Congestion and throughput optimization protocol for providing better quality of service and experience

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ABSTRACT

Multimedia traffic in internet of things (IoT) applications is generated for various purposes and encompasses a wide range of multimedia data, including video streams, audio files, images, and sensor data. Network providers employ various strategies to handle multimedia traffic in IoT applications efficiently. But most of these methods have not considered optimizing the real-time streaming protocol (RTSP), real-time transport protocol (RTP), and real-time control protocol (RTCP) to improve the throughput and quality of service (QoS) of the IoT applications. Hence, in this congestion and throughput optimization protocol (CTOP) work, we present a model which optimizes the RTSP, RTP, and RTCP protocol to improve the throughput and QoS. The CTOP model outperforms the big packet protocol model in terms of average throughput, multimedia loss, delay, and energy consumption for both less and high-traffic scenarios. For less-level of traffic and high level of traffic, the CTOP model achieves a better average throughput, and average multimedia delay, reducing the average multimedia loss and average energy consumption in comparison to the existing big-packet-protocol (BBP) model. These results highlight the improved performance and efficiency of the CTOP model compared to the BBP model.

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1. INTRODUCTION

Multimedia is the integration of multiple forms of media, such as text, audio, images, video, and interactive elements, into a single digital experience. It involves the representation, processing, storage, and transmission of various types of media data [1]. The availability and consumption of high-resolution video content, including 4K and 8K resolution, have increased due to advancements in camera technology, network bandwidth, and streaming services [2]. Virtual reality (VR) and augmented reality (AR) technologies offer immersive multimedia experiences, finding applications in gaming, training, and education [2]. The 360-degree video provides interactive and immersive viewing experiences for applications like virtual tours and live events [3], [4]. Live streaming of multimedia content has become prevalent on platforms such as YouTube and Facebook live. Artificial intelligence (AI) and machine learning (ML) techniques are applied to multimedia applications, enabling image and video recognition, content recommendation, and video summarization [5]. Personalization and user-generated content have gained popularity, allowing users to customize their multimedia experiences and interact with others in multimedia-rich environments. Staying updated on the latest advancements in multimedia technology is essential as the field continues to evolve [6].

Multimedia in IoT networks refers to the integration of multimedia data, such as audio, video, and images, into the internet of things (IoT) ecosystem [7]. IoT devices, which are interconnected physical objects embedded with sensors, actuators, and communication capabilities, can capture, process, and transmit multimedia data, enabling various applications and services [8]. As the IoT continues to grow, more devices are connected to the internet and capable of generating and transmitting multimedia content. Due to the generation and transmission of multimedia content, multimedia traffic is generated [9]. Multimedia traffic refers to the data traffic generated by multimedia applications and services that transmit audio, video, images, and interactive content over networks [10]. It requires high bandwidth and real-time delivery, posing demands on network resources. IoT applications play a significant role in generating multimedia traffic [11]. To handle this demand, network providers optimize infrastructure, use efficient transmission protocols, and employ traffic management techniques like content delivery networks (CDNs) [12]. Multimedia traffic drives the need for network advancements to meet the demands of multimedia applications and services.

Network providers employ various strategies to handle multimedia traffic in IoT applications efficiently [13]. They allocate sufficient bandwidth, prioritize multimedia traffic through quality of service (QoS) mechanisms, and optimize traffic using techniques like data compression and CDNs [14]. Monitoring and analysis help identify congestion points, while edge computing reduces latency by processing data closer to IoT devices. Moreover, in multimedia IoT applications, real-time streaming protocol (RTSP), real-time transport protocol (RTP), and real-time control protocol (RTCP) play important roles in enabling efficient streaming and control of multimedia data [15]. A basic framework of multimedia transmission using the RTSP, RTP, and RTCP has been given in Figure 1. In this framework, the client using an IoT device request the server to view the multimedia. The client establishes the connection using the hypertext transfer protocol (HTTP) and requests the media using the RTSP media player. The RTSP media player connects to the media server using the RTSP. The RTP and RTCP are used to transmit the audio/video content from the server to the client and vice versa. An example of an IoT device transmitting multimedia to the client using the RTSP, RTP, and RTCP has been given in Figure 2.

