UNIVERSITI PUTRA MALAYSIA

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Using Carrier Sense Multiple Access with Collision Detection (CSMA/CD), Ethernet Local Area Networks (LANs) suffers from capture effect in packet loss. As a result of capture effect, some nodes may be locked-out of using the medium for a period of time. Hence, CSMA/CD based Ethernet is unsuitable for real-time multimedia traffic. It does not guarantee delay bound, behaves poorly under heavy load conditions.

To overcome these shortcomings and enhance performance of CSMA/CD based LAN, three new concepts are added to the conventional CSMA/CD. Firstly, each node in the LAN has a finite buffer. A node competes for access to the medium after its buffer is full. It will transmit all packets in the buffer if access is permitted. To minimize the waiting delay of packets in the buffer prior to transmission, a time-out period is set, beyond which a node tries to transmit considering its buffer is full.

Due to buffer, the number of nodes trying to transmit at a time is reduced, thereby collision rate is reduced. Capture effect, locked-out probability, bandwidth loss and backoff delays are also reduced. To support all types of traffic (mainly real-time traffic), the optimum buffer size obtained is 10 packets/buffer. Using this buffer, multimedia traffic can be sent in a streamed fashion within a delay bound. Secondly, the maximum retransmission attempt limit and backoff limit are reduced to 10 and 8 times respectively to guarantee a tolerable delay for multimedia applications. A new special-jamming signal is introduced. It gives transmission priority to the node that already has finished its maximum retransmission attempt. This prevents packet loss and quality degradation of received normal data traffic and multimedia traffic.

The final one is the priority scheduler, which is activated when multiple nodes send the special-jamming signal at a time. It gives permission to the node having either the lowest time-stamp or the smallest source address (SA) to transmit while other nodes wait until their access is permitted accordingly.

The proposed protocol is based on bus topology for a single channel LAN. Throughput, transmission efficiency, average delay and percentage of collision of the proposed network is evaluated against number of nodes, bus length and offered load within two environments, i.e. Fast Ethernet and Gigabit Ethernet. The results show significant performance improvement. Throughput, transmission efficiency are increased more than 10% in average. On the other hand, average delay and percentage of collision are reduced to less than 2 ms and 3.5% respectively compared to the conventional CSMA/CD based LAN.

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Oleh

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Dengan menggunakan CSMA/CD, 'LAN Ethernet' terbeban dengan kesan tangkapan daripada pembelakangan algoritm CSMA/CD. Disebabkan kesan tangkapan ini, beberapa nod mungkin akan terkunci akibat daripada menggunakan medium pada suatu jangkamasa yang tertentu. Oleh yang demikian, CSMA/CD yang berasaskan Ethernet tidak sesuai untuk menyokong trafik pelbagai mediamasa. Ia tidak menjanjikan keterikatan pelambatan dan dan juga berkeadaan terlalu lemah di bawah kondisi bebanan berat. Oleh yang demikian, ini akan membawa kepada pelambatan yang berlebihan yang mana di sebabkan oleh berlebihan pelanggaran yang berlaku.

Untuk mengatasi masalah tersebut, tiga jenis konsep baru di masukkan di dalam system yang sedia ada bagi mempertingkatkan kepada CSMA/CD untuk satu saluran LAN optik. Ethernet/IEE 802.3 dicadangkan. Ini adalah kerana, kemampuan Ethernet untuk meningkatkan jangkamasa pemancaran hingga ke satu gigabit di dalam satu saat. Cadangan ini akan merangkumi kepada topologi bus fizikal. Bagi bentuk topologi, semua nod-nod diletakkan sekata di sepanjang bus.

Merujuk kepada konsep yang pertama, setiap nod di dalam LAN mempunyai kapasiti bufer yang tertentu. Suatu nod berlumba untuk mendapatkan laluan di dalam medium selepas bufernya penuh serta kesemua paket-paketnya telah di hantar. Bagi mengurangkan lembapan masa untuk paket-paket tersebut kepada pemancaran, suatu masa rehat ditetapkan, di mana suatu nod itu cuba untuk dipancarkan walaupun bufernya sudah penuh. Oleh yang demikian, bilangan nod-nod yang berkeadaan demikian akan berkurangan dan masa pelanggaran juga berkurangan. Justeru, kesan penangkapan juga berkurangan dengan menghalang suatu nod itu daripada menghantar bilangan paket secara berlebihan.

