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A COMPARATIVE STUDY OF DISTRIBUTED LEDGER TECHNOLOGY AND THEIR USE IN DIFFERENT APPLICATIONS

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A comparative study of Distributed ledger Technology and their use in different applications

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ABSTRACT

Distributed ledger technology (DLT) has the potential to revolutionize various industries by creating more efficient, transparent, and secure systems. This paper provided a comprehensive comparative study of different types of DLT, including blockchain, directed acyclic graphs, and hashgraph, and their applications in various industries, such as finance, supply chain management and healthcare. The study highlights the unique features and benefits of each type of DLT, its advantages and limitations, and provides real-world use cases of DLT in each industry. The potential future developments of DLT and its impact on various industries, such as decentralization, security, automation, innovation, and collaboration were also discussed. The study analyzes which types of DLT are best suited for certain applications and industries, and predicts how DLT will shape the future of technology and business. The potential impact of DLT on industries such as finance, supply chain management, healthcare, voting systems and the energy industry is significant, and the future of DLT is promising.

Keywords: *distributed ledger technology, blockchain, directed acyclic graphs, supply chain management, decentralization.*

1.0 Introduction

Distributed ledger technology (DLT) is a digital ledger of transactions that is distributed across a network of computers [1]. It allows for the secure, transparent, and tamper-proof storage and sharing of data without the need for a central authority or intermediary. According to [2], DLT has the potential to revolutionize various industries by creating more efficient, transparent, and secure systems.

One of the most popular forms of DLT is Blockchain technology, which was first introduced in 2008 as the underlying technology for the cryptocurrency Bitcoin [3]. Blockchain technology is a decentralized digital ledger that is maintained by a network of computers, making it a secure and transparent way to store and share data [4]. Blockchain technology has gained significant attention in recent years due to its potential to revolutionize various industries, such as finance [5], supply chain management [6], and healthcare [7].

Other types of DLT include directed acyclic graphs (DAGs) and hashgraph technology [8]. DAGs are a type of DLT that uses a non-linear data structure, which allows for a more efficient and scalable network [9]. Hashgraph technology, on the other hand, is a consensus mechanism that allows for fast and secure transactions on a distributed ledger.

The use of DLT in various industries has the potential to increase transparency, reduce costs, and increase efficiency. For instance, in finance, DLT can enable faster and more secure transactions, reduce fraud, and lower transaction costs [10]. In supply chain management, DLT can provide a transparent and secure record of transactions, improve traceability, and reduce the risk of counterfeit goods [11]. In healthcare, DLT can improve patient privacy, streamline the sharing of medical records, and reduce medical errors [12].

Furthermore, DLT is a relatively new technology, and there is a lot of potential for innovation in its applications. As the technology continues to develop, we could see new and innovative use cases for DLT in various industries. This could lead to the development of new business models and revenue streams that were not possible before.
In summary, the use of DLT has the potential to revolutionize various industries by creating more efficient, transparent, and secure systems. Its potential impact on industries such as finance, supply chain management, healthcare, voting systems and the energy industry is significant, and the future of DLT is promising.

The objective of the study is to provide a comprehensive comparative study of different types of distributed ledger technology (DLT) and their applications in various industries. The study aims to educate readers on the unique features and benefits of each type of DLT and how they can be used in various industries. The study also aims to highlight the potential of DLT to revolutionize various

industries by creating more efficient, transparent, and secure systems, as well as predicting how DLT will shape the future of technology and business.

2.0 Literature Review on Distributed Ledger Technology

2.1 Distribution Ledger Technology

DLTs can be categorized based on their access permissions, which may include private, public, permissioned, permissionless, or a combination of these [13].

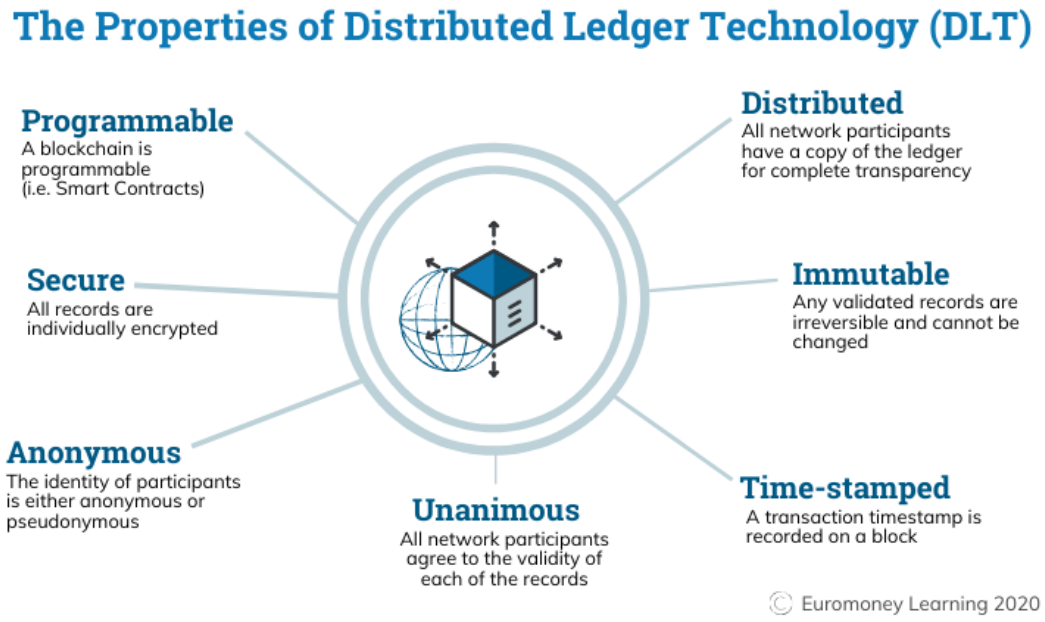

Figure 2.1: Key properties of a distributed ledger technology [14]

