Business Process Models to Blockchain

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"Trust is the most important element that drives both a successful transaction in a business and a meaningful personal or social value exchange in a society. "

—Jai Singh Arun

CCS Concepts: • **Distributed Systems → Blockchain**; • **Blockchain based solutions**; • **Computer systems organization** → Blockchain;

Additional Key Words and Phrases: Blockchain, Business Process Model, Business Process Management, Use-case, Blockchain-based solution

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1 INTRODUCTION

Business Process Management is a systematic approach to improving an organization's operational efficiency and effectiveness by analyzing, designing, executing, monitoring, and controlling business processes. The objective of BPM is to ensure that an organization's processes are aligned with its strategic goals, and that they are executed consistently, efficiently, and effectively.

A well known used tool in Business Process Management are **business process models**. Business process models provides a visual representation of how different processes function and gives organizations better visibility into how their business works. BPM relies on business process models to understand, analyze, and improve business processes, while business process models are key artifacts that enable stakeholders to visualize and communicate the current and desired states of a process.

In the process of improving business processes, **transitioning to new technological advances and solutions** is necessary for every organization that wants to take its processes to the next level. Technologies like Robotic Process Automation (RPA) enable the automation of processes, optimizing an enterprise's processes and workflows by increasing efficiency, reducing costs and errors, and decreasing cycle times. Taking advantage of a combination of emerging technologies can lead to significant improvements in business performance.

One trendy new technology right now is **blockchain**, and many have discussed the opportunities that blockchain can bring to enterprises. Although there are advantages in using blockchain technology intra-organizational processes, there are larger advantages in in using it for inter-organizational processes, such as business-to-business (B2B) models, where organizations have to collaborate to complete their business goals, blockchain can also bring trust to an untrusted network of participants.

In this paper, we will discuss the key aspects of BPM, its importance for organizations, how organizations' business processes are represented with business process models, and how emerging technologies such as blockchain can transform BPM practices, particularly in B2B business process models, to improve business processes. We will explore how to implement a blockchain-based solution and the benefits it can bring to enterprises, using one use case. In the last section, we will examine commercial Business Process Management System tools that are available to create blockchain-based solutions from a business process model.

2 BACKGROUND

2.1 Business Process Management

Business Process Management (BPM) is a systematic approach to managing and optimizing a company's business processes to achieve its objectives. The goal of BPM is to improve efficiency, reduce costs, increase productivity, and enhance customer satisfaction by streamlining and automating workflows.

BPM involves several steps, including:

(1) Identifying and documenting the company's business processes
(2) Analyzing the processes to identify areas for improvement
(3) Redesigning the processes to eliminate bottlenecks and streamline workflows
(4) Implementing the new processes
(5) Monitoring and measuring the new processes to ensure they are achieving the desired results
(6) Continuously improving the processes to adapt to changing business needs.

To support BPM, organizations use business process models to represent their business processes graphically. Business process models provide a visual representation of a process, which helps to identify inefficiencies and redundancies, and to communicate the process to stakeholders. The following are some of the most common business process models used in BPM:

Flowchart A flowchart is a graphical representation of a process that shows the steps involved and the order in which they occur. Flowcharts are easy to understand and are widely used in BPM.

Business Process Modeling Notation (BPMN) BPMN is a standardized graphical notation for representing business processes. It provides a comprehensive set of symbols and rules for modeling processes and is widely used in BPM.

Unified Modeling Language (UML) UML is a general-purpose modeling language that can be used to model business processes. It provides a standardized notation for representing processes, objects, and relationships.

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Value Stream Mapping (VSM) VSM is a graphical representation of a process that shows the flow of materials and information from the supplier to the customer. It is commonly used in lean manufacturing and service industries.

Swimlane Diagram A swimlane diagram is a type of flowchart that separates process steps by roles or departments. It is useful for modeling cross-functional processes.

When choosing a business process model, organizations should consider the complexity of the process, the level of detail required, the audience, and the purpose of the model. For example, a simple flowchart may be sufficient for a small process, while a complex process may require a more detailed BPMN diagram.

