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White Paper

Reimagining Auditing in a Wired World[1]

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ABSTRACT:

How would financial statement audits be designed if auditing were a new service that had just been invented? There can be little doubt but that audit processes would be designed from the get-go to make optimal use of today's amazing technology in order to enable auditors to provide the most effective and efficient service possible within the bounds of economic viability. Instead, for the most part, auditors use legacy processes that are not much different from those of fifty years ago except that they have been computerized. The emphasis has been on improving efficiency, and while effectiveness has improved as well, there has not been the quantum leap that technology can enable.

Our thesis is that the profession needs to achieve that quantum leap. This will involve deconstructing and re-engineering processes; researching how data science and related technologies can be harnessed and tailored into applications for auditors; extending auditing theory to encompass new approaches; modifying auditing standards where necessary and providing plenty of new guidance; and using today's ubiquitous computing and connectivity to transform where and how work gets done and to enable continuous auditing. We use a "blue sky" scenario to describe what future reporting and auditing systems might resemble and we discuss how technology could be used to transform auditing.

[1] From the AICPA Assurance Services Executive Committee (ASEC) Emerging Assurance Technologies Task Force.

Introduction: Blue Sky Scenario

It was 7:30 in the morning on Tuesday, June 17, 2020, and Sally was just settling in for another day as the external audit partner of ML Enterprises, Inc. (MLE), a $12 billion U.S. construction company operating in over 30 countries. As usual, her first task after getting her skinny latte, was to sign in to AART, the audit firm's Automated Audit, Reporting, and Tracking system. AART was developed to leverage the widespread availability of information on a 24/7 basis, so that technology could monitor MLE's controls, transactions, and account balances continuously. AART had been initially configured and customized for MLE business operations and technology platforms, but was also capable of learning over time. In that sense, AART was able to better 'understand' the client's business. This offered the dual benefits of reducing the number of legitimate events flagged for auditor review (false positives), as well as identifying trends, anomalies, and patterns that Sally and her team had not explicitly addressed or considered.

As she looked at the AART dashboard that she had customized for her use, the majority of her audit status indicators were solid green. However, she noticed a flashing red indicator relating to the Hong Kong Treasury Operations group, and a yellow warning icon associated with the Brazilian operations. She had also been copied on a message that AART sent to her controls team notifying them of a modification to a key control parameter in the centralized SAP system. She clicked on the red indicator, and saw that an unusually large transfer had been executed in Hong Kong last night between the Asian and European regional operations. She then forwarded the pertinent information to her partners in Hong Kong and Munich, and set a flag to remind her to review their responses the following day. In addition, she transmitted the Brazil-related information to one of her managers for follow-up activities.

Sally then examined the Daily Transaction Testing Report from the previous day. This was a randomly generated list of transactions chosen for testing in addition to those specifically identified by the AART system. Of the 12 transactions selected yesterday, 10 had already been reviewed and closed by the audit team, while two remained open. She reviewed the tests performed and resulting conclusions, and was satisfied that the evidence and explanations provided were appropriate and sufficient. She also reviewed the status of the two open items, and noted that management had promised to respond by close of business today.

After meeting with the controller, she returned to her office at 11 a.m. She realized that the continuously audited financial statements would be posted on MLE's website at noon, as they were every day, and she wanted to confirm whether there were any significant unresolved issues requiring prior attention. After logging in to AART, she noticed a message from her controls specialist indicating that the SAP password complexity parameter had been updated to require at least one number and one special character, and he believed this change to be an improvement. He had previously discussed this matter with the chief security officer, who provided evidence of the policy change and the related approvals. Sally then reviewed a number of statistical reports, charts, and graphs produced by AART, and concluded that the financial statements could be published and the audit opinion would remain unqualified. Although the Hong Kong transaction had not yet been verified, there was nothing to indicate that it was improper, and, in the worst case, would result in an adjustment the following day.

