The Potential for Blockchain and Artificial Intelligence to Enhance the Transport Sector

Dr Karlson 'Charlie' Hargroves
Curtin University Sustainability Policy Institute, Perth, Australia
(email: charlie.hargroves@curtin.edu.au)
Daniel Conley
Curtin University Sustainability Policy Institute, Perth, Australia
(email: daniel.conley@curtin.edu.au)
Professor Bela Stantic
Big Data and Smart Analytics Lab, Griffith University, Brisbane, Australia.
(email: b.stantic@griffith.edu.au)

Abstract

This paper outlines research that explores 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. The paper identifies specific potential applications and outlines where such technology can provide tangible benefits for the transport sector and the associated policy and management structures. Specific benefits explored include cost savings (such as digital payment mechanisms, virtual toll collection and congestion charging, capital deferment through greater network utilisation); time savings (from improved transport network operation and management processes); improved operations (such as real-time pay-as-you-drive systems with network differential pricing ability); improved safety (from less collisions and reduced impacts); improved user experience (such as improved platforms and automated payments for parking and bookings); and improved freight and logistics (such as secure storage of time-stamped travel-related data). The paper presents a set of industry partner-preferred use cases such as congestion management, road user pricing, asset management, mobility-as-a-service and freight logistics. The paper outlines specific opportunities for Artificial Intelligence and Blockchain technology to provide value to transport agencies and service providers, either individually or in combination. The paper highlights risks and rewards for the transport sector, including a further review of early findings from the application of such technologies in transport sectors around the world. This research has been developed with funding and support provided by Australia's Sustainable Built Environment National Research Centre (SBEnrc) and its partners.

Keywords: Blockchain, Transport, Artificial Intelligence

1. Introduction

In response to the 2008 global financial crisis an anonymous programmer released the blueprints for what they called a 'Bitcoin' which brought together various forms of cryptography and computer science to create a functioning digital currency that does not require a central authority. The underlying programming is now referred to as a 'Blockchain' and it overcomes the double spend issue of previous attempts to create a digital currency by creating an online distributed database that contains encrypted time stamped information that cannot be tampered with without detection. In simple terms, this is done by replicating the database over many computers and rewarding those that hold it for validating transactions and ensuring an unamended version to allow comparison with others also holding the database to quickly identify hacking attempts – and in doing so has created a truly world changing technology which has a range of applications to the transport sector among many others.

For the first time in history this new digital architecture allows for financial transactions to be done directly between two strangers without the risk of default or double spending – eliminating the need for an intermediary like a credit card company or a bank. Despite obvious resistance by financial intermediaries, in April 2017 Japan eliminated consumption taxes on such 'crypto-currency' transactions and deemed them a legal tender. The World Economic Forum predicts that by 2027 some

10 percent of global GDP will be stored on Blockchains, in the order of $8 trillion (WEF, 2015). Chief Executive of the Australian Stock Exchange Elmer Funke Kupper reflects that, '*Every now and then, something comes along that might just change everything. And this is one of those moments'* (Eyres, 2016). Given the implications for the financial sector it has been one of the first to adopt the technology.

According to a United Nations report, by 2016 over 60 percent of the global financial system had started to explore the application of Blockchain technology to increase operational efficiency and reduce transaction costs (UNEP, 2016). For instance, HSBC, the Bank of America, Merrill Lynch, and the Infocomm Development Authority of Singapore are trialing a Blockchain based 'Letter of Credit' system. A Letter of Credit is essentially a statement from a bank guaranteeing the payment for some form of goods or services in the future, mainly used when the buyer and seller are in different countries. By using a Blockchain based system, transactions can be broken down into multiple smart contracts, which can be monitored in real time by all parties. Benefits of this system include a reduction in paperwork needed, reduction in errors, and an increase in convenience and security for all parties (DHL, 2018).

