common. Unfortunately there are no precise definitions of materiality in the auditing standards literature (Elliott, 1986). Furthermore, information technology has changed the cost structure of both the benefits of an audit as well as the costs of performing audits by making information storage and retrieval very different.

The new environment changes the costs and benefits of assurance. Source documents are indexed and electronic. Analysis activities can be mainly automated. A wide net of automatic document reviews can be communicated to staff and serve as a serious deterrent to malfeasance. If auditor substantive processes can be formalized and support systems evolve towards all electronic processes, full population evaluations may be possible and desirable depending of a set of very different cost-benefit tradeoffs.

A new conceptualization of materiality may be needed now with different considerations of dimensions such as monetary value, volume of transactions, type of usage, and probability of outcome. Furthermore, for the audit to be more informative, it may be desirable to disclose more details of relative expected error and the auditor may create a product that provides a more detailed set of relative error assessments. Furthermore, there are qualitative and quantitative aspects in audit decision making, as many of the analytic-based monitoring processes will be out of the eyesight of the auditors, there must serious thought given to automatically bringing relevant qualitative evidence to auditors.

5.2.   *New Audit Products*

The creation of new digital products has faced a Cambrian moment (Siegele, 2014) of dramatic change where the cost characteristics of e-products (mainly fixed cost

and very low marginal variable costs) are being reflected by the method of provisioning and charging for new products. Auditors need to develop layered monitoring systems with embedded elements such as sensors (for example, RFID, GPS, computer vision), analytic intelligence, and exception detecting and rerouting capabilities in order to provide additional assurance services.

Table 1-10 expands the conceptualization of the audit opinion and table 1-11 adds features that could be parts of the nature of the product. Clearly, unintended consequences and the legal environment would permeate the world of expanded assurances.

Table 1-11: Imagined Automation, Migration of Functions, Technologies, New Processes and Methods.

Technology	Automation	Migration of functions	New processes
RFID	Of inventory counts Verification of retail sales Verification or warehouse deliveries	Overlap between management, control and assurance	Inventory counts, inventory tracking, sales, purchases
GPS	Of payroll validation Of travel expenses		Employee work location and existence confirmation
Dashboards	Audit by exception (ABE) Audit plans are complemented by exception activators	Monitoring of alerts, macro process indicators	Auditor close to the event examination of perceived alerts
Cloud storage	Group based Work-papers	Some work-paper functionality goes to audit back Boxes	Some sharing of auditor files and black boxes between management and auditors
Big data	Process integrity monitoring is included in the audit process	Bots are integrated into process flows instead of human Intervention	Creation of monitoring functions relating big data variables and assurance
Clustering	Automatic outlier detection processes are incorporated into the ecosystem	Outlier cluster measurements are automated	
Continuity equations	Process efficiencies are measured through inter-process equations	Process relationship equations are created, disclosed, and used for monitoring	

Table 1-11: (*Continued*)

Technology	Automation	Migration of functions	New processes
Machine learning techniques	Predictive/preventive audits facilitated by better predictions. Predictive technology further expands audit by exceptions		
Process mining		Automatic transaction path analysis and monitoring is implemented	
Text mining	Of client acceptance and engagement renewal		Continuous client investigation examining news-pieces and social media
	Confirmations	Database to database population and value resolution	

5.3. *Management, Control, Assurance, and Other Meta-Processes Confusion of Concepts*

It may be overambitious to attempt to resolve the confusion generated by the expansion of functions taken over by technology and their effect on the "lines of defense" discussed earlier in this essay. It suffices to understand that internal and external business related functions aim to achieve corporate objectives. The nature of the objective, the characteristic of job functions, the type of technology progressively being used, and the nature of the contractual relationship with vendors, assurers, suppliers, and customers will affect several management controls and assurance functions. The historically evolved set of rules and regulations that permeate the environment rely on definitions that may not be relevant in this age of automation and piggybacking (Siegele, 2014) of technologies and processes. Some examples of concept confusion include the following:

1. If a business has an audit group that reviews and decides on alarms found (Elder et al., 2013), are they performing an audit or a management function? By doing this are they losing their independence but as internal auditors still maintaining their objectivity?

2. If the auditor intervenes in the process when a flag arises, is he/she losing independence but as an internal auditor still maintaining objectivity?
3. If a system flags thousands of exceptions and only the "exceptional exceptions" are being examined by auditors, is this lack of due diligence?

