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Continuous Online Auditing: A Program of Research

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ABSTRACT: The progressive computerization of business processes and widespread availability of computer networking make it possible to dramatically increase the frequency of periodic audits by redesigning the auditing architecture around Continuous Online Auditing (COA). Continuous auditing is viewed here as a type of auditing that produces audit results simultaneously with, or a short period of time after, the occurrence of relevant events. It is arguable that continuous auditing can be implemented only as an online system, i.e., a system that is permanently connected through computer networking to both auditees and auditors. This article proposes a research agenda for the emerging field of COA. First, the history, institutional background, feasibility of and some experiences in COA are briefly reviewed. Thereafter, a number of research issues relating to the architecture of COA, factors affecting the use of COA, and the major consequences of COA are presented. Finally, a selected number of research issues are highlighted as priorities for future research in COA.

Key Words: Continuous online auditing, Online monitoring, Real-time auditing, Program of research, Accounting information systems.

I. INTRODUCTION

The advent of computers has affected numerous aspects of accounting and auditing. Computerization of accounting operations induced the development of electronic data processing (EDP) auditing as a new auditing field (e.g., Cash et al. 1977; Hansen and Hill 1989; Boritz 1995; Warren et al. 1996). Computer-assisted auditing has become commonplace, leading to a significant increase in the efficiency of auditing. Developments in information technology enabled management and reporting (internal and external) of finer information sets at progressively narrower time frames. Internal corporate management and many business processes are increasingly dependent on daily closing balances and even online real-time reporting.

The proliferation of corporate-wide networks is enabling progressive integration of worldwide manufacturing, inventory keeping, and financial management. In turn, these developments have substantially reduced the incremental costs and complexity of consolidated reporting and its disclosure to related parties. Widespread availability of computer networking makes it possible to dramatically increase the frequency of periodic audits by redesigning the auditing architecture around online auditing.

The spectacular growth of the Internet in general, and the World Wide Web (WWW) in particular, has created a new set of opportunities and challenges confronting corporate management and reporting. These developments have set the stage for the continuous online reporting, and in parallel, the WWW has spawned the rapid development of the area of electronic commerce. The exponential growth of

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online retailing, online securities trading, and online procurement systems emphasizes the need for continuous online monitoring of transactions (see Elliott 1995; Debreceny and Gray 1996; Kogan et al. 1996). This article focuses on the evolving field of continuous online auditing and provides a framework for identifying research issues related to its reasons, methods, implications, and available experiences.

What is Continuous Online Auditing?

Continuous auditing is defined here as a type of auditing that produces audit results simultaneously with, or a short period of time after, the occurrence of relevant events. While this definition reflects the commonly accepted meaning of continuous auditing, it would be more accurate to call this type of auditing *instant* rather than *continuous*.[1]

Continuous auditing can be feasible only if implemented as (1) a fully automated process, and (2) a process with instant access to relevant events and their outcomes. The only known way to satisfy these requirements is to implement continuous auditing on an *online* computer system. In this context, an online system refers to a system that is permanently connected through computer networking to both auditees and auditors. Therefore, this article discusses auditing that is both continuous and online, i.e., *continuous online auditing* (COA).

Feasibility of Continuous Online Auditing

COA is a very intriguing concept. However, the interest in COA will remain purely academic as long as its feasibility is in doubt. Two important dimensions of COA's feasibility are its technological feasibility and economic feasibility, which are briefly discussed below.

Technological Feasibility

In theory, the technological feasibility of COA rests on two important technological advances. First, accounting information is now almost always recorded and stored in electronic form. Second, ubiquitous computer networking allows continuous remote access to this information. This access is further facilitated by the apparent marketplace success of open Internet standards. Not only is the networking infrastructure widely available, but the protocols and tools have also become prevalent and affordable.

In practice, however, the development of COA has to surmount numerous technological and organizational challenges. The great variety of software systems used in enterprises makes it very difficult for auditors to develop integrated online auditing systems. Most of these enterprise systems were designed as stand-alone systems having only rudimentary, if any, networking capabilities. These legacy systems are being slowly replaced. The current developments in enterprise information systems[2] clearly exhibit the trend toward more standardization and better integration of related subsystems. This trend suggests that many of the technological hurdles in the way of continuous online auditing are likely to be overcome in the near future.

