

ATTACHMENT A

Blockchain

A **blockchain**,^{[1][2][3]} originally **block chain**,^{[4][5]} is a continuously growing list of records, called *blocks*, which are linked and secured using cryptography.^{[1][6]} Each block typically contains a hash pointer as a link to a previous block,^[6] a timestamp and transaction data.^[7] By design, blockchains are inherently resistant to modification of the data. The *Harvard Business Review* describes it as "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way."^[8] For use as a distributed ledger, a blockchain is typically managed by a peer-to-peer network collectively adhering to a protocol for validating new blocks. Once recorded, the data in any given block cannot be altered retroactively without the alteration of all subsequent blocks, which requires collusion of the network majority.

Blockchains are secure by design and are an example of a distributed computing system with high Byzantine fault tolerance. Decentralized consensus has therefore been achieved with a blockchain.^[9] This makes blockchains potentially suitable for the recording of events, medical records,^{[10][11]} and other records management activities, such as identity management,^{[12][13][14]} transaction processing, documenting provenance, food traceability^[15] or voting.^[16]

The first blockchain was conceptualized in 2008 by an anonymous person or group known as Satoshi Nakamoto and implemented in 2009 as a core component of bitcoin where it serves as the public ledger for all transactions.^[1] The invention of the blockchain for bitcoin made it the first digital currency to solve the double spending problem without the need of a trusted authority or central server. The bitcoin design has been the inspiration for other applications.^{[1][3]}

Contents

History

Description

- Decentralization
- Hard forks
- Openness
- Applications
- Alternative blockchains
- Other uses

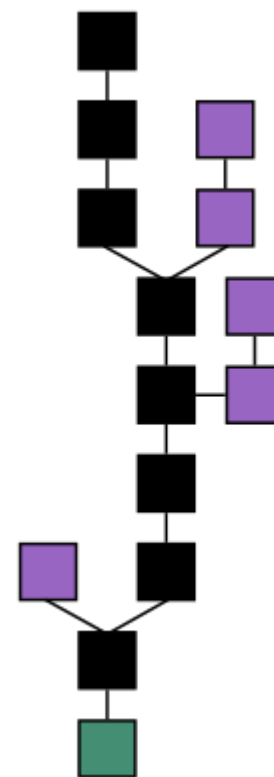
National currencies

Academic research

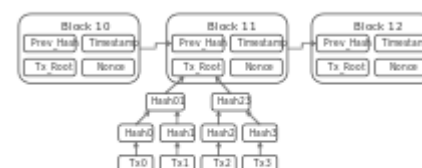
- Journals

Projects

- Nonprofit organizations
- Governments
- Decentralized networks



Blockchain formation. The main chain (black) consists of the longest series of blocks from the genesis block (green) to the current block. Orphan blocks (purple) exist outside of the main chain.



Bitcoin network data

Standards

Predictions

See also

References

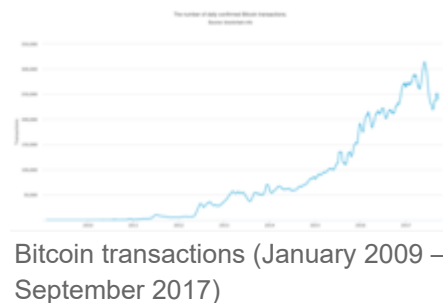
Further reading

External links

History

The first work on a cryptographically secured chain of blocks was described in 1991 by Stuart Haber and W. Scott Stornetta.^[17] In 1992, Bayer, Haber and Stornetta incorporated Merkle trees to the design, which improved its efficiency by allowing several documents to be collected into one block.^{[6][18]}

A blockchain database is managed autonomously using a peer-to-peer network and a distributed timestamping server. The first blockchain was conceptualised by an anonymous person or group known as Satoshi Nakamoto in 2008. It was implemented the following year as a core component of the digital currency bitcoin, where it serves as the public ledger for all transactions on the network.^[1] By using a blockchain, bitcoin became the first digital currency to solve the double spending problem without requiring a trusted administrator and has been the inspiration for many additional applications.^{[4][1][3]}



In August 2014, the bitcoin blockchain file size, containing records of all transactions that have occurred on the network, reached 20GB (gigabytes).^[19] In January 2015, the size had grown to almost 30GB, and from January 2016 to January 2017, the bitcoin blockchain grew from 50GB to 100GB in size.^[20] The words *block* and *chain* were used separately in Satoshi Nakamoto's original paper, but were eventually popularized as a single word, *blockchain*, by 2016.

The term *blockchain 2.0* refers to new applications of the distributed blockchain database, first emerging in 2014.^[21] *The Economist* described one implementation of this second-generation programmable blockchain as coming with "a programming language that allows users to write more sophisticated smart contracts, thus creating invoices that pay themselves when a shipment arrives or share certificates which automatically send their owners dividends if profits reach a certain level."^[1] Blockchain 2.0 technologies go beyond transactions and enable "exchange of value without powerful intermediaries acting as arbiters of money and information". They are expected to enable excluded people to enter the global economy, protect the privacy of participants, allow people to "monetize their own information", and provide the capability to ensure creators are compensated for their intellectual property. Second-generation blockchain technology makes it possible to store an individual's "persistent digital ID and persona" and are providing an avenue to help solve the problem of social inequality by "[potentially changing] the way wealth is distributed".^{[22]:14–15} As of 2016, blockchain 2.0 implementations continue to require an off-chain oracle to access any "external data or events based on time or market conditions [that need] to interact with the blockchain".^[23]

In 2016, the central securities depository of the Russian Federation (NSD) announced a pilot project, based on the Nxt blockchain 2.0 platform, that would explore the use of blockchain-based automated voting systems.^[24] IBM opened a blockchain innovation research center in Singapore in July 2016.^[25] A working group for the World Economic Forum met in November 2016 to discuss the development of governance models related to blockchain.^[26] According to Accenture, an application of the diffusion of innovations theory suggests that blockchains attained a 13.5% adoption rate within financial services in 2016, therefore reaching the early adopters phase.^[27] Industry trade groups joined to create the Global Blockchain Forum in 2016, an initiative of the Chamber of Digital Commerce.^[28]

In early 2017, the *Harvard Business Review* suggested that blockchain is a foundational technology and thus "has the potential to create new foundations for our economic and social systems." It further observed that, while foundational innovations can have enormous impact, "It will take decades for blockchain to seep into our economic and social infrastructure."^[8]

Description

A blockchain facilitates secure online transactions.^[29] A blockchain is a decentralized and distributed digital ledger that is used to record transactions across many computers so that the record cannot be altered retroactively without the alteration of all subsequent blocks and the collusion of the network.^{[1][30]} This allows the participants to verify and audit transactions inexpensively.^[31] They are authenticated by mass collaboration powered by collective self-interests.^[32] The result is a robust workflow where participants' uncertainty regarding data security is marginal. The use of a blockchain removes the characteristic of infinite reproducibility from a digital asset. It confirms that each unit of value was transferred only once, solving the long-standing problem of double spending. Blockchains have been described as a value-exchange protocol.^[21] This blockchain-based exchange of value can be completed more quickly, more safely and more cheaply than with traditional systems.^[33] A blockchain can assign title rights because it provides a record that compels offer and acceptance.^[1]

A blockchain database consists of two kinds of records: transactions and blocks.^[1] Blocks hold batches of valid transactions that are hashed and encoded into a Merkle tree.^[1] Each block includes the hash of the prior block in the blockchain, linking the two. The linked blocks form a chain.^[1] This iterative process confirms the integrity of the previous block, all the way back to the original genesis block.^[34] Some blockchains create a new block as frequently as every five seconds.^[35]

Sometimes separate blocks can be produced concurrently, creating a temporary fork. In addition to a secure hash based history, any blockchain has a specified algorithm for scoring different versions of the history so that one with a higher value can be selected over others. Blocks not selected for inclusion in the chain are called orphan blocks.^[34] Peers supporting the database have different versions of the history from time to time. They only keep the highest scoring version of the database known to them. Whenever a peer receives a higher scoring version (usually the old version with a single new block added) they extend or overwrite their own database and retransmit the improvement to their peers. There is never an absolute guarantee that any particular entry will remain in the best version of the history forever. Because blockchains are typically built to add the score of new blocks onto old blocks and because there are incentives to work only on extending with new blocks rather than overwriting old blocks, the probability of an entry becoming superseded goes down exponentially^[36] as more blocks are built on top of it, eventually becoming very low.^{[1][37]:ch. 08[38]} For example, in a blockchain using the proof-of-work system, the chain with the most cumulative proof-of-work is always considered the valid one by the network. There are a number of methods that can be used to demonstrate a sufficient level of computation. Within a blockchain the computation is carried out redundantly rather than in the traditional segregated and parallel manner.^[39]

Decentralization

By storing data across its network, the blockchain eliminates the risks that come with data being held centrally.^[1] The decentralized blockchain may use ad-hoc message passing and distributed networking.

