THE LEDGER OF THINGS

Community Whitepaper, Volume 1
October 2022

New Zealand IoT Alliance

BLOCKCHAIN NZ

The Executive Councils of the New Zealand IoT Alliance and BlockchainNZ have identified organisational synergies that could deliver significant societal and commercial benefits.

Significant efficiency gains and security improvements can be achieved by leveraging blockchain's decentralised ledger models in combination with IoT. These gains can also be realised at speed and at low transaction cost.

The purpose of this paper is to showcase the opportunities for alignment of these technologies and demonstrate how these integrated decentralised models can add value in the New Zealand context.

Members of The NZ Tech Alliance

The Tech Alliance is a group of independent technology associations from across New Zealand, that work together with a common purpose to connect, promote, and advance technology ecosystems in New Zealand to help create a more equitable, sustainable and prosperous Aotearoa New Zealand underpinned by good tech.

New Zealand IoT Alliance

The New Zealand Internet of Things Alliance (NZIoTA) is a member representing the industries utilising IoT and smart technology. Its key purpose is to actively contribute to the acceleration and adoption of IoT innovation by promoting collaboration (across industry and government) to create a connected New Zealand.

BLOCKCHAIN NZ

BlockchainNZ is a member association representing the rapidly emerging business sectors being built using blockchain technology. These business sectors encompass IT, trade and supply chains, virtual asset service providers, financial services, the public sector and more. BlockchainNZ has a leading role in growing our country's ability to maximise opportunities enabled by blockchain technology and address key challenges.

TABLE OF CONTENTS

THE INTERNET OF THINGS

Technology Breakdown

WHAT IS THE INTERNET OF THINGS?

The Internet of Things (IoT) is a collection of real life things that are connected to the internet and each other. Network connectivity and computing capability usually seen in laptops or mobile phones is now achievable with everyday items that have traditionally not been considered computers. For example, devices, objects, machines, animals or people, can now be connected and interact with each other.
In our connected world, IoT enables devices to generate, exchange and consume data between objects and the environment with minimal human intervention. The data these devices generate can help facilitate decision making, problem solving and improve productivity.

Although there is no singular definition, IoT is seen as an enabling technology which can be employed with other technology, for example artificial intelligence (AI), location based technology and blockchain. Together, these technologies can provide deeper insights and meaning to collected data.

COMMUNICATION

IoT devices can communicate with each other and deliver data through four main communication models, including:

1. Device-to-device
2. Device-to-cloud
3. Device-to-gateway
4. Back-end data sharing.

These communication models, utilised by internet architecture boards, allow for flexibility in how different devices interact with each other, and how they collect and deliver data. In addition, the data collected can be further utilised alongside other technologies.

Data analytics and visualisation also play a considerable role:

DATA

The true value of data collection and exchange is its analysis and provision of further insights. Instead of simply inspecting raw data, there are three core components to IoT enabling improved usage of the data - collection, analysis and visualisation.

ANALYSIS

Data analysis is the process of inspecting, cleansing and modelling data to discover useful information and insights. Additional technologies, including AI, blockchain, location-based technology and machine learning can help interpret the data and provide insights.

VISUALISATION

The third component is presenting the data analysis in a meaningful way. Data has traditionally been presented using charts, graphs, infographics, maps and multimedia. However, current innovations also include 3D printing and the metaverse.

BLOCKCHAIN

Technology Breakdown

HISTORY OF BLOCKCHAIN

The 2008 global financial crisis (GFC) was the catalyst for an alternative financial system that no longer relied on traditional banking institutions.

In response to the GFC, Satoshi Nakamoto published a whitepaper on a peer-to-peer electronic cash system, which could disrupt the traditional banking system. This heralded the introduction of the decentralised digital currency, Bitcoin. Although cryptocurrency was developed as a global economic solution, the use of distributed ledger technology can also be applied to better manage other real world resources. For example, energy, logistics, real estate, supply chains, water and more.

WHAT IS BLOCKCHAIN

A blockchain is a decentralised ledger of all transactions across a peer-to-peer network. It has the potential to dramatically shift the way we interact with data and information systems. Essentially a distributed database, it establishes fairness and equity in how we store and use data, and conduct transactions. Traditional ledger systems are often closed-access and housed on one network within an organisation. Only those with permission can access and make changes to the data. What makes blockchain a revolutionary step is it's decentralised and open-source. This means anyone with a computer and internet access can view and build data upon it. Importantly, it is open-source, open protocol, permissionless and trustless.