Economic Feasibility

Presently, continuous online auditing is technologically feasible only in certain industry sectors and for certain limited purposes. The acceptance of COA, however, depends on whether it is economically feasible, i.e., whether the costs of COA can be lowered to levels that make its application cost-effective. A COA system can save auditors substantial costs (e.g., costs of travel, physical presence, manual collection of evidence). Furthermore, the costs of the technology required to implement online auditing (software, hardware, network connectivity) have been declining rapidly. These savings are likely to make it possible to develop and deploy online auditing systems without incurring prohibitive costs.

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[1] The confusion arises because in many cases instant auditing leads to producing audit results at very high frequency, approaching a continuous stream of results (if the population of relevant-to-the-audit events is large). However, a continuous audit, in the sense of being instant according to our definition, can produce results infrequently if relevant events occur only sporadically.

[2] These systems are commonly referred to as "enterprise resource planning" (ERP) systems; the leading ERP systems on the market are SAP R/3, Oracle Financials, PeopleSoft, BAAN, and J. D. Edwards.

Note, however, that the actual system development costs of COA will remain substantial, as the cost of software *development* has not benefited significantly from technological developments.

The developments described above strongly suggest that COA is becoming feasible both technologically and economically. This article proposes a research agenda for the emerging field of COA. The next section reviews the history and institutional background of, and some experiences in COA. Next, a number of research issues relating to the architecture of COA, factors affecting the use of COA, and major consequences of COA are presented. The concluding section highlights certain COA research priorities and presents a brief summary of the article.

II. HISTORY AND INSTITUTIONAL BACKGROUND

Prompted by developments in information technology, COA research started over a decade ago (see Koch 1981; Groomer and Murthy 1989; Vasarhelyi and Halper 1991; Vasarhelyi et al. 1991; Halper et al. 1992). Following early developments in EDP auditing, Cash et al. (1977) and Groomer and Murthy (1989) described a prototype system for the continuous audit of database applications. Subsequently, the accounting profession, as represented by the American Institute of Certified Public Accountants (AICPA) and the Canadian Institute of Chartered Accountants (CICA) came to realize that practice needs to expand beyond the traditional annual audits of financial statements to the provision of broader types of assurance services. These developments were addressed in detail by the AICPA's Special Committee on Assurance Services, which was chaired by Robert K. Elliott (the Elliott Committee).

Continuous Audit of Database Applications

Groomer and Murthy (1989) proposed an approach to address the unique control and security concerns in database environment. Their approach used embedded audit modules that capture information on a continuous basis. This approach is consistent with an evolutionary view of continuous auditing as the next natural step after traditional legacy-system-based EDP auditing. This early development in COA is especially important since it presents an implementation of COA based on relational database technology, which is the cornerstone of modern enterprise information systems. Embedded audit modules continue to be an essential part of COA architecture.

A further important theoretical development in the use of embedded audit modules for *independent* continuous online monitoring was described in Minsky (1996), where a law-governed architecture was proposed as the means of resolving the conflict between being independent and being embedded, i.e., part of the system. Early research efforts (Bailey et al. 1985; Gal and McCarthy 1985) in the formalization of the representation of internal controls can be linked to the concepts around embedded audit modules. This formal representation would allow for adaptive analysis of transactions based on some normative progressive review of the perceived risk of existing internal control structures.

The Elliott Committee

The Elliot Committee argued that significant societal, economic, and technological developments were generating substantial changes in the accounting profession and that major opportunities existed for accountants. The Committee proposed a new plan of action involving the development of new types of assurance services, including Information Systems Reliability and Electronic Commerce assurance services.[3] The committee gave the following description of the Information Systems Reliability service:

> "The CPA monitors the functioning of the organization's systems to ensure that they provide reliable data. This service involves either *regular* or, ultimately, *continuous* oversight. It presumes some level of direct involvement in computer operations by the CPA. He or she would either (1) embed some level of monitoring or control in the client's system or (2) direct regular inquiries into client processing systems/databases. This service, while *initially* aimed at *internal* users, would have its greatest appeal to external users who want to rely on entity data delivered at interim dates and, ultimately, continuously….

[3] Further developments in Electronic Commerce assurance have lead to the announcement of CPA WebTrust (see AICPA 1998; also see Greenstein 1998; Srivastava and Mock 1998).

