UNIVERSITI PUTRA MALAYSIA

BATTERY AWARE HYBRID FORWARDING SCHEME FOR 6LOWPAN

FARHAD MESRINEJAD

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BATTERY AWARE HYBRID FORWARDING SCHEME FOR 6LOWPAN

By

FARHAD MESRINEJAD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

June 2012

DEDICATION

Dedicated to

My family members particularly to my understanding and patient wife, Elaheh, our precious children Houra and Amir Mohammad and my ever-encouraging parents for their love.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

BATTERY AWARE HYBRID FORWARDING SCHEME FOR 6LOWPAN

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June 2012

Chairman: Prof. Nor Kamariah Noordin, PhD

Faculty: Engineering

This thesis mainly focuses on fragments forwarding of 6LoWPAN through adaptation layer since the fragmentation and header compression, the main responsibilities of the adaptation layer, are necessary to fit the IPv6 packets with the sensor nodes. Proposed energy model considers the data payload size and the header size of different layers to evaluate the energy consumption and lifetime of network before and after fragmentation and header compression. Likewise, an analysis of simulation based scenario is carried out to investigate the effect of fragmentation on energy consumption. In order to improve the functionalities of adaptation layer, battery level of each node located at the first level of sensor network -the nodes that can directly communicate with the gateway- is used as a primary parameter to manage data forwarding between 6LoWPAN gateway and the sensors at the first level.

Furthermore, two existing forwarding schemes namely route-over and mesh-under are evaluated. Based on evaluation in this thesis, route-over and mesh-under suffers

from high end-to-end delay and energy consumption respectively. Therefore, 6LoWPAN requires a more efficient forwarding scheme in terms of energy consumption and delay. In this research, Hybrid Forwarding Scheme (HFS) is proposed which exploits the features of route-over and mesh-under. In HFS, all fragments of each packet are sent to the same destination. Intermediate nodes, in addition to forward the fragments to the next hop, check the lost fragments and request from the previous hop. Reassembling process will be done at the final destination. The proposed method reduces the delay, decreases energy consumption especially when there is retransmission, and increases the lifetime of network.

The research data in this thesis is drawn from two main sources: mathematical model and QualNet simulator. Based on the obtained results, the fragmentation increases the energy consumption from 57.8 to 69.8 percent. Higher energy consumption reduces the lifetime of the networks; accordingly the lifetime is reduced from 7.7% to 38.5%. Thus, the number of alive nodes especially at the first level is decreased during the simulation time. By using the battery level as a decision parameter to deliver fragments to the next hop, the lifetime is increased from 6.9 to 20.9 percent. Furthermore, the number of alive nodes is also a parameter which is improved during the simulation time. HFS reduces delay about four times compared to the route-over and from 20.3 to 29.8 percent compared to the mesh-under scheme. Hybrid forwarding scheme also decreases energy consumption from 18.1 to 35.1 percent compared to the route-over scheme and 50.68 to 58.43 percent compared to the mesh-under. Finally, by combining two methods (using battery level and HFS), the improvements are of lifetime from 17 to 19.22 percent, energy consumption from 25.57 to 26.3, and delay from 1 to 6.44 percent.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

