MIT Roofnet Performance

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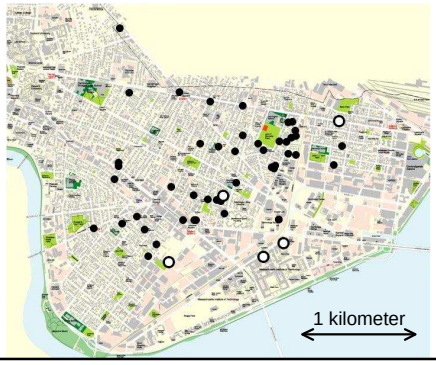
http://pdos.lcs.mit.edu/roofnet

Roofnet node map



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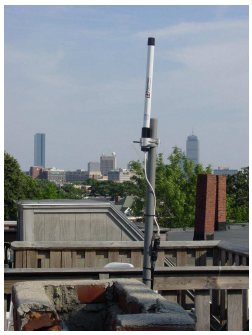
Typical rooftop view



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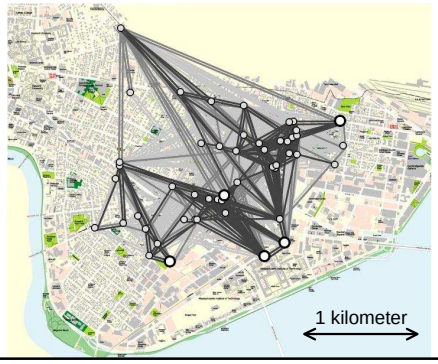
Roofnet radio links



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A Roofnet Self-Installation Kit

Antenna ($65)
8dBi, 20 degree vertical

Computer ($340)
533 MHz PC, hard disk, CDROM

802.11b card ($155)
Engenius Prism 2.5, 200mW

50 ft. Cable ($40)
Low loss (3dB/100ft)

Miscellaneous ($75)
Chimney Mount, Lightning Arrestor, etc.

Software ("free")
Our networking software based on Click

Total: $685

Takes a user about 45 minutes to install on a flat roof

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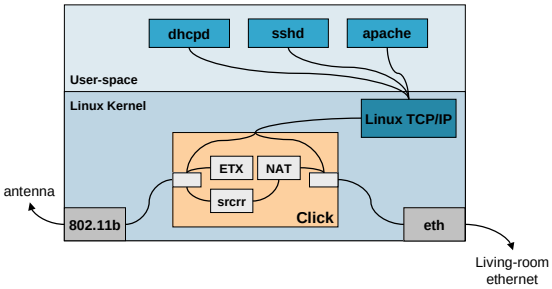
Roofnet Node Software



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Basic Roofnet performance

Hops	# of Pairs	Avg TCP Kilobits/sec	Latency ms
1	179	2528	12
2	354	784	22
3	354	368	39
4	256	272	44
5	127	216	61
6	43	248	81
7	38	184	72
8	17	168	98
9	6	152	121

- High TCP throughput even w/ many hops
- Why is 2-hop b/w less than half 1-hop b/w?

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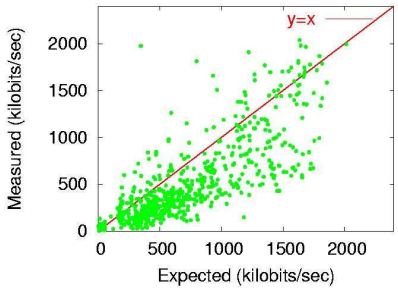
Multi-hop collisions cut b/w by about 2x



- x-axis: expected multi-hop b/w based on single-hop b/w
- y-axis: actual Roofnet b/w is often much lower

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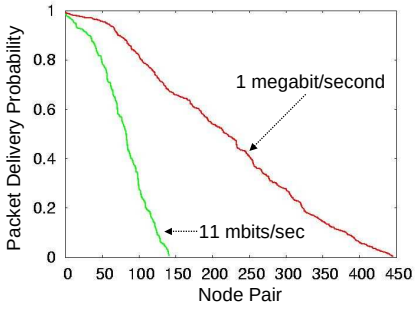
Roofnet link quality distribution



- Why do most links have intermediate loss rates?