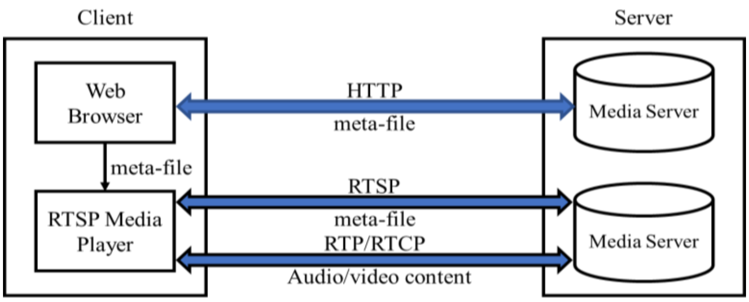

Figure 1. A basic framework of multimedia transmission using the RTSP, RTP, and RTCP

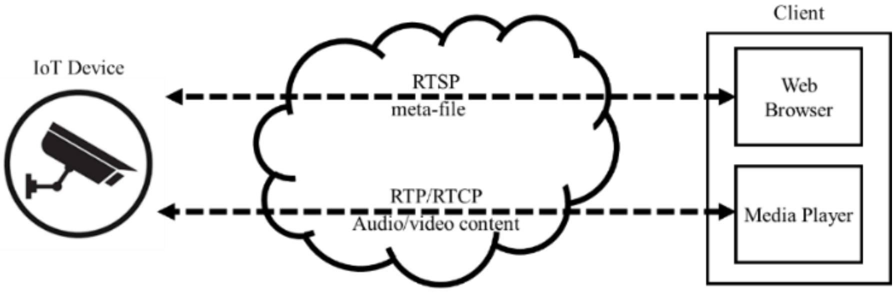

Figure 2. IoT device transmitting multimedia to the client using the RTSP, RTP, and RTCP

Optimizing RTSP, RTP, and RTCP in IoT applications can reduce multimedia traffic and improve throughput and QoS. Efficient resource allocation ensures adequate bandwidth and processing power for multimedia traffic, reducing congestion [16]. Compression techniques in RTP decrease data size, improving network efficiency. Adaptive bitrate streaming dynamically adjusts multimedia quality based on network conditions, optimizing throughput and reducing interruptions. QoS prioritization in RTCP prioritizes multimedia packets, lowering latency, and enhancing user experience. Network optimization and traffic management techniques identify bottlenecks, optimize infrastructure, and implement load balancing and congestion control mechanisms [17]. Optimizing these protocols enhances multimedia transmission efficiency, reduces congestion, and improves the overall multimedia experience in IoT applications. Hence, this work contribution is as follows:

- Present a model to reduce the multimedia traffic in the IoT network by optimizing the RTCP, RTP, and RTSP protocol to provide better throughput and QoS.
- Evaluate the congestion and throughput optimization protocol (CTOP) model with the existing work in terms of multimedia loss, multimedia delay, throughput, and energy consumption.

2. LITERATURE SURVEY

Said *et al.* [18], they have added extra fields to the RTCP and RTP protocol headers and then presented two algorithms IoT-RTP and IoT-RTCP for providing better multimedia streaming. The algorithms were evaluated in the NS2 simulator. The results show that they have improved the end-to-end delay by 2.05%, delay jitter by 39.14%, receiver-report by 36.61%, packet loss by 37.42%, throughput by 16.51%, energy consumption by 17.54%, 18.35% and 20.72% for mobile adhoc network (MAN), wireless sensor network (WSN), and radio-frequency identification (RFID) respectively when compared with the existing RTCP and RTP protocols. Rehman *et al.* [19] presented a low-cost computational algorithm for finding resources for the transmission using the software-defined-network (SDN) to reduce the delay constraint and response interval in multimedia applications. This work provided security and protected the data from various kinds of attacks which is being transmitted from the multimedia application to the user. The results show that the presented work provided an average delivery rate of 35 percent, average processing delay of 29 percent, average network overhead of 41 percent, packet drop-ratio (PDR) of 39 percent, and average packet transmission of 34 percent when compared with the existing works.

Park *et al.* [20], they have presented an optimal multimedia data-streaming management method for ordering the packets for transmission to the mobile nodes in the IoT network. In this work, the correspondent nodes and home agents serve as the primary devices, and they employ a novel routing optimization strategy in combination with the L2-snoop-capable gateway routers and a changed transport control protocol (TCP) packet header structure. They have presented an algorithm called as optimized-multimedia data-streaming management algorithm with traffic-distribution (OMDSM). The algorithm was evaluated and the results show that it has attained better results which increases the TCP efficiency and QoS in the cellular network which resides in the IoT network. Asadi [21], they have presented a routing protocol called as enhanced greedy-forwarding with efficient-multi-path and dynamic-routing (EGFMDR) for multimedia applications to provide better performance in the wireless mesh sensor network. In this protocol, they have used two methods, perimeter forwarding, and throughput-based forwarding. The results have been compared with two methods, dynamic-manet on-demand (DYMO) and ad-hoc-on-demand distance-vector (ADHOV). The results show that the presented work increased energy consumption and decreased delay and PDR.

