

# Objectives

- Find the best practices of using open access points for Internet access
- Require no changes on the APs
- Study the ways of increasing duration of link layer connectivity
- Study the ways of extending the usable range of the APs via non-interfering V2V networks

# Some of the measured facts

Region	Area (km <sup>2</sup> )	Access Points	Density (APs/km <sup>2</sup> )
U.S.	9,166,600	5,615,451	0.6
Las Vegas	240	26,069	109
Kansas City	270	29,438	109
Atlanta	460	65,364	142
San Francisco	213	69,502	326
Seattle	165	64,923	395
Boston	225	164,072	729
Manhattan	105	194,651	1,854

[1] Kipp Jones and Ling Liu. ``What Where Wi: An Analysis of Millions of WiFi Access Points'', To appear in Proceedings of 2007 IEEE Portable: International Conference on Portable Information Devices. Orlando, FL, March 25-29

Type of connectivity	Mean (sec)	Std. dev.(sec)
End-to-end conn.	260	642
Local IP conn.	162	447
Successful assoc.	75	300
Assoc. attempts	23	151

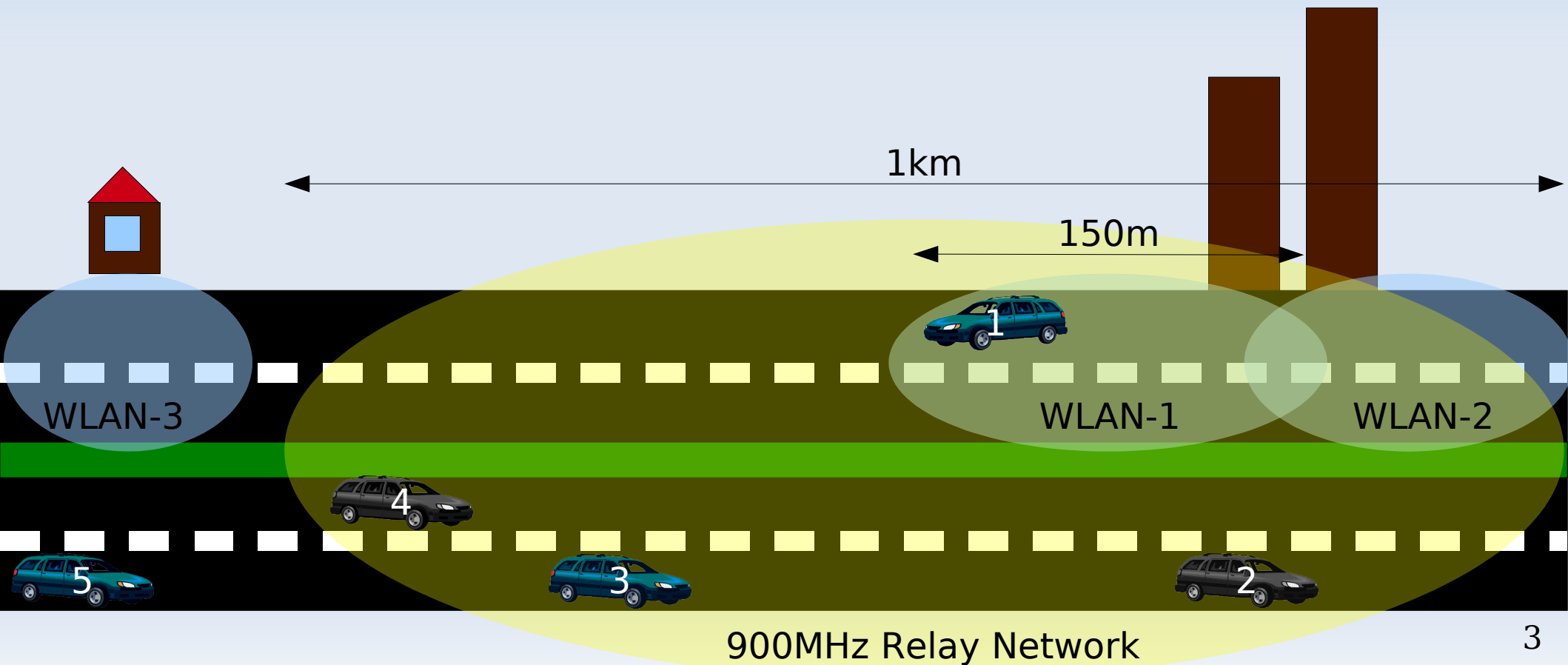
With a simple caching optimization to speed-up IP address acquisition, we find that for our driving patterns the median duration of link-layer connectivity at vehicular speeds is 13 seconds, the median connection upload bandwidth is 30 KBytes/s, and that the mean duration between successful associations to APs is 75 seconds. We also find that connections are equally probable across a range of urban speeds (up to 60 km/hour in our measurements). Our end-to-end TCP upload experiments had a median throughput of about 30 KBytes/s, which is consistent with typical uplink speeds of home broadband links in the US. The median TCP connection is capable of uploading about 216 KBytes of data.

[2] Vladimir Bychkovsky, Bret Hull, Allen K. Miu, Hari Balakrishnan, Samuel Madden, ``A Measurement Study of Vehicular Internet Access Using In Situ Wi-Fi Networks'', 12th ACM MOBICOM Conf., Los Angeles, CA, September 2006

# Extending Range of Open WLANs through relaying at 900Mhz

Cars Equipped with

- One best of breed a/b/g WiFi radio (Ubiquiti XR2)
- One 900Mhz WiFi radio (Ubiquiti SR9)



# Simple relaying strategies

- No multi-hopping (no routing) over 900MHz relays
- Each relay emits heartbeats (e.g. of period 1-sec) whenever it has usable connection to an open WLAN
- Cars maintain an SNR-ordered preference list for available 900MHz relays
- Each car prefers its own direct WLAN connection over a 900MHz relay