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Blockchain in Banking

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Abstract

Traditionally, banks have maintained separate databases and exchanged messages to reconcile their records. Blockchain technology offers a different form of recordkeeping: a shared ledger whose approved entries are synchronized across authorized participants and protected by cryptographic controls. It offers banking a new way to organize trust among institutions that need to share records but do not want to surrender all control to one participant. The central question is not whether blockchain will replace banks, but how banks and public authorities can use distributed systems without weakening the trust on which money depends. Banks are turning to blockchain for speed, transparency, and cost savings. The blockchain revolution in the banking sector promises secure transactions, lower costs, and faster settlements. It reshapes everything from cross-border payments to compliance. This paper explains how banks are using blockchain technology today.

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Keywords: blockchain, blockchain technology, distributed digital ledger, digital ledger technology (DLT), banking, banker, banking industry

1. Introduction

The banking sector has been a cornerstone of many economic activities, including lending, trading, transaction settlement, and payment processing. Banking is fundamentally an industry of records. Deposits, loans, securities, payments, and ownership claim all depend on institutions maintaining accurate ledgers and agreeing about when transactions are valid and final. Conventional banking systems accomplish this through centralized databases controlled by banks, clearing houses, payment networks, and central banks. Blockchain introduces a different model: a shared ledger in which authorized participants can verify and update synchronized records according to agreed rules. It can change how banks issue, trade, and settle financial assets. Blockchain is best understood as one form of distributed ledger technology: a system in which records are shared and synchronized across a network rather than maintained in a single database. Tokenization uses such technology to issue or represent money and other assets as digital tokens. Digital tokens can represent bonds, deposits, fund shares, or claims on real-world assets [1]. Major financial institutions, from JPMorgan Chase & Co. (JPM) to Goldman Sachs (GS), have been developing blockchain services. Banks are jumping on the blockchain bandwagon not just to keep up with tech trends but to transform banking standards completely.

2. Methodology

This paper uses a qualitative approach supported by a literature review. The review draws on a range of sources, including peer-reviewed scholarly journals and official reports from organizations and industry experts on Blockchain technologies and their key characteristics. The research design is both descriptive and analytical. The systematic reviews enabled a comprehensive analysis of the measurable effects of Blockchain technology on banking operations, applications, implementation experiences; regulatory concerns; security issues; and baking industry readiness for its adoption.

3. Overview of Blockchain Technology

Blockchain combines existing technologies such as distributed digital ledgers, encryption, immutable record management, asset tokenization, and decentralized governance to capture and record the information participants in a network need to interact and transact. As illustrated in Figure 1, a complete blockchain incorporates all the following five elements such as distribution, encryption, immutability, tokenization, and decentralization as described in detail below [7]:

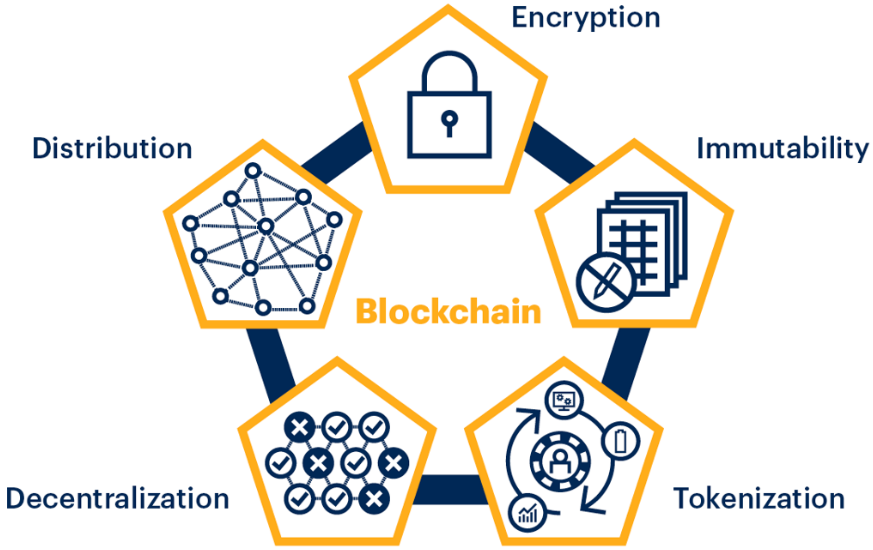

Fig 1: Five key elements of Blockchain [7].

Digital assets are distributed, not copied or transferred. A protocol establishes rules in the form of distributed mathematical computations that ensure the integrity of data exchanged among many computing devices without going through a trusted third party. Centralized architecture presents several issues, including a single point of failure and scalability problems.

No single entity controls most nodes or dictates the rules. A consensus mechanism verifies and approves transactions, eliminating the need for a central intermediary to govern the network, referred to as decentralization.

Bitcoin and its underlying blockchain technology increasingly impact all facets of society. Bitcoin's status as digital gold is merely the tip of this technology. Figure 2 shows Bitcoin [8], while Figure 5 shows how Blockchain works [9].

Fig 2: Bitcoin [8].

Although blockchain technology will always be associated with Bitcoin because of their shared origin, it has broader applications. Cryptocurrency will also factor into family law issues.

