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Medium access in cloud-based for the internet of things based on mobile vehicular infrastructure

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ABSTRACT

Smart cities are made up of a large number of smart, intelligent gadgets that can sense, compute, act, and communicate. Focusing on how data is transferred between sensory devices and applications in the internet of things (IoT), and cyber-physical systems have led to 5G/IoT integration. This paper proposes a revolutionary architecture for mobile vehicular cloud infrastructure that takes variable weather, road, and traffic circumstances into consideration. It proposes a dynamic speed management system for smart cities. To optimize system flexibility and reduce costs, the system makes advantage of the most recent advancements in wireless communication and utilizes current telecommunication infrastructures utilized in data streaming, sound, and video. The study presents an internet protocol (IP) real-time subsystem-network-based framework for requesting bandwidth from free wireless channel resources using the channell quality indicator channel.

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1. INTRODUCTION

Smart cities are becoming not only a reality but also more popular and spreading day by day. In fact, the deployment of smart and cognitive cities is expected to be very dominant in several regions of the world in the near future due to their advantages and merits in making our life easier, faster, simpler, and safer [1]–[4]. However, still thousands of people die in car accidents/collisions every year. For example, over 1.2 million died, for example, in traffic accidents around the world in 2016 [1]. There are a number of different reasons for road accidents/collisions in different countries. Nevertheless, the major cause of these road collisions is mainly driving the car under unpredicted weather conditions. Iqbal *et al*. [1] note that 50% of the fatal collisions happens while driving under a speed of 55 km/h. We therefore need a system where the speed limits are set according to the existing weather, traffic, and road conditions. Smart cities are composed of a massive amount of smart, intelligent devices that have sensing, computing, actuating, and communication capabilities. These devices are designed in such a way that reduces human intervention through cognition and automation in communication. They are commonly termed as internet of things (IoT) devices, which are expected to dominate the infrastructure of smart cities. Among the massive design requirements of IoT devices, low complexity with highly reliable communication channels comes as a key priority besides energy efficiency, latency, and security in emerging 5th generation (5G) services [5].

Of course, the impact of such an enabling technology is expected to be revolutionary. The new infrastructure for communication is expected to transform the world of connected sensors and reshape several existing industries. Such a revolution would, of course, require extensive research and development for the coexistence and device interoperability with 5G systems, and deployed sensor networks. This is a must for cooperative and smart sensing techniques, improved quality of service (QoS), and energy-efficient architectures in new intelligent transportation systems (ITS) infrastructure. This can be achieved by developing new sensor/5G protocols and standards, which can communicate with the cloud reliably. Focusing on optimization of the ways, the data is exchanged between the sensory devices and applications in IoT, and cyber-physical systems have led to the 5G/IoT integration as well. For example, studies on approaches tol constructl higher level abstractions of data at local gateways are proposed to reduce the traffic load imposed on the communication networks that provide the real-world data [5]. Test beds and real-world data sets are popularly employed to analyze the methods proposed.

With this recent revolution in wireless telecommunications, several advanced solutions relying on wireless communication standers have been proposed to provide ITS in the IoT paradigm. For instance, Ali *et al*. [2] projected an automatic speed control (ASC) system that adjusts the speed of the vehicle according to the speed limit on the road. The feasibility of a smart box called "telematics," which has the ability to capture, analyze, and communicate, is being studied in cooperation with IBM's engineering and technology services. Using multiple microprocessors and tiny sensors attached to the vehicle body, it is able to observe the vehicle's velocity, for example, and compare it to the upper speed limit of the road. In case the speed of the car is higher than the announced limit allowed by authorities, the box will verbally notify the driver. Moreover, a digital image processing system has been proposed by Baro *et al.* [3] while utilizing on board cameras to read and recognize signs at the side of the road and send the warning signal to the driver and/or directly control the car. Different versions of this system have been investigated intensively all over the world.

The results in Beek *et al.* [4] have shown that this solution is able to cut down the accident rate by 35%. In the near future, the speed control system will be very dependent on the standard of IEEE 802.16 to locate each vehicle and satisfy the demands of the required real-time services such as voice and video [5]. In IEEE 802.16, there are different medium access control (MAC) scheduling services, such as unsolicited grant service (UGS), real-time polling service (rtPS), and non-real-time polling service (nrtPS) to provide better QoS. There are two commonly used schedulers for real-time traffic: the UGS and the rtPS [6]. However, these schedulers do not fulfill the requirements for the real-time services in smart cities. Hence, the suitability of al batch Markovian arrival process (BMAP) is analyzed [7] for modeling of IP-based data traffic. Accordingly, the BMAP has been found to be better in comparison with Markovian-based models. Hence, we propose a real-time-BMAP (RT-BMAP) model for real-time services. The objective of this approach is to provide the required QoS level with the minimum delay. Accordingly, the majorl contributions of this paper are as:

- We present the enhanced-rtPS (E-rtPS) integrated with RT-BMAP to solve the interference problem in the smart cities paradigm optimistically.
- Our proposed approach has less computational overhead and betterl performance in terms of resource utilization.
- The examination of real-time results shows thatl the proposed framework outperforms the existing IEEE 802.16 services in terms of delay, throughput, and reception percentages.

