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Traffic Regulation Using Advanced Internet Technologies Based on Blockchain

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Abstract: Today, a large number of citizens have to use public transport as well as their own, in order to go to work, to complete business obligations in different parts of the city or to use them during vacation or recreation. The above implies an organized traffic system that implies the functioning of all entities that directly or indirectly participate in the implementation. A large number of means of public transport, private cars, motorcycles, scooters and cyclists can at a certain moment create congestion that certainly disrupts daily traffic flows. When unplanned actions take place, there is a danger that for a certain period of time there will be a stoppage and even an interruption of traffic on a certain section of the road. Such situations cause nervousness among drivers, decrease concentration and unintentionally cause traffic accidents. The main goal of this paper is to present a model of electronic business that includes remote regulation of traffic from the dispatch centre, available horizontal and vertical signalling using blockchain technology. Innovative blockchain technology is currently the best protection mechanism for digital processes that take place in wired and wireless networks. In addition to the above, the protection system includes the storage, memorization and forwarding of a large amount of information, which, through later analysis, can represent the starting point for planning future models. Traffic regulation based on advanced Internet technologies certainly increases the throughput of major intersections as well as primary roads that are important for fire engines, police and emergency services.

Keywords: Regulation of traffic flows, safety of road users, innovative models of remote control, electronic business in traffic.

INTRODUCTION

This paper deals with the regulation of traffic flows on roads with increased participation of a large number of means of transport. Given that the safety of all participants is in the first place, innovative models must be applied that improve the safety of participants as well as processes that directly affect the functioning of traffic (Subotić et al. 2021:1271). By applying available technologies, a large number of potential problems in traffic and transport can be improved in a safe and secure way (Pavlović et al. 2020:500) (Pavlović et al. 2024:564). This paper presents related research by other authors, where various models for regulating traffic are presented. In the following, factors that can affect the safe flow of traffic will be analyzed, as well as an overview of the number of traffic accidents and the number of victims. The modelling of the innovative model for traffic regulation includes the necessary infrastructure and architecture that is the basis for the functioning of the system for collecting, analyzing and forwarding messages in a secure way that is based on blockchain technology.

RELATED RESEARCH

In the available literature, one can find a large number of works that apply blockchain technology for the security of a computer system that solves a certain problem using the Internet (Pavlović et al. 2023:424) (Pavlović 2022:1). Traditional traffic light control systems rely on traffic light intervals. Because they use technology that works in accordance with a system that lacks real-time flexibility, traditional fixed traffic light controllers have limitations and are less efficient. The ability to adjust the time intervals between the green and red light signals on the traffic lights must result in fixed time intervals that are constant. Excessive and unnecessary traffic jams occur, and cars use more gasoline. This ultimately causes environmental problems as well as a number of health problems for humans. The increase in the number of private cars has a negative impact on the environment. The authors (Khare et al. 2022:235) in their paper analyze the development of a traffic system that adapts to the current traffic conditions in one lane. In most cases, the average waiting time for all lanes is set. This idea proposes to monitor the number of vehicles in the lane to reduce the average waiting time. They represent a predictive model, which will make decisions based on previous traffic patterns, mostly at normally congested crossings. Emergency vehicles will also be identified and a faster route will be established for them.

Traffic congestion is a big problem all over the world, and especially for big cities.. It can lead to reduced productivity, increased CO 2 emissions and a negative impact on the economy. One solution to this problem is to rethink the design of the traditional traffic light system using modern technologies to make it smarter. The author (Migabo 2023:1) in his paper proposes the design and implementation of a smart traffic light system. The designed smart traffic management system uses image processing techniques to detect and track vehicles on the road. By comparing the number of lanes at an intersection, a smart traffic management system is able to determine which lanes have a higher density of vehicles. Lanes with a higher density of vehicles have priority, which means they are given a longer green light to allow more vehicles to pass. Lanes with lower vehicle density have lower priority, which means they are given a shorter green light to prevent unnecessary delays. The designed system has an additional function where it detects emergency vehicles on the road. Performance evaluation and experimental evaluation of the proposed smart system demonstrate its ability to accurately and reliably detect and prioritize emergency vehicles, detect and count other vehicles, and implement lane prioritization, traffic timing, and balancing. Overall, it was found that the designed smart traffic management system is an effective tool that can help regulate traffic flow.

