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Artificial Intelligence based QoS optimization for multimedia communication in IoV systems

Ali Hassan Sodhro [a,b], Zongwei Luo [c,*], Gul Hassan Sodhro [d], Muhammad Muzamal [e], Joel J.P.C. Rodrigues [f,g], Victor Hugo C. de Albuquerque [h]

[a] Sukkur IBA University, Sukkur, Sindh, 65200, Pakistan
[b] IDA-Computer and Information Science Department, Linkoping University, Linkoping 58183, Sweden
[c] Shenzhen Key Laboratory of Computational Intelligence, Department of Computer Science and Engineering, Southern University of Science and Technology, Shenzhen 518055, China
[d] Shah Abdul Latif University, Khairpur Miras, Sindh, Pakistan
[e] Bahria University, Islamabad, Pakistan
[f] National Institute of Telecommunications (Inatel), Brazil
[g] Instituto de Telecomunicações, Portugal
[h] University of Fortaleza, Brazil

HIGHLIGHTS

- We propose an AI-enabled QoE optimization platform during media communication in IoV System.
- Framework for QoE optimization during multimedia communication in IoV is proposed.
- Several challenges and state-of-the art solutions are proposed for future research in IoV.

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ABSTRACT

Due to the advancements in multimedia communication in internet of vehicles (IoV) through emerging technologies i.e., WiFi, Bluetooth, and fifth generation (5G) etc. The critical challenge for IoV during multimedia communication in healthcare is the quality of experience (QoE) optimization by managing the mobility of wireless channel between vehicles. Besides, Artificial Intelligence (AI) based approaches have entirely changed the landscape of IoVs, also the portable devices for transmitting multimedia content in IoV system has become very necessary for the end-users in their respective fields. Most of the end users are facing is their annoyed and less satisfactory perspective about the quality they are experiencing i.e., QoE. If the service provisioning is not pleasant then most of the end-users/consumers give-up to continue, and finally market devaluates the overall performance of the devices, company or entire system. So remedy that problem this paper first proposes two novel algorithms named, Power-aware QoE Optimization (PQO) and Buffer-aware QoE Optimization (BQO) and compares their performance with the Baseline. Second proposes multimedia communication mechanism. Third, proposes the QoE optimization framework during multimedia communication in IoV system through portable devices. Besides, experimental results reveal that proposed PQO and BQO algorithms optimizes the QoE at (31%, 33.5%) with improved lifetime of portable devices at (25%, 27%) higher level than the Baseline (25%, 17) accordingly by satisfying the end-users. Hence, it is concluded that our proposed algorithms outperforms the Baseline, so can be considered as potential candidates for the IoV applications during multimedia communication.

1. Introduction

The key ingredients of Internet of Vehicles (IoV) system are the sensors, personal devices, actuators, etc to communicate with other devices and the infrastructure using different technologies. Such device interactions face several design challenges such as, high quality of service and user satisfaction, incompatibility among the devices, different qualities and response times for the internet connection, limited processing and storage capabilities. Connected vehicles and devices are integral components of the IoV concept

* Corresponding author.
E-mail address: luozw@sustc.edu.cn (Z. Luo).

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which is a mobile system which allows information exchanges involving Vehicle to Vehicle (V2V), Vehicle and Device (V&D), Vehicle and Person (V&P) and Device to Device (D2D) etc. Deployment of IoV platform during multimedia communication needs portable devices with large screen size to exchange the data and interact with other devices with the help of sensors, actuators, connectors in WSN, personal area networks and IoT etc. Flexible, scalable and seamless connection is very vital for IoV by integrating vehicles, sensors, actuators, humans, machines etc to enhance the user perception, i.e., QoE and decrease the power drain.

The sensor oriented intelligent automation of vehicle's mechanical functionality improve safety of transportation system, while coordinated traffic data exchanging in vehicular network increases traveling efficiency. Nevertheless, power and buffer-aware Green and sustainable transportation via Internet of connected Vehicles (IoV) came with a high risk of quality compromise during medical media information transmission. For instance, illegitimate accessing of wheels, locking doors, engine disruption to path forging, location and identity changing, denial of traffic service, motion tracking, etc. Thus it is very vital since long time to remedy the virtual vehicle hijacking in IoV networks with potential solutions. Because of less-efficient, low QoE-aware traditional methods, the current IoV scenarios are not effectively and completely entertained while transmitting multimedia enabled healthcare data through connected vehicles. Also the no appropriate practical solution is planned to provide the cost-effective power and buffer aware QoE optimization solutions for designing and deploying the vehicular networks. Every day lots of queries are coming and do not entertained and explored accordingly and remain un-answered. For instance, how to manage the motion of the vehicles and provide the effective monitoring mechanism? What are the key steps to get-rid of the eavesdropping and unwanted conditions while using phones on the vehicles? At what level less power and buffer drains are obtained while collecting the secret traffic information in the IoV networks? How to satisfy the users by providing high QoE during communication process in IoV networks with suitable tools and techniques?

In the mean-time Artificial Intelligence (AI) based self-driven vehicles in IoV encourage several applications to get maximum benefit of it by interacting with the humans. With the increase of the information amount, complex will be the computation procedure, and more effective and accurate will be the future game predictions. As the increase in voluminous amount of IoV data, there is need of modern tools, trends and practices to effectively manage and monitor the needs of modern digital world for the benefit of the society. With the rapid revolution in the digital technologies for advanced multimedia based IoV system there is a need of portable devices for collecting the huge amount of the data to assist and guide the future trend setters for carefully analyzing the demands of the transportation industry by promoting the internet of things (IoT)-based platforms. As in this world of digital information every corner of the landscape meets the huge challenges while categorizing and clustering the large amount of the data, and to extract the desired output from that raw and unsmoothed data is the cumbersome task for which the manual conventional tools and techniques are not so efficient and up-to-mark. At present several endeavors are made by the both industry and academia to spent large amount of assets in IoV system management during multimedia communication for the accurate and effective information analysis and observation [1–3]. The vehicle manufacturing environment is full of communication and connectivity protocols that are not interconnected and often not interoperable. That is why convergence and interoperability are critical if this revolution is up to the expectations of IoV system users. Convergence aims to interconnect the things so communication can be initiated. Interoperability between vehicles in IoV is the key parameter to easily exchange the information between vehicles and outside the IoV platform at remote location. There are several types of specialist technologies in use within an increasingly automated manufacturing environment of vehicles.

Generally, increasing pool of several networks in-line with the business personnel there is a huge change in the showcase mechanism of the developed products from functional process to sailing phase with quite cumbersome trends. Complex traits and practices with large hindrances in putting and getting product preparation order, adaptation of new business strategies, recruitment and resignation of the skilful employees, decisive actions for the salaries and bounces of the workers etc, there are critical challenges because of non-technological trends. Best way to bridge the gap between every entity in the globe is to decorate the entire world with the cyber and information sharing/exchanging environment by dealing with the internet of things networks, which are very intelligent and decisive networks. Besides, there is a high demand to develop the uniform and integrated platform to invite all the standards to talk the one uniform language. In the broad sense this challenge can be transformed into opportunity by developing the convergent and interoperable IoT environment in the every application of the industry. With this bold step the emerging and revolutionized wave of medical evolution can be brought at the door steps of the every corner from industry to academia, because it intends to digitize the every single area in this physical. This all can be possible with the dram world of sensor technologies which in nut-shell is known as the IoT for the medical applications, or we can say that IoT. So, after successfully introducing the concept of the IoT key problems start while bringing and inviting every industry, enterprise, higher education institute, form and factory to collaborate and coordinate to sustain the digital village, digital industry or IoT-village. That core problem is the convergence and interoperability between reliable and cloud-based technologies in the IoT world. Moreover, IoT and IoV, cloud based technologies and services all lies in the umbrella of the cyber–physical system (CPS) ; which is integrated and embedded systems of sensors, actuators, connectors, men and machines, etc. First time the notion of CPS was very vague and unacceptable due to less development in the technology, then with the passage of the time computers, handheld devices, networks started to interact among themselves and the real-world by efficiently managing, regulating and monitoring the all functions. Due to mobility of the vehicles while transmitting multimedia data more power is drained with large delay, jitter and channel quality degradation, which will show the blurred media quality on the large screen cell phones, and hence the less QoE. And in the mean-time frequent switch of the vehicles such as, ambulances in the healthcare deteriorates the quality of wireless channel by more packet loss hence, high power drain and short battery lifetime of IoV based sensor nodes, which are the critical challenges during multimedia communication in IoV networks while monitoring the healthcare of patients.

