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REGULAR ARTICLE

Optimizing Data Traffic: Effective Management of Physical Processes in Networked Information Systems

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Urban traffic congestion is difficult for modern urban management due to Rapid City expansion, outdated traffic control methods, inadequate road design and construction, and rising car ownership. The literature provides a detailed Internet of Things (IoT) based Intelligent Transportation System (ITS) architecture, focusing on the application, network, and perception levels. The application layer processes traffic data and supports various ITS. Through sensors and communication networks, the perception layer collects real-time traffic data, while the network layer ensures reliable and secure data transfer. The design delves into vehicular communication network protocol architecture, with a focus on Mobile Ad-hoc Networks (MANETs). In the context of Vehicle Ad-hoc Networks (VANETs), it covers security issues, the transport layer, the Physical and Media access control (PHY/MAC) layer, and routing protocols. The paper explores the integration of mobile models with network simulation tools, outlining two methods: the Mobile Fusion Model and the Mobile Embedded Model. In conclusion, a simulation study utilizing the Optimized Network Engineering Tool (OPNET) Modeler platform is presented, this study evaluates Destination Sequenced Distance Vector (DSDV) Protocol, and Optimized Link State Routing (OLSR) Protocol about packet loss performance, network load, and Vehicle-to-Vehicle (V2V) communication networks.

Keywords: Vehicle-to-Vehicle (V2V), Traffic Control, Intelligent Transportation System (ITS), Network Layers.

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1. INTRODUCTION

Urban traffic has been more congested due to the rising use of private motor cars in recent years. Consequently, traffic monitoring is quickly rising to the ranks of critical issues plaguing the infrastructure of the world's largest smart cities. Problems like these include traffic jams and accidents, which take lot of time and lead to damage property and degradation of the environment [1]. Losses in capital are the result of any kind of traffic jam. Hence, better traffic management is very necessary. A new direction in intelligent traffic development has emerged because of the development of the IoT[2]. Better traffic conditions and less congestion are the use of agents and other technologies. All roads can contribute to the data provided by traffic IoT, which can be shared with users. The system was able to identify the present traffic operation, traffic flow circumstances, and future traffic flow by collecting data on traffic in real time [3]. If the system is up-to-date, it can provide drivers with real-time traffic information, which is useful for planning the best routes. In this way, the system can accurately manage, keep tabs on, and control vehicles in motion. Built on the IoT, an intelligent traffic system can enhance traffic conditions, decrease management costs and jams, increase safety on the road and function from weather changes, among many other advantages [4]. The IoT is a game-changing concept that improves traffic management systems by linking physical infrastructure with digital connection and the traffic Information System, a smart and adaptable network that uses IoT technology to gather, process and share traffic data in real time. Smart gadgets, cameras and networked sensors are carefully placed across cities to support the

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Traffic Information System [5]. In a never-ending stream of data, these gadgets track traffic, road conditions, and other pertinent variables. Commuters, municipal planners, and traffic control centers get actionable insights from this data analyzed in real-time using cloud computing and modern data analytics [6]. The technology allows for adaptive regulation of traffic signals, and predictive analysis, and gives authorities the ability to regulate traffic in a dynamic way [7].

The Traffic Information System (TIS) reduces traffic jams and prepares the way for smart cities, where people's capacity to move about city centers is carefully considered to maximize productivity, environmental friendliness, and residents' happiness.

2. RELATED WORK

The study [8] suggested meticulously categorizing the literature into the major macro areas of algorithms, networks, data, cyber-physical systems (CPS), and security, this report conducts a comprehensive assessment of the literature on this topic. The paper [9] examined sensors transmit packets shared multi-hop network, sampling them according to the detected plant status. The study [10] aimed to show that cognitive manufacturing incorporates Artificial Intelligence (AI) based decision-making algorithms, digitalized mass production, sustainable industrial value creation, real-time big data analytics and previous research. The study [11] examined the current state of the art in network design and evaluation by factoring in information semanticsin this context, is defined as the messages' relevance rather than their meaning possibly under a time restriction given the intended purpose of the data exchange. The article [12] examined CPSimplementation in the construction sector and compared to other chosen industries. Measures for its implementation in the construction business were emphasized, and its potential advantages in diverse industries were examined. The study [13] suggested adding to the existing literature by demonstrating that computerized, robust, and flexible cyber-physical factories run easily with AI-based decision-making algorithms, and it finds that sustainable manufacturing systems based on the IoT function as well consequently. The study [14] provided the synergistic method to the problem of source reconstruction in real-time for remote actuation and making use of communication strategies and semantics-enhanced sampling. The study [15] investigated the need to acquire today's traffic management system that incorporates 3D model data and digital twin (DT) technology. The vast majority of studies in this area have focused on various technical details of its design, despite the amount of literature on the subject. The study [16] provided a new approach to evaluating the trustworthiness of vehicle sensors to oversee their data analysis in a cost-effective and trustworthy manner. Additionally, its rarity sensor data from vehicle sparse zones contributes more. The study [17] examined how to manage traffic in a Software design networking (SDN) cloud data center owned by the operator; the study suggests a multi-service differentiated (MSD) approach. Data center operations in the cloud informed the development of the MSD traffic management architecture and policies. The study [18] presented a method for optimizing channel allocation in information physical fusion systems that use hybrid wireless mesh networks. The paper [19] suggested beginning by reviewing the current state of research on ant colony algorithms and their significance. It went on to explain the history, present state and future obstacles of distributed CPS task optimization and scheduling.

