Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 45 No. 12
December 2024

Algorithm in Concerns with Time Equity in Transmission Control Protocol for Wireless Networks

***Dr. Surekha Lanka[1], Dr. Nay Myo Sandar[2], Shuvra tripura[3], Thinzar Aung Win[4], Dr. Colin A. Pinto[5,]**

[1]Director of Bachelor of Science Information Technology, Faculty of Business and Technology, Stamford International University, Thailand,

[2]Lecturer, Bachelor of Science Information Technology, Faculty of Business and Technology, Stamford International University, Thailand

[3]Lecturer, Bachelor of Science Information Technology, Faculty of Business and Technology, Stamford International University, Thailand

[4] Lecturer, Bachelor of Science Information Technology, Faculty of Business and Technology, Stamford International University, Thailand

[5]Dean of Undergraduate Studies, Faculty of Business and Technology, Stamford International University, Thailand

Abstract

User demand for wireless technologies has been increasing dramatically day by day, resulting in widespread network deployment. Even today, several challenges remain for obtaining the fairness of TCP. Maintaining equitable network access is crucial. This review paper discusses the problems of congestion control in wireless network's getting access to the wired network, studies the time unfairness especially time inequities phenomenon of uplink or downlink TCP flow in wireless network access point and this paper firstly explains a fair scheduling algorithm for TCP flow in a wireless network which uses the method of fast TCP flow transmission priority, not only ensuring the throughput rate equities of each TCP flow but solving the problem of slow TCP flow's occupying too much channel time with realization of channel time fairness of TCP flow. I have shown a network simulation experiment, which showed that the new fair scheduling algorithm has better performance than traditional algorithms, which improves the overall efficiency of the network. After the simulation experiment, the measurements are made on congestion, throughput finish time of the file transfer.

Keywords: : wireless network; congestion control; packet scheduling; network efficiency; time equities; Network slicing, TCP, Protocols, ACK, uplink, downlink.

1.0 Introduction

Wireless networks have been widely spread throughout the world and it has become the most popular method of accessing Internet services [1]. Providing Fair bandwidth allocation between peers is a critical objective for the network operators since a minority of users requesting much transmission capacity shouldn't adversely influence on the quality of service (QOS). However, depart allocation of bandwidth is completely dedicated to congestion control. In operation end hosts may result in allocation of unfairness congestion control. Distribution of fair bandwidth is thus an essential function of the network. As networks grow in speed and users, implementing fair bandwidth distribution becomes more progressively complicated [2]. To provide internet access to the users, some of the most known protocols such as TCP (Transmission Control Protocol)/P(Internet Protocol). IP is the one providing a model of datagram over the internet. As we are aware TCP (Transmission Control Protocol) is the most popular and extensively used transport layer protocol in the Internet. Since 1980 TCP has been a more popular protocol. TCP originated on fixed networks. Wireless data connections are becoming more widespread. In recent years has been observed there is a most extensive interest towards using the TCP (Transmission control protocol). So, there are huge advances in technologies like cellular such as 4G/5G and deployments of broadband internet services [3].

Usually, wireless links and wired links differ in several ways. Firstly, the wireless link often faces greater bit error rates. Which means here segments of TCP can be unreliable links (corrupted) or have significant variations in the transmission time across the link of reliable. As per this first situation, none of the retransmission layer link appears, but in the second case, the link layer appears and handles the retransmission layer links [4].

When wireless network is accessed to a wired network, there are many inequities. When various up(uplink) TCP flows coexist, there are throughout rate inequities. When uplink TCP flow and down(downlink) TCP flow coexist, there are phenomena that the throughput rate of up TCP flow is far beyond that of down TCP flow. In variable-rate wireless network, as slow TCP flow occupies the wireless channel for too much time, the inequities of TCP flow's holding time in the wireless channel occur.

2.0 Research Objectives

This Research studies all about the fairness issues in the Transmission control Protocol in a wireless networking environment. Although there are various studies of wireless local-area network (WLAN). Many authors focused their research interest on medium access control (MAC) protocol fairness issues in the wireless network. However, to understand clearly how the bandwidth is distributed by the devices in a network of wireless, TCP and MAC Shouldn't be seen alone. In my research I have studied clearly about TCP. In precisely behavior interactions between protocols are explored to produce wide understanding of problem in fairness issues that occurs in a wires network.

