The Creation of One Truth: Single-Ledger Entries for Multiple Stakeholders Using Blockchain Technology to Address the Reconciliation Problem

Ahmed Gomaa
Associate Professor of Operations and Information Management Kania School of Management
University of Scranton ahmed.gomaa@scranton.edu

Salem Boumediene
Associate Professor of Accounting College of Business Administration Montana State University
Billings, salem.boumediene@msubillings.edu

Mohamed Gomaa
Assistant Professor of Accounting College of Business Administration California State
Polytechnic University, Pomona mgomaa@cpp.edu

Magdy Farag*
Professor of Accounting
College of Business Administration California State Polytechnic University, Pomona
mfarag@cpp.edu

Abstract

Originally elaborated for digital currency, blockchain technology has undeniably evolved beyond its original uses to support various business applications. Based on accounting technology, it is no surprise, that over the past few years, it increasingly draws the accounting profession's attention. This paper presents a new methodological framework, based on a single-ledger model, to implement and apply blockchain technology in the accounting profession. The objective of our study is to addresses the reconciliation problem. Following our approach, transaction details are recorded in the blockchain ledger. This ledger represents a single source of truth that can be viewed directly by the transacting parties, without the need of having information silos as a part of the design in the ERP systems. Therefore, addressing the reconciliation challenges. The framework has been specifically designed to create one truth for all parties involved in a transaction that in turn eliminates what is perceived to be unnecessary redundancy in current accounting systems.

* Corresponding Author

I. Introduction

In the last two decades, information technology has played an essential role in the development of the business world. It has shaped the structure, processes, and regulations of many businesses. For the accounting profession, this is no different. Accounting has been shaped by the emergence of computers and has been optimized through the development of accounting software. However, just like all businesses, accountants are looking for new and upcoming technologies to improve the accounting profession. One of the most recent technologies on the horizon is blockchain technology.

Reconciliation between trading parties is an expensive and time-consuming process. With the introduction of blockchain, reconciliation costs and time may be lowered due to its digital nature leading to increased efficiency and transaction speed, immutability, controlled transparency, and enhanced security. Prior studies have proposed various approaches to implementing blockchain technology in accounting transactions. In a recent study, McCarthy and Gal (2018) presented a Resources, Events, Agents (REA) ontology approach to implementing accounting transactions. The REA model was initially introduced in McCarthy (1982). The REA framework simulates the business processes for accounting purposes. It considers resources as the goods, services, or money, and events as transactions that affect resources. It also considers agents as entities generating the events. When a transaction is recorded, the REA framework is used instead of the traditional double-entry accounting system. The advantage of using the REA framework to model accounting transactions within an Enterprise Resource Planning (ERP) system is the model abstracting capabilities. These capabilities translate to the ability to run detailed analytics on the value added by each decision within the enterprise, related to the resources used and their impact.

McCarthy and Gal (2018) propose using the REA framework to allow for the proper implementation of complex transactions within an ERP system using Blockchain technology. Since the REA framework models the interactions between Resources, Events, and Agents, it is well suited as a framework where automation of complex transactions is a requirement.

In an earlier study, Dai and Vasarhelyi (2017) proposed a blockchain-based triple-entry accounting system. Their approach results in a transaction being recorded in three places. Each transaction would be recorded in a traditional double-entry ERP system within each transacting enterprise. The two ERP systems will relay their information on the blockchain ledger. The result is a common view of the same transaction on the blockchain for both transacting parties using accounting and obligation tokens. This paves the way for using existing double-entry ERP systems in conjunction with the blockchain. The result is three ledgers, one at each transacting enterprise and one on the blockchain adding up to three ledgers, hence the naming of Triple Entry Accounting within their paper. Still, Dai and Vasarhelyi build on existing ERP systems using double-entry accounting systems instead of the REA framework for recording transactions.

This study builds on the works of McCarthy and Gal (2018), and Dai and Vasarhelyi (2017). This paper first identifies the requirements to have a transaction recorded on the blockchain between trading parties without facing a reconciliation challenge. It then proposes a new framework using Blockchain technology resulting in a single-ledger model. Fundamentally, the proposed framework ensures a challenge-free reconciliation process that supports the concept of recording the information one time, as transactions take place, in an automated fashion. Once recorded, every enterprise may use the information as it sees fit for its own optimization and operational purposes.

This study shows that blockchain technology will have an enduring impact on the accounting profession. It proposes a new conceptual framework to implement and apply blockchain technology in the accounting profession that is based on a single-ledger. This framework will create one truth for all parties involved in a transaction to eliminate reconciliation challenges.

The paper proceeds as follows. The next section presents the literature review, including the history of double-entry bookkeeping and blockchain technology. The third section provides the proposed framework that includes the reconciliation requirement, followed by the concept of one truth, and explains the single-ledger accounting framework. The last section concludes and provides avenues for future single-ledger accounting research.