This paper contributes in three distinct ways. First proposes two novel algorithms named, Power-aware QoE Optimization (PQO) and Buffer-aware QoE Optimization (BQO) and compares their performance with the Baseline. Second proposes multimedia communication mechanism. Third, proposes the QoE optimization framework during multimedia communication in internet of vehicles (IoV) while using the portable devices to keep the long-lasting communication with high level of satisfaction in multimedia domain.

The remaining of this review paper is organized as follows. Section 2 presents the existing solutions of AI-based techniques, frameworks, protocols. AI-based QoE optimization framework is proposed in Section 3. Section 4, presents the experimental results. Future directions and tentative solutions are discussed in Section 5. Paper is concluded in Section 6.

2. Related work

This section presents the rigorous literature on the Artificial Intelligence based techniques for the QoS optimization during media communication in the Internet of Vehicles (IoVs). Besides, latest and relevant works are highlighted with the major contributions in the aforementioned domains. Technology and internet oriented medical world is one of the most favorite regions with ease and comfort in everyone's life which has become the demand and desire of the every citizen. In the mean-time the boom and rapid revolution in the portable devices for sharing and exchanging the unique information in terms of various services for instance, physiological signals, medical video and images etc. For making distinct services as the prominent and valuable active actors are needed to perform the separate tasks in terms of the network managers, service and stuff providers. These all entities combined together to form the one platform in fulfilling the end user's requirements in the hospitals and medical theaters. For the high satisfaction and the on-time services users have to pay a lot while entertaining their main demands. For the effective use and analysis of the QoE services with high level of optimization it will be great to propose the innovative techniques and frameworks which are very necessary for the entire medical system and its management. For highly important information for enhancing the user's satisfaction several ingredients must be taken into account e.g., the effect of the network, and impact of the environment for gathering the overall information with the greater visibility with the support of the data analysis tools and techniques e.g., ML. With the rapidly increasing boom of the ML oriented technologies it is very important to optimize, visualize, and present the better picture of the QoE for the better service provision from the network, which also will help in the assessing and examining the faults and quality degrading factors. Besides, these key factors are important to sustain the performance of the network and user's satisfaction at the economical rates. Effective QoE monitoring and optimization is related to the bold and strong initiatives are taken while recognizing the degradation in the customer's satisfaction when they are getting poor services while using the network facilities (see Table 1).

It is not easy to optimize and manage the QoE in the best-effort network types and services due to the allocation of the assets among the several users and services. Hence, managers and vendors are always curious to see the new strategies of the network from the traffic management to the service provisioning perspective. In this regard effective and fairly optimization of the QoE in the medical domain is very vital to share and transfer the services among the patients, physicians and the other users for clearly analyzing the big picture of the system from the customer's satisfaction level. For this process the heavy and self-adaptive ML techniques are need to be developed in association with the currents technological trends and the customer's satisfaction from every perspective such as from network usage to the service availing in the medical hospitals and centers. With the increasing market of the wearable devices in the medical healthcare, and voluminous amount of the data from several sources such as, physiological as well as the video, image and other related information highly visible and bright picture of the scene is required for both the physicians and the patients with acceptable level of satisfaction. So, at this stage it very necessary to understand the clear knot between QoE and QoS to measure the network performance and user's perception [1–3]. This research proposes the framework for the QoE optimization in the medical healthcare by considering the MAC and PHY layers characteristics in terms of several performance metrics for example, duty-cycle, QoS, and power drain for effectively managing and monitoring the QoE with the high level of the satisfaction. Also due to the increase of the chronic diseases and big screen size mobile devices it is very vital to synchronize the services of the network and the QoE level of the users in the medical hospitals and the theaters. Because today's QoE patterns and practices are more relevant to the human perception, assumption and the cognition level of their overall environment. Clear visibility and the big picture of the medical event is very important, thus video and image transmission over the large size wearable devices in the medical domain for the ease and comfort of both the physicians and the patients is needed. Key performance indicators playing the remarkable role in presenting the actual face and ground realty about the networks and the satisfaction level of the patients and doctors in the medical healthcare environment.

3. Proposed QoE optimization algorithms in IoV System

This section proposes the two AI-enabled QoE optimization algorithms, multimedia communication mechanism, and QoE optimization framework in IoV system, each of this is described individually in the detail as follows.

3.1. Multimedia communication mechanism in IoV

This section presents the media communication process through sensor nodes in internet of vehicles (IoV) system. There are four key parameters of this entire procedure. In Fig. 1, contains three key sections of the multimedia communication in IoV platform. First, multimedia communication mechanism is established in association with the media server. Second, the inter-vehicle, intra-vehicle and extra-vehicle communication among different entities is carried-out by exchanging very sensitive and urgent healthcare data among the vehicles for healthcare through dynamic wireless link (i.e., mobile station). Third, vehicles for healthcare are exchanging the sensitive, secret and important data to the patient theaters, hospitals and medical centers where physicians, nurses and other related staff members will examine/perceive the quality of the multimedia data over the IoV network. Than the quality of experience (QoE) or user perception will be improved by adopting the large screen smart devices for the better and big picture according to the resources available to the IoV networks. Moreover, IoV's traffic will be prioritized according to the class such as, urgent/normal, pre-recorded, online, or high definition respectively. For achieving the timely and delay-tolerant multimedia transmission fast and less buffered techniques with less power drain must be encouraged to make the raw unsmoothed multimedia data into uniform and synchronized pattern with high and clear visibility. Besides, that smoother data will consume less power and battery lifetime of the portable devices at the customers side. Fourth, smoothed data will be transferred to the client/customer side to achieve high QoE with longer and sustainable media transmission as the final target.

In Fig. 3, first internal part shows the communication among the healthcare vehicles in-line with the body sensor networks (BSNs), hospital and the patient's car for revealing the big and better picture of the multimedia communication in IoV framework. Second, that part is connected to the internet and multimedia server to adaptively monitor the human perception level after receiving/examining the QoE from IoV environment. Third, perceived QoE will be further analyzed and examined with the large screen smart mobile sets by properly adopting the QoE tools and techniques. Finally, QoE level will be checked by getting the user's opinion/feedback on the basis of IoV performance (i.e., reasonable buffer space of smart wearable device, their longer battery lifetime and less power drain, etc.) (see Figs. 4 and 5).

So, by analyzing that huge demand we propose the novel QoE optimization framework during multimedia communication in IoV system. Besides, QoE optimization has caught the attention from every sector from industry to academia with the emerging proliferation in big screen mobile cell phones for better and bigger

Table 1
QoE/QoS optimization based on the artificial intelligence in multimedia communication.

Ref. No	Applications	Proposed technique	Component being optimized	Results
[1–3]	Multimedia Monitoring, IoT	Adaptive, Machine Learning	MAC Layer components	Self-adaptive ices
[4–6]	Energy-efficient computation for IoT	Energy-efficient power down policy, routing	latency and energy consumption	Minimum latency and energy consumption level.
[7–10]	QoS/QoE in multimedia	MAC, Phylayer Protocols	Energy consumption model	Low power consumption
[11–13]	IoV and Multimedia	Bluetooth-based body sensor network platform	Duty cycle	Minimize cost and energy consumption
[14–17]	Reliable data communication in IoT	Adaptive resource allocation	Frequency and transmit power	Reduce energy consumption
[18–21]	QoE/QoS regulation in the multimedia healthcare	Energy-efficient health monitoring techniques	Heat absorption and energy consumption	Improve quality of healthcare
[22–24]	To monitor the QoE/QoS in individual's multimedia mobile	Computation and Communication techniques	Mobile phone's energy consumption	To extend battery lifetime
[25–27]	To monitor QoS/QoE in the multimedia	Energy harvesting, TPC, QoS optimization techniques	Low duty cycle MAC, PHY parameters	To enhance energy-efficiency, QoS and lifetime of BSNs
[28–30]	To monitor QoE in IoV system	Energy Harvesting, TPC, scheduling methods	To manage power and enhance energy	To reduce energy consumption of sensor nodes
[31–33]	To develop energy-efficient IoT	Joint routing and TPC techniques	To enhance energy-efficiency	To optimize and manage
[34,35]	Power adaptive in multimedia	Rectifier circuit technique	To optimize power consumption	To optimize energy and extend lifetime of BSN
[36]	Energy-efficient IoT, IoV and multimedia	Adaptive, MAC and routing power control techniques	To optimize energy, channel parameters	To manage power and extend lifetime of BAN
[37–39]	Energy-efficient cloud, framework, algorithm for IoV	Cloud computing energy-efficient techniques	To optimize, transmission power, and cloud energy	To obtain energy-efficient BSN
[40–47]	Multimedia and Energy-efficiency in IoT, IoV	TPC, energy harvesting, and MAC Strategies	To optimize, manage the TPC and duty-cycle	Temperature requirement by different strategies
	Internet of vehicles, cognitive computing, AI,	Self-driven and adaptive AI techniques,	To optimize the cognition level based entities	Efficient IoV systems

