Home Network Interference Detection with Passive Measurements

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Presentation Structure

- Introduction and motivation
- The NETHINT tool
- Passive measurement
- Statistical metrics
- Tests and results
- Live demo
- Conclusion and Future Work

Introduction and Motivation 1/2

- Home offices are here to stay
- Local interference vs. remote bottleneck
- Who is to blame?

Introduction and Motivation 2/2

- Problems with diagnosing network issues:
  - Requires knowledge
  - Issues need to persist
  - Transfers are often short or bursty
  - Single-device statistics
- Solution: Long-term measurements and statistics

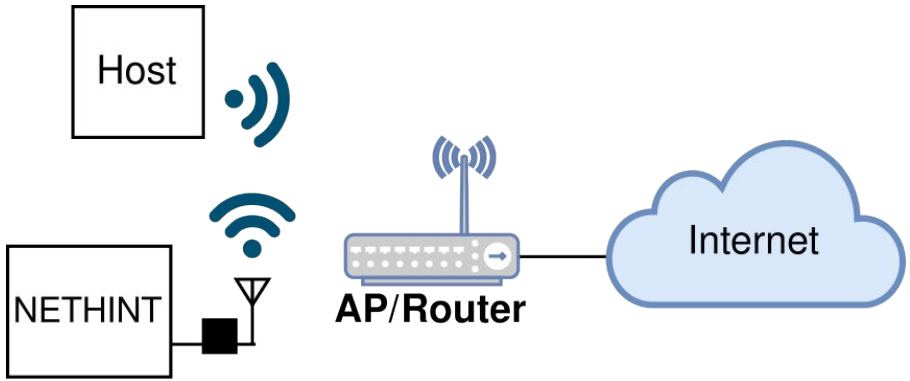
Presenting: NETHINT (1/2)

(NETwork Home INTerference)

- A tool for collecting and parsing metrics
- User-friendly(er)
- Passive measurement
- Multi-device
- Operating modes

Presenting: NETHINT (2/2)

- Disregards intra-network latency
- Expandable
- Portable
- Export options



NETHINT is placed close to the hosts on the WLAN

Passive Measurement

Pros:

- No additional processing time
- No traffic discrimination
- Enables long-term statistics

Cons:

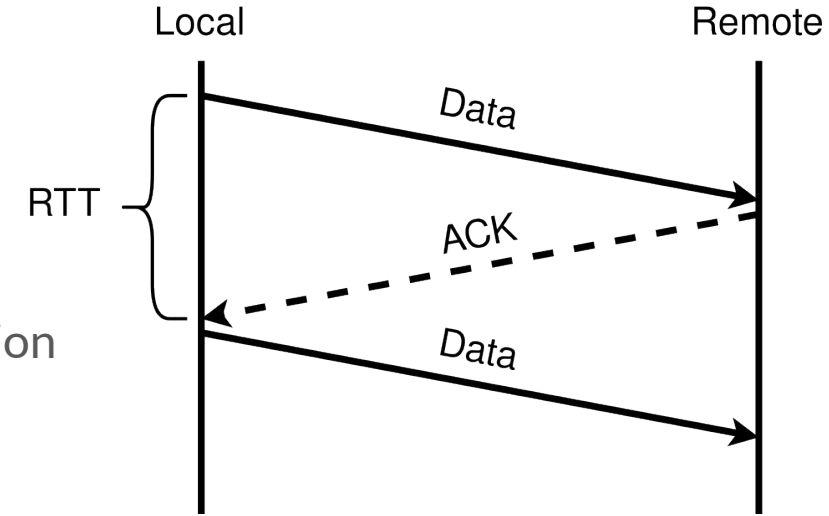
- We have to rely on present header data
- This information is disappearing

Statistical Metrics

- Latency/delay (vs. capacity/bandwidth)
- Packet loss (transport-layer retransmissions)
  - Informs congestion control
  - Kind of rare
- Wireless signal quality

Measuring Latency Reliably

- TCP
  - Incoming or outgoing data
  - SEQ/ACK-based pairing
  - Timestamp-based pairing
  - Connection establishment/termination Packets
- QUIC
  - Initial
  - Spin bit



Primary reliable delay source: Pairing incoming ACKs with their corresponding data packets

