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

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Abstract

Reconciliation of transactions between multiple parties is a time-consuming process. This paper presents a new conceptual framework that may lower costs and shorten the reconciliation time. The proposed framework recommends recording transactions on the blockchain prior to populating the transacting parties' respective ERP systems, which will be the source of a single truth. This information flow will result in all involved parties having access to the same transaction details. Further, the paper presents a technical feasibility demonstration with two examples, where all involved parties are executing transaction details on the blockchain after meeting the governing smart contract constraints using their digital wallets. The new conceptual framework has been specifically designed to create one truth for all parties involved in a transaction that in turn may eliminate what is perceived to be unnecessary redundancy in current accounting systems.

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. Blockchain technology is transforming existing business models and facilitating the emergence of new ones, which will have an enduring impact on the accounting profession (Zhang et al. 2018).

Reconciliation between trading parties is an expensive and time-consuming process. With the introduction of blockchain, reconciliation costs may be reduced, and time will be shortened due to its digital nature (Maslova 2018; ABI 2019; Ribeiro et al. 2020; AICPA 2017). This leads 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, Gal and McCarthy (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 goods, services, or cash and events as transactions that affect resources. It also considers agents as entities generating the events. When a transaction is recorded, the REA framework within an Enterprise Resource Planning (ERP) system is used instead of the traditional double-entry accounting system. The advantage of using the REA framework to model accounting transactions is the model abstracting capabilities that create a conceptual framework. Gal and McCarthy (2018) propose using the REA framework to properly implement 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 locations. 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. This leads to a common view of the same transaction on the blockchain for both transacting parties using accounting and obligation tokens assuming there is no reconciliation need. They use 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, hence the naming of Triple Entry Accounting within their paper.

This study builds on the works of Gal and McCarthy (2018) and Dai and Vasarhelyi (2017). It contributes to the literature in several ways. First, it identifies the requirements to have a transaction recorded between all involved parties in the same transaction, thus eliminating information silos. This is done by changing the information flow to prevent a reconciliation challenge. Second, it proposes recording the transaction on the blockchain prior to populating the transacting parties' respective ERP systems. This generates a single-ledger view, where only one token related to one transaction is needed on the blockchain. Third, the study presents a technical feasibility demonstration. We showcase our framework by implementing two scenarios that generate blockchain transactions after meeting their respective smart contract constraints and have the details of the transactions available to update the transacting parties' respective ERP systems. Essentially, 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.

The paper proceeds as follows. The next section presents the literature review, including the history of double-entry bookkeeping and blockchain technology, its potential use to address the reconciliation problem, and its current potential and challenges. The third section provides the proposed framework that includes the reconciliation requirement and the need to change the information flow, followed by the concept of the single truth, and explains the new conceptual single-ledger accounting framework. The fourth section provides two separate examples. The first example uses a customer, supplier, and bank to reconcile a product shipment transaction. The second example uses an advertiser, an ad agency (website displaying the online ad), and an ad viewer to reconcile an ad view transaction. 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 centuries. Luca Pacioli published a book on double-entry accounting 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 businesses 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 et al. 2017). The current regulatory approach to fraud mitigation is insufficient, and a broader solution is necessary (Boyle et al. 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

Blockchain is a new technology that may impact the accounting profession. Delahaye (2015) describes it as "*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.*" Blockchain 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, obligations, or ownership (AICPA 2017). An entry results from one party sending value to another. To do this, there are five steps that need to take effect. During the first step, one party registers a request for another party to post on a blockchain ledger (e.g., financial transaction, accounting entry, contract, delivery, transfer of ownership, etc.). A digital wallet (software) for this registration will transmit the request to a network of computers (nodes). The entry 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 (step 3). It is a cryptographic protocol that allows for the validation of block information via network nodes. Some blockchains are publicly available, similar to the Bitcoin or Ethereum Blockchain, where anyone can join or leave as they please. On the other hand, private blockchains maintain anonymity, where only involved parties can see the data on the blockchain (Nakamoto 2008).

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 from those who have more stake in the validated transaction. Every blockchain protocol follows a certain truth. The users who carry out this validation are called "miners." 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 (Nakamoto 2008). 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 members of the network who hold the same copy of the information recorded within the blockchain (step 5) (Desplebin et al. 2019).

Blockchain has now been acknowledged in the accounting industry due to its flexibility and enhanced security. As a decentralized-shared-ledger technology, it has the ability to promote transparency and facilitate reconciliation within multiple parties involved while reducing inconsistencies and the number of reconciliations needed (Maslova 2018). Blockchain offers a sound approach, especially when the reconciliation process involves many disparate ERP systems that lack standardization. It can facilitate the process by reducing the time, effort, and costs associated with the reconciliation process. Maslova (2018) states that Ernst & Young Global Limited (EY) estimates the reconciliation process costs between 50 and 100 working days per month for a typical finance team at banks and insurance companies due to the complexity of the transactions, the multiple different platforms, and the required manual checkpoints. On the other hand, stock trades can be securely and efficiently settled within two business days when using blockchain. The Italian Banking Association asserts that the blockchain-based approach emerges as an obvious solution for interbank reconciliations (ABI 2019). After a successful technical test on 200 million transactions simulating the production phase for 200 Italian banks, a blockchain-based solution has made the interbank reconciliation process faster, more effective, and more transparent. Banks can benefit from real-time management of the reconciliation process, rather than monthly reconciliations, with enhanced visibility of the transactions and more effective communication between involved counterparties (ABI 2019). Since the blockchain consists of an unbreakable chain of numerous blocks where data, decisions, and all needed information about the transactions are recorded, it enables flexible tracking, comprehensive traceability, and a truthful and immutable log history (Ribeiro et al. 2020). 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 the adoption of the blockchain are financial services, consumer products, healthcare, government, and energy. Each of these industries depends on some element of registration, data keeping, and transactions involving assets that can be represented digitally (Gomaa and Li 2020).

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. 2015). 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

[1] Smart contracts are open source, distributed, transparent agreements, that can be verified using a consensus algorithm to ensure accuracy and prompt payment. In other words, a smart contract is intended to digitally facilitate and 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.

facilitates the agreement, automating the calculations, and automating the settlement of amounts owed to either party (Coyne and McMickle 2017).