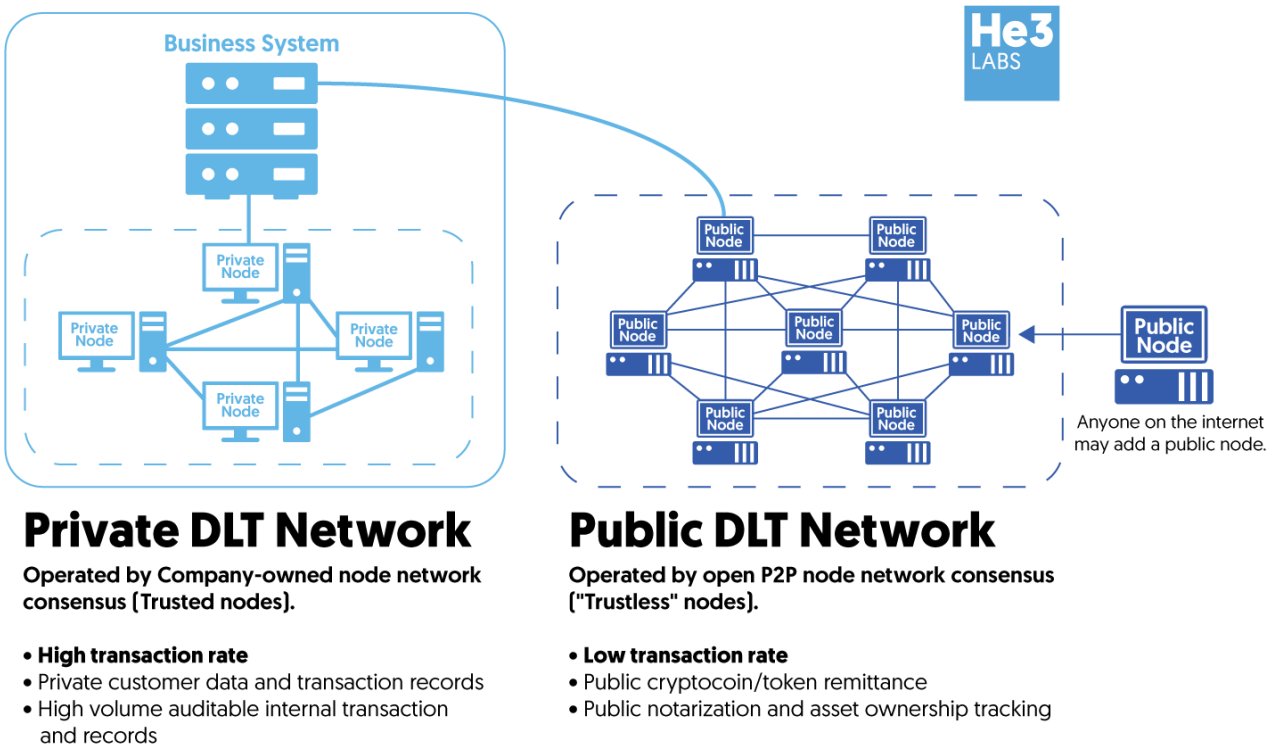

Figure 2.2: Differences and similarities between public and private DL network [15]

2.2 Types of Distributed Ledger Technology

1. Public DLT

Public DLTs are open to anyone who wants to participate in the network [16]. Transactions on the ledger are publicly visible and can be verified by any user on the network [17]. The most well-known example of a public DLT is the Bitcoin blockchain.

2. Private DLT

Private DLTs are only accessible to a select group of users who have been granted permission to participate in the network [18]. Transactions on the ledger are only visible to authorized users. Private DLTs are often used by organizations or groups that require a high level of privacy and security.

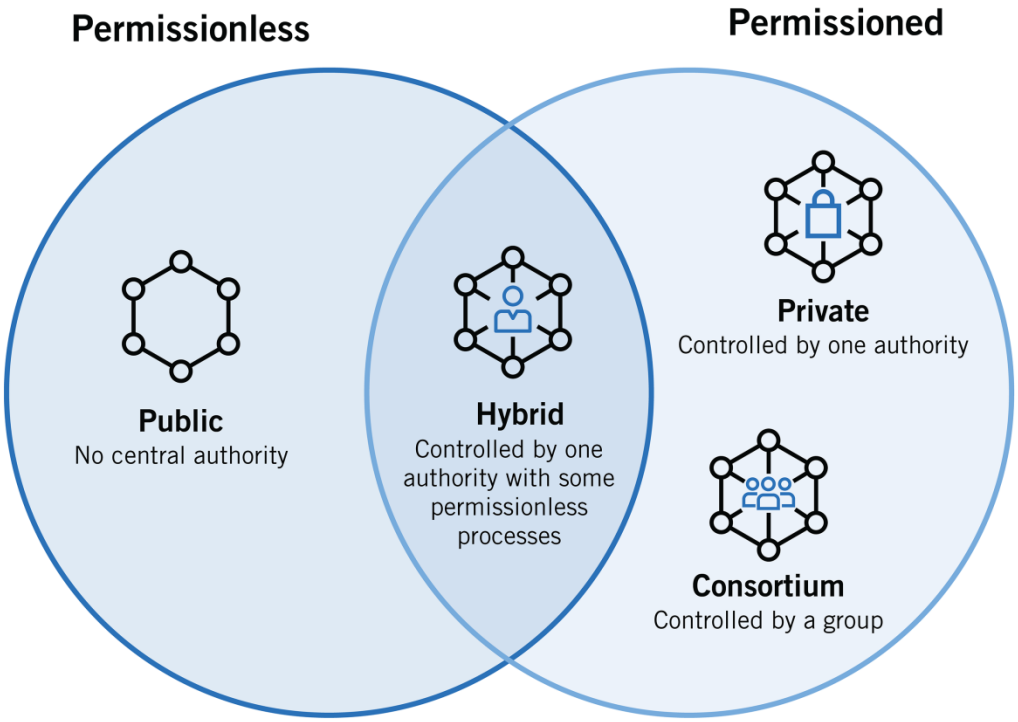

Figure 2.3 Comparisons and differences between permissioned and permissionless DLT [19]

3. Permissioned DLT

Permissioned DLTs are a combination of public and private DLTs. They are open to anyone who has been granted permission to participate in the network [20]. Transactions on the ledger are only visible to authorized users, but the identity of those users is publicly known. Permissioned DLTs are often used in industries such as finance, supply chain management, and healthcare.