5.4. *Independence*

Sarbanes Oxley required CPA firms not to perform a wide variety of consulting services for their clients. At first blush, this seemed a good step in light of the egregious aberrations of the Enron and WorldCom nature where the perception was the large audit fees paid for system services to the client blurred the vision and integrity of external auditors.

Likely the need for understanding large systems, partnership with internal organizations, and a dramatic set of environment-changing events[19] may change the view of independence impairment and may revert to some degree of auto-policing and the redefinition of independence conflict. This statement is not aimed to really discuss independence, but it is an illustration of changing conditions that may change concepts in management function as well as the migration of functions to automation and their consequences on organizations, regulations, and social matters.

5.5. *Migration of Functions to Automation*

The original applications of computers focused on facilitating intensively computational tasks such as the calculation of trajectory tables for cannons in warfare, a task that was being performed manually by a large number of soldiers (Fishman, 1982). With the introduction of magnetic tapes into computer systems, and their sequential data organization, the business purpose of computers became obvious and hundreds of employees manually preparing utility bills were let go and replaced by massive process automation. Once the very obvious large labor replacement tasks were accomplished, demonstrating the economic benefits of automation became more complex. Typically IT solutions at a more advanced stage improve data quality and processes but are not very closely tied to labor replacement. One of the key lessons from decades of IT and now analytic technology implementation is that to achieve the real benefits of substantially changed technology, processes much be rethought and reengineered (Hammer, 1990; Davenport, 1992, O'Leary, 2000).

Essay 4, "Reimagining Auditing in a Wired World" illustrates the blue sky scenario of a potential imaginary future audit. The ensuing fictitious vignette illustrates the potential prospective evolution of audit automation—progressively embracing different technologies and automating business processes, control methods, and its assurance layer and processes.

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[19]Such as breaches in computer systems, cross country mergers, substantive integration of machine intelligence into decision making processes, and the integration of robots into corporate production processes.

AIC auditors serve a large clientele mainly focusing on retailers. In order to improve its efficiencies over the years, AIC has implemented a series of changes in its technological capacity and methods of assurance. Its relation with CL Grocers (CLG) illustrates this fact.

- AIC convinced CLG to make agreements with its larger suppliers, banks, and clients to adopt a transaction and account level confirmatory protocol where, at pre-established intervals, CLG and its partners exchange confirmatory pings. A dashboard manages this process, which is shared between AIC and CLG, although with different reports.
- AIC runs on frequent basis text protocols examining social networks and news pieces for items relevant to CLG, its competitors, directors, managers, and employees.
- AIC has by and large changed to a risk-based audit by exception methodology whereby risk monitoring encompasses external and internal factors and the assurance effort coordinates with management.
- AIC has adopted a commercial system of automated working papers that track auditor keystrokes, phone communications, and several embedded modules in the client system on a constant basis.
- AIC and CLG cooperate on fine tuning a system of predictive analytics that creates forecasts for key accounts and processes of CLG. These are used for process monitoring, preventive monitoring, and for some of CLG's communications with its stakeholders.
- AIC's staff has a wide variety of skills, in particular IT and analytics, and has a very intensive lifelong training program. AIC also monitors its staff through external and internal information sources.
- Larger inventory items have RFID chips and their movement is recorded through the supply chain with the participation of external partners.
- AIC has a wide menu of assurance and advisory services it offers and it contracts not only with CLG but also many of its partners for services such as covenant monitoring, asset existence, process monitoring, financial statement assurance, and so on. The compensation for these services is mainly parameterized on the characteristics of CLG's business, not labor hours. AIC will also perform compensated work for the government relative to tax, ecology, and labor practices. The coordinated audit has many partners.

New protocols, technologies, and standards must cooperate in order to achieve a progressive layering and coordination of management, control, risk, and assurance functions. The following section discusses a symbolic view of what the audit ecosystem would entail.

5.6.   *The Audit Ecosystem*

Businesses are now often described as ecosystems. A logistic supply chain is managed by a multitude of information flows, actors, and IT infrastructures within an evolving timeframe. *The Economist* described practical ecosystems:

Pioneers such as Amazon have built cloud-based "ecosystems" that make content such as its electronic books widely available. Even though the firm has its own e-reader, the Kindle, and has hatched a tablet computer too, it has also created apps and other software that let people get at their digital stuff on all sorts of devices, including PCs.

