

Integrating Directional Links with Omni-Directional Tactical MANET Stack: An Experimental Analysis



Titus Pottinger, Boeing IDS

Homayoun Yousefi'zadeh, Boeing IDS

Alex White, Agile Communications

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Statement of Work

- Objective:
 - Profile throughput and delay characteristics of a given topology after augmenting the bandwidth of OMNI directional tactical MANET with directional links
- Integration approach of directional capability:
 - Common Mobile Layer (CML) inserted between IP and link layers
 - Common Network Layer (CNL) at the IP layer
- Perform two phases of experiments:
 - Phase I: Moderate loads
 - Phase II: heavy loads

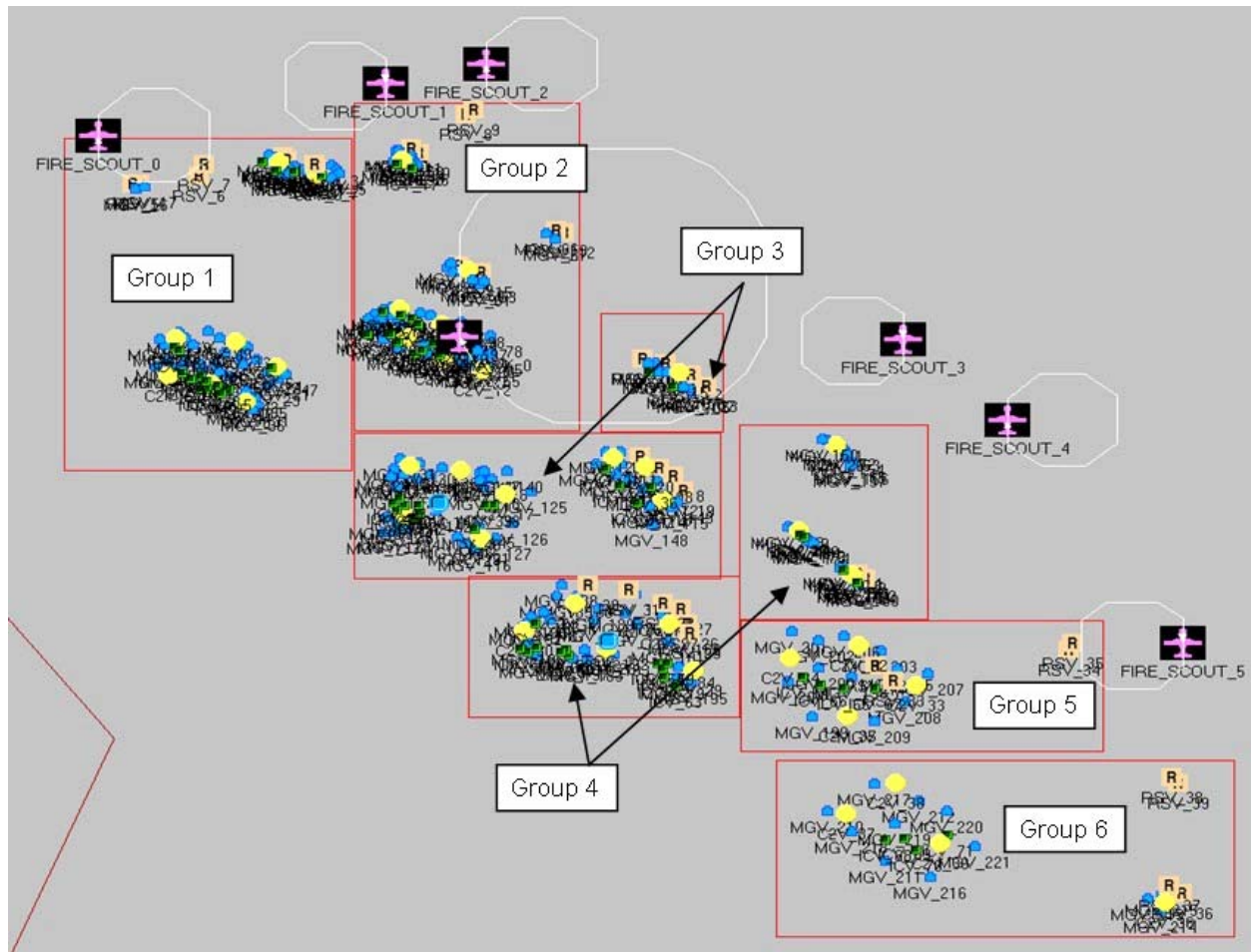
Routing Protocols

- ❑ MANET nodes operate over multiple frequency channels
- ❑ CNL routing: Operate OSPF and flooding link state updates through the subnet
 - One subnet for Omni Directional Links (ODL) and one subnet for Directional Links (DL)
- ❑ CML routing: Operate Hazy Sight Link State (HSLS) only within a subnet and R-OSPF among the subnets
 - Each node has full topology information about its own contiguous cluster sharing the same channel
 - Each node has abstracted topology information outside its cluster
 - One subnet covering both ODL and DL

Topology (1)

