Dynamic mesh networks/ Dynamic ad hoc networks

Mathematical modeling of dynamic ad hoc networks [1]

Routing overhead: $M > M_{threshold}$, $\Omega_P(M) > \Omega_R(M) \geq 0$ (5.1.3)

$\Omega_P(M, N) \geq \Omega_R(M, N)$ (5.7.1)

End-to-end delay: $M > M_{threshold}$, $D_P(M) > D_R(M) \geq 0$ (5.2.3)

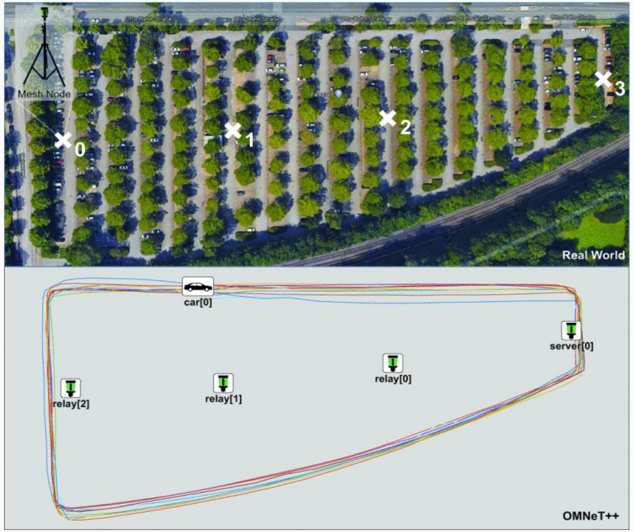
Package loss: $M > M_{threshold}$, $L_P(M) > L_R(M) > 0$ (5.3.3)

Optimal routes: $\Pi_P(M) > \Pi_R(M)$ (5.5.1)

Study 1 - Setup [2]

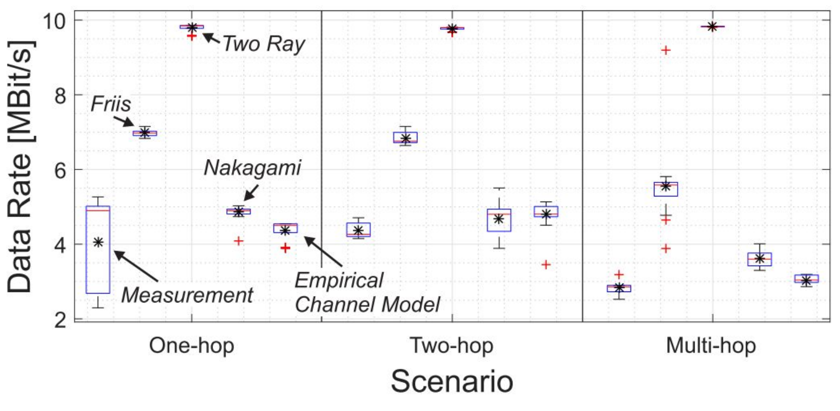
Parameter	Value
MAC	IEEE 802.11g
Channel model: Rural / Urban	{Friis, Nakagami (m=2)}
Path loss exponent η	2.65
Receiver sensitivity	-83 dBm
Transmission power	$\{10, 20\}$ dBm
Carrier frequency	2.4 GHz
Number of mesh nodes	10
Stream data rate	10 MBit/s
Simulation duration per run	300 s
Simulation runs per setting	25
Playground size: Generic scenario	600 m x 600 m x 10 m
Playground size: UAV scenario	500 m x 500 m x 250 m
Playground size: Vehicular scenario	1500 m x 1000 m x 10 m
B.A.T.M.A.N. version	2018.0
OMNeT++/ INET version	5.2.1 / 3.6.3
OGM interval	0.33 s
ELP interval	0.2 s
Weighting exponent α: Rural / Urban	$\{1, 2\}$
Prediction lookahead τ: Rural / Urban	$\{3, 4\}$ s

