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BLOCKCHAIN FOR MULTIPARTY, LARGE-SCALE AUTONOMOUS VEHICLE MANAGEMENT

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ABSTRACT

Techniques are described herein to utilize blockchain for multiparty, large-scale autonomous vehicle management. In particular, techniques described herein utilize a permissioned blockchain to incentivize multiple parties to participate in a shared, trusted, secured, and coordinated Autonomous Vehicle (AV) messaging system that ultimately serves to benefit city and/or transportation authorities by enabling them to control AV traffic and manage congestion on a large scale.

DETAILED DESCRIPTION

As the number of Autonomous Vehicles (AVs) on our roads increases, mechanisms will be needed to manage traffic flow at scale. There is much work being done to control specific groups or fleets of AVs; however, no work yet seems to be considering large-scale public flow control, which can include corporate/public fleets, platoons, and/or large numbers of single/personal AVs. This is due to two main problems:

1) Lack of a common control message management system and related infrastructure to support the common control message management system; and
2) The fact that multiple entities wish to assert some level of control over AVs.

Addressing such problems may involve a managed hierarchy of controlling entities and a level of trust that ensures all those separate entities will not act maliciously or in discord. Techniques presented herein seek to address the fact that multiple entities wish to assert some level of control over AVs.

Different AV companies are looking to control their vehicles for various reasons. For example, freight companies may have AV platoons that will follow each other more closely than separate personal AVs. In another example, car rental and ride-share companies may have fleets of AVs that may require specific instructions to meet at specific destinations. At the same time, all these AVs will coexist and additionally share the road with manually controlled vehicles. There will also be intersections, on/off ramps, merge zones, etc. (which may be more impacting to platoons) and also varying degrees of traffic congestion at different times and places. There may also be city events such as ballgames, concerts, maintenance work, or emergencies that may involve broad traffic management and/or road closures on demand.

With the various levels of control that may be involved, cities may struggle to manage congestion more than ever. It may also be more difficult to enable new modes of mobility (e.g., safe bike and scooter sharing routes) due to a hindered ability to plan for them, if AV control is in the hands of many.

If cities can manage all levels of AV control-messaging into a single trusted messaging network, they can better manage city-wide traffic flow and congestion, provide coordination of city maintenance activities, emergency situations, and/or future city-planning initiatives, while still supporting different AV vendors and allowing enhanced mobility options to flourish.

Techniques proposed herein utilize a specific blockchain implementation that includes a central, authoritative controller for message/transaction validation; a hierarchy of message parameters which are sent by permissioned senders; and a roadside infrastructure to assemble these multi-party parameters into single messages, reach consensus on the blockchain through Proof of Authority, and transmit the messages via the appropriate transmitters to the passing AVs; thereby facilitating a trusted multiparty solution.

In this permissioned blockchain, the ***senders*** are entities who wish to assert some level of control over all AVs, or a subset of AVs, on public roads, by sending control messages to the AVs. This assumes multiple sender entities can participate in the composition of these control messages, which will be consumed by the public; thus, involving a system that is secure and which establishes trust between all senders to act in accord. The novelty exists in the technique of combining instructions from multiple parties, which are all targeted at the same platform (e.g., the autonomous vehicle) in a way that is trusted and complimentary in order to benefit overall city traffic management and/or city planning.

For techniques proposed herein, it is not necessary for the AVs themselves to also join and participate in the blockchain, but they may be allowed to do so. Rather, the AVs may consume the outputs of the blockchain. The outputs of the blockchain are control messages, which are to be valid and trustworthy. Thus, each new block will be a control message that will be published by the blockchain and consumed by the AVs. If AVs join the blockchain, it may be to support their message consumption, but not for AVs to send/share data.

Various system components may be implemented to facilitate the trusted multiparty solution of the proposed techniques including, but not limited to, a Message Controller, a Roadside Infrastructure, and a Permissioned Blockchain.

In at least one implementation, the Message Controller may be a programmable message controller, such as a software-based scalable platform deployed in the cloud. The Message Controller may perform various operations including, but not limited to, managing the physical Roadside Infrastructure, commonly referred to as Roadside Units (RSUs). The Message Controller may contain RSU rules and a defined hierarchy of sender entities and related parameter types. Examples of entity types can include: fleets, platoons, transportation authorities. The parameters may be layered and classified per entity type. For example, transportation authority type parameters may reside at a top-most layer (with precedence), with more specific parameters for participating fleets sitting in layers below (with lower precedence).

