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Integrating Blockchain with ERP systems for better supply chain performance

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***Abstract*— Technology evolution has long allowed for the better supply chain management. Now, the world is experiencing the emergence of new technologies: for example, blockchain technology. This technology has already proven itself in several areas, including the financial sector. It is now a question of exploiting it with Enterprise Resource Planning systems (ERP) to improve the supply chain performance. Thanks to a study of the literature, we were able to present how blockchain can improve the supply chain management by integrating it with ERP systems and the problems it can solve.**

Keywords— Blockchain, ERP systems, supply chain.

I. INTRODUCTION

Technological advancement that world knows opens several possibilities to address some problems that the supply chain suffers. This evolution allows for new management perspectives to fill traditional system's void.

This evolution had begun with control system inventory, which was the software that managed traditional inventory processes [1]. Then, there was production-oriented information systems known as Material Requirement Planning (MRP) [1]. This system developed and became even more sophisticated, being able to manage practically all of company's resources, it became known as Manufacturing Resource Planning (MRP II) [1]. The last improvement of MRP II was ERP (Enterprise Resource Planning) which, unlike MRP II, allows plannings and scheduling of supplier resources according to demands and dynamic schedules of customers in real-time [2].

It is now about integrating a new technology, which is blockchain, alongside ERP to improve the supply chain management [3]. In other words, blockchain would be a complementary technology to ERP systems.

Blockchain can be defined as open registry that allows transactions between two parties to be established in efficient, permanent, and verifiable way [4] [5]. Transactions can be made without a third party. This feature is called veracity, it is among the most appreciated features of blockchain [6] [3].

Blockchain technology can be beneficial to the entire supply chain. It can bring several benefits. Such as minimizing transportation costs, reducing errors and delays, increasing trust, improving logistics operations, and increasing the supply chain sustainability [7].

Despite the many benefits that blockchain can bring to the supply chain management, it is unlikely to replace ERP systems. It would therefore be interesting to study the integration of this new technology into the supply chain alongside ERP systems [3].

First, this article deals with ERP systems. The next point is about blockchain technology. Ultimately, blockchain integration with ERP systems is presented.

II. LITERATURE REVIEW

A. ERP systems

Several definitions have been presented in the literature to define ERP systems. We have gathered the most relevant of them to shed more light on what ERP is and why companies are moving toward these systems.

ERP has been defined as configurable commercial off-the-shelf (COTS system), integrated into several companies' functions [8]. That is, standard IT product designed for several companies in several geographical locations [9]. Indeed, ERP is generally designed by its vendor to be used in several environments [10]. However, it can also be configured and parameterized to fulfill the company's needs. Therefore, we can also define it as software package that manages company's internal activities [11].

ERP is modular system, developed by vendor, based on single database, procedures and management rules, with set of standard functions (Purchasing, Sales, Production, Human Resources, Accounting, Finance, etc). It was designed not only to standardize and automate existing business processes but also to provide industry best practices [12].

We can therefore, summarize ERP systems definition in five essential points:

- ERP is a standard computer product designed by vendor for several companies ;
- ERP manages and integrates all the internal functions of the company;

- ERP is based on a single database, procedures and management rules ;
- ERP brings best practices to company's existing processes ;
- ERP is modular, each module can be configured to meet the customer's need ;

B. Blockchain Technology

Blockchain technology can be seen as structured set of data grouped in blocks form chained to each other [6]. These data are secured thanks to cryptography [6]. Each block contains cryptographic hash of the previous blocks and timestamp [12]. Block can also contain information from few transactions [12]. Blockchain size is currently limited, but it will continue to grow over time [13].

Blockchain technology is part of a larger family which is the Distributed Ledger Technology (DLT). DLT technology has the particularity of distributed registers [13]. Blockchain is therefore grouped in the form of "peer-to-peer" networks adhering to collective protocol for communication between nodes and validation of new transactions [14]. Once recorded, the data cannot be modified without the consent of most network users [6].

