Wi-Fi Goes to Town: Rapid Picocell Switching for Rapid Transit

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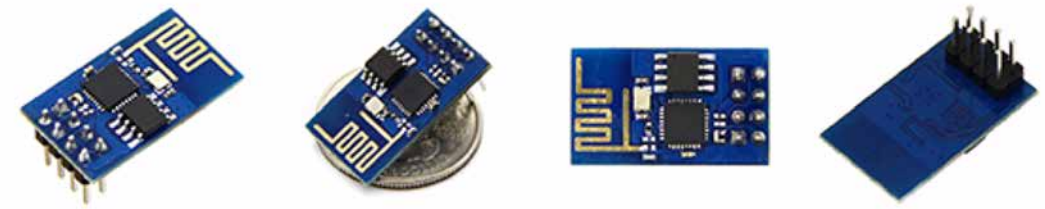
1. More people, more mobility
2. More data consumption

How to scale up bits/second/Hertz network delivers, roadside and trackside?

Two observations

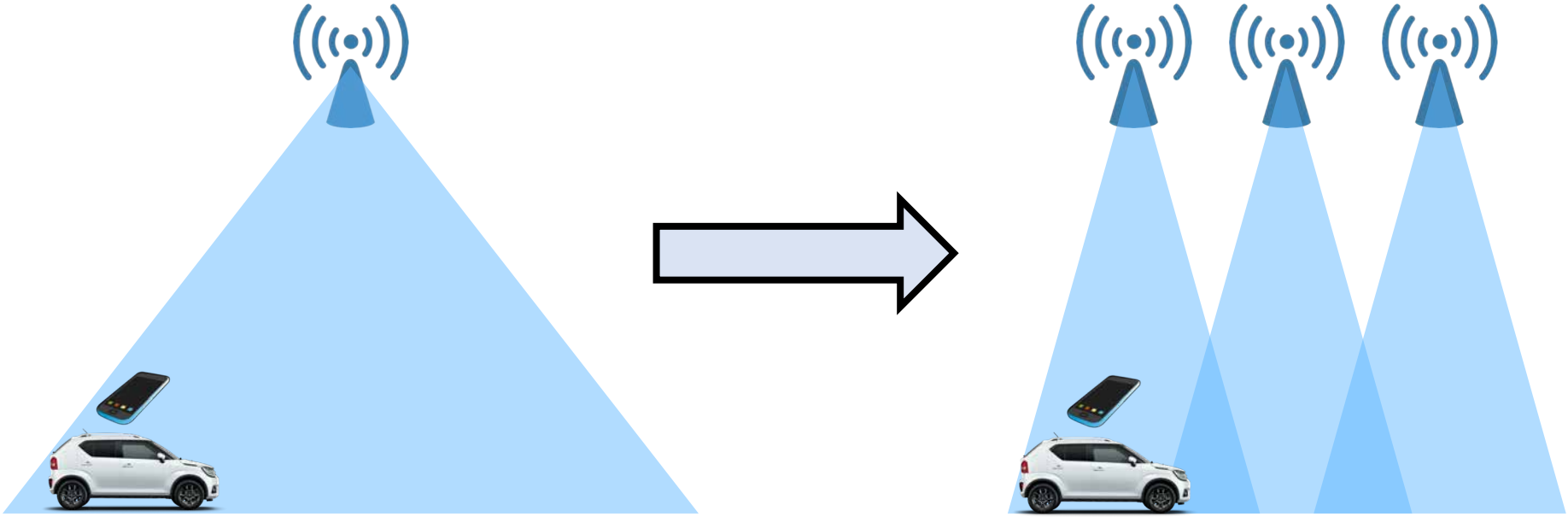
1. Falling analog and digital logic cost →
   - ESP8266 $5 Wi-Fi system-on-chip today (tomorrow, ¢?)