Blockchain technology is a database that can be accessed by anyone and everyone can see the changes being made to the data. Blockchain benefits include automation, enhanced security, greater transparency, instant traceability and increased efficiency.

CONSENSUS

Instead of relying on a third-party to ensure its validity, blockchain uses cryptography and distributed consensus to verify each transaction. Every transaction is broadcast to each node on the network, which after a short processing time is verified. A blockchain node is a device that runs the protocol's software, allowing it to help keep the network secure and validate transactions. The nodes communicate with each other and the more nodes there are, the more decentralised the network is.

Distributed consensus ensures all nodes on the network must agree that the transaction is valid. Following verification, the information is published and recorded on the public ledger. From this point, it can never be changed. As blockchain is 'append only' and stores an irreversible record of all previous data, all previous information can be compared against new information being appended.

SMART CONTRACTS

In 2015, the blockchain network Ethereum launch introduced an additional transaction protocol , known as 'smart contracts'. Smart contracts are programs that can only be executed once specific criteria have been met. While a blockchain stores and manages data, smart contracts ensure the conditions of the transactions are met and validated.

ENERGY

ENERGY

THE PROBLEM

In June 2022, a number of factors created an energy crisis in Australia that cannot be readily resolved under the current electricity model. Suppliers and regulators struggled to keep the lights on throughout the densely populated eastern states of Australia.

The perfect storm was created by a combination of; opaque and complex energy market regulations (at a national and state level); the impact of pandemic restrictions and the subsequent return-to-work demand; the spiralling price of oil and gas; the reliance on dilapidated coal-fired power plants; climate change impacts; and the drive towards a low-carbon emission economy requiring the phasing out of fossil fuel energy generation.

In short, it became uneconomic to produce electricity in Australia to sell at the regulated price-cap. No business can survive in a market where the cost of producing goods is approximately twice the retail price required by a regulator.

If society wishes to move towards a low carbon future for the energy sector, then maximising the use of green energy sources is a clear winner. However, in Australia there is an abundance of solar radiation that is largely untapped.

A GREEN ENERGY SOLUTION

According to Geoscience Australia, the continent receives an average of 58 million PetaJoules (PJ) of solar radiation annually - approximately 10,000 times larger than its total demand. This primary resource is free and is distributed across the nation. The only costs are in the capture, storage and transmission of the energy.

Considering its nationwide distribution, there would be less reliance on costly transmission infrastructure, as users would be supplied from their closest producer. Similarly, other green energy sources including wind, micro-hydro and bioenergy producers (bio-digesters and pyrolysis plants for waste recycling) could also contribute to the grid.

These distributed energy resources (DERs) can operate on a blockchain energy trading platform, offering their energy output in a spot-market managed by smart contract auctions and governed by a decentralised autonomous organisation (DAO).

This approach to local energy trading also greatly reduces energy loss that is a common feature of long distance transmission lines.

POTENTIAL FOR A DECENTRALISED SMART GRID

One organisation leading the way in enabling peer-to-peer green energy networks is WePower (https://wepower.com), who are based in Lithuania and operate within Europe and Australia.

WePower have developed a next generation renewable energy and procurement trading platform, that allows green energy producers (solar, wind or micro-hydro) to market their spare production to energy users, through a decentralised smart contract procurement platform and have effectively tokenised the energy market.

"WePower facilitates the global shift to renewable energy by democratizing the energy procurement process. WePower's Platform connects organizations seeking to procure renewable electricity (Energy Buyers) directly with owners of renewable energy projects (Project Owners) and provides both parties with standardized tools and contracts to enable the transaction. Energy Buyers are able to reduce their electricity costs to below market rates at any given time with full transparency and ease. Project Owners are therefore able to contract the electricity output of their projects to a wider range of buyers, making it easier for their projects to secure financing."

WATER

WATER

Water Scarcity, Quality and Climate Change

A global shift in consciousness and awareness has led to a trend towards sustainability being an integral aspect in our decision-making.

