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Blockchain-Based ERP System: Architecture and Opportunities for Future

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Abstract

Although Blockchain can significantly change the future of ERP systems as an innovative tech-nology, few researchers have gone into the details of this development. Most have given an overview of the changes ahead. Therefore, in this research, we have tried to use the method of Exploratory Content Analysis (ECA) by reviewing more than three hundred scientific articles in the field of Blockchain to analyze the effects of this technology on ERP system modules such as supply chain management, maintenance, finance, project management, manufacturing, and hu-man capital management. The result of this exploratory research is an architectural model for a blockchain-based ERP system. The researchers describe the functions of this system carefully, and the role of supporting technologies such as Smart Contract, IoT, Digital Wallet, Cloud Com-puting, and Building Information Model is clarified. We genuinely believe that this research could use as a reference model for ERP vendors and researchers in information systems and business process management.

Keywords: Blockchain; Blockchain-based ERP; ERP; Smart Contract

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Introduction

Blockchain is a revolutionary new paradigm that is believed to noticeably change the business processes in local and international organizations worldwide. (Yoo, S.,2018). This ground-breaking technology was first introduced as a subset to Bitcoin's underlying infrastructure in 2008 but almost immediately it stretched to different aspects of information technology such as information systems (Abeyratne, S. A., & Monfared, R. P., 2016). Blockchain, as a decentralized system of information sharing, generates new kinds of modern, reliable, and trustworthy sub-systems (Beck, R. et al, 2017) that the conventional centralized and unencrypted information systems such as ERPs are fully unable to create. (Brandon, D., 2016). The Blockchain technology provides users with several significant advanced advantages including durability, transparency, immutability, and last but not least, process integrity (Abeyratne, S. A., & Monfared, R. P., 2016). Some of Blockchain's features are most beneficiary to business operations. For instance, Blockchains can eliminate manual processes and paperwork as paper documents are couriered among organizations around the world and contracts and compliances are printed for wet signatures. These processes are inefficient, time consuming, error-prone and subject to fraud. By digitizing the processes, Blockchain can help to reduce time and costs, automatically enforce compliance and streamline payments.

ERPs, as today's most leading information sharing systems, mostly focus on internal processes and relational and centralized databases. To deal with such disadvantages the concepts of ERP II and ERP III were introduced with the aim of creating more integrated ERPs through building strong connections as well as interactions among companies and their business partners such as suppliers, and customers. (Bond, B. et al, 2000). These concepts have gradually changed the deep nature of ERP from an integrated internal solution to an integrated solution for the upstream and downstream of the value chain. (Vasilev, J. 2013). Banerjee anticipated that the advent of Blockchain will also upgrade ERPs to a new and high level of integration among all stakeholders, for instance, manufacturers, suppliers, customers, governments, etc. He believes that the inherent immutability of Blockchain assures stakeholders that the transaction records are not manipulated in any step which leads to extension of audit trails throughout the process. (Banerjee, A., 2018). Actually, the nature of the new ERP Systems seeks to create deep collaboration among different units in an organization. (Kuvvarapu, R., & Kuvvarapu, B., 2018). Blockchain, moreover, will prompt dramatic shifts in the way ERPs manage transactions by means of their shared and encrypted network. (Swan, M., 2018). Through employing new concepts such as digital wallet, Smart Contracts, and decentralized finance (DeFi), ERPs are renovated into systems that are fully capable of tracking, controlling, and exchanging any kind of assets, resources, money, and transactions. (Gomaa, A. A., 2019; Sokolov, B., & Kolosov, A., 2018). As Blockchain passes on the power of transaction, storing, and organization to different cloud-based servers, it could largely reduce risks of single point of failure (SPOF) in ERP systems. (Dai, J., & Vasarhelyi, M. A., 2017). Blockchain-based ERPs are able to verify the unique identity of

each component, organization and person involved in a process, and this identity and how it interacts with other identities can be tracked throughout the value chain.

Smart Contracts play an important role in implementing the features of Blockchain technology. They simply are programs or protocols that execute transactions based on preset terms and conditions. For example, when a shipment arrives, the payment process will automatically be initiated, and if one party goes out of agreement the process will be revoked. This example revolutionizes the account payable and account receivable significantly and provides all parties with an effective and temper-proof audit trail on entire business processes. This functionality can be used to eliminate the need in authorized intermediators leading to significant cost reduction and agility.

In the last few years, ERP vendors have come to an understanding that Blockchain will significantly disrupt their current systems (Parikh, T., 2018). The famous vendors like SAP, Oracle and IFS have announced that they release Blockchain services as part of their cloud-based initiatives (Stackpole B., 2019). It, however, seems that there is a lack of sufficient research and consensus as well over the solutions surrounding the Blockchain-based ERP. While more researches have tried to deeply focus on the relationships among the ERPs, Blockchain, and the Supply Chain, less research have been carried out with a focus on the architecture of a Blockchain-based ERP and the fundamental changes in its modules. With this respect, researches have to be conducted on concerns including the effect of Blockchain technology in creating changes in the concept of enterprise resource planning, the future image of a Blockchain-based ERP system, and, the effect of Blockchain ERP in business processes such as personnel recruitment, inventory control, production planning, customer order management, and cost accounting. To answer and demystify the issues in place, we make use of an Exploratory Content Analysis (ECA) as well as an integrated model that explain the relationships between Blockchain and changes it will definitely cause in different modules of an ERP system.

As per our scholar review, while there have been many researchers who support the application of Blockchain in the ERPs, a detailed architecture and specification of a Blockchain-based ERP has not been presented. Therefore, this paper is presented to answer following questions:

1. What are the components of a blockchain-based ERP system architecture?
2. What are the capabilities of each module of a blockchain-based ERP system?
3. What are the core technologies used in a blockchain-based ERP system?
4. What are the applications of a blockchain-based ERP system?
5. Which stakeholders will be affected by developing blockchain-based ERP system?

The architecture illustrated in this study to answer these questions expresses the purpose of this research and the research gap that we try to address.

Literature Review

Enterprise Resource Planning

Enterprise Resource Planning (ERP) systems are business and information management systems which consist of a collection of functional modules that integrate different business processes within an organization. These processes include the interconnected components of different departments including human resources, financial and accounting, maintenance, sales and distribution, project management, material management, Supply Chain management (SCM), as well as the quality management. (Shehab et al, 2004). ERPs maintain the information in and around a business in a database and flow it throughout the organizations with the aim of managing key functions such as procurement, sales, assets, shop orders, work orders, human resource, and general ledger. (Upadhyay & Dan, 2008; Xu, Yu, Lim, & Hock, 2010). ERP systems are today's most comprehensive information sharing software which provide businesses with useful information they need for managing their business processes and decision-making. (Fadlalla & Amani, 2015). One of the most important and influential characteristics of ERP is providing real-time and essential data needed by the businesses. With this applied capacity in place, ERP plays an effective role in automating the key factors required for an enterprise to do a thorough decision-making process for its internal and external affairs. (Seng Woo, 2007; Razmi et al 2009). These features support local and international organizations to increase their productivity by enabling their access to precise and timely information. Moreover, they give businesses the capability of employing a productive and cost-optimized work flow through running paperless processes, knowledge sharing trends, and internal controls. (Bhamangol et al, 2011). Also, ERPs are able to enhance the corporate governance and the compliance through simplifying the monitoring of business processes. (Al-Mashari, 2003). ERP systems not only connect internal parts of an organization to each other but they, one way or another, have been successful in establishing network-based capabilities to link enterprises to their customers and suppliers. (Bond et al. 2000; Weston (Jr), 2003).