> Evaluating controls over real-time systems must be computer-based....Data flowing through the system will be monitored and analyzed using CPA-defined rules. Exceptions to these rules trigger real-time warnings to call the CPA's attention to potential problem areas and issues that need immediate resolution."[4]

One can easily notice in this description several important features characteristic of COA. These features relate to the timing, tooling, and deployment of the audit process.

The Systems Reliability Task Force

The AICPA/CICA Systems Reliability Task Force was established in part to institutionalize the process begun by the Elliott Committee, as well as to respond to anticipated demand for new assurance services related to systems reliability. These services are deemed necessary in the evolution of systems toward online audit and assurance. The steps evolving toward a continuous audit encompass a new product under the umbrella of the AICPA/CICA *SYSTRUST* denomination—system reliability assurance (including software reliability, infrastructure reliability, process reliability, and data reliability). This proposed service is still at a conceptual stage, with numerous barriers to overcome. However, it illustrates a growing tendency on the part of the profession to provide services that bridge the route toward COA.

CICA/AICPA Committee on Continuous Auditing

The CICA and later the AICPA established a committee chaired by Richard Wood to examine "continuous auditing." The committee submitted its report in December 1998 (see CICA/AICPA 1999). This report discusses the nature, purpose, scope, and fundamentals of a continuous audit. Subsequently, the report deals with more complex continuous audits and draws a set of conclusions. It concludes with the following statement:

> This study has discussed a conceptual framework for continuous audits in general, and described some significant issues that would need to be addressed in performing such services. If some of the significant hurdles associated with continuous audits can be overcome, there are likely many types of subject matter regarding which an auditor could add significant value to an entity by performing a continuous audit. (CICA/AICPA 1999, chap. 5, draft 3)

The report provides several examples of potential continuous auditing services. These include: (1) continuous assurance regarding the authenticity, integrity, and nonrepudiation of electronic commerce transactions in connection with the AICPA/CICA WebTrust Seal assurance service; (2) continuous assurance on controls over electronic commerce systems, over compliance with debt covenants, and over the security of web sites containing reports on significant decision-making information; (3) continuous assurance on specific financial information (e.g., inventory levels), on mutual fund unit values, including assurance on effective controls over the unit-holder system; (4) continuous audits of financial statements; and (5) continuous assurance regarding marketing information (e.g., sales of a new product by a software vendor), regarding media ratings, hits to the web site, and banner downloads.

Some Experiences in Continuous Online Auditing

CPAS

In 1991, Vasarhelyi and Halper (1991) focused on the "Continuous Process Auditing System" (CPAS) designed to deal with the problems of auditing large paperless database systems. It developed a methodology for continuous auditing and described its implementation at AT&T.

The CPAS methodology was designed to measure and monitor large systems, drawing key metrics and analytics into a workstation environment. The data were displayed interactively, providing auditors with a work platform to examine extracted data and prepare auditing reports. CPAS monitored key operational analytics, compared these with standards, and rang alarms when necessary. Data collection, performed in the shadow of the corporate legacy system, was based on scanning patterns of reporting

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[4] Adapted from the ASEC report (see AICPA [1997], the corresponding section of the web site), emphasis added.

data, and on inserting those patterns in a relational database that supported its "advanced audit decision support tool."[5]

The CPAS effort entailed the continuous audit and monitoring of AT&T billers that were processed at four large data centers in different parts of the nation. The CPAS process used a "measurement" methodology to capture data and to feed its "Advanced Decision Support System." The "measurement" method of data provisioning can be contrasted with the "monitoring" data provisioning that actually draws information from direct computer processes while they are being performed.

The CPAS architecture is described in Figure 1. Systems reports, regularly distributed to process management, are also mailed to the CPAS workstation. Upon arrival, the appropriate data is filtered out, extracted, and placed in a relational database. This relational database is then utilized to perform the analytic functions, which define the Continuous Audit Process in CPAS. The system relates actual data to many standards through analytics and issues alarms when substantive discrepancies are found.