4. Permissionless DLT

Permissionless DLTs are similar to public DLTs in that they are open to anyone who wants to participate in the network [21]. However, the identity of the users on the network is not publicly known. Permissionless DLTs are often used in applications such as anonymous online marketplaces and voting systems.

2.3 Functions of different Distributed Ledgers

There are several types of DLT, each with its own unique features and benefits. The most well-known type of DLT is block-chain, which is a decentralized, distributed digital ledger that allows data to be securely and transparently stored and shared. Another type of DLT is directed acyclic graphs (DAGs), which is a more recent development [22]. Unlike blockchain, which uses blocks of

transactions linked together in a chain, DAGs use a more complex structure of nodes and edges [23]. This allows for faster transaction processing and a higher degree of scalability compared to blockchain. Other types of DLT include hashgraphs, which use a voting-based consensus algorithm, and Holochain, which is designed to be agent-centric and allows for highly customizable distributed applications. Each type of DLT has its own unique benefits and limitations, and the choice of which to use will depend on the specific needs of the application. For example, blockchain is often used for applications that require high security, while DAGs are better suited for applications that require fast transaction processing and scalability.

2.3.1 Blockchain

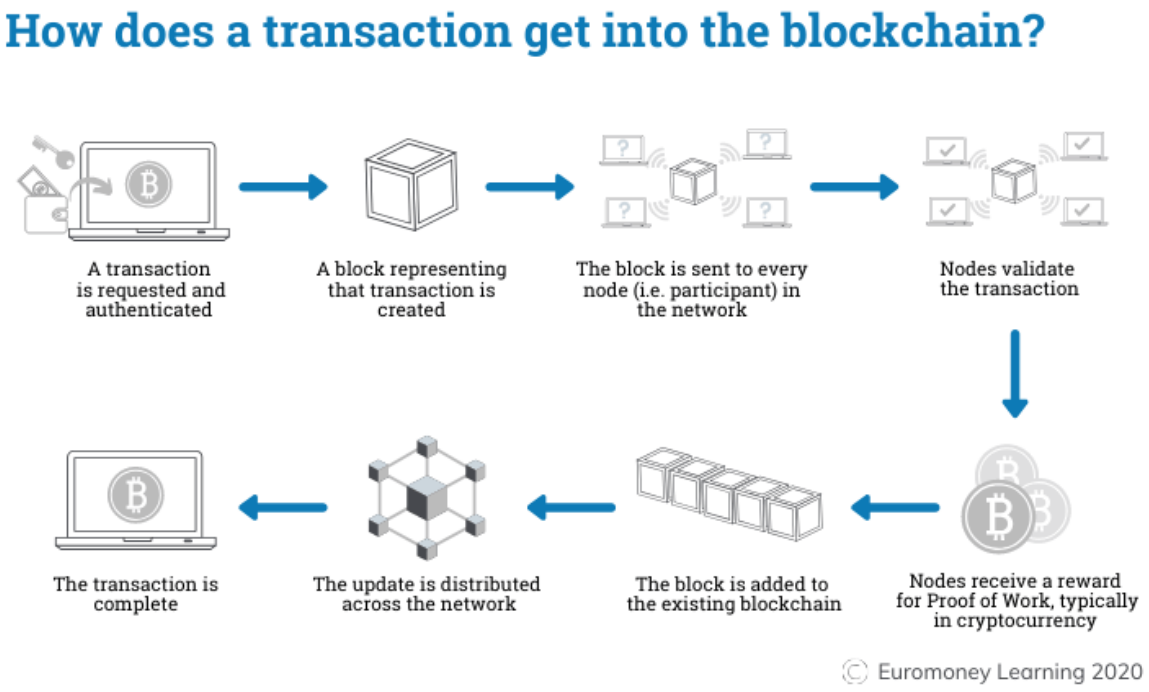

Figure 2.4: How transactions get into the blockchain [24]

i. **Decentralized and secure:** The distributed nature of blockchain means that there is no central point of failure, making it more secure than centralized systems.

ii. **Transparency:** All transactions are visible to all participants, providing a high level of transparency.

iii. **Immutability:** Once a transaction is recorded on the blockchain, it cannot be modified or deleted, ensuring the integrity of the data.