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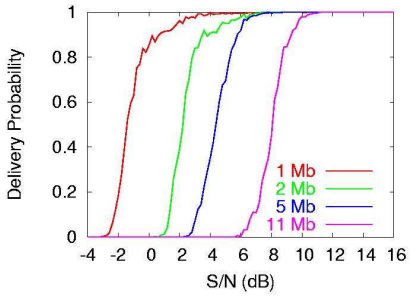
S/N vs loss w/ cable + attenuator



- In principle, the intermediate-loss S/N region is narrow

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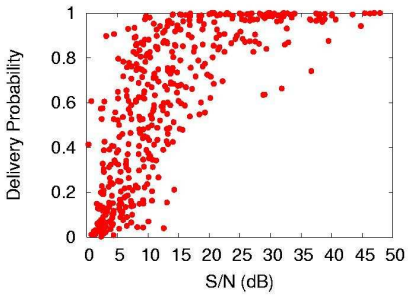
S/N vs loss for Roofnet links



- Roofnet loss rates cannot be explained by S/N

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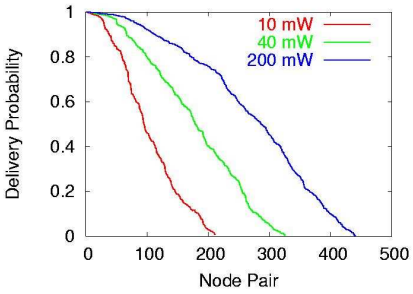
Effect of transmit power level on Roofnet



- Higher tx power increases radio "range"
- Increase in # of links between $1/r^2$ and $1/r^3$

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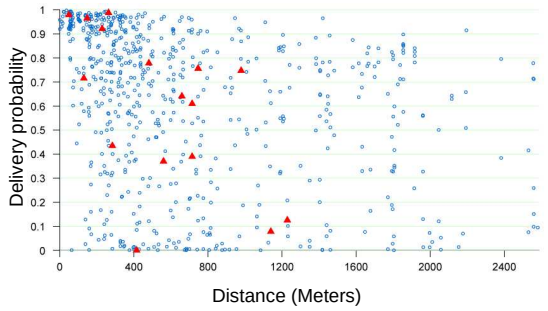
What is a typical radio range?



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Would a less-dense mesh work?

Nodes	Connectivity	Avg TCP Kilobits/sec	Hop Count
4	17%	16	1.3
9	50%	80	2.2
14	95%	144	3.0
19	100%	224	3.5
24	100%	256	3.5
29	100%	256	3.2
34	100%	320	3.3

- Roofnet is about twice as dense as it needs to be
- Higher densities provide higher throughput

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Mesh versus access points

APs or gateways	AP throughput	AP connections	Mesh throughput
1	160	25	952
2	688	34	1616
3	864	38	1880
4	1144	40	2096
5	1152	41	2040
6	1608	41	2184
7	1856	41	2296

- 5 APs are required for full connectivity
- *N* mesh gateways give higher throughput than *N* APs

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Conclusions

- **Roofnet provides Internet access to 40+ users**
- **Even 9-hop routes average 150 kilobits/second**
- **Radio range up to 2km**
- **Hard to beat mesh performance w/ access points**
- **Multi-hop packet loss costs about a factor of two**

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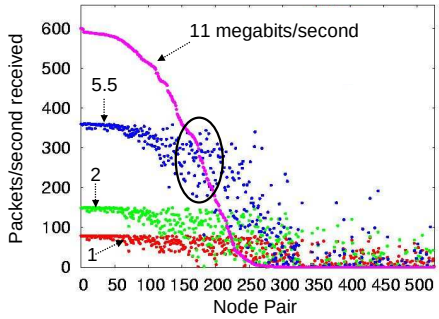
Transmit bit-rate choice



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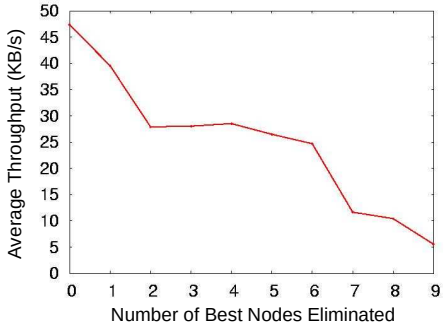
How reliant on the “best” nodes?



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