At present, most road traffic systems adopt a static time allocation mode, that is, whether the traffic flow is in the peak or low peak period, the time allocation period and the traffic time of signal lights are fixed and constant. This time allocation method is very easy to cause traffic jams because it cannot handle the changing traffic situation in real time. In order to solve the congestion caused by the increase in traffic flow in a short time, a method of dynamic time regulation of traffic lights is proposed for quick relief of traffic pressure. First, the appropriate value of traffic flow and green light time is obtained. The dynamic optimization of the signal timing is performed with reference to the length of the queue of vehicles, so that the time of the green light of the traffic intersection becomes a variable parameter. In the process of adjusting the traffic flow, the traditional mechanism is improved by adding the idea of a variable target value. The actual output value of the vehicle adjusted to each cycle at the previous intersection is taken as the target value of the next intersection adjustment, which can dynamically change the timing scheme with the change of traffic flow, thus reducing the invalid intersection green light time to obtain the optimal timing regulation scheme. In this way, the traffic flow of each intersection can be reasonably adjusted and finally the target value can be achieved. The experimental results show that when the traffic flow increases in a short time, the traffic congestion will be caused by the static time distribution method in a short time. The method of time distribution and flow regulation in this work by the author (Huang et al. 2021:1152) can dynamically adjust the flow of traffic and effectively relieve traffic pressure.

In the present scenario, each traffic signal is switched on and off according to the time set for it. This causes unnecessary delay in the process of clearing the traffic jam. This is because roads with no vehicles get a green signal and sides with very heavy traffic get a red signal. This causes unnecessary congestion at intersections. This can be minimized by converting traffic signals from time-based systems to traffic density-based systems. When a traffic signal is based on density rather than time, the signals are switched on and off according to the amount of traffic on the roads. This system is used to reduce congestion on the roads. Here, a camera system is used for traffic control. In order to adjust traffic signals and advise alternative routes in case of traffic jams, they collect information at their individual locations and work together with other cameras in the system. The data obtained from the cameras are processed and the density of each corresponding side is determined, and according to the data, the traffic light is turned on (Prakash et al. 2023:1).

In their work, the authors (Elchaama et al. 2017:1350) propose a road regulation system that enables the expansion of the functional coverage of city traffic regulation centres. The proposed system helps in detecting the average speed in the system, reducing the number of accidents, smoothing the flow of traffic, reducing congestion and thus making travel easier. The proposed approach

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is based on a system where cooperative-vehicles participate in the election of a local leader by generating, analyzing and processing complex events. The rules in this network of complex event processing are semantically defined to ensure reactivity and adaptability to any situation. The proposed approach will help reduce congestion by making traffic more fluid with a traffic regulation system that does not depend on network infrastructure and is characterized by its reactivity, self-adaptation and autonomy.

TRAFFIC SAFETY LEVEL INDICATORS

Basic factors affecting traffic safety

In everyday traffic, various situations occur in which participants can be potential culprits. Their behaviour while driving, their attitude towards themselves and other participants is not at an enviable level. In this paper, some indicators have been selected as well as a proposal of measures that an individual should take before and during driving in accordance with traffic regulations. The most prevalent factors can be presented as follows:

- **Fatigue and exhaustion:** Fatigue prevails as a cause of traffic accidents with the most serious consequences. Tired drivers make mistakes that are not the result of ignorance but poor concentration and sleepiness. To avoid a bad driving outcome, we recommend not getting behind the wheel when you are tired and sleep deprived. During driving, especially on long destinations, you should take breaks as often as possible. In every car there should be at least one bottle of drinking water and some candy, which in moments of fatigue raises the driver's concentration.
- **Non-observance of traffic rules:** The most important item when it comes to driving safety is high-quality driver training, where traffic rules are mastered in detail. High-quality driver training at a driving school must include theoretical classes prescribed by law, where material related to driving rules is adopted. This is followed by comprehensive driving training in the field, during which the drivers apply the previously learned rules. It is good for drivers from time to time to refresh the material that they may have forgotten if they do not drive for a long period of time.
- **Stress and anxiety:** The driver's psychophysical condition significantly affects traffic safety due to reduced ability to perceive and speed of reaction due to stress. If the driver is under stress due to private events, the best solution is to take a break or stop driving.
- **Technical malfunction of the vehicle:** It is not uncommon for drivers not to check the vehicle's condition in detail before setting out on the road. Validation is a very important habit that should be adopted immediately after obtaining a driver's license. Failure of the brake system, lights and other parts can cause collisions with fatal consequences.
- **Bad weather conditions:** Fog and reduced visibility on the road are among the biggest causes of traffic accidents. Winter conditions, snow, rain and ice require additional equipment, but also great caution, because then driving a motor vehicle requires considerable experience. There are sections on our roads that are very inconvenient for driving in fog or snow due to poor signalling and should be avoided.
- **Traffic jam:** Increased intensity of vehicles in certain directions is a characteristic of the summer period and annual vacations. Taking into account other factors such as fatigue and heat, the probability of a crash on the open road is much higher. If you are forced to drive on sections of the road where there is a lot of traffic, plan more frequent breaks. Check the condition of the tires and the technical condition of the vehicle before setting off on the road.
- **Driving too fast:** Incorrect driving speed can be very fatal in the event of a traffic accident, because then the consequences are more drastic. In addition to the prescribed speed, you should also keep in mind the conditions on the road, such as works, landslides and narrowing.
- **Driving under the influence of alcohol:** Drunk driving is a very common cause of traffic accidents in urban areas, especially on weekends and during major holidays. Driving under the influence of alcohol must be absolutely avoided. If you plan to travel to the celebration, plan in advance who will bring you home. A little better organization can save more lives.
- **Awkward two-wheelers:** In the summer months, there are a large number of motorcycles and bicycles on the streets, which are often a real challenge in traffic. The reason for this is that cyclists and motorcyclists do not always follow traffic rules and do not wear adequate equipment. A particular problem is that they are not sufficiently visible to other road users.
- **Use of mobile phones:** Although the use of mobile phones while driving is prohibited, it is a habit that is difficult to change. The law stipulates a fine of 10,000 dinars for drivers who use the phone, but the number of traffic accidents does not decrease. A connection between the use of a mobile phone while driving and an increased number of accidents was established. Advice to turn off phones before driving so that calls and messages do not distract drivers.
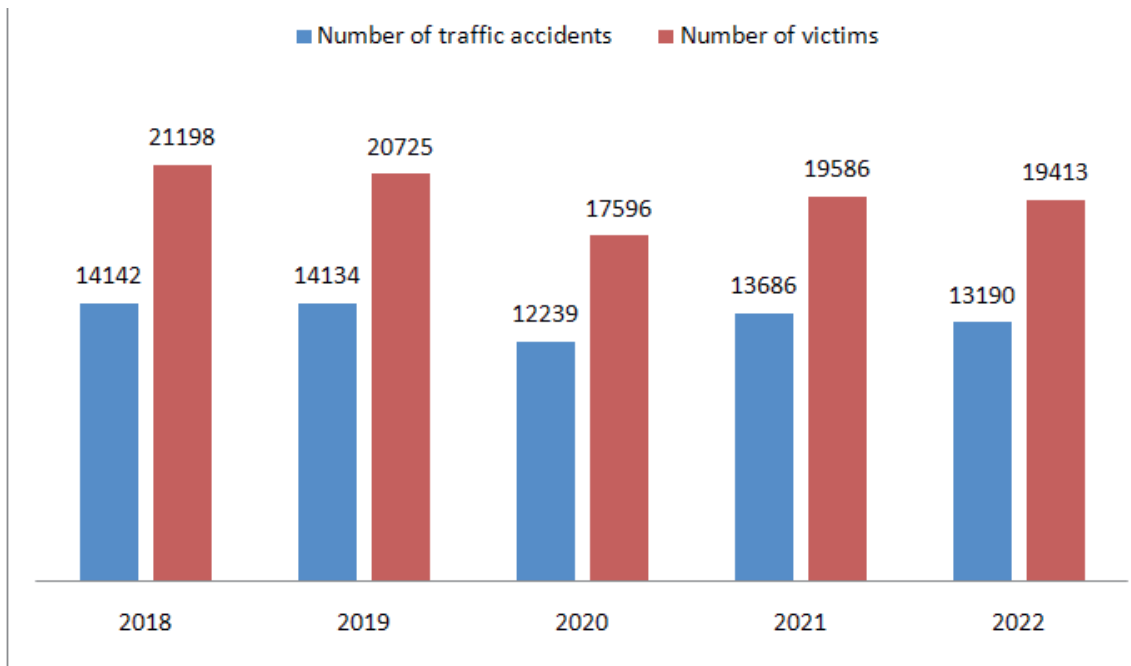
Figure 1. Indicators of the number of traffic accidents and casualties