Businesses that adopt blockchain technology will have a reliable source of evidence that transactions verifiable through the blockchain have occurred (Lo et al. 2020). Since 2008, Bitcoin Blockchain is the only public open-source data source that has not been tampered with to date. Anyone can download the blockchain and view it, but no one could alter it, making it a reliable source of information. This may reduce the need for a reconciliation audit (for example, Accounts Receivable reconciliation, Accounts Payable reconciliation, etc.) due to the Read-Only (RO) property of the blockchain technology by reducing the Audit risk (Gomaa et al. 2019). However, regulators will need to play a role in shaping 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 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 blockchain technology are discussed in this study, there is certainly more to come as organizations begin to actually use the technology.

Accounting and Blockchain Potential and Challenges

Accounting media have evolved many times to adapt to available technology and 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 the quality of the transactions, and could constitute the next generalized evolution of accounting supports (Coyne and McMickle 2017; Degos 2017). As a relatively new technology, blockchain faces some inherent challenges. These include a lack of expertise in the marketplace to implement it on a large scale, a challenge to process a large number of transactions in a short period of time on the blockchain, and blockchain's current model that requires a large amount of energy to execute. Ibanez et al. (2021) state that "the challenge for many use cases is to jump from proof-of-concept to production while achieving scalability, user-friendliness, cost-effectiveness, security, trustlessness, as well as adjusting the system privacy and rigidity to business needs, without sacrificing throughput and latency."

The main difference between traditional databases, which currently support accounting systems, and the blockchain is the ability to trust the execution of transactions between parties. 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, and (2) pinpoint any discrepancies so they can be investigated by accounting staff. However, the process is complex in practice due to the number of parties involved.

A transaction does not need to be reconciled if it results from an **approved**, **validated** process and is **accessible** by all involved parties. If a transaction does not need to be reconciled, it means that all involved parties share the same views; thus, they agree on a single truth. Therefore, the reconciliation requirement is met when all involved parties agree on a single truth,

REA Model and Reconciliation

Capturing data through the REA model means we do not need journal entries, reducing the requirement for reconciliation itself. In addition, reconciliation will no longer be a requirement due to its automation and integration with the blockchain. Figure 1 represents the standard REA pattern. The first step in this figure is to identify the exchange events: 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 with whom the exchange is made. A stockflow (S) in an REA represents either an inflow or an outflow of a resource. Between events, a “duality” reflects the concept of having a “give” event and a “get” event. Organizations must give up one resource in exchange for another resource. For example, an organization may give up inventory during a sales event in exchange for cash. The participation (P) in an REA reflects the two parties (Agents) participating in an event.

Insert Figure 1 Here

In this REA representation, participating Agents are not able to see the full set of records, thus making it very difficult to reach a consensus between all involved parties. Reconciliation becomes a challenge when some of the involved parties hold part of the information. This is a classical problem that a number of business models are facing. In this study, the proposed conceptual framework presents a solution by first implementing a reconciliation requirement that allows all involved parties to participate in a single transaction. The following section will provide further insights.

Change of Information Flow to Achieve Reconciliation

In today's world, reconciliation is needed in several business models, due to the 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. To address the reconciliation challenges, before considering technical solutions, we need to reimagine existing business models, where all involved parties in the transaction are reflected in the ledger while ensuring privacy and security.

This paper argues that the solution to reconciliation challenges is that if all parties involved in a certain transaction are notified of the status of this transaction in a transparent environment, each party will be able to use the same information to populate its current ERP system. Such a solution removes the need to reconcile since the source of information for all involved parties is the same. To achieve this, we need to change the transaction recording information flow. This premise is the first contribution of the paper, where all parties involved in the same transaction must be willing to collaborate to address their existing reconciliation challenges to have an approved and validated process for all parties involved. All existing models, traditional and new, are still following the linear relationship paradigm, where each transacting party acts as a part of the exchange transaction. Figure 2 depicts the current and newly proposed information flow in the business model.

Consider a current model where a shipping company is sending a product from a supplier to a customer. The shipping company controls the customer receipt. The shipping company then communicates the receipt information with the supplier and the supplier bank. In a newly proposed information flow, when the shipping event takes place, all involved parties are notified. For example, the customer, supplier, and the bank are all being notified when the product exchanges hands, regardless of where the product is located in the exchange transaction. This switches the information flow direction from a linear relationship to a centric relationship, where the product that connects all parties is at the center of information. When any party interacts with the product, this interaction will be available for all other parties involved. Figures 2a and 2b depict the current and newly proposed information flow in the business model. In Section IV, we will discuss this example in more detail.

Insert Figure 2 Here

Similarly, in an advertisement example, in a typical scenario, the advertiser will pay an ad agency to place an advertisement on a website for the customer to view. Reconciliation is needed to address the discrepancy that will take place between the number of views counted by the adviser and the number of views counted by the ad agency. If the advertisement is at the center of the information flow, where all interacting parties share the same information of the advertisement location, there will be no need for reconciliation since the information source is consistent across all involved parties as shown in Figures 3a and 3b.

Insert Figure 3 Here

The Concept of One Truth and Blockchain

Ibanez et al. (2021) suggest that supply chains and logistics sectors will be the leaders in adopting a reconciliation solution using blockchain technology. The main advantage of using blockchain in the reconciliation case is its transparency and trust in transferring information/content between parties. Using blockchain technology, multiple parties may be involved in the same transaction. This allows for a centric relationship rather than the current linear relationship. Blockchain allows all involved parties to approve and validate the process and have access to all related transactions, which is the requirement for a reconciliation solution. To have an approved process, the transacting parties need to agree on a set of smart contract constraints that governs their financial relationship. The smart contract is readable by all involved parties. When a transaction takes place, the blockchain infrastructure executes a validation process. The transaction is then saved on the blockchain and is accessible by all involved parties to use as a single point of truth. 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 no longer be needed, as all the parties involved in the transaction are using the same blockchain resulting in what we call a single-ledger model.

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.

Keeping information silos can be very penalizing for enterprises. It is very difficult to reconcile, with confidence, different sources with different data formats. Regardless of the implementation mechanism of the smart contract, the industry should ensure having one record. Gal and McCarthy (2018) presented a mechanism to implement complex accounting transactions, like smart contracts, using REA ontology. This allows an implementation that fits complex transactions within an ERP system. They are 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 with having a single source of truth for all transactions. 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 system 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. 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 4). 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.