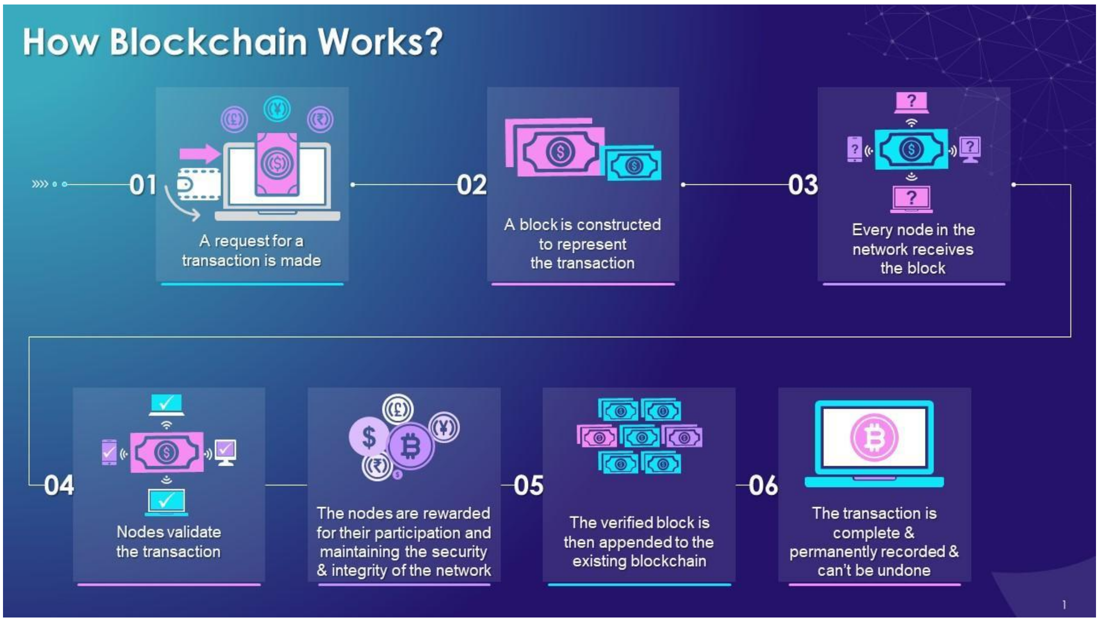

Fig 3: How blockchain works [9].

In a nutshell, blockchain technology involves three basic concepts: (1) It is a system for recording a series of data items (such as transactions between parties); (2) It uses cryptography to make it difficult to tamper with past entries; (3) It has an agreed process for storing copies of the ledger and adding new entries (also called a consensus protocol).

Blockchain is a novel decentralized infrastructure and distributed computing paradigm that uses a chained data structure for verification and storage, along with distributed consensus algorithms to generate and update data. Decentralization is a key feature of blockchain technology, referring to the distribution of power and decision-making across a network of nodes or participants rather than control by a central authority or system. It provides robustness while eliminating many-to-one traffic flows, avoiding delays and single points of failure. Figure 4 shows the decentralized property of Blockchain [9].

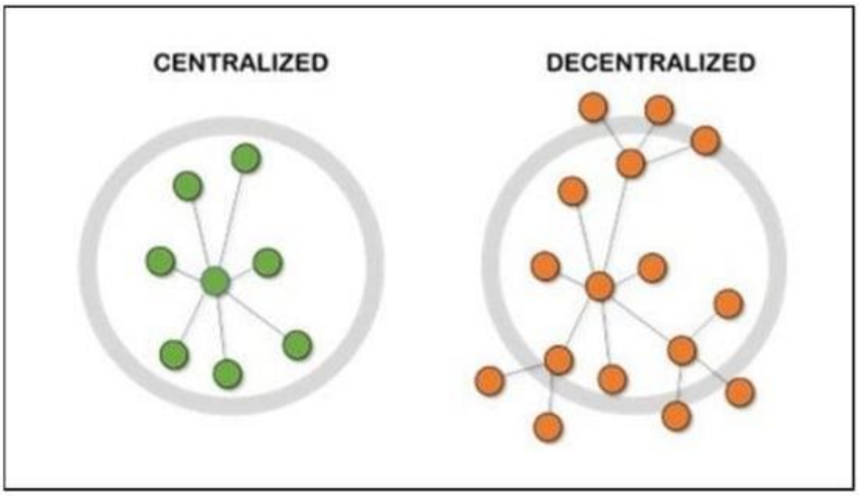

Fig 4: The decentralized property of blockchain [9].

The advantages of the decentralized property of blockchain networks include the following [9]: It makes blockchain less prone to failure and more expensive for hackers to attack. There is no third-party involvement; therefore, there is no added risk.

- Every change made in the network is traceable and concrete.
- Users maintain full autonomy of their properties and are not dependent on third parties to maintain and manage their assets.
- It provides enhanced security.

