An Adaptive Cross-Layer Architecture to Optimize QOS Provisioning in MANET

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Abstract

Mobile Ad Hoc Network (MANET) is a collection of mobile nodes, which dynamically form a temporary network, without using any infrastructure like wireless access points or base-stations. The provision of QoS guarantees is much more challenging in Mobile Ad hoc Networks. There are many interesting applications such as multimedia services; disaster recovery etc can be supported if Quality-of-Service (QoS) support can be provided for MANETs. But QoS provisioning in MANETs is a very challenging problem when compared to wired IP networks. This is because of unpredictable node mobility, wireless multi-hop communication, contention for wireless channel access, limited battery power and range of mobile devices as well as the absence of a central coordination authority. So, the design of an efficient and reliable routing scheme providing QoS support for such applications is a difficult task. In this paper we studied the challenges and approaches for QoS aware routing techniques.

Keywords: MANET, QoS, throughput, cross-layer

1. Introduction

Nowadays, along with the increasing multimedia applications, video traffic is booming over wireless ad hoc networks in scenarios such as vehicular communication for intelligent transportation, disaster recovery, social networking, etc [1-3]. With the flexibility of ad hoc networks, nodes could self-recognize to create a network and any two nodes can communicate directly without relying on any infrastructure. However, there are also many challenges for a wireless ad hoc network to support video transmission especially with stringent Quality of Service (QoS) requirement [4] due to the following reasons. First, when there is no multiple access strategy to be utilized in the wireless ad hoc network, all the sessions tend to compete to access the shared available spectrum resource. Consequently, each session could be a potential interferer to the other sessions, which makes their transmission strategies affect each other through aggregate interference. As a result, video transmission is affected. Second, the mobility of wireless nodes will lead to a time-varying network topology. This could result in much more complicated interference among sessions. Finally, since many video applications are real-time and delay sensitive, it is very important to consider the queue state which will impact the queueing delay. Furthermore, the queue state is also determined jointly by the arrival rate of video data packets and the service rate of the wireless link. Moreover, the interference among sessions could degrade the link service rate and thus affect the queueing delay. These constraints and challenges make video delivery over wireless ad hoc networks very challenging.

Since interference is one of the main performance-limiting factors in wireless ad hoc networks, performance analysis of video transmission requires a good characterization of the aggregate interference incurred by each node. However, to the best of our knowledge, there exists very limited work on modeling the interference for video transmission [4-6]. In addition, when modeling interference for video transmission, most of the existing work assumes fixed node position without considering the dynamic network topology. In reality, similar to the distribution of node location, the distribution of the interference also affects the video

transmission quality. Till now, no related work has been conducted to study this issue. Therefore, in this work we investigate the interference-aware video transmission by utilizing a stochastic interference model to characterize the interference.

Other than interference, the mismatching between the video encoding rate and the system transmission methodology would prompt long delay in packet or underutilization of system assets, and in this manner degrade the system execution [7], [8]. Hence, it is better that the video encoding rate is versatile to the system transmission procedure. To this end, cross-layer video transmission has pulled in heaps of consideration including cross-layer rate control [7], [9-13], cross-layer asset allotment [14-18]. Not the same as these current works, we concentrate on examining the effect of video encoding rate and the transmission procedure of all sessions on the video transmission quality while considering the stochastic property of obstruction. Critically, we consider a limit based video transmission procedure, where every session chooses whether to transmit a bundle on the chose channel by contrasting the channel pick up and a divert pick up edge in a given space. Since every one of the sessions in the system are combined with one another through impedance, the transmission technique of every session influences all the rest sessions. In this work, we go for giving a viable video transmission plan in remote obstruction constrained systems through tending to the accompanying issues: i) What is the best video encoding rate picked by every session to adjust to the system transmission approach? ii) What is the ideal channel pick up edge set by every session to coordinate up with the video rate and the system condition? Since the above issues include the distinctive layers of the correspondence conventions, a proficient cross-layer control component is basic to determine the above issues. To this end, we propose an impedance mindful traverse remote specially appointed systems. Uncommonly, we consider the methodology for joint advancement of the video encoding rate and the system transmission procedure to expand the normal top sign to clamor proportion (PSNR) of the considerable number of sessions in the system.