BATERI SEDAR PENGHANTARAN SKIM BERGABUNG UNTUK 6LOWPAN

Oleh

FARHAD MESRINEJAD

Jun 2012

Pengerusi: Prof. Nor Kamariah Noordin, PhD

Fakulti: Kejuruteraan

Thesis ini difokuskan kepada pembawaan kehadapan fragment-fragment 6LoWPAN melalui adaptasi lapisan dari fragmentasi dan kompresi pengepala, tanggungjawab utama adaptasi lapisan yang penting untuk memutakan paket-paket IPv6 degan nod sensor. Model tenaga yang telah dicadangkan mengambil kira akan saiz muatan data dan saiz pengepala bagi lapisan-lapisan yang berbeza bagi menilai penggunaan tenaga dan jangka hayat jaringan sebelum dan selepas pemecahan serta mampatan pengepala. Sebagaimana juga sebuah analisis kepada simulasi berdasarkan senario telah dijalankan bagi menyiasat kesan bagi pemecahan kepada penggunaan tenaga. Bagi memperbaiki kegunaan lapisan yang diadaptasi, tahap bateri bagi setiap nod yang ditempatkan di aras pertama bagi jaringan pengesan – nod-nod yang mana boleh berhubung secara lansung dengan pintu masuk – adalah digunakan sebagai parameter utama bagi menyusun penghantaran data di antara pintu masuk 6LoWPAN dan pengesan-pengesan pada tahap satu.

Tambahan pula, dua skim lanjutan yang sedia ada yang dinamakan route-over dan mesh-under adalah dinilai. Berdasarkan penilaian dalam tesis ini, secara amnya, 'route-over dan mesh under' mengalami penangguhan pada penamat dan penggunaan tenaga. Di samping itu, 6LoWPAN memerlukan skim lanjutan yang lebih berkesan dari segi penggunaan tenaga dan penangguhan. Dalam kajian ini, Hybrid Forwarding Scheme (HFS) adalah dicadangkan yang mana mengeksploitasi ciri-ciri kepada route-over dan mesh-under. Dalam HFS, kesemua pecahan-pecahan bagi setiap paket adalah dihantar ke destinasi yang sama. Nod-nod pengantara, penambahan kepada lanjutan pecahan-pecahan kepada hop yang seterusnya, pemeriksaan dibuat ke atas pecahan-pecahan yang hilang dan permintaan dari hop yang sebelumnya. Proses pemasangan semula akan dibuat pada destinasi terakhir. Teknik yang dicadangkan mengurangkan penangguhan, menurunkan penggunaan tenaga terutamanya bila mana terdapatnya penghantaran semula, dan peningkatan dari segi jangka hayat jaringan tersebut.

Data kajian dalam tesis ini adalah diperoleh dari dua sumber utama: model matematik dan 'QualNet' simulator. Berdasarkan kepada hasil yang diperolehi, pemecahan telah meningkatkan penggunaan tenaga dari 57.8 kepada 69.8%. Penggunaan tenaga yang lebih tinggi mengurangkan jangka hayat bagi jaringan-jaringan tersebut secara tersusun mengikut jangka hayat yang dikurangkan dari 7.7% kepada 38.5%. Maka, bilangan bagi nod yang hidup terutamanya pada tahap pertama berkurang semasa waktu simulasi. Dengan menggunakan tahap bateri sebagai parameter penentu bagi menghantar pecahan-pecahan ke hop yang seterusnya, jangka hayat adalah ditingkatkan dari 6.9 kepada 20.9%. Tambahan pula, bilangan nod-nod yang hidup juga adalah satu parameter yang mana telah ditingkatkan semasa

waktu simulasi. HFS mengurangkan penangguhan sekitar empat kali berbanding dengan route-over dan dari 20.3 kepada 29.8% berbanding dengan skim mesh-under. Skim lanjutan hibrid juga mengurangkan penggunaan tenaga dari 18.1 kepada 35.1% berbanding dengan skim 'route-over' dan 50.68 kepada 58.43% berbanding dengan mesh-under. Akhirnya, dengan menggabungkan dua teknik, (menggunakan aras bateri dan HFS), peningkatan bagi jangka hayat, penggunaan tenaga, dan pengangguhan adalah dari 17 kepada 19.22%, dari 25.57 kepada 26.3%, dan dari 1 kepada 6.44% secara tepatnya.

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APPROVAL

I certify that a Thesis Examination Committee has met on 25 June 2012 to conduct the final examination of Farhad Mesrinejad on his thesis entitled "Battery Aware Hybrid Forwarding Scheme for 6LoWPAN" in accordance with the Universties and University colleges act 1971 and Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the candidate be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

FARHAD MESRINEJAD

Date: 25 June 2012

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