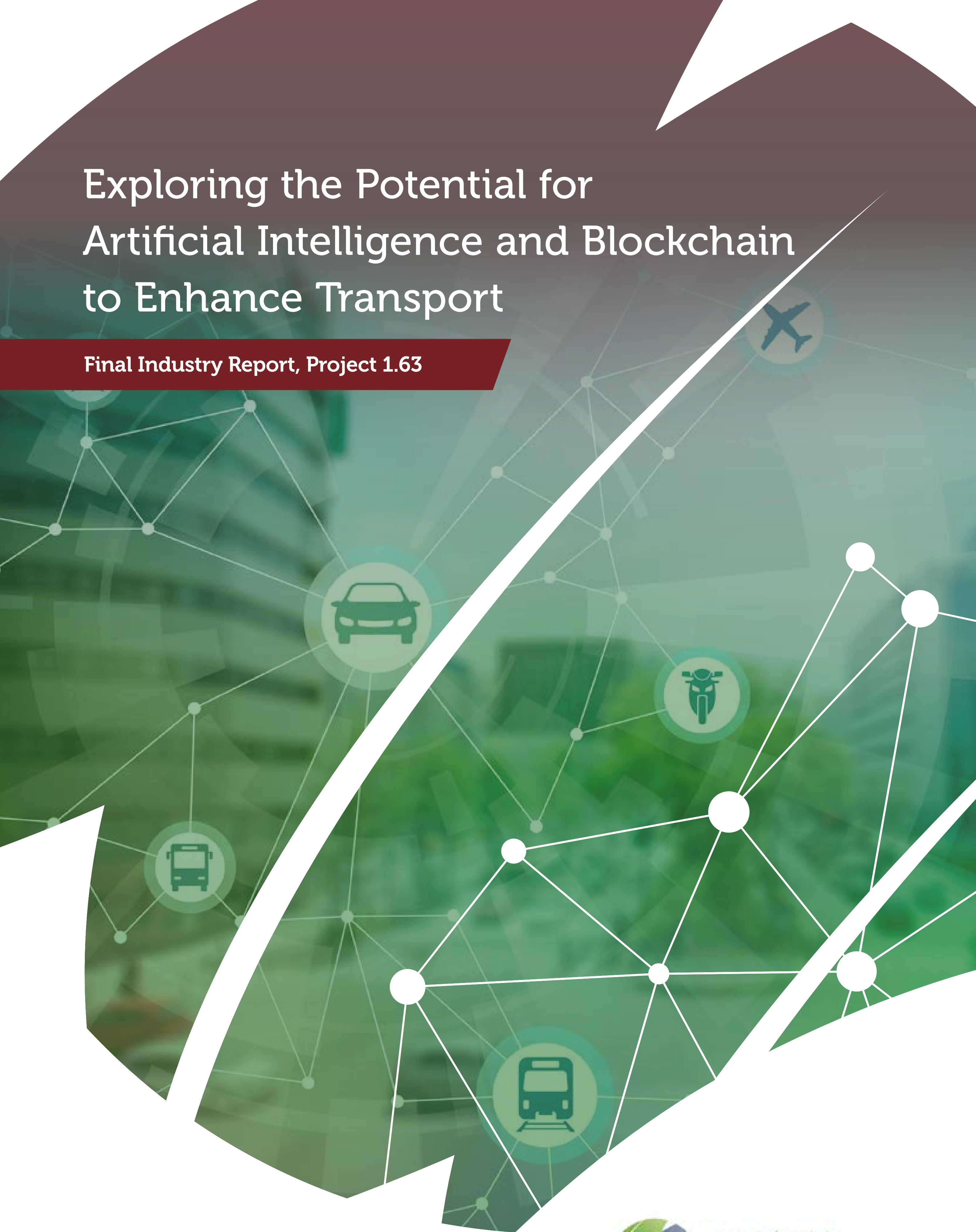

Exploring the Potential for Artificial Intelligence and Blockchain to Enhance Transport

Final Industry Report, Project 1.63

April 2020

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Sustainable Built Environment National Research Centre AUSTRALIA

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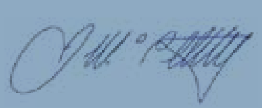
FREMANTLE PORTS

Preface

The Sustainable Built Environment National Research Centre (SBEnrc), the successor to Australia's Cooperative Research Centre (CRC) for Construction Innovation, is committed to making a leading contribution to innovation across the Australian built environment industry. We are dedicated to working collaboratively with industry and government to develop and apply practical research outcomes that improve industry practice and enhance our nation's competitiveness.

We encourage you to draw on the results of this applied research to deliver tangible outcomes for your organisation. By working together, we can transform our industry and communities through enhanced and sustainable business processes, environmental performance and productivity.



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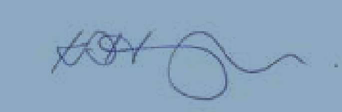

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Executive Summary

The International Data Corporation anticipates that spending on Artificial Intelligence technologies will increase by more than 50 percent each year, reaching US$57.6 billion in investments by 2021[1]. While the World Economic Forum predicts that by 2027 some 10 percent of global GDP, in the order of US$8 trillion, will be Blockchain-based[2]. In 2020 the Australian Government released the 'National Blockchain Roadmap' to identify specific opportunities for Blockchain across a range of sectors. In response to growing interest in the potential for such digital technologies to assist the transport sector, the SBEnrc was tasked by its core members to investigate potential use cases. The research found that, as with previous waves of innovation, if effectively deployed the transport sector stands to gain significant benefits from the application of both Artificial Intelligence and Blockchain Technology.

The research found that these technologies will provide a number of new and unique opportunities across the transport sector, many that even at the completion of the project were only being glimpsed. This industry report provides an overview of the key functionality of various applications of Artificial Intelligence and Blockchain Technology relevant to transport, before selecting specific use cases for further investigation. The project brought together some of Australia's leading academics and experts to work closely with a steering group comprised of a range of government and industry representatives both nationally and internationally.

The research project identified 15 applications of Artificial Intelligence and 9 applications of Blockchain Technology and undertook an investigation into each to inform the selection of a combined short-list of 6 applications, including: identification of network characteristics, traffic management, traffic signal optimisation, vehicle prioritisation, real time road user pricing, establishing identification, and enhanced freight tracking and authenticity. As part of the process the research team facilitated a set of workshops to explore the main functionality of both types of technology with an emphasis on what is new or unique, focusing on functionality rather than the technical details. The sessions also considered the potential value to partners of each type of application and the current level of implementation in order to inform the selection of the short-list.