The ability to operate a digital currency is just the beginning of the promise of Blockchain technology that can also store information, agreements, and contracts that cannot be amended and can have digitally self-executing functionality. Such records are also accessible by any computer in the world as an immutable record - which is a game changer for the global economy. Government agencies around the world are applying Blockchain technology for a range of applications such as: tax and business registration (Singapore), health records (Estonia), real-time auditing land registry (Georgia), voting (Sierra Leone, Russia, Columbia), anti-fraud for imports and exports (Singapore), welfare payment and budgeting support (United Kingdom), government operations (Dubai), identity management (Switzerland), supply chain traceability (Texas), storage of passports and birth certificates (Australia) (US DoT, 2018).

Early movers in the transport sector 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 (Shieber, 2017). The Blockchain in Transport Association (BiTA) brings together over 300 companies from across transport, logistics and relevant technology sectors including large players like FedEx, UPS and Schneider to ensure consistent standards for the use of Blockchains in freight and logistics. According to BiTA, '*Members know that Blockchain is the way of the future … and understand that Blockchain isn't just an industry disruptor, it's technology that will revolutionize the way people do business*' (Baker, 2018).

Blockchain technology can be further enhanced by combination with artificial intelligence options such as machine learning and deep learning algorithms. According to 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'* (Forbes Insights, 2018). Further the respondents highlighted a number of potential drivers for this shift, I particular '*technologies like artificial intelligence (AI), machine learning (ML) and increasingly, Blockchain*'." This paper seeks to provide an overview of the tangible applications to the Transport sector to identify specific areas where further investigation stands to provide valuable guidance to transport agencies and transport related companies.

2. The Application of Blockchain to Transport

For the first time Blockchain technology allows for the creation of intermediary free trusted online databases that can be used for a range of applications where trust and transparency are required, such as currency transactions, supply chain management and validation of provenance. For instance this new digital architecture allows for financial transactions to be done directly between two strangers without the risk of default or double spending. From a transport perspective much of the functionality is improved with greater technology enablement of vehicles and transport modes however third party devices and physical identification methods can be used in the interim. In practical terms this provides

the ability to have tamperproof timestamped records and data storage, process intermediary free micro-payments, and manage identity and ownership credentials. This functionality can then allow a range of innovative options such as:

- *Vehicle Registrations:* Using a Blockchain based database to process vehicle registrations and sales to reduce transactions costs and time.
- *Establishing Identification:* Providing tamperproof identification for digital driver's licences, infringements, insurances, vehicle ownership, driving history, etc.
- *Real Time Road User Pricing:* The charging for time of day and road type usage direct to the vehicle to compensate for reduced revenue from fuel excise from electric/hybrid vehicles.
- *Congestion and Toll Charging:* Creating virtual zones and gantries across the traffic network to allow intermediary free differential charging to assist with congestion management.
- *Automatic Car Parking Payments:* Charging vehicles for time of use and location of parking and being able to reduce cost to reduce underutilisation or increase cost in periods of high demand.
- *Intermediary Free Ride Sharing:* Fares agreed between driver and passenger allowing for more affordable fares without reducing revenue to driver/vehicle.
- *Vehicle Generated Collision Information:* Details of collisions can be uploaded from vehicles and securely store and validated.
- *Enhanced Freight Tracking and Authenticity:* Tamperproof records of transactions along the supply chain to reduce transaction time and cost and allow for authentication, provenance and real time location and confirmation of delivery to allow funds release.

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*' (IBD, 2018). Craig Fuller, Managing Director of BiTA believes that Blockchain is ideally suited to the transport sector and its impact will be transformational (Forbes Insights, 2018). Fuller reflects on the potential of Blockchains by saying, '*Transportation is a massive segment of the global economy - as much as 12% of cash flows - and there are so many parties involved: shippers, carriers, customs and the companies that provide fuel for trucks, planes, trains, etc. There are so many transactions associated with any shipment. Now think about having to wait 60 to 90 days for payment across each and every segment from each and every participant involved. What if, instead, we use blockchain and smart contracts to speed up payments? That introduces trust and automation, speeding verification and eliminating an enormous drag; there's so much payment float in the global economy'*. German logistics company, JDA, is researching Blockchain solutions for managing supply chains and believe that it could be a game changer for Germany's food industry, which is currently monitored manually (Hanrahan, 2018).