2.1 Research Questions

As per my research interests, after I go through the many research papers, I have concluded that I can propose alternative solutions to the issues in the TCP Fairness. Thess are my following research questions.

1. Are there any issues related to TCP unfairness in the network?
2. If there exists, what is the root cause of these problems?
3. How can the issues be fixed?

TCP and TCP Variants

TCP is the predominant protocol used for reliable end-to-end communications in the transport layer of the TCP/IP protocol stack. In addition to ensure end-to-end reliability, TCP incorporates a congestion control mechanism to effectively manage unacknowledged packets and optimize the utilization of the available bandwidth and retransmitting lost packets [5]. The primary control for this mechanism lies in the CWND (congestion window), which is responsible for regulating the sending rate. The congestion control mechanism technique has four phases: delayed, avoidance, quick retransmit and quick recovery. During the initial delay, the congestion window size is typically expanded by one segment for each incoming ACK (Acknowledgement), that means round trip time will be twice. This mechanism will be processed until congestion window size is greater than a prescribed threshold value [6], usually in network the pack lost shown or size of window overtake transmission window which was announced by the destination receiver.

Furthermore, due to the packet loss in the network, reliable packet delivery is assured by retransmitting and retrieving the missing packets using the acknowledgement (ACK) message sent by the receiver. With the swift advancement of hardware network and the spread of wireless Internet, several TCP congestion management studies have been carried out to obtain higher throughput and lower latency [7-9]. Congestion control algorithms (CCAs) are an essential component of the network and the sector of networking has been studying and developing them for over thirty years [10,11]. I am especially interested in the wide-area setting. In this context, throughput and fairness are critical CCA features because they influence the accuracy with which information may be transmitted over the Internet and the capacity of numerous TCP flows to coexist. Many previous efforts have employed systematic models and experimental studies to better understand these features. forecast the throughput of a New Reno flow as a packet lost function and round-trip time (RTT).

2.3 Related Research work

In the previous research we analyze the effective performance of on demand routing protocols in the mobile ad hoc network simulator environment [34]. This interest drives us to diversify and deeper in the fairness issues of TCP in the wireless networks. In terms of issues of congestion control in wireless network access to wired networks, numerous academics do research and propose several fairness algorithms [12-19] to address these issues.

Fairness issues exist in uplink TCP flows: for TCP flows with larger congestion windows, because ACK groupings are large in number and have an accumulated acknowledgement effect and the timeout retransmission will not occur if ACK groupings are received before the timeout retransmission, and the loss of partial ACK groupings will result in minimal impact on the transmit speed of the up TCP flow. For TCP flows with lower congestion windows, a loss of ACK groups will result in a drop in TCP flow transmit speed, as well as rate inequalities between different up flows.

In terms of addressing inequalities between various uplink flows, [20] presents a strategy for reasonable scheduling. Because ACK groupings for each flow are inversely related to congestion windows in their mean arrival interval, ACK groupings are determined by their arrival interval restrictions. When the arrival intervals of ACK groupings exceed the restrictions, dispatching priority is offered. TCP flow ACK groupings with narrower congestion windows have a longer transmission time interval, are simpler to achieve dispatching priority, and result in overall rate inequalities between different uplink flows.

One of the researchers provided a single queue LAS scheduling mechanism [21-25], which determined the number of arrived groupings based on the arriving grouping number. The flow groupings that are less than the number of arrived groupings will break in the buffer queue at the front and preferentially dequeue, resolving the issue of up/down TCP flow inequalities.

According to Reference [26-29], throughout rate equities are ensured by dividing the buffer into various sub-queues in the down-going buffer queue of the Access Point through which the wireless network connects to the wired network and adjusting the dequeue rate of DATA groupings of the down TCP flow and ACK groupings of the up flow based on the multi-queue scheduling mechanism.

Meanwhile, the issues of inequities in variable-rate flows' holding time in the channel caused by the multi-channel rate of the wireless network are neglected. To ensure throughout rate uniformity, the slow-speed TCP must occupy a longer period in the channel, taking up more channels time than the fast-speed TCP flow, resulting in a drop in network efficiency. To address this issue, an expected equilibrium between overall network efficiency and rate equities must be found [30-31].

