


Mobisteer: Using Steerable Beam Directional Antenna for Vehicular Network Access



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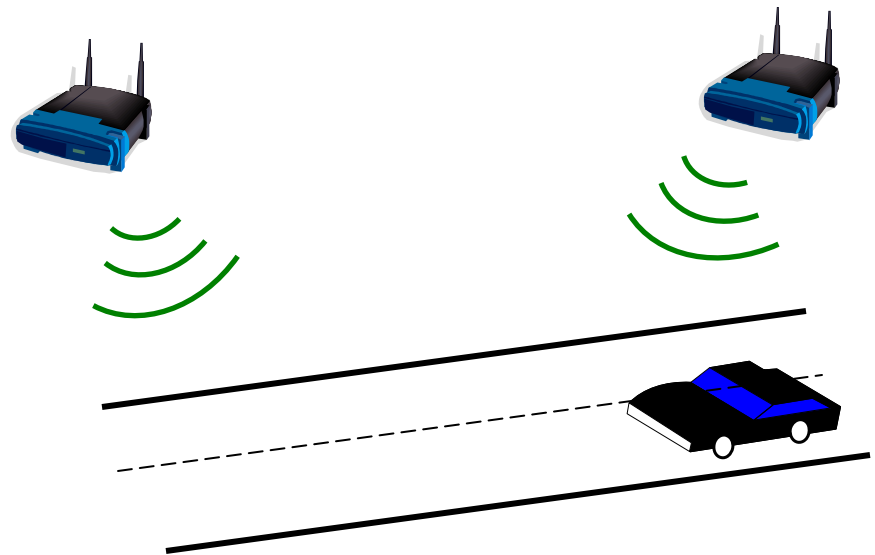
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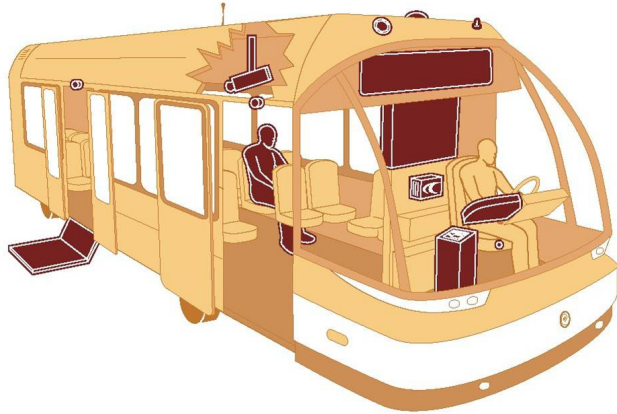
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Vehicular Networking Scenario

- Vehicle ↔ Fixed Wifi AP
- Fixed AP deployments
 - In-situ APs
 - City Mesh Networks like Google Wifi
- Realistic - CarTel Project at MIT



Applications



Internet Access



Rear-seat Entertainment



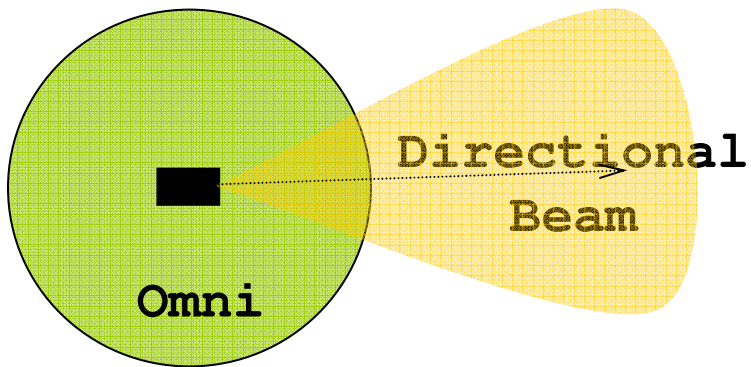
Traffic and Weather Information

Performance Problems in Vehicular Network Access

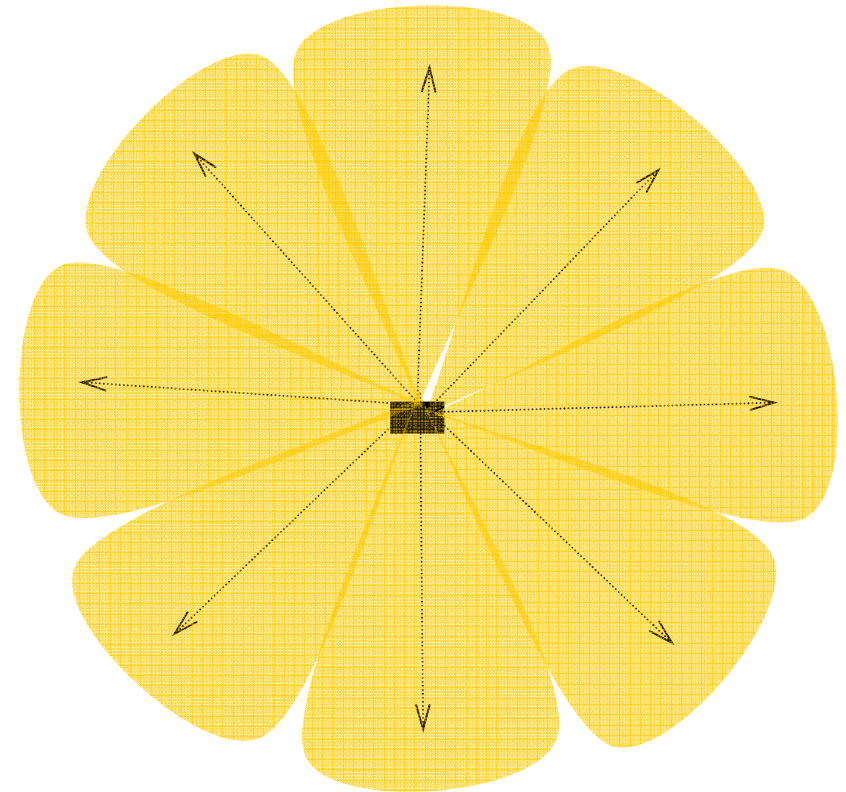
**In-situ Wifi Study
MIT CarTel Project
[Mobicom 06]**

❑ Poor link quality	80% link delivery ratio
❑ Short duration of connectivity	13 seconds connectivity time
❑ High handoff / association overhead	1-2 seconds association time