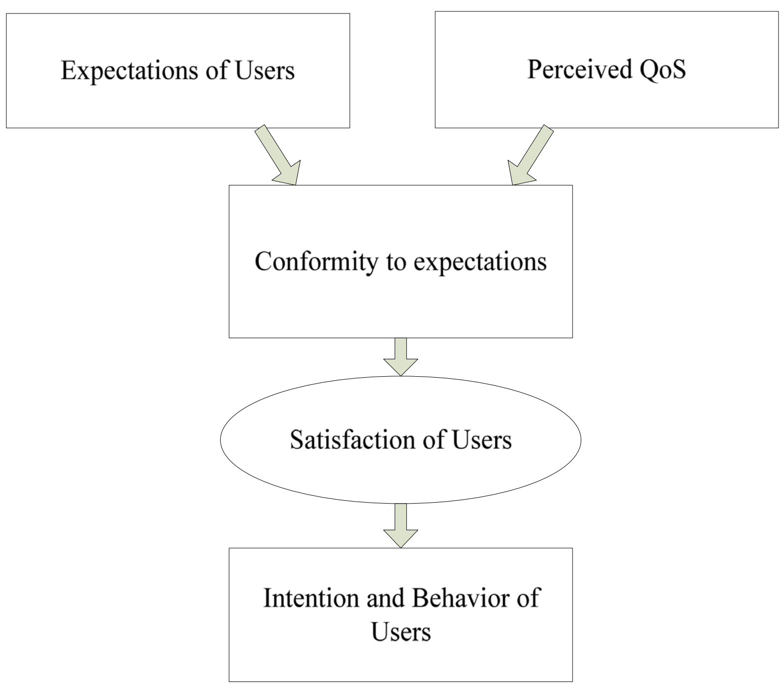

Fig. 1. QoE optimization during multimedia communication in IoV.

picture [11–13]. Less efforts are made to promote the QoE optimization during media transmission in IoV environment with adaptive and self-learning techniques such as, AI and unique architectures. Few related works on QoS/QoE management in wireless, and cellular networks are presented, but still large room is vacant to deal the QoE optimization problem with the intelligent and resource efficient AI-enabled methods during media transmission in IoV system. Our proposed AI-enabled based end-user QoE optimization framework and novel algorithms reveals the significant performance of the entire system while fulfilling the expectations of the customers with the consideration of the performance metrics for instance, delay, power drain and battery lifetime in IoV system. Besides, AI-based schemes are the popular and the high performance indicators with less resource as shown in Figs. 2 and 3.

3.2. *Artificial intelligence based QoE optimization framework for multimedia communication*

The proposed QoE optimization framework through multimedia platform in IoV comprises several steps. First, media stream will be watched by customers/users through big screen portable devices at the YouTube, second the quality of the multimedia is perceived by the users with the help of the QoE measuring tool,

Fig. 2. Multimedia communication mechanism in IoV.

third that measured quality video/image is examined by the IoV system by deploying the real-time applications, fourth feedback of the overall users will collected to analyze the QoE of the entire multimedia system. Lastly, if performance is not satisfactory than will be improved/enhanced by connecting with the QoE server on the basis of the feedback. Than reports will be generated accordingly to further amend the entire multimedia system in the IoV applications.

3.3. Artificial intelligence enabled QoE optimization algorithms

This sub-section proposes two novel AI-based QoE optimization algorithms named, Buffer-aware QoE Optimization (BQO) and Power-aware QoE Optimization (PQO) during multimedia communication in the IoV system.

3.3.1. Buffer-aware QoE optimization algorithm

We propose a novel algorithm based on the buffer allocation mechanism to optimize the QoE during multimedia communication in the IoV system. Proposed BQOA optimizes the QoE by controlling high peak variable rate of multimedia by allocating proper buffer size in IoV.

A discrete multimedia model is considered for clearly describing the mechanism of a BQOA, $t \in \{1, 2, \ldots, F\}$, in which F are taken from receiver's buffer size $(Buffer)$ with frame rate $r(t)$ at time period t. In the case of constant $Buffer$, $B(t) = min\{D(t-1) + Buffer, D(F)\}$ for $t = 2, \ldots, F$, with $Buffer\,(1) = Buffer$ and $Buffer(1) = 0$, will be achieved. To remedy the $Buffer$ abundance and starvation $\left(R_{min} \leq R_{avg} \leq R_{max}\right)$ during video streaming, a suitable transmission schedule must be followed in the presence of N-dimensional real vector $= [a(1), \ldots, a(F)]$. BQOA remarkably optimizes the QoE by minimizing PMR, Std dev and energy (encoding and transmission), and adapts video rate $[R_{max}, R_{min}]$ according to the $Buffer$ (i.e., starvation or overflowing) during video transmission through sensor nodes. Now for energy optimization, media frame rate is considered in the range of $[R_{max}, R_{min}]$. While average frame rate R_{avg} (see Eq. (5)) lies in between R_{max} and R_{min}, and video sequence is delivered at R_{avg}, which leads to less energy drain. If R_{avg} is larger than R_{max}, the F has to be transmitted at R_{max} to avoid $Buffer$ overflow. If R_{avg} is smaller than R_{min}, the video frame data rate is R_{min} to avoid $Buffer$ starvation. This guarantees that the energy drain is minimized without overflow or starvation of $Buffer$. R_{max} reveals the maximum multimedia transmission rate without $Buffer$ overflow as presented in Eq. (1).