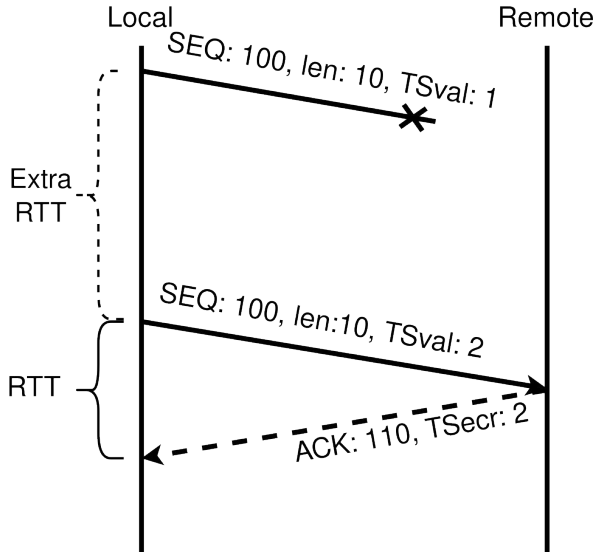
Outgoing Data: Retransmission RTT Deviation

SEQ/ACK-based pairing

- Incorrect for retransmitted data
- Potential solution: filter lost packets

Timestamp-based pairing

- Correct for retransmitted data



Retransmission RTT deviation

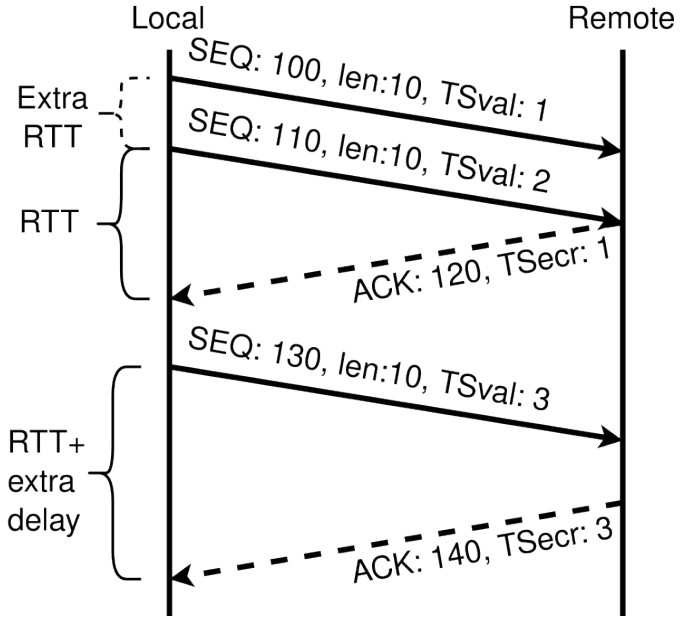
Outgoing Data: Delayed ACK RTT Deviation

SEQ/ACK-based pairing

- Correct measurement of delayed ACKs

Timestamp-based pairing

- Overestimates RTTs for delayed ACKs



Delayed ACK RTT deviation

Outgoing Data: Combining Pairing Methods

	SEQ/ACK	TCP Timestamps	NETHINT
Retransmitted data	❌	✅	✅
More samples on lossy links	❌	✅	✅
Delayed ACKs	✅	❌	✅

