PENNSTATE

IP Address Passing

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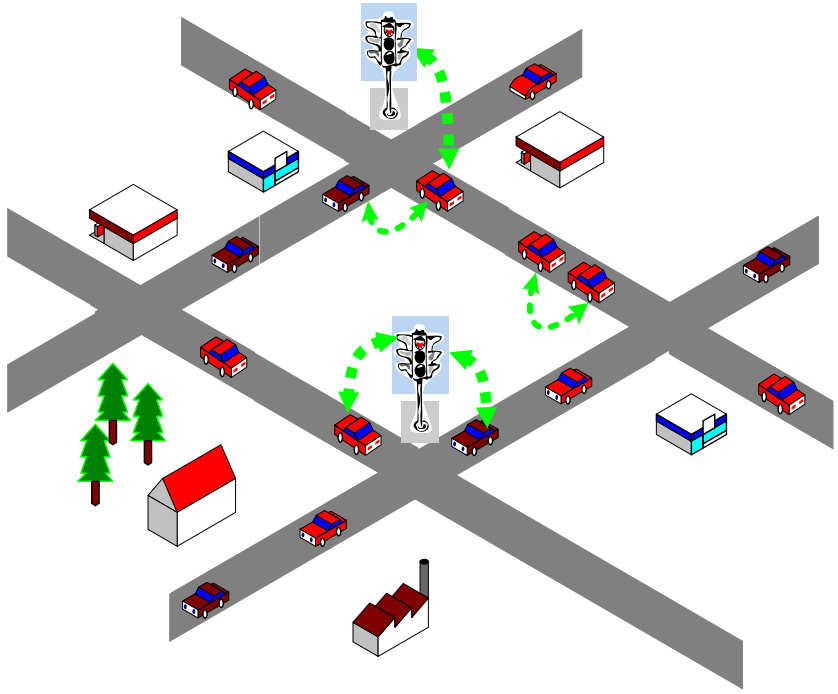
The Big Picture

- Vehicular ad hoc networks - VANET
  - Moving vehicles
  - Roadside Access Points (AP)
  - CarTel Project or Infostation
- Services
  - Traditional Internet access
  - Updated traffic information
  - Driving pattern analyses
- Challenges
  - Mobility of clients
  - Intermittent connectivity



802.11 Connection Process

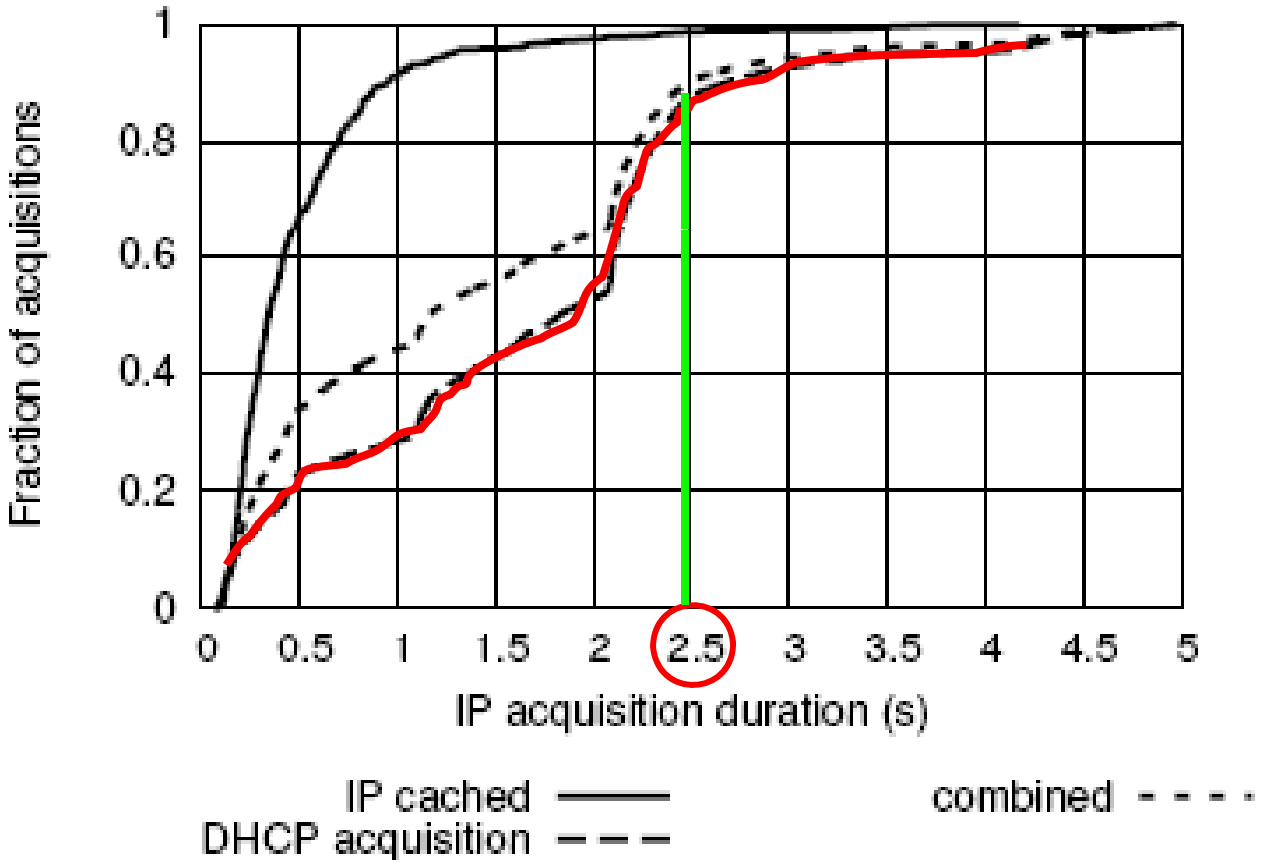
- Client associates with the AP
- Client requests DHCP
- Challenge in VANETs
  - Connection time very short
  - Small delays reduce overall connectivity