II. Literature Review

The History of Double-Entry Bookkeeping

The history of the double-entry bookkeeping system goes back many centires ago. However, the first book on double-entry accounting was published by Luca Pacioli in 1494. The impact of this book was so significant that accountants around the world still use its principles until this day (Sangster and Scataglinibelghitar 2010). The double-entry bookkeeping system is perceived as an important tool for business as it enables the organization of accounting transactions in dual records. Despite the benefits of the double-entry bookkeeping system, it has historically been perceived as being difficult to learn (Sangster, 2018). Also, in modern history, it failed to prevent major fraud cases from happening with an estimated total loss of $6.3 billion in 2016 (Dai, Wang, & Vasarhelyi, 2017). The current “regulatory approach” to fraud mitigation is not sufficient (Boyle, Boyle, & Mahoney, 2018).

Prior to the wide adoption of the double-entry accounting system, the single-entry bookkeeping system was originally the method used in business. It had many forms, like notations for business transactions; records of debts and dues; and records for goods on hand. This single-entry accounting system was too primitive lacking much of the essential information needed to calculate profit or loss, or to present the overall equity of business owners (Sangster, 2018; Kuter et al., 2017).

This study represents a paradigm shift away from the traditional accounting system and towards an intra-enterprise single-ledger accounting system that relies on blockchain technology using the REA framework to address reconciliation problems.

Blockchain Technology in Accounting

Imagine "*a very large notebook, which everyone can read freely and free of charge, on which everyone can write, but which is impossible to erase and indestructible*" (Delahaye, 2015) Blockchain is a new technology that may impact the accounting profession. It is a digital ledger that captures transactions conducted by different parties. The transactions are validated by consensus between a group of computers called nodes. Entries into the blockchain are transactions that "represent exchanges of value, rights, obligation, or ownership" (AICPA, 2017). An entry results from one party sending value to another. In order to do this, there are five steps that needs to take effect. During the first step (1) an agent A registers for an agent B a request to write to the *Blockchain* ledger (e.g., financial transaction, accounting entry, contract, delivery, transfer of ownership, etc.). Agent A uses software (Digital Wallet) for this registration which will transmit the request to a network of computers (nodes). This entry by agent A is then added to a "block" of information, which brings together the entry requests entered in the ledger by all of the users during a certain period. This block is then placed in a queue (step 2). The validation of this block and the

effective writing of its information to be added to the blockchain will require validation by a consensus of the nodes within the network. This validation is the key step in *Blockchain* technology (step 3). It is a cryptographic protocol which allows validation of block information via a network nodes. The underlying protocol for reaching a validated block varies between different blockchains. The variation stems from the definition of truth within a network. In some blockchain networks, the truth in a community reflects the majority approval. In other blockchain networks, the truth is it from those who have more stake in the validated transaction. Every blockchain protocol follows a certain truth. In the bitcoin case, it is the proof of work, and the majority consensus. The users who carry out this validation are called "minors." These provide the network with the computing capacity of their computers in order to carry out the cryptographic operations necessary for the validation of information. The purpose of these operations is to subsequently allow the identification of blocks of information, without the content being revealed, which authorizes verification of the integrity of the entries. When the block is validated, it is time-stamped and added to the blockchain (step 4). This validation is irreversible, the block is added in an orderly fashion following the others in the ledger. The data in the block is then hashed to create a unique signature for that block that is created from its exact transactional data. This hash is attached to the block along with the transactional data, which is then chained to other blocks. As parties continue to exchange value with one another, each transaction is captured and added to the blockchain which creates a large public ledger of all exchanges of value that have taken place on the network (Kokina et al. 2017). This blockchain is accessible by all the members of the network (agents A and B) who hold the same copy of the information recorded within the Blockchain (step 5) (Desplebin, Lux, & Petit, 2019).

General benefits to the business environment inherent in this technology stem from the "near real-time settlement, irreversibility of transactions, public distribution of the ledger, and a resistance to censorship," (AICPA, 2017). Specific industries that are anticipated to benefit the most from adoption of the blockchain are financial services, consumer products, healthcare, government, and energy. Each of these industries depend on some element of registration, data keeping, and transactions involving assets that can be represented digitally.

Also supporting the usefulness of the blockchain are Smart Contracts[1]. These can be added to the code of transactions in the blockchain to trigger responses under certain circumstances (Watanabe et al., 2017). They extend the security of the technology by providing an additional layer of protection for parties involved in a transaction. Logical rules would then be applied as dictated by contract terms to determine which party has ultimately benefited and would make a payment to them from the other party. Prospective benefits to the business environment are increased efficiency through the elimination of a third-party intermediary (Gomaa, 2018). This facilitates the agreement, automating the calculations, and automating the settlement of amounts owed to either party (Coyne & McMickle, 2017).