Today, the most apparent capacity and the main focus of the current ERPs and all other available information systems could be summarized just and only to catering of internal needs of organizations. This lack of proper networked-based ERP systems has brought forward and caused conflict of interests between companies and their stakeholders. (Daneva et al. 2006). To address this issue ERP vendors worldwide had tried to bring an extended web-based solution known as ERP II to offer new modules including E-Business, Business Intelligence (BI), and Cloud SaaS. (L Rusu & E Gerőcs-Szász,2018; S.Rouhani & M.Mehri,2016). This new type of ERP has sought to resolve problems including problems with the information conflict, information imbalance, and failures in establishing an integrated and continuous relationship between the organization and its business partners within the Supply Chain (M.Ghazanfari, et al,2009). Mullaney believes that many large ERP vendors, such as SAP and Oracle, have added CRM modules and other e-commerce systems to their products and this

comes as many companies have still preferred to purchase and use distinct versions of these systems. (Mullaney, 2012; Moutaz Haddara & Angelo Constantini, 2017). They explored four reasons why organizations are reluctant to use those CRM systems in their ERP domains; Reason 1: 'Scoping during ERP acquisition' which means companies hardly think about CRM when implementing ERP; Reason 2: The lower cost of cloud-based CRMs in comparison to the running CRMs in ERPs; Reason 3: The failure of ERP's CRM in being user-friendly; and the last but not least; Reason 4: The specialized functions offered by the CRM vendors who are experts in customer relationship.

It is undeniable that the process of implementing and using ERP is time consuming and pricey and it is not possible to consider ERP as a permanent successful option (M.Moalagh & A. Z. Ravasan, 2013). Statistics have shown that, contrary to all previous expectations by the researchers and the customer organizations, the failure rate with the ERP projects was simply high. M. Al-Mashari states that about 70% of these projects failed to implement the expected objectives defined by the ERPs and 75% were totally unsuccessful. (M. Al-Mashari, 2000 and V. Kumar et al, 2003; T. Griffith et al, 1999; K. Hong et al, 2002). Amin Amid listed a number of key factors behind the failure of ERPs with some element yet to be addressed properly including 'Internal conflicts among departments', 'Misfits between the IT and the business strategies', 'Conflicts between organization and their vendors' and 'Governmental structure of the organization'. (Amin Amid et al, 2012). The failure with these element factors is mostly rooted in the quality of interactions between the interconnected internal units of an organization and the way they treat concepts including information flow. Since each unit is willing to, even by manipulating information, show its performance more diligently, no effective solution has been found to prevent and/or to control the concept of conflict of interests. Despite strict internal arrangements and strong corporate governance, there are still many failed examples listed in researches worldwide. (S Goyal et al, 2018; S Giamporcaro et al, 2018).

ERP has come under use mostly because of its ability to bring transparency between the management of an organization and its stakeholders. (Jidong & Liyan, 2010). This transparency is achieved mostly by providing reliable, accessible, relevant, and accurate information about a company's performance. (Urbach et al, 2010). To maintain the healthy relationship between the management section and the stakeholders, the earlier team including the managers has to be accountable and responsible as well, but these ethical codes of being accountable and responsible are always needed to be tested to stop any chance of corruption and fraud. (Al-Bassam et al, 2018).

To address such doubts theories including Agency and Policeman could be employed. Due to the existence of an inevitable separation between the ownership and the management, as the theory of Agency explains, there is always a conflict of interests between the managers and the stakeholders as the earlier party (the managers) always tries and tends to maximize its profits against the former party (the stakeholders). (Alsurayyi et al, 2021). This theory shows

the need for establishing effective corporate governance in companies. (Gillan, 2006). Since, as the theory adds, the privilege of 'information asymmetry' is a shared option between the managers and the stakeholders, it allows the managers to practice a direct and better access to more relevant and timely information while this opportunity is not a fixed and frequent option to the stakeholders. (Nikkinen and Sahlstrom 2004). Many researches have shown that ERP systems can greatly alleviate information imbalances between managers and stakeholders to mitigate the problem within the company. (Jidong and Liyan, 2010). Meanwhile, the theory of Policeman outlines the idea that under some specific circumstances including the situations with no solid control in place, fraudulent activities are inevitable, so the auditor's role and responsibility in such a critical situation is to prevent such wrongdoings, in the most effective way. (Owolabi et al, 2020). The actions taken by the auditors are extremely important as they remove problems including lack of accountability by the managers and lack of reliability and credibility of information.

These theories cast doubt on the reliability of all information prepared in the shape of business reports, financial statements, audit report etc. This is as it seems that they all are manipulated towards the interests of the top management of an organization. To remove such a doubt and to make external and internal stakeholders assured about the processes, organizations use corporate governance, risk analysis, internal controls, and independent audits to decrease the possibility of manipulation of information. (Nikkinen and Sahlstrom 2004). One of the most common ways to reach the given target is the proper use of auditing as a functional controlling body. Auditing is generally divided into two categories of internal audit and external audit where internal audit, as a structured procedure, tries to guide the organization towards its strategic goals and maintain organizational values to improve the quality of the organization's performance (Institute of Internal Auditors, accessed on 28 October 2015) while External audit, on the other hand, is a procedure that is used for verifying the financial statements of companies prepared by the management. (Jovanova and Josheski, 2012). To facilitate these two types of auditing processes, ERPs offer a special database containing all daily undertakings of a company including business operations and information flow. But one question is that have they been successful in doing so? A. P. Silva, R. P. Marques, M Athanasaki, and A Dimitras conducted separate surveys to show that the performance of an internal audit has no direct relationship with the use of ERPs. They believe that because of the complexity of ERPs system and the lack of proper IT knowledge among external auditors, the risk of conducting a proper and thorough controlling and auditing is significantly high. (M Athanasaki & A Dimitras, 2019 and A. P. Silva and R. P. Marques, 2020).

ERPs have been trying to address data management issues such as immutability, traceability, security, visibility and transparency. While ERPs are relatively successful in completing this mission, the cost and the time the companies spend to reach the desired point are quite high (Sokolov, B., & Kolosov, A., 2018). Immutability in ERPs can be achieved by creating a high level of monitoring process over the segregation of duties and granting proper

access roles to users with all their required and requested functional and technical capabilities (Alsurayyi et al, 2021). In the same way, data security is assured by the specialized Database Administrator (DBA) as well as the network the companies employ and the infrastructure experts they hire. Also, in order to track and visualize the data in a proper mode, organizations should have in place their own data scientists and business intelligence tools, as well (Parikh, T., 2018). With all these tasks done, external auditors still have no way but to spend time, cost and energy to review and approve the reliability and accuracy of data for the use by external stakeholders. The problem is that all these solutions are extremely time consuming and costly and they spend a significant portion of the vital resources owned by the organization. On the other hand, it should also be noted that the controlling policies and the preventive measures as well as the anti-fraud laws and strict internal controls limit the operational capacities of the company and reduce its agility (Amin Amid et al, 2012). Noteworthy, despite all these controls and audits, there are still financial scandals in different countries worldwide. Awolowo and Hogan listed the most famous scandals in the last two decades such as Enron accounting in 2001, WorldCom, Adelphia and Tyco in 2002, Parmalat accounting in 2003, Olympus in 2011, Tesco with 263$ million overstating in its profit 2014 and Toshiba in 2015. (Hogan et al, 2008 and Awolowo et al, 2016). Such financial crimes and irregularities are now the biggest challenges in the world of accounting.