Blockchain is then decentralized system [13]. We can explain the difference between centralized and decentralized system from their level of control [13]. Indeed, centralized system is controlled from a single entity [13], which can be person, company or institution [13]. However, decentralized system control is divided among several independent entities [13]. Figure.1 shows the difference between a centralized, decentralized and distributed network [13].

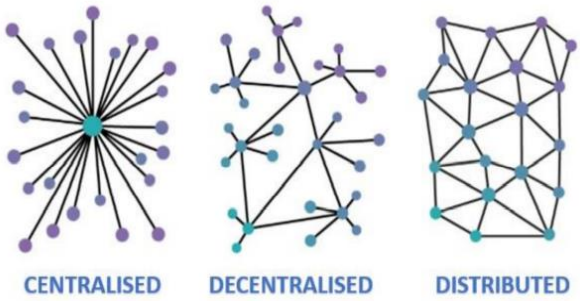

Fig. 1. Centralised, decentralised and distributed network.

Iansiti and Lakhani defined blockchain according to five characteristics [4]. The first is that it is distributed database with the same access for each user [4]. The second is that this network works with peer-to-peer link connecting its users [4]. The third is system transparency since each transaction is visible to each user [4]. The fourth is transaction irreversibility, no modification can be made because it will affect the other blocks. And, finally the fifth characteristic is the register digitalization, this characteristic allows the use of algorithms allowing transactions automation [4]. Figure.2 summarizes these five characteristics.

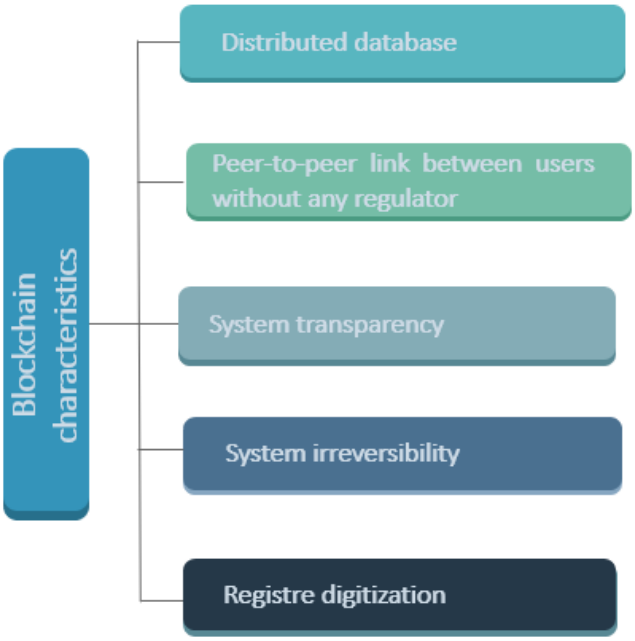

Fig. 2. Blockchain characteristics according to Iansiti and Lakhani.

We also note three blockchain technology types: public, private and hybrid [15]. Public blockchain has the characteristic of not having an owner but being visible to all participants in the network, which is the case of bitcoin [16]. Unlike public blockchain, private blockchain is authorized and controlled blockchain. That is, only a few participants with authorization characteristics can participate in carrying out operations in the network. While hybrid blockchain is public for a part of participants and private for another part of participants [15]. Figure 3 shows the three types of blockchain.

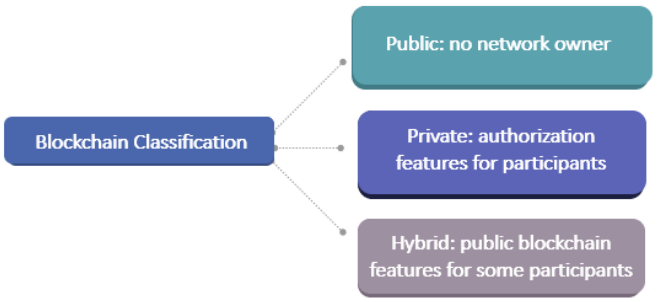

Fig. 3. Blockchain classification.