Sally then recalled that she had a 3:30 p.m. meeting next Monday with representatives from Future Financial (FF) to approve guidelines of an evolving lending arrangement with MLE's U.S. operations. Negotiations were being finalized relative to a line of credit with FF, and part of this final discussion was to involve associated covenant terms. Specifically, FF was looking for regular access to particular information in addition to associated independent assurances. As Sally reflected upon this proposal, she theorized that it would not present any insurmountable challenges. Essentially, MLE was historically proactive, and, as such, recognized long ago that a wider variety of stakeholders were increasingly demanding access to a diverse mixture of real-time information with attached assurances. Among other things, the AART system was designed to facilitate this stakeholder-centric approach. Consequently, she envisioned a rather simple solution. First, a web-based dashboard would be constructed specifically for FF, and it would contain all of the required information and metrics relative to the lending arrangement.

Second, this page would be dynamically refreshed on a daily basis immediately subsequent to the posting of financial statements. Third, FF would be assigned permissions and issued a user name and password combination (or set of combinations) to access, in an ongoing manner, the formulated web page, as well as the area(s) containing relevant assurances. Sally actually viewed this as a type of pilot project, because bondholders and other lenders were starting to request information on a similar platform. She knew it was only a matter of time that such provisioning of information would become the norm. Whatever the case, Sally was meeting with her team later today to construct an action plan concerning the issue with FF, and was confident that a suitable solution would be established.

On a more challenging level, rumblings were beginning to be felt on a global basis relative to corporate social responsibility concerns. In particular, environmental groups and community members were placing increasing pressure on MLE to provide relevant information in more of a real time format. While Sally felt confident that this could ultimately be accomplished via the AART system, she wondered about the complexity of maintaining such quantitative and qualitative information on a current basis. Like most companies, MLE presently publishes an annual sustainability report that outlines key initiatives and metrics about social responsibility at MLE, and it is historically a very challenging and time-consuming project. While she believes that the quantitative portion of reporting could be readily presented on a more frequent basis, she envisions significant coordination barriers in maintaining the independently assured qualitative information in a comparable manner, largely because of MLE's international presence. Not surprisingly, Sally feels fortunate that this is an issue not requiring an immediate resolution. Nevertheless, she has scheduled an initial brainstorming session with her team in an effort to begin articulating potential operational strategies.

On a lighter note, Sally had previously arranged for lunch to be delivered to celebrate the 33rd birthday of one of her team members, Rob, who was her construction accounting specialist. He had four years of public accounting experience, including two years with the SEC, and had been an assistant controller in another construction company for six years. Rob's background was indicative of the experience level of her team in general. The junior member was Allison, who had a Ph.D. in statistics as well as seven years of experience at a major insurance company. The audit specialist, Trevor, was a CPA with nine years of experience, and was responsible for the configuration of the AART system, as well as the design and execution of all substantive audit procedures. Rounding out the team were Subrata, the controls specialist who came to the firm after eight years in IT and internal audit, and Jorge, who was a construction industry analyst for 17 years at Deutsche Bank. Sally reflected back to the day she was hired directly out of business school, and noted how AART had radically changed the staffing model and audit dynamics. The audit was now being conducted with a handful of highly experienced and well-compensated specialists. In addition, having a skillset including extensive technical and analytical expertise was no longer optional. Essentially, there was little demand at MLE for an inexperienced, traditionally educated accounting graduate.

While the above anecdote may be perceived as visionary, it is nevertheless a window into what the future audit might entail. As the now economy continues to evolve, and stakeholder groups progressively seek access to more timely information, the audit and reporting models will need to adapt in accommodating this landscape. Given this, the balance of the paper will be primarily devoted to presenting issues, observations, and potential challenges relevant to audit theory, process, and technology. In doing so, emphasis will be placed upon offering preliminary insight concerning how these items might be addressed to better meet the future needs of stakeholders. In concluding, future audit technology considerations will be briefly explored to develop an improved overview of how the audit might evolve in the coming years.

