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PERSPECTIVES ON PROSPERITY

The Future of Blockchain:

APPLICATIONS AND IMPLICATIONS OF DISTRIBUTED LEDGER TECHNOLOGY

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Executive Summary

Technology has transformed how we work, play and do business. It has provided new solutions to old problems, disrupted traditional business models and helped us become more efficient.

The speed and scale of this change are not abating. New developments are still being introduced and applied – and this creates a significant dividend for Australia and New Zealand. A report published by Deloitte Access Economics in 2015 estimated that the digital economy in Australia could be worth A$139 billion by 2020.[1]

This growth will be underpinned by new technologies. One of these is distributed ledger technology and its most common application – blockchain. The World Economic Forum lists blockchain as one of the top ten emerging technologies of 2016.[2]

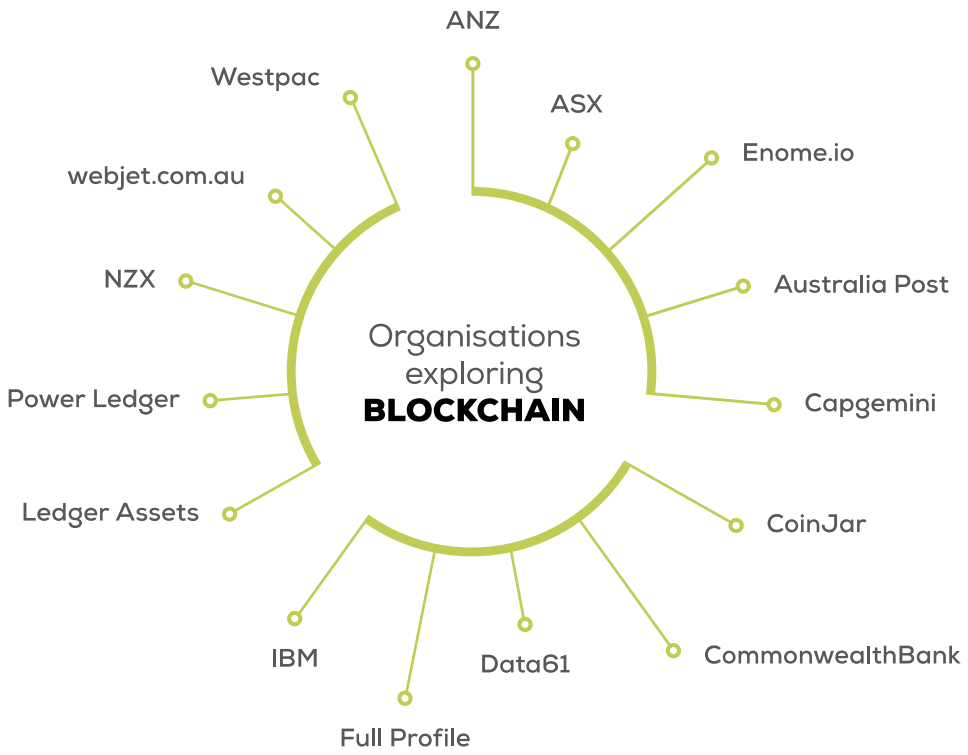
Distributed ledger technology (of which blockchain is an example) uses cryptographic tools and a distributed consensus process to create a significant innovation in traditional record keeping. It has three main features:

- Veracity – multiple copies (as opposed to a single copy) of the complete historical record of ledger entries are each verified by consensus. (Bogus entries are identified and eliminated by failure to reach consensus.)
- Transparency – it is a public record of activity that can be seen by all market participants.
- Disintermediation – it operates using a peer-to-peer network, rather than requiring a specific central organisation.

Disintermediation is the core feature which drives the benefits associated with distributed ledgers. Traditionally, systems that have centralised ledgers have required the participation of a trusted third party to maintain a record of transactions between organisations. A distributed ledger overcomes the need for a third party, which can be a significant benefit when there is no clear trusted central organisation, or if the costs of intermediation are high.

There has been significant investment in exploring the technology. According to Coindesk (2016), the total global venture capital investment in Bitcoin and blockchain start-ups exceeds US$1.1 billion.[3]

These benefits must be considered alongside costs. For example, distributed ledger technology requires multiple peers to verify transactions, rather than a single central party. This duplication can be costly.



Initial uses are being tested across a range of industries – in agriculture, government, transport and financial services. Broadly, these uses can be classified as solutions for transaction record keeping.

Transactions play a significant role in the economy, with nearly 13 million transactions daily in Australia,[4] and nearly 1.5 billion debit and credit card transactions in New Zealand over the course of a year.[5] Similarly, record-keeping needs can be significant: there were around 9.15 million security registrations on the Personal Property and Securities Register in Australia by June 2015.[6] In New Zealand, there were nearly 2.2 million property titles on record at November 2016.[7]

Most of the applications of distributed ledger technology so far have been in financial services. To date, however, it has not made a significant impact on the core operations of the banking and payments systems. But many financial institutions are experimenting with broader uses. Further, interviews with innovators like Australia Post, IBM and Data61 show that broader applications – like supply chain tracking and digital identity management – are emerging.

Broader adoption of distributed ledger technology could have wide ranging impacts.

For businesses, it could mean significant operational simplifications, reductions in fraud, and greater transparency, with less need to duplicate and verify records across and within organisations. And these benefits could translate to regulators, who may have more timely and transparent access to data, enabling more informed decision making.

But these benefits will only be realised when the costs associated with maintaining and updating a distributed ledger can be contained. Ensuring that governance is appropriate will be important to each distributed ledger's success.

In these early stages of development and adoption, some have likened the emergence of blockchain technology to the birth of the internet. The accuracy of this comparison remains to be seen; however, as additional uses of the technology emerge over time, the full potential of the blockchain will be revealed.

We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't let yourself be lulled into inaction.

