



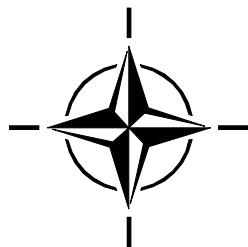
RTO TECHNICAL REPORT

TR-IST-030-W3

Cross-Layer Issues in the Design of Tactical Mobile Ad Hoc Wireless Networks: Integration of Communication and Networking Functions to Support Optimal Information Management

Technical Evaluation prepared by IST-030/RTG-012
(Information Management over Disadvantaged Grids)
of an Informal RTG-012 Workshop held at
Naval Research Laboratory, Washington, DC, USA.

June 2-3, 2004



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Authors: Dr. Jeffrey E. Wieselthier, Mr. Michael Schmeing

Executive Summary

Task Group IST-030/RTG-012 on ‘Information Management over Disadvantaged Grids’ was formed in January 2001 under the Information Systems Technology Panel of the NATO Research and Technology Organisation. Member countries were: Canada, Germany, Poland and United States. The Task Group limited its scope to a national Land Force operating in the wireless tactical domain. Its objective was to investigate how adaptive information management schemes, implemented in mobile tactical command and control nodes, can mitigate the effects of low bandwidth, variable throughput, unreliable connectivity and energy constraints imposed by the wireless communications grid that links the nodes. The Task Group organized three informal workshops. The subject of the third workshop was ‘Cross-Layer Issues in the Design of Tactical Mobile Ad Hoc Wireless Networks: Integration of Communication and Networking Functions to Support Optimal Information Management’. The objective of this workshop was to address the challenge of “top-to-bottom” information management in disadvantaged (unreliable, low bandwidth or energy-constrained) mobile wireless military communication networks. This report provides a technical evaluation of that workshop.

The overwhelming consensus among the expert panel members and participants in the workshop was that, to fully exploit the nature of the wireless channel, some use of cross-layer techniques would be necessary in future wireless network applications, both in commercial and military environments. Appropriate use of cross-layer techniques would not involve the abandonment of the layered protocol structure; rather, cross layering would be used to augment the network’s capability by sharing information among the layers and by jointly optimizing their performance. There appears to be considerable potential for performance improvement. Nevertheless, this field is still in its early stages of development, and the research community does not yet have sufficient insight to understand the big picture. One fundamental question, which has not yet been answered, is that of which layer interactions provide the best opportunities for performance improvement. The research community is just starting to ask the right questions, and there is now a basis for fruitful research and development.

Energy concerns are extremely important in ad hoc networks, and especially in sensor networks (which may be viewed as a special case of ad hoc networks). The fact that a finite quantity of energy must be shared among all of a node’s functions (e.g., transmission, reception, and signal processing) strongly links virtually all layers of the protocol stack.

Despite the overall positive assessment of the value of cross-layer approaches, a cautionary message was also delivered at the workshop. An obstacle to the use of cross-layer approaches is the need to accommodate legacy systems, which may not have the capabilities to implement such control functions. Additionally, excessive coordination among the layers may result in the design of special purpose systems, thereby eliminating some of the advantages of layered design. However, it should be emphasized that this cautionary message was intended not to discourage the use of cross-layer techniques, but rather to warn of the unintended consequences of protocol interactions that are not yet well understood.

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List of Acronyms

ACK	Acknowledgement
API	Application Programme Interface
BER	Bit Error Rate
BIP	Broadcast Incremental Power
C2IS	Command and Control Information System
DC	District of Columbia
DRDC	Defence Research and Development Canada
FEC	Forward error correction
FGAN	Forschungsgesellschaft für Angewandte Naturwissenschaften
FhG	Fraunhofer-Gesellschaft
FKIE	Forschungsinstitut für Kommunikation, Informationsverarbeitung und Ergonomie
FOKUS	Fraunhofer Institut Offene Kommunikationssysteme
FTP	File Transfer Protocol
GPS	Global Positioning System
http	Hypertext Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IST	Information Systems Technology
JTRS	Joint Tactical Radio System
Kbps	Kilobits per second
LAN	Local Area Network
LOS	Line of sight
MAC	Media Access Control
MANET	Mobile Ad Hoc Network
Mbps	Megabits per second
MTIR	MIP Tactical C2IS Interoperability Requirement
NATO	North Atlantic Treaty Organisation
NSA	National Security Agency
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open Systems Interconnection
OWG	Operational Working Group
PSK	Phase-shift keying

QAM	Quadrature amplitude modulation
QoS	Quality of Service
RF	Radio Frequency
RS	Reed-Solomon
RTG	Research Task Group
SINCGARS	Single Channel Ground and Airborne Radio System
SIP	Session Initiation Protocol
TCP	Transport Control Protocol
UDP	User Datagram Protocol
UHF	Ultra High Frequency
USA	United States of America
VHF	Very High Frequency

Acknowledgements

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The Task Group members who organized the workshop would like to thank the US Naval Research Laboratory, Washington, DC for agreeing to host the workshop. Special thanks are due to the staff of the Networks and Communication Systems Branch of the Information Technology Division, and in particular to its Branch Head Mr. Ray Cole and to Ms. BarbaraJo Cox, for their administrative and logistic support before and during the workshop.

Thanks are also due to the workshop participants for their enthusiastic participation and excellent presentations. A special word of thanks is due to the Keynote Speaker, Prof. Michael Pursley of Clemson University, whose presentation provided an excellent introduction to the issues and challenges associated with the cross-layer design of mobile wireless tactical communications networks.

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