The next stage of the project involved a process to refine the short-list to identify one use case for each technology type, based on a set of criteria nominated by partners. As a result the use of Artificial Intelligence to enhance traffic optimisation with a focus on traffic management and signalling, and the use of Blockchain Technology to enhance freight tracking and authenticity, including real-time location and confirmation of origin and delivery, were chosen for further investigation. Consideration was given to how the technology is currently being used, what new functionality is being promised, which of the applications are most suited, what are the associated risks and rewards, what are recommended strategic approaches to implementation that transport agencies should consider, and what policies and mechanisms could be used to support these technology applications, as outlined in this report.[3]

[1] Shirer, M (2017) International Data Corporation, Press Release 25 September 2017

[2] WEF (2015) 'Deep Shift: Technology Tipping Points and Societal Impact', World Economic Forum, September 2015.

[3] For more details please refer to: 'Hargroves, K., Stantic, B., and Allan, D. (2019) Investigating the Viability of Artificial Intelligence and Blockchain Technology to Enhance the Transport Sector, Sustainable Built Environment National Research Centre (SBEnrc)'.

Introduction

The purpose of this project was to build on the research undertaken in SBEnrc Project 1.45 Big Data, Technology and Transportation, and explore a range of digitally-driven opportunities and challenges in seeking to get cities moving and functioning better; with a focus on the application of Artificial Intelligence and Blockchain Technologies to the transport sector. This industry report provides the key findings related to specific potential applications selected by partners and suggests where such technology can provide tangible benefits.

The core industry challenge that this project sought to address was how to quickly identify valuable applications of new technologies to harness increasing volumes of data and to build strategic approaches to their application in the transport sector across Australia — focusing on applications of Artificial Intelligence and Blockchain Technology (see Table A)[4]. A key element of harnessing both of these types of technology will be to ensure that industry, government and researchers work together to identify early stage applications that provide reliable, fast, affordable and sustainable mobility in the Australian transport sector.

Table A: Summary of applications identified that stand to provide value to the transport sector

Applications of Artificial Intelligence	
Identification of Transport Network Characteristic	Enhanced Traffic Risk Management
Simulating Behaviours of Self-Driving Vehicle	Optimisation of Ride-Sharing Services (MaaS)
Enhanced Traffic Management	Detecting Fare Evasion and Turnstile Shadowing
Tracking Vehicle Behaviour	Routing and Management of Drones
Identification of Vehicle Breaches	Enhanced Asset Management
Enhanced Real Time Traffic Signal Optimisation	Monitoring Vehicle Locations
Vehicle Prioritisation (Emergency and Shared Transit)	Comparing Modal Trip Times
Route Optimisation (Emergency and Freight)	
Applications of Blockchain Technology	
Verified Vehicle Ownership Documentation	Establishing Identification
Real Time Road User Pricing	Enabling Intermediary Free Ride Sharing
Congestion Zone Charging (Virtual Zones)	Vehicle Generated Collision Information
Collection of Tolls and Charges (Virtual Gantries)	Enhanced Freight Tracking and Authenticity
Automated Car Parking and Payments	

[4] For more details please refer to: Hargroves, K., Conley, D., Emmoth, E, Warmerdam, S, Kahindi, N., Cui, F., and Spajic, L. (2019)
[5] 'Investigating the Potential for Artificial Intelligence and Blockchain Technology to Enhance the Transport — Project Report', Sustainable Built Environment National Research Centre (SBEnrc), Australia.

The project undertook stakeholder sessions to clarify the main functionality of both types of technology with an emphasis on what is new or unique that is relevant to transport, and to consider the potential value to partners (see Part 1 and 2). A short-list of 6 use cases was then selected, informed by the perceived level of value and the level of current application across the partners.

Short-listed use cases for Artificial Intelligence in Transport

- Identification of Network Characteristics and Asset Management.
- Traffic Optimisation (Management and Signalling).
- Vehicle Prioritisation (Emergency and Shared Transit).

Short-listed use cases for Blockchain Technology in Transport

- Real Time Road User Pricing (Charging for time of day and road type usage).
- Establishing Identification (Digital drivers' licences and vehicle ownership).
- Enhanced Freight Tracking and Authenticity (Real time location and confirmation of delivery).

Following the identification of the short-list a process of engagement with partners was undertaken to identify preferred criteria to inform the selection of the final applications for further investigation. The results of this process identified 5 key questions to ask when comparing the use cases, listed below in order of priority:

- What is the level of maturity of technology? (Has the technology been proven or is it still in development? Is there venture capital behind it? Is there a regulatory framework in development or in place?)
- Is there potential for quick wins with minimal expenditure and time commitment that will catalyse early efforts? (Are there opportunities to pick 'low hanging fruit'?)
- What are the pre-requisites for data availability, format and intervals? (What are the expectations around data, are there requirements for data collection or cleaning, are there data standards in development or in place?)
- What are the capital and operational expenditures? (What costs are involved in both setting up the system and running it?)
- What is the level of difficulty? (Can the solution be implemented and maintained internally without expert support, or minimal support? Is the solution modular and/or open architecture?)

The results of the comparison was the selection of two lead applications of the technology for further investigation using the questioning approach outlined below:

1. The use of Artificial Intelligence to enhance Traffic Optimisation with a focus on traffic management and signalling.
   - How is Artificial Intelligence currently being used to enhance traffic management and what new functionality is being promised?
   - Which of the applications of AI are most suited to traffic optimisation in Australia and what are the associated risks and rewards?
   - What are recommended strategic approaches to implement the AI applications that transport agencies should consider?
   - What policies and mechanisms should be used to support the AI applications?

2. The use of Blockchain Technology to enhance Freight Tracking and Authenticity, including real-time location and confirmation of origin and delivery.
   - How is Blockchain Technology currently being used to enhance freight tracking and authenticity and what new functionality is being promised?
   - Which of the applications of Blockchain Technology are most suited to freight tracking and authenticity in Australia and what are the associated risks and rewards?
   - What are recommended strategic approaches to implement these Blockchain technologies that transport agencies should consider?
   - What policies and mechanisms should be used to support these Blockchain Technology applications?

The results of the investigation are summarised in this report and it is recommended that additional investigation is undertaken on these and other applications selected as part of the short list.

1. Application of Artificial Intelligence to the Transport Sector

1. Application of Artificial Intelligence to the Transport Sector

What do we mean by Artificial Intelligence?

Artificial Intelligence can be a powerful tool for managing and predicting flows of objects, making it particularly useful for the transport sector, allowing greater use of current data in automated decision making. In order to contemplate the potential it is important to make a distinction between 'rule-based learning' and the growing area of 'machine learning':

- Rule-Based Learning: This is where a computer uses a long list of computer codes using sets of organised and labelled input data to account for every eventuality that the program could face and provides options for each. For example, the code may call for the program to answer a question such as 'Are the doors on the train all closed?' and then provide two command options. If after checking the data from the door sensor the answer to the question is 'Yes' then the program can move to the next question needed to answer before the driverless train departs the station, and if the answer is 'No' then the program may ask other pre-departure questions and then come back to this one and will wait until all answers are 'Yes' before departing. This approach is intensive and limited as it calls for each eventuation to be foreseen and responses designed. This is however valuable, but is best used with a clear set of potential options and outcomes involving relatively small data sets.

