Smart City Total Transport-Managing System

(A Vision Including the Cooperating, Contract-Based and Priority Transport Management)

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Abstract. Today's nations are facing numerous challenges in transforming living environments in a way better-serving people's demands of the future. The principal point in this transformation is reinventing cities as smart cities that combine their data, their resources, their infrastructure and their people to continually focus on improving livability while minimizing the use of resources. The usage data and sensor network is the primary characteristics of any smart city. However, just having data is not enough, data points themselves are only information. It is good to have, but hardly useful by themselves.

This paper gives a short overview of the concepts for transport management system in the smart city and proposes a new transport management approach that is contract-based and priority transport management. These methods allow to estimate and control traffic efficiently. Based on these concepts, the authors propose a new transport management system that is working as a single system. This proposed system has three layers: physical, info-communication and control generation. The system deals with four different classes of tasks: (i) handling the non-cooperative vehicle, (ii) traffic management based on the cooperative vehicle information, (iii) contract-based traffic management, (iv) priority transport management. Some benefits of implementing this system are also expected in this paper.

Keywords: Smart city · Transport system · Intelligent transport management
Contract-based transport management · Priority transport management

1 Introduction

There are various definitions of a smart city, which have been given over the years. The original concept is the "information city", and then evolving into an idea of the information and communication technology (ICT) – centered smart city. There are six main dimensions of the concept: (1) a smart economy, (2) smart mobility, (3) a smart environment, (4) smart people, (5) smart living, and (6) smart governance [1, 2]. The smart city prefers to focus on factors such as human capital and education than the digital city or intelligent city do.

Taking everything into account, the functions of a smart city are (i) reducing the amount of resources used to provide features to citizens, (ii) focusing on services – not

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on infrastructure – to provide these functions, and (iii) integration of services, respectively service providers to gain a suitable and pleasant user experience [3].

In this paper, transportation management will be determined by the authors due to it is the primary public function of a smart city. Drivers and service providers (SPs) have different goals that each strives to satisfy. SPs try to optimize overall system-wide task. Drivers discovery trip plans whose performance will complete their individual travel preferences subject to current network conditions. They also want their trip performance to be equivalent to others who are making similar trips through the network. A driver might interpret this trips because of the need to optimize the perceived ‘quality of service’. Therefore, the roadway routing problem is solved by global solutions that must be acceptable on two levels: (i) satisfying individual drivers, and (ii) the network as a whole.

The successes of the intelligent transportation system (ITS) technologies, such as route guidance systems [4], were measured by improvements in system performance as a function of market penetration and levels of user compliance. The issue of individual driver quality of service is overlooked or down-played as supply-side traffic management systems strive to optimize network performance. Traffic assignment approaches are based on assumptions regarding driver preferences and system-wide objectives [5]. While “equilibrium” solutions often satisfy supply-side objectives [6, 7], there is little evidence that expectations of individual drivers are met.

Approaches to traffic management that will be perceived by drivers as increasing quality of service and resulting in increased compliance will require the more active involvement of drivers themselves. Directly involving drivers in the assignment process can help achieve this goal. A traffic management system that is a contract-based method has the potential to overcome the problems of compliance and encouraging drivers to work with the system operators to generate assignments that are mutually beneficial.

Contract-based transport management (CTM) proposes an innovative traffic management solution able to face the challenge of traffic growth and improves the efficiency of the European transportation systems.

There is only a few research on the effect of the transport management approach, which is based on the contract between management centers and drivers, or priority management. All most of them consider the cooperative system or full priority such as emergency and police vehicles. In this study, we propose novels contract-based and priority transportation management, which is likely to the cooperative type but the users have to pay for the contract to get service.

The objective of this paper is introducing the transport management depending on the possible cooperativeness and needs of drivers.

This paper is organized as the following: Sect. 2 provides an overview of the related literature and determines the research questions. The supporting systems are presented in Sect. 3. The proposed transport management system is given in Sect. 4. There are some conclusions in Sect. 5.

2 Literature Review

While giving a better service to the inhabitants by fulfilling personal demands in an easy to use, flexible and cost-efficient way, the smart transport expects to reduce the pollution and the related health risks to improve quality of life in urban areas [8]. To allow active traffic management the current traffic situation and operating grade has to be captured to enable predictions on future conditions to hedge decisions made by actors and decision engines.