To defeat these issues cross-layer construction modeling has been proposed which enhances the general execution of the MANET. Configuration of cross-layer is an enhanced procedure which permits system layers to trade the data to acquire the enhanced execution. In this situation there is a need to add to a plan for adjusting the transmission rates. The configuration of cross layer is capable handle the rates of video transmission in remote systems. By states of the system the rate of transmission of information ought to be adjusted consequently without making any clog in the system. Remembering this, to enhance the execution of the model, input free rate adjustment plan is proposed by Z. Chen et al [4]. This outcomes deferral and clog in the system. Abrougui et al [5] proposed a successful plan for the adaption of transmission rates. The key purpose of this plan is that it doesn't require any input system and gives the upgraded system asset use. In this work transmission rate of the specific hub was registered utilizing a directing calculation.

Another approach to enhance the QoS of the MANET framework is checking the hubs as indicated by the particular prerequisites of the system. In remote Ad-Hoc Network situation, necessities of the system change taking into account the area of the hubs. A connection approval system is proposed to decide the necessities of the system [6].

The For any correspondence framework there are a few parameters to be accomplished effectively to demonstrate the execution of the framework. These parameters are packet drop, data transmission, delay and so on. The point of the QoS change is to upgrade the system execution and better usage of the assets. For constant application MANET is imperative for sight and sound transmission yet it confronts a few difficulties when goes to the execution as we have talked about in before area.

1.1. The main requirements for the QoS improvement are:

Minimized overhead – Computational resources, capacity parameters and power resources are limited in the wireless Ad-Hoc Network so minimization of the computational overhead and resource utilization is the key point for QoS provisioning in wireless ad hoc network.

Robust architecture – As we have discussed that node deployment in the MANET is dynamical in the nature which causes failure and interference due to the frequent change in the network so there is a need to design an adaptive network model.

Fairness – Resource sharing is also one of the challenges in the MANET which improves the fairness of the system. To overcome this, a spectrum sensing and spectrum sharing technique need to be combined with the adaptability to improvise the QoS.

The remainder of this paper is organized as follows. Section 2 presents the system model, and Section 3 describes the results achieved and Section 4 provides conclusions.

2. Research Method

Video transmission has long been a vital exploration subject in remote correspondence systems [22], and there have existed a lot of work tending to the video transmission issue using cross-layer outline approach in remote systems [23]. Authors referred to [24], [25], and references in that for far reaching overviews of this range.

Underneath we concentrate on examining a few agents and the most related work. For instance, the creators of [26] proposed a cross-layer rate versatile plan for the video transmission over LTE system through together streamlining video encoding quantization parameter at the application layer and adjustment and encoding plan at the physical layer.. Moreover, a framework level cross-layer outline system was created for sight and sound transmission under deferral and vitality requirements in [27]. The creators in [28] proposed an imaginative and compelling vitality productive 3D video cross-layer transmission plan. In [29], the creators displayed a fundamental cross-layer configuration technique which could adjust with the channel condition and foreordained key parameters edges. Spurred by these works, we consider a novel edge based transmission procedure for video transmission and together advance the video encoding rate and transmission system under deferral QoS requirement.

Obstruction has additionally been considered in past work to be an essential element to influence video transmission execution. In [30], the creators utilized a contention chart to show the impedance reliance between various video transmission joins. [31] Proposed a system level impedance forming approach for continuous video spilling. Impedance Alignment procedure was utilized to relieve obstruction for video application in subjective helpful system [6]. However, these investigates was finished by expecting settled hub or altered obstruction without considering impedance stochastic property brought about by the dynamic system topology. [32] Presented a review on examination and outline of multi-level psychological cell remote systems utilizing stochastic geometry hypothesis, where the distinctive circulations of hubs were considered when demonstrating the accumulated impedance. Besides, in [33], [34], the creators proposed to utilize gamma appropriation capacity to display the obstruction dissemination and afterward examined the adequacy of the proposed estimate model. Inspired by these works, we depend on stochastic geometry hypothesis to plan a novel obstruction estimate model for transmitting video spilling in view of the sessions' transmission system.