- Machine Learning: This is where rule-based learning is enhanced or replaced by a capacity to automatically detect relationships in the input data, some previously unforeseen, rather than having set relationships predetermined. Typically based on artificial neural networks that mimic the way the human brain functions these systems investigate the relationships between data in order to: predict associated outcomes; cluster like inputs; compare real time input to historic records; and identify when a new input varies from the typical input. For instance a decision can be made based on comparing examples from the past and the associated outcomes, with the current situation, to estimate a likely outcome, such as likelihood of a high congestion event, updating itself as it goes much like the human brain. Such systems may need some training and require large data sets to learn from in order to be able to interpret incoming data and make a decision, that in many cases can be as good as, or better than, a human operator. Other machine learning options include regression, clustering, random forests, and decision trees. Machine learning can also be extended in to Deep Learning that can learn from unstructured and unlabelled datasets.

In basic terms, 'Artificial Intelligence' is the capacity of computers to not only make decisions that were previously made by humans, but also to be able to make decisions that humans are not capable of making given the complexity and volume of data. The academic field of Artificial Intelligence was created in the mid 1950's and more recently it has seen a revival of interest due to the proliferation of computers and growing amounts of data becoming available from all across society (used in Google searching, electronic home assistants, Spotify, etc.). Artificial Intelligence is more than just about making decisions; it is also concerned with developing computers that think and act like humans, and hence involves a range of disciplines such as computer science, psychology, ethics, cognitive studies and neuroscience.

How can AI be applied to the Transport Sector?

Although a focus on Artificial Intelligence is not new there are a number of new or underutilised applications that are very relevant to the transport sector, such as:[5]

- Traffic Management: The 'Malaysia City Brain' created by Alibaba uses Artificial Intelligence to process data from traffic lights, CCTV cameras, public transport, and other data streams, to reduce traffic congestion and direct emergency services. Deployed in Hangzhou China the system resulted in an average increase of 15 percent in vehicle speed.

- Vehicle Behaviour: How vehicles interact with other vehicles, the frequency and location of stops, time spent at traffic signals etc. can be used to build a baseline of expected behaviour that can be used to identify abnormalities on the network and create vehicle risk profiles.

- Traffic Signal Optimisation: The application of AI to optimise traffic signalling is in its early stages and delivering a system that can allow for variations in real time comes with challenges as such programs need to learn favourable traffic light cycles and timings.

- Vehicle Prioritisation: The 'Public Transport Information and Priority System' in Sydney can detect if a bus is more than 2 minutes behind schedule and provide priority signalling. A 2001 trial on the Sydney Airport Express Bus showed a reduction in travel time of 21 percent and reduce variability of travel time by 49 percent.[6]

- Route Optimisation: Logistics company UPS has created an AI system called ORION (On-road Integrated Optimisation and Navigation) that identifies the most efficient routes for its fleet based on customer, driver and vehicle data, with routes updated in real time depending on road conditions and other factors.

- Traffic Risk Management: A system designed by UK company Predina uses AI and geospatial analytics to predict road transport risks. The system generates risk mitigation intervention suggestions based on historical incidents and near-misses, weather data, real-time traffic information and driver risk profiles.

- Self-Driving Vehicles: Developed by Cornell University, 'DeepTraffic' is a computer program using neural network technology to simulate self-driving vehicles at varying speeds in dense traffic conditions to identify efficient vehicle movement patterns to avoid collisions.

- Ride-Sharing: German company Door2door has created an on-demand ride-sharing service that uses AI to optimise pooling configurations and routes to simulate demand and respond in real time, while managing dispatches, bookings, route planning and drivers.

- Fare Evasion: Spanish company AWAAIT has created a system for detecting when someone sneaks through entry gates behind paying customers on the Barcelona Metro that uses AI to analyse camera images of travellers entering the metro entry barriers for suspicious behaviour resulting in a 70 percent decrease in fare evasion.

[5] For more details on these examples see Hargroves et al (2019).

[6] BITRE (2017) Costs and benefits of emerging road transport technologies, Report 146, Bureau of Infrastructure, Transport and Regional Economics, BITRE, Canberra ACT.


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2. Application of Blockchain Technology to the Transport Sector

What do we mean by Blockchain Technology?

Shortly after the 2008 global financial crisis the blueprints for what was referred to as a 'Bitcoin' was released anonymously. The blueprint brought together various forms of cryptography and computer science to create a digital architecture suitable to run a decentralised digital currency that does not require a central authority. The underlying programming is now referred to as a 'Blockchain' and in simple terms the technology replicates a single timestamped database over millions of computers around the world, rewarding hosts for validating transactions to allow them to be added to the shared database. This allows for hacking attempts to be swiftly identified and in doing so, despite early criticism and scepticism, created a truly world-changing technology which has a range of applications to the transport sector. According to Rich Strader, Vice President of Mobility Product Solutions for Ford Motor Corporation, 'Blockchain will transform the way people and businesses interact, creating new opportunities in mobility'.[7]

The ability to operate a trusted digital ledger without a central authority is a significant advance in computer science and not only does it allow for digital currency it can also store information, agreements, and contracts that cannot be amended or coerced and that can have self-executing functionality. According to Blockchain in Transport Association (BiTA), 'Blockchain is the way of the future … it isn't just an industry disruptor, it's technology that will revolutionise the way people do business'.[8]

Early movers to apply the technology to transport include Toyota, having launched a collaboration with the MIT Media Lab and a selection of Blockchain-based companies in 2017 to explore the value of the technology to the automotive industry. The focus of the initiative is to explore four main areas, namely: how it can assist uptake of automated vehicles, capture and share trip data from driverless vehicles, offer applications to enable greater ride sharing, and offer pay-as-you-drive options.[9]

An early example of harnessing Blockchain in the transport sector is the 'Mobility Open Blockchain Initiative' (MOBI). MOBI is a global non-profit consortium exploring how Blockchain Technology can make transportation safer, more affordable and more widely accessible. According to MOBI Chairman and CEO, and former CFO for Toyota Financial Services, Chris Ballinger, 'Blockchain and related trust enhancing technologies are poised to redefine the automotive industry and how consumers purchase, insure and use vehicles'.[10] MOBI is currently developing Blockchain applications for vehicle identity and history, supply chain tracking, autonomous payments, and pay-as-you travel charging and insurance platforms. Together with the Trusted Internet of Things Alliance, MOBI has created the MOBI Grand Challenge, which offers $350,000 of prizes for organisations that can show potential uses of Blockchain to control traffic and improve urban transport.

[7] Peters, B. (2018) 'Ford, GM, IBM Want Transportation to Run on Blockchain', Investors Business Daily, 02 May 2018.
[8] Baker, M. (2018) 'Blockchain on the Rise and the Search for Solutions', Freight Waves, June 27, 2018.
[9] Shieber, J. (2017) 'Toyota pushes into Blockchain Technology to enable the Next Generation of Cars', Tech Crunch, May 22, 2017.
[10] Marinoff, N. (2018) 'New Blockchain Initiative for the Automotive Industry Announced in Dubai', Bitcoin Magazine, 02 May 2018

How can Blockchain Technology be applied to the transport sector?