3. METHOD AND MATERIALS

3.1 Data Collection

Libyan domestic transportation is mostly on land, with a few cars, trucks, aircraft, and land use expansion, increased noise as well as air pollution, increased accident rates, and private vehicle traffic's major contributors to these problems. Sadly, these side effects become severe with increased use of these devices [20]. Its accident fatality rate is 26.1 per 100,000, one of the highest in the world. The nation's enormous automotive population and decaying road infrastructure, which require improvement, may cause this. The 2013 automobile registration totaled 3,553,497, and traffic-related deaths between 1995 and 2018. They are high relative to other countries. The country lacks advanced transportation systems. Assume most crossroads lack traffic signals and those are broken.

3.2 IoT-Based ITS Architecture

An ITS that operates on the Internet must take into consideration various transportation infrastructures, vehicles and items. In addition to developing various advanced management and service systems, must build a basic traffic system identifying network. New business demands transport network modifications, in these procedures, the proposal shared data asset systems and the concurrent growth in present business demands. If it wants to use the IoT for intelligent transportation, it has to build ITS architecture in the IoT framework. Intelligent transportation systems established on the Internet include three layers: identification, network, and application.

3.2.1. Application Layer

Processing, analyzing, and applying information about the traffic that the traffic-aware network has collected, application layer tasks include supporting intelligent traffic services. At the application layer, user application service types can be generally categorized as government, social, industrial, and enterprise application demonstration systems, as well as industry and enterprise application demonstration systems. Applications such as dynamic traffic information services and intelligent traffic control systems are common and systems, smart automobiles, intelligent electronic toll collecting systems, and public transit management systems. Fig. 1 shows the architecture of the IoT-based ITS.

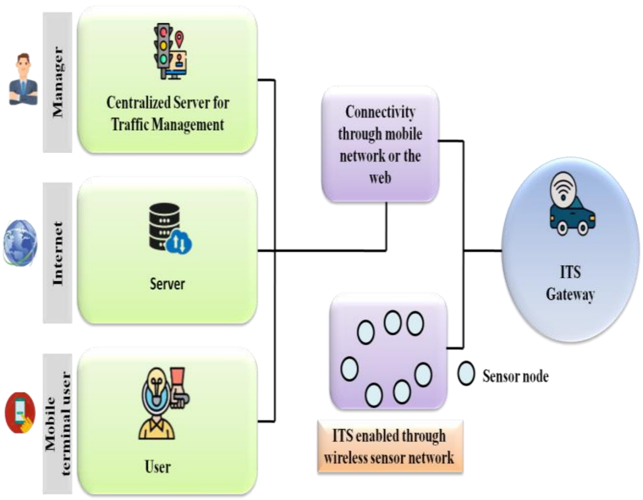

Fig. 1 – ITS Architecture

An intelligent wireless self-organizing network system with task orientation is a wireless sensor network. It has numerous sensor and data aggregation nodes in an environmental monitoring zone. Along with wireless transceivers, embedded processors, and other components, sensor nodes process, forward and acquire traffic data. Transforming communication protocols and controlling the network are done concurrently.

3.2.2. Network Layer

For reliable and secure traffic information transmission, the network layer is responsible. Massive, safe, and fast data transport needs a vast communication network at the network layer. Additionally, it must enable application-sensor access layer communication. Wired or wireless communication networks depend on access methods.

3.2.3. Perception Layer

Accurate and real-time traffic data collection is the primary function of the perception layer. Sensors and communication networks, including pressure, temperature, microwave radar, ultrasonic, and video capture devices by the traffic information is perceived. The data aggregation process is ultimately finished after the sensor's data has been delivered over the wireless sensor network.

