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Digitalization Transformation Guides

Solutions for a New Economy

There are numerous applications in which Blockchain is the right solution and can bring benefit to the industry.

In this issue:

What is the Role of Blockchain in Digitalization Transformation?

Blockchain, also known as Hyperledger or Distributed Ledger Technology (DLT), has seen an increased interest in the last decade. The blockchain is very useful in engineering as it could possibly meet a key digitization requirement, i.e. the requirement for immutable data and robust traceable data sources that currently do not exist.

As the name suggests, blockchain stems from a technical structure of "a chain of blocks" [5], each block connected to the preceding block and identified by a cryptographic hash. Peers involved within the blockchain perform transactions and subsequently transactions are stored within this data structure as a result of peer-to-peer consensus [12]. The access and permissions of participants in the network depend on the type of blockchain, which are commonly summarised as; permissionless blockchains, permissioned (public permissioned) blockchains, and private blockchains [5], [13], [14].

This can be confusing because other journals classify them slightly differently i.e. public blockchains, private blockchains and consortium blockchains [15]. Key differences in the types of blockchains are summarised in the guide and supplemented with citations where further information can be found regarding the specific properties of each blockchain type.

Loughborough University

Contents

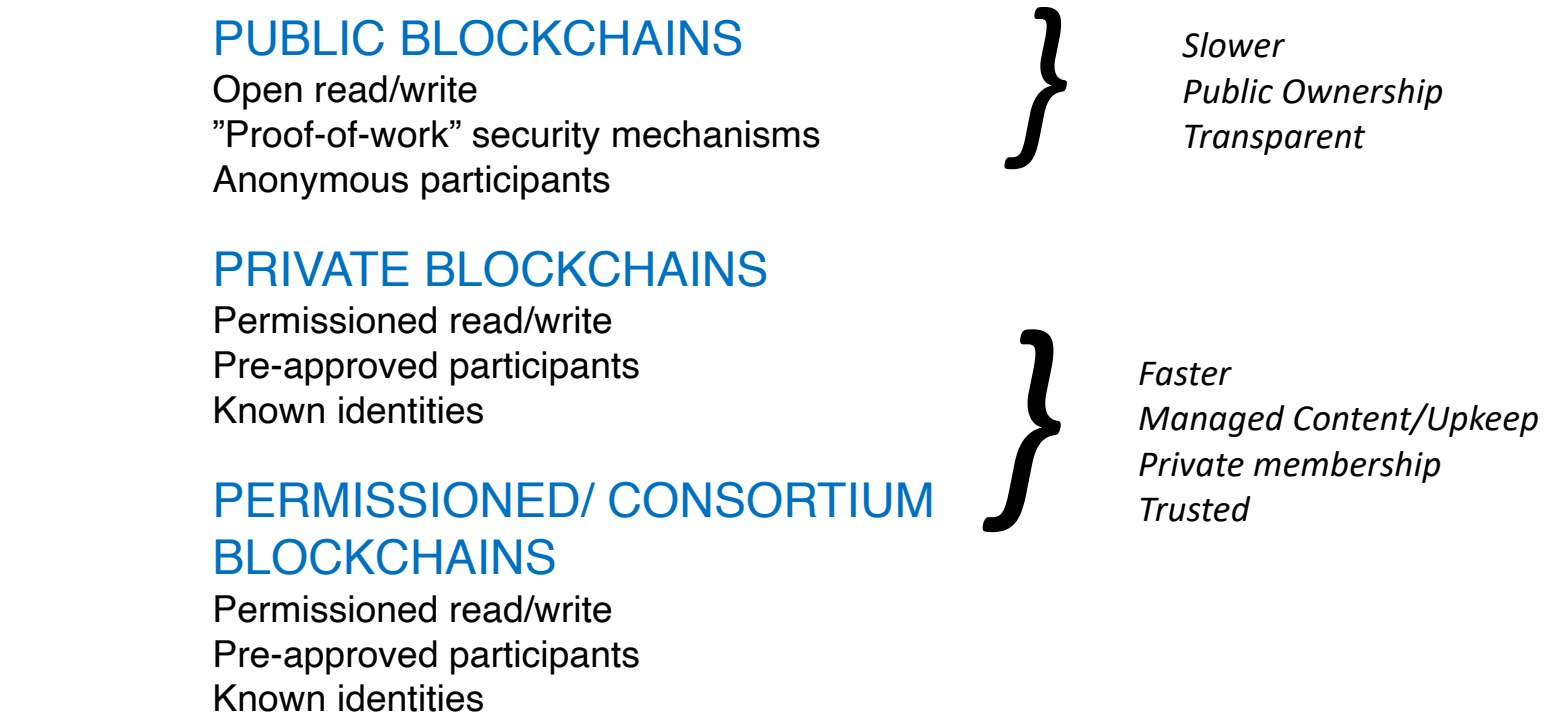
Blockchain Basics

Brief History

Blockchain technology has advanced across multiple domains since its introduction by Satoshi Nakamoto around a decade ago, where it was proposed as a solution to structuring transactions and avoiding double spending [1]. As the name suggests, blockchain stems from a technical structure of “a chain of blocks” [2], each block connected to the preceding block and identified by a cryptographic hash. Peers involved within the blockchain perform transactions and subsequently transactions are stored within this data structure as a result of peer-to-peer consensus [3]. The access and permissions of participants in the network depend on the type of blockchain, which are commonly summarised as; permissionless blockchains, permissioned (public permissioned) blockchains, and private blockchains [2], [4], [5].

Types of Blockchains

Understanding the various categories of blockchain enables understanding of their potential application. A specific blockchain technology known as permissioned blockchain can be accessed by everyone or by a restricted consortium of participants. Such blockchains are classified depending on their access status; Permissioned [6], [7] or Permissionless [2], [8]; and also, on their level of centralisation; Public [9], [10], where there is no centralised management, Private [11]–[13] , where there is a single entity who manages the network, or Consortium [14], [15], where multiple organisations or participants manage the network. In addition to these criterium for classification, different distributed ledger technologies have different models/ architectures which are used to classify the blockchain type, including; participants, privacy levels, computation energy consumption, speed of validation, consensus mechanisms, fees and so forth. Some of these characteristics have been provided for the different classes of blockchain in Table 1.



ACCESS	*PERMISSIONED*	*PERMISSIONLESS*	*PERMISSIONED*	*PERMISSIONLESS*	*PERMISSIONED*