Now, the objectives for which wireless fairness techniques are available are all subject to rate-based limitations. For example, throughout rate equities of uplink/downlink flow are based on the same wireless channel rate, however throughout frequency equities of up flow are based on the same direction. When the variable-rate wireless network has multiple channel rates, these throughout-based equity solutions reduce the overall efficiency of the network. However, in an outstanding equity strategy, numerous equity objectives are always considered to the greatest extent feasible, making this strategy the ideal scenario for a variety of purposes [32-33].

2.4 LAS(Least Attains service) based Improved Algorithm TFLAS(Time Fairness of Least Attains Service)

Considering the aforementioned factors, I initialized the TFLAS algorithm. TFLAS (Time Fairness of LAS) is based on LAS (Least Attains Service) to achieve two main objectives: when the wireless channel rate is the same, throughout rate equities are ensured by adjusting the dequeue probability of Data and ACK groupings in the down link-going buffer queue, and when the wireless channel rate is different, various TCP flows' average channel time equities are ensured by adjusting various flows' scheduling probability.

Model of Scheduling

The LAS algorithm is used to assure the consistent equities of uplink/downlink flow. In the situation of varying channel rates, slow flows will take up too much time in the channel, reducing overall network efficiency. TFLAS designed a new scheduling method to address the above-mentioned issue. Eff is based on the wireless network rate, tracking the speed with an efficiency factor, and deciding the position of the flow to insert in the buffer queue based on the efficiency factor value and the number of arrived groupings. When the deciding value is large, the flow should be placed at the back or front of the queue. This advantage ensures not only the entire rate equities, but also the holding-time equities for each flow in the channel, hence enhancing total network efficiency.

2.5 The computation of efficiency factor

By ignoring transmission delay, the groupings of flow "x" are in the holding

time: tx=sx/rx+tov------------- (1)
Where: sx represents the length of the groupings
tx represents the speed of the groupings.
Tov controls latency and session.
Eff(x)= Eff(x)= tx/tmax----------(2)
Where:
Eff(x)= (sx/tx+tov) / （smax/tmax+tov).

According to equation (2), the efficiency factor of the flow at maximal speed is one, or Eff = 1. For other flows, Eff(x) > 1 since the holding duration of the groups, ti, is greater than tmax. Thus, we may track the speed by efficiency factor; when the efficiency factor is great, the grouping rate is low, and when the efficiency factor is small, the grouping rate is high.

2.6 Description of algorithm

To display the number of arrived groupings, assign an increasing dispatching key Keyx to flow x with a value equal to the number of arrived groupings. Insert the groupings into the buffer queue correctly based on the product of the flow's Keyx and the efficiency factor. The groupings of Keyi's smaller products and efficiency factors will be moved to the head of the line, and the flow of fewer arrived groupings and smaller efficiency factors will be dispatched first. Steps for implementation.

In the AP down buffer queue, when one grouping of flow x is received, if it is the initial grouping of flow x, the key Keyx takes 1 or plus 1.

1. Calculate the effectiveness factor Eff(x) using relation (1).
2. Grouping mark Keyx.
3. When a grouping enters the buffer queue, if the queue is full, give up the grouping or calculate Keyx*Eff. The grouping with the lowest value is at the front of the line.

The Algorithm snippet

```
On receive Packet PC
{  x=classify(PC) ;
if P  is NO.1,Keyx=1
else Kex=Keyx+1;
Mark_packet(Keyx,PC);// Grouping mark Key
Count_Eff(x);// Calculate Eff
bi=Eff(x);
y=0;
while(y<buffer_size and by*Keyx>by*Keyx)
x++;
if(y=buffer_size) Drop(PC);
else  Insert(PC,PCY);//Grouping PC is inserted before
Py
}
```

2.7. Simulation Experiment and Analysis

Simulation experiments are used to verify the efficiency of the TFLAS algorithm. Figure 1 shows the experiment's network structure, with wired nodes N1, N2, and N3 and a router connection bandwidth of 15Mbps. The link bandwidth between the router and the wireless network is 15Mbps, with a latency of 2ms. The transmission control protocol for various nodes is CP NewReno, while the wireless network's MAC layer uses the IEEE 802.11b protocol.