Surprisingly, in all these cases deep hesitations are still detectable all over the available structures and financial statements and this comes as these official accounting statements were all fully and deeply reviewed by certified independent auditors who at the end provide the applicant company with high quality audit reports which cover the outcomes and consequences in and around the status of the company's financial statements. Bhasin stated that accounting scandals of any type have deep negative effects on the level of trust and credibility stakeholders share with the ongoing auditing procedures in an organization. (Bhasin, 2013) During these recent years and with the intensification of financial violations, legislators have made great efforts to establish new applied control systems including corporate governance (e.g., Sarbanes Oxley Act (SOA), Kings Report, and UK Code of Corporate Governance). (Awolowo et al, 2016). Regardless of what legislators have already done, the continuation and recurrence of such financial misconducts and scams prove that the adopted preventive methods and measures have not been effective. (Hogan et al, 2008). There seems to be a serious need for newer and more advanced technologies that are fully capable of minimizing the financial irregularities with the aim of stopping the severe losses that such acts of crimes may cause.

The Blockchain Technology

The Blockchain technology, introduced by Nakamoto, was first used to provide a decentralized platform for a public but secured access to digital currency data, for instance Bitcoin. (Nakamoto, 2008). With this in place, there is no further need for any intermediary financial services (Jun Dai et al, 2017). Blockchain, in its most common definition, is "a chain

of blocks that store information with digital signatures in a decentralized and distributed network." A Blockchain is a chain of shared chronological ordered (linear manner) information blocks (Swan 2015; Fanning and Centers 2016; Yermack 2017) that contains public ledger transactions data. (K. Salah et al, 2019). The Blockchain-based transactions take place in a decentralized environment without the presence of any auditing and reviewing mediators. (A. Litke et al, 2019). Distinctive characteristics such as decentralization, non-changeability, transparency, and auditability have made the Blockchain technology to be regarded as a highly protected platform for any types of transactions among different parties coming from the internal and/or external units of an organization. (A.A. Monrat et al, 2019). Enjoying such unique features, the Blockchain technology seems to be proper choice for processes in domains including accounting, auditing, project management, contract management, human resources management, and Supply Chain management. Using digital signatures and proving the capability of tracking the origin of any transactions all based on the technologies supporting the user's IP, this technology allows its users to experience the very most secure mode of performing transactions they have ever seen and practiced in their business life. (A. Biryukov et al, 2014).

There are two types of Blockchains; Public Blockchain and Private Blockchain or known as Permissioned Blockchain or Consortium Blockchain. The Public Blockchain is an open network where the information is available in a public mode and anyone can insert, read and view the data which will be immutable once after the validation. (Pilkington 2016). On the other hand, Private Blockchain or known as Permissioned Blockchain or Consortium Blockchain is an invitation-only network where every member will have access to the roles including viewing, reading and writing all granted by a central entity at the Blockchain. While offering a high level of security, privacy and reliability, the Private Blockchain network seeks to improve the decentralized nature of the Blockchain technology all based on the interests of the organizations including the matter of confidentialities, and so on. (AIPCA and CPA Canada, 2017).

Blockchain-based applications have increasingly been expanded in a variety of ranges with different functions for the use in different areas such as Supply Chain, healthcare, human resources, education, and data management. Blockchain brings new specific attributes and at the same time it enhances former characteristics like transparency, robustness, auditability, and security. (Christidis and Devetsikiotis, 2016). Smart Contracts plays an important role in using Blockchain in a variety of fields. Smart Contracts are automatic contracts stored in the Blockchain that are executed all based on a series of predetermined rules and conditions. This advantage allows the parties to a contract to experience confidence about the accuracy of all information and data circulating in a specific process, procedure, event, and so on. (Fran Casino et al, 2019). To enjoy the automatic spirit of this technology, these preset terms and conditions use a set of codes which are stored in a decentralized environment in the Blockchain. (Christidis and Devetsikiotis, 2016).

This feature enables the Blockchain-based systems to properly manage the most complex business processes and creates extensive relationships between a department with the its other internal departments and/or with its the external parties. (Fran Casino et al, 2019). Gausdal expressed that about one-third of G-suite (Google Apps) product owners are either being engaged with or considering the use of Blockchain (AH Gausdal et al, 2018). Several financial service organizations, governments, enterprises, and startups are considering utilization of Blockchain-based applications in their processes with the aim of managing the services, payments, procurement processes, accounting affairs, and human resources. Researches show that Supply Chains is the most promising sector for the application of Blockchain and its capabilities. (M Walport, 2016 & M. Staples et al, 2019).

ERP and Blockchain Research and Theories

It is undeniable that the integration of all companies' business processes has been a dream for many ERP providers (Hughes, D. L. et al, 2020). To properly use Blockchain in practice, a concept called Blockchain as a Service (Baas) has been invented that means creating a platform for implementing different parts of blockchain such as decentralized database, smart contract and nodes on the cloud (Onik, M. M. H., & Miraz, M. H., 2019). Using these concepts, SAP presented two cloud platforms named SAP HANA blockchain and SAP-Cloud Platform Blockchain Service (Onik, M. M. H., & Miraz, M. H., 2019). In theory, Blockchain offers several benefits to ERP systems and many researchers have studied the potential impact of introducing this technology to ERPs. For instance, Blockchain is able to alter ERPs from a separated system for a company to a multi-company platform where all stakeholders can actively collaborate on it (Kuvvarapu, R., & Kuvvarapu, B.,2018). Banerjee believes that supply chain can perform far efficient and productive with the help of Blockchain-based ERP (Banerjee, A, 2018). Blockchain's impacts on ERP can be considered from three perspectives: technically, process flow and compliance (Parikh, T., 2018). From technical perspective, Blockchain with the help of its decentralized network can create a platform for high speed transactions (Kaid, D., & Eljazzar, M. M., 2018). Blockchain can reduce the cost of transactions, particularly within supply chain management, as it utilizes a decentralized network (Schmidt, C. G., & Wagner, S. M., 2019). Transactional foundation of Blockchain enable it to enhance the effectiveness and productivity of financial procedures (Saurabh Ahluwalia et al, 2020). This technology also brings innovative solutions such as distributed ledger and smart contract to improve the performance of processes within organizations (Chang, S. E. et al, 2019). Consensus mechanism, transparency and immutability brought by Blockchain to ERPs can guarantee the high level of trust among all peers and answer the issues related to principal agent theory (C Chedrawi and P Howayeck, 2018). This technology almost obsoletes the need for monitoring business processes which currently is one of the main and crucial responsibilities of internal audit and corporate governance leading to sustained compliance to organizational rules and regulations (Kaal, W. A., 2021).

With blockchain-based ERP all peers are experiencing a systematic, accurate and immutable flow of information (Fran Casino et al, 2019). This combination will decrease arguments over financial transactions such as invoices and payments (Swan, M., 2018). Banerjee, A. named cost effectiveness and transparency as positive consequences resulted from the integration of ERP and Blockchain (Banerjee, A., 2018). To achieve these benefits, some researches have been conducted on presenting theoretical models in using Blockchain in ERPs even though we believe that more effort should be made to cover the significance of this subject comprehensively. Linke, D., and Strahringer, S. presented a model of purchase to pay process using SAP S/4HANA and Hyperledger Fabric (Linke, D., & Strahringer, S., 2018). Ranade, V. et al designed a model to illustrate the application of Blockchain in ERP using Hyperledger Fabric and Ethereum platform to prove the agility and transparency of data flow brought by Blockchain innovative qualities (Ranade, V. et al 2018). Banerjee, A. listed several companies which are developing blockchain-based ERPs such as FinLync and Skye which both integrated SAP with two famous blockchain platforms, Ethereum and Hyperledger (Banerjee, A., 2018). He also predicted that with developing middleware technologies, the connection between Blockchain and ERPs will become much achievable. As mentioned earlier in this paper, Blockchain and associated features and functions is going to revolutionize the future of information systems and with integrating with ERPs can increase the productivity and efficiency of organizations.