4. Blockchain Technology in Banking

For decades, banks have relied on centralized systems to process transactions, manage records, and ensure compliance. Banking depends on trusted records. A payment, loan, securities trade, or letter of credit is ultimately a set of legally significant claims recorded across the systems of banks, customers, clearing institutions, and regulators. Traditional databases perform this work efficiently inside

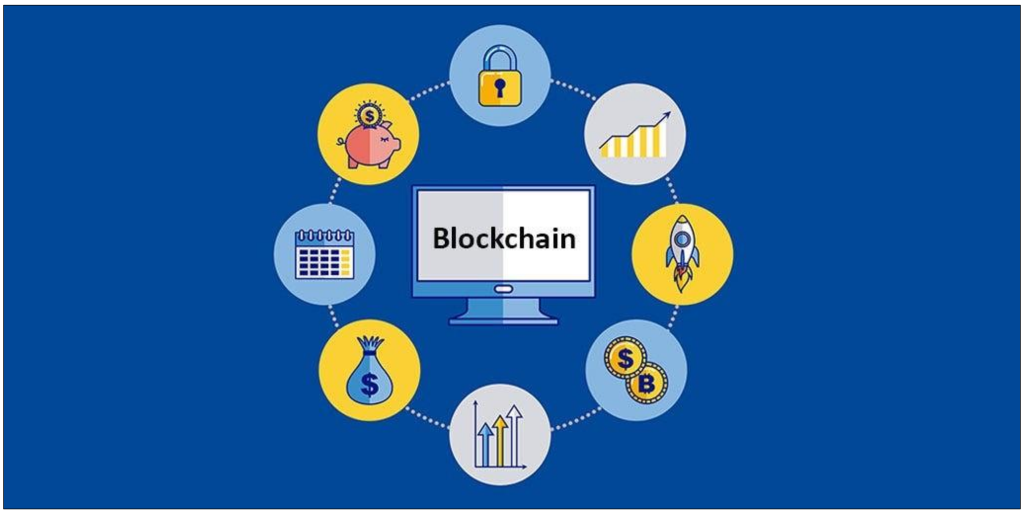

Fig 5: The symbol of blockchain [2].

individual organizations, but transactions spanning several organizations often require repeated messaging, verification, reconciliation, and manual exception handling. Blockchain technology offers a different approach: authorized parties can share a synchronized record and use software rules to coordinate changes. Blockchain is one form of DLT in which records are grouped into cryptographically linked blocks. Its most credible role in banking is not eliminating trusted institutions, but creating shared, programmable infrastructure for activities that currently require many parties to maintain and reconcile separate records [1]. Banks are using Blockchain to improve payments, reduce fraud, and simplify complex financial operations. Figure 6 shows a representation of Blockchain in banking [10].

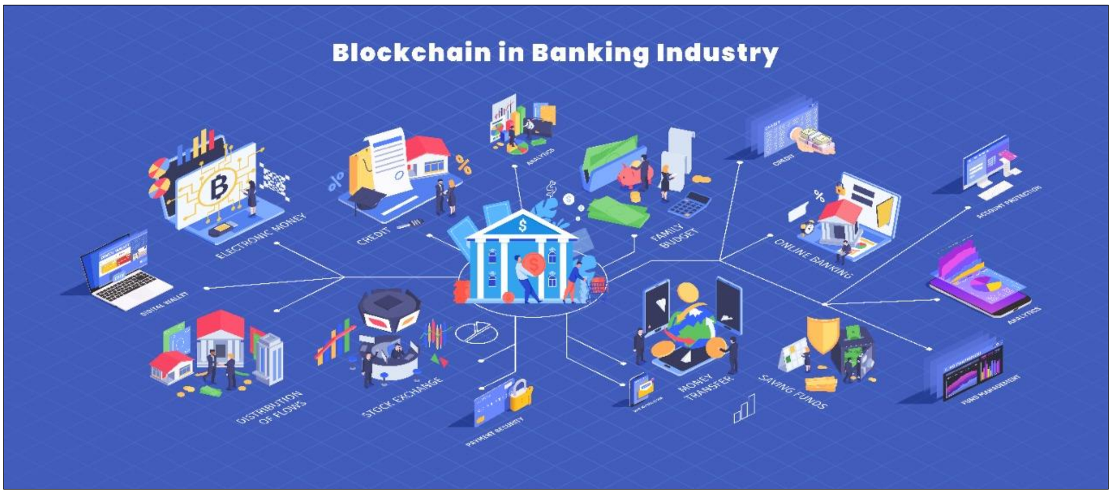

Fig 6: A representation of blockchain in banking [10].

Banking is not a one-size-fits-all industry. Blockchain is reshaping the banking sector by offering a secure, efficient, and transparent way to handle transactions. It has become a practical tool for banks, helping them streamline operations, improve transparency, and explore new opportunities. Different markets operate under distinct regulations, legal systems, and technological adoption rates. While some regions actively integrate blockchain solutions, others take a more measured approach. From speeding up international payments to simplifying asset management, blockchain is quietly but effectively reshaping financial systems. Frameworks like MiCA (Markets in Crypto-Assets) and CASP (Crypto-Asset Service Providers) set the stage for broader adoption. By establishing clear rules for compliance, transparency, and risk management, they provide trust and structure financial institutions need to move forward confidently. International transactions have long been slow and expensive, tangled in bureaucracy and intermediaries taking their cut. Blockchain simplifies these payments, allowing money to move directly between parties without unnecessary stops along the way [11]. Figure 7 shows how Blockchain works in banking [12].