Our Approach – Use Steerable Directional Antenna

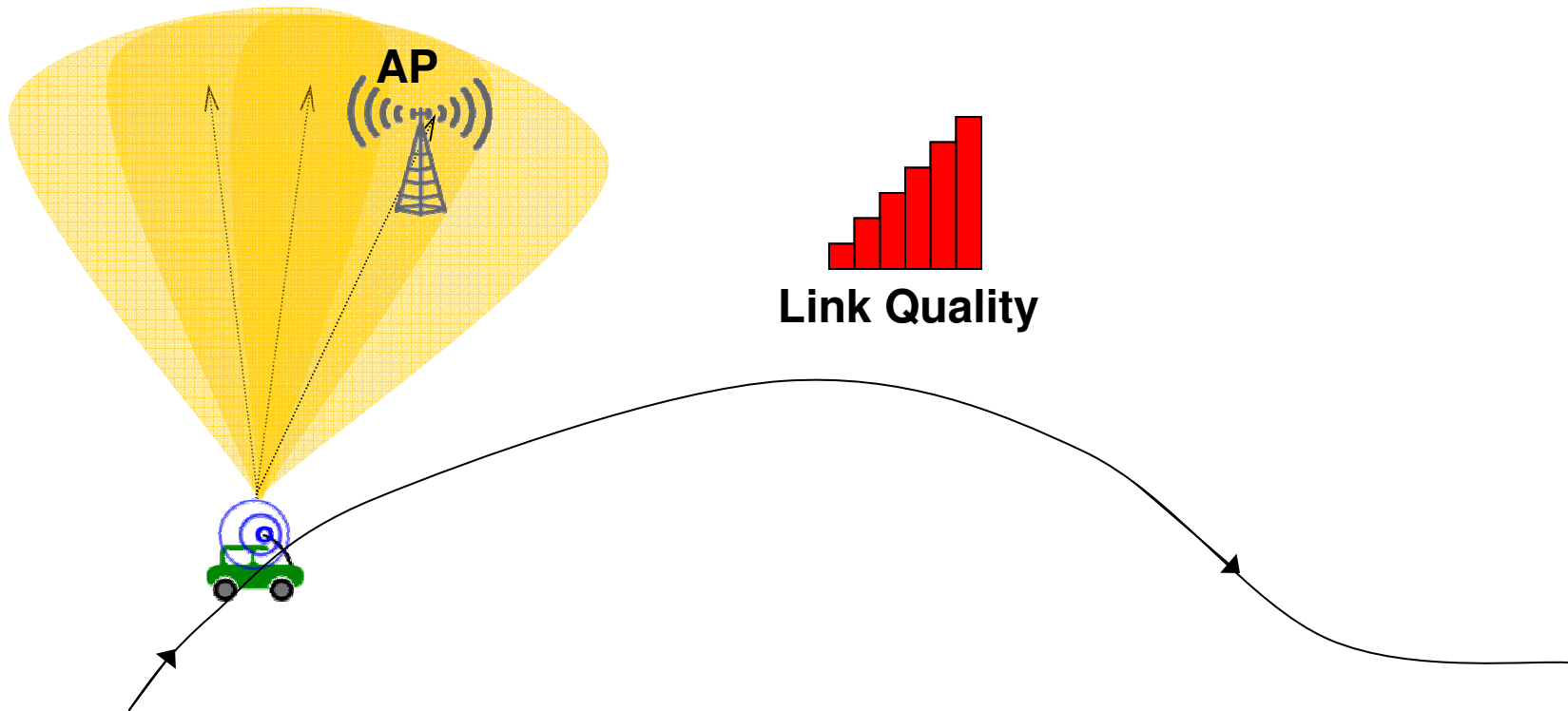


- High Tx/Rx gain
- Long range

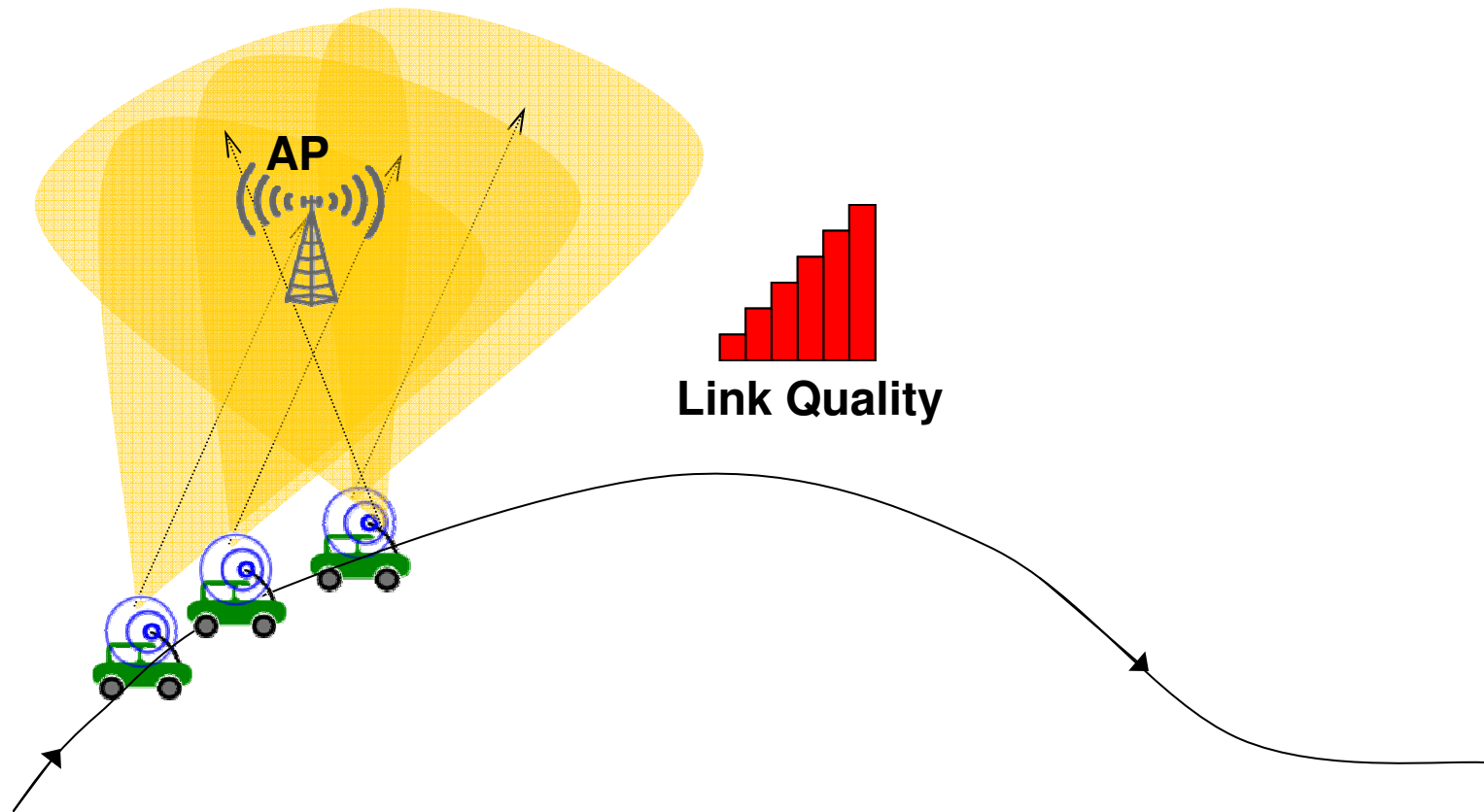


- Beam steering programmable

Effect of Beam Steering on Link Quality