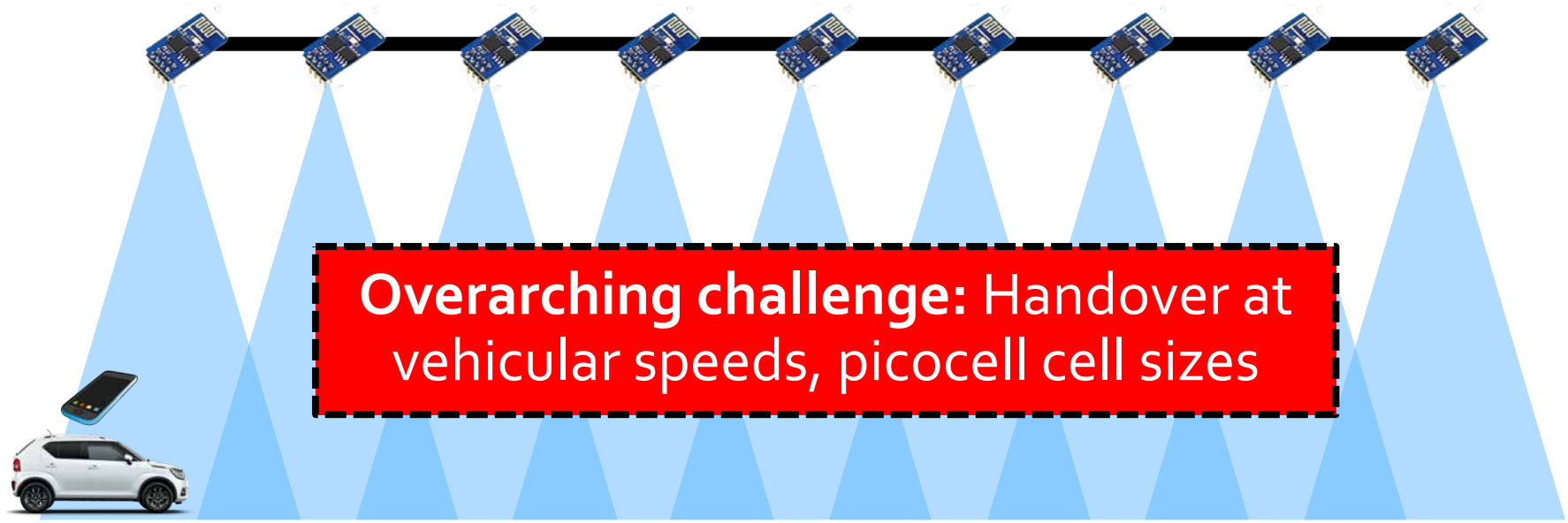
Two observations

1. Falling analog and digital logic cost →
   - ESP8266 $5 Wi-Fi system-on-chip today (tomorrow, ¢?)

2. **Smaller wireless cells yield greater capacity**

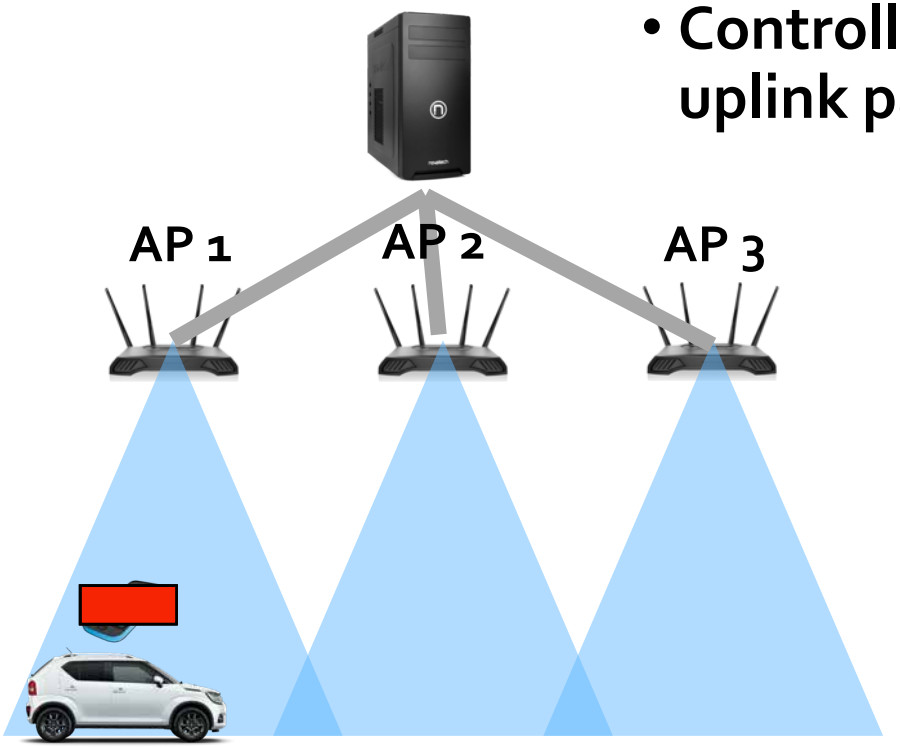


Wi-Fi Goes to Town



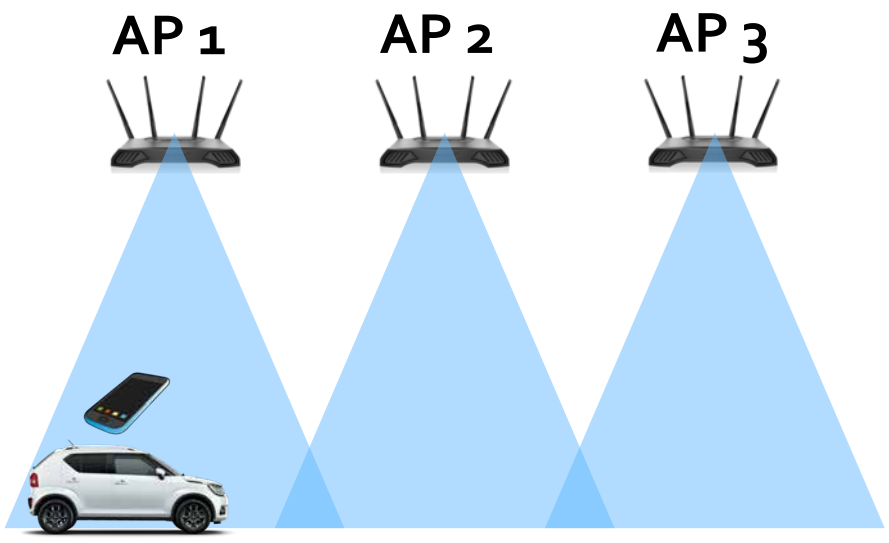
An array of cheap access points serving mobiles