The significant issue while implementing those kinds of systems is providing a reasonable basis for a decision. The best foundation for decisions is knowing about the current state of the overall system. Therefore, the autonomic transport management systems (ATMS) has an essential aspect that is the data acquisition and the networks transporting the information about the current situation in the field. At this point, it was evident that the reliability of data is essential and an essential requirement to the ATMS. Establishing an autonomic system gives some significant advantages in increasing the safety of the overall operations.

Traffic planning is powered by online timetables calculating the optimal way to use public transport regarding time and costs. The travel planner can use a typical graph for all requests and generate lookup tables to guaranty short answering times. Since the upcoming mega trends smart cities, personalized medicine and personalized production by industry 4.0, the ATMS used to establish smart transportation that solves a wide range of new requirements for transport. Moreover, the smart transit provides personalized mobility and goods transportation.

However, users prefer to share contents than to interconnect themselves to remote devices. Thus, the trend of imminent possibility of the future smart cities will affect enhancing services that will be given and employed [9].

Contract-based and priority transportation management approaches are relatively new ones. Consequently, very little academic literature deals directly with such managing types applied in city transport. In the only relevant research paper found on the topic, [10] presented a case study based on blockchains. This research is a case study for blockchain-based real-time ride-sharing services, in which the newly developed parallel transportation management systems are built based on blockchain that is considered as one of the secured and trusted architectures.

In the level of priority transportation management, an adaptive control algorithm for pre-signals tailored to real-time private and public transportation demands was developed as well as established the necessary infrastructure to operate an adaptive pre-signal [11]. They suggested that the travel times of buses in cities can be reduced by using the pre-signal approach to public transport. The primary purpose of this method is to allow buses to jump the car queues upstream of the intersection while cars can still use all the lanes at the primary signal to fully utilize the capacity of the intersection. By this way, the bus delays are reduced, while the capacity loss at the intersection is minimized.

The operation buses on signal-controlled using special lanes was also evaluated [12]. The results showed that bus lanes with intermittent priority did not significantly reduce street capacity, but increased the average traffic density at which the demand is served, and therefore, increased traffic delay. Thus, they proposed the homogeneous system which is estimated travel and arrival times reduction.

Above literature suggests that the real-time dynamic roadway routing problem on instrumented networks is unique in that communication between drivers and system managers (or service providers) is needed to promote optimal solutions. The real-time information is necessary to choose an effective route. Although drivers can aid with routing decisions, they are not capable of handling the significant data needs and must rely on the knowledge network to gather needed information from the system. Thus, it is necessary to establish the contract between demand (drivers) and supply-side (service providers) because of both attain efficient capacity allocation network-wide and satisfy each driver's routing needs and preferences.

The overall idea of contract based transport management in a smart city has been born by studying the air traffic management.

The air traffic is observed and managed by air traffic controllers. The primary surveillance system uses radar for observing all the flying objects. The secondary radar system detects the – so-called – cooperative targets, namely aircraft identifying themselves by sending a response on the radar signal [13]. The contract-based air transport concept introduced a new principle in air traffic management by moving it to a market-driven air transportation system [14].

Principally connected transport principle [15] is on somehow analogue to the cooperating transport idea.

3 Supporting Services

3.1 Internet of Thing Devices

Everything in a smart city is tied together by the Internet of things (IoT) that is one of the essential components in any smart cities. The smart cities work based on the data created by sensor networks that gather and share useful information. The cities can be managed in real-time with this information, and minimize unintended consequences with sufficient integration data. Because of dependence on sensors grows, it is the need that sensors are reliable and that the systems to which sensors are connected will be able to put up with the inevitable failures.

The transfer usable and potentially could be challenged since cities improve from millions to billions, and the trillions of devices. It is noticed that the need for a user-selected can be fulfilled nearby, by which the convenience will be presented without tying up some of the bandwidth of the carrier data networks.

Using data and sensor technologies to present insight is at the core of what it means to be an ITS. However, just having data is not enough; data points themselves are merely information. It is good to have, but hardly useful by themselves. So, a transport system that can connect data points can build a picture of its users. A knowledgeable transport system combines enough data to make unique practices better. Because more and more objects become joined through the Internet of Things (IoT), so they accumulate more data that can be used to inform planning tailored to individuals and populaces. It is estimated that 50 billion objects will be connected by 2020 for an added economic value of US$19 billion [16, 17].