In [13], Tom Goff et. al. proposed a technique which checks the received bundle energy to see whether way is prone to break or not. In the event that it is near the base perceptible force, a notice is sent to the source showing the probability of a separation with the goal that source can start way re-disclosure early conceivably evading the detachment. Creators have exhibited through analysis that the proposed system fundamentally diminishes the quantity of broken ways with a little increment in convention overhead. In [14], Fabius Klemm et. al. proposed a sign quality based method to enhance the TCP execution and connection management in Ad Hoc Networks. In the event that the deliberate sign quality shows that a connection disappointment is likely because of a neighbor moving out of the reach, higher transmission force is utilized to incidentally keep the connection alive likewise course re-disclosure procedure is started proactively before the connection really comes up short. Through recreation the creators have demonstrated that TCP session increments as much as 54% when their strategy is fused. In [15], Ning Yang et. al. proposed a cross layer model to enhance the execution of the specially appointed systems. Cross layer handling is connected between Physical, MAC and Network Layer where MAC layer adaptively chooses a transmission information rate taking into account the channel signal quality data from physical layer.

The creators have utilized DSR routing protocol for the test and they have exhibited through ns-2 that the proposed system enhances the execution. In [16] San-Yung Wang et al. proposed a sign quality construct, in light of interest routing protocol which first uses the most punctual set up way to forward apackets, then changes to the most grounded sign quality way

for long transmissions. Through reproductions on ns-2, creators have demonstrated that the proposed technique displays predominant execution.

In [17] Wooi King Soo et.al proposed a keen connection symptomatic controller for IEEE 802.11B remote systems. The proposed technique fuses fluffy controller in the MAC layer which in view of the separations and relative speeds determination the connection before the endeavor to reconnect is made and in like manner as far as possible is balanced. Through reproduction the creators have demonstrated that the proposed system enhances the TCP execution by 7% all things considered. In [18] Fuad Alnajjar et al, proposed cross layer outline to accomplish a solid information transmission in MANET. The proposed strategy permits the Network Layer to change its directing convention powerfully in view of SNR and got power along the end-to-end steering way for every transmission join.

Through assessment creators have indicated proposed cross layer outline enhances the execution. In [19], Boumedjout Amel et al, proposed a cross layer outline among Physical and Routing layers utilizing Pr as cross layer parameter. The creators have actualized and tried new steering convention in ns-2 which ensures the improved availability. Here in [35] author tried to eshtablish a relationship between traffic flow and time slot in MANET end to end delay in manet based on time slot and length of packet, QoS improvent is not done by the author. In [36] improved routing protocol AODV is used by the author in MANET, for QoS author used the hybrid controlled channek access concept but this is limited for voice over ip only author nothing said about video transmission. Here author [38] motive is to identify the QoS problem in MANET and try to resolve it with ticket based QoS steering. In [20], Yaser Taj et al, proposed another plan called Signal Strength Based Reliability (SSBR) which utilizes signal quality as a metric for picking the way. The new plan utilizes the deliberate sign quality changes of the neighbor hubs, and distinguishes which hubs have high versatility and might bring about connection disappointment keeping in mind way determination such hubs are ignored. Through recreation creators have demonstrated that the SSBR gives better execution when contrasted with conventional impromptu AODV directing convention. Vijay T Raisinghani and Sridhar Iyer [21] have inferred that the current layered convention stack works wastefully in portable remote environment because of exceptionally variable and the restricted way of the cell phones. Cross Layer Design is getting huge consideration among the specialists for expanding the proficiency of portable remote systems. In the writing the majority of the writers have focused mostly on whole system throughput and not on the per stream throughput of the system. Author [37] present an adaptive algorithms, in this approach path selection is based on real time network traffic. This approach help in gurantee of least delivery time of packet for destination.

Our goal in this paper is to include mindfulness in MANET as far as neighborhood hub separations and to expand the throughput of the organized stream by finding the main driver of the parcel drop in view of the separation of the accepting hub from the transmitting hub. While the separation between the hubs is discovered utilizing Received Signal Strength (Pr) from the Physical Layer.

3. System Model

Here In this section we present the system architecture to enhance the quality of service (QoS). We consider a mobile Ad-Hoc network, which contains the N active corresponding sessions and a single-hop route. This type of network can be used for the various communication scenarios in multi-cell networks when frequency sharing is required for video transmission. In every session of the communication n, the source nodes and destination nodes are identified for the communication. Wireless spectrum of the network is divided into a set of frequency F for orthogonal channels and these orthogonal channels can be shared among various sessions of correspondence.