$$R_{max} = \frac{\sum_{t=1}^{F} D(t) + Buffer}{t_B} \tag{1}$$

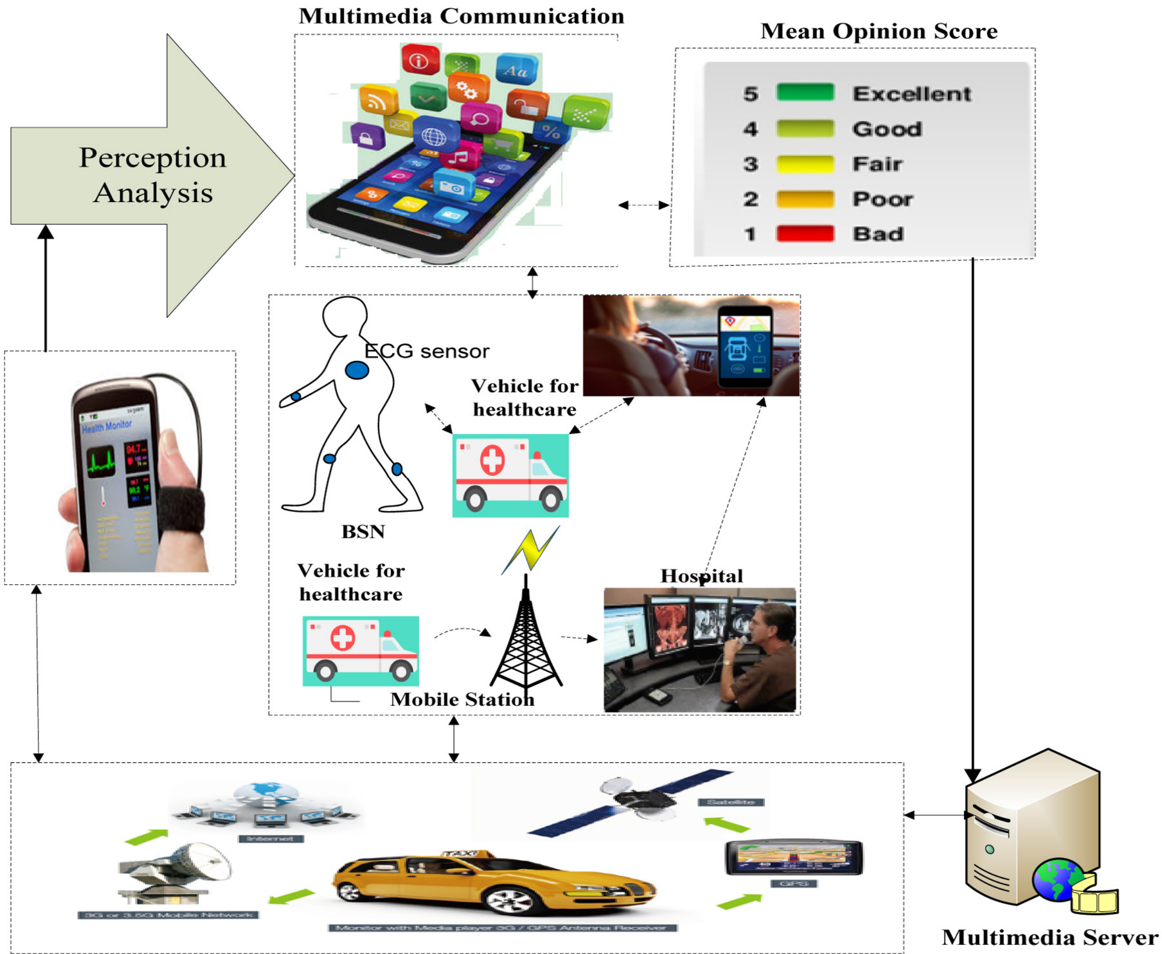

Fig. 3. Proposed AI based QoE optimization framework of multimedia communication in IoV.

$$t_B = \frac{B\,(t) - q\_buffer}{t} \tag{2}$$

$$R_{min} = \frac{\sum_{t=1}^{F} D\,(t) - q\_buffer}{t_D} \tag{3}$$

$$t_D = \frac{D\,(t) - q\_buffer}{t} \tag{4}$$

$$R_{avg} = \frac{R_{max} + R_{min}}{2} \tag{5}$$

t_B, presents the prior time when *Buffer* size is entirely full and transmitter node starts working (see Eq. (2)) at R_{max}.

Similarly, R_{min} is the minimum multimedia communication rate to avoid the *Buffer* starvation (see Eq. (3)), by adopting *q_buffer*. Whereas t_D is the period of time when *Buffer* is empty while transmitting at R_{min} as given in Eq. (3) by adopting *q_buffer*. Optimal and efficient multimedia communication schedule can be obtained at the condition $R_{min} \leq R_{avg} \leq R_{max}$ to optimize the QoE. BQOA remarkably gets efficient and reliable multimedia communication schedule by avoiding large peak rates, and deviation, thus, QoE is optimized accordingly.

3.3.2. Power-aware QoE optimization algorithm

This sub-section proposes the novel power-aware QoE optimization algorithm (PQOA) to effectively manage the resources during multimedia communication in the IoV system. In addition proposed PQOA is based on the channel features in association with the IoV as an individual and realistic network. According to AI-enabled PQOA and path loss model for IoV system during multimedia communication to facilitate the end-users there is a rigorous mathematical description in following Eqs. (6) and (7)

$$PL_{dB} = 10 \times log\left(\frac{16\pi^2.d^2.L}{Gr.Gt.\lambda^2}\right) \tag{6}$$

$$\frac{16\pi^2.d^2.L}{Gr.Gt.\lambda^2} = 10^{\frac{PL_{dB}}{10}} \tag{7}$$

Whereas, Gt, Gr, L, λ are the gain (for transmitter, receiver antennas), length and bandwidth, respectively for IoV system during multimedia communication as in Eq. (8)

$$10^{\frac{PL_{dB}(d_0)+S}{10}} . \left(\frac{d}{d_0}\right)^n = 10^{\frac{PL_{dB}}{10}} \tag{8}$$

Eqs. (8) to (9) are used to express the path loss of the individual network at the patient's body in association with received signal strength indicator (RSSI), transmission power (TP) level and QoE monitoring level over adaptive edge-computing healthcare platform for the disable patients. When calculate the power consumption in-line with the impact of the fading and path loss on the entire healthcare environment. Besides, power drain of the class A linear power amplifies (PA) with modulation schemes for instance, binary phase shift keying (BPSK), quadrature phase shift keying (QPSK) and M-array amplitude modulation (MQAM).

$$P'_{PA} = 10^{\frac{PL_{dB}(d_0)+S}{10}} . \left(\frac{d}{d_0}\right)^n . \frac{1}{3K}\left(2^b - 1\right)$$

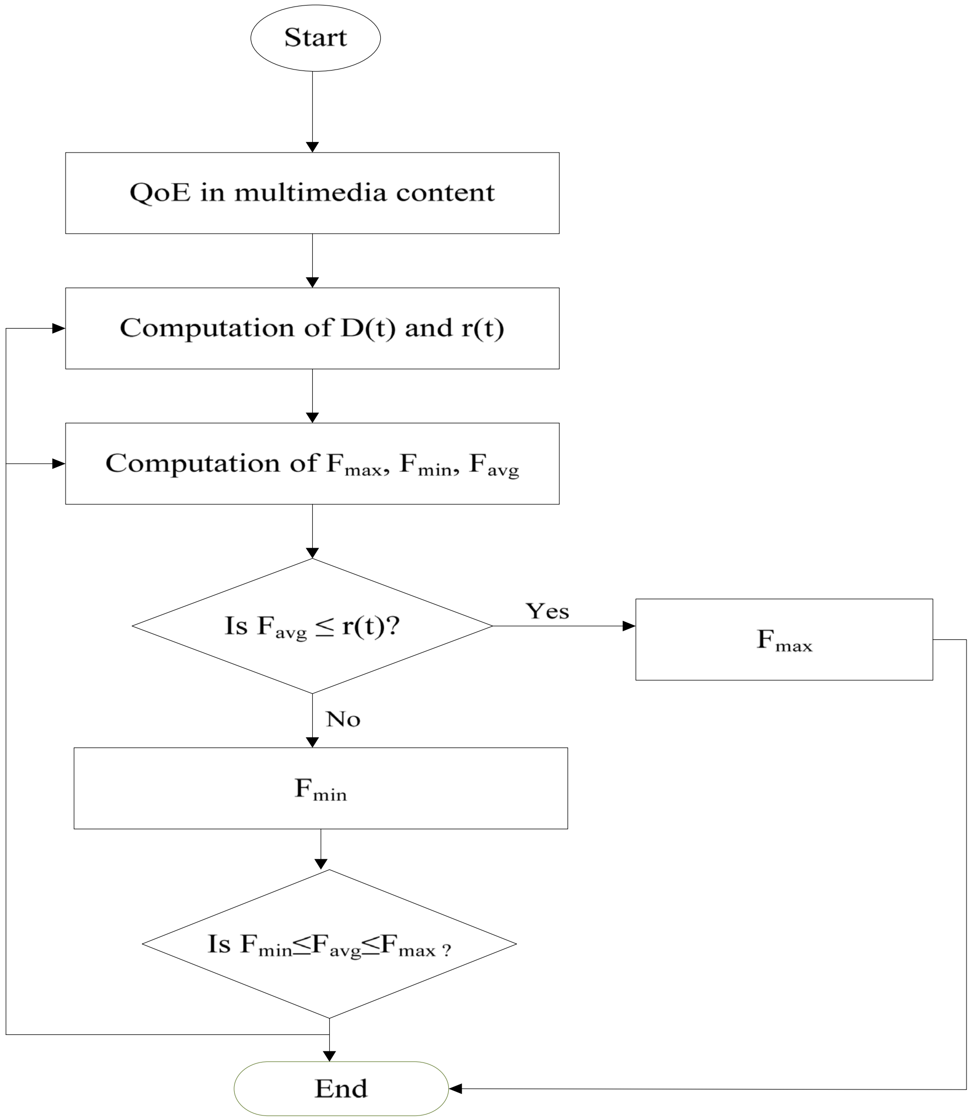

Fig. 4. Flow chart of AI-based proposed BQOA in IoV System.

$$.N.\left(Q^{-1}\left(\frac{1}{4}\left(1-\frac{1}{2^{b/2}}\right)^{-1}b.BER\right)\right)^{2}.PAR \tag{9}$$