Despite Blockchain Technology being relatively new, and early applications such as cryptocurrencies experiencing challenges, there are a growing number of applications of this form of distributed ledger technology that will be of significant benefit to the transport sector. The following list includes some of these applications that harness Blockchain-based platforms:

- Global Freight Tracking: IBM and Danish shipping container company Maersk released a Blockchain for global freight tracking, with 94 groups initially involved, to instantly share customs releases, commercial invoices and cargo lists. The system quickly reached over 160 million shipping events, with roughly one million events per day.
- Logistics Documentation: Europe's largest port, the Port of Rotterdam, has set up a 'BlockLab' to use Blockchain to replace the paper-based 'Bill of Lading' system. This allows tamper-proof records to be available in real time to all necessary parties in the supply chain, significantly reducing transaction costs and associated time spent along the supply chain.
- Traffic Management: Blockchain Technology can provide the ability for vehicles to make and receive payments using a cryptocurrency wallet based on real-time vehicle location. This can allow for encouraging or discouraging the use of particular routes using a financial mechanism, along with processing fines and parking fees in real time.
- Supply Chain Transactions: The company ShipChain has a Blockchain system that tracks products from the manufacturer to its arrival with the customer, allowing for automated delivery confirmation, which means that all the parties involved across the supply chain can automatically be paid when it has been verified that they have completed their part.
- Digital Identification (Drivers Licences): Secure Logic Group has developed a 'TrustGrid' platform as the digital platform for digital driver's licenses and was trialled in NSW. The second trial will see more than 140,000 drivers entitled to opt-in for a digital driver's license that can be used for police checks and to gain entry o pubs and clubs.

- Establishing Provenance: Walmart is testing Blockchain Technology to track the movement of food to identify which producer is responsible in the event of poor quality or spoiled food, including accessing temperature sensor data from shipping spaces. In 2018, the Commonwealth Bank of Australia supported a trial of Blockchain Technology to track an international shipment of almonds.
- Establishing Authenticity: In the UK, the company Everledger is developing a Blockchain system that provides access to secured proof of origin and sourcing evidence for a range of high-value goods including diamonds, wine and fine art. De Beers mines, trades and markets more than 30 percent of the world's diamonds and plans to use Blockchain Technology to allow permitted agents – such as those involved in mining, cutting, wholesale and retail – to enter or edit data to ensure validation of non-conflict and child labour diamonds.

3. Combining Applications of Artificial Intelligence and Blockchain

According to a survey by Forbes Insights involving over 400 senior transportation-focused executives, some '65% believe the logistics, supply chain and transportation sector is experiencing nothing short of a tectonic shift'[11]. Further, the respondents highlighted a number of potential drivers for this shift, in particular 'technologies like Artificial Intelligence (AI), machine learning (ML) and increasingly, Blockchain'. As we have seen, Blockchain Technology can create a range of solutions that can provide benefits in areas of the transport sector. Also Artificial Intelligence can be used to process incoming data to optimise routes and improve network efficiency. The combination of the two can unlock never before seen opportunities in the transport sector, such as the following examples.

- Congestion Charging: By creating virtual zones, using GPS geo-fencing, vehicles can be charged for using specific parts of the transport network in real time using Blockchain Technology. This can for instance be used to discourage congestion or encourage vehicles to avoid ad hoc events such as sporting matches, construction works, and areas of high pedestrian traffic. This will generate data around where and when vehicles are entering prescribed areas and allow AI applications to monitor the impact on congestion levels from particular pricing levels to inform the selection of appropriate pricing.

- Road User Charging: Extending this, a variable fee or incentive can be applied to every street, intersection and motorway, with vehicles comparing potential routes based on both trip time and road user charges. This would allow AI to enact real-time pricing interventions to encourage vehicles away from particular areas of the network into underutilised sections, while collecting road charges in real time, which is of particular interest given vehicle electrification will see reductions in fuel excise tax revenue.

- Car Parking: GPS and Blockchain can be used for automatic car parking payments and AI can keep track of available parking spaces and notify vehicles of cheaper parking rates in specific locations during periods of low utilisation along with automated parking infringements. AI can then use this data to encourage greater utilisation of parking assets along with identifying areas with parking shortages and recommend alternatives, also providing insight into the implications for parking from driverless vehicles.

- Ride Sharing: The ability for Blockchain Technology to allow secure payments between two parties without the use of an intermediary allows for a new generation of ride-sharing. Rather than being offered by an intermediary like Uber that takes a percentage of each fare the rides would be agreed, booked and transacted directly between the rider and the driver (or driverless vehicle) as in the case of the ride-share app La'Zooz. AI can then not only be used to improve pickup precision using satellite imagery and GPS, but it can optimise fares.

[11] Forbes Insights (2018) 'How Blockchain May Impact Logistics, Supply Chain and Transportation', Forbes Insights, Sep. 2018

