行政院國家科學委員會專題研究計畫　成果報告

含行動隨意網的 MPLS 無線基礎網路(3/3)

計畫類別：個別型計畫
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計畫主持人：曾建超

計畫參與人員：黃貴笠　黃勇智　陳家銘　張乃心　劉育宗

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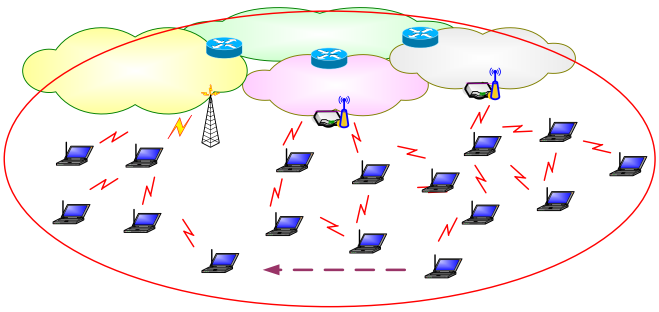
中文摘要

有鑑於多媒體傳輸的需求快速增加，網路使用者使用網路的方式也越來越多樣化，相對的各種網路型態的結合也日趨重要。未來服務品質保證(Quality of Service; QoS)不僅可以在當地(Local Region)有很完整方案可以提供之外，也必須在各種網路型態之間，提供一套很簡單的完整 End-to-end 服務品質保證。同時也希望有一套機制提供不斷線的異質網路換手(Seamless Handoff)服務，讓網路使用者可以很快速不斷線又同時擁有固定的服務品質保證漫遊在各種網路之間。

本研究計畫為期三年，主要之目的是透過 Multi-Protocol Label Switching (MPLS)的機制整合各種型態網路(Internet、Ad-hoc、GRPS 和 WLAN;如圖一所示)以提供 End-to-end 的服務品質保證。透過此機制不僅可以加速網路封包傳遞（Packet Forwarding），也同時提供網路使用者擁有 End-to-End 的服務品質保證。此外，我們也利用行動智慧代理人（Mobile Intelligent Agent）的機制提供在異質網路之間漫遊的無接縫換手（Seamless Handoff）。



圖一：各種網路型態（Internet、GPRS、WLAN、Ad-hoc）的結合

因此，本研究計畫主要分三個部分加以探討。首先，我們希望利用 MPLS 的技術，支援 GPRS 網路傳輸的服務品質，以達到 GPRS 與 Internet 之間的 End-to-End 的服務品質保證(本方法也適用 3G 網路)，以及 inter-SGSN 順暢換手(smooth handoff)。接下來，在無線區域網路方面，Ad-hoc 網路填補 Infrastructure 骨幹網路不能涵蓋之處，作為 Infrastructure 骨幹網路的延伸(Extension)。因此，我們在 Ad-hoc 網路中加入 MPLS，並利用 MPLS 特點，進一步提出支援服務品質保證的機制。最後，我們也特別針對 multi-homed 無線網狀網路(Wireless Mesh Network，WMN)的環境下，提出一個傳輸流量平衡(load-balanced)的閘道伺服器(gateway)選取演算法和一個考量到傳輸服務品質狀態的路由協定。

關鍵詞： 無線隨意行動網路，MPLS，QoS，GPRS，Ad-hoc，WMN

報告內容

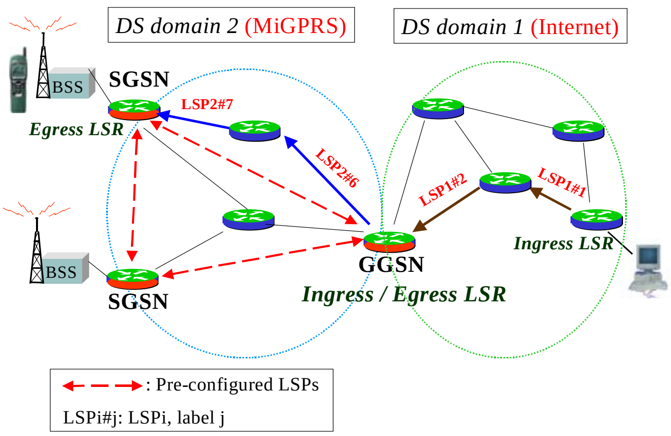
綜合上述，我們分三個部分簡述本計畫的研究成果內容:

一、 利用 MPLS 的技術，支援 GPRS 網路傳輸的 QoS。

審視目前 GPRS 傳輸網路的協定堆疊，最根本的問題在於 IP-in-IP 隧道技術的協定額外負擔(protocol overhead)太大了。另外，由於 GPRS 傳輸網路內的封包其兩層 IP 的 QoS 控制機制必須協調以符合一致的 QoS 需求，這將會提高即時資料流在建立連線時的複雜度。因此，我們提出了 MPLS in GPRS (MiGPRS)的方法加以改善(此部分研究成果已獲得國內專利，美國專利審查中)。

A.　Pre-configured LSPs in MiGPRS 網路

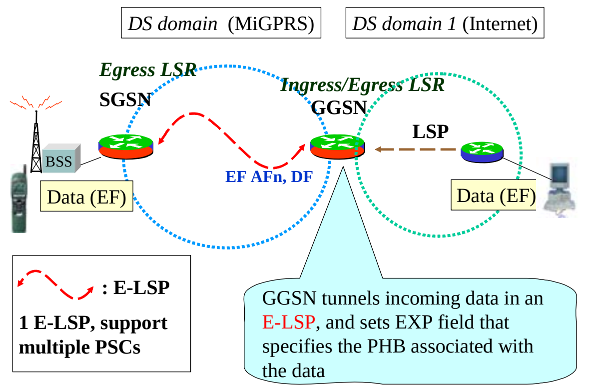
在每個 SGSN 之間以及每對 GGSN-SGSN 之間預先建立好 label switched paths，稱為 pre-configured LSPs。如圖二所示，當外部 Internet 上的 CN 端欲傳送資料封包給行動台端時，資料封包會先被繞送到 MiGPRS 網路的 GGSN 節點。GGSN 只需要將行動台所屬的資料封包導入到對應的 pre-configured LSP，就可以將資料封包經由 label switching 的方式傳達到 SGSN。



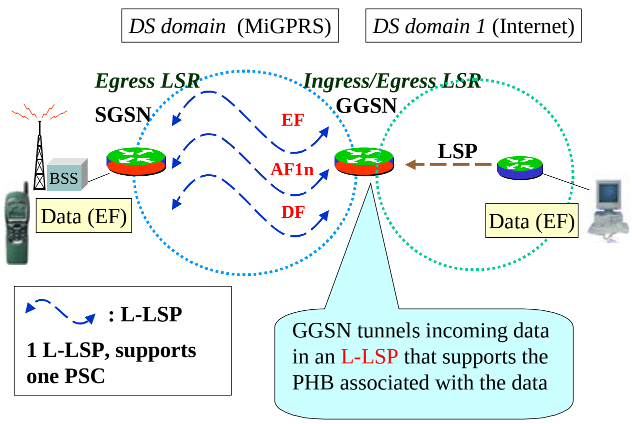
圖二：Pre-configured LSPs in MiGPRS Networks

B.　支援 MiGPRS 的 Differentiated Services

因為 label switched paths 具有連線導向 (connection-oriented)的特性，所以很適合用於支援 QoS control 服務。在圖三中，我們將 pre-configured LSPs 建立成 E-LSPs。而在圖四中，我們將 pre-configured LSPs 建立成 L-LSPs。當具有 QoS control 要求的資料封包要送到 MiGPRS 網路的行動台端時，GGSN 會依據此封包的 QoS 需求，設定封包標籤標頭的 EXP field 以提供相同的 QoS 等級，再將資料封包導入進 E-LSP (圖三)，或將資料封包導入可支援其 QoS 要求的 L-LSP (圖四)，傳送到 SGSN。



