HFAQM: A HYBRID FAIR ACTIVE QUEUE MANAGEMENT MECHANISM TO IMPROVE FAIRNESS AND STABILITY FOR WIRELESS LOCAL AREA NETWORK

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Abstrak

Pengurusan Baris-gilir Aktif (AQM) adalah satu skim proaktif yang mengawal kesesakan rangkaian dengan mengelakkannya sebelum ia berlaku. Apabila melaksanakan AQM dalam rangkaian wayarles, beberapa isu kontemporari perlu dipertimbangkan, seperti gangguan, perlanggaran, pemudaran berbilang laluan, perambatan jarak dan kesan pembayangan, yang menjejaskan kadar penghantaran pautan-pautan tersebut. Isu-isu ini mempunyai kesan langsung terhadap kesaksamaan dalam rangkaian WLAN dengan adanya jenis aliran yang berbeza. Idea utama di sebalik rangkaian wayarles ialah menggunakan fleksibiliti gelombang radio untuk memindahkan data dari titik ke titik yang memberi WLAN fleksibiliti dan kebolehgerakan: nod wayarles boleh menyambung, memutuskan atau bergerak dari satu titik akses ke titik akses lain dengan cepat. Bagaimanapun, ini memberi kesan kepada kestabilan rangkaian WLAN. Penyelidikan ini bertujuan untuk mengurangkan ketaksamaan dan ketidakstabilan dengan mencadangkan skim Saksama-Hibrid AQM (HFAQM). HFAQM terdiri daripada dua mekanisme: Mekanisme Penunjuk Kesesakan (CIM) dan Mekanisme Fungsi Kawalan (CFM). CIM telah direka untuk meningkatkan kesaksamaan dalam WLAN melalui hibridisasi penglambatan baris-gilir dengan kadar ketibaan sebagai parameter untuk mengira tahap kesesakan. Sedangkan, CFM telah dibangunkan untuk meningkatkan kestabilan rangkaian dengan menggunakan fungsi kawalan suai dengan keupayaan untuk mengugur dan menandakan paket untuk mengatasi ciri-ciri rangkaian WLAN yang cepat berubah. Satu siri kajian eksperimen telah dijalankan untuk mengesahkan mekanisme yang dicadangkan dan empat varian skim AQM; RED, REM, AVQ dan CoDel, dipilih untuk menilai prestasi HFAQM melalui penyelakuan. Penemuan menunjukkan bahawa pencapaian utama HFAQM ialah kesaksamaan 99% dan kestabilan meningkat 10% daripada skim terdekat, dengan daya pemproses lebih baik, panjang baris-gilir, kehilangan baris-gilir, dan penggunaan pautan keluar sebagai pencapaian sekunder. Skim yang dicadangkan memberikan kesaksamaan dan kestabilan yang lebih baik dalam persekitaran WLAN, dengan adanya pelbagai jenis aliran.

Kata kunci: Pengelakan kesesakan, Penilaian eksperimen, Rangkaian wayarles, Kawalan kesesakan.

Abstract

Active Queue Management (AQM) is a proactive scheme that controls network congestion by avoiding it before it happens. When implementing AQM in wireless networks, several contemporary issues must be considered, such as interference, collisions, multipath-fading, propagation distance and shadowing effects, which affect the transmission rate of the links. These issues in WLAN networks with the existence of different types of flow have a direct effect on fairness. The main idea behind the wireless network is using the flexibility of radio waves to transfer data from point to point that is giving WLAN the flexibility and mobility: wireless nodes can connect, disconnect or even move from one access point to another rapidly. However, this affects the stability of the WLAN network. This research aims to reduce unfairness and instability by proposing a Hybrid-Fair AQM (HFAQM) scheme. HFAQM comprises two mechanisms: Congestion Indicator Mechanism (CIM), and Control Function Mechanism (CFM). CIM was designed to improve fairness in WLANs by hybridizing queue delay with arrival rate as parameters to calculate the congestion level. Whereas, CFM was developed to improve network stability by using an adaptive control function with the ability to drop and mark packets to overcome the rapidly changing characteristics of WLAN network. A series of experimental studies were conducted to validate the proposed mechanisms and four variants of AQM schemes, RED, REM, AVQ and CoDel, were chosen to evaluate the performance of HFAQM through simulation. The findings show that HFAQM's main achievement is 99% fairness and improved stability by 10% from the closest scheme, with better throughput, queue length, queue loss, and outgoing link utilization as secondary achievements. The proposed scheme provides significantly better fairness and stability in WLAN environment, with the existence of different types of flow.

