



**UNIVERSITI PUTRA MALAYSIA**

**TWO LEVEL AGGREGATION SCHEME WITH  
OPTIMIZATION IN SUBFRAMES HEADERS  
FOR IEEE 802.11N WIRELESS NETWORKS**

**ADAMU MUHAMMAD NOMA**

**FSKTM 2014 3**



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BERILMU BERBAKTI

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**MASTER OF SCIENCE  
UNIVERSITI PUTRA MALAYSIA**

**2014**



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NETWORKS**

By

**ADAMU MUHAMMAD NOMA**

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

May 2014

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## DEDICATIONS

*To you, my beloved wife Ummussalama, for your enduring, support and taking care of our children in my absence.*



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

## **TWO LEVEL AGGREGATION SCHEME WITH OPTIMIZATION IN SUBFRAMES HEADERS FOR IEEE 802.11n WIRELESS NETWORKS**

By

**ADAMU MUHAMMAD NOMA**

**May 2014**

**Chairman: Professor Mohamed Othman, PhD**  
**Faculty: Computer Science and Information Technology**

Frames aggregation is a means of utilizing channel efficiency at MAC of WLAN device, through amortizing the MAC overheads over multiple frames. IEEE 802.11n define two standards of the scheme: A-MSDU and A-MPDU. They proved efficient but introduced yet another headers overhead due to the aggregation, which parts with large part of the efficiency gained. Furthermore, investigations revealed that while one of the schemes shortfalls in one situation the other is efficient in that same condition, vice versa: depending on the PHY rate, aggregation size, frames sizes and/or channel conditions. We are motivated by the efficiencies of the schemes; considered that the overhead can be minimized when the frame structure is well reformulated and that their complementary efficiencies are exploitable to arrive at a more efficient scheme. This work, therefore, is carried out with the aim of minimizing the overhead due to the aggregation so as to maximize the throughput gain, and also to utilize the efficiency of both of the scheme by systematically merging them to co-work together in what is referred to as two-level aggregation.

We extended Markov's discrete even chain model and arrived at generic model for the aggregation throughput. A model is also derived for the headers overhead. The duo proved to accurately predict and comparatively analyze various aggregations behaviours. Based on the study of the aggregations conducted, we designed an enhanced A-MSDU (eA-MSDU), with optimized header overhead. By both analytical and simulation, the eA-MSDU improved channel's utilization by up to 10% and 20% in terms of throughput increase and overhead reduction respectively. Furthermore, a new two-level aggregation model is developed by integrating the eA-MSDU into

A-MPDU and designing suitable operating algorithm. This results to further improvements in respect of both the overheads reduction and throughput gain, by 18% and 7% respectively. It also show consistent channel utilization of around 90% and an average of 4% overhead, irrespective of the subframes or aggregation size.

With the newly designed two-level aggregation scheme; overhead due to aggregation is contained; channel utilization improved; and the aggregation efficiency is consistent, even with varying conditions mentioned. When applied therefore, WLANs could compete with other technologies in serving throughput-intensive applications such as grid computing and on-demand multimedia streaming. With proper scheduling and adaptation on top of the scheme, it will serves best in real-time applications.





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

**DUA TAHAP SKIM PENGAGREGATAN DENGAN  
PENGOPTIMUMAN DALAM *SUBFRAMES HEADERS* UNTUK  
RANGKAIAN WAYARLES IEEE 802.11n**

Oleh

**ADAMU MUHAMMAD NOMA**

**Mei 2014**

**Pengerusi: Professor Mohamed Othman, PhD**  
**Fakulti: Sains Komputer dan Teknologi Maklumat**

Pengagregatan bingkai adalah satu cara untuk menggunakan kecekapan saluran di MAC peranti WLAN, melalui merencana overhead MAC atas berbilang bingkai. IEEE 802.11n menentukan dua piawaian skim ini: A-MSDU dan A-MPDU. Mereka terbukti cekap tetapi memperkenalkan satu lagi header overhead kerana pengagregatan, yang bahagian dengan sebahagian besar kecekapan yang diperoleh. Tambahan pula, siasatan mendapati manakala salah satu skim kekurangan dalam satu keadaan yang lain adalah cekap dalam keadaan yang sama, naib visa: bergantung kepada kadar PHY, saiz pengagregatan, bingkai saiz dan/atau syarat saluran. Kami didorong oleh kecekapan skim; dianggap bahawa overhead dapat dikurangkan apabila struktur kerangka adalah juga semula digubal dan bahawa kecekapan pelengkap mereka exploitable untuk tiba di skim yang lebih cekap. Kerja ini, oleh itu, dijalankan dengan tujuan untuk mengurangkan overhead kerana pengagregatan supaya dapat memaksimumkan keuntungan pemprosesan, dan juga untuk menggunakan kecekapan kedua-dua skim itu oleh sistematik menggabungkan mereka untuk bersama-kerja bersama-sama dalam apa yang dirujuk sebagai pengagregatan dua peringkat.

Kami dilanjutkan *model* rangkaian walaupun diskret Markov dan tiba di model generik untuk pemprosesan pengagregatan. Model juga diperolehi untuk overhead *header* ini. *Duo* ini terbukti meramalkan dengan tepat dan agak menganalisis pelbagai tingkah laku kesatuan. Berdasarkan kajian yang dijalankan kesatuan, kami direka dipertingkatkan A-MSDU (eA-MSDU), dengan overhead *header* dioptimumkan.

Oleh kedua-dua analisis dan simulasi, eA- MSDU baik penggunaan saluran itu masing-masing sehingga 10% dan 20% dari segi peningkatan daya pemprosesan dan pengurangan overhed. Tambahan pula, dua tahap model pengagregatan baru dibangunkan dengan mengintegrasikan eA-MSDU ke dalam A-MPDU dan mereka bentuk algoritma operasi yang sesuai. Ini menyebabkan kepada peningkatan selanjutnya berkenaan dengan kedua-dua pengurangan overhed dan keuntungan pemprosesan, masing-masing sebanyak 18% dan 7%. Ia juga menunjukkan penggunaan saluran yang konsisten kira-kira 90% dan purata 4% atas, tanpa mengira subframes atau saiz pengagregatan.

Dengan dua peringkat skim pengagregatan yang baru direka; overhed kerana pengagregatan terkandung; penggunaan saluran bertambah baik; dan kecekapan pengagregatan adalah konsisten, walaupun dengan keadaan yang berbeza-beza yang dinyatakan. Apabila digunakan oleh itu, WLAN boleh bersaing dengan teknologi lain dalam berkhidmat aplikasi pemprosesan intensif seperti pengkomputeran grid dan atas permintaan streaming multimedia. Dengan penjadualan yang betul dan penyesuaian di atas skim ini, ia akan berfungsi terbaik dalam aplikasi masa nyata.

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## APPROVAL

I certify that a Thesis Examination Committee has met on **8th day of May 2014** to conduct the final examination of **Adamu Muhammad Noma** on his thesis entitled "**Two level Aggregation Scheme with Optimization in Subframes Headers for IEEE 802.11n Wireless Networks**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the **Master of Science**.

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## DECLARATION

### Declaration by graduate student

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