

# Measurement-based Characterization of 802.11 in a Hotspot Setting

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# Interested in Protocol Itself

- Many components of 802.11 MAC / PHY
- How well do they work in practice?

Acks / Retries

Rate Selection

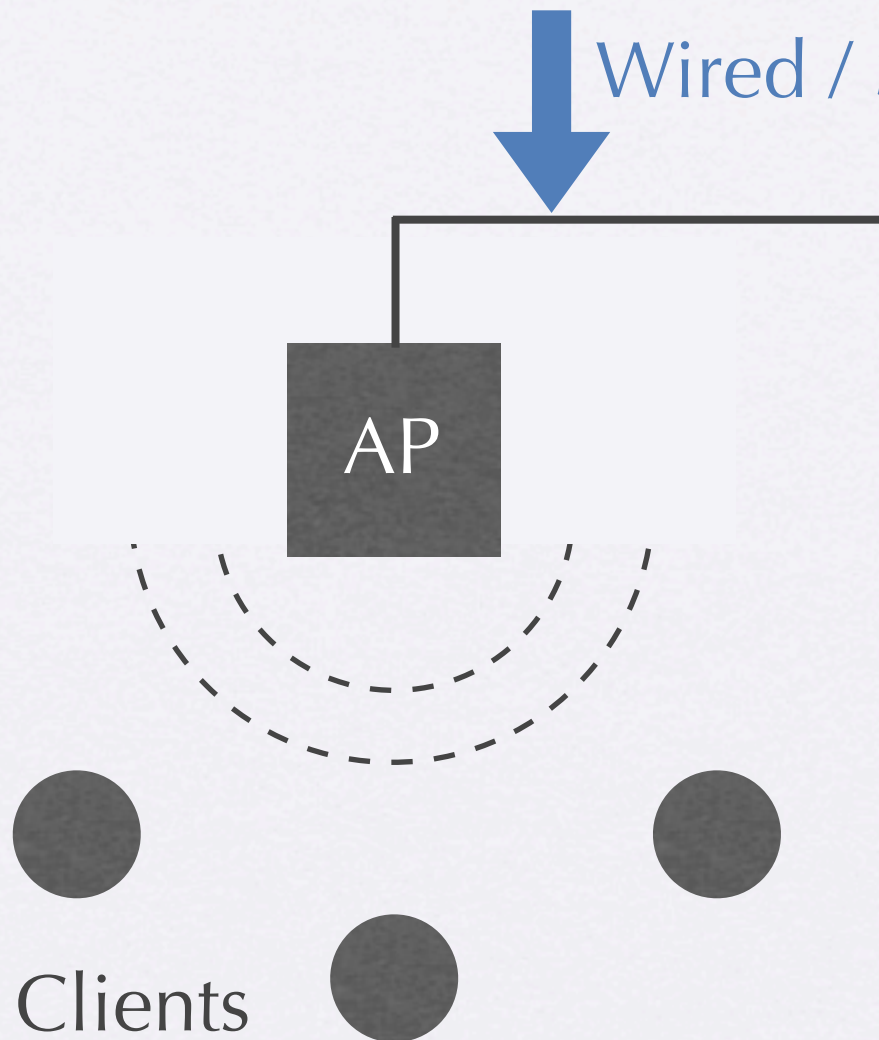
Beacon Frames

Association

# How well does 802.11 work?

- Many things we don't know:
  - *How much air time spent on real data?*
  - *How well do clients choose bit rates?*
  - *How does 802.11 react to contention?*
  - *etc.*

