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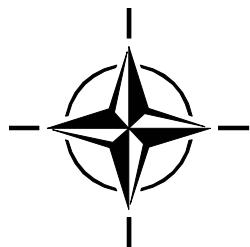
TR-IST-030-W1

Data Replication over Disadvantaged Tactical Communication Links

Technical Evaluation prepared by IST-030/RTG-012
(Information Management over Disadvantaged Grids)

of an Informal RTG-012 Workshop held at
DRDC – Valcartier, Québec City, Canada.

September 11-12, 2002



Published December 2007





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Authors: Dr. Allan Gibb, Dr. Heinz Faßbender

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 workshops. The objective of the first workshop, on ‘Data Replication over Disadvantaged Tactical Communication Links’, was to address the problem of data replication among distributed databases over wireless military communication networks. This report provides a technical evaluation of that workshop.

Operational benefits of new command and control systems based on digital technology are highly dependent upon the ability to exchange structured data of operational importance with the speed necessary to support operational tempo. In such systems, data are exchanged in one of two forms – structured messages or database transactions. The latter form can be more bandwidth-efficient because it propagates data changes only. It is implemented via a data replication mechanism. The term ‘replication’ refers to the systematic propagation and maintenance of copies of data between datastores within a distributed computing environment. Data replication middleware copies database transactions from a source database to multiple replicate databases. In the military context of the workshop, the databases in question are contained in computers located in stationary or mobile command headquarters, in military vehicles, or on dismounted soldiers, all operating forward of battalion. Each of these entities is considered a node on a military command and control network. The nodes communicate via a combat net radio, operating in either the VHF or UHF band. The combat net radio environment, when compared to wired networks, is characterized by low bandwidth (e.g., 1 – 80 kilobits per second), high and variable latency (delay), and intermittent connectivity.

A data replication service can be considered to consist of two basic components, a Replication Mechanism and a Replication Transport Layer. The Replication Mechanism is responsible to determine when replication is to occur and what data is to be replicated. It also packages data to be replicated and unpackages data that has been replicated. The Replication Transport Layer provides a transport mechanism for the purposes of passing replication data over the communications bearer. To be effective in the low bandwidth tactical wireless environment, the data replication and transport mechanisms must include intelligent information management protocols capable of adapting to the variable throughput of the radio network and to changing battlefield priorities. Adaptivity requires that the mechanisms must have dynamic awareness of the network state and battlefield state. This requirement is poorly addressed in existing replication mechanisms.

Two data distribution models were identified at the workshop. The “all-informed” model assumes that there is value in maintaining synchronized data content across all participating nodes on a subnetwork. A “selective” distribution model makes the opposite assumption, i.e., that only data relevant to a particular node should be sent to that node. All-informed distribution takes maximum advantage of the shared radio medium and may have some important operational advantages in a bandwidth-constrained tactical radio environment.

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List of Acronyms

ARDS ADM	Artillery Regimental Data System Advanced Development Model
ARM	ATCCIS Replication Mechanism
ATCCIS	Army Tactical Command and Control Information System
BER	Bit-Error Rate
C2	Command and Control
C2IEDM	Command and Control Information Exchange Data Model
C2IS	Command and Control Information System
DBMS	Database management system
DC	District of Columbia
DP	Data Provider
DR	Data Receiver
DRDC	Defence Research and Development Canada
FEC	Forward error correction
FGAN	Forschungsgesellschaft für Angewandte Naturwissenschaften
FKIE	Forschungsinstitut für Kommunikation, Informationsverarbeitung und Ergonomie
HQ	Headquarters
IP	Internet Protocol
ISO	International Standards Organisation
IST	Information Systems Technology
Kbps	Kilobits per second
LC2IEDM	Land Command and Control Information Exchange Data Model
LOS	Line of sight
Mbps	Megabits per second
MIP	Multilateral Interoperability Programme
MTIR	MIP Tactical C2IS Interoperability Requirement
MTU	Maximum Transmission Unit
NATO	North Atlantic Treaty Organisation
OSI	Open Systems Interconnection
OWG	Operational Working Group
PDU	Protocol Data Unit
RM	Replication mechanism
RTG	Research Task Group
RTL	Replication Transport Layer

TCP	Transport Control Protocol
TF	Transfer Facility
TCO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
UDP	User Datagram Protocol
UHF	Ultra High Frequency
VHF	Very High Frequency

Acknowledgements

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The Task Group members who organized the workshop would like to thank DRDC Valcartier for agreeing to host the workshop and the staff of the System of Systems Section, in particular Mr. Jean-Claude St-Jacques, 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, Dr. Sam Chamberlain of U.S. Army Research Laboratory, whose presentation provided an excellent introduction to the issues and challenges associated with replicating data over mobile wireless tactical communications networks.

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