Other companies are developing their own ecosystems in a bid to make people's mobile-computing experience even more seamless. Google's recent $12.5 billion acquisition of Motorola Mobility, which makes smartphones, tablets, and other gadgets, will enable it to produce a new crop of devices to show off its cloud services, such as Gmail and Google Docs, to best effect. Apple is stepping up its integration efforts, rolling out an "iCloud" in which people can store up to 5GB of content for nothing, and more if they pay. (Economist, Nov. 4, 2010)

Figure 1-9 represents a potential schemata for an audit ecosystem with a set of elements aimed at dealing with the emerging 21st century information technology environment (21CITA) (Kozlovski and Vasarhelyi, 2014).

Its main elements include the following:

- Examination of transactions and account levels at their entry point in the system, typically with process evaluation apps looking for a variety of generic problems with transactions such as incomplete or incoherent data, high loadings in
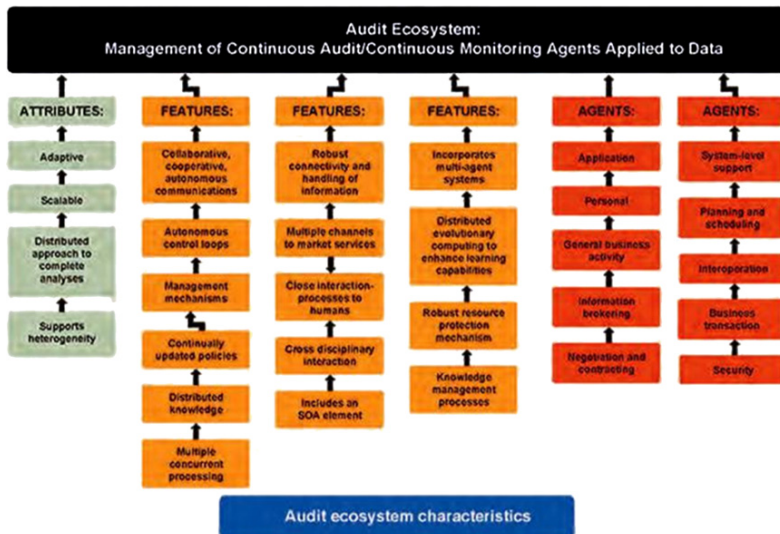

Figure 1-9: Audit Ecosystem Characteristics (Kozlovski and Vasarhelyi, 2014).

potential fault discriminant functions, data out of the normal transaction stream, and so on.

- Examination of transactions / account levels using time-series, cross-sectional, and time-series cross-sectional analyses to detect aberrant transactions on a comparative and historical trend basis.
- Constant monitoring of the environment through soft bridges with social media, news pieces, competitor monitoring, and so on.
- Development and monitoring of mixed loading factor equations for exception detection.
- Large audit databases aimed at validation of daily feeds and collection of account-level data for cross-sectional analytics.
- Audit plans that are sensitive to risk levels and variations. The audit plan in a real time audit environment has to be adaptive contingent on changing conditions and rely on continuous monitoring of transactions (and adjustments) entering the system as well as monitoring the time series and cross-sectional trends.
- Hundreds or thousands of apps available in the environment respond by creating tests with the dynamic adaptation of assertions.
- Many of the apps would be autonomous agents either time activated (krons), circumstance activated (daemons), or audit plan activated.

Kozlovski and Vasarhelyi (2014) discuss agents in an audit context as follows:
The various agents presented by Papazoglou (2001) for use in a digital ecosystem are also applicable to an audit ecosystem:

- Application agents: CA/CM agents that are specialized to a single area of expertise and work in cooperation with other agents to solve complex audit problems are but one example of the many application agents that encompass an audit ecosystem
- Personal: (or interface) agent: Work directly with users, primarily client and provider staff, to help support the presentation, organization, requests, and information collections, such as providing user access to audit results
- General business activity agents: Perform a large number of general support activities such as search agents that navigate effectively through fragmented online electronic information in order to provide guidance to the CA/CM agents
  - Information brokering agents: Provide facilities such as locating information on Web sources or other agents that are required to solve a common problem, such as specialized agents to support CA/CM agents in addressing data anomalies, for example
  - Negotiation and contracting agents: Negotiate the terms of a business transaction as regards to exchange and payment, as is required when transacting for audit services
- System-level support agents: Provides objects with access not only to other application objects but also to such facilities as transaction processing when acquiring audit services

- Planning and scheduling agents: a multi-agent plan is formed that specifies the future actions and interactions for each agent. Typically, an agent may act as the group planner for a cluster of agents surrounding an application agent such as to support multiple CA/CM agents analyzing big data simultaneously, for example
- Interoperation agents: Audit processes may require accessing information from legacy systems and CA/CM agents from separate providers
- Business transaction agents: Can be used to determine new CA/CM product offerings to incorporate in the audit ecosystem
- Security agents: Provide security measures for information, communications and data to or from the audit ecosystem (Based on Papazoglou 2001).