Ghotbou and Khansari [22], they have done a review and compared various protocols which are used for the transmission of multimedia applications. The protocols include constrained application protocol (CoAP), advanced message queuing protocol (AMQP), extensible messaging and presence protocol (XMPP), message queuing telemetry transport-sensor network (MQTT-SN), HTTP, Websocket, real-time transport control protocol (RTCP), and RTP. After comparison, they have concluded that the CoAP protocol provides better video transmission for the low-power and lossy environments. Clayman and Sayıt [23], they present different methods which can be used for mapping the layered scalable video-coding video-streams utilizing the big-packet protocol. In this work, when utilizing the big-packet protocol, the packets which are to be transmitted have to be constructed using the RTP, user datagram protocol (UDP), and HTTP. The results show that the presented work increased quality of experience (QoE) and reduced latency and loss delivery.

3. MODEL

This CTOP work presents a model for reducing multimedia traffic in IoT networks by optimizing the RTCP, RTP, and RTSP protocols for providing better throughput and QoS. In an IoT environment, there always exists an IoT gateway that connects various devices or platforms connecting sensors, IoT sensors, IoT devices, and smart devices to the cloud using a wireless network. Moreover, multiple IoT gateways are connected using the Internet. The complete structure of how the devices are connected has been given in Figure 3. In this CTOP model, for providing better QoS, a media access control (MAC) optimization algorithm has been presented. Finally, to increase the overall throughput for addressing the multimedia traffic in IoT networks has been presented. Also, the optimization of the gateways has been done using the technique for order of preference by similarity to ideal solution (TOPSIS) method presented in [24].

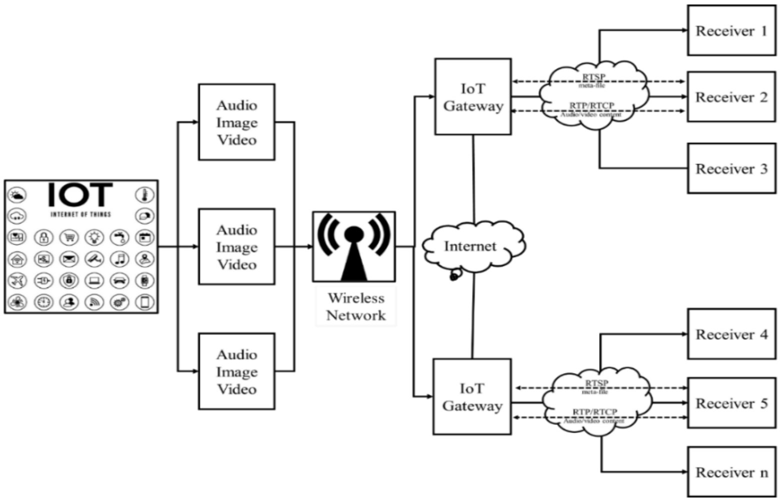

Figure 3. The architecture of an IoT network having IoT devices and IoT gateways

3.1. Media access control optimization

MAC optimization techniques can enhance IoT networks throughput and QoS for multimedia protocols such as RTCP, RTP, and RTSP. These techniques include traffic prioritization, channel access optimization, packet aggregation, error control mechanisms, and quality-aware scheduling. By implementing these strategies, real-time media packets can be transmitted with minimal delay and jitter, collisions can be reduced, transmission parameters can be adjusted based on channel conditions, overhead can be minimized, reliability can be improved through error control, and scheduling can prioritize multimedia traffic. These optimizations improve the network's ability to handle multimedia traffic and deliver better performance and QoS. Hence, in this work, to achieve better throughput and QoS, we present an algorithm that optimizes the MAC for multimedia protocols RTCP, RTP, and RTSP. The Algorithm 1 has been presented as follows:

Algorithm 1: MAC optimization for multimedia protocols RTCP, RTP, and RTSP.

Step 1 Perform a sensing operation to detect and identify the available IoT gateways in the network. The result of this operation is the set of available IoT gateways, denoted as $\mathcal{D}$.

Step 2. Sort the available IoT gateways $[\beta_1, \beta_2, \beta_3, \dots, \beta_D]$ in decreasing order. This sorting is done using [25] with respect to the respective time u_t.