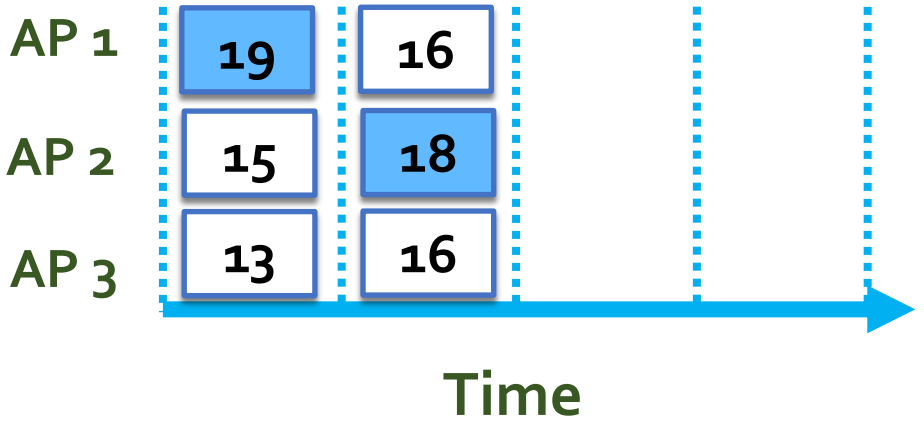
Uplink: Can leverage link diversity



- Controller de-duplicates uplink packets

Downlink: Best to Choose one AP

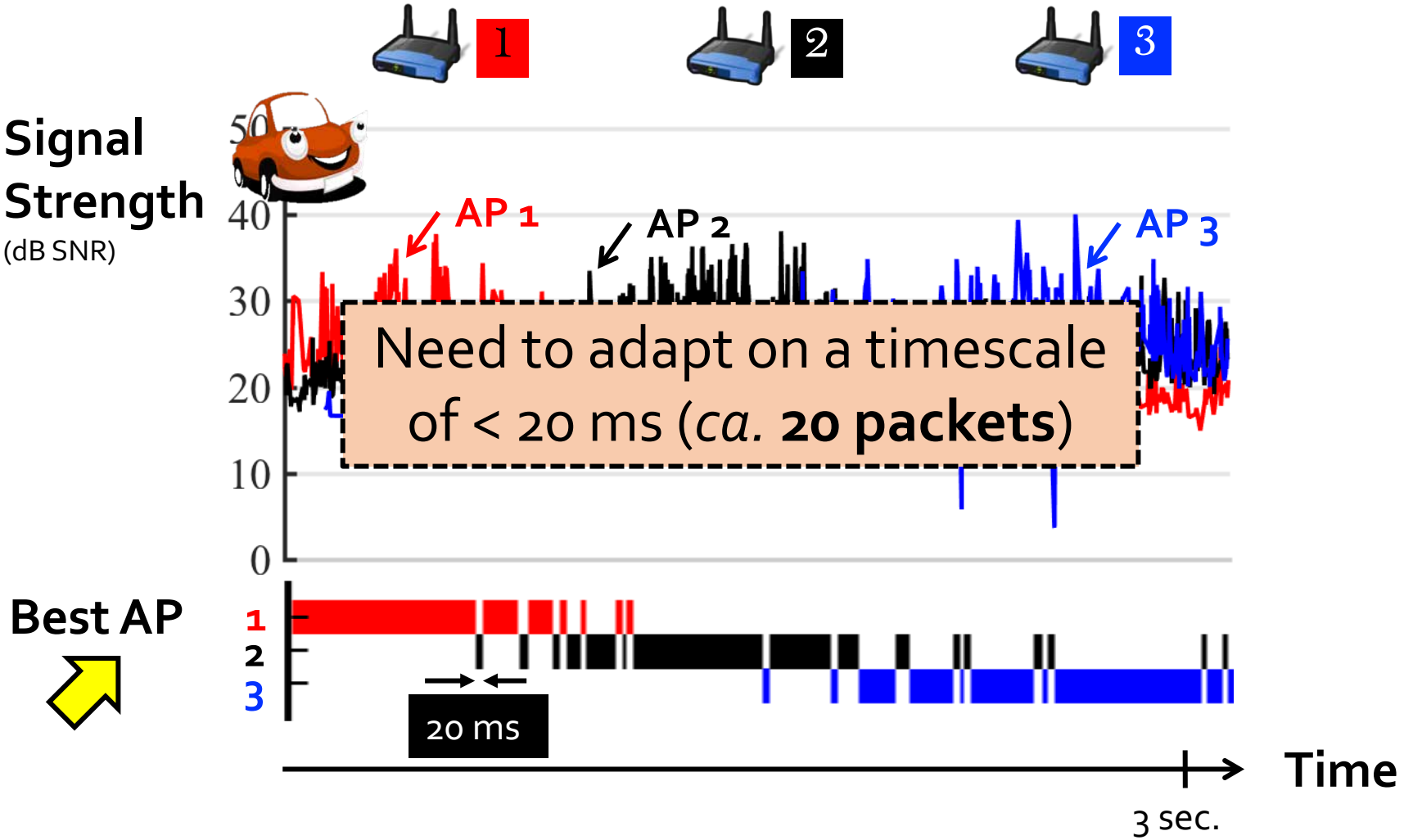




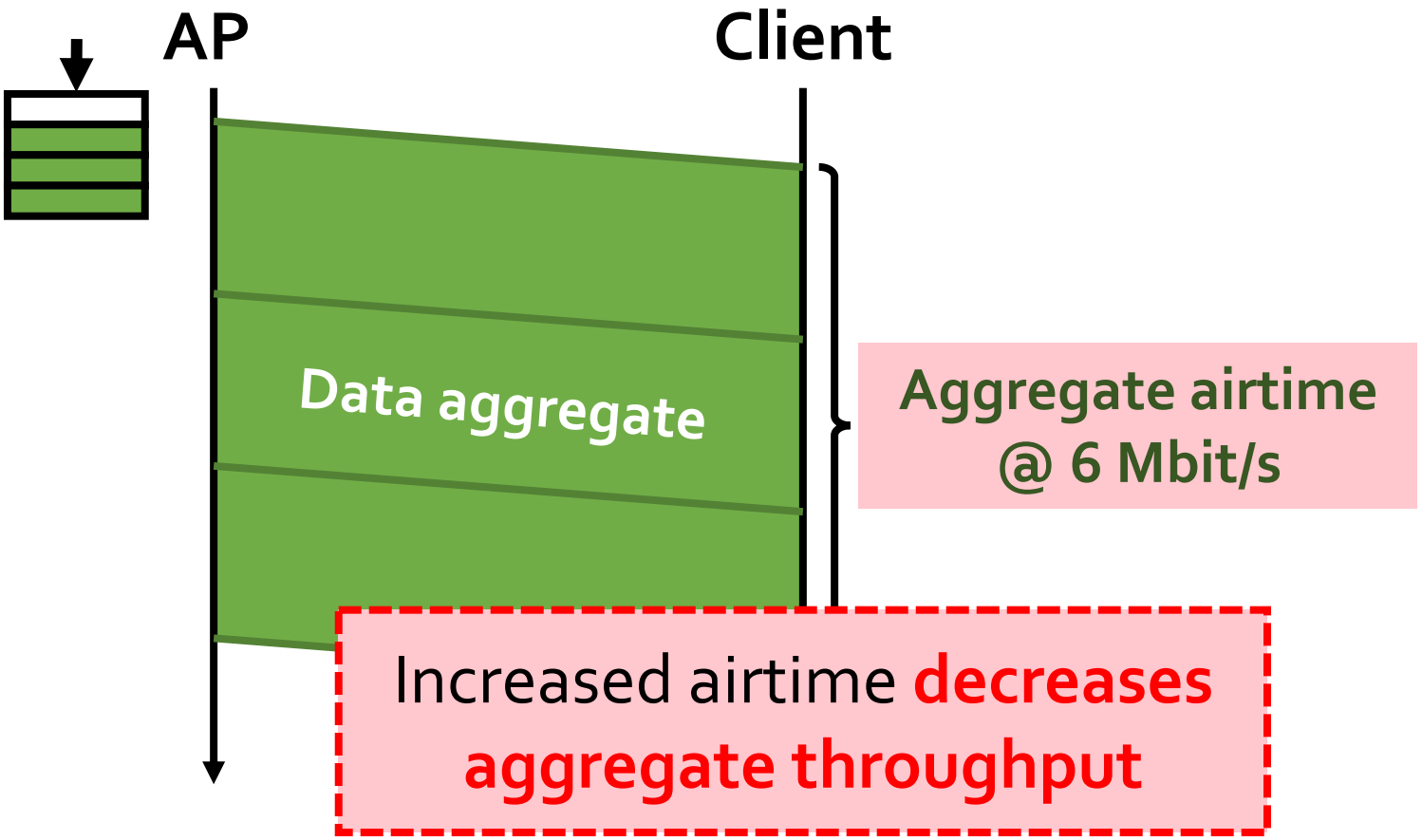
Challenges