QuickTime?and a
TIFF (LZW) decompressor
are needed to see this picture.

Issues

- Length of association time related to distance from AP
- DHCP Requests require a large amount of time
- Long association delay identified in:
  - V. Bychkovsky et. al, “A measurement study of vehicular Internet access using in situ wi-fi networks.” MobiCom ‘06
  - J. Ott and D. Kutscher, “Drive-thru Internet:IEEE 802.11b for ”Automobile” Users,” INFOCOM, 2004.
  - D. Hadaller, S. Keshav, T. Brecht, and S. Agarwal, “Vehicular Opportunistic Communication Under the Microscope,” ACM MobiSys 2007

DHCP Conclusions



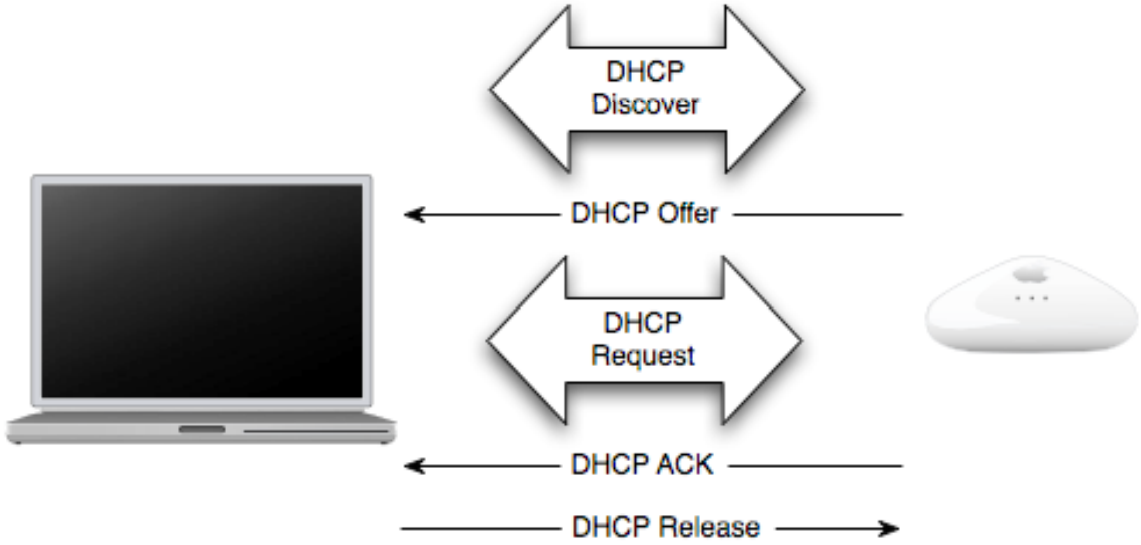
From CarTEL Project, V. Bychkovsky et. al

Goals

- Determine the source of the delay
- Determine whether the delay can be reduced to improve performance