III. Research Methodology

The objective of this paper is to present how integration of blockchain technology would be beneficial to the whole supply chain alongside ERP systems. To do this, we conducted a literature review on the relationship between blockchain and ERP systems using the method proposed by Kitchenham et al. [17] [18]. The literature review allows us to be familiar with a field, especially when this field arouses the interest of a large

number of researchers. This article then answers the following questions:

- **What are the benefits that integrating blockchain technology with ERP systems can bring to the supply chain?**
- **What are the problems that will be solved through this integration?**

IV. INTEGRATION OF BLOCKCHAIN WITH ERP SYSTEMS

ERP systems have proven themselves over the years to provide many benefits, including improved financial performance [19] [20]. But despite these many advantages, ERP systems are not without flaws. In fact, many implementation projects have failed [21]. We also note other problems such as the high maintenance cost and problems related to their customization. It would then be interesting to try to use complementary technologies to address the ERP systems issues. Blockchain could be that technology that can complement ERP systems and bring improvements to the supply chain [3]. Indeed, several studies dealing with this subject are beginning to emerge [3] [13], but they remain few in number.

Facia and Petratos had already assumed that modules such as quality management (QM), supplier relationship management (SRM) or supply chain management (SCM) can definitely be integrated into public distributed computing system [13]. Other modules can potentially be integrated according to Facia and Petratos if private blockchain is considered [13]. ERP systems vendors have also begun to consider this path by starting new projects related to blockchain [13], such as "SAP Leonardo Blockchain". Indeed, blockchain could bring many benefits to the supply chain. Sislian and Jaegler [3] cited five of them:

- minimization of the transportation costs;
- reduction of errors and delays;
- increased confidence;
- improved the logistics operations;
- increasing the supply chain sustainability.

Facia and Petratos also reported on how blockchain can be exploited within company. First, by using it to exchange value through blockchain [13]. Blockchain can also be used for data verification, using time-stamping technology to determine the data creation of each document and therefore verify whether it has been modified [13]. It can also be used to coordinate data between the various actors in the supply chain, thus playing intermediary role for the data exchange [13]. And finally, the realization of reliable processes, guaranteeing each step reliability of the company's processes [13].

V. PROBLEMS ADRESSED BY THE INTEGRATION OF BLOCKHAIN

As mentioned earlier, ERP systems are centralized systems with single database to manage all business processes. Unlike ERP systems, blockchain technology is decentralized. From this point of view, integration of blockchain technology could allow to move from centralized system to decentralized system and thus, to benefit from the advantages of blockchain. We can therefore cite the benefits that integrating blockchain technology with ERP systems can bring below:

Be the intermediary of several heterogeneous systems: blockchain technology could address a serious problem, which is the different management systems heterogeneity [22] [3]. Decentralized nature of the system will facilitate communication and data exchange between different partners, regardless of the solution and the ERP version used by each of them. The principle is that all the partners join a single blockchain network, this can be a public or private network [23].

However, it was strongly recommended to use the private network for manufacturing industries, considered more appropriate to collate data from different ERPs between [23] :

- customers;
- suppliers;
- distributors;
- contract producer.

This blockchain feature eliminates the need for EDI messages, emails, and B2B message systems while facilitating data transfer [23]. It is about sharing data in real time and in full transparency between different partners [23], allowing to save time, to have a better visibility on the forecasts, a better quality and consequently a reduction of the frauds and the counterfeiting. This real-time data availability would therefore be an excellent tool for decision support [23].

Having a single network where all the partners in the supply chain are connected to it allows better visibility to follow the different actions of the supply chain and the path of the product throughout it.

Various studies are beginning to emerge in this direction. For example, Debe et al [24] propose a prototype management architecture for tracking the commercial flow of drugs. Sharma et al. [25] put forward a blockchain-based framework in the automotive industry for tracking the product throughout its life cycle, from raw material to maintenance and recycling phases. The food industry has also been interested in using blockchain for improving raw material tracking and increasing efficiency transactions efficiency, which will now all be recorded on the blockchain [26] [27] [28].