3.3 Architecture of Vehicle Communication Networks

Vehicle-to-vehicle (V2V) and vehicle-to-roadside facility communication are common types of vehicle-mounted communication networks. There isn't a significant change in the overall network design since the roadside facilities in this context are defined as infrastructure such as petrol stations, convenience shops, speed limit signs, etc. This set of stationary nodes can be seen as a subset of mobile nodes.

3.3.1. Mobile AD HOC Networks (MANETs)

Mobile ad hoc networks (MANETs) consist of temporary, equal nodes and no access points (APs) in a service set. The focus on a dispersed, mobile, wireless, multi-hop, self-organizing network that doesn't depend on existing base station infrastructure. The wireless network's topology is subject to sudden and unpredictable changes due to the unrestricted mobility and total self-organization of its pathways. People can utilize mobile ad hoc networks for a variety of purposes, including home/local networks, businesses, vehicle communication networks, emergency rescue services, and computer-to-computer communication. The sensor network and other parts are adaptive and self-organizing.

3.3.2. Design of a Protocol for a Vehicle Communication Network

The Transmission Control Protocol/Internet Protocol (TCP/IP) model, extensively used in contemporary computer networks, and open system interconnection (OSI), the traditional OSI approach for worldwide open systems, represent the current network protocol architecture. Each mobile node establishes a wireless network via wireless communication, unlike a TCP/IP-based wired network. While VANETs are distinct from other types of MANET, protocol parameters vary at every layer. It shows how urban obstacles affect transport and its regularity. Vehicle communication network protocols are based on TCP/IP.

4. RESULT AND DISCUSSION

4.1 Vehicle Communication Network Modeling and Simulation

The OPNET Modeler simulation platform is used to construct a vehicle communication network model consisting of nine cars. Here are the results of an investigation into the technique for routing vehicle communication networks using simulation.

4.1.1. Bits of Throughput

OLSR is less efficient than DSDV, which is more costly and has larger throughputs. Since it has root maintenance and detection features like the OLSR mechanism. The DSDV protocol uses source routing to combine the OLSR and DSDV protocols, optimize network bandwidth use, and outperform the OLSR protocol. Table 1 and Fig. 2 illustrate simulation findings. The DSDV protocol outperforms the OLSR protocol. DSDV's ability to merge OLSR is the main reason. Network broadband utilization is better and higher than OLSR.

Table 1 – Throughput bits of OLSR and DSDV protocol

Time/s	Throughput bit/s	
	OLSR	DSDV
60	4500	4800
120	4800	4700
180	4900	4600
240	5000	4900
300	10000	5000
360	15000	10000
420	20000	12000
480	22000	15000
540	25000	20000

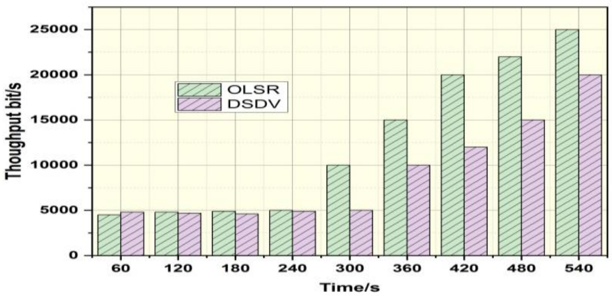

Fig. 2 – Bits of Throughput

4.1.2. Network Load Comparison for V2V Communications

The OLSR procedure is less demanding than DSDV. This is because the OLSR protocol's routing burden is largely route response (RREP) and route error (RERR) packets, which build several paths to the destination node. OLSR listens for routing request packets employing hybrid access and caching to reduce routing demand. Routing is handled by the routing request (RREQ) packet in the DSDV protocol. Table 2 and Fig. 3 show how different the two approaches' burdens are. In size, the DSDV and OLSR protocols vary greatly.

Table 2 – V2V network load of OLSR and DSDV protocol

Time/s	Payload bit/s	
	OLSR	DSDV
60	9000	12000
120	7000	10000
180	12000	11000
240	5000	8000
300	8500	13000
360	9500	8200
420	9200	9000
480	11000	9500
540	10000	9200
600	11500	13000

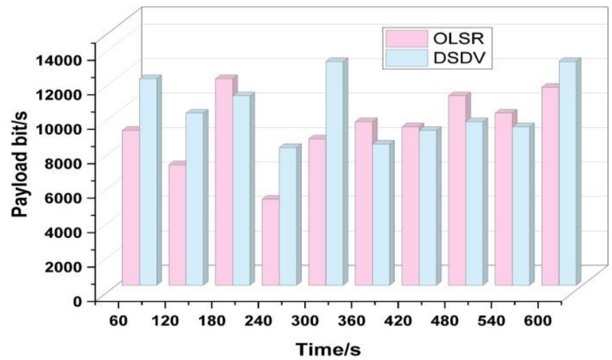

Fig. 3 – V2V network load communication

4.1.3. Rate of Packet Loss in V2V Communication Networks

When contrasted with the DSDV protocol, the OLSR protocol is far more prone to packet loss. Regardless of the change in the simulation duration, the OLSR protocol's performance remains constant as compared to the DSDV protocol, which stays with a small range. As long as the simulation stays with the stable range, the DSDV protocol experiences significant growth. Fig.4 displays the outcomes of the simulation.