Methodology

Due to its novelty and since the number of researches on Blockchain and its impacts on the ERP systems is scarcely limited, extracting a model for the development of Blockchain-based ERP solutions is a challenging matter. (Zareravasan et al, 2020). For that reason, we used the Exploratory Content Analysis (ECA) to deeply review 129 different scholarly articles out of 300 in six areas of Finance, Human Capitals, Project Management, Maintenance, Manufacturing, and Supply Chain all based on the architecture of world-renowned ERPs such as SAP, Oracle and IFS to identify the functions needed to develop these systems in the future. We screened these 300 articles to include those publications whose content was related to potential application of Blockchain in ERP systems to the mentioned areas and should have qualities including achievability, efficiency and understandability. Those sources which proposed their blockchain functionality based on old and obsolete industrial methodology were excluded and only state of the art framework was used. We also excluded articles which described only technical aspect of blockchain without mentioning any functional application of it. As shown in Table 1, in each area, some of the best articles published in recent years were studied with the aim of finding the possibility of conducting new researches and/or introducing any probable and possible changes in this new domain. As you may read in the following pages, we through employing ECA have identified some functions and technologies in each area which are not supported by ERPs.

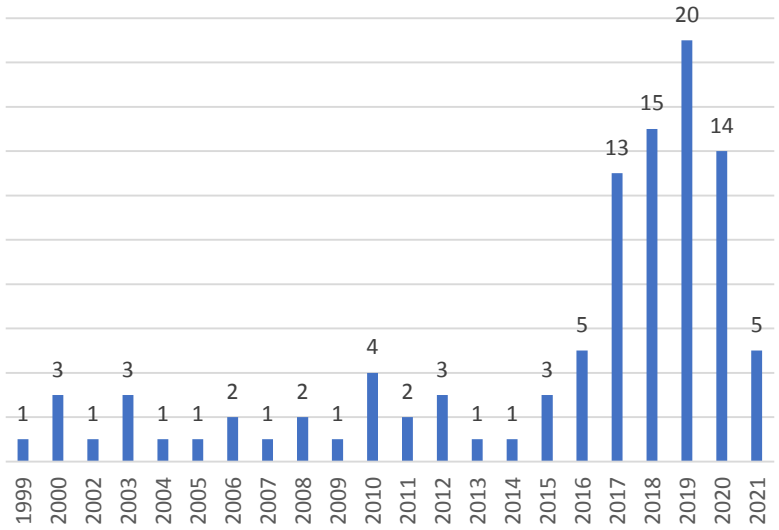

Figure 1 . Articles Divided by Publishing Date

Table 1 . Number of Articles in Each Area

Subject	**Count**
Finance	27
Blockchain	24
ERP	17
Supply Chain	15
Manufacturing	14
Project Management	14
Human Capital Management	9
Maintenance	9
	129

Results

What is tangible in all these researches is that solving the current ongoing issues in the business chain management process (these kind of issues are detectable in the internal relationships between different in-house departments of a local and/or an international organization and the relationship of the same organization with all its external parties including legislators and governments) depends on adding some loops that support issues including immutability of information, the ability to track and trace items, data security and corporate privacy, and building a high level of trust throughout the realm of the value chain. In most researches the following factors have been cited as the main benefits of using the Blockchain technology including an increase in the level of trust, a reduction in the costs required for data collecting processes, maintaining and auditing, agility, expanding

communication networks between different companies and industries located in different geographical areas, creating effective and profitable Supply Chain management methods, efficient use of equipment and assets, and creating efficient knowledge sharing processes. The synergy between the Blockchain and ERP intensifies the quality required for productivity, effectiveness, and efficiency of an organization. By adding up the inherent features of a Blockchain network to that of ERPs, the information flow can take a new look through being agile, secure and expanded. To achieve this goal, the local managing processes and functions in ERPs have to be replaced by the Blockchain's function of Smart Contracts in addition to Internet of Things (IoT), cloud computing, and digital wallets.

In the model presented in this paper, a number of these functions are described. Modules that can benefit from this synergy include Supply Chain management, maintenance, financial management, project management, manufacturing, and human capital management about which you may find more information below.

Supply Chain Management (SCM)

Supply Chain Management seeks to design, plan, execute, control, and monitor the Supply Chain activities with the aim of creating net value, competitive infrastructure, conditions for leveraging worldwide logistics, proper synchronization between supply and demand, and last but not least, grounds for measuring the performance from a global perspective." (ASCM: APICS Dictionary). The unprecedented expansion of global trade (S Saberi et al, 2019), and on the other hand, the story of the unbridled rise of counterfeit goods in global markets (Verma, M. 2021), has led the supply chain move from its current level of operation to a next level of Smart Supply Chain through focusing on principles of transparency, traceability, and trustability more than ever. (Saveen A et al, 2016). For instance, it is vital for healthcare organizations to be assured of standard quality of any incoming shipment. The trackability of products and material provenance in consortium blockchain guarantees that they are real.

The key ingredients of a perfect supply management are traceability and communication (Nanayakkara et al., 2015). While in a traditional Supply Chain management the common means for communication were telephone, mobile, email, and paperwork, Blockchain obsoletes these tools and introduces more functioning ones with its associated features (Jang, 2007). Trackability of distributed items in the Blockchain network increases the level of trust among all main parties. (Hughes, 2017 & Aste, Tasca, & Di Matteo, 2017 & Wang, Luo, & Lee, 2019). Furthermore, the Blockchain resolves traceability issues of Supply Chain (Lu & Xu, 2017) and increases the integration of all SCM functions (Cole et al., 2019). Table 2 shows the changes that can greatly help ERPs to achieve such a goal.

Table 2 . Supply Chain Module Suggested Features for Blockchain-based ERP

Supply Chain Module	
ERP Features	**Change Description**
Part Catalogue	**Global Part Number:** The Blockchain offers a decentralized and publicly available data warehouse which contains a unique Part Number generated by manufacturers participating in the Blockchain network. This unique Part Number contains information including description, Unit of Measure (UoM), manufacturer, configuration, characteristics, transportation data, and supplier for purchased parts. (Banerjee, 2018). For example, many products or materials may be temperature sensitive or equipment can be sensitive to vibration, or electronic components could be sensitive to humidity.
Business Partners	**Business Partners Library:** The Blockchain offers a decentralized, publicly available data warehouse containing all business information including address, contact information, quality certifications, payment, and delivery terms that are required for doing trades with companies joining the Blockchain network (Banerjee, 2018).
Procurement	**E-Procurement:** The Blockchain with the help of Smart Contract brings every business rule into predefined codes and commands to make all processes such as purchase requisition verification, sourcing, and request for quotation, ordering, receiving, purchase order (PO) confirmation, supplier agreements, invoicing, and payment progress automatic. (Mir Hassan & Adnan Iftekhar, 2020).
Purchased Part Inspection	**Material Tracing**: The origin, specification, and integrity of materials purchased through the Blockchain-based Supply Chain are transparent enough to enhance counterfeit detection. (Montecchi, et al, 2019).
Supplier Evaluation	**Global Supplier Evaluation:** As a decentralized, immutable, and publicly available data set, all companies can share their criteria, experience, and evaluation scores to vendors joining the Blockchain Network. Also, lead times and inspection results of any procurement process is available for companies participating in the Blockchain Network. (Z Li et al, 2020).
Shipment	**Smart Shipment:** The Blockchain with the help of Smart Contract and its decentralized database offers a high level of traceability to all shipments. Using permissioned Blockchain network, the companies can monitor and be informed about their case shipment conditions all based on the real-time information. (H Hasan et al, 2019).

