Energy Affluent Mobile Ad-Hoc Networks

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August 20, 2011

Abstract

A Mobile Ad-Hoc Network (MANET) is a network of moving nodes that without human intervention can crate its own topology and ensure successful routing of messages between nodes.

In this thesis I will give an overview of the elements required to create a MANET and several already existing solutions that fulfil these requirements.

Furthermore, I will give a performance evaluation of my own implementation of the GOAFR algorithm [23] compared to several other algorithms. I will also perform a comparison between the average distance of two nodes in randomly generated non-planar graphs, compared to the Gabriel Graph (GG) [10, 28] and the Relative Neighbourhood Graph (RNG) [33], compared to the average number of neighbours in the graph.

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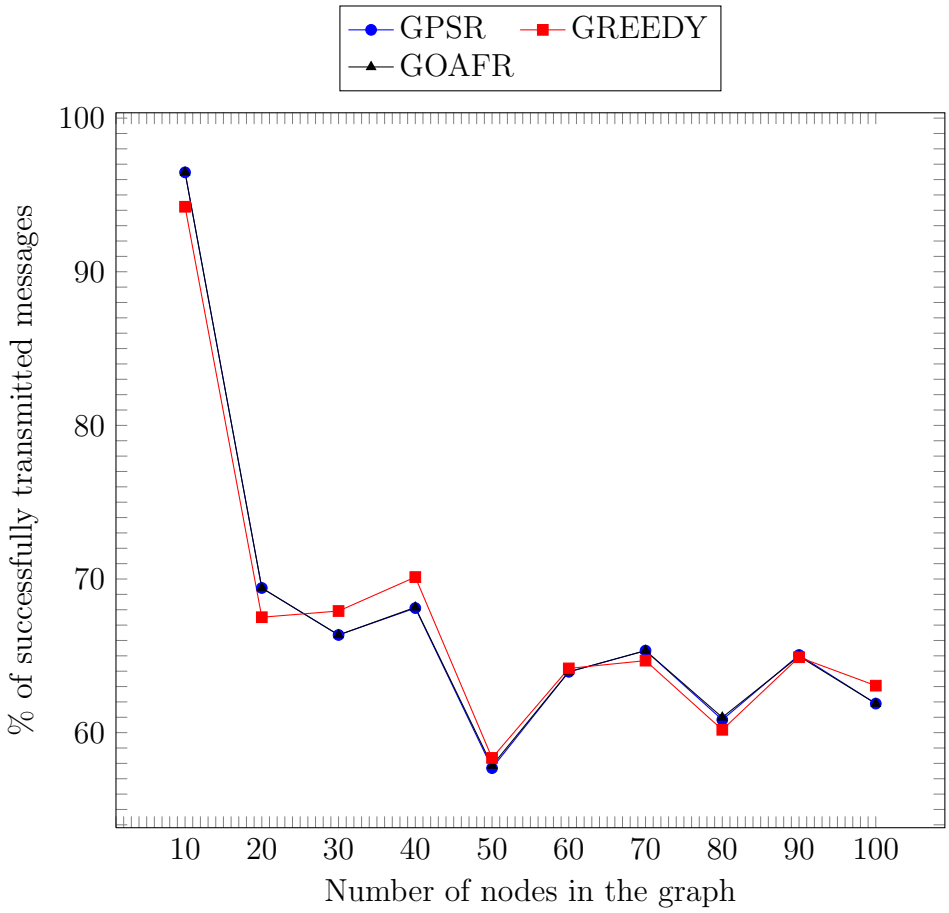

Figure 1: test

A Appendix

A.1 Limited-range spanner distance results

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
Eucldian Distance	NML	2028995.47	40.58	87.23	3.74	20.54
	GG	2225467.95	44.51	95.82	3.80	22.52
	RNG	2556437.92	51.13	110.35	3.84	26.27
Unit Distance	NML	140168	2.80	5.81	1.00	1.33
	GG	248359	4.97	10.67	1.00	2.46
	RNG	322897	6.46	13.94	1.01	3.28

		Distance:	Unit Distance:		# Missing paths
Percentage compared to the normal graph	NML	100.00 %	100.00 %	NML	0
	GG	109.68 %	177.19 %	GG	0
	RNG	126.00 %	230.36 %	RNG	0

# Connected Components:	1.078

Table 1: The distance results for 50 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	2843864.90	56.88	120.69	5.07	27.67
Eucldian Distance	GG	3111039.29	62.22	131.66	5.25	30.15
	RNG	3555742.22	71.11	151.05	5.44	34.61
	NML	190687	3.81	7.90	1.00	1.77
Unit Distance	GG	339200	6.78	14.27	1.04	3.21
	RNG	443490	8.87	18.80	1.09	4.26

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	109.39 %	177.88 %	GG	0
normal graph	RNG	125.03 %	232.57 %	RNG	0

# Connected Components:	1.084

Table 2: The distance results for 100 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	4417569.54	88.35	186.93	7.80	42.02
Eucldian Distance	GG	4815616.44	96.31	202.88	8.28	45.57
	RNG	5468182.38	109.36	229.61	8.91	51.47
	NML	287706	5.75	11.89	1.00	2.63
Unit Distance	GG	507061	10.14	21.13	1.23	4.64
	RNG	670397	13.41	28.02	1.45	6.20

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	109.01 %	176.24 %	GG	0
normal graph	RNG	123.78 %	233.01 %	RNG	0

