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MODULE 4 UNIT 1
Blockchain and the democratization of finance

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Learning outcomes:

LO1: Identify the key principles of blockchain technology.

LO2: Articulate the uses of blockchain and decentralized systems.

LO3: Deduce the impact of blockchain on trade and development finance.

LO5: Analyze how blockchain can be used by different industries.

1. Introduction

Throughout history, the transfer of financial information has required that a trusted third party verifies the claims made by individuals involved in these transactions. This has led to a complex system of contract verifications using lawyers and other third-party systems to confirm non-fraudulent payment. Similarly, government regulatory bodies were established to confirm the identities of individuals and the validity of legal contracts. Governments established institutions to carry out these tasks as essential for contract verification. Organizations like Visa were also established to confirm fund availability for card transactions to prevent fraudulent payments, while charging a percentage of the transaction to fund their operations. All these processes have required a centralized system based on the incorruptibility of third parties.

The reason that centralized systems for information sharing emerged before decentralized systems can be illustrated by a philosophical thought experiment: the Byzantine Generals' Problem. This thought experiment introduces the concept of an army that surrounds a city, with four divisions posted on opposite sides of the city walls. To successfully take the city, each general in command of their respective divisions must unanimously agree to either attack the city walls or retreat from battle. Should one of them disagree with the others or refuse to make a decision, the entire army will be defeated. However, in this situation, the other generals cannot be certain of their peers' thoughts or the trustworthiness of the messengers communicating between the four. Due to this, consensus is ultimately rendered impossible to attain, which renders the attack likely to fail (Vaidya, 2016).

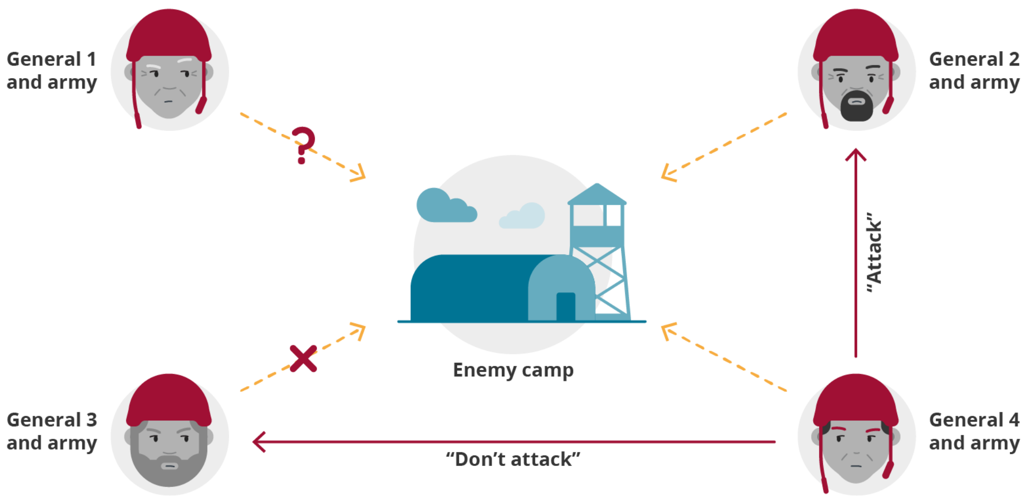

Figure 1: The Byzantine Generals' Problem.

This thought experiment outlines why decentralized networks are difficult to put in practice; only one untrustworthy member of the network is needed to falsify information for the consensus to be rendered unachievable. The difficulties associated with this problem are what ultimately led to the establishment of traditional, trustworthy third parties.

The development of blockchain technology has, however, changed the security associated with a network's ability to share and operate securely. This is done by distributing the information throughout a network, with members then cooperating to verify the data.

This set of notes outlines what blockchain is, how it operates, and, most importantly, examines the issue of trust between two parties in a transaction resolved by blockchain. Furthermore, an explanation of blockchain technology explores the rise of new digital assets and discusses concerns regarding its longevity.

2. What is blockchain?

An authoritative and widely used definition of blockchain is stated as:

> Self-sustaining, peer-to-peer ledger technology with an integrated set of computer codes for managing and recording transactions without the involvement of any central authority.
>
> (Yoffie & Woo, 2017:1)

Blockchain technology is a digital infrastructure that serves as the foundation for various network applications. The computer codes that form the basis of the blockchain create a secure and transparent way to track the ownership and transaction of data. Each transaction is recorded as a block and linked to the previous transaction, forming a chain. The chain is open to all its members, who can view each transaction (which are permanently recorded).