For more readability, a list of used abbreviations along with their definitions is provided in Table 1. The rest of this paper is organized as: section 2 overviews related works in the literature. Section 3 presents a detailed description of the proposed framework. Section 4 discusses extensive simulation results. Finally, Section 5 concludes the work in this paper.

2. RELATED WORK

By 2021, the mobile networks will triple the amount of used smart devices in 2016. In addition, mobile video services will increase nine times what we experienced in 2017. Given that our resources are limited and QoS is critical, the system basestation (BS) shall allocate the existing system bandwidth proactively. In smart cities, smart transportation systems, cellular network, wireless sensor network (WSN), device-to-device (D2D), and many of these smart paradigms involve the wireless mobile multimedia communications and/or transmissions. Specifically, the D2D has received increased attention from wireless cellular networks because it can noticeably off-load the network traffic and reduce the transmission energy since the communicating devices are in close proximity to each other [2]. This close proximity makes it an eminent networking architecture for relay-based transmission employed by energy-constrained devices, such as smartphones, tablets, and personal digital assistants (PDAs). Therefore, it is considered to be vital to improve the energy efficiency of D2D networks while maintaining their reliability in terms of the experienced throughput and latency. Most of the existing works have considered the direct link situation for the degradation of long-distance communication [2], poor propagation [3], and interference [4]. As relay-based transmission can improve the longer distance D2D communication, most of the researchers have given their attention for the multi- hop D2D communication.

Abdulkadir and Al-Turjman [5] deal with spatial density and power transmission to get better transmission capacity. However, it is declared without specifying a routing technique. Al-Turjman *et al.* [8] propose a multi-hop routing technique to maximize the hop count of the networking systems. But then, it is proven undependable to minimize the distance between the users. Since the existing relay-based techniques do not consider the energy efficiency for the D2D communication, there is a need to formulate a combinatorial optimization that improves the energy efficiency of such communication systems. Accordingly, technological advancements are balancing the act between bandwidth usage and time delay in any data delivery approach. In addition, low complexity with high-reliability communication comes as a first key priority besides energy efficiency, latency, and security [5].

Table 1. Used abbreviations and acronyms

Abbreviations	Definitions
IoT	Internet of things
BMAP	Batch Markovian arrival process
RT-BMAP	Real-time batch Markovian arrival process
MAC	Medium access control
UGS	Unsolicited grant service
nrtPS	Non-real-time polling service
rtPS	Real-time polling service
QoS	Quality of service
ASC	Automatic speed control
ITS	Intelligent transportation systems
LTE-A	Long term evolution-advanced
E-rtPS	Enhanced-real-time polling service
SNR	Signal-to-noise ratio
WSN	Wireless sensor network
BS	Base station
RF	Radio frequency
OFDM	Orthogonal frequency division multiplexing
MCC	Management and control center
PSTN	Public switched telephone network
IRSN	IP real-time subsystem-network
GS	Grant size
MC	Mobile controllers
LC	Local controllers
VolP	Voice over IP
MST	Minimum spanning tree
RS	Real-time server
RC	Real-time client
RSU	Road-side unit
BER	Bit error rate
FER	Frame error rate
CSCF	Call session control function
HSS	Home subscriber station
D2D	Device-to-device communication
IP	Internet protocol
IMS	IP multimedia subsystem
D2D	Device-to-device communication
QPSK	Quadrative phase-shift keying
QAM	Quadrature amplitude modulation