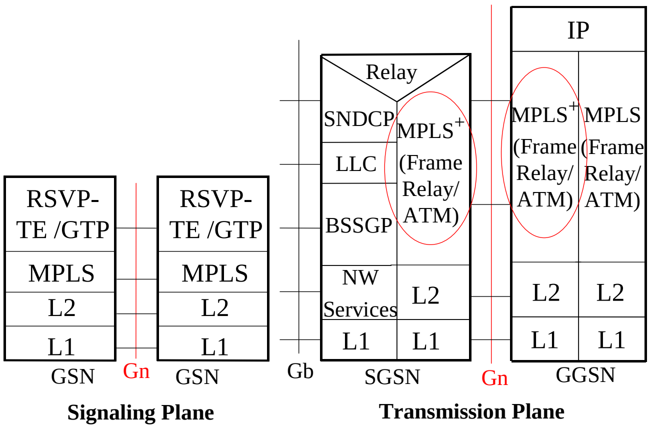
圖三：Pre-configure E-LSPs in MiGPRS Networks to Support DiffServ



圖四：Pre-configure L-LSPs in MiGPRS Networks to Support DiffServ

C.　MiGPRS without GTP Tunneling

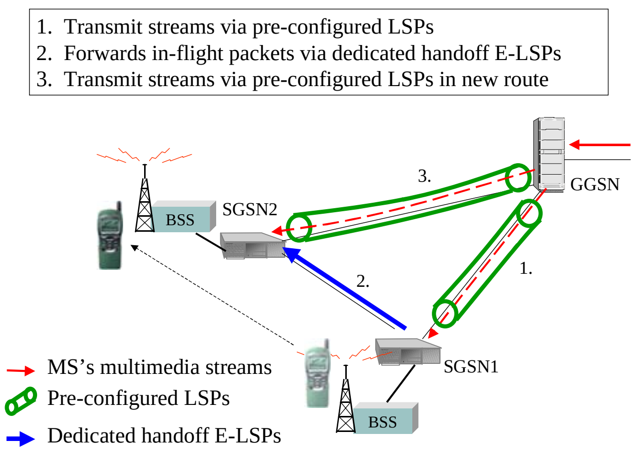
我們將 Gn 介面中 signaling plane 和 transmission plane 的封包標頭加以修改，因而不再需要使用 IP-in-IP tunneling 的技術，也達到縮短封包標頭的目的。



圖五：Protocol Stack of Gn Interface of the MiGPRS without GTP Tunneling

D. 支援 QoS 於 Inter-SGSN 平滑換手流程

如圖六所示，我們在每個 SGSN 之間預先建立兩條互通、單向的 E-LSPs，我們稱這些 E-LSPs 為 dedicated handoff E-LSPs。MiGPRS 傳輸網路使用預先建立於新 SGSN 與舊 SGSN 之間的 dedicated handoff E-LSP 來轉傳(forwarding)行動台 in-flight 的資料封包，同時保證 in-flight 資料封包的 QoS 要求，以達到平滑換手的目標。