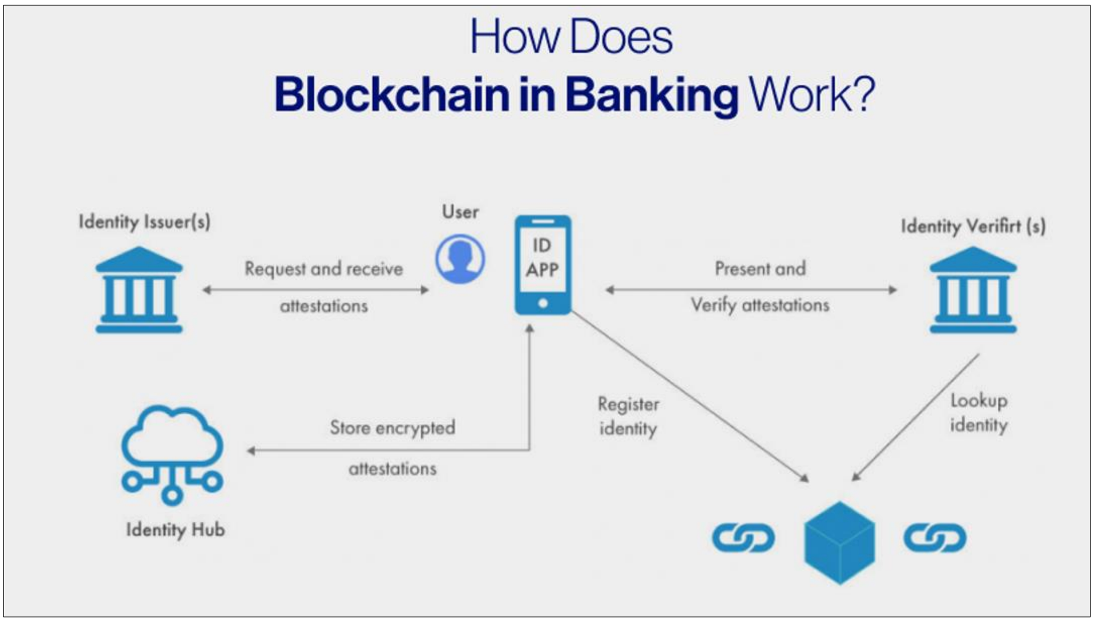

Fig 7: How blockchain works in banking [12].

5. Application of Blockchain Technology in Banking

The most promising applications of Blockchain include cross-border payments, securities settlement, trade finance, collateral management, compliance, audit trails, and syndicated lending. Figure 8 shows some cases on Blockchain in banking [13].

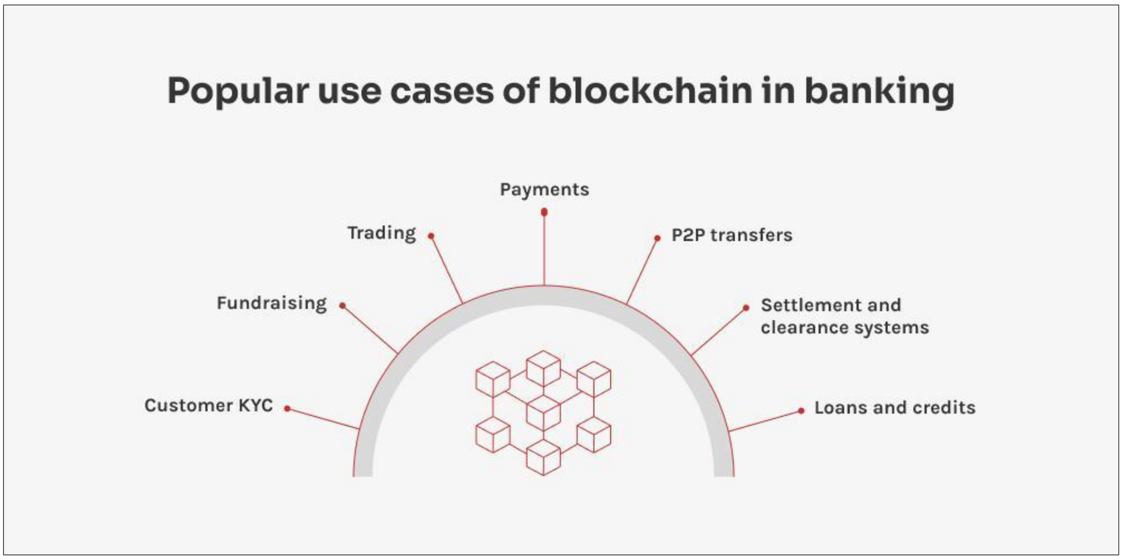

Fig 8: Some use cases on blockchain in banking [13].