Using Technology to Transform Auditing

Although auditors embrace and make extensive use of information technology, little has been done to consider how auditing might be transformed by it. For the most part, IT has been used to computerize and improve the efficiency of established processes rather than transform or replace them. Consequently, improvements have been incremental rather than transformative. We discuss some of today's IT enablers and their potential for improving audits.

Technology Enablers

Thanks to the Internet and exponential advances in core technologies, today's auditors practice in a globally connected world of ubiquitous computing and communications devices that collectively provide a platform for transformational applications. Smartphones, tablets, and other mobile computing and communications devices are pervasive and always on; and information workers are no longer tethered to office desks but work from home, coffee shops, public libraries and parks, airport terminals and airplanes, and from rent-by-the-hour office suites (AICPA 2012).

Whereas in years past, auditors worked in relatively isolated local teams from the same office, today's auditors are able to operate more fluidly, connecting to teams from wherever they happen to be, as seamlessly as if they were in the same room; and individual skills can be leveraged globally across many audit engagements. A statistical specialist in Amsterdam can participate in audits conducted in Adelaide or Ankara.

Whereas in years past, audit procedures had to be performed on site by vertically integrated audit teams of local office resources, many audit procedures today can be deconstructed into tasks that can be performed wherever is most effective. For example, the on-site client-facing audit team can focus on tasks that only they can perform (such as observing the performance of internal controls, or meeting with the CFO), while outsourcing back-end tasks that may be better performed remotely by teams of specialists or third party providers. For example, as we will describe later, the mechanics of bank confirmations can be performed by third party organizations that specialize in that mundane but critical task and can perform at the highest standards of reliability and security—higher than is likely from the generalist client-facing team. Analytical procedures or journal entry testing for audits in Boston or Budapest can be performed better by a specialist team in Bangalore that performs the procedure day in and day out for dozens of audit engagements. This Internet-enabled deconstruction of tasks into separate processes that are performed wherever it is most effective, is mirrored by similar developments in computing.

Cloud computing is one example of how tasks are deconstructed into separate processes that migrate over the Internet to where they can be performed most effectively. Rather than operate its own IT infrastructure and software, here, an entity effectively plugs into an IT utility that provides and maintains the necessary software, manages, and stores data. End users may need nothing more than browsing software. Thus, the total task is deconstructed into a simple front end, and a back end somewhere in the cloud, where a massively equipped provider does the heavy lifting for hundreds of entities.

Data science and related technologies have advanced enormously in recent years, incorporating theories, techniques, and software applications from many fields, including data analysis, business intelligence, mathematics and probability, statistical learning including pattern recognition, data visualization, gamification, big data analytics, and text and process mining. Applications from the world of data science can be applied by auditors to perform more effective audits and to provide new forms of audit evidence not previously available to practitioners (Hoogduin, Yoon, and Zhang, 2014). Using new applications effectively requires learning new skills and the support of specialists, which can be in large part enabled by the Internet.

Audit Opportunities

The technology enablers discussed in the previous section provide opportunities for significantly improving audit effectiveness as well as efficiency. In this section we discuss some of those opportunities and their implications for the profession.

More Effective Audit Data Analytics

Audit Data Analytics (ADA) is the science and art of discovering and analyzing patterns, identifying anomalies, and extracting other useful information in data underlying or related to the subject matter of an audit through analysis, modeling, and visualization for the purpose of planning or performing the audit. ADA includes methodologies for identifying and analyzing anomalous patterns and outliers in data; mapping and visualizing financial performance and other data across operating units, systems, products, or other dimensions for the purpose of focusing the audit on risks; building statistical (for example, regression) or other models that explain the data in relation to other factors and identify significant fluctuations from the model; and combining information from disparate analyses and data sources for the purpose of gaining additional insights.