Currently, we are facing a global water crisis. For example, in 2018, Cape Town, South Africa, faced Day Zero, where the demand for drinking water significantly exceeded the supply available. This left the city facing the prospect of water shut downs and strict water rationing. More recently, the city of Chennai, India, has experienced a critical water shortage affecting the lives of their 9 million residents. Similar water scarcity is also occurring in India and England.

While climate change and global warming are a key cause, mismanagement of our water resources also plays a significant role.

Roland Liemberger, a non-revenue water management specialist from International Water Association (IWA), provides sobering data on the volume and cost of water lost. It is estimated a global annual water loss of 126 billion m3 per year (or 77 litres per capita per day) represents a loss of US$39 billion per year. With clear evidence of climate change, severe weather events threatening our drinking water resources, the availability of fresh water will only continue to become scarcer.

However, there is potential for technology to help mitigate the effects of climate change. Developing smart technology is part of the solution to help combat climate change. For example, big data will help inform public policy and improve the quality of decision making regarding future infrastructure investment.

THE TECHNOLOGICAL SOLUTION

Imagine if we valued, measured and managed water in the same way we managed and valued money. Money is highly regulated and subject to stringent market rules. Money is measured on a global ledger(s) and is mostly accounted for. Large losses of money are given a great deal of attention by authorities and regulators. Is this true for water?

Considering the potential of IoT, blockchain and the concept of a distributed water ledger, we can improve current water management practices, while promoting fairness, equity and access to clean, safe drinking water, plus avoiding environmental harm in the discharge of wastewater products.

Historically, the Supervisory Control and Data Acquisition (SCADA) systems that emerged in New Zealand in the 1980s have managed water networks. However, due to their high costs, it is not economically viable to continue deploying this legacy technology broadly across water networks.

Low cost IoT devices and blockchain secured data protocols can overcome this challenge. Commercially available monitoring products include:

- Smart domestic water meters and mains flow meters where data is available on smartphones and tablet devices.
- Acoustic sensors used to locate leaks by correlating leak-noise in water networks.
- Temperature sensors in wastewater lines used to detect ground or surface water inflow that can result in sewer overflows.
- Real-time sensors used to detect chemical changes in pH levels, chlorine residual, total organic carbon (TOC), nitrogen and phosphorus.
- Real-time sensors used to detect physical parameters, for example conductivity, vibration, depth (of flow), velocity and direction of travel.

Supported by AI and machine learning algorithms, the analysis of these big data sets allows water utility agencies to operate intelligent water networks. This results in substantial savings in operating and future capital costs.

IMPROVED WATER ACCOUNTING

A distributed water ledger, recording transactions for every water user, will provide an immutable record on a public blockchain network. This will prevent any unauthorised data alteration and using digital water tokens could form the basis for customer billing. The usage information can be held in a widely distributed, open-source, open access public network to ensure transparency (but would not include private user data). The ledger would be scalable, from a local water ledger, a regional ledger, to a national and potentially global ledger.

THE FUTURE OF WATER MANAGEMENT

Many of the issues of allocation, abstraction and consumption can be resolved using improved water management.

This includes using modern hydrological (and hydrogeological) modelling techniques to better understand the availability of water from surface and ground water sources; combined with the data able to be provided from IoT monitoring devices; and securely held and managed in a decentralised ledger and allocated and/or traded, using smart contracts.

Prior to the advent of smart contacts, this future for water management and Smart Water Markets was envisioned by Dr John Raffensberger in Matching users' rights to available groundwater, published in April 2011, (University of Canterbury).

SUPPLY CHAIN AND LOGISTICS

SUPPLY CHAIN AND LOGISTICS

THE CASE FOR CHANGE

For some time, tracking and monitoring goods throughout supply chains has been a logistical challenge for businesses, manufacturers, factories and consumers. Verifying the origin of goods, geolocation at any stage, or condition often relies on trusting a series of third parties.

In recent years, supply chains have become increasingly diversified and complex. To cope with this dynamic environment and the rising need to digitise supply chains and enhance competitiveness, companies are applying IoT, cloud computing, business intelligence, AI and blockchain technology to help streamline logistics.

