International Journal of Engineering

Journal Homepage: www.ije.ir

RESEARCH NOTE

Improving Bandwidth-power Efficiency of Homogeneous Wireless Networks Using On-meet Threshold Strategy

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PAPER INFO

Paper history:
Received 17 April 2013
Received in revised form 14 March 2014
Accepted 22 May 2014

Keywords:
Hidden Terminal Problem
Bandwidth Utilization
Network Simulator Tool
Power Consumption
Throughput Rate
Average Delay

ABSTRACT

Over two decades, the problem of location dependent has been focused for improving the communication bandwidth-power efficiency of homogeneous networks. The efficiencies of communication links are weakened by the hidden terminal problem. Thus we propose a Fine–Tune strategy for analyzing the on-off communication region. We observed that the proposed technique was able to track and monitor the off-region nodes for improving the fidelity of the link. Testing of TCP variants was done to cross validate the value of on-demand bandwidth-power transmission parameters. The proposed technique of on–meet threshold (O-MT) was deployed in the network simulator tool of NS2 (v2.34) and while probing, the parameters of packet reception rate, packet dropping rate and throughput rate, bandwidth and power utilization rates were analyzed and found as best for TCP-EPRT (enhanced packet reception time) compared of TCP New Reno.

doi: 10.5829/idosi.ije.2014.27.09c.04

1. INTRODUCTION

Wireless network has the problem of location dependent. As a consequence, it may frequently trigger the Hidden Terminal Problem (HTP) and this occurrence may also downgrade the throughput performance. This downgrading factor could be meliorated by the technique of RTS (Request To Send) / CTS (Clear To Send) which partially overcomes the problem of HTP [1]. The aforementioned technique not only upgrades the Network Performance (NP) but also increases the transmission power efficiency of the nodes. The former parameter is the key objective of this paper whose results will be distinctively shown in Section IV for 3-nodes of communication. The degradation of network performance occurs for two important aspects. Former, it occurs for unnecessary reduction of congestion size and causes for congestion loss. Later, it occurs for frequent Retransmission Timeout (RTO) and causes for wireless loss. The classification scenario is shown in Figure 1.

The latter parameter is the key model wherein Fine-Tuning (F-T) parameters are available for probing the efficiency of bandwidth-power. The melioration of HTP has now become one of the challenging design issues of Media Access Control (MAC). IEEE 802.11 [1] has distributed coordination function which employs carrier sensing along with four ways handshaking for maximizing the NP by the prevention of collision of the packets. This strategy does eliminate the unnecessary packet loss and packet delay. The F-T does increase the transmission power to solve the problem of HTP for enhancing the node detection, which as well eliminates the loss and delay to upgrade the NP. The handshaking technique of RTS/CTS has an assumption that all the HTP are within the range of communication receiver (to receive the generated packet of CTS successfully). This assumption does not hold while the Transmitter-

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Please cite this article as: B. D. Deebak, R. Muthaiah, J. Rubert, N. Sathurappan, Improving Bandwidth-power Efficiency of Homogeneous Wireless Networks Using On-meet Threshold Strategy, International Journal of Engineering (IJE), TRANSACTIONS C: Aspects Vol. 27, No. 9, (September 2014) 1349-1358

Receiver (T-R) distance exceeds the range of communication. On the other hand, the parameter value may be exceeded between the T-R that may disrupt the communication of Sender–Receiver (S-R). Thus, a technique of F-T has been proposed for enhancing the communication range of network. Even if the nodes are out of the communication range, our technique does an automatic change in setting parameter values to provide the S-R communication reliably. This is a situation which happens in Wireless Local Area Network (WLAN) rarely. Because, the nodes which are available in WLAN will always be in the communication region that does an enhancement for either transmitter or receiver. In wireless Adhoc network, it has been a serious issue which comes for larger distribution of the nodes and frequent multihop operation.