Insert Figure 4 Here

To promote the concept of one truth, a new framework is presented using blockchain technology resulting in a single-ledger model, where all parties involved in the transaction are connected to prevent information silos between involved parties. Figure 5 summarizes the main structure of the framework. In the framework, the initial premise is to have all involved parties become a part of the transaction preventing information silos and discrepancies. A smart contract is created for every workflow between distinct parties. The smart contract generates a record stored in the blockchain ledger. Involved 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. Involved parties may download transaction details into their ERP systems as needed for internal or external reporting needs. Unlike other studies on blockchain integration with ERP, which recommend that the blockchain be populated from the ERP, this study suggests that ERP systems are populated from the blockchain.

Insert Figure 5 Here

It is important to emphasize that no multiple entries exist on a certain blockchain. There is just one entry point. All involved parties have a view of the blockchain through their digital wallet interface. The proposed framework is feasible and can be implemented.

IV. BLOCKCHAIN RECONCILIATION EXAMPLES

We use two examples to present the reconciliation problem. First, accounts receivable and accounts payable reconciliation between a customer, a supplier, and a bank. Second, online advertising reconciliation between an advertiser, an ad agency, and an ad viewer.

Accounts Receivable/Payable Reconciliation Example

For accrual transactions, following accounting standards requires keeping track of payments received or paid and allocating them in either of receivables, payables, revenue, or expense. Tracking receivables and payables among participating parties is an extremely time-consuming process that is subject to errors or fraud. When all involved business parties have access to the same transaction, this leads to smoother transaction processing that is based on one truth with no information silos. Smart contracts will enable real-time reconciliation of accounts receivable and accounts payable for the supplier, customer, and bank at each stage of an agreement.

This may eliminate the need for accountants to audit individual transactions at different information silos, but rather observe them. The process then becomes smoothly managed from ordering to payment via access to a blockchain that is updated in real-time between parties. Efficiencies are achieved due to the reduced need for manual reconciliation as well as the elimination of disagreement claims as information is stored in a single blockchain ledger (Seiffert-Murphy 2018). Figure 6 is an REA representation of an accounts receivable/payable reconciliation example in an online environment.

Insert Figure 6 Here

For clarification purposes, one may consider the creation of a smart contract defining a workflow between all involved transacting parties (customer, supplier, and bank). To establish a new supplier in an ERP system, certain rules need to be followed. Similarly, to add a new supplier to the blockchain framework, certain rules need to be followed. In Figure 7, pseudo-code in Solidity programming language for smart contracts presents a simple addition of a new supplier.

Insert Figure 7 Here

To create a transaction on the blockchain, first, each party needs to have a digital wallet. In our case, all three parties, the customer, supplier, and bank have digital wallets that can interact with the smart contract via a cryptocurrency coin, also called a Token. For demonstration purposes, we created a Truth Coin on the blockchain to be used in transactions between the involved parties.

Figure 8 shows the digital wallet addresses and QR codes for the customer, supplier, and bank from their digital wallet interfaces. The same information is recorded and can be viewed, on the blockchain portal (Etherscan).

Insert Figure 8 Here

Figure 9 shows the notification from the bank to both the supplier and the customer that a shipping bill of lading is received by the shipping company using the Truth Coin. Events among parties trigger the execution of smart contracts. For instance, when a supplier's shipping company sends a copy of its bill of lading to the bank, the bank notifies both the supplier and the customer by issuing a transaction as shown in Figure 9. This triggers the smart contract governing the relationship between the supplier and the customer to release payment to the supplier after meeting the required time delay. The event creates a transaction with textual details including shipping date, reference number, supplier and customer ID, and a payment request, where those details will be saved on the blockchain (Lee 2019). The final output is considered a single source of truth. Both customer and supplier ERP systems will retrieve this textual information and process it accordingly to populate their respective ERP systems from a single point of truth, removing the need for reconciliation. Since all parties are involved in the same transaction, information processing errors are removed.

Insert Figure 9 Here

Figure 10 presents pseudo-code for a sample function in the smart contract to allow the customer to release the balance to the supplier 60 days after the shipping date. The respective ERPs will read the blockchain transaction and update the appropriate records on the customer ERP system to reflect the accounts payable and cash changes with the bank involved. At the same time, the supplier ERP system will update the appropriate records to reflect the changes in accounts receivable and cash with the bank involved. Since ERP systems are populated from the same blockchain transaction, the need for reconciliation due to inconsistent information, or unnotified parties disappear.

Insert Figure 10 Here

This demonstration shows the potential technical feasibility of our proposed framework. The fundamental distinction between this work and prior research, in addition to having a technical feasibility demonstration, is the change in the information flow between involved parties. Specifically, transactions are first recorded on the blockchain and then on all involved parties' respective ERP systems. This generates a single-ledger view where only one token related to one transaction is needed on the blockchain. Therefore, there is no need to have a Digital Accounting Token and an Obligation Token. The transaction on the blockchain is sufficient to record the truth, as triggered by an event that is articulated in the smart contract. For instance, as presented in Figure 9, when the shipping company sends the bill of lading with a confirmation of the shipment of the product to the bank, the bank issues a blockchain transaction to the customer, and the supplier, and records it on the blockchain. Similarly, after 60 days, when the customer pays its accounts payable to the supplier, one transaction is issued on the blockchain, with the bank involved.

Online Advertising Example

Fraud is one of the primary threats to the effectiveness of online advertising. According to the Interactive Advertising Bureau[2] (IAB), ad fraud alone costs the industry almost $8.2 billion a year to advertisers in the United States. Online ad fraud is a complex and unsolved problem (IAB 2015). Ten percent of discrepancy in reported viewed advertisements have been the de-facto standard for the online advertising industry, and it can go up over 50% in mobile platforms (IAB 2013). Online advertisers are responsible for identifying millions of websites that are relevant to their segmented markets. In the online advertisement space, there is more susceptibility of clicks and views being accounted for due to the considerable number of parties in the online advertisement transactions when compared to other types of online transactions.