According to a report by the Queensland Investment Commission, Blockchain is initially being used in the automotive industry to help facilitate payments, pointing out that AT&T had filed for a patent to enable the use of crypto-currencies for payments direct from vehicles (QIC, 2017). The QIC then suggests that the '*benefits of widespread adoption could be immense*' and considering the future prospects predicts that, '*Blockchain technology will enable vehicles to be reimagined as information-rich devices capable of mobile payments, and will be at the centre of initiatives to improve economic efficiency, quality of life and better commercial outcomes. It could enable greater optimisation of car parking assets and arterial road networks*'. For instance, a Blockchain could be used to collect real-time location information from vehicles and provide the ability to make and receive payments using a cryptocurrency wallet. As will be expanded further in this paper, this has the potential for a number of applications, including road user charges, parking, congestion charging, toll collection and the increased utilisation of the transport network.

An early example of harnessing Blockchain in the transport sector is the 'Mobility Open Blockchain Initiative' (MOBI). MOBI is a global non-profit consortium to explore 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, '*Blockchain and related trust enhancing technologies are poised to redefine the automotive industry and how consumers purchase, insure and use vehicles*.' (Marinoff, 2018). MOBI is currently developing blockchain applications for vehicle identity and history, supply chain tracking, autonomous payments, and pay as you travel charging and insurance. Together with the Trusted Internet of Things Alliance (TIoTA), MOBI has created the MOBI Grand Challenge (MGC), which offers $350,000 of prizes for organisations that can show potential uses of Blockchain to control traffic and improve urban transport.

Despite Blockchain technology being relatively new there is a growing number of applications focused on the transport sector. The following section outlines some of these applications that have been built on blockchain based platforms, such as:

- *Blockchain for Traffic Management*: Blockchain technology can provide the ability for vehicles to make and receive payments using a cryptocurrency wallet based on real-time location information. Canadian company, Array Systems Computing, has created a Blockchain based solution called 'ZeroTraffic' that allows drivers and government agencies to use digital tokens to incentivise preferred routing for vehicles to assist in traffic management.

- *Blockchain for Logistics Documentation*: Blockchain technology stands to enhance the transport and logistics industry by enabling secure and tamper-proof records in real time, bringing new levels of transparency and efficiency (Newman, 2018). For instance, Europe's largest Port, the Port of Rotterdam has set up a 'BlockLab' and is using a Blockchain solution to replace the paper based 'bill of lading' system used in ports with a digital system that allows tamper-proof records that are available in real time to all necessary parties in the supply chain, significantly reducing transaction cost and time.

- *Blockchain for Global Freight Tracking*: In August of 2018, IBM and Danish shipping container company Maersk released a joint electronic ledger for global freight tracking, with 94 groups initially involved. Information shared on the Blockchain includes customs releases, commercial invoices, and cargo lists, which are shared with all parties right after they are produced. So far over 160 million shipping events have been stored by the system, with roughly one million events happening per day (Mearian, 2018).

- *Blockchain for Supply Chain Transactions*: The company ShipChain has a similar Blockchain based tracking system that tracks products from the moment it leaves the manufacturer, to when it arriving with the customer. This tracking system allows for the automatic confirmation of delivery, which means that all the parties involved across the supply chain can automatically be paid when they have completed their part (ShipChain, 2018).