Its network lacks centralized points of vulnerability that computer crackers can exploit; likewise, it has no central point of failure. Blockchain security methods include the use of public-key cryptography.^{[4]:5} A *public key* (a long, random-looking string of numbers) is an address on the blockchain. Value tokens sent across the network are recorded as belonging to that

address. A *private key* is like a password that gives its owner access to their digital assets or the means to otherwise interact with the various capabilities that blockchains now support. Data stored on the blockchain is generally considered incorruptible.^[1]

This is where blockchain has its advantage. While centralized data is more controllable, information and data manipulation are common. By decentralizing it, blockchain makes data transparent to everyone involved.^[40]

Every node or miner in a decentralized system has a copy of the blockchain. Data quality is maintained by massive database replication^[9] and computational trust. No centralized "official" copy exists and no user is "trusted" more than any other.^[4] Transactions are broadcast to the network using software. Messages are delivered on a best effort basis. Mining nodes validate transactions,^[34] add them to the block they are building, and then broadcast the completed block to other nodes.^{[37]:ch. 08} Blockchains use various time-stamping schemes, such as proof-of-work, to serialize changes.^[41] Alternate consensus methods include proof-of-stake, proof-of-authority and proof-of-burn.^[34] Growth of a decentralized blockchain is accompanied by the risk of node centralization because computer resources required to operate bigger data become more expensive.^[42]

Hard forks

see Fork (blockchain)

A *hard fork* term refers to a situation when a blockchain splits into two separate chains in consequence of the use of two distinct sets of rules trying to govern the system.^[43] For example, Ethereum has hard-forked to "make whole" the investors in The DAO, which had been hacked by exploiting a vulnerability in its code.^[44] In 2014 the Nxt community was asked to consider a hard fork that would have led to a rollback of the blockchain records to mitigate the effects of a theft of 50 million NXT from a major cryptocurrency exchange. The hard fork proposal was rejected, and some of the funds were recovered after negotiations and ransom payment.^[45]

Openness

Open blockchains are more user friendly than some traditional ownership records, which, while open to the public, still require physical access to view. Because all early blockchains were permissionless, controversy has arisen over the blockchain definition. An issue in this ongoing debate is whether a private system with verifiers tasked and authorized (permissioned) by a central authority should be considered a blockchain.^{[46][47][48][49][50]} Proponents of permissioned or private chains argue that the term "blockchain" may be applied to any data structure that batches data into time-stamped blocks. These blockchains serve as a distributed version of multiversion concurrency control (MVCC) in databases.^[51] Just as MVCC prevents two transactions from concurrently modifying a single object in a database, blockchains prevent two transactions from spending the same single output in a blockchain.^{[22]:30–31} Opponents say that permissioned systems resemble traditional corporate databases, not supporting decentralized data verification, and that such systems are not hardened against operator tampering and revision.^{[46][48]} *Computerworld* claims that "many in-house blockchain solutions will be nothing more than cumbersome databases."^[52] The *Harvard Business Review* defines blockchain as a distributed ledger or database open to anyone.^[53]

Permissionless

The great advantage to an open, permissionless, or public, blockchain network is that guarding against bad actors is not required and no access control is needed.^[36] This means that applications can be added to the network without the approval or trust of others, using the blockchain as a transport layer.^[36]

Bitcoin and other cryptocurrencies currently secure their blockchain by requiring new entries including a proof of work. To prolong the blockchain, bitcoin uses Hashcash puzzles developed by Adam Back in the 1990s.^[54]

Financial companies have not prioritised decentralized blockchains.^[55] In 2016, venture capital investment for blockchain related projects was weakening in the USA but increasing in China.^[56] Bitcoin and many other cryptocurrencies use open (public) blockchains. As of November 2017, bitcoin has the highest market capitalization.

Permissioned (private) blockchain

Permissioned blockchains use an access control layer to govern who has access to the network.^[57] In contrast to public blockchain networks, validators on private blockchain networks are vetted by the network owner. They do not rely on anonymous nodes to validate transactions nor do they benefit from the network effect.^[58] Permissioned blockchains can also go by the name of 'consortium' or 'hybrid' blockchains.

The *New York Times* noted in both 2016 and 2017 that many corporations are using blockchain networks "with private blockchains, independent of the public system."^{[59][60]}

Disadvantages

Nikolai Hampton pointed out in *Computerworld* that "There is also no need for a '51 percent' attack on a private blockchain, as the private blockchain (most likely) already controls 100 percent of all block creation resources. If you could attack or damage the blockchain creation tools on a private corporate server, you could effectively control 100 percent of their network and alter transactions however you wished."^[52] This has a set of particularly profound adverse implications during a financial crisis or debt crisis like the financial crisis of 2007–08, where politically powerful actors may make decisions that favor some groups at the expense of others. and "the bitcoin blockchain is protected by the massive group mining effort. It's unlikely that any private blockchain will try to protect records using gigawatts of computing power — it's time consuming and expensive."^[52] He also said, "Within a private blockchain there is also no 'race'; there's no incentive to use more power or discover blocks faster than competitors. This means that many in-house blockchain solutions will be nothing more than cumbersome databases."^[52]

Applications

Blockchain technology has a large potential to transform business operating models in the long term. Blockchain distributed ledger technology is more a foundational technology—with the potential to create new foundations for global economic and social systems—than a disruptive technology, which typically "attack a traditional business model with a lower-cost solution and overtake incumbent firms quickly."^[8] Even so, there are a few operational products maturing from proof of concept by late 2016.^[56] The use of blockchains promises to bring significant efficiencies to global supply chains, financial transactions, asset ledgers and decentralized social networking.^[8]

As of 2016, some observers remain skeptical. Steve Wilson, of Constellation Research, believes the technology has been hyped with unrealistic claims.^[61] To mitigate risk businesses are reluctant to place blockchain at the core of the business structure.^[62]

Blockchain technology can be integrated into multiple areas. This means specific blockchain applications may be a disruptive innovation, because substantially lower-cost solutions can be instantiated, which can disrupt existing business models.^[8] Blockchain protocols facilitate businesses to use new methods of processing digital transactions.^[63] Examples include a payment system and digital currency, facilitating crowdsales, or implementing prediction markets and generic governance tools.^[64]

Blockchains can be thought of as an automatically notarised ledger. They alleviate the need for a trust service provider and are predicted to result in less capital being tied up in disputes. Blockchains have the potential to reduce systemic risk and financial fraud. They automate processes that were previously time-consuming and done manually, such as the incorporation of businesses.^[65] In theory, it would be possible to collect taxes, conduct conveyancing and provide risk management with blockchains.

Major applications of blockchain include cryptocurrencies, such as bitcoin, and blockchain platforms such as Factom as a distributed registry, Gems for decentralized messaging, Storj and Sia for distributed cloud storage, and Tezos for decentralized voting.^{[22]:94}

New distribution methods are available for the insurance industry such as peer-to-peer insurance, parametric insurance and microinsurance following the adoption of blockchain.^[63] Banks are interested in this technology because it has potential to speed up back office settlement systems.^[66] The sharing economy and IoT are also set to benefit from blockchains because they involve many collaborating peers.^[67] Online voting is another application of the blockchain.^[68] Blockchains are being used to develop information systems for medical records, which increases interoperability. In theory, legacy disparate systems can be completely replaced by blockchains.^[69] Blockchains are being developed for data storage, publishing texts and identifying the origin of digital art. Blockchains facilitate users could take ownership of game assets (digital assets), an example of this is Cryptokitties.^[70]

Banks such as UBS are opening new research labs dedicated to blockchain technology in order to explore how blockchain can be used in financial services to increase efficiency and reduce costs.^{[71][72]}

Land registration

"Land is a financial source, if people can prove they own it, they can borrow against it."
Emmanuel Noah, CEO of Ghanian startup BenBen, New York Observer^[73]

Frameworks and trials such as the one at the Sweden Land Registry aim to demonstrate the effectiveness of the blockchain at speeding land sale deals.^[74] The Republic of Georgia is piloting a blockchain-based property registry.^[75] The Ethical and Fair Creators Association uses blockchain to help startups protect their authentic ideas.^[76]

The Government of India is fighting land fraud with the help of a blockchain^[77].