Blockchains are a form of distributed ledger technology (DLT). DLT, which is a decentralized database managed across many different participants and locations (or nodes), removes the need for a central authority, or intermediary, to oversee, validate, and authenticate entries. By sharing this information through a distributed ledger, the information disburses among members of the network making all transactions transparent and auditable. All members can examine each transaction and agree that it took place. Due to the permanency of the blockchain, all historic transactions can also be viewed and verified (Nanda et al., 2017).

However, while all blockchains are a form of DLT, not all DLTs are blockchains. Blockchains add an additional layer of cryptographic security and links a ledger's records into an immutable chain within a specific order based upon a consensus mechanism that facilitates synchronization between different nodes. Other DLTs do not necessarily require the same cryptographic security, structure, sequence, or consensus mechanisms, and as a result, they require less energy and scale at a more rapid pace.

Figure 2 illustrates the application of blockchain technology, demonstrating its distributed ledger network.

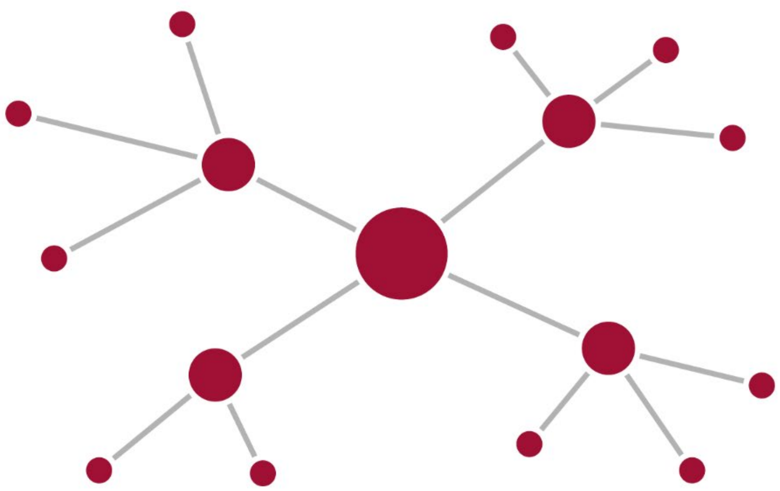

Figure 2: Blockchain and the distributed network.

Additionally, transactions of data on the blockchain remain secure and private, due to the way the blockchain stores and adds information onto its ledgers. As illustrated in Figure 3, no personal data is visible in the transaction and no third party is required to house this information. This limits opportunities for data breaches on the blockchain itself, although not in all cases.

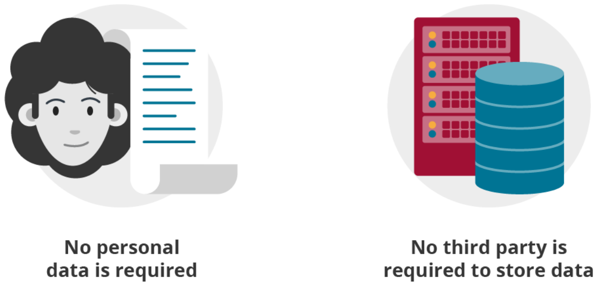

Figure 3: How security and privacy are secured in the blockchain.

In practice, blockchain vulnerabilities can vary based on its type and security practices. The four main attacks on blockchains are:

1. **Phishing:** Hackers attempt to gain access to a user's log-in credentials, often through a fraudulent link sent by email.

2. **Routing:** Hackers intercept data as it is transferring over the Internet, a modification of which can prevent the blockchain from reaching consensus.

3. **Sybil:** Hackers create so many false identities to gain sufficient influence over a network's true nodes that the entire blockchain system collapses.

4. **51%:** Should hackers gain more than 50% of a blockchain network's mining power, the attack becomes a 51% attack, in which hackers can control the ledger and fraudulently modify transactions.

(Costa, 2021)

Explore further:

Blockchain can be particularly appealing to hackers, as you cannot reverse fraudulent transactions. Blockchain has various vulnerabilities and complexities that exist between how the blockchain's system is built, its economics, and the ever-present factor of human greed.