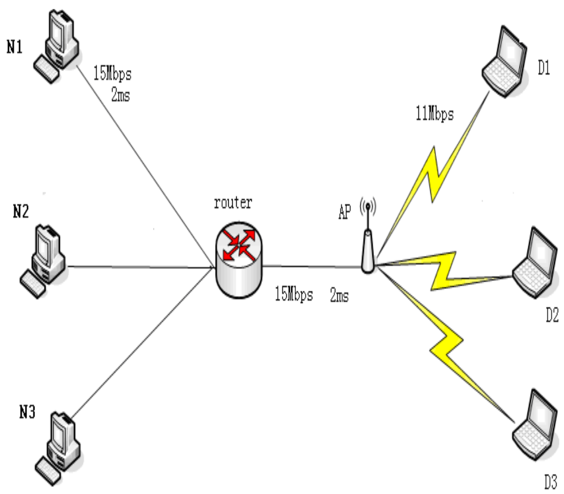

Fig.1 Network Topology

In the experiment, LAS, and TFLAS are tested within sixty seconds and compared to each other in terms of time equities and total network during up link/down link flow.

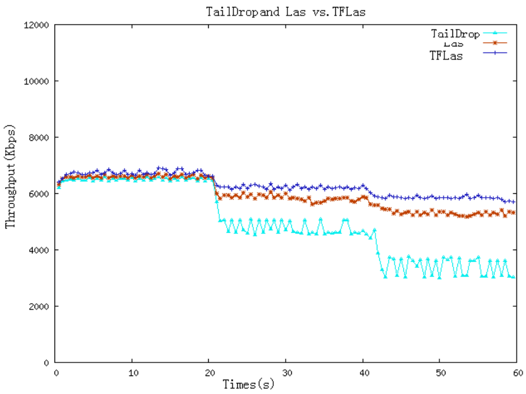

Figure 2: Network Throughout Each flow's holding duration ratio in the channel.

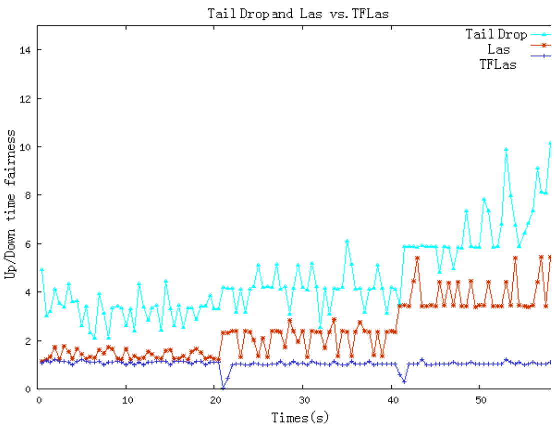

Figure 3: Average holding time ratio for each up link/downlink flow in the channel.

Downlink traffic is always higher than uplink traffic. With two downstream and one downstream at a time, nodes N1 and N2 send TCP downstream to D1 and D2. Wireless transmission rate remains constant at 11Mbps. When D3 delivers TCP upstream, the wireless transmission rate initially remains constant at 11Mbps but gradually declines to 5.5Mbps and 2Mbps at 20s-40s, creating a wireless network. The experiment summarizes the average holding-time ratio of uplink/downlink flows in the channel and network at various rates. Figure 2 shows the average holing-time ratio of uplink/downlink flows in the channel, and Figure 3 shows the network throughput rate.

The channel holding time equity of each uplink/downlink flow improve when the average holding time ratio of uplink and downlink flow approaches 1. Figure 2 shows that the average holding time ratio of uplink and downlink flows is near to one based on TFLas, with the best average channel holding time values of uplink/downlink. The average holding time ratio of uplink and downlink flow based on Las is greater than that based on TFLas, but less than that of Taildrop with middle equities. The average holding time ratio of uplink and downlink flow based on Taildrop is the highest, indicating that uplink flow reserves time for downlink flow in the channel with the lowest time equities. With the gradual reduction of node D3 in wireless channel rate, great differences of network throughout rate appear obviously between the three algorithms: the throughout rate based on TFLAS algorithm is the highest, while that based on LAS algorithm is in the middle, and that based on Taildrop obviously decreases when there are changes in channel rate, which shows that when there are throughout rate equities, slow TCP flow occupies more channel time, bringing a reduction in through rate.