1. The real wireless channel is **unpredictable**

Real wireless is unpredictable



Channel degradation decreases efficiency

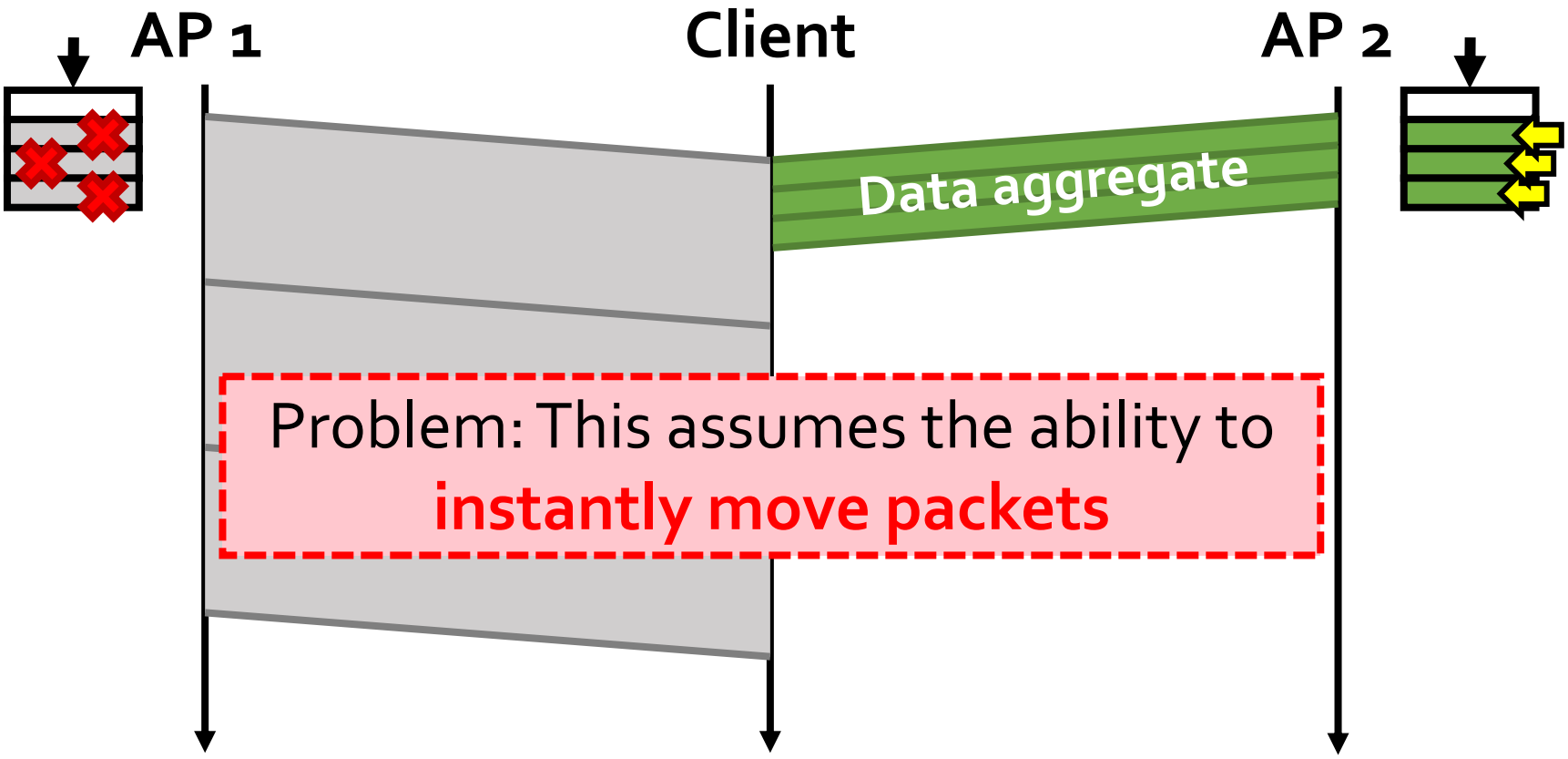


Challenges

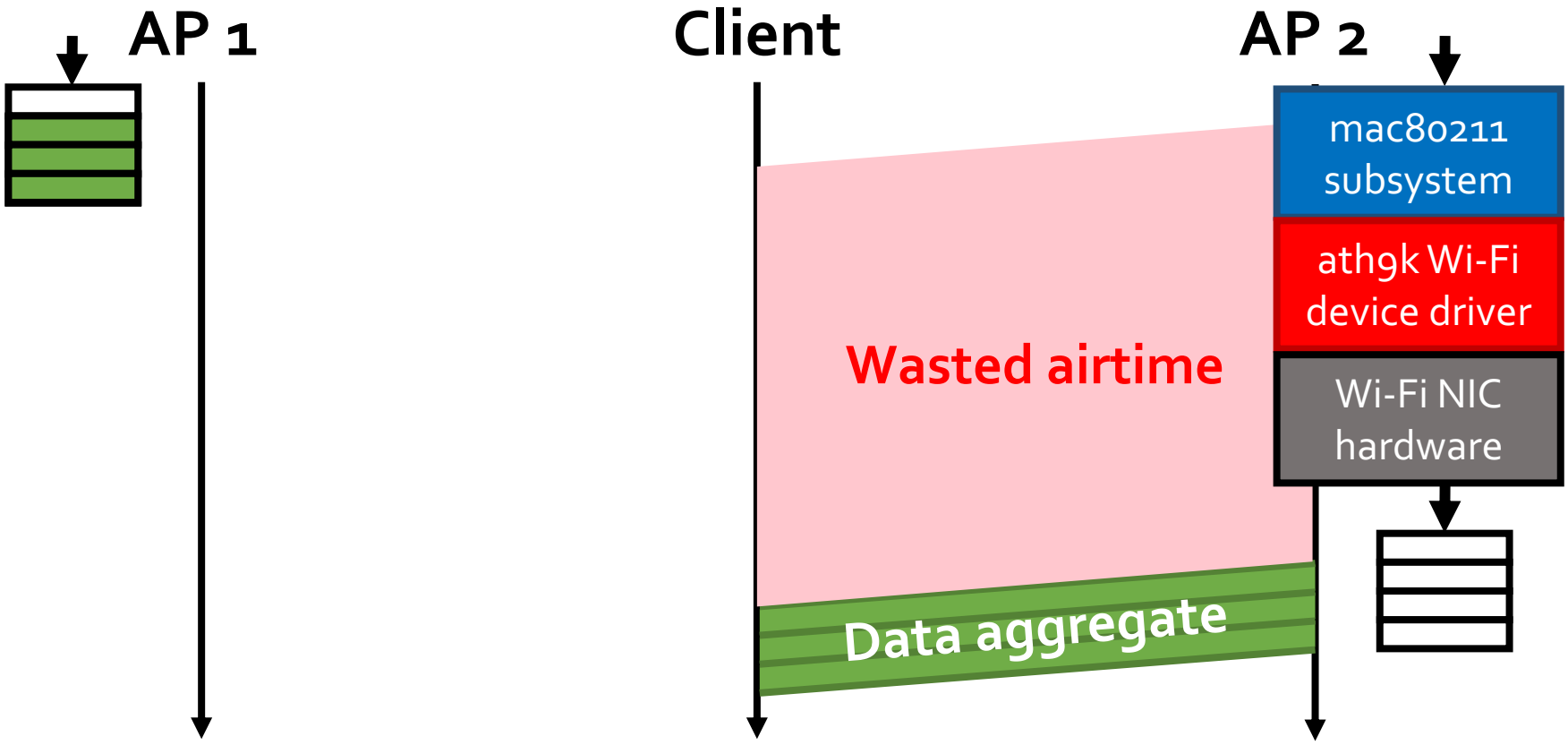
1. The real wireless channel is **unpredictable**