Keywords: Congestion avoidance; Experimental evaluation; Wireless network; Congestion control.

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In the name of ALLAH, Most Gracious and Most Merciful.

"Read; And your Lord is the Most Generous, Who taught by the pen, Taught man that which he knew not;"

(The Holy Quran - Al-Alaq (96): 3-5)

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List of Abbreviations

ACK	-	Acknowledge Packet
AIMD	-	Additive Increase Multiplicative Decrease
AP	-	Access Point
AQM	-	Active Queue Management
ARED	-	Adaptive Random Early Detection
AVQ	-	Adaptive Virtual Queue
BDP	-	Bandwidth-Distance Product
BLACK	-	BLACK-listing unresponsive flows
CBR	-	Constant Bit Rate
CFM	-	Control Function Mechanism
CHOKe	-	CHOose and Keep
CIM	-	Congestion Indicator Mechanism
CoDel	-	Controlled Delay
CPCN	-	Congestion and Pre-Congestion Notification
DREAM	-	Deterministic with Random Ergodic Alignment Marking
DRM	-	Design Research Methodology
DS-1	-	Descriptive Study 1
ECN	-	Explicit Congestion Notification
EWMA	-	Exponential Weighted Moving Average
FIFO	-	First In First Out
FRED	-	Fair Random Early Detection
FTP	-	File Transfer Protocol
GREEN	-	Generalized Random Early Evasion Network
GUI	-	Graphical User Interface
HBF	-	High Bandwidth Flow
HFAQM	-	Hybrid-Fair AQM
HTTP	-	Hypertext Transfer Protocol
ICC	-	Internet Congestion Control
IDE	-	Integrated Development Environment
IETF	-	Internet Engineering Task Force
LBL	-	Lawrence Berkeley Laboratory
MANET	-	Mobile Ad-hoc Network
MTU	-	Maximum Transmission Unit
NED	-	Network Description Language
NS-2	-	Network Simulation Version 2
OTcl	-	Object-Oriented Tcl
PI	-	Proportional Integral
PS	-	Perspective Study
QoS	-	Quality of Service
RC	-	Research Clarification
RED	-	Random Early Detection
REM	-	Random Exponential Marking
RTT	-	Round Trip Time
SFB	-	Stochastic Fair BLUE
SHRED	-	Short-lived Flow Friendly RED
SVB	-	Stabilized Virtual Buffer
Tcl	-	Tool Command Language

TCP	-	Transmission Control Protocol
UC	-	University of California
UDP	-	User Datagram Protocol
WLAN	-	Wireless Local Area Network

CHAPTER ONE
INTRODUCTION

Congestion has long been a serious problem in Internet [1]–[4], whether the network is wired or wireless, due to their rapid growth and changes. Many mechanisms, algorithms, and protocols have been developed to overcome this issue. The Active Queue Management (AQM) algorithm is one of the significant solutions to avoid and control the congestion. This chapter presents an overview of wireless networks, followed by a brief introduction to congestion control mechanisms and algorithms. The problem statement, research questions and objectives are also stated in this chapter.

AQM has played a significant role in indicating and controlling congestion proactively in the Internet. AQM also has to work in all types of network topologies and types. With the growth of WLAN networks in recent decades, finding an AQM that works in WLAN as well as in wired networks has become urgent. Moreover, AQM has failed to achieve some objectives of wireless networks such as fairness, due to the growth of real-time Internet services and applications which require QoS; and stability, due to the rapidly changing characteristics of wireless networks.

1.1 Wireless Network

Wireless networks have increased dramatically over the last two decades and are essential in all mobile devices and laptops for access to the Internet anytime, anywhere. The main idea behind the wireless network is using the flexibility of radio waves instead of wires to transfer the data from point to point. The first wireless network standard was IEEE 802.11, published in 1997 by IEEE. Since then many standards

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