Centralised Management	**Public**		**Consortium**		**Private**
Access Permissions	*Open read/ permissioned validation of transactions*	*Open read/ open validation of transactions*	*Permissioned OR open read/permissioned validation of transactions*	*Open read/open validation of transactions*	*Permissioned read/ validation of transactions*
Participants	*Unknown*	*Unknown*	*Known*	*Known (usually)*	*Known*
Privacy	*None*	*None*	*Tailored to requirements of platform*	*Tailored to requirements of platform*	*Tailored to requirements of platform*
Validation Based on Consensus	*Open to every participant in the network, subject to certain conditions*	*Open to every participant in the network*	*By pre-approved entities*	*Depending on the consensus protocol chosen*	*By pre-approved entities (within the single entity)*
Validation Speed	*Quick*	*Slow*	*Quick*	*Quick*	*Quick*
Computing Energy Consumption	*High (depending on consensus mechanism)*	*Very high*	*Low*	*Low*	*Low*

Limitations of Blockchain Technologies

To summarise the strengths and weaknesses of the permissioned blockchain type refer to the Table below. It can be seen, a number of strengths are seen to provide value within the engineering lifecycle, for example, traceability of transactions alone will ensure transparency and allow for legitimate contracts to be executed. Further to this, changes in data within the blockchain can be monitored, and the potential to trace back over time and gather the rationale as to why certain decisions were made will prove invaluable to some stakeholders further down the lifecycle

STRENGTHS	WEAKNESSES
• High level of encryption • Lower risks • More secure • Traceable trail of transactions • No reliance on third party • Open Source • Digital transfers of resources and assets	• Technology not 100% mature • Ownership challenges • Low capacity and processing speed • Security threats from cyber criminals • Storage capacity – especially long term
OPPORTUNITIES	**THREATS**
• Speed up transaction processes • Programmable access and control mechanisms • Smart contracts and insurances • Improved customer experience	• Regulations • Moderately young technology, more research required • High investment costs • Uncertainty

Blockchain Landscape Beyond the Hype

The topic of data management and information control is currently a highly active research area, primarily due to the emergence of Industry 4.0 and its encompassing digital technologies [16], [17]. Industry 4.0 is synonymous with the movement of manufacturing to more digitised processes to create products using smart and autonomous systems, driven by data and machine learning [18]. Although blockchain is not directly linked with Industry 4.0 in much of the literature, the value which it brings from a data and information perspective brings value to the SE lifecycle process. Some of the key features of blockchain, which will be discussed at length, are features such as: traceability of transactions and information changes; higher levels of data encryption, and no reliance on third parties to mediate transactions and decisions. As a result, there has been a clear increase in the adoption of blockchain since an

earlier blockchain survey [19] in 2016, where the application domains were identified as; finance, IoT, public service, reputation systems, and security. A recent systematic literature review of blockchain-based applications by F. Casino et al. [8] highlight the main application areas of which some are revisited here to demonstrate their recognition. An obvious place to start is its financial application, as this is where the growth of blockchain adoption stems from.