2.3.2 Directed Acyclic Graphs (DAGs)

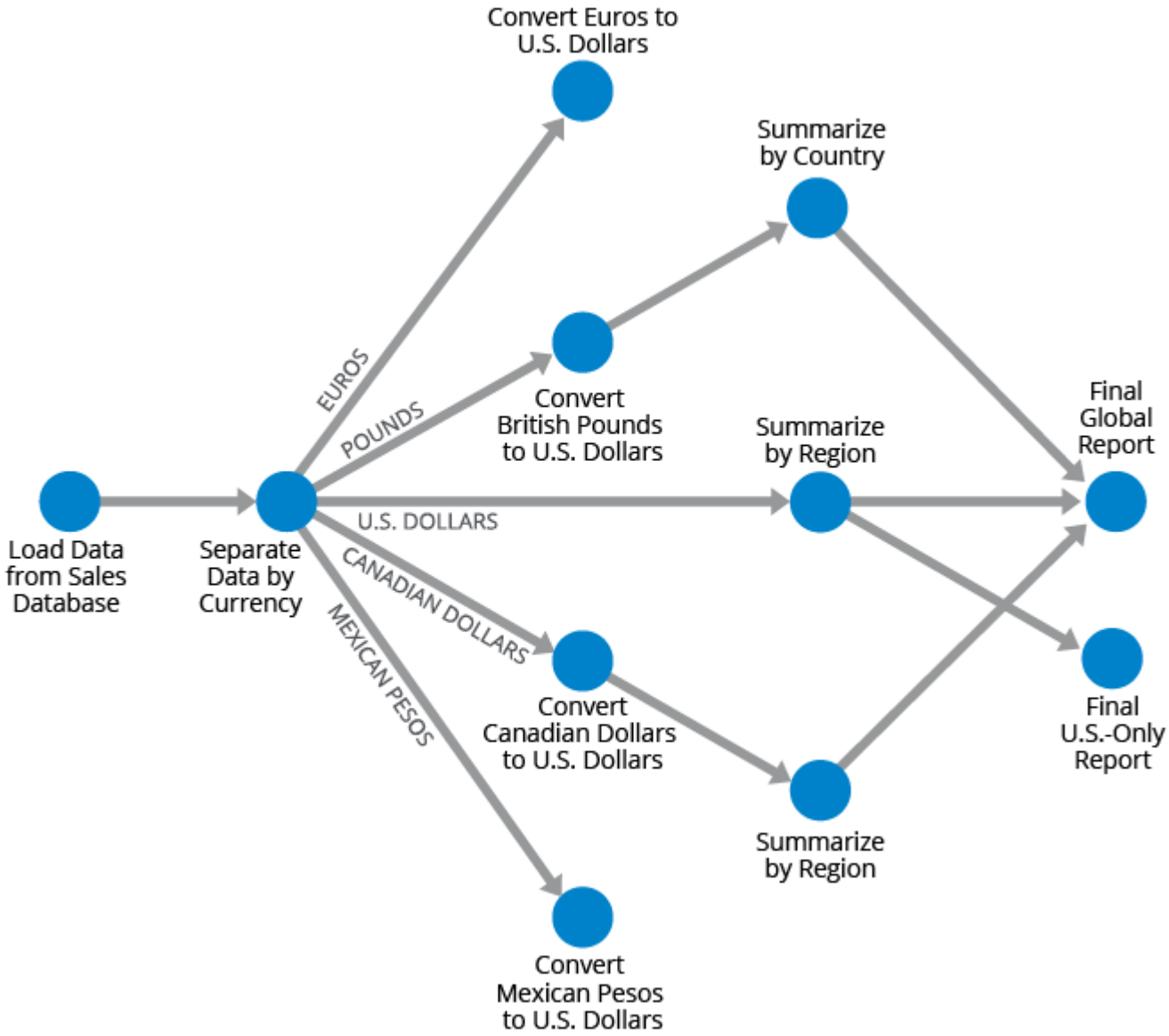

Figure 2.5: Directed Acyclic Graph (DAG) and how it is applied: Use Cases [25]

i. **Scalability:** DAGs are highly scalable, allowing for high transaction throughput and faster confirmation times.

ii. **No mining required:** DAGs do not require the complex mining process used in blockchain, making them more energy-efficient.

iii. **Flexible structure:** The structure of DAGs allows for more flexibility in how data is stored and shared, making them a good fit for certain types of applications.

2.3.3 Hashgraphs

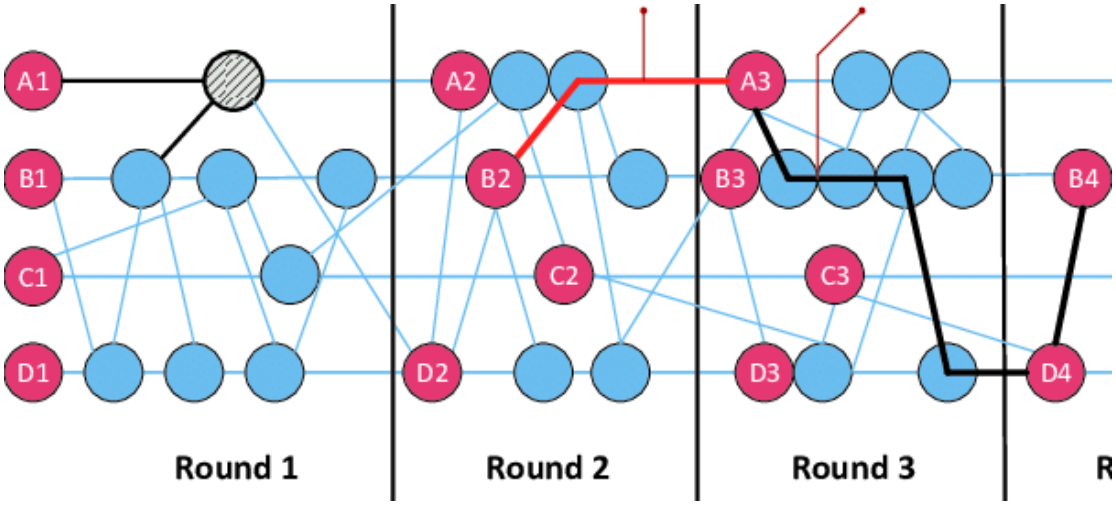

Figure 2.6: An illustration of a Hashgraph [26]

i. **Fast transaction processing:** Hashgraphs use a voting-based consensus algorithm that allows for very fast transaction processing.

ii. **Fairness:** The consensus algorithm used in hashgraphs is designed to be fair and ensures that no single participant has too much influence over the decision-making process.

iii. **High security:** Hashgraphs use a virtual voting algorithm that prevents attackers from manipulating the network.

2.3.4 Holochain

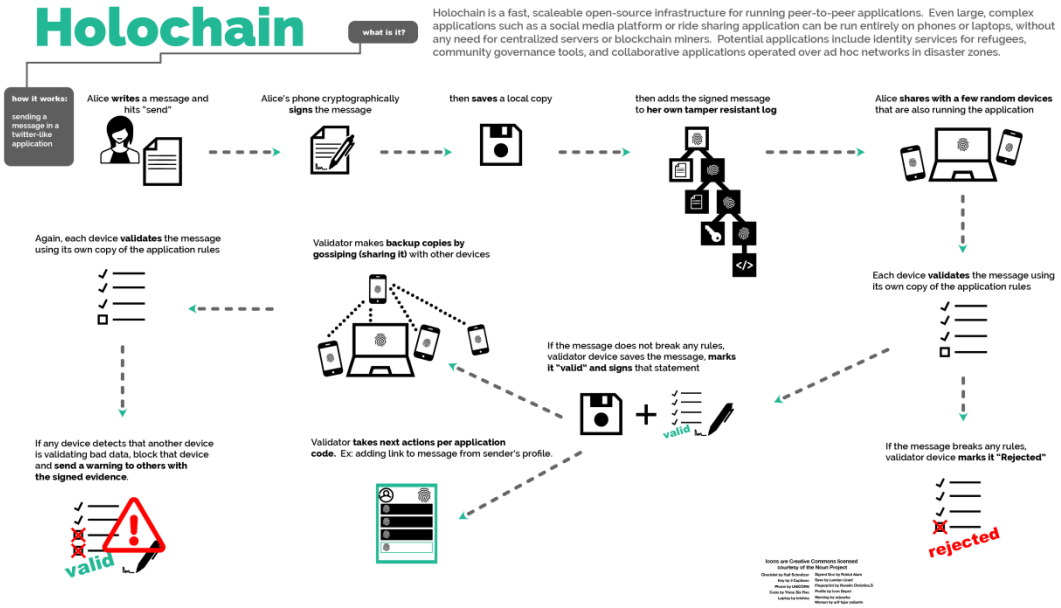

Figure 2.7: A Holochain distribution ledger Technology [27]