Conclusion

Network congestion and network resource distribution inequalities are common at wireless network and wired network access points, becoming the bottleneck of the wireless network. There are time allocation inequalities in a variable-rate wireless network, in addition to a drop in network throughput due to variable-rate TCP traffic, so an analysis is conducted, and solutions are provided. Delay flows that take up too much channel time are avoided by modifying their transmit time, further enhancing network efficiency. The new method can also alter the efficiency factor of flow, making it easy to provide differentiated QoS services with tremendous scalability. It has been proven that the novel congestion control algorithm TFLAS is of substantial improvement in the parameters of network overall rate and average channel time.

References

1. Kassa, L.; Davis, M.; Cai, J.; Deng, J. A New Adaptive Frame Aggregation Method for Downlink WLAN MU-MIMO Channels. J. Commun. 2021, 16, 311–322. [Google Scholar] [CrossRef]
2. R. MacDavid, X. Chen and J. Rexford, "Scalable Real-Time Bandwidth Fairness in Switches," IEEE INFOCOM 2023 - IEEE Conference on Computer Communications, New York City, NY, USA, 2023, pp. 1-10, doi: 10.1109/INFOCOM53939.2023.10228997.

3. K. Winstein and H. Balakrishnan, ''TCP ex machina: Computer-generated congestion control,'' in Proc. SIGCOMM, Hong Kong, Aug. 2013, pp. 123–134.
4. L. Guo and J. Y. B. Lee, "TCP-FLASH - A Fast Reacting TCP for Modern Networks," in IEEE Access, vol. 9, pp. 68861-68879, 2021, doi: 10.1109/ACCESS.2021.3077612.
5. R. Poorzare and A. C. Augé, "Challenges on the Way of Implementing TCP Over 5G Networks," in IEEE Access, vol. 8, pp. 176393-176415, 2020, doi: 10.1109/ACCESS.2020.3026540.
6. M. Allman, V. Paxson and E. Blanton, TCP Congestion Control, Sep. 2009, [online] Available: https://tools.ietf.org/html/rfc5681.
7. Mittal, R.; Lam, V.T.; Dukkipati, N.; Blem, E.; Wassel, H.; Ghobadi, M.; Vahdat, A.; Wang, Y.; Wetherall, D.; Zats, D. TIMELY: RTT-based Congestion Control for the Datacenter. ACM SIGCOMM Comput. Commun. Rev. 2015, 45, 537–550. [Google Scholar] [CrossRef]
8. Cardwell, N.; Cheng, Y.; Gunn, C.S.; Yeganeh, S.H.; Jacobson, V. BBR: Congestion-based congestion control. ACM Queue 2016, 14, 58–66. [Google Scholar] [CrossRef]
9. Hock, M.; Neumeister, F.; Zitterbart, M.; Bless, R. TCP LoLa: Congestion Control for Low Latencies and High Throughput. In Proceedings of the IEEE 42nd Conference on Local Computer Networks (LCN), Singapore, 9–12 October 2017; pp. 215–218. [Google Scholar]
10. Neal Cardwell, Yuchung Cheng, C. Stephen Gunn, Soheil Hassas Yeganeh, and Van Jacobson. 2016. BBR: Congestion-Based Congestion Control. ACM Queue 14, September-October (2016), 20– 53. http://queue.acm.org/detail.cfm?id=3022184
11. Ranysha Ware, Matthew K. Mukerjee, Srinivasan Seshan, and Justine Sherry. 2019. Modeling BBR's Interactions with Loss-Based Congestion Control. IMC (2019).
12. Mansour Sheikhan, Ehsan Hemmati. Transient chaotic neural network-based disjoint multipath routing for mobile ad-hoc networks[J]. Neural Computing and Applications, 2012, 21(6):1403-1412
13. M.Shreedhar, George varghese.Efficient fair queueing using deficit round robin[J].IEEE/ACM Transactions on networking,1996,4(3):375-385
14. Donglin Wang, Michel Fattouche. Range Estimation in a Time Varying Multipath Channel[J]. Wireless Personal Communications, 2013, 71 (2):887-908
15. Faissal El Bouanani, Hussain Ben-Azza, Mostafa Belkasmi. New results for Shannon capacity over generalized multipath fading channels with MRC diversity[J]. EURASIP Journal on Wireless Communications and Networking, 2012, 2012 (1), 1-12
16. Parekh A K,Gallager R G.A generalized processor sharing approach to flow Control in integrated services networks:The single-node case[J].IEEE/ACM Transactions on networking.1993,1(3):344-357
17. Stiliadis D,Varma A.Effieient fair queueing algorithms for packet-switched networks[J].IEEE/ACM Transactions on networking,1998,6(2):175-185
18. Shivali Goel, Jemal H. Abawajy, Tai-hoon Kim. Performance Analysis of Receive Diversity in Wireless Sensor Networks over GBSBE Models[J]. Sensors, 2010, 10 (12):11021
19. Qiaoxing LI,Yi LIN. A Briefing to Grey Systems Theory[J]. Journal of Systems Science and Information, 2014, 2(2): 178-192
20. Ping LI, Jie LIU. Design and Pricing of Chinese Contingent Convertible Bonds[J].Journal of Systems Science and Information, 2014, 2(5): 428-436.
21. YANG Yanbo, CAI Feng, GUO Wangmei. On Error Detection of Intermediate Nodes Offour-Node Network with Small Downstream Links[J].Wuhan University Journal of Natural Sciences, 2015, 20(1):39-46
22. Katevenis M,Sidiropoulos S,Courcoubetis C.Weighted round-robin cell Multiplexing in a general-purpose ATM switch chip[J].IEEE Journal on Selected Areas in Communications,1991,9(8):1265-1279
23. Hao Wang, Nan Liu, ZhiHang Li,et al. A unified algorithm for mobility load balancing in 3GPP LTE multi-cell networks[J]. Science China Information Sciences, 2013,56 (2),1-11
24. DengSheng Lin,Ming Xiao,ShaoQian Li. Packet combining based on cross-packet coding[J]. Science China Information Sciences,2013,56 (2):1-10
25. Mirhakkak M, Schult N, et al. Dynamic Bandwidth Management and Adaptive Applieations for a Variable Bandwidth Wireless Environment[J], IEEE Journal On Seleeted Area in Communieations, 2001, 19(10):1984-1997
26. ElRakabawy S.M,Lindermann C.A Practical Adaptive Pacing Scheme for TCP inMultihop Wireless Networks[J].Networking,2011,19(4):75-988.
27. Jorge A. Cobb, Mohamed G. Gouda, Amal El Nahas.Time-shift scheduling:Fair seheduling of flow in high-speed networks[J].IEEE/ACM Transactions on networking,1998,6(3):274-285