In October 2017, one of the first international property transactions was completed successfully using a blockchain based smart contract.^[78]

In the first half of 2018, an experiment will be conducted on the use of blocking technology to monitor the reliability of the Unified State Real Estate Register (USRER) data in the territory of Moscow.^[79]

The Big Four

Each of the Big Four accounting firms is testing blockchain technologies in various formats. Ernst & Young has provided cryptocurrency wallets to all (Swiss) employees,^[80] has installed a bitcoin ATM in their office in Switzerland, and accepts bitcoin as payment for all its consulting services.^[81] Marcel Stalder, CEO of Ernst & Young Switzerland stated "We don't only want to talk about digitalization, but also actively drive this process together with our employees and our clients. It is important to us that everybody gets on board and prepares themselves for the revolution set to take place in the business world through blockchains, [to] smart contracts and digital currencies."^[81] PwC, Deloitte, and KPMG have taken a different path from Ernst & Young and are all testing private blockchains.^[81]

Smart contracts

Blockchain-based smart contracts are contracts that can be partially or fully executed or enforced without human interaction.^[82] One of the main objectives of a smart contract is automated escrow. The IMF believes blockchains could reduce moral hazards and optimize the use of contracts in general.^[83] Due to the lack of widespread use their legal status is unclear.^[83]

Some blockchain implementations could enable the coding of contracts that will execute when specified conditions are met. A blockchain smart contract would be enabled by extensible programming instructions that define and execute an agreement.^[84] For example, Ethereum Solidity is an open source blockchain project that was built specifically to realize this possibility by implementing a Turing-complete programming language capability to implement such contracts.^{[22]:ch. 11}

Another example of smart contract utilization is in the music industry. Every time the dj mix is played, the smart contracts attached to the dj mix pays the artists almost instantly.^[85]

An application has been suggested for securing the spectrum sharing for wireless networks.^[86]

Alternative blockchains

Alternative blockchains, also known as altchains, are based on bitcoin technology in concept and/or code.^[7] The term encompasses all blockchains but bitcoin's main chain. Compared to bitcoin, these designs generally add functionality to the blockchain design. Altchains can provide solutions, including other digital currencies, though tokens in these designs are not always considered as such. Altchains target performance, anonymity, storage and applications such as smart contracts.^[87] Starting with a strong focus on financial applications, blockchain technology is extending to activities including decentralized applications and collaborative organizations that eliminate a middleman.^[88]

Notable non-cryptocurrency designs include:

- Steemit combines a blogging site/social networking website and a cryptocurrency
- Hyperledger — cross-industry collaborative effort from the Linux Foundation to support blockchain-based distributed ledgers. Most notable projects under this initiative includes Hyperledger Burrow (by Monax) and Hyperledger Fabric (spearheaded by IBM).
- Counterparty — open source financial platform for creating peer-to-peer financial applications on the bitcoin blockchain
- Bitnation is the world's first operational Decentralized Borderless Voluntary Nation, a Blockchain Powered Jurisdiction.
- JPMorgan Chase's Quorum permissionable private blockchain with private store for smart contracts^[89]
- Ethereum is a blockchain,^[90] with a Turing complete scripting language that enables the processing of smart-contracts on the blockchain.

For a list of cryptocurrencies, see *List of cryptocurrencies*.

Other uses

Blockchain technology can be used to create a permanent, public, transparent ledger system for compiling data on sales, storing rights data by authenticating copyright registration,^[91] and tracking digital use and payments to content creators, such as musicians.^[92] In 2017, IBM partnered with ASCAP and PRS for Music to adopt blockchain technology in music distribution.^[93] Imogen Heap's Mycelia^[94] service, which allows managers to use a blockchain for tracking high-value parts moving through a supply chain, was launched as a concept in July 2016. Everledger is one of the inaugural clients of IBM's blockchain-based tracking service.^[95]

CLS Group is using blockchain technology to expand the number of currency trade deals it can settle.^[62]

VISA payment systems,^[96] Mastercard,^[97] Unionpay and SWIFT^[98] have announced the development and plans for using blockchain technology.

Russia has officially completed its first government-level blockchain implementation. The state-run bank Sberbank announced 20 December 2017 that it is partnering with Russia's Federal Antimonopoly Service (FAS) to implement document transfer and storage via blockchain.^[99]

Commercial offerings

Distributed ledgers and other blockchain-inspired software are being developed by commercial organizations for various applications:

- Deloitte and ConsenSys announced plans in 2016 to create a digital bank called Project ConsenSys.^[100]
- R3 connects 42 banks to distributed ledgers built by Ethereum, Chain.com, Intel, IBM and Monax.^[101]
- Microsoft Visual Studio is making the Ethereum Solidity language available to application developers.^[102]
- A Swiss industry consortium, including Swisscom, the Zurich Cantonal Bank and the Swiss stock exchange, is prototyping over-the-counter asset trading on a blockchain-based Ethereum technology.^[103]
- IBM offers a cloud blockchain service based on the open source Hyperledger Fabric project^{[104][105]}
- Oracle Cloud offers Blockchain Cloud Service based on Hyperledger Fabric. Oracle has joined the Hyperledger consortium.^{[106][107]}

In August 2016, a research team at the Technical University of Munich published a research document about how blockchains may disrupt industries. They analyzed the venture funding that went into blockchain ventures. Their research shows that \$1.55 billion went into startups with an industry focus on finance and insurance, information and communication, and professional services. High startup density was found in the USA, UK and Canada.^[108]

ABN Amro announced a project in real estate to facilitate the sharing and recording of real estate transactions, and a second project in partnership with the Port of Rotterdam to develop logistics tools.^[109]

National currencies

Companies have supposedly been suggesting blockchain-based currency solutions in the following two countries:

- e-Dinar, Tunisia's national currency, was the first state currency using blockchain technology.^[110]
- eCFA is Senegal's blockchain-based national digital currency.^[111]

Academic research

Journals

In September 2015, the first peer-reviewed academic journal dedicated to cryptocurrency and blockchain technology research, *Ledger*, was announced. The inaugural issue was published in December 2016.^{[112][113]} The journal covers aspects of mathematics, computer science, engineering, law, economics and philosophy that relate to cryptocurrencies such as bitcoin.^{[114][115]} There are also research platforms like Strategic coin that offer research for the blockchain and crypto space.

The journal encourages authors to digitally sign a file hash of submitted papers, which will then be timestamped into the bitcoin blockchain. Authors are also asked to include a personal bitcoin address in the first page of their papers.^[116]

Projects

Nonprofit organizations

- Level One Project from the Bill & Melinda Gates Foundation aims to use blockchain technology to help the two billion people worldwide who lack bank accounts.^{[117][118]}
- Building Blocks project from The U.N.'s World Food Programme (WFP) aims to make WFP's growing cash-based transfer operations faster, cheaper, and more secure. Building Blocks commenced field pilots in Pakistan in January 2017 that will continue throughout Spring.^{[119][120]}
- The Government Blockchain Association (www.governmentblockchain.org) is a membership organization interested in promoting blockchain related solutions to government challenges. It is free for civil servants and sponsors training, working groups and networking events for members around the world.



Blockchain panel discussion at the first IEEE Computer Society TechIgnite conference

Governments

- The director of the Office of IT Schedule Contract Operations at the US General Services Administration, Mr. Jose Arrieta, disclosed at the 20 Sep ACT-IAC (American Council for Technology and Industry Advisory Council) Forum that its organization is using blockchain distributed ledger technology to speed up the FASt Lane process for IT Schedule 70 contracts through automation. Two companies, United Solutions (prime contractor) and Sapient Consulting (Subcontractor) are developing for FASt Lane a prototype to automate and shorten the time required to perform the contract review process.^{[121][122]}
- The Commercial Customs Operations Advisory Committee, a subcommittee of the U.S. Customs and Border Protection, is working on finding practical ways Blockchain could be implemented in its duties.^[1] (<https://www.cbp.gov/sites/default/files/assets/documents/2017-Nov/Global%20Supply%20Chain%20Subcommittee%20Trade%20Executive%20Summary%20Nov%202017.pdf>)

Decentralized networks

- Backfeed project develops a distributed governance system for blockchain-based applications allowing for the collaborative creation and distribution of value in spontaneously emerging networks of peers.^{[123][124]}
- The Alexandria project is a blockchain-based Decentralized Library.^{[125][126]}
- Tezos is a blockchain project that governs itself by voting of its token holders.^{[127][128][129]} Bitcoin blockchain performs as a cryptocurrency and payment system. Ethereum blockchain added smart contract system on top of a blockchain. Tezos blockchain will add an autonomy system - a decentralized code Development function on top of both bitcoin and Ethereum blockchains.^[130]

Standards

There are *de facto* standards like the Bitcoin and Ethereum blockchain architectures (they are reference models for many others), and relevant initiatives like the "ISO/TC 307 - Blockchain and distributed ledger technologies".^[131]

