UNIVERSITI PUTRA MALAYSIA

DESIGN AND DEVELOPMENT OF DYNAMIC QUEUE STORAGE AND FLOATING IP PACKET ACTIVE MEASUREMENT IN IP NETWORKS

SEYED REZA KAMEL TABBAKH FARIZANI

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By

SEYED REZA KAMEL TABBAKH FARIZANI

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

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In the Name of Allah,

…Who taught man what he knew not

DEDICATION

To my dearest parents,

…for their unconditional and everlasting love and support

To my kindest wife and my sweetest son

…in all love and gratitude

ABSTRACT

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

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SEYED REZA KAMEL TABBAKH FARIZANI

APRIL 2011

Chairman: Professor Borhanuddin Mohd Ali, PhD

Faculty: Engineering

The Next Generation Network (NGN) has been anticipated to be an infrastructure of many newly emerging applications and majority of traditional services like legacy telephone networks that have been reshaped into the Internet services. Although NGN does not promise fundamental changes, the infrastructure is proposed in two main directions: wired and wireless networks, both relying on IPv6 as the network layer architecture. However, IPv6 still relies on TCP/IP architecture which has advanced with countless patches and temporary solutions. Although it is expected that in future Internet the packet loss/drop due to network errors reduces, the intentional packet drop that occurs in non-real-time and delay tolerant traffic types increases significantly especially over the Access Networks. This is either due to extensive Quality of Service (QoS) and

traffic/flow management schemes developed for real-time traffic or due to temporary out-of-coverage in wireless networks.

Another problem is that it is essential for service providers to have a precise insight about the delivery path on the Internet. However, most of the current measurement techniques rely on ICMP protocol and terminal hosts. Majority of today's network operators block ICMP traffic or give them least possible priority which leads to inaccurate or unsuccessful results. Furthermore, in future high speed networks, where the network speed exceeds the host's I/O speed, host-based approaches significantly reduce the accuracy.

In this thesis an approach that utilizes routing loops and network delay to keep IP packets in the network in the form of Floating IP Packets (FIPs) is proposed. The development and validation of the proposed technique is given using the OpNet Modeller simulation tool and actual IPv4 and IPv6 test-beds. The two problems mentioned above will then be addressed based on the proposed FIP technique. As for the packet drop problem, a FIP-based Dynamic Queue Storage (DQS) for delay-tolerant traffic types is proposed. Applying DQS, the network can play the role of temporary non-physical data storage. Loop-delay dynamic storage capacity is discussed based on analytical model and simulation experiment and it is shown that DQS capacity only depends on the total delay and the maximum available bandwidth/processing power of the routing loop. To address the measurement problem based on FIP, a concise measurement technique is proposed which is called Floating IP Packet Active Measurement (FIPAM). This technique utilizes routing loop for keeping a single packet

in the network to calculate delay and throughput in the network. FIPAM uses the IP protocol and allows flexible packet size, packet format and QoS parameters.

It is shown that the proposed DQS reduces packet drop arising from insufficient queue space by up to 6% with respect to loop parameters, without consuming more space in the physical queue from real-time traffic. However, it is also shown that by applying DQS, the total delay of the otherwise discarded packets increases with the maximum of 200 milliseconds. The results of keeping a single IPv4 and IPv6 packet on the test-bed network for more than 60 seconds are presented and it is shown by simulation that maximum 5,500 packets are kept on the network in a routing loop for more than 80 seconds without using physical queue. Results from comparing the proposed FIPAM with popular and widely used IPv4 Ping on an actual IPv4 test-bed show that FIPAM offers similar behaviour to Ping with up to 60% higher efficiency in measuring Round Trip Time (RTT) on the test-bed's wired Ethernet LAN. Furthermore, several simulation scenarios similar to the test-bed have been developed in OpNet Modeller on several popular links. It is shown that the variation of the trend and values of the measured RTT based on FIPAM follows the same trend and values of the links' speed.

ABSTRAK

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

REKABENTUK DAN PEMBANGUNAN SIMPANAN AGIHAN BARIS-GILIR DAN PENGUKURAN PAKET IP TERAPUNG AKTIF

Oleh

SEYED REZA KAMEL TABBAKH FARIZANI

APRIL 2011

Pengerusi: Profesor Borhanuddin Mohd Ali, PhD

Fakulti: Kejuruteraan

Rangkaian generasi hadapan (NGN) telah dijangka menjadi sebuah infrastruktur untuk menyokong banyak aplikasi yang baru dilahirkan. Pada masa yang sama, ia dijangkakan menjadi sebuah infrastruktur untuk majoriti perkhidmatan tradisional seperti rangkaian-rangkaian telefon warisan yang telah diubah bentuk ke dalam perkhidmatan internet menggunakan teknologi IP terkini. Walau bagaimanapun, IPv6 masih bergantung kepada senibina TCP/IP yang telah berkembang dengan sekian banyak penambah baikan dan penyelesaian sementara. Walau pun dijangkakan bahawa dalam internet akan datang kehilangan/pengguguran paket disebabkan ralat rangkaian akan bekurangan, namun pengguguran paket secara sengaja yang terjadi pada jenis paket bukan masa-