- ❑ The experimentation topology was developed based on a hypothetical ARMY CONOPS characterizing a Communications-On-The-Quick-Halt (COTQH) scenario
- ❑ The experimentation scenario incorporates one Unit of Action (UA) consisting of
 - 7 mobile UAVs providing directional capability
 - 383 stationary (aggregated) ground vehicles, each vehicle belonging to 6 battalion-sized groups
 - Operational area: 120 mi x 50 mi
 - Number of vehicles with directional capability was increased from 0% to 5%, 10%, 15%, and 20%

Topology (2)



DL-Equipped Platform Selection

% Directional Links	DL-Equipped Units	Quantity	
		DL	ODL
0% (Baseline)	None (All vehicles are ODL-only)	0	383
5%	Unmanned Aerial Vehicle (UAV)	7	334
	Tactical Operation Center (TOC)	2	
	Command Control Vehicles (C2V)	40	
	Total	49	
10%	Reconnaissance Surveillance Vehicles (RSV)	40	294
	Total	89	
15%	Infantry Carrier Vehicles (ICV)	36	258
	Total	125	
20%	Infantry Carrier Vehicles (ICV)	36	222
	Total	161	

Key Simulation Parameters

Parameters and Assumptions	ODL	DL
Link Bandwidth	1 Mbps	10 Mbps per connection
Carrier Frequency	1.8 GHz	38 GHz
Antenna Gain	3 dB (oblate spheroidal)	24 dB (directional)
Radio Tx Power	5W	5W
Buffer Size	2 MB	2 MB per connection
Mobile Layer Hop Cost	50	1-10
IP Routing	Static Routing Tables	
Transport Protocol	UDP for all applications	
Path Loss Calculation	TIREM (Longley-Rice)	