Some countries, especially Australia, are providing keynote participation in identify the various technical issues associated with developing, governing and utilising blockchains:

In April 2016 Standards Australia submitted a New Field of Technical Activity (NFTA) proposal on behalf of Australia for the International Organization for Standardization (ISO) to consider developing standards to support blockchain technology. The proposal for an NFTA to the ISO was intended to establish a new ISO technical committee for blockchain. The new committee

would be responsible for supporting innovation and competition by covering blockchain standards topics including interoperability, terminology, privacy, security and auditing.^[132]

Predictions

A World Economic Forum report from September 2015 predicted that by 2025 ten percent of global GDP would be stored on blockchains technology.^{[133][134]}

See also

- Changelog a record of all notable changes made to a project
- Checklist an informational aid used to reduce failure
- Economics of digitization
- Ledger (journal) academic journal on blockchains
- List of cryptocurrencies currency based blockchains
- List of emerging technologies
- Patent Landscape Report on Blockchain^[135]

References

1. Economist Staff (31 October 2015). "Blockchains: The great chain of being sure about things" (<https://www.economist.com/news/briefing/21677228-technology-behind-bitcoin-lets-people-who-do-not-know-or-trust-each-other-build-dependable>). *The Economist*. Retrieved 18 June 2016. "The technology behind bitcoin lets people who do not know or trust each other build a dependable ledger. This has implications far beyond the crypto currency."
2. Morris, David Z. (15 May 2016). "Leaderless, Blockchain-Based Venture Capital Fund Raises \$100 Million, And Counting" (<http://fortune.com/2016/05/15/leaderless-blockchain-vc-fund/>). *Fortune*. Retrieved 2016-05-23.
3. Popper, Nathan (21 May 2016). "A Venture Fund With Plenty of Virtual Capital, but No Capitalist" (https://www.nytimes.com/2016/05/22/business/dealbook/crypto-ether-bitcoin-currency.html?_r=1). *New York Times*. Retrieved 2016-05-23.
4. Brito, Jerry; Castillo, Andrea (2013). Bitcoin: A Primer for Policymakers (http://mercatus.org/sites/default/files/Brito_BitcoinPrimer.pdf) (PDF) (Report). Fairfax, VA: Mercatus Center, George Mason University. Retrieved 22 October 2013.
5. Trottier, Leo (18 June 2016). "original-bitcoin" (<https://github.com/trottier/original-bitcoin/blob/master/src/main.h#L795-L803>) (self-published code collection). github. Retrieved 2016-06-18. "This is a historical repository of Satoshi Nakamoto's original bit coin sourcecode"
6. Narayanan, Arvind; Bonneau, Joseph; Felten, Edward; Miller, Andrew; Goldfeder, Steven (2016). *Bitcoin and cryptocurrency technologies: a comprehensive introduction*. Princeton: Princeton University Press. ISBN 978-0-691-17169-2.
7. "Blockchain" (<http://www.investopedia.com/terms/b/blockchain.asp>). *Investopedia*. Retrieved 19 March 2016. "Based on the Bitcoin protocol, the blockchain database is shared by all nodes participating in a system."
8. Iansiti, Marco; Lakhani, Karim R. (January 2017). "The Truth About Blockchain" (<https://hbr.org/2017/01/the-truth-about-blockchain>). *Harvard Business Review*. Harvard University. Retrieved 2017-01-17. "The technology at the heart of bitcoin and other virtual currencies, blockchai is an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way."
9. Raval, Siraj (2016). "What Is a Decentralized Application?" (<https://books.google.com/books?id=fvywDAAAQBAJ&pg=PA1>). *Decentralized Applications: Harnessing Bitcoin's Blockchain Technology* (<https://books.google.com/books?id=fvywDAAAQBAJ>). O'Reilly Media, Inc. pp. 1 (<https://books.google.com/books?id=fvywDAAAQBAJ&pg=PA1>)–2 (<https://books.google.com/books?id=fvywDAAAQBAJ&pg=PA2>). ISBN 978-1-4919-2452-5. OCLC 968277125 (<https://www.worldcat.org/oclc/968277125>). Retrieved 6 November 2016 – via Google Books.
10. Yuan, Ben; Lin, Wendy; McDonnell, Colin. "Blockchains and electronic health records" (http://mcdonnell.mit.edu/blockchain_ehr.pdf) (PDF). *mcdonnell.mit.edu*.

11. Ekblaw, Ariel; Azaria, Asaf (19 September 2016). "[MedRec: Medical Data Management on the Blockchain](https://www.pubpub.org/pub/medrec)" (<https://www.pubpub.org/pub/medrec>). *PubPub*.
12. Yurcan, Bryan (8 April 2016). "How Blockchain Fits into the Future of Digital Identity" (<https://www.americanbanker.com/news/how-blockchain-fits-into-the-future-of-digital-identity>). *American Banker*. SourceMedia.
13. Prisco, Giulio (3 June 2016). "Microsoft Building Open Blockchain-Based Identity System With Blockstack, ConsenSys" (<https://bitcoinmagazine.com/articles/microsoft-building-open-blockchain-based-identity-system-with-blockstack-consensys-1464968713/>). *Bitcoin Magazine*. BTC Media LLC.
14. Prisco, Giulio (18 August 2016). "Department of Homeland Security Awards Blockchain Tech Development Grants for Identity Management and Privacy Protection" (<https://bitcoinmagazine.com/articles/department-of-homeland-security-awards-blockchain-tech-development-grants-for-identity-management-and-privacy-protection-1471551442/>). *Bitcoin Magazine*. BTC Media LLC.
15. Browne, Ryan (22 August 2017). "IBM partners with Nestle, Unilever and other food giants to trace food contamination with blockchain" (<https://www.cnbc.com/2017/08/22/ibm-nestle-unilever-walmart-blockchain-food-contamination.html>). CNBC.
16. *followmyvote.com* <https://followmyvote.com/online-voting-technology/blockchain-technology/>. Retrieved 18 December 2017. Missing or empty |title= (help)
17. Haber, Stuart; Stornetta, W. Scott (January 1991). "How to time-stamp a digital document" (<https://link.springer.com/article/10.1007/BF00196791>). *Journal of Cryptology*. **3** (2): 99–111. Retrieved 4 July 2017.
18. Bayer, Dave; Haber, Stuart; Stornetta, W. Scott (March 1992). "Improving the Efficiency and Reliability of Digital Time-Stamping" (https://link.springer.com/chapter/10.1007/978-1-4613-9323-8_24). *Sequences*. **2**: 329–334. Retrieved 4 July 2017.
19. Nian, Lam Pak; Chuen, David LEE Kuo (2015). "A Light Touch of Regulation for Virtual Currencies". In Chuen, David LEE Kuo. *Handbook of Digital Currency: Bitcoin, Innovation, Financial Instruments, and Big Data*. Academic Press. p. 319. ISBN 978-0-12-802351-8.
20. "Blockchain Size" (<https://blockchain.info/charts/blocks-size?timespan=3years>). *Blockchain*. Blockchain Luxembourg S.A. Archived (<https://web.archive.org/web/20170303055245/https://blockchain.info/charts/blocks-size?timespan=3years>) from the original on 2017-03-03.
21. Bheemaiah, Kariappa (January 2015). "Block Chain 2.0: The Renaissance of Money" (<https://www.wired.com/insights/2015/01/block-chain-2-0/>). *Wired*. Retrieved 13 November 2016.
22. Tapscott, Don; Tapscott, Alex (May 2016). *The Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World*. ISBN 978-0-670-06997-2.
23. Project Bletchley Whitepaper (<https://github.com/Azure/azure-blockchain-projects/blob/master/bletchley/bletchley-whitepaper.md>), Microsoft, 2016-09-19, accessed 2016-12-24.
24. Yakovlev, Alexander (15 April 2016). "НРД проголосовал за блокчейн" (<http://bankir.ru/publikacii/20160415/nrd-progolosoval-za-blokchein-10007428/>) [NSD blockchain vote]. *Bankir.ru* (Interview) (in Russian). Interview with Kovlyagina, Tatiana. Retrieved 18 June 2016. ""Национальный расчетный депозитарий запустил пилотный проект на основе технологии распределенного реестра. Создание прототипа системы электронного голосования владельцев облигаций на блокчейне анонсировал на Биржевом форуме председатель правления НРД Эдди Астанин [The National Settlement Depository started the pilot project based on the technology of the distributed register. Creation of the prototype system of electronic voting for owners of bonds based on blockchain was announced at the Exchange forum by the chairman of the board of NSD, Eddie Astanin.]"
25. Williams, Ann (12 July 2016). "IBM to open first blockchain innovation centre in Singapore, to create applications and grow new markets in finance and trade" (<http://www.straitstimes.com/business/economy/ibm-to-open-first-blockchain-innovation-centre-in-singapore-to-create-applications>). *The Straits Times*. Singapore Press Holdings Ltd. Co. Retrieved 13 November 2016.
26. Higgins, Stan (9 November 2016). "Former Estonian President to Lead World Economic Forum Blockchain Group" (<http://www.coindesk.com/estonia-president-world-economic-forum-blockchain/>). *CoinDesk*. Retrieved 13 November 2016.
27. "The future of blockchain in 8 charts" (<http://raconteur.net/business/the-future-of-blockchain-in-8-charts>). *Raconteur*. Raconteur Media. 27 June 2016. Retrieved 3 December 2016.