Furthermore, it has a variety of bandwidth and power demanding application that needs some efficient methodology for increasing the NP. The NP fully relies on the data rate achievability which is determined by Signal To Interference and Noise Ratio (SINR) and spatial reuse. The result of former parameter is obtained by the individual wireless link and the latter is found by the total number of concurrent transmission on the network. In 802.11 MAC protocols [2], when any node of wireless intends to packet transmission, it first deduces the channel whether it is idle or busy. If the deduction found the channel as idle, it starts its transmission to the intended recipient otherwise it waits till it deduces the channel as idle. For better Spatial Reuse (SR), the setting parameter values should be redone often for finding the On-Meet Threshold (O-MT) whose value has a provision for larger Wireless Distribution Network (WDN). In this paper, a technique of O-MT is proposed:

- Increase the bandwidth utilization of the networks
- Reduce the packet drop and packet delay
- Deduces the idle/busy efficiently.

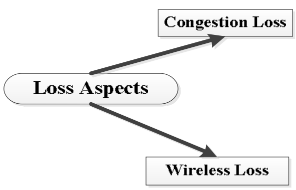

Figure 1. Classification of loss aspects

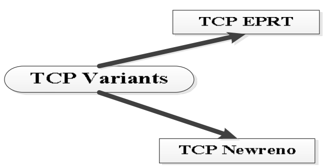

Figure 2. Bandwidth an power – An analysis

The TCP variant of TCP–EPRT [3] (Enhanced Packet Reception Time) and TCPNew Reno have been chosen for validating the communication efficiency of bandwidth-power of homogeneous networks and the variant of TCP scenario is shown in Figure 2. Reduction of transmission rate leads the TCP variants like TCP–EPRT and New Reno to reduce the flow of packets and it has thus faced the problem of throughput degradation. A technique of on-demand improves the aforementioned parameters to reasonable extents for the variants of TCP-EPRT. The rest of the paper is devised as mentioned henceforth. Section 2 exhibits the related work therein issues on MAC protocol, solving methodologies, issue on bandwidth utilization and power consumption are explained in the aspects of wireless Adhoc network. Section 3 portrays the wireless Adhoc network model using to probe the bandwidth-power. Section 4 proposes a methodology of O-MT to increase bandwidth utilization, packet delay as well as loss. Section 5 furnishes the performance evaluation and Section 6 concludes our research work.

2. RELATED WORK

In IEEE 802.11 [4] standards had been explained to design the connection oriented services. The enabling of IEEE 802.11 has added the feature of bandwidth and energy model for measuring the utilization Factor and throughput rate as well. The standard of 802.11 is developed for single hop communication and the communication would happen between the available nodes. If not, it would happen between available nodes and base station/access point. The available nodes could be acted sometimes as sender/receiver or relay. In the literature [3], Deebak and Sakthivel have discussed the specific key areas for the reconsideration of Mobile Adhoc Network (MANET). The specific factor is relay communication and it is often employed to probe the multihop communication environment and it is being an environment for testing wireless and mobile based Adhoc network. Section 2 discusses the following concisely, 1. Issues on MAC protocol explained about the issue of interference and solving methodologies 2. Issues on bandwidth utilization explained about the communication service requirement and its testing applications 3. Issues of energy consumption explained about the significance of power for network life time prolongation.

3. ISSUES ON MAC PROTOCOL

For wireless networks, interference is become location dependent and it may so have the hidden terminal problem [5]. It has been noted as one of the major design issues of Media Access Control (MAC) wherein

IEEE 802.11 becomes a popular protocol for mobile and wireless Adhoc network. It has two-way handshaking such as Request To Send (RTS) and Clear To Send (CTS) for probing the transmission range of the receiver (for an instance, to validate the CTS packet success) and this assumption is done to identify the hidden terminal nodes.

Some nodes may interfere with transmitter/receiver, even though it is out of range of transmission. In some works [1, 2], the authors have stated that the situation of node's interference would rarely happen in the wireless LAN environment, because most of the nodes are available in the transmission range of either transmitter/receiver. Though, this has been a serious problem of mobile and wireless Adhoc network and it is due to the large distribution of mobile nodes and the multihop operation.