Blockchain is often confused with cryptocurrencies, such as bitcoin, which is the first and best-known example of cryptocurrencies. Although blockchain is used in the creation, recording, and distribution of cryptocurrencies, they are not the same thing. Blockchain is a technology used to store data on decentralized networks, whereas cryptocurrency is a medium of exchange. For example, the currency of a country such as the US dollar, is created and saved in the blockchain technology. Cryptocurrencies are not physical entities, cannot be exchanged for physical commodities, and are based in a decentralized network (PwC, n.d.), but all cryptocurrencies have monetary value. While cryptocurrencies are primarily used for buying goods or services, blockchain technology has other uses besides cryptocurrency transactions. For example, blockchain technology can be used for recording transactions across the banking, healthcare, supply chain, and retail sectors. Examples of this include digital IDs, copyright and royalty protections, digital voting, digitalizing the process of verifying customer data as is done in electronic know your customer (e-KYC), and even the loyalty program at your local coffee shop. Its valuable for improving businesses' software and could be used in transactions like insurance for financial entities (PwC, n.d.). You will explore cryptocurrencies in more detail in Module 5.

Explore further:

Watch this video exploring the function and application of blockchain.

2.1 Securitization and the mechanics of blockchain transactions

Further security of transactions is built within the system of linking throughout the chain (Yoffie & Woo, 2017). The first step to authorizing the process involves solving a mathematical puzzle to complete a proof of work. This process is referred to as mining, and individuals who complete this process are known as miners. They are incentivized through payment in an amount of crypto and in the case of a bitcoin transaction, miners are compensated in bitcoin.

Definition:

A proof of work is a process that is followed to achieve consensus in a blockchain network. It follows a series of steps:

1. A transaction is proposed by two parties.

2. Miners verify the transaction by ensuring that the parties' accounts can complete the transaction.

3. Miners complete a complex mathematical puzzle to add a new block to the chain.

4. The solution to the puzzle requires computational power, resulting in the production of a hash function, an algorithm that transforms an input of numbers or letters of any length into a fixed length.

5. This hash function then confirms the authenticity of the transaction. A hash function's input will always produce the same output, but only one input will generate a singular output. Furthermore, a hash function's output cannot be reverse engineered to produce the input.

Once this calculation is complete, a hash function is produced, which acts as a cryptographic key that unlocks the information and confirms the transaction. A hash function can also be viewed as a digital fingerprint that validates the new transaction. A cryptographic hash function is designed to be a one-way function, meaning that it is easy to verify, but requires a computationally expensive force to be generated, making it almost impossible to hack into with current levels of technology. The network blockchain can then verify that the hash function is correct, and the block is added to the chain. If the hash is incorrect, the validation process will be rejected by the network (Nanda et al., 2017). Furthermore, each block is linked by including the hash from the previous block in the chain, along with the data of the most recent transaction. Therefore, to fraudulently alter the chain, every single block in the chain needs to be altered. Figure 4 illustrates how the blocks are added to the chain.

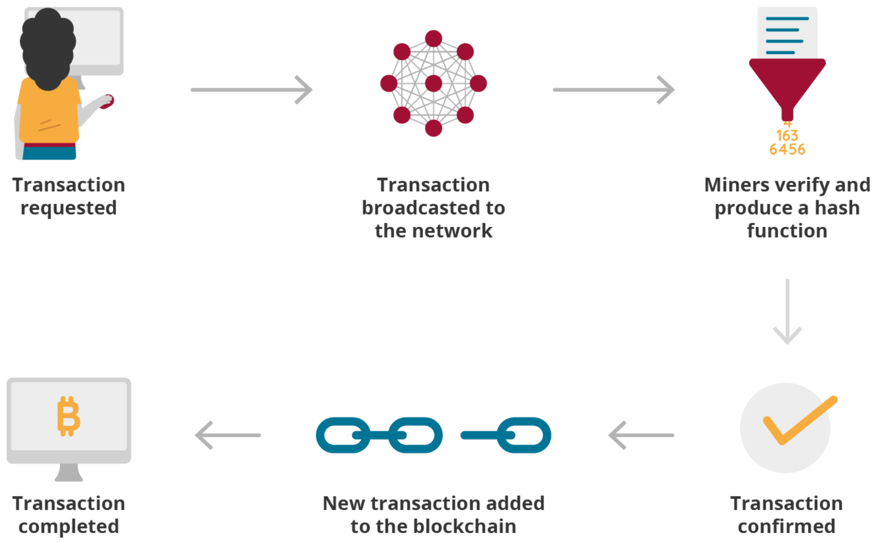

Figure 4: Completing a blockchain transaction. (Adapted from: Nanda et al., 2017)

Section 3 assesses blockchain's potential to disrupt the banking and financial industries, as well as this technology's potential applications.