Maintenance

One of the key factors in having an efficient production process as well as preventing abrupt costs and production downtime is the use of an intelligent, agile, and proactive maintenance system. (Chang, F et al. 2019). This specific maintenance system enjoys features including fault diagnosis system, maintenance planning algorithm, smart selection system of providers, and system for scheduling the plans by the executors. (Chang, F et al. 2021). Traditional maintenance methods were not efficient and effective, and so the expectation here with the complexities in the production methods such as Just in Time (JIT) is that such new and advanced methods fully prevent the previous breakdowns and failures. (X Zhang et al, 2018). In addition, several researchers have addressed the challenges surrounding the information security and privacy while they share data in ERP maintenance modules. (Makhdoom et al, 2020). To deal with such challenges, the Blockchain technology provides a high level of information security using its immutability, transparency, and traceability capabilities. (Abbas, Y. et al, 2020). Modern maintenance systems with the help of the Blockchain

technology can illustrate the real-time condition of operation, maintenance resource, and optimal Service Level Agreement (SLA) (Holgado, 2019) that could enable advanced analysis and lead to intelligent controls.

Table 3 shows some of the functions that could be added to the maintenance module by employing the Blockchain capabilities.

Table 3. Maintenance Module Suggested Features for Blockchain-based ERP

Maintenance Module	
ERP Features	**Change Description**
Work Order Management	**1.** Crowdsourcing on Work Order Execution: **The Blockchain drastically changes work order planning and execution in ERP Systems. Every Order could be operated by a crowd of trusted workers whose service levels are under supervision by the Blockchain network. (Li, M et al, 2018).** 2. **SLA Control & Enforcement:** Issuing work order, appointing or bidding vendors, conducting follow-ups over the performance of the technicians, validating spare part ordering, and every detail related to the operating work orders are monitored by smart machines operating under the rule of Smart Contracts. These contracts are based on Service Level Agreements (SLA). The payment for the maintenance agencies and spare part vendors are processed by crypto currencies which are validated by Smart Contracts. (Scheid, E. J et al, 2019).
Preventive Maintenance	1. **Automatic Fault Diagnosis (AFD):** The Automatic Fault Diagnosis (AFD) is one the potentialities that the Blockchain brings forward for predicting equipment failures. It allows the companies in the network to issue diagnostic requests and participate in decentralized failure analysis. Every Failure has a vast majority of history in different companies and with sharing such cases in the network it adds up to the promised synergy vowed by the Blockchain. (X. Zhang and M. Fan et al, 2018). 2. **Advanced Analytics:** The Blockchain technology could enable ERP systems to use Advanced Analytics for preventive maintenance. This technology in combination with IOT could enable companies to log every change in every equipment in different blocks and it could be a significant source to run advanced analytics all based on the Blockchain. (AH Gausdal et al, 2018). By using advanced analytics, expected End-of-Life (EoL) of the assets, recommendations about the assets' maintenance, and early identification of problems or malfunctions could be handled. 3. **Process Simulation:** This is another new feature in the Blockchain-based ERP systems. It provides several scenarios, predicts solutions, analyzes processes, and deals with questions that may arise in the preventive maintenance of equipment. (Li, Z et al, 2020).
Equipment Administration	1. **Intelligent Machinery Monitoring:** By using Smart Contracts, ERP system could enable the monitoring process of equipment, invoke conditions, and create alerts for maintenance agencies in the Blockchain network. In addition, the Smart Contracts monitor the state and the history of changes in every machine which include updating or replacing the features all based on real-time conditions. (XL Liu et al, 2020). 2. **Distributed Asset Registry:** A scalable registry of equipment which is accessible to all parties in the supply network is another new feature in the Blockchain-based ERPs. This registry contains every change in assets and all recent updates by manufacturers, maintenance agencies, product designers, and inspection parties. (S Ølnes et al, 2017). 3. **Real-time Traceability of Assets:** All maintenance activities could be traced online through a network by any participating company. Moreover, the status of all assets through its life cycle could be tracked and monitored by the related technicians. The technicians have direct access to the history of installment, maintenance, and support of these assets. (Tian F, 2017). Every company has access to the latest information including the faults and problems not only by the company itself but also by every company in the Blockchain network. (66. Ho, G. T. S. et al, 2021).

Financial Management

Financial Management is one of the fields that can greatly benefit from the features of the Blockchain technology. All financial information can be stored in a Blockchain environment and can be provided to stakeholders in a timely and reliable manner. Also, due to the immutability of the information blocks and the high security of the Blockchain, the auditing of financial data is an easy and effective task. Addressing issues surrounding the Agency and the Policeman theories, features including trackability, traceability, and immutability can greatly prevent financial scandals, attract investors, secure investment in markets, and increase credibility of the accounting profession. Smart Contract along with its associated IOT can also facilitate the collection and monitoring of financial data and make them available in a timely manner for appropriate analysis. (Jun Dai et al, 2017). The term "Decentralized Finance" is a topic of debate in many industries today. Unlike centralized financial systems, in which financial institutions play an important role in conducting transactions, in a decentralized financial system, the main goal is to eliminate the intermediary roles; a process that ultimately will make agility and effectiveness of peer-to-peer transactions in the economic cycle. (Chen, Y., & Bellavitis, C., 2020). Moreover, many researchers have been studying a disruptive innovation called Triple-entry Accounting (Elias, 2011; Tyra 2014). In Triple-entry accounting using Blockchain technology, accounting records are no longer just recorded independently by the parties to the transaction, but these entries are recorded using Smart Contact and are protected by a third record in the blockchain space. With this method, there is no possibility of human error or manipulation of accounting records and it leads to the high quality and reliability of financial statements and prevents financial scandals to a considerable extent. (Grigg, I. 2005) With this method in place and with the presence of the characteristics (e.g., immutability) of the Permissioned Blockchain, the reliability of financial information will be increased and the need for time-consuming and costly audit processes will be reduced (Jun Dai et al, 2017). Additionally, to protect the privacy of companies' confidential information, the Blockchain keeps all information encrypted and only members who have the password keys will be allowed to have access to the information they need. (Jun Dai et al, 2017). Table 4 contains suggestions for changes in ERPs' financial modules for the utilization in the Blockchain.