Then total energy consumption per bit can be expressed by Eq. (10) with power of power amplifier as in Eq. (11)

$$E'_{active\_bit} = P'_{active}.T_{bit} = \left(P_e + P'_{PA}\right).\frac{1}{R_S.b}$$

$$E'_{active_{bit}} = \frac{13\times 10^{-3}}{R_S.b} + 10^{\frac{PL_{dB}(d_0)+S}{10}}.\left(\frac{d}{d_0}\right)^{n}.\frac{1}{3K}\left(2^{b}-1\right) \tag{10}$$
$$.N0.\frac{1}{b}.N.\left(Q^{-1}\left(\frac{1}{4}\left(1-\frac{1}{2^{b/2}}\right)^{-1}b.BER\right)\right)^{2}.\sqrt{\frac{3.(2^{b/2}-1)}{2^{b/2}+1}}$$
$$.PAR_c.PAR_{roll-off(\alpha)}$$

$$P_{PA} = TP + P_{amp} = (1+\beta)\,TP = \frac{PAR}{\rho}TP \tag{11}$$

Adaptive power for optimizing the QoE in IoV system during multimedia communication as represented in Eq. (12)

$$P_t = \frac{P_{PA}\times\rho}{PAR}\times t \tag{12}$$

4. Experimental set-up

In order to simulate the mobility scenarios of vehicles, it is supposed that the emergency vehicles or ambulances have moving speed from 10 km/h to 24 km/h. The vehicles deliver/exchange the information to the healthcare network by transmitter sensor node and base station (BS) with the help of an access point. The data generator and access point are inter-connected through ZigBee and Wi-Fi enabled networks. The direction of producer is set to enable the producer pass from one AP to another. The selected key factors are compatible with the IoV environment. Besides a detailed methodology is presented by adopting the single-hop topology-based sensor clusters in IoV system during multimedia communication. QoS computation model is to minimize the power consumption, resource cost, delay and overhead. Besides, mobility management based channel model is considered for QoS computation during multimedia communication in terms of less delay, low cost and power optimization in the IoV systems. Furthermore, MATLAB based Convex Optimization tool is used to estimate the transmission power levels and the received signal strength indicator (RSSI) value of each sensor nodes then average values are obtained by combining individual score of both former and later entity for entire system. As due to the random individual quality

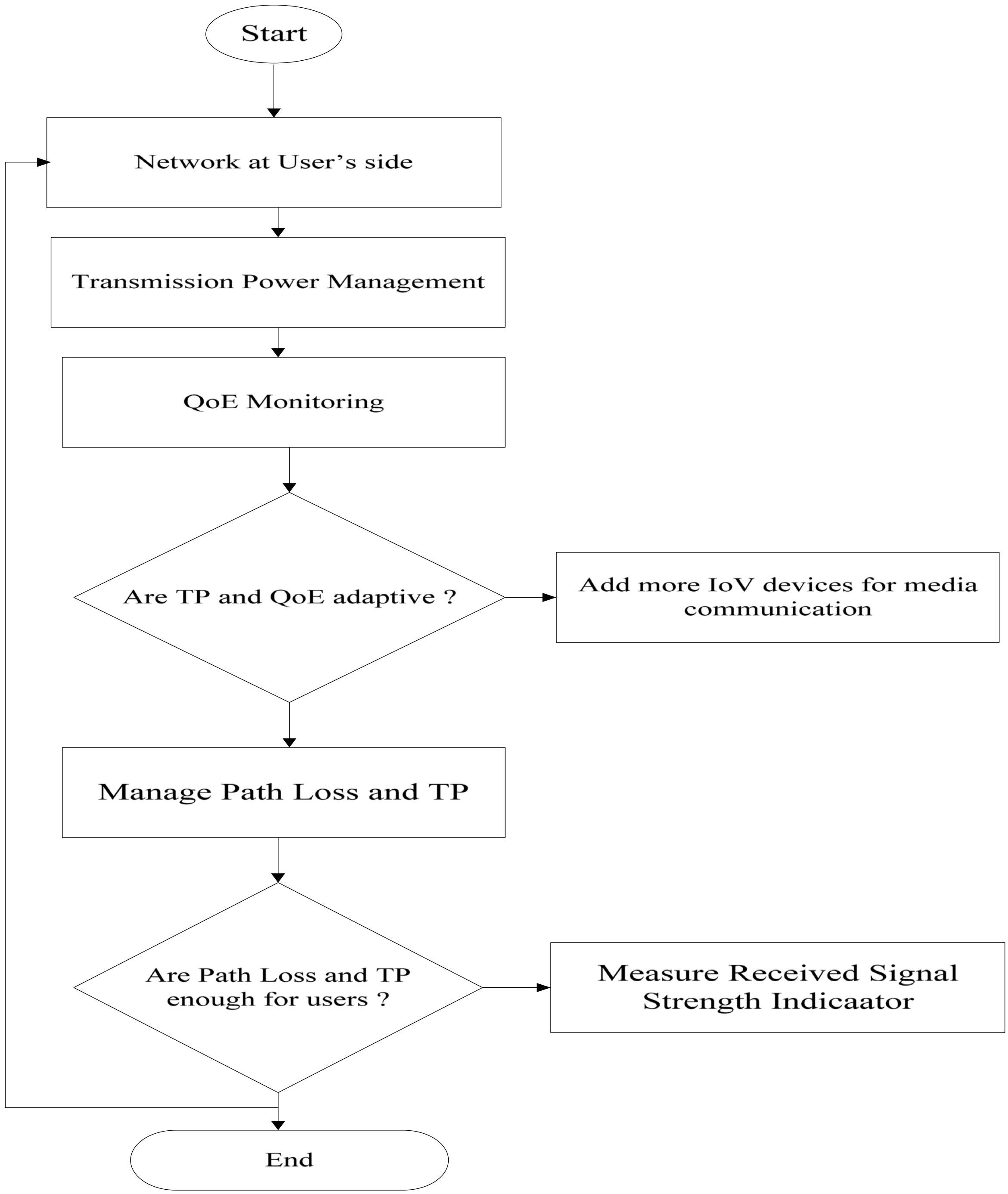

Fig. 5. Flow chart of AI-based proposed PQOA in IoV System.

and high mobility or less stability in the channel there are more chances QoS degradation (high power drain, more delay and less throughput, etc.). So, it is very vital to optimize the resources then find the aggregate values and the less risk-bearable and critical point to defeat the attackers. Also the channel stability (i.e., less deviation in the RSSI value) or mobility management is the critical and demanding factor to stabilize the entire IoV environment during multimedia communication.

We also validate the proposed PQA, BQA and conventional methods by considering the real-time data sets from US department of transportation [44] for further observing the optimized QoE, less power drain results. For example, connected vehicles are the most successful things in the era of IoT. The connections between vehicles and networks grow and provide more convenience to users. However, vehicles become exposed to several challenges due to dynamic nature of wireless channel. Therefore, a connected vehicles now need high QoE during multimedia communication. We establish the test-bed for validating the proposed and conventional methods to exploit the ground truth in terms of the QoE and energy drain while detecting the critical status of vehicles. Besides, we obtained the vehicle traffic data as the real-time use-case and performed the one-way analysis of variance (ANOVA) test. As a result, our statistical and mobility management based proposed PQA and BQA can accurately analyze the power, QoE and energy saving level of the connected vehicles in IoV platform. Besides, we adopt the real-time transportation dataset from motion sensors [44] gathered from vehicles [45]. There are a total of 3220 stations and 47,719 vehicles total. Virtual identities are allocated to each vehicle with a specific station

4.1. Experimental results

This section presents in detail the experimental results and discussion. Extensive experimental subjective test as per the requirement of the medical healthcare services and platform is conducted in a closed room over 50 subjects (25 male and 25 female) between age groups of 40–70 without any visual problem to them such as, color blindness etc. Before involving them into experiment their color-identifying test was conducted by showing them on the stick over the wall in the vehicle to easily monitor the entire satisfaction level. Our experiments are conducted in MATLAB by using questionnaire survey data of 10 samples (i.e. patients) to model and evaluate QoE. Besides, patient's satisfaction survey is performed and then results are compared with the polynomial, exponential and logarithmic mapping functions based on Webb Fechner's law and average grading score. Furthermore, QoE is assessed in terms of two performance metrics such as, duty cycle, QoS and power drain. ML enabled framework is proposed by considering both the PHY and MAC layer parameters, besides, mean opinion score (MOS) is the better yardstick to examine the user perception about the quality of the multimedia service in the IoV system while monitoring healthcare. The increasing demand of the joint PHY and MAC layers usage provides the remarkable results during QoE optimization in satisfying the user expectations during media transmission over the large screen mobile devices. So, the vigilant and active techniques such as ML based self-adaptive methods are considered as the dire need of today's emerging medical market with wearable devices to fulfill the desires of the users. Usually, QoS of the networks is not the sole candidate to portray the perception and notions of the users, humans, customers, so to know about the user's actions and reactions, about the service provided by the network. Thus it is very important to deal with the QoE from the perspective of both the user and network for big and better picture of the network by adopting the various components from MAC, Network and PHY layers.