3. How blockchain can disrupt and transform the financial industry

There are various mechanisms that enable blockchain to resolve issues of trust in decentralized networks. However, questions remain as to how best to apply this technology to the financial industry.

One of the major benefits of a blockchain is that it operates as one ledger detailing multiple transactions. Therefore, each member of the system and participants in each transaction can view any changes to contracts or balances in real time. No coordination is required to update the system and no third party is required. This has the potential to lower transaction costs, as there are no additional fees charged on transactions. Additionally, the system is widely perceived as secure since any changes must be verified by consensus (Yoffie & Woo, 2017).

Financial applications that are developed on blockchain systems are also known as decentralized finance (DeFi) and have grown at a fast pace during the past few years. Several major categories of use have been identified, including the following three commonly explored categories:

1. **Clearing and payments:** This is the most common use of blockchain, and is popularized using bitcoin as a payment method. This use offers the potential for blockchain to be used to efficiently process cross-border payments. Currently, cross-border payments involve a long and costly process and require a variety of different intermediaries. This process can increase costs by around 10%, which will not be finalized until the funds are received. With blockchain, the payment could happen in real time without intermediaries and, therefore, at a much lower cost. The process is secure and verifiable, as all members of the network are able to track the payment transaction as it happens (Allayannis & Fernstrom, 2017).

2. **Digital identification:** This would require the development of a block to store personal data and could be used in government records or for financial services businesses. The subsequent possibilities could result in the speeding up of applications for insurance and banking products, thereby improving user experience. The use of blockchain for digital identification would also eliminate the need to complete detailed applications, and supply businesses with copies of identification and proofs of address. The block storing this data would be consistent, secure, and relatively easy to update. Additionally, a block storing personal data could revolutionize governmental functions. For example, house ownership could be easily transferred, and voter IDs could be verified quickly.

3. **Smart contracts:** Blockchain can also be used in the operation of "smart contracts," which are a series of automatic processes that are executed upon certain specified conditions. They are not like legal contracts, but rather a specified state or set of procedures to be followed when certain conditions occur. Think of smart contracts as an "if…, then…" statement written in a computer's code. If certain conditions are fulfilled, then a certain process will occur. They are powered by the code that creates the block. Once a certain set of obligations has been fulfilled and detected by the code, a transaction is triggered. This could help to revolutionize dividend payments to shareholders, since the transaction should take place once a share price reaches a certain level. Other application examples include those in the logistics industry, such as the processing of shipping documentation, which will be addressed in greater detail in Unit 3.

Organizations, such as companies and governments, are already adopting these processes for their documentation. For example, India created Aadhaar, the world's largest online digital identity platform, to provide its citizens with digital biometric IDs. In late 2021, officials announced that the government planned to further develop a blockchain platform to serve as a single access point for all IDs across various government services (Blockchain India, 2021). In Australia, Powerledger software enables peer-to-peer renewable energy trading between small-scale producers and consumers in real time (Australian Trade and Investment Commission, 2021). For many companies, blockchain technology further automates e-KYC and anti-money laundering due diligence on potential clients by expediting identification verification and reducing the workload of manual checks.

In the future, blockchain could also make capital markets and stock exchanges more accessible. In 2022, the US Securities and Exchange Commission, its primary regulator of financial markets, approved the US's 17th stock exchange, which aims to extend its applications of blockchain technology. The BOX Exchange (BSTX) in Boston, Massachusetts will be the first national securities exchange to incorporate blockchain for settlements. Future applications of blockchain also include tokenized securities (Mccrank. 2022).

Explore further:

Aadhaar's identification system has enabled economic access to millions of people. Although Aadhaar has been successful, its wide spread adoption has raised the question of whether any public or private entity should have access to everyone's digital profiles. What are the trade-offs between automated identification systems on the blockchain and the risk to a person's data privacy and security? Do similar trade-offs apply to e-KYC systems based on the blockchain?

In addition, Barclays bank uses these three major applications of blockchain.

Figure 5 outlines other potential uses of blockchain in the financial and other sectors.