Step 3. Each user that seeks data selects a random back-off time u_c from the interval $\left(0, u_{c^{\uparrow}}\right)$. This back-off time is initialized.

Step 4. $\boldsymbol{While}\ present\ time \leq \left(u_t + u_{c^{\uparrow}}\right)\ \boldsymbol{do}$
(Execute the following steps repeatedly until the present time is greater than the sum of the initial time and the maximum back-off time.)

Step 5. $\boldsymbol{if}\ the\ backoff\ time\ of\ user\ j\ finishes\ \boldsymbol{then}$
(If the back-off time of user j finishes, proceed to the next step. Otherwise, continue waiting)

Step 6. $\boldsymbol{If}$ the algorithm utilizes a contention-less-based IoT gateway allocation method, $\boldsymbol{then}$

Step 7. Select the free IoT gateway and assign it as the Best Solution (BS).

Step 8. **End** $\boldsymbol{if}$

Step 9. $\boldsymbol{If}$ the algorithm utilizes a contention-based IoT gateway allocation method, $\boldsymbol{then}$

Step 10. Select the free IoT gateway and assign it as the Best Solution (BS).

Step 11. **End** $\boldsymbol{if}$

Step 12. Once the appropriate IoT gateway is determined, broadcast the data to the selected IoT gateway.

Step 13. **End** $\boldsymbol{if}$

Step 14. **End** $\boldsymbol{While}$

Step 15. Each user optimizes its network settings according to the ideal IoT gateway, considering factors such as channel quality or signal strength. Furthermore, the user initializes communication utilizing the desired IoT gateway allocation schemes.

Step 16. **Return**

In this algorithm, the focus is on optimizing the MAC layer to enhance the performance and quality of multimedia protocols RTCP, RTP, and RTSP in IoT networks. Users select IoT gateways based on contention-less or contention-based methods, and their networks are optimized for the ideal IoT gateways. Finally, communication is established using the chosen resource allocation schemes.

3.2. Throughput optimization

Throughput optimization techniques can improve multimedia traffic in IoT networks, benefiting the RTCP, RTP, and RTSP protocols. Prioritizing multimedia traffic, managing bandwidth, implementing error control mechanisms, aggregating packets, utilizing adaptive streaming, and optimizing the network infrastructure are some approaches to achieve this. These techniques enhance throughput and QoS, enabling multimedia packets to be transmitted with minimal delay and jitter, reducing packet loss, optimizing data transmission efficiency, dynamically adjusting video quality, and addressing network congestion, routing, and latency. By applying these techniques, IoT networks can enhance throughput and QoS for multimedia protocols. Adapting the optimizations to specific multimedia application requirements is crucial for optimal results.

Using Algorithm 1, by using the contention-less or contention-based methods, the IoT gateways are selected. For maximizing and providing better throughput for the IoT gateways, in this work, we consider a contention-window attribute represented as $\mathcal{A}$. Consider a slot-assignment decision attribute represented as e_{xy} which provides the essential throughput required by the user X for accessing the data in the IoT network represented as S_X. Consider a scenario where the user needs to access the data, then $e_{X\mathcal{N}} = 1$. Consider a scenario where the user doesn't access the data, then $e_{X\mathcal{N}} = 0$. Using this, the issue of throughput gain can be defined mathematically using (1):

$$\max_{E} \sum_{x}^{R} S_x. \tag{1}$$

Where R is used for representing the number of users present inside the IoT network. Furthermore, the slot-assignment constraint (allocation of IoT gateways) in a non-overlapping IoT environment is defined using (2):

$$\sum_{x}^{R} e_{xy} = 1 \quad \forall y \tag{2}$$

This presented work evaluates the essential throughput required by the user X based on the allocation of the IoT gateway. Consider slots allocated to be represented as V_X for a user x and the likelihood that the slot $\mathcal{N}$ can be accessed by the user X be represented as $l_{X\mathcal{N}}$. In this work, it is assumed that $l_{X\mathcal{N}}$ is not reliant on each other. Hence, using this assumption, the S_X is evaluated using (3):

$$S_x = 1 - \prod_{y \in V_x} l'_{xy} = 1 - \prod_{y=1}^{T} \left(l'_{xy}\right)^{e_{xy}} \tag{3}$$