4.2. Discussion

This sub-section presents the detailed discussion of the revealed experimental results by properly computing and comparing QoS in association with conventional methods. Besides, the role and importance of the MAC and PHY layer parameters in clearly depicting the performance of the entire medical network is the game changer step. Mean Opinion Score (MOS) values to medical media transmission changes the network performance metrics. These MOS always gives the user satisfaction toward the network services and the product usage in an efficient and visible pattern. That is why a novel QoE framework with the intelligent ML techniques and the consideration of the MAC and PHY layers parameters over the big screen mobile cell phones and the wearable devices is proposed. In addition the perception level of the customers is examined while transmitting, sharing the clear picture of the medical event. For obtaining this rigorous subjective and objectives tests are performed, which are entirely based on the survey and customer's expectations fulfillment while watching the video clips or image over the large screen devices. Moreover, it is also examined that how the users are interpreting the service after provisioning. Duty cycle, power drain and the QoS at the MAC, physical and network layers accordingly playing the major role in obtaining the overall perception and expectation level of the users while observing the media quality. These parameters are either directly associated to MAC layer (i.e., duty cycle) or indirectly associated QoS and the power dissipation. These all entities are the important role players with the high impact on the evaluation of the user perception in the medical healthcare domain. Multimedia QoE assessment and monitoring is essential to deliver an optimized end to end high QoE service. This requires a deep understanding and efficient identification of different objective and subjective parameters that impact the user experience. Multimedia content delivery is a large and continuously evolving field that involves various actors from content service providers to Internet service providers, and to content consumers (users) themselves.

Therefore, a comprehensive QoE assessment requires the understanding, the role, and impact of these actors on multimedia content from delivery till consumption. There are close ties between the QoS, QoE and end-customers in this increased era of the mobile healthcare. In the mean-time the boom in the wearable devices to easily transfer and receive the data to/from customer/physician is the dire need to set-up the innovative and needful experimental test-bed. In this regard, we consider the several sensor nodes and various performance parameters such as, QoS, QoE, duty-cycle and the power consumption analysis. Fig. 6 presents the QoE optimization in the IoV system by taking into account the various performance indicators In Fig. 6(a) relationship between IoVs and QoE optimization is revealed for Baseline and proposed PQOA, BQOA. It is analyzed and observed that QoE is optimized at high, medium and low level by BQOA, PQOA and Baseline approaches respectively. Fig. 6(b) presents the relationship between buffer size and delay for Baseline and proposed BQOA, PQOA, we examined that there is a linear trade-off between buffer size and delay which is higher for Baseline, relatively high for BQOA and small for PQOA respectively, due to their power and bandwidth management capabilities in IoV system. Similarly, battery lifetime is optimized with respect to time for Baseline, and PQOA, BQOA accordingly. PQOA extends the battery lifetime at higher level, BQOA increases battery lifetime at medium level and Baseline at low level consequently. Finally, relationship between time and QoE optimization with respect to the IoVs count for PQOA, BQOA and Baseline accordingly. We observed that PQOA significantly improves the QoE during media streaming than BQOA and Baseline in IoV system. Fig. 7, presents the performance evaluation of the entire multimedia communication through IoV system with several parameters for example, QoE optimization, duty cycle, power and the quality of service (QoS) in line with the number of nodes for perceiving the satisfaction level of the end-users/customers for the entire medical health system. After the large and rigorous experimental set-up it is interpreted that self-adaptive and intelligent machine learning techniques are high performance oriented methods in the experimental results and discussion part. Fig. 7(a), presents the relationship between number of sensor nodes and QoE optimization in the healthcare system by adopting several values of the sampling rate at the physical layer.

It is examined that QoE is exponentially increasing as the number of sensor nodes increases, besides it is examined that QoE is optimized significantly at smaller value of the sampling rate and degrades with the increase of the sampling rate. Fig. 7(b) reveals the trade-off between number of sensor nodes and duty cycle optimization while portraying the clear image of the QoE from the end-user's aspect.

It is observed and interpreted that the duty cycle is remarkably improved at the sampling rate and exponentially decreases with the number of sensor nodes. Duty cycle optimization is one of the key performance analysis components especially from the end user's perspective whether there is an acceptable satisfaction level or not. Fig. 7(c), reveals the relationship between the number of nodes and power consumption at the various sampling rate values to examine the value of QoE, and less power is consumed at small

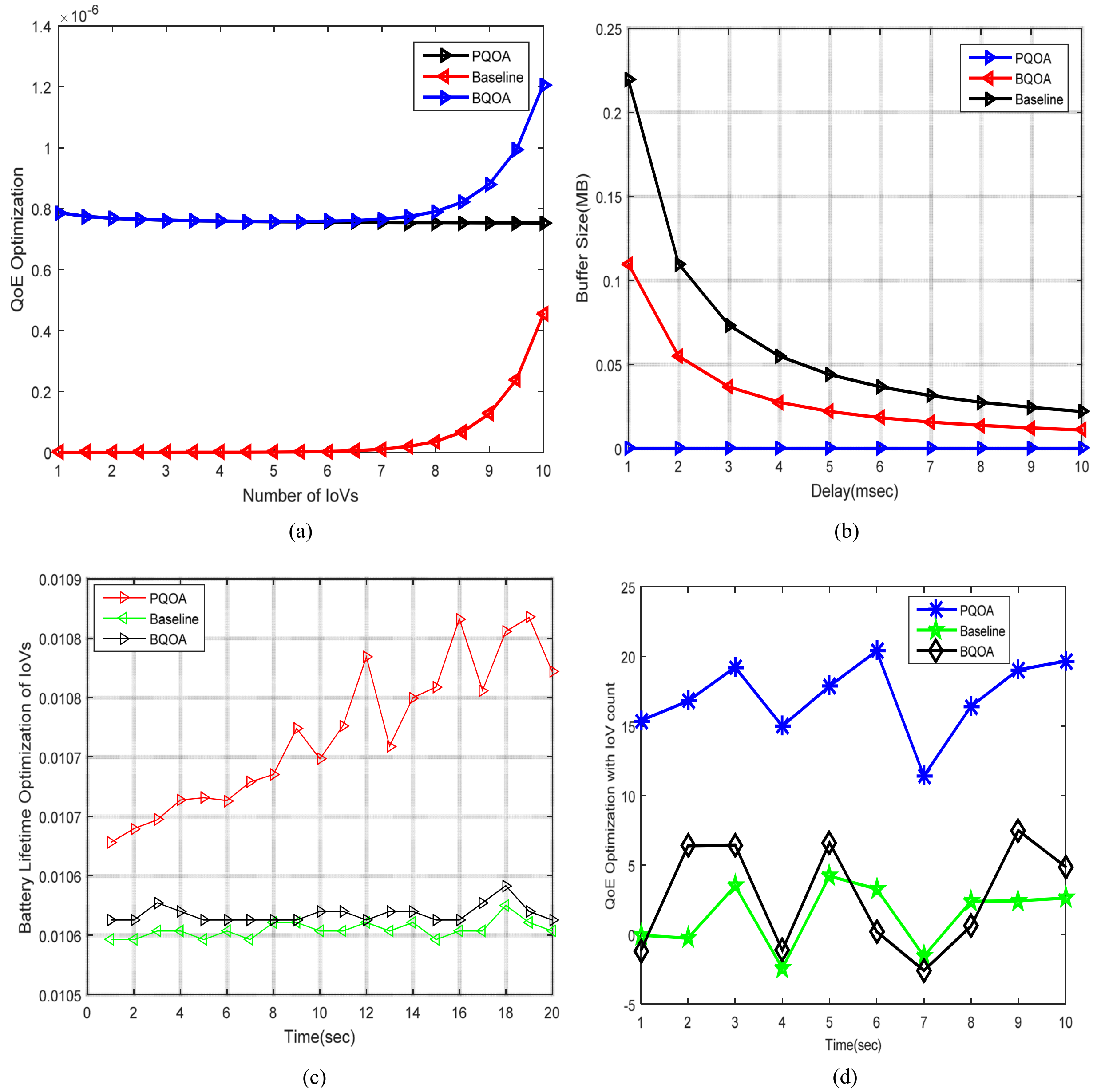

Fig. 6. QoE optimization in IoVs. (a) Number of IoVs vs. QoE optimization, (b) delay vs. Buffer size, (c) Batter lifetime optimization vs. time, (d) QoE optimization with IoV count vs. time.

sampling rate and vice versa. Similarly, it is shown in Fig. 7(d) that there is a direct relationship between number of nodes and the QoS optimization at the various sampling rates. It is examined that more QoS is achieved and hence the high QoE with satisfactory user level. Moreover, it can be said that the joint MAC and PHY layer provides the high QoS and QoE optimization with respective to the need of the end-user/customer satisfaction from the perspective the medical system's requirement.