There are two main categories of approaches that are focusing on addressing these challenges; the distributed versus centralized approaches. The distributed approach is a distributed routing in the network, which is very popular, and it has many sub-approaches. Distributed coding is also proposed and adopted to be used in future 5G and beyond systems as an indispensable channel coding scheme [9], [10]. However, different channel codes are constructed and generated according to a pre-specified value of the signal-to-noise ratio (SNR). This issue becomes even more complicated with fading channel consideration due to multipath existence. In an attempt toward proposing reliable channel codes which considers fading conditions, several studies have been conducted and performed in the literature. In [11], a multilevel fading channels, which utilizes the nested coding, has been exhibited. It was demonstrated that this approach tends to tackle fading channels with a limited number of states. In [12], polar codes are connected to remote channels. A strategy for acquiring the Bhattacharyya parameters related to Rayleigh channels is exhibited. In [13], lower and upper limits on Bhattacharyya parameters were selected to develop competitive channel codes. Boutros and Biglieri [14] detailed the coding procedures for the radio frequency (RF) channel with realized channel state data at the two ends of the connection with known channel dissemination data. Another example on investigating the coding for block-fading channels can be found in [15]. The channel use is exhibited with the objective that codes could be grasped to be encoded over isolated squares in [16]. In [17], the creators analyze the general sort of the superfluous information trade and coding with multistage understanding. In light of this examination, they proposed a graphical structure methodology to create channel codes for picture hindrance. In Al-Turjman *et al.* [18], a clear system for the improvement of portable channel codes considering Rayleigh impacts was displayed. The sub-channels are shown as multipath obscuring channels, and their varying decent requests are pursued. In [19], codes are planned solely for square-based channels. The authors-built channel codes customized for square fading channels while polarizing them with codes. The accomplished arrangements are shown to convey a significant increase contrasted with ordinary coding. Mehmood *et al*. [20] gave an elective structure of this methodology by treating the shadowing, fading, and coding of the channel as a solitary element. This empowers developing channel codes by mapping the codes with shadowing and fading effects. The acquired codes are adjusted to divert vacillation in versatile situations. Arikan [21] proposed a scheduling scheme of dynamic carrier aggregation (DCA) to provide higher energy efficiency in uplink communication. In Santos [12] have not considered the uplink real-time scheduling and resource allocation framework for the demand of the 3rd generation partnership project (3GPP) long term evolution-advanced (LTE-A) networks.

Xu *et al.* [22], an orthogonal frequency division multiplexing (OFDM) approach under multipath fading channels is proposed. In this methodology, the codes are permuted with the goal that the code bits contrasting with the hardened bits are doled out to subcarriers causing ceaseless piece goofs. This change can be considered as a kind of interleaving that can distinguishably upgrade the channel coding. Nevertheless, changing the codes depending on the channel is not always required. That is on the grounds that it would result in a persistent change in the code of the correspondence channel type. This is viewed as a bulky, complex, and wasteful, particularly for cloud-based applications. As a conclusion, the greater part of the previously mentioned methodologies accepts either the LTE-A or the IEEE 802.16 in their correspondence conventions. However, these measures have not been viewed as productive in planning. Subsequently, it is yet an open research issue [23].

In this work, we aim at proposing an adaptive framework for dynamic channel management in smart cities. We propose a novel design for the mobile vehicular cloud infrastructure that takes into account varying weather, road, and traffic conditions. This framework utilizes the latest channel coding techniques while utilizing the existing cellular infrastructure to stream data, sound, and video with the least latency.

3. FRAMEWORK DESCRIPTION

In this section, we recommend a complete depiction for the proposed vehicular cloud frame-work. We define our framework components as:

- Management and control center (MCC): this component controls the velocity of the vehicle depending on the street, traffic, and surrounding environment conditions.
- Speed limit transmitter (SLT-x): this component is used to communicate the speed limit to the end-driver. The speed limits are transmitted as a wireless message. The MCC controls/adapts the speed of the vehicle based on road, traffic, and weather conditions, given that enough road-side units (RSUs) are located at predefined points on the road.
- Speed limit receiver (SLR-x): this component takes the transmitted street upper limit and displays it clearly in the vehicle. It will also be communicated to the driver's smartphone.
- Vehicle speed sensor: this component is required to measure the speed of the vehicle accurately. The speed measurement system that already exists in the car can be used as well.
- In-vehicle microcontroller: its main task is to compare the actual speed to the road speed limit, which is received by the SLR-x. Based on the vehicle speed, the controller may generate an audio warning or may communicate such incidence to the MCC through the 5G network via the driver's smartphone.
- 5G modem: this modem is used to send a speed data to a central station, which is monitored and operated by any other governmental or private entity.
- Drivers' records server (DRS): it stores information about the drive. The DRS is updated when the global system for mobile communications (GSM) modem sends a signal from the driver's car. The DRS can be accessible by third parties with the approval of the driver. Such third parties include parents, family members, and insurance companies.

3.1. Functioning of the vehicular cloud framework

Figure 1 shows a simplified schematic for the planned vehicular cloud system in normal conditions. The SLT-xs are connected to the MCC component through the public switched telephone network (PSTN) and the GSM/5G networks, which are usually connected to cloud data centers. They are controlled by the MCC, which recommends changing the speed limit depending on the road, weather, and traffic conditions [24]. The MCC gets the required information from the patrol police, forecast stations, and driver's smartphones. The vehicle speed is continuously compared to the received speed limit, which is also displayed to the driver.