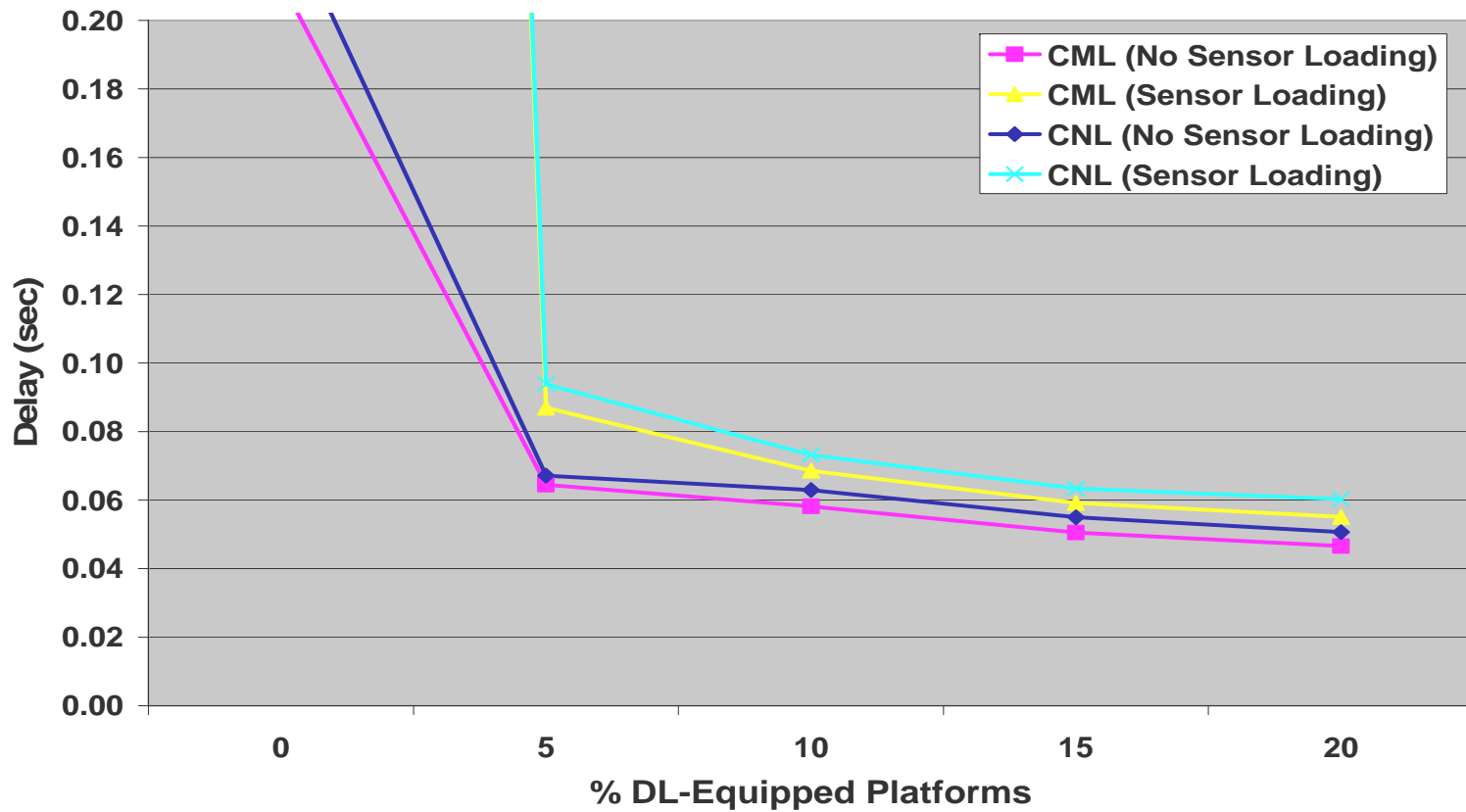
Phase I: Application Traffic Profile

Traffic Type	Application	Message Size	Aggregate Load
Sensor	Sensor Data	256 kB	20.2 Mbps
		128 kB	
	Video	2,048 kB	
	Processed Video	4,096 kB	
	Processed Imagery	2,048 kB	
	SAR Imagery	512 kB	
Non-Sensor	SA	40 bytes	3.2 Mbps
	Red SA	512 bytes	
	SA Dissemination	64 kB	
	Voice	32 kB	
	C2	4 kB	
	C2 Orders	512 kB	
		128 kB	

In Phase II all nodes were assigned the same traffic profile.

Phase I: CML and CNL Message Delays

Average End-to-End Delay of Non-Sensor Applications



Phase I: CML and CNL Comparison of Loads

DL-Equipped Platforms	ODL Average Throughput	
	CML	CNL
10% DL	2.78 Mbps	2.90 Mbps
15% DL	2.28 Mbps	2.48 Mbps
20% DL	2.00 Mbps	2.20 Mbps