4. SOLVING METHODOLOGIES

Large interference ranges have been realized in most of the research articles [6-10]. The large interference range was studied in the Adhoc network and recognized along with some major factors such as TCP unfairness and capture problem. So far as we concern on the interference range, no paper has shown much importance for factor of mitigation of interference.
The following strategies should be considered for mitigating the issues of interference:

- Analyze RF interference potentiality
- Understand the requirement of wireless nodes/base station/access point
- Obtain full structure view of the environment
- Visually probe the wireless environment
- Assess existing and coming-forth network structures
- Assess the coverage area
- Determine node communication transmission range
- Prevent the operation of interference by disabling the unwanted communication in the wireless environment
- Provide reasonable coverage, wireless LAN coverage
- Set interference mitigation parameters properly
- Deploy in 802.11a

5. ISSUES ON BANDWIDTH UTILIZATION

In the physical layer communication, the term bandwidth relates to the frequency spectrum of electromagnetic waves or to the propagation of radio signals. In the context of the data network, bandwidth refers to the data transfer rate or a network path rate where the data transfer can happen. The bandwidth is so important to the digital communication systems wherein one node transfers the packet; other node receives and sends back an acknowledgement for the received packet [11].

This kind of communication is so called as Packet Network. For data transfer based application such as file transfer and multimedia streaming, the availability of bandwidth must be fulfilled which would greatly impact the network performance. Some interactive application does focus on lower latency rather than high throughput whereof the lower end to end delay transmission and low packet transmission latencies could be achieved with high data rate link. Bandwidth becomes a key factor of several network applications. Peer to peer communication application forms the dynamic user level network based on available bandwidth between the network peers. Routing table of overlay network can be configured by the bandwidth of the overlay link. Upgradation of carrier plan capacity is based on the rate of the growth of bandwidth utilization of users. It is noted as a key concept for distributed network, intelligent routing systems, end to end admission control and audio /video streaming. It is used in the throughput related concepts.

6. ISSUES ON ENERGY CONSUMPTION

Most of the communication (cell phone, laptop and PDA) devices [11] are dependent on battery power. Thus, it is an important issue to prolong the lifetime of the device. On the other hand, it needs to minimize the consumption of energy. Handheld devices have got the significant attention for energy consumption. Because it is structured around base station and centralized servers. Bandwidth utilization is focused much on the research rather than energy consumption and it is especially concerned about the multihop environment of Adhoc network [12, 13].

Hosseinirad et al. [14] have proposed the leach routing algorithm for the minimization of power consumption, even though it doesn't trade-off the power consumption reliably over the technique of network connectivity. Taghizadeh and Mohammadi [15] have proposed a novel routing strategy for the network lifetime, however, it does not fit for the larger access network, owing to the power constraints.

Recently, the energy-aware Adhoc routing protocol has been proposed for distributed sensor network wherein the term of energy is treated as "Commodity" to minimize cost and maximize the lifetime of the nodes in the communication environment. The environment of the Adhoc routing protocol is required, some practical knowledge of the energy aware routing behavior of actual wireless routing devices. No paper has shown the per packet power consumption of the wireless nodes.

7. ROUTING PROTOCOLS

The RP shows off the way to traverse the packet from one area to another area by communicator who is so called Router on the computer network. It is done by the routing algorithm. The router has only had a prior knowledge of network that is attached directly. The information which has been collected by the router will be disseminated to the entire neighbor node first and then the dissemination happens throughout the network. It is comprised of three major classes and they are widely used on IP networks.

- Interior gateway routing via link state routing.
- Interior gateway routing via distance vector routing.
- Exterior gateway routing via border gateway protocol.

7. 1. Distance Vector Routing Protocol (DSDV)

It is known to be a proactive protocol for solving the major problem which has been associated with the distance vector routing of wired network. This does an advertisement for each of its current neighbors and it also does an updating to its own routing table. The entrie of routing table updates dynamically over time so that the mobile nodes can get the service without breaking up the connection. The mobile nodes agree to relay the data packet to other mobile nodes upon their request. It guarantees loop-free path to each of the destinations.

