

ENHANCEMENT OF DATA TRANSMISSION FOR MOBILE MULTI HOP
RELAY WORLDWIDE INTEROPERABILITY FOR MICROWAVE ACCESS
NETWORK

FATH ELRAHMAN ISMAEL KHALIFA AHMED

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Electrical Engineering)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2012

To my family

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Assoc. Prof. Dr. Sharifah Kamilah Syed Yusof for her guidance and support. I really benefited from working with her both professionally and intellectually. More importantly, I have benefited tremendously from her broad range of experience, technical insights, vision, inspiration and enthusiasm for research. In fact, I appreciate her care, patience and dedication in constructively criticizing my research work and thesis as well.

I am grateful to my co-supervisor Prof. Dr. Mazlan Abbas for his invaluable support and guidance that allowed me to fully concentrate on the research. Without his guidance and patience my Ph.D research would not be accomplished.

I learned a lot from Prof. Dr. Norsheila Fisal. Her experience in the field of wireless networks and cross-layer design helped me to enrich my own knowledge in this very sphere. She opened for me insights of the research community, its organization, and its past and future trends.

Also, I would like to thank all the members of the UTM MIMOS CoE Telecommunication Technology (CT2) for their support, encouragement, friendship and stimulating atmosphere. I owe special thanks to Adnan Shahid khan, Dahiru Sani, Yakubu Baguda and Hashim El-shafie and all those who have contributed toward making this research a reality.

On a final note, I would to thanks all the members of my family for their support and encouragement which has been my source of encouragement and strength.

ABSTRACT

Mobile Multi-hop Relay (MMR) Worldwide Interoperability for Microwave Access (WiMAX) uses Non-Transparent Relay Station (NT-RS) to extend the Base Station (BS) coverage and improve the channel quality and throughput of the network. Nevertheless, the use of NT-RS in MMR WiMAX network increases the delay of relaying packets across multiple hops. Transmission Control Protocol (TCP) and Automatic Repeat reQuest (ARQ) are used to achieve the data transmission reliability in the wireless systems. However, the setting of ARQ parameters are optimised for single hop network and it does not consider the Quality of Service (QoS) limits required of WiMAX networks. In addition, the TCP is adapted to deal with the congestion in the wired network without considering the QoS requirements. In order to enhance the performance of data transmission over MMR WiMAX networks, resource management, transmission control and error control mechanisms should be optimised for MMR WiMAX network. Therefore, this research proposes resource management schemes to decrease the delay of relaying the packets across multiple hops scenario. Transmission control mechanism is then proposed to optimise the transmission control for MMR WiMAX network. Lastly, ARQ parameters are optimised to enhance the link utilisation in order to achieve the QoS rates required. The proposed algorithms performances are evaluated through simulation work. The proposed resource management schemes reduce the delay of relaying packets across multiple hops by 33% and 40% for the second and third hops respectively. Therefore, the link layer throughput is enhanced by 35% and 53% and TCP throughput by 30% and 40% for the second and third hops correspondingly. The proposed transmission control scheme reduces the timeout occurrences which increase the resource utilisation up to 90% and hence the TCP throughput is enhanced by 26% to 75% for different hops. In conclusion, the optimised ARQ parameters for MMR WiMAX network reduce the TCP packet loss by 8%, 44% and 64% for the first, second and third hops. Hence, the link layer and TCP performances are improved by 10% to 140% for diverse scenarios.

ABSTRAK

Kebolehkendalian antara seluruh dunia bagi Akses Gelombang Mikro (WiMAX) iaitu Rangkaian Geganti Berbilang-Lompatan mudah alih (MMR) menggunakan Stesen Geganti Tidak-Telus (NT-RS) untuk melanjutkan Stesen Tapak (BS) liputan dan meningkatkan kualiti saluran dan keluaran rangkaian. Walau bagaimanapun, penggunaan NT-RS dalam rangkaian WiMAX MMR meningkatkan kelewatan paket menghantar ke seluruh berbilang lompatan. Protokol Kawalan Transmisi (TCP) dan permintaan Ulang Automatik (ARQ) digunakan untuk mencapai kebolehpercayaan penghantaran data dalam sistem tanpa wayar. Walau bagaimanapun, ketetapan parameter ARQ di optimumkan bagi rangkaian lompatan tunggal, dan ia tidak mempertimbangkan Kualiti Perkhidmatan (QoS) had yang diperlukan dalam rangkaian WiMAX. Disamping itu, TCP disesuaikan untuk berhadapan dengan kesesakan dalam rangkaian berwayar dan ia tidak mempertimbangkan keperluan QoS WiMAX. Dalam usaha untuk meningkatkan prestasi penghantaran data melalui rangkaian WiMAX MMR, pengurusan sumber, kawalan transmisi dan mekanisme kawalan kesilapan harus dioptimumkan bagi rangkaian WiMAX MMR. Oleh itu, kajian penyelidikan ini mencadangkan skim pengurusan sumber untuk mengurangkan kelewatan paket penyampai melalui senario hop berbilang. Seterusnya, kawalan mekanisme penghantaran adalah dicadangkan untuk mengoptimumkan kawalan penghantaran bagi rangkaian WiMAX MMR. Akhir sekali, ARQ parameter yang optimum untuk meningkatkan penggunaan pautan dalam usaha mencapai kadar QoS yang dikehendaki. Pencapaian, algoritma yang dicadangkan dinilai melalui kerja simulasi. Skim cadangan pengurusan sumber mengurangkan kelewatan paket penyampai melalui hop pelbagai sebanyak 33% dan 40% untuk hop kedua dan ketiga masing-masing. Oleh itu, kendalian pautan lapisan dipertingkatkan oleh 35% dan 53% dan keluaran TCP sebanyak 30% dan 40% untuk hop kedua dan ketiga sepadan. Skim kawalan penghantaran yang dicadangkan mengurangkan kejadian timeout yang meningkatkan penggunaan sumber sehingga 90% dan oleh itu kendalian TCP dipertingkatkan sebanyak 26% kepada 75% untuk hop yang berbeza. Kesimpulannya, parameter ARQ dioptimumkan untuk MMR WiMAX rangkaian mengurangkan kerugian paket TCP sebanyak 8%, 44% dan 64% untuk hop pertama, kedua dan ketiga. Oleh itu, lapisan pautan dan prestasi TCP meningkat sebanyak 10% kepada 140% untuk senario pelbagai.