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Gezgin Tasarsız Ağlarda Tahsisli Güvenilir Akış Denetimi Algoritması Geliştirilmesi

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ÖZET

Kablosuz ağlar, kablolu ağlara göre kapasite oranı limitli bir yapıya sahiptir. Mobil tasarsız ağlar (MANET)'de ise hareketlilik nedeniyle kapasite yönetimi gittikçe zorlaşmaktadır. MANET, mobil cihazların kendi kendilerine konfigüre olarak kablosuz bağlantı ile oluşturdukları ağlardır. MANET'lerin belli bir omurgası ve alt yapısı yoktur. Bundan dolayı, trafik akışının kontrolü ise merkezi yapıya sahip ağlara göre daha karmaşık olmaktadır. MANET'te düğümler arasındaki iletişim esnasında meydana gelen tıkanıklıklardan dolayı aksayan iletişimin devamlılığını sağlamak için yeni bir algoritma önerilmiştir. Bu çalışmada gezgin tasarsız ağlar için rezervasyon tabanlı güvenilir akış denetimi (Reservation Based-Reliable Flow Control - RB-RFC) algoritması önerilmektedir. RB-RFC algoritması bant genişliği rezervasyon işlemi için kullanıcıların atlama noktalarına başvuru yapmaları temeline dayanmaktadır. Atlama noktaları, kendilerine başvuran kullanıcılar arasında bant genişliğini eşit olarak paylaştırmaktadır. RB-RFC algoritmasının benzetimi ns-2 ile yapılmış ve elde edilen sonuçlar karşılaştırılmıştır. Deneysel sonuçlara göre önerilen algoritmanın başarılı olduğu görülmüştür.

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Development of Reserved Reliable Flow Control Algorithm in Mobile Ad Hoc Networks

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ABSTRACT

Wireless networks have limited capacity compared to wired networks. Capacity management becomes relatively more difficult in mobile ad hoc networks (MANET) due to mobility. MANETs are networks established by wireless connections of mobile devices that are configured automatically. MANETs do not have a specific backbone or infrastructure. Thus, traffic flow control is more complex than the networks with centralized structures. This study proposed a new algorithm, a Reservation Based-Reliable Flow Control (RB-RFC), for mobile ad hoc networks to ease the congestion occurring in MANET during the communication between the nodes and to maintain the continuity of the communication hindered. RB-RFC is based on users' requests for bandwidth reservation to hop nodes. Hop nodes share the bandwidth equally among the requesting users. RB-RFC algorithm was simulated by using ns-2 and the obtained results were compared. According to the experimental studies, the algorithm gives better results.

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1. INTRODUCTION *(GİRİŞ)*

Today, MANET is a widely used technology and interest in this technology is continuously increasing. Mobile ad hoc networks are temporary wireless networks without a fixed infrastructure and a central administrative management that can dynamically configure themselves. This special feature has made them attractive for many applications. Mobile nodes can communicate with each other, as well as transmitting data to each other. During their use, many problems may emerge as they are dynamic and may change instantly [1-5].

To maintain the quality of service in wireless networks, bandwidth should be used effectively, as energy, processing capacity, bandwidth, battery, and memory resources are limited in MANET, unlike wired networks. However, minimizing energy consumption when the route is being setup is critically important in energy efficiency.

In these network structures in MANET, the nodes' mobility makes the topology changeable. When the traffic is congested or many users use the channel, communication conflicts and network congestion may occur. Therefore, the efficiency of end-to-end communication decreases and communication delays increase. Protocols on the MAC layer cannot usually resolve the congestion problems and the congestion cannot be prevented because of the congestion in the shared channel.

Due to the abovementioned reasons, there are many studies conducted pertaining to flow control in MANETs [1-5]. In these studies, improvements were made on flow control and the network load was kept at a critical level. When the level is exceeded, packet losses and delays cause inflexible flows and these result in a waste of network resources. The present study proposed a new algorithm, a Reservation Based-Reliable Flow Control (RB-RFC), for mobile ad hoc networks to ease the congestion occurring in MANET during the communication between the nodes and to maintain the continuity of the communication hindered. First, the studies made on flow control for MANETs are explained. Next, the simulation of the RB-RFC algorithm with ns-2 and the results obtained are presented. Finally, the results obtained are compared to the cases where the RB-RFC algorithm is not used and a detailed analysis and evaluation are presented.

2. RELATED WORK *(YAPILAN ÇALIŞMALAR)*

The first study on this subject is Resource Reservation Protocol (RSVP), which uses bandwidth reservation on a communication line. RSVP reserves the bandwidth from one device to the other starting from the destination. Since RSVP is used in wired networks, the full topology is known in detail [6]. Hence, every routing device can make request reservations directly to a resource device. However, using methods such as bandwidth reservation in wireless networks causes some difficulties. First, the network topology information kept by each device is limited. Secondly, because of the secret terminal bandwidth, sharing becomes more difficult. Thirdly, channel quality is unstable in wireless networks. In such cases, the route should be kept stable to maintain quality of service.

In the study titled, "Admission Control and Flow Termination in Mobile Ad-hoc Networks with Pre-Congestion Notification," simulations and analyses on pre-congestion notifications were conducted [7]. The study indicated that since the capacity in MTA structures is limited, the network load should be kept at a critical level. If the level is exceeded, packet losses and delays cause inflexible flows and these result in wasted network resources. The study proposed an admission control (AC) mechanism that aims to control the active flows to obtain a satisfactory level of quality of experience (QoE). Using this mechanism, an upper limit of the network load can be established and this level can be kept below the network capacity. Thus, packets with higher privilege levels would have the right of way over the packets with lesser value and optimization could be achieved over network values. Moreover, to terminate the needless flows, flow termination (FT) mechanism was used in this paper [7].

In the study titled, "Policy-based Flow Control for Multi-Homed Mobile Terminals with the IEEE 802.11u Standard," address allocation and management ability of 802.11u was improved and made capable of supporting simultaneous access to multiple networks [7]. Furthermore, a principle based flow control system was developed for incoming-outgoing packets to allow users to get better service quality and to manage packet carriers more efficiently. Furthermore, a testing medium was set up and the proposed system's accuracy and performance was tested [8].

In the study titled, "Multipath Load Balancing and Rate Based Congestion Control for Mobile Ad Hoc

Networks (MANET)," multipath load balancing and rate-based congestion control (MLBRBCC) was proposed to resolve congestion in the communication. The proposed approach contains an adaptive-speed-control-based technique, in which the destination node copies the estimated speed it has received from the middle node and sends it to the sender as feedback with an approval message. Thus, the sender adjusts the sending speed in compliance with the feedback it has acquired [9].

