# Crowdsourcing Access Network Spectrum Allocation Using Smartphones

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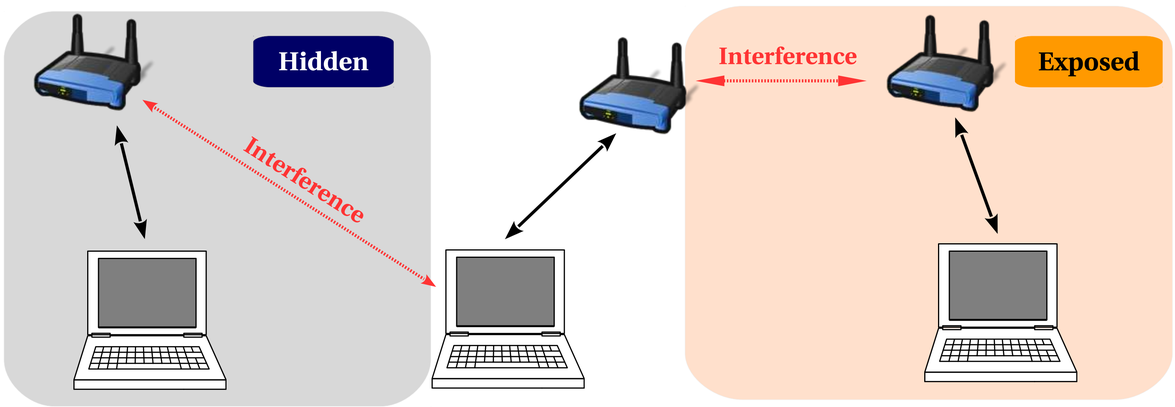
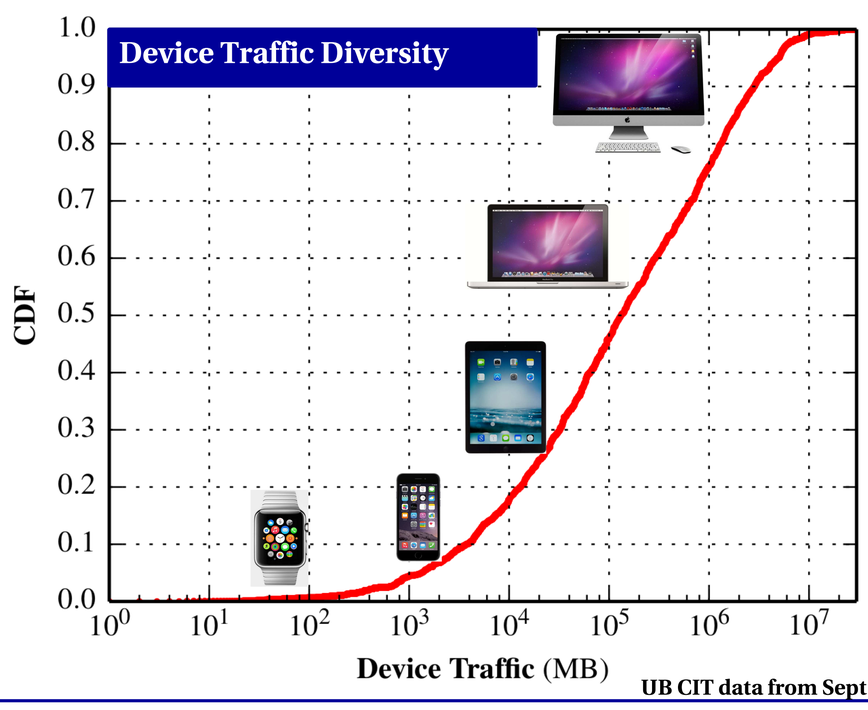
## Client-Side View Is Important

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.