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 transactions is 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 a banner ad. Tracking millions of data points every second, with a lack of a common standard, can result in a large number of inconsistencies in the accounting figures. The discrepancy increases as malicious software inflate the number of clicks and views. The IAB 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

[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.

if all the participating parties connect: the advertiser, ad agency, and ad viewer who can confirm that the viewed ad from the ad agency led him/her to the advertiser website. That would be possible within the blockchain technology. In this example, we introduce the ad viewer to be a part of the transaction, with the advertiser and the ad agency (Figure 11). 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.

Insert Figure 11 Here

A good example would be running a campaign on Facebook (Meta) 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. 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.

When an Ad agency provides services to an advertiser on credit, it will record the services rendered and the Accounts Receivable in its ERP system. The Ad agency will record this event to the blockchain ledger in the form of a transfer of an accounting digital token between two blockchain accounts (Figure 12). When payment is received for rendered services, the Ad agency will record this event in the blockchain ledger in the form of a transfer of an accounting digital token between two accounts on the blockchain in addition to recording the Cash and the Accounts Receivable in its ERP system. This can be viewed from the Ad agency perspective (Figure 12).

Insert Figure 12 Here

From the advertiser's 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 accounts on the blockchain (Figure 13). 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 accounts on the blockchain in addition to recording the Cash and the Accounts Payable in the ERP system.

Insert Figure 13 Here

In an online environment, the three parties are the advertiser, ad agency, and ad viewer. By adding the ad viewer to the transaction, a three-party transaction is created. The payout is defined in straightforward cases, where the ad agency, advertiser, and ad viewers subscribe to the same model of recording their transaction on the blockchain prior to importing it to their own systems, and their systems are only populated by blockchain recorded transactions. The ad agency will receive the right amount of money for each time a visitor of their site clicks on an advertisement leading them to the advertiser promotional website. 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 a trusted relationship between all parties. Figure 14 shows the digital wallet addresses and QR codes for the ad agency, ad viewer, and advertiser from their digital wallet interfaces. The same information is recorded and can be viewed on the blockchain portal (Etherscan).

Insert Figure 14 Here

In parallel with the example of the supplier, customer, and bank, events among parties trigger the execution of smart contracts. For instance, when an advertiser sends its ad to the ad agency to ultimately display it to the ad viewer, the advertiser notifies both the ad agency and the ad viewer by issuing a transaction as shown in Figure 15 using the Truth Coin. This triggers the smart contract governing the relationship between the ad agency and the ad viewer to release payment to the ad viewer as compensation to view the ad. The event creates a transaction with textual details including advertisement number, ad agency ID, ad viewer ID, and payments request, where those details will be saved on the blockchain (Lee 2019). Lee (2019) presents the technical details for saving text on the blockchain. The final output is considered a single source of truth. Both ad viewer and ad agency ERP systems will retrieve this textual information and process it accordingly to populate their respective ERP systems from a single point of truth, removing the need for reconciliation. Since all parties are involved in the same transaction, information processing errors are removed.

Insert Figure 15 Here

From the two illustrated examples, it is clear that the proposed framework will apply in different scenarios, regardless of the content of the transaction. The information flow will result in all involved parties having access to the same transaction details. These examples demonstrate the technical feasibility of the proposed framework of creating one truth for all parties involved in a transaction.

V. 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 and support various business applications. It has the potential to transform the current paradigm through improved collaboration between businesses and individuals. This is accomplished through the improved transparency of transactions, data integrity, and instant sharing of necessary information.

This study addresses the reconciliation problem that defines the requirements of having an accounting system without reconciliation challenges. We highlight the importance of having a well-defined process, where all involved parties in the transaction must be reflected on the blockchain and potentially remove the need to reconcile the different ledgers. The study introduces and identifies the requirements of having a transaction recorded between all involved parties in the same transaction by changing the information flow, thus eliminating information silos and preventing a reconciliation challenge. Additionally, in contrast with the works of Gal and McCarthy (2018) and Dai and Vasarhelyi (2017), our paper implements a single distributed ledger. We propose recording the transaction on the Blockchain prior to populating the transacting parties' respective ERP systems. This generates a single-ledger view, where only one token related to one transaction is needed on the blockchain. Specifically, this study proposes a new framework using

Blockchain technology resulting in a single-ledger model. Our framework does not require an obligation token since a single transaction is needed on the blockchain.

As a technical feasibility demonstration, two examples depicting a workflow between multiple parties are presented. The first is between a customer, supplier, and bank; and the second is between an ad viewer, ad agency, and advertiser. The workflows are executed on the Ethereum blockchain for the parties' related ERPs to use as a single point of truth.

Essentially, 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.

To have a functional system, we share the views of (Ibanez et al. 2021), when moving from a proof of concept to a full production system. A number of limitations need to be addressed. First, we will need a module that translates every relation in the local ERP system to a smart contract function to be triggered when an event takes place. This will require a substantial amount of development that may be carried out by existing ERP solution providers or small third-party dedicated companies that focuses on the mapping process. To study the cost-effectiveness of using the blockchain single truth framework, future research can develop simulations that can technically compare the processing cost between the use of smart contracts and other traditional alternatives. Additionally, not all tasks may be executed on the blockchain. Numerous tasks will be executed off-chain, which would lead to the need for reconciliation efforts. Furthermore, this research only presents a proof of concept of creating a single truth transaction based on events that trigger a smart contract to execute a set of transactions for the ERP systems to use. Our examples deal with one type of transaction, where all involved parties are members of the same blockchain single truth framework, which might not be generalizable in other situations. Additional considerations are required to address the needs of more generalizable situations. In addition, to ensure wide adoption of the framework, additional tools are needed to automate the creation of smart contracts to represent workflows.

In this paper, we present a proof of concept to confirm that blockchain technology will have an enduring impact on the accounting profession. It opens the door for researchers to explore a new school of thought that impacts different areas of the accounting profession. Blockchain allows the advantages of having the merits of a centralized system in a distributed environment. The new technologies that emerged in the past 30 years, based on cloud computing, cryptography, and trust-related algorithms, made it possible to lower the current required costs in order to maintain reconciliation under GAAP.