Yang keduanya, penghantaran balik tertinggi dan tahap pembelakangan adalah dikurangkan kepada 10 dan 8 setiap satu bagi menjanjikan pelembapan yang munasabah bagi aplikasi-aplikasi pelbagai media. Suatu kaedah isyarat gangguan-istimewa diperkenalkan adalah untuk memberikan keutamaan kepada nod-nod yang sudah menghabiskan penghantaran tertinggi di dalam penghantaran paket-paket. Oleh yang demikian, isyarat ini akan menghalang kehilangan paket dalam masa yang sama kualiti pengurangan bagi penerimaan data di dalam trafik biasa dan pelbagai media trafik.

Yang terakhir adalah keutamaan jadual yang diaktifkan apabila lebih daripada satu nod menghantar isyarat gangguan-istimewa yang dihantar pada masa yang sama. Ia memberi kebenaran kepada nod untuk mempunyai samada paling rendah tahap masa yang ditentukan atau sumber alamat (SA) yang paling kurang bagi memancarkan paket-paket sementara menunggu nod-nod lain menerima kelulusan kemasukan secara teratur.

Pencapaian rangkaian (i.e. throughput, penghantaran yang efisen, purata pelambatan dan peratusan pelanggaran) berdasarkan kepada cadangan CSMA/CD dikaji dengan beberapa parameter rekabentuk (i.e. biloangan nod, jarak bus, dan bebanan yang ditawarkan). Pengkajian ini dilakukan di dalam dua keadaan, iaitu 'Fast Ethernet' dan 'Gigabit Ethernet'. Keputusan menunjukkan suatu pencapaian yang memberangsangkan di mana hasil output dan efisen pemancaran meningkat kepada purata sebanyak 10%. Dalam masa yang sama, purata pelembapan dan peratusan pelanggaran dapat dikurangkan kepada 2 ms dan 3.5% setiap satu berbanding dengan system yang ada sekarang.

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LIST OF ABBREVIATIONS

ANSI	American National Standards Institute
ATM	Asynchronous Transfer Mode
BEB	Binary Exponential Backoff
BER	Bit Error Rate
BLAM	Binary Logarithmic Arbitration Method
CSMA	Carrier Sense Multiple Access
CSMA/CD	Carrier Sense Multiple Access with Collision detection
CSMA/RI	Carrier Sense Multiple Access with Reservation by Interruption
CU	Comparator Unit
DCR	Deterministic Contention Resolution
DFPQ	Distribute Fair Priority Queue
DiffServ	Differentiated Services
DQDB	Distributed Queue Duel Bus
DTE	Data Terminal Equipment
ECE	Ethernet Capture Effect
EMI	Electro Magnetic Interference
EPA	Equilibrium Point Analysis
FC	Fiber Channel
FCFS	First-Come-First-Served
FCS	Frame Check Sequence
FDDI	Fiber Distributed Data Interface
FOIRL	Fiber Optic Inter Repeater Link
FTP	File Transfer Protocol

FTTX	Fiber-To-The-X
HomePNA	Home Phoneline Networking Aliance
IEEE	Institute of Electrical and Electronic Engineers
ISO	International Standards Organization
LAN	Local Area Network
LD	Laser Diode
LED	Light Emitting Diode
LLC	Logical Link Control
MAC	Medium Access Control
MAN	Metropolitan Area network
MAU	Media Attachment Unit
MDI	Medium Dependent Interface
MII	Medium Independent Interface
OSI	Open Systems Interconnection
PCS	Physical Coding Sublayer
PD	Photo Detector
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent Sublayer
QoS	Quality of Service
RETHER	Real-time ETHERnet
SA	Source Address
SBVS	Stony Brook Video Server
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical NETwork
TDMA	Time Division Multiple Access