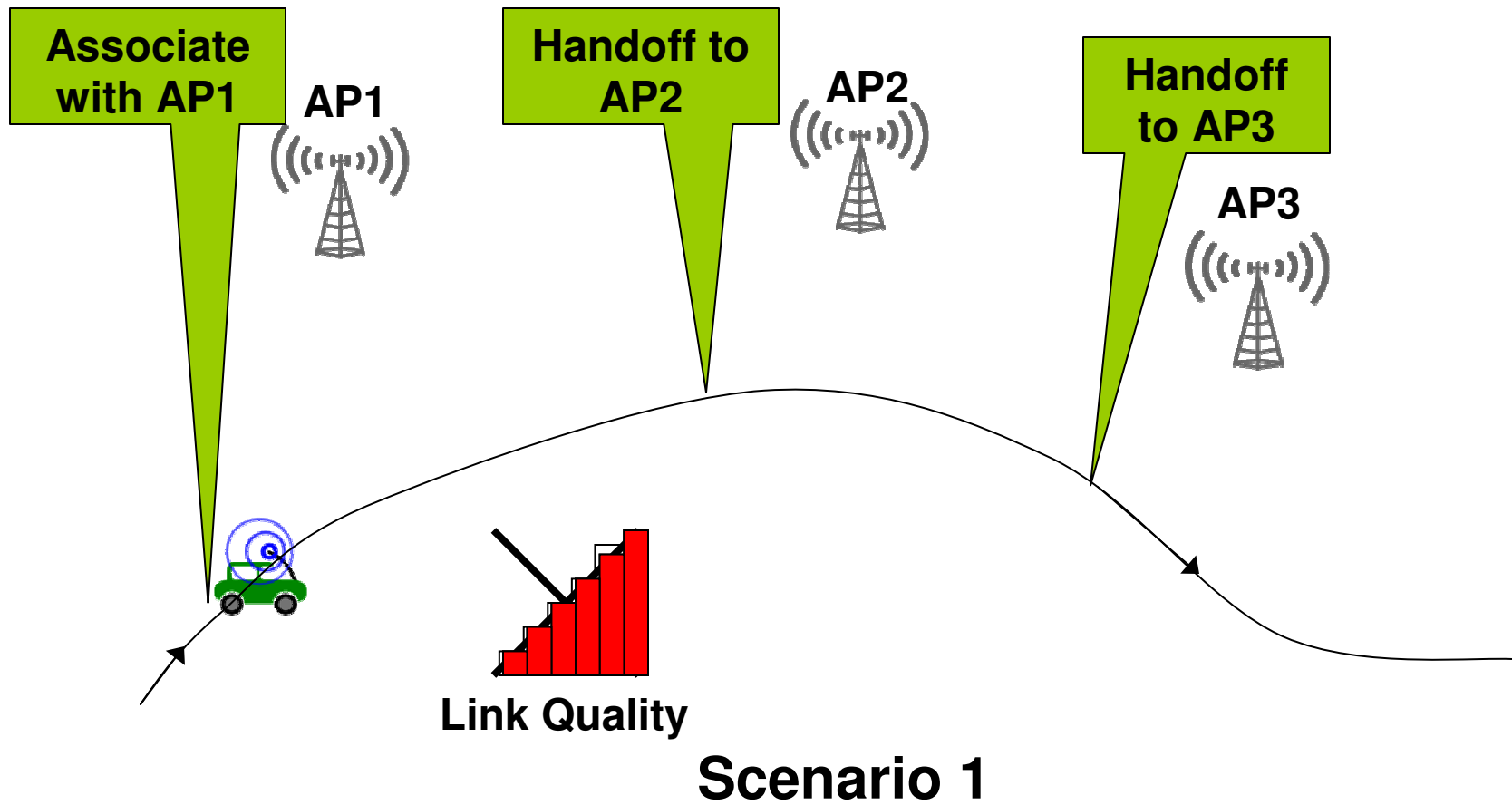


Problem – How to Beam Steer?

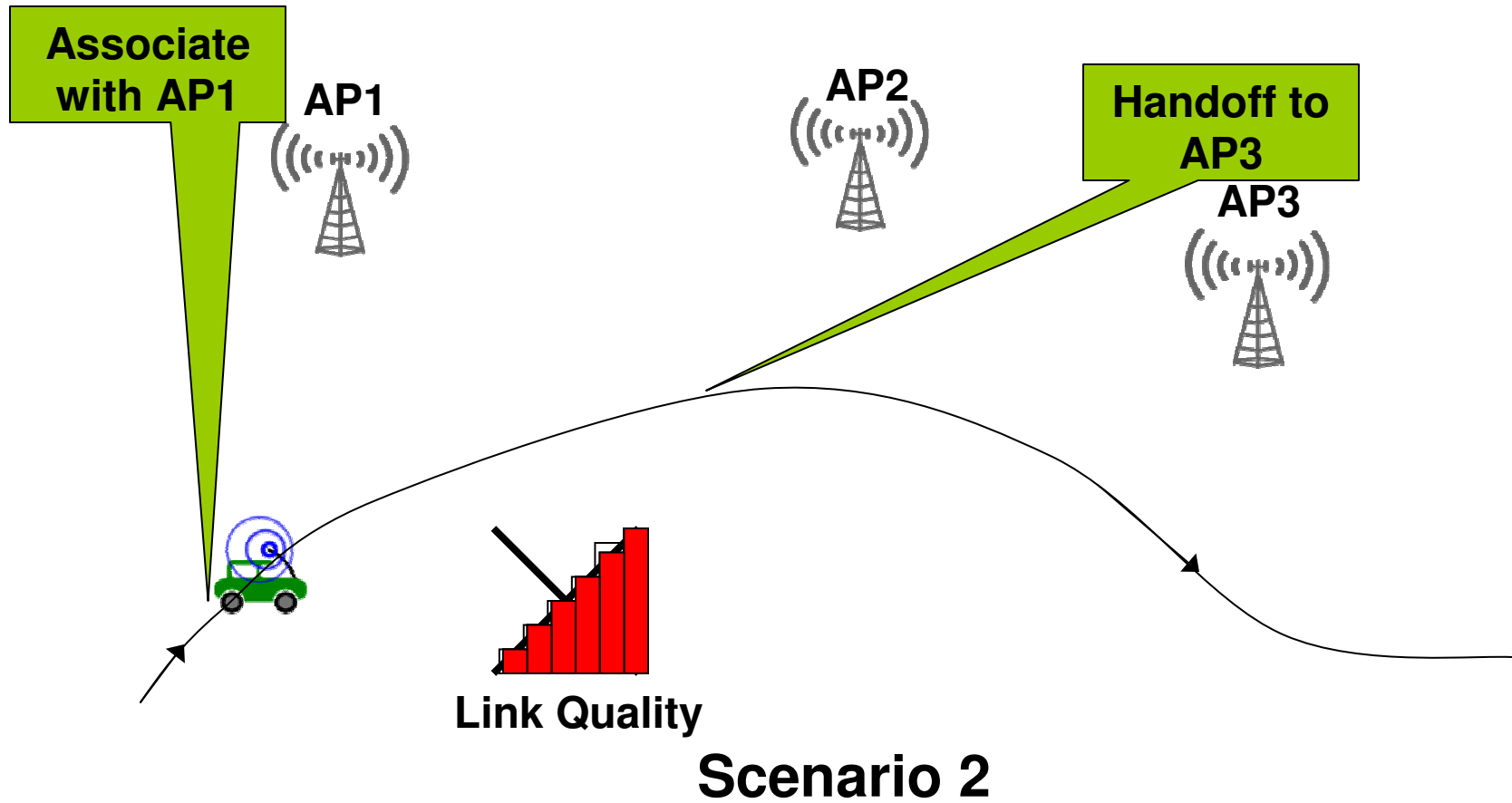


Practical beam-steering technique to improve overall link quality b/w AP and mobile