Businesses that adopt blockchain technology will have a reliable source of evidence that transactions verifiable through the blockchain have occurred. Since 2008, Bitcoin Blockchain is the only public, open source data source that is not tampered with to date. Anyone can download the blockchain and view it, but not one could alter it, making it a reliable source of information. This may reduce the need for a financial statement audit due to the Read Only (RO) property of the

[1] A smart contract is a computer protocol intended to digitally facilitate, verify, or enforce the negotiation or performance of a contract. Smart contracts allow the performance of credible transactions without third parties. These transactions are trackable and irreversible. The paper does not focus on Smart Contracts, instead, it focuses on a the sequence and workflow of transaction recording on the blockchain.

blockchain technology by reducing the Audit risk (JETA). However, regulators will need to play a role in the shaping of the blockchain environment. Regulations can impact the number of responsibilities that blockchain providers, users, and auditors must comply with (Kokina et al. 2017). Currently, it is still too early to determine how this will unfold. While the use of the blockchain technology as an environment for digital currency is fairly well established, the use of blockchain as a platform for business and accounting is still in its infancy. Whereas benefits of the use of the blockchain technology are discussed in this study, there is certainly more to come as organizations begin to actually use the technology.

Accounting and Blockchain Potentials and Challenges

Accounting media have already evolved many times to adapt to available technology and to economic life. In the current digital age, these ledgers take the form of databases with similar fundamental characteristics. The Blockchain is also a database, with its own properties, including for example the quality of the transactions, and could constitute the next generalized evolution of accounting supports (Coyne & McMickle, 2017); (Degos, 2017).

The main difference between the traditional databases which currently support accounting and the Blockchain is ability to trust the execution of transactions between parties, without the need of an intermediary (Bank) to act as a centralized system. In addition, Blockchain allows the possibility of defining degrees of transparency, via the use of cryptography, which allows having a ledger either public or private depending on the user configurations (Leloup, 2017). These features allow the Blockchain to assert itself as a particularly relevant medium for keeping a Journal and a General Ledger shared at an intra-organizational level, as well as with carefully selected external third parties (shareholders or external auditors) and intra-organizational entities

may have access to the information related to their roles given the blockchain defined constraints (Rückeshäuser, 2017).

III. Proposed Framework

Reconciliation Requirement

In accounting, reconciliation is essential for the financial health of a company, as it helps to detect errors, discrepancies, or fraud. It is the process of ensuring that the sets of economic exchanges are in agreement across the relevant involved parties. It consists of two steps: (1) compare account balances between different sources, (2) and then pinpoints any discrepancies so they can be investigated by accounting staff. But in practice, the process is complex due to the number of parties involved. Capturing data through the REA model, means we do not need journal entries, reducing the requirement for reconciliation itself. In addition, with blockchain, reconciliation will no longer be a requirement.

Let's go over the REA pattern. The first step is to identify the exchange: what is being given and what is being received. These are two separate events that are linked together to bring value and may occur in several ways. Then for every Event, we recognize the Resources, being increased and decreased and the Agents, or parties involved in the exchange. At all times there is at least one internal Agent, responsible for the transaction and, one external Agent, parties with whom the exchange is made.

That said, if the record is accessible by all involved parties, then those parties have a single truth. In reality, the participating Agents are not able to see a full set of the record, thus making it very difficult to reach a consensus between transacting parties. In this case, reconciliation becomes a challenge when intermediaries in the supply chain hold part of the information. This is a classical problem that a number of business models are facing, and the current accounting systems fail to

solve. In the next section, we will give a detailed example of such a complex, unsolved accounting problem.

Accounting Reconciliation in an Online Environment

In today's world, reconciliation identified a number of inconsistencies in business models, due to the simple fact that each entity is maintaining its own accounting ledger or just because the information is not available from other parties involved in the transaction. Online advertising is a good example for big data analytics usage in accounting reconciliation. Online advertisers are responsible of identifying millions of websites that are relevant to their segmented markets.

The lack of standardization across websites, leads to several opportunities to track and record each advertisement's views and the click-through-rate (CTR), at different levels. CTR, measures the average number of clicks advertisers receive on their ads. As of today, accounting for online advertising transaction are a function of tracked events proving an ad's impact on traffic to the website such as: a customer click, a web search list, or a view of banner ad. Tracking millions of data points every second, with a lack of a common standard, can result in large number of inconsistencies in the accounting figures. The discrepancy increases as malicious software inflates the numbers of clicks and views. The IAB[2] standard agrees that a 10% discrepancy is acceptable. Therefore, an advertiser may claim that 90 ads were received. On the other hand, an ad agency claims that 100 ads were delivered. Both, the advertiser claim and the ad agency claim, are considered within acceptable error margins. These two claims can converge into only one truth if all the participating parties connect: the advertiser, the ad agency and the ad viewer who can confirm that the viewed ad from the ad agency led him/her to the advertiser website. That would

[2] The Interactive Advertising Bureau (**IAB**) is an advertising business organization that develops industry **standards**, conducts research, and provides legal support for the online advertising industry.

be possible within the blockchain technology. In this case, we introduce the customer to be a part of the transaction, with the advertiser and the ad agency. The three parties (agents) interact on the blockchain by exchanging tokens to view and deliver ads. Therefore, the one truth will reveal itself in the blockchain.