Kozlovski and Vasarhelyi (2014) also discuss the characteristics of an audit ecosystem in figure 1-9. It represents the many characteristics of an audit ecosystem in a single view including attributes, features, and software agents. The schema presented in figure 1-10 complements figure 1-9 as it focuses on the dynamics of transaction processing, rather than on detailed characteristics.

The 21CITE promises different levels of integration between the organization and its data environment. The data sources to be scrutinized closer are in internal data, and often outsourced data requires reliance on a third party (the auditor of the outsourcer). As experiences with viruses and control structures, new forms of technology, analytic methods, and human inventiveness constantly change the panorama, new forms of fraud, as well as weaknesses in software, are constantly appearing and must be considered.
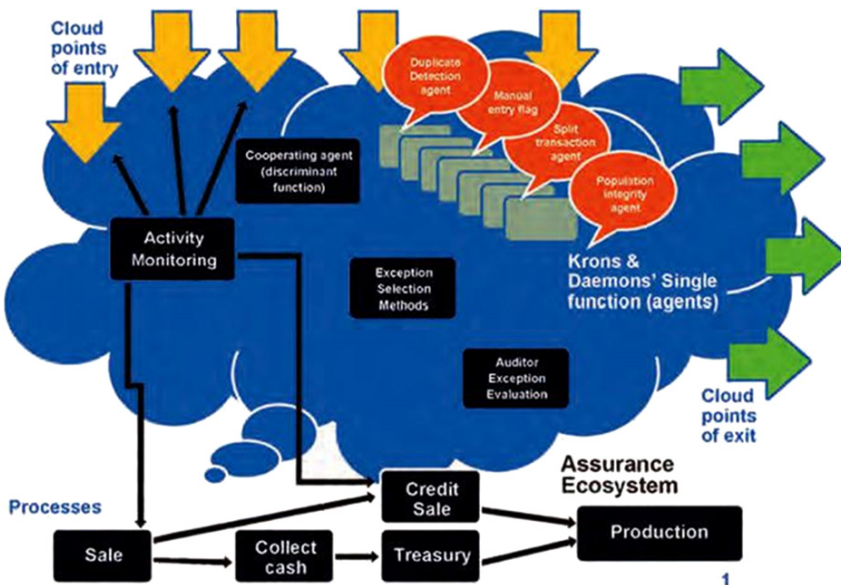

Figure 1-10: The Audit Ecosystem.

6.   CONCLUSIONS

The rapidly accelerating pace of technological change has created a social drag where socioeconomic systems hold back technological progress. The ubiquity of computers in the performance of business processes brings the need for strict formalization of legal and business rules (Krahel, 2011) and automation has also resulted in a change in economics. This essay sets the groundwork for the evolution of continuous assurance initially formulated by Groomer and Murthy (1989) and Vasarhelyi and Halper (1991) and divulged by the publication of the CICA and AICPA continuous auditing guidance (Red Book, 1999) later supplemented by the IIA (2003) and ISACA (2010).

The early work on CA focused on using the benefits of automation to perform a more frequent and deeper audit. This essay emphasized a wider frame of thought by considering the effects of technological change on business and the role of a more continuous form of assurance, with different economics, conditions, and processes than are used today.

In this new environment there are no reasonable limits of sources of data, but there are great limits on what data an organization can actually store and make useful. Data will tend to exist to support particular decisions or processes, but the great challenge is to anticipate needs and create software and processes for its examination. The costs of system development, improvement, and overlay obey much different rules than the traditional fixed and variable cost managerial accounting model. The fact that many IT provisioning economic models are charged on an incremental basis proportional to usage will change the profession's usage of technology.

The new environment of audit is a mix of technology (TDA), analytics (ABA), and human (HBA) efforts just as in the past, but the dramatic evolution of TDA and ABA makes it necessary to change business processes, legislation, regulations, and consequently HBA.

The introduction of IT-based analytic monitoring is the introduction of meta-processes, meta-controls, and meta-management functions. These meta functions, such as meta-data providing data about data (for example, in XBRL), meta-control (information about controls being extracted from ERP systems), or meta-control of controls (information about the control of controls), provide increasing conceptual confusion between what auditors and managers should do. The modern IT environment is aggravating this problem. Migration between functions is happening and requires new flexible conceptualizations.