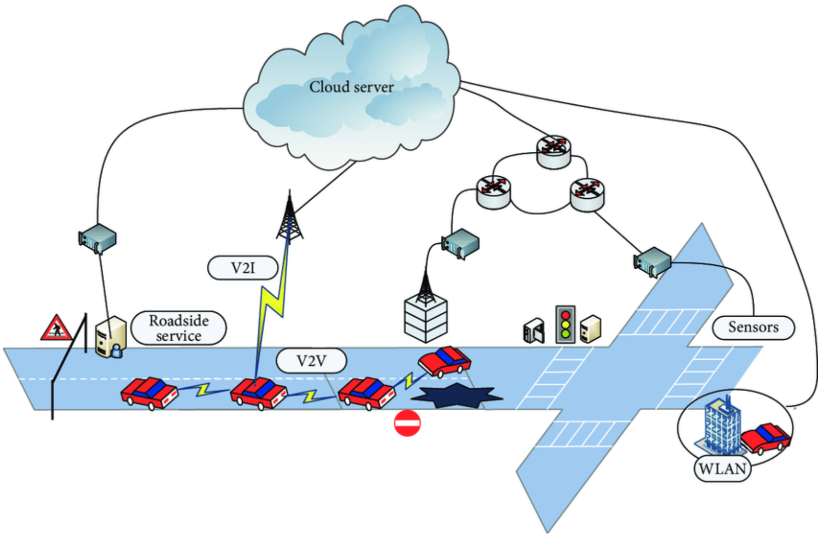

Figure 1. A schematic for the vehicular cloud in smart cities

Hence, the driver will always know the upper limit of the street he or she is on. This is a better method than the conven-tonal speed limit signs located on the side of the road. If a driver is driving below the speed limit,there is nothing to do except that it might be a congestion case. If the vehicle speed limit exceeds the received one, a warning signal will be generated to alert the driver that he or she exceeded the speed limit. If the driver does not respond within a given period, the In-vehicle Microcontroller sends a note (violation) through the 5G modem to the DRS. The violation can also be sent to the driver's smartphone. The violation can also be recorded using various network-positioning techniques. Other forms of violations such as tail tracking and red light tracking can be motored in the car, which has other types of sensors. In such a case where a violation was recorded, the DRS can inform the driver instantaneously through his or her mobile/e-mail/ mail, or by some other IEEE 802.16 standard means. We remark that this study focused on the voice over IP (VoIP) service as an example of the exchanged realtime contents over the vehicular cloud.

3.2. Registration phase

We assume that RSUs are located in different places along a given road. Local controllers (LCs) are static BSs in the city. mobile controllers (MCs) are sensing platforms attached to vehicles. We use a minimum spanning tree (MST) algorithm to select an LC at each route. Each MC is considered as a node in the MST, whereas all RSUs are considered as terminal nodes, as depicted in Figure 2. Accordingly, this registration phase is summarized in the following four main steps:

- Step 1: the MC first transmits a control message such as a Hello message to all RSUs in range to determine the layout of the network as depicted in Figure 1.
- Step 2: the RSU computes its associated delay and compares it with the neighboring RSUs in the same depth based on the IEEE 802.16 standard means. The RSU with the lowest delay declares itself as the LC.
- Step 3: the selected LC broadcasts a message to the MC and all RSUs in range, with the updated information about all the nodes; these are vehicles and RSUs. All nodes contacted record the routes to an MC in their flow table.
- Step 4: the previous three steps are repeated, and finally, the MC institutes a global layout and sends it to all LCs, RSUs, and vehicle networks.

We remark that RSUs can calculate the number of Hello messages sent previously as the vehicle moves and updates each other and the nearby RSUs. This helps in improving the stability of the vehicular cloud system by averting sparse network conditions, thus selecting an LC with the highest connectivity. We similarly calculate the hop count by looking at the number of RSUs a message has passed by (see Figure 2). At the end of this phase, the selected LCs create a localized global view at each depth from the MC. Therefore, different kind's of controllers are used to reduce the system burden from the single main controller and reduce the overall overhead and delay.