Where $1 - \prod_{\mathcal{N} \in V_X} l'_{X\mathcal{N}}$ is used for defining the probability that each user X inside the IoT network has at least one slot. Furthermore, the variable $l'_{X\mathcal{N}}$ is used for defining the probability that the given slot $\mathcal{N}$ for a given user X is not able to reach the slot which is evaluated using (4):

$$l'_{X\mathcal{N}} = 1 - l_{X\mathcal{N}} \tag{4}$$

Because each user can utilize at most one of their allocated slots, the highest possible throughput would be 1 at any given data rate and overall possible IoT network environments. When calculating the contention-window $\mathcal{A}$, it is important to take into account the likelihood of collisions involving contending users V. The collision likelihood decreases whereas the MAC overhead rises when the value of the contention-window $\mathcal{A}$ increases. Likewise, the collision likelihood increases whereas the MAC overhead decreases when the value of the contention-window $\mathcal{A}$ decreases. This is because each user selects their own unique back-off time. As a result, the likelihood of any initial-collision $\mathcal{L}_u$ occurring is quite high because the number of users keeps getting reduced with each collision that could occur. To provide the best trade-off among the users, consider the bounds, $\mathcal{L}_u \leq \epsilon L$, where ϵL provides an optimizing value for the collision likelihood trade-off as well as for induced overhead to establish the contention-window $\mathcal{A}$. During the contention-window $\mathcal{A}$, this work evaluates the initial-collision $\mathcal{L}_u$ by analyzing it as a function of $\mathcal{A}$ while taking into account r users. The back-off time for the r users is randomized and is denoted by $g_1 \leq g_2 \leq g_3 \leq \cdots \leq g_r$. Hence, when there are r users in the given contention-window $\mathcal{A}$, the conditional likelihood for any initial-collision $\mathcal{L}_u$ can be evaluated using (5):

$$\mathcal{L}_u^{(r)} = \sum_{y=2}^{r} \mathbb{L}(y\ users\ collide) = \sum_{y=2}^{r} \sum_{x=0}^{\mathcal{A}-2} U_r^y \left(1/_{\mathcal{A}}\right)^y \left(\mathcal{A} - x - 1/_{\mathcal{A}}\right)^{r-y} \quad (5)$$

Where, each parameter under double-summation indicates the likelihood that y users would collide whenever it selects the similar back-off setting while taking X users into consideration. Hence, the likelihood of any initial-collision $\mathcal{L}_{\mathrm{u}}$ is calculated by using (6):

$$\mathcal{L}_u = \sum_{r=2}^{R} \mathcal{L}_u^{(r)} * \mathbb{L}\{r\ users\ contend\} \quad (6)$$

Where, the $\mathbb{L}\ \{r\ users\ contend\}$ is used for describing the likelihood that the given users r will participate in the contention-window $\mathcal{A}$. To solve (5), $\mathcal{L}_{\mathrm{u}}^{(\mathrm{r})}$ is used for calculating the likelihood of the initial-collision. Further, for the evaluation of the $\mathcal{L}_u$, the $\mathbb{L}\{r\ users\ contend\}$ is utilized. Further, the likelihood that the user X participates in the contention-window $\mathcal{A}$ is when there are some idle IoT gateways V_x^C and all the other IoT gateways V_x are allocated to all the other users or when the users are busy, then this scenario can be denoted by using (7):

$$\mathcal{L}_{\mathrm{C}}^{(\mathrm{x})} = \mathbb{L}\left\{\begin{matrix} there\ exist\ exactly\ one\ channels\ in\ V_x^C\ are\ accessible\ and \\ all\ achannel\ in\ V_x\ are\ busy \end{matrix}\right\}$$

$$= \left(\prod_{y \epsilon V_x} \bar{l}_{xy}\right)\left(1 - \prod_{y \epsilon V_x^C} \bar{l}_{xy}\right) \quad (7)$$

Further, the likelihood that a given user r participates in the contention-window $\mathcal{A}$ can be evaluated using (8):

$$\mathbb{L}\{r\ user\ contend\} = \sum_{t=1}^{U_R^r} \prod_{x \in \wedge_t} \mathcal{L}_C^{(x)} \prod_{x \in \wedge_R \backslash \wedge_t} \mathcal{L}_C^{(x)} \quad (8)$$

where, the $\wedge_R$ defines the R set of users $(\{1,2,3, \ldots, R\})$, $\wedge_t$ defines the set of r users. From (6) and (8), the initial-collision $\mathcal{L}_{\mathrm{u}}$ can be calculated. Hence, the contention-window $\mathcal{A}$ can be attained from (9):

$$\mathcal{A} = \min\{\mathcal{A} | \mathcal{L}_{\mathrm{u}}(\mathcal{A}) \leq \epsilon L\} \quad (9)$$