3.2 Information and Communication Technology – Cooperating Transport

Information and Communication Technology (ICT) platforms became the ground floor of the Smart City foundation, thanks to their capability to offer advanced services in ITS, environmental and energy monitoring, building management, healthcare, public safety and security, remote working, and e-commerce domains [18]. Therefore, ICT plays a vital role by interconnecting all the actors of a Smart City [19] and by supporting the provision of seamless, everywhere services [20].

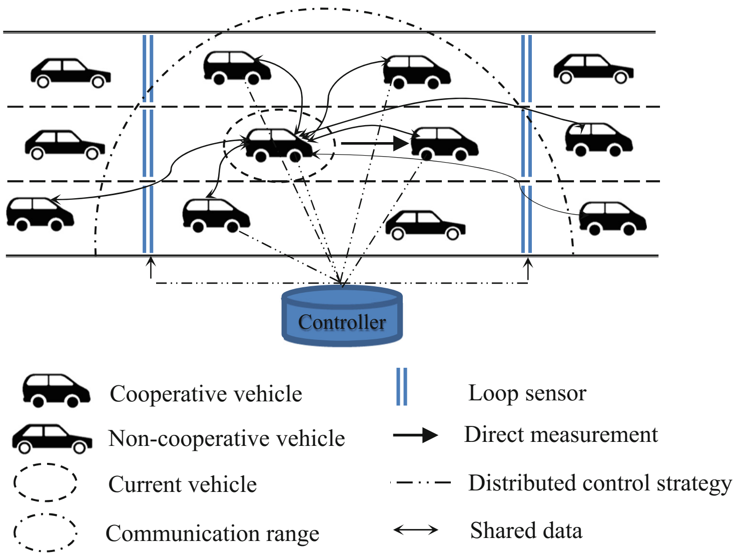

Fig. 1. The general framework of cooperative systems

Advances in ICT enable the transportation community to anticipate dramatic improvements concerning a more efficient, environmentally friendly and safe traffic management. One of potential traffic management systems is a cooperative system with the methodological concerns following the development of such systems [15]. The cooperative traffic models were used as a framework to simulate. The simulation results have shown that (i) with a high amount of cooperative vehicle, only fewer lane changes occur because the cars are organized around an equilibrium state; (ii) the defined cooperative strategy presents a higher impact than adaptive cruise control (ACC) for low penetration rates; (iii) the transition between congested and free flow states appears smoother with the cooperative strategy than the ACC system; (iv) the trust layer reinforces the homogenization effect and this approach provides the best performances.

Furthermore, Information-Centric Networking (ICN) is a concept which has risen as a hopeful candidate for the design of the future Internet [21]. The ICN provides the use of in-network caching and multicast mechanisms by indexing information at the network layer. Therefore, the facilitation is efficiency, and the delivery of the data to the users is opportune. They provided seven ICN approaches to provide a unified view of the alternative proposals by defining a set of core ICN functionalities, e.g., name resolution and data routing, mobility and security.

However, despite the fact that the current Internet architecture corroborates the communication among all of these technologies, it appears a set of conditions related to the decoupling of materials from the knowledge of their location, security aspects, and services scalability.

The future Internet can contribute solutions to many requests that transport management system has to face, but, contrariwise, also this system can give an outstanding experimental environment for probing advantages and disadvantages of future Internet architectures in a variety of application domains.

Each of these technologies works together to make a transport system even more improvement. Because the world's population grows, and more people move into urban areas, the need for more improved transport system will increase to make the best use of available sources.

In our terminology, the non-connected vehicles are the non-cooperative vehicles. The connected ones are the cooperating vehicles. The cooperation might be realized on the local basis (as is shown in Fig. 1) or globally when the transport management is harmonized from the control center. Generally, the cooperating vehicles publish and allow to use their vehicle performance, travel goal and (GPS) positioning data.

4 The Transport Management System

4.1 System Description

The developing traffic-managing system (TMS) is a net-centric system uses the military strategic command concept that in the highest level called as C4ISR (Command, Control, Communications, Computers and Intelligence, Surveillance, and Reconnaissance). The system uses the vast distributed network of sensors for surveillance and recognition of the different cooperating and non-cooperating vehicles, extreme traffic situations (Fig. 2). The sensors are mechanical, optical, electromagnetic, biological, etc. sensors. Extensive wireless communication transfers the sensed data to the system center (working as a command point). The intelligent system generates the controls for avoiding the extreme and dangerous situations as well as for managing the more useful, greener traffic and supporting the contracting vehicles and priority traffic. The controls are realized through the traffic controls (control lights, control signalization, and actuators integrated into the infrastructure). There is no principal difference in cases when the vehicles are moving autonomously, or driver controlled. A driver screen may show the position of the other vehicles, obstacles around the vehicle.