Fund Radar

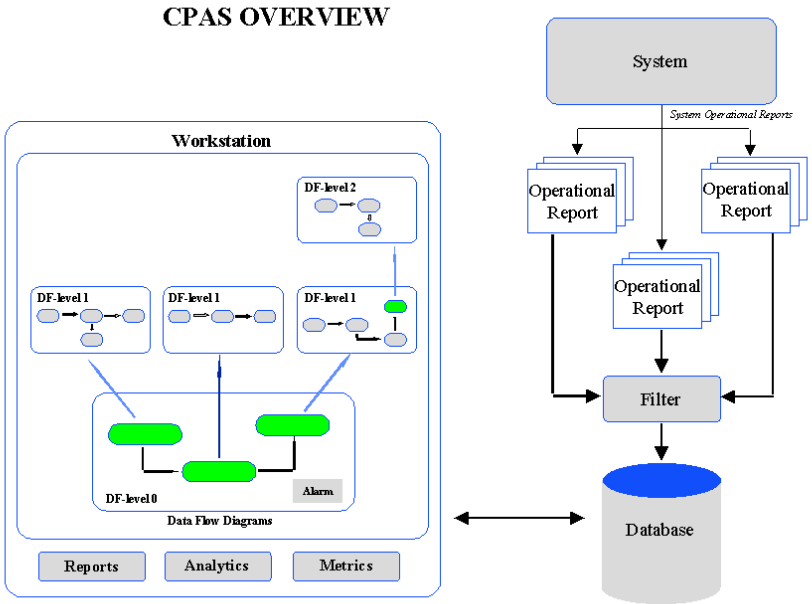
Fund Radar is used at KPMG to audit mutual funds. The principles of operation are similar to the ones in CPAS with industry averages drawn from an online source and serving as benchmarks. The mutual funds industry is particularly suitable for COA as three vendors supply software to most funds in the industry. Consequently, three software implementations of Fund Radar with similar analytics and different data provisioning could conceivably be sufficient for the majority of the firms in the industry.

Ernst & Young

The accounting firm of Ernst & Young (E&Y) is using online auditing and monitoring in several applications. In particular, they use online monitoring of a client's network for network monitoring and

[5] To the best of our knowledge, CPAS (see also Vasarhelyi et al. 1991; Halper et al. 1992) is the only operational COA system in actual use whose architecture is described in detail in scholarly publications.

FIGURE 1
CPAS Architecture



security purposes, and are developing a CPAS-like application using HMOs as the application domain. HMOs, as in the mutual fund industry example above, have one software package with substantial market share. Consequently, that makes it easier for E&Y to capitalize on a COA investment and deploy it in other HMO clients that use the same software.

Bank Case

A local bank in Spain has developed a suite of applications programmed in COBOL within legacy systems,that create analytics relating products, customer care, marketing, and risk management. Although the applications are not real time, many monitoring functions are performed during system operations.

III. A PROGRAM OF RESEARCH IN COA

Since COA is in its embryonic stage, numerous problems and research issues are bound to arise. Outlined below are some of the more important research issues relating to the *architecture of COA,* the *factors affecting the use of COA*, and the major *consequences of COA*. This same schema is used in Table 1, in Section IV, presenting the COA research priorities.

Architectural Issues Relating to Continuous Online Auditing

Continuous online auditing requires an elaborate architecture anchored in a more intricate and formal structure as compared to traditional auditing. The most important architectural issues related to the methods of performing COA are now presented.

General Architecture

The design of a COA system presents a serious challenge. The architectural decisions are made very early in the process of COA development and deployment. These decisions have to be consistent with audit objectives. Margins for errors are very narrow, since almost any architectural decision is either irreversible or prohibitively expensive to change later in the process.

> **Research Issue:** Develop theoretical models of COA that relate formal specifications of a COA system to various audit objectives.

Audit Risk Assessment

Audit risk measurements and estimates of traditional nature can be arbitrary and judgmental. The advent of COA and its extensive data collection and monitoring features brings new meaning to actual risk measurement. Quantitative techniques that will substantially anchor audit risk measurements and estimates with real empirical values must be developed. The application of COA opens new venues for this well-established area of auditing research.

> **Research Issue:** Develop new or refine the existing audit risk model for continuous online auditing.

Data Capture

COA systems need elaborate data-capture mechanisms that supply the enterprise data for auditing. Today, these data capture mechanisms have to be custom-made for individual audit clients. Enterprise resource planning systems (e.g., SAP, PeopleSoft, Oracle) and special industry software (e.g., Funds Radar) may allow for actual generation of specific records/reports designed to support audit analytics for the COA process. These solutions are clearly superior to the custom-built data-capture mechanisms that were needed prior to the proliferation of ERP systems, and provide a degree of standardization that improves the economics of COA. Standard formats for enterprise data will greatly simplify data-capture problems of COA.