8. TCP VARIANTS

TCP is a transport layer protocol. It adjusts its window size according to the available bandwidth. In wired networks, there are fewer chances of losses, but in wireless network packet loss cannot be neglected. Bit errors occur with high possibility on the channel in TCP/IP wireless networks. Standard TCP versions are not able to differentiate between losses due to congestion and losses due to bit-error and it simply reduces the window size for both types of packet losses.

8. 1. TCP-New Reno

TCP New Reno is an experimental version of TCP Reno. It is efficient when more packet loss occurs. As soon as all outstanding data has been acknowledged TCP New Reno comes out of its fast recovery phase. Partial acknowledgement in TCP New Reno shows that a packet has been lost and should be retransmitted. The limitation of TCP New Reno is its ability of detecting and retransmitting a single packet loss, however it is very efficient when multiple packet loss occurs.

8. 2. TCP-EPRT

In the literature [4], the retransmission for packet loss can only be happened by the deduction of retransmission timeout TCP variants of TCP New Reno wherein the network performance is degraded. To achieve better network performance, the proposed work has identified two major issues wherein the performance of the network is gotten degrading. The issues are packet dropping rate and packet reception time which are stately given in the related work.

To improve the packet reception time, TCP Sender uses the technique of explicit loss notification that check mark the last sequence number of TCP sender and the current acknowledgement number of TCP receiver if that is equalized in same then that will be considered as packet loss for immediate retransmission thereby the network idle time is cut down to achieve better packet reception time and end-to-end throughput compared to exiting TCP New Reno. As well the packet dropping rate is minimized to enhance the overall performance of the network.

9. WIRELESS ADHOC NETWORK MODEL

Since we admit that the interference is one of the sources contributed by the transmitter to the receiver, as a consequence, the reception will be suffered. Therefore, a technique of O-MT is necessitated for quantifying the accumulation of the interference wherein we have done the Deep Analysis (DA) for SR. This section discusses the wireless Adhoc network model which has the aforementioned technique as: 1. Enhancing bandwidth utilization 2. Reducing power consumption, packet loss and delay.

9. 1. Physical Layer Model

In the Wireless Environment (WE), the propagating signals are often attenuated by several factors that include path loss, multipath fading and shadowing. The former parameter describes the radio propagation property in Wireless Network (WN). Long Distance Path Loss Model (LD-PLM) is expressed as follows:

$$P_L = P_{Tx}.B_m - P_{Rx}.B_m = P_{L0} + 10g\log_{10}\frac{d}{d_0} + X_g \qquad (1)$$

where P_L is the total path loss measured in Decibel (dB), $P_{Tx}.B_m = 10\log_{10}\frac{P_{Tx}}{1mW}$ is the transmitted power in dBm, P_{Tx} is the transmitted power in Watt, B_m is the bandwidth measurement, $P_{Rx}.B_m = 10\log_{10}\frac{P_{Rx}}{1mW}$ is the received power in dBm, P_{Rx} is the received power in Watt, P_{L0} is the path loss at the reference distance $\boldsymbol{d_o}$, $\boldsymbol{d}$ is the length of the path, $\boldsymbol{d_o}$ is the reference distance, usually 1 km, g is the path loss component.

X_g is a normal or Gaussian random variable with zero mean.This paper considers the attenuation which is caused by path loss and its equation is approximately expressed as in the terms of receiving power is (P_0) at d_0.

$$P_{rx}(dt)=P_0(d_0/dt)g \quad (2)$$

10. INTERFERENCE RANGE AND AREA

The transmission range and carrier sensing should be made as fixed and is only able to affect the properties of the wireless radio which is installed at the S-R. Thus, the range of interference has drawn a little attention in this paper for meliorating the aforementioned network parameters. Many research works have not given that much importance in the range of transmission [1-7]. Whereas, in our work that has been taken as a sake of seeing the betterment in B-P utilization. Most of the times, the O-MT achieved the best results, but sometimes, the interference range went further than the transmission range at that time the achieving results are slightly varying than before. HTP is defined as the nodes within the range of interference that usually occurs at the receiver. When the signal is propagated from the transmitter to receiver, some validation is done to have the receiver in the range of transmission power for deteoriating the interference. The Receiving Power (Pr) can be better calculated as,

$$P_r=P_t.G_t.G_r(h_t^2.h_r^2/d^k) \quad (3)$$

where G_t and G_r are antenna gain of transmitter and receiver, h_t and h_r are the height of both the antenna.