The system has three layers: physical, info-communication and control generation. The physical part including all the vehicles, the available infrastructure and the sensor network, traffic controls integrated into the infrastructure. The infrastructure takes part in the system entirely. That means, for example, a series of signal lights are built into the line dividing the lanes. The communication is based on the wireless system, partly on using the Internet. The control layer is a hierarchically organized software set. It is

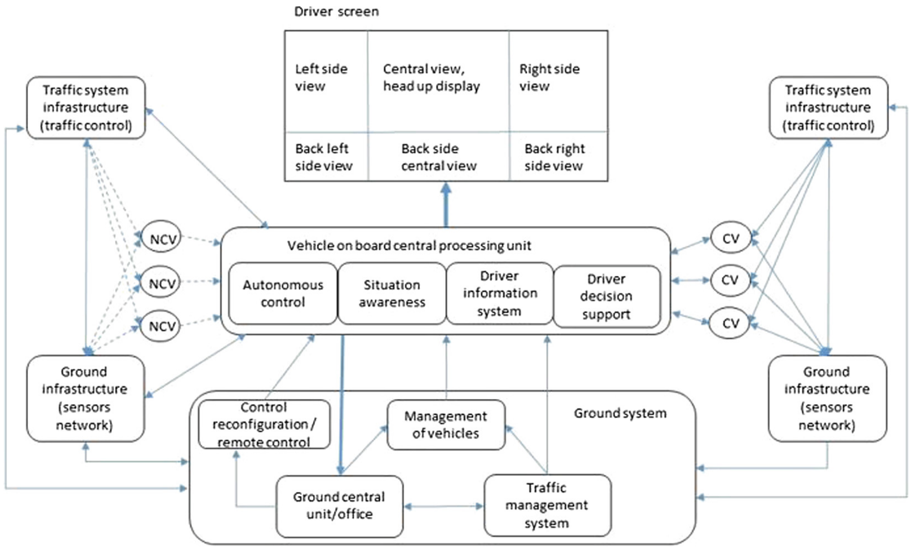

Fig. 2. The traffic-managing system architecture (NCV - non-cooperative vehicle, CV - cooperative vehicle)

used for recognition and classification of the vehicles, traffic situation awareness, conflict detection and resolution including the sense and avoidance of the obstacles, other vehicles, people, etc. The system uses the simulation evaluation of the systems and developing the required traffic and vehicle controls.

4.2 Concept of Operation

The system is working as a single system, while it deals with four different classes of tasks.

Handling the Non-cooperative Vehicles

The system collects all the available and measured information about the traffic infrastructure condition, traffic intensity and complexity, and about all the vehicles regardless of they are cooperative or non-cooperative vehicles, here vehicles mean all the types of vehicles including the road or railway, water transport vehicles, that may be individual, personal vehicles, or vehicles of mass transport systems. This information is the primary input (data of primary surveillance).

The system identifies the non-cooperative vehicles and classifies them depending on their size, mass, predicted performances (as acceleration, turning radius) and predictable goal of trips. The optical, infrared, ultrasonic, radar, etc. sensors built into the traffic infrastructure, into the road, lampposts, traffic lights, nearby buildings, etc. as the elements of the first surveillance, provide the inputs. The system applies this information in short time forecast of the traffic intensity and complexity together with information provided by the cooperating vehicles. The goal is to evaluate where, which direction will increase the traffic, where the traffic jam might appear. With managing such traffic situation, traffic jam, the developing system will support even the drivers of the non-cooperative vehicles. For example, the 4 lanes road might be dynamically controlled: two lanes supporting the traffic into the more intensive traffic direction and one, only, for the other direction, while one lane will dedicate to the contract-based and priority traffic.