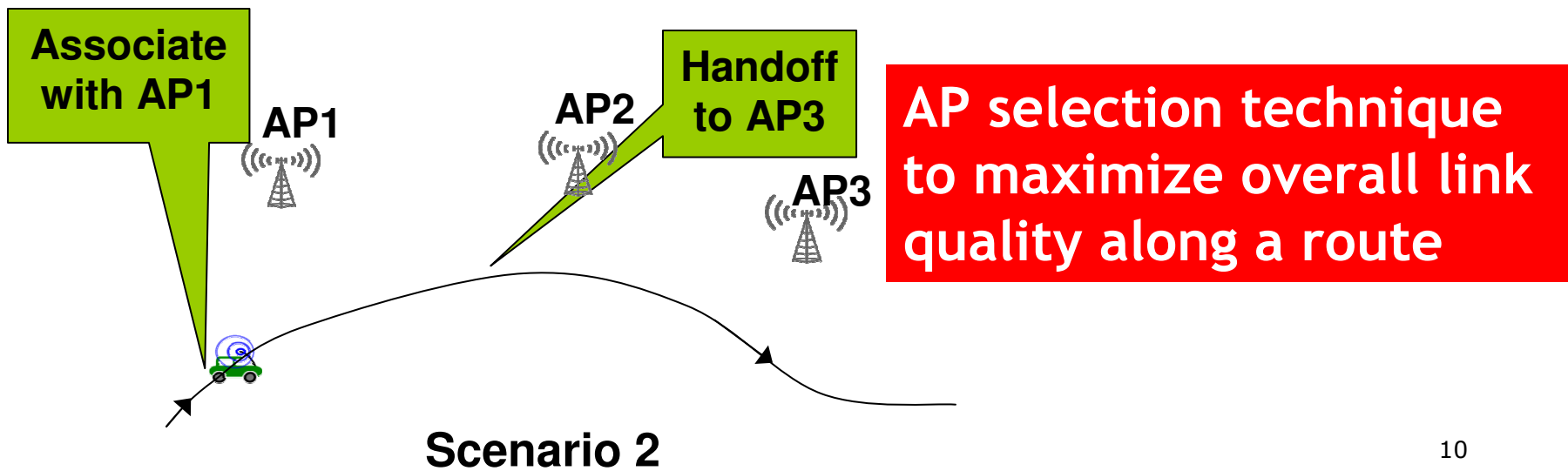
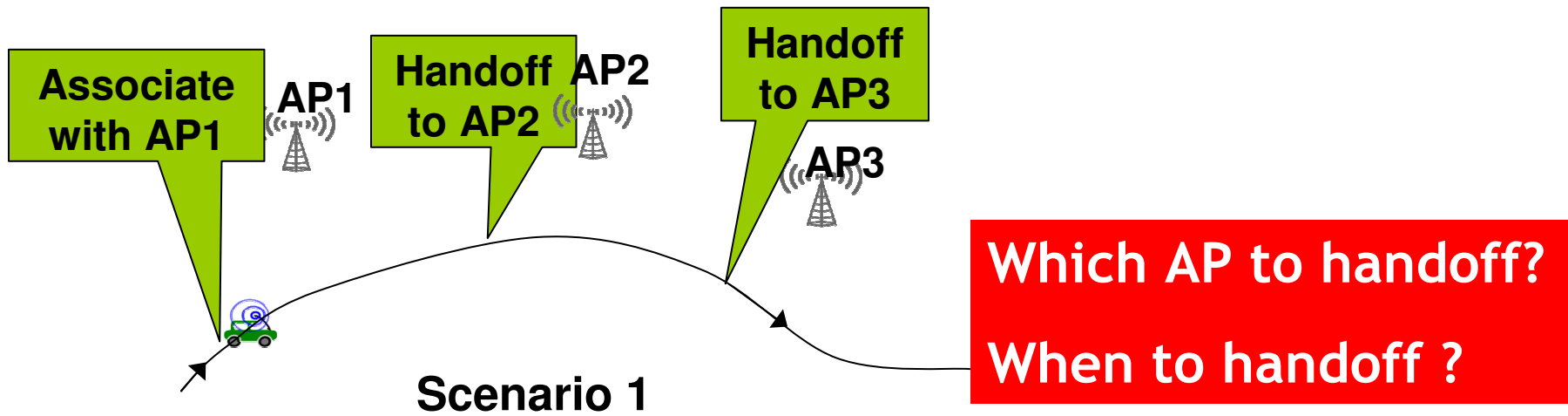
Effect of AP Selection on Link Quality



Effect of AP Selection on Link Quality



Problem – AP Selection



Objective

Joint <AP,Beam> selection technique to maximize overall link throughput along the route

