Crowdsourcing Access Network Spectrum Allocation Using Smartphones

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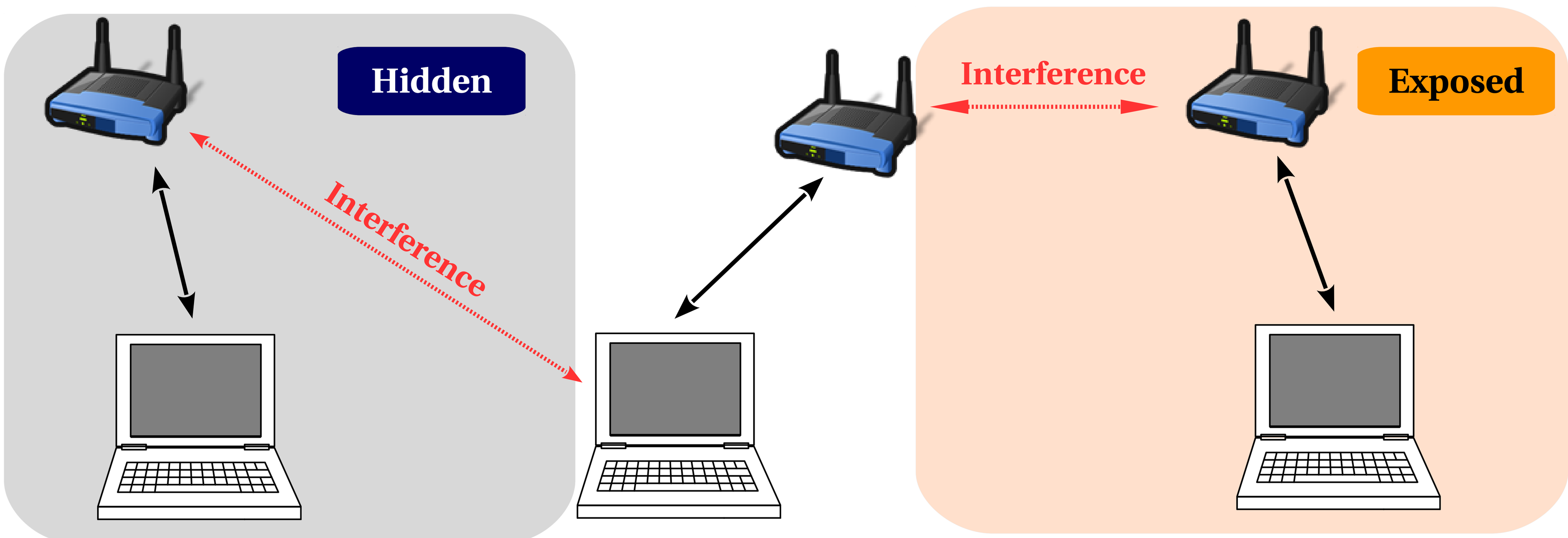
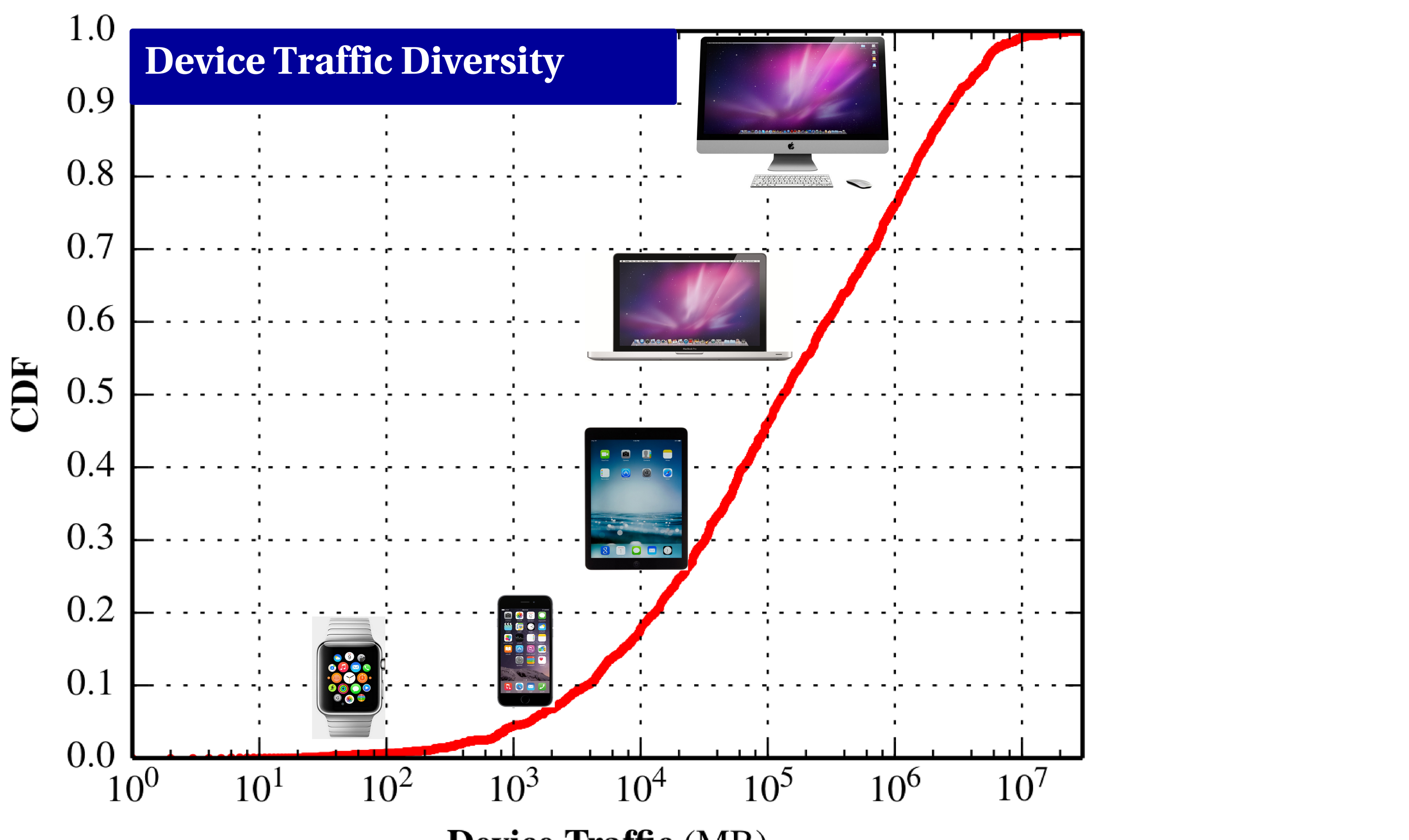
Client-Side View Is Important