2.2 Blockchain technology

The concept of blockchain was initially proposed by Cryptographer David Chaum in 1982 in his dissertation on "Computer Systems Established, Maintained, and Trusted by Mutually Suspicious Groups." Stuart Haber and W. Scott Stornetta began working on the blockchain concept in 1991, followed by many attempts to develop it further. However, the credit for inventing the blockchain technology goes to Satoshi Nakamoto, who introduced it in 2008 as part of the cryptocurrency called Bitcoin. The unique feature of blockchain technology is that it operates without a central trusted authority. This is a significant departure from traditional payment systems, which require a central entity to process transactions and maintain account balances. Instead, trust is established through interactions between nodes in the network, which validate and relay transactions.

The blockchain data structure consists of an ordered list of blocks, with each block containing a set of transactions. Transactions are identifiable data packages that store parameters and function call results, and their integrity is ensured by cryptographic techniques. When a transaction is signed, it is broadcast to other nodes on the network, which validate its authenticity and send it to their peers until it reaches all nodes in the network. Miners are responsible for aggregating transactions into blocks and appending them to the blockchain.

Smart contracts are an important feature of blockchain technology, as they allow users to define and execute programs on the blockchain network. Although not all blockchain allow the creation of smart contracts. However, smart contracts can be used to solve common problems and reach agreements in a decentralized and trustless manner. The Ethereum platform is particularly noteworthy for its support of smart contracts, viewing them as a first-class element. Ethereum provides a built-in scripting language called Solidity for writing smart contracts, which are executed by all connected nodes. The correct execution of smart contracts is ensured through the same cryptographic techniques used to ensure the integrity of transactions, and extends directly from regular transactions.

3 BLOCKCHAIN AND BUSINESS PROCESSES MODELS

3.1 From business process model to blockchain

After defining Business Process Management, business process models, and blockchain technology, it becomes feasible to envision the implementation of a blockchain-based solution based on the business process model representation.

Business process concept can be simplified as a set of interconnected activities, were each activity within the process represents a specific step that transforms an input into an output. The inputs can be assets or services where each activity changes the state of the assets or services, or create new ones, what in business is call adding value.

Blockchain brings to BPM a shared and immutable ledger where states of the assets or services can be store. Business activities or processes can be perceived as blockchain transactions where states of assets and services change depending on the predetermined conditions or requirements. Furthermore, predetermined conditions that need to be met to change or transition from one state to another can be establish by using smart contracts, that will automate the execution of an agreement so that all participants can be immediately certain of the outcome.

The so-called trigger components or events will serve as a bridge between the blockchain and enterprise application and if cryptocurrency is used as payment method, it will enable the optional implementation of conditional payment.

The term "trustless" is often used to describe blockchain, not because individual actors distrust one another, but because it is unnecessary. This feature is particularly beneficial for business-to-business transactions, where trust between different organizations is necessary [**2**].

Organizations use blockchain to facilitate the collaborative business process in two different ways[**7**]:

(1) **Blockchain monitors the process** execution status cross all involved actors by observing message exchanges, acting as an unchangeable data storage to share the process status and create an audit trail. Smart contracts ensure that interactions follow the choreography model (A choreography model describes the interactions and message exchanges between multiple parties in a collaborative process). It can also handle automated payments and escrow.
(2) **Blockchain serves as a mediator** between participants to facilitate the collaborative process execution. This involves utilizing smart contracts to drive the process and perform data transformation or calculations, in addition to the functions mentioned earlier

These options are supported by the following main components:

A translator Although, the redesign of the business process model to the to-be blockchain-based model can be done manually, a translator can facilitate and speed up the design of to-be model. A translator derives from business process model to a smart contract in a script language (such as Solidity).

A choreography monitor For blockchain used-cased as a monitor, a smart contracts that act as a choreography monitors of the collaborative business processes by keeping track of the interactions of the different participant and combines them into a consolidated view of the current state of the execution.

A active mediator It uses a smart contract to implement the collaborative business processes. In contrast to the choreography Monitor, the mediator always plays an active role,

receiving and sending messages according to the business logic defined in the process model. It also may transform data or execute other computations. Optionally, it can trigger automatic conditional payment from escrow, when certain points in the choreography are reached.