Common applications of blockchain technology in banking include the following [1,14,15]:

The clearest application is known as payments and settlement, especially transactions involving several intermediaries. Cross-border payments commonly require sequential updates across correspondent banks, compliance systems, and settlement arrangements. The Bank for International Settlements (BIS) argues that tokenization could combine messaging, reconciliation, and asset transfer in a more integrated process, reducing delays, costs, and operational risks while retaining modern compliance controls. If both the payment instrument and the transferred asset exist on compatible programmable platforms, settlement can also become conditional: the asset moves only if payment occurs, reducing the risk that one side performs while the other does not.

The Blockchain is based on currency. The technology is rapidly changing the way assets are transferred, stored, and accounted for. Public and private blockchain-based currencies are being developed and utilized by private individuals, companies and even nation-states. As market capitalization and institutional support for cryptoassets grow, banks that develop infrastructure for cryptoasset banking services (including custody, payment processing, and lending offerings) will be well positioned to serve customers participating in this new and exciting asset class. As more individuals and entities participate in the cryptoasset market, the importance of providing cryptoasset services will only grow. Bitcoin is quickly growing as a new store-of-value asset similar to real estate or gold. Stablecoins are cryptoassets designed to have their value pegged to an external reference asset, such as a fiat currency. Banks should carefully consider tax consequences associated with cryptoassets.

It uses Central Bank Digital Currencies (CBDCs): CBDCs are another growing trend, as central banks research and pilot their own digital currencies. These are digital versions of regular money, like dollars or euros, issued by central banks using Blockchain. They are digital payment instruments issued by a country's central bank, like physical currency but in digital form. Central banks exploring Blockchain for CBDCs aim to provide secure, efficient transactions, foster financial inclusion, and streamline cross-border payments, potentially reshaping the economic landscape. The Central Bank of the Bahamas was the first to launch a digital currency, deploying its digital Sand Dollar in October 2020. China is piloting its digital yuan, in development since 2014, in Beijing and other cities. China has recently taken the lead in promoting the worldwide development of CBDCs by proposing a global set of rules to govern information flows between central banks and encourage interoperability between CBDCs from different jurisdictions.

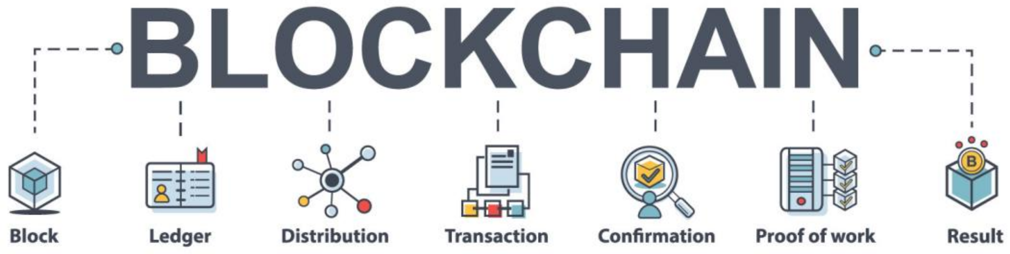

Fig 9: Different components of blockchain [6].

Financial market applications include the securities and wholesale financial markets. Bonds, funds, collateral, and other claims can be represented as digital tokens. Tokenization may make ownership records easier to update, support more precise collateral management, and enable delivery-versus-payment arrangements. The ECB states that tokenization can enhance efficiency, transparency, and programmability. Still, it also emphasizes that transactions involving tokenized assets must remain safe and capable of settlement in central bank money. This requirement reveals an important principle: technical innovation does not remove the need for a trusted final settlement asset.

Another application is trade finance because a single transaction may involve importers, exporters, commercial banks, insurers, shipping companies, customs authorities, and document providers. A shared ledger can help participants verify invoices, shipping documents, letters of credit, and delivery events without repeatedly reproducing the same records. Blockchain can make trade transactions more transparent and programmable, but its value depends on whether banks, ports, carriers, corporations, and regulators adopt compatible standards.

Cross-border payments are widely used. Cross-border payments commonly pass through multiple intermediaries that separately update accounts and exchange messages. Cross-border transactions usually take days. This can lead to delays, uncertainty over fees, trapped liquidity, and operational risk. A shared ledger can give participating banks a consistent view of a transfer's status. At the same time, tokenized commercial-bank or central-bank money can allow payment and settlement to occur as part of one coordinated process. The BIS argues that tokenization could replace sequential account updates across correspondent-banking chains with an integrated operation that combines messaging, reconciliation, compliance, and asset transfer.

The term Know-Your-Customer (KYC) is key in Blockchain. Banks repeatedly collect and verify customer information to satisfy know-your-customer (KYC), customer due diligence, and anti-money-laundering requirements. This repetition raises costs for institutions and creates friction for customers. A permissioned identity network could allow an approved institution to issue a verifiable attestation, for example, that a customer's identity has been checked—while the customer controls which information is disclosed to another bank.

The term "lending" is widely used. Blockchain-based lending can provide a secure way of offering loans to an inclusive pool of consumers and can lower costs for all parties. Blockchain can improve lending when several parties need reliable information about ownership, collateral, or contractual performance. There are two main ways to involve Blockchain in the lending process. The first is to use blockchain-based products as collateral in lending (*e.g.*, cryptoassets). The second is to develop and use blockchain solutions to streamline lending. Tokenized collateral registries can make prior claims easier to verify, reduce duplicate pledging, and automate specified actions after covenant breaches. Syndicated loans may benefit because participating banks, agents, and borrowers could work from a shared version of the loan record. The same principles apply to mortgages, guarantees, and supply-chain finance, although legal rights must remain enforceable outside the ledger.