Without client feedback, AP can either:
Fail to detect hidden interference **or** Miss channel reuse opportunity



Traffic Details Are Needed!

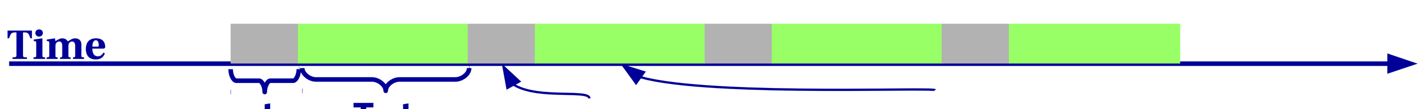
- Fewer stations == Less Interference? [1, 2] False!
- Station count is not a good prediction of channel load.



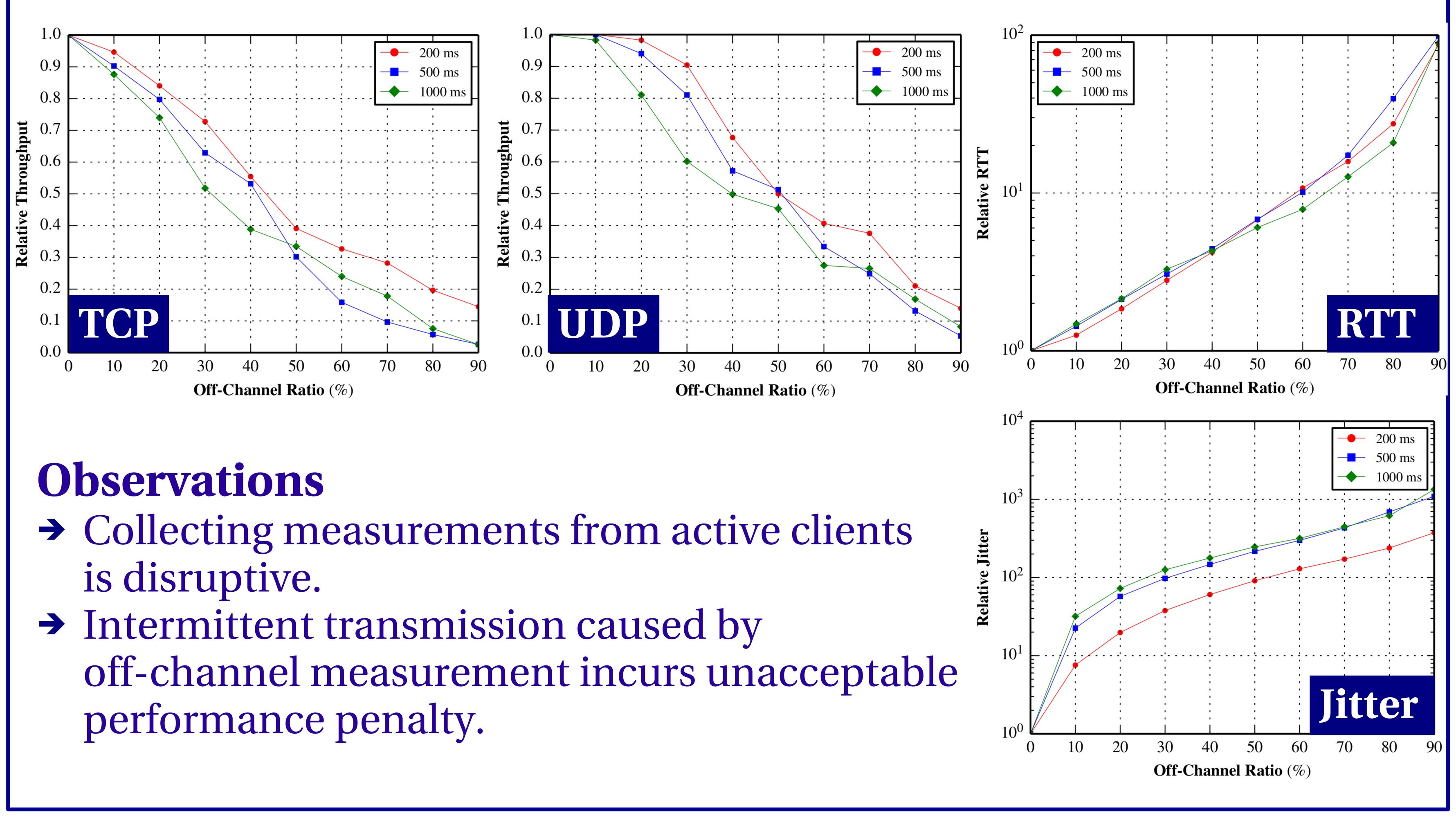
Off-Channel Measurement Overhead

802.11k Radio Resource Management

- A framework for AP to collect channel statistics from clients.
- Off-channel measurement interrupts active clients' transmission.



- We measure the penalty of 802.11k's off-channel measurement by pausing transmission for `t` ms in each `T` ms interval, and measure application level performance with different `T` and `t` (in % of `T`).
- In experiments, we use a clear channel, place device on top of AP and fix device's transmission rate. Therefore, these results show the penalty in *best-case scenario* (no interference, no unnecessary rate adaptation).



Observations

- Collecting measurements from active clients is disruptive.
- Intermittent transmission caused by off-channel measurement incurs unacceptable performance penalty.