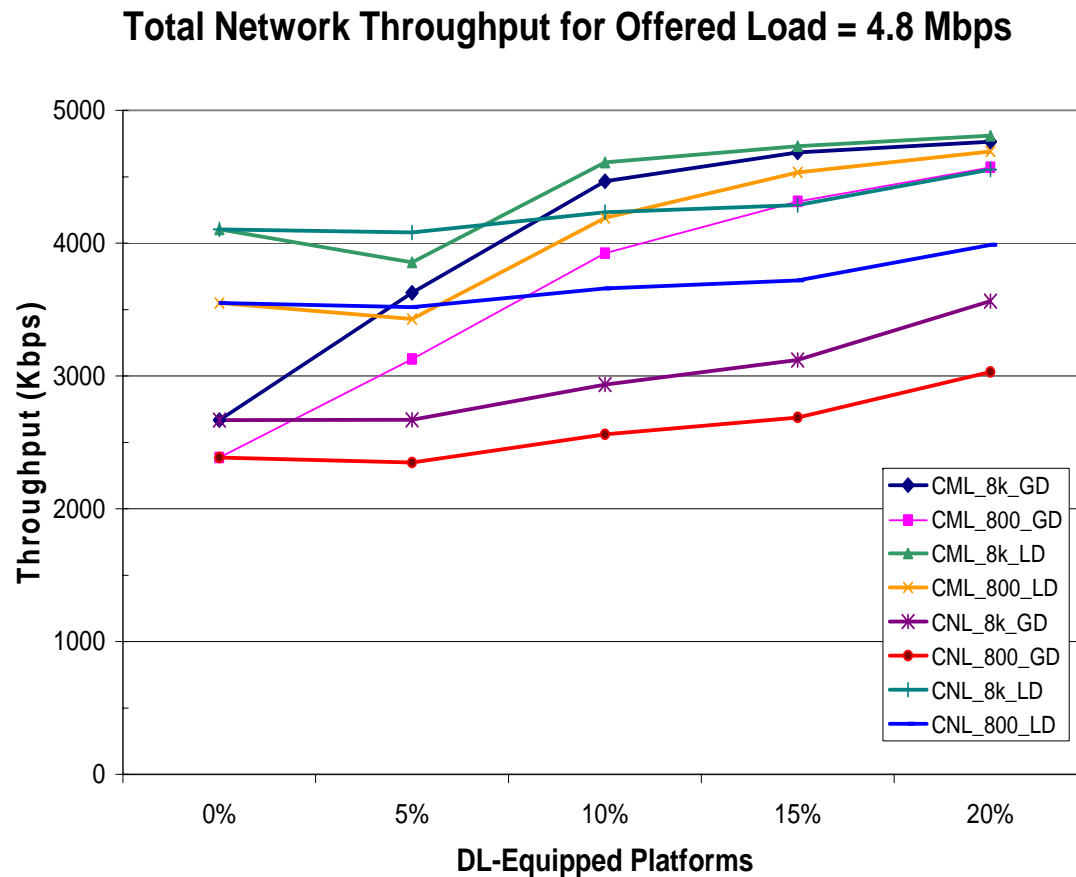
The aggregate load on ODL is roughly 10%-12% less for CML than CNL.

Phase II: CML and CNL Max Supported Load

DL%	0%	5%	10%	15%	20%
CML Global 8KB Msg	2.4 Mbps	3.6 Mbps	4.8 Mbps	4.8 Mbps	7.2 Mbps
CNL Global 8KB Msg	2.4 Mbps	2.4 Mbps	2.4 Mbps	2.4 Mbps	2.4 Mbps
CML Global 800B Msg	<2.4 Mbps	2.4 Mbps	3.6 Mbps	4.8 Mbps	4.8 Mbps
CNL Global 800B Msg	<2.4 Mbps	<2.4 Mbps	<2.4 Mbps	<2.4 Mbps	<2.4 Mbps
CML Local 8KB Msg	3.6 Mbps	3.6 Mbps	4.8 Mbps	4.8 Mbps	7.2 Mbps
CNL Local 8KB Msg	3.6 Mbps	3.6 Mbps	3.6 Mbps	4.8 Mbps	4.8 Mbps
CML Local 800B Msg	2.4 Mbps	2.4 Mbps	3.6 Mbps	4.8 Mbps	7.2 Mbps
CNL Local 800B Msg	2.4 Mbps	2.4 Mbps	2.4 Mbps	2.4 Mbps	3.6 Mbps