2. **Packet buffering** inhibits rapid adaptation

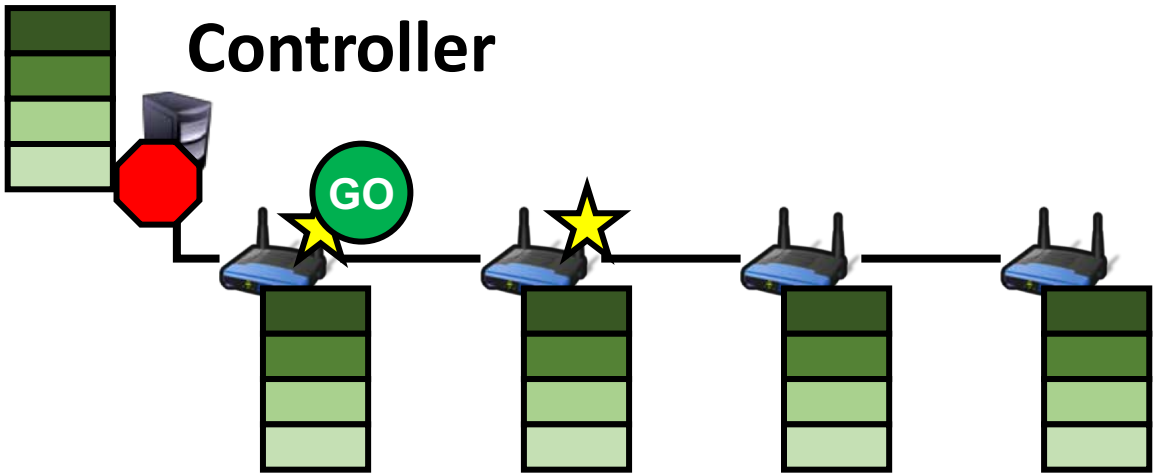
Possible solution: Move the packets



But moving packets harms throughput



Pre-buffering maintains high throughput

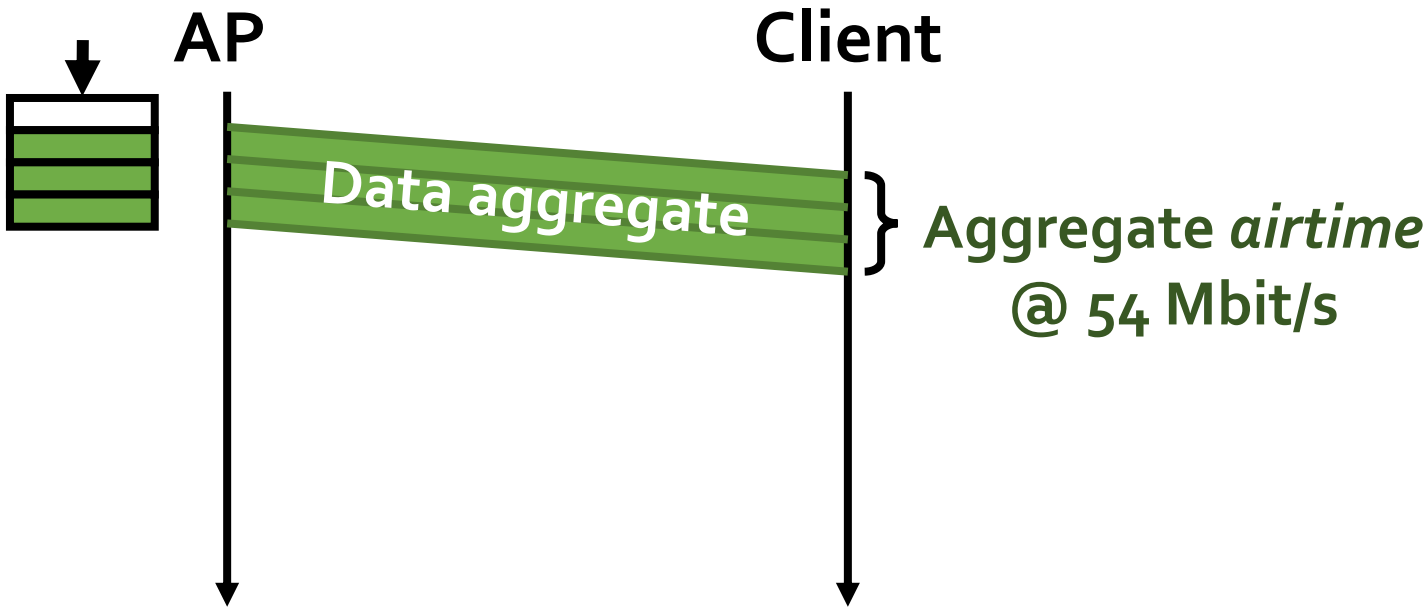


- All downlink packets sent to all APs
- *Control messages* **de-queue** delivered packets, **increasing efficiency**

Challenges

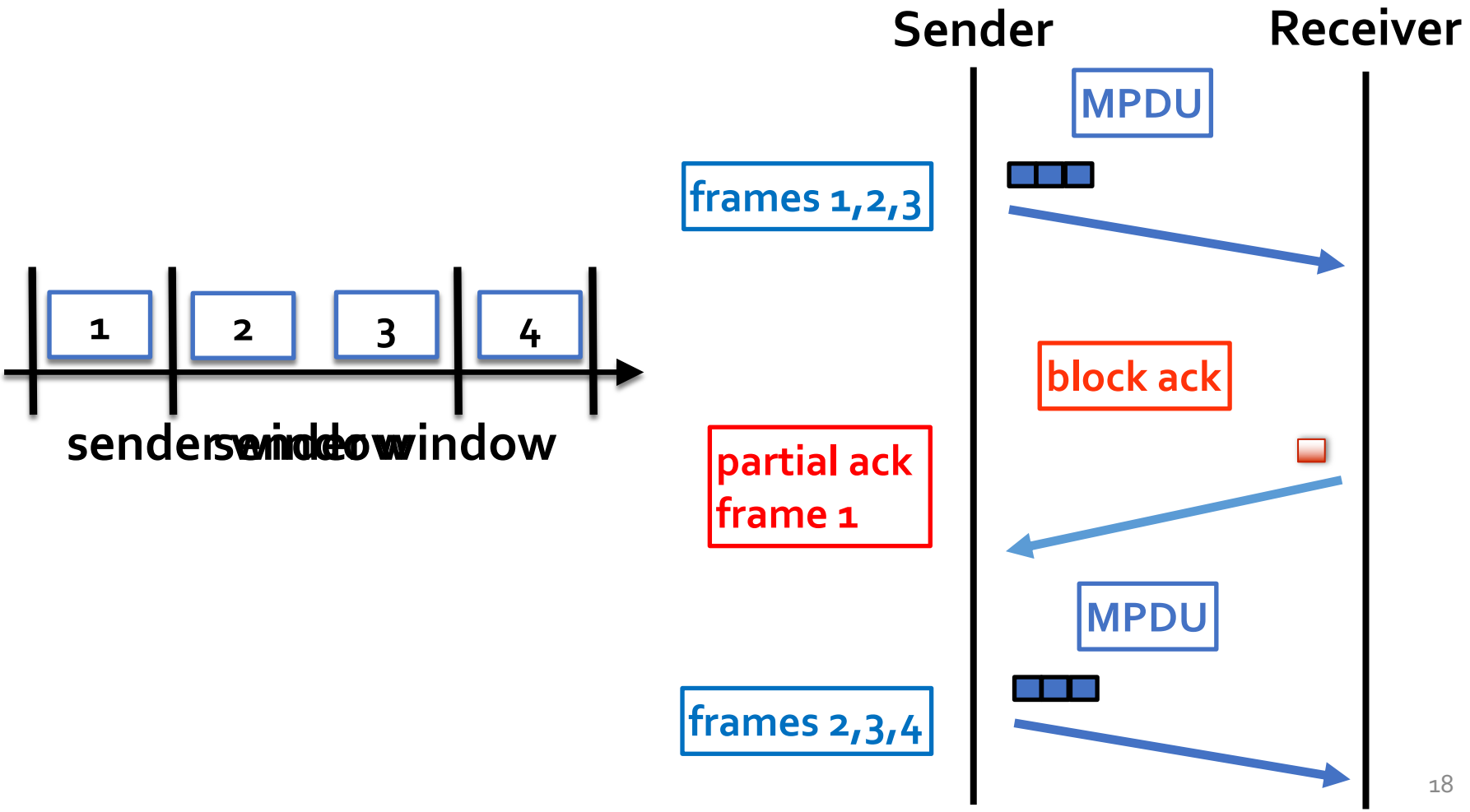
1. The real wireless channel is **unpredictable**
2. **Packet buffering** inhibits rapid adaptation
3. **Frame aggregation** complicates rapid adaptation