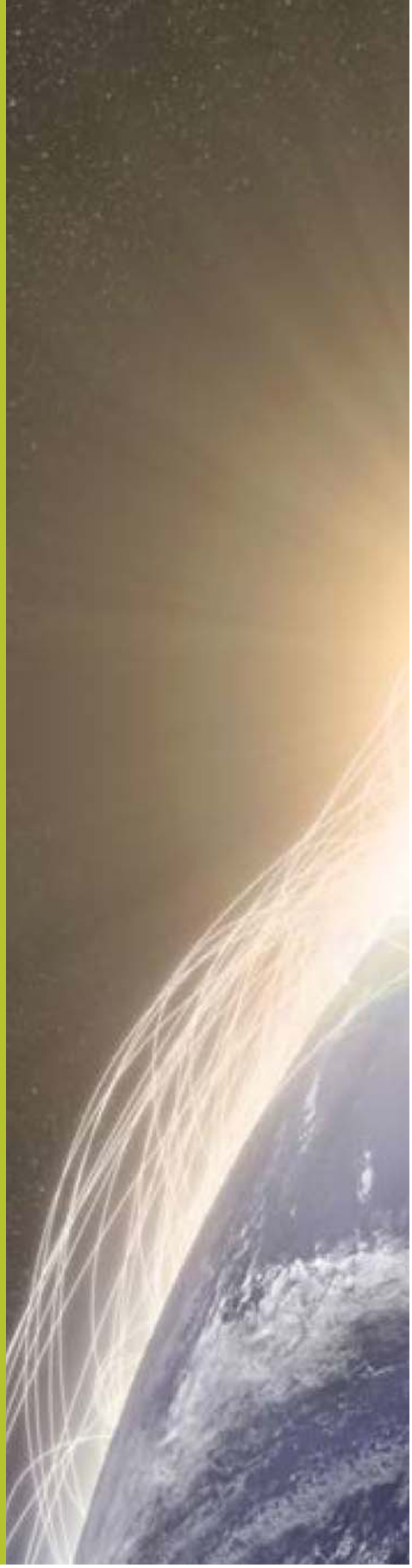
– Bill Gates, The Road Ahead

01

What is blockchain and distributed ledger technology?

In 2008, Bitcoin (a cryptocurrency and payment platform) was introduced. Our 2015 *future*[inc] report *Digital Currencies: Where to From Here?* discussed Bitcoin, an "electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party".[8]

Yet Bitcoin was only the first (albeit most widely discussed) implementation of a broader class of technologies. Blockchain and distributed ledger technology underpin Bitcoin. But blockchain and distributed ledger technology have much broader applications and implications. They have been used in an array of different fields for varying purposes.



Blockchain technology has been used to facilitate payments and settlements in a range of different circumstances, offering near real-time transfer of funds and settlement time reduction. For example, the Ripple network is now facilitating almost 30,000 currency trades daily.[9] By removing the need for a trusted intermediary to monitor transactions, blockchain-based payments can reduce the costs usually associated with a third-party intermediary.

To understand the applications and implications of the technology, it's first important to define the terminology.

Cryptocurrency is an electronic currency and asset.

Bitcoin is the well-known cryptocurrency underpinned by blockchain technology.[10]

A **blockchain** is a type of distributed ledger, which enables records to be stored and sorted into blocks.[11] This might be as simple as using the same open source code as Bitcoin to create a new ledger, or more complex, such as swapping alternative implementations or algorithms.[12] Blockchain can create trust, which may remove the need for third parties. consequently reducing costs and friction in processes.

Distributed ledger technology is a family of technologies that includes blockchain, where a ledger is maintained by a group of peers rather than a single central authority.[13]

Miner – A peer in the Bitcoin blockchain network that confirms or verifies a transaction by solving a challenging cryptographic problem and adds the transaction or 'block' to the blockchain, thus updating the ledger.

Figure 1 shows the relationship between Bitcoin, blockchain and distributed ledger technology. Effectively, Bitcoin is a specific application of blockchain, which is in turn one type of distributed ledger.

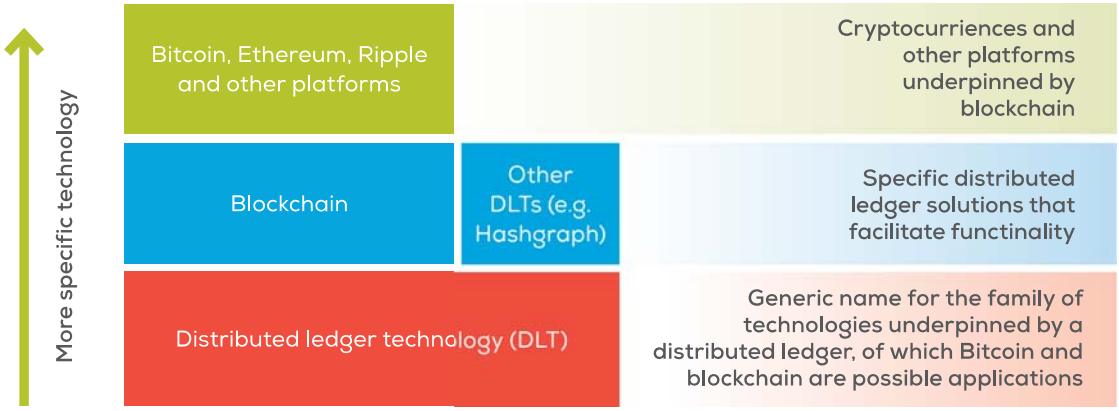


Figure 1: Distributed ledger technologies[14]

To date, most practical applications of distributed ledgers have used blockchain technology to store and sort transactions. Figure 2 shows one example of how the process can work in practice.