Table 4. Financial Module Suggested Features for Blockchain-based ERP

Financial Module	
ERP Features	**Change Description**
Accounting Rules	1. **Standard Chart of Account (COA):** A standard COA can be created and stored in a decentralized database in the Blockchain network. This enables all members to use the same Accounts and Code Parts. This privilege increases uniformity, transparency, better interpretation of transactions, and efficient auditing. 2. **Unified Posting Control:** A Unified Posting Control is a coded system for posting all transactions to relative accounts and general ledgers, automatically. (Grigg, I. 2005).
Financial Accounting	1. **Distributed General Ledger:** Using the Blockchain technology and Smart Contracts, companies can enter all the accounting vouchers and those information blocks related to each transaction. This action is

Financial Module	
	only available after the occurrence of a transaction and its approval according to the posting controls coded in the Smart Contract in the General Ledger. (Dai, J., & Vasarhelyi, M. A. (2017)). 2. **Smart Audit:** The approval of vouchers and the validity of monetary information in the financial statements are performed by the Blockchain and Smart Contract. (Faccia, A., & Mosteanu, N. R. (2019)). Blockchain offers a permanent, tamper-resistant audit trail across even highly-complex business ecosystems. This gives finance and accounting professionals end to end transparency across organizational operations. 3. **Real-Time Financial Statement:** All financial statements including the balance sheet, income statement, statement of cash flow, statement of changes in equity, and notes are generated based on general ledger information and all external and internal stakeholders will have timely and economic access to such reports. (Yu, T., Lin, Z., & Tang, Q. 2018).
Treasury Accounting	1. **Autopay:** When a Purchase Order Line arrives, and all preset terms and conditions are met, the payment process is automatically initiated, and in any step if supplier goes out of compliance the payment process is automatically revoked. In fact, Blockchain merges the movement of money with the Account Payable transactions (Narayanam, K., Goel). 2. **Auto Receive:** When a Customer Order Line is delivered, and all preset terms and conditions are met, the related invoice is sent to customer and the payment process is automatically initiated, and in any step if customer goes out of compliance the payment process is automatically revoked. In fact, Blockchain merges the movement of money with the Account Payable transactions (Narayanam, K., Goel)
Budgeting	1. **Smart Budgeting:** A scheduled budget process is initiated by the budget unit through carrying and distributing all information needed for a networked environment where all budget centers can suggest their budget amounts. Entire process is transparently monitored and remains immutable after sending back to the budget unit. (Молчанова, С. М. 2020). 2. **Automatic Budget Control:** Since in a Blockchain environment all financial transactions are recorded instantly and processed economically with considerably high speed, it is possible to perform timely budget controls (Молчанова, С. М. 2020).

Project Management

Today, the construction and engineering projects have become much more complicated so there is a sensible need for conducting actions including performance management, project control, legal issues, and contractor relations. There are also many factors that could affect the success of a project. For example, researchers found that the lack of effective communication as well as cooperation are two main reasons for project failures. (Turk, Ž., & Klinc, R., 2017). Also due to the legal requirements issued by legislators as well as the risk and the complexity of projects, trust, transparency, being trackable, and privacy have turned to be among highly significant issues in project management. (Laan, A. et al, 2011). The Blockchain technology and its associated Smart Contracts provide project managers with functions to facilitate project planning, subcontract management, progression monitoring, project Supply Chain management, and knowledge sharing. Table 5 shows the potential improvements of the Blockchain in the ERP systems that covers projects' life cycle.

Table 5. Project Management Module Suggested Features for Blockchain-based ERP

Project Management Module	
ERP Features	**Change Description**
Project Initiation and Planning	1. **Intelligent Project Configuration Database:** The changes in a project item could be registered in an intelligent project configuration database that will subsequently can be tracked by the Smart Contracts in the Blockchain network. (Pastor et al, 2018). 2. **Smart Sub Contracts:** All contract obligations and settlements are configured in the environment of the system and based on predetermined events, the rules will be run at specific times. On that basis, there is no need for any further meeting to reach agreement. (Hewavitharana et al, 2019). 3. **Intelligent Project Planning based on Smart Contract:** The Blockchain provides a unique platform for sharing project planning data all across its network to get the acceptance of all stakeholders for every and any changes in the plan. Additionally, every change could be logged and integrated with the Smart Contracts that could be fired automatically when the agreed results are reached. (Lee, E., & Yoon, Y. I. 2019).
Project Execution, Monitoring & Control	1. **Automatic Updating of Project Status:** By eliminating the verification time of the documents authenticity, improving transparency among parties, and using disruptive technologies like Building Information Modeling (BIM) and IOT, the data that are required for the updating process of the project status will be accessible. Therefore, ERP systems can automatically update the progress of the projects and their status all based on the real-time information which are gathered from different business processes and procedures. (Wang, J. et al, 2017). 2. **Automatic Traceability of Project Items:** Coordinating tasks between parties, managing digital records, exchanging digital assets, and keeping the changes of all project items could be traced by the Blockchain-based ERP system. Technologies like BIM and IOT could also enable companies to record all events and changes in project items and this could help project management specialists to balance costs, scope and time of the projects all based on the real changes. (Amoah, E., & Oh, J. Y., 2020). 3. **Automatic Project Material Requisition:** With integrating technologies like IOT and the Blockchain, the ERP systems will be enabled to automatically provide material monitoring systems and issue orders when needed. In case of requesting any materials, all previously stored related information like sources, characteristics, and attributes could be accessible by the ERP systems through the Blockchain network that covers and traces the area including the vendors, manufacturers, and even sub-contractors. (Shojaei et al, 2019).
Project Close	1. **Smart Contract Fulfilment Tool:** Smart Contracts are event-driven and autonomous machined readable codes. (Mohanta, B. K. et al, 2018). Based on Smart Contract's rules and all previously gathered data located in the database, the ERP can intelligently decide over the time to bring an end to a project activity. (Lamb, K., 2018). 2. **Distributed Knowledge Database:** The lessons learned from different projects, documents, and records could be shared with project stakeholders. The knowledge engine gathers all information from project events and stores them in a reliable and sharable data warehouse. (Pastor et al, 2018).

Manufacturing

A rise in the number of products manufactured around the world and the complexity of the Supply Chain processes have made the use of modern and digital manufacturing solutions such as Industry 4 more vital. (SA Abeyratne, 2016). In the current methods of production, a

series of issues and problems are observed that need to be addressed through using up-to-date technologies. (Khan, P. W., & Byun, Y., 2020). Manufacturers have requested systems and methods that are able to provide certainty about the reliability and the quality of the products and equipment. (Shahbazi, Z., & Byun, Y. C., 2020). These methods usually lack the trust between Supply Chain parties as there is insufficient management and monitoring over the required processes. (Wang, B et al. 2021). While Industry 4, with the proper use of smart technologies, machine-to-machine communication, and IOT leads to a high level of automation in monitoring production processes (S.M.H.Bamakan et al.2021), troubleshooting, and eliminating the intermediation role of human (H Kagermann et al. 2011), it has yet to cope with some challenges ahead including connectivity and exchange of information. (K Collins, 2020). Combination of Industry 4 and the Blockchain technology could result in a significant enhancement in traceability, trackability, transparency, efficiency, and profitability of any future manufacturing processes. (Shahbazi, Z., & Byun, Y. C., 2021).

Table 6 presents capabilities that have to be added up to ERPs to make them empowered to deal with above mentioned challenge that may affect the future industry.

Table 6. Manufacturing Module Suggested Features for Blockchain-based ERP

Manufacturing and Quality Management Module	
ERP Features	**Change Description**
Product Design	1. **Product Digital Identity:** Each product in the Blockchain network has its own digital identity. It could be in the form of an attachable RFID or QR barcode which is placed on the physical product, carrying information including their description, location, certifications, and so on. The identity which is encrypted at least by public and private keys could be tracked in the network from creation to extinction. (SA Abeyratne, 2016). 2. **Digital Twin:** The Blockchain technology enables different suppliers and manufacturers to participate in designing virtual products. All actions of a digital twin over a product are registered through the network and the ERP systems could enhance the process of designing and testing of the new products by using Peer to Peer (P2P) networks. (94. Huang et al, 2020). By using this new feature in ERP systems, insufficient information about product design could be extracted and subsequently they could be shared between participants in all stages of the product life cycle. (Tao, F. et al, 2020)
Production Schedule	1. **Collaborative Production Scheduling (CPS):** With the rise of collaborative manufacturing and using the Blockchain technology, firms could use CPS and P2P networks to control the scheduling manufacturing processes that are supported by Smart Contracts. The capacity information CPS and P2P networks will be stored in the decentralized databases of Blockchain network. (Lohmer, J., 2019).
Resource Utilization	1. **Resource Operation Blockchain (ROB):** Sharing resources based on their capacity and operation with other companies participating in the Blockchain network is the main function of ROB solution in a Blockchain-based ERP system. By implementing Smart Contracts and device to device communication, this new function could enhance resource utilization rate. (Xu, H. et al, 2020). This function could be implemented both for Job shops and process manufacturing that follow a shared manufacturing approach to assemble new products. (Yu, C. et al,2020). 2. **Real-Time Surveillance:** Through using the real-time surveillance tools in the Blockchain-based ERP systems, costs could be reduced. (Ko, T. et al, 2018). By using this tool, all necessary information about processing shop orders will be shared with other participating companies through the Blockchain network.

