MANET Routing with Prediction

Raymee Chau

Thesis submitted for the degree of

Master of Engineering Science

in

Electrical and Electronic Engineering

at

The University of Adelaide

School of Electrical and Electronic Engineering

Faculty of Engineering, Computer & Mathematical Sciences

November, 2012

Contents

Abstract

Route stability of Mobile Ad-Hoc Networks (MANETs) is one of the major problems in defence tactical wireless networks. The dynamic nature of MANETs may cause the network topology to change frequently as a result of unstable links, which may result in frequent route changes. Unstable routes may cause retransmissions and drop outs. Therefore, the network can experience heavy traffic overload and high packet losses. Many network applications rely on a stable and reliable route. Hence, it is important for the military to have a reliable network that allows effective communications amongst various platforms to effectively perform the tasks they have been assigned. For this reason, the route's stability in MANETs needs to be understood. However, many existing MANET routing protocols are not explicitly designed for route stability. It is expected that prediction can assist in increasing a MANET's route stability. This thesis explores the potential benefits and the trade-offs in the use of prediction with the Ad-hoc On-demand Distance Vector (AODV) routing protocol.

In the context of using prediction in routing, research has shown that using "accurate" predictions can improve MANETs' routing performance. However, Chapter 3 shows that it is difficult to achieve accurate predictions. To the author's knowledge, very little work has been attempted to analyse the routing performance with reduced prediction accuracies, and the effects of having inaccurate prediction. Thus more specifically, this thesis examines the robustness of using link duration prediction with various accuracies for MANETs, and identifies the conditions for which predictions can improve routing performance.

This is achieved by first examining how using perfectly accurate link duration prediction can improve routing performance. For this purpose, a new routing protocol, Ad-hoc On-demand Distance Vector with Perfect Prediction (AODV-PP), has been created to propagate link duration prediction information for route establishment. The OPNET simulator was used to simulate network scenarios with AODV and AODV-PP for analysis, and the routing performance of the two protocols have been compared.

The thesis later explores how inaccurate link duration prediction affects routing performance. However, the AODV-PP protocol does not inform the source about the change in predicted link duration. This can cause delays in route re-establishment and high packet loss. Hence, AODV with Prediction Update (AODV-PU) has been proposed to allow link duration prediction updates to be sent to the source for route maintenance. Network scenarios with AODV-PU were simulated to analyse and compare its routing performance with AODV and AODV-PP.

This thesis shows stable routes can be found with perfect prediction, which reduces packet loss and routing overhead. However, it also indicates that it is difficult to use link duration prediction to find a more stable route with inaccurate long-term predictions. Nevertheless, link duration prediction can be useful for route updates and route re-establishments, which only requires short-term predictions, to allow more seamless route transitions and to reduce packet loss. The trade-off being that more control traffic is required for route maintenance. This in turn creates a more robust platform for the military applications that require this type of network.

Statement of Originality

I certify that this work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library catalogue and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

SIGNED: . . . . DATE: . . . .

Acknowledgment

This thesis is made possible with the assistance of many people. I would like to express my deep appreciation to all those who have provided me support and guidance.

Firstly, I would like to express my sincere gratitude to my supervisors, Professor Langford White, Dr Andrew Coyle and Dr Michael Rumsewicz, at the University of Adelaide, for their patience, advise, support and guidance. Their expertise and insightful suggestions have clarified my ideas, provided advise in analysing and presenting the results, and expanded my visions in other related research areas. In particular, Dr Andrew Coyle has provided many valuable comments and suggestions towards this thesis. And I would like to thank those from the Centre for Defence Communications and Information Network at the University of Adelaide who have assisted.

I would also like to thank my managers at the Defence Science and Technology Organisation (DSTO), Dr Peter Shoubridge, Dr Jeff McCarthy, Dr Perry Blackmore and Mr Darren Wilksch for the support, opportunity and flexibility provided for me to do this study. Finally, I wish to thank my colleagues at DSTO who have provided me advice and guidance on technical issues, results analysis and thesis writing.

Acronyms

AODV	Ad-hoc On-demand Distance Vector
AODV-PP	AODV with Perfect Prediction
AODV-PU	AODV with Prediction Update
ARP	Address Resolution Protocol
BATMAN	Better Approach To Mobile Adhoc Networking
CTS	Clear-to-Send
CVBP	Constant-Velocity Based Prediction
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic Source Routing
EMM	Entity Mobility Model
FSR	Fisheye State Routing
GMM	Gauss Markov Model
GPS	Global Positioning Systems
HMM	Hidden Markov Model
IARP	Intrazone Routing Protocol
IPLC	Incorrectly Predicted Link Change
IPLS	Incorrectly Predicted Link State
LAN	Local Area Network
LET	Link Expiration Time
MAC	Medium Access Control
MANET	Mobile Ad-hoc Network
OLSR	Optimized Link State Routing

OPNET	Optimized Network Engineering Tools
OSI	Open Systems Interconnection
OSPF	Open Shortest Path First
OSPF-MDR	OSPF MANET Designated Routers (extension of OSPFv3 to support MANETs)
PreRREQ	Pre-Route RREQ
RERR	Route Error
RMSE	Root Mean Square Error
RREP	Route Reply
RREQ	Route Request
RSS	Received Signal Strength
RTS	Request-to-Send
RUPDATE	Route Update
RWM	Random Walk Model
RWP	Random Waypoint
SNR	Signal-to-Noise Ratio
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
TTL	Time-To-Live
UDP	User Datagram Protocol
ZRP	Zone Routing Protocol