Others also include tokenization. It converts assets into digital tokens. Blockchain enables tokenization, the representation of money, securities, or other claims as digital tokens on a programmable platform. Tokenization can allow ownership and payment instructions to move within the same technological environment, making it possible to coordinate an asset transfer with a funds transfer. This arrangement can reduce settlement risk and make financial products easier to divide, transfer, or use as collateral. The Bank for International Settlements argues that platforms bringing together tokenized central bank reserves, commercial bank money, and government bonds could unlock new efficiencies in payments, securities markets, liquidity, and collateral management.

Loans and credit are another area where Blockchain really shines. In the old-school lending world, banks tend to assess risk using centralized credit reporting systems, looking at factors like credit scores and debt-to-income ratios. The process can be inefficient and opaque, which may adversely affect consumers. Blockchain in banking brings a decentralized approach to the table — creating a transparent and unchangeable record of your financial history. This means banks can make quicker, better-informed lending decisions.

Additionally, Decentralized Finance (DeFi) is an important application. Decentralized finance is a new category of applications that are built on blockchains like Ethereum or Solana. Unlike traditional financial applications, which a single company or institution centrally manages, DeFi applications are open source and decentralized, meaning a network of computers around the world runs them. This makes them more resistant to censorship and fraud and allows them to offer new kinds of financial products and services. Some popular DeFi applications include decentralized exchanges, lending platforms, and stablecoins. By using various blockchains, DeFi applications can offer users a high degree of security and transparency and execute smart contracts. Smart contracts are self-executing contracts stored on the Blockchain. These contracts can automate various processes, such as payments, asset transfers, and voting. Smart contracts are self-executing contracts in which the terms of the agreement between buyer and seller are written directly into lines of code. The code and the agreements contained therein exist across a distributed, decentralized blockchain network. Smart contracts enable trusted transactions and agreements among disparate, anonymous parties without a central authority, legal system, or external enforcement mechanism. In finance and banking, smart contracts can automate many processes, including clearing and settling trades, loan origination, and payments.

6. The Benefits and Challenges in Blockchain Technology in Banking

6.1 The Benefit of Blockchain Technology in Banking

Blockchain can benefit banking by creating shared, auditable records; accelerating payments and settlement; reducing reconciliation; automating contractual processes; and enabling programmable money and financial assets. Blockchain's innovative characteristics include distributed control, immutability, pseudonymous participation, and programmable assets. Other benefits of blockchain technology in banking include the following [1,11,16]:

Automation in Blockchain is a major advantage. It uses smart contracts, programs that execute agreed actions when specified conditions are met. In banking, smart contracts can automate routine steps such as releasing funds after delivery is confirmed, transferring collateral when exposure changes, distributing interest payments, or checking whether required approvals are present. The technology can reduce manual intervention, shorten processing times, and lower the risk of clerical mistakes.

One advantage is improved efficiency: Blockchain could automate many processes, from transaction verification to compliance, significantly reducing manual errors and administrative tasks. This efficiency could cut costs for banks and enable faster transaction settlements. Another area is cost reduction*:* Depending on its design, Blockchain can reduce the need for some intermediaries and may lower costs for cross-border payments, clearing and settlement, and trade finance. The cost advantage does not come from eliminating banks or trust altogether. In regulated finance, blockchain networks are likely to be permissioned, meaning that participation and access are restricted to approved institutions. The principal economic benefit is better coordination: banks can spend less effort proving that their separate records match and more effort delivering services, managing risk, and serving customers.

Furthermore, it enables faster payments. One of Blockchain's clearest benefits is its potential to accelerate payments and settlement. Conventional cross-border payments may pass through several correspondent banks, each maintaining its own ledger and conducting separate compliance and reconciliation procedures. Speed is important not merely because customers prefer convenience. A shorter settlement period reduces the interval during which one party has performed its obligation while another has not. It can therefore limit counterparty exposure and release cash or securities that would otherwise remain tied up during processing. For banks, these effects can translate into more efficient treasury operations; for customers, they can mean faster access to funds and greater certainty about whether a transaction is complete.

The technology reduces reconciliation errors. Banks often store overlapping versions of the same information. When two institutions record a transaction independently, they must investigate and correct discrepancies. This reconciliation process requires staff time, specialized systems, and communication among intermediaries. Blockchain can reduce this duplication by giving permitted participants access to a synchronized ledger. Once the network validates a transaction under its rules, all authorized copies can update from the same agreed state.