- *Blockchain for Identification (Drivers Licences)*: A Blockchain based platform is helping ensure the security of the New South Wales Government's rollout of digital driver's licenses. Secure Logic Group announced the launch of its 'TrustGrid' platform that has been used as the digital platform for a digital driver's license pilot in Dubbo, NSW, with 1,400 participants in November 2017. The platform is now being used as part of the first metro trial of the digital driver's license in Sydney's eastern suburbs. The second pilot 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 to pubs and clubs in the trial area. (Pearce, 2018)

- *Blockchain for Establishing Provenance*: Enhanced product tracking through blockchain technology can also have major positive effects in the food industry. Walmart is currently testing blockchain technology to track the movement of food, from producer to the store. This allows Walmart to immediately know precisely which producer is responsible in the event of poor quality or spoiled food, including temperature sensor data from shipping spaces. In 2018, the Commonwealth Bank of Australia supported an experiment which used Blockchain technology to track an international shipment of almonds. The use of an Ethereum based Blockchain was successful in reducing administrative burden and enabling transparent tracking of both location and quality of the shipment. Devices were used to allow viewing of relevant conditions within the

container such as temperature and humidity.

- *Blockchain for Establishing Authenticity*: Authenticity can be a major problem in the transport sector, with counterfeit pharmaceuticals and luxury goods requiring extensive documentation to establish proof of legitimacy. Interpol estimates that around 1 million people die each year due to counterfeit drugs and up to 30 percent of pharmaceuticals sold worldwide are counterfeit (Southwick, 2013). Blockchain technology can give all involved parties access to a list of the supply chain, which gives the consumer more knowledge about the product they are buying, including the authenticity, transportation conditions, and the place of origin. 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 (DHL, 2018). De Beers mines, trades and markets more than 30 percent of the world's diamonds and plan 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. (Bernard Mac & Co., 2018)

- *Blockchain for Ride-Sharing*: The ability for a Blockchain to allow secure payments between two parties without the use of an intermediary allows for a new generation of ridesharing. Rather than being offered by an intermediary like Uber, that can apply mandatory surge pricing, the rides would be agreed, booked, and transacted directly between the rider and the driver (or driverless vehicle) as in the case of the rideshare app La'Zooz (Cassano, 2015). This platform would then offer the potential for lower ride costs as the driver or vehicle will receive the majority of the fare with a small proportion being absorbed by the transaction fee on the Blockchain. This also opens the potential for ride-share businesses to operate locally in cities rather than be monopolised by global corporations.

3. How can Artificial Intelligence enhance Blockchains?

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 making decisions however and is also concerned with developing computers that think and act like humans, and hence involves a range of disciplines such as computer science, phycology, ethics, cognitive studies and neuroscience.

An application of Artificial Intelligence that is of particular value to the transport sector is called 'Machine Learning', and it allows greater use of current data to make decisions, many that are unnecessarily made by human operators or are not currently able to be made given the complexity. In simple terms there are two main forms of Machine Learning.

1. *Supervised Learning*: The first is where a computer programmer writes a lengthy set of computer code that is designed to allow for every eventuality that the program could face and provides options for each, in essence the programmer 'teaches' the computer. This is commonly referred to as 'Supervised Learning' and can be thought of as 'Programmed Learning'. 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 with all requiring a 'Yes' in order to depart. This approach is intensive and limited as it calls for each eventuation to be foreseen and a set of options designed into the code. This approach is valuable however and is best used with a clear set of potential options and outcomes involving relatively small data sets.

2. *Un-Supervised Learning*: The second type is where the lengthy computer code involving questions and commands is replaced by an artificial neural network which investigates the relationships between data and associated outcomes, requiring substantial computational power and extensive data sources. This is commonly referred to as 'un-supervised Learning' or 'Deep Learning' and can be thought of as 'Self-Learning' where the computer makes decisions based on comparing examples from the past and associated outcomes, with the current situation to estimate a likely outcome, updating itself as it goes, much like the human brain. Unlike the case of programmed learning this approach requires large data sets to enable the system to learn in order to be able to interpret a set of incoming data streams and make a decision as well as or better than a human can.