Financial applications

Bitcoin [20]–[22], the first of the cryptocurrencies popularised the interest and attracted great attentions in blockchain technology from academia and industry. It is by far the most successful cryptocurrency with the capital market exceeding $65 billion dollars in 2019 [23]. The key characteristics blockchains offer is why the finance sector is expected to adopt a substantial role for the technology to ensure sustainability in the future global economy [24], [25]. The most obvious advantage of blockchain and cryptocurrencies is the potential it has of transforming capital markets and enhancing the way operations such as digital payments [26], [27], securities [28], general banking services [28], [29], loan management schemes [30], and auditing [10] amongst other operations. Blockchain acts as a ledger on a global scale, recording financial (but not limited to) transactions on a “trustless network” [30] where there is no middle man to authorise transactions. The beauty of this ledger is that it is immutable [22] and cannot be altered once a transaction has been recorded within the blockchain. This is as a result of proof-of-work, where mathematical puzzles are set to be solved by the different nodes in the network as a means of creating a protection mechanism against hackers [31], [32]. This is ideal for financial transactions of all kinds for security, transparency and a permeant record of transaction history embedded within the blockchain which is almost impossible to erase [33].

Data management

Data management is one of the most prominent and undisputable properties of blockchain [33]–[36]. Some claim that blockchain has enhanced data management and have created auditability by default as a result of all actions being verifiable [35]. The blockchain also enhances data storage according to Wang et al. [37] however the integrity of this secured data depends of the architecture of the blockchain and the privacy keys which are allocated by the blockchain developer. As a means of navigating through stored data, [38] propose a solution using cryptographic primitives. Building on this idea, Jiang et al [39] proposed a blockchain-based key word search system.

Internet of Things (IoT)

As one of the main internet technologies, IoT has been closely tied with blockchain in having a potentially synergetic relationship [3], [8], [40]–[44]. There is a substantial amount of literature which emphasise the potential of blockchain architectures to enhance the potential of IoT and to minimise its deficiencies and drawbacks [45]–[47]. The prospects of IoT and blockchain can be mapped onto many contexts, for capturing information monitored by heterogeneous devices and stored as transactions into the blockchain, or even in the form of smart contracts [30], [48], [49]. Potential applications of this kind are commonly associated with supply chains, inventory management and transportation services [8]. Again, the benefit of blockchain solutions and the decentralisation network architecture could increase the privacy and security of wireless sensor networks which make up the IoT [50]. A potential bottleneck which is a current issue is the low computational power of IoT devices and their storage capabilities [43], [51].