Interfaces or triggers components Since the Blockchain is a closed environment, where the deployed smart contracts cannot call external APIs, triggers or blockchain interfaces act as intermediaries between the blockchain and the external environment. These triggers work as agents for organizations, maintaining the context and status of business procedures while protecting confidential data on a complete blockchain node. Their duties include contacting external APIs, obtaining API requests from external components, and updating the blockchain's process state based on external observations. Triggers also track the data payload in API calls and store it in an external database when necessary. They are usually programs that run on full nodes of the blockchain network, and each participant typically runs their own trigger on a node they control. As triggers must possess the private keys of all participants on whose behalf they operate, a significant level of trust is necessary. Communication between the participant's systems and their trigger is typical, and this is the standard setup assumed for trigger operation.

These components help the collaboration between business by enabling participants to execute collaborative procedures over a network of untrusted nodes, ensure that only valid messages progress the process state, encode payments and escrow into the process, and whether successful or not.

3.2 An use-case implementation

Figure 1 presents a simplified supply chain business process model that will be used to demonstrate the conversion of a business process model into a blockchain-based solution using the components mentioned. Supply chain management is one of the most promising applications of emerging blockchain technology[**5**], where supply chains are large and there isn't a player that can claim to know with certainty the life cycle of their products.

The given business process model involves a bulk buyer who orders goods from a manufacturer that sources supplies via a middleman, with a specialized carrier transporting them. The are in total five different actors in this business process: the bulk buyer, the manufacturer, the middleman, the specialized carrier and the supplier.

In the Figure 2 are depict in detail the different interaction of the participant of the collaborative business execution. Because not all messages are seen by a single party, the process can be described as a choreography. If the manufacturer were to serve as a mediator and receive all messages, it would be considered an orchestration. Without global monitoring, participants have restricted visibility into the overall progress where each of the participant would maintain their own information and the shared information with their business collaborators may be outdated and unstrusted. This would lead into conflicts in case of delays, errors or in case of products damage or theft.

In the blockchain-based solution shown in Figure 3 the two first processes of the scenario are redesign to the blockchain solution: the order of good of the bulk buyer to the manufacturer and the place order for supplies of the manufacturer to the middleman. The two processes are redesign to used smart contract and trigger components to automate the process. Each of the participants will deploy their own smart contract and their own trigger components to interact with the blockchain. The blockchain-based solution model show how the different smart contracts interact with each other via trigger components.

In this case, smart contracts can be used as choreography mediators or as active mediators. In the first case, smart contracts and the blockchain shared ledger will maintain the current state of the process and the exchange of messages of the different participant. Will provide visibility to all the participant and improve efficiently by automating processes and therefore, reducing process times and possibles human errors.

On the other hand, smart contract used as active mediators have the added functionality to not trigger events in case the predetermined business conditions are not met. For example, the manufactured could set a minimum amount of goods that need to be order or the minimum price to accept an order from the bulk buyer and only if these predetermined condition are met, the manufacturer smart contract will activate the middleman trigger. In consequence, the hole collaborative process execution can be automated and the process state can be stored in the common ledger.

In [**6**], smart sensors are used inside or attached to parcels to bridge the gap between the blockchain and the external environment and monitor in real time. They keep track of environmental conditions specific to the parcel's service level agreements, allowing participants to monitor the cargo and goods' location and conditions in real time, reducing the possibilities of product spoilage damage, delay and theft. This strategy permits IoT devices to transmit data to the blockchain network in real time, and any infringement of the service agreement will be immediately detected and recorded by the smart sensors onto the blockchain.

The implementation of current process in a blockchain-based solution demands a significant amount of work to analyze and redesign current processes. Important tasks, such as what data share in the shared ledger and with whom, are critical and will determine which type of blockchain to use.

Public blockchains like Ethereum will grant free access to the blockchain and share the stored information with all the participants. On the other hand, private blockchains like those created with the Hyperledger Fabric framework will restrict access to permissioned participants, and the ledgers will be shared only with participants who have the correct credentials. In our use case implementation, data such as the price that each participant pays to each other for their service or goods will be considered private information that none of the participants would like to share.

