行政院國家科學委員會專題研究計畫
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具備多封包接收能力的無線網路中的機會式媒體接取控制

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執行單位：國立交通大學電機工程學系/電信工程研究所

計畫主持人：高榮鴻

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中文摘要：

從 2008 年 8 月 1 日至今我們總共發表了兩篇 IEEE 期刊論文；其中一篇發表於 IEEE Transactions on Mobile Computing，另一篇發表於 IEEE Communications Letters。此外，目前我們還有一篇論文已於 2009 年投稿至 IEEE Transactions on Mobile Computing 進行 peer review。

分散式的媒體接取控制方案可以分為 3 大類：Aloha、Tree Splitting 及 CSMA。在 2008 年我們推導出在具備同時多封包接收能力的無線網路中使用 Tree/Stack Splitting Algorithm 的整體效能。在 2009 年我們推導出在具備同時多封包接收能力的無線網路中使用 nonpersistent CSMA 的 network throughput。我們目前正在針對這 3 大類的 MAC Protocols 來研究如何使之與 Opportunistic Packet Transmission 相結合。

中文關鍵字： 多封包接收能力，無線網路媒體接取控制

Abstract:

We have published two IEEE journal papers since this research project starts in August 2008. In particular, one paper is published in IEEE Transactions on Mobile Computing in December 2008, while another paper is published in IEEE Communications Letters in October 2009. In addition, we have submitted an additional paper to IEEE Transactions on Mobile Computing in 2009.

Random access control schemes can be classified into three classes: Aloha, Tree Splitting, and CSMA. In 2008, we analytically derive the network throughput and the average packet delay for the tree/stack splitting algorithm. In 2009, we derive the network throughput for the slotted nonpersistent CSMA protocol without retransmission. We are working on modifying the classic MAC protocols so that they could benefit from being opportunistic.

Keywords: Multipacket Reception,

Medium Access Control in Wireless Networks

1. Introduction

機會式媒體接取控制主要是利用無線通訊管道的時變性(如 fading)，只使用瞬間情況良好的管道傳送封包，以增加無線網路的總體產出(throughput)。傳統的通訊理論把通訊管道的時變性視為必須克服的缺點；而機會式媒體接取控制則將無線通訊管道的時變性視為一種可以利用的資源。目前，大多數關於機會式媒體接取控制的文獻都是假設基地台不能同時接收多個封包。多封包接收能力是指一個基地台可以在同一時間(time slot)、同一頻帶(frequency band)同時成功地接收並解碼來自不同網路節點的多個封包。在傳統的(0,1,e)通道模型中，同時傳送兩個以上的封包只會造成碰撞，對網路 Throughput 並沒有任何貢獻。然而，網路消息理論(Network Information Theory)與先進的通訊技術(如 CDMA+Multi-user Detection 及 Smart Antennas+SIC 等)允許基地台可以同時成功地接收多個封包。以先進的通訊技術為基礎的 medium access control scheme 可以達到傳統的 medium access control schemes 所無法達到的無線網路效能。

2. 主要研究成果

從 2008 年 8 月 1 日至今我們總共發表了兩篇 IEEE 期刊論文。在 2008 年 12 月我們發表了一篇論文[2]於 IEEE Transactions on Mobile Computing。論文提目為"Probability Models for The Splitting Algorithm in Wireless Access Networks with Multi-Packet Reception and Finite Nodes"。樹狀分裂演算法（splitting algorithm）是一個經典的網路媒體接取控制方法，從被美國麻省理工學院的學者發明至今已有約三十年的歷史。我們的研究和之前關於樹狀分裂演算法效能分析的研究有兩大不同點。第一，我們的研究考慮比之前相關研究所使用的(0,1,e)碰撞模型更廣義的同時多封包接收通道模型。第二，之前相關的研究絕大多數假設網路中有無窮多個節點，而且每個節點的資料流在加入回饋後仍然是 Poisson Process；而我們的研究則忠實反映真實網路中只有有限個節點而每個節點的資料流在加入回饋前後都不一定是 Poisson Process。我們推導出樹狀分裂演算法的網路 throughput、average queueing delay 及 average retransmission delay。除了利用解數學方程式以得到數值解外，我們也使用離散事件驅動電腦模擬來得到一致的結果。