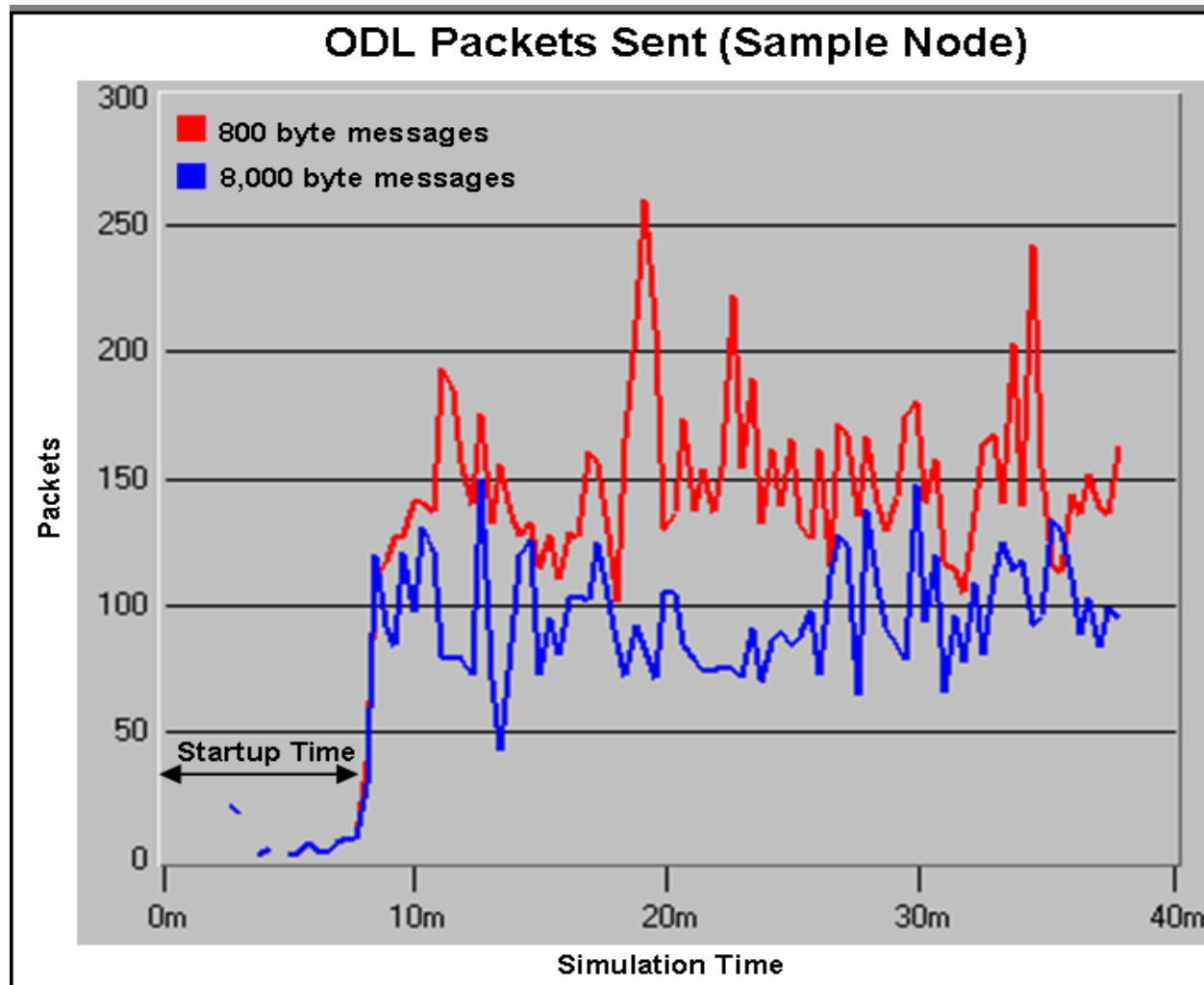
A minimum 90% completion rate was set as the threshold of supporting an offered load. There was one subnet in the case of CML and two subnets in the case of CNL.

Phase II: Throughput of CML and CNL



An offered load of 4.8Mbps has been used along with different combinations of message size and source-destination pair distributions.

Phase II :Per Minute ODL Packets Sent



Conclusion

- ❑ Our results indicated that CML integration provides significant throughput and delay improvements over CNL integration
- ❑ Based on our results, we concluded that the modified stack represents a better alternative than the standard stack for use with military programs such as JTRS GMR and FCS.

Thank You!



Questions:

hyousefi@uci.edu