This study is in the same direction of a growing school of thought recommending the usage of blockchain to address the reconciliation challenge in the financial, online marketing, and logistics domains. Future research can investigate the technical implementation issues related to the implications for internal and external auditing tools, smart contracts, digital wallet applications, ERP integration modules, risk management and mitigation tools, and valuation models to name a few.

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Figure 1: REA Representation of an Exchange

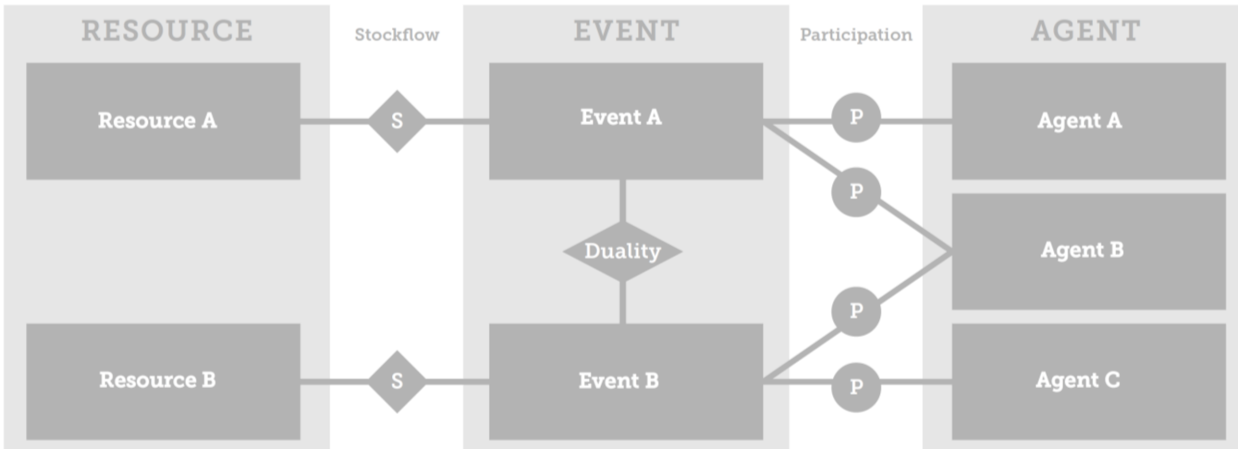


Figure 2: Adjustment in the Information Flow to Address Reconciliation on the Blockchain – Accounts Receivable/Payable Reconciliation Example

Figure 2 (a) depicts the current information flow in the business model
Before Blockchain: Each party is controlling part of the information and transactions are hard to reconcile

Figure 2 (b) depicts the proposed centric transaction information flow where all involved parties in the transaction have access to it
After Blockchain: Product is the center of information, and all transactions are on the blockchain

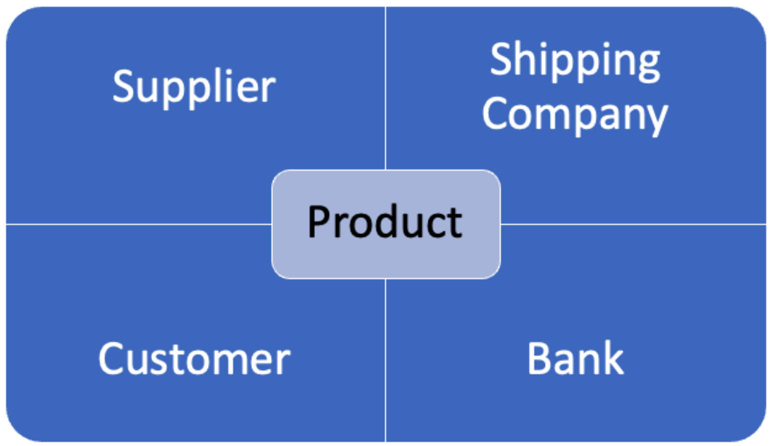


Figure 3: Adjustment in the Information Flow to Address Reconciliation on the Blockchain – Online Advertising Example.

Figure 3 (a) depicts the current information flow in the business model
Before Blockchain: Each party is controlling part of the information and transactions are hard to reconcile

Figure 3 (b) depicts the proposed centric transaction information flow where all involved parties in the transaction have access to it
After Blockchain: Product is the center of information, and all transactions are on the blockchain

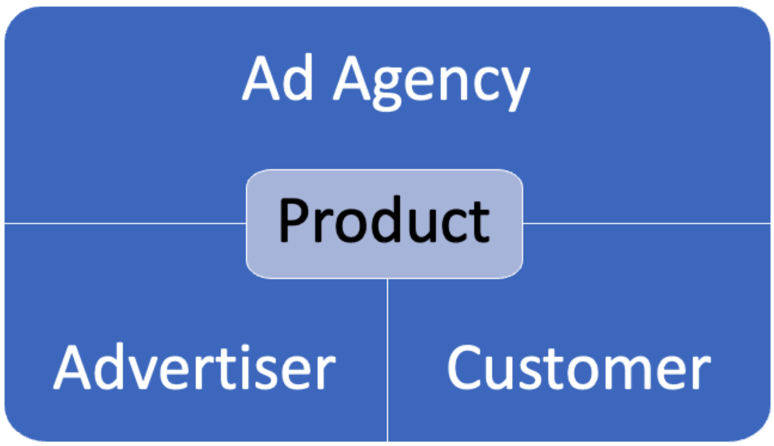
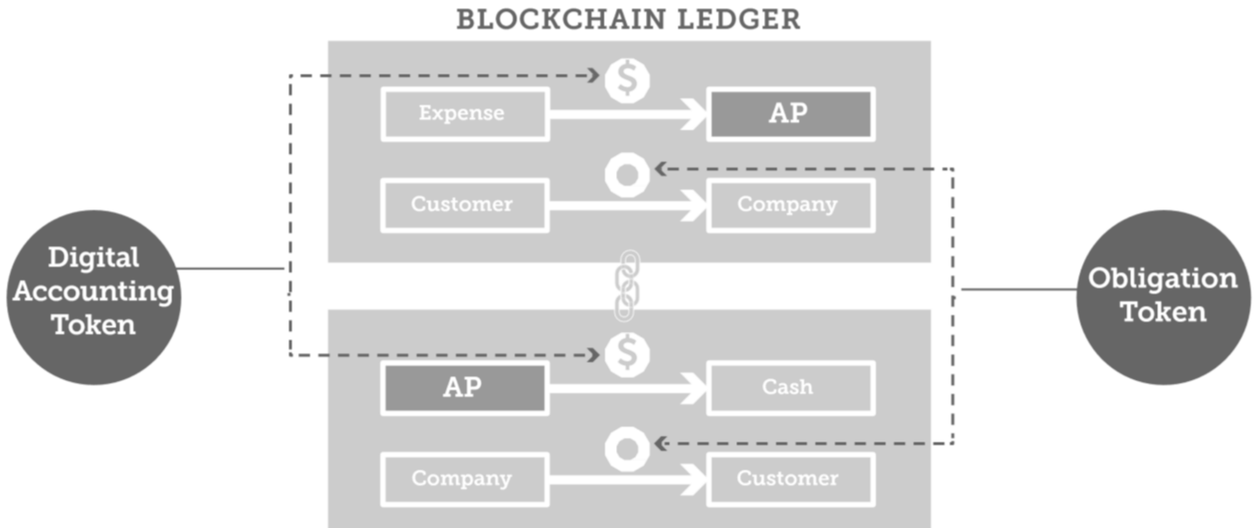