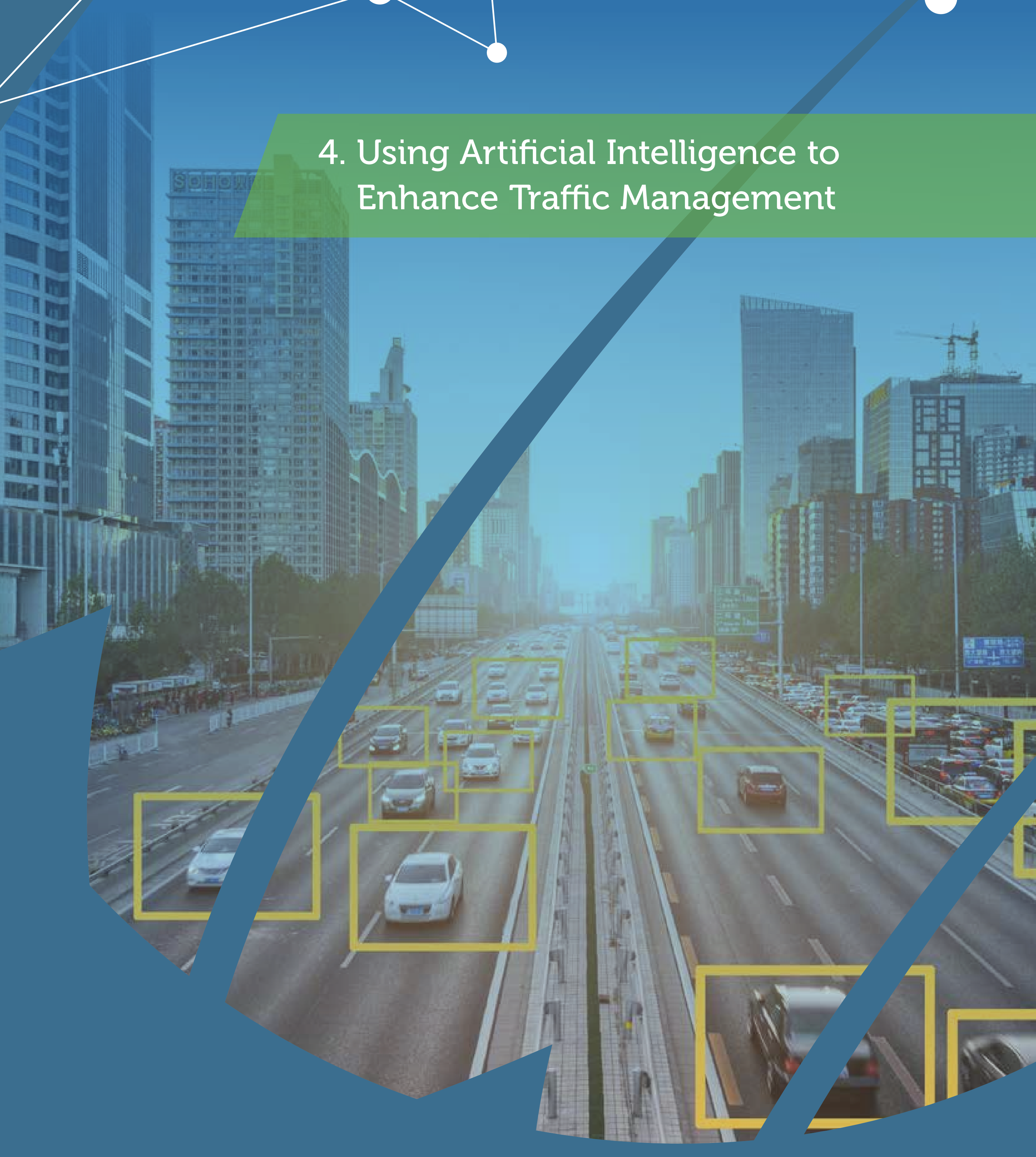
- Freight Management: Using the ability of Blockchain Technology to store information that cannot be altered or edited, a range of information can be extracted in real time from freight vehicles to enhance logistics management. For instance, this can provide a central up to date load board to broker loads. Such a database would provide a rich pool of information for machine learning to optimise freight routes, staging and storage of freight, and inform the potential for sharing of facilities and avoiding running empty. A Russian Based shipping company, Infotech Baltika, is developing a Blockchain-based system for port logistics called 'EdgePort' and claim that it will reduce time spent in port operations from 4 hours to 25 minutes, and increase port capacity by 3-5 percent.[12]

- Vehicle History and Sales: Using the ability of Blockchain Technology to store timestamped information that cannot be altered, vehicle information could be stored to validate service history, previous ownership, mileage, etc. This could also allow intermediary free peer to peer car sales with a trusted vehicle history. AI could use such trusted data on vehicle maintenance and compare it to the vehicles road use, driving patterns, brand of oil and lubricants, etc., to provide valuable correlations for improving vehicle design.

- Accident Information: Accident information from vehicles can be sent to a Blockchain to be accessed by incident investigators, insurance companies etc. Trusted accident data is a rich pool of information that can be mined by AI to inform network management, insurance premium levels, assist in identifying vehicle responsibility in collisions and infringements, etc.

[12] Bernman, A. (2019) Russia: Cargo Shipping Firm to Use Blockchain in Port Logistics, Cointelegraph, Feb 2019.

4. Using Artificial Intelligence to Enhance Traffic Management



4. Using Artificial Intelligence to Enhance Traffic Management

1. How is Artificial Intelligence currently being used to enhance traffic management and what new functionality is being promised?

- Traffic Fleet Optimisation: Vazifeh et al[13] have proposed a scalable solution to fleet sizing and operation that can inform estimates of minimum fleet size. By introducing the notion of a 'vehicle-sharing network' a nearly optimal solution amenable to real-time implementation is created. Using a dataset of 150 million taxi trips in New York City over one year the solution simulated a 30 percent reduction in fleet size to meet the same demand.

- Predictive Logistics: AI can help the logistics industry to shift from being reactive and forecasting using historical data and personal experience to data driven operations that take advantage of predictive intelligence. DHL uses AI to predict air freight transit time delays by analysing fifty-eight different parameters to predict changes to the average daily transit time up to a week in advance. Furthermore, this solution can identify the top factors influencing shipment delays which can help air freight forwarders select carriers.

- Traffic Accident Detection: Vision-based frameworks for object detection, multiple object tracking, and traffic near accident detection are important applications of Artificial Intelligence. Huang et. al. (2019)[14] proposed a two-stream 'Convolutional Neural Network' architecture that performs real-time detection, tracking, and near accident detection of road users using traffic video data.

- Artificial Intelligence in Rail Network: 4Tel and the University of Newcastle have created an AI solution called 'Horus' to assist train drivers in detecting hazards in the rail corridor by comparing real time footage to footage of clear conditions to allow earlier detection.[15]

[13] Vazifeh, M., Santi, P., Resta, G., Strogatz, S. and Ratti, C. (2018) Addressing the minimum fleet problem in on-demand urban mobility. Nature, 557(7706): 534, 2018.

[14] Huang, X., He, P., Rangarajan, A. and Ranka, S. (2019) Intelligent Intersection: Two-Stream Convolutional Networks for Real-time Near Accident Detection in Traffic Video, ACM Transactions on Spatial Algorithms and Systems.

[15] 4Tel (n.d.) Artificial Intelligence, 4Tel.

The following case studies provide examples of such technologies in practice:

– Intelligence Traffic Management System in Delhi, India: The Delhi Traffic Police have developed a system based on radar-based monitoring to analyse traffic patterns, overall vehicle volumes, and the number of vehicles in order to improve traffic management on motorways. The system also contains features like high-resolution CCTV cameras to capture commuters and motorists breaking laws and automated number plate recognition to directly send the fine. Approximately, 7,500 cameras with multidirectional infrared and colourless laser sensors will count the volume on arterial roads based on image pattern analysis. The aim is to all but eliminate the manual interface.

– AI-based Traffic Management: Kuala Lumpur, Malaysia: As previously mentioned, Chinese e-commerce company Alibaba has launched a traffic management service called the 'City Brain' to minimise congestion in Kuala Lumpur. City Brain sorts through incoming data from traffic lights, CCTV cameras, and public transport systems and uses data mining, video processing, image recognition, and other processes to determine live traffic predictions and recommendations, for instance, calculating the fastest and least disruptive route for an ambulance through the city using real-time data. City Brain has been deployed in China where average traffic speeds increased by 15 percent and traffic violations were reported with 92 percent accuracy.[16]

– Bengaluru, India: The city of Bengaluru regularly faces long traffic jams with an average speed during peak hours in some areas of just 4 km/h. Siemens Mobility has built a prototype monitoring system for the city that uses AI and traffic cameras to automatically detect vehicles and estimate the density of traffic on the road to alter traffic light patterns based on real-time road congestions.