The influence of basic factors on traffic safety

The constant increase in the number of road users, especially at intersections, leads to traffic jams that can also cause traffic accidents. The Republic Statistical Office (RSO, 2024) analyzes the number of traffic accidents every year, where the number of people who were killed is also analyzed (figure 1).

INFRASTRUCTURE AND ARCHITECTURE PROPOSAL FOR TRAFFIC REGULATION

Available technology that is applied in traffic creates intelligent transport systems that include the automation of traffic horizontal and vertical signalling. Today, when the exploitation of road infrastructure is increasing, it is also necessary to carry out reconstruction and regular maintenance in addition to the applied technologies. The application of intelligent transport systems based on advanced Internet technologies can increase road capacity and traffic safety. The protection of intelligent traffic systems is based on the application of blockchain technology, which today has become the strongest mechanism for storing, memorizing and transmitting all messages that arise in digital processes.

Traffic congestion is increasing all over the world, in large urban areas due to the increase in the number of cars, population growth, urbanization and new changes in population density. Basic factors that include the efficiency of the traffic infrastructure, increased travel time, fuel consumption, air pollution due to the burning of petroleum products can be improved with the application of advanced internet technologies in the segment of traffic regulation. Special attention should be paid to ad-vanced applications that, with the basic goal of providing traffic participants with various services that can also be related to traffic regulation. Application of advanced technologies in traffic can be a solution to the problem of regulating and increasing safety through digital communication as well as control of the intelligent system and all traffic participants.

Infrastructure components

The model in this work should include infrastructure consisting of hardware and software in the traffic control centre, sensors embedded in horizontal and vertical signalling, video surveillance cameras and equipment for wired and wireless connectivity. The proposed model for road traffic regulation includes the following components:

K1. Physical infrastructure architecture:
- Passive equipment;
- Servers;
- Routers;

K2. Software infrastructure:
- Blockchain technology;
- Wireless transmission technologies;
- Wireless transmission standards;

K3. Infrastructure management for:
- Analysis of technical performance;
- Supervision of the infrastructure;
- User interface;

K4. E-business services:
- Content creation;
- Management of notifications;
- Data analytics;

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K5. Infrastructure of quantitative components:
- Security;
- Availability;
- Efficiency.

Components of the architecture of the innovative model

The architecture of the model must provide a safe and secure way of collecting and forwarding messages detected by sensors on horizontal and vertical signalling. Messages are protected by an innovative mechanism called blockchain. The innovative architecture model contains the following components:

K1. System architecture for the storage of Regulations, Instructions, Legal Provisions:
- Database;
- Management of data on registered means of transport;
- Data archiving;
- Security and data protection.

K2. The architecture of the system for storing the generated digital messages:
- Database;
- Management of collected data;
- Data archiving;
- Security and data protection.

K3. Blockchain Technology Architecture:
- Blockchain platform;
- Closed network and right of access;
- Identification of the nodal network;
- Implementation of consensus protocols

K4. Integration of blockchain technology, computing devices, sensors with a data storage system:
- Interface for connecting to an innovative database;
- Communication protocols;
- Security and data protection.

K5. Application integration with authorized traffic regulation services:
- Interface for communication with blockchain technology;
- Services for the exchange of messages between locations on roads and the control centre;
- Security and data protection.

The main purpose of the model in this paper is to protect the data exchanged between devices and computers in the traffic regulation system. Data protection is performed using blockchain technology, which today is the most suitable data protection in a reliable and verifiable way. Blockchain represents a series of chronologically sorted records that are organized into blocks and linked, recorded in a ledger (a large database) and protected by cryptography. Each block contains a cryptographic hash code, a timestamp, and information about the transaction itself. A hash code is actually the result of a mathematical function of transforming an input of arbitrary length into an encrypted output of a fixed length and is the basic tool of modern cryptography. Each new block that is created must have a hash of the previous block, where data integrity is guaranteed because if a malicious person tries to make certain changes, he must also make changes to all previous blocks. In practice so far this has not been achievable and that is why blockchain technology is the most reliable protection mechanism. The basic functioning of blockchain technology, which has been applied to develop a model for regulating traffic and increasing security, is shown in the figure 2.