In at least one implementation, the Roadside Infrastructure (e.g., RSUs) may be physical nodes that are owned by transportation authorities who wish to manage AV traffic via transmitted messages. In some implementations, the RSUs may be placed within city and roadway infrastructure and may continuously publish/transmit the latest assembled messages per their given area/zone. Other variations can be envisioned (e.g., periodic publication/transmission, etc.).

In at least one implementation for the Permissioned Blockchain, sender clients are permissioned client wallets that may send AV message parameters to the blockchain network with the intention of having them included in AV control messages. The Message

Controller serves as the validator to determine that a transaction is 'legal' based, at least in part, on determining that the parameters are allowed based on the sender's status in the hierarchy, the parameters themselves, and intended RSU transmitter(s). The RSUs may serve to reach consensus and to transmit/publish the assembled messages. Participating sender entities will receive tokens that will ultimately be recycled to satisfy payment for using the roadway.

Accordingly, the proposed techniques may broadly include:

1. A Programmable Message Controller including:
    1. A message parameter hierarchy; and
    2. RSU rules
2. Physical RSU devices
3. A Permissioned Blockchain including:
    1. A centralized and authoritative message Validator
    2. Client wallet software; and
    3. Participation tokens
4. Multi-purpose consensus workers and AV control-message transmitters

During operation, components of this proposal may operate in a manner such that a city/municipality authority may grant controlling entities permission to transact (e.g., send message parameters) on the blockchain. The authority also defines, within the message controller (**1**), the hierarchy of control message parameters (**1-1**), and potentially rules (**1-2**) for which RSUs (**2**) can transmit certain messages.

Controller instances that are listening on the blockchain (**3**) can serve to validate (**3-1**) that the transactions are legal (e.g., the message parameters are allowed based on the sending entity, their status in the hierarchy, and the intended RSU transmitter(s)). The permissioned senders are clients who use blockchain client software (**3-2**), known as a 'wallet', to send message parameters they wish to have published in a message block and subsequently sent to the AVs.

Along with the message parameters, each sender will automatically include an amount of tokens (**3-3**) as the fee to be paid to the block *winner* (see, e.g., ***recipients***, discussed in further detail below). These tokens can be provided to participating senders upon joining and can serve to incentivize the use of the system.

The ***recipients*** may be one or more RSUs that may be responsible for several tasks (**3-4**) including, but not limited to:

- Ordering the control parameters sent from various senders into a message (a new block), according to the established messaging hierarchy.
- Reaching consensus with other RSUs, via Proof of Authority, to agree on which message (block) is added to the chain.
- Once consensus is reached, the appropriate RSU(s) publishing the control message for consumption by the passing AVs.
- The RSU who wins the block addition will provide for distributing the tokens (fees) back to the senders, which in turn satisfies as payment for using the roadways.

It is to be understood that the use of tokens to satisfy as payment for using the roadways implies that the city/transportation authority would have fees in place for AV operators using the public roadways. Thus, by using the system provided by this proposal, the distribution and cycling of tokens would act as payment for using them. Otherwise, if the senders don't participate in the system but allow their AVs to use the roads, they could pay the roadway fees/tolls out of pocket.

In some implementations, the control messages (blocks) can appear in a Blockchain (**3**) 'explorer', making these published messages visible to anyone, thereby enabling transparency and the ability for all participating sender entities to verify their message parameters are being published as expected.

Implementing techniques of this proposal may include developing a new blockchain implementation, as described, or building upon an open-source implementation (such as Hyperledger™), that enables permissioned participation, proof of authority, and token disbursement as described herein. Further, installation of physical roadside units to act as the described RSUs, with the appropriate blockchain software, data communications lines, and radio transmitters may be needed. Additionally, implementing the techniques would involve provisioning and programing the Message Controller with rules, as described, and adding the RSUs under its management. In various implementations, the Message Controller can be software or hardware based, local, or remote and can be envisioned as a service available pervasively through a private or public cloud service.

In summary, techniques are described herein to utilize blockchain for multiparty, large-scale autonomous vehicle management. In particular, techniques described herein utilize a permissioned blockchain to incentivize multiple parties to participate in a shared, trusted, secured, and coordinated AV messaging system that ultimately serves to benefit city and/or transportation authorities by enabling them to control AV traffic and manage congestion on a large scale.