Pittsburgh, USA: An adaptive traffic control system developed by researchers at the Robotics Institute, Carnegie Mellon University, is being used at 50 intersections in Pittsburgh and since launching has reduced wait times at intersections by up to 40 percent and journey times by 25 percent. The system uses a range of real time data inputs to identify the optimal way to move traffic through the intersection. Decisions can be made autonomously and shared with neighbouring intersections to enhance network wide benefits.

Lisbon, Portugal: Siemens Mobility is operating a fleet of 1,400 electric bikes in Lisbon using machine learning to analyse various data sources, like the weather, to predict future demand at each of the 140 bike-sharing stations. This allows the monitoring of availability of bikes and spaces in charging docks for those returning bikes. The predictions are used along with recent traffic information to help bike collection teams restock docking stations and provide optimal routing for service technicians who maintain the bikes.

[16] Kumar, V. (2018) Artificial Intelligence: Application in traffic management system, Medium, 12 October 2018
[17] IA (2013) A Review of Current Traffic Congestion Management in the City of Sydney, Infrastructure Australia.

2. Which of the applications of AI are most suited to traffic optimisation in Australia and what are the associated risks and rewards?

Australia is 'playing from behind' according to the 'State of AI in the Enterprise' report by Deloitte, which investigated market readiness across seven countries to effectively leverage AI technologies. Furthermore many organisations report a significant AI skills gap, with 68 percent of global respondents indicating a 'moderate-to-extreme' gap. AI will demand new skills and capabilities, and adaptability, in our workforce.

- Incident Detection: AI can be used to identify the time, location and the severity of incidents on the road to support traffic managers to mitigate resulting congestion. Early algorithms for incident detection use statistical techniques such as the California Algorithm however the shift is to neural network approaches. Also incidents can be detected by monitoring social media, with Twitter providing a cost-effective and efficient option.

- Traffic Signal Optimisation (Green Wave): Green wave is a traffic management control strategy which provides vehicles with optimal speeds to catch green lights based on bunching vehicles into platoons. The spaces between platoons are exploited by platoons in other directions. However, the model has a high probability of breakdown which can occur when there is a disturbance in which vehicles cannot maintain the uniform speed. Results from a case study in Manchester showed a 35.2 percent reduction in journey time compared to an unsynchronised network.[17]

- Pre-Emptive Traffic Signals: There is scope for improvement to the green wave idea as it can be extended to the use for emergency vehicle pre-emption by detecting when emergency vehicles are approaching an intersection and changing the signals to prioritise the movement of these vehicles. Buses and emergency vehicles can be fitted with transponders to communicate with detectors upstream to prioritise flow through traffic using the green-wave progression from coordinated signal controllers. Traffic-adaptive pre-emption techniques have been shown to improved travel-time of these vehicles by 39 percent.

3. What are the recommended strategic approaches to implement the AI applications that transport agencies should consider?

The 'AI Transformation Playbook' by Andrew Ng in 2018 draws on insights from leading the Google Brain team and the Baidu AI Group, both leading AI companies.[18] Any enterprise, including transport agencies, can learn from the Playbook to inform AI strategies. The Playbook recommends a number of steps with the following two most suited to transport agencies.

- Execute Pilot Projects to Gain Momentum: It is more important for the first few AI applications to succeed rather than be the most valuable AI projects right off the bat. They should be meaningful enough so that the initial successes will help gain familiarity with AI and also convince others of the merits. Suggested characteristics for the first few AI projects are: partnerships between the internal AI team and experts/researchers; ensuring the technology does not reach beyond its current capacity; and setting clearly defined and measurable objectives that create business value.

- Build an In-house AI Team: While outsourced partners with deep AI expertise can help gain initial momentum faster, in the long term it will be more effective to execute some projects with an in-house AI team. The key responsibilities would be to: build up and support AI applications; be responsible for initial projects involving different divisions/units; learn from projects to inform standard protocols and procedures; and develop an organisation-wide platform that brings value to multiple divisions/units, such as standardised data storage processes.

- Develop Internal and External Communications: Because AI is still poorly understood and over-hyped, there is fear and uncertainty that needs to be addressed through effective communication. For instance employees are concerned about their jobs being automated and citizens have a range of safety concerns.

[18] Ng, A. (2018) AI Transformation Playbook: How to lead your company into the AI era, Landing AI, Dec. 2018.

4. What should policies consider to support AI applications?

The ultimate success of AI projects will likely depend on how suitable its environment is for such powerful applications. While the cloud is emerging as a major resource for data-intensive workloads, many projects still rely on on-premises IT environments. According to 'TechTarget' the following are key considerations related to supporting AI applications:[19]

- AI Data Storage: As organisations prepare enterprise AI strategies and build the necessary infrastructure, storage must be a top priority. Organisations need to know where the source data resides and how AI applications will use it.

- AI Networking Infrastructure: AI processing will require high-bandwidth, low-latency and creative architectures and as such organisations should consider automation whenever possible, such as automated infrastructure management tools in data centres.

- Processing AI Data: It is critical for AI infrastructure to have sufficient computational resources which will likely see a shift from central processing units (CPUs) to graphics processing units (GPUs) as in the case of Blockchain Technology.

- Preparing AI Data: One of the important tasks for successful AI applications is data cleansing or data scrubbing, which is the process of updating or removing data from a database that is inaccurate, incomplete, improperly formatted or duplicated.

- AI and IoT: It is estimated that the number of things or devices connected to the internet will reach over 20 billion by 2020. Organisations will need to look at their networks, data storage, data analytics, and security platforms to make sure they can effectively handle the growth of their IoT ecosystems.

- AI Training and Skill Requirement: Raphael Kohler explains that organisations have to consider legacy systems and are challenged with change management of the existing systems. Innovation and Science Australia has released recommendations to inform the development of AI strategies and lists education as the primary imperative.

[19] Violino, B (2018) Designing and building Artificial Intelligence infrastructure, TechTarget, 05 April 2018.

5. Blockchain Technology to Enhance Freight Tracking and Authenticity

1. How is Blockchain Technology currently being used to enhance freight tracking and authenticity and what new functionality is being promised?

Blockchain applications are rapidly evolving and with many different focuses with two main benefits emerging for the freight sector. First, the traceability of products, such as provenance and the characteristics of goods for both consumers and logistics provider. And second, better management of supply chain information to lower transaction and regulatory compliance costs by reducing and automating paperwork and B-2-B transactions.