The majority of early efforts to apply artificial intelligence to transport are around enabling vehicles to be driven by computers, freeing up the human driver and improving safety and efficiency outcomes. This is most commonly referred to making the vehicle 'Autonomous', meaning that it does not need the passenger to do anything. This term is misleading however as although the vehicle can drive itself at this stage it still needs assistance to refuel, recharge, pay for registration, go through the car-wash etc, hence it's more accurate to call it a 'Self-Driving' vehicle. It is likely that once self-driving is achieved the focus will shift to the interaction with the traveller allowing a passenger to talk freely to the car (much like Google Home and Amazon Alexa) and discuss routes, set functions in the vehicle like temperature and music, and access information to display on internal screens. Again, rather than being 'autonomous' and not needing any input from the passenger these vehicles will be very interactive with travellers.

4. How can Blockchain and Artificial Intelligence be coupled and applied to Transport?

Road User Charging
Blockchain: The functionality could also allow for real time charging of a replacement to the fuel excise current used to collect taxes from road users for electric vehicles, rather than wait for annual payments based on odometer readings. With an odometer-based approach providing no information about what parts of the network the vehicle has used, how often and how long or when it was used – valuable information for network management. It is foreseeable that vehicles without adequate balances in on-board wallets could be disabled to disallow access to the transport network.

Artificial Intelligence: Given that this approach will generate data around how vehicles access the network and how much they charge machine learning could be used to optimise network management and allow for a learning process on the level of charging on each element of the system considering the implications for vehicle use, safety, congestion etc.

Congestion Charging
Blockchain: The above functionality could also be used to create virtual zones for congestion management by geo-fencing specific parts the road network, either a zone of the city or a specific corridor. Unlike current methods that require physical infrastructure vehicles would communicate with the system to allow them to be recognised entering different areas of the city. This then enables either a real time charge to discourage entry or the provision of an incentive to encourage entry, transacting directly to the vehicle using a cryptocurrency. For non-technology enabled vehicles this will require installation of on-board equipment and the creation of a bitcoin wallet connected to the licence plate number.

Artificial Intelligence: The above interaction with vehicles will generate data around where vehicles are entering prescribed areas and how much of an impact a pricing mechanism has on this level of entry that machine learning could be used to optimise charging to achieve network management outcomes.

Increased Utilisation of Network
Blockchain: Extending the road user charging and congestion charging approach a Blockchain can be used to identify every element of the transport network and apply a differential fee or incentive based on the preferred utilisation. For instance an automated vehicle could calculate the route of travel based on both congestion levels and road charges and provide the occupant either the fastest option or the

cheapest option, or a combination of both.

Artificial Intelligence: This would allow machine learning to learn from the system and enact real time interventions to increase road costs and encourage vehicles to re-route away from areas of high congestion, ad hoc events such as sporting matches, around construction works, areas of high pedestrian traffic, or just into underutilised sections of the network etc. all while collecting road charges in real time.

Collection Tolls and Charges

Blockchain: According to the QIC smart vehicles linked to a Blockchain would allow for the use of 'virtual gantries' on motorways that could be placed in specific locations to collect variable tolls directly from vehicles (QIC, 2017).

Artificial Intelligence: Machine Learning can make us of real time data to make decisions around potential changes of rates depending on the time of day, type of customer, or levels of congestion on the motorway (this may even include incentives to use the motorway when it is underutilised or the provision of refunds if the motorway is interrupted by roadworks or a collision).

Car Parking

Blockchain: This functionality would allow for automatic car parking payments when vehicles leave a parking structure or a street car park. The functionality also allows for easy time of use charging that could for instance provide cheaper rates during periods of low utilisation that the vehicle is notified of and can recommend to the driver or integrate into route planning for automated vehicles. The technology would also allow for automated parking infringements to be issued to and paid by the vehicle when it exceeds parking restrictions or is parked illegally.

Artificial Intelligence: Machine Learning can use the data produced to allow for greater utilisation of parking assets along with identifying areas with parking shortages and recommending alternatives. Machine Learning may also provide insight into the implications for parking as the fleet transitions to driverless vehicles that may require less parking services.

