



**UNIVERSITI PUTRA MALAYSIA**

**ENHANCED MEDIUM ACCESS CONTROL PROTOCOL FOR  
RESOLVING NODE MISBEHAVIOR IN WIRELESS NETWORKS-1**

**NOORSALWATI BINTI NORDIN**

**FSKTM 2007 8**

**ENHANCED MEDIUM ACCESS CONTROL PROTOCOL FOR  
RESOLVING NODE MISBEHAVIOR IN WIRELESS NETWORKS**

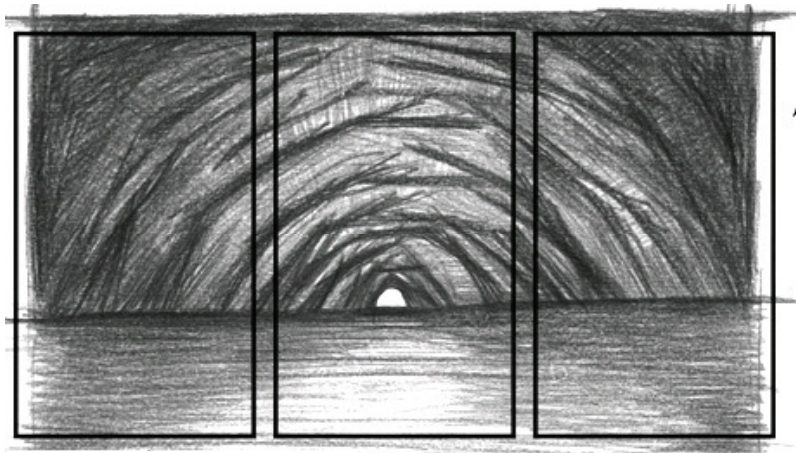
**By**

**NOORSALWATI BINTI NORDIN**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirement for the Degree of Master of Science**

**JUNE 2007**





THE LIGHT  
AT THE END  
OF THE  
THESIS.

CAN YOU  
SEE IT?

"Piled Higher and Deeper" by Jorge Cham ([www.phdcomics.com](http://www.phdcomics.com))



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in  
fulfilment of the requirement for the degree of Master of Science

**ENHANCED MEDIUM ACCESS CONTROL PROTOCOL FOR  
RESOLVING NODE MISBEHAVIOR IN WIRELESS NETWORKS**

By

**NOORSALWATI NORDIN**

**June 2007**

**Chair : Shamala Subramaniam, PhD**

**Faculty : Computer Science and Information Technology**

In this research, two schemes that enhance the existing misbehavior handling strategy are proposed. The first scheme correlates misbehavior with the traffic characteristics generated by the node deviating from the stipulated protocol. It eliminates the stereotyping of deviation by deriving a multi-scale deviation definition ranging from misbehavior to the underestimation of resource allocation. The scale adaptively enables varying types of misbehavior according to resource requirement. From the performance analysis, it was determined that the scheme is successful in differentiating between misbehavior due to selfishness and under-allocation of resource. In addition, the scheme also enables nodes that are allocated with inadequate resource to achieve higher share of throughput as per its requirement.



The second proposed scheme further extends the existing misbehavior handling strategy by detecting excessive allocation of resources. This scheme effectively diminishes the wastage of resources by re-distributing them among the rest of the nodes. The allocation of the resources is carried out on a First-Come-First-Serve basis in order maintain fair characteristics of the 802.11 access mechanism. From the analysis, it was found that when this scheme is employed, the presence of nodes that are over-allocated with resources enables the rest of the nodes to increase their throughput share.

The performance analysis of the proposed schemes was conducted with the use of a discrete-event simulator. The simulator was specifically developed for wireless networks incorporating the proposed schemes. It simulates a wireless network comprising non-deviating nodes and nodes that deviate from the MAC protocol due to selfishness, under-allocation and over-allocation of resources. The metrics employed to measure the performance of the proposed algorithms are average throughput, fairness index, channel utilization and throughput ratio.