Traffic Management Based on the Cooperative Vehicle Information

In air traffic management, the aircraft have transponders that reply to each interrogation signal by transmitting a response containing encoded data identifying the given aircraft. This is the secondary surveillance. In a smart city, net-centric transport managing system, the cooperating vehicles continually provide information about the type of vehicle, motion condition (velocity, changing in velocity, direction, etc.) and actual (GPS) position. This is simple, first level cooperation. The connected vehicles provide this information to the nearby vehicles, too, and harmonize their motions.

The second level of cooperation is characterized by sending the information about the goal and target (geographical positions) of trips to the traffic-managing center. The vehicles applying the third level cooperation send data to the traffic managing center about the nearby vehicles, the condition of infrastructure, traffic situations, etc.

The inputs from primary and secondary surveillance allow introducing total traffic management. Of course, the traffic management may support the cooperating vehicles directly.

Contract-Based Traffic Management

Nowadays, many researchers, cities are working on developing special support the smarter transport. These activities deal with developing the information systems for mass transport, supporting the mode choices, developing optimal transport modal systems, developing the control for connected vehicles, organization, and management of information control for groups of vehicles, supporting the car sharing, information on parking availability, autonomous control of vehicles, etc.

The contract-based traffic management (CTM) introduces a new service opening new market segments for people would like to use it for reducing their travel time. That possible services may start from the dedicated parking areas at P + R systems, through the special small buses transport from parking place to the city business centers, drop off car system. When the driver stops the car anywhere in the city and the traffic-managing system will park it at the nearest parking place. Later the system will transfer the car to the driver defined place. The system may use a remote control or the car may have the required information from the transport-managing system and may pay autonomous.

The CTM is a supporting service that brings together drivers and service providers (SPs) of transportation services to increase the efficiency of both drivers and SPs operation. One way this service benefits driver is that they are the first people who have essential information, thereby they increasing their satisfaction and obtaining their goals. SPs, too, may benefit from contract-based by gaining profit from this contract, allowing for efficient operation increasing supply competition.

The CTM model uses goals rather than positions to achieve an efficient reallocation of network-capacity over time and space without seriously violating any individual driver's preferences for routing, departure, and arrival time. The goal is to achieve more efficient metering of scarce roadway capacity by steering drivers toward paths that will satisfy their individual needs while also improving overall network execution. A good solution derived from CTM will result in drivers being satisfied that their needs and preferences were achieved by their resultant trip itinerary and the SPs being satisfied with the improved system-wide performance.

Figure 3 presents the CTM for roadway routing. It is proposed that if drivers and SPs pursue a collaborative, problem-solving approach to negotiate trip planning, better results will be realized on both sides. Drivers will be able to follow a trip itinerary that better meets their travel objectives.

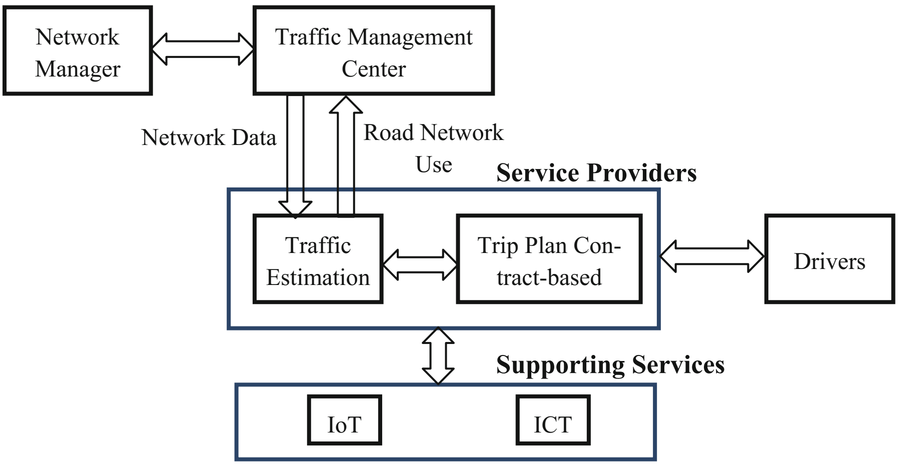

Fig. 3. Conceptual view of contract-based transport management

The SP receives traffic data and driver information from the network managers and in return provides the network managers with information on current and anticipated roadway use gathered from its driver base. Drivers rely on the SP for giving traffic advisories and seek to negotiate trip plans. However, since the SP has a cooperative arrangement with the system, and the system-side traffic management objectives may differ from those of the individual driver, there is always an element of distrust among drivers.