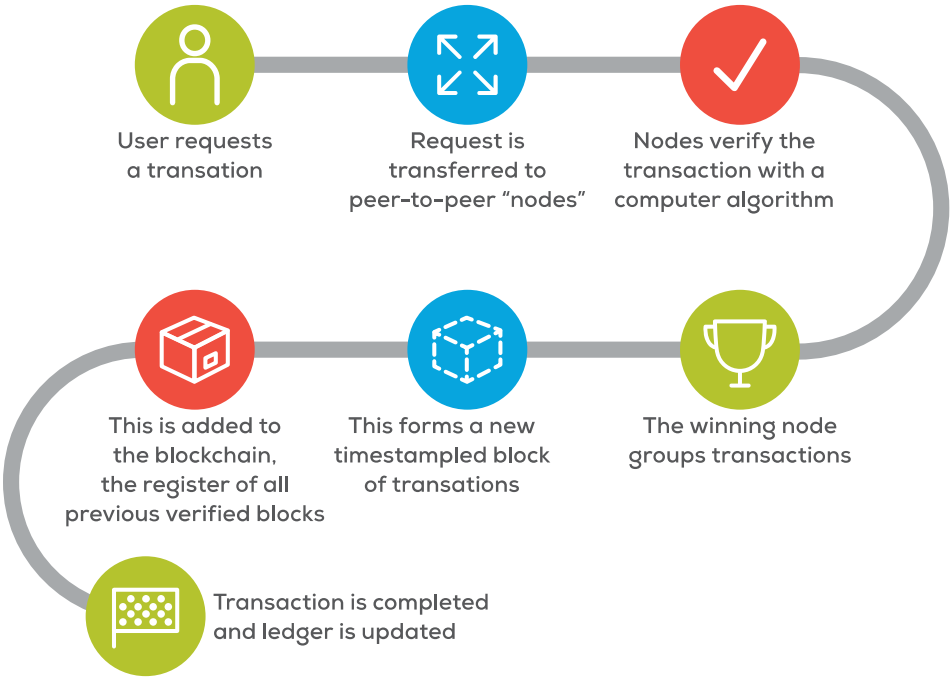


Figure 2: Illustrative blockchain process

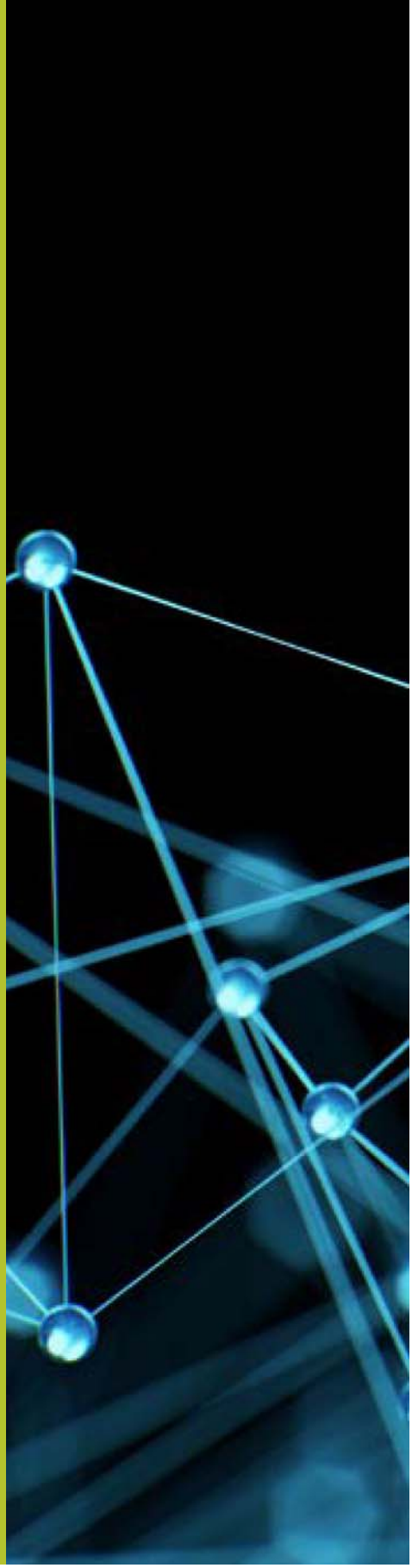
Blockchain can also support other functions. For example, smart contracts can be embedded in blockchain networks. These are commonly agreed terms between parties which will automatically execute once conditions are met. Ethereum is an example of a blockchain platform which has an embedded capability for smart contracts.[15] The implications of smart contracts, particularly when embedded in blockchain networks, could be significant.

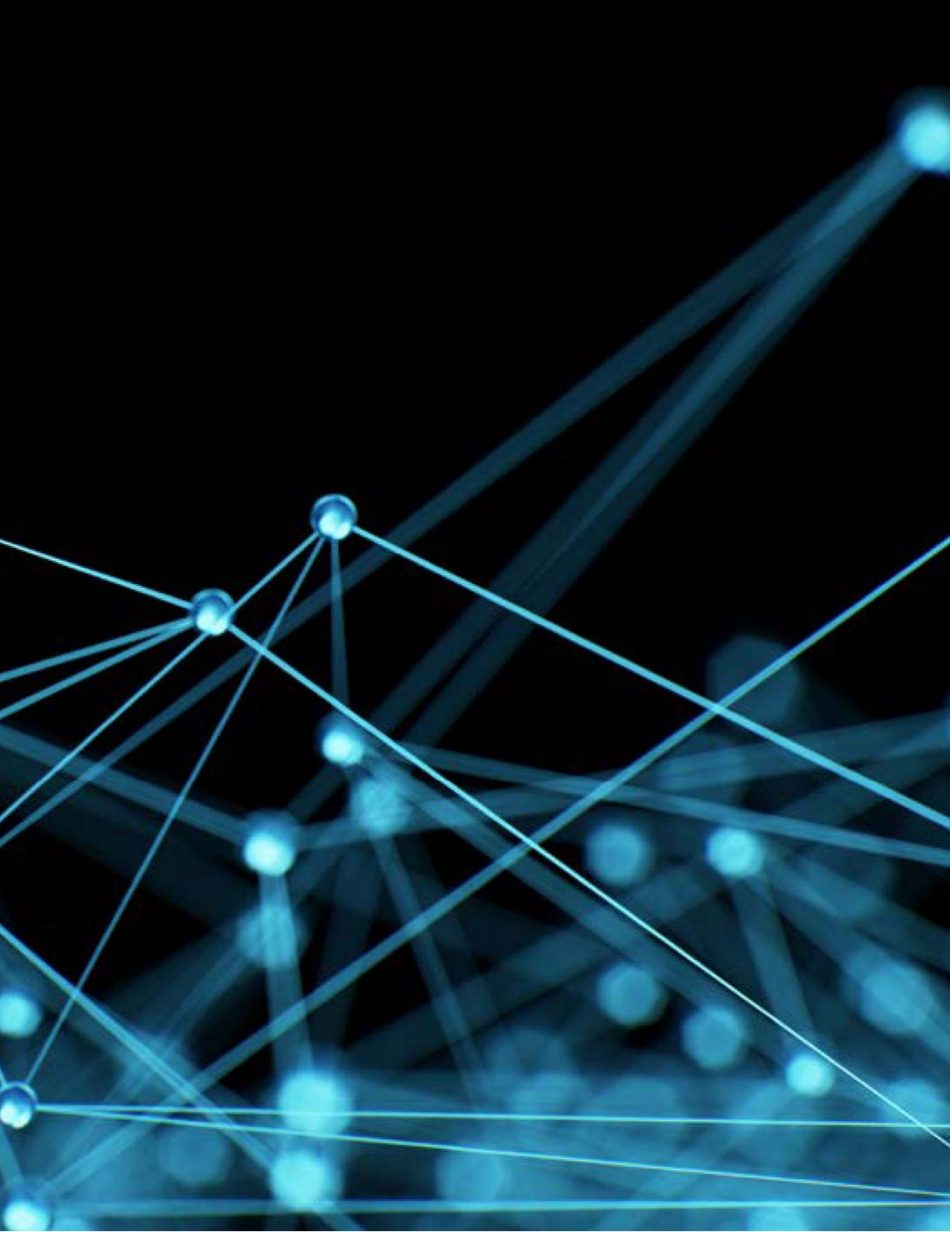
Mark Pascall, the organiser of the ethereum.nz conference noted: "If two people can easily agree and create a set of rules..[and]...we also agree to put those rules (a smart contract) on this immutable system that we both trust (the blockchain) then we have created a transaction between two untrusted parties without an intermediary. The same concepts could apply in theory to a will, a loan, a mortgage, a Trade Me/eBay purchase, an Uber trip. The list is endless and implications are huge. If you think about it, most of our global financial/commerce system and government is made up of centralised intermediary organisations who are performing these transactions on our behalf."[16]