i. **Agent-centric:** Holochain is designed to be agent-centric, meaning that each user has control over their own data and applications.

ii. **Customizability:** The distributed nature of Holochain allows for highly customizable applications that can be tailored to specific use cases.

iii. **High scalability:** Holochain is highly scalable, allowing for fast transaction processing and high throughput. Overall, each type of DLT has its own unique features and benefits, and the choice of which to use will depend on the specific needs of the application.

3.0 Applications of Distributed Ledger Technology

DLT has the potential to revolutionize a wide range of industries by providing a more secure, efficient, and transparent way of storing and sharing data. Here are some examples of how DLT is currently being used in various applications:

i. **Finance:** DLT is being used in finance for applications such as digital currencies, smart contracts, and decentralized finance (DeFi). DLT provides benefits such as faster transaction processing, lower costs, and increased security.

ii. **Supply Chain:** DLT is being used in supply chain management for applications such as tracking and verifying the origin of goods, ensuring product authenticity, and reducing the risk of fraud. DLT provides benefits such as increased transparency, traceability, and efficiency.

iii. **Healthcare:** DLT is being used in healthcare for applications such as patient data management, medical record sharing, and drug supply chain management. DLT provides benefits such as increased security, privacy, and data accuracy.

iv. **Real Estate:** DLT is being used in real estate for applications such as property title management, smart contracts, and fractional ownership. DLT provides benefits such as increased transparency, efficiency, and reduced transaction costs.

Overall, the use of DLT in different applications provides a wide range of benefits, including increased security, transparency, efficiency, and reduced costs. As DLT continues to evolve and be adopted by more industries, its potential for transforming the way businesses and industries operate will only continue to grow.

3.1 Real-World Use Cases of DLT in various Industries

I. **Finance**

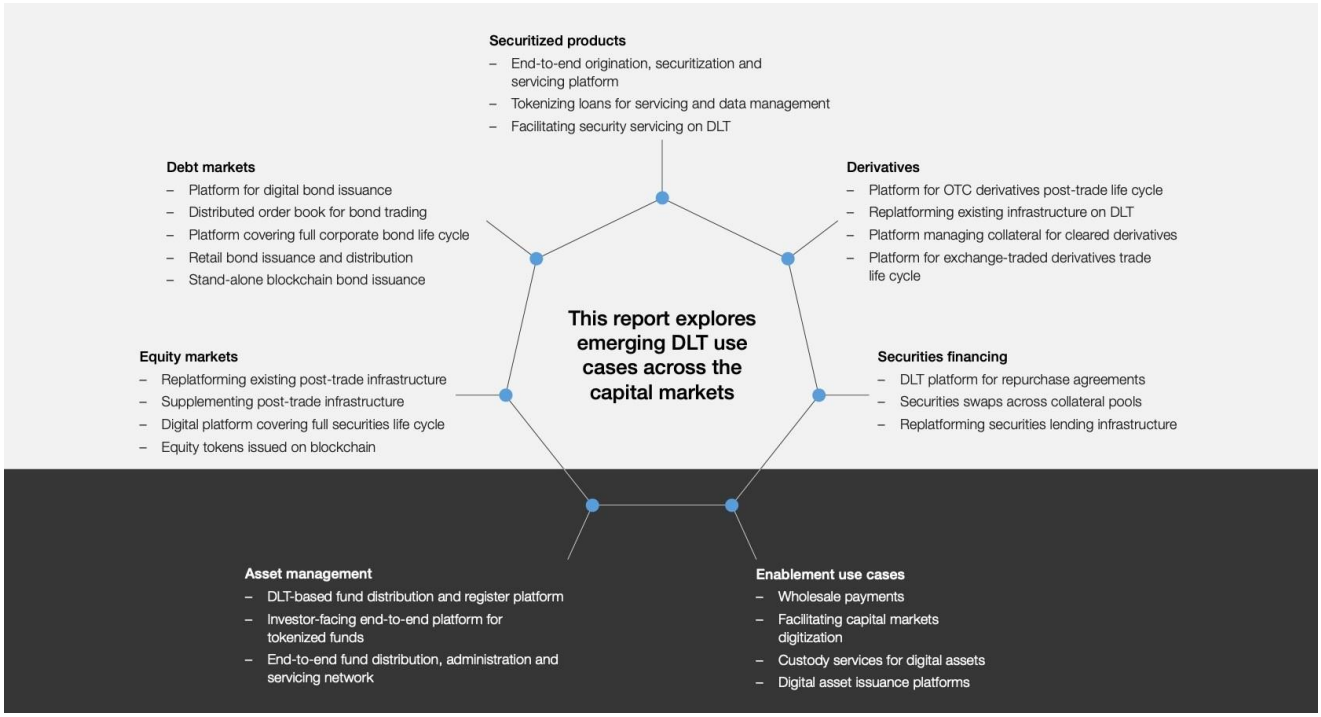

Figure 3.1: Use cases of DLT in finance [28]

A. Digital currencies: Bitcoin and other cryptocurrencies are perhaps the most well-known application of DLT in finance. DLT provides a secure and decentralized way of storing and transferring digital currencies, allowing for fast and low-cost transactions.

B. Smart contracts: DLT can be used to create smart contracts, which are self-executing contracts that automatically enforce the terms of an agreement. Smart contracts can be used to automate many financial processes, such as settling trades and managing insurance claims.