Fraud is one of the primary threats to the effectiveness of online advertising. According to the Interactive Advertising Bureau (IAB, 2015), ad fraud alone costs the industry almost $8.2 billion a year to advertisers in the US. Online ad fraud is a complex and unsolved problem. Ten percent (10%) of discrepancy in reported viewed advertisements have been the de-facto standard for the online advertising industry. A good example would be running a campaign on Facebook, and comparing the results generated by Facebook insights, and Google analytics, where both are applications used to track the number of online views. The results will provide a difference in the number of views, due to the difference in how a view is defined. The research community attempted several solutions for this problem, with limited success. In addition to the divergence between different reputable tracking systems, the challenge is augmented by having so many intermediaries between the involved parties. Endless work hours are spent going back and forth, attempting to resolve these issues and leading frequently to dissatisfaction. This creates an accounting challenge to accurately reconcile advertising expenses with the accounting records.

To eliminate the reconciliation requirement, we need new business models, where all involved agents in the transaction are reflected in the ledger, ensuring privacy and security (Figure 1). Using blockchain technology, multiple agents may be involved in the same transaction without the need of an intermediary. This allows a circular relationship, rather than the current linear relationships that enforces intermediaries. For instance, in real-world, an intermediary is

usually needed to connect two parties, which ends up creating a supply chain of a product or service. With blockchain technology, the entire supply chain may interact without the need of connectors or intermediaries. Blockchain uses automated workflows. One of the most interesting features of the blockchain is creating and managing smart contracts, used to establish, manage and deliver on agreements between involved parties in a trade. Consequently, the reconciliation will not be needed any more, as all the parties involved in the transaction are using the same blockchain resulting in a single-ledger model.

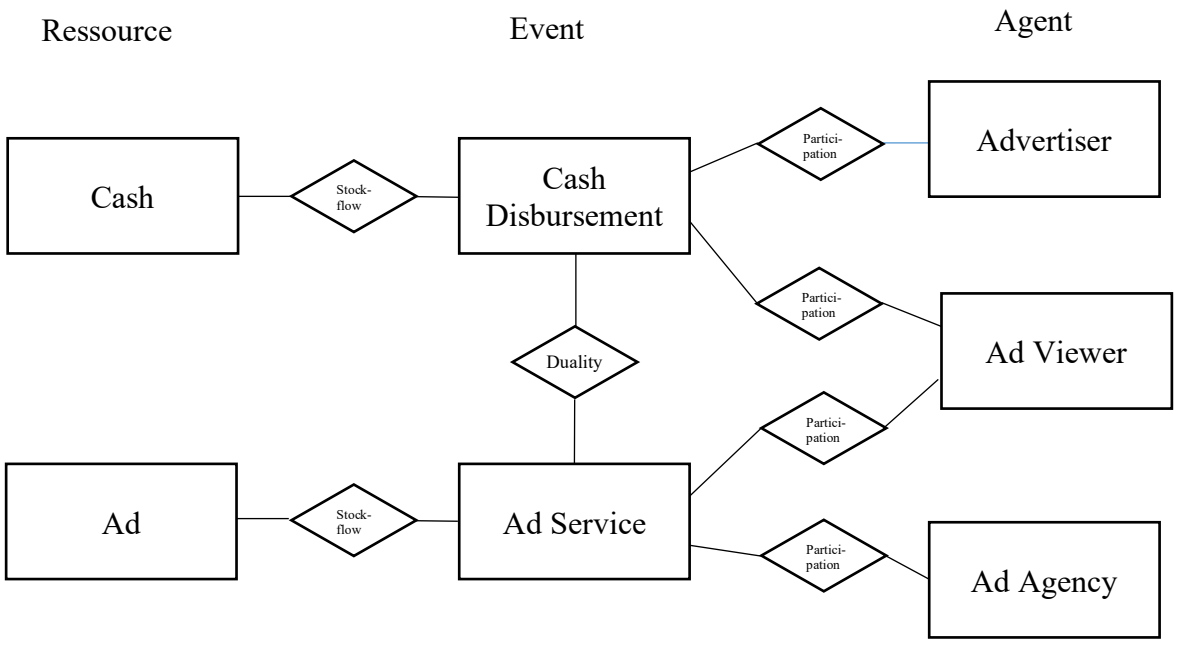

Figure 1. REA Representation of Online Advertising

Blockchain is a single point of truth generated using a distributed ledger technology. The challenge will be to identify all stakeholders to be on the blockchain to ensure that we have this single point of truth. When a transaction takes place on the Blockchain, it becomes the one and only ledger, and the only source of truth. All other internal ledgers are a simple view of the original

ledger, and not another separate transaction. We note that Blockchain cannot be considered a multiple Ledger system. It is a single, distributed ledger.