02

What makes distributed ledger technology different?

Historically, ledgers have taken two key forms: two-party (or "nostro-vostro"), and centralised. Two-party ledgers are based in traditional double-entry bookkeeping: when processing a transaction, one organisation will record a credit and the other a debit. In a centralised ledger, a central authority maintains and appends records to a single ledger, and may choose to show a copy of that ledger to other market participants.

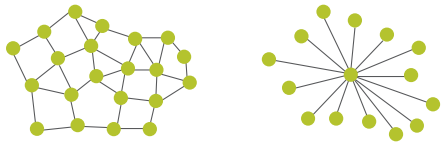




Ledgers have been at the heart of commerce since ancient times and are used to record many things, most commonly assets such as money and property... However, in all this time the only notable innovation has been computerisation, which initially was simply a transfer from paper to bytes. Now, for the first time algorithms enable the collaborative creation of digital distributed ledgers with properties and capabilities that go far beyond traditional paper-based ledgers.[17]

– UK Government Chief Scientific Adviser

The key differentiator of blockchain is disintermediation of the ledger – the ability to transact without the need for a trusted third party (like a bank), enabled through the distributed ledger. The following table highlights the key differences between distributed and centralised ledgers.



	Distributed ledger	Centralised ledger
Maintenance cost *(The cost of maintaining the ledger, including verifying transactions and adding them to the ledger)*	$$$	$
Intermediation cost *(The cost involved in having the presence of a trusted third party)*	$	$$$
Transparency *(The ability of all market participants to view the ledger)*	✓✓	✓
Security *(How difficult it is to alter transactions or enter fraudulent transactions, by malfeasance for example)*	✓✓	✓

Figure 3: Types of ledgers and their characteristics

The central ledger

All economies ultimately rely on creating and maintaining trust in the system. For example, people trust that banks will provide them with access to their deposits on request, and that property ownership will be verified and defended by central authorities.

Typically, this trust has been maintained by the existence of a central authority, who maintains and updates a ledger – an add-only record of all transactions in a system.

These are some common central authorities.

- **Stock exchange** – central electronic ledgers are operated and maintained by a central party, known as the clearing house. The clearing house records transactions, verifies ownership and facilitates the exchange of stocks.
- **National payments system** – although other institutions can hold copies of the ledger, or verify information on it, the central bank ultimately determines the authoritative version of the ledger, holding sole responsibility for adding transactions to the ledger and maintaining a record of all previous transactions.
- **Property registers** – land title records are maintained by government authorities in New Zealand and in Australian states and territories. Again, these authorities hold a central record of all transfers of ownership of land, and update this ledger whenever a transaction occurs.

Reliance on a single centralised record can create concerns, including the following.

- **Privacy** – the Deloitte Australian Privacy Index 2016 consumer survey shows that 94% of consumers believe trust is more important than convenience, and 67% of respondents are concerned when organisations send personal information outside Australia.[18] At the same time, approximately two-thirds of New Zealanders are concerned with privacy, and over the last few years 46% of New Zealanders have become more concerned about individual privacy issues.[19]
- **Intermediation** – The involvement of intermediaries can create costs. For example, the NZX charges up to $75 to clear equity and debt trades,[20] and the ASX charges 0.225 basis points for clearance of equities and investment products.[21] In some cases, these intermediaries can slow the processing of transactions. For example, both the NZX and ASX settle on a T+2 cycle for cash equities.[22]
- **Security** – A centralised ledger can potentially be a central point of failure. This can be mitigated through backups and security; however, the risk is relatively higher compared to a distributed system.

Blockchain and the distributed ledger

The World Economic Forum identifies three key value propositions for blockchain.[23]

- **Veracity** – multiple copies (as opposed to a single copy) of the complete historical record of ledger entries are each verified by consensus. (Bogus entries are identified and eliminated by failure to reach consensus.)
- **Transparency** – it is a public record of activity that can be seen by all market participants.
- **Disintermediation** – it operates using a peer-to-peer network, rather than requiring a specific central organisation.

Blockchain can mitigate concerns about privacy by providing more transparency and control over the use of information with cryptographic keys. The technology also removes the problem of involving costly intermediaries by eliminating the intermediary. Since the ledger is distributed – it does not sit in a central location – it is less vulnerable to online attacks.[24]

SPOTLIGHT – VALUE PROPOSITION FOR DISTRIBUTED LEDGERS

Property ownership is a fundamental part of how any economy operates. Indeed, excludability – the ability to prevent those who have not paid for a good from using it – is an important factor underpinning market efficiency.

If a good or service is not "owned", or ownership rights are not enforced, then it can be under-supplied (because it is difficult for producers to profit when a good can be obtained for free) as well as over-used (because there is no cost associated with using it). There are many examples of this, from over-fishing of oceans to pollution of air. This problem is known to economists as "the tragedy of the commons".

In most developed economies, trusted third-party institutions, such as governments and banks, are responsible for registering and tracking property rights. They give the registered "owners" exclusive authority to dispose of those properties via various transactions. It is the certainty of these rights that underpins decision making of all players in the economy.

However, trust in these third parties can be undermined. For example, online transactions involve a third party constantly reconciling transactions, which can be more prone to error with the increasing complexity of processes. Distributed ledger technology provides a technological solution to some of these issues, by providing an "immutable ledger". It means that all participants in the system can see and verify property ownership and the validity of transactions. Further, it is a historical record that cannot be altered, which provides security and auditability.