Governance

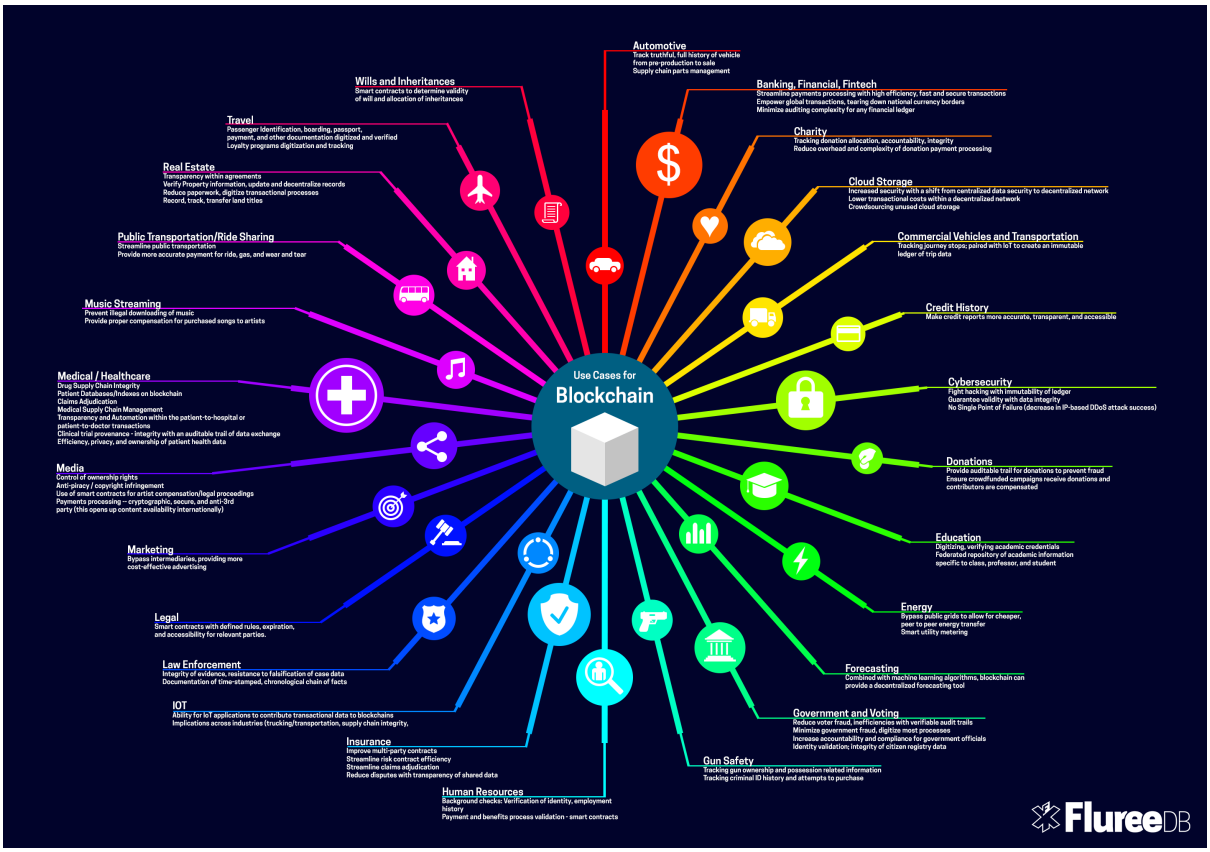
The role of governments at both the state or local level have been to manage official records of residents and enterprises. It has been declared that governments globally are trialling blockchain and creating pilot studies using the technology [52]. The Dutch government for example, makes the pilot projects being ran, online [53], which cover the likes of passports, digital identity, judicial outcomes, money tracing, e-voting, marital status, business licences and so on. Many of these services plus others such as, taxes and attestation are covered by Swan [54] in her book Blockchain: Blueprint for a New Economy.

Integrity verification

Integrity verification [55]–[59] is one of the most emerging blockchain-related fields. A set of applications storing information and transactions related to the “creation and lifetime of products and services” [8]. The possible applications have been identified as: (i) provenance and counterfeit, (ii) insurance; and (iii) intellectual property management [8]. IP protection is high on the research agenda where blockchain applications are attempting to provide such protection to online content for both storage and simultaneous online validation of (digital) assets [60], [61]. Certain applications have been developed on blockchain and smart contracts to avoid bank fraud and insurances and to assure transparency in supply chains [62].

Supply Chain management

The transparency and accountability features of blockchain have made them of interest to supply chain management researchers [63]–[67]. IBM solutions claim that blockchain has the potential to enhance supply chain management in terms of optimization, visibility and demand [68]. The key benefit here is the ability for parties to transact with one another without the need of an intermediary, whilst achieving increased and safeguarded security [69] whilst ensuring robust contract management mechanisms between parties [70]. The prospects have been recognised to be far reaching in terms of application areas within supply chain and include; better information management across supply chains [14]; IP protection [71]; improved inventory management [72]; and finally, offer decentralised manufacturing architectures [8], [73].



https://www.ibm.com/blockchain/industries/supply-chain
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https://medicalchain.com/en/
https://ripple.com/
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https://www.circle.com/en-gb/
https://www.blockchain.com/

How to bring benefit from Blockchain in industry?

Benefits of blockchain in manufacturing industry

1. Facilitating collaboration
2. Enabling capabilities for new business models
3. Single source of data
4. Facilitates device-to-device transactions
5. Smart contracts
6. Real-time processing

Dangers and ethical considerations.

Although many people are speculative about blockchain's potential impact in domains other than financial, blockchain's true value in application will be achieved by understanding and exploring its implementation for how it works, and the different types of blockchain mechanisms. A blockchain architecture has the potential to provide value to enterprises and organisations in the form of; cost reduction, by eliminating the money spent on central databases; data validity and security, as it becomes extremely difficult to corrupt data, although the processing time becomes longer since all participants need to validate changes, and; traceability, where data and historic transactions can be traced back to when they occurred. Where blockchain becomes interesting, is when there are more nodes within a consortium and more time is required to complete a transaction, as one node may take longer to validate and thus slow the transaction down.

Challenges of Implementing Blockchain

Some of the challenges faced for implementing blockchain from a SE perspective:

- Requirement for Large Data Storage Capacity
- Access Control
- Trust Management
- Connecting Heterogeneous Databases
- Conflicting Consensus
- Integrated Blockchains

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Useful information sources

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Videos:

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