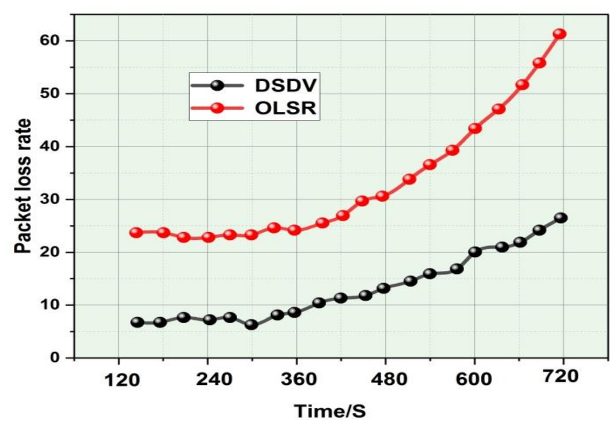

Fig. 4 – Packet loss in V2V communication networks

Due to noise, interference, and roaming mobile terminals, wireless network channel conditions vary over time. Changes also affect network performance. Thus, using appropriate technical standards and network features during network formation may improve vehicle self-organizing network performance. During deployment, the vehicle self-organizing network's wireless communication technology poses risks. Many ground access devices, severe location limitations, and substantial development and implementation expenses are involved.

5. CONCLUSION

The vehicle communication network, a new smart mobility research area, blends tourist attractions with city planning to establish an invisible web that enhances driving safety and interacts with transportation networks, urban planning, vehicles and base stations. It gives encouraging recommendations for reducing road accidents and improving drivers' fuel economy. This article presents a script for wireless data transmission that utilizes autos' self-organized networks to traverse urban highways. The multi-hop V2V script used by an Internet-based ITS serves as the script foundation. In addition to simulating and modeling the wireless communication network in a car, the OPNET Modeler provides a platform for developing and testing self-organizing networks in automobiles. This research found that the DSDV protocol for low-speed, mobile V2V communication network's network layer routing protocol than the OLSR protocol. Noise, interference, and roaming mobile terminals cause wireless network channel conditions to change over time. These modifications affect network performance. Future machine learning techniques for dynamic wireless channel adaption may enhance smart transport system vehicle communication networks, improving city efficiency and safety.

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Оптимізація трафіку даних: ефективне управління фізичними процесами в мережевих інформаційних системах

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Затори в містах є складними для сучасного міського управління через швидке розширення Рапід-Сіті, застарілі методи контролю дорожнього руху, неналежне проектування та будівництво доріг, а також зростання кількості автомобілів. Література надає детальну архітектуру інтелектуальної транспортної системи (ITS) на основі Інтернету речей (IoT), зосереджуючись на рівнях програми, мережі та сприйняття. Прикладний рівень обробляє дані про трафік і підтримує різні ІТС. За допомогою датчиків і комунікаційних мереж рівень сприйняття збирає дані про трафік у реальному часі, а мережевий рівень забезпечує надійну та безпечну передачу даних. Розробка заглиблюється в архітектуру протоколу автомобільної мережі зв'язку з акцентом на мобільних спеціальних мережах (MANET). У контексті транспортних спеціальних мереж (VANET) він охоплює питання безпеки, транспортний рівень, фізичний і медіа-контроль (PHY/MAC) рівень і протоколи маршрутизації. У статті досліджується інтеграція мобільних моделей із інструментами мережевого моделювання, окреслюючись двома методами: Mobile Fusion Model і Mobile Embedded Model. На завершення представлено дослідження моделювання з використанням платформи Optimized Network Engineering Tool (OPNET) Modeler, це дослідження оцінює Destination Sequenced Distance Vector (DSDV) Protocol і Optimized Link State Routing (OLSR) Protocol щодо продуктивності втрати пакетів, навантаження на мережу та Мережі зв'язку від автомобіля до автомобіля (V2V).

Ключові слова: V2V, Управління дорожнім рухом, Інтелектуальна транспортна система (ITS), Мережеві рівні.