There are variations in how distributed ledgers are structured, managed and maintained. These differences reflect the degree to which participants in a network are trusted.

There are two types of blockchain networks: permissioned and permissionless.

- **Permissioned** networks are those where a limited number of trusted entities have gained permission to join the network in order to validate transactions.[25]
- In **permissionless** networks, any individual can validate transactions as no permission is required to join a network. It may allow transactions to be validated pseudonymously.

CASE STUDY: DATA61 – BLOCKCHAIN TO FACILITATE COMMERCIAL AND SOCIAL RELATIONSHIPS

The Commonwealth Scientific and Industrial Research Organisation (CSIRO), an Australian government entity, carries out scientific research for the benefit of Australia. The CSIRO's Data61 group is the largest data innovation group in Australia.

Mark Staples, Principal Researcher at CSIRO's Data61, describes blockchain as a database system that facilitates commercial and social relationships. "Anywhere that a database can be used as a means of storing information, a blockchain could be used. But that doesn't mean that it should be used."

The most effective uses for blockchain technology are in complex markets with multiple organisations interacting with each other. According to Rob Hanson, Senior Research Consultant, "Blockchain is best used as a solution where, under existing systems, transactions and relationships are intermediated by third parties. Blockchain can create trust, which may remove the need for these third parties, consequently reducing costs and friction in processes."

When well implemented, it will not be immediately obvious to customers or clients that an organisation is using distributed ledger technology. "Blockchain is an internal back-office system, rather than an interface," explains Hanson, "as it becomes embedded in existing systems, you won't even know that it's there." However, businesses considering blockchain solutions need to consider how they will integrate with other legacy systems.

The governance arrangements that support these solutions will ultimately determine their effectiveness and appropriateness, as well as the take-up of distributed ledgers. Staples notes that poor governance can undermine – and even neutralise – the benefits of blockchain.

Staples and Hanson think that the accounting profession and financial industry, not just technologists, should be invested in blockchain, because, as Staples puts it, "blockchain has its origins in accounting; it is a technology built around an auditable record of financial transactions."

03

Applications

Bitcoin and blockchain have triggered a new technological gold rush. If we're to believe the hype, there's no problem that can't be solved by putting it "on the blockchain"... the challenge is to cut through the noise and understand what new capabilities are implied, what new solutions are enabled, and what solutions are beyond the reach of the new technology.[26]

Distributed ledger technology is being promoted as a potential solution for a range of problems. And businesses are investing extensively: Coindesk estimates that total venture capital investment in Bitcoin and blockchain start-ups exceeded US$1.1billion globally by the first quarter of 2016.[27]

However, the successful applications will be the ones which effectively harness blockchain's value drivers. They are underpinned by two core functions that blockchain technology offers: record-keeping and transaction-settling.

Figure 4: The core functions of blockchain technology[28]

Distributed ledger technology and blockchain are important innovations in themselves. But there are many exciting potential uses ahead, as augmenting these technologies with others can create novel applications.

For example, Ethereum has embedded smart contracts into blockchain ledger, providing a novel way of building trust without an intermediary. This has potential impact in industries such as the legal profession, where smart contracts could disintermediate a lawyer's role in drafting and exchanging paper contracts.[29] The German start-up Slock.it utilises Ethereum's smart contracts for "smart locks", where a rental home can be unlocked via computer upon payment by the renter.[30]

Figure 5 summarises some uses of blockchain technology in Australia and New Zealand.

Figure 5: Examples of industry development in distributed ledger technology in Australia and New Zealand

Company	Notes	Under development or currently in use?	Immutable ledger or payments and settlements?
AGRICULTURE, FORESTRY, AND FISHING			
Full Profile	Launching a trial using a variation of blockchain to track grains through the supply chain	Under development	Immutable ledger
ELECTRICITY, GAS AND WATER SUPPLY			
Power Ledger	Using blockchain to enable energy producers and consumers to trade their energy directly	Under development	Payments and settlements
TRANSPORT, POSTAL AND WAREHOUSING			
Australia Post	Looking at blockchain technology to store digital identities and build an e-voting system for Victoria	Under development	Immutable ledger
Webjet	Using blockchain between its own divisions with smart contracts to document a hotel booking, creating an indisputable record where any subsequent changes can be clearly lodged	Currently in use	Immutable ledger
INFORMATION MEDIA AND TELECOMS			
IBM	Allowing people to set up blockchain networks and launching a platform for companies to test blockchain record-keeping technology in their supply chains	Currently in use	Immutable ledger

Company	Notes	Under development or currently in use?	Immutable ledger or payments and settlements?
FINANCIAL AND INSURANCE SERVICES			
ASX	Pursuing blockchain technology to reduce the reconciliation related expense of keeping multiple data records.	Under development	Payments and settlements
Commonwealth Bank	Looking at using blockchain in a number of areas, including internal transfers between subsidiaries	Under development	Immutable ledger, and payments and settlements
CoinJar	Operates an Australian Bitcoin trading platform	Currently in use	Payments and settlements
Westpac	Using the technology to trial making low-value payments to other countries and solving payment anonymity issues	Under development	Payments and settlements
ANZ	Part of Hyperledger project that is exploring how blockchain may help businesses and potentially replace the dated international money transfer system	Under development	Payments and settlements
NZX	Early stages of working with technology partners and considering where and how blockchain could provide benefits to NZ capital markets	Under development	Payments and settlements

Company	Notes	Under development or currently in use?	Immutable ledger or payments and settlements?
PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES			
Capgemini	Developing a blockchain solution for a rewards and loyalty system for consumer banking that tracks processed transactions in real time	Under development	Payments and settlements
Ledger Assets	Has created a proof-of-stake blockchain that uses less energy than the original technology	Technology developed, applications under development.	Immutable ledger, and payments and settlements
HEALTH SERVICES			
Enome.io	Has created a decentralised, verifiable ledger for personal health records using blockchain technology. These records are then able to be retrieved, aggregated, and stored uniquely by the consumer on their personal mobile device.	Technology developed, patent pending.	Immutable ledger
PUBLIC ADMINISTRATION AND SAFETY			
Data61	Collaborating with the Treasury to study possible uses of blockchain technology	Under development	Immutable ledger, and payments and settlements

CASE STUDY ON IBM – USING BLOCKCHAIN FOR INTERNAL EFFICIENCIES AND EXTERNAL VALUE CREATION

Blockchain technology has the potential to change how transactions are recorded. "Blockchain is the most significant innovation in bookkeeping since double-entry accounting was introduced over 700 years ago," explains Juerg von Kaenel, Associate Director at IBM Research Australia." Traditional accounting required transactions to be recorded in two (or more) separate ledgers, depending upon the number of participants in the business network, and reconciled with each other. Blockchain means that there is only one common and indisputable ledger, which is agreed to by all parties."