ADA includes but is not limited to analytical procedures: preliminary analytical procedures used for planning (AU-C 315); substantive analytical procedures used for substantive testing (AU-C 520.05); and analytical procedures performed near the end of the audit to assist the auditor when forming an overall conclusion about whether the financial statements are consistent with the auditor's understanding of the entity (AU-C 520.06). ADA also includes traditional file interrogation. The scope of ADA is illustrated in Figure 1.

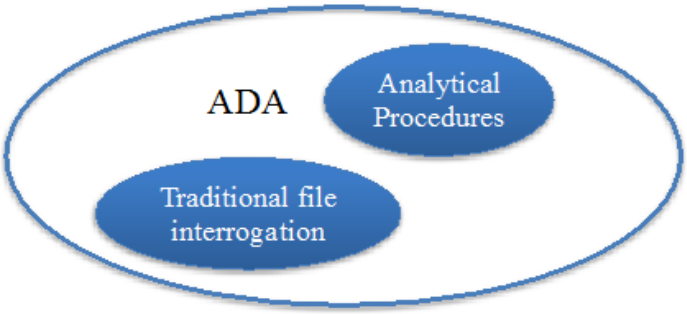

Figure 1: ADA includes but is not limited to traditional analytical procedures and file interrogation.

The data analytics literature distinguishes between two different modes of analysis, exploratory and confirmatory (Tukey 1977), and we continue that distinction here in the context of ADA. Exploratory ADA is bottom-up and inductive. It starts with the data and the auditor asking questions such as, What do the data suggest is going on here? Do the data suggest something might have gone wrong? Where do the risks appear to be? Are there potential fraud indicators? On what assertions should we focus? What models and approaches appear to be optimal for analytical procedures? Exploratory ADA is most useful in audit planning—understanding the entity and its environment, identifying and assessing the risks of material misstatement, and designing further audit procedures. Confirmatory ADA, on the other hand, is top down and deductive. It starts with audit objectives and assertions. It tends to be model-driven with the auditor asking questions such as, Is the subject matter consistent with my model, that is, with expectations? Are there deviations that are individually significant or that form a pattern, such that they indicate the potential presence of material misstatement? Confirmatory ADA is used to provide the auditor with substantive or controls assurance about whether management's assertions are materially correct—ultimately, whether the financial statements are free from material misstatement.[2]

The use of visual exploratory techniques can help auditors see patterns, trends, and outliers that are otherwise hidden, and reveal relationships between variables that could be the foundation for a confirmatory model. Confirmatory techniques are more formal and tend to be more mathematical and analytical (Behrens 1997); for example, they might utilize multiple regression analysis or the extraction and summarization of transactions meeting certain risk criteria. However, there is no bright line distinction between exploratory and confirmatory ADA, and they tend to be used iteratively. For example, initial exploratory techniques may suggest a fruitful confirmatory model to be used for substantive analytical procedures, but the residuals from that model (actual minus expected) may lead

[2] Tukey (1977) draws an analogy with the processes of Anglo-Saxon criminal justice where there is a clear divide between the search for evidence, which is the responsibility of the police and other investigative forces, and the evaluation of the strength of evidence and degree of guilt, which is the responsibility of the courts. Exploratory data analysis is detective in character; confirmatory data analysis is judicial or quasi-judicial in character.

to the discovery of additional factors that can be used to improve the model. Some of the same techniques can be used for exploratory and confirmatory analytics.