11. METHODOLOGY

IEEE 801.11 does provide certain level of Quality of Service (QoS) by the means of service differentiation and it has come by the amendment of IEEE 802.11e. As such amendments have been made for O-MT of single relay and multi-relay communication and that would estimate the parameters of bandwidth and energy to show off the reasonable throughput performance.

Issues solved by above methodology are listed below:

- Efficient utilization of bandwidth
- Minimum consumption of energy/power
- Good throughput rate
- Reasonable average delay

The adopted solution brings out the better throughput performance compared of TCP New Reno by thorough investigation using the network simulator tool NS2.The throughput of the network could be enhanced by increasing packet reception time and reducing the packet dropping rate that is achieved by the explicit loss notification. Figure 3 illustrates the verification flow of TCP-EPRT.

11. 1. Algorithm1: Pseudo-Code of TCP-EPRT

Step 1: If (Ackno and Seqno of Sender–Receiver are same and Intimation is done by Co-Ordination Nodes (CN)) Then (Check In ELN)
Step 2: If (Flag of ELN is raised By CN) {Retransmitting Lost Packets; Return ;}
Step 3: If (Dupacks &&! NoFastRetrans are Validated by CN) {Enter into Duplicate Action ;}
Step 4: Else {Enter into Send-One Function and then Transmit the Packets According To Current
Set of Transmission Rate ;}

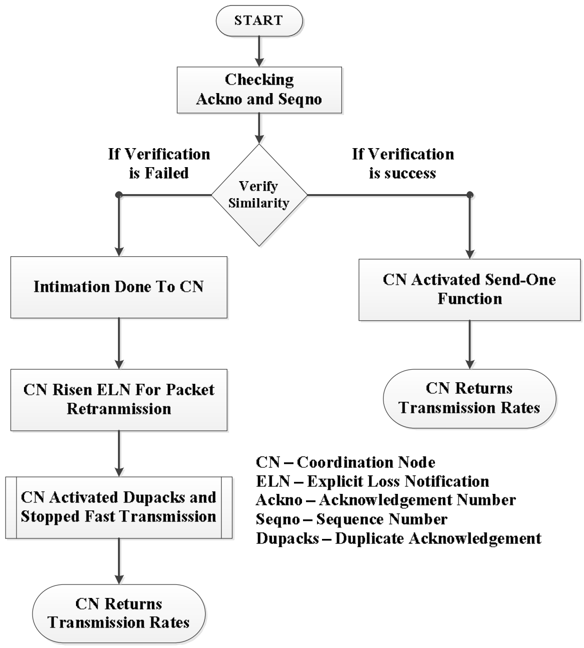

Figure 3. Verification flow of TCP-EPRT

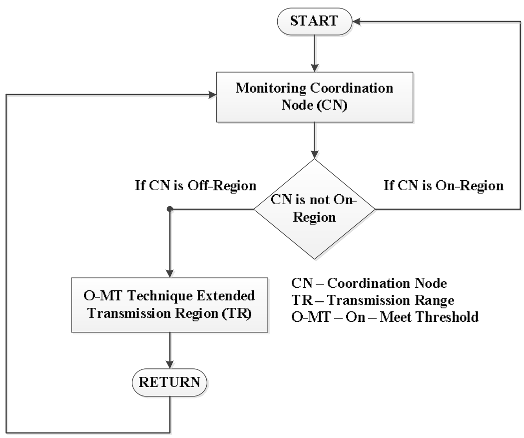

Figure 4. Fine tune strategies

11. 2. Algorithm 2: Pseudo-Code of Fine Tune On-Meet Threshold does the following action when any Communicating Nodes (CN) leaves the On-Region to Off-Region. Figure 4 illustrates the Fine–Tune Strategies.