In our proposed model we consider video frames to be transmitted over mobile ad-hoc network and the time of transmission is divided into slots for better evaluation. In each time slot, each session searches for the best channel based on the best channel frequency. After selection of the channel, the proposed model adapts the transmission method i.e. session decides whether data to be transmitted based on the gain of channel g or threshold t. At this stage if gain of the channel g is higher than t, then transmission of packets occurs otherwise it is stored to buffer memory b for retransmission. For computation of the threshold data encoding

rate and conditions of the link channel are considered together which is described in the following experiment.

Packet loss in the video transmission occurs due to error in the transmission link or expiration of packet delay threshold. If the transmission is excessive in the network then the demand of efficient channel increases which results the lower error rate in the transmission and the delay induced due to buffer memory is also reduced. On other hand, if transmission is very low then the error rate of the network increases and delay reduces. As we have discussed, encoding rate also have some impact on the delay constraint. Therefore, a network is required which can encode the video at different rates and it can dynamically adapt the conditions of the network by using cross-layer architecture.

Figure 1 depicts the system model of the proposed cross-layer scheme. In order to describe the cross-layer scheme, the communication models at different layers will be introduced as follows. The proposed cross-layer model is given in Figure 1. First of all wireless channel is introduced then interference model and finally the transmission model is presented.

Figure 1. Cross-layer model

3.1. Channel Modeling

Video packets are transmitted based on the probability which can be computed by using a channel model applied at physical layer. In the channel it is assumed that it suffers from the path loss and channel fading. The channel model considered in this work suffers from both the large scale path loss and the small scale Rayleigh fading. The distribution of fading in each session is considered identical. Let g_n^F denotes the gain of the channel of the session $n \in N$ between its transmitter and receiver on channelϵ F, then g_n^F can be represented as. Video packets are transmitted based on the probability which cang_n^f is channel fading gain.

$$g_n^{\mathbb{F}} = g_n \cdot g_n^f \tag{1}$$

Since the path loss usually tends to be infinity with the singular path loss model when the transmitter-receiver distance tends to zero, a non-singular path loss model is considered in this paper. Then path loss gain can be denoted as:

$$PL_{gain} = (1 + dist_n^a)^{-1} \tag{2}$$

$dist_n^a$ is the communication distance by considering path loss exponent a for n session. The fading varies when the time interval of communication varies else it remains constant. The probability distribution function of each channel can be computed as:

$$Prob\left(\beta_n^f = \mathcal{A}\right) = \exp\left(-\frac{\mathcal{A}^2}{\delta}\right)\frac{2\mathcal{A}}{\delta}, \forall_n \epsilon\ N \qquad (3)$$

3.2. Interference Modelling

In this in our proposed model the transmission model and interference model can be developed based on the channel model. Interference is caused if only one channel is used for the continuous transmission.

Let us consider signal to interference –plus –noise ratio of session is denoted by β_n^f. The probability of transmission in terms of successful packets is denoted by:

$$Prob\left(\beta_n^f = t_{Th}\right) = Prob\left(\frac{Tx_{Power.n}.gain_n^f}{l_n^2 + D_n^f(\gamma_{-n})} > t_{Th}\right) \qquad (4)$$

Were t_{Th} is the threshold value, $Tx_{Power.n}$ is the transmission power for each session, $D_n^f(\gamma_{-n})$ is the interference between data and channels and l_n^2 is the power of noise (Gaussian).

3.3. Cross Layer design

Once In our model a discrete time based cross-layer architecture is considered. Let us consider a node $n \in N$ transmitting content D to its neighbor $i \in I$. In a time duration of -2, total α frames are transmitted. The C_{t-1} frame consisting of C_{t-1}^r and C_{t-1}^q is transmitted at the $(t-1)^{th}$ time instance. In the proposed model the q frame is considered to consist of two sub-frames which are $q1$ and $q2$ i.e. $q = q1 + q2$. The sub frames are constructed at the time of encoding the previous frame r and then transmitted to the MANET nodes. This method of adopting subframe enables the efficient reconstruction while transmitting the multimedia data. The encoded frame $C1_t^{q,e}$ is defined as:

$$C1_t^{q,e} = \left(\left(1 - Ql_{Ql1}\right)C_{t-1}^r\right) + \left(Ql_{Ql1} \times C_{t-1}^r\right) \qquad (5)$$