Wi-Fi frame aggregation

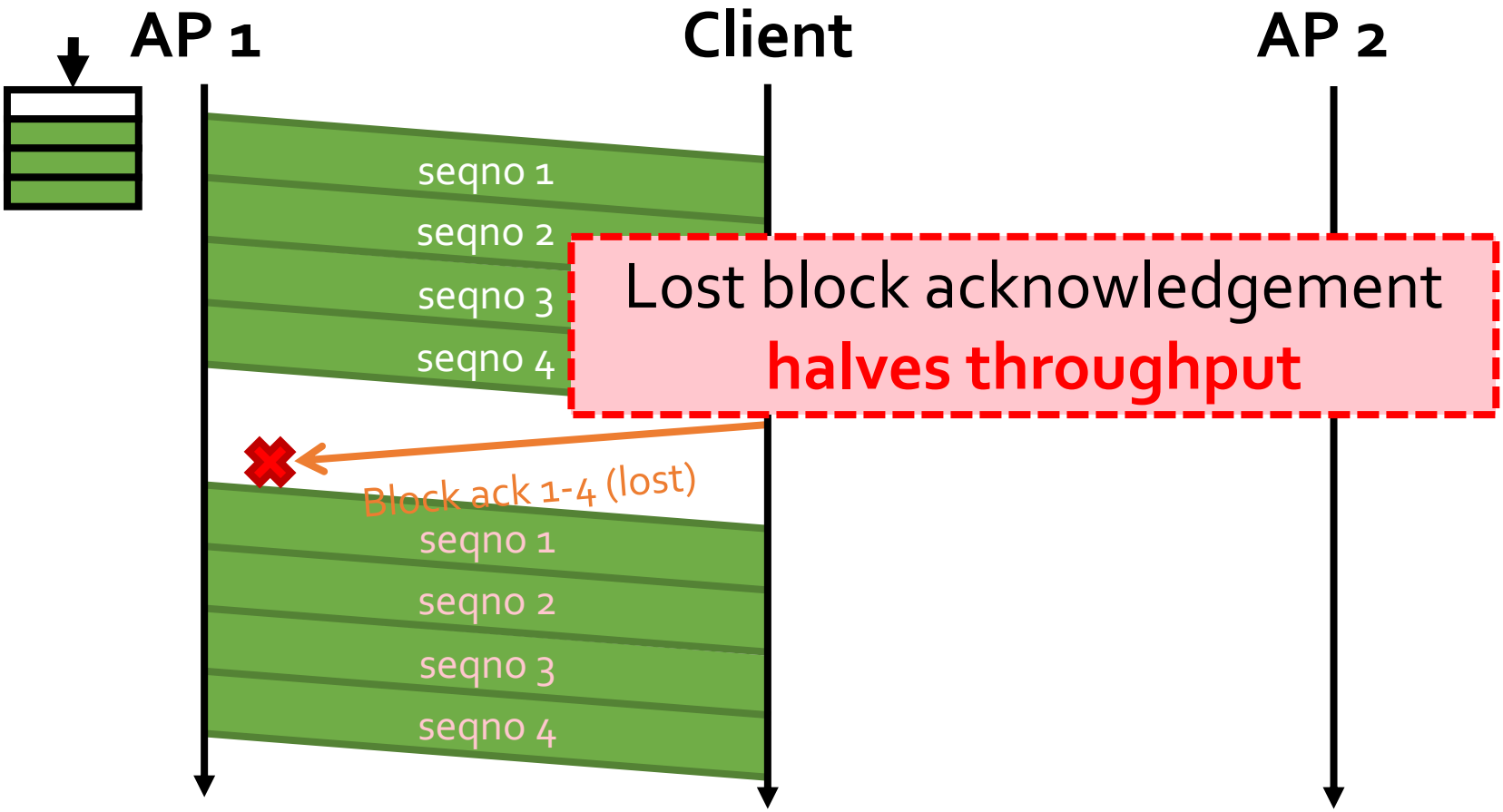


- Aggregates **amortize** the medium acquisition performance overhead

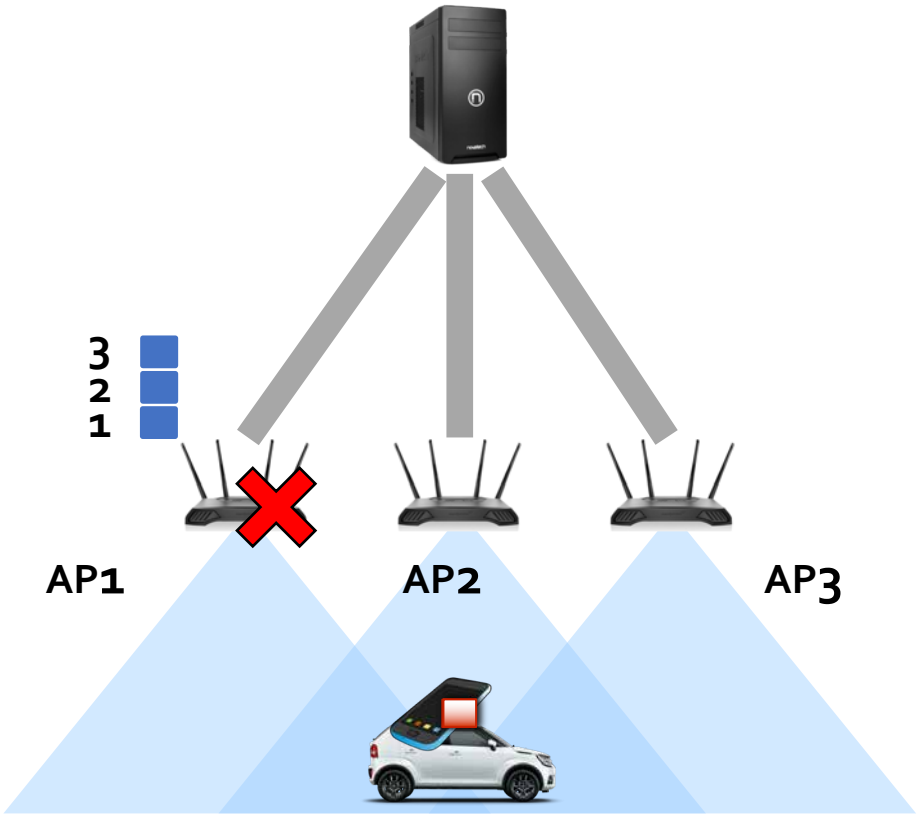
Wi-Fi frame aggregation and block acknowledgements