C. Decentralized finance (DeFi): DeFi is an emerging field that uses DLT to create decentralized financial applications that allow users to lend, borrow, and trade assets without the need for intermediaries. DeFi applications are built on top of DLT platforms such as Ethereum and provide a more open and transparent way of accessing financial services.

II. Supply Chain

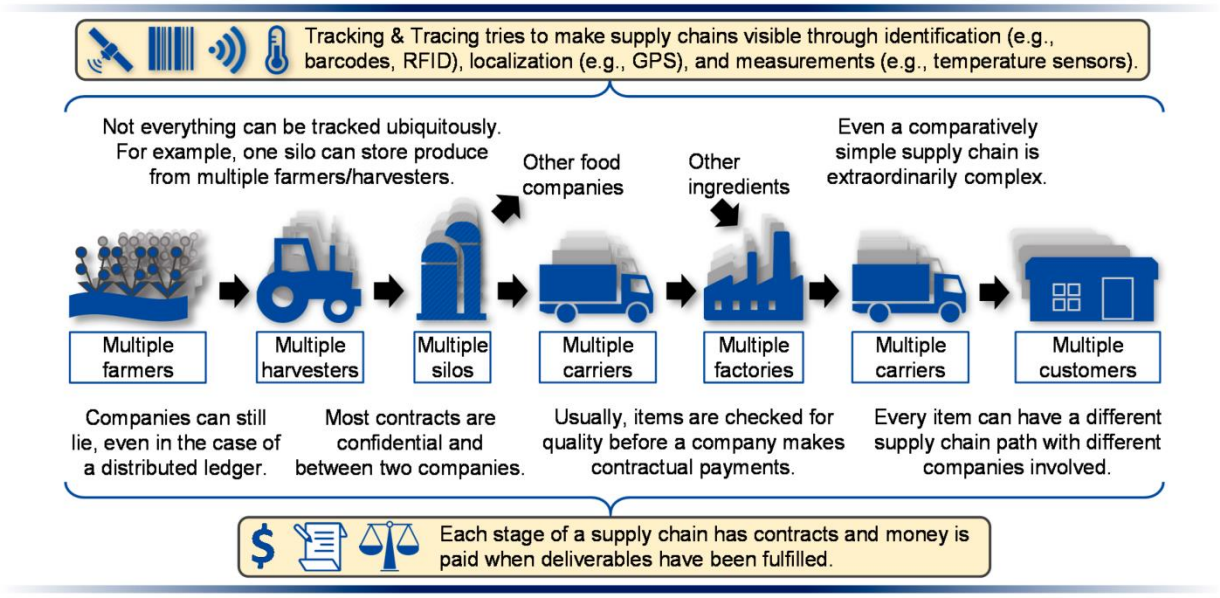

Figure 3.2: The application of DLT for tracking and tracing [29]

(A) **Traceability:** DLT can be used to create a transparent and tamper-proof record of a product's journey from origin to destination. This can help to improve supply chain transparency and traceability, reduce the risk of fraud and counterfeiting, and improve product quality.

(B) Product authentication: DLT can be used to verify the authenticity of products, such as luxury goods and pharmaceuticals, by creating a permanent and immutable record of their origin and ownership.

(C) Supply chain financing: DLT can be used to create more efficient and transparent supply chain financing processes by allowing suppliers to finance their receivables through a decentralized platform.

III. Healthcare

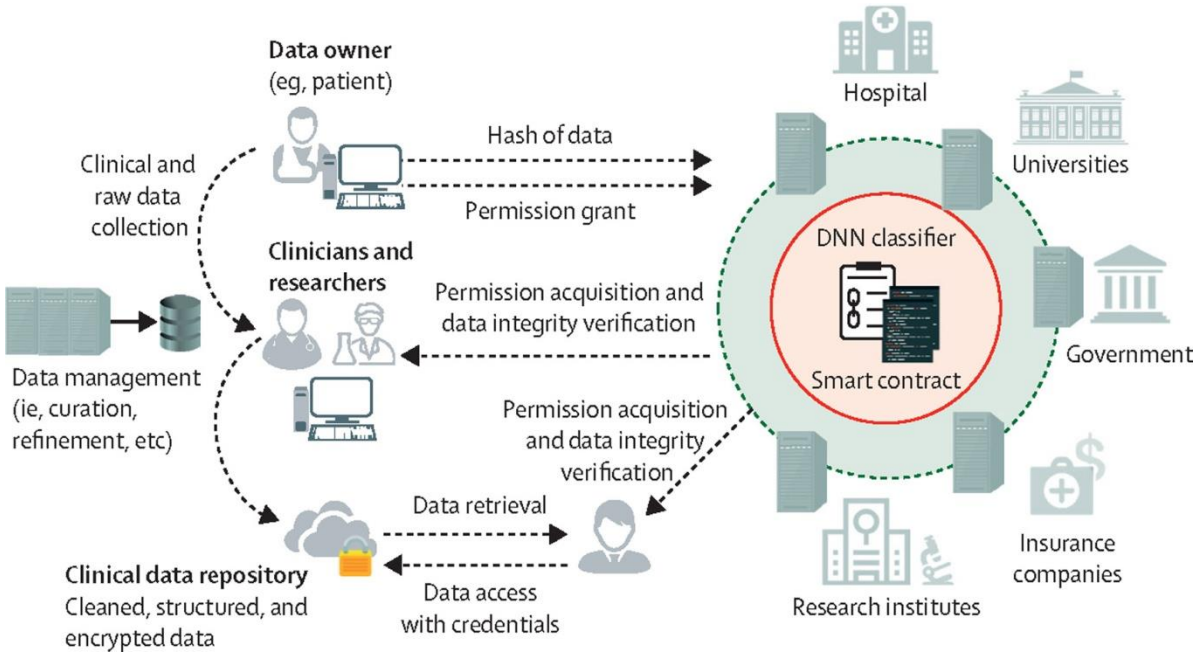

Figure 3.3: Blockchain applications in health care for COVID-19 [30]

A Patient data management: DLT can be used to create a secure and decentralized platform for storing and sharing patient data, allowing patients to control who has access to their data and ensuring the privacy and security of their sensitive information.