Step 1: Start Monitoring the CN's.

Step 2: If any CN's leave off the Transmission Range (TR), then that corresponding details gets captured, logged and extended the range of communication automatically by the technique of O–MT).

Step 3: If TR is extended, then go to Step 1Otherswise Continue Step 1 Action.

12. PERFORMANCE EVALUATION

In this section, the designed W-ANM has been trained with the Network Simulator 2 (NS2) and the following networking parameters (such as load balancing, number of packet successfully sent, number of packets successfully received, total number of dropped packets, average packet Delay, throughput rate, bandwidth and power utilization) are validated for 3–node communication. Table 1 illustrates the simulation setup options of NS2.

The strategies which this methodology has shown have been successfully configured for evaluating the network parameters. Those parameters were being validated with 3–node communication. The setting parameters of O-MT and its values are detailedly described in Table 2. Table 3 illustrates comparison of network metrics. To probe the consumption of power and bandwidth, we consider a 3-nodes wireless environment in which node 0 acts as a source; node 1 acts as a destination and node 2 acts as a relay. Besides, we randomly distribute the nodes, namely source and destination in the wireless environment with the static communication nodes of relay. Though we introduce an unbalanced resource allocation, the TCP variant named TCP-EPRT gains the most estimable results for the bandwidth and power consumption relatively than the TCP New Reno.

TABLE 1. Simulation setup parameters

Setup Options	Values
Number of wireless nodes	3
Simulation time	720 sec
Bandwidth	1 ~ 6 Mbps
Packet interval	0.2 ms
Packet size	512 – 1024 Bytes
Burst time	500 ms
Idle time	250 ms

TABLE 2. Parameters of O–MT

$r_c(Mbps)$	$k(Mbps)$	$r_d(Mbps)$	g
6	3	1.01	≥ 2.45
9	3	1.23	≥ 2.95
12	3	1.38	≥ 3.35
18	3	1.5	≥ 3.85
24	4	1.29	≥ 3.85
36	5	1.09	≥ 3.35
48	6	0.9	≥ 3.65
54	6	0.96	≥ 3.75

TABLE 3. Comparison of network metrics

Network parameters	Achievable rate of TCP New Reno (%)	Achievable rate of TCP-EPRT (%)
Bandwidth utilization	85.35 – 95.75	93.5 – 98.65
Average power consumption	55 – 75	45 – 50
Throughput rate	98.1	99.7
Average delay	≤ 0.16	<0.001%
Dropping	3 (O-R) & 20 (OFF-R)	0.2 (O-R) & 4 (OFF-R)

12. 1. Node Communication

The Wireless Topology (WT) has three nodes in which Node 0 acts as a source; Node 1 acts as destination and Node 2 acts as relay and the wireless topology diagram is shown in Figure 5.

Progress 1: Nodes 0 disseminate the mode of PREQ which is herein the topology acting as source

Progress 2: Node 1 exchanges the mode of PREP for the confirmation of destination node

Progress 3: Node 2 acts as relay when either source or destination be out of the range of transmission

Progress 4: Node 0 starts transferring the data to Node 1 and Node 2 gets into act when any one of those goes out of the range or off-zone.

Figure 6 shows simulation time vs number of generated packets. When the simulation starts, our WT of 3–node communication generates the packets during the duration of the On-Region (O-R nodes) communication.

When it comes out of the O-R, it automatically reduces the generation of packet, whereas the TCP-EPRT uses the duration of the On-Region (O-R nodes) communication. When it comes out of the O-R, it also automatically reduces the generation of packet. The figures depict the generation of packet and moreover the packet generation was consistent in the TCP-EPRT compared to TCP New Reno.