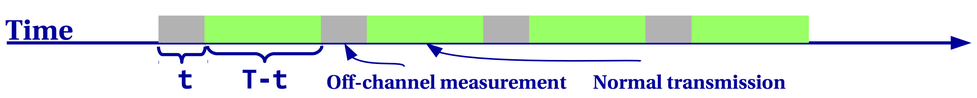



UB CIT data from Sept 16, 2014 to Dec 03, 2014

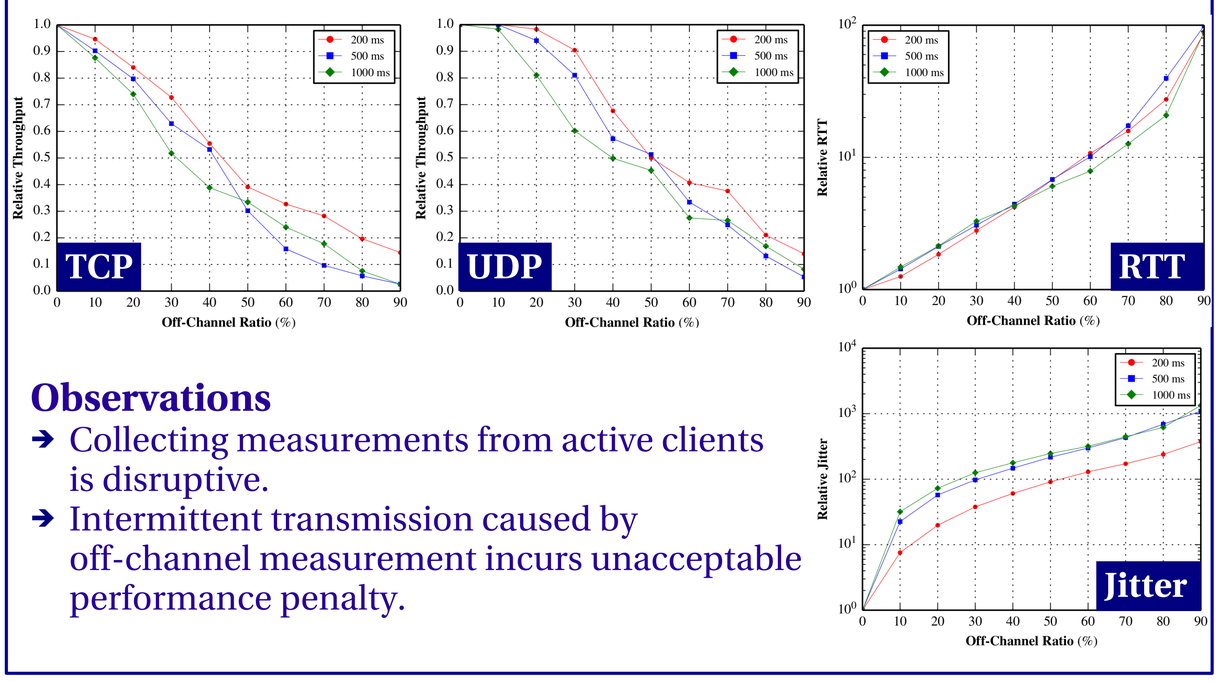
## Off-Channel Measurement Overhead

### 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).

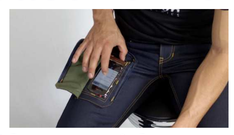



### Observations

- 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.**



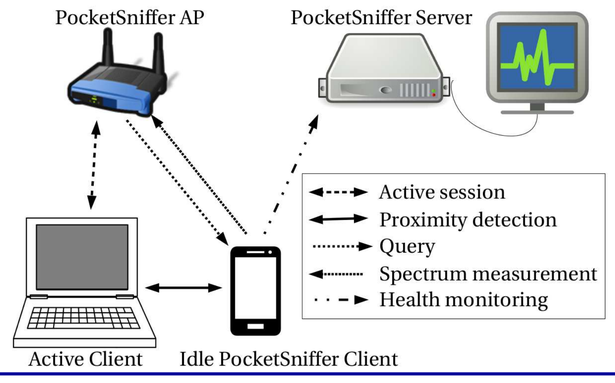
**Always with you**

**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

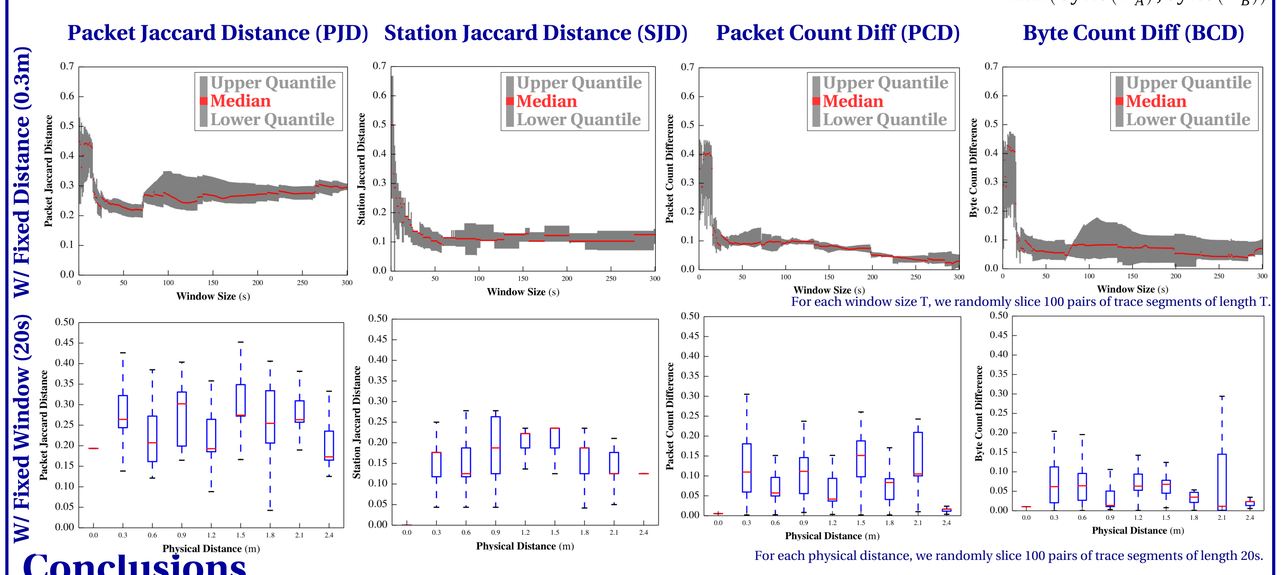
## Similarity of Measurements

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




For each window size T, we randomly slice 100 pairs of trace segments of length T.

For each physical distance, we randomly slice 100 pairs of trace segments of length 20s.

### 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.