B Medical record sharing: DLT can be used to create a secure and efficient way of sharing medical records between healthcare providers, improving patient care and reducing administrative costs.

C Drug supply chain management: DLT can be used to create a transparent and secure supply chain for pharmaceuticals, allowing for better tracking of drugs from manufacturer to patient and reducing the risk of counterfeiting and fraud.

IV. Real Estate

A. Property title management: DLT can be used to create a secure and transparent way of managing property titles, reducing the risk of fraud and errors in the title transfer process.

B. Smart contracts: DLT can be used to create smart contracts for real estate transactions, allowing for automated and secure execution of agreements between buyers and sellers.

C. Fractional ownership: DLT can be used to create a platform for fractional ownership of real estate, allowing multiple investors to own a share of a property and reducing the barriers to entry for real estate investment.

4.0 Comparative Study of DLT

4.1 Evaluation of DLT

While DLT has the potential to revolutionize a wide range of industries, it is important to critically evaluate its strengths and weaknesses, as well as the potential challenges and limitations that may arise as the technology is adopted more widely [31].

4.2 Strengths of DLT

i. **Decentralization:** DLT provides a decentralized way of storing and sharing data, which reduces the need for intermediaries and increases trust and transparency.

ii. **Security:** DLT uses cryptographic algorithms to secure data and prevent tampering or hacking.

iii. **Efficiency:** DLT can provide faster and more efficient ways of processing transactions and managing data.

4.3 Weaknesses of DLT

i. **Scalability:** Current DLT platforms may not be able to handle the scale and speed of transactions required by some industries, which could limit their widespread adoption.

ii. **Energy consumption:** DLT platforms such as Bitcoin require significant amounts of energy to operate, which could have negative environmental impacts.

iii. **Complexity:** DLT is a complex and rapidly evolving technology, which may make it difficult for businesses and consumers to understand and adopt.

4.4 Challenges and Limitations of DLT

i. **Regulation:** DLT is a relatively new technology, and there is currently a lack of clear regulation in many countries. This could create legal and regulatory challenges for businesses and consumers.

ii. **Interoperability:** There are currently many different DLT platforms and protocols, which may not be compatible with each other. This could limit the ability of businesses and consumers to use DLT across different applications and industries.

iii. **Adoption:** DLT is still in the early stages of adoption, and it may take time for businesses and consumers to fully understand and trust the technology.

5.0 DLT and Their Applications in Different Industries

I. Public DLT

Public DLTs, such as Bitcoin and Ethereum, are best suited for applications and industries that require open and transparent networks. They are commonly used in the financial industry for peer-to-peer payments and for creating decentralized applications (DApps) that require a high level of security and transparency. They are also useful for applications that require censorship resistance, such as in cases where governments or other central authorities may try to shut down the network[32].

II. Private DLT

Private DLTs, such as Corda and Hyperledger Fabric, are best suited for applications and industries that require a higher level of privacy and control. Private DLTs are commonly used in industries such as healthcare, supply chain management, and government where sensitive data needs to be shared securely between a selected group of participants. Private DLTs are useful for applications that require faster transaction times and higher throughput, such as in trading and settlement platforms.

III. Hybrid DLT

Hybrid DLTs, such as Ripple and Quorum, are best suited for applications and industries that require both transparency and privacy. Hybrid DLTs are commonly used in the financial industry for cross-border payments, where both transparency and privacy are important.

They are useful for supply chain management, where a combination of public and private data is needed to track products from manufacturer to consumer. Hybrid DLTs are suitable for applications that require interoperability, such as in cases where multiple DLT platforms need to communicate with each other.

In summary, the best type of DLT for a specific application or industry will depend on the specific use case and requirements of the network. Public DLTs are best suited for applications and industries that require open and transparent networks, while private DLTs are better suited for applications and industries that require a higher level of privacy and control. Hybrid DLTs are suitable for applications and industries that require both transparency and privacy, as well as interoperability.

5.1 Potential Impact of DLT

Despite the challenges and limitations of DLT, it has the potential to have a significant impact on various industries and the economy as a whole [33]. Here are some potential impacts of DLT:

i. **Increased efficiency and reduced costs:** DLT can provide more efficient and transparent ways of processing transactions and managing data, which could reduce costs for businesses and consumers.
ii. **Disintermediation:** DLT can reduce the need for intermediaries in many industries, which could lead to a more open and competitive marketplace.

iii. **Innovation:** DLT is a rapidly evolving technology, which could lead to new and innovative applications and business models.

It will be important to address the advantages and limitations of DLT and ensure that it is used in a responsible and sustainable way.

Table 4.1: Advantages and limitations of DLT

		Advantages	Limitations

1	**Public DLT (e.g. Bitcoin and Ethereum)**	**Decentralized:** Anyone can join and participate in the network, making it more open and transparent. **Security:** Public DLT uses cryptography to secure the network, making it difficult to hack or tamper with data. **No permission needed:** Anyone can create a new account and start using the network without permission.	**Scalability:** Public DLTs have limitations in terms of the number of transactions they can process, which can lead to network congestion and slow transaction speeds. **Energy consumption:** Public DLTs such as Bitcoin require significant amounts of energy to operate, which can have negative environmental impacts. **Anonymity:** Public DLTs can be used for anonymous transactions, which may raise concerns about money laundering and illegal activities.
2	**Private DLT (e.g. Corda and Hyperledger Fabric)**	**Controlled access:** Private DLTs are accessible only to authorized participants, which can increase security and privacy. **Scalability:** Private DLTs can handle more transactions than public DLTs, making them more suitable for enterprise use cases. **Governance:** Private DLTs allow for more control over the network and the rules that govern it.	**Centralization:** Private DLTs are more centralized than public DLTs, which can lead to concerns about security and censorship. **Limited transparency:** Private DLTs may not be as transparent as public DLTs, which can lead to concerns about trust and accountability. **Higher cost:** Private DLTs can be more expensive to set up and maintain than public DLTs.
3	**Hybrid DLT (e.g. Ripple and Quorum)**	**Flexibility:** Hybrid DLTs offer a combination of the advantages of both public and private DLTs,	**Complexity:** Hybrid DLTs can be more complex than other types of DLT, which can lead to

		making them suitable for a wide range of use cases. **Scalability:** Hybrid DLTs can handle more transactions than public DLTs, making them suitable for enterprise use cases. **Interoperability:** Hybrid DLTs can be compatible with other DLT platforms, allowing for more flexibility in their use.	challenges in implementation and adoption. **Centralization:** Hybrid DLTs can still be more centralized than pure public DLTs, which can raise concerns about security and censorship. **Governance:** Hybrid DLTs can be more complex to govern than other types of DLT, which can lead to challenges in decision-making and conflict resolution.