Were $C1_t^{q,e}$ denotes the encoded frame, Ql_{Ql1} denotes the quality layer of network. Physical layer conditions of the network are achieved by:

$$C_{s2} = Val : Val = \{0, \dots 1\} \qquad (6)$$

Subframe decomposition is achieved by the C_{s2}. In the condition of distortion when $C_{s2} = 0$ then $q1 = r$ and $q2 = \emptyset$, at this point on physical layer is used for communication which shows the adaptability of the model and dynamic changes in the model. Based on the physical layer conditions C_{s2} and C_{s1} are achieved and transmission of multimedia data is done for Δt intervals.

4. Results and Analysis

In this section, we show the simulation results of the proposed cross-layer design for video transmission. This model is simulated in MATLAB tool under varying conditions of the network as varied load, varied frames rate and various scenarios of mobility and the performance matrices are evaluated to show the feasibility and effectiveness of the system.

The below given Figure 2, shows the performance of the system in terms of through put when the transition probability is considered as 0.2 and 0.8. As the time of simulation increases, the throughput of the system also increases and at the end of the simulation it achieves 70% throughput.

In the same way we have simulated another scenario with the transition probability of 0.5 and 0.5 for the same simulation time and same parameters. And finally with the probability is taken as 0.2 and 0.8 which gives the low quality of service in terms of throughput (Figure 3 and Figure 4).
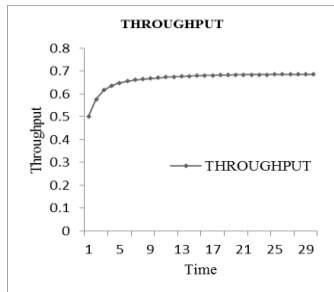

Figure 1. Throughput performance of the proposed mode under varied spectrum occupancy (bandwidth =1 and probability of transition = {0.2 and 0.8})
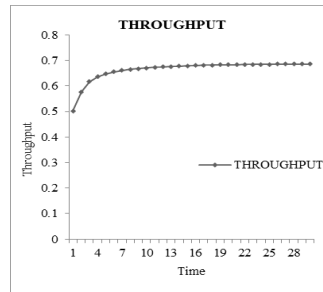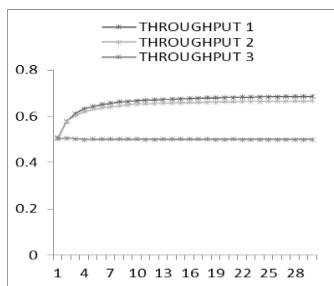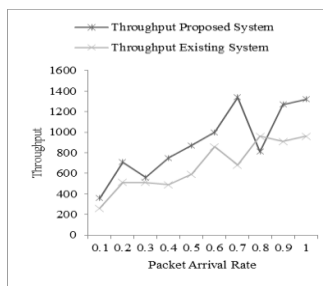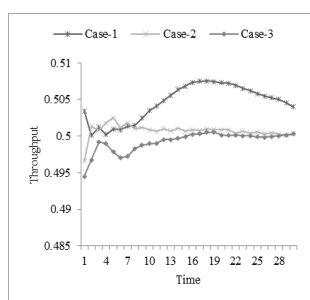

Figure 2. Throughput performance of the proposed mode under varied spectrum occupancy (bandwidth =1 and probability of transition = {0.5 and 0.5})

Figure 3. Throughput performance of the proposed mode under varied spectrum occupancy (bandwidth =1 and probability of transition = {0.2, 0.5 and 0.8})

Figure 5. Throughput performance vs packet arrival rate

Figure 6. Throughput vs time based on varied transition probability
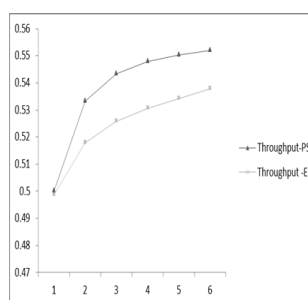
Figure 7. Throughput Performance

In Figure 5 it shows the performance of throughput based on the arrival rate of packets. This result is achieved for the same simulation time and the same bandwidth of the channel. It can be analyzed from the result that initially when packet arrival rate is low, the throughput performance is low but when the simulation time increases, the packet arrival rate is also increases and it achieves the best performance when all the packets are received at the receiver node. In this simulation it is achieved that the performance of the system is enhanced by 76.91% in terms of the through put.