Freight Management

Blockchain: According to the US Department of Transportation, '*the freight logistics sector could benefit greatly from Blockchains*'. In particular, using the ability of a Blockchain to store information that cannot be altered or edited after its inclusion, a range of information can be extracted in real time from freight vehicles to enhance logistics management. The Department of Transport suggests that information such as '*accident records, GPS and accelerometer tracking, weather information, crew information, inspection and certificate data, and mileage could all be stored on a Blockchain*' (US DoT, 2018). According to Mauricio Paredes, vice president of technology for PS Logistics, '*Through Blockchain technology every transaction in the trucking ecosystem can be interconnected, providing the potential to dramatically change workflows and the way people do business for the better*.' (Santori, 2016) For instance load boards are systems which allow transport brokers to post loads they need transported, which transportation companies apply for, allowing shippers and carriers to meet. Currently, load boards can be out of date, or the data may be entered multiple times in multiple different load boards. By using a single Blockchain system, all parties involved will be working off the same list, resulting in the correct information being available at the same time for everyone (TMW, 2017).

Artificial Intelligence: 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.

Vehicle Ownership

Blockchain: A key concern with the purchase of used vehicles is the validity of the service information and previous history. Using the ability of a Blockchain to store timestamped information that cannot be altered vehicle information could be stored to validate service history, previous ownership, mileage, etc. to inform buyers. This could then be taken a step further to have the ownership of the vehicle entered into a Blockchain to facilitate an intermediary free change of ownership by having the current owner

providing the new owner with the encryption to the ownership documentation and entering a record of the transfer of ownership (which may need to be validated by an intermediary).

Artificial Intelligence: Machine Learning may be used to asses such trusted data on vehicle maintenance and compare it to things like the vehicles road use, driving patterns, brand of oil and lubricants etc to provide valuable correlations for improving vehicle design and allowing for predictive maintenance where the vehicle alerts the owner when it is likely to need maintenance rather than alerting after the damage has been done.

Accident information

Blockchain: According to the US Department of Transportation '*As autonomous vehicles become popular and humans are removed from the controls, investigators may rely on black boxes for reliable information after incidents happen. A black box could be made secure from hackers, but cybersecurity is irrelevant if the black box can be removed and destroyed. A Blockchain's inherent distributed database could provide information storage security*.' (US DoT, 2018)

Artificial Intelligence: As with many of the opportunities associated with artificial intelligence they are based on the data that can be accessed and trusted accident data is again a rich pool of information that can be mined by machine learning to inform network management, insurance premium levels, responsibility of driverless vehicles etc.

Development of CarApps

Blockchain: According to Don and Alex Tapscott (2016) in the seminal book 'Blockchain Revolution', '*think of the car itself, it would exist as part of a Blockchain-based network where everyone can share information, and various parts of the vehicle can do transactions and exchange money. Given such an open platform, thousands of programmers and niche businesses could customise applications for your car*'. Hence once cars become suitably technology enabled they will be able to do things like play music from Spotify rather than Bluetooth to a mobile phone and stream videos in the back seats from Netflix. Then once they are able to access Blockchain based value exchange platforms they can access apps to book and pay for parking, pay for fuel, book in a vehicle service and provide real time information to the garage, pay for registration and insurance as the car drives, and pay speeding fines and other infringements without the need for financial intermediaries like banks or credit cards that involve their own fees and delays.

Artificial Intelligence: Given this direction in technology enabled vehicles the level of data and the range of data sources will continue to increase providing again a rich pool of information that only machine learning, in particular self-learning machines, can interpret to generate new value for transport agencies, vehicle manufactures, and travellers.

5. Conclusion

For the first time in history Blockchain technology allows for trusted transactions to be done directly between two parties without the need for intermediary. In the transport sector this presents a range of opportunities worthy of detailed investigation such as using the database functionality to track goods in and allow for payments to be made along the supply chain in one single system, and allowing cars of the future to have the ability 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, increasing utilisation of the transport network. It is the conclusion of this paper that Blockchain stands to revolutionise a number of functions across the transport sector and that there is cause for a significant increase in the level of research in this area.