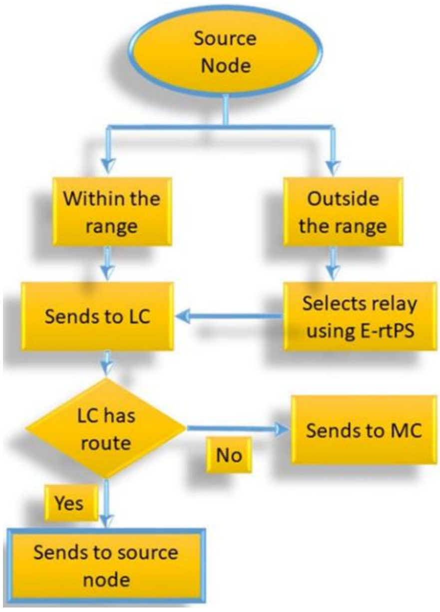

Figure 2. A schematic for the vehicular cloud in smart cities

3.3. Channel coding phase

We assume an IP real-time subsystem-network (IRS-N)-based framework utilizing the channel quality indicator channel (CQICH) for demanding the bandwidth from the free wireless channel resources. We make use of the two reserved bits in the universal MAC header of IEEE 802.16. One of these bits, which is called the grant size (GS) bit, is responsible for informing the BS about the state of the voice transition. For example, when the voice connection of the MCC is on, the MCC ascribes the GS bit to zero. Moreover, the MCC imparts any changes in the voice transition using the traditional MAC header. So, the BS keeps informed of the changes happen to the voice state with- out causing any MAC overhead. Alternately, the uplink resources can be used to get the bandwidth request process while using the MCC and BS resources to monitor the GS bit transmission. The BS assignment considers the uplink resource to realize an enhanced RT-BMAP. Accordingly, many performance problems, such as delay, medium access, bit/frame error rate, and resource management, arise while supporting the multimedia services in a smart city. We assume the reserved bits of IEEE 802.16 are used for this purpose. Furthermore, the MCC is used to privilege the SC bit. The IRS-N employs the required bandwidth in order to hold the uplink usage and the frame of voice codec acquired by the network.

Table 2. Simulation parameters of IMS networks

Parameters	Values
Number of cells	19
Bandwidth	5 MHz
Shadowing standard deviation	8dB
Number of RBs	25
Path loss	128.1 + 3.76 log (R), R in km
R	500 m
Frequency	2 GHz
Uplink transmission power	24 bBm
Modulation scheme	QPSK, 16, 64 QAM
Proximity distance	10 m
Maximum transmission P_m	24 dBm
Threshold η	0.8
Channel model	200 Tap

4. RESULTS AND DISCUSSIONS

In this section, we present the results of our planned framework. It involves hardware and software implementation parts. The main purpose of the hardware part is to construct a simple test bed for such projects/ideas. This test bed has been proved to be very helpful with the cost approximation, and it provides critical information about design challenges such as the delay and system throughput. This simple test bed is composed of three subsystems: the in-vehicle subsystem connected via cellular networks, the IP-based network (internet), and the MCC represented by the network client. E-rtPS as an online resource for voice services.

Also, we deploy real-time client (RC) and real-time server (RS) as agents to support the voice call creation and dissolution. These agents use the real-time transport protocol (RTP)/user datagram protocol (UDP) to control messages transmissions.

We assume the IEEE 802.16 model is built in the MAC layer to use UGS and we remark here that we assumed ten cars while obtaining the results in this section for realistic verification purposes. The MCC is implemented via Ubuntu PC (laptop) for experimental purposes. The car toys were equipped with Arduino boards attached to the general packet radio service (GPRS) modules. To evaluate the performance of the assumed resource allocation framework in the central cell, we consider using 5 MHz LTE-A with 19 cells working at 2.0 GHz as a wireless cellular network. For each user, the packet arrival process follows the Poisson distribution with a mean arrival rate of 1 kbps. In Table 2, our stimulation parameters are presented. Figure 3 depicts the use of an IRS core function in Ubuntu, consisting of proxy call session control function (P-CSCF), interrogating call session control function (I-CSCF), servicing call session control function (S-CSCF), and home subscriber station (HSS) in order to monitor the quality of the online service. The system depicted in Figure 3 does not only possess the ability to allocate the network service resources but can also mask out roaming restrictions [25], [26]. We use IRS core functions to transform voice connection to real-time service. The data can be transformed inl serial or parallel mode to investigate the efficiency of E-rtPS with RT-BMAP compared to UGS and rtPS in [15].