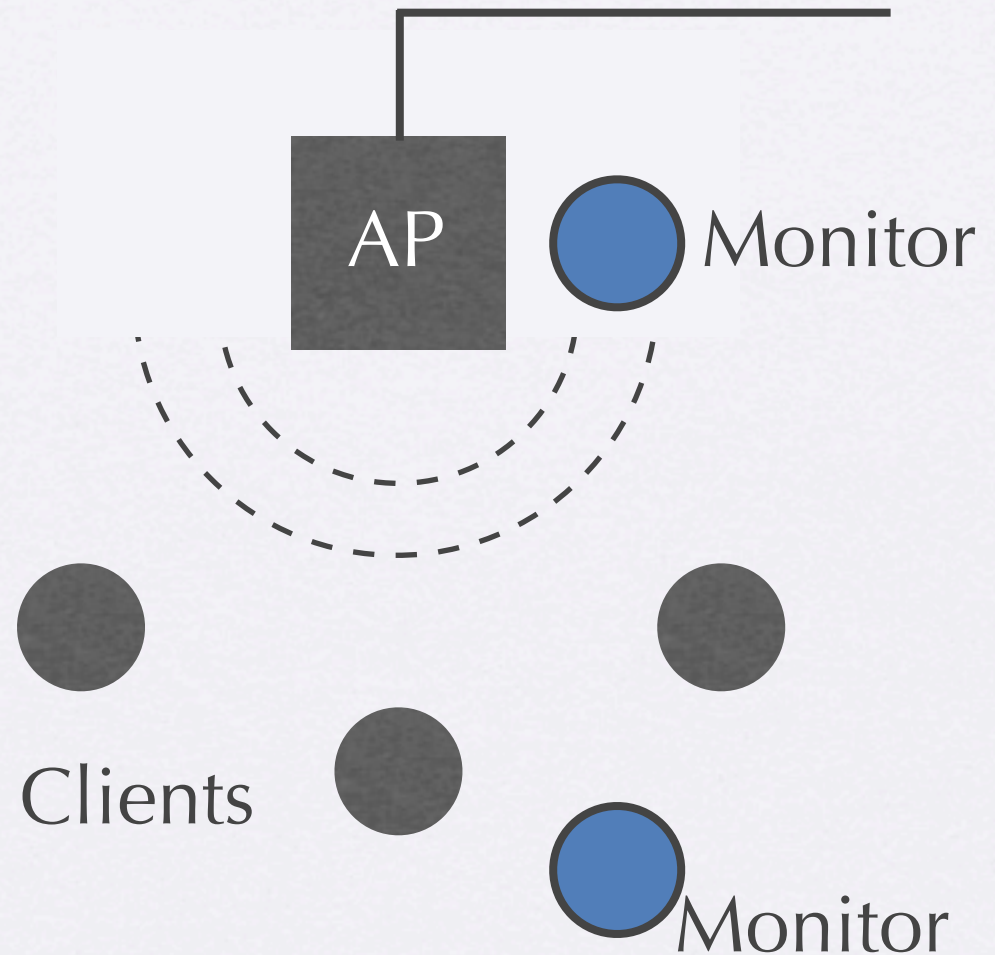
# Prior Studies Can't Answer



- Shows user / application behavior, not MAC

# Use Wireless Traces

- *Record packets in air*
- Learn tracing challenges
- Learn how well 802.11 really works
- Share data for studies