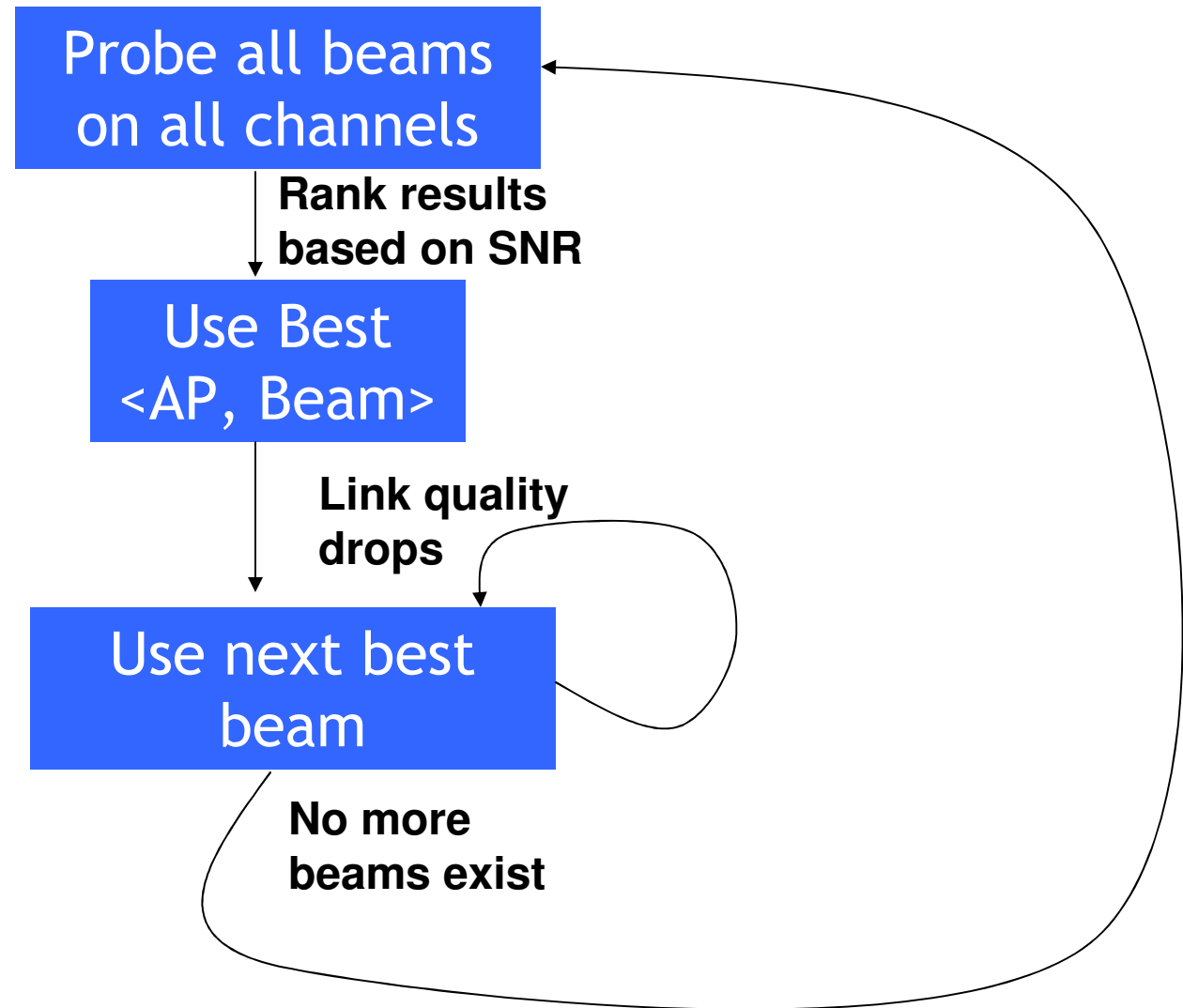
Outline

- ✓ Problem Description
 - ✓ Beam steering
 - ✓ AP Selection

- Mobisteer System
 - Online Mode
 - Cached Mode

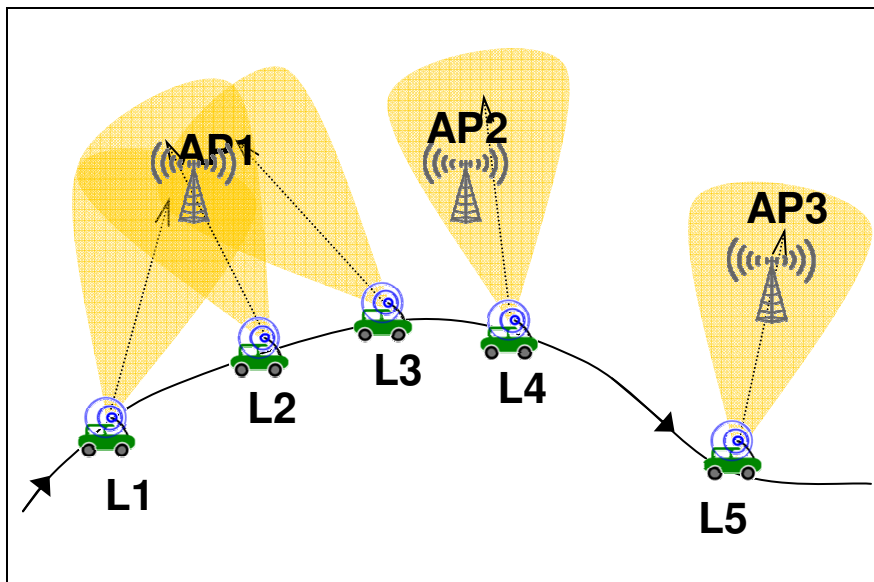
- Performance Evaluation

Simple Online Heuristic

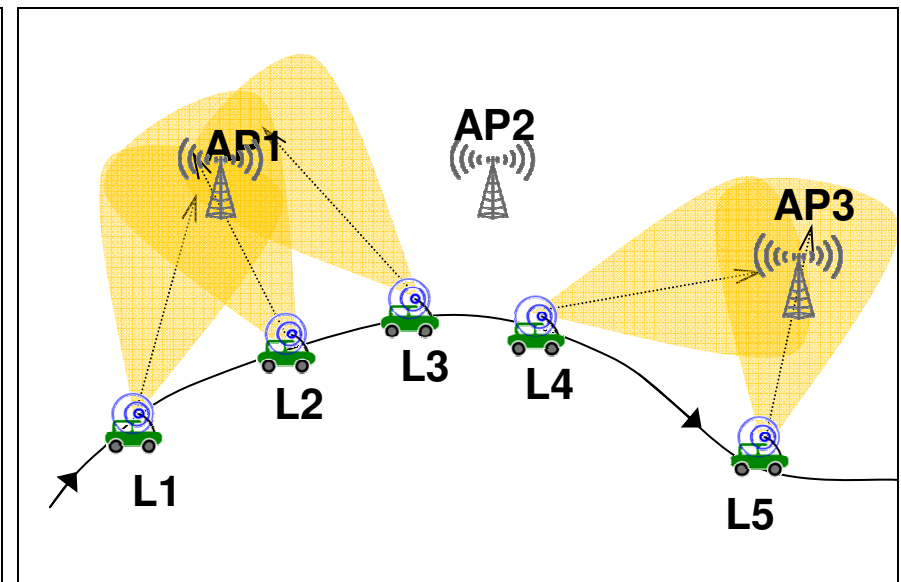


Drawbacks of Online Heuristics

- High probing overhead
 - ~3 seconds – 8 beams x 11 channels
- Local handoff decisions suboptimal
 - At L4, local best is AP2, but AP3 may be better