Overall, the choice of which type of DLT to use will depend on the specific use case and requirements of the application. While public DLTs are more decentralized and open, they may not be suitable for enterprise use cases due to scalability limitations and concerns about anonymity. Private DLTs offer more control and privacy, but can be more expensive to set up and maintain. Hybrid DLTs offer a combination of the advantages of both public and private DLTs, but may be more complex to implement and govern.

6.0 The Future of Distributed Ledger Technology

I. Financial Industry

DLT has already made a significant impact on the financial industry by providing a secure and efficient way to transfer funds globally. In the future, DLT has the potential to replace traditional financial infrastructure and make transactions faster, cheaper, and more secure.

II. Supply Chain Management

DLT has the potential to streamline supply chain management by creating a secure and transparent record of all transactions in the supply chain. This would enable more efficient tracking of products, reducing the risk of fraud and counterfeit products.

III. Healthcare Industry

DLT has the potential to improve the healthcare industry by providing a secure and transparent way to store and share medical records. This could improve patient outcomes by enabling healthcare providers to make more informed decisions based on a patient's complete medical history. DLT could also enable the development of more personalized and precise medicine by facilitating the sharing of large datasets and research findings.

IV. Voting Systems

DLT has the potential to revolutionize voting systems by creating a secure and transparent way to vote. DLT-based voting systems could eliminate the risk of fraud and ensure that every vote is counted. It could also increase voter participation by enabling remote voting and making the voting process more accessible.

V. Energy Industry

DLT has the potential to transform the energy industry by enabling peer-to-peer energy trading. DLT-based energy trading platforms could enable individuals and businesses to trade excess energy they generate from renewable sources, reducing dependence on traditional energy sources and promoting sustainability.

In conclusion, DLT has the potential to disrupt and revolutionize various industries by creating more efficient, transparent, and secure systems. As DLT technology continues to develop, it is likely that we will see further adoption and implementation of DLT-based systems in various industries, paving the way for a more decentralized and transparent future.

7.0 A Prediction of How DLT Will Shape the Future of Technology and Business

DLT has the potential to shape the future of technology and business in several ways. Here are some predictions of how DLT could shape the future of technology and business:

I. Decentralization

DLT enables decentralized systems that can operate without a central authority or intermediary. This has the potential to revolutionize many industries by creating more

efficient and transparent systems. In the future, we could see more decentralized applications and platforms that provide greater control and privacy to users.

II. Security

DLT provides a secure and tamper-proof way to store and share data. This could significantly improve security in various industries, such as finance, healthcare, and supply chain management. In the future, we could see more widespread adoption of DLT-based systems as a way to improve data security and reduce the risk of fraud.

III. Automation

DLT can enable the automation of various processes by creating smart contracts that can execute automatically when certain conditions are met. This could significantly reduce the need for intermediaries and streamline many business processes. In the future, we could see more automation of processes in industries such as finance, supply chain management, and healthcare.

IV. Innovation

DLT is still a relatively new technology, and there is a lot of potential for innovation in its applications. As the technology continues to develop, we could see new and innovative use cases for DLT in various industries. This could lead to the development of new business models and revenue streams that were not possible before.

V. Collaboration

DLT can enable greater collaboration between different organizations and stakeholders by creating a shared and transparent record of transactions. This could lead to more efficient and collaborative business processes that benefit all parties involved. In the future, we could see more collaboration between different organizations in industries such as finance, supply chain management, and healthcare.

In conclusion, DLT has the potential to shape the future of technology and business in significant ways. As the technology continues to develop and mature, we are likely to see more widespread adoption of DLT-based systems in various industries, paving the way for a more decentralized, secure, and innovative future.

8.0 Conclusion

Summary of the Main Findings

This study is a comparative study of different types of distributed ledger technology (DLT) and their use in various industries. The study begins by explaining the concept of DLT and describing the various types of DLT, including blockchain, directed acyclic graphs, and hashgraph. It then discusses the unique features and benefits of each type of DLT, including their advantages and limitations.

The study goes on to provide real-world use cases of DLT in various industries, including finance, supply chain management, healthcare, voting systems, and the energy industry. The potential future developments of DLT and their impact on various industries are also discussed, including the potential for decentralization, security, automation, innovation, and collaboration.

Finally, the study analyzes which types of DLT are best suited for certain applications and industries and predicts how DLT will shape the future of technology and business. In conclusion, the article highlights the potential of DLT to revolutionize various industries by creating more efficient, transparent, and secure systems and paving the way for a more decentralized, secure, and innovative future.

The Significance of DLT and Its Potential to Revolutionize Various Industries

The significance of distributed ledger technology (DLT) lies in its potential to revolutionize various industries by creating more efficient, transparent, and secure systems. DLT enables decentralized systems that can operate without a central authority or intermediary, leading to greater control and privacy for users. DLT provides a secure and tamper-proof way to store and share data, which could significantly improve security in various industries, such as finance, healthcare, and supply chain management. DLT can enable the automation of various processes, reducing the need for intermediaries and streamlining many business processes.

Furthermore, DLT is a relatively new technology, and there is a lot of potential for innovation in its applications. As the technology continues to develop, we could see new and innovative use cases

for DLT in various industries. This could lead to the development of new business models and revenue streams that were not possible before.

In summary, DLT has the potential to revolutionize various industries by creating more efficient, transparent, and secure systems. Its potential impact on industries such as finance, supply chain management, healthcare, voting systems and the energy industry is significant, and the future of DLT is promising.

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