In the audit of financial statements in accordance with GAAS, there are numerous potential opportunities for making use of Audit Data Analytics. These include the following:

- Identifying and assessing the risks associated with accepting or continuing an audit engagement (for example, the risks of bankruptcy or high-level management fraud).
- Identifying and assessing the risks of material misstatement through understanding the entity and its environment (AU-C 315). This includes performing preliminary analytical procedures as well as evaluating the design and implementation of internal controls and testing their operating effectiveness.
- Performing substantive analytical procedures in response to the auditor's assessment of the risks of material misstatement (AU-C 520).
- Identifying and assessing the risks of material misstatement of the financial statements due to fraud, and testing for fraud having regard to the assessed risks (AU-C 240).
- Performing analytical procedures near the end of the audit to assist the auditor when forming an overall conclusion about whether the financial statements are consistent with the auditor's understanding of the entity (AU-C 520)

More Assurance

The auditor's overall objective is to obtain a reasonably high level of assurance about whether the financial statements are free from material misstatement. Reasonably high is not defined, but is commonly understood to mean no less than 95 percent confidence, where degree of confidence is a measure of the auditor's degree of subjective professional belief rather than some objectively calculable probability. Technology can be used to achieve the same level of assurance but more efficiently at a lower cost, or it can be used to achieve a higher level of assurance via a more effective audit at similar cost. Technology also enables statistical techniques (for example, sampling and regression analysis) that can provide objectively quantifiable confidence levels to help build assurance. Economics has driven auditors to focus mostly on improving efficiency—achieving the same level of assurance but at lower cost. Less attention has been paid to increasing assurance at the same cost by improving effectiveness, even though that cost would buy the additional benefits of better meeting client and investor expectations and of reducing audit and reputational risk and liability. In medicine, physicians are expected to use better technologies as they come along if they significantly improve patient outcomes at reasonable cost. In auditing, professional standards should encourage auditors to consider and use technologies that increase assurance beyond the minimum required where economically feasible. Professional standards need to be technology agnostic, but that does not mean that they should not encourage auditors to make the best use of technology to perform the best possible economically viable audits.

An example of where technology can and should be used to increase assurance is in detailed tests of transactions and balances. Traditionally, such tests were performed on a small sample of items. This was the only way to do it when items had to be selected from a printed or hand-written listing. With computerized data and file interrogation audit software, however, many tests can be performed on 100 percent of the population. It is also possible to simultaneously analyze and visualize the complete population in ways that can reveal unexpected patterns and outliers worthy of special investigation. For certain procedures, sampling is still necessary—for example, the physical inspection or third-party confirmation of assets, or the analysis of complex contracts. Nevertheless, even where sampling is necessary for certain essentials, it is often possible to increase audit assurance at little additional cost by analyzing and performing other procedures on the entire population.

Auditing with Big Data [3]

Big Data is the product of a technological environment in which almost anything can be recorded, measured and captured digitally, and thereby turned into data. The process, often called "datafication," may track thousands of simultaneous events; be performed in real time; involve numbers, text, images, sound, and video; and require petabytes of storage capacity. Big Data has been used in marketing to target potential customers, in political campaigning to study voter demographics, in sports to evaluate teams and players, in national security to identify threats, in biology to study DNA, in law enforcement to identify crime suspects, in public health to identify epidemics, and in securities regulation by the SEC to identify a multitude of behaviors including insider trading and accounting fraud.

Big Data analytics is the science and art of improving knowledge about or gaining insights into some field of interest or subject matter by identifying and analyzing related patterns and correlations in Big Data. In auditing, the basic subject matter consists of the transactions and balances that underlie the financial statements. These usually reside in the entity's ERP and data warehouse systems and, even if voluminous, do not in themselves constitute Big Data within the normal meaning of the term. The audit opportunity is to use related Big Data as an auxiliary to the data actually being audited—to audit *with* Big Data, using analytics to identify and analyze patterns and correlations that reveal matters of audit interest.

There are certain characteristics of Big Data analytics that are causing users to rethink data usage. The first is that it is increasingly possible to analyze the entirety or almost all data rather than just a small, carefully chosen subset or sample. This can lead to more robust models. For example, if an auditor wants to determine what characteristics of journal entries are indicators of risk of error or fraud, it is possible to analyze all the journal entries and use this information to identify current journal entries that are really unusual. Whereas in the past, a high degree of care was necessary to eliminate bad data, when all the data are available, a certain degree of pollution is acceptable for many applications. For example, if a model is based on just a small number of observations, the auditor must take great care to ensure that they are accurate in order not to skew the model. If the model is based on a large number of observations, then the auditor can tolerate some errors because, unless they are systemic, their effect will be insignificant.