The applied blockchain technology as well as the functioning of the innovative model is shown in the picture. The sensors installed on the horizontal and vertical signalling collect data, forward it via applications to the database located in the cloud, after the flow, the collected messages are analyzed by the applications in the control centre for traffic regulation and from the centre there is feedback that determines new time intervals on the vertical signalling as and the duration of the green light. All the mentioned transactions in the computer system are protected by blockchain technology. The architecture of the model is shown in Figure 3.
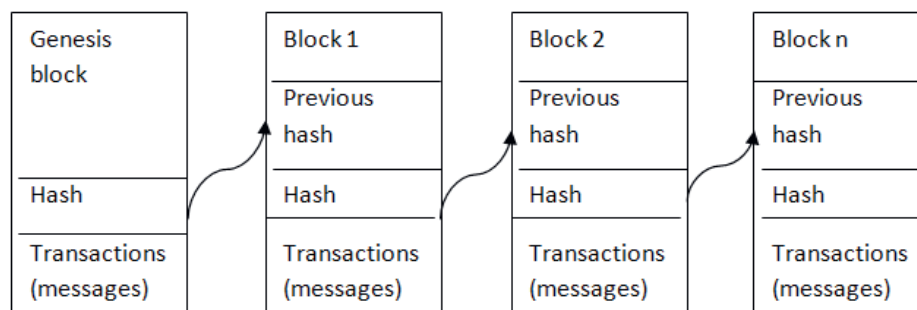

Figure 2. Functioning of blockchain technology

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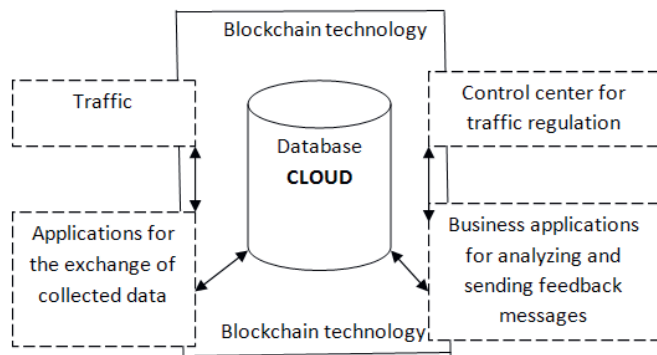
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Figure 3. The architecture of the blockchain-based model

The presented architecture and infrastructure is an integral part of the traffic regulation system based on electronic business. The benefits of applying digital models multiply speed up and improve business activities when it comes to the time needed for data collection (counting means of transport at potential places where congestion may occur), a large number of people who perform the work (for counting means of transport, for processing of collected data, for calculating time intervals when changing the green light on the traffic light or prolonged retention of the red light on the traffic light) and a large number of roads on which analysis must be performed and the like. Given that it is a question of transforming previous activities involving a large number of people, this model has been reduced to a minimum. Also available computer equipment can be upgraded with certain software add-ons with minimal financial investments.

The protection of such innovative electronic business systems is carried out by advanced internet technologies with a blockchain mechanism. Blockchain provides the protection of the entire system because it includes all processes from the detection of means of transport to the feedback to the vertical signaling, the traffic light, which at that moment works on the basis of new instructions. In particular, it should be noted that after removing the potential congestion and on the basis of new information about the reduced flow of vehicles, new information is automatically created in the traffic regulation system, which is forwarded to the vertical signaling to start the regular mode of operation.

CONCLUSION

This paper presents the infrastructure and architecture of the traffic regulation model where communication and message exchange are protected by blockchain technology. Traffic regulation activities in digital transformation include a model where the human factor can be completely eliminated in current situations that can be a potential threat.

The main purpose of the model is that it automatically forwards to the control centre based on the real state of the roads detected by sensors and based on that

information, feedback messages are sent that are also an order to adjust the vertical signalling. Adjusting the vertical signalling implies that the green light on the traffic light extends the time interval in order to speed up the flow of vehicles from the busy direction, while on the other side where the traffic intensity is lower, the interval of the red light prohibiting movement from that direction is extended.