The Concept of One Truth

McCarthy, and Gal (2018) presented a mechanism to implement complex accounting transactions, as smart contracts, using REA ontology. This allows an implementation that fits complex transactions within an ERP system. This paper is in favor of having an ERP system that follows an REA ontology, as it promotes interoperability between ERP systems using semantic web capabilities. This helps having a single source of truth for all transactions. In fact, keeping information silos can be very penalizing for enterprises. It is very difficult to reconcile with confidence different sources, with probably different data formats.

Regardless of the implementation mechanism of the smart contract, the industry should assure having one record. When developing systems, there should be one source of information, instead of having information silos as a part of the design.

Dai and Vasarhelyi (2017) proposed a blockchain-based triple-entry accounting systems that would record the information regarding the transactions between business parties in addition to the information about the data flows within the organization. In their system, each transaction would result in entries being recorded in a traditional double-entry system as well as a record stored in the blockchain ledger. In order to represent the data flows within the organization, Dai and Vasarhelyi (2017) proposed using tokens for recording and tracking purposes. They are used to record transfers between accounts, and as certificates to attest for obligations or ownership of assets among transacting parties. Following this approach, Gomaa et al. (2019) suggested that when a company provides services to a customer on credit, it will record the services rendered and the Accounts Receivable in its ERP system. In addition, the company will record this event to the

blockchain ledger in the form of a transfer of an accounting digital token between two blockchain accounts (Figure 2). When payment is received for rendered services, the company will record this event in the blockchain ledger in the form of a transfer of an accounting digital token between two blockchain accounts in addition to recording the Cash and the Accounts Receivable in its ERP system. This can be viewed from the Ad Agency perspective (Figure 2).

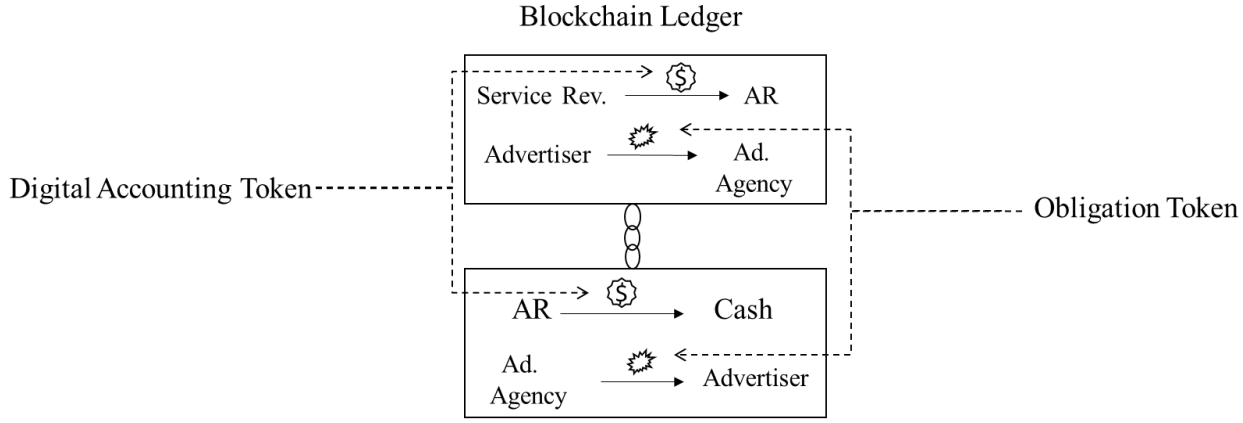

Figure 2: Blockchain Ledger[3]
Ad Agency view

From the advertiser perspective, when ads are delivered, the advertiser will record the services received and the Accounts Payable in the ERP system. In addition, the company will record this event to the blockchain ledger in the form of a transfer of an accounting digital token between two blockchain accounts (Figure 3). When payment is made for rendered services, the company will record this event in the blockchain ledger in the form of a transfer of an accounting digital token between two blockchain accounts in addition to recording the Cash and the Accounts Payable in the ERP system.

[3] Adapted from Gomaa, et al. 2019.