Thus, for convenience, the variable $\mathcal{L}_{\mathrm{u}}(\mathcal{A})$ in (9) can be interpreted as a function for the contention window $\mathcal{A}$. By utilizing (9), the average overhead for the MAC can be attained. Consider h, which is used for defining the average magnitude of the backoff-time selected by various contending users. The h is evaluated by (10). In (10), the value of the backoff is selected from 0 to $\mathcal{A} - 1$. Hence, from this, the MAC average overhead is evaluated by (11).

$$h = {}^{(\mathcal{A} - 1)}/_{2} \quad (10)$$

$$\mathcal{D}(\mathcal{A}) = \left(([\mathcal{A} - 1]\varphi/2) + s_{CTS} + s_{RTS} + 3s_{SIFS} + s_{SYNC} + s_{SEN}\right)/S_{\mathcal{J}} \quad (11)$$

In (11), φ is used for defining the initial value of the back-off time, s_{SIFS} is used for defining the short-inter frame-space data. s_{SEN} is used for denoting the time required to carry out any sensing process by the respective user. s_{RTS} is used for denoting the request-to-send. s_{CTS} is used for denoting clear-to-send. s_{SYNC} is used for denoting the size of the packet synchronization. $S_{\mathcal{J}}$ is used for denoting the cycle-time. Depending on how resources are distributed, the value of variable $\mathcal{D}$ will change. Hence, due to this problem, the IoT gateways always update the value of the variable $\mathcal{D}$ dynamically depending on the allocation of the IoT gateways for the users. The CTOP model has been evaluated and the results have been discussed in the next sections.

4. RESULTS AND DISCUSSIONS

In this section, the performance of the CTOP model and the big-packet-protocol (BBP) [23] has been evaluated in terms of throughput, multimedia delay and loss, and energy consumption. The CTOP work and the BBP model have been run using the NS-3 simulator and SIMITS simulator. For running the simulator, Windows 10 operating system with 16 GB random access memory (RAM) and 500 GB read only memory (ROM) was considered. In the next section, the throughput has been discussed. For evaluation, two scenarios have been considered. In the first scenario, the IoT network is considered to be having less traffic among the devices where users are accessing data (audio, video, and image), and in the next scenario, the IoT network is considered to be having high traffic among the devices where users are accessing data (audio, video, and image) simultaneously.

4.1. Throughput

In this section, the throughput achieved by the CTOP model and BBP model has been compared. The result for the throughput achieved having less traffic and high traffic have been given in Figures 4 and 5 respectively. In Figure 4, it can be seen that as the number of IoT device increase, the throughput achieved by the CTOP model also increases, whereas, for the BBP model, the throughput achieved is less in comparison to the CTOP model. The results show that the CTOP model attained better average throughput of 25.58%, for less traffic in comparison to the BBP model. Further, In Figure 5, it can be seen that as the number of IoT device increase, the throughput achieved by the CTOP model also increases, whereas, for the BBP model, the throughput achieved is less in comparison to the CTOP model. The results show that the CTOP model attained better average throughput of 19.01%, for high traffic in comparison to the BBP model. The results show that the CTOP model attains better throughput in comparison to the BBP model.