DHCP

- RFC 2131
- Client - Server model
- Requires exchange of 4 messages to complete



Observed DHCP Activity

- DHCP capture on Linksys AP

Packet #	Elapsed Time	Source	Destination	Protocol	Bytes	Information
1	0	0.0.0.0	255.255.255.255	DHCP	428	DHCP Discover - Transaction ID 0x4c08f26e
2	0.059079	00:18:39:ea:5f:02	Broadcast	ARP	128	Who has 192.168.1.100? Tell 192.168.1.1
3	1.078637	00:18:39:ea:5f:02	Broadcast	ARP	128	Who has 192.168.1.100? Tell 192.168.1.1
4	1.999697	00:18:39:ea:5f:02	Broadcast	ARP	128	Who has 192.168.1.100? Tell 192.168.1.1
5	2.495476	192.168.1.1	192.168.1.100	DHCP	428	DHCP Offer - Transaction ID 0x4c08f26e
6	2.497751	0.0.0.0	255.255.255.255	DHCP	428	DHCP Request - Transaction ID 0x4c08f26e
7	2.504289	192.168.1.1	192.168.1.100	DHCP	428	DHCP ACK - Transaction ID 0x4c08f26e

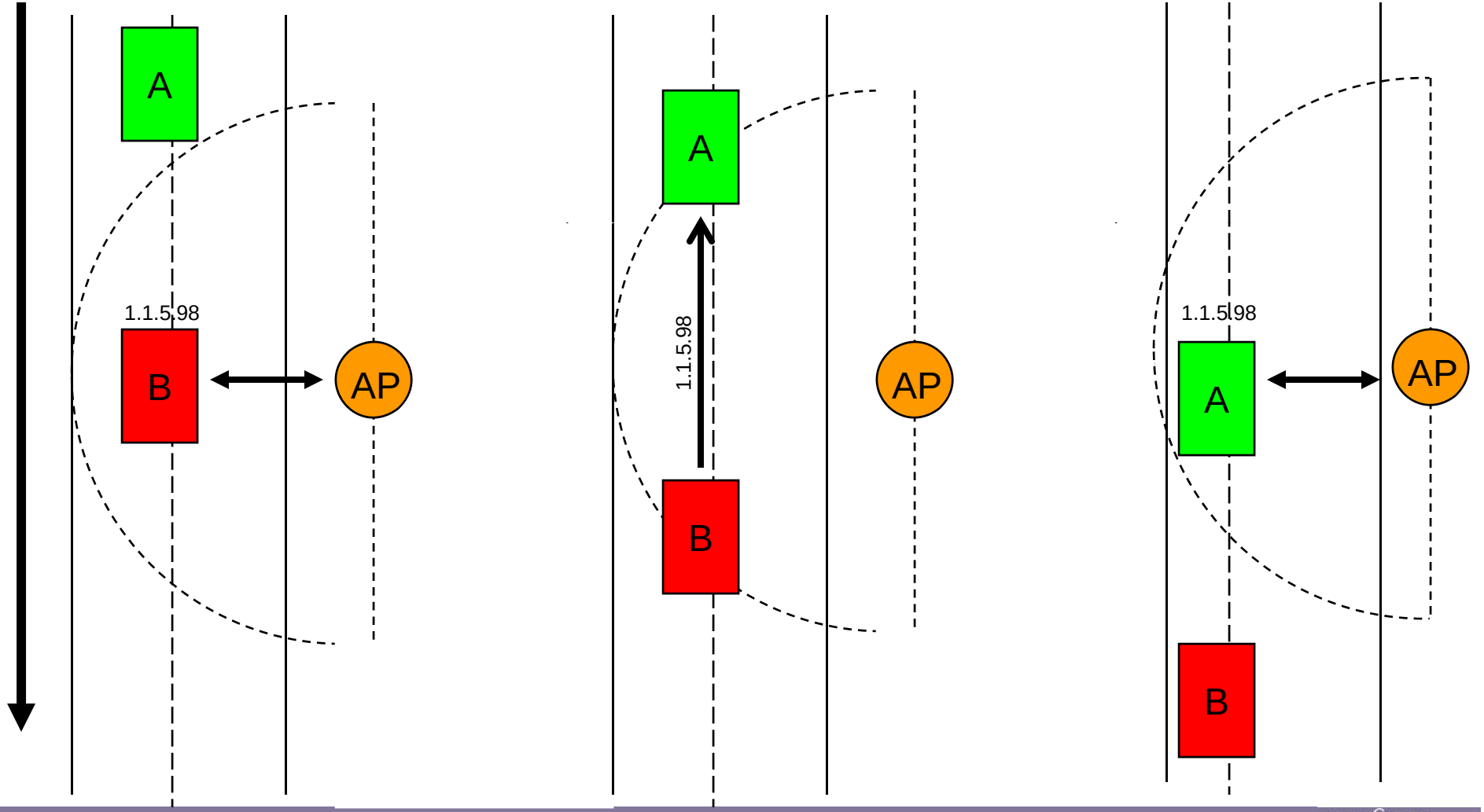
- DHCP delay is implementation dependent
- Association always occurs when clients are far away from AP, which can increase delay