The top level of contract-based traffic may include a “semi priority” system. By using this principle, the contract-based vehicles may use for example bus lane opening provisionally (for a short time) if it was not disturbing the bus transport. In such cases, the drivers will have information from the transport-managing centers about the recommended shortest ways and possible shorting the traveling time and the same time they will see special commanding signals on the road (appearing for the short time and the given vehicles).

The contract-based transport may work on the basis first come – first served without disturbing the existing transport concept and system and even – in case of extra service – it may apply as the personalized taxi.

Priority Transport Management

The developing transport management system uses all the available information about the transport infrastructure, vehicles, traffic complexity, appeared in traffic situations and may simulate the transport and determine the future optimal, more efficient transportation. Therefore, it may manage the priority transport, too.

Generally, the transport-managing system uses passive methods for monitoring the non-cooperative transport, semi-active methods (for partly controlling) the cooperating transport, active method for supporting the contract-based transportation and proactive approach for managing with priority transport.

The priority transport (as police, fire machines, ambulances, traveling the protected persons, etc.) might be supported by opening them the free lanes, freeways by the total transport-managing system.

4.3 Benefits

At a conceptual level, the CTM and priority transport management (PTM) can be regarded as operational ways of achieving the satisfaction of users and service providers. They represent a possible means by which all the operators can share a unique and impartial view of each other's priorities. Thus, they ensure a standard translation and representation of the performance targets to be achieved by the overall transport chain.

At a second more operational level, CTM unequivocally identifies the transfer of responsibility areas between partners, and at the same time, they organize a way of controlling doubtfully and monitoring disruptions. Measurement of compliance with CTM established during the negotiation process could represent a new and reliable metric for assessing the quality of a provided service.

CTM and PTM concepts are expected to directly bring the following substantial benefits to the transport management system:

Firstly, more punctuality at the destination: The CTM and PTM are designed to achieve an ultimate goal, namely arrival on time at the destination places. Through the CTM and PTM the users, drivers, and services providers share the same goal for the vehicles represented by an agreed contract. The synergy between the service providers and users is thus reinforced. Users will reduce delay-related costs and optimize their cars. Service providers will be able to optimize their operations and maximal profits. Even though the efficiency design target identified by IoT and ICT services applies to on-time, a strong correlation between punctuality at departure and the destination exists. It would be interesting to evaluate this correlation during the assessment process, especially in the real-time process.

Secondly, improved predictability: The CTM and PTM are designed taking into account vehicle technical constraints, with built-in scope for disruption management aiming to achieve the ultimate target of the objectives, which is arriving on time at the destination. Each operator knows it's part of the contract, i.e., those contract it must fulfill. Drivers will be able to build on their programs, as predictability will be improved, and they should get a better payoff from their fleet. The management centers will also be able to rely on their schedules, and so optimization of their operations will be possible, which will not only enhance the quality of service delivered to users but also improve the infrastructure pay-off.

Thirdly, reduced overall costs: Drivers will be able to place more trust in scheduling, which will allow them to mitigate delay-related costs, and thus improve the operational costs of vehicles. Providers will get a better approach and better scheduling of their operations, and will, therefore, be able to dedicate the right number of resources to service equipment, which will lead to cost-efficiency.

Finally, reduced environmental impacts: like cost reductions, environmental benefits are mostly linked to the better use of resources (e.g., real-time information, capacities of traffic system) and improved predictability. Drivers will state their preferred routes by economic business models, and thus minimize fuel/energy consumption and improve the "distance/fuel consumption" ratio.

5 Conclusion

The primary aim of implementing the contract-based and priority transportation management is to work towards real-time operations in the traffic system. As these CTM and PTM are consensual trade-offs issued during negotiation between all the actors, even if the economic models of this different actors change, this proposed concepts will be still viable. These concepts also allow all traffic management operational methods, which are bound up with the specific characteristics of the various types of traffic and local areas, to become genuinely adaptable.

This study also describes the transport management system including three layers: physical, info-communication and control generation. The system uses the vast distributed network of sensors for surveillance and recognition of the different cooperating and non-cooperating vehicles. The operational system based on four different classes of tasks. Some benefits of this system are also estimated as the results of this research.

Our future research considers the assessments regarding the systemic and operational issues. The traffic management system works in these ways for establishing fitness for the proposed ideas, based on pieces of evidence.