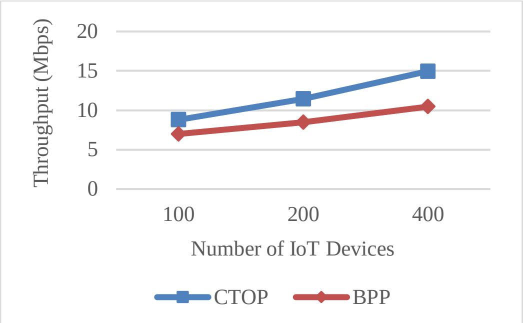

Figure 4. Throughput for less traffic among the multimedia IoT devices

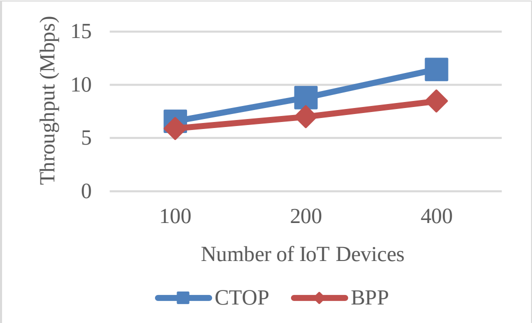

Figure 5. Throughput for high traffic among multimedia IoT devices

4.2. Multimedia loss

In this section, the multimedia loss achieved by the CTOP model and BBP model have been compared. The result for the multimedia loss achieved having less traffic and high traffic have been given in Figures 6 and 7 respectively. In Figure 6, it can be seen that as the number of IoT device increase, the multimedia loss achieved by the CTOP model decreases, whereas, for the BBP model, the multimedia loss achieved is more in comparison to the CTOP model. The results show that the CTOP model reduces average multimedia loss by 54.00% for less traffic. Further, in Figure 7, it can be seen that as the number of IoT device increase, the multimedia loss achieved by the CTOP model decreases, whereas, for the BBP model, the multimedia loss achieved is more in comparison to the CTOP model. The results show that the CTOP model reduces average multimedia loss by 51.62% for high traffic. The results show that the CTOP model reduces the loss of content during the transmission of data from the multimedia IoT device to the user in comparison to the BBP model.

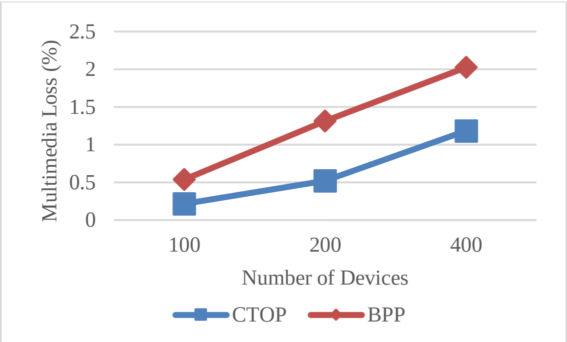

Figure 6. Multimedia loss for less traffic among the multimedia IoT devices

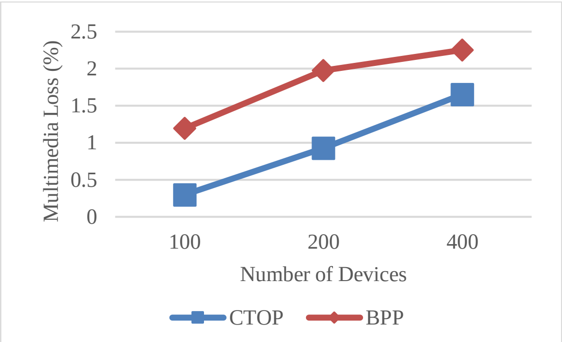

Figure 7. Multimedia loss for high traffic among the multimedia IoT devices

4.3. Multimedia delay

In this section, the multimedia delay achieved by the CTOP model and BBP model have been compared. The result for the multimedia delay achieved having less traffic and high traffic have been given in Figures 8 and 9 respectively. In Figure 8, it can be seen that as the number of IoT device increase, the multimedia delay achieved by the CTOP model decreases, whereas, for the BBP model, the multimedia delay achieved is more in comparison to the CTOP model. The results show that the CTOP model reduces average multimedia delay by 42.14% for less traffic. Further, in Figure 9, it can be seen that as the number of IoT device increase, the multimedia delay achieved by the CTOP model decreases, whereas, for the BBP model, the multimedia delay achieved is more in comparison to the CTOP model. The results show that the CTOP model reduces average multimedia loss by 45.28% for high traffic. The results show that the CTOP model reduces the delay in delivering the content during the transmission of data from the multimedia IoT device to the user in comparison to the BBP model.