# Challenges for Tracing

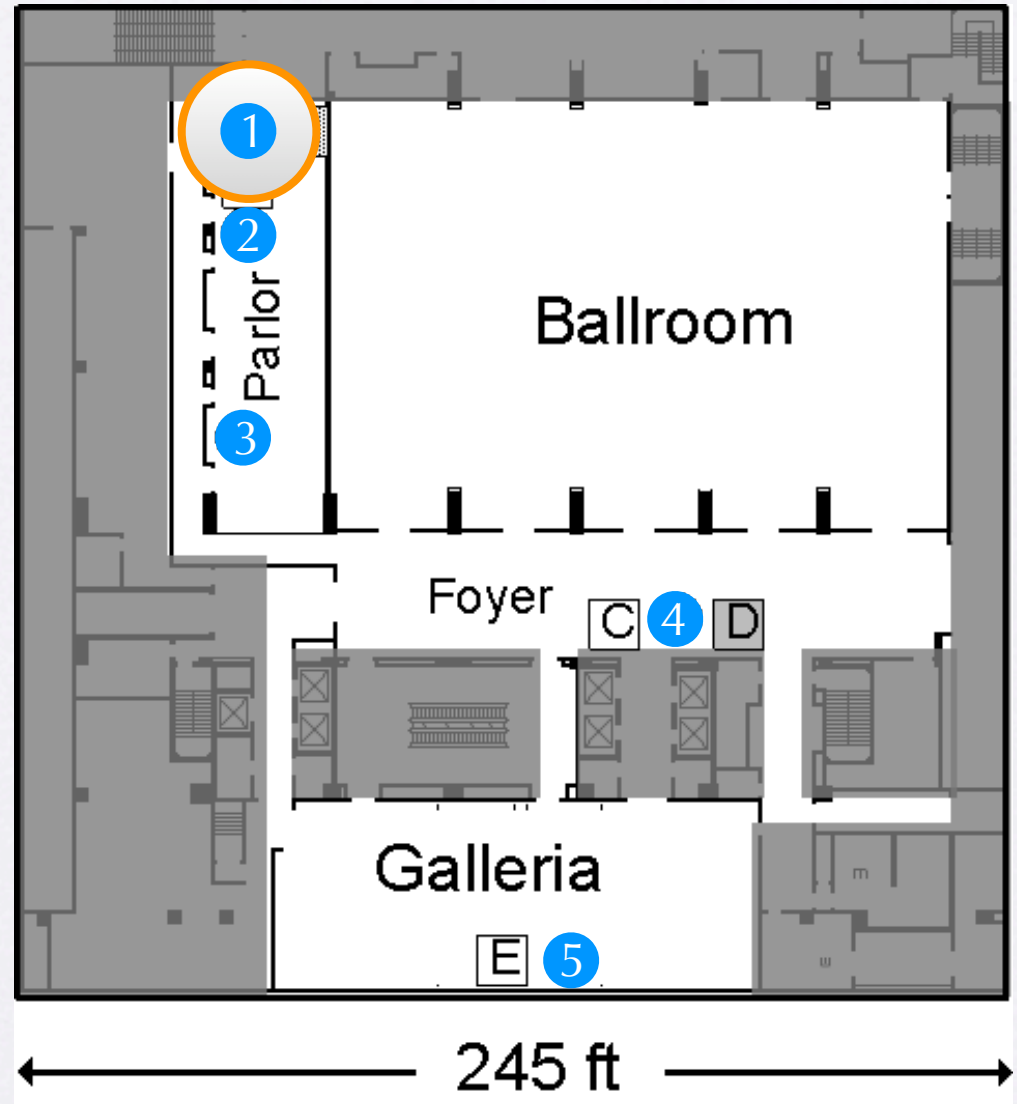
- Inherently incomplete view
  - Capture as much as possible
  - Must understand what's missing

# Analysis Techniques

- Leverage Hints in Traces
  - Data / ack pairs
  - Retry bit in header
  - Gaps in sequence numbers
- Related work: Merge traces (*Yeo, et al*)

# SIGCOMM 2004 Traces

- 5 days, 5 wireless monitors, 3 channels
- Focus on subset:
  - Tues, 8/31/2005
  - 8 am - 7:30 pm
  - Monitor 1, Channel 1





# Overhead for Data

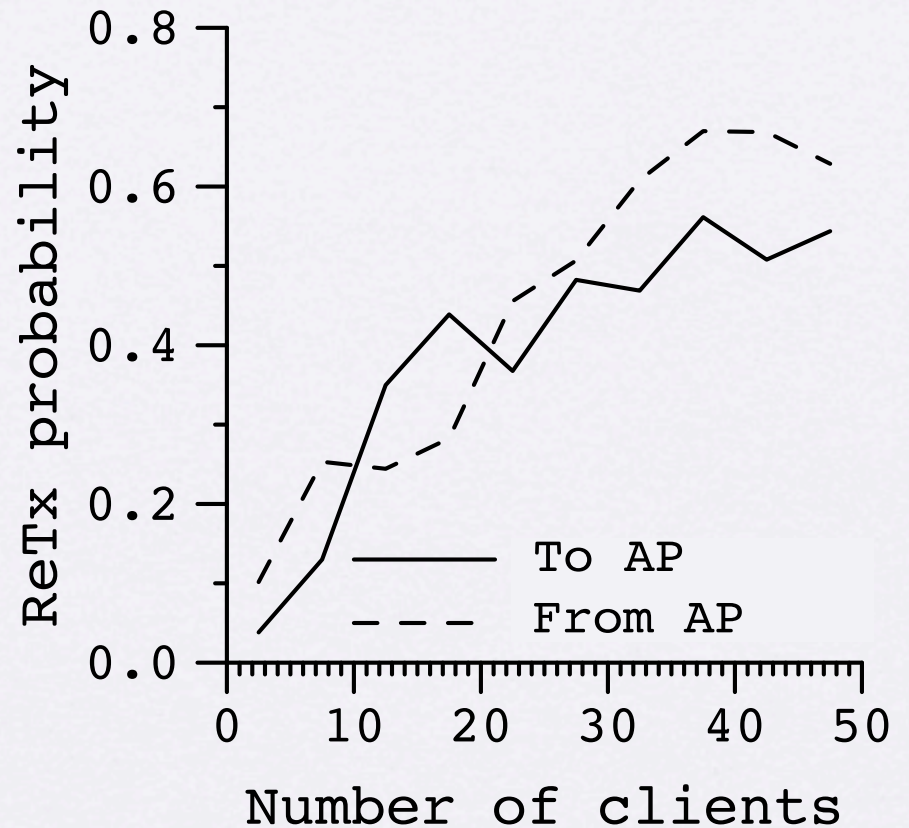
| Frame Type       | Frames          |
|------------------|-----------------|
| <i>Data</i>      | 5540 <b>43%</b> |
| <i>Originals</i> | 3988            |
| <i>Retries</i>   | 1552            |
| <i>Control</i>   | 5442            |
| <i>Mgmt</i>      | 1098            |
| <i>Totals</i>    | 12080           |