References

1. Lee, J.H., Phaal, R., Lee, S.-H.: An integrated service-device-technology roadmap for smart city development. Technol. Forecast. Soc. Change **80**(2), 286–306 (2013)
2. Giffinger, R., Gudrun, H.: Smart cities ranking: an effective instrument for the positioning of the cities? ACE Arch. City Environ. **4**(12), 7–26 (2010)
3. Schlingensiepen, J., Mehmood, R., Nemtanu, F.C.: Framework for an autonomic transport system in smart cities. Cybern. Inf. Technol. **15**(5), 50–62 (2015)
4. He, Z., Guan, W., Ma, S.: A traffic-condition-based route guidance strategy for a single destination road network. Transp. Res. Part C Emerg. Technol. **32**, 89–102 (2013)
5. Peeta, S., Ziliaskopoulos, A.K.: Foundations of dynamic traffic assignment: the past, the present and the future. Netw. Spat. Econ. **1**(3–4), 233–265 (2001)
6. Yang, H., Bell, M.G.: Traffic restraint, road pricing and network equilibrium. Transp. Res. Part B Methodol. **31**(4), 303–314 (1997)
7. Yang, H., Huang, H.J.: The multi-class, multi-criteria traffic network equilibrium and systems optimum problem. Transp. Res. Part C Emerg. Technol. **38**(1), 1–15 (2004)

8. Accenture: Building and managing an intelligent city. Technical report (2011). http://www.accenturecom/SiteCollectionDocuments/PDF/Accenture-Building-Managing-Intelligent-City.pdf
9. Ahlgren, B., Dannewitz, C., Imbrenda, C., Kutscher, D., Ohlman, B.: A survey of information-centric networking. IEEE Commun. Mag. **50**(7), 26–36 (2012)
10. Yuan, Y., Wang, F.-Y.: Towards blockchain-based intelligent transportation systems. In: 19th International Conference on IEEE Intelligent Transportation Systems (ITSC) (2016)
11. Guler, S.I., Gayah, V.V., Menendez, M.: Bus priority at signalized intersections with single-lane approaches: a novel pre-signal strategy. Transp. Res. Part C Emerg. Technol. **63**, 51–70 (2016)
12. Eichler, M., Daganzo, C.F.: Bus lanes with intermittent priority: strategy formulae and an evaluation. Transp. Res. Part B Methodol. **40**(9), 731–744 (2006)
13. Galotti, V.: The Future Air Navigation System (FANS): Communications, Navigation, Surveillance – Air Traffic Management (CNS/ATM), p. 362. Aldershot, Avebury Aviation (1997)
14. Guibert, S., Guichard, L., Rihacek, C., Castelli, L., Ranieri, A.: Contract-based air transportation system to fulfil the arriving–on-time objectives. In: 26th International Congress of th International Council of aeronautical sciences, (ICAS), p. 8 (2008). https://www.eurocontrol.int/eec/gallery/content/public/document/eec/conference/paper/2008/004_CATS.pdf
15. Guériau, M., Billot, R., El Faouzi, N.E., Monteil, J., Armetta, F., Hassas, S.: How to assess the benefits of connected vehicles? A simulation framework for the design of cooperative traffic management strategies. Transp. Res. Part C Emerg. Technol. **67**, 266–279 (2016)
16. Minch, R.P.: Location privacy in the Era of the Internet of Things and Big Data analytics. In: 48th Hawaii International Conference on IEEE System Sciences (HICSS), pp. 1521–1530 (2015)
17. Coppa, I., Woodgate, P., Mohamed-Ghouse, Z.: Global outlook 2016: spatial information industry (2016)
18. Piro, G., Cianci, I., Grieco, L.A., Boggia, G., Camarda, P.: Information centric services in smart cities. J. Syst. Softw. **88**, 169–188 (2014)
19. Hernández-Muñoz, J.M., et al.: Smart cities at the forefront of the future internet. In: Domingue, J., et al. (eds.) The Future Internet Assembly, pp. 447–462. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-20898-0_32
20. Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., Oliveira, A.: Smart cities and the future internet: towards cooperation frameworks for open innovation. In: Domingue, J., et al. (eds.) The Future Internet Assembly, pp. 431–446. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-20898-0_31
21. Xylomenos, G., et al.: A survey of information-centric networking research. IEEE Commun. Surv. Tutor. **16**(2), 1024–1049 (2014)