The need for increased verification due to the many layers of technology adding opacity and a more complex society has led to many levels of ALO and the recommendations of the King Commission (Institute of Directors in Southern Africa, 1994, 2009). The new continuous audit model aims to liberate from these shackles, creating a new set of assurance opinions and functions to be provided by the assurance function in a partnership of management, internal control, internal audit, and external audit.
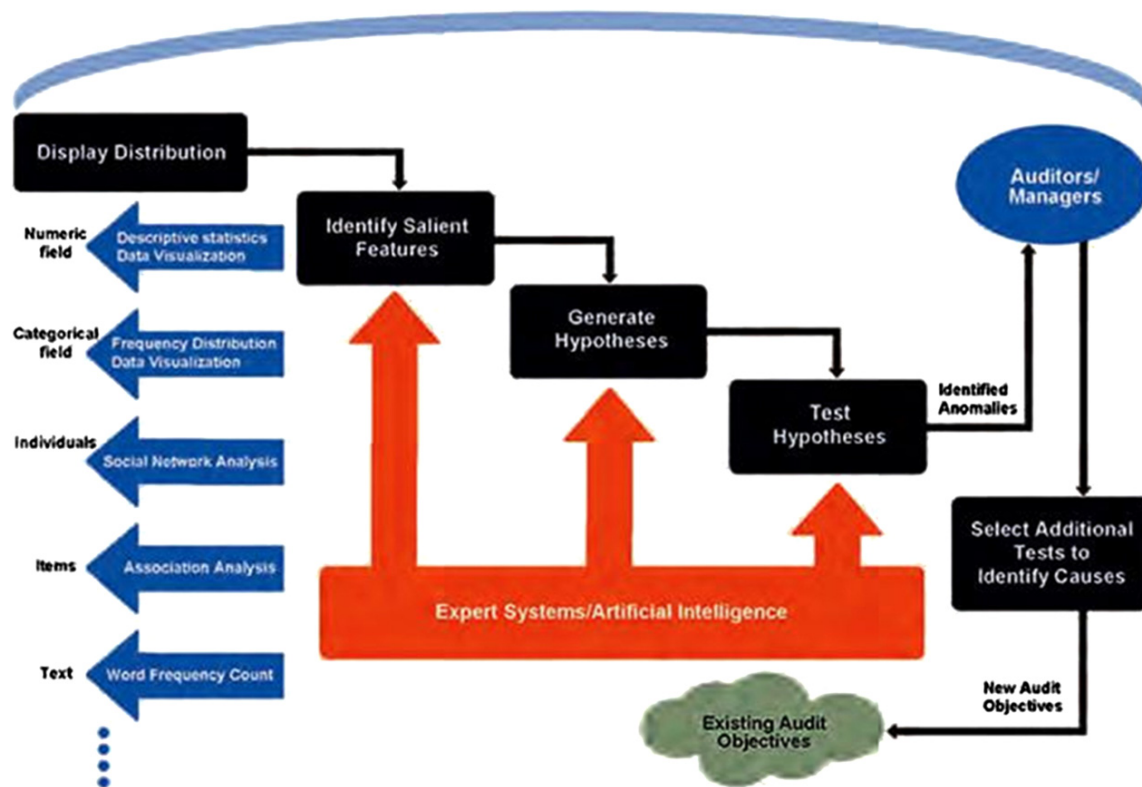
Figure 1-11: EDA and CA (from Liu, 2014).

6.1.   The New CA

The major changes to CA that are emerging and should be permeating the audit environment, and hopefully standards, are as follows:

- Progressive adoption of a standard data interface to allow for the usage of assertion and analytic based apps.
- The need to incorporate exploratory data analysis into extant audit methodology. Liu (2014) proposes such a step in figure 1-11 where she expects intelligent modules to interface with a wide variety of data sources.
- Progressive impounding of audit apps into the operating environment.
- The evolution of an audit ecosystem with a progressive level of automation over financial and non-financial systems.

CA can be redefined as

  a methodology that enables auditors to provide assurance on a subject matter for which an entity's management is responsible, using a continuous opinion schema issued virtually simultaneously with, or a short period of time after, the occurrence of events underlying the subject matter. The continuous audit may entail predictive modules and may supplement organizational controls. The continuous audit environment will be progressively automated with auditors taking progressively higher judgment functions. The audit will be by analytic, by exception, adaptive, and cover financial and non-financial functions.

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[21]CPAS stands for Continuous Process Auditing. CCM stands for Continuous Control Monitoring.