In the study titled, "The Research of AD-HOC Network Bandwidth Control Distribution Mechanism," aimed at determining each data flow rate for the channel time by allocating a fair bandwidth in multi-hop wireless networks. According to their model, it was assumed that channel switching was much slower than the time. The simulation was configured to use a reliable data connection layer; therefore, the packet loss rate was neglected. They assumed that a node in the simulation could not send or receive for a specific period of time [10].

In the study titled, "Admission Control and Bandwidth Reservation in Multi-Hop Ad Hoc Networks", IEEE 802.11 access technologies in multi-hop ad hoc networks were highlighted and bandwidth reservation and admission control issues were mentioned. Admission control and bandwidth reservation in ad hoc networks are very important in terms of preventing the network from reaching a full state and increasing the network performance. This employable bandwidth estimation requires solutions such as service quality based routing, admission decision, bandwidth reservation, and signaling. They proposed a framework for admission control and bandwidth reservation in IEEE 802.11-based multi-hop ad hoc networks as a solution. In the framework, the cooperation between 802.11 media access control (MAC) and Ad-hoc On-Demand Distance Vector (AODV) - Quality of Service (QoS) routing protocols offer advantages. Thanks to this advantage, in order for AODV to be compatible with QoS, modifications are necessary. The proposed framework can prevent the network from reaching the full state without excessive AODV load. Thus, a lower end-to-end delay, jitter, and higher packet production rates can be obtained [11-12].

Seung Joon Seok et al. conducted a study titled "A modification of TCP flow control for improving end-to-end TCP performance over networks with wireless links". Performance of the end-to-end Transmission Control Protocol (TCP) takes up a significant place in wireless Internet services. The authors developed a protocol called, "TCP aware link layer" Adaptive Transmission Control Protocol (A-TCP) to improve the end-to-end TCP performance. The main goal of the protocol is to make an A-TCP agent that is available at every base station look like a moving node as if there were a wired connection at the base station [13].

G. Boggia et al. conducted a study called, "Feedback-based bandwidth allocation with call admission control for providing delay guarantees in IEEE 802.11e networks". The authors made some proposals for Wireless Local Area Networks to support real-time, delay-sensitive multimedia applications such as voice and video applications. The study conducted consists of signalization configuration for 802.11 Hybrid Coordination Function, Call Acceptance Control and Service Request and Service Quality Agreement [14].

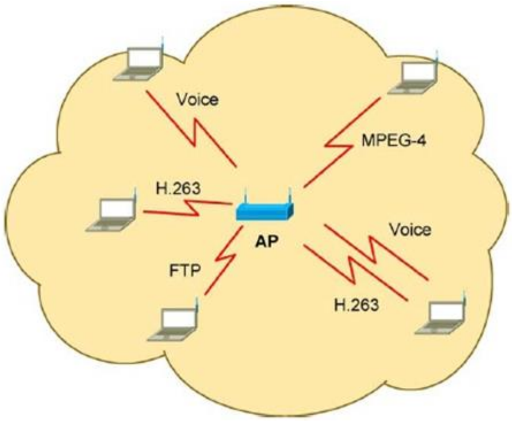

Figure 1. A Multimedia Flow Scenario *(Multimedya Akış Senaryosu)* [14]

To test the suggested bandwidth distribution in a real scenario, transfers of voice, video and data were defined and a simulation was performed using ns2 simulator [15]. In Figure 1, voice streams coded in Moving Pictures Experts Group-4 (MPEG-4) [16], voice streams coded in G.729 [17] standards or voice streams coded in H.263 standards [18] and File Transfer Protocol (FTP) streams in 802.11 WLAN networks are shown. They used the traces of traffic taken from the Trace Library for video streams [19].

Go Hasegawa et al. conducted a study called, "Simulation studies on router buffer sizing for short-lived and pacing TCP flows". The authors determined the available buffer sizes on IEEE routers through the bandwidth of the connection and the average return

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time of the flows passing through the routers in this study [20].

Zvi Rosberg et al. made a study called, “A network rate management protocol with TCP congestion control and fairness for all". The authors aimed to provide the correctly performance of the flow management of all end applications and provision of the congestion service quality. They proposed a method different from current applications, intended for meeting the existing needs using existing TCP applications. Their approach coincides with a network use controlling the whole flow. Rate Management Protocol (RMP) control makes TCP Sliding Window Congestion control easier. They said congestion control is intended for open target rating managed by RMP [21].

Hongjuan Li et al. conducted a study called, “The research of AD-HOC network bandwidth control distribution mechanism”. They determined each data flow rate for channel time in multi-hop wireless networks through allocation of a fair bandwidth. their simulation results of the algorithm showed that it assigned the bandwidth fairly. In their study model, the channel switching was assumed much slower than the time. A simulation was set up using a secure data connection layer, and thus the packet loss rate was neglected. They assumed that a node in the simulation could not send and receive at a specific period of time [22].

Zhou and Maxemchuk conducted a study called, “Scalable max-min in wireless ad hoc networks”. They discussed the fair bandwidth assignment problem in wireless ad hoc networks. They proposed a simple estimation model to obtain a maximum-minimum fair flow control in wireless ad hoc networks. The proposed study ran on macro-model and implemented it on wired techniques of the wireless networks with a small change. Results of the simulation showed that the methods were able to make optimum maximum and minimum fair bandwidth assignment in small scaled networks [23].

Maxemchuk and Zhou made a study called, “Distributed Bottleneck Flow Control in Mobile Ad Hoc Networks”. He suggested a Scattered Bottleneck Flow Control technique in mobile ad hoc networks. The author suggested a macro model to implement flow and access control in ever changing mobile ad hoc networks, in his earlier studies [24-26]. The diagram he suggested utilized a distributed flow control mechanism that used the distribution of reservation load as well as bottleneck flow control in wireless networks distributed queue dual-band. The protocol he developed showed that it could allocate network resources in an effective manner in a dynamic medium. He stated that service quality could be enhanced for real-time applications. His simulation results demonstrated that the flow control mechanism was able to effectively improve the end-to-end throughput when it was faced with situations not available in a static network [27].

Muhammad Mahbub Alam et al. conducted a study called, “Congestion-aware fair rate control in wireless mesh networks”. The authors took in consideration a wireless mesh networks based fair and effective flow rate control mechanism for IEEE 802.11. They suggested a fair data rate control mechanism for wireless mesh networks running in the second layer. Congestion-aware fair rate control (CFRC) aims to fairly use the GoodPut reached by the flows without damaging [28].

Muhammad Mahbub Alam et al. conducted a study called, “Optimal Scheduling for Fair Resource Allocation in Ad Hoc Networks with Elastic and Inelastic Traffic”. They investigated the congestion control and timing problems in wireless ad hoc networks. Optimization and stochastic network theories succeeded in fair resource use architectural design meeting the throughput requests. They suggested a model consisting of the service quality in this study [29].