Figure 4: Blockchain Ledger[3]



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

Figure 5: Single-Ledger Accounting Information System

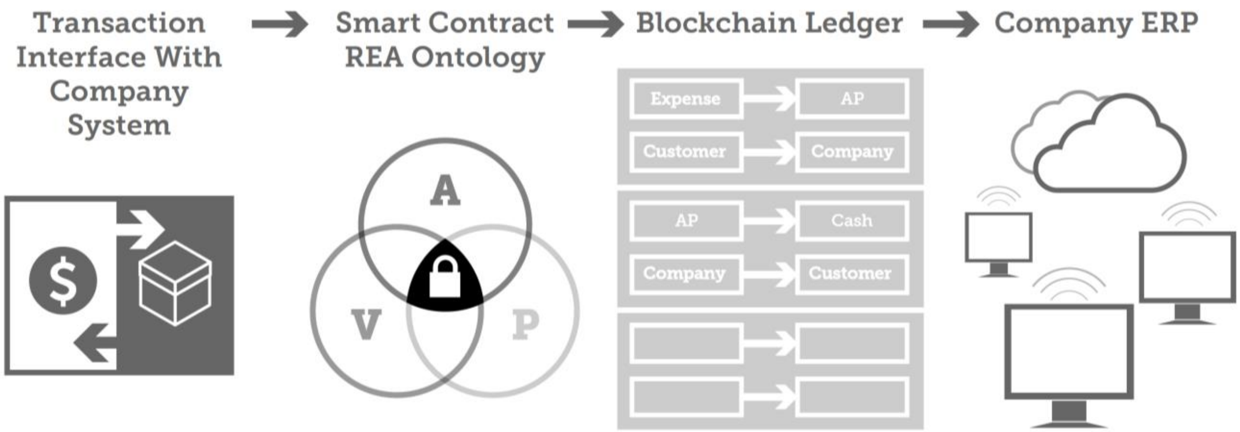


Figure 6: REA Representation of an Accounts Receivable/Payable Reconciliation Example in an Online Environment

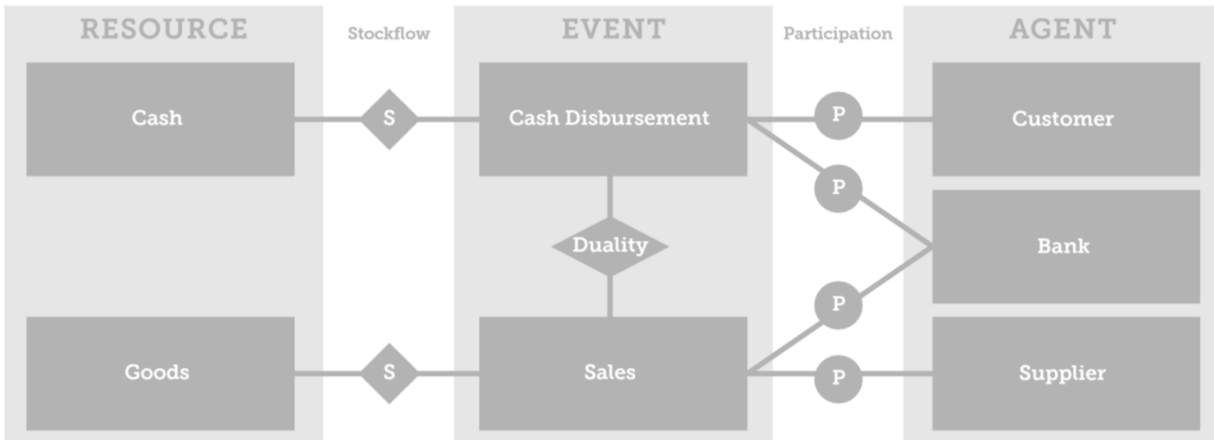


Figure 7: Sample Function in Solidity to Add a New Supplier

```
//Adding a new supplier

function createSupplier(address _supplierAddress, uint256 _supplierId, bytes32 _supplierName) public {
    Supplier storage Supplier = Suppliers[_supplierAddress];
    // Check that the Supplier did not already exist:
    require(!supplier.set);
    //Store the user
    Suppliers[_supplierAddress] = supplier({
        id: _supplierId,
        name: _supplierName,
        set: true
    });
```