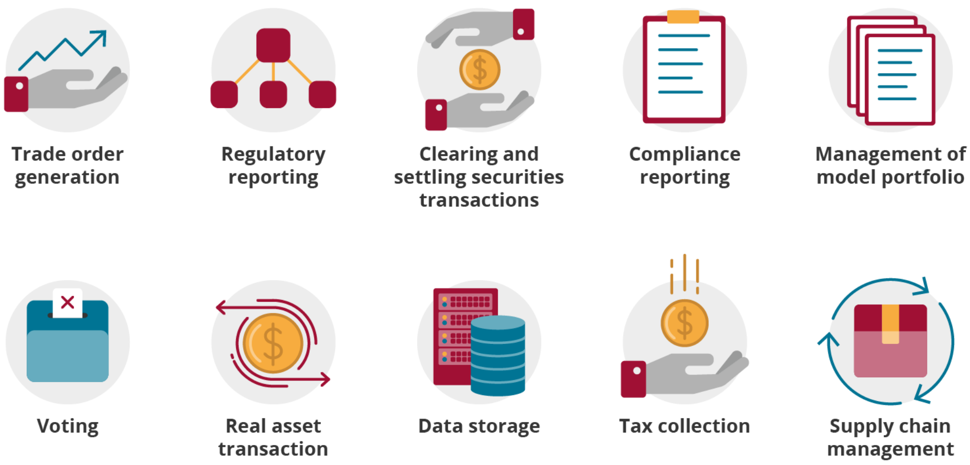

Figure 5: The potential uses of blockchain.

Explore further:

Globally, FinTech organizations are utilizing blockchain in a number of ways to transform their industry.

4. Bond-I & Blockchain Bonds in development finance

Blockchain technology also holds the potential to enhance access to investment opportunities, such as bonds, loans, and other debt securities. The next section covers the first blockchain bond, Bond-I, as issued by the World Bank and the Commonwealth Bank of Australia in 2018.

4.1 Digital assets and blockchain bonds

A digital asset is a liquid, digital representation of a traditional asset, typically transformed into a token – a process known as “tokenization.” When a traditional asset is tokenized, it becomes easier to trade and may be bought in smaller fractions. The tokens are registered on a blockchain network, on which it may be traded.

Instead of physical certificates, blockchain bonds are issued as tokens that are registered on a given blockchain network, and investors would pay for the tokens’ ownership using traditional fiat currency. On the blockchain, the tokenized bonds could then be traded on secondary market platforms, thereby reducing the need for traditional intermediaries and their associated costs.

4.2 World Bank bonds and Bond-I

Since the World Bank issued its first bond in 1947, it has leveraged its capital base of US$18 billion to raise over US$1 trillion in international bond markets. Whereas individual central banks may not invest directly in development projects due to the requirements that they invest in safe instruments, they will purchase World Bank bonds, which receive the highest AAA-bond rating possible. AAA-bonding is the highest rating that a credit rating agency can give out to an issuer's bonds. This transformation of risk enables the World Bank to direct pockets of wealth into needed development finance projects that might not happen otherwise. Approximately 80% or US$800 billion has been funneled into development finance to invest in member countries’ infrastructure, healthcare, educational systems, climate change resistance, and various other development needs. Figure 6 illustrates the bond issuance process.