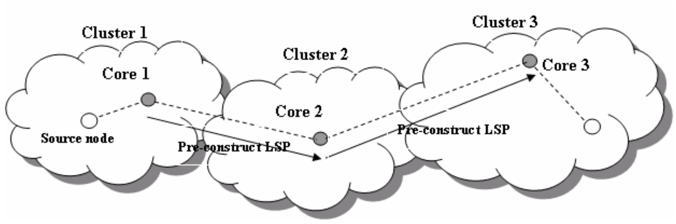


圖六：QoS Support for Inter-SGSN Handoff

二、 利用 MPLS 的特性，改善 Ad-hoc 的 routing 效率以及達到更佳的 QoS 控制。

A. 完成 Ad-hoc Network 在 Network Layer 中的 Routing Protocol 設計

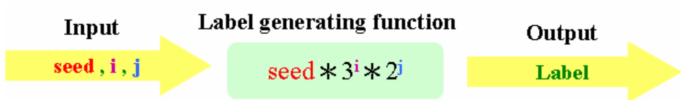
我們採用 Virtual Backbone 的架構，將整個 Mobile Ad-hoc Network 做階層式的管理。如圖七所示，先將整個 Ad-hoc 網路分成若干 clusters，再從每個 cluster 中選出一個核心且較不移動的點，再以這些點為 cores 來建立 Virtual Backbone，藉由 cores 來達成 QoS guarantee 及 traffic engineering，以及使 MANET 具 connection-oriented 之特性。



圖七：MANET 階層式管理

B. 改良 MPLS 的 Label Distribution and Switch 方法以適用於 Ad-hoc Networks

利用分散式的機制選出 label manager 來負責 LSP 的 label distribution 與 label assignment。這個方法中的每一個 LSR 會紀錄 MAC address/Label 的對應，因此一條 LSP 隧道就是由 routing path 所經過的每一 LSR 所紀錄 MAC address/Label 的對應關係串聯而成的。圖八是我們產生 label 的函式。此函式產生的 Label 唯一，而且具祖先/後代關係，可簡化 label distribution 和 assignment 的程序和時間。



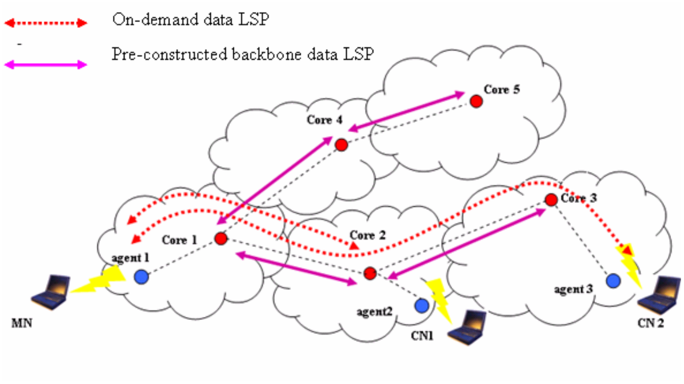
圖八：Label Generating Function

C. 整合 Ad-hoc MPLS 與 infrastructure 架設 Extended Infrastructure 網路

我們將 AMPLS 網路架設成 infrastructure 無線網路的 extension，是為了提高 MN 的通訊範圍與保持網際網路連線的能力。當 data packet 真正要在 AMPLS 網路內傳送時，就可利用 Label switching 的方式來 forward data。

D. 完成建立 Pre-constructed LSP 及 On-demand LSP 的機制

我們利用之前所描述改良 Label distribution and switching 的機制，在我們之前所建立的 Virtual Backbone 上預先建立 LSP 隧道，也就是建立 Pre-constructed LSP。On-demand data LSP 會在 MN (mobile node)要求建立連線時所建，是一條 end-to-end 的 LSP。