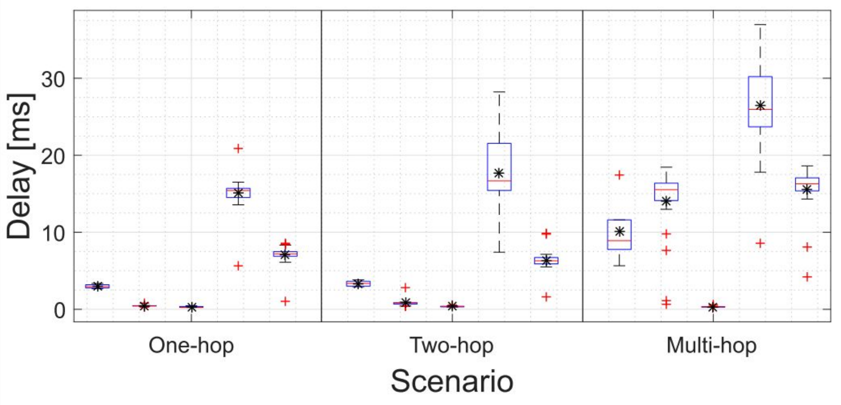
Simulation parameter in the study



Overview of the field test scenario

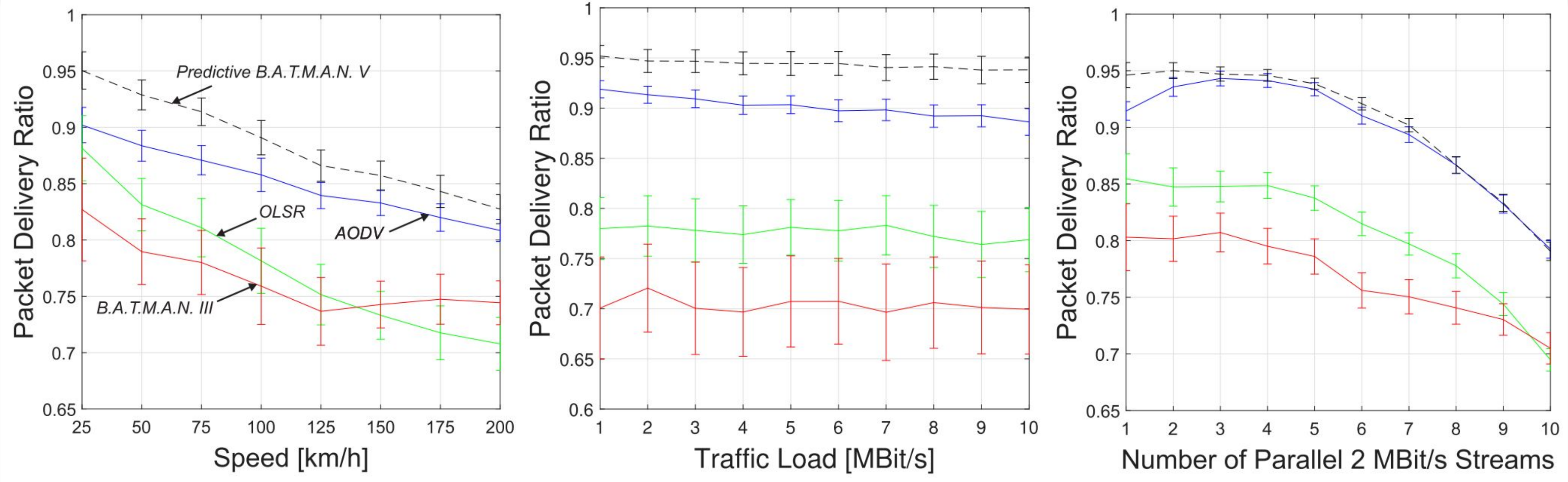
Study 1 - Result [2]





Model validation: Comparison of measurements for data rate and delay with simulation results using different channel models

Study 1 - Result [2] cont.