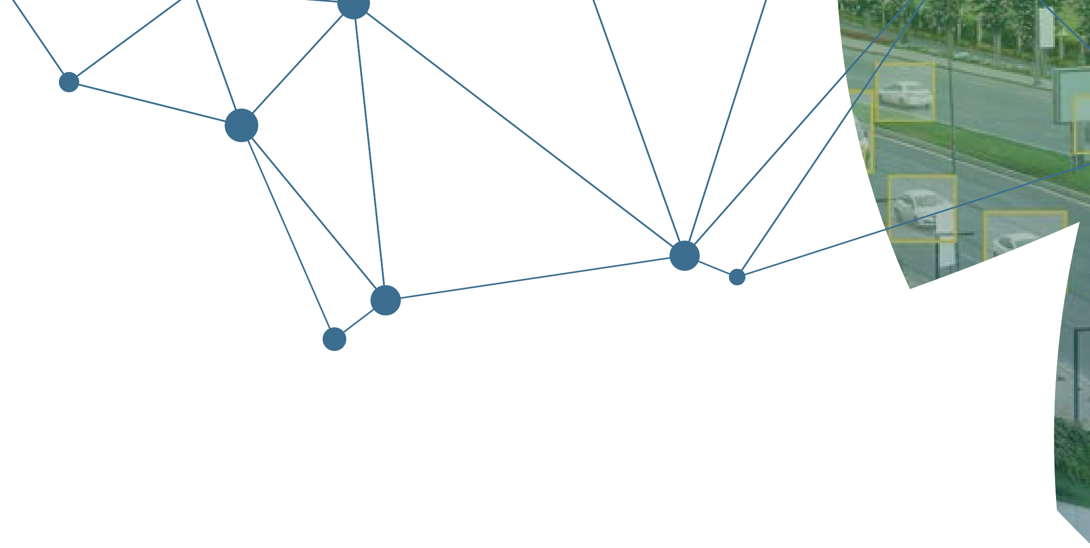
Freight transport and logistics services account for up to 10 per cent of GDP and contributes over $130 billion to the Australian economy.[20] As Australia's freight task is projected to double in the next 20 years, there is growing interest in how improvements can be made to the productivity, efficiency and capacity of Australian transport infrastructure.[21] One potential area of improvement is recording, maintaining and coordinating information about freight in real time and using this to inform traffic management and transport planning.

Through the process of globalisation, we have developed a complex and often inefficient mix of institutional infrastructure (e.g. databases) often at high cost. For instance, one study found that a simple shipment of refrigerated flowers from Kenya to the Netherlands required trade documentation and administrative processes to pass through nearly 30 actors and organisations with over 200 interactions across multiple systems.[22] In the 34 days it took from farm to retailers, 10 days were spent waiting for document processing. Such examples raise the question of how we can build better institutional infrastructure for supply chains and freight logistics.

Current systems of managing and recording information along supply chains are often paper-based and are spread across multiple organisations. The attention being paid to Blockchain and other distributed ledger technologies is because they provide a powerful new decentralised database for supply chain information. Blockchain Technology offers a potential solution to the problem of tracking freight, and therefore helping to ensure the authenticity of products. Rather than storing information within siloed centralised databases, supply chain participants could use Blockchain Technology as a decentralised digital infrastructure for holding verified and authentic information about freight that can be made selectively available. This process includes creating digital representations for products, where records are updated to include information such as ownership, location, history, characteristics and finance and tax obligations.

While Blockchain Technology is nascent—and will rely on other complementary technologies as sources of information—there is significant investment from major international companies, such as IBM and Maersk, to create new digital supply chain infrastructure. As with all frontier technologies, however, there are risks and rewards in adoption. Some of these challenges are strategic—for instance, it might simply be too early to invest in this infrastructure. Other challenges relate to the background policy environment, or governance challenges of bringing together supply chain actors into a consortium to access supply chain information in a new way.

[20] Department of Transport (2018) Perth and Peel@3.5million: The Transport Network, WA Government.
[21] COA (2018) Inquiry into the National Freight and Supply Chain Priorities, Commonwealth of Australia.
[22] IBM (2017) Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain, IBM.



2. Which of the applications of Blockchain Technology are most suited to freight tracking and authenticity in Australia and what are the associated risks and rewards?

Blockchain Technology isn't just a single technology, there are hundreds of different types that vary in terms of their level of decentralisation, scalability, cost, speed and privacy - and they are constantly evolving. Freight tracking and logistics providers should pay particular interest in two aspects, firstly if the system is to be public or private, and secondly if it will take advantage of self-executing digital (smart) contracts.

Public Blockchains

In a public, or permission-less, system typically anyone can join, use and leave the network without permission, such as the Bitcoin Blockchain. The challenge with a public Blockchain is not just that the network of nodes must come to agreement and avoid malicious actors, but also that the network must be incentivised to continually maintain and update the Blockchain with new transactions.

Private Blockchains

In a private, permissioned, system rather than anyone being able to join and access the network, permission to read and write are only given to approved participants. For instance, a consortium of parties within a supply chain will be given different rights to view and write to the Blockchain digital ledger. Certain data might only be able to be viewed by certain parties (e.g. customs authorities or traffic management systems) and not others (e.g. competitors or customers).

In both types governance around how rules and decisions are made will be critical. According to the University College London, "The technological solutions are there and have been proven to work. The challenge is aligning a wide group of stakeholders around implementation – which is particularly challenging in the case of complex logistics and dynamic supply chains."

Smart Contracts

'Smart' contracts are agreements that are written computer code that can be automatically executed when specific conditions are met and validated with the creation of the contract and all subsequent interactions recorded in the Blockchain. For instance, rather than having a warehouse manually log in the arrival of a parcel it can be scanned into the Blockchain, releasing payment for the delivery. Currently $140 billion per day is spent in disputes of payments in the transportation industry, with average invoices taking 42 days to be paid.[23] A Blockchain-based system is likely to reduce the potential for these disputes. But there are challenges, such as understanding what jurisdiction applies to a particular smart contract and the avenue for the application of contractual remedies as they are global instruments. Further, smart contracts are reliant on inputs from trusted external sources.

[23] Commendatore, C. (2017) Blockchain in trucking: What about the middlemen? FleetOwner, 20 October 2017.

3. What are the recommended strategic approaches to implement these Blockchain Technologies that transport agencies should consider?

Blockchains cannot authenticate the information added to the ledger but rather can ensure the information is not tampered with. One way to reduce the risk of inaccurate or inappropriate data entries is to use automated data collection from a range of devices connected to the internet (referred to as 'Internet of Things' or IoT devices). An IoT device, for instance, may be used to reduce food spoilage by monitoring temperature and humidity levels in containers and transmitting the data to the ledger to form an accurate and tamper-proof log to be used to trigger alerts if conditions are exceeded. One key strategic consideration for the logistics and the supply chain sector will be how to leverage existing IoT technology and who in the network pays for the necessary hardware upgrades or sensors.

There are several current examples of IoT and Blockchain projects:

- AT&T is developing a system for improving fleet and cargo management, goods tracking and regulating driver compliance.
- The World Wildlife Fund and ConsenSys have piloted a project to trace tuna throughout the supply chain using Radio-Frequency Identification (RFID) and QR codes.
- Bosch has developed an open-source system to connect over 10 million IoT devices by various manufacturers, and working with German energy supplier EnBW, have announced a prototype system to manage devices that charge electric vehicles allowing for reserving and paying for e-charging services.
- Bosch and Siemens have a system for smart parking where vehicles communicate with parking facilities and negotiate parking terms.