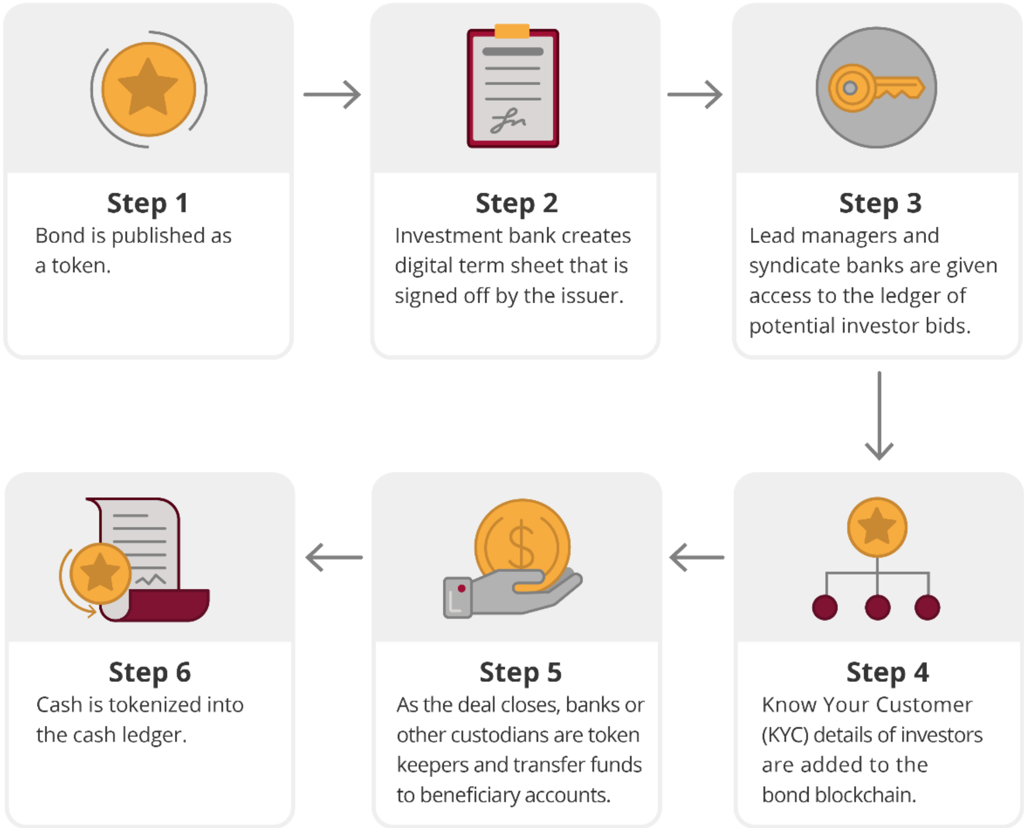

Figure 6: The bond issuance process (adapted from: International Finance, 2021)

In 2018, the World Bank collaborated with the Commonwealth Bank of Australia to launch the Blockchain Operated New Debt Instrument (Bond-I). Valued at AU$100 million, Bond-I was the world's first global bond that used distributed ledger technology to automate previously manual processes throughout the bond's two-year lifecycle at a quicker speed and lower cost. The bond's issuance was not valued or processed in a cryptocurrency denomination.

Explore further:

The World Bank has used the blockchain to create the first global blockchain bond: Bond-i. Watch this video and consider the possibilities for faster and more secure financial transactions on a global scale.

4.3 After Bond-I

Since Bond-I's launch, the blockchain bond market has proliferated. In April 2021, the European Investment Bank (EIB) raised €100 million in a two-year bond on the Ethereum blockchain (Stubbington, 2021). Olam International, a Singapore-based food producer, sold a bond in partnership with HSBC in 2020, and other banks, such as JP Morgan have also tested blockchain financial instruments (Stubbington, 2021). Morningstar, a primary US based credit agency that evaluates the risk of a bond, has discussed publicly how it has researched how to put its bond ratings system directly on a blockchain. According to Morningstar's Chief Operations Officer (COO), Michael Brawer, "the objective would ultimately be to allow investors in a digital debt security to be able to run an independent, third-party model and see the results of that model on the blockchain" (del Castillo, 2019).

A 2020 study by Cashlink (2020), a German FinTech firm, calculated that incorporating blockchain into a bond's lifecycle could save between 35–65% of its issuance costs solely by automating previously manual processes. For example, by using DLT, blockchain can automatically update information across various systems to update the bond's ownership as it is traded or permit instant settlement, a process that previously took up to three business days (Stubbington, 2021). With lower costs and no need for an intermediary, some analysts have predicted blockchain based bond platforms will open debt markets both to retail investors and smaller companies alike.

However, blockchain bonds need to gain additional credibility and public acceptance and understanding of the market. Commonly cited barriers to wider adoption include regulatory uncertainty, privacy concerns, low awareness, and cross-chain interoperability challenges (Dodds, 2021). Because blockchain and DLT are still relatively new technologies, few regulatory jurisdictions have passed comprehensive regulations, and many jurisdictions that have passed partial regulations conflict with one another. For an international bond market, new, unforeseen challenges may arise as different jurisdictions issue regulations over time. Most public and private blockchain platforms lack the ability to keep identity anonymous, and data privacy concerns can be further complicated by KYC and Anti-money laundering (AML) requirements. Furthermore, while this space is rapidly growing, public awareness of blockchain technologies – even among finance professionals – remain low. For example, a 2019 annual study on financial professionals found that only 29% had a basic understanding of blockchain technology (Pana & Gangal, 2021:222). Lastly, at its simplest, blockchain interoperability is the capability to access, share, and modify data across various blockchain networks. In digital capital markets, this might look like the ability to transfer assets from one blockchain to another, such as from an issuance platform to a secondary market. As the space has grown exponentially in recent years with many independent yet incompatible protocols, cross-chain solutions remain in nascent stages of development. With its future still undetermined, can blockchain and DLT enable the democratization of debt instrument markets in the near future? Engage with Poll 2 and consider the potential threats to bond markets if they transfer onto the blockchain.