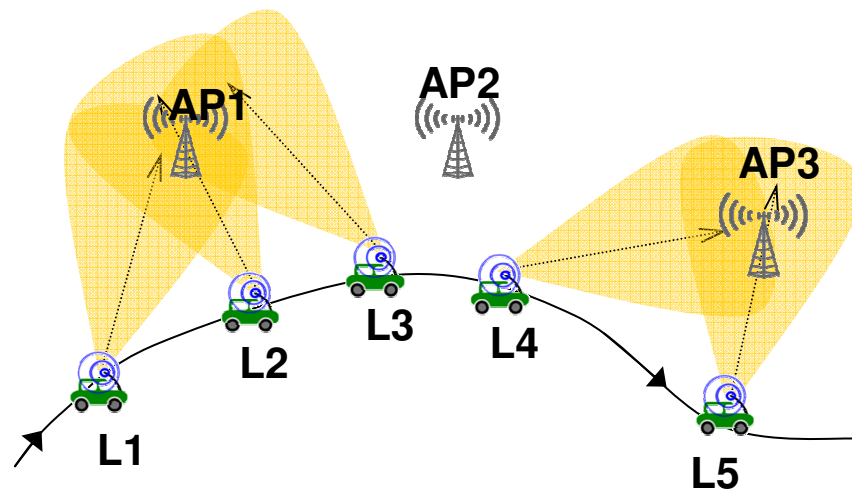
Scenario 1



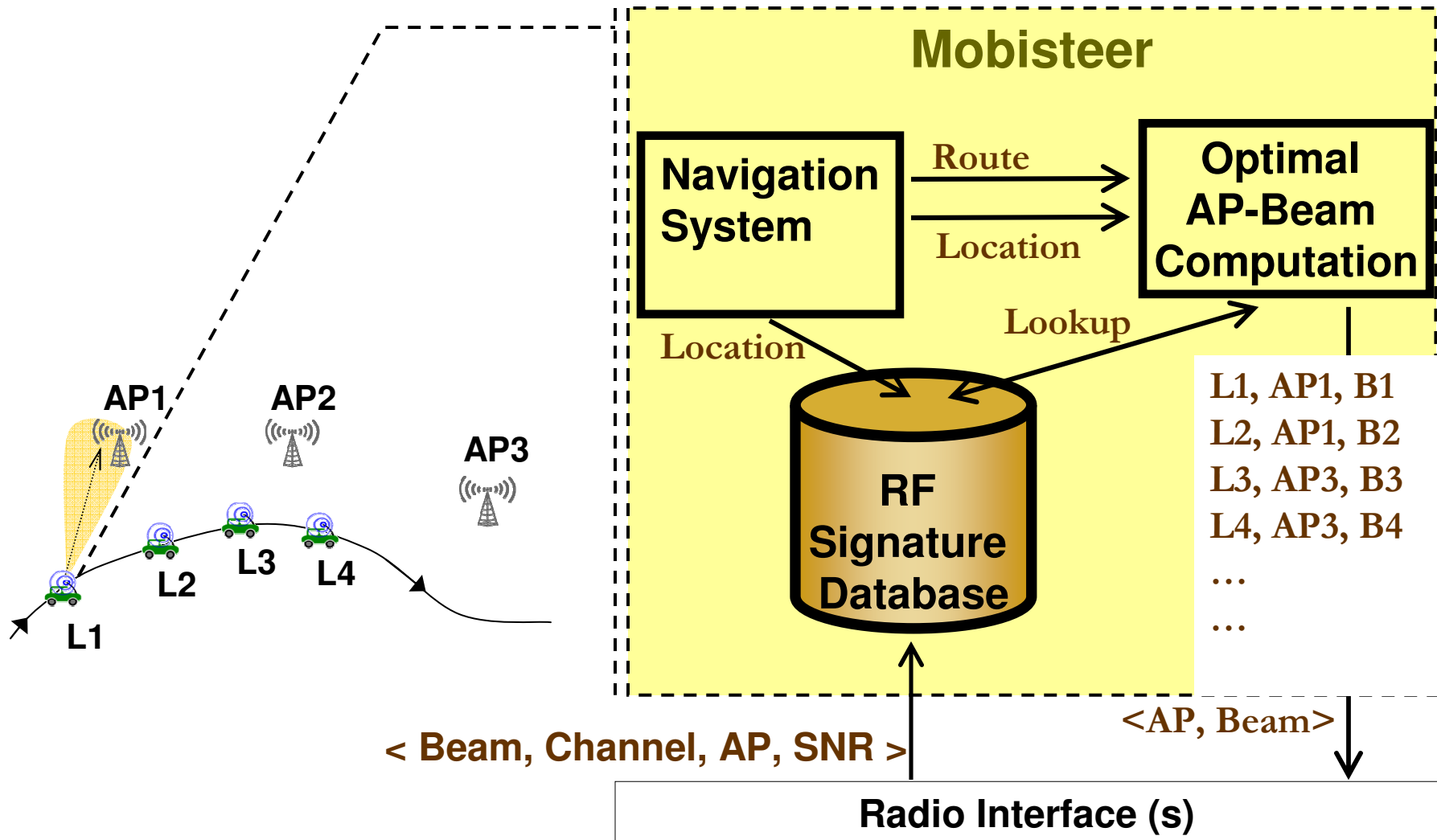
Scenario 2

Improving Online Heuristics

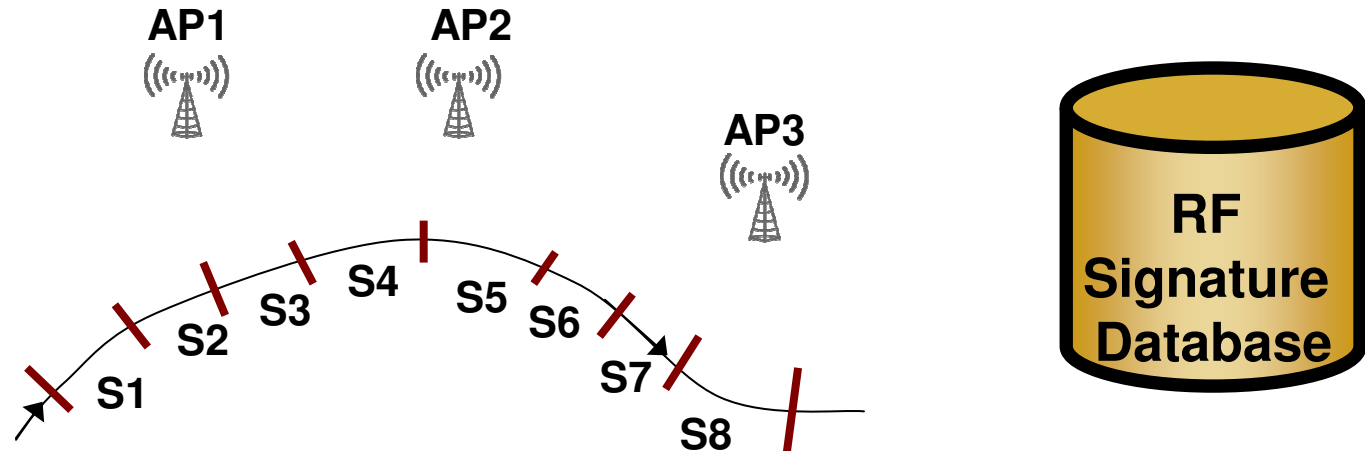
- Key Intuition – Caching AP and Beam information along a route
 - No probing overhead
 - Informed handoff using global view



Cached Mode Operation



Optimal AP-Beam Computation



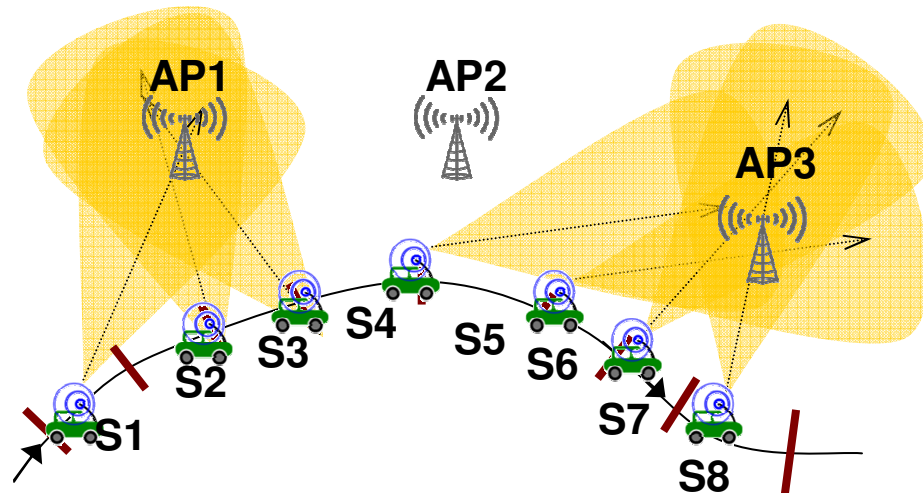
Dynamic Programming Formulation

	s1	s2	s3	s4	s5	s6	s7	s8	-
AP1									
AP2									
AP3									

Best beam
Average link quality using best beam

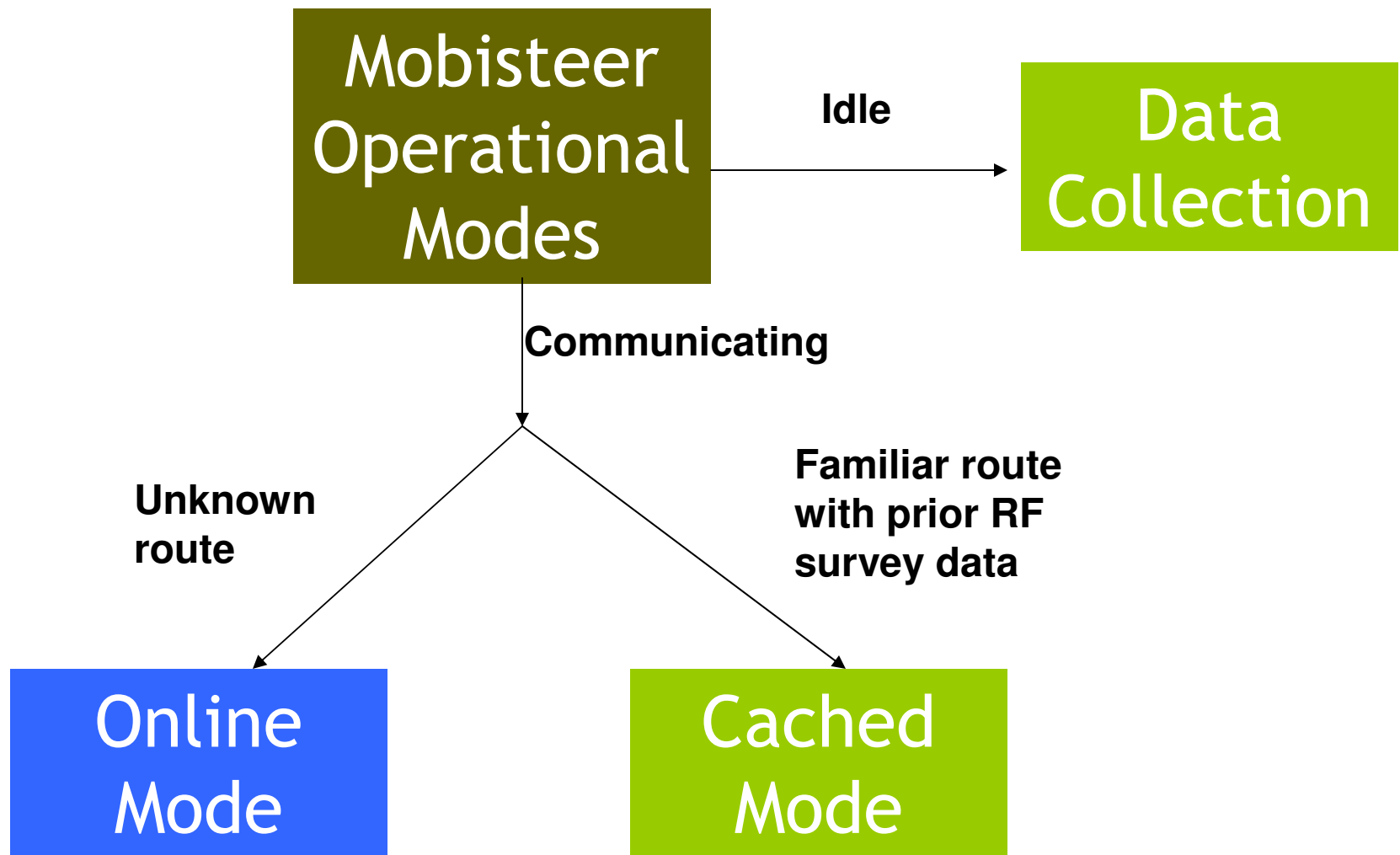
Determine $\langle \text{AP}, \text{Beam} \rangle / \text{Segment}$ that maximizes the aggregate link quality accounting handoff cost