BIBLIOGRAPHY

[1] Subotić, M.; Radičević, V.; Pavlović, Z.; Ćirović, G. Development of a New Risk Assessment Methodology for Light Goods Vehicles on Two-Lane Road Sections. Computer and Engineering Science, *Symmetry* 2021, Vol.*13*, Iss.7, pp.1271 https://doi.org/10.3390/sym13071271

[2] Pavlović Z, Banjanin M, Vukmirović J, Vukmirović D., (2020,05,04): *Contactless ICT Transaction Model Of The Urban Transport Service*; Research journal TRANSPORT, ISSN: 1648-4142 / eISSN: 1648-3480, Vol 35 No 5, pp 500-510. https://doi.org/10.3846/transport.2020.12529

[3] Zoran G. Pavlović, Veljko Radičević, Miloš Stojanović, Vasko Nikolov, Zlatko Belancan; Analysis *of application of mobile internet technologies in digitalization activities,* Book of Proceedings, International Multidisciplinary Conference "Challenges of Contemporary Higher Education" - CCHE 2024 Serbia, Kopaonik January 29th - February 2nd 2024 Vol_1, pp564-569 https://drive.google.com/drive/folders/15cMDG0QcNFyAIeeKTUMhqASA1NGZmvzJ

[4] Zoran G. Pavlović, Veljko Radičević, Marko Bursać, Miloš Milanović, Nevena Veljović: RAIL TRAFFIC SAFETY BASED ON ADVANCED INTERNET TECHNOLOGIES, Proceedings IX International Symposium NEW HORIZONS 2023 of Transport and Communications, 24-25 November , 2023, Doboj, Republic of Serbia , BH, University of East Sarajevo, Faculty of Transport and Traffic Engineering Doboj. pp 424-430, ISBN 978-99976-12-06-9,   http://novihorizonti.sf.ues.rs.ba/wp-content/uploads/2024/02/NH23_Proceedings.pdf

[5] Z. G. Pavlović, "Technologies of electronic business in traffic," *2022 21st International Symposium INFOTEH-JAHORINA (INFOTEH)*, 2022, pp. 1-4, doi: 10.1109/INFOTEH53737.2022.9751297. https://ieeexplore.ieee.org/document/9751297

[6] R. Khare, A. Naik, S. Raj, A. Srivastava and S. Khandare, "Green Corridor Implementation and Real Time Adaptive Traffic Regulation using Machine Learning and Image Processing," *2022 IEEE Industrial Electronics and Applications Conference (IEACon)*, Kuala Lumpur, Malaysia, 2022, pp. 235-239, doi: 10.1109/IEACon55029.2022.9951734.

[7] E. M. Migabo, "Design and Implementation of A Smart Traffic Light System for Efficient Traffic Regulation," *2023 IEEE AFRICON*, Nairobi, Kenya, 2023, pp. 1-6, doi: 10.1109/AFRICON55910.2023.10293281.

[8] Y. Huang, Y. Yu and Z. Guo, "Research on Intelligent Timing and Flow Regulation of Traffic Lights," *2021 IEEE 5th Information Technology,Networking,Electronic and Automation Control Conference (ITNEC)*, Xi'an, China, 2021, pp. 1152-1156, doi: 10.1109/ITNEC52019.2021.9587309.

[9] D. Prakash, K. Sathiyasekar, N. Chitra and T. Pragadeeshwaran, "An Efficient Traffic Regulation Using Real Time Pixel Based Density Identification Techniques," *2023 Eighth International Conference on Science Technology Engineering and Mathematics (ICONSTEM)*, Chennai, India, 2023, pp. 1-6, doi: 10.1109/ICONSTEM56934.2023.10142430.

[10] R. Elchaama, B. Dafflon, R. K. Chamoun and Y. Ouzrout, "Toward a traffic regulation based on event processing agent system," *2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC)*, Madeira, Portugal, 2017, pp. 1350-1356, doi: 10.1109/ICE.2017.8280038. (RSO, 2024) https://www.stat.gov.rs/publikacije/publication/?p=15710 05.05.2024.