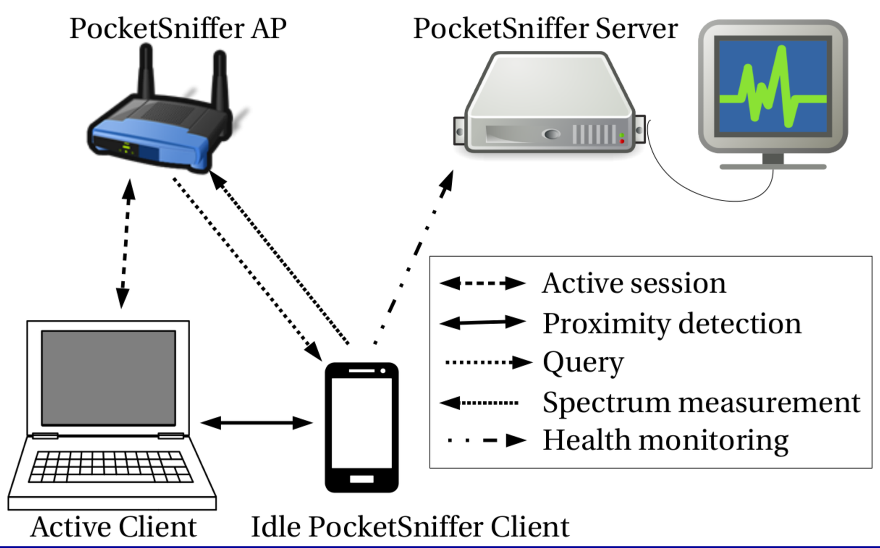
Smartphone to the Rescue!

Smartphones are ideal for performing measurement for other nearby active devices.

Always with you **Always on**
Near your other active devices.

Mostly idle
Measurements are unlikely to interfere with normal usage.

System Design



PocketSniffer AP
- Monitors active link performance
- Triggers measurements for active clients
- Adapts channel based on smartphone measurements

PocketSniffer Client
- Performs measurements *on behalf of nearby devices*
- Reports long-term network statistics for health monitoring

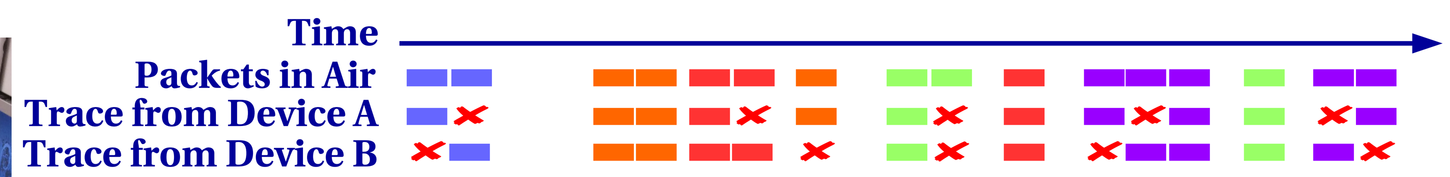
Challenges

- **Can smartphones accurately predict channel conditions of nearby devices?**
- Energy overhead of measurement (monitor mode, pcap parsing)
- Incentives for smartphone participation
- Validating measurements from untrusted clients
- Non-cooperative overlapping networks