Mallapur et al. conducted a study called, “Fuzzy Based Packet Dropping Scheme in Wireless Cellular Networks”. On the diagram drawn, the performance was revealed taking into consideration the data rejections, priority of packets, length of queue holds, and adaptive queue length threshold value. The adaptive queue length threshold value was used for dynamic set up [30].

Peculea et al. conducted a study called, “A Novel QoS Framework Based on Admission Control and Self-Adaptive Bandwidth Reconfiguration.” They suggested a new end-to-end service quality framework called Self-Adaptive Bandwidth Reconfiguration QoS Framework. They guaranteed the end-to-end service quality over each flow through SAR input control and end-to-end bandwidth reservation [31].

3. RB-RFC ALGORITHM *(RB-RFC ALGORİTMASI)*

This study proposes a new algorithm to maintain the continuity of communication that halts due to the congestion among nodes in MANETs. In RB-RFC algorithm, bandwidth reservations of nodes were based on admission requests of the users made to the hopping nodes, and therefore continuous communication was obtained. Hopping nodes were shared fairly among the users that requested admission to the hopping nodes depending on the available bandwidth. With the provision of medium nodes sending as much data as available buffer size and preventing buffer overflows, congestion was prevented and an efficient use of bandwidth was ensured. The flow diagram in Figure 2 shows the behavior of a source node.

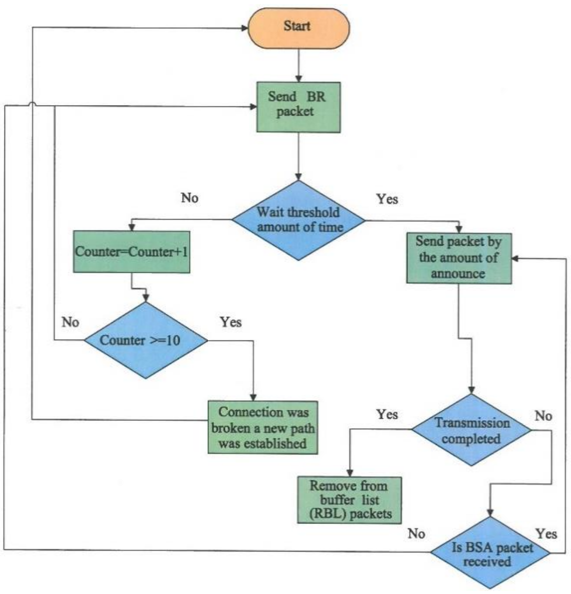

Figure 2. Behavior Flow Diagram of a Source Node in RB-RFC Algorithm *(RB-RFC Algoritmasında Bir Kaynak Düğümün Davranış Akış Şeması)*

Every node that needs to use a node as a hopping node sends a buffer request (BR) packet (Figure 2). If there is no response made within the threshold amount of time, the counter is increased by one. If the response is received, then as many packets as the number of announced packets are sent. If the transfer is complete, the source node sends a remove from buffer announcement (BSA) packet is put on hold. If the packet does not arrive, a re-request packet is sent. If the BSA packet is received, the source node sends out as many packets as the number of announced packets. The flow diagram in Figure 3 shows the behavior of the hopping node. The hopping node resets the timer. It updates the timeout values of the records in the table. Should there be any records timed out, it deletes the source from the RBL and queries new records. Should there be no records timed out, it queries about new records. If new records exist, it inserts them into the buffer allocation list (BAL). If there are no new records, it sends the BSA packets. If registered nodes send as many packets as they are allowed to, it updates the timeout values of the records in the table. If registered nodes do not send as many packets as they are allowed to, it keeps waiting as long as the threshold amount of time. Then it returns to the state of updating the timeout values of records in the table.

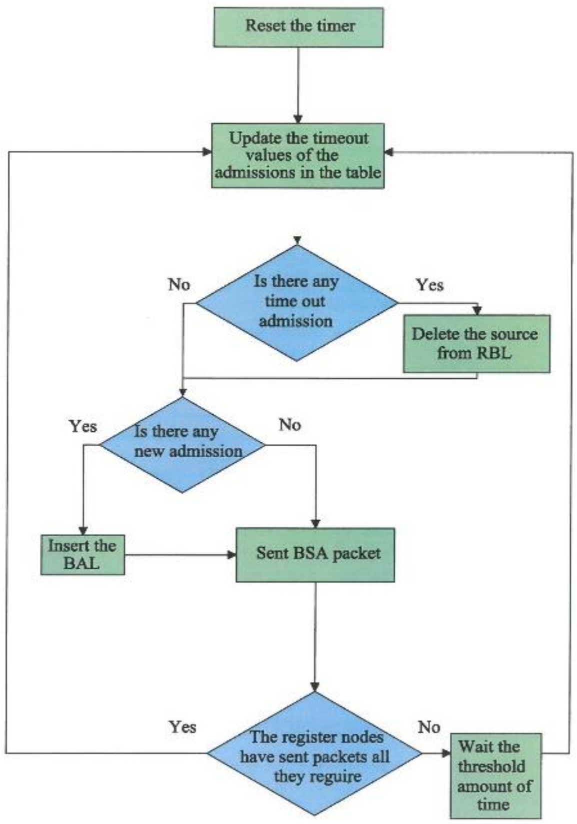

Figure 3. Behavior Flow Diagram of a Hopping Node in RB-RFC Algorithm *(RB-RFC Algoritmasında bir Atlama Noktası Davranışının Akış Şeması)*

As RB-RFC method requires route information, a need for this method to work in cooperation with a routing protocol turned up. Moreover, if static routing were used on the nodes, the RB-RFC method would operate without problems. However, because the topology becomes larger and the nodes are mobile, it is a more convenient approach to use a dynamic routing protocol. The need to use a routing protocol is not a necessity of the RB-RFC method, but it is for

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providing ease of manageability. Hence, the RB-RFC method was coded to obtain the routing information from AODV, which is the most widely used protocol in mobile ad hoc networks. As RB-RFC is based on sharing the buffers of the nodes on the communication path to the users, it is essential that the route of the communication be known. This is only possible by obtaining the information from the routing protocol. Figure 4 shows how the RB-RFC method works during the route setup stage.