Increase data security: thanks to register digitalization and certain procedures for validating transactions such as POW (Proof Of Work) [6], the system is protected from cyber-attacks. Data security is therefore enhanced. However, it can be vulnerable in cloud computing, because of enormous resources available in centralized location [29]. ERP systems are also a centralized system, which makes them vulnerable.

Blockchain immutability also helps to secure data. Thanks to this characteristic data cannot be modified. Indeed, this is part of the advantages of distributed registers that allow to provide

a secure environment [16]. Thanks to this feature, the trust between different partners in the supply chain is increased.

The data can be both transparent between the different partners and protected in case some customers request it, they will be hidden under metadata [23].

Increase system flexibility: Espinoza Perez et al. had demonstrated according to a study conducted that blockchain could address production problem process changes [6]. However, they have demonstrated that this is possible in Industries 4.0 mainly supported by the Internet of Things and Cyber-Physical Systems, which introduce connectivity and artificial intelligence within industrial control [6]. Indeed, ERP systems alone are unable to manage business process change.

Increase process automation: blockchain intelligent properties make it possible to automate a large number of processes, in particular the payment between the customers and the suppliers, thanks to the cryptocurrency without the bank as intermediary [13] [30]. Audit could also be automated, thanks to data transparency throughout the supply chain and automation of data exchanges. Auditors will have the privilege to know actions of all partners in real time. This allows for processes control. Audit will therefore be carried out in an automated way.

The Port Authority of Rotterdam, Netherlands has leveraged blockchain for customs checks to reduce the turnaround time of ships on bridges. This is a valuable time saver as there is no need to fill out country of origin reports and other customs documents for border crossing, thanks to blockchain technology [23]. This is a way to automate customs control.

Even though ERP systems also have the role of automating business processes, the aim is to increase this automation capability through blockchain technology. Figure.4 (Appendix) shows the improvements made through the integration of blockchain with ERP systems.

VI. THE LIMITS OF BLOCKCHAIN

Blockchain would have some limitations to consider when implementing it. We mention five of them:

Infrastructure: blockchain requires a considerable infrastructure to store data that is immutable [23]. This characteristic, which is data immutability, is the strength of blockchain but at the same time its weakness. Storing a huge amount of data and managing complex algorithms requires preparation in terms of human and technological infrastructure.

Costs: blockchain implementation costs and its maintenance also remains a point to discuss [23]. Maintaining network encompassing all supply chain partners, i.e. customers, suppliers, distributors and producers, requires high costs [23].

Trust: the consent of all partners is required to use blockchain for supply chain management. This is a double-edged point. It allows you to choose the right suppliers who are willing to work in full transparency [23] but requires the consent of several partners and this is a challenge for the use of blockchain. A mutual trust is therefore necessary between the different partners in order to use this technology.

Legislation: legal acceptance of blockchain can be a limitation [25]. Indeed, each country has its own point of view regarding blockchain. It is a new technology and it would take time to accept it from a legal point of view.

Blockchain size: blockchain size is limited, but it is constantly growing over time [25]. However, a study examining blockchain applications in 50 Chinese companies found that the company's expansion assets is an important factor for blockchain implementation [6]. 6] The key is to be sure that the company can store all of its data in the blockchain.

VII. CONCLUSION AND LIMITATIONS

Blockchain can be beneficial to improve business performance, especially if used as a complementary technology to ERP systems. It will allow to fill in ERP systems gaps and consequently allow a better supply chain management. The advantages of using this technology are multiple.

It can save time in the various supply chain transactions, save various costs, improve data sharing, increase trust between partners and improve information systems flexibility in the face of business changes.

Blockchain would indeed be an asset for the entire supply chain management but it represents some limitations to be taken into consideration. These are infrastructure required to store data, which are important because they are immutable. Limitations concerning the implementation costs which are not much mentioned in the literature. Blockchain size which remains limited but is constantly evolving over time. And, the legislation concerning blockchain which differs from one country to another. Finally, the consent all partners to be part of this network and to work in full transparency.

However, this study remains purely theoretical, it needs to be backed up by a field study to know if companies are ready to move to a new technological era. It would be a mistake to introduce blockchain technology without knowing it well and without knowing how it is implemented.