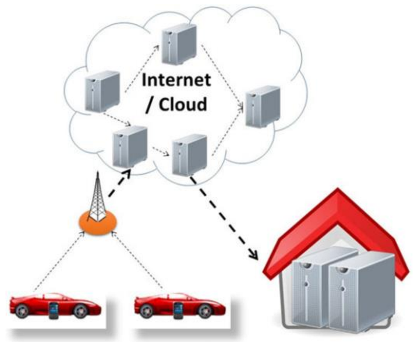

Figure 3. Experimental test bed for the vehicular cloud system of IEEE 802.16d/e

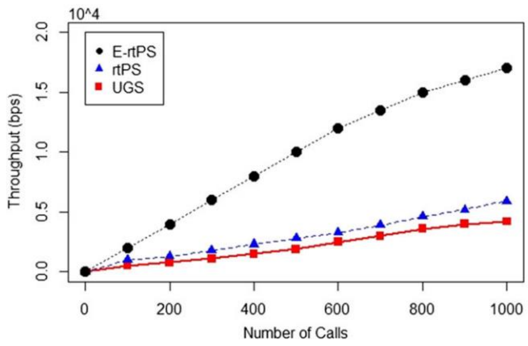

Figure 4. Throughput versus number of calls

In the work [27]-[32] say that through the knowledge of 3GPP, RTS provides a better service scalability to the devices connected; therefore, an IRS core system with features of LTE-Advanced has been deployed to provide better scalability and services. In this study, the core network is assimilated with HSS to analyze the stability of voice services across available networks. Moreover, the IRS core is embedded with its CSCF to generate a realistic test bed. Since the system is designed for real-time services, we gradually increase the voice connectivity in order to examine the system throughput and connectivity delay. Moreover, an emergency call is registered as an unidentified caller to analyze the session setup delay and throughput of real-time services. We perform an experiment to weigh the performance of the session initiation protocol (SIP)-based VoIP compared to IRS core using wireless connectivity and also to inspect the voice connectivity delay and throughput of the network. We employ the use of IRS clients and packet analyzers in order to establish a connection between VoIP call and service connection. As depicted in Figure 4, the throughput of the proposed algorithm is much higher compared to UGS or rtPS. Moreover, Figure 5 shows that the delay of the proposed algorithm is lower at all critical points in comparison with the other services. It is imperative to note that getting the predefined delay of a service is important in the system of IEEE 802.16d/e [5] for the packet with delay violations.

Figure 6 depicts the bit error rate performance versus the energy per bit of the wireless channel codes using our proposed framework. From this figure, we can conclude that the achieved performance over a multiway channel is almost the same as that obtained in [16]. The gain is also attained as a result of canceling the dispersion and fading effects. This can dramatically enhance the mobile communication channel performance in terms of reliability. Meanwhile, Figure 7 depicts the frame error rate performance versus the energy per bit of the wireless channel codes at varying block sizes. Obviously, as the block length increases, the performance gets improved. It is worth mentioning that the obtained reliability in terms of bit and/or frame error rate of the proposed framework makes the designed codes more appropriate over multipath fading channels. However, this might be associated with a slight channel loss at the maximum exchange rate. Therefore, quantifying the amount of data exchange rate incurred by the proposed framework is recommended.

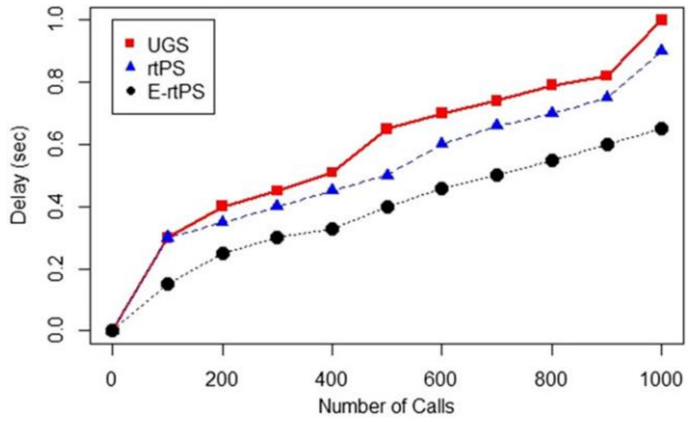

Figure 5. Average packet delay versus number of voice connections

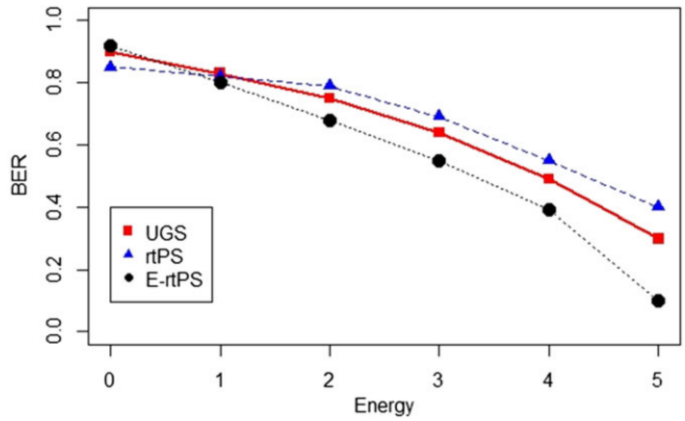

Figure 6. Bit error rate versus energy per bit

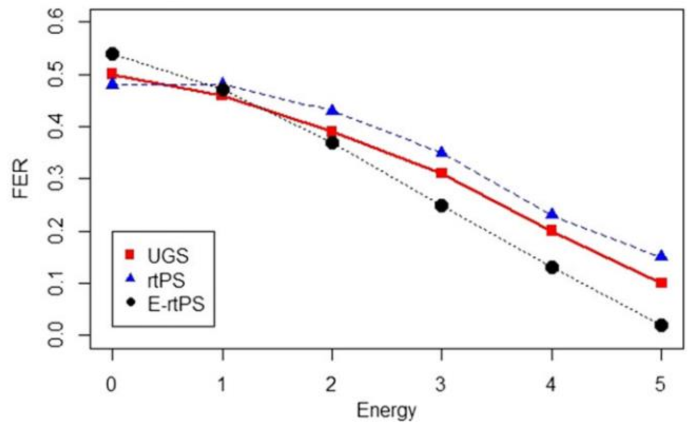

Figure 7. Frame error rate versus energy/power per bit

5. CONCLUSION

This paper presents an adaptive framework for dynamic speed management in smart cities. The system makes use of the latest development in wireless communication and exploits the existing telecommunication infrastructures, which have been used in data streaming, sound, and video to maximize the system adaptability and reduce the price. A key component to the planned framework is the dynamic medium access approach for real-time communications. Accordingly, this paper proposes the E-rtPS for the vehicular cloud of IEEE 802.16.