From the analysis of the metrics, it is concluded that with the employment of the proposed scheme, if a node deviates from the protocol and it is allocated with inadequate resources, the scheme will adaptively allow the node to gain the resource as per the degree of its resource under-allocation. On the other hand, if it deviates due to over-allocation, the excess resources will be



distributed to other nodes, hence, enabling for the increase of overall network throughput.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan ijazah Master Sains

**PEMBAIKAN PROTOKOL KAWALAN CAPAIAN MEDIA UNTUK  
PENGENDALIAN NOD YANG BERKELAKUAN BURUK  
DALAM RANGKAIAN WAYARLES**

Oleh

**NOORSALWATI NORDIN**

**Jun 2007**

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Di dalam kajian ini, dua skema yang memperbaiki strategi pengendalian kelakuan buruk pada masakini dicadangkan. Skema yang pertama mengaitkan kelakuan buruk nod-nod yang menyimpang dari protokol yang ditetapkan dengan jenis trafik yang ia hasilkan. Ia tidak lagi menyamakan penyimpangan dari protokol sebagai kelakuan buruk, dengan menggunakan skala penyimpangan yang merangkumi kelakuan buruk hingga ke tahap peruntukan sumber yang tidak mencukupi. Skala ini dapat membezakan jenis kelakuan buruk berdasarkan keperluan sumber. Berdasarkan analisa prestasi protokol tersebut, skema ini didapati berjaya membezakan antara kelakuan buruk berdasarkan penting diri dari kelakuan yang disebabkan oleh kurang peruntukan sumber. Di samping itu juga, skema ini membolehkan nod-nod yang dibekalkan dengan sumber yang tidak mencukupi untuk mencapai truput yang lebih tinggi mengikut keperluannya.



Skema kedua yang dicadangkan meluaskan strategi menangani kelakuan buruk yang sedia ada dengan mengesan peruntukan sumber yang berlebihan. Skema ini berjaya mengurangkan pembaziran sumber dengan mengagihkan sumber tersebut kepada nod-nod yang lain. Pengagihan semula sumber ini dijalankan menurut kaedah Tiba Dahulu Layan Dahulu supaya dapat mengekalkan sifat adil mekanisme capaian 802.11. Berdasarkan analisa, apabila skema ini digunakan, kehadiran nod-nod yang dibekalkan dengan sumber yang berlebihan membolehkan nod-nod yang lain meningkatkan truput mereka.

Analisa prestasi kedua-dua skema yang dicadangkan telah dijalankan dengan menggunakan pensimulasi peristiwa diskret. Pensimulasi ini dibangunkan khas untuk rangkaian wayarles dengan menggabungkan skema-skema yang dicadangkan. Ia mensimulasikan rangkaian wayarles yang terdiri daripada nod-nod yang patuh dan nod-nod yang menyimpang dari skema disebabkan oleh penting diri, kurang peruntukan sumber dan peruntukan sumber yang berlebihan. Metrik-metrik yang digunakan untuk mengukur prestasi algoritma-algoritma yang dicadangkan adalah truput purata, indeks kesaksamaan, penggunaan saluran dan nisbah truput.

Dari analisa metrik-metrik tersebut, rumusan yang dapat dibuat adalah, sekiranya sesebuah nod menyimpang dari protokol itu diperuntukkan dengan sumber yang tidak mencukupi, skema-skema yang dicadangkan ini akan





memudahsuaikan nod tersebut untuk memperoleh sumber yang banyak mengikut keperluannya. Di samping itu juga, sekiranya sesebuah nod menyimpang disebabkan oleh peruntukkan yang berlebihan, sumber yang berlebihan itu akan diagihkan kepada nod-nod yang lain, dan seterusnya meningkatkan truput rangkaian tersebut secara keseluruhannya.



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I certify that an Examination Committee has met on the 11<sup>th</sup> of June 2007 to conduct the final examination of Noorsalwati Binti Nordin on her Master of Science thesis entitled "Enhanced Medium Access Control Protocol for Resolving Node Misbehavior in Wireless Networks" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the relevant degree.

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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citation, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

---

**NOORSALWATI BINTI NORDIN**

Date:



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## LIST OF ABBREVIATIONS

|           |   |
|-----------|---|
| ABA       | Adaptive Bandwidth Allocation                             |
| ACK       | Acknowledgment  |
| AODV      | Ad Hoc On Demand Distance Vector                          |
| AP        | Access Points   |
| BEB       | Binary Backoff Exponential                                |
| BD        | Backoff Deviation index                                   |
| BI        | Bandwidth Increase index                                  |
| BS        | Base Station  |
| BSS       | Basic Service Set   |
| CBA       | Cooperative Bandwidth Allocation                          |
| CBR       | Constant-Bit-Rate   |
| CCS       | Credit Clearance Service                                  |
| CONFIDANT | Cooperation Of Nodes: Fairness In Dynamic Ad-hoc NeTworks |
| CORE      | COllaborative REputation                                  |
| CPU       | Central Processing Unit                                   |
| CSMA      | Carrier Sense Multiple Access                             |
| CSMA/CA   | Carrier Sense Multiple Access with Collision Avoidance    |
| CTS       | Clear To Send   |
| CW        | Contention Window   |
| DCF       | Distributed Coordination Function                         |
| DES       | Discrete Event Simulator                                  |



