**Blockchain Technology for Intelligent Transportation Systems**

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**Abstract:**

Since the Population is rapidly increasing day by day and so the vehicles, Despite Traffic improvements in infrastructure, rules, and regulations, the solutions are inefficient for today's increasing traffic problems. so this increases the necessity of integrating intelligent transportation systems (ITS) to reduce traffic problems. This system focuses on reducing traffic problems, enhancing traffic efficiency, and so on to the traffic improvements. So this survey aims to provide a systematic review of Blockchain applications to intelligent transportation systems in general and the Internet of Vehicles (IoV) in particular.

**Introduction:-**

The purpose of this study is to explore how to use blockchain technology in intelligent transportation and has an important role in the ITS. Intelligent Transportation System(ITS) resolved various issues of transportation like congestion, traffic light cameras, traffic updates, and ecological forecasting. The goal of ITS is to gather, analyze and apply all transport-related data to monitor the flow of vehicles to increase traffic quality and safety [1]. In recent years, business growth in ITS and provide services to manage the traffic and the use of the traffic network safely. In this field, using physics, computer science, Internet of Things technology, and integrated traffic information to establish a dynamic information service.

In general, ITS services are namely:

1) intelligent transport, a favorable path can be selected in terms of economy and navigation, preventing traffic jams, etc.

2) With the help of vehicle interconnectivity, and barriers early warnings can be issued, or internal or external system failures can be efficiently conveyed to the driver.

3) Driver or vehicle support services, such as violation of road laws, and automated repair of vehicles.

4) Entertainment for real-time users, such as streaming media, etc.

5) providing statistical data about the surrounding areas, traffic, and environment [2].



Blockchain Technology was first introduced in 1991. Satoshi Nakamoto implemented blockchain technology first time in 2008 and introduced a cryptocurrency named Bitcoin. Bitcoin is freely available; its design is public, nobody handles or controls Bitcoin and everyone can take part. Bitcoin allows enthusiastic usage that is not provided by any previous payment system.

**BLOCKCHAIN MEANING:**

**Blockchain technology allows transparent information sharing within a business network. The data is stored in blocks that are linked together in a chain.**

Blockchain is known as one of the most transformative technologies of the current time. A distributed ledger system in form of a blockchain is new data storage and processing method. The major characteristics of blockchain technology is mutual honesty, anonymity, data confidentiality, and transparency have a great opportunity for resolving the challenges of the established ITS.

**Components of Blockchain.**

There are a set of basic components of blockchain which include ledger, block, hashing, transaction, minor, and consensus mechanism.[3].

The data structure named **ledger** is used to store different kinds of data. It is used to keep all transactions ever made on the network by all participating users. The ledger was also distributed between the participating nodes, so every user has a copy of the ledger.

Each block includes a collection of transactions and has been chained together by storing the preceding block's unique hash value in the current block. The connection has an interaction with each other in an interlocking manner like a chain.

To find a block, minors must crack the Hash function which technically is a mathematical problem.

The transaction is a smallest process unit which put into a collection making it a block and then sending it for its processing.

If most of the participating nodes in the blockchain network don’t allow a certain transaction it cannot be added to the block. For minors, the size of a transaction is important as small transactions require less power and are simpler to verify. Minors are computers/agents that attempt mining to discover new blocks [3].When make a chain then different blocks are chronologically connected in a blockchain. While making the chain, the header of each block must contain the address of the previous block hash. Each block in the chain contains the previous block hash, data, nonce, and timestamp. The first book of the chain is called genesis. A nonce is a magical number given by miners to complete the hash according to the format of the blockchain, timestamp describes the time and day at which the block is created [4].

**Blockchain Types**.

Types of blockchain Mainly blockchain is dividing into three types [5]. Following are the main types:

• Private blockchain.

• Public blockchain.

• Consortium blockchain.

**Private blockchain:**

It is observed that the public blockchain is more decentralized as compared to these blockchains as only selected node can participate in the process, which makes it more secure than the others.

* Only authorized users are allowed to access them.
* A closed network operates these blockchains.
* In this, a network within a company/organization is limited to the participation of a few people.