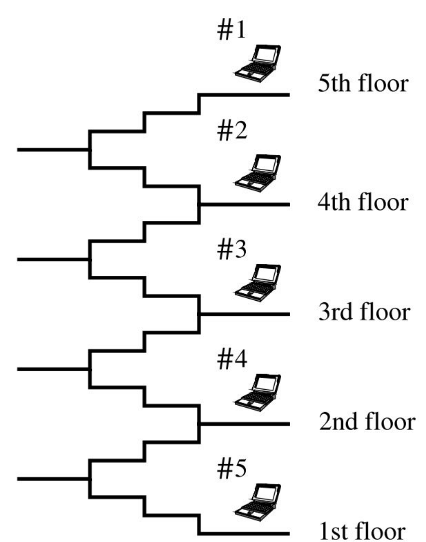


Scalability analysis: Comparison of the resulting PDR with respect to vehicle speed, traffic load and number of streams

Study 2 - Setup [3]

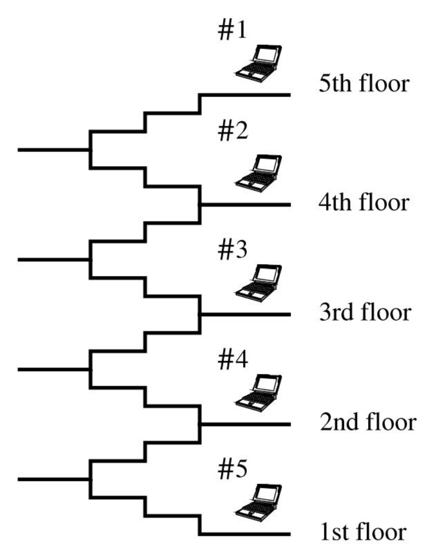
Parameters	Values
Number of nodes	5
MAC	IEEE 802.11b/Channel 2
Transmitted power	16 + / − 1 dBm
Flow type	CBR
Packet rate	200 pps
Packet size	256 bytes
Number of trials	10
Duration	150 s
Routing protocol	OLSR, BATMAN

Simulation parameter in the study

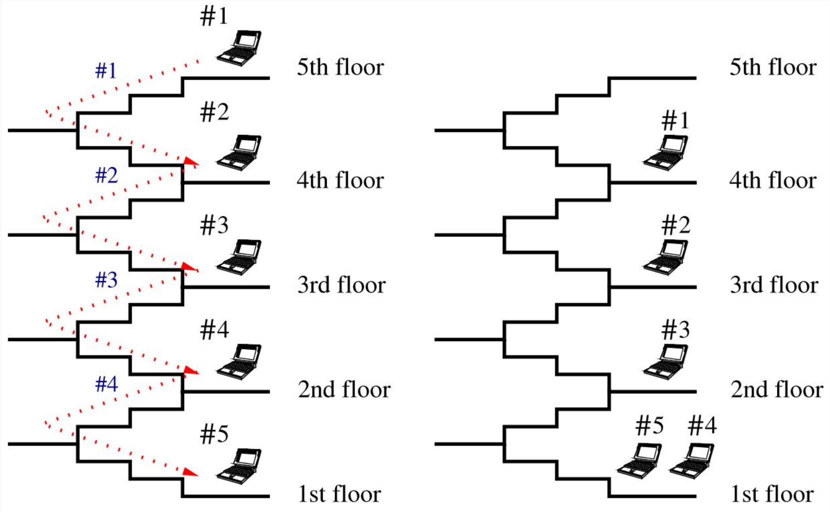


Overview of the field test scenario

Study 2 - Setup [3] cont.



Static - “STAR” scenario



(b) Node movement. (c) Final position.

Dynamic - “SHIS” scenario

Study 2 - Result [3]

Average throughput (kb/s).

Flow	Floor	STAS scenario		SHIS scenario	
		OLSR	BATMAN	OLSR	BATMAN
#1 → #2	4th	409.6000	409.6000	409.5904	409.2450
#1 → #3	3rd	409.5304	407.2257	391.7681	345.1153
#1 → #4	2nd	232.4234	184.5043	166.2921	132.5324
#1 → #5	1st	112.7911	76.7847	63.4341	146.5412

Average delay (s).