Another area is improved resilience: Because a distributed ledger is replicated across several authorized nodes, it reduces reliance on a single central database as the sole source of truth. If one node becomes unavailable, other validated copies may continue to preserve the transaction history. This architecture can improve continuity and make unilateral manipulation more difficult. Distributed architecture may also improve resilience by avoiding dependence on a single database, although the wider system remains vulnerable through software defects, compromised credentials, faulty smart contracts, and external interfaces. Furthermore, Blockchain can also improve transparency and auditability. Blockchain's immutable ledger enhances transparency, reduces fraud, and improves trust among stakeholders. Validated changes are recorded in sequence, creating a durable transaction history. This makes unauthorized alteration harder and helps participants determine when and how a record changed. Finally, programmability is another benefit. Blockchain enables programmable money, allowing transactions to execute automatically when predefined conditions are met. This capability streamlines complex financial operations, such as automated disbursements and conditional payments. In a regulated banking environment, the most important innovation is programmable settlement. Programmable systems can also automate collateral transfers, interest distributions, margin calls, and corporate actions. The EBA notes that DLT may add programmability to retail value transfers and permit tokens to be redeemed for goods, services, discounts, or prices.

Figure 10 shows some benefits of blockchain technology in banking [12].

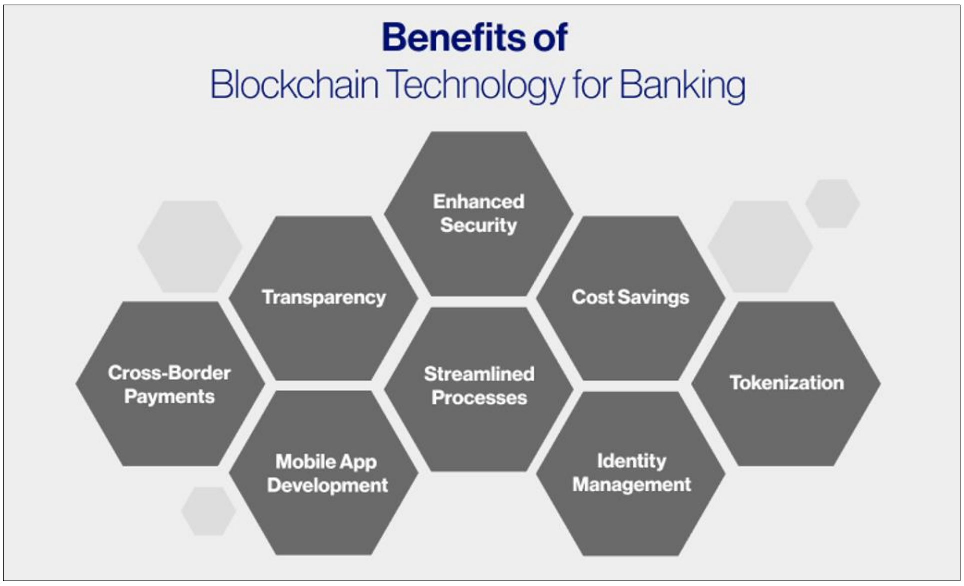

Fig 10: Some benefits of blockchain technology in banking [12].

6.2. The challenges of Blockchain Technology in Banking

Despite its promise, Blockchain is not automatically superior to a conventional database. Banking networks must agree on governance, technical standards, liability, software upgrades, data permissions, and dispute resolution. Interoperability, cybersecurity, privacy, compliance uncertainty, scalability, legal finality, governance, and operational risk have been identified as obstacles to broad adoption. Other challenges of blockchain technology in banking include the following [1, 11, 17]:

Fig 11: The future of blockchain in finance and banking [15].

Privacy presents a disadvantage. Privacy is particularly difficult because authorized participants need enough information to validate transactions without exposing confidential customer or trading data. The privacy design is crucial. Banks cannot simply place sensitive customer information on a broadly visible ledger. Effective systems may need to store personal data off-chain, record only proofs or references on the ledger, limit role-based access, and establish procedures for correcting information. With these safeguards, Blockchain can improve coordination among regulated institutions without abandoning the confidentiality obligations central to banking. Another area is Risks. Technical risks include scalability limits, software defects, compromised cryptographic keys, attacks on consensus mechanisms, and dependence on data oracles that connect the ledger to external events.

Blockchain should not be assumed to be automatically secure. A distributed system may create additional access points, and stolen credentials, flawed software, weak governance, or compromised smart contracts can still cause serious losses. Immutability can even complicate correcting mistaken or fraudulent entries. Blockchain does not eliminate cybersecurity risk; it changes where that risk is concentrated. Interoperability with legacy systems also poses a significant issue. A bank cannot usually replace all its existing infrastructure at once. A blockchain platform must therefore communicate with core banking software, identity systems, compliance tools, real-time gross settlement systems, messaging networks, and other institutions' ledgers. Open networks can promote broad interoperability, but pseudonymous participation and public transaction histories can conflict with banking regulation and confidentiality. Permissioned systems offer stronger access control and clearer governance, but they may recreate central points of control and reduce the benefits of open decentralization. For this reason, banking applications increasingly use hybrid designs, with permissioned access or application layers connected to shared settlement infrastructure. Further, financial inclusion becomes a disadvantage. Blockchain-based infrastructure may also expand access to selected banking services, particularly where existing payment networks are costly, fragmented, or unavailable outside business hours. Faster cross-border transfers can benefit migrants, small firms, and households that depend on remittances. Tokenized assets may also permit smaller transaction sizes or fractional ownership, potentially broadening participation in savings and investment products. These gains are not automatic: users still need reliable connectivity, appropriate legal protection, usable interfaces, and trusted ways to exchange digital value for national currency.