**Advantages:**

* High transaction rate is achieved due to small size, making verification less-time consuming for each node.
* Scalability can be adjusted as per requirement, with the option to manually decide the network size.

**Disadvantages:**

* Due to the limited number of nodes in this type, there is higher possibility of manipulation, making these blockchains more vulnerable to security threats.
* The limited number of nodes in this type means that if nodes go offline, the entire blockchain system can be endangered.

**Public blockchain:**

The idea of decentralization is completely followed by these blockchains, and there are no restrictions, as the network can be participated in by anyone with a computer and internet connection.

* As the name is public, this blockchain is open to the public, which implies that it is not owed by anyone.
* Participation in this public blockchain is possible for anyone with internet access and a computer with good hardware.
* All the nodes or blocks present in the network are held in copy by all the computers in the network
* Verification of transactions or records can also be carried out in this public blockchain.

**Advantages:**

* No fraud can be detected through algorithms, which makes it trustworthy. The participation do not need to worry about the other nodes in the network.
* Due to its openness to the public, this blockchain is large in size, which results in a greater distribution of records and thus, enhances its security.

**Disadvantages:**

* The transaction process is very slow due to its large size, resulting in a very time-consuming process for the verification of each node.
* High energy consumption is required for proof of work, and good computer hardware is needed to participate in the network.

**Consortium blockchain.**

The needs of the organization are solved by a creative approach that validates transactions and also initiates or receives them.

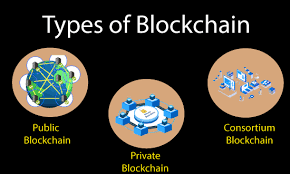
* This type of blockchain is also known as Federated Blockchain.
* The organisation’s needs can be solved by this innovative method.
* There is a mix of public and private components
* In this type, the blockchain is managed by more than one organisation.

**Advantages:**

* Speed: Fast verification is enabled due to the limited number of users. The high speed makes it more usable for organizations.
* Authority: Decentralization is achieved at every level as multiple organizations can participate. It is made more secure by decentralized authority.

**Disadvantages:**

* Approval: The protocol is approved by all members, which makes it less flexible. Differences in the vision of interest may arise due to the involvement of one or more organizations.
* Transparency: It can be hacked if the organization becomes corrupt. Information may be hidden from the users by organizations.



**Literature Review:**

The blockchain which comprehensively utilizes distributed data storage, consensus mechanisms, point-to-point transmission, encryption algorithms, intelligent contracts, and other computer technologies, is essentially a decentralized database that is used as the underlying technology of bitcoin. Blocks in the blockchain package data with timestamps and digital signatures and are linked by hash pointers to form a chained ledger structure. The correctness of the data can be self-verified by the digital signature in the data records, and the distributed storage of the blockchain facilitates data sharing. The data can be traced back to its source because of the linking of blocks with hash pointers, who prevents hackers from falsifying the data. The technological novelty of blockchain lies in the fact that it is possible to build a consensus on the true state of the ledger without trusting any centralized entity or an intermediary [6]. Therefore, the blockchain is suitable for building an information system to deal with multiparty collaborative business because it has excellent characteristics of being tamper-proof, trustworthy, and traceable, and supporting data sharing.

A transportation consortium blockchain has been built by our research team through the application of blockchain technology to intelligent transportation, This blockchain is led by the government and involves multiple parties, allowing for the carrying capacity of the road network to be fully utilized, varios traffic problems to be solved, and traffic safety and environmental protection to be improved. The economic, social, and environmental aspects of the system have been analysed in this study, based on the triple bottom line principle. Cost analysis is focused on in the economic aspect, social issues are managed in the social aspect, and environmental benefits of blockchain-based intelligent transportation system are mainly referred to in the environmental aspect. The application system of blockchain in intelligent transportation, including 3 aspects and 15 criteria, has been built by combining new technologies such as the Internet of Things and the characteristics of blockchain.