Optimal AP-Beam Computation



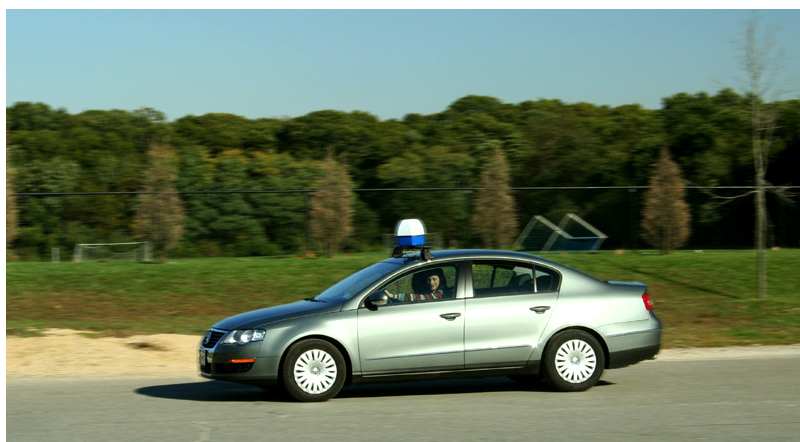
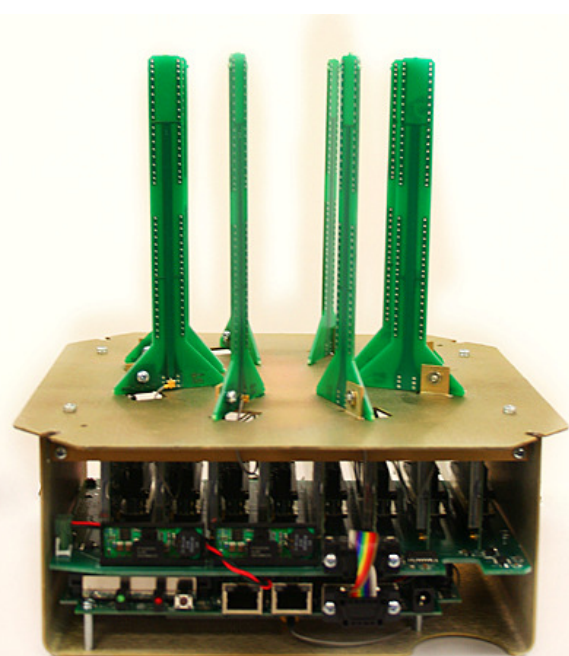
	s1	s2	s3	s4	s5	s6	s7	s8	-
AP1					AP1 → AP3 Handoff				
AP2									
AP3									

System Description



Mobisteer Prototype

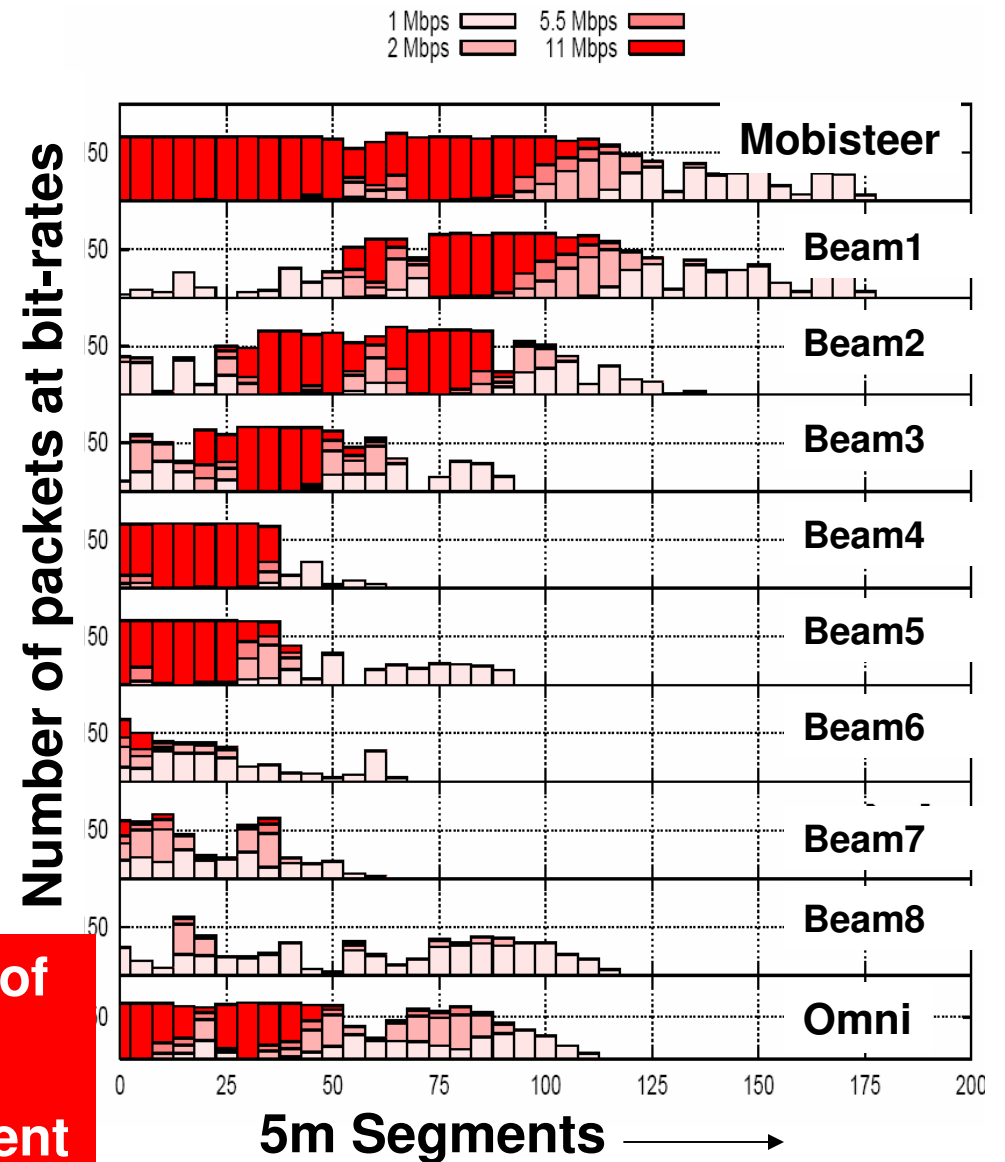
- Phocus Array Steerable Antenna system from Fidelity Comtech
 - 8 Beams - 45° beam width/ 15dBi gain
 - Atheros 802.11b/g radio
 - 250usec beam steering