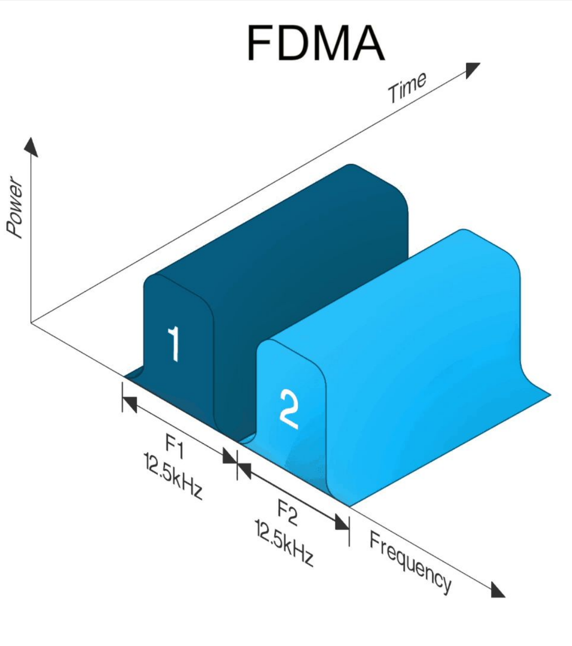
Flow	Floor	STAS scenario		SHIS scenario	
		OLSR	BATMAN	OLSR	BATMAN
#1 → #2	4th	0.0045	0.0198	0.0209	0.0241
#1 → #3	3rd	0.0210	0.0885	0.4754	0.7207
#1 → #4	2nd	1.3185	2.6800	2.6742	3.6724
#1 → #5	1st	1.6403	4.0517	3.5424	4.4339

Average packet loss (pps).

Flow	Floor	STAS scenario		SHIS scenario	
		OLSR	BATMAN	OLSR	BATMAN
#1 → #2	4th	0.0063	0	0.0133	0.0867
#1 → #3	3rd	0.0170	0.4703	3.5033	10.7967
#1 → #4	2nd	18.5473	17.5783	29.8418	23.0733
#1 → #5	1st	35.0030	38.7510	25.5562	18.8267

Frequency-division multiple access (FDMA) [4]

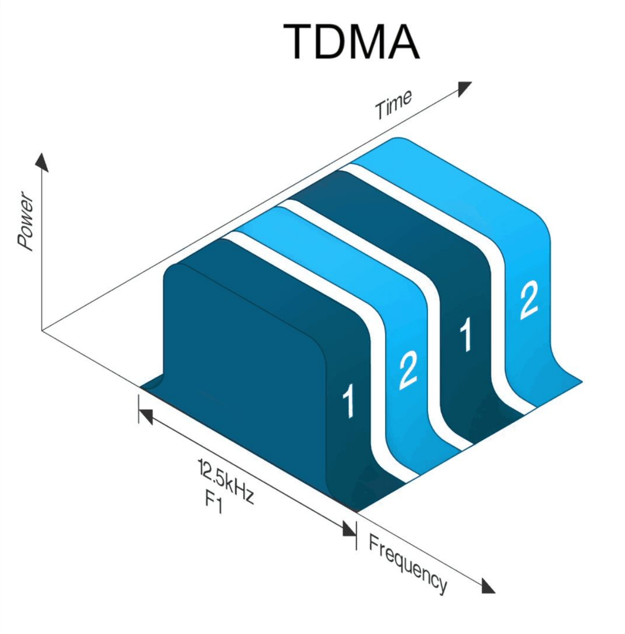
The RF (radio frequency) channel is split into several smaller sub-channels.



Time-division multiple access (TDMA) [4]

Instead of splitting the original RF channel into two RF sub-channels, it is instead split into time slots.

The transmitted RF frequency is identical in each slot, but each slot is still capable of carrying a separate conversation.



FDMA vs. TDMA [5,6,7]