|            |   |
|------------|---|
| DI         | Deviation Index   |
| DIFS       | DCF Interframe Space  |
| DIFS       | Distributed Inter Frame Space   |
| DOMINO     | Detection Of Greedy Behavior In MAC Layer Of IEEE 802.11 Public Network |
| DoS        | Denial of Service   |
| DSR        | Dynamic Source Routing  |
| DSSS       | Direct Sequence Spread Spectrum   |
| ERA-802.11 | Ensuring Randomness for 802.11  |
| ESS        | Extended Service Set  |
| FCFS       | First-Come-First-Serve  |
| FHSS       | Frequency Hopping Spread Spectrum                                       |
| GPL        | General Purpose Language  |
| GPRS       | General Packet Radio Service  |
| IDM        | Intrusion Detection Model   |
| IDS        | Intrusion Detection System  |
| IEEE       | Institute of Electrical and Electronics Engineers                       |
| IFS        | Interframe Space  |
| IRM        | Intrusion Response Model  |
| ISM        | Industrial, Scientific, And Medical                                     |
| KV         | Kyasanur and Vaidya   |
| LAN        | Local Area Network  |
| LARS       | Locally-Aware Reputation System   |



|       |  |
|-------|--|
| LIDS  | Local Intrusion Detection System                             |
| LIDS  | Local Intrusion Detection System                             |
| MAC   | Medium Access Control  |
| MANET | Mobile Ad Hoc Network  |
| MIB   | Management Information Base                                  |
| MIT   | Massachusetts Institute of Technology                        |
| ns-2  | Network Simulator-2  |
| OCEAN | Observation-based Cooperation Enforcement in Ad hoc Networks |
| Opnet | OPtimized Network Enginerring Tool                           |
| OSI   | Open Systems Interconnection                                 |
| Otcl  | Object Tcl   |
| PC    | Point Coordinator  |
| PD    | Percentage of Deviation                                      |
| PIFS  | Point Coordination Interframe Space                          |
| PM    | Percentage of Misbehavior                                    |
| PPM   | Packet Purse Model   |
| PTM   | Packet Trade Model   |
| QoS   | Quality of Service   |
| RTS   | Request To Send  |
| SCFQ  | Self-Clocked Fair Queuing                                    |
| SIFS  | Short Interframe Space                                       |
| SNMP  | Simple Network Management Protocol                           |



|        |  |
|--------|--|
| SPRITE | Simple, Cheat-Proof, Credit-Based System                     |
| SSD    | Stationary Secure Database                                   |
| SSFNet | Scalable Simulation Framework simulator                      |
| STA    | Station  |
| TCP    | Transport Control Protocol                                   |
| Tcl    | Tool Command Language  |
| TIARA  | Techniques for Intrusion-Resistant Ad Hoc Routing Algorithms |
| UDP    | User Datagram Protocol                                       |
| VBR    | Variable-Bit-Rat   |
| VCG    | Vickrey, Clarke and Grove                                    |
| WSN    | Wireless Sensor Networks                                     |





# CHAPTER 1

## INTRODUCTION

The adoption of wireless Local Area Network (LAN) is growing rapidly. According to the research done by In-Stat, the wireless LAN chipset market is on a phenomenal growth pace that is projected to soar from just over 140 million annual chipset unit shipments in 2005 to 430 million in 2009 [1].

Wireless LAN is a group of computers and devices that share a common communication link via radio frequencies. Wireless LANs mostly operate under the specifications established by the Institute of Electrical and Electronics Engineers (IEEE), which is known as the 802.11 standard. In the next section, background information on the 802.11 standard is provided in more detail, as it is the domain area of this research.

### 1.1 Background

The 802.11 standard defines the physical and Medium Access Control (MAC) layers of wireless LAN for two topologies, which are the infrastructure-based (Figure 1.1) and ad hoc (Figure 1.2) networks [2]. Both topologies comprise at least one Basic Service Set (BSS). The minimum BSS is made up of two nodes that can communicate with each other.