Reduce Delay

- Want to maximize connectivity to AP
- Minimize message passing and overhead
- Cannot change AP

IP Passing

Direction of travel

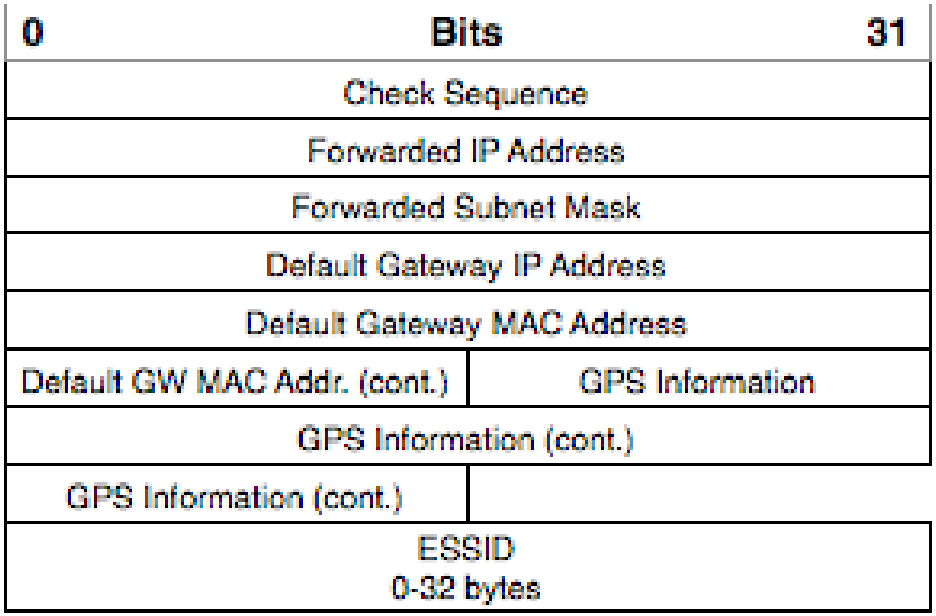


IP Passing

- B sends a broadcast message including
  - IP address
  - Subnet Mask
  - Default Gateway
- A receives the broadcast
  - Sets interface parameters
  - Sends GARP
- AP receives GARP and updates ARP-cache entry

Required Information

- IP Address
- Subnet Mask
- Default Gateway IP
- Default Gateway MAC
- ESSID
- GPS Coordinates

