Video: Micropayments for Trusted Vehicular Services using MOTIVE

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ABSTRACT

The connected and autonomous vehicles are expected to rely heavily on connectivity to exchange data and computation services with other vehicles and remote infrastructure including roadside units and other edge infrastructure to increase their immediate view, which leads to greater safety, coordination and more comfortable experience for their human occupants. In order for vehicles to obtain data, compute and other services from other vehicles or road-side infrastructure, it is important to be able to make micropayments for those services and for the services to run seamlessly despite the challenges posed by mobility and ephemeral interactions with a dynamic set of neighboring devices. We present MOTIVE, a trusted and decentralized framework that allows vehicles to make peer-to-peer micropayments for data, compute and other services obtained from other vehicles or road-side infrastructure within radio range. The framework utilizes distributed ledger technologies including smart contracts to enable autonomous operation and trusted interactions between vehicles and nearby entities.

CCS CONCEPTS

• **Networks → Peer-to-peer protocols**.

KEYWORDS

V2X;Micropayments;Connected and Autonomous Vehicles; Blockchain; Edge Computing

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1 INTRODUCTION

The automotive industry is moving towards autonom-ous driving, connectivity, and electrification to increase driver comfort, safety and eco-friendly driving. Modern day vehicles are increasingly being equipped with computing platforms, sensors, cameras, artificial intelligence and machine learning algorithms to assist the drivers, or in some cases, an autonomous software agent is making decisions for the drivers. The latest developments in artificial intelligence technologies are expected to further propel the adoption of such technologies in the race for the realization of connected and autonomous vehicles. Thus, applications such as electric vehicle charging and real-time traffic prediction are expected to exchange data and computation using vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication [3].

Connected vehicles in the future can communicate with other vehicles on the road to help the driver make informed decisions when navigating through intersections [4], changing lanes [1], or driving under adverse weather conditions. In such cases, each vehicle is expected to coordinate with other vehicles and the road-side infrastructure in the neighbourhood to ensure safe-ty [1]. Such applications require aggregation and processing of sensor data from multiple vehicles and the road-side units. In summary, the V2V and V2I (referred to as V2X from now on) applications require communication and computation services from nearby vehicles and road-side units in a dynamic environment.

When the V2X applications exchange data and compute services between devices and infrastructures owned and managed by multiple users and organizations under transient conditions, a trust mechanism is necessary to reliably provide or consume services. Besides, the introduction of micropayments encourage vehicles and infrastructure nodes to contribute resources including data and computation, allowing them to gain monetary benefit for their contributions. It is essential to create a V2X platform with built-in mechanisms to guarantee trust while providing support for micropayments. Such a V2X platform has the potential to enable what we call "financially autonomous vehicles". Another problem in the V2X application scenario is that each vehicle stays in contact with other vehicles or the road-side units for a limited time. Thus, the service agreements between devices have to be made based on the contact duration for reliable transaction.

In this video demo, we demonstrate MOTIVE (an acronym coined from "Micropayments fOr Trusted vehIcular serVicEs"), a novel V2X platform with support for trust management, micropayments, and mechanisms to provide and consume data and compute services with other vehicles and road-side units following a decentralized architecture. MOTIVE incorporates a link prediction algorithm which allows the vehicles to calculate the contact duration based on other vehicle's destination, speed, and the surrounding traffic conditions. MOTIVE is developed in a technology agnostic fashion, which means it can work with any blockchain platform and V2x

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Figure 1: Channels between MOTIVE Instances.

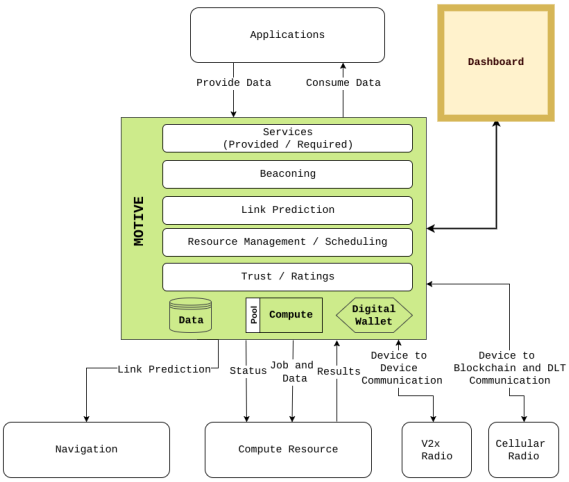

Figure 2: Architecture of MOTIVE.

communication technologies. Our preliminary implementation is discussed in [2].

2 MOTIVE ARCHITECTURE

MOTIVE enables vehicles and infrastructures to exchange data and compute services in a peer-to-peer network. Figure 1 shows the different communication channels that exist between two MOTIVE instances. Each MOTIVE instance is:

- Capable of **beaconing** the provided and required data and compute services to other MOTIVE instances in the neighborhood using a V2X radio.
- Able to exchange **data**, including sensor readings, computation tasks, inputs, and results, with other MOTIVE instances.
- Storing the **records** of all the transactions in a distributed ledger or a blockchain platform.
- Attached to a digital wallet for paying or receiving **payments** for the services consumed or provided respectively.
- Able to **rate** the other MOTIVE instance based on the transaction experience.

Figure 2 shows the architecture and the building blocks of MOTIVE. Each MOTIVE instance is capable of advertising the services it can provide and the services it requires to other MOTIVE instances using the V2X radio. Note that the MOTIVE instances can be running on both the vehicles and the road-side infrastructure.

All the MOTIVE devices in the operational environment can receive beacons and process the information in the beacon. The decision to offer the service to the other devices are made based on how long the two devices will stay in contact along with the rating and the account balance in the wallet. MOTIVE consists of a link prediction algorithm, which computes the contact duration based on the navigation data including speed and heading, traffic situation, and wireless communication range of the radio. When the contact duration is well within the duration required to complete the transaction, the reputation of the device is above the acceptable threshold, and the account has sufficient balance to pay for the requested service, the service agreement is made between devices. The service provider then schedules the services by allocating the desired computation and storage resources and serve the peer in return for micropayment.

3 VIDEO DEMONSTRATION

We built a simulator to demonstrate the capabilities of MOTIVE. The V2X communication is emulated in the simulator, but the service exchanges, micropayment, and rating functionalities are implemented using blockchain and distributed ledger technologies. The **ratings** smart contract, implemented in Ethereum, consists of three functions to add a new user to the MOTIVE ecosystem, get the rating of an existing user, and rate an user after a transaction. We implemented client applications for handling the **payment and recording** the transactions using IOTA and Ethereum. Our proof-of-concept implementation is available at https://github.com/ANRGUSC/MOTIVE.

The MOTIVE framework is agnostic to the underlying blockchain platform although our proof-of-concept implementations are carried out on particular platforms, namely IOTA and Ethereum. The one minute video demo is available at the following link: https://youtu.be/uSzivWFawls.

4 CONCLUSION

In this work, we have presented MOTIVE, a platform with support for providing and consuming data and computing services in return for micropayments. Besides, the link prediction algorithm of MOTIVE allows the vehicle to estimate the contact duration before scheduling the services. We have shown the rating and micropayment capabilities of MOTIVE using distributed ledger technologies and blockchain platforms such as IOTA and Ethereum.

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