ADAPTING AD HOC NETWORK CONCEPTS to LAND MOBILE RADIO SYSTEMS

by

Duncan Scott Sharp B.Sc.E.E., University of Alberta, 1972

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING in the School of Engineering Science

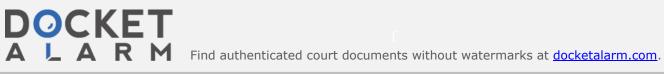
© Duncan Scott Sharp 2002 SIMON FRASER UNIVERSITY December 2002

All rights reserved. This work may not be reproduced in whole or in part, by photocopy or other means, without permission of the author.



Approval

Name:	Duncan Sharp
Degree:	Master of Engineering
Title of project:	Adapting Ad Hoc Network Concepts to Land Mobile Radio Systems
Examining Committee:	
	Dr. Paul Ho Chair
	Dr. Ljiljana Trajkovic Senior Supervisor
	Dr. Lossah Dataus
	Dr. Joseph Peters Supervisor
Date Approved:	December 9, 2002



ABSTRACT

Ad hoc networks are self-organizing networks of user terminals that form without the need for prior infrastructure. In theory, an ad hoc network could deliver adaptable, robust, and rapidly deployable communication services to meet the needs of public safety related agencies for emergency response and disaster recovery operations. In this project, I investigated the potential to develop a next generation land mobile radio system for public safety communications using ad hoc network architectures and concepts. I applied a four step methodology: (i) identify the communication requirements of public safety agencies in terms of the types of services, traffic characteristics, and quality of service; (ii) explore current technology and research relating to mobile ad hoc networks; (iii) conceptualize a design for a hypothetical next generation network by selecting approaches from the literature that should provide good results against the needs of public safety; and (iv) assess the potential performance of this hypothetical design. Among the many factors considered, the following four had a major influence on the design: (i) the dominant communication need is half duplex multicast voice; (ii) in most instances users have access to a vehicle; (iii) location information is becoming economically available through the Global Positioning System; and (iv) satellite-based mobile communications is available. The hypothetical network I propose is hierarchical with single hop "cluster nets" that are interconnected by a dominating-set based "backbone net". A satellite network tier simplifies routing across large geographic distances and provides a backbone of last resort for sparse networks. For the cluster net media access control, I applied the well known Packet Reservation Multiple Access protocol. The delay performance of this approach was investigated by applying genuine traffic traces to a software model of the cluster net. Before a complete terrestrial-based backbone net can be developed, further work is required; particularly in the area of multi hop routing. A central conclusion is that, although there are major challenges (e.g., spectrum, network self configuration algorithms, routing protocols, standards, and security), enough critical elements are available that prototypes and simple first generation systems can be built.



Table of Contents

Appro	val			
Abstra	ct			
Table o	of Cont	ents		
List of	Tables			
List of	Figures	S		
1	Introd	ntroduction		
2	Operat	Operational Requirements for Public Safety Related Agencies		
2.1	Missions, Agencies, and Groups of Users			
2.2	General Operational Requirements and Context			
2.3	Communication Services and Applications			
2.4	User Terminals			
2.5	Quality of Service			
2.6	Network Management			
3 Traffic Characteristics of P		Characteristics of Public Safety Networks		
	3.1	Voice Traffic Source		
	3.2	Traffic Analysis		
	3.3	Overall Voice Traffic Characteristics		
	3.4	Detailed Analysis of Call Holding Times		
	3.5	Detailed Analysis of Call Inter-arrival Times		
	3.6	Geographic Distribution and Mobility		
	3.7	Data Traffic		
4	Conceptual Design of a Hypothetical Ad Hoc Network			
	4.1	System Elements, Basic Organization, and Topology		
	4.2	Radio Frequency Spectrum		
	4.3	User Terminals		
	4.4	Addressing Scheme		
	4.5	Media Access Control Protocol		
	4.6	Multi Hop Routing		
	4.7	Network Management		
	4.8	Application Design		
	4.9	Conceptual System Design Summary		



Preliminary Feasibility of the Hypothetical Ad Hoc Network		ninary Feasibility of the Hypothetical Ad Hoc Network
	5.1	Performance Evaluation Scenarios
	5.2	Connectivity Performance
	5.3	Capacity Performance
	5.4	Delay Performance
	5.5	Cost Estimates
	5.6	A Possible Phased Development Program
6	Concl	usions
Apper	ndix A	Selected Terminology
Apper	ndix B	Primer on Ad Hoc Networks
Apper	ndix C	Primer on Mobile Radio Systems
Listot	f Dafara	97



DOCKET

Explore Litigation Insights



Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time** alerts and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