nyata dan tahan lengah dijangka akan meningkat dengan banyak terutama di atas Rangkaian Pencapaian. . Ini adalah disebabkan oleh skim Kualiti Perkhidmatan (QoS) dan pengurusan trafik/arus yang luas yang dibangunkan untuk perkhidmatan trafik masa-nyata atau disebabkan keadaan di luar liputan buat sementara dalam rangkaian tanpa-wayar. Satu masalah lagi ialah penawar perkhidmatan perlu mempunyai gambaran tepat berkenaan dengan laluan penghantaran dalam Internet. Namun, kebanyakan teknik pengukuran masakini bergantung kepada protokol ICMP dan hos terminal. Kebanyakan pengendali rangkaian masakini menyekat trafik ICMP atau beri mereka keutamaan yang paling rendah yang mengakibatkan keputusan tak tepat atau tidak berjaya. Selain dari itu, dalam rangkaian pantas masa depan, di mana kelajuan rangkaian melebih kelajuan I/O hos, kaedah berasaskan hos akan mengurangkan ketepatan dengan signifikan.

Di dalam tesis ini satu pendekatan yang menggunakan gelung penghalaan dan lengah rangkaian untuk mengekalkan paket IP di dalam rangkaian dalam bentuk Paket IP terapung adalah dicadangkan. Pembangunan dan validasi teknik cadangan ini adalah diberikan menggunakan alat simulasi OpNet Modeller dan tapak uji sebenar IPv4 dan IPv6. Kedua-dua masalah yang disebutkan di atas akan di kendalikan berdasarkan teknik cadangan FIP. Manakala untuk masalah pengguguran paket, Penyimpanan Baris-gilir Dinamik (DQS) berasaskan FIP untuk jenik trafik yang tahan lengah adalah dicadangkan. Dengan mengaplikasikan DQS, rangkaian akan memainkan peranan sebagai penyimpanan data bukan fizikal. Kapasiti penyimpanan dinamik lengah gegelung adalah dibincangkan berasaskan model analitik dan eksperimen simulasi dan adalah ditunjukkan bahawa kapasiti DQS hanya bergantung kepada jumlan kelengahan dan lebarjalur maksimum yang ada/kuasa pemerosesan gegelung penghalaan. Untuk

mengatasi masalah pengukuran berasaskan FIP, teknik pengukuran ringkas adalah dicadangkan yang dipanggil Pengukuran Aktif Paket IP Terapong (FIPAM). Teknik ini menggunakan gegelung penghalaan untuk mengekalkan satu-satu paket dalam rangkaian untuk mengira kelengahan dan truput dalam rangkaian. FIPAM menggunakan protokol IP dan membenarkan saiz paket, format paket dan parameter QoS yang fleksibel.

Adalah ditunjukkan bahawa DQS cadangan ini mengurangkan pengguguran paket hasil dari ruang barisgilir yang terhad sehingga 6% berasaskan parameter gegelung, tanpa mengambil lebih ruang dalam baris-gilir fizikal dari trafik masa-nyata. Walau bagaimanapun, adalah ditunjukkan bahawa dengan mengaplikasikan DQS, jumlah lengah untuk paket yang jika sebaliknya akan digugurkan meningkat sehingga maksimum 200 ms. Hasil keputusan mengekalkan satu paket IPv4 dan IPv6 dalam rangkaian tapak-uji melebih 60 saat adalah dibentangkan dan telah ditunjukkan melalui simulasi bahawa maksimum 5,500 paket dapat disimpan dalam rangkaian dalam gegelong penghalaan melebihi 80 saat tanpa menggunakan baris-gilir fizikal.

Hasil keputusan dari pembandingan dengan FIPAM yang dicadangkan ini dengan Ping IPv4 yang terkenal dan banyak sekali digunakan, ke atas satu tapak-uji IPv4 sebenar, menunjukkan FIPAM menawarkan tingkah-laku yang serupa dengan Ping sehingga 60% lebih kecekapan dalam mengukur Masa Pusingan Perjalanan (RTT) pada tapak-uji LAN Ethernet berwayer. Tambahan pula, beberapa scenario simulasi yang serupa dengan tapak-uji telah dibangunkan dalam OpNet Modeller pada beberapa pautan terkenal. Adalah ditunjukkan bahawa variasi pada trend dan nilai RTT yang diukurkan berasaskan FIPAM mematuhi trend dan nilai kelajuan pautan tersebut.

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I certify that a Thesis Examination Committee has met on April 1, 2011 to conduct the final examination of Seyed Reza Kamel on his thesis entitled "Design and Development Of Dynamic Queue Storage and Floating IP Packet Active Measurement" in accordance with the universities and university colleges Act 1971 and the constitution of the Universiti Putra Malaysia (P.U. [A] 106) March 15, 1998. The Committee recommends that the candidate be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Raja Syamsul Azmir Raja Abdullah, PhD
Assistant Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohamed Bin Othman, PhD
Professor
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Internal Examiner)

Mohd Fadlee Bin A Rasid, PhD
Assistant Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Abbas Jamalipour, PhD
Professor
School of Electrical and Information Engineering
University of Sydney
(External Examiner)

BUJANG KIM HUAT, PhD

Professor and Deputy Dean
School Of Graduate Studies
Universiti Putra Malaysia

Date:

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

Borhanuddin Mohd Ali, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Sabira Khatun, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Shamala Sabramanian, PhD
Associate Professor
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Member)

HASANAH MOHD GHAZALI, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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.

SEYED REZA KAMEL TABBAKH FARIZANI

Date: 1 April 2011

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