28. Coleman, Lestor (12 April 2016). "Global Blockchain Forum Launched to Coordinate Regulatory Interoperability and Best Practices" (<https://www.cryptocoinsnews.com/global-blockchain-forum-launched/>). *cryptoCoinNews*. Retrieved 4 December 2016.
29. iFour-Team (4 October 2016). "Blockchain - Secured way of transaction" (<http://blog.ifourtechnolab.com/post/2016/10/04/blockchain-a-forward-step-to-secure-transaction>). *iFour Technolab Pvt. Ltd*. Retrieved 2016-11-15.
30. Armstrong, Stephen (7 November 2016). "Move over Bitcoin, the blockchain is only just getting started" (<https://www.wired.co.uk/article/unlock-the-blockchain>). *Wired*. Retrieved 2016-11-09.
31. Catalini, Christian; Gans, Joshua S. (23 November 2016). "Some Simple Economics of the Blockchain". doi:10.2139/ssrn.2874598 (<https://doi.org/10.2139%2Fssrn.2874598>). SSRN 2874598 (<https://ssrn.com/abstract=2874598>) .
32. Tapscott, Don; Tapscott, Alex (8 May 2016). "Here's Why Blockchains Will Change the World" (<http://fortune.com/2016/05/08/why-blockchains-will-change-the-world/>). *Fortune*. Retrieved 16 November 2016.
33. Tucci, Michele (29 November 2015). "Can blockchain help the cards and payments industry?" (<https://www.techinasia.com/talk/blockchain-cards-payments-industry>). *Tech in Asia*. Retrieved 16 November 2016.
34. Bhaskar, Nirupama Devi; Chuen, David LEE Kuo (2015). "3 – Bitcoin Mining Technology" (<http://www.sciencedirect.com/science/article/pii/B9780128021170000035>). In Cheun, David Lee Kuo. *Handbook of Digital Currency: Bitcoin, Innovation, Financial Instruments, and Big Data* (<http://www.sciencedirect.com/science/book/9780128021170>). Academic Press. pp. 47–51. ISBN 978-0-12-802117-0. Retrieved 2 December 2016 – via ScienceDirect.
35. Redman, Jamie (25 October 2016). "Disney Reveals Dragonchain, an Interoperable Ledger" (<https://news.bitcoin.com/disney-dragonchain-interoperable-ledger/>). *Bitcoin.com*. Retrieved 4 December 2016.
36. Antonopoulos, Andreas (20 February 2014). "Bitcoin security model: trust by computation" (<http://radar.oreilly.com/2014/02/bitcoin-security-model-trust-by-computation.html>). *Radar*. O'Reilly. Retrieved 19 November 2016.
37. Antonopoulos, Andreas M. (2014). *Mastering Bitcoin. Unlocking Digital Cryptocurrencies* (<http://chimera.labs.oreilly.com/books/1234000001802/ch01.html>). Sebastopol, CA: O'Reilly Media. ISBN 1449374034. Retrieved 3 November 2015.
38. Nakamoto, Satoshi (October 2008). "Bitcoin: A Peer-to-Peer Electronic Cash System" (<https://bitcoin.org/bitcoin.pdf>) (PDF). bitcoin.org. Retrieved 28 April 2014.
39. "Permissioned Blockchains" (https://monax.io/explainers/permissioned_blockchains/). *Explainer*. Monax. Retrieved 20 November 2016.
40. "How Blockchain Technology Can Change The Way Modern Businesses Work" (<https://www.eyerys.com/articles/how-blockchain-technology-can-changes-how-modern-businesses-work/>). *Eyerys*. Retrieved 19 October 2017.
41. Kopfstein, Janus (12 December 2013). "The Mission to Decentralize the Internet" (<http://www.newyorker.com/tech/elements/the-mission-to-decentralize-the-internet>). *The New Yorker*. Retrieved 30 December 2014. "The network's 'nodes'—users running the bitcoin software on their computers—collectively check the integrity of other nodes to ensure that no one spends the same coins twice. All transactions are published on a shared public ledger, called the 'block chain.'"
42. Gervais, Arthur; Karame, Ghassan O.; Capkun, Vedran; Capkun, Srdjan. "Is Bitcoin a Decentralized Currency?" (<https://www.infoq.com/articles/is-bitcoin-a-decentralized-currency/>). *InfoQ*. InfoQ & IEEE computer society. Retrieved 11 October 2016.
43. Hayes, Adam (21 March 2017). "Can Bitcoin Hard Fork?" (<http://www.investopedia.com/news/can-bitcoin-hardfork/>). *Investopedia*. Retrieved 8 June 2017.
44. Coppola, Frances (21 July 2016). "A Painful Lesson For The Ethereum Community" (<https://www.forbes.com/sites/francescoppola/2016/07/21/a-painful-lesson-for-the-ethereum-community/#31abce3d5714>). *Forbes*.
45. Gillespie, Clay Michael (15 August 2014). "Official NXT Decision: No Blockchain Rollback" (<https://www.cryptocoinsnews.com/official-nxt-decision-blockchain-rollback/>). *Cryptocoins News*. Retrieved 13 November 2016.
46. Voorhees, Erik (30 October 2015). "It's All About the Blockchain" (<http://moneyandstate.com/its-all-about-the-blockchain/>). *Money and State*. Retrieved 2015-11-02.
47. Reutzell, Bailey (13 July 2015). "A Very Public Conflict Over Private Blockchains" (<http://www.paymentsource.com/news/technology/a-very-public-conflict-over-private-blockchains-3021831-1.html>). *PaymentsSource*. New York, NY: SourceMedia, Inc. Retrieved 18 June 2016.