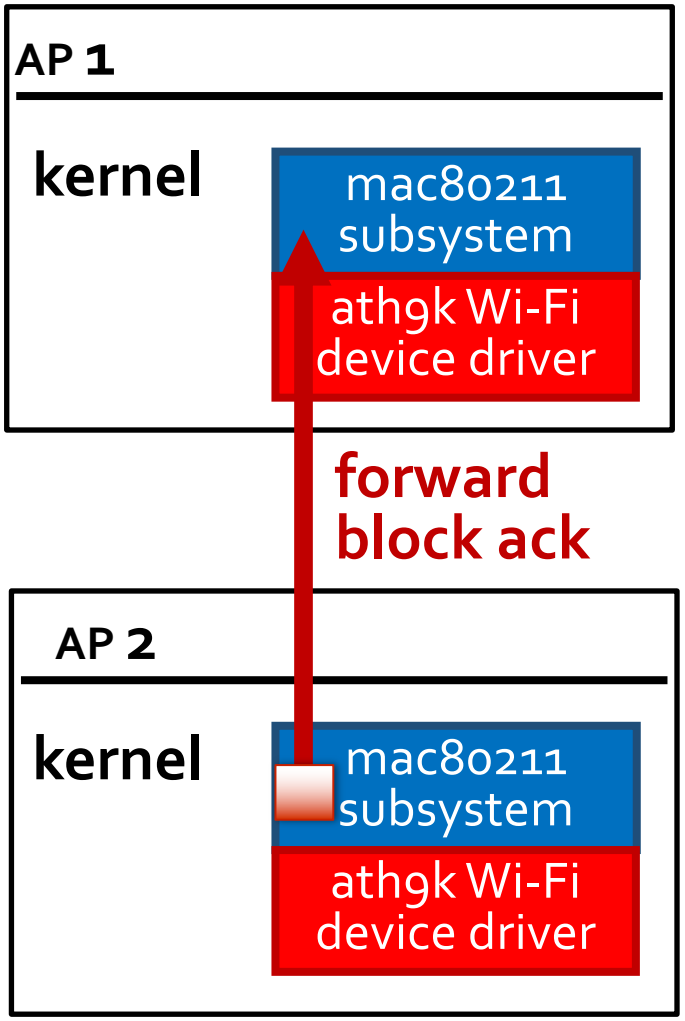


Problem: Lost block acknowledgements



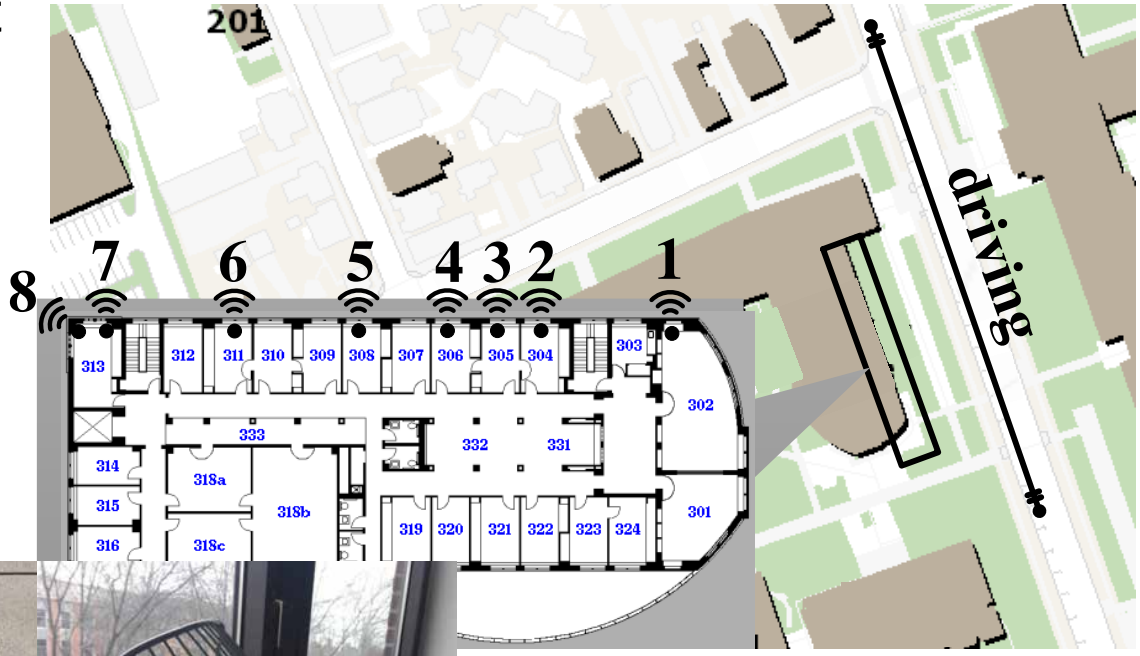
Solution: Block ACK forwarding





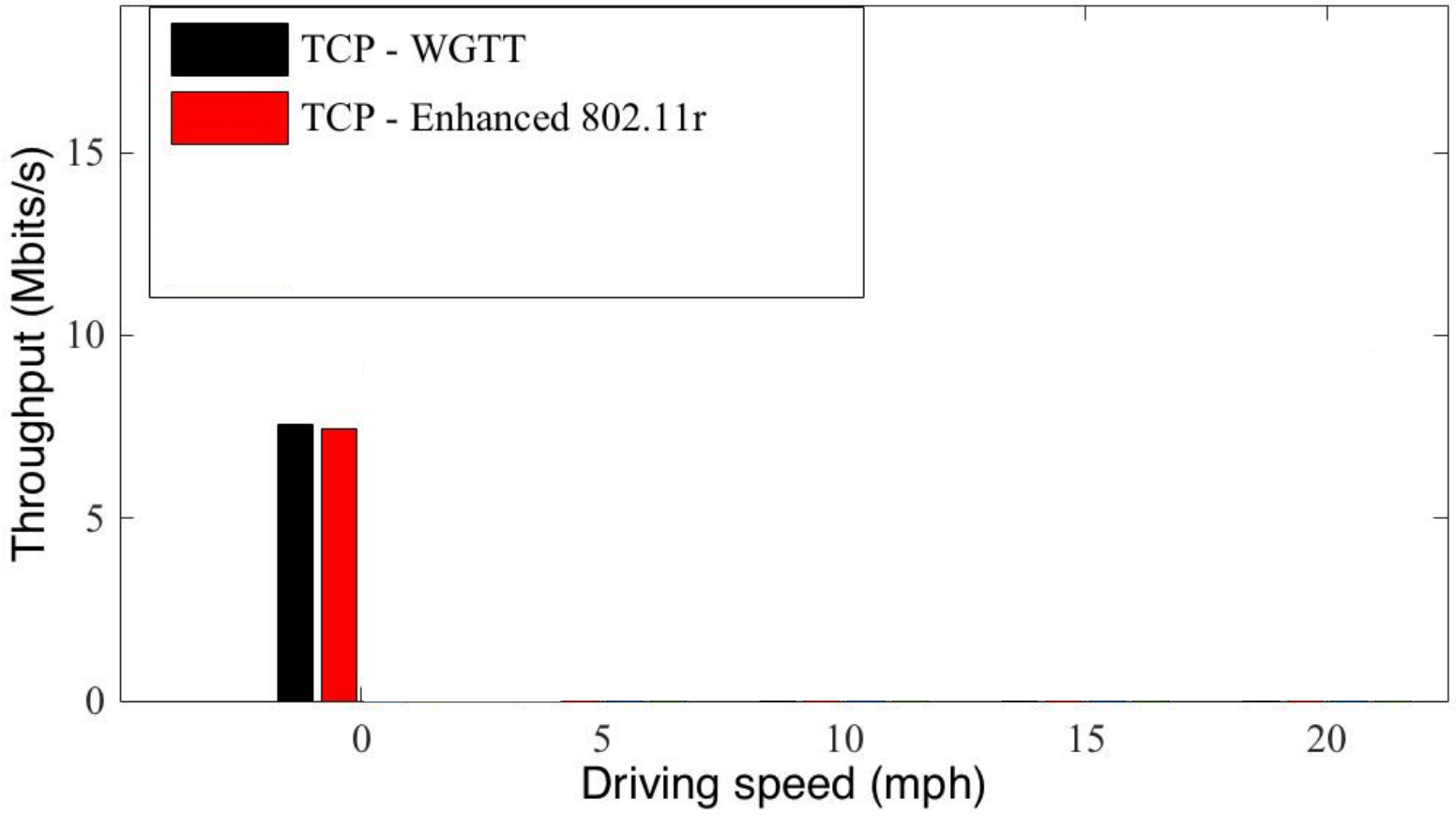
Implementation and a first testbed

- 8-AP roadside hotspot testbed at Princeton
- 25 mph car-driving experiments on road