Furthermore, Hyperledger Fabric allows the creation of channels. Channels create subnets of blockchains between two or more network participant, for the purpose of sharing private and confidential data.

Other blockchain key parameters to consider when selecting the blockchain where to host the business process are the blockchain

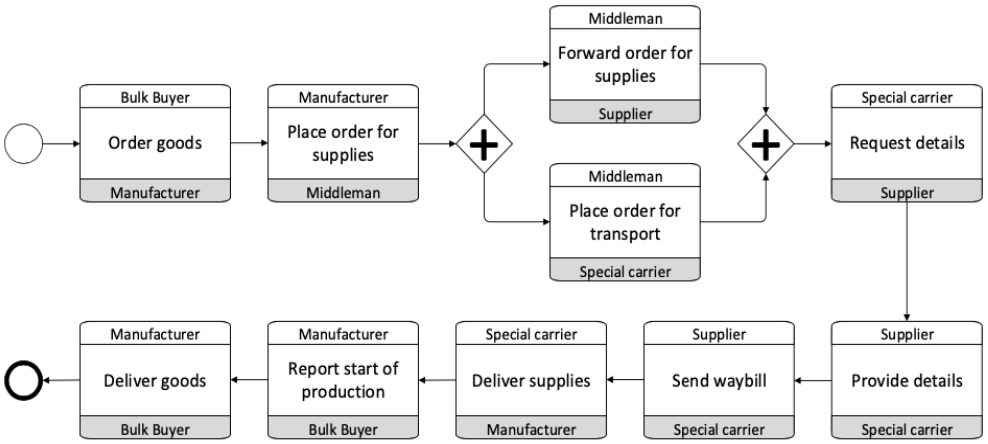

Fig. 1. The figure shows a business process model of a supply chain business process with five different participants. The process starts with the order of goods of the bulk buyer and ends when the manufacturer delivers the goods to the bulk buyer[7].

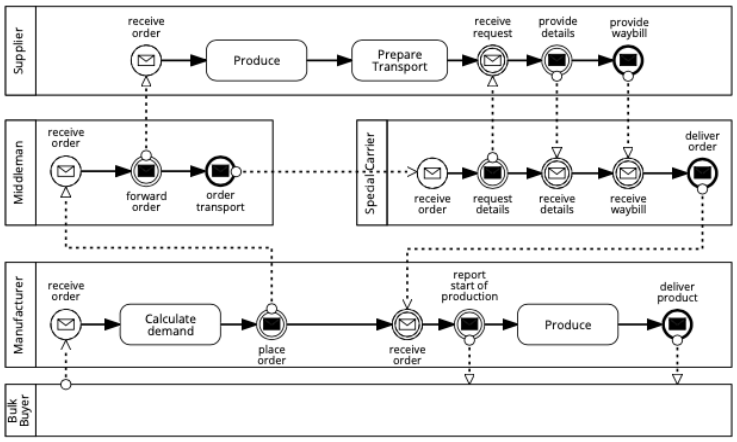

Fig. 2. Simplified overview of the choreography model of the previous supply chain management model presented in [4] and of the business process model in Figure 1.

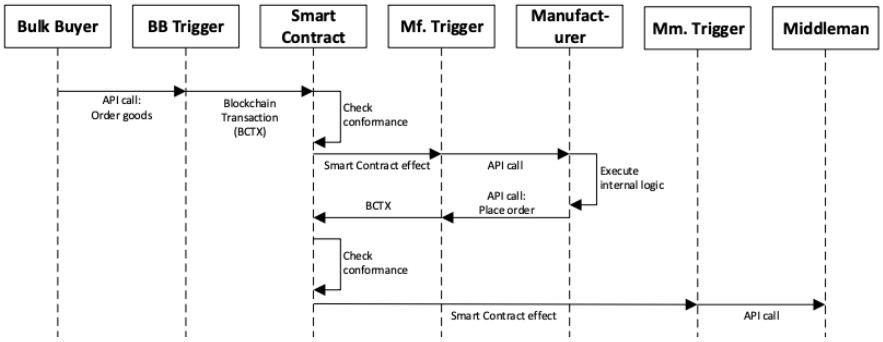

Fig. 3. Implementation of the blockchain-based solution of the two first processes of Figure 1 model. The re-designed processes of the interaction to order supplies of the bulk buyer to the manufacturer and the manufacturer interaction with the middleman to order the supplies[7].

speed, concesious algorithms or the scalability rate. All this key parameters need to be consider in the design phase of the blockchain-based solution.