* **Intelligent Transportation under Blockchain: Economic Aspect**

A reduction in well-designed opportunistic behavior can be achieved by blockchain, which keeps a permanent record of past transactions and has a tamper-proof system. Reliable ledgers can create an economic environment with low transaction cost, which is a prerequisite for achieving economic efficiency and prosperity[7]. The behavioral uncertainty in the transaction relationship can be reduced by intelligent contracts and information sharing technology, which can establish a better trust mechanism. The costs associated with intermediaries can be reduced by the distributed accounting system and decentralized nature of blockchain. All these factors reduce the transaction cost of government and enterprises [8,9]. In terms of management cost, the cost of monitoring, controlling, and approving the fund flow to prevent fraud and increase the supervision of the fund flow can be reduced by automatic data uploading and traceability systems. Immutable and distributed bookkeeping reduces the human cost of information research, monitoring, and management for governments and enterprises [10]. The use of smart contracts can reduce the use of paper and other consumables, realize rapid discussion, and save time, and sharing databases can reduce management work [11]. The traffic information in the blockchain can be analysed and processed to support the overall planning of the urban traffic network layout, including logistics and transportation, road planning, road construction, bus station construction and optimization of the supporting infrastructure construction scheme, which can reduce the infrastructure construction cost. The electronic bill management of companies can be facilitated by the automatic data uploading and traceability system, which reduces financial costs. The right to examine company accounts through blockchain can be given to the government and auditing institutions by blockchain technology, strengthening the supervision of company profits and taxes, and reducing tax fraud. Coyne and McMickle [12] believe that blockchain-based digital currency only exists in the blockchain, while economic transactions exist outside the blockchain records, which will prevent the use of the blockchain model for acceptable transaction verification. However, this problem can be effectively solved by combining blockchain with the Internet of Things technology, making blockchain accounting possible in the field of transportation.

##### Intelligent Transportation under Blockchain: Social Aspect

##### *Blockchain Features Have an Impact on Society:-* The characteristics of the blockchain, which involve mathematics, cryptography, the Internet, computer programming, and other fields, make it a decentralized, tamper-proof, and traceable distributed shared ledger and database. It has the characteristics of being decentralized, tamper-proof, and traceable and supporting whole-process marking, collective maintenance, openness, and transparency [13]. The reliability of the blockchain is ensured by these features. The combination of blockchain and the Internet of Things technology can realize automatic data upload and timely information update, which can improve the timeliness of transactions by instantly forming smart contracts [14]. Therefore, the characteristics of blockchain are classified as reliability and timeliness.

##### *Problem Management: -* In terms of Internet-based traffic management, blockchain technology allows the use of the aggregate signature scheme to connect the channels under the chain to build a secure large-scale real-time payment system and improve the capacity of the blockchain system [15]. Internet-based traffic information is recorded using the blockchain and basic personal information and credit ratings of internet-based traffic drivers are made public to ensure that those responsible for traffic accidents are held accountable. At the same time, transaction information for internet-based traffic can be tracked and conditions investigated, which make it easier for the government to collect taxes and facilitate tax administration.

##### *Top-Level System Design:-* The foundation of entire blockchain-based intelligent traffic index framework is the top-level system design, which includes the reward and punishment system and the credit evaluation system, and plays a crucial supporting role in the system.  The reward and punishment system refers to virtual currency rewards for users who actively participate in blockchain and publish real information [16]. The credit evaluation system, which evaluates user trust by assessing service trust, behavior trust, and task trust, and ensures data integrity and non-repudiation using blockchain technology, is used to establish a secure and reliable database that supports analytical queries with different query timestamps. Yang et al. [17] proposed a blockchain-based decentralized trust management system for vehicle networks.

##### Intelligent Transportation under Blockchain: Environmental Aspect

##### Blockchain can be used to reduce urban traffic pollution, with the most series part being the excessive emission of automobile exhaust. Methods to reduce urban traffic pollution through blockchain include optimizing traffic routes through blockchain, reasonably controlling speed; reducing instantaneous acceleration and idling to reduce carbon dioxide emissions [18, 19]; and encouraging or requiring heavy truck lines to reduce air resistance and fuel consumption [20].The increase in popularity of energy transactions between electric vehicles and charging stations in the vehicle-to-grid(V2G) environment has led to an increase in the use of electric vehicles. A more comprehensive public transport system has also contributed to higher rates of public travel. In addition, a reasonable urban greening layout based on multiple pieces of information in the transportation consortium blockchain [21] is also beneficial to urban environmental governance.

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