Removing these frictions can have significant benefits. For IBM, blockchain is used internally by its Global Financing arm to resolve contract disputes between partners on the network. IBM estimates that each year, of its 2.9 million transactions, an average of 25,000 result in disputes. These disputes typically tie up around US$100 million in capital. "With our blockchain solution, we can combine data provided by the participants in the network to create a consolidated and detailed view of transactions, while strong privacy and confidentiality controls ensure that parties can only access the data they need to. This has significantly reduced the number of disputes, as well as the time taken to resolve them," says von Kaenel.

IBM is also offering blockchain solutions based on Hyperledger for its customers. The Hyperledger Project is a collaborative effort created to advance open standard blockchain technology and build an ecosystem of partners. IBM is a founding member and has contributed significant amounts of the code to help transform the way business transactions are conducted globally.

Recently, IBM opened an IBM Centre for Blockchain Innovation in Singapore. The centre will initially focus on solutions for finance and trade. For example, all the parties to a transaction can be put on the blockchain, where the locations of goods are visible and terms can be executed automatically with a smart contract.

Although most of the initial applications have been in financial services, von Kaenel thinks that blockchain will have broad applications in a range of industries, and its application to other industries will surpass financial services applications.

"Whenever there are multiple parties which do business together in a network but don't quite trust each other (the 'trust but verify' approach), blockchain based solutions could be helpful. It could work for land registries, healthcare records, freedom of information requests, passport and visa control and even tracking international flights."

CASE STUDY ON IBM *CONTINUED*

Businesses considering blockchain solutions will need to think about how they manage the intersection of customer experience and human interaction. It will also be important to think about how blockchain solutions interact and integrate with existing processes and the supporting technology investments. "At IBM, our initial blockchain systems are 'shadowed'; they run in parallel to existing systems as a check, rather than replacing them," explains von Kaenel. This method of piloting can demonstrate the benefits of blockchain without requiring a large scale overhaul of legacy systems until the business case is demonstrated.

Ultimately, von Kaenel thinks that the most significant applications of blockchain are yet to be seen. "Right now, many businesses are prototyping and experimenting with blockchain technology; there is a lot of test and trial." But, as the technology and business models mature, von Kaenel thinks that adoption will become more widespread. "In ten years' time, blockchain will just be a part of the fabric of systems. It won't be discussed – it will just become part of how we operate."

In recent developments, Australia is set to lead a committee tasked by the International Organisation for Standardisation to develop globally approved blockchain standards. The standards will go towards supporting interoperability between systems, privacy, security and terminology. As a result, Australia will position itself at the forefront of the implementation of blockchain technology.[31]

Blockchain adoption is still in its early stages: Gartner (2016) estimates that blockchain is being used by less than 1% of its total audience.[32] The following sections consider some local examples of the two key applications for blockchain – payments and settlements, and immutable ledgers.

Applications of blockchain for payments and settlements

Transactions underpin the economy and people's everyday lives – buying a coffee, taking out a mortgage, insuring a car. Billions of transactions occur daily. In Australia, as at July 2016, nearly 13 million transactions were conducted daily on debit cards alone, and this number is increasing.[33] Additionally, 1,473.5 million debit card and credit card transactions were made in New Zealand from November 2014 to October 2015.[34]

Blockchain's first application in Bitcoin was as a new way of making payments. It enables organisations or individuals to transact without the intermediation of a third party, even when they don't trust each other.

Beyond Bitcoin, blockchain's application as a payments and settlements mechanism has been in banking, where reconciliations of records relating to transactions between banks can be costly and time consuming when performed via traditional channels. In Australia, three of the Big 4 banks (Commonwealth Bank, Westpac and NAB) have joined the global R3 CEV consortium,[35] which aims to design and deliver advanced distributed ledger technologies to global financial markets.[36] Similarly, three out of the five major New Zealand banks are testing or considering using blockchain.[37] By adopting a shared and commonly agreed ledger, banks feel that they "may be able to reduce, or eliminate altogether, various costs," [38] with some estimates suggesting that distributed ledger technology could reduce infrastructure costs for banks by over US$15 billion annually by 2022.[39]

This is done using a permissioned blockchain to allow participating banks to transfer value between them.[40] It has also enabled the participating banks to design and use self-executing transaction agreements (smart contracts) to process globally recognised transactions.[41] This technology is being tested by the banks in an effort to speed up international transfers with instantaneous payments that are faster, more reliable and cost effective. As a result, real-time settlement will allow an increase in profitability, thereby reducing liquidity and operational costs.[42]

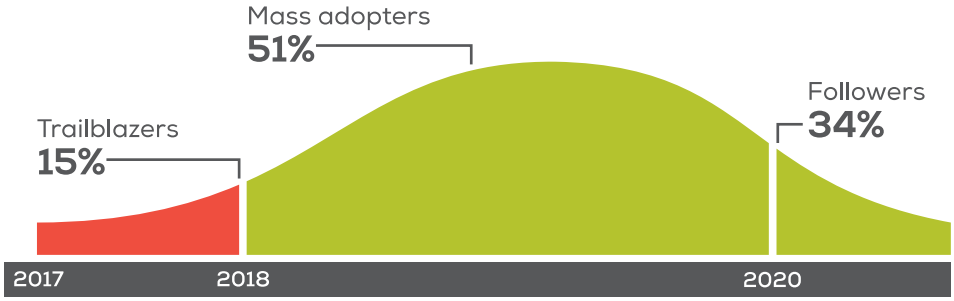


Figure 6: Global banks' expectations of when they will have blockchains in commercial production and at scale[43]

At the same time, ANZ Bank has been participating in the Hyperledger Project, where a group of technology organisations and financial institutions are exploring how blockchain may potentially replace the international money transfer system.[44]

Similarly, the ASX is testing blockchain solutions to see whether it has the potential to replace its existing settlement systems.[45] It has made a significant investment in blockchain, putting $14.9 million into US firm Digital Asset Holdings to develop these solutions for the Australian market.[46] The aim is to enable near real-time settlement of equities trades and reduce administration costs.[47] The NZX is also at the early stages of working with technology partners and considering where and how blockchain could provide benefits to New Zealand capital markets.[48]

Additionally, the Commonwealth Bank is about to begin using Ripple technology produced by Google Ventures-backed start-up Ripple, to allow its subsidiaries (including ASB) to transfer payments between themselves.[49] The Ripple network utilises blockchain technology to allow transactions in all kinds of currencies, unlike the Bitcoin blockchain which only uses the Bitcoin currency.[50] The immutable ledger enables a strict record of payments between subsidiaries, via a specific private key. As a result, reconciliation will be easier for the Bank and will reduce costs and time in transferring funds.