Acknowledgements

This research has been developed with funding and support provided by Australia's Sustainable Built Environment National Research Centre (SBEnrc) and its partners. Core Members of SBEnrc include Aurecon, BGC, Queensland Government, Government of Western Australia, New South Wales Roads

and Maritime Services, New South Wales Land and Housing Corporation, Curtin University, Griffith University and RMIT. The Authors would also like to thank Elin Emmoth, Sam Warmerdam, Nikko Kahindi, and Luke Spajic for providing research support. The research is advised by a Project Steering Group with representatives from the Australian Roads Research Board (ARRB), Austroads, Royal Automobile Club (RAC), National Transport Commission (NTC), Roads Australia, CSIRO Data61, Blockchain in Transport Alliance (BiTA), Blockchain Research Institute (CA), Curtin University Sustainability Policy Institute (CUSP), Griffith University Big Data and Smart Analytics Lab, and the RMIT Blockchain Innovation Hub.

References

Baker, M 2018, 'Blockchain on the rise and the search for solutions', Freight Waves, 27 June 2018.

Cassano, J 2015, 'Could La'Zooz Be The Ride-Sharing App We've Been Waiting For?', Fast Company. 27 January 2015.

DHL 2018, Blockchain in Logistics: Perspectives on the upcoming impact of blockchain technology and use cases for the logistics industry, DHL Trend Research.

Eyres, J 2016, 'Blockchain and how it will change everything', The Sydney Morning Herald, 06 February 2016.

Forbes Insights 2018, 'How Blockchain May Impact Logistics, Supply Chain and Transportation: A Conversation with The Blockchain In Transport Alliance', Forbes Insights, 04 September 2018.

Hanrahan, B 2018, 'Industry gets on the blockchain', Handelsblatt Today, 27 April 2018.

Marinoff, 2018, 'New Blockchain Initiative for the Automotive Industry Announced in Dubai', Bitcoin Magazine, 02 May 2018.

Marr, B 2018, 'How Blockchain Could End The Trade In Blood Diamonds - An Incredible Use Case Everyone Should Read', Bernard Marr & Co.

Mearian, L 2018, 'IBM, Maersk launch blockchain-based shipping platform with 94 early adopters', ComputerWorld, 20 August 2018.

Newman, N 2018, 'Could blockchain transform transport?', Engineering and Technology, 21 June 2018.

Pearce, R 2018, 'NSW digital licence rollout driven by blockchain', ComputerWorld, September 10, 2018.

Peters, B 2018, 'Ford, GM, IBM Want Transportation To Run On Blockchain', Investors Business Daily, 02 May 2018.

QIC 2017, Blockchain is knocking at infrastructure's door, Queensland Investment Corporation, Brisbane, Queensland.

Santori, M 2016, 'The Delaware Blockchain Initiative', Global Delaware, 10 June 2016.

Shieber, J 2017, 'Toyota pushes into blockchain tech to enable the next generation of cars', Tech Crunch, 22 May 2017.

ShipChain 2018, 'Using Blockchain to Better Understand the Total Cost of Transportation', ShipChain, 15 November 2018.

Southwick, N 2013, 'Counterfeit Drugs Kill 1 Mn People Annually: Interpol', InSight Crime, 24 October 2013.

Tapscott, D and Tapscott, A 2016, Blockchain Revolution: How the technology behind Bitcoin is changing money, business and the world, Penguin Random House, USA.

TMW Systems 2017, 'Blockchain for Transportation: Where the Future Starts', TMW Systems.

UNEP 2016, ‘Fintech and Sustainable Development: Assessing the Implications’, United Nations Environment Programme.

US DoT 2018, What Blockchains could mean for government and transportation operations, United States Department of Transportation, Volpe Centre, DOT-VNTSC-18-03.

WEF 2015, ‘Deep Shift: Technology Tipping Points and Societal Impact’, World Economic Forum, September 2015.