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2009

## TrainNet: a novel transport infrastructure for non real-time data delivery

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# TrainNet: A Novel Transport Infrastructure for Non Real-Time Data Delivery

A thesis submitted in fulfilment of the  
requirements for the award of the degree

Master of Engineering (Research)

from

THE UNIVERSITY OF WOLLONGONG

by

Mohammad ZARAFSHAN ARAKI  
Master of Internet Technology (with Distinction)

SCHOOL OF ELECTRICAL, COMPUTER  
AND TELECOMMUNICATIONS ENGINEERING  
2009



# Abstract

To date, researchers have proposed many vehicular networks in which cars or buses act as a mechanical backhaul for transporting data. For example, a bus can be retrofitted with a computer and wireless card to automatically ferry data to/from rural villages without Internet connectivity. Alternatively, a person carrying a portable storage device can be used to link geographically disparate networks. These examples of challenged networks are characterized by frequent disruptions, long delays, and/or intermittent connectivity.

This thesis proposes TrainNet, a vehicular network that uses trains to transport latency insensitive data. TrainNet augments a railway network by equipping stations and trains with mass storage devices; e.g., a rack of portable hard disks. TrainNet has two applications. First, it provides a low cost, very high bandwidth link that can be used to deliver non real-time data. In particular, cable TV operators can use TrainNet to meet the high bandwidth requirement associated with Video on Demand (VoD) services. Moreover, TrainNet is able to meet this requirement easily because its links are scalable, meaning their capacity can be increased inexpensively due to the continual fall of hard disk price. Secondly, TrainNet provides an alternative, economically viable, broadband solution to rural regions that are reachable via a railway network. Therefore, using TrainNet, rural communities will be able to gain access to bandwidth intensive digital contents such as music, video, television programs, and movies cheaply.

A key problem in TrainNet is resource scheduling. This problem arises because stations compete for the fixed storage capacity on each train. To this

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end, this thesis is the first to propose three max-min scheduling algorithms, namely LMMF, WGMMF and GMMF, for use in challenged networks. These algorithms arbitrate the hard disk space among competing stations using local traffic information at each station, or those from other stations. To study these algorithms, the Unified Modeling Language (UML) is first used to construct a model of TrainNet, before a simulator is constructed using the DESMO-J framework. The resulting TrainNet simulator is then used to investigate the behavior of said max-min algorithms in scenarios with realistic traffic patterns. Results show that while LMMF is the fairest algorithm, it results in data loss and has the longest mean delay, the lowest average throughput, and the lowest hard disk utilization. Furthermore, Jain's fairness index shows WGMMF to be the least fair algorithm. However, it avoids data loss as is the case with GMMF, and achieves the best performance in terms of mean delay, averaged throughput, and hard disk utilization.

# Statement of Originality

This is to certify that the work described in this thesis is entirely my own, except where due reference is made in the text.

No work in this thesis has been submitted for a degree to any other university or institution.

Signed

Mohammad Zarafshan Araki

... .., 2009



# Acknowledgments

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# List of Abbreviations

AAA	Authentication, Authorization, and Accounting
ADSL	Asymmetric Digital Subscriber Line
ARQ	Automatic Repeat Request
AS	Autonomous System
BGP	Border Gateway Protocol
CATV	Cable Television
DDoS	Distributed Denial of Service
DRR	Deficit Round Robin
DSL	Digital Subscriber Line
DTN	Delay Tolerant Networking
ECN	Explicit Congestion Notification
EIGRP	Enhanced Interior Gateway Routing Protocol
FCSF	First Come First Served
GMMF	Global Max-Min Fair
GPS	Generalized Processor Sharing
GSM	Global System for Mobile Communications
HFC	Hybrid Fiber Co-axial
HIBC	Hierarchical Identity-based Cryptography
HTTP	Hypertext Transfer Protocol
I/O	Input/Output
ICT	Information and Communication Technology
IP	Internet Protocol
IPN	InterPlaNetary Internet
IS-IS	Intermediate System to Intermediate System
ISP	Internet Service Provider

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LAN	Local Area Network
LMMF	Local Max-Min Fair
MAP	Mobile Access Point
MANET	Mobile Ad hoc Network
MBF	Mobile Bundle Forwarder
MIM	Multipurpose Internet Mail Extensions
MPLS	Multiprotocol Label Switching
ONU	Optical Network Units
OSPF	Open Shortest Path First
PC	Personal Computer
PCMP	Persistent Connection Management Protocol
PDA	Personal Digital Assistant
PEP	Performance Enhancing Proxy
PKG	Private Key Generator
PKI	Public Key Infrastructure
POP	Point-of-Presence
QoS	Quality of Service
RAID	Redundant Array of Independent Disks
RMI	Remote Method Invocation
RPC	Remote Procedure Call
RTP	Real-time Transport Protocol
RTT	Round-Trip Time
SCTP	Stream Control Transmission Protocol
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UML	Unified Modeling Language
UUCP	Unix-to-Unix Copy Program
VoD	Video on Demand
VSP	Video Service Provider
WCATV	Wireless Cable Television
WFQ	Weighted Fair Queuing
WF <sup>2</sup> Q	Worst-case Fair Weighted Fair Queuing

WGMMF	Weighted Global Max-Min Fair
WiFi	Wireless Fidelity

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