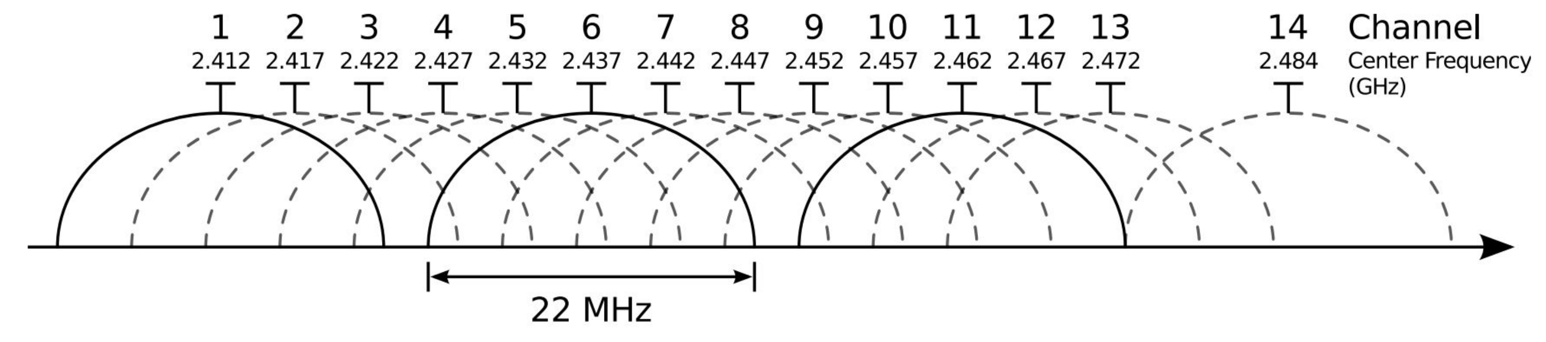
	Pro	Con
TDMA	Efficient for a large number of nodes Higher channel utilization Efficient reuse of the available bandwidth	Not continuous transmission Possible collision
FDMA	Separate bands + continuous transmission Efficient for constant traffic & fewer nodes	Frequencies are (semi)permanently allocated Wastes frequency resources Less effective for changing traffic & more nodes Need receiver/transmitter for each frequency

IEEE 802.11 Wireless Network Standard [8]

14 channels

Channel 1, 6, 11 are used since no overlap

22MHz width



B.A.T.M.A.N

- Batman defaults use as single channel TDM however it can be configured with more channels
- Batman-adv proactive OLSR network good for low node count

Metrics

- Frame Delay vs Number of Hops
- Minimizing hop size

Reference

[1] J. Costa-Requena, "Ad Hoc Routing Modeling and Mathematical Analysis," in *Mobile Ad Hoc Networks - Current Status and Future Trends*. Boca Raton, Florida: Taylor & Francis Group, 2012, ch. 5, pp. 103–148. [Online]. doi:10.1201/b11447

[2] B. Sliwa, S. Falten, and C. Wietfeld, "Performance evaluation and optimization of B.A.T.M.A.N. v routing for aerial and ground-based mobile ad-hoc networks," *IEEE Veh. Technol. Conf.*, vol. 2019-April, pp. 1–7, 2019.

[3] E. Kulla, M. Hiyama, M. Ikeda, and L. Barolli, "Performance comparison of OLSR and BATMAN routing protocols by a MANET testbed in stairs environment," *Comput. Math. with Appl.*, vol. 63, no. 2, pp. 339–349, 2012.

[4] "Channel Sharing Explained: FDMA, TDMA and CDMA". (October 9, 2012). [Blog] Tait Communications. Available at: https://blog.taitradio.com/2012/10/09/channel-sharing-explained-fdma-tdma-and-cdma/ [Accessed 21 Nov. 2019].

[5] Office of Research, "System and Method for Ad Hoc Network Access Employing the Distributed Election of a Shared Transmission Schedule". University of California, Santa Cruz. [Online]. Available at: https://techtransfer.universityofcalifornia.edu/NCD/10196.html [Accessed 21 Nov. 2019].

[6] Icom America, "Key Differences between FDMA vs. TDMA Technology". (December 2, 2014). [Blog] Icom America. Available at: https://blog.icomamerica.com/2014/12/02/key-differences-between-fdma-vs-tdma-technology/ [Accessed 21 Nov. 2019].

[7] Office of Research, "Advantages and Disadvantages of TDMA and FDMA". RF Wireless World. [Online]. Available at: https://techtransfer.universityofcalifornia.edu/NCD/10196.html [Accessed 21 Nov. 2019].

[8] M. Hundebøll, J. Ledet-Pedersen. "Inter-Flow Network Coding for Wireless Mesh Networks," 2011, Aalborg University: Aalborg, Denmark.