Beyond financial services, other industries – like professional services and energy – are exploring blockchain-based payments and settlements solutions. Power Ledger is using Blockchain with the aim of devising business models for peer-to-peer energy, effectively cutting out energy retailers.[51] Power Ledger uses blockchain technology to identify who owns generated energy, and then manage multiple trading agreements where consumers buy excess solar power direct from the original producer, without the addition of market costs and commercial margins.[52]

Applications of blockchain as an immutable ledger

Record keeping, such as through a ledger, has become increasingly complex. The number of participants involved in a market, the complexity of transactions, and a lack of trust can lead to disputes or uncertainty.

A number of solutions to this problem have been developed. For example, some centralised ledgers (like the New Payments Platform) allow all participants to view the ledger in real time, while maintaining integrity through a single central ledger.[53] Similarly, blockchain provides a commonly agreed and accessible record of all past transactions, which can only be added to, not amended. This can be useful in a range of circumstances – from supply chain transparency and cross-border transactions to reconciliations and regulatory compliance.

This application can improve transparency and create trust between organisations or different parts of a supply chain. For example, Sydney-based Full Profile is piloting distributed ledger technology in the grains industry. The goal will be to provide field-to-plate provenance tracking, so that buyers and consumers can be certain of where their products come from.[54] It will also help growers and traders with smart contracts to ensure that payments are made as soon as goods are delivered or ownership changes.

Other companies are also using blockchain for its immutable ledger application.

- **Everledger** helps companies to track the provenance of diamonds, allowing buyers to check whether stones were mined in regions with forced labour or whether proceeds from previous sales were used to fund violence.[55]
- **IBM** has launched a platform for companies to test blockchain technology within their own supply chains. The service enables companies that need to track high-value items through complex supply chains, to build and test blockchains in a secure cloud.[56]
- **Webjet** is using blockchain between its own divisions in its business-to-business wholesaling arm, which offers hotel booking to travel agents. Its goal is to solve issues with suboptimal communication between intermediaries, which results in about 4% of transactions not being paid for. With built-in smart contracts which document hotel bookings, there is an indisputable and permanent record, and any subsequent changes to a booking can be clearly logged.[57]

SPOTLIGHT: DISTRIBUTED LEDGER TECHNOLOGY – BEYOND BLOCKCHAIN

Blockchain is just one type of distributed ledger technology. To date, there are few functional examples of distributed ledgers which do not use blockchain.

Hashgraph is just one of a few potential applications of distributed ledger technology outside the blockchain realm. This platform differs from blockchain by recording multiple transactions at the same time, rather than recording one transaction after another in a chain.[58] In doing so, unlike blockchain where the chain must form a single consecutive chain of blocks with no branches, Hashgraph claims that it allows for multiple branches to be recorded simultaneously.[59]

Most recently, the Commonwealth Bank of Australia has been involved in the first trade finance transaction as one of two independent banks using a combination of blockchain, smart contracts and the internet of things to facilitate the transaction.[60] Using the smart contracts on a specialist blockchain technology system, the contract codifying the letter of credit was created. The goods were tracked by connecting the goods container to the internet of things, and once it reached a certain location, the smart contract was triggered to release the payment.[61] It appears that we are only at the very beginning of fully exploring the potential of blockchain arising from opportunities to combine it with other technologies.

04

Implications

Distributed ledger technology has the potential to generate benefits through the disintermediation of networks. It can reduce the costs of intermediation (i.e. the need to incentivise a third party to verify transactions) and does not provide a central point of potential failure.

As with any innovation, though, these benefits should be weighed against the costs. For example, current distributed ledgers require multiple parties to check each transaction in order to come to a consensus. This process is duplicative, and so may be less efficient than a centralised ledger.[62] For example, Bitcoin miners are being paid between US$7 and $9 to process each transaction (though this cost is not currently passed on to those initiating transactions).[63]

Ultimately, blockchain and distributed ledger technology represent significant innovations. They have broad implications, including:

- operational simplification and fraud minimisation
- digital identity
- more transparency in transactions.

Clearly, distributed ledger technology is still developing. It is not yet clear how and where it will be applied and exactly what impact it will have on society. However, the range of applications already being considered will have implications for individuals, businesses and government.

Operational simplification and fraud minimisation

One of the advantages of distributed ledger technology is that it can reduce or eliminate manual efforts required to perform reconciliation and resolve disputes. For example, traditional double-entry bookkeeping means both parties have to check their systems and find the source of a discrepancy and the reason why they disagree. Indeed, the same transaction can be recorded differently by each of the parties. This can be mitigated in a number of ways, for example through the use of a distributed ledger like in blockchain technology. However, it should be noted that centralised ledgers can also mitigate the risk of transactions being recorded differently. This is because all parties share the same records and can understand the history of the transaction.[64]

These reconciliations may have historically been central to the current role of some **individuals**. Thus, there may be some concern around what widespread adoption might mean for employment in these occupations.

For **businesses**, this operational simplification creates clear benefits. It can mean a reduction in duplicated and manual tasks, thus increasing efficiency and cutting costs.[65] It could result in opportunities for businesses to focus on more value-adding tasks.

Similarly, it can improve relationships and facilitate trust along the supply chain. Businesses which regularly deal with new or unknown customers face default or counterparty risks, where a business is not sure that its customer will comply with contractual terms. The most typical example of this is settlement times. Goods are delivered, but the customer may not make payment for days or weeks. This ties up capital and can cause cash flow problems.[66] Blockchain technology has the potential to minimise counterparty risk and settlement times, which helps to improve balance sheet efficiency.[67]

Most recently, the San Francisco-based start-up Chain has released 30,000 lines of open-source blockchain code to the public.[68] This release will enable people from software developers to executives to build and test any application they think will help improve efficiency in their businesses.