Incoming Packets: One-Way Delay

Base = Capture time - TSval

Base = 1000 - 500 = 500

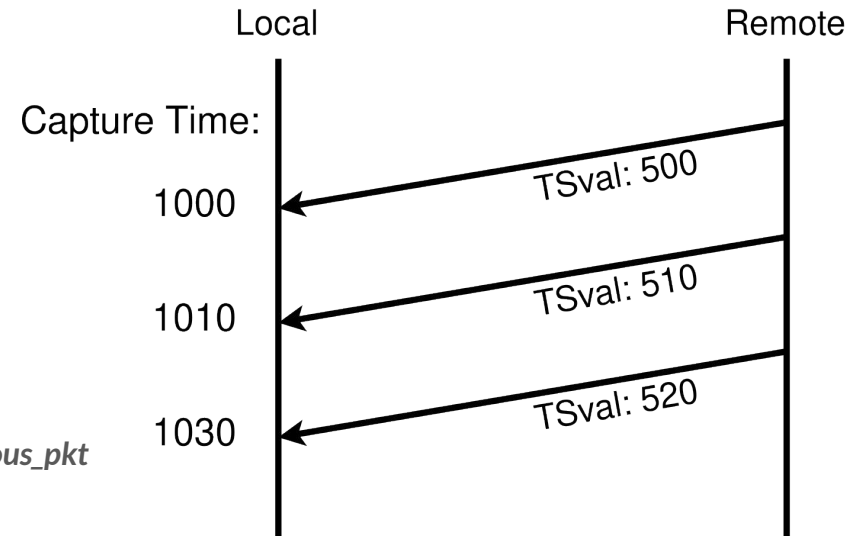
Base = 1010 - 510 = 500

Base = 1030 - 520 = **510**

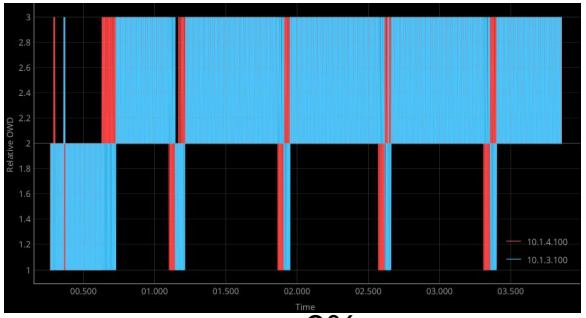
Relative OWD = Base $_{current\_pkt}$ ***- Base*** $_{previous\_pkt}$

510 - 500 = **-10**

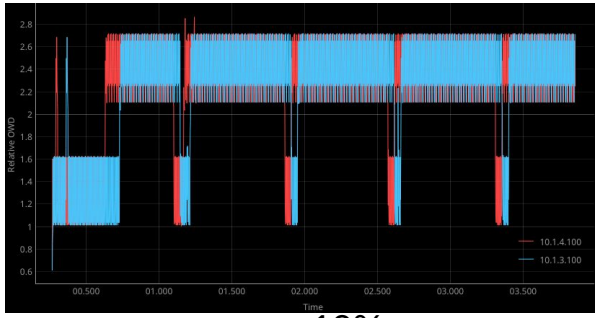
Relative OWD decreases: Indication of congestion



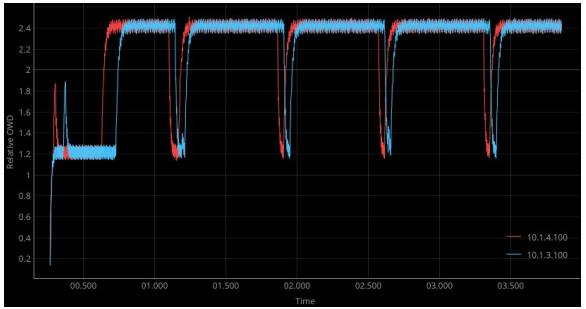
One-Way Delay: EWMA



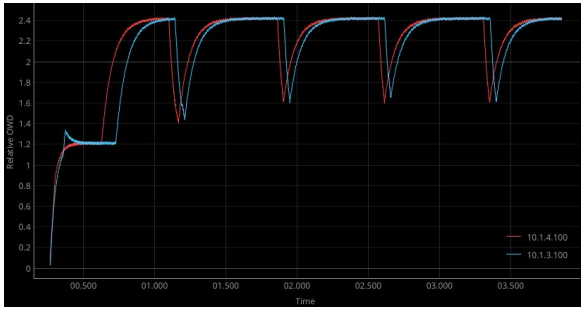
$x = 0\%$



$x = 10\%$



$x = 40\%$



$x = 70\%$

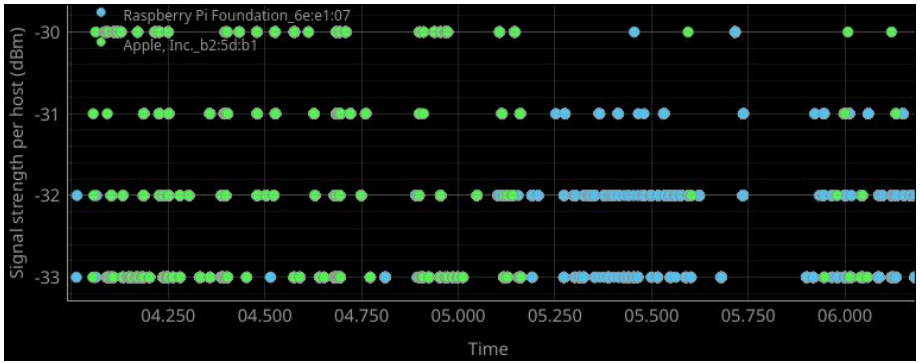
$$\alpha = 0.83e^{-0.06x},$$

where

x = smoothness percentage adjustable by user