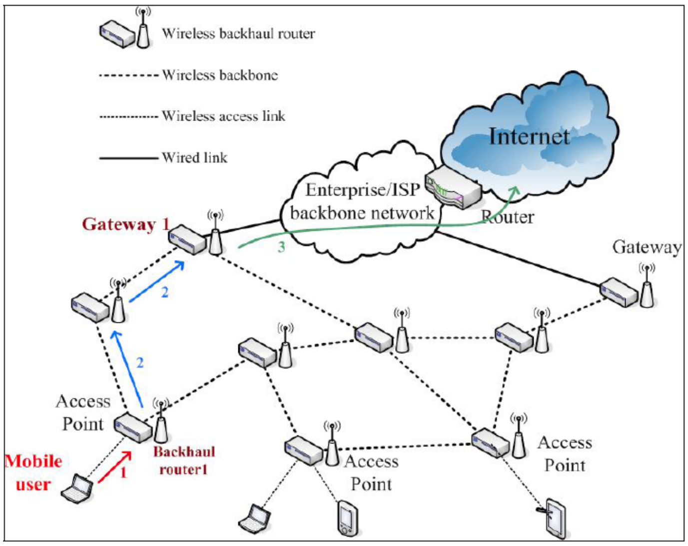


圖九：Pre-constructed Backbone Data LSP 與 On-demand data LSP

E. 完成 QoS negotiation for Differentiated services through Pre-constructed LSPs

在 Pre-constructed LSP 上保留適當的頻寬資源，用以提供 Ad-hoc 網路 Differentiated Service (DiffServ)，且分享頻寬給所有經過此 LSP tunnel 的 On-demand LSP，進而做到他們的 QoS 保證。

三、 在 WMN，設計出一套具有 QoS 的路由技術與流量傳輸平衡策略。



圖十：Wireless Mesh Network架構

A. Initial access router要選擇path request要到達的閘道伺服器

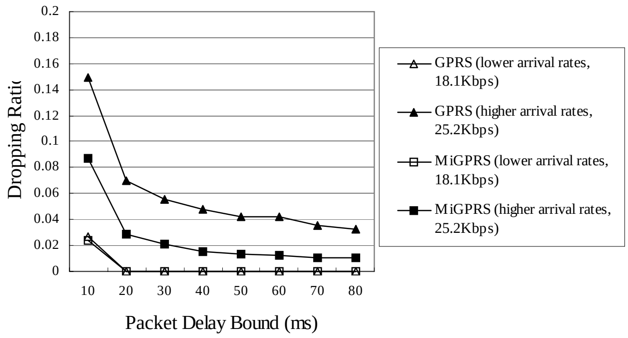
Initial backhaul router一開始會依據各個所能到達的閘道伺服器的負載量，選定適合的閘道伺服器。在閘道伺服器端，會根據目前本身的流量和其他閘道伺服器的流量，以及本身和其他閘道伺服器的capacity，算出一個權重出來，並將權重廣播出去給所有與之有路徑可走的backhaul router知道。

B. Path的選擇

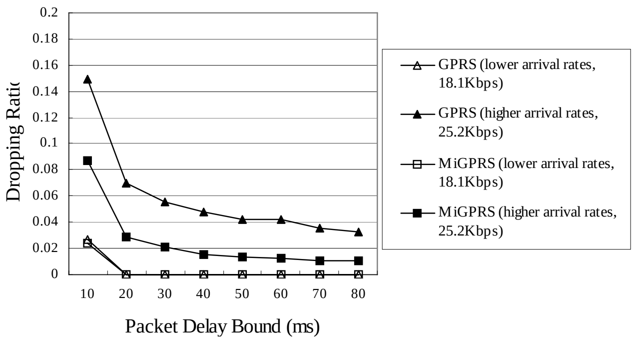
設定好閘道伺服器與distance threshold之後，initial backhaul router就會開始要選擇下一個要走的link。該link滿足(1) mobile node的bandwidth request， (2) hop count不超過distance threshold，(3) 不屬於fail backhaul router。當path request到達閘道伺服器時，則會一路從走過來時的路徑利用RSVP，reserve link bandwidth回去initial backhaul router。