Fig. 8 presents the relationship between time (in hour) and the vehicle count in the IoV, where three regions at three different distance (in kilometer) values i.e. (50, 50),(0, 100) and (100, 100) coverage is considered to examine the overall QoE and energy optimization. In addition results are validated by adopting real-time transportation data sets [44,45] over time scale of 10 h time period with a confidence interval of 93%. While each pair for example (50, 50) shows the area of covered region (50 square meter) with respect to distance (50 km), similarly (0, 100) represents the zero covered region up to 100 km due to less QoE and high power drain issues. And finally the data pair (100, 100) exploits that 100 square meters are covered up to 100 kilometer to properly provide the QoE during multimedia communication in IoV.

5. Future directions and tentative solutions

High mobility in the IoV networks during multimedia communication in healthcare drains more power in the wearable/portable devices, which degrades the QoE i.e., user perception about the entire system performance. So, in order to efficiently optimize the QoE with cost-effective services AI and ML based methods are the appropriate and promising options. Still the presence of manual systems pulling back the entire system into the age of stones so it is very vital to introduce the modern and automatic system to improve the product of the system. ML infrastructure is cumbersome and hard to be integrate with the other medical healthcare platforms. Besides, many healthcare facilities are not inspirational and sustainable for the future applications for maintaining the overall staff to design the self-adaptive and intelligent

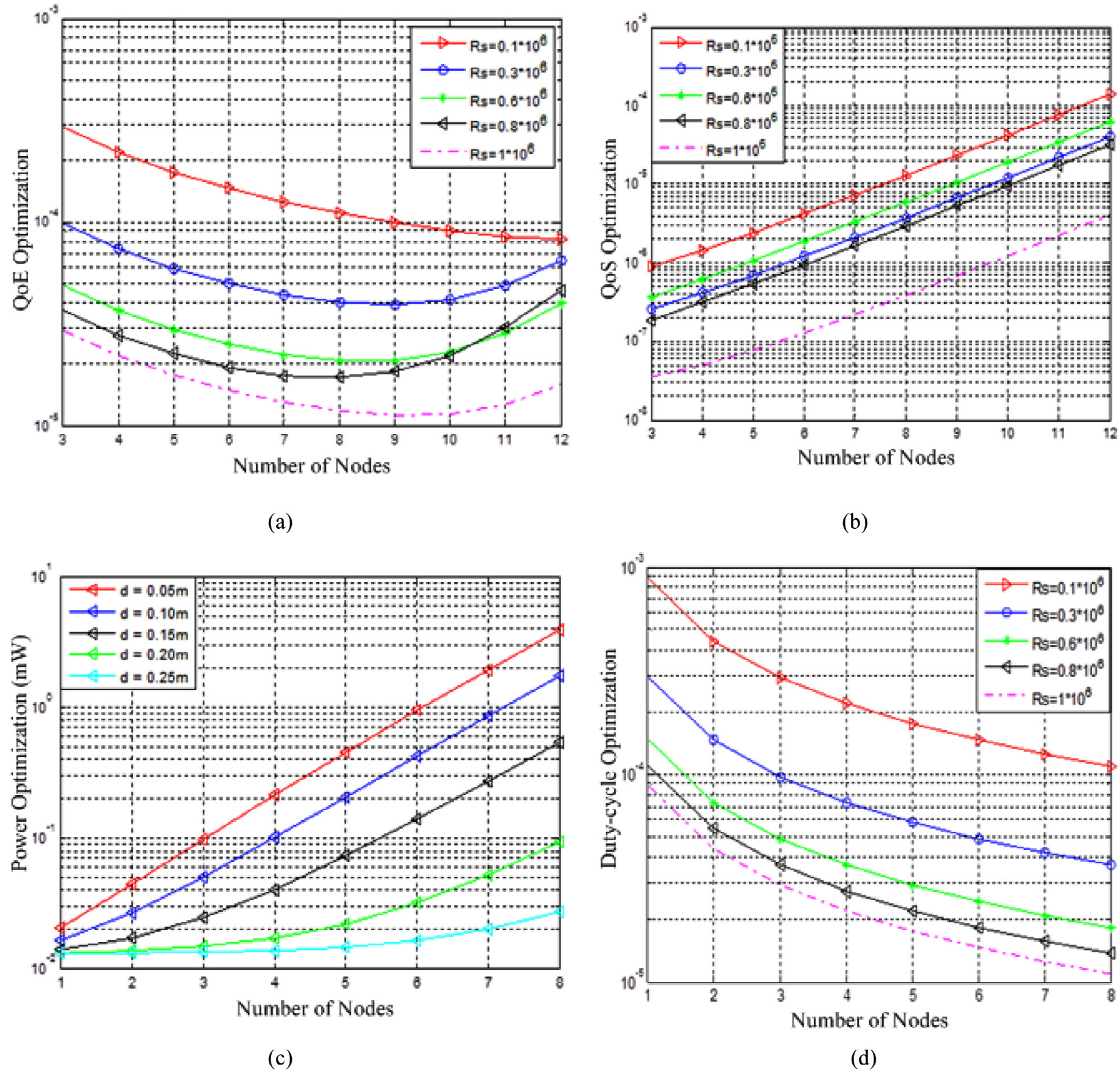

Fig. 7. Performance evaluation of medical healthcare, (a) QoE optimization, (b) duty-cycle optimization, (c) Power optimization, (d) Quality of Service optimization.

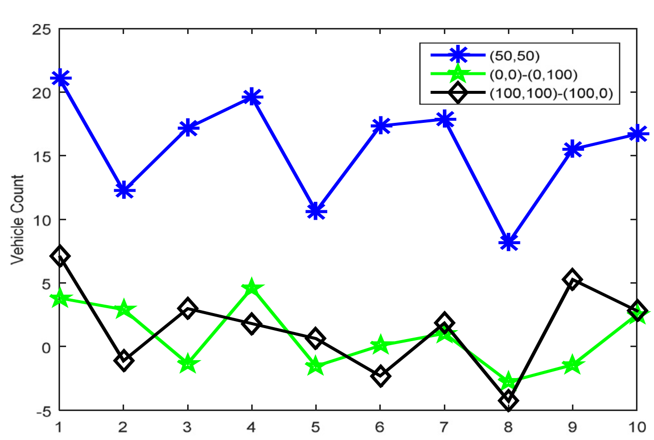

Fig. 8. Relationship between the time and vehicle count in IoV network.

ML schemes. Self-derived IoVs are playing the key role in transmitting the sensitive medical information through e-healthcare vehicles i.e., ambulances with high end user satisfaction i.e., better QoE by watching clear, big and better picture of the critical event. Also the adjustment of the artificial intelligence and ML is famous throughout the main world. US is the leading investor in the healthcare market with the major portion of the budget allocation for the elderly healthcare and the critical situation analysis. With the rapid progress in the system there from technological view point it is important to facilitate the common people according to the needs of their locality. IoVs are the key area lies under the umbrella of IoT in association with sensors, actuators, etc to manage the resources i.e., QoE of the end users while transmitting multimedia information from e-healthcare vehicles to physicians, hospitals and medical centers for facilitating the aging society. Traditional static nature vehicles are not the suitable option to deal with the multimedia data transmission from patients side to the hospital, but the current mobile e-healthcare vehicles in IoV is the appropriate option to manage the QoE of the users while watching/receiving the video clip or images on the large screen of the smart phones. QoE optimization and analysis frameworks and the algorithms are the key ingredients to deal with QoE and QoS linearity model. To remedy that problem we propose the ML based self-adaptive framework by considering the MAC and PHY layer entities for QoE optimization while watching the video or image transmitted through mobile e-healthcare vehicles over the large screen smart phones. Following are the tentative proposed solutions.

