**Blockchains and Distributed Ledgers Technical Report**

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Table of Contents

[Introduction 3](#_Toc190019098)

[Definitions and Key Concepts 3](#_Toc190019099)

[Historical Context 4](#_Toc190019100)

[Current Landscape 5](#_Toc190019101)

[Technical Overview 5](#_Toc190019102)

[Benefits 6](#_Toc190019103)

[Challenges 6](#_Toc190019104)

[Future Outlook 6](#_Toc190019105)

[Recommendations 7](#_Toc190019106)

[Case Study 7](#_Toc190019107)

[Conclusion 8](#_Toc190019108)

[References 9](#_Toc190019109)

## 

## Introduction

Since the debut of Bitcoin in 2009, the blockchain and Distributed Ledger Technology (DLT) have advanced beyond cryptocurrency. They now offer immutable, transparent, and decentralized solutions in many sectors where trust and security are non-negotiable.

With the swift blockchain adoption, organizations are challenged to maintain a pace with rapid developments. This creates a gradually increasing necessity for implementation expertise.

This technical report will examine:

* Historical context
* Current landscape
* Technical overview
* Benefits and challenges
* Future outlook
* Recommendations
* Real-world example

The report aims to provide an understanding of blockchain and distributed ledger technology to allow individuals to make informed decisions.

## Definitions and Key Concepts

The following table will contain key terms and concepts with their definition that will be used in this report.

|  |  |
| --- | --- |
| **Key Term/Concept** | **Definition** |
| Blockchain | A public database that records digital transaction information without the need of a third-party. It is distributed across a peer-to-peer network and is composed of blocks linked together with immutable hashes. |
| Distributed Ledger Technology (DLT) | A digital system that records the transactions’ assets in multiple places at the same time. |
| Block | A data structure, simitar to a file that holds information about a set of transactions passed in a specific time interval. Each block is linked to the previous block with a hash. |
| Hash | A unique alphanumeric string based on a timestamp that is assigned to a block. |
| Immutability | Something that is not capable nor susceptible to change and tampering after being initially recorded. |
| Consensus | A process used to determine the legitimacy of a transaction before adding to the chain. It works by needing most nodes to conclude that a transaction is legit |
| Peer-to-Peer | A network where peers can directly interact with each other without having to go through a central authority. |
| Mining | The process of determining transaction legitimacy by solving cryptographic equations in exchange for cryptocurrency as a reward. |
| Public Key Cryptography | A method of encrypting and decrypting data using a pair of keys. |
| Node | A computer within the blockchain network that maintains a copy of the ledger. |

## Historical Context

The origins of distributed ledger technology started a few hundred years ago, on a small island in the South Pacific called Yap. The Yapese people had large Rai stones as their currency and could not transport them when looking for a trade. They would instead resort to holding community consensus for each trade to determine whether the owner of the stone was believed to own it by the community. If the majority voted in favor of the owner of the stone, then the transaction would take place, and the new owner of the stone would be documented.

Blockchains are a more recent implementation of distributed ledgers that emerged in 2008 through Satoshi Nakamoto’s white paper. Its architecture was then formalized in 2009 alongside Bitcoin’s launch.

Key milestones include the first Bitcoin transaction through the blockchain, made by a programmer named Laszlo Hanyecz who used 10,000 Bitcoin to pay for a forty-dollar pizza order. Another milestone involved the exploration of the potential use of blockchains beyond cryptocurrency around 2014. This led to the creation of Ethereum.

This era sparked the “Wild West” of cryptocurrencies in 2014, which later evolved to enterprise-level applications in 2016. This was initiated by integrations with technologies such as artificial intelligence, Internet of Things (IoT), and cloud computing. Future trends point towards cloud-based blockchains, and governments embracing and using DLTs.

## Current Landscape

Blockchains along with DLT systems, experience growing adoption across numerous industry sectors. The financial sector, healthcare industry, supply chain management and retail businesses are implementing these technologies.

The Singapore Exchange utilizes blockchain technology to make interbank payments more efficient. Walmart uses Hyperledger to manage its supply chain operations. Amazon has secured a patent for its proprietary DLT system which verifies transactions and website products.

According to a Deloitte survey almost forty percent of surveyed companies had integrated blockchains into their production processes by 2020, while fifty-five percent of those surveyed stated blockchains were a top priority for their businesses.

Blockchain market value stands at six billion dollars globally today with projections showing it will exceed one trillion dollars by 2030.

The development of blockchain protocols along with solutions from organizations like IBM, Hyperledger, and Ethereum drives the current trend in blockchain technology.

## Technical Overview

Blockchains and DLT consist of distributed programs or scripts stored across multiple machines (nodes) on a peer-to-peer network that conduct database-related tasks. It collects transaction information that is stored on a block and then passed through a cryptographic hash function to create a unique hexadecimal number called the block header hash that is used to identify the block.