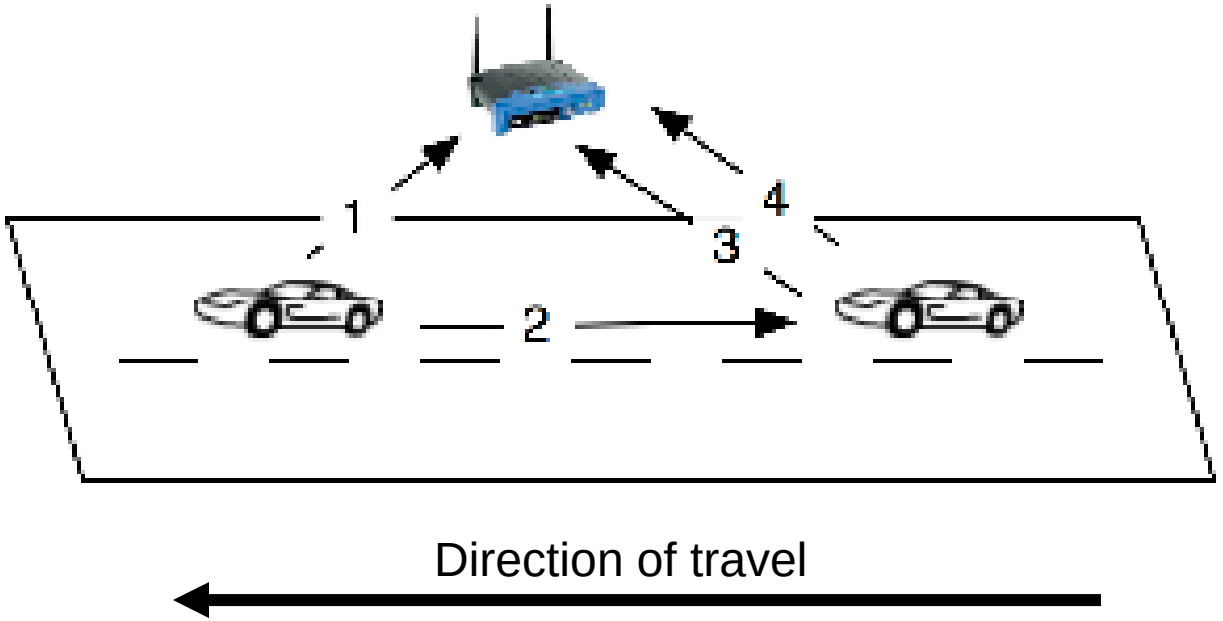


Implementation Setup

- AP
  - Linksys WRT54GL
  - OS: DD-WRTv23 SP3
- Nodes:
  - Redhat Linux 2.4.25
  - PCAP Library
- Monitor: Powerbook G4 using ethereal 0.10.12-1011

Implementation

- Traditional DHCP request
- Layer 2 broadcast
- GARP to update AP's ARP table



Results

Packet #	Elapsed Time	Source	Destination	Protocol	Bytes	Information
1	0.000000	Agere_b6:34:9e	Broadcast	IEEE 802.3	128	Source port: picknfs Destination port: picknfs
2	0.078179	D-Link_d5:a9:dc	Broadcast	IEEE 802.11	104	Probe Request SSID: "598b[Malformed Packet]"
...						Association Process
3	1.997938	00:18:39:ea:5f:04	D-Link_d5:a9:dc	IEEE 802.11	122	Association Response[Malformed Packet]
4	2.013008	D-Link_d5:a9:dc	Broadcast	ARP	160	Who has 192.168.1.122? Gratuitous ARP

Implementation	Time	Bytes	# of Messages
Traditional DHCP	2.5 s	2096	7
IP Passing	0.09 s	296	2

Algorithm Overview

- Considerations
  - When to pass
  - Who to pass to
- Maximize usage if IP received before car is associated
- Two classes of algorithms: with or without neighbor topology awareness

Algorithm Comparisons

- Farthest Neighbor
  - Pass the IP to the one-hop neighbor furthest from itself

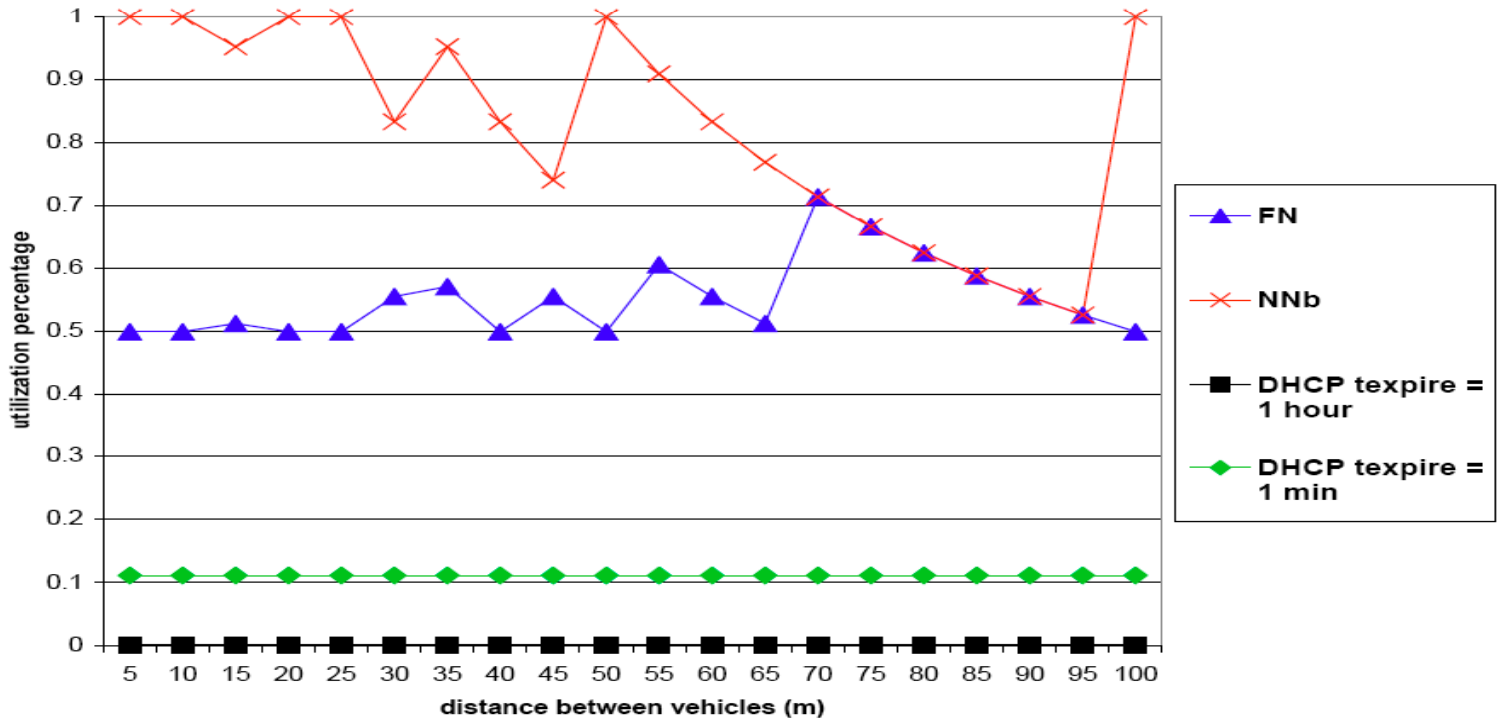
$$D_{FN} = \max_{1 \le i \le n} \left\lfloor \frac{r}{d_i} \right\rfloor * d_i$$

