Chapter 9
Temporal Blockchains for Intelligent Transportation Management and Autonomous Vehicle Support in the Internet of Vehicles

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ABSTRACT

In the internet of vehicles (IoV) field, blockchain technology has been proposed for durable and trustworthy bookkeeping of the exchanged data. However, block timestamps assigned by miners are usually delayed with respect to events that generate the stored data, making them unusable for applications dealing with exact timing, like traffic law enforcement and insurance accident investigation. To overcome this shortcoming, the authors propose to add new timestamps to the blockchain, which are assigned by data originators to represent the valid time of data recorded within a transaction. The resulting enhanced blockchain data model, named BiTchain, can

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be considered from a temporal database perspective as a bitemporal data model. In order to let users and applications enjoy the potential of BiTchain, they also introduce an expressive temporal query language, named BiTEQL, defined as a TSQL2-like temporal extension of the EQL blockchain query language.

INTRODUCTION

Present and future intelligent transportation and autonomous vehicles applications are using Internet of Vehicles (IoV) (Yang et al., 2014), Flying Ad-Hoc Networks (FANETs) (Bekmezci et al., 2013) and Vehicular Ad-Hoc Networks (VANETs) (Zeadally et al., 2012) as communication infrastructures. In this context, the Blockchain technology has been proposed for durable and trustworthy bookkeeping of the exchanged data (Guo et al., 2018; Diallo et al., 2020; Fu et al., 2020; Gupta et al., 2020; Li et al., 2020a; Narbayeva et al., 2020; Rehman et al., 2020; Javaid et al., 2021; Uddin et al., 2021; Chondrogiannis et al., 2022; Six et al., 2022). A blockchain (Nofer et al., 2017; Dinh et al., 2018; Zheng et al., 2018; Li et al., 2020b) is a public distributed ledger that stores committed transactions in an ordered list, or a chain, of blocks. Such a ledger is maintained by multiple distributed nodes (computers), which are linked in a peer-to-peer network (i.e., without a server node that has full control and central authority) and possibly do not trust each other, through a consensus mechanism (i.e., an agreement among these nodes on the truth of data stored in the blockchain) and cryptography (essentially hash algorithms and digital signatures). Notice that the ledger is replicated over all nodes. A transaction is a sequence of operations applied on some state respecting the ACID properties as in classical database systems. It cannot be modified once it is recorded in a block of the blockchain. A block is made up of a block header and a block body: the former contains, among others, the parent block hash that points to the previous block and a timestamp; the latter essentially contains transactions.

From a database point of view, a blockchain (Dinh et al., 2018; Mohan, 2018; Vo et al., 2018; Xu et al., 2019) can be considered as a distributed and replicated temporal database (Grandi, 2015; Jensen & Snodgrass, 2018a) that stores a large list of blocks: each timestamped block is replicated over all nodes of the network. More precisely, since block timestamps cannot be updated and the whole blockchain is an append-only data structure, a blockchain can be viewed as a transaction-time (Jensen & Snodgrass, 2018b) database, that is a database where each version of a time-varying datum (like the salary of an employee or the price of a product) is stamped with the time when such a version has been inserted in the database.

Among the strengths of blockchain, we find immutability, data integrity, transparency, distribution, absence of central/intermediary entity, and provision

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