A second shift in thinking is that instead of trying to understand the fundamental causes of complex phenomena it is increasingly possible to identify and make use of correlations. For example, "researchers in Canada are developing a big-data approach to spot infections in premature babies before overt symptoms appear. By converting 16 vital signs, including heartbeat, blood pressure, respiration, and blood-oxygen levels, into an information flow of more than 1,000 data points per second, they have been able to find correlations between very minor changes and more serious problems" (Mayer-Schönberger and Cukier, 2013). While these observations may allow doctors to eventually understand fundamental causes, simply knowing that something is likely to occur is more important than understanding exactly the reason. It is analogous to auditing applications in which restatements, accounting fraud, bankruptcy, or going concern issues are correlated with indicators obtained from company filings and sources of data. As stated earlier, the SEC uses Big Data analytics to identify insider trading and accounting fraud.

Continuous Auditing, Continuous Assurance

It is possible with today's technology to continuously monitor and audit an entity's transactions in close to real time, or at least at frequent intervals. This ability may be used to monitor and assess the operating effectiveness of automated internal controls, or to perform substantive tests. While many internal auditors already do continuous auditing, at least for some applications, it is still rare among external auditors. Because internal auditors are part of the entity's internal control system, an ability to detect potential problems as soon as they occur is an enhancement to internal control that should factor into the external auditor's evaluation of internal control.

There are at least two ways in which continuous monitoring and auditing techniques can be directly useful to external auditors. First, such techniques can alert them to potential problems as early as

[3] See Stewart, T., M. Cao, and R. Chychyla, "Big Data Analytics in financial Statement Audits," *Accounting Horizons*, forthcoming 2014.

possible, thus giving them more time to respond and adapt plans for the remainder of the audit. This enhances audit quality and client service. Second, continuous monitoring and auditing can help spread the work effort throughout the year. This is not necessarily useful in an environment where the audit team needs to be on the client's premises, as that typically involves travel and set-up time. However, in today's connected world it is possible to monitor and audit remotely. To the extent that this can reduce workloads and stress during "busy season," it will tend to also improve audit quality. The ability to use correlation models with big data in order to pinpoint transactions or events of audit interest becomes significantly more useful when applied continuously.

There are many reasons that reporting entities issue audited financial statements only once a year, including the cost and effort of gathering, preparing, auditing, and presenting information. Because ERP systems update general ledger accounts as transactions are initially recorded, it is possible to produce financial statements on a more frequent, almost continuous basis, and web-based technologies can make such statements almost instantly available online. The use of interactive data reporting standards such as XBRL greatly enhances the appeal and utility of online reporting. As outlined in the MLE story, today a company could, in principle, provide condensed financial statements of some kind on a daily or even close to real-time basis. If stakeholders demand such continuous reporting and are unwilling to accept additional information risk, it is likely that audit assurance will also be required on a continuous basis. Should that occur, continuous auditing will be essential rather than optional.

More Effective Fraud Detection

Audit Data Analytic techniques together with the ability to analyze and correlate vast amounts of data have revolutionized fraud detection. Patterns and connections that might never have been discovered in the past can be much more easily identified, analyzed, and visualized. Network analysis, used to analyze connections and relationships between people and/or entities, can be used to identify related parties possibly involved in fraudulent activities. The SEC is using data analytics applied to Big Data to look for inside traders—individual or collusive—and for indications of potential accounting fraud (Financial Times 2014).