Human Capital Management

The reliability of human capital information has a great impact on increasing the productivity and efficiency of human resources management. The authenticity of human resources can support and enhance the effectiveness of the recruitment process. (Wang, X et al, 2017). Companies actually face many risks when recruiting the human resources; a factor which can later have negative impacts on the overall performance of the organization. For example, job seekers often try to change the interviewer's opinion in their favor by giving unrealistic and exaggerated information. Wang lists the information that is most effective in reducing risks surrounding the human resources issue, including age, marital status, health record, work experience, educational background and certificates, salary background, job evaluation results, career advancement, bonuses, and penalties. (Wang, X et al, 2017). All this information could be provided to human resources units in the Blockchain environment to help the decision-making process be highly reliable, transparent, and secure. In addition, after hiring, the manpower needs training, adaptation, welfare, and facilities to be able to use their maximum performance capacity.

Table 7 shows the improvement points that can lead the ERPs HR module to use the Blockchain technology, properly.

Table 7. Human Resource Management Module Suggested Features for Blockchain-based ERP

Human Capital Management Module	
ERP Features	**Change Description**
Employee Administration	1. **Candidate Verification Tool:** As the fake information by the candidates is one the major problems in the recruitment process, the Blockchain technology provides an opportunity to verify and validate candidates' resumes all based on different databases in the network. (MMH Onik et al, 2018). Companies can check candidates' background through their IDs in Recruitment Blockchain networks and their certificates' authenticity, proper references, criminal history, and their claimed experiences. (CSS Yi et al, 2020). On other hand, candidates could manage sharing their information including birth date, citizenship, financials, and educational records in virtual blocks and only in case of their consent, the employers could use the related information for the verification processes. (D Tapscott, A Tapscott, 2017; Michailidis, M. P., 2021). 2. **HR Smart Contracts:** Smart Contracts with employees could change the HR processes significantly. Based on Smart Contracts and its full control over the performance of the employees, rewards, salaries, and welfare services could automatically be settled. Based on Smart Contracts, annual performance evaluation of employees could occur in shorter periods and this information could be used by next employer when he/she is going to verify the status of an employee from the view point of claims about his/her experiences and abilities. (DC Coita et al, 2019). 3. **Intelligent Health Monitoring:** By using the Blockchain technology, ERP could analyze and improve the health quality and status of employees. The employees' health records could be tracked and monitored, and the potential problems will be forecasted, and the early alarms will be raised in case of detecting any health-related problems. (S Bhattacharya et al, 2019).
HR Organization and Structure	1. **Employment Record Management:** All employee-related records like training, health, education certificates, enrollment advantages, performance reviews, and so on are registered in a central repository that could be accessed and updated by internal and external stakeholders. The Blockchain could save time for data entry and validating employees' records in ERP systems. (CSS Yi et al, 2020).
Human Capital	1. **Smart Team Builder:** Since the new organizations have tough times in matching

Human Capital Management Module	
Competency Management	different people with different skills for different projects and teams, the Blockchain with the use of Artificial Intelligence (AI) could help them to choose the best ones through using and selecting from the entire pool of employees all based on their latest performance, skill tests, expertise, and trainings. This trend reduces risks of conflict. (E Markopoulos et al, 2019). 2. **Qualification-Competence Register:** The qualification characteristics of the employees are accessible to employers in different databases as they are registered around the web. Something such as certificates of participation in professional contests and competitions, employees' personal interests, performance scores, and education background could all be easily assessed and verified through the Blockchain network. The competency model which is created by this register is more reliable for HR business partners. (NN Pokrovskaia et al, 2018).
Salary and Compensation Management	1. **Salary Reference Check:** The salary information is stored in distributed databases and could be accessed through predefined privileges by different parties to verify salary information. Moreover, all governmental and insurance agencies could check salary history which is unchangeable in the Blockchain network. (Wang, X et al, 2017).

Discussion

With the introduction of the Blockchain technology in the field of information systems, a fundamental change has occurred in this field and consequently the ERP system will be affected by these changes. At present, due to the complexity and ambiguity in the field of the Blockchain and the novelty of research in this field, many changes are still unclear. In this research, an attempt was made to summarize the existing researches and present a model providing a new research path to study the changes in the future ERP systems. The proposed model has different aspects and we have tried to examine the changes made in the ERP systems from different angles. We have also tried to figure out the operation quality of a future ERP system in a large interconnected network and find about the possible solutions over all mentioned issues in and around the ERP with the help of the emerging Blockchain technology. Also, this model illustrates the position of Smart Contract in the ERP systems, how to connect together each ERP-based contract with different modules and how to use different technologies.

Compared to previous researches that focused more on the impact of blockchain on ERP modules such as supply chain or finance separately, this research focuses more on providing an integrated architecture for creating a new generation of ERP systems. Therefore, researchers have tried to provide a common understanding of future developments by providing a conceptual architecture model of a blockchain-based ERP system. In addition, the difference between these paper and former articles is in the study of the influence of new technologies such as smart contracts or fourth-generation technologies on blockchain-based ERP systems. Researchers have tried to examine the changes in each module of the ERP system from a practical perspective and explain the capabilities of a blockchain-based ERP system. Some articles, such as Basl and Novakava's research (Basl, J., & Novakova, 2019) or Wamba et al. (Wamba et al., 2018), have examined fourth-generation ERP models. Still, none

have explicitly described a blockchain-based ERP system and have not provided the details and dimensions of such a system with its applications.

According to the studies performed by the Exploratory Content Analysis (ECA), the necessary changes were extracted for each of the modules of the ERP system all based on the published scientific articles. These changes are based on the analyzes provided by researchers in each field, and therefore, in future research, new aspects of changes in business processes may be discovered through the introduction of the Blockchain technology. Using the ECA, we have presented a model that could be used as an architectural model of the Blockchain-based ERP solution. In this model, the functions of the Blockchain technology in six areas of supply chain, maintenance, finance, project management, manufacturing, and human capital management are described. In addition to the said areas, we also described the characteristics of IoT, Smart Contracts, Digital Wallets, Cloud Computing, and Building Information Model that as the most dominant supportive technologies must be placed next to each function to empower the use of the Blockchain technology.

Smart Contracts are one of the most exciting features of the Blockchain that play a very important role in reducing the complexity and cost of organizational processes. The self-executing feature of Smart Contracts allows, for example, when predetermined terms and conditions are met, the automatic payment to be completed and/or the delivery of goods and services take its steps and process. IOT in the ERP provides real-time data from machines, equipment, and other assets for stakeholders enabling them to be updated and informed. However, this information must be reliable, and accurate to be the base of an effective decision-making process. IOT in the Blockchain network can flow data among stakeholders in a far secure and temper-resistant mode leading to high immutable, reliable, and accurate data for decision-making process. Blockchain and IoT capabilities help users monitor the organization's activities, evaluate their performance, find areas for improvement and issues, take appropriate preventive measures, and respond to those issues with appropriate flexibility.