四、 效能評估

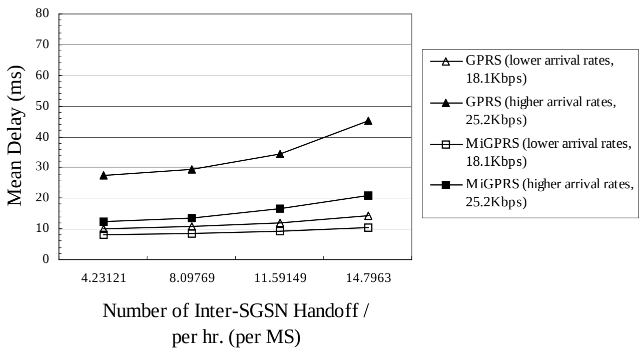
此外，我們也進行了模擬分析，對於我們所提出的技術做更進一步的效能評估。



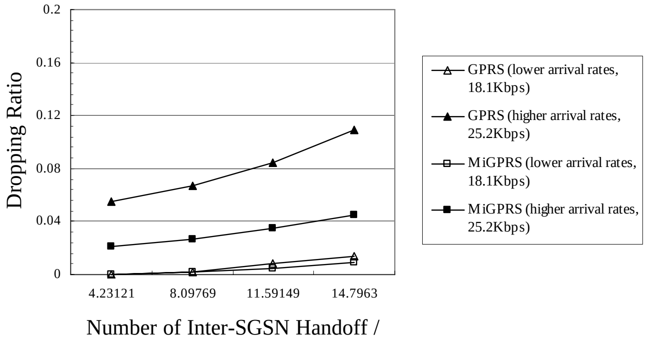
圖十一：Mean delay under various arrival rates



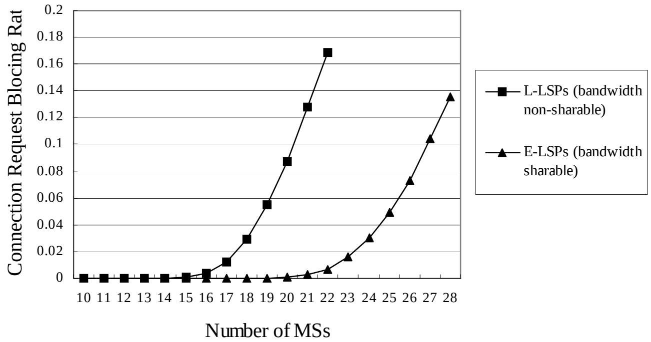
圖十二：Dropping ratio under different delay bounds



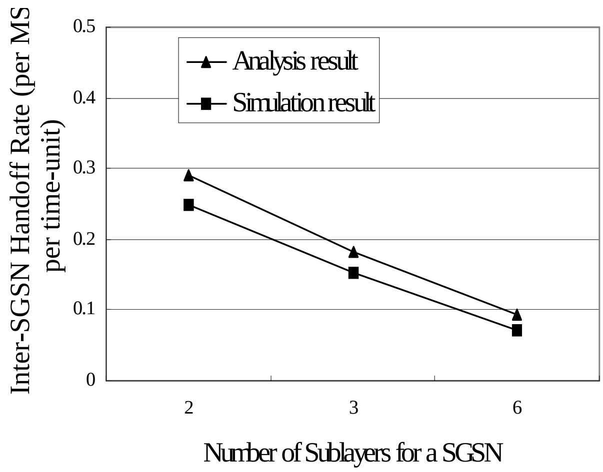
圖十三：Mean delay under various inter-SGSN handoff rates



圖十四：Dropping ratio under various inter-SGSN handoff rates



圖十五：Connection request blocking ratio under various number of MSs



圖十六：Analytical Result vs. Simulation Result (inter-SGSN handoff rate)

圖十一至圖十六是 MiGPRS 與 GPRS 在平均延遲、封包捨棄比率、連線要求阻斷以及

inter-SGSN 換手速率等各方面的效能比較，我們可以發現 MiGPRS 明顯有較優異的效能表現。

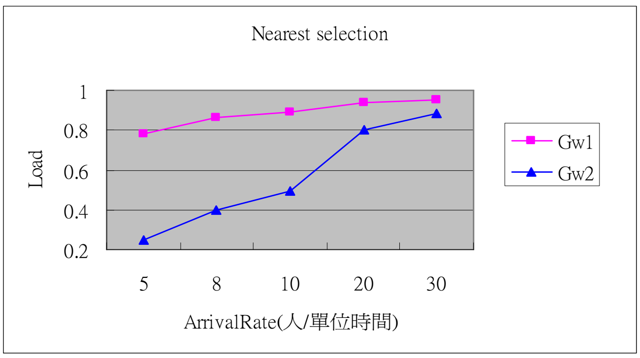
Blocking prob.	Avg.Signal	Avg.hop
1.1912%	6.6	26.03