> **Research Issue:** Explore and design standard formats for enterprise data to facilitate data capture for COA. Explore the possibility of using the eXtensible Markup Language (XML) for defining such standard formats for presentation of accounting information.[6]

[6] Note that XML is quickly becoming the main tool for describing semantics of data. This development extends well beyond Internet applications in general and WWW in particular.

Scope of Auditing

COA systems are potentially capable of reprocessing or parallel processing the whole population of business transactions. This capability will allow for dramatic changes in how evidence is collected in COA.

> **Research Issue:** Investigate whether and when the complete reprocessing of the entire population of business transactions is feasible and desirable.

COA allows real-time decisions concerning the level of review desirable for a particular transaction. The desirability of auditing larger samples, and the level of rule-based scrutiny of transactions of diverse populations, will impose constraints on the design of COA systems.

> **Research Issue:** Investigate the trade-offs between the frequency of auditing and the scope and diversity of its tasks (e.g., expanding the audit to cover nonfinancial variables like intangibles or quality).

Systems Audit

The field of COA inherits a long-standing debate from EDP auditing about whether to audit the information system or to audit the data flowing through that system. There seems to be a growing consensus that the information system has to be audited. Focus on information system auditing will provide important assurance on the quality of data fed into the COA system.

> **Research Issue:** Determine the trade-offs and complementary relations between system structure auditing and transactions auditing. Analyze whether both transactions and system structure have to be controlled and subjected to high frequency auditing.

Since an enterprise information system can be assumed to be fairly stable over time, high frequency auditing for these systems can be accomplished by simply continuously monitoring that the system has not changed. For example, this can be achieved by using cryptographic techniques of digital signatures (e.g., see Stallings 1999). These techniques have been successfully implemented in modern intrusion detection systems. A case in point is the widely used file system integrity checker called Tripwire (e.g., Kim and Spafford 1993), which maintains a database of digital signatures of numerous system files. In traditional EDP auditing this function would be accomplished by simply controlling the size and the date of the executable files.

Real-Time Analytical Review Procedures

Analytical review has become one of the more important tools for auditors. These procedures are being used both at the engagement-planning stages as well as at the final stages of the audit. At present, analytical review procedures are mainly focused on financial ratios, which are analyzed cross-sectionally and over time.

In a conventional audit, the scale and scope of analytical review procedures is necessarily limited by the type and amount of data that can be collected by traditional techniques. COA has the potential to increase the quantity and scope of data available to the auditor by orders of magnitude. The deployment of COA systems provides the opportunity to widen the scope and increase the scale of analytical review procedures dramatically. This increase in the scale of analytical review procedures will require the development and utilization of auditor heuristics and expert system type rules, allowing the systematization (wiring in) of auditing tests in the auditors' own COA system. For example, reconciliations that auditors perform annually, once formulated, can be built into the COA software and performed as frequently as desired. Ratios that are calculated in analytical review can be programmed in the COA system. These ratios can then be monitored and compared with critical values so that significant variances can be flagged in real-time. The time-series data can be kept to provide an expanded data view and a wider choice of analytical methods, possibly including the wide array of time-series analyses.

COA high frequency data allow for extensive exploratory and visual analyses of data (see Tukey 1977). Some recently proposed analytical review methods (like those based on Bedford's law, see Nigrini and Mittermaier [1997]) can be used to complement standard ones.

The deployment of COA will lead to a variety of new analytical review issues. For example, since the auditing system is by its own nature a parallel system, it should not be relied on for routine control functions, i.e., for detecting systematic problems. Therefore, the auditing system's alarms should be *truly random*, i.e., these alarms should be a Poisson-like process. This hypothesis should be tested empirically after COA systems are deployed. If the stream of audit alarms is not completely random, then the COA system is probably being relied on for some systematic signals. These signals should be normally provided by the internal management control system.

Research Issue: Develop new analytical review procedures to take full advantage of the capabilities of COA systems. Identify and analyze potential difficulties associated with the evaluation of data, interpretation of alarms, and lack of specific data.

Security of COA

The security arrangements are crucially important for the architecture of COA. In general, COA performed by internal auditing will be implemented over corporate intranets. All the security issues (like firewalls, packet filters, and access control) apply in this setting. COA performed by independent auditors can be implemented over either dedicated private leased lines, or over the appropriately configured extranet or virtual private network. Since the former is extremely costly, it is very likely that the latter will be the main choice. As extranets use the networking infrastructure of the public Internet, their security technology and policies are even more important. Sophisticated protocols utilizing both the modern public key cryptography and the traditional secret key cryptography (e.g., see Stallings 1999) need to be developed for this purpose.