Due to increasing demand of the highly intelligent and mobile sensor enabled IoV platforms for the quick and rapid multimedia communication in healthcare through e-healthcare vehicles is basic and important need to be fulfilled by providing the high QoE i.e., user perception.

Solution 1, first due to the emerging demand of the mobility-aware IoV platform for healthcare domain Artificial intelligence and machine learning based self-adaptive solutions for the medical system monitoring are the dire need of the future.

Solution 2, Fuzzy-logic based novel decision making techniques in IoV while transmitting the real-time data of the patients need to be developed in the business and enterprises to effectively increase the product of the entire system

Solution 3, adaptive resource sharing based algorithms in IoV system while transmitting the multimedia information with high computation capabilities are considered as the need of the hour in the medical health applications. Hence, the benefits of machine learning and adaptive methods are higher and long-lasting.

6. Conclusions

This research proposes a state-of-the art QoE framework for the analysis of the end-user's perception about the services provided in the medical healthcare informatics. Besides, QoE optimization in the MAC and PHY layers is performed based state-of-the art techniques for the health informatics and personalized health planning. Proposed framework is very generic and can be adopted for the several healthcare management and monitoring applications to entertain various latest issues such as, cardiovascular, diabetic, and the stress etc., where the disease process is a complex dynamic process that can be modified by exogenous variables such as some behavioral and clinical variables. Our framework holds great potential to provide scalable solutions for mitigating these health problems, which can promote healthier lifestyles outside of clinical settings. We further apply our proposed models to extensive experiments on real-world daily behavioral data, which demonstrate promising utility and efficacy of our method. Future works include extensions of the model to other dynamic models that have different characteristic than linear models, e.g., some diseases, such as Depression, might follow a different dynamic process. While currently we assume sufficient data has been collected for each individual, it is also of interest to develop an adaptive learning and planning model that can be applied to scenarios where data come in sequentially.

Main limitations of this research are as follows

- Fuzzy-based strategy merely supports in the decision making and prioritizing the critical factors in healthcare sector
- Fuzzy-enabled algorithm is not creating the strong bond between the convergence and interoperability for the sustainable IoMT.

In near future interoperability in joint transmission power control and IoMT networks for low-power healthcare applications will be center of attention.

Disclosures

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Ali Hassan Sodhro works as the Postdoctoral Research Fellow in DISP LAB of University Lumiere Lyon 2, Lyon, France under Erasmus Mundus's SMARTLINK2017 Project and Assistant Professor in Electrical Engineering Department at Sukkur IBA University, Sukkur, Sindh, Pakistan. He is also Head of International Research Collaboration Committee. He is also reviewer of many peer-reviewed international journals, IEEE Sensor Journal, International Journal of Distributed Sensor Networks, Digital Communication and Networks-Elsevier, Wireless Personal Communication-Springer, etc. He is TPC member of ACM's 12th International Conference on BondyNets 2017. Dr. Ali Sodhro completed his Ph.D. from Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences (SIAT, CAS) and University of Chinese Academy of Sciences (UCAS) China in Biomedical Electronic Systems on Energy-efficient Communication for Wireless Body Sensor Networks, 2016. He did his M.E (Communication Systems and Networks) and B.E (Telecommunication) both from Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan in 2008 and 2010, respectively. He has a vast experience of 9 years in Academia & Research. He is a recipient of Full funded Merit Scholarship Award from Sindh Technical Board, Karachi, Pakistan, for B.Engg:, from Jan 2004 to Dec. 2007. Fully funded Merit Scholarship Award from Sindh Technical Board, Karachi and Illm-e-Foundation Lahore, Pakistan, for M.Engg:, from Jan 2008 to July 2009. Fully funded Ph.D. scholarship Award from University of Chinese Academy of Sciences and Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China, from August 2011 to July 2016. He is also recipient of many research awards, i.e., Third Best Paper Award with Cash Prize & Certificate at Guangzhou Annual Report Competition at Guangzhou, China, 2012; Best Student Presentation Award with Cash Prize at 3rd Global Health Informatics Summit 2015 in Conjunction with The 11th IEEE-EMBS International Summer School & Symposium on MDBS'2015 & The 10th International School & Symposium on BHE'2015; outstanding Graduate Award, 2015 with Cash Prize and Certificate. He is Author of 35 Research Journal & International conference Proceeding Papers, 6 Book Chapters.

Zongwei Luo is a researcher and an associate professor in SUSTech located in Shenzhen, China, with over 15 years R&D and project management experiences. Dr. Luo obtained his Ph.D. from University of Georgia, USA, focusing on workflow automation and enterprise integration. After that, Dr. Luo was with IBM TJ Watson Research Center in Yorktown Heights, NY, USA, before coming to E-Business Technologies Institute, the University of Hong Kong. Dr. Luo has been actively working on Big Data and FinTech, RFID/Internet of Things, Virtual Reality and Interactive Media, Service Innovation and Mechanism Design and their applications with over 100 publications.

Gul Hassan Sodhro, completed his Bachelor of Science (BS) in Physics from Shah Abdul Latif University, Khairpur, Mirs, Khairpur, Sindh, Pakistan. Currently he is planning to pursue his Master and Ph.D. in Biomedical Physics especially in medical imaging, wearable BioNano devices, etc. He has more than 2 years of teaching experience at college level, and published some conference papers and book chapters.

M. Muzammal is working at the Shenzhen Institute of Advanced Technology (SIAT), Chinese Academy of Sciences (CAS), China, and the Department of Computer Science, Bahria University, Islamabad, Pakistan. He received his Ph.D. degree in Computer Science from the University of Leicester, UK. His research interests are in data mining, uncertain data, and human-centered computing.

Joel J.P.C. Rodrigues [S'01–M'06–SM'06] is a professor and senior researcher at the National Institute of Telecommunications (Inatel), Brazil and senior researcher at the Instituto de Telecomunicações, Portugal. He has been a professor at the University of Beira Interior (UBI), Portugal and a visiting professor at the University of Fortaleza (UNIFOR), Brazil. He received the Academic Title of Aggregated Professor in informatics engineering from UBI, the Habilitation in computer science and engineering from the University of Haute Alsace, France, a Ph.D. degree in informatics engineering and an M.Sc. degree from the UBI, and a five-year B.Sc. degree (licentiate) in informatics engineering from the University of Coimbra, Portugal. Prof. Rodrigues is the leader of the Internet of Things research group (CNPq), Director for Conference Development — IEEE ComSoc Board of Governors, IEEE Distinguished Lecturer, the President of the scientific council at ParkUrbis — Covilha Science and Technology Park, the Past-Chair of the IEEE ComSoc Technical Committees on eHealth and on Communications

Software. He is the editor in-chief of three International Journals. He has authored or coauthored over 550 papers in refereed international journals and conferences, 3 books, and 2 patents. Prof. Rodrigues is a licensed professional engineer (as senior member), member of the Internet Society, and a senior member ACM and IEEE

Victor Hugo C. de Albuquerque has a Ph.D. in Mechanical Engineering with emphasis on Materials from the Federal University of Paraiba (UFPB, 2010), an M.Sc. in Teleinformatics Engineering from the Federal University of Ceará (UFC, 2007), and he graduated in Mechatronics Technology at the Federal Center of Technological Education of Ceará (CEFETCE, 2006). He is currently Assistant VI Professor of the Graduate Program in Applied Informatics, and coordinator of the Laboratory of Bioinformatics at the University of Fortaleza (UNIFOR). He has experience in Computer Systems, mainly in the research fields of: Applied Computing, Intelligent Systems, Visualization and Interaction, with specific interest in Pattern Recognition, Artificial Intelligence, Image Processing and Analysis, as well as Automation with respect to biological signal/image processing, image segmentation, biomedical circuits and human/brain–machine interaction, including Augmented and Virtual Reality Simulation Modeling for animals and humans. Additionally, he has research at the microstructural characterization field through the combination of non-destructive techniques with signal/image processing and analysis and pattern recognition. Prof. Victor is the leader of the Computational Methods in Bioinformatics Research Group. He is an editorial board member of the IEEE Access, Computational Intelligence and Neuroscience, Journal of Nanomedicine and Nanotechnology Research, and Journal of Mechatronics Engineering, and he has been Lead Guest Editor of several high-reputed journals, and TPC member of many international conferences. He has authored or coauthored over 160 papers in refereed international journals, conferences, four book chapters, and four patents.