Reducing False Positives

When an entire population is analyzed for anomalies and outliers, it is possible for a huge number of false positives to be flagged; and it is the fear of being thus overwhelmed that often leads auditors not to perform such analyses in the first place. While false positives can never be eliminated entirely, their incidence can be significantly reduced via statistical learning and other techniques that enable the identification of "exceptional exceptions" (Issa 2013). Credit card companies use such techniques to identify potentially fraudulent transactions without overwhelming cardholders with false alarms.

Audit Process Re-Engineering: An Example

Today, many audit processes are essentially unchanged from those performed decades ago, even though newer technology may be used to perform them more efficiently and opportunities abound for using technology to reengineer processes so they achieve the same objectives more effectively. In this section, we illustrate this with account confirmations—a mundane but critical audit process—that includes confirmations of bank account balances, accounts receivable, and accounts payable.

In a traditional confirmation, the auditor selects a sample of accounts to confirm and then generates and mails letters asking account holders to confirm the amount. If an account holder does not respond then alternative procedures are performed.

Although simple in principle, confirmations must be carefully performed so that the auditor can be sure that the process is not subverted by fraudulent actors and that requests for confirmation are directed at parties who are authorized to respond. One way to improve the process in terms of added security and reduced tedium is to outsource it to an organization that specializes in confirmations. Typically, the auditor provides the confirmation service with a list of accounts to confirm; the service contacts the account and receives the response, and communicates it back to the auditor, as illustrated in Figure 2. The value added by the service provider is (a) an established secure network including a public key

infrastructure that ensures all communications are secured and digitally signed, thus guaranteeing that communications are not intercepted or subverted, and that the parties are who they purport to be; (b) a network of authenticated participating banks or other organizations that sign up and agree to confirm via the service provider; and (c) the performance and administration of a mundane tedious task, thus freeing up audit personnel to focus on higher-level tasks.

When the service provider is asked to confirm an account not in the network, they attempt to authenticate and add it to the network. Because the service provider works for many different audit firms the investment in the network can be leveraged over a large base.

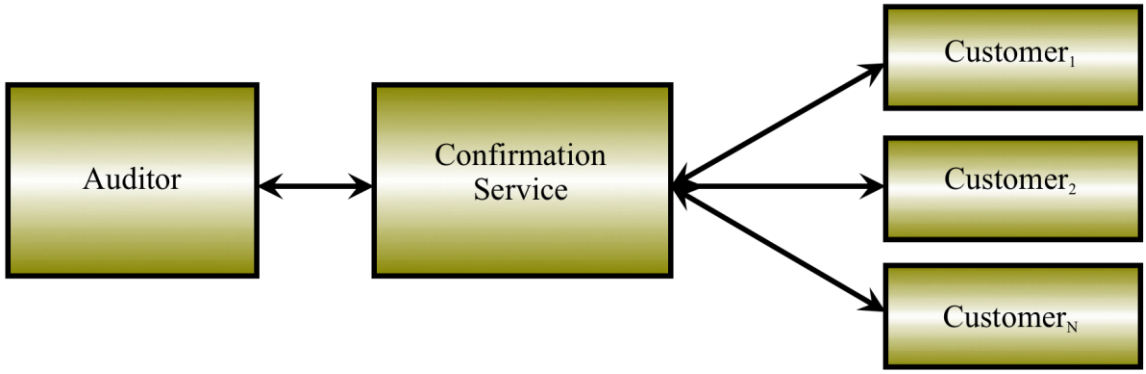

Figure 2: Basic connectivity in auditor use of confirmation service in performing the A/R confirmation procedure.

When it comes to accounts receivable, Titera (2013) suggests yet another approach that could provide greater assurance than a traditional confirmation in certain businesses. If there is a short average collection cycle, balances outstanding at the date of the accounts receivable audit could be matched with subsequent receipts on the basis that those receipts are confirmation by the customers that the amounts were owed. The auditor would need to ensure, at least on a test basis, that receipts were in fact from the customer and related to the matched invoice. The entire AR population could thus either be "confirmed" or identified as still outstanding and therefore worthy of special investigation as risks. Confirmation directly with the customer could be focused on the invoices not paid by the test date.