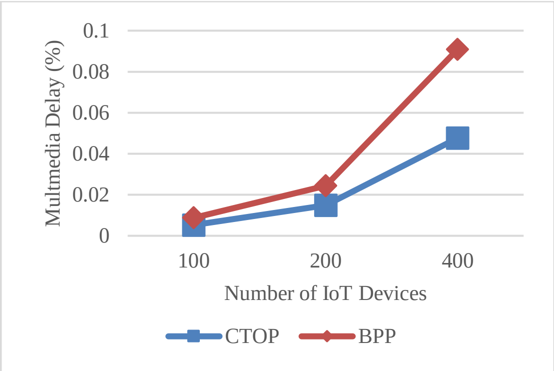

Figure 8. Multimedia delay for less traffic among the multimedia IoT devices

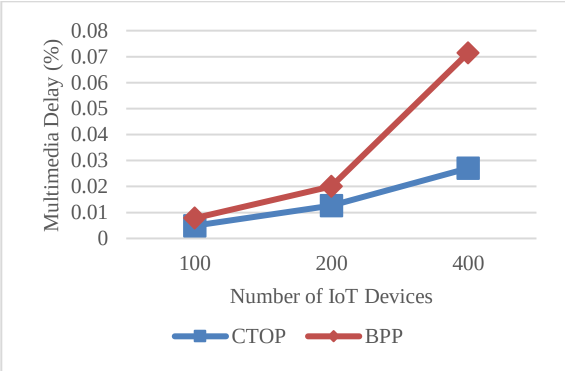

Figure 9. Multimedia delay for high traffic among the multimedia IoT devices

4.4. Energy consumption

In this section, the energy consumed by the CTOP model and BBP model has been compared. The result for the energy consumed for less traffic and high traffic have been given in Figures 10 and 11 respectively. In Figure 10, it can be seen that as the number of IoT device increase, the energy consumed by the CTOP model decreases, whereas, for the BBP model, the energy consumed is more in comparison to the CTOP model. The results show that the CTOP model reduces average energy consumption by 35.22% for less traffic. Further, in Figure 11, it can be seen that as the number of IoT device increase, the energy consumed by the CTOP model decreases, whereas, for the BBP model, the energy consumed is more in comparison to the CTOP model. The results show that the CTOP model reduces average energy consumption by 37.29% for high traffic. The results show that the CTOP model reduces the energy consumption for the transmission of data from the multimedia IoT device to the user in comparison to the BBP model.

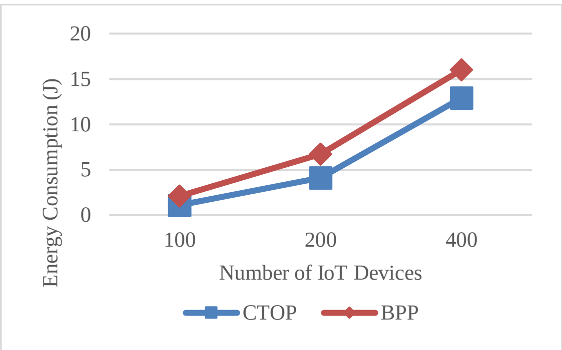

Figure 10. Energy consumption for less traffic among the multimedia IoT devices

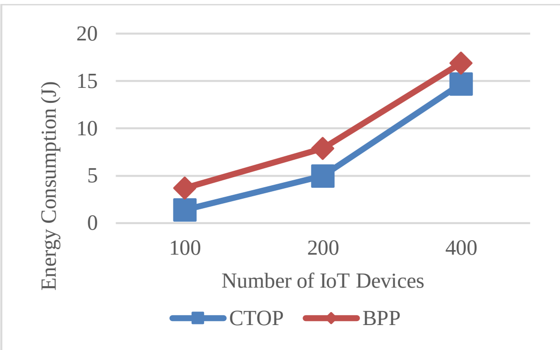

Figure 11. Multimedia delay for high traffic among the multimedia IoT devices

5. CONCLUSION

In IoT applications, multimedia traffic refers to the transmission of multimedia content between IoT devices, cloud platforms, and end-users. To address multimedia traffic challenges in IoT applications, several solutions have been employed. In this work, we implement RTP which facilitates efficient delivery of audio and video content, ensuring synchronized and reliable multimedia transmission. Further, RTCP enables real-time monitoring of multimedia stream quality, dynamically adapting transmission parameters for optimal QoS. Finally, RTSP enables efficient control and management of multimedia sessions, allowing flexible interaction between IoT devices and servers. Further, we present an IoT gateway optimization model which enhances multimedia traffic management through weight prioritization. Further, the MAC optimization method has been presented which reduces latency and improves network efficiency. Finally, a throughput optimization has been presented which maximizes data transfer rates, ensuring smooth and uninterrupted multimedia delivery. By combining these solutions, the CTOP model provides multimedia IoT applications to achieve reliable transmission, low latency, and optimal QoS for a seamless user experience. The CTOP model outperforms the BBP model in terms of average throughput, multimedia loss, delay, and energy consumption for both less and high traffic scenarios. For less traffic, the CTOP model achieves a better average throughput of 25.58% and reduces multimedia loss by 54.00%, as well as multimedia delay by 42.14%. In the case of high traffic, the CTOP model demonstrates a higher average throughput of 19.01% and reduces multimedia loss by 51.62%, as well as multimedia delay by 45.28%. Additionally, the CTOP model achieves an average energy consumption reduction of 35.22% for less traffic and 37.29% for high traffic. These results highlight the improved performance and efficiency of the CTOP model compared to the BBP model.

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