28. Afanasyev A, Tilley N,Reiher P,Kleinrock L.Host-to-Host Congestion Control for TCP[J].Communications Surverys&Tutorials,2010,12(3):304-342
29. Lizhi Peng ,Bo Yang , Yuehui Chen.Effective packet number for early stage internet traffic identification[J].Neurocomputing. 2015,156(25):252–267
30. Jiang Qi-ming, Mi Chun-qiao,Yue Guang-xue. A dynamic network QoS control mechanism based on traffic prediction[J].Journal of Chongqing University(English Edition) ,2015,14(2):73-78
31. WANG Ya-li,SONG Mei,WEI Yi-fei. Improved ant colony-based multi-constrained QoS energy-saving routing and throughput optimization in wireless Ad-hoc networks[J]. The Journal of China Universities of Posts and Telecommunications. 2014, 21(01):43-53, 59
32. QIAO Yuan-yuan,LEI Zhen-ming,YUAN Lun,GUO Min-jie. Offline traffic analysis system based on Hadoop[J]. The Journal of China Universities of Posts and Telecommunications. 2013, 20(05):97-103
33. WANG Ruo-yu,LIU Zhen,ZHANG Ling. Method of data cleaning for network traffic classification[J]. The Journal of China Universities of Posts and Telecommunications. 2014:35-45
34. Surekha Lanka & Ilogu Ikechukwu, 2020. "An effective performance of dynamic and ad-hoc on-demand routing protocols for mobile ad-hoc networks under NS environment," International Journal of Networking and Virtual Organisations, Inderscience Enterprises Ltd, vol. 22(4), pages 325-333