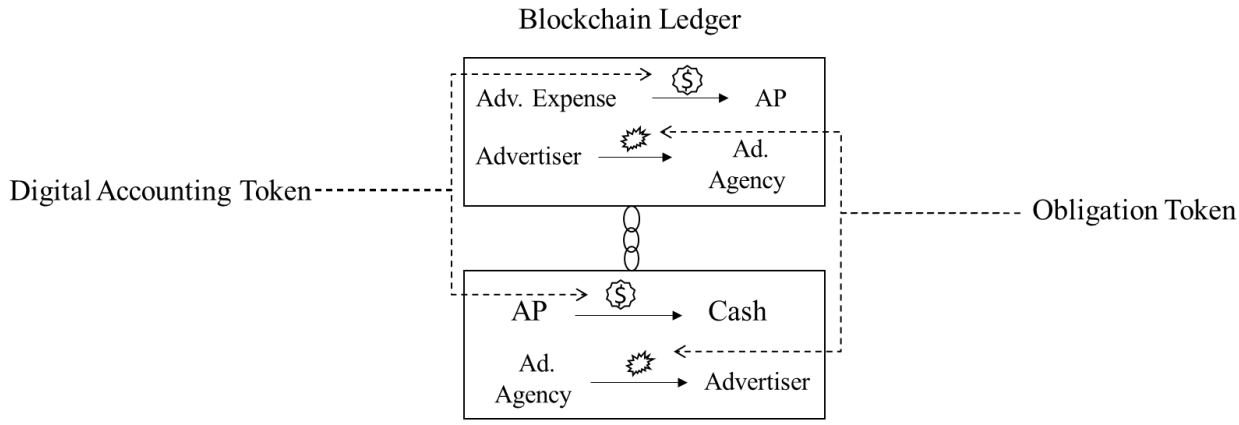

Figure 3: Blockchain Ledger[2]
Advertiser view

Blockchain Solution

As we saw in our example, there are three parties involved in the accounting reconciliation transaction, in an online environment: the advertiser, the publisher (website displaying the online ad) and the ad viewer. By adding the ad viewer to the transaction, a three-party transaction is created. Advertisers buy ad space from publishers, who help them communicate their message to the viewers. Specifically, the advertiser sends the advertisement to the publisher. The publisher displays the advertisement on the website, and the viewer confirms that he/she has viewed the advertisement. The advertisers spend money to display their advertisement. The publisher receives money to display advertiser's message, making it available to the viewer.

As a result of blockchain technology, an exchange between all participants of the advertising value circle is possible. A new viewer can be seen as a virtual identity, for which the advertisers need to know how much they can pay for. All those steps are then recorded in the blockchain. Advertisers buy ad space from publisher. Having access to the open public ledger, advertisers can get statistics reports on publishers to analyze their performance, before choosing a publisher. They can have access to a list of publishers, sorted out by the revenue from all actions performed (CTR, cost, etc.) by ad space. Therefore, they can evaluate publishers' work quality and select the appropriate publisher who will bring the best return on their investment. The blockchain

technology eliminates any confusion and uncertainty about the viewers and all actions performed on the publishers' website. Then the payout is clearly defined, and the publishers will receive the right amount of money for each time their traffic converts. In other words, get any visitors landing to the advertiser's ad page lead to conversion rate optimization (CRO). CRO is the process of turning more users that visit publishers' website into desired actions. Once a transaction is validated through a validation process, it will then be committed to all ledgers across a large network. This is the core of blockchain transparency that will establish the trust relationship between all parties.

Multiple Parties Involved in a Transaction

Blockchain provides an open ledger solution to address the advertising reconciliation dilemma. Once validated, the transaction is recorded in the blockchain. Then, there would no longer be any confusion or debate concerning the transaction and the reconciliation dilemma. In its simplest form, online advertising blockchain, is a white list of legitimate publishers, advertisers and ad viewers. In order to enforce this transaction, online advertising blockchain utilizes smart contracts. The smart contract ensures that a token is transferred from the advertiser to both the viewer and the publisher every time a viewer sees an ad. If an ad is not viewed, no token transfer takes place. The outcome is recorded and provable, consequently any potential debate over reconciliation disappears.

As noted above, Advertisers, Publishers and Viewers are all involved in the same transaction to account for an advertisement view. The transaction workflow is recorded in the blockchain. The workflow details and its associated transactions will be fully accessible by transacting parties, who agreed on rules for secure data entry and sharing. Blockchain provides an immutable record of transactions, enhancing trust among all involved parties

Due to its distributed nature and the cryptographic key security used in blockchain technology, data integrity is preserved. Moreover, blockchain-based identity and access management prevents unauthorized access. For instance, the blockchain in the case of advertising reconciliation may be used to validate the views, while having the financial dimension not recorded on an accessible blockchain.

To promote the concept of one truth, a new framework is presented using blockchain technology resulting in a single-ledger model. asaBlockchain should be promoted as a single point of truth, generated using a distributed consensus mechanism.