Regulators – such as in tax, prudential and corporate compliance – need to be certain of the validity and integrity of data provided, as well as transactions. For example, the Treasury is exploring possible uses of blockchain technology in a collaboration with CSIRO Data61. Thus, blockchain technology may reduce or remove regulatory friction and uncertainty, by making fraud or forgery more difficult and providing more detailed oversight to regulators.[69] Further, more timely provision of data could potentially help regulators react faster and make better decisions.

CASE STUDY: AUSTRALIA POST – EMPOWERING INDIVIDUALS WITH BLOCKCHAIN-BASED DIGITAL IDENTITIES

People are increasingly conscious of their security and privacy, both online and in person. Digital and national identities are often considered a convenient solution. However, there has traditionally been a trade-off between convenience and privacy. Australia Post is exploring how blockchain-based digital identities may offer Australians both convenience and privacy.

"Blockchain technology can give people more control over their own information. Cryptography means that you can choose precisely what information you release, when, for how long and to who," says Rick Wingfield, a partner at the Australia Post Accelerator.

Australia Post acts as an agent for more than 100 government bodies and corporates. With Australians undertaking more than 800 million transactions with government agencies annually,[70] 40% of which are completed via traditional channels, Wingfield sees the opportunity for more efficient services.

"People are often required to prove their identity through their credentials. For example, a driver's licence is intended to certify that you are qualified to drive but they are more often used to prove who you are.

"Blockchain could be used to attach credentials such as a driver's licence to people's digital identity. This means blockchain could be a single source for people's credentials, which simplifies how they manage their data by reducing the need to access it from multiple databases and systems."

For most organisations, understanding the precise technology which lies behind blockchain is less important than the restructuring needed to accommodate new ways of transacting and dealing with other parties. "In any system where there are multiple parties interacting with a limited amount of trust, there is the potential for blockchain to be helpful. For example, in logistics, particularly across national borders, there is extensive paperwork to track who has been responsible for goods and what condition they are in. Blockchain could track these shipments and allow businesses to trust each other more readily across borders."

Despite these benefits, it is important to note that blockchain technology has its own costs, which vary with the governance of the blockchain network. In public blockchains, in particular, power consumption and transaction costs are quite high. Wingfield suggests that some of these costs can be overcome by private blockchain networks between parties on a blockchain rather than using miners.

Looking to the future, Wingfield notes that blockchain is starting to pass the peak of inflated expectations and move in to the trough of disillusionment.

"Blockchain has been discussed as a technology that can completely change the way people do business.

"While the technology involved is still in developmental stages, and may prove impractical, blockchain still has significant potential that should not be ignored. In another three to five years, we will see blockchain come in to full implementation, and really see the benefits emerge."

More transparency in transactions

Distributed ledger technology provides transparent information to all market participants for historical and real-time transactions.[71] As a result, those that currently gain competitive advantages via the imbalance of information are likely to be put on an equal footing with the rest of the market.

For example, greater transparency could mean that individuals are able to understand which organisations have used their data and under what circumstances. Blockchain solutions could allow information to flow both ways; for example, individuals might be able to better understand the provenance of goods and services that they buy. This could allow more informed consumer decision making.

The potential tracking of supply chains via blockchain will also provide greater transparency and simpler processes for businesses. In addition, there is likely to be less cost and time involved in tracking product sources, thus adding more benefits to businesses.

From a government perspective, greater transparency will also enable increased cooperation between regulators and regulated entities. Particularly in the context of financial markets, regulators are likely to be better able to fulfil their mandates of ensuring legality, security and stability of financial markets.

Opportunities

Distributed ledger technology and blockchain represent a significant innovation, by offering a disintermediated solution to record keeping. As one of the top ten emerging technologies in 2016, it may become a driver in the growth of the digital economy. And the digital economy in Australia is likely to be worth A$139 billion in 2020.[72]

Businesses and governments are in the process of examining and developing a range of applications, from digital identity to supply chain management. This research has highlighted the amount of activity in Australia and New Zealand alone – and leading organisations see great potential.

Even more is happening globally. The speed and level of investment in potential solutions shows that many organisations see the potential benefits of distributed ledgers and blockchain. But it is also important to consider whether it is the most appropriate solution to a defined problem or need.

Anywhere that a database can be used as a means of storing information, a blockchain could be used...

– Mark Staples, Data61

Whenever there are multiple parties which do business together in a network but don't quite trust each other (the "trust but verify" approach), blockchain based solutions could be helpful. It could work for land registries, healthcare records, freedom of information requests, passport and visa control and even tracking international flights.

– Juerg von Kaenel, IBM Research Australia

While the technology involved is still in developmental stages, and may prove impractical, blockchain still has significant potential that should not be ignored. In another three to five years, we will see blockchain come in to full implementation, and really see the benefits emerge.

– Rick Wingfield, Australia Post

Where there is an unmet need for veracity, transparency and disintermediation, blockchain should be considered as a potential solution. But this need not be all or nothing. There are three possible tiers of solutions that businesses can consider:

- blockchain as a means of operational simplification or fraud minimisation
- blockchain as a means of collaboration across the supply chain
- blockchain in concert with other technologies, like smart contracts and the internet of things, to create new business models or ways of working.

Are there blockchain applications which could allow your business to operate more efficiently? Which solution is most appropriate for your business?

For regulators, blockchain can offer both opportunities and challenges. Clearly, many of the opportunities for business could be just as powerful inside government. And the increased transparency offered by blockchain could assist in regulatory oversight. But regulators need to think ahead and consider whether existing legislation and regulation could needlessly hamper blockchain implementation and innovation in the sector.

In what ways could blockchain assist in the provision of government services?

How will existing regulatory systems need to adapt to encompass blockchain-based systems?

Just as nobody forecast social networks, blogging or Netflix in the 1990s, the absence for now of any tangible applications other than Bitcoin for the blockchain merely points to humankind's deficient imagination.[73]

Ultimately, we are still only at the initial stages of exploring the potential of this technology, but already it is showing many benefits. As the technology becomes more embedded and efficient, the full extent of its applications and implications will emerge. This will be particularly evident as it is combined with other emerging technologies. As additional uses for the technology emerge over time, the full potential of the blockchain – and the opportunities it offers to businesses and individuals – will be revealed.

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