A major challenge is scalability and integration. Banks operate high-volume systems that must remain available, secure, and fast. A DLT platform must connect with core banking software, payment rails, accounting systems, identity services, and regulatory reporting. Different ledgers must also communicate with one another. The World Bank identifies scalability, interoperability, cybersecurity, privacy, governance, transaction finality, and migration costs as central implementation challenges.

Similarly, another challenge is law and regulation. Unclear or evolving regulations often hinder blockchain adoption. Banking transactions require clear answers about ownership, jurisdiction, settlement finality, liability, consumer protection, and dispute resolution. An immutable record does not mean an erroneous or fraudulent transaction is impossible to remedy; a governed system needs procedures for corrective transactions and legal recourse. Permissionless networks also complicate anti-money-laundering and know-your-customer obligations because participants may be represented only by pseudonymous addresses. Regulated banking applications consequently tend to favor permissioned participation and identifiable counterparties. Regulators have started giving banks more room to experiment.

Furthermore, regulatory compliance is a challenge. Permissioned blockchain networks can support regulatory compliance by allowing only verified participants to transact and by recording approvals in an auditable form. In principle, banks could share attestations that a customer has completed specific Know Your Customer checks without distributing all underlying personal data. This could reduce repetitive verification, improve the provenance of compliance information, and give regulators more timely access to authorized records.

Governance is the most fundamental institutional challenge. Blockchain projects face a governance problem. Banks must decide who may join a network, who can change its rules, who is liable when code fails, what information regulators can inspect, and how to upgrade a platform without disrupting transactions. These are institutional questions rather than purely technical ones. Indeed, the need for governance helps explain why Blockchain does not necessarily disintermediate banks. Trusted intermediaries continue to provide credit assessment, liquidity, compliance, customer service, and legal accountability even when recordkeeping becomes distributed.

Resistance to change is another important factor, especially around regulatory compliance. Resistance within organizations is another significant barrier to blockchain adoption. Legacy systems and entrenched workflows can make employees hesitant to embrace new technologies. Gradual implementation and education are essential. This helps employees see Blockchain's value without overwhelming them.

Finally, skill shortage is a challenge. Investing in talent is essential for successful blockchain implementation. Banks should upskill their existing workforce and hire experts in Blockchain technology, smart contracts, and cybersecurity. Continuous training and development will keep the team up to date on the latest advancements and best practices.

7. The Future of Blockchain Technology in Banking

The future of Blockchain in banking is likely to be a hybrid system: partly centralized, partly distributed, and connected by standards that allow old and new infrastructures to coexist. Banks will continue using centralized databases where those systems are efficient, while adopting DLT for selected multi-party processes in which shared state, tokenization, or programmable settlement adds clear value. The BIS describes this combination as a possible foundation for a next-generation monetary and financial system, while noting that tokenization does not always require DLT. Long-term success will depend on interoperability, legal certainty, common technical standards, strong cyber controls, privacy-preserving design, and credible governance [1].

The decisive question is not whether blockchain is inherently superior to traditional databases. It is whether a particular distributed architecture solves a clearly defined banking problem more safely, legally, and economically than the alternatives. The most realistic future for blockchain in banking is likely to be selective rather than universal. Permissioned or hybrid systems may be appropriate where several known institutions need a shared record and can agree on governance. At the same time, permissionless networks will require stronger mechanisms for identity, compliance, finality, and accountability before they can support critical banking functions on a scale. Banks are unlikely to disappear. Instead, they may issue programmable deposits, settle tokenized assets against central-bank money, and operate across shared networks that compress payment, clearing, custody, and compliance into integrated workflows. Central banks will continue to anchor the value of money. Figure 11 illustrates the future of blockchain in finance and banking [15].

8. Conclusion

Blockchain has significant implications for banking because many financial processes depend on coordination across institutional and jurisdictional boundaries. Its most compelling applications include cross-border payments, securities settlement, trade finance, interbank reconciliation, digital identity attestations, collateral management, programmable retail services, and compliance reporting. Nevertheless, blockchain should not be understood as a universal substitute for databases, commercial banks, or central banks. Financial systems require confidentiality, legal certainty, liquidity, accountability, and mechanisms for correcting errors. Consequently, the future role of Blockchain in banking will depend less on maximal decentralization than on effective governance, interoperability, software security, proportionate regulation, and its integration with trusted forms of money.

In conclusion, the most plausible future for Blockchain in banking is not the wholesale replacement of banks, regulators, or conventional monetary systems. Rather, Blockchain is more appropriately viewed as an emerging infrastructure layer through which trusted institutions may exchange value and information with greater speed, transparency, programmability, and operational efficiency. If implemented selectively and governed responsibly, blockchain can reduce delays and discrepancies while preserving the legal, regulatory, and institutional safeguards on which financial stability depends. Further discussion of blockchain integration in the banking industry can be found in the books cited in [18–22] and in the related journals listed below:

- Blockchain
- IEEE Blockchain
- International Journal of Blockchain Technologies and Applications

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