Similarity of Measurements

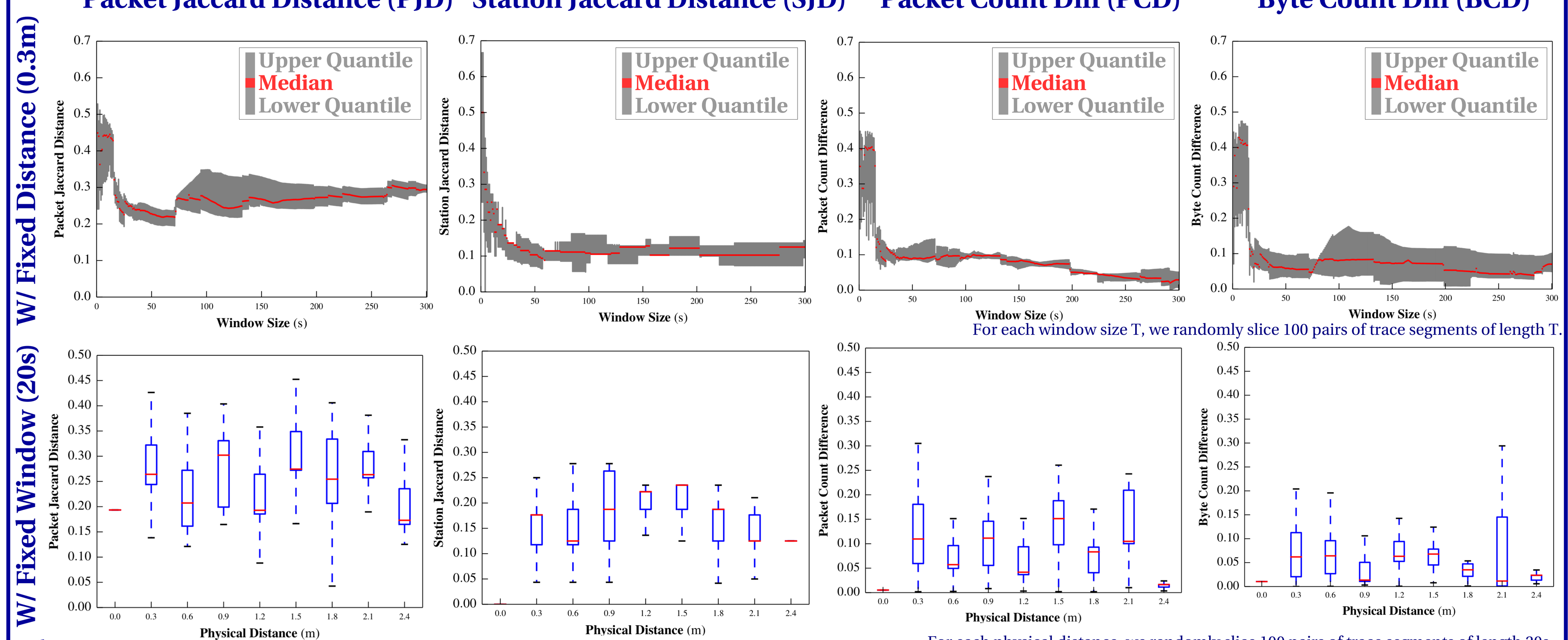
Experiment setup

- Place smartphones in a row with constant separation distance (0.3m).
- Simultaneously collect packet traces from all smartphones by putting them into *monitor mode.*
- Analyze various similarity metrics between pairs of packet traces.



Each device provides a sample of all packets in air.
Interesting trace distance metrics are:

- Do they see same subset of packets? $\text{Packet Jaccard Distance} = 1 - \frac{T_A \cap T_B}{T_A \cup T_B}$
- Do they see same set of stations? $\text{Station Jaccard Distance} = 1 - \frac{sta(T_A) \cap sta(T_B)}{sta(T_A) \cup sta(T_B)}$
- Do they see same number of packets? $\text{Packet Count Diff} = \frac{abs(\|T_A\| - \|T_B\|)}{\max(\|T_A\|, \|T_B\|)}$
- Do they see same amount of traffic? $\text{Byte Count Diff} = \frac{abs(bytes(T_A) - bytes(T_B))}{\max(bytes(T_A), bytes(T_B))}$



Conclusions

- Although different devices may capture different subset of packets (PJD), the aggregate metrics (SJD, PCD and BCD) converge to small values quickly.
- Within short physical range (2.4m in our experiments), trace similarity is not correlated with physical distance.
- **Smartphones can accurately predict channel conditions of nearby devices!**

References

[1] Mishra, Arunesh, Suman Banerjee, and William Arbaugh. "Weighted coloring based channel assignment for WLANs." ACM SIGMOBILE Mobile Computing and Communications Review 9.3 (2005)
[2] Mishra, Arunesh, Vladimir Brik, Suman Banerjee, Aravind Srinivasan, and William Arbaugh. "A client-driven approach for channel management in wireless LANs." In In IEEE Infocom. 2006.