Only 31%  
original data

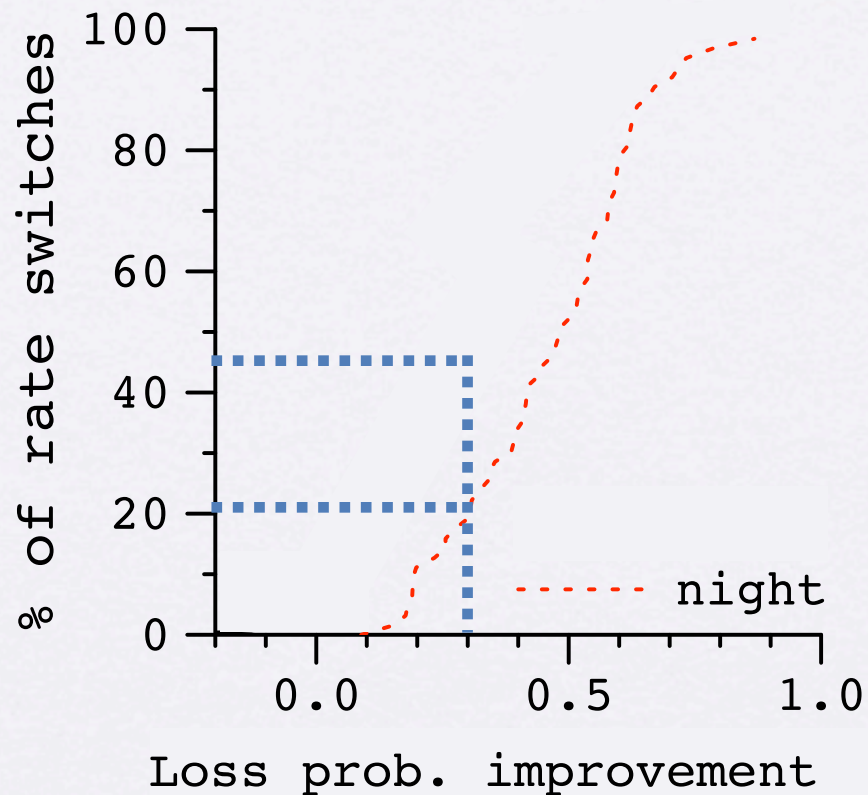


# Retransmissions

- Correlated with *low signal strength*, as expected
- But, also correlated with *contention*
  - Carrier sense not working
  - Leads to slower rates, thus further contention



# Rate Change Effectiveness



- Designed for clients with low signal strength
- Does changing rate lower loss probability?
  - At night, usually so
  - Much worse, given contention

# Future Directions

- **Better Analysis Techniques**
  - Merge traces
  - Better protocol inference (time, RSSI, etc)
- **More Protocol Questions**
  - Spatial diversity?
  - Effect of error packets / collisions?

## **Anonymized Traces Available (22 GB):**

*<http://www.cs.washington.edu/research/networking/wireless/>*

- Tons of wireless data left to explore:
  - Learn low level protocol behavior
  - Test new analysis techniques
  - Compare against other settings