Poll 2: Threats to transitioning bond markets and financial instruments onto blockchain. (Access this set of notes on the Online Campus to engage with this poll.)

What do you view as the largest threat to the transition of bond markets and other financial instruments onto the blockchain?
Low public awareness
Regulatory uncertainty

Privacy concerns
Interoperability challenges

Explore further:

In 2021, the European Investment Bank (EIB) created its first-ever digital bond using Ethereum blockchain technology. In this interview, the transaction for EIB's first digital bond and its implications for capital markets and digital finance is discussed.

5. Web 3.0 and Non-fungible tokens

Web 3.0, smart contracts, and Non-fungible tokens (NFTs) are part of an online evolution to decentralize online platforms. The creation of new social networks, transactions, and businesses on the blockchain bypass the powerhouses that own existing online platforms. Through this, systems like Web 3.0 are giving agency back to the content creators. This means that the people who add value to these platforms are the ones who will benefit, and not big companies who own the platform they are working through. The following section will explore the concept of decentralized networks and Web 3.0, as well as the expansion of NFTs, and how these blockchain-based advancements are creating value for society.

5.1 Web 3.0 and decentralization

The vision for Web 3.0 is defined by decentralized networks, such as blockchains, over which users will disintermediate Web 2.0's large middlemen, such as Facebook, Google, and Amazon. Instead of the intermediary reaping the profits from their centralization of everyday user's interactions with their platforms, users would gain tokens for their digital contributions to platforms, such as posting a comment or sharing a photo (Allyn 2021). In this way, the value created by digital platforms would be shared among all of its users – not just its owners, investors, and employees. Figure 7 highlights the difference between Web 1.0, Web 2.0 and Web 3.0.

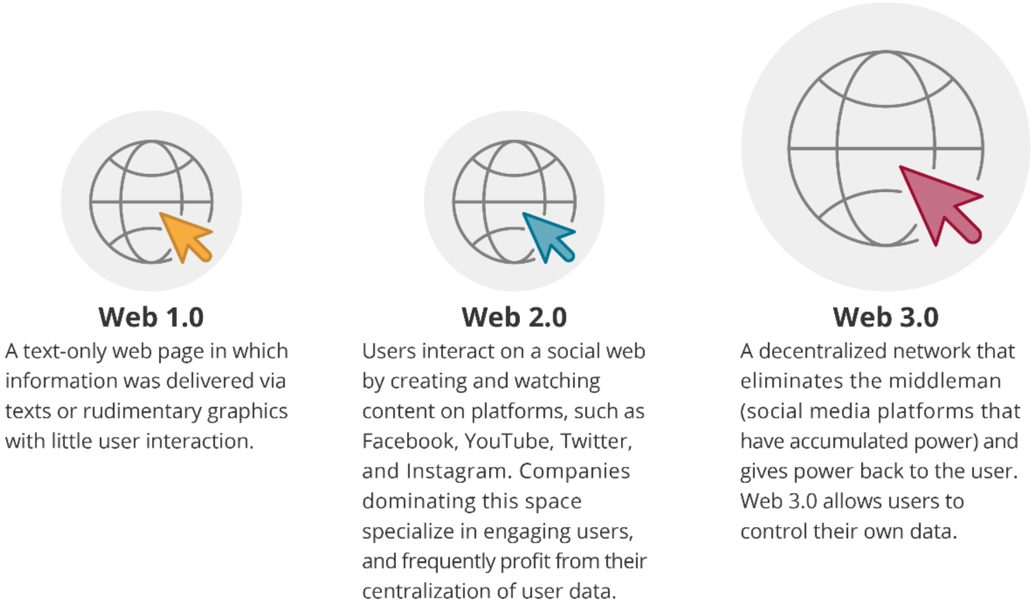

Figure 7: The potential of decentralized networks (adapted from: Allyn, 2021)