The proposed approach integrates RT-BMAP tol analyze the throughput rate and average packet delay. It enables using the same coding design used for multipath selective channels while maintaining the same reliability performance in terms of delay and throughput. In future work, data that is collected from the RSUs will be published in the cloud after a preprocessing stage. The cloud will be able to employ machine learning and prediction techniques towards more efficient decisions. These decisions will be communicated back to relevant drivers on the road.

REFERENCES

[1] R. Iqbal, T. A. Butt, M. O. Shafiq, M. W. A. Talib, and T. Umar, "Context-Aware Data-Driven Intelligent Framework for Fog Infrastructures in Internet of Vehicles," *IEEE Access*, vol. 6, pp. 58182-58194, 2018, doi: 10.1109/ACCESS.2018.2874592.

[2] S. Ali, A. Ahmad, R. Iqbal, S. Saleem, and T. Umer, "Joint RRH-Association, Sub-Channel Assignment and Power Allocation in Multi-Tier 5G C-Rans," *IEEE Access*, vol. 6, pp. 34393-34402, 2018, doi: 10.1109/ACCESS.2018.2847718.

[3] X. Baro, S. Escalera, J. Vitria, O. Pujol, and P. Radeva, "Traffic Sign Recognition Using Evolutionary Adaboost Detection and Forest-ECOC Classification," *IEEE Transactions on Intelligent Transportation Systems*, vol. 10, no. 1, pp. 113-126, 2009, doi: 10.1109/TITS.2008.2011702.

[4] J. J. V. D. Beek, M. Sandell, and P. O. Borjesson, "ML estimation of time and frequency offset in OFDM systems," *IEEE Transactions on Signal Processing*, vol. 45, no. 7, pp. 1800-1805, 1997, doi: 10.1109/78.599949.

[5] A. D. Wankhade and K. Wagh, "A Survey on Security Challenges and Defending Methods in Cloud Based Internet of Things Network," *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)*, 2021, pp. 1414-1417, doi: 10.1109/ICAC3N53548.2021.9725559.

[6] G. L. Harika, H. Chowdary and T. S. Kiranmai, "Cloud-based Internet of things for Smart Water Consumption Monitoring System," *2020 5th International Conference on Communication and Electronics Systems (ICCES)*, 2020, pp. 967-972, doi: 10.1109/ICCES48766.2020.9138074.

[7] A. Klemm, C. Lindemann, and M. Lohmann, "Modeling IP traffic using the batch Markovian arrival process," *Performance Evaluation*, vol. 54, no. 2, pp. 149-173, 2003, doi: 10.1016/S0166-5316(03)00067-1.

[8] S. Oyucu, "Integration of Cloud-Based Speech Recognition System to the Internet of Things Based Smart Home Automation," *2021 3rd International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA)*, 2021, pp. 1-3, doi: 10.1109/HORA52670.2021.9461360.

[9] K. Aggarwal and S. K. Yadav, "Nature Inspired Approach Integration in Cloud Environment for Performance Elevation with Internet of Things," *2020 International Conference on Computing and Information Technology (ICCIT-1441)*, 2020, pp. 1-5, doi: 10.1109/ICCIT-144147971.2020.9213776.

[10] E. O. Zaballa, C. Vanhelleputte, S. Ruepp, M. N. Petersen and M. S. Berger, "Design and implementation of a cloud-based multi-LPWAN IoT data collection service," *2020 IEEE 6th World Forum on Internet of Things (WF-IoT)*, 2020, pp. 1-2, doi: 10.1109/WF-IoT48130.2020.9221200.

[11] J. Hao, J. Liu, W. Wu, F. Tang and M. Xian, "Secure and Fine-Grained Self-Controlled Outsourced Data Deletion in Cloud-Based IoT," in *IEEE Internet of Things Journal*, vol. 7, no. 2, pp. 1140-1153, 2020, doi: 10.1109/JIOT.2019.2953082.

[12] A. B. -Santos, "Polar Codes for the Rayleigh Fading Channel," *IEEE Communications Letters*, vol. 17, no. 12, pp. 2352-2355, 2013, doi: 10.1109/LCOMM.2013.111113.132103.

[13] J. J. Boutros and E. Biglieri, "Polarization of quasi-static fading channels," in *2013 IEEE International Symposium on Information Theory*, 2013, pp. 769-773, doi: 10.1109/ISIT.2013.6620330.

[14] M. Gassara, M. Elleuchi and M. Abid, "LoRa Cloud-based platform for Internet of Things Applications," *2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*, 2021, pp. 1-6, doi: 10.1109/IEMTRONICS52119.2021.9422531.