Figure 4 summarizes the main structure of the framework. In the framework, a smart contact is created for every workflow resulting in a record stored in the blockchain ledger. Related parties do not need to separately replicate transaction details in their ERP systems. Since transaction details are recorded on the blockchain ledger, this ledger will be a single point of truth that can be viewed directly without the need for a separate entry in the ERP system. Related parties may download transaction details into their ERP systems as needed for internal or external reporting needs. Une other studies on blockchain integration with ERP which recommend that blockchain is populated from the ERP, our research suggests that ERP systems are populated from the Blockchain.

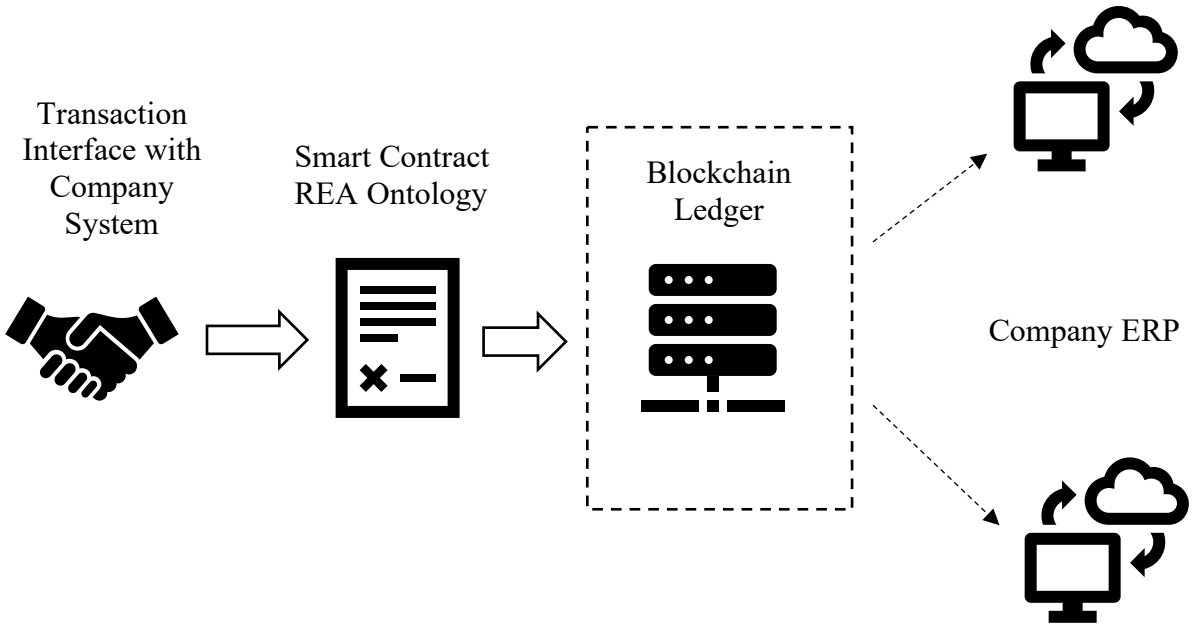

Figure 4: Single-Ledger Accounting Information System

It is important to emphasize that no multiple entries exist on a certain blockchain. There is just one entry point. All related parties have a view of the blockchain through their digital wallet interface.

IV. Conclusion and Future Research

Blockchain technology has gained increased attention in the accounting profession over the past few years. This technology has evolved beyond its original uses as a methodology to record cryptocurrency transactions to support various business applications. It has the potential to transform the current paradigm through improved collaboration between businesses and individuals, improved transparency of transactions and data, protecting the integrity of the data, and instant sharing of necessary information.

The paper addresses the reconciliation problem. It defines the requirements to have an accounting system without reconciliation challenges were all involved parties in the transaction must be reflected on the blockchain to ensure a reconciliation process free of challenges. The paper

then builds on the works of McCarthy and Gal (2018), and Dai and Vasarhelyi (2017). In their study, McCarthy and Gal (2018) present an REA ontology approach to implementing complex accounting transactions as smart contracts allowing for the proper implementation of complex transactions within an ERP system. Dai and Vasarhelyi (2017) propose a blockchain-based triple-entry accounting system. Following their approach, each transaction would result in a transaction being recorded in three places. This would include entries being recorded in a traditional double-entry system as well as a record stored in the blockchain ledger.

The current study proposes a new framework using Blockchain technology resulting in a single-ledger model. In the proposed system, a smart contact is created for every workflow resulting in a set of records stored in the blockchain ledger, where all parties involved in the transaction are reflected in the workflow and the blockchain. Separate entries that replicate transaction details in the ERP systems of related parties are not needed. Since transaction details are recorded on the blockchain ledger, this ledger will be a single point of truth that can be viewed directly without the need for a separate entry in the ERP system. If needed, related parties may download transaction details into their ERP systems for internal or external reporting needs.