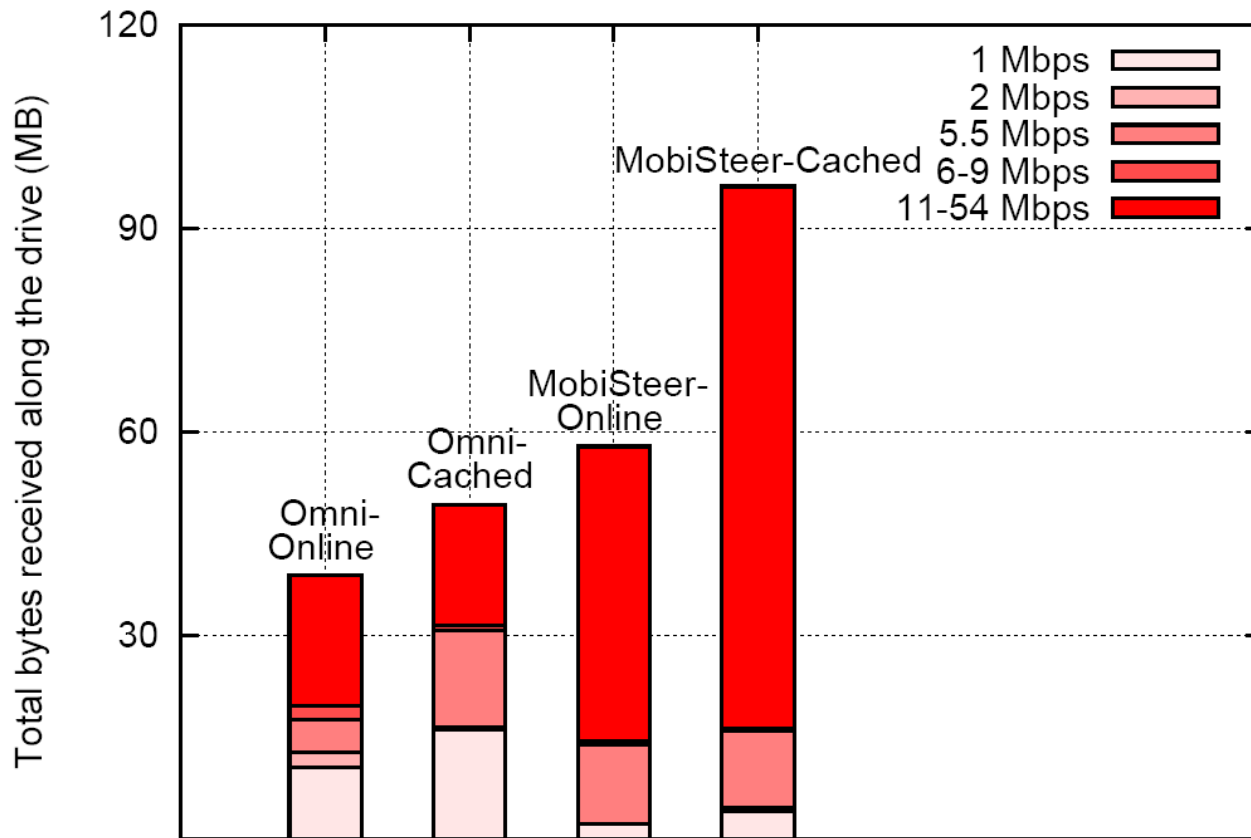
Controlled Outdoor Experiments



- 1. Mobisteer increases duration of connectivity
- 2. Higher bit-rates in each segment

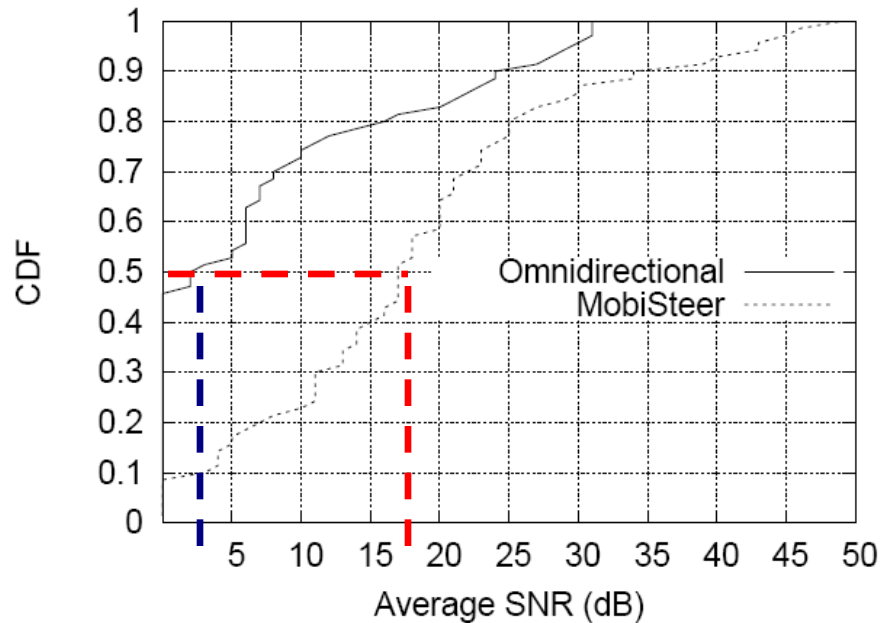


Online vs Cached

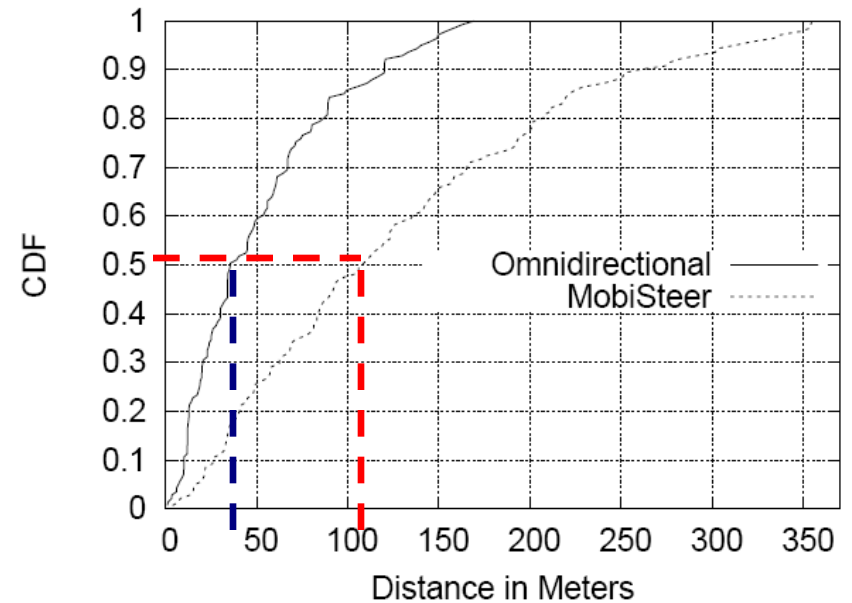


1. Mobisteer Online lower than Cached by 39%
2. Online still better than Omni by 50%
3. Caching benefits Omni too

Large-scale Urban Experiments



Around 14dB gain in link quality (SNR)



2.5x improvement in range

Summary

- First detailed study of steerable beam antennas for vehicular communication
- Beam steering and AP selection techniques
- Controlled Experiments
 - 2-4 times improvement in throughput
- In-situ Experiments
 - >2 times increase in connectivity duration
 - +15dB gain in SNR

Experimental Data Traces

- Available at

www.wings.cs.sunysb.edu/mobisteer.html

- Also on CRAWDAD

Thank You