Similarly, DeFi eliminates financial middlemen by allowing users to conduct transactions directly using decentralized technologies, such as blockchain. At its core, they are peer-to-peer transactions, when two individual parties exchange goods or services. Oftentimes, this leverages smart contract code, an automatic and self-executing agreement hosted on the blockchain, to execute a transaction safely and securely by ensuring both parties fulfill their sections of the agreement. In a smart contract, if one condition is fulfilled then it will automatically execute the consequence according to its code. For example, if a user purchases a digital token for token's coded price on a smart contract, then its ownership will transfer to the purchaser.

5.2 Non-fungible tokens

One example of a digital token that is quickly rising in popularity is an NFT. An NFT can tokenize nearly any form of media – a drawing, a music clip, a video recording, a newspaper article, a poem, or even a CryptoKicks Nike sneaker. They are similar to collectibles, such as baseball cards or Pokémon cards. Artists can upload their creations to the blockchain to sell to receive payments from an original sale and secondary sales for a fee. Buyers can purchase an NFT for a flat fee or at an auction for basic user rights, such as using the picture as your Twitter profile picture.

> **Explore further:**
>
> Nike owns the [patent for "CryptoKicks"] where blockchain technology has been used to attach digital assets securely through cryptography to a physical shoe.

NFTs are traded on platforms, such as OpenSea or Rarible, that operate on the blockchain. Smart contracts facilitate the trading of NFTs by tracking its price and ownership. NFTs record of ownership are held on a transparent and open ledger on the platform. Some NFTs, such as the Bored Apes, CryptoPunks, or CryptoKitties, are a wide-ranging collection of thousands of NFTs – with some valued at tens or hundreds of thousands of dollars. Some collections are linked to game experiences. For example, in CryptoKitties, users trade and breed virtual cats to produce new virtual cats with varying levels of rarity.

5.2.1 What is fungibility?

Fungibility is a concept from law and economics. A fungible item is interchangeable and can be easily exchanged. For example, a physical dollar may be exchanged for any other physical dollar, and the holder would have the same value. However, a rare, one-of-a-kind painting is non-fungible. There is only one Mona Lisa painting housed at the Louvre in Paris, and much of its value derives from its originality and uniqueness. While copies of the painting may mimic its beauty and serenity, they are non-fungible with the original and do not retain the same value. However, under US copyright law, the buyer only purchases the rights to the digital version uploaded on the blockchain; the artist retains the copyright to the original artwork.

5.2.2 Art as a digital asset

Apart from memes and pop culture, traditional art brokers have also entered the NFT space. The first purely digital work offered as an NFT by a major auction house, Mike Winkelmann's "Everydays – the First 5000 Days," sold for US$69 million at Christie's auction in February 2021 (Reyburn, 2021). Unlike other art auctions, Winkelmann will receive a 10% royalty from each future resale of his artwork (Reyburn, 2021). In April 2021, Sotheby's, a notable art auction house, entered the NFT space with a three-day online sale in which the creator's artwork sold for US$16.8 million. Over the course of the year, it launched many other NFT sales on its NFT marketplace, named Sotheby's Metaverse, and it recorded its largest sales year in its history with US$7.3 billion in total sales (Lau, 2021). With a rising demand and prices for digital art, many have also asked themselves the question that dominated Sotheby's first NFT sale: "What does value mean, and from where does it derive authority?" (Pak, n.d.).

Explore further:

Read more about how NFTs can create value and the three ways in which this value can be assessed.

6. Conclusion

The growing popularity of blockchain and the potential applications of this technology have led to a growing interest in it in the FinTech sphere. As a technology with a large variety of possible functions, blockchain could revolutionize how business is conducted globally.

This set of notes has explained the basic features of blockchain and the problems it could solve as a technology used to overcome issues of trust when transferring data between strangers. It has also addressed some of the possible applications of blockchain and the rates of adoption globally, with a focus digital assets and blockchain bonds. It also looked at emerging blockchain-based, decentralized platforms such as NFTs and Web 3.0, and analyzed some of their benefits and potential drawbacks as means of exchange.

Module 5 will further explore the concept of decentralization and consider the applications of cryptocurrencies and digital currencies for the future of money.

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