The study shows that blockchain technology will have an enduring impact on the accounting profession. It identifies the requirements to prevent reconciliation challenges by reflecting all transacting parties on the blockchain. It then proposes a new conceptual framework to implement and apply blockchain technology in the accounting profession that is based on a single-ledger prior to populating the transacting ERP systems. This framework creates one truth for all parties involved in a transaction. The paper does not address implementation issues. Future research can investigate the technical implementation issues related to the model as well a security

models required to prevent reverse engineering the accessible transactions on the blockchain in an attempt to gain insights about different businesses.

REFERENCES

American Institution of Certified Public Accountants (AICPA). 2017. Blockchain Technology and Its Potential Impact on the Audit and Assurance Profession. Available at: https://www.aicpa.org/content/dam/aicpa/interestareas/frc/assuranceadvisoryservices/downloadabledocuments/blockchain-technology-and-its-potential-impact-on-the-audit-and-assurance-profession.pdf

Apostolou, B., J. Dorminey, J. Hassell, and J. Rebele. 2016. Accounting education literature review (2015). *Journal of Accounting Education* 35: 20-55. doi: 10.1016/j.jaccedu.2016.03.002

Boyle, D., Boyle, J., & Mahoney, D. 2018. Behavioral Assessment and Modification in Fraud Mitigation Efforts. Management Accounting Quarterly.

Coyne, J. and P. McMickle. 2017. Can Blockchains serve an accounting purpose? *Journal of Emerging Technologies in Accounting* 14 (2): 101-111. doi: 10.2308/jeta-51910

Dai, J. and M. Vasarhelyi. 2017. Toward blockchain-based accounting and assurance. *Journal of Information Systems* 31 (3): 5-21. doi: 10.2308/isys-51804

Degos, J. 2017. Chained blocks and the future reliability of accounting missions. Blockchain file.

Delahaye, J. 2015. Blockchains, the key to a new world. Pour la Sciences, 39(449).

Desplebin, O., Lux, G., & Petit, N. 2019. Comprendre la blockchain : quels impacts pour la comptabilité et ses métiers ? ACCRA, 5(2).

Gomaa, A., Gomaa, M., and Stampone. A. 2019. A transaction on the blockchain: An AIS perspective, intro case to explain transactions on the ERP and the role of the internal and external auditor. *Journal of Emergng Technologies in Accounting*. Forthcoming.

Gomaa, A. 2018. The Creation of a Cryptocurrency to Support Disintermediation. Operations Management Education Review Journal 12:63-100.

Kokina, J., R. Mancha, and D. Pachamanova. 2017. Blockchain: Emergent industry adoption and implications for accounting. *Journal of Emerging Technologies in Accounting* 14 (2): 91-100. doi: 10.2308/jeta-51911

Kuter, M., M. Gurskaya, A. Andreenkova, and R. Bagdasaryan. 2017. The early practices of financial statements formation in medieval Italy. *Accounting Historians Journal* 44 (2): 17–25. doi: 10.2308/aahj-10543

Leloup, L. (2017). Blockchain, the revolution of trust. Eyrolles.

McCarthy, William E. 1982. The REA accounting model: A generalized framework for accounting systems in a shared data environment. *Accounting Review* 554-578.

Pacioli, L. 1514. *Paciolo on Accounting (Summa de Arithmetica, Geometria, Proportioni e Proportionalita: Distintio Nona—Tractatus XI, Particularis de Computis et Scripturis*: McGraw-Hill.

PricewaterhouseCoopers (PwC). 2015. *Money Is No Object: Understanding the Evolving Cryptocurrency Market*. Available at: https://www.pwc.com/us/en/financial-services/publications/assets/pwc-cryptocurrency-evolution.pdf

Rückeshäuser, N. 2017. Do We Really Want Blockchain-Based Accounting? Decentralized Consensus as Enabler of Management Override of Internal Controls. Proceedings der 13. Internationalen Tagung Wirtschaftsinformatik (WI 2017) (pp. 16-30). St. Gallen: Leimeister, JM; Brenner, W. (Hrsg.).

Sangster, A. 2018. Pacioli's lens: God, humanism, euclid, and the rehtoric of double entry. *The Accounting Review* 93 (2): 299–314. doi: 10.2308/accr-51850

Sangster, A., and G. Scataglinibelghitar. 2010. Luca Pacioli: The father of accounting education. *Accounting Education: An International Journal* 19 (4): 423–438. doi: 10.1080/09639284.2010.501955

Watanabe, H., S. Fujimura, A. Nakadaira, Y. Miyazaki, A. Akutsu, and J. Kishigami. 2015. Blockchain contract: A complete consensus using blockchain. *Proceedings of the Consumer Electronics (GCCE)*, 2015 IEEE 4th Global Conference, 577–578. doi: 10.1109/GCCE.2015.7398721