Figure 8: Digital wallet for a supplier and a customer

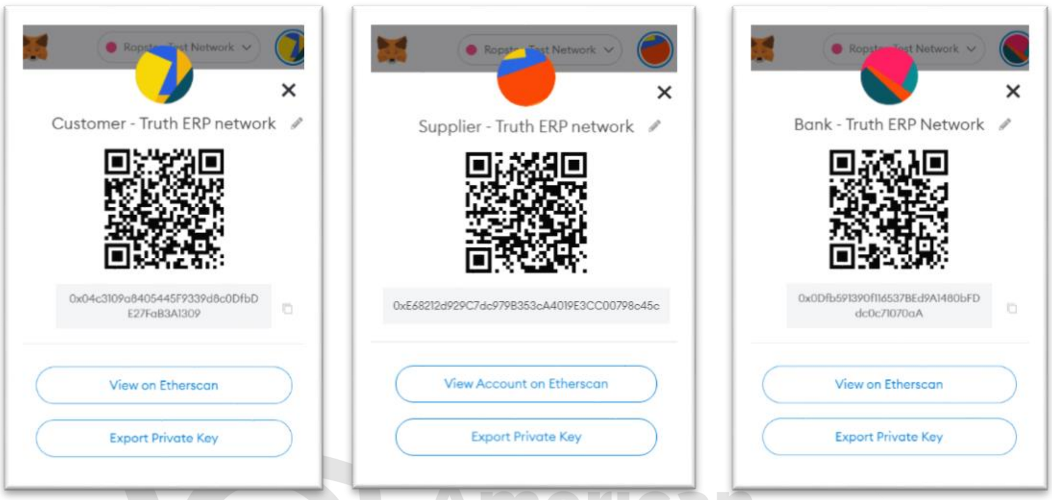


Figure 9: A Notification on the Blockchain from the Bank to Both the Supplier and Customer.

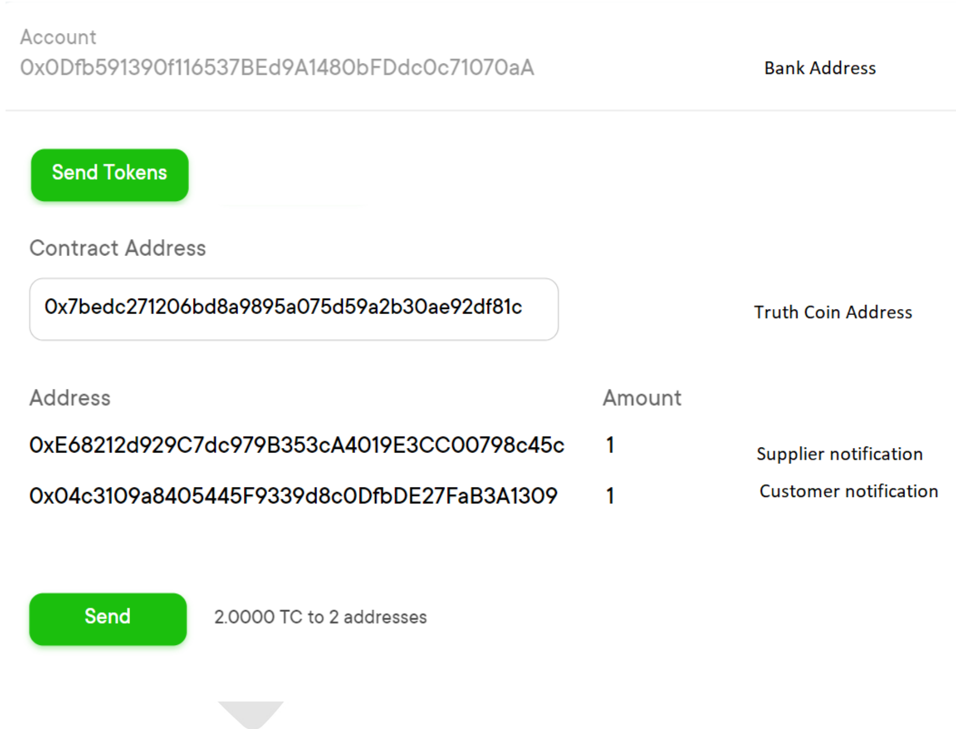


Figure 10: Sample Function in Solidity to Release from the Customer

```
// callable by customer only, after 60 days for shippment
 function withdraw() onlyCustomer public {
    require(now = sippmentDate + 60);
    //now send all the balance
    msg.sender.transfer(this.balance);
    Withdrew(msg.sender, this.balance);
 }
```

Figure 11. REA Representation of Online Advertising

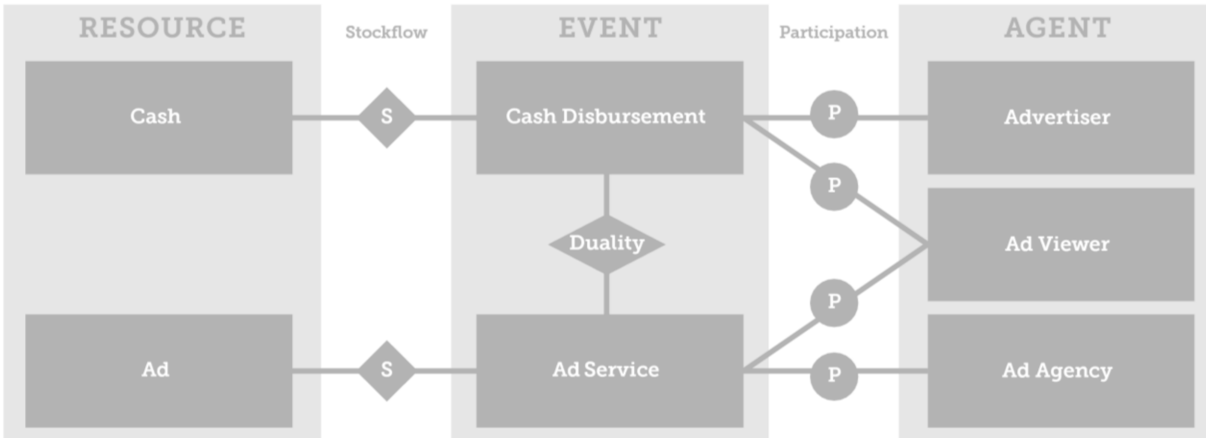
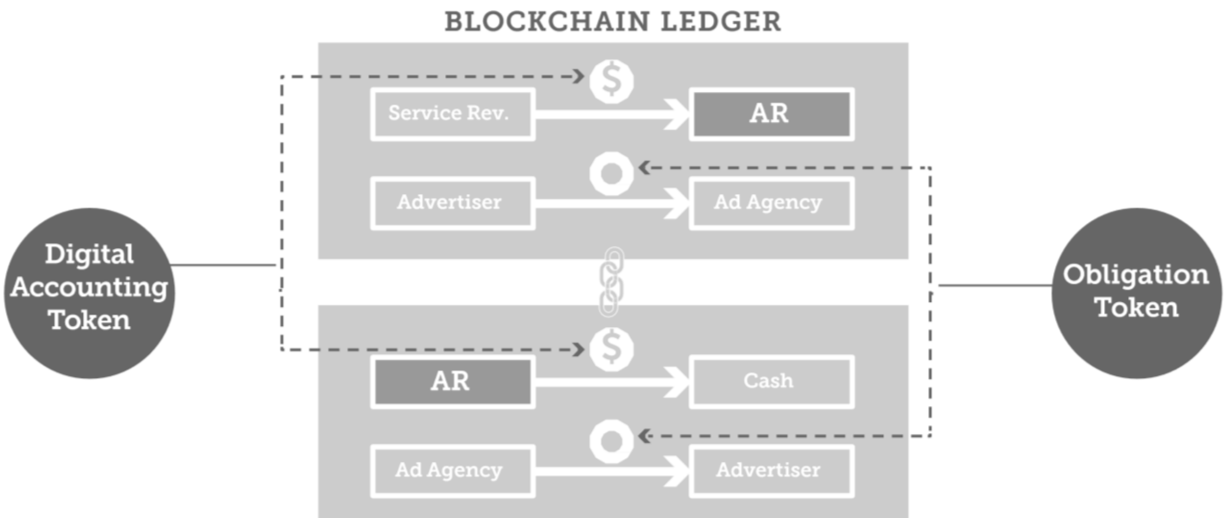