Digital wallet is another technology that can revolutionize the organization's cash flow by integrating with ERP and blockchain. Using public and private keys, each Digital Wallet is used to receive and pay bills for goods and services, staff salaries, taxes and other expenses without the need for an intermediary such as financial institutions and banks with lower cost and higher security. Cloud Computing is a set of servers on the Internet which stores, maintains and manages information with less cost and higher efficiency (C. V. N. U. B. Murthy et al, 2020). Integrating Blockchain and Cloud Computing brings the high level of privacy, availability and security of information to ERPs. Building Information Modeling (BIM) is another technology that will support extending Blockchain to areas such as project management and manufacturing. This technology as a digital representation of a building or any structure could use as a distributed ledger to record all changes in physical structures, help technicians to track efficient material consumption and facilitate controlling contract with suppliers and sub-contractors.

The architecture model that represents all functional areas and supporting technologies is illustrated in figure 2.

Figure 2 . Blockchain-based ERP Architecture

Implication for Research and Practice

The first application this research may have for the other researchers is to create a comprehensive model that includes all the ERP system modules based on the Blockchain technology. Thus, this model could be used as a cornerstone for more extensive researches on each of the modules of the ERP system, the underuse basic technologies as well as examining the implementation of various dimensions of the ERP system. The presentation of such a model had been neglected in previous researches, as most researchers had been focusing only on one module and examining the dimensions of the Blockchain impact on that area. The next application of the research is for a group of researchers who are working on changes in organizational processes due to the arrival of the Blockchain. This group of researchers can use the model presented in this study to examine the extent of changes in process models due to the increase in inter-organizational collaboration and the need for transparency in processes.

Another application of this research is for researchers who work on changes in information systems architecture models in the world of Blockchain technology. The method of achieving the model presented in this research could significantly help similar articles on how changes can be made to various information systems by the Blockchain technology and how a graphical diagram could create a better understanding of future changes in single view. The perspective presented in this paper, which is mostly based on the modification ERP modules, can be used to examine changes in other types of information systems. This view can also be replaced by a functional or a process group perspective to provide architectural models. In this study, researchers reviewed several articles and many technologies were examined in order to analyze and classify the relationships between supportive technologies and the Blockchain and the role of these technologies in future changes, therefore another application of this research is to representing a classification of supportive and complementary Blockchain technologies. Given that this study could be a source of inspiration for new researches, less attention was paid to this and therefore this field is new for more explorations and discoveries.

The ERP systems have changed a lot since their advent. Their changes from MRP systems to ERP II have all been in the direction of increasing the penetration of this system in the business processes of organizations. But today, the ERP systems are facing new challenges with the advent of new technologies such as the Blockchain and the Internet of Things. In addition, the increasing demand for ERP-based cloud computing systems has led to major changes in the business model of companies developing ERP systems. This article has tried to summarize these cases and their effects on the ERP systems in a model. The first application of this model is to provide a macro architecture for designing the ERP systems based on the Blockchain network. This model describes how to change the various modules of the ERP systems to respond to emerging requirements. The proposed model can also be used as a tool to verify the claims of the Blockchain ERP developers. The second application

of this research is to establish a two-way relationship between the properties of the ERP systems and the characteristics of the Blockchain. By expressing the salient features of a Blockchain-based ERP system, many future changes can be identified and, as a measure, these changes could be categorized according to the characteristics of the Blockchain network. Thus, with such criteria in place, the functions (feature) that are needed to be changed after adapting to the Blockchain, the functions that are obsoleted, and the new functions that are created can be identified. The criteria that has been presented in this model could be used as a filter on any requirement while it helps us identify the way changes come forth. The third application of the present study for the ERP system developers is to determine how to use Smart Contract infrastructure in designing new features of a Blockchain-based ERP system. It has always been debated how stakeholders could interact in a trust-based Blockchain system and how it can also be financially and legally supported. The answer to this question in this research is in the form of how to conclude Smart Contracts as well as the application of these contracts in the new functions of the Blockchain-based ERPs.

The application of this research, on the other hand, is for companies that want to update their ERP systems due to changes in the Blockchain technology or purchase a new generation of the Blockchain-based ERP system, or requesting services offers by the ERP cloud providers. These companies can use the list of functions provided in the architectural model of this research to evaluate the ERP suppliers. As most the ERP vendors shift to the Blockchain-based solutions, their competition for new capabilities will be much intensive, and gradually these companies will try to buy smaller companies, develop new startups or merge with their competitors to offer better options to their customers in a competitive market. Usually in choosing between the ERP vendors in the future, supporting the applications of the Blockchain technology will be one of the competitive advantages and therefore choosing a system that could use this technology in practice to improve its weaknesses and also provide better services to the value chain will become a key measure in the selection process.

Another implication of this scientific research is for decision makers in the public and private sectors. Using this research, they can identify their expectations of a blockchain-based ERP system and even create new ideas and requirements and also estimate the amount of investment required to develop such systems. Given that the development of ERP systems has always been costly, the existence of such an architecture can serve as a guide to such a huge investment in the right, effective and efficient way. However, it seems that to develop a blockchain-based ERP system, there is always a need for more detailed architectures, and more research is needed to depict these details for each of the ERP modules. In addition, legislators and government agencies can use this architecture to create regulatory rules and regulations for the next generation of blockchain-based ERPs. As the blockchain extensively alter ERP systems, new generation of rules and regulations for inert-company networks, financial transactions based on cryptocurrencies and also monitoring transactions for tax legislations should be established and monitored.

Conclusion

The Blockchain, as a disruptive technology, will revolutionize the future of information systems. The ERP systems, as the most important information system used globally in organizations, will be greatly influenced by the Blockchain technology. Unfortunately, so far very little research has been published in this field (less than 15 cases until the publication of this article). Therefore, in this paper, by focusing on the effects of the Blockchain and its associated technologies covering the processes and modules of the ERPs, we have tried to model how to implement these effects in the ERP platform and provide an integrated architecture for fundamental changes. The proposed architecture, which has been extracted through using the Exploratory Content Analysis (ECA) and by reviewing more than three hundred articles in the field of the Blockchain between 2017 to 2021, includes processes that change with the introduction of the Blockchain technology. This model also includes new functions that could be developed by the ERP systems and supportive technologies, as well. This model through better deployment of these functions leads us to the achievement of the goals by the Blockchain technology including transparency, traceability, immutability, decentralized processing, and process integrity.

The main contribution of this paper, as one of the first researches in this field, is to provide an integrated architecture for the new generation of the Blockchain-based ERP systems. To date, no integrated architectural model has been proposed to examine changes in the Blockchain technology on the ERP systems, and previous researches had only examined the impact of the Blockchain technology on one part of the organization's business processes. Each of these changes and functions has been extracted by examining the models and proposals presented in each of the six areas of finance, human capital, maintenance, supply chain, project management, and manufacturing. In designing this model, first the effect of the previous studies and researches in each of these areas were examined and in the next step the essential capabilities which must be developed in the ERP systems to respond to these changes were determined. The researchers in this paper believe that the proposed model could be used as a reference for future researches in the field of information systems and the ERP to examine the changes made by the Blockchain technology. In addition, researchers in the field of business processes could use this research to examine the dimensions of changes caused by the Blockchain technology in organizations.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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