[15] M. M. Rosales *et al*., "Cloud-based Portable Rice Milling Machine using Internet of Things," *2022 2nd International Conference on Intelligent Technologies (CONIT)*, 2022, pp. 1-7, doi: 10.1109/CONIT55038.2022.9848042.

[16] P. Trifonov, "Design of polar codes for Rayleigh fading channel," in *2015 International Symposium on Wireless Communication Systems (ISWCS)*, 2015, pp. 331-335, doi: 10.1109/ISWCS.2015.7454357.

[17] F. Al-Turjman and S. Alturjman, "Confidential smart-sensing framework in the IoT era," *The Journal of Supercomputing*, vol. 74, pp. 5187–5198, 2018, doi: 10.1007/s11227-018-2524-1.

[18] F. Al-Turjman, M. Z. Hasan, and H. Al-Rizzo, "Task scheduling in cloud-based survivability applications using swarm optimization in IoT," *Transactions on Emerging Telecommunications Technologies*, vol. 30, no. 8, 2018, doi: 10.1002/ett.3539.

[19] I. Mehmood *et al*., "Efficient image recognition and retrieval on IoT-assisted energy-constrained platforms from big data repositories," *IEEE Internet of Things Journal*, vol. 6, no. 6, pp. 9246-9255, 2019, doi: 10.1109/JIOT.2019.2896151.

[20] E. Arikan, "Channel Polarization: A Method for Constructing Capacity-Achieving Codes for Symmetric Binary-Input Memoryless Channels," *IEEE Transactions on Information Theory*, vol. 55, no. 7, pp. 3051-3073, 2009, doi: 10.1109/TIT.2009.2021379.

[21] R. Xu, M. Chen, C. Tian, X. Lu and C. Diao, "Statistical distributions of OFDM signals on multi-path fading channel," in *2011 International Conference on Wireless Communications and Signal Processing (WCSP)*, 2011, pp. 1-6, doi: 10.1109/WCSP.2011.6096871.

[22] H. -C. Hsieh and J. -L. Chen, "Distributed multi-agent scheme support for service continuity in IMS-4G-cloud networks," *Computers and Electrical Engineering*, vol. 42, 49–59, 2015, doi: 10.1016/j.compeleceng.2014.07.017.

[23] M. Patel, "SOS Uniform Resource Identifier (URI) parameter for marking of Session Initiation Protocol (SIP) requests related to emergency services." Data tracker. https://datatracker.ietf.org/doc/draft-patel-ecrit-sos-parameter/11/ (Accesed Oct. 26, 2009).

[24] ETSI, "3GPP TS 23.167, IP Multimedia Subsystem (IMS) emergency sessions," Release 11, 2013. [Online] Available: https://www.etsi.org/deliver/etsi_ts/123100_123199/123167/11.08.00_60/ts_123167v110800p.pdf

[25] R. Dugyala, N. H. Reddy, and S. Kumar, "Implementation of SCADA Through Cloud Based IoT Devices - Initial Design Steps," *2019 Fifth International Conference on Image Information Processing (ICIIP)*, 2019, pp. 367-372, doi: 10.1109/ICIIP47207.2019.8985966.

[26] G. Li, S. Hua, L. Liu, X. Zheng, and H. Ma, "SDN Based Computation Offloading for Industrial Internet of Things," *2020 16th International Conference on Mobility, Sensing and Networking (MSN)*, 2020, pp. 402-409, doi: 10.1109/MSN50589.2020.00072.

[27] Y. Sabri, A. Siham, and A. Maizate, "Internet ofthings (IoT) based smart vehicle security and safety system," *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 12, no. 4, 2021, doi: 10.14569/IJACSA.2021.0120487.

[28] Y. Sabri, N. El Kamoun, and F. Lakrami, "Investigation of energy efficient routing protocols in wireless sensor networks on

variant energy models," in *Proc. of the 4th International Conference on Big Data and Internet of Things (BDIoT'19),* 2019, no. 51, pp. 1–5, doi: 10.1145/3372938.3372989.
[29] Y. Sabri and N. El Kamoun, "Attacks and secure geographic routing in wireless sensor networks," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 5, no. 1, pp. 147-158, 2017, doi: 10.11591/ijeecs.v5.i1.pp147-158.
[30] Y. Sabri and N. El Kamoun, "A prototype for wireless sensor networks to the detection of forest fires in large-scale," in *2012 Next Generation Networks and Services (NGNS)*, 2012, pp. 116-122, doi: 10.1109/NGNS.2012.6656065.
[31] Y. Sabri, E. Najib, and L. Fatima, "Dynamic cluster head selection method for wireless sensor network for agricultural application of internet of things based fuzzy c-means clustering algorithm," in *2019 7th Mediterranean Congress of Telecommunications (CMT)*, 2019, pp. 1-9, doi: 10.1109/CMT.2019.8931313.

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