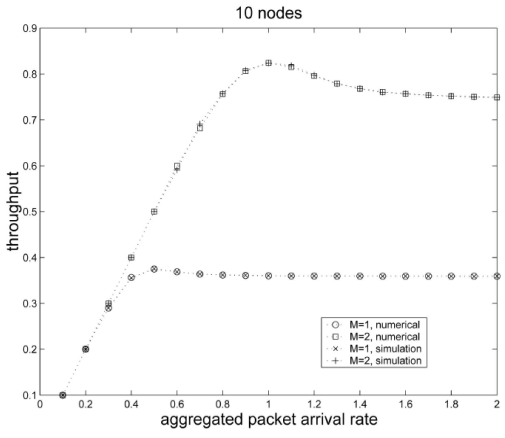

Figure 1: The throughput of the tree/stack splitting algorithm with multipacket reception

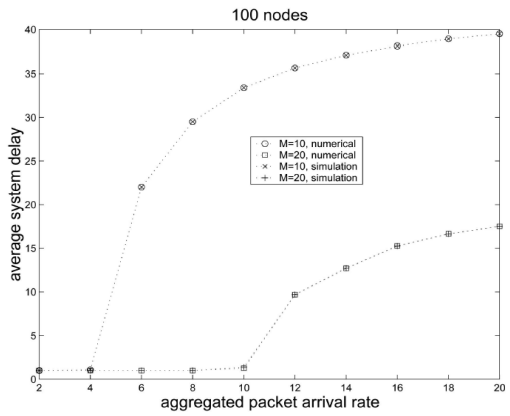

Figure 2: The average system delay of the tree/stack splitting algorithm with multipacket reception

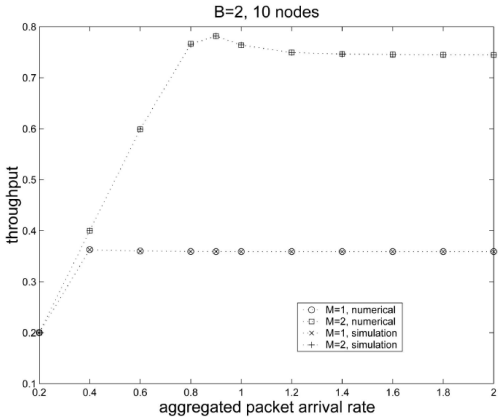

Figure 3: The throughput of the tree/stack splitting algorithm with multipacket reception, when buffer size is two

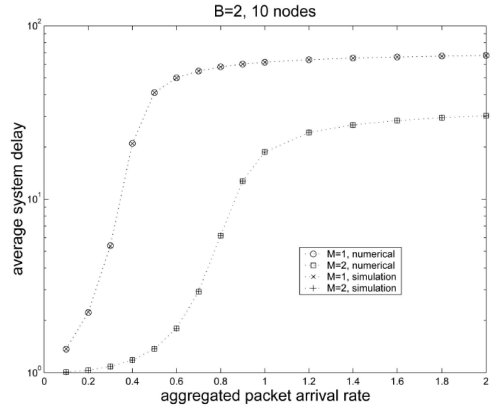

Figure 4: The average system delay of the tree/stack splitting algorithm with multipacket reception, when buffer size is two

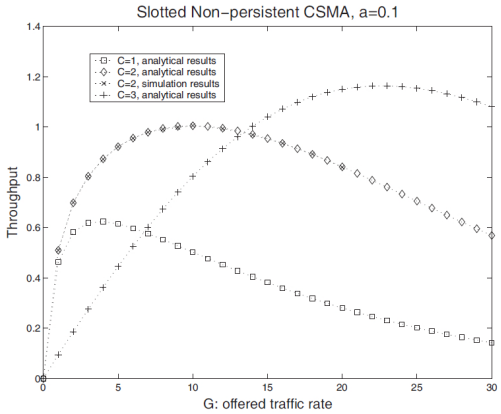

Figure 5: The throughput of the nonpersistent CSMA protocol with multipacket reception, when buffer size is two

在 2009 年 10 月我們發表了一篇論文 [3] 於 IEEE Communications Letters。論文提目為"Modeling The Slotted Nonpersistent CSMA Protocol for Wireless Access Networks with Multiple Packet Reception"。CSMA (Carrier-Sense Multiple-Access)是許多有名的媒體接取控制國際標準(如 IEEE 802.11 MAC Layer 及 IEEE 802.15.4 MAC Layer)的基礎。因此如何得到 CSMA 正確的效能分析結果就成為一個很重要的研究議題。在這篇論文中我們推導出沒有重傳機制 (retransmissions) 下的 slotted nonpersistent CSMA protocol 的 network throughput。我們的研究成果和大多數之前的研究成果最大的差異在於我們的研究成果不只適用於傳統的 (0,1,e)通道模型；也適用於具備同時多封包接收能力的無線網路。接著，我們也推導出有重傳機制下的 slotted nonpersistent CSMA protocol 的 network throughput 及 average packet delay；此部份的研究成果已經投稿到 IEEE Transactions on Mobile Computing [4]。

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