- Nearest Neighbor behind association point
  - Pass to the neighbor nearest the AP's association point but not yet within the AP coverage area

$$D_{NNb} = \min_{1 \le i \le n} \left\lceil \frac{|l_p - l_a|}{d_i} \right\rceil * d_i$$

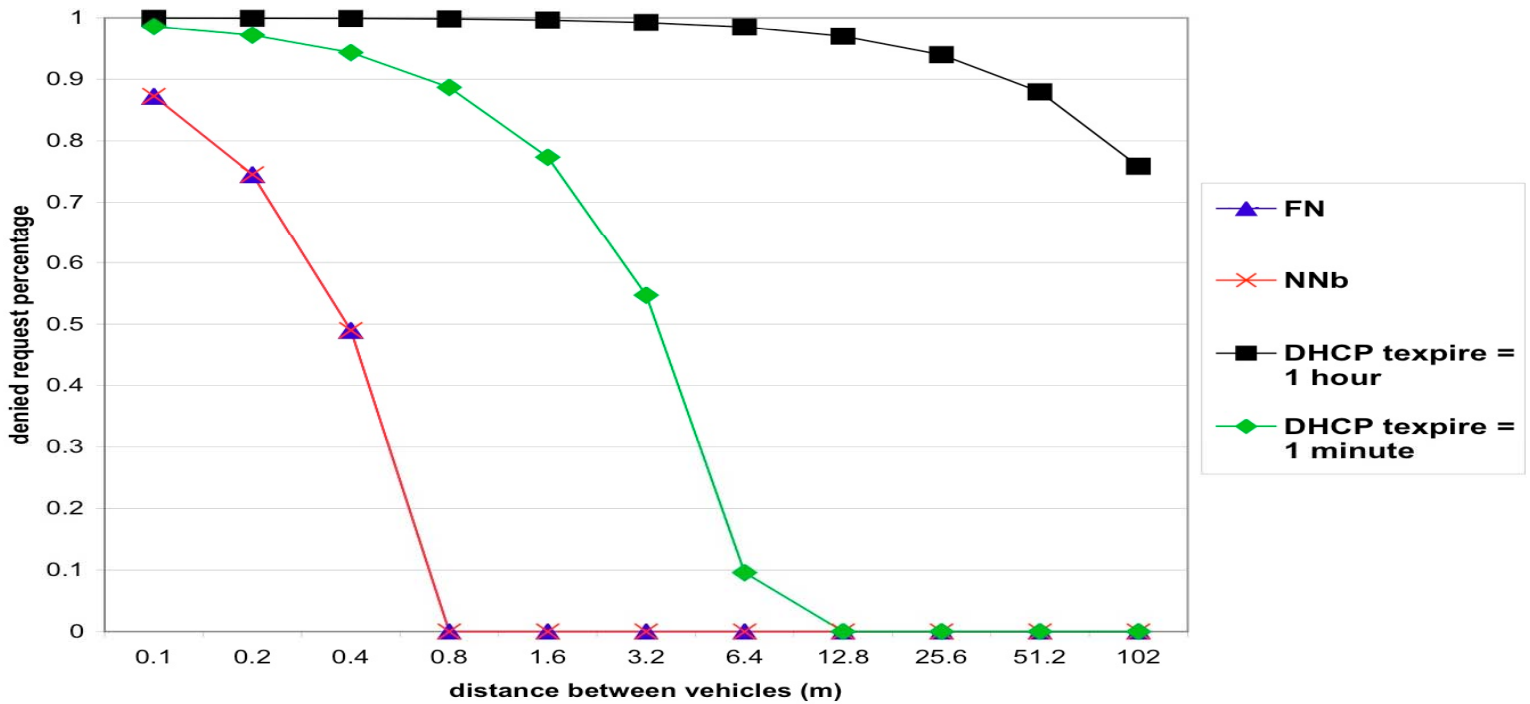
Algorithm Analyses

- Use fraction: fraction of time an issued IP is in use
- Parameters
  - AP Range and vehicle communication range: 200 m
  - Vehicle speed: 30 m/s



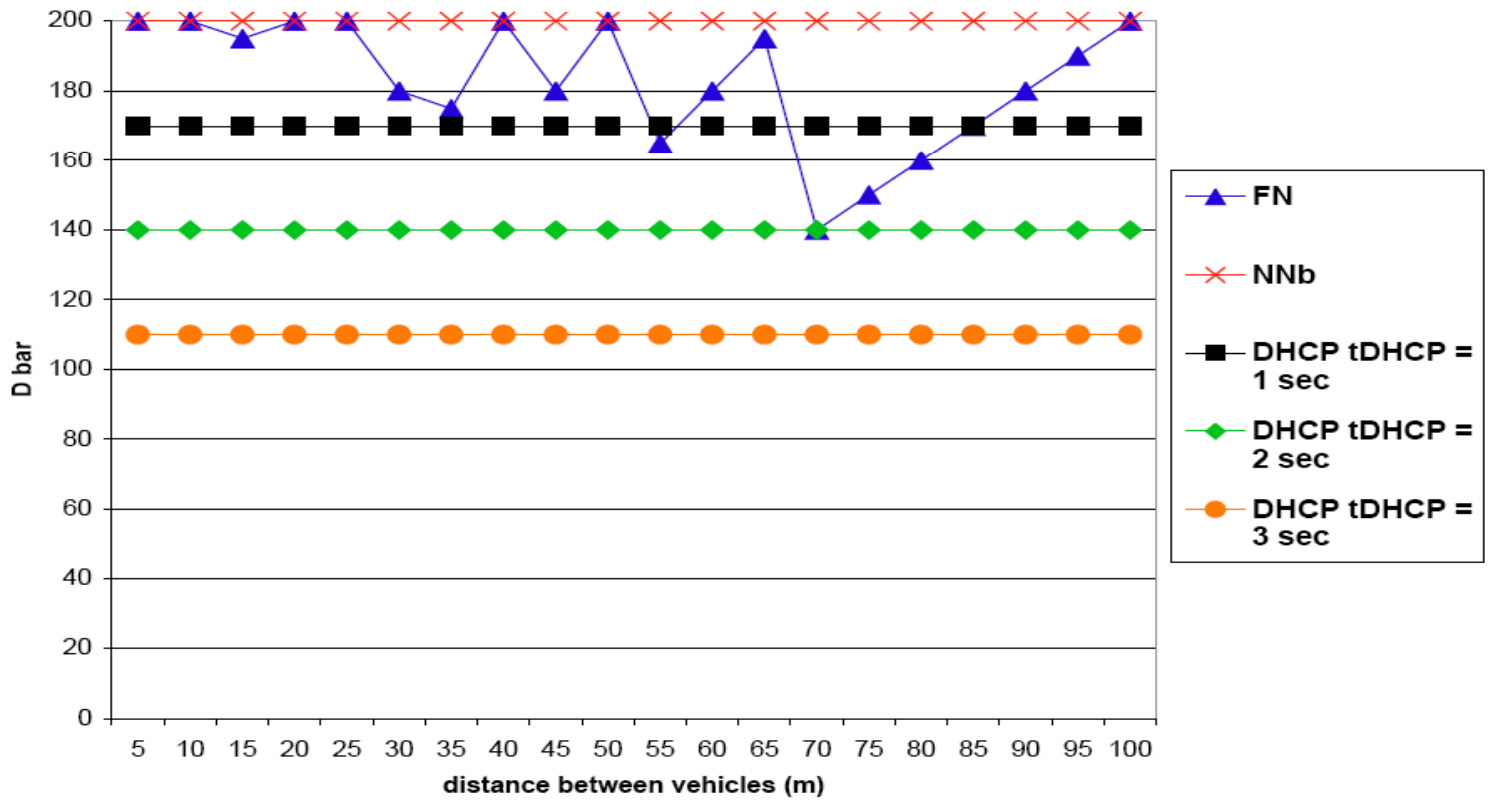
Analyses (cont.)