# Connected Components:	1.096

Table 3: The distance results for 250 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	6273997.77	125.48	263.96	12.07	58.93
Eucldian Distance	GG	6811420.32	136.23	285.41	13.16	63.60
	RNG	7693137.02	153.86	320.84	14.61	71.18
	NML	401448	8.03	16.55	1.11	3.65
Unit Distance	GG	696197	13.92	28.71	1.66	6.27
	RNG	921640	18.43	38.18	2.02	8.33

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	108.57 %	173.42 %	GG	0
normal graph	RNG	122.62 %	229.58 %	RNG	0

# Connected Components:	1.134

Table 4: The distance results for 500 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	8769730.56	175.39	369.88	16.58	82.56
Eucldian Distance	GG	9504069.51	190.08	399.69	18.13	89.02
	RNG	10682855.03	213.66	447.23	20.58	99.12
	NML	553064	11.06	22.88	1.33	5.06
Unit Distance	GG	955784	19.12	39.41	2.19	8.63
	RNG	1265833	25.32	52.28	2.77	11.44

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	108.37 %	172.82 %	GG	0
normal graph	RNG	121.82 %	228.88 %	RNG	0

# Connected Components:	1.136

Table 5: The distance results for 1000 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	13674233.94	273.48	575.30	26.58	128.40
Eucldian Distance	GG	14773056.90	295.46	619.76	29.17	138.14
	RNG	16520167.71	330.40	689.07	33.35	153.05
	NML	850137	17.00	35.26	1.94	7.80
Unit Distance	GG	1452255	29.05	59.84	3.33	13.16
	RNG	1922688	38.45	79.21	4.33	17.40

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	108.04 %	170.83 %	GG	0
normal graph	RNG	120.81 %	226.16 %	RNG	0

# Connected Components:	1.198

Table 6: The distance results for 2500 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	19298656.69	385.97	817.69	38.67	182.23
Eucldian Distance	GG	20814836.25	416.30	880.48	42.49	195.82
	RNG	23201190.73	464.02	976.18	48.45	216.53
	NML	1189019	23.78	49.70	2.63	11.01
Unit Distance	GG	2018675	40.37	84.16	4.65	18.47
	RNG	2674346	53.49	111.21	6.09	24.43

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	107.86 %	169.78 %	GG	0
normal graph	RNG	120.22 %	224.92 %	RNG	0

# Connected Components:	1.244

Table 7: The distance results for 5000 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	23517511.18	470.35	992.48	47.83	221.32
Eucldian Distance	GG	25338291.02	506.77	1067.82	52.25	237.67
	RNG	28200744.98	564.01	1182.81	59.64	262.70
	NML	1443294	28.87	60.19	3.21	13.35
Unit Distance	GG	2441861	48.84	101.50	5.69	22.31
	RNG	3231995	64.64	133.99	7.41	29.49

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	107.74 %	169.19 %	GG	0
normal graph	RNG	119.91 %	223.93 %	RNG	0

# Connected Components:	1.356

Table 8: The distance results for 7500 nodes

		Length of graph:	Avg node-pair	Max node-pair:	Min node-pair:	Std Deviation:
	NML	27229847.01	544.60	1150.55	54.05	256.45
Eucldian Distance	GG	29322041.31	586.44	1236.26	59.32	275.21
	RNG	32590894.46	651.82	1369.27	67.47	303.88
	NML	1666688	33.33	69.71	3.58	15.45
Unit Distance	GG	2811085	56.22	116.92	6.44	25.74
	RNG	3720550	74.41	154.50	8.41	34.00

		Distance:	Unit Distance:		# Missing paths
Percentage	NML	100.00 %	100.00 %	NML	0
compared to the	GG	107.68 %	168.66 %	GG	0
normal graph	RNG	119.69 %	223.23 %	RNG	0

# Connected Components:	1.386

Table 9: The distance results for 10000 nodes

A.2 Limited-range spanner neighbour results

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
Neighbours	NML	9.26	15.99	2.24	0.86
	GG	3.19	5.76	1.06	0.20
	RNG	2.31	3.83	1.00	0.09

Table 10: The neighbour results for 50 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	10.20	18.42	2.19	0.60
Neighbours	GG	3.33	6.23	1.01	0.16
	RNG	2.39	4.01	0.96	0.07

Table 11: The neighbour results for 100 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	11.09	20.93	1.88	0.38
Neighbours	GG	3.48	6.77	0.96	0.10
	RNG	2.46	4.11	0.95	0.05

Table 12: The neighbour results for 250 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	11.47	22.26	1.63	0.26
Neighbours	GG	3.57	7.19	0.92	0.07
	RNG	2.50	4.21	0.92	0.03

Table 13: The neighbour results for 500 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	11.84	23.71	1.50	0.19
Neighbours	GG	3.62	7.44	0.92	0.05
	RNG	2.52	4.43	0.92	0.02

Table 14: The neighbour results for 1000 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	12.08	25.30	1.28	0.11
Neighbours	GG	3.67	7.86	0.88	0.03
	RNG	2.55	4.80	0.88	0.01

Table 15: The neighbour results for 2500 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	12.23	26.26	1.06	0.07
Neighbours	GG	3.69	8.16	0.85	0.02
	RNG	2.56	4.95	0.85	0.01

Table 16: The neighbour results for 5000 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	12.28	26.84	0.98	0.06
Neighbours	GG	3.70	8.26	0.80	0.02
	RNG	2.57	5.01	0.80	0.01

Table 17: The neighbour results for 7500 nodes

		Avg Neighbours	Max Neighbours	Min Neighbours	Std. Deviation
	NML	12.32	27.28	0.88	0.05
Neighbours	GG	3.71	8.38	0.77	0.02
	RNG	2.57	5.02	0.77	0.01

Table 18: The neighbour results for 10000 nodes

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