48. Casey, Michael J. (15 April 2015). "Moneybeat/BitBeat: Blockchains Without Coins Stir Tensions in Bitcoin Community" (<https://blogs.wsj.com/moneybeat/2015/04/14/bitbeat-blockchains-without-coins-stir-tensions-in-bitcoin-community/>). *The Wall Street Journal*. Retrieved 18 June 2016.
49. dinbits Staff (3 November 2015). "The "Blockchain Technology" Bandwagon Has A Lesson Left To Learn" (<http://news.dinbits.com/2015/11/the-blockchain-technology-bandwagon-has.html>). *dinbits.com*. Retrieved 2016-06-18.
50. DeRose, Chris (26 June 2015). "Why the Bitcoin Blockchain Beats Out Competitors" (<http://www.americanbanker.com/bankthink/why-the-bitcoin-blockchain-beats-out-competitors-1075100-1.html>). *American Banker*. Retrieved 18 June 2016.
51. Greenspan, Gideon (19 July 2015). "Ending the bitcoin vs blockchain debate" (<http://www.multichain.com/blog/2015/07/bitcoin-vs-blockchain-debate/>). *multichain.com*. Retrieved 2016-06-18.
52. Hampton, Nikolai (5 September 2016). "Understanding the blockchain hype: Why much of it is nothing more than snake oil and spin" (<http://www.computerworld.com.au/article/606253/understanding-blockchain-hype-why-much-it-nothing-more-than-snake-oil-spin/>). *Computerworld*. IDG. Retrieved 2016-09-05.
53. Tapscott, Don (10 May 2016). "The Impact of the Blockchain Goes Beyond Financial Services" (<https://hbr.org/2016/05/the-impact-of-the-blockchain-goes-beyond-financial-services>). *Harvard Business Review*. Retrieved 16 May 2016.
54. Blocki, Jeremiah (24 August 2016). "Designing Proof of Human-work Puzzles for Cryptocurrency and Beyond*" (<https://eprint.iacr.org/2016/145.pdf>) (PDF). *International Association for Cryptologic Research (IACR)*. Retrieved 2016-11-20.
55. Buntinx, J.P. (1 May 2016). "The Road To Bitcoin Adoption Passes Through Many Stages" (<http://www.newsbtc.com/2016/05/01/road-bitcoin-adoption-passes-many-stages/>). *News BTC*. Retrieved 4 December 2016.
56. Ovenden, James. "Blockchain Top Trends In 2017" (<https://channels.theinnovationenterprise.com/articles/blockchain-top-trends-in-2017>). The Innovation Enterprise. Retrieved 4 December 2016.
57. Bob Marvin (30 August 2017). "Blockchain: The Invisible Technology That's Changing the World" (<http://au.pcmag.com/amazon-web-services/46389/feature/blockchain-the-invisible-technology-thats-changing-the-world>). *PC MAG Australia*. ZiffDavis, LLC. Retrieved 25 September 2017.
58. Prisco, Giulio (25 August 2016). "Sandia National Laboratories Joins the War on Bitcoin Anonymity" (<https://bitcoinmagazine.com/articles/sandia-national-laboratories-joins-the-war-on-bitcoin-anonymity-1472151009>). *Bitcoin Magazine*. BTC Inc. Retrieved 21 November 2016.
59. Popper, Nathan (27 March 2016). "Ethereum, a Virtual Currency, Enables Transactions That Rival Bitcoin's" (<https://www.nytimes.com/2016/03/28/business/dealbook/ethereum-a-virtual-currency-enables-transactions-that-rival-bitcoins.html>). *New York Times*. Retrieved 2017-02-07.
60. Popper, Nathaniel (27 February 2017). "Business Giants to Announce Creation of a Computing System Based on Ethereum" (<https://www.nytimes.com/2017/02/27/business/dealbook/ethereum-alliance-business-banking-security.html>) – via NYTimes.com.
61. Wilson, Steve (3 May 2016). "Blockchain: Almost Everything You Read Is Wrong" (<https://www.constellationr.com/blog-news/blockchain-almost-everything-you-read-wrong>). Constellation Research Inc. Retrieved 13 November 2016.
62. Katie Martin (27 September 2016). "CLS dips into blockchain to net new currencies" (<https://www.ft.com/content/c905b6fc-4dd2-3170-9d2a-c79cddb24f16>). *The Financial Times*. Retrieved 7 November 2016.
63. Wang, Kevin; Safavi, Ali (29 October 2016). "Blockchain is empowering the future of insurance" (<https://techcrunch.com/2016/10/29/blockchain-is-empowering-the-future-of-insurance/>). *Tech Crunch*. AOL Inc. Retrieved 7 November 2016.
64. "New Ethereum Blockchain Consortium Could Run on Experimental Tech - CoinDesk" (<http://www.coindesk.com/ethereums-new-blockchain-consortium-run-experimental-tech/>). 21 February 2017.
65. Prisco, Giulio (9 May 2016). "Delaware Blockchain Initiative to Streamline Record-Keeping for Private Companies" (<https://bitcoinmagazine.com/articles/delaware-blockchain-initiative-to-streamline-record-keeping-for-private-companies-1462812187>). *Bitcoin Magazine*. BTC Inc. Retrieved 5 December 2016.
66. Arnold, Martin (23 September 2013). "IBM in blockchain project with China UnionPay" (<https://www.ft.com/content/719f4e7e-80e1-11e6-bc52-0c7211ef3198>). *The Financial Times*. Retrieved 7 November 2016.

67. ["Blockchain reaction: Tech companies plan for critical mass"](http://www.ey.com/Publication/vwLUAssets/ey-blockchain-reaction-tech-companies-plan-for-critical-mass/$FILE/ey-blockchain-reaction.pdf) ([http://www.ey.com/Publication/vwLUAssets/ey-blockchain-reaction-tech-companies-plan-for-critical-mass/\\$FILE/ey-blockchain-reaction.pdf](http://www.ey.com/Publication/vwLUAssets/ey-blockchain-reaction.pdf)) (PDF). Ernst & Young. p. 5. Retrieved 13 November 2016.
68. ["Online Voting Platform FAQ's"](https://followmyvote.com/online-voting-platform-faqs/) (<https://followmyvote.com/online-voting-platform-faqs/>). Follow My Vote. Retrieved 7 December 2016.
69. Bryant, Meg (5 May 2016). ["Blockchain may be healthcare's answer to interoperability, data security"](http://www.healthcarediver.com/news/blockchain-may-be-healthcares-answer-to-interoperability-data-security/418708/) (<http://www.healthcarediver.com/news/blockchain-may-be-healthcares-answer-to-interoperability-data-security/418708/>). *Health Care Dive*. Industry Dive. Retrieved 4 December 2016.
70. ["CryptoKitties craze slows down transactions on Ethereum"](http://www.bbc.com/news/technology-42237162) (<http://www.bbc.com/news/technology-42237162>). 12 May 2017.
71. ["UBS leads team of banks working on blockchain settlement system"](https://www.reuters.com/article/us-banks-block-chain-ubs-idUSKCN10Z147) (<https://www.reuters.com/article/us-banks-block-chain-ubs-idUSKCN10Z147>). *Reuters*. 24 August 2016. Retrieved 13 May 2017.
72. ["Cryptocurrency Blockchain"](https://www.capgemini.com/beyond-the-buzz/cryptocurrency-blockchain) (<https://www.capgemini.com/beyond-the-buzz/cryptocurrency-blockchain>). *capgemini.com*. Retrieved 13 May 2017.
73. Dale, Brady (10 May 2016). ["Three Small Economies Where Land Title Could Use Blockchain to Leapfrog the US"](http://observer.com/2016/10/benben-factor-bitfury-ghana-georgia-honduras/) (<http://observer.com/2016/10/benben-factor-bitfury-ghana-georgia-honduras/>). *New York Observer*. Retrieved 2017-09-22.
74. Chavez-Dreyfuss, Gertrude (16 June 2016). ["Sweden tests blockchain technology for land registry"](https://www.reuters.com/article/us-sweden-blockchain-idUSKCN0Z22KV) (<https://www.reuters.com/article/us-sweden-blockchain-idUSKCN0Z22KV>). *Reuters*. Retrieved 7 November 2016.
75. Shin, Laura (21 April 2016). ["Republic Of Georgia To Pilot Land Titling On Blockchain With Economist Hernando De Soto, BitFury"](https://www.forbes.com/sites/laurashin/2016/04/21/republic-of-georgia-to-pilot-land-titling-on-blockchain-with-economist-hernando-de-soto-bitfury/#4c6631266550) (<https://www.forbes.com/sites/laurashin/2016/04/21/republic-of-georgia-to-pilot-land-titling-on-blockchain-with-economist-hernando-de-soto-bitfury/#4c6631266550>). *Forbes*. Retrieved 13 November 2016.
76. ["The Ethical and Fair Creators Association"](http://macrostarter.net) (<http://macrostarter.net>). Retrieved 2 December 2016.
77. ["Indian State Uses Blockchain Technology to Stop Land Ownership Fraud"](https://cointelegraph.com/news/indian-state-uses-blockchain-technology-to-stop-land-ownership-fraud) (<https://cointelegraph.com/news/indian-state-uses-blockchain-technology-to-stop-land-ownership-fraud>).
78. <https://medium.com/@tradersnow/how-i-sold-5-acres-of-land-using-bitbays-trustless-smart-contracts-28f18b83125>
79. Meyer, David (20 October 2017). ["Russia experiments with using blockchain tech for land registry: Pilot project uses blockchain in Moscow"](http://www.zdnet.com/article/russia-experiments-with-using-blockchain-tech-for-land-registry/) (<http://www.zdnet.com/article/russia-experiments-with-using-blockchain-tech-for-land-registry/>). *ZDNet*. CBS Interactive. Retrieved 17 November 2017.
80. Karin Kirchner (25 November 2016). ["EY Switzerland to digitalize itself and become first advisory firm to accept Bitcoins for its services"](http://www.ey.com/Publication/vwLUAssets/ey-news-release-switzerland-accepts-bitcoins-for-payment-of-its-services/$FILE/ey-news-release-switzerland-accepts-bitcoins-for-payment-of-its-services.pdf) ([http://www.ey.com/Publication/vwLUAssets/ey-news-release-switzerland-accepts-bitcoins-for-payment-of-its-services/\\$FILE/ey-news-release-switzerland-accepts-bitcoins-for-payment-of-its-services.pdf](http://www.ey.com/Publication/vwLUAssets/ey-news-release-switzerland-accepts-bitcoins-for-payment-of-its-services/$FILE/ey-news-release-switzerland-accepts-bitcoins-for-payment-of-its-services.pdf)) (PDF) (Press release). Ernst & Young.
81. Young, Joesph (15 December 2016). ["Ernst & Young Is Going Bitcoin While PwC, Deloitte and KPMG Push Permissioned Blockchains"](https://cointelegraph.com/news/ernst-young-is-going-bitcoin-while-pwc-deloitte-and-kpmg-push-permissioned-blockchains) (<https://cointelegraph.com/news/ernst-young-is-going-bitcoin-while-pwc-deloitte-and-kpmg-push-permissioned-blockchains>). *CoinTelegraph.com*. Retrieved 17 December 2016.
82. Franco, Pedro (2014). *Understanding Bitcoin: Cryptography, Engineering and Economics* (<https://books.google.com/books?id=YHfCBwAAQBAJ>). John Wiley & Sons. p. 9. ISBN 978-1-119-01916-9. Retrieved 4 January 2017 – via Google Books.
83. *Virtual Currencies and Beyond: Initial Considerations* (https://play.google.com/store/books/details?id=ttt_CwAAQBAJ). IMF Discussion Note. International Monetary Fund. 2016. p. 23. ISBN 978-1-5135-5297-2. Retrieved 12 November 2016 – via Google Play.
84. Swan, Melanie (2015). *Blockchain: Blueprint for a New Economy* (<https://books.google.com/books?id=RHJmBgAAQBAJ>). O'Reilly Media, Inc. p. 16. ISBN 978-1-4919-2047-3. Retrieved 12 November 2016 – via Google Books.
85. Kastelein, Richard (24 August 2017). ["The World's First DJ Mix That Pays Artists in Seconds Using Blockchain Technology"](http://www.the-blockchain.com/2017/08/24/worlds-first-dj-mix-pays-artists-seconds-using-blockchain-technology/) (<http://www.the-blockchain.com/2017/08/24/worlds-first-dj-mix-pays-artists-seconds-using-blockchain-technology/>). *Blockchain News*. Retrieved 2017-09-03.
86. K. Kotobi, and S. G. Bilen, "Blockchain-enabled spectrum access in cognitive radio networks" (<http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7943523>), 2017 Wireless Telecommunications Symposium (WTS), 2017.