- Denied Request Fraction: The fraction of DHCP requests the AP cannot service due to lack of available IP addresses



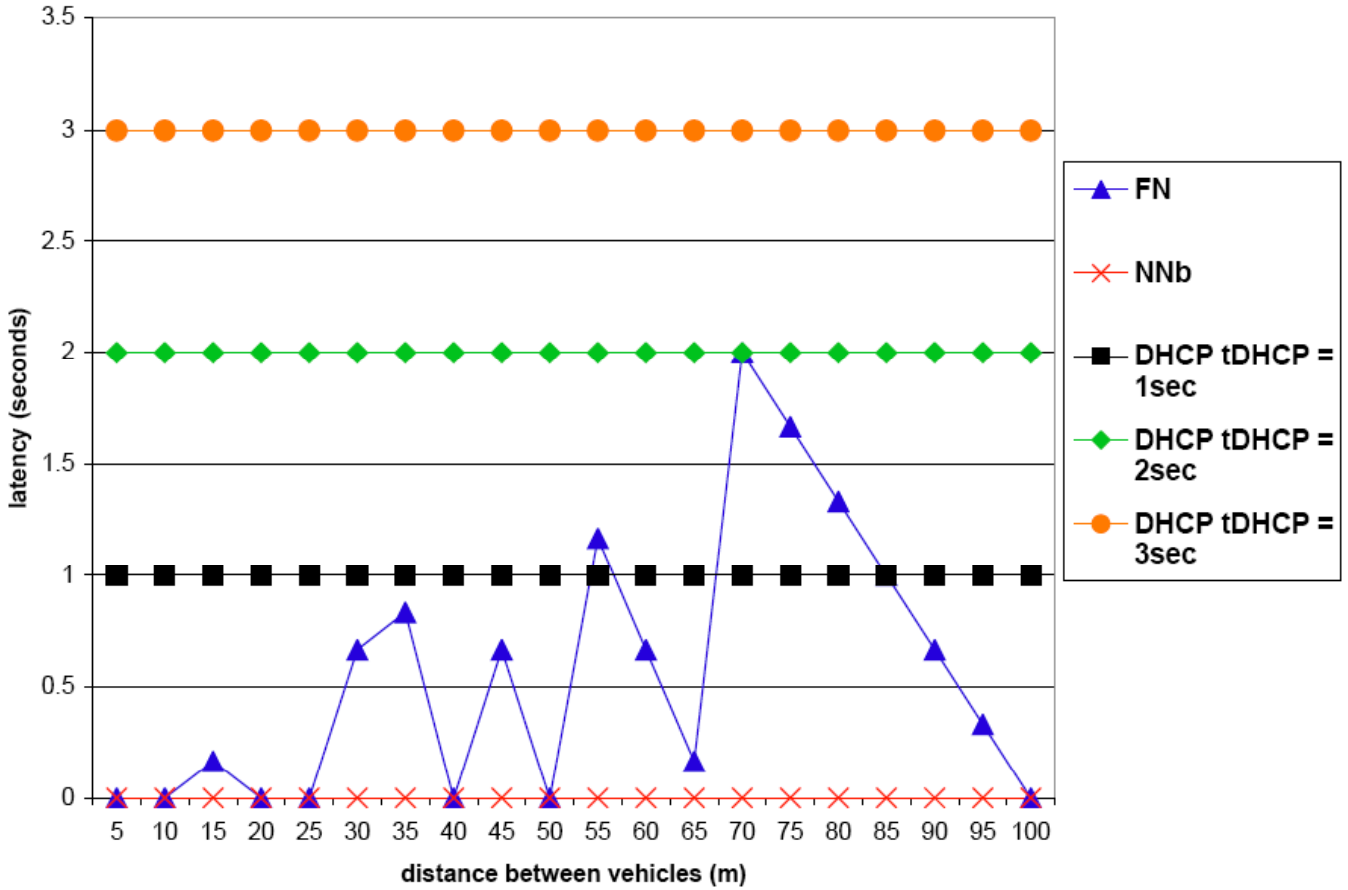
Analyses (cont.)

- Average Distance Used: the average distance traveled within the AP's range with a usable IP



Analyses (cont.)

- Average Latency to Connectivity: The average amount of time from when a node enters the AP's range until it has an IP
- Typical roadside access is 5-24 seconds



Conclusions

- Reduce the average IP acquisition latency to less than one-tenth of a second
- Backwards compatible solution with existing infrastructure
- First work to reduce IP acquisition latency in VANET
- Solution is implemented and tested