3.3 Benefits of blockchain-based solutions

Blockchain for business delivers the next benefits[**1**] based on the attributes of this technology:

A more secure environment The importance of data cannot be overstated, which is why blockchain technology has the potential to revolutionize how we handle sensitive information. By utilizing the power of blockchain, data can be kept secure and protected from unauthorized access. Through end-to-end encryption and immutability, the blockchain ensures that records cannot be tampered with or altered. Moreover, personal data can be anonymized and access can be restricted, thereby addressing privacy concerns. By distributing data across a network of computers, blockchain technology provides an added layer of security, making it difficult for hackers to compromise the system.

Traceability at your fingertips The use of blockchain technology enables the documentation of every asset's journey through an audit trail. This is especially useful in industries where consumers are concerned about issues such as human rights or the environment, as well as in industries with high levels of fraud and counterfeiting. With blockchain, customers can directly access information about an asset's origin, while traceability data can help to identify potential weak points in the supply chain, such as goods that are waiting to be transported.

A greater degree of transparency By utilizing a distributed ledger, blockchain technology removes the necessity for individual organizations to maintain their own database. This system ensures that transactions and data are recorded in multiple locations simultaneously. All participants have access to the same information at the same time, guaranteeing complete transparency. As an added benefit, all transactions are time-stamped and can be traced, making it nearly impossible to commit fraud. Members can review the complete history of a transaction, thus increasing accountability and reducing the risk of malfeasance.

Automated systems The use of "smart contracts" can even automate transactions, which can significantly increase efficiency and accelerate the process. Smart contracts automatically trigger the next step in a transaction or process once predetermined conditions have been met. This automation reduces the need for human intervention and third-party verification to ensure that contractual terms have been fulfilled. For example, in the insurance industry, once a customer has submitted all required documentation for a claim, a smart contract can automatically settle and pay the claim.

3.4 Collaborative business process challenges

Business-to-business (B2B) sales are transactions between two businesses rather than between a business and an individual consumer for the consumer's personal use. The challenges that business-to-business processes encounter[**8**], which blockchain technology can resolve are:

Payment processing B2B sales are characterized by larger transaction amounts, more educated buyers, a multistakeholder approval process and thus a longer sales cycle. B2B payments require longer decision-making processes and more complicated payment terms. B2B payments face several challenges, such as high transaction fees, lengthy settlement times, currency conversions, and the need for intermediaries. These challenges can cause delays, increased costs, and decreased transparency in the payment process.

However, blockchain technology can offer solutions to these challenges by providing faster, cheaper, and more secure B2B payment options. By utilizing blockchain, B2B transactions can occur directly between parties, eliminating the need for intermediaries, and reducing transaction fees. The use of smart contracts on a blockchain can also automate payment processes, providing for more efficient and timely settlements. Moreover, blockchain-based payments can enable immediate and secure transfers across borders without the need for currency conversions.

Overall, blockchain can help streamline B2B payments, improve efficiency, reduce costs, and increase transparency and security in the payment process.

Lack of transparency Lack of transparency is a significant challenge that B2B transactions face, as these transactions often involve multiple parties, complex supply chains, and diverse payment methods. This lack of transparency can lead to disputes, delays, and increased costs.

Blockchain technology can address this challenge by providing an immutable and transparent ledger that can track every step of a B2B transaction. This distributed ledger technology allows for all authorized parties to access and verify the transaction history in real-time, ensuring transparency and accuracy. Moreover, the use of smart contracts on a blockchain can provide for automatic execution of contractual terms, further increasing transparency and reducing the need for intermediaries.