表一：Flooding

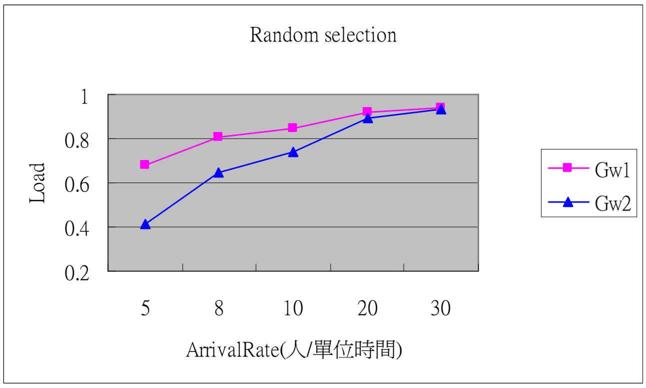
Backup path	Blocking prob.	Avg.Signal	Avg.Hop
1	5.9645%	4.0213	5.1023
2	2.3917%	4.1886	5.3172
3	1.1966%	4.2478	5.3999

表二：AMPLS

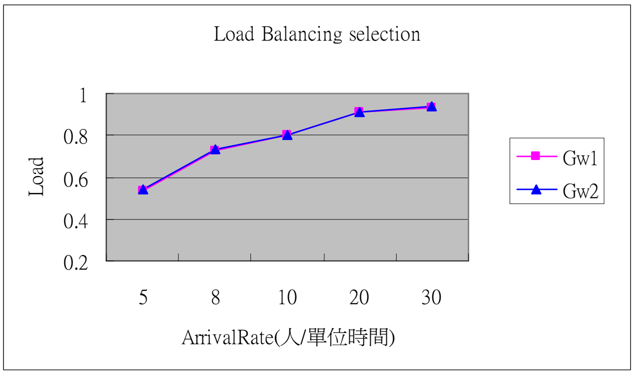
表一及表二為每次建立連線時，Flooding 與 AMPLS 在阻斷機率、平均 signal 次數以及平均轉送 host 個數等各方面的比較，我們可以發現 AMPLS 均有較佳的效能呈現。



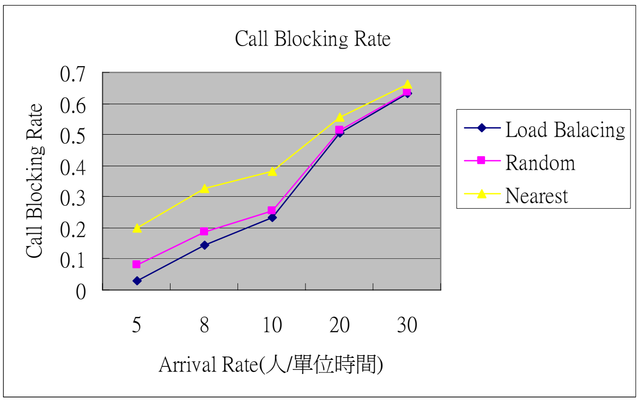
圖十七：gateway load distribution of “nearest selection”



圖十八：gateway load distribution of “random selection”



圖十九：gateway load distribution of “load balancing selection”



圖二十：call blocking

圖十七至圖二十為不同 gateway 選擇方法(nearest selection、random selection、load balancing selection)在 gateway 負載以及連線要求阻斷率等各方面的效能比較，由圖可以發現我們所提出的 load balancing selection 方法擁有較佳的效能表現。

五、 計畫成果

本計畫年度共發表國際期刊論文 3 篇和國內外會議論文 4 篇，此外已獲得國內專利 3 項，另有國內外專利共 5 項審查中。同時也培養了 3 位碩士即 1 位博士生，技術移轉 1 項。

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計畫成果自評

本計畫依時程順利進行，並發表多篇論文，獲得多項專利，培養碩博士研究生多位，以及技術移轉 1 項，成果豐碩。