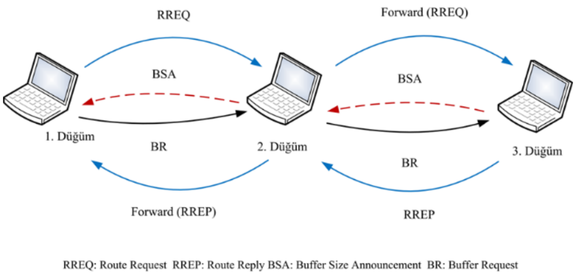

Figure 4. Buffer request and Buffer Size Announcement during Route Setup *(Yol kurulma aşamasında tampon isteği ve tampon anonsu)*

When the source node announces a route request (Route Request - RREQ), each node receiving this request forwards it to the destination node. The destination node receiving the RREQ sends a route reply packet (Route Reply - RREP) in return. Each node receiving this RREP packet routes it up to the source node. Furthermore, if a node receives a RREP packet, this means a route is being set up over that node. In that case, the RB-RFC method sends a BR packet to the node that sends the RREP packet. When the source node receives the RREP packet, it sends a BR packet to the RREP sender. Each node that receives the BR packet adds the requesting node in its buffer share list and sends a buffer size BSA packet to it. After the BSA announcements are made at the route setup stage, the communication may begin.

Once the route is set up, since the RREP packets will no longer be generated, the buffer size announcements need to be made periodically. Each node that shares the available space in its buffer with the other nodes sends BSA packets periodically to the nodes that it made its buffer available. First, after this stage, the packets that will process the buffer request BR, BSA and RBL operations are defined in the routing protocol. At the route setup stage, the destination node sends a response packet to the source node. This response packet reaches the sender node passing through the nodes on the route. This is an ideal stage to request for buffer sharing. Following the buffer sharing performed at route setup stage, available buffer size needs to be announced continuously when the traffic is on the go. To accomplish this, BSA packets are sent to the nodes in the buffer share list periodically.

The nodes that receive BSA packets need to determine the number of packets they will send in accordance with this announcement. The packets are produced in the application layer. Thus, the available buffer size information in the received packets needs to be accessed by these protocols.

3.1. Operation Logic of the RB-RFC Algorithm According to OSI *(RB-RFC Algoritmasının OSI'ye göre Çalışma Mantığı)*

The available buffer size announcement among the nodes is made at network layer (Figure 5). This is because the RB-RFC requires route information, as previously was mentioned. When the protocol in the network layer receives the available buffer size announcement, it forwards this to the application layer. Applications in the application layer determine how much information they can produce and they transmit that information to the relevant transmission protocol in the communication layer. RB-RFC has a hybrid layered structure (Figure 6).

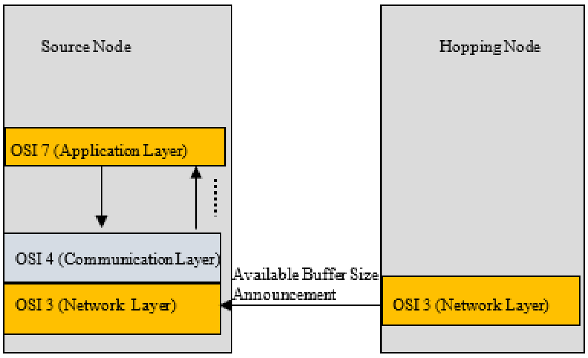

Figure 5. Operation Logic of RB-RFC Method on a Node According to OSI Layers *(RB-RFC yönteminin bir düğüm üzerinde OSI katmanlarına göre çalışma mantığı)*

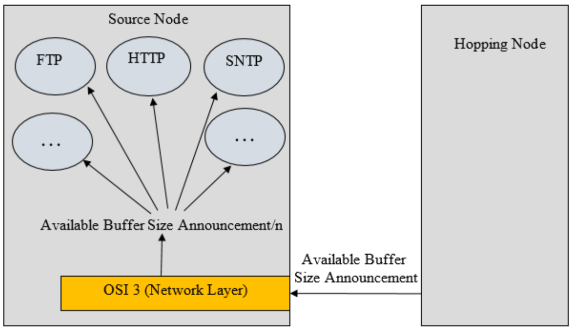

Figure 6. Operation Logic of the RB-RFC Method on a Node in Accordance with the Application *(RB-RFC yönteminin bir düğüm üzerinde uygulamalara göre çalışma mantığı)*

Sharing can be made either equally or in different sizes, depending on needs of each application. The buffer size that an application is not using at a specific moment can be transferred to another application.

3.2. Mathematical Analysis of RB-RFC Algorithm *(RB-RFC Algoritmasının Matematiksel Analizi)*

RB-RFC aims to keep data drop rates at 0. Results will be obtained with the improvements on RB-RFC and it is possible to get closer to the theoretically expected values in the mathematical analysis.

3.2.1. Using RB-RFC for a node (Bir düğüm için RB-RFC'nin çalışması)

In mediums like the Internet, the incoming traffic is expressed by Poisson distribution. That is to say, it is almost impossible to control data entries. For a router, if the incoming data rate is expressed by λ and the outgoing bandwidth is expressed by μ, then the usage rate of the line is expressed by the equation "ρ = " λ/μ. If $\rho = 1$, this means the router works at full capacity. If $\rho < 1$, this means the line has idle bandwidth. If $\rho > 1$, this means there is congestion in the line. In the case of congestion, since controlling the data entrance in a mobile ad hoc network is more likely than in a medium like the Internet, the congestion can be controlled. The purpose of this study is to keep ρ≃1 to use the line at maximum efficiency. Mobile ad hoc networks are temporary networks and have fewer users than other networks. Because of their mobile nature, it may not be possible for them to provide a specific bandwidth (μ)for a long time. An example queue state is shown in Figure 7.

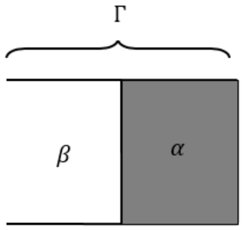

Figure 7. Queue State

β represents the available size in the queue and α represents the busy portion in the queue (Figure 7). In the RB-RFC method, announcements are made by the routing node periodically every t seconds, which was previously determined. Thus, in the RB-RFC method, n users each has the right to produce β/n amount of traffic at t amount of time. Therefore, the entrance data rate is fixed at t time period; the outgoing data amount will be $\psi = t \cdot \mu$. If $\psi = \beta$ is kept equal, ρ=1 will be obtained. Let Γ be the data amount received until the next period, observing change of β over time, at time t_0 the available size will be equal to the data amount received until the next period β=Γ. Since the outgoing data amount will be ψ, and the β value at the next announcement will be equal to ψ. Since the incoming data amount at unit time β is determined according to μ, value change of μ in time will not change the result.

Maximum Queue Size Selection

The above explanation shows that there is a relationship between time t and Γ. If Γ is selected as Γ<t·μ, then ((t·μ-Γ))/sn amount of bandwidth will be unused. For this reason, the equation t·μ-Γ≃0 should be satisfied to use the bandwidth efficiently.