The next block header receives the block hash as its own. It is encrypted using the information inside the next block's header. Using the prior block in the same way, a chain of blocks that represent the transaction history for a specific time frame is formed.

It is then that all past records become extremely hard to alter. Changing any block would require changing all subsequent blocks. Each block contains the hash of the one before it.

Consensus mechanisms such as Proof of Work (PoW) or Proof of Stake (PoS) further enhance security and integrity. They validate transactions using the same principles employed by the Yapese people.

## Benefits

Blockchains and DLTs bring several key benefits. They make transactions more efficient by eliminating duplicate records and removing the need for a third-party authority for transaction validation. Automation tools like smart contracts, make transactions much faster.

They reduce costs from their decentralized nature. By removing intermediaries, they reduce transaction fees.

These technologies also enhance overall transaction transparency and greatly reduce fraud, which can be applied as a secure alternative to traditional banking in countries where the economy is unstable.

## Challenges

As much as blockchains and DLTs present multiple benefits, they face several challenges. Scalability is one of them, as most blockchains use the Proof of Work consensus algorithm to validate transactions. Its peer-to-peer consensus validation is not a scalable design as more nodes need to validate transactions the bigger the blockchain gets. This affects transaction throughput and confirmation times.

Even though larger networks such as Bitcoin are generally resilient, some smaller networks that use code to create their security level can contain exploitable vulnerabilities.

Moreover, standardized protocols are still evolving that aim to protect consumers. This makes it highly uncertain and prone to fraudulent application.

These technologies also have a large skill gap and require expertise for proper implementation.

These challenges need to be carefully evaluated by businesses before proceeding in deploying blockchain and DLT solutions.

## Future Outlook

The future of blockchain technology aims to improve its limitations to broaden its real-world applications. Developers are working on multiple fronts and have taken up several initiatives to improve the technology. They are implementing scaling solutions, like on- and off-chain modifications, building bridges between different blockchain networks using Blockstream and fortifying the security of the blockchain network via smart contract checkers and quantum resilient platforms.

When these technical problems are solved, blockchain is thought to be more practical and efficient. Various industries implementing it will expand, giving researchers in those sectors the chance to study the impact that the technology is having on their organizations. Their findings should shed light on the effectiveness of blockchains. Potential study areas include areas like governance, business, industry, finance, and IoT applications.

As academic institutions, government agencies, and businesses continue to invest in it, blockchain technology is likely to see substantial progress in areas of security, privacy, scalability and interoperability. These advances are working together to mature the technology and push it toward new applications beyond its current use cases.

## Recommendations

Organizations can benefit using the technology as it introduces new potential business models and makes existing business processes more efficient and transparent.

Policymakers will have to address challenges by implementing security standardization measures and ensure that development of these technologies follows rules, laws, policies and regulations of the government as it can be challenging to manage the governance of the Blockchain platform among different participants.

Researchers can explore areas of study regarding technical aspects that need improvement, quantum resilience, AI integration, and many existing problems such as smart contract vulnerabilities and selfish mining that promote blockchain attacks.

## Case Study

One notable case study where blockchains have been used by a company is in 2021 by Walmart, who used DLT to improve daily processes regarding data tracking and management. Alongside IBM, Walmart is also using blockchains to track meat and poultry products sold in its multiple outlets to ensure food quality.

Additionally, they implemented a blockchain system capable of tracking information between farmers, brokers, distributors and retailers. This allows consumers to easily find the origins of products through the ledgers that gives transparent and trusted information.

Notable lessons learnt from Walmart’s blockchain implementation is to have a deep understanding of the business case, let the business lead the project instead of technical experts, as they have the knowledge to implement the technology but may not have the business sense to know when it is beneficial to implement the technology, and to start small before expanding.

The results Walmart had from implementing blockchain technology is the ability to trace the origin of over 25 products from 5 different suppliers. The company plans rolling out the system to more products and categories. They have recently announced that they will start requiring all its suppliers of fresh leafy greens (like salad and spinach) to trace their products using the system.

## Conclusion

In conclusion, the powerful new technologies of blockchain and distributed ledger technology (DLT) have surged well beyond cryptocurrency to offer verifiable trust and transparency across an astonishing array of industries. From financial services to supply chain management, organizations are finding novel ways to harness these technologies to drive operational efficiencies and cut costs, even as the tech world has begun to acknowledge that, in their current state, blockchain and DLT have some rather serious issues with scalability and standardization.

Organizations should carefully evaluate blockchain solutions for their specific needs, starting small and scaling based on demonstrated success, as exemplified by Walmart's methodical implementation approach.

As the technology matures and adoption grows, blockchain is poised to fundamentally transform how we handle digital trust and transparency across the global economy.

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