By utilizing blockchain technology, B2B transactions can be conducted with increased transparency, reduced risks, and greater efficiency, thereby improving the overall quality of B2B transactions.

Slow and inefficient processes Blockchain has the potential to improve slow and inefficient B2B processes by streamlining and automating them, reducing the time and cost involved in transactions.

For example, blockchain-based smart contracts can automatically execute agreements between parties once the predetermined conditions are met, eliminating the need for intermediaries and reducing the time required for manual processing. By reducing the time and cost associated with B2B transactions, blockchain can improve operational efficiency and increase profitability for businesses.

Lack of trust The lack of trust is a significant challenge faced by many B2B companies, and blockchain technology can help address this challenge.

Blockchain creates a tamper-proof and transparent record of transactions, which is distributed across a network of nodes. Each node maintains a copy of the ledger, which is synchronized and updated through consensus mechanisms. As a result, all parties involved in a transaction can have a shared, immutable view of the transaction history, which reduces the risk of fraud or dispute.

Additionally, blockchain technology can enable the use of digital signatures and encryption, which can authenticate the identity of participants and ensure the confidentiality and integrity of data. This can help build trust among parties that may not have a pre-existing relationship, and reduce the need for intermediaries in B2B transactions.

Overall, blockchain has the potential to increase transparency, accountability, and trust in B2B transactions, which can ultimately lead to increased efficiency and profitability for businesses.

4 TRANSLATION TOOLS: CATERPILAR

As mentioned before, the process of transition from the traditional business process to a blockchain-based solution require to analyze possible process that can be hosted in the blockchain and redesign the to-be model in the blockchain and implement it. Therefore. this process can be an obstacle for many business that don't have the tools or the talent to complete the transaction. An useful tool that seek to facilitate this transaction is Caterpillar open-source Business Process Management System (BPMS)[**9**] that runs on top of the Ethereum blockchain. Caterpillar enables the creation of process model instances (as defined by BPMN) and allows users to monitor the progress of these instances and carry out associated tasks. What sets Caterpillar apart is that it maintains the state of each instance on the Ethereum blockchain, and uses smart contracts generated by a BPMN-to-Solidity compiler to direct workflow routing. The compiler is capable of handling a broad range of BPMN elements, such as user, script, and service tasks, parallel and exclusive gateways, subprocesses, multi-instance activities, and event handlers.

The process of translating a Business Process Model and Notation (BPMN) to a blockchain-based business process management system like Caterpillar involves several steps. Here is a brief overview of the process:

(1) Model the Business Process in BPMN: The first step is to create a visual representation of the business process using BPMN. This includes defining the process flow, tasks, events, and gateways, as well as the roles and responsibilities of the different stakeholders involved.
(2) Identify the Smart Contracts: Once the business process is modeled in BPMN, the next step is to identify the parts of the process that can be automated using smart contracts.
(3) Define the Smart Contract Logic: After identifying the smart contracts, the next step is to define the logic of the smart contracts. This involves specifying the conditions that need to be met for the smart contract to execute, as well as the actions that the smart contract should take once it is triggered.
(4) Convert BPMN to Blockchain-Specific Language: The BPMN model is then converted into a blockchain-specific language, such as Solidity, which is used to develop smart contracts on the Ethereum blockchain. The conversion process involves mapping the BPMN elements to their corresponding blockchain components, such as events, tasks, and gateways.
(5) Test and Deploy the Smart Contracts: Once the smart contracts are developed, they are tested to ensure that they are functioning correctly and are meeting the requirements of the business process. The smart contracts are then deployed on the blockchain, where they are executed in a decentralized and secure environment.
(6) Monitor and Improve the Business Process: After the smart contracts are deployed, the business process can be monitored and analyzed using the analytics capabilities of the blockchain-based business process management system. This can provide insights into performance, efficiency, and areas for improvement, allowing the organization to optimize its operations and achieve better results.

Overall, the process of translating a BPMN to a blockchain-based business process management system involves a combination of modeling, automation, and deployment on a decentralized platform, with the ultimate goal of improving the efficiency and security of the business process.

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