In Figure 6 we show the simulation for varied parameters to show the throughput performance. In this we have considered three scenarios for static bandwidth and with a simulation time of 30 sec. For case-1, the probability of transition is considered 0.2 and 0.8 for that it achieves the best performance, and then case-2 is considered based on the probability of transition (0.5, 0.5) and in 3rd case 0.8 and 0.2 are considered as the transition probability.

Above given Figure 7 shows the through put performance of the proposed model. This result is achieved for the various transmission probabilities which is considered as 0.2, 0.5, 0.8. Simulation results show that when the probability of transmission increases the throughput of the system also increases.
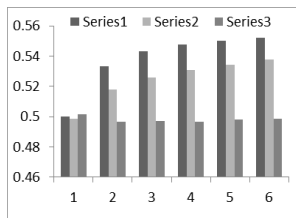

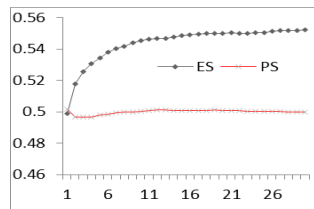Figure 8. Cumulative throughput performance

Figure 9. Delay performance

Figure 8, the Markovian channel state evolution is utilized for system performance evaluation. This simulation shows the system performance in terms of throughput. In Figure 9 we study the performance of the delay as compared with the optimal protocol. For the channels used in this approach, the performance of proposed approach matches the optimal criteria. For the channels in the lower plot, the performance loss of the proposed approach is within 3%. In both cases, significant gain over a random selection of channels is achieved by the proposed approach of cross layer.

Shown in Figure 9 is the performance of the proposed approach under different spectrum transmission statistics. We consider three independent channels with the same bandwidth B=1 and transition probabilities {α, β}. In Case 1, the channel state remains unchanged with a large probability 0.8. Case 3 is the opposite of Case 1: the inter-arrival time and the message length of the primary network are relatively small, resulting in more frequent changes in the channel state. In Case 2, the channel is equally likely to change the state or remain at the current state. Note that in all three cases, the channels have the same stationary distribution: with probability 0.5 a channel is available.
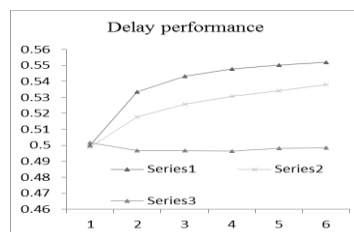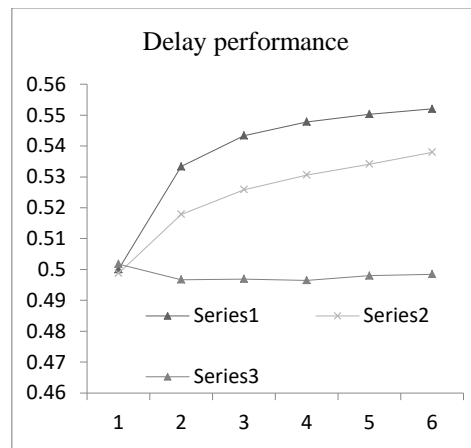
Figure. 10 Cumulative Delay performance

In Figure 10 we study the performance of the proposed approach as in terms of delay allowed by the primary network. We use the three parameters in the simulation study as mentioned above 0.2,0.5 and 0.8. Series 1, series 2 and series 3 denotes 0.2,0.5, and 0.8 respectively. We measured the delay performance of the system which is lowest in the case 3 and highest in the case 1.

4. Conclusion

In this paper, an efficient architecture for video transmission over interference affected Mobile Ad-Hoc network is proposed by designing a cross-layer approach of transmission. In this scheme we compute the probability of transmission of a video data using proposed method. The performance of the system is computed in terms of throughput of the network. The proposed cross-layer scheme aims to maximize the average video quality of the whole network. The cross-layer optimization problem has been mathematically formulated and solved by a proposed layer specifier method which performance the selection of layer while transmitting. It improves the adaptability and dynamic configurability of proposed model. Moreover, the numerical and simulation results showed the superiority of the proposed cross-layer scheme in terms of the network throughput.

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