VoIP	Voice over IP
WAN	Wide Area Network

LIST OF NOTATIONS

N	Number of nodes
a	Ratio of channel propagation delay to packet transmission time
T_x	Transmitter
R_x	Receiver
R_j	Nominal rate at node j
T	Time-out period
d	Fiber optic bus length
v	Propagation speed
c	Light velocity
n	Fiber index
S	Throughput
E	Transmission efficiency
D	Average delay

CHAPTER 1

INTRODUCTION

In this chapter, the background of fiber optics networks and problems of the conventional Carrier Sense Multiple Access with Collision detection (CSMA/CD) based Local Area Networks (LANs) are given to provide the motivation of this research. It also provides an overview of the research accomplishment.

1.1 Background

Fiber optic cables have been widely used in today's communication systems. They are the best medium that can provide a large bandwidth at a very low loss. Most of the backbone copper cables have been replaced by fibers. The fiber installation is even expanded to the smaller network such as junction and access network where the Fiber-To-The-X (FTTX) series emerged as the solution. The main objective is to provide an end-to-end fiber connectivity to provide a better transmission performance and bandwidth utilization. Therefore, fiber implementation in the local area networks have been proposed and implemented by many organizations.

Now-a-days, there are a lot of fiber installations in large network areas. When it comes to the smaller area, the installation is back to the conventional copper cable. For this reason, the fiber-copper interfacing needs to be considered. Though the speed of the combined fiber-copper network architecture is faster than the all copper based system, bottleneck still occurs due to the different bandwidth and transmission capacity of these two media. To overcome this problem, fiber

connection is implemented in the small geographical area such as LAN. As a result, end-to-end fiber connectivity is achieved.

The key advantage of optical LAN is a large number of nodes can be connected to the network without using amplifiers [1]. This is due to its small network area, thus shorter length of fiber is needed.

1.2 Motivation and Problem Statements

Fiber optic LANs typically use one of the two methods for medium access, which are random access protocols (CSMA/CD) and controlled access protocols (token passing). In fiber LAN, when two or more nodes attempt to transmit at the same time, the performance of CSMA/CD is less predictable. The degradation in terms of channel utilization and throughput occurs as some bandwidth is wasted by collisions and backoff delays. If there are many nodes competing to share the bandwidth, an overload condition may occur. In this case, throughput of Ethernet LANs reduces drastically as much of the capacity is wasted by the CSMA/CD algorithm [2].

Using CSMA/CD, the sharing is not necessarily fair. When the nodes connected to the LAN have little data to send, the network exhibits almost equal access time for each node. However, if a node has large number of frames to transmit, it may dominate the network resulting Ethernet Capture Effect (ECE) [2-8]. Such conditions may occur, for instance, when a node in a LAN acts as a source of high quality packetised video. Ethernet Capture Effect means, one node in the LAN has an increased probability of holding the channel and sending consecutive frames

even though other nodes are contending for access. The effect is primarily noticeable when an Ethernet/IEEE 802.3 LAN is under high load [3]. This short term unfairness occurs because of the CSMA/CD backoff algorithm.

The problem with the CSMA/CD backoff scheme is that, the node that is successful in sending its frame after a collision starts with a new frame having the collision counter set to zero. All other nodes involved in the collision try to retransmit their old frames, and therefore keep their old collision counter values. As a result, if the successful node has another frame to send, it will likely be involved in a new collision with the same nodes that were involved in the previous collision. The successful node chooses its random wait time in a narrower range than the other nodes. This increases its probability of being successful again in the new collision. For every consecutive collision, the probability for the winner to win again (against the same set of competing nodes) increases, and quickly tends to 1 [3-4]. This increase of probability leads to the unfairness that is called the Ethernet capture effect [3]. Under these situations some nodes may be locked out of using the medium for a period of time.

The use of higher speed transmission (e.g. 100 Mbps) significantly reduces the probability of capture and the use of full duplex cabling eliminates the effect [2]. Actually full duplex operation is restricted to point-to-point links connecting exactly two nodes. Since there is no contention for a shared medium, collision can not occur and the CSMA/CD protocol is unnecessary. Frames may be transmitted at will, limited only by the required separation of the minimum inter frame gap.