Figure 12: Blockchain Ledger[4]
Ad Agency view



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

Figure 13: Blockchain Ledger
Advertiser view

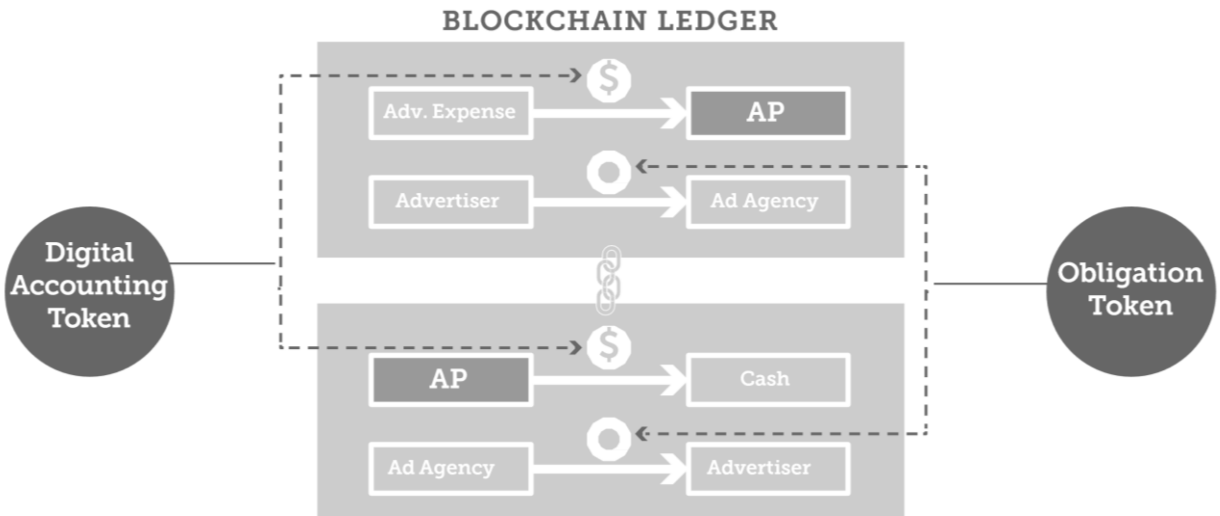


Figure 14: Digital Wallet for Ad Agency, Ad Viewer, and Advertiser

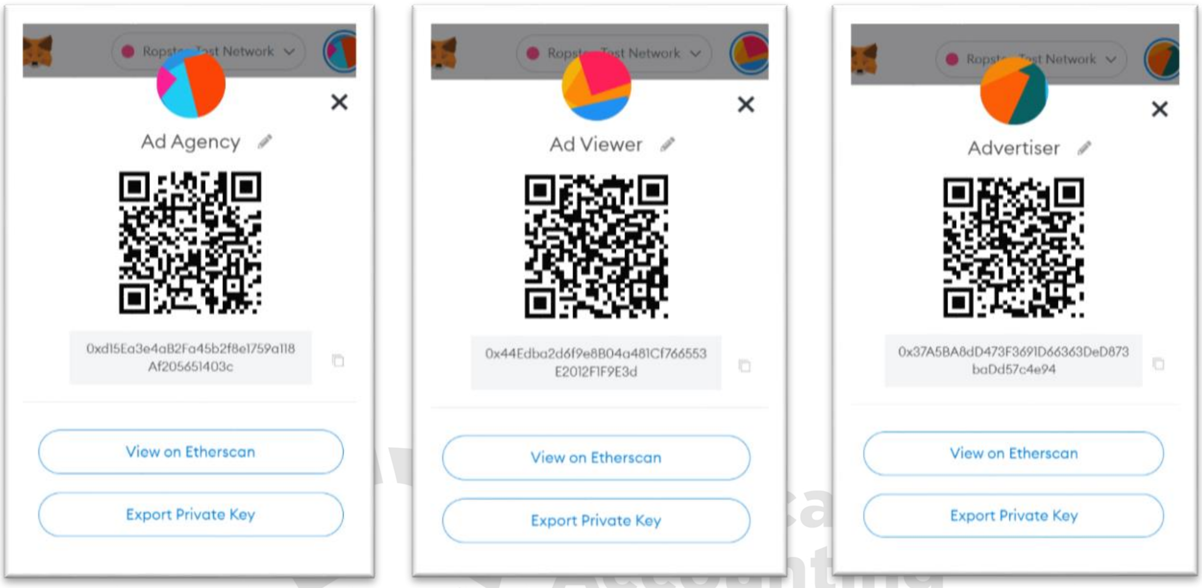


Figure 15: Transactions sending tokens to ad viewer and publisher from the ad agency.