87. "Why Bitcoin may herald a new era in finance" (<http://www.economistsights.com/technology-innovation/analysis/money-no-middleman/tab/1>). *www.economistsights.com*. The Economist Group. Retrieved 9 June 2015.
88. De Filippi, Primavera. *From competition to cooperation* (<https://www.youtube.com/watch?v=aYOPcHRO3tc>). TEDxCambridge. Retrieved 8 October 2015.
89. "Why J.P. Morgan Chase Is Building a Blockchain on Ethereum" (<http://fortune.com/2016/10/04/jp-morgan-chase-blockchain-ethereum-quorum/>). *Fortune*. Retrieved 2017-01-24.
90. Understanding Ethereum (Report). CoinDesk. 24 June 2016.
91. Jean-Pierre Buntinx (4 August 2015). "Future Use Cases for Blockchain Technology: Copyright Registration" (<https://news.bitcoin.com/future-use-cases-for-blockchain-technology-copyright-registration/>). *bitcoin.com*. Saint Bitts. Retrieved 5 November 2016.
92. "Blockchain Could Be Music's Next Disruptor" (<http://fortune.com/2016/09/22/blockchain-music-disruption/>). 22 September 2016.
93. "ASCAP, PRS AND SACEM JOIN FORCES FOR BLOCKCHAIN COPYRIGHT SYSTEM" (<http://www.musicbusinessworldwide.com/ascap-prs-sacem-join-forces-blockchain-copyright-system/>). Music Business Worldwide. 9 April 2017.
94. Bartlett, Jamie (6 September 2015). "Imogen Heap: saviour of the music industry?" (<https://www.theguardian.com/music/2015/sep/06/imogen-heap-saviour-of-music-industry>). *theguardian.com*. Retrieved 18 June 2016.
95. Nash, Kim S. (14 July 2016). "IBM Pushes Blockchain into the Supply Chain" (<https://www.wsj.com/articles/ibm-pushes-blockchain-into-the-supply-chain-1468528824>). *Wall Street Journal*. Retrieved 2016-07-24.
96. "World's Fastest Blockchain Tested in Australia" (<https://cryptovest.com/news/worlds-fastest-blockchain-tested-in-australia-beats-visas-payment-system/>).
97. "Mastercard Seeks Patent for Instant Blockchain Payments Processing" (<https://www.coindesk.com/mastercard-patent-filings-detail-blockchains-use-speeding-payments/>).
98. "Swift Blockchain Success Sets Stage for Sibos" (<https://www.coindesk.com/unanimous-swift-blockchain-success-sets-stage-sibos/>).
99. "First Government Blockchain Implementation For Russia" (<https://cointelegraph.com/news/first-government-blockchain-implementation-for-russia>). Cointelegraph. Retrieved 20 December 2017.
100. Allison, Ian (3 May 2016). "Deloitte to build Ethereum-based 'digital bank' with New York City's ConsenSys" (<http://www.ibtimes.co.uk/deloitte-build-ethereum-based-digital-bank-new-york-citys-consensys-1557864>). *International Business Times*.
101. Allison, Ian (20 January 2016). "R3 completes trial of five cloud-based blockchain technologies at 40 banks" (<http://www.ibtimes.co.uk/r3-completes-trial-five-cloud-based-blockchain-technologies-40-banks-1547260>). *International Business Times*.
102. "Hyperledger blockchain code almost comes together for IoT" (<http://rethink-iot.com/2016/04/01/hyperledger-blockchain-code-almost-comes-together-for-iot/>). *rethink-iot.com*. 1 April 2016. Retrieved 18 June 2016.
103. Andrew Quentson (11 September 2016). Swiss Industry Consortium to Use Ethereum's Blockchain (<https://www.cryptocoinsnews.com/swiss-industry-consortium-use-ethereums-blockchain/>). *cryptocoins news*. Retrieved 6 November 2016.
104. Miller, Ron. "IBM unveils Blockchain as a Service based on open source Hyperledger Fabric technology - TechCrunch" (<https://techcrunch.com/2017/03/19/ibm-unveils-blockchain-as-a-service-based-on-open-source-hyperledger-fabric-technology/>).
105. "IBM Blockchain based on Hyperledger Fabric from the Linux Foundation" (<https://www.ibm.com/blockchain/hyperledger.html>). *www.ibm.com*. 25 August 2017. Retrieved 2017-09-20.
106. "Oracle Launches Enterprise-Grade Blockchain Cloud Service" (<https://www.oracle.com/corporate/pressrelease/oow17-oracle-launches-blockchain-cloud-service-100217.html>). *www.oracle.com*. Retrieved 2017-11-15.
107. Jacobsen, Eric. "Oracle Cements Interest on Blockchain: Joins Hyperledger" (<https://blogs.oracle.com/cloud-platform/oracle-joins-hyperledger-consortium>). Retrieved 2017-11-15.