3.2.2. Using RB-RFC for a Communication Route (Bir iletişim yolu için RB-RFC'nin çalışması)

RB-RFC's success in congestion prevention stems from considering all of the hopping nodes as a whole rather than one by one. Figure 8 illustrates an example route.

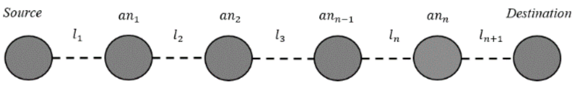

Figure 8. A Sample Communication Route (Örnek bir iletişim yolu)

In a communication route, let the hopping nodes through the route from source to destination be represented as an_i; $1 \leq i \leq n$; let all of the physical connections from source to destination be represented as l_i; and let capacities of these connections be represented as C_i By using RB-RFC, the maximum data amount that the source node can send to this connection will be $min(C_i)$, $1 \leq i \leq n+1$. Assuming k_{l_i} users use the l_i connection, the maximum data amount that the source node can send to the connection will be $\min(C_i/k_{li})$. In the RB-RFC method, each source node keeps pace with the bottlenecking connection on the communication route. Therefore, no congestion occurs anywhere in the network. A communication route that has a bottleneck is shown in Figure 9.

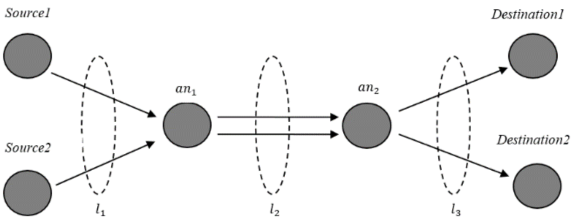

Figure 9. A Communication Route with a Bottleneck (Darboğazı olan bir iletişim yolu)

Let C_1, C_2 and C_3be capacities of l_1, l_2 ve l_3, respectively, and $C_1 = C_3 > C_2$. In this example, the connection that will cause a bottleneck is l_2; an_1 has the right to use the whole C_2 capacity. Furthermore, an_1 allows source1 and source2 use the capacity it obtains from an_2 each ($C_2/2$). In reality, although $C_1 > C_2$, the data amount that source1 and source2 can inject into the network will be limited to C_2. This way, by preventing $(C_1 - C_2)$, the amount of data to be injected into the network, both congestion and the wasting of energies of source1 and source2 are avoided.

4. SIMULATION *(SİMÜLASYON)*

Drop rates, instantaneous queue length and average queue lengths were used as comparison criteria data. Data drop rates are the ratio of the data amount that has dropped over the total amount of data produced by sources. It is possible, using this criterion, to measure how efficiently the total bandwidth in the network is used. Instantaneous queue length shows the change of buffer sizes of router nodes used in network cards over time. Instantaneous queue length, usually being at maximum levels, indicates congestion. Like data drop rate, average queue length is a parameter that shows how efficiently the total bandwidth in the network is used. While average queue length being close to maximum queue length indicates congestion in the network, queue length being at very low levels indicates that the bandwidth is not being used efficiently. To interpret this criterion, its value is checked to determine whether it is too low or too high. Since the medium nodes are important in this study, to analyze the behaviors of medium nodes in terms of different topologies, one and two medium nodes were used in the immobile scenarios. Additionally, for their behaviors, for the case of source node, three incremental scenarios were used. For their behaviors in dynamic topologies, an immobile scenario was used and this is explained in detail in the following sections.

4.1. Immobile Scenarios Used in Simulation (Benzetimde kullanılan hareketsiz senaryolar)

In order to evaluate RB-RFC's performance and compare its use with the cases in which it is not used, topologies with four, five, and seven nodes over three different scenarios were simulated. Ns-2 provides the necessary media for mobile ad hoc networks.

4.1.1. First Immobile Scenario Used in the Simulation (Benzetimde kullanılan 1. hareketsiz senaryo)

The values used for the RB-RFC algorithm in this simulation tool are shown in Table 1. The code proposed in the ns-2 environment was implemented. Each simulation was run ten times, and the averages of the obtained results were added here (Figure 10).

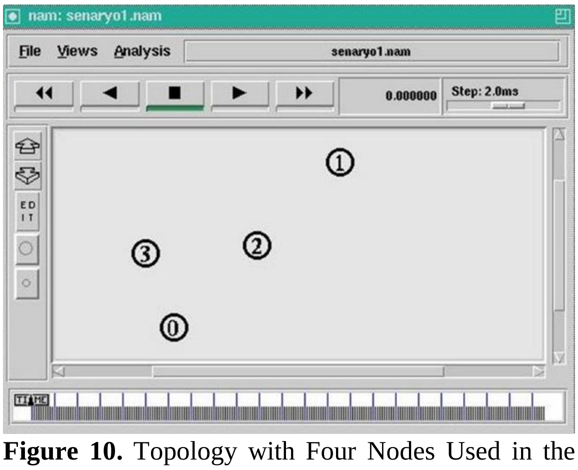

Figure 10. Topology with Four Nodes Used in the Simulation (Gerçekleştirilen Benzetimin 4 düğümlük topolojisi)

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Table 1. Parameters Used in the First Scenario (Birinci senaryoda kullanılan parametreler)

Simulation time	
150 h	
+Nodes Acting As Routers	
2	
Mobility	
No	
Communicating Nodes	
0-1	3-1
Communication Time	*Communication Time*
1-140h	5-145h

The averaged instantaneous queue length graph obtained using the first scenario is shown in Figure 11.

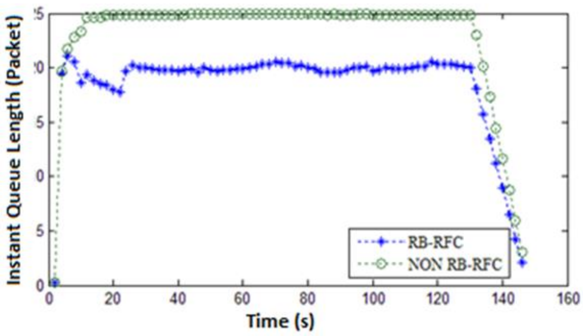

Figure 11. Averaged Instantaneous Queue Length Values of the First Scenario *(Birinci senaryo ortalaması alınmış anlık kuyruk uzunluğu değerleri)*

4.1.2. Second Immobile Scenario Used in the Simulation (Benzetimde kullanılan 2. hareketsiz senaryo)

The topology with five nodes used in the simulation is shown in Figure 12.