Research Issue: Examine the extent to which system security issues associated with opening numerous new channels between auditors and auditees will slow down the growth of online audits.

Research Issue: Examine the adequacy of existing security arrangements for remote access to a COA system (e.g., through virtual private networks and/or extranets). Develop new security arrangements to the extent that existing arrangements are found to be inadequate.

Electronic Records

Online auditing systems have inherent capabilities of automatically generating electronic records of auditing procedures. These electronic records facilitate better evaluation of the auditing process, and at the same time provide extensive documentation to protect the external auditor in the case of litigation.

Research Issue: Determine the level and scope of electronic record keeping in a COA system that is sufficient to meet auditors' needs. Explore ways of designing the architecture of COA to satisfy these requirements.

Distance Auditing

The nature of certain methods of gathering evidence changes when they are performed on a remote basis. Consider physical observation in COA, which can be performed through video cameras. These practices may change the reliability of physical observation. For example, video cameras can be manipulated to stage fictitious physical checks and counts, thereby reducing their reliability.

Research Issue: Design innovative forms of remote observation, investigate the use of video-monitoring tools, and ascertain the extent to which these types of observation methods can be relied upon.

Person-to-person contact between the auditor and the auditee is beneficial. It allows for direct observation of an individual's behavior, body language, and a better feel for the auditee's environment. Person-to-person contacts may expand the opportunities for selling additional services. COA is therefore unlikely to completely replace traditional contacts between auditors and auditees.

Research Issue: Explore the extent to which the auditor can rely on COA distance-auditing techniques without compromising the quality of the audit.

Factors Affecting the Use of COA

The use of COA is likely to be affected by numerous factors such as enterprise functional area, industry, type of audit, and the specific accounting firm performing the external audit. Thus, COA deployment is likely to be uneven across the factors indicated above.

Functional Areas

Certain parts of an enterprise information system lend themselves to COA technologies more readily than others. For example, the functional area of cash management will likely be one of the first candidates for COA deployment because of its high exposure and automation. The choice of functional areas for COA deployment will probably depend on (1) the importance of higher frequency auditing for an area, and (2) the ease of deploying COA in that area. In the case of cash management, it is arguably important to audit cash positions frequently, and, at the same time, auditing cash positions automatically is relatively easy since cash management systems are almost always highly automated.

> **Research Issue:** Investigate whether COA is better suited for certain functional areas or whether it is equally well suited for all functional areas of business. Determine which functional areas have higher rates of COA deployment. Ascertain the characteristics of those functional areas that make them more amenable to COA.

Industrial Sectors

Certain industries are more amenable to COA than others. For example, the securities industry is almost completely computerized, and much of the data is available almost continuously. Moreover, fast and unpredictable changes in the environment and the high stakes involved make it especially important for the stakeholders to know the ongoing state of affairs. It is therefore reasonable to expect some early COA deployments in the securities industry.

> **Research Issue:** Identify important characteristics of industries that affect the intensity, comprehensiveness, and success of COA deployment.

Internal vs. External Use

The CICA/AICPA Committee on Continuous Auditing has stressed the particular importance of internal audit in the evolution of COA (CICA/AICPA 1999). Relative to external auditors, internal auditors are bound to have more intimate knowledge of a company's computerized accounting systems.

> **Research Issue:** Investigate whether the use of COA is more likely to be initiated by internal auditors than external auditors.

Characteristics of an External Auditor

COA is a capital-intensive technology, which requires sizable initial investments in hardware, software, networking, etc. Furthermore, being new and unproven in the marketplace, COA carries substantial risk. It is therefore reasonable to expect that initially only large firms will be able and willing to use COA in external audit engagements.

> **Research Issue:** Investigate whether the use of COA is more likely to be initiated by large rather than small public accounting firms.

Effects or Consequences of COA

Having discussed issues related to the architecture of COA and factors affecting the use of COA, issues relating to the effects or consequences of COA will now be presented. The anticipated effects of COA on direct costs and agency costs, on audit frequency and audit quality, the managerial and behavioral consequences, and the effects on audit practice are discussed.

Effects on Direct Costs and Agency Costs

The market demand for continuous online auditing is closely associated with the benefits that higher