108. Friedlmaier, Maximilian; Tumasjan, Andranik; Welp, Isabell (26 August 2016). "Disrupting industries with blockchain: The industry, venture capital funding, and regional distribution of blockchain ventures" (<https://poseidon01.ssrn.com/delivery.php?ID=342110087101019118108085090101111006002092063023032070066028019098080089119103014117121123020058055102054115079081088000013118049055017040015004071102104126069096101033093000102070112110089072005076102084087098005024098124007022103023126086003114124121&EXT=pdf>). Retrieved 2016-11-29.
109. Higgins, Stan (16 December 2016). "ABN Amro Tests Blockchain for Real Estate Transactions" (<http://www.coindesk.com/abn-amro-blockchain-real-estate/>). *Coindesk.com*. Retrieved 2016-12-18.
110. "Tunisia To Replace eDinar With Blockchain-Based Currency" (<http://www.econotimes.com/Tunisia-To-Replace-eDinar-With-Blockchain-Based-Currency-140836>). *EconoTimes*. 11 January 2016.
111. "Senegal To Introduce A New Blockchain-Based National Digital Currency, The Second Such Currency In The World" (<https://www.iafrik.com/2016/11/24/senegal-to-introduce-a-new-blockchain-based-national-digital-currency-making-it-only-the-second-country-to-have-a-national-digital-currency/>). *iAfrikan News*. 24 November 2016.
112. Extance, Andy (30 September 2015). "The future of cryptocurrencies: Bitcoin and beyond" (<http://www.nature.com/news/the-future-of-cryptocurrencies-bitcoin-and-beyond-1.18447>). *Nature*. **526** (7571): 21–23. doi:10.1038/526021a (<https://doi.org/10.1038%2F526021a>)  ISSN 0028-0836 (<https://www.worldcat.org/issn/0028-0836>). OCLC 421716612 (<https://www.worldcat.org/oclc/421716612>).
113. del Castillo, Michael (22 December 2016). "Ledger Publishes First Volume of Peer-Reviewed Blockchain Research" (<http://www.coindesk.com/ledger-first-volume-blockchain-research/>). *CoinDesk*. Archived (<https://web.archive.org/web/20170110165805/http://www.coindesk.com/ledger-first-volume-blockchain-research/>) from the original on 10 January 2017. Retrieved 10 January 2017.
114. "Ledger (eJournal / eMagazine, 2015)" (<https://www.worldcat.org/title/ledger/oclc/910895894>). *OCLC WorldCat*. OCLC. Archived (<https://web.archive.org/web/2017011113930/https://www.worldcat.org/title/ledger/oclc/910895894>) from the original on 11 January 2017. Retrieved 11 January 2017.
115. Hertig, Alyssa (15 September 2015). "Introducing Ledger, the First Bitcoin-Only Academic Journal" (<http://motherboard.vice.com/read/introducing-ledger-the-first-bitcoin-only-academic-journal>). *Motherboard*. Vice Media. Archived (<https://web.archive.org/web/20170110172807/http://motherboard.vice.com/read/introducing-ledger-the-first-bitcoin-only-academic-journal>) from the original on 10 January 2017. Retrieved 10 January 2017.
116. Rizun, Peter R.; Wilmer, Christopher E.; Burley, Richard Ford; Miller, Andrew (2015). "How to Write and Format an Article for Ledger" (<http://ledger.pitt.edu/ojs/public/journals/1/AuthorGuide.pdf>) (PDF). *Ledger*. **1** (1): 1–12. doi:10.5195/LEDGER.2015.1 (<https://doi.org/10.5195%2FLEDGER.2015.1>) (inactive 13 March 2017). ISSN 2379-5980 (<https://www.worldcat.org/issn/2379-5980>). OCLC 910895894 (<https://www.worldcat.org/oclc/910895894>). Retrieved 11 January 2017. 
117. "Level One Project" (<https://leveloneproject.org/>). Bill & Melinda Gates Foundation.
118. Woyke, Elizabeth (18 April 2017). "How Blockchain Can Bring Financial Services to the Poor" (<https://www.technologyreview.com/s/604144/how-blockchain-can-lift-up-the-worlds-poor/>). MIT Technology Review.
119. "Building Blocks" (<http://innovation.wfp.org/project/building-blocks/>). World Food Program. 1 January 2017.
120. "What is 'Blockchain' and How is it Connected to Fighting Hunger?" (<https://insight.wfp.org/what-is-blockchain-and-how-is-it-connected-to-fighting-hunger-7f1b42da9fe/>). World Food Programme. 6 March 2017.
121. "Government Computer News" (<https://gcn.com/articles/2017/09/21/gsa-looks-to-blockchain-for-procurement.aspx>). Government Computer News.
122. Friedman, Sara (21 September 2017). "GSA looks to blockchain for speeding procurement processes" (<https://gcn.com/articles/2017/09/21/gsa-looks-to-blockchain-for-procurement.aspx>). Government Computer News.
123. "Backfeed" (<http://backfeed.cc/>). Backfeed.
124. Pazaitis, Alex (1 January 2017). "Blockchain and Value Systems in the Sharing Economy: The Illustrative Case of Backfeed" (<http://technologygovernance.eu/files/main/2017012509590909.pdf>) (PDF). *Technology governance*.
125. "Alexandria" (<http://www.alexandria.io/>). Alexandria.
126. PORUP, J.M. (29 June 2015). "Could Cyberwar Cause a Library of Alexandria Event?" (https://motherboard.vice.com/en_us/article/could-cyberwar-cause-a-library-of-alexandria-event). *Vice*.

127. "Tezos: The self-amending cryptographic ledger" (https://www.tezos.com/static/papers/Tezos_Overview.pdf) (PDF). Tezos.
128. "A self-amending cryptographic ledger" (<https://github.com/tezos/tezos/>). GitHub.
129. METZ, CADE (29 March 2017). "A Plan to Save Blockchain Democracy From Bitcoin's Civil War" (<https://www.wired.com/2017/03/plan-save-blockchain-democracy-bitcoins-civil-war/>). *Wired*.
130. Madore, P. H. (12 May 2017). "ICO Analysis: Tezos" (<https://hacked.com/ico-analysis-tezos/>). Hacked.
131. "ISO/TC 307 - Blockchain and distributed ledger technologies", a standard under construction, <https://www.iso.org/committee/6266604.html>
132. Last RoadMap of Australia, http://www.standards.org.au/OurOrganisation/News/Documents/Roadmap_for_Blockchain_Standards_report.pdf
133. Marr, Bernard. "How Blockchain Technology Could Change The World" (<https://www.forbes.com/sites/bernardmarr/2016/05/27/how-blockchain-technology-could-change-the-world/#b9fc7e49e09a>). *Forbes*. Retrieved 2017-01-06.
134. "Deep Shift: Technology Tipping Points and Societal Impact, Survey Report" (http://www3.weforum.org/docs/WEF_AC15_Technological_Tipping_Points_report_2015.pdf#page=24) (PDF). World Economic Forum. September 2015. p. 24. Retrieved 7 November 2017.
135. "Patent Landscape Report on Blockchain by PatSeer Pro" (<https://patseer.com/2017/03/patent-landscape-report-on-blockchain-by-patseer-pro/>). *PatSeer*. Retrieved 2017-11-03.

Further reading

- Bashir, Imran (2017). *Mastering Blockchain*. Packt Publishing, Ltd. ISBN 978-1-78712-544-5. OCLC 967373845 (<http://www.worldcat.org/oclc/967373845>).
- Crosby, Michael; Nachiappan; Pattanayak, Pradhan; Verma, Sanjeev; Kalyanaraman, Vignesh (16 October 2015). *BlockChain Technology: Beyond Bitcoin* (<http://scet.berkeley.edu/wp-content/uploads/BlockchainPaper.pdf>) (PDF) (Report). Sutardja Center for Entrepreneurship & Technology Technical Report. University of California, Berkeley. Retrieved 2017-03-19.
- Higgins, Stan (3 March 2016). "40 Banks Trial Commercial Paper Trading in Latest R3 Blockchain Test" (<http://www.coindesk.com/r3-consortium-banks-blockchain-solutions/>). *CoinDesk*. Retrieved 2016-03-21.
- Kakavand, Hossein; De Sevres, Nicolette Kost; Chilton, Bart (12 October 2016). *The Blockchain Revolution: An Analysis of Regulation and Technology Related to Distributed Ledger Technologies* (Report). Luther Systems & DLA Piper. SSRN 2849251 (<https://ssrn.com/abstract=2849251>) .
- Mazonka, Oleg (29 December 2016). "Blockchain: Simple Explanation" (<http://jrxv.net/x/16/chain.pdf>) (PDF). *Journal of Reference*.
- Saito, Kenji; Yamada, Hiroyuki (June 2016). *What's So Different about Blockchain? Blockchain is a Probabilistic State Machine* (<https://www.computer.org/csdl/proceedings/icdcs/2016/3686/00/5878a168-abs.html>). IEEE 36th International Conference on Distributed Computing Systems Workshops. Nara, Nara, Japan: IEEE. pp. 168–75. doi:10.1109/ICDCSW.2016.28 (<https://doi.org/10.1109/2FICDCSW.2016.28>). ISBN 978-1-5090-3686-8. ISSN 2332-5666 (<https://www.worldcat.org/issn/2332-5666>). Retrieved 2017-02-15.
- Tapscott, Don; Tapscott, Alex (2016). *Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business and the World* (<http://blockchain-revolution.com/>). London: Portfolio Penguin. ISBN 978-0-241-23785-4. OCLC 971395169 (<https://www.worldcat.org/oclc/971395169>).
- Raval, Siraj (2016). *Decentralized Applications: Harnessing Bitcoin's Blockchain Technology* (<http://shop.oreilly.com/product/0636920039334.do?sortBy=publicationDate>). O'Reilly.
- Santiago, Ismael (2017). *La Revolución de la tecnología de Cadenas de Bloques en la economía* (https://www.amazon.es/Revoluci%C3%B3n-tecnolog%C3%ADa-Cadenas-Bloques-econom%C3%ADa/dp/3639536878/ref=sr_1_sc_1?ie=UTF8&qid=1498553601&sr=8-1-spell&keywords=ismae+santiago+moreno). EAE.

External links

Media related to Blockchain at Wikimedia Commons

- [ledgerjournal.org](http://www.ledgerjournal.org) (<http://www.ledgerjournal.org>), a peer-reviewed scholarly journal on cryptocurrency and blockchain technology.

Retrieved from "<https://en.wikipedia.org/w/index.php?title=Blockchain&oldid=819267542>"

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