It is worth noting that a host of other technologies complement Blockchain-based supply chains that will increasingly be designed to create value from the trusted ledger. As mentioned AI applications can use data to augment decision making by detecting patterns and creating predictions. For logistics providers and retailers this could help to manage inventory, sourcing and supply of products on-demand, adjusting price data, predictive shipping of goods through anticipated demand, and choosing the fastest transport route.

4. What should policies consider to support Blockchain Technology applications?

Blockchain Technology is highly likely to become the new digital infrastructure underpinning dynamic supply chains, storing synchronised real-time data across organisational boundaries. This system will have two key benefits to the logistics industry, namely: tracking and authenticity, and regulatory compliance. The first looks to dramatically increase the tracking of goods along the supply chain. The second is to use this information and integrate it into existing regulatory processes, enabling a reduction in the costs and time spent in demonstrating regulatory compliance.

Logistics providers need to know where products are to optimise their services. Governments need to know the history of products to determine their regulatory obligations. And consumer price decisions are increasingly influenced by the verified features of products, such as if they are organic or ethically sourced. For instance an Australian company, BeefLedger, is tracking beef exports to enable consumers to validate the source of beef products.

Tracking and Authenticity

One of the most prominent applications of Blockchain Technology in supply chains is by IBM and Maersk called ‘TradeLens’ that has created efficiencies of up to 40 per cent in transit time for US shipments.[24] TradeLens tracks shipments in real-time on a secure, permissioned ledger and comprises logistics companies, inland and intermodal providers, ports and terminals, ocean carriers and some customs and other governmental authorities. Over 1.5 million shipping events are recorded per day, including information on contractual shipping data, cargo movements, IoT sensor information, and identification details about shippers, carriers and other participants. TradeLens enables permissioned sharing of data between authorised parties, and is working on developing new standardised structured document types for better document functionality and analysis (including integration into existing systems). The Blockchain Technology underlying TradeLens also ensures the immutability and integrity of documentation by checking the consistency of documentation against their previous record.

Regulatory Compliance

Regulatory authorities mandate logistics companies to comply with manual data-entry and paper-based documentation processes. Customs or other regulatory compliance issues can arise if entities cannot ascertain the authenticity of documents and the provenance of goods. International import and export approval processes can incorporate numerous paper-based, individual approvals, and customs clearance delays can result from missing, inaccurate or fraudulent paperwork. Blockchain Technology can be used to verify the authenticity and accuracy, as well as facilitate the creation, management, and dissemination of import and export documents. There are also opportunities for automation of regulatory processes, such as ‘smart containers’ inputting to a Blockchain to allow port authorities to automatically determine regulatory compliance, and levy relevant tariffs using smart contracts. This will require not just an institutional or software upgrade of existing systems, but also a physical upgrade of ports.

[24] GTR, TradeLens Blockchain platform for global trade expands to Russia,
https://www.gtreview.com/news/fintech/tradelens-Blockchain-platform-for-global-trade-expands-to-russia/

The relationship between Blockchain and the regulatory state is complex and evolving for many reasons. On one hand Blockchain might facilitate the process of regulatory enforcement and compliance, while on the other it will transform some of the fundamental roles of government (e.g. replacing government-maintained asset registries). As Blockchain Technology is applied in practice further regulatory challenges are anticipated and will need careful consideration. While entrepreneurs and existing businesses seek certainty in how Blockchain Technology will fit with existing laws, developing standards too hastily can lock-in technologies and business models.

Data Security

Because Blockchain ledgers store and distribute various types of data, there are data retention and sharing questions from a legal perspective, such as who owns the data, who can access the data, and just how secure is it from being accessed. Data rights should be clearly defined in agreements with contracting parties. Often, technology companies rely on standard-form, non-negotiable software contracts that can, by default, restrict a producer's control, ownership and use of the collected data. The Australian 'Precision to Decision Agriculture Project' found that 56 percent of producers have no or little trust in service or technology providers to maintain their data privacy, contributing to challenges for consortia-building around new systems.

Financial Transactions

A final policy consideration is around financial transactions. Blockchain Technology offers a platform to reduce reliance on financial institution intermediaries to enact payments along the supply chain. For instance, Blockchain platforms such as 'AgriDigital' and 'GrainPay' create digital tokens from fiat currency to use for transactions all along the supply chain inside the ledger that are controlled by smart contracts and then the tokens can be converted back to currency. Hence such tokens may not need to be regulated if the token performs a mere utility token function, and the final payment is made using traditional banking methods.

Conclusion

For the first time in human history, Artificial Intelligence allows for decision making far beyond the capacity of human beings and Blockchain Technology allows for trusted transactions to be done directly and automatically between parties without the need for an intermediary. It is the conclusion of this project that both Artificial Intelligence and Blockchain Technology, both alone and coupled, stand to revolutionise a number of functions across the transport sector and that this will soon lead to a significant increase of research and practice in this area.

There are a number of mature applications of Artificial Intelligence available for improving transport network management such as traffic light optimisation, fleet optimisation, predictive logistics, accident detection, rail system optimisation and general traffic management. The research also found that there are emerging applications that could provide great value including adaptive traffic control, vehicle prioritisation, parking detection, and green waves. The research suggests that efforts to support strategic approaches should focus on well informed pilot projects, the development of in-house AI capability, and clear communications strategies.

Likewise Blockchain Technology presents a range of opportunities worthy of detailed investigation, such as using the database functionality to track goods and allow for payments to be made along the supply chain in a single system. Blockchain can also allow vehicles to make payments for road user charges, parking, congestion charging, toll collection, etc., which can be used to influence time-of-use and route selection, improving utilisation of the transport network.

When seeking to create both AI and Blockchain solutions there are issues to consider such as such as privacy (how is data stored and linked to its source), security (how is the data protected from unauthorised users), access (how are authorised users allowed to access data), ownership (who owns the data), transactions (are these subject to financial services laws), and what happens to data after the purpose of the system has been achieved.

When considering potentially revolutionary technologies it is important to understand that the new functionality may compete with existing systems and that there may be push back from incumbents using misinformation and other mechanisms to attempt to block uptake, however in the end the functionality will speak for itself and the market will choose as has happened in every wave of innovation since the start of the industrial revolution.

In conclusion both Artificial Intelligence and Blockchain Technology present significant opportunities to enhance all sectors, especially the transport sector, and this warrants careful further investigation and trialling.

"These particular technologies, Artificial Intelligence and Blockchain, make a significant difference to the future of roads. They're practical, they're measured, and they can be applied with some confidence in hoping to build better signals, better management and certainly better freight tracking"
— Dr Ken Michael AC, Project Steering Group Chair

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