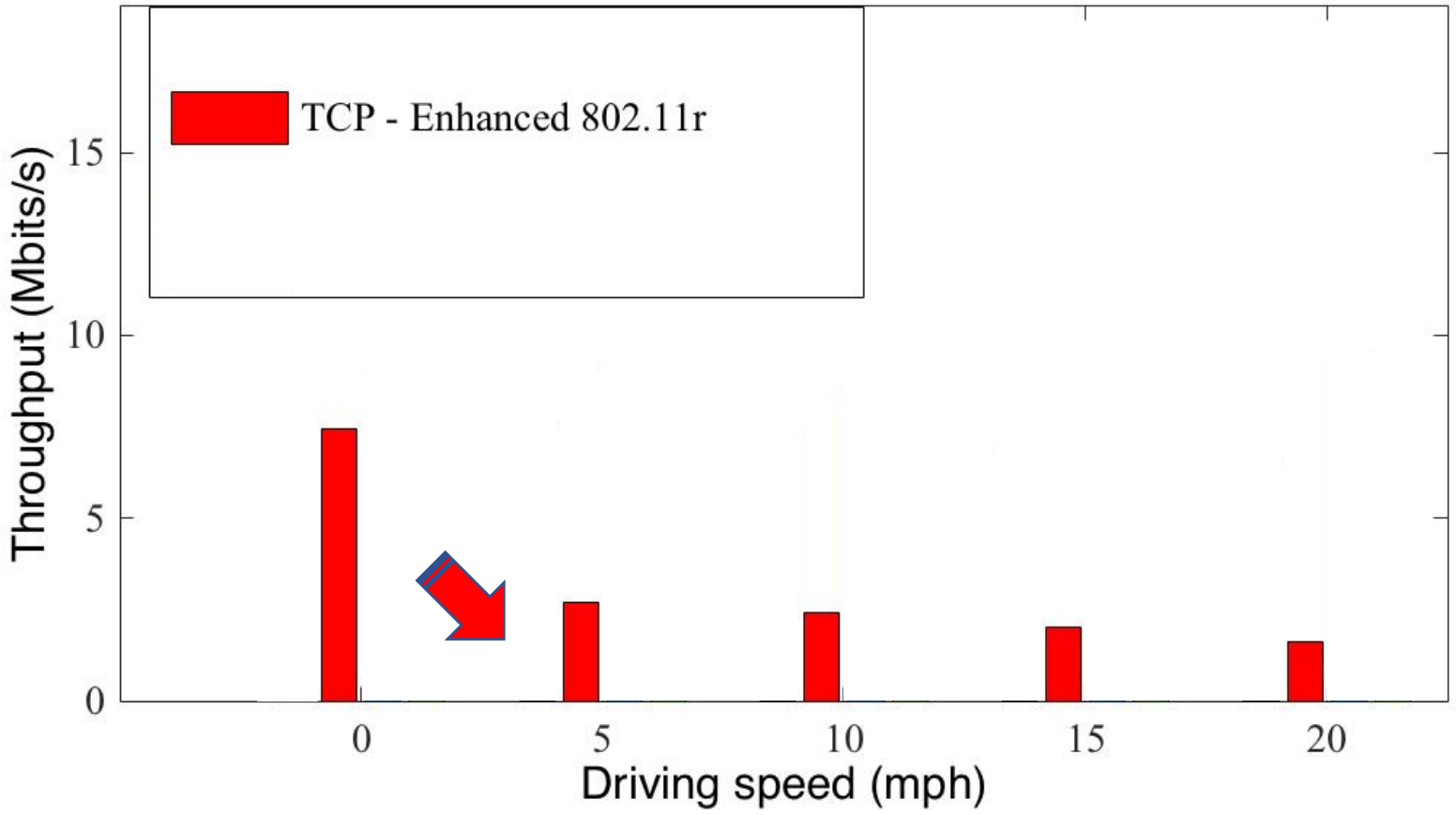


- Commodity Atheros Wi-Fi cards
- Directional antennas

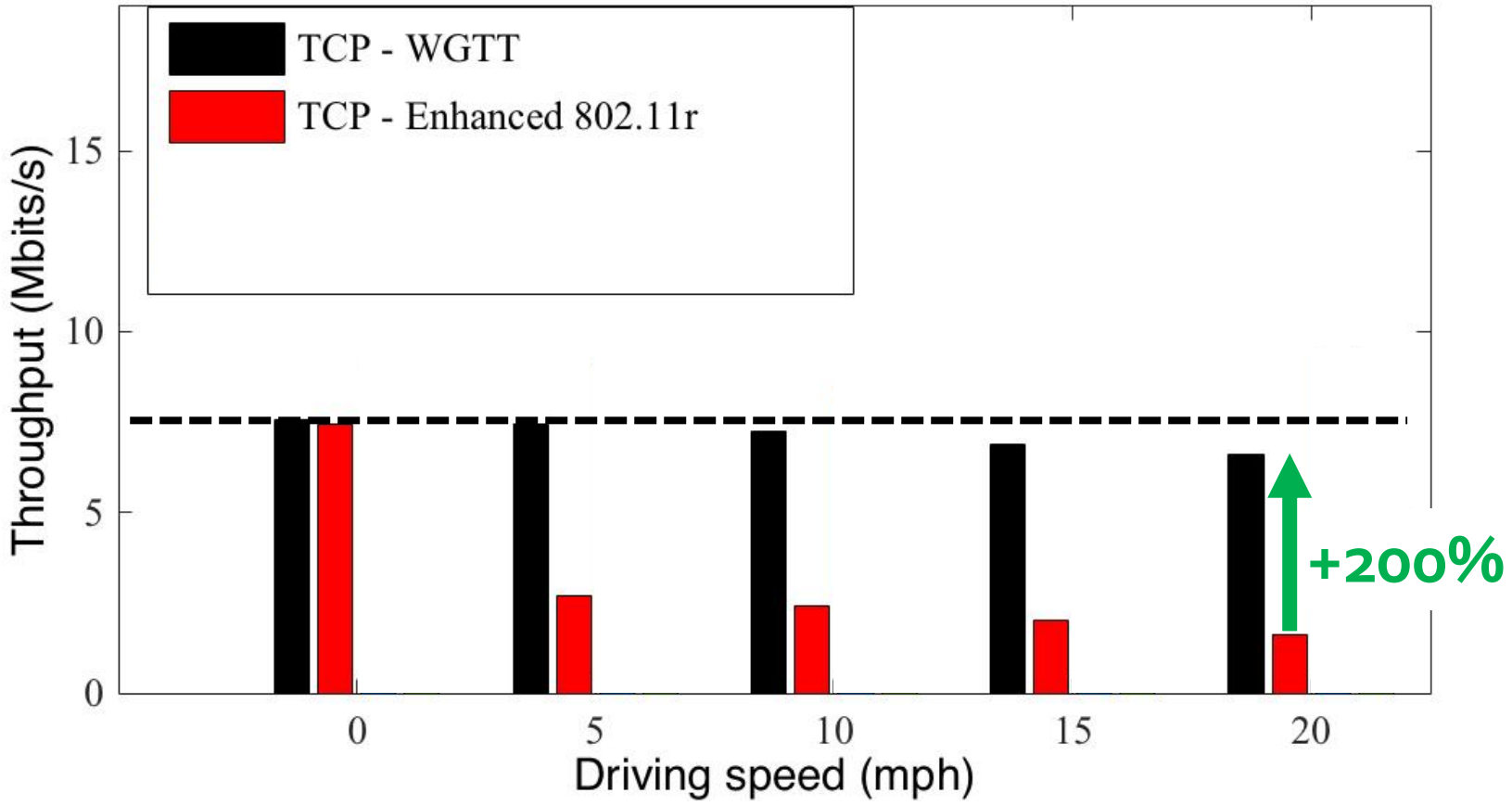
Wi-Fi works fine when stationary



But Wi-Fi can't handoff fast enough

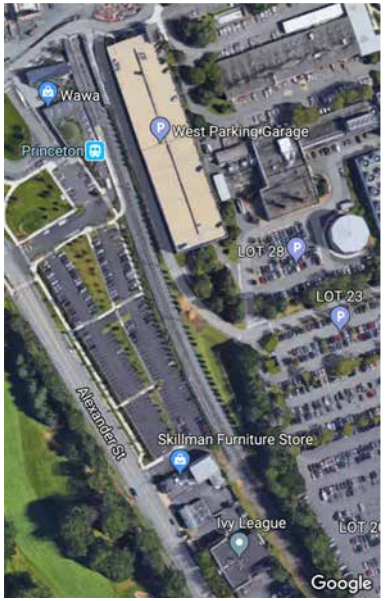


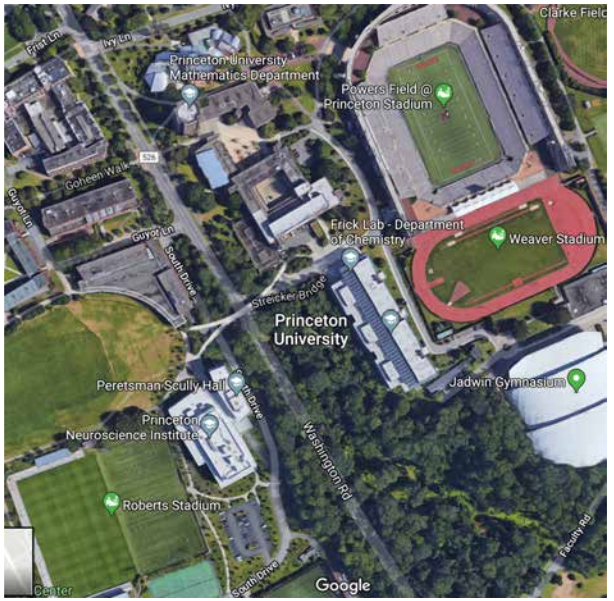
Driving, WGTT maintains high throughput



Next steps

- Scale up AP counts, deploy alongside Princeton campus **light rail line,** and **campus roads**





- **Integration with eduroam** for automatic association

Thanks and further details

- Grateful for support from a **Google Research Award and the Princeton IP Accelerator Fund**

- Further details: see **SIGCOMM 2017 paper**

- **Papers and videos** available for public download at the Princeton PAWS group website:

  http://paws.cs.princeton.edu