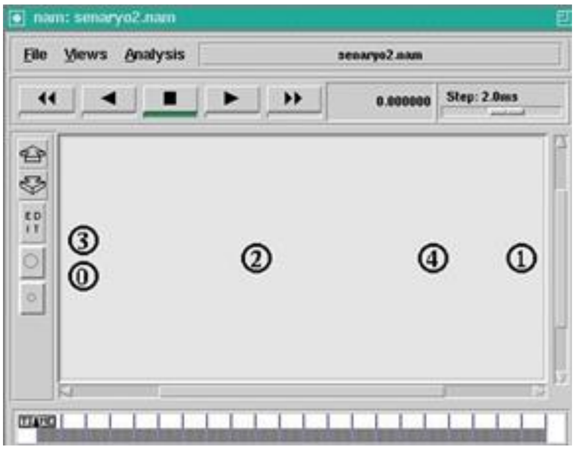

Figure 12. The Topology with Five Nodes Used in the Simulation (Gerçekleştirilen Benzetimin 5 düğümlük topolojisi)

Values used for the RB-RFC algorithm in this simulation tool are shown in Table 2.

Table 2. Parameters Used in the Second Scenario (İkinci senaryoda kullanılan parametreler)

Simulation time			
150 h			
Nodes Acting As Routers			
2-4			
Mobility			
No			
Communicating Nodes			
0-1	3-1	5-1	6-1
Communication Time	*Communication Time*	*Communication Time*	*Communication Time*
1-145h	1-145h	5-145h	5-145h

The instantaneous queue length graph obtained using the second scenario is shown in Figure 13.

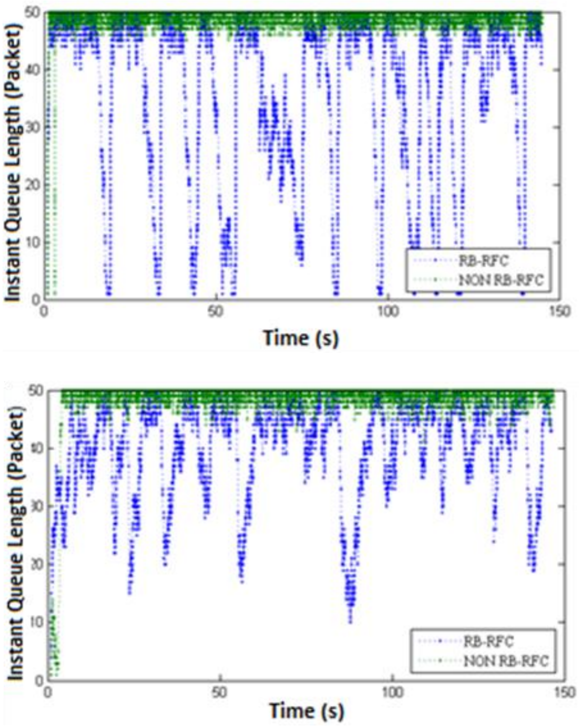

Figure 13. Averaged Instantaneous Queue Length Values Obtained Using Nodes Number 2 (a) and 4 (b) in the Second Scenario (İkinci senaryo' da 2 (a) ve 4 (b) numaralı düğüm ile elde edilen ortalaması alınmış anlık kuyruk uzunluğu değerleri)

4.1.3. Third Immobile Scenario Used in the Simulation (Benzetimde kullanılan 3. hareketsiz senaryo)

The topology with seven nodes used in the simulation is shown in Figure 14.

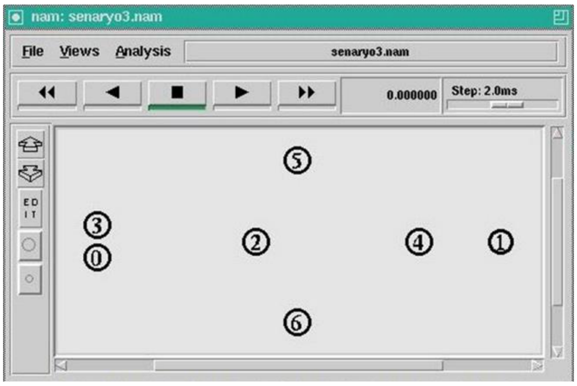

Figure 14. The Topology with Seven Nodes Used in the Simulation *(Gerçekleştirilen Benzetimin 7 düğümlük topolojisi)*

The values used for the RB-RFC Algorithm in this simulation tool are shown in Table 3.

Table 3. Parameters Used in the Simulation *(Benzetimde Kullanılan Parametreler)*

Simulation time			
150 h			
Nodes Acting As Routers			
2-4			
Mobility			
No			
Communicating Nodes			
0-1	3-1	5-1	6-1
Communication Time	Communication Time	Communication Time	Communication Time
1-145h	1-145h	5-145h	5-145h

The instantaneous queue length graph obtained using the second scenario is shown in Figure 15.

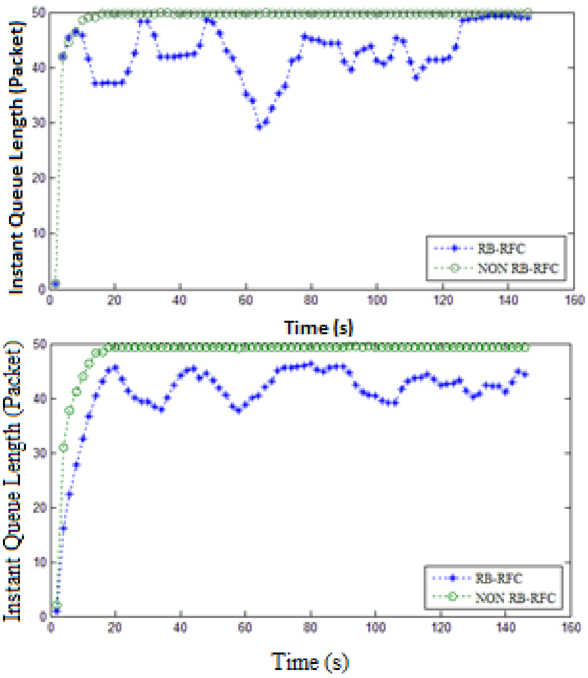

Figure 15. Averaged Instantaneous Queue Length Values Obtained Using Nodes Number 2 (a) and 4 (b) (2 ve 4 numaralı düğüm ile elde edilen ortalaması alınmış anlık kuyruk uzunluğu değerleri)

In the scenarios implemented using the RB-RFC method in Figure 15, the queue length of the node acting as a router changes over time, whereas in the scenarios implemented without using the RB-RFC method, queue length is usually at maximum queue length level. This shows that when RB-RFC is not used, congestions occur on the routing node during the simulation. The simulations were run using topologies with four, five, and seven nodes over three different scenarios. The graph of average queue length rates obtained over all scenarios are shown in Figure 16. In all scenarios, examining average queue lengths of routing nodes in RB-RFC and in NON RB-RFC conditions, it is possible to observe that in non-RB-RFC conditions average queue lengths are at maximum queue length level or close to that level. In RB-RFC conditions, on average, buffer use of 80% is observed. This shows that the routing nodes have no congestion and the bandwidth is used efficiently.

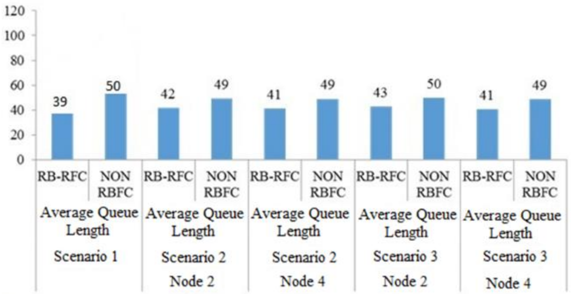

Figure 16. The Average Queue Length Rates of All Scenarios *(Tüm senaryoların ortalama kuyruk uzunlukları oranları)*

The data drop rates graph obtained over three different scenarios is shown in Figure 17.

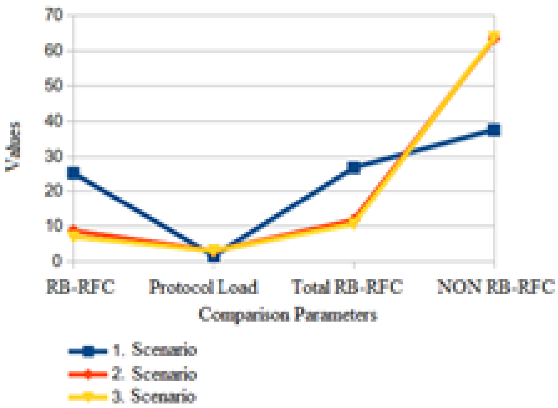

Figure 17. Data Drop Rates of All Scenarios (Tüm senaryoların veri atılma oranları)

In Scenario 1, an RB-RFC condition, data drop rate decreases by 12%. When the data produced to make RB-RFC method work are included in the data drop rate, the improvement rate will be around 10%. In Scenario 2, an RB-RFC condition, data drop rate decreases by about 55%. When the data produced to make the RB-RFC method work are included in the data drop rate, the improvement rate will be around 52%. In Scenario 3, an RB-RFC condition, data drop rate decreases by about 56%. When the data produced to make the RB-RFC method work are included in the data drop rate, the improvement rate will be around 53%. According to the results, when the RB-RFC algorithm is used, it is observed that the bandwidth and energy of the nodes are used more efficiently.

4.2. Mobile Scenario Used in the Simulation (Benzetimde kullanılan hareketli senaryo)

The topology of 40 nodes used in the simulation is shown in Figure 18. Ns-2 provides the necessary media for MANET. The reason for forming the topology in such a manner is to evaluate the performance of RB-RFC and to compare the results with non-RB-RFC conditions.

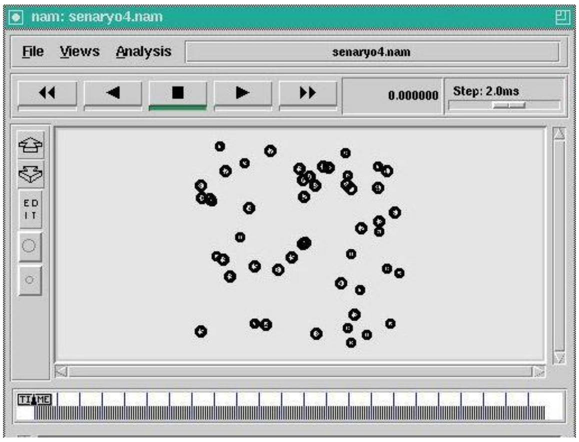

Figure 17. Screenshot of the Mobile Scenario (Hareketli senaryonun ekran görüntüsü)

Unlike the previous scenarios, the nodes are given the ability of being mobile (Figure 18). The data drop rate graphs obtained over the fourth scenario are shown in Figure 19. In the RB-RFC condition, a decrease of 29% in the data drop rate can be observed with respect to the non-RB-RFC condition (Figure 19). When the data produced to make the RB-RFC method work are included in the data drop rate, the improvement rate will be around 15%.

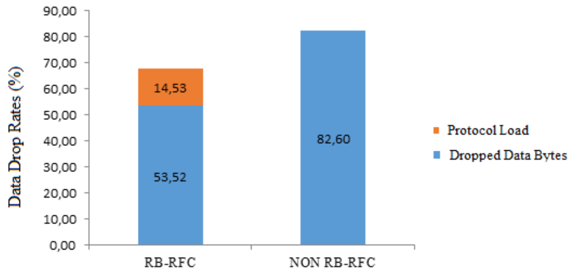

Figure 19. Data Drop Rates in the Mobile Scenario (Hareketli senaryo'da veri atılma oranları)

5. CONCLUSION *(SONUÇ)*

In this study, the RB-RFC algorithm was coded on the ns-2 simulation tool; the obtained results were applied in real environment and compared to Non-RB-RFC conditions. In RB-RFC method, the nodes that will use the hopping node are able to send as many packets as they were announced. Therefore, the data entries are put under control. In the existing methods, since the hopping nodes are not controlled during the flow control from source to destination, more packet losses, buffer overflows, and congestions occur. As the resources are shared unfairly, the networks of some nodes are never used. In this case, the problem of limiting the number of users emerges.

The RB-RFC method adjusts the data flows according to the conditions of the hopping nodes on the setup route. Resource reservation is node-based rather than flow-based. The number of users is not limited. In the cases in which the RB-RFC method is used, a decrease occurs in data drop rates of at least 12%, and 54% at the most. When the data produced to make the RB-RFC method work are included in the data drop rate, it is understood that the improvement rate is at least 10% and around 52% at the most.

In the scenarios implemented the RB-RFC method is used, the queue length of the router nodes changes over time, whereas in the scenarios the RB-RFC method is not used, the queue lengths are usually at maximum queue length levels. As a consequence of the implemented scenarios, in the cases that used the RB-RFC method, the data drop rates decreased and instantaneous queue lengths changed over time. Additionally, in these cases, by keeping the average queue length around 20%, congestions were prevented and the bandwidth was used efficiently.

Although the developed method is not directly a queue management method, its effect on queue lengths of the routing nodes were positive and these nodes were prevented from getting in congestion conditions. The basic purpose of the RB-RFC method is to prevent overloading of the network. Another advantage of the RB-RFC method is to decrease packet drop rates, and thus, decrease the number resending attempts and prevent the nodes from wasting more energy. As the results of the implemented simulations show, RB-RFC produces results compatible with mathematical analysis results.

The RB-RFC model was simulated over some scenarios that could possibly occur in networks and the results show that it was successful. It is foreseen that in future studies, if a few missing parts of the model defined above are completed and a few improvements are made, far better results could be obtained.

REFERENCES *(KAYNAKLAR)*

[1] L. E. Quispe and L. M Galan, "Behavior of ad hoc routing protocols, analyzed for emergency and rescue scenarios, on a real urban area", Expert systems with applications, vol. 41(5), pp. 2565-2573, 2014.

[2] F. Çetinkaya, İ.A. Doğru, M. Dörterler, R. Kocaoğlu, "E-AODV: A protocol devoted to emergency and rescue scenarios for mobile ad hoc networks", Jornal of Polytechnic, vol. 21(3), pp. 739-751, 2018.

[3] R. Torres, L. Mengual, O. Marban, S. Eibe, E. Menasalvas, and B. Maza, "A management ad hoc networks model for rescue and emergency scenarios", Expert Systems with Applications, vol. 39(10), pp. 9554-9563, 2012.

[4] A. Munja, Y. N. Singh, "Review of stateful address auto configuration protocols in MANETs", Ad Hoc Networks, vol. 33, pp. 257-268, 2015.

[5]. A. W. Gyanappa , C. B. Rajashekar, "A survey on hybrid routing mechanisms in mobile ad hoc networks", Journal of Network and Computer Applications, vol. 77, pp. 48-63, 2017.

[6] R. Braden, S. Berson, S. Herzog, Resource Reservation Protocol, RFC 793, ISI, 1997.

[7] B. Libaek, M. Hauge ,Landmark L., Kure O., "Admission Control and Flow Termination in Mobile Ad-hoc Networks with Pre-congestion Notification", Military Communications Conference MILCOM, pp. 1-8, 2012.

[8] Yong Cui a, Xiao Ma a, Jiangchuan Liu b, Lian Wang a, Yuri Ismailov c,"Policy-based flow control for multi-homed mobile terminals with IEEE 802.11u standard", Computer Comunications, 2013

[9] S. Soundararajan, R.S. Bhuvaneswaran, "Multipath Load Balancing & Rate Based Congestion Control for Mobile Ad Hoc Networks (MANET)", 2012 Second International Conference on Digital Information and Communication Technology and it's Applications (DICTAP), pp. 30-35, 2012.

[10] J. L. Hong, , K. Jincui, D. Qian, B. H. Dong, "The research of AD-HOC network bandwidth control distribution mechanism", Military Communications Conference, vol. 216, pp. 65–69, 2011.

[11].Cisco Systems, "Understanding Jitter in Packet Voice Networks (Cisco IOS Platforms)", Cisco, 2006.

[12] H. Zhu, I. Chlamtac, "Admission control and bandwidth reservation in multi-hop ad hoc networks", Computer Networks, vol. 50(11), pp. 1653–1674, 2016.

[13] Seok S. J., Y. S. K. , Kim S. W., Kang C. H., "A modification of TCP flow control for improving end-to-end TCP performance over networks with wireless links, Computer Communications", vol. 26, pp. 1998–2010, 2003,

[14].G. Boggia, P. Camarda, L.A. Grieco, S. Mascolo, "Feedback-based bandwidth allocation with call admission control for providing delay guarantees in IEEE 802.11e networks Computer", Computer Communications, vol. 28, pp. 325-337, 2005.

[15].ns-2, Network simulator, available at http://www-mash.cs.berkeley.edu/ns, 2003.

[16].International Telecommunication Union (ITU), "Coding of Speech at 8 kbit/s using Conjugate-Structure Algebraic-Code-Excited Linear Prediction (CS-ACELP)", ITU-T Recommendation G.729, March 1996.

[17].Internet: MPEG-4 Video Group, Mpeg-4 overview, http://mpeg.telecomitalialab.com/, March 2002.

[18].International Telecommunication Union (ITU), "Video coding for low bit rate communication", ITU-T Recommendation H.263, February 1998.

[19].Internet: Video trace library, http://www.tkn.ee.tuberlin.de/research/trace/trace.html, 2018

[20] G. Hasegawa , T. Tomioka , K. Tada , Murata M., "Simulation studies on router buffer sizing for short-lived and pacing TCP flows", Computer Communications, vol 3, pp. 3789–3798, 2008.

[21] Z. Rosberg , J. Matthews , M. Zukerman, "A network rate management protocol with TCP congestion control and fairness for all", Computer Networks, pp. 1–17, 2008.

[22 L. Hongjuan , K. Jincui , D. Qian , H. Dongbin, "The research of AD-HOC network bandwidth control distribution mechanism", Advanced Materials Research, vol. 2016, pp. 65–69, 2011.

[23] C. Zhou, F. Maxemchuk, "Scable max-min in wireless ad hoc networks", International Conference on Ad Hoc Networks, pp. 79-93, January 2011.

[24] F. Maxemchuk, C. Zhou, "A macro model of frequently changing mobile networks to perform flow and access control", The second International Conference on Broadband Networks, Boston, MA, Oct. 7 2005.

[25] F. Maxemchuk, C. Zhou, "A macro model of frequently changing mobile networks to perform flow and access control". Mobile Networks and Applications, vol. 11, pp. 649-659, 2006.

[26] C. Zhou, F. Maxemchuk, "Applying a macro model of ad hoc networks to Access control", The seventh International Conference on Networking (ICN 2008). Cancun, Mexico, April 13-18 2008.

[27] C. Zhou., "Distributed Bottleneck Flow Control in Mobile Ad Hoc Networks", Network Protocols and Algorithms, vol. 3, pp.1943-3581, 2011.

[28] M. M. Alam , S. Islam , A. Hamid. , C. S. Hong, S. Lee, "Congestion-aware fair rate control in wireless mesh networks", Ann. Telecommun, vol. 66, pp. 275–291, 2011.

[29] M. M. Alam , S. Islam , A. Hamid. , C. S. Hong, S. Lee, "Optimal Scheduling for Fair Resource Allocation in Ad Hoc Networks With Elastic and Inelastic Traffic" Ann. Telecommun, vol. 66, pp.275–291, 2011.

[30] J.D. Mallapur ,Manvi S.S., D. H. Rao, "Fuzzy Based Packet Dropping Scheme in Wireless Cellular Networks", Int. J. of Computers, Communications & Control, vol. 2, pp. 305-316, 2011.

[31] A. Peculea , B. Iancu , V. Dadarlat , I. Ignat, A Novel QoS Framework Based on Admission Control and Self-Adaptive Bandwidth Reconfiguration, Int. J. of Computers, Communications & Control, vol. 5, pp. 862-870, 2010.

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