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Appendix

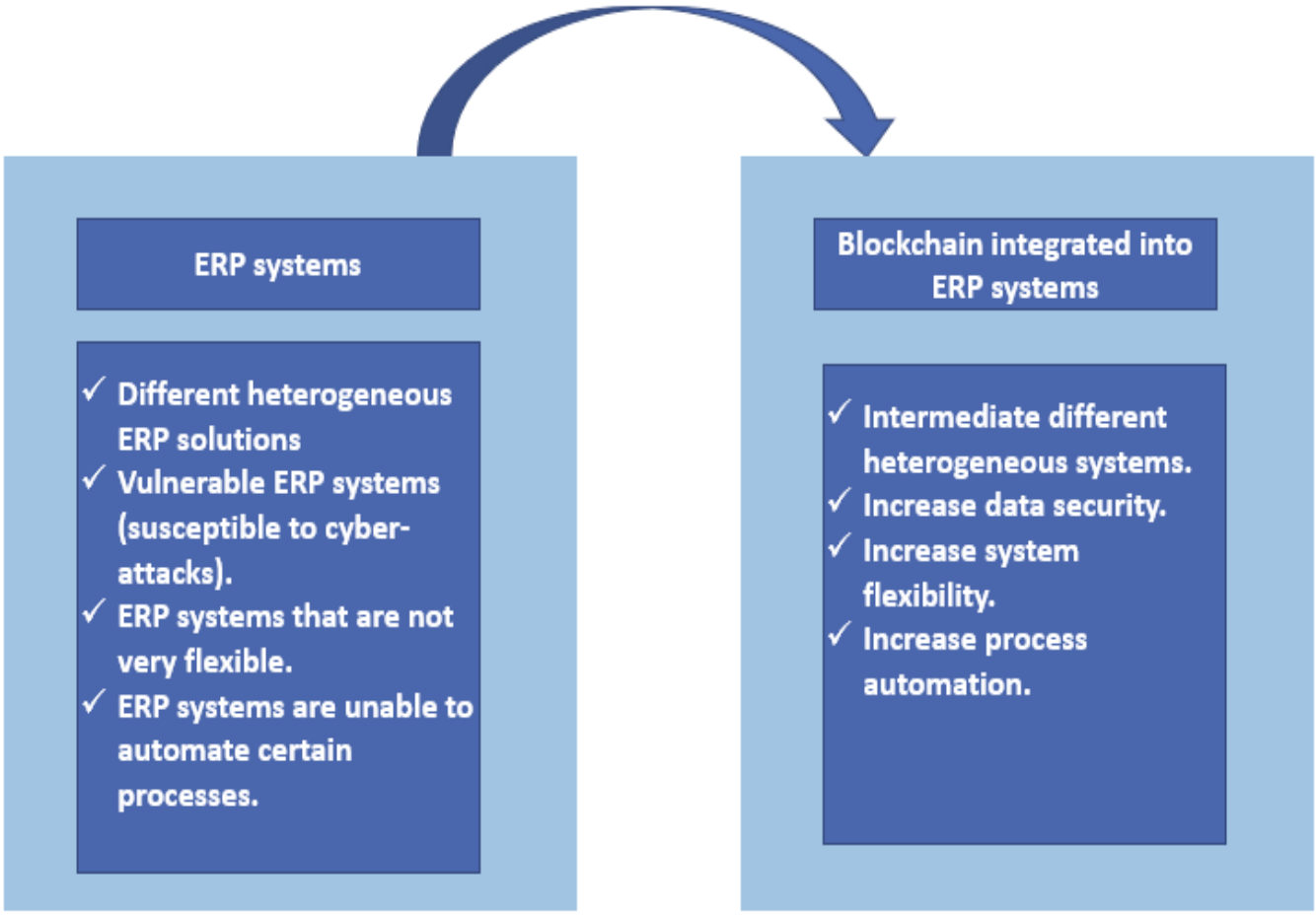

Fig. 4. Problems addressed by the integration of blockchain