These technologies promise to reshape the modus operandi of modern supply chains through enhanced data collection, information sharing and analysis between collaborating supply chain stakeholders. This enhanced information transparency also helps create increased trust between the exchange partners.

However, a key challenge is IoT devices cannot be entirely relied on. Using blockchain, businesses can be assured that all relevant parties across the supply chain can access the information they need, as it is secured on an immutable, tamper-proof ledger. It is estimated by Gartner that blockchain will be used to track and trace $2 trillion worth of goods and provisions annually. It is imperative investment is made in technologies that will help meet our future supply chain requirements..

KEY CHALLENGES

- Manual, paper-based recordkeeping and reporting systems often lead to scattered, incomplete, unauthentic manifests, bills of lading (BOL) and certifications.
- It is often challenging to track the source of flawed parts or faulty products, and trace the provenance of previously shipped products.
- Knowing where goods are in real-time continues to be a key challenge, especially with international shipments.
- Availability of relevant logistical information is seldom accessible and is difficult to report on.
- Cross-border financial transactions are unreliable, convoluted and in many cases interceptable.

TANGIBLE BENEFITS

Suppliers, manufacturers and logistics providers can achieve extraordinary results with blockchain and IoT. Key benefits include:

DATA-DRIVEN INSIGHTS

As IoT sensors track the physical location of goods, smart contracts on blockchain can document the transfer of ownership and custody between parties. Data-driven insights can provide a variety of meaningful, actionable insights including accurate cost recording and billing.

MAXIMISE TRANSPARENCY

Digital BOL and smart contracts can help track the status of goods in real-time, ensuring the accuracy of fulfilment obligations. An additional benefit is product provenance detailing where products (or their components) originated.

REGULATED RELIABILITY

In highly regulated industries like pharmaceuticals and food, goods need to be transported under strictly controlled temperatures within given time frames..
Using onboard sensors, it is possible to capture temperature feeds and transfer them to a blockchain framework, guaranteeing the security and reliability of the information.

END TO END REAL-TIME VISIBILITY

Product journey tracking using IoT and blockchain also allows organisations to share accurate product location information, including concerning incidents or disruptions. While IoT sensors track the physical location of goods, smart contracts on a blockchain can document the transfer of ownership and custody between parties.

IMPROVED GLOBAL FINANCING

The global supply chain involves bureaucratic transactions and banking regulations across borders which can impact the time taken for international payments.Paperwork-related shipping complications, including falsified documents or manual errors, can lead to supply chain delays, losses and other risks. This is especially problematic with time sensitive shipments of fast moving consumer goods (FMCG) such as dairy, medicines, and meat. IoT generated shipping information can be uploaded directly to the blockchain, resulting in digitised paperwork and automated validation and verification.

REDUCING THE INCIDENCE OF 'DARK SHIP' ACTIVITIES

Illicit activities can occur when vessels turn off their Automatic Identification System (AIS) transponders to avoid the detection of ship-to-ship transfers of cargo. The practice has been used for many years in an attempt to avoid trade sanctions, and disguise the origin and destination of crude oil and other goods.

Using synthetic aperture radar systems and recording all logistics data on a blockchain, could readily detect, expose and reduce this activity.

Introducing new technologies to provide authorities with an immutable record of ships and their cargo, will help prevent Dark Ship activities. Using blockchain technology with IoT can significantly speed up the process of shipping goods across borders, resulting in systematic, secure and cost-effective transactions that eliminate fraud through an immutable distributed ledger. Smart contracts can be used to implement preprogrammed, automatically executed agreements between parties.

AUTHORS

KEAGAN LEHMANN

Keagan is the NZ Leader for AI & Advanced Analytics at GHD Digital, an industry thought leader in IoT and digital solution development and is a member of the NZ IoT Alliance Executive Council

ALISON MACKIE

Alison is the Executive Director of NZ IoT Alliance and BlockchainNZ, and the co-founder of the blockchain for utilities company, Meterme.

JOHN MACKIE

John is a Chartered Professional Engineer and a Fellow of Engineering New Zealand and is a previous member of the Blockchain New Zealand Executive Council.

New Zealand IoT Alliance

e. info@iotalliance.org.nz
w. iotalliance.org.nz

BLOCKCHAIN NZ

e. team@blockchain.org.nz
w. blockchain.org.nz