Making It Happen

As indicated earlier, the profession has not realized the full potential of technology to improve audit effectiveness. There are at least three things the profession could do to accelerate the adoption of better technologies:

- Encourage audit research and development.
- Provide guidance to practitioners and update auditing standards to encourage the adoption of better technologies.
- Encourage and recognize new resource models that bring to bear the new skills required in today's world to complement traditional CPA skills.

Encouraging Audit Research and Development

The profession should promote research into how data science and related IT can improve the quality and effectiveness of auditing. Very little such research is being done by universities, which have the capability. Nor is much being done by firms, which mostly do not have much research capability, but certainly have a great deal of auditing expertise. The vehicle for promoting such research could be a consortium of universities, firms, professional bodies, solutions providers, and experts in related fields such as AI, machine learning, statistics, and big data analytics. If successful, such a consortium could lead to a flowering of "useful" audit research and the development and implementation of solutions that

significantly improve audit effectiveness. Funding, governance, and similar issues would need to be worked out.

Providing Guidance and Updating Auditing Standards

An impediment to transformative thinking is that basic auditing standards were set a long time ago and the need to comply with them discourages auditors from considering how to do things better by doing them totally differently; and in some cases available technology-enabled better auditing methods would appear to contravene auditing standards (Titera, 2013). Furthermore, there is virtually no professional auditing guidance on the theory and practice of applying new data analytic, continuous auditing, and other techniques and technologies to auditing. For example, auditing standards recognize audit sampling but there is nothing that explains or encourages the types of 100 percent tests and detailed data analyses of entire populations that can significantly increase effectiveness. Auditing standard setters should review current standards and guidance with a view to removing barriers and encouraging the optimal use of technology to improve audit effectiveness.

Encouraging and Recognizing New Resource Models

CPAs are required to lead teams auditing financial statements because accounting is the indispensable field of knowledge required to perform an audit of financial statements and opine whether they are in accordance with GAAP. However, audits with any degree of complexity usually require the participation of specialists in tax, information technology, valuations, statistics, actuarial science, or other fields, who are not necessarily CPAs. As auditors make increasing use of the technologies described in this essay, they will be obliged to depend even more on professionals who have the skills traditionally-trained auditors lack. In some cases, it will make sense to have these resources within audit firms; in other cases, it will not. Regardless, firms will need to reassess their HR models and alternative sources to ensure that they strike the right balance.

In the auditing profession as a whole, where there are many auditing firms and tens of thousands of audits, it seems to us that there should be opportunities for solution providers to offer auditing applications and skilled resources as a profession-wide service. The advent of cloud computing creates opportunities for such solution providers to offer services that do not require software installation and maintenance. There are clearly confidentiality, privacy, and independence challenges that would need to be overcome, and the profession should take the lead in doing so.

Blue Sky Scenario Revisited

Sally is now close to retirement and ponders how AART was replaced by Eco-AART that changed not only her assurance role but also the business world where highly automated corporate and audit systems coexist, and regulations are formalized into software and updated in an ongoing manner. The audit is now conducted substantially via automated mechanisms such that an evergreen opinion (AICPA, 1999) is dynamically maintained, multiple audit opinions exist continuously for different stakeholders, and a “pink” system status implies the need for immediate corrective action by members of the audit team. In fact, the audit function is now one of the most expensive components of the business process, as it is not fully automated like many of the other robotic processes at MLE. Furthermore, much of the highly technical competencies are being provided by specialized staff with hybridized employment links to the firm. Sally recognizes that the consistent leveraging of advanced technologies and processes was a key ingredient in the long-term prosperity of MLE. As she prepares for dematerialization and subsequent beaming to Jupiter for a tour of the Galilean moons, she reflects back to 2013, and barely remembers why so many practitioners resisted the paradigm shift in auditing for so many years…How times have changed!

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