Therefore, TCP-EPRT could be able to minimize the packet delay and maximize the packet reception time rather than TCP New Reno. Whereby we achieve the minimum plotting lines which the graph has in th initial, starts hiking up that means nodes are O-R and after some time it starts generating the packets at constant that means it is achieving good packet reception time. After some while of that the constant packet generation has come that means nodes are not O-R whereby we achieve Reasonable Throughput Rate (RTR).

Figure 7 shows the simulation time vs number of dropping packets. On the graph, the plotted line is showing the dropping rate of this technique. It does not have any % of packet drop up to 122 seconds whereas it has minimum dropping rate at 3% and the maximum dropping rate as 25%, whereas TCP–EPRT depicts that the maximum packet dropping rate was 4% and the minimum packet dropping rate was 0.2%. Therefore, TCP-EPRT outperforms TCP New Reno by giving out of reasonable dropping rate while the nodes move out of on-region to off-region. It has some high pitch of packet drop (that is around 20%) and it is owing to Off-Region (OFF-R) communication. Thus, when the node is O-R, there would be less packet drop; whereas when the node is OFF-R, there would be high pitch of packet drop.

Figure 8 shows simulation time vs end to end delay in which the plotted line of the graph is steadily declining that means when nodes are O-R our technique automatically miniaturizes the delay of packets and moreover it starts boosting up the throughput rate of the communication network. When the slicing of packet is less than 1K and initial sending time, there is 0.2% to 0.4% delay per packet.

When the slicing of packet is greater than 1K and in the middle of sending time, there is >.01% of delay per packet, whereas the end-to-end delay of TCP-EPRT, wherein neither decline nor ascend presents until the simulation time of 1200 ms while the wireless nodes move out of region, the delays are presented that happens in between 1200 ms to 2000ms. Even though the delays are much higher in TCP-EPRT than TCPNew Reno, the TCP-EPRT is able to reduce 1/10 delay time than TCP New Reno.

The O-MT technique is configured with the designed topology to deduce the O-R and OFF-R for achieving reasonable result on the aforementioned parameters.

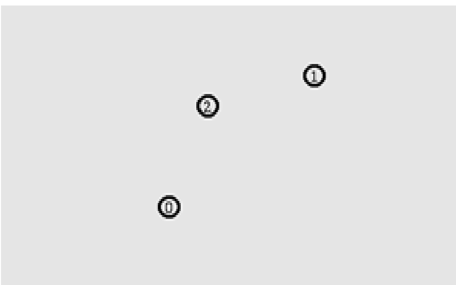

Figure 5. Three nodes wireless schema

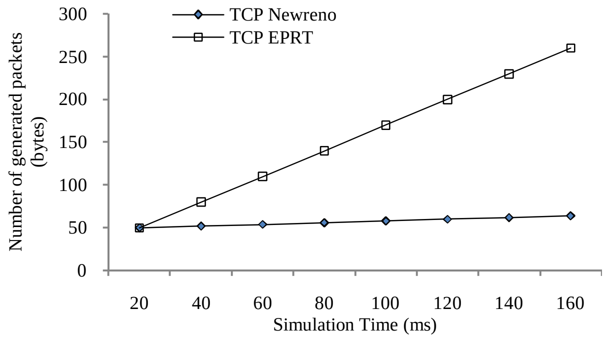

Figure 6. Simulation time vs number of generated packets

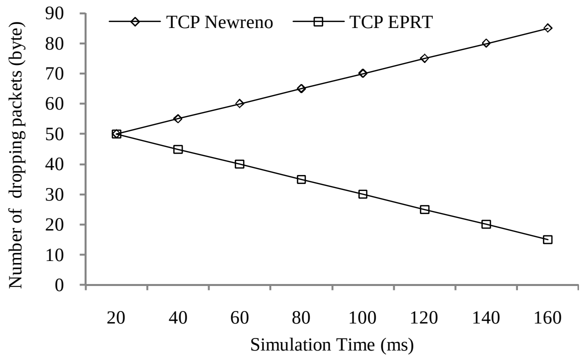

Figure 7. Simulation time vs number of dropping packets

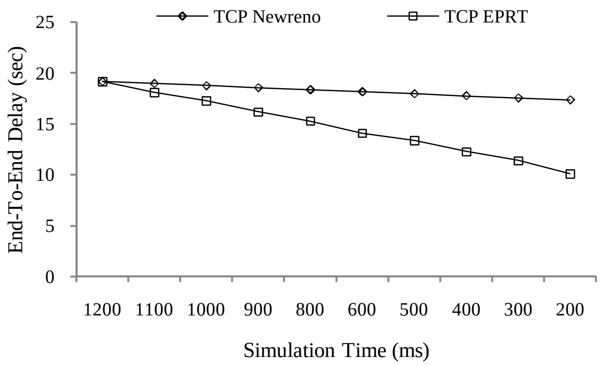

Figure 8. Simulation time vs end to end delay

13. CONCLUSION

A technique of O-MT has been successfully configured and the evaluation of results have shown that bandwidth utilization of the TCP-EPRT was near about 93.35% to 98.75% whereas TCP New Reno was near about 85.35% – 95.75% and almost all the time of simulation, the band width utilization of TCP-EPRT had laid between 93.56 to 98.746.; power consumption of TCP-EPRT was 44.86 – 49.533 whereas TCP New Reno was near about 55.35% – 75.75% and the total simulation of

WT had set to 2200 (seconds); TCP-EPRT had good throughput rate which was about 99.7% whereas TCP New Reno had a through put rate of 98.1% and moreover TCP-EPRT was able to steadily achieve the throughout rate rather than TCP New Reno; average delay of TCP-EPRT was so minimum which was about ≤ 0.001% whereas in TCP New Reno it was 0.16% and moreover TCP-EPRT was able to achieve the same delay rate even though the node were OFF-R; dropping rate of TCP-EPRT was estimable which was of 0.2% when it was O-R and 4% when it was OFF-R whereas the O-R dropping rate of TCP New Reno was 3% and OFF-R dropping rate was 20%. The technique which has been employed for 3–node communication could be as well employed for large distribution network node for parameter negotiation.

14. ACKNOWLEDGEMENT

The corresponding author would like to thank TATA Consultancy Services (TCS) for research guidance and financial support under the scheme of Research Scholar Program (RSP).

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Improving Bandwidth-power Efficiency of Homogeneous Wireless Networks Using On-meet Threshold Strategy

RESEARCH NOTE

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PAPER INFO

Paper history:
Received 17 April 2013
Received in revised form 14 March 2014
Accepted 22 May 2014

Keywords:
Hidden Terminal Problem
Bandwidth Utilization
Network Simulator Tool
Power Consumption
Throughput Rate
Average Delay

چکیده

برای بیش از دو دهه، مشکل وابستگی منطقه ای برای بهبود راندمان پهنای باند- قدرت ارتباطات شبکه های همگن مورد توجه و تمرکز قرار گرفته است. بازدهی لینک های ارتباطی تحت تاثیر مشکل ترمینال مخفی تضعیف شده است. بنابراین ما استراتژی Fine-Tune را برای تجزیه و تحلیل ارتباطات منطقه ای روشن-خاموش پیشنهاد می کنیم. ما مشاهده کردیم که روش پیشنهادی قابلیت ردیابی و نظارت بر گره های خارج منطقه ای را برای بهبود راحتی لینک دارد. تست پارامترهای TCP برای اعتبار بخشی بر روی تقاضای انتقال پهنای باند-قدرت انجام شد. روش ارائه شده آستانه دیدار (O-MT) در شبکه ابزار شبیه ساز NS2 (v2.34) به کار گرفته شد و در حالت کاوش، پارامترهای نرخ بسته پذیرش، نرخ رها سازی بسته و نرخ توان عملیاتی، نرخ پهنای باند و استفاده از قدرت مورد تجزیه و تحلیل قرار گرفته و بسته TCP-EPRT در مقایسه با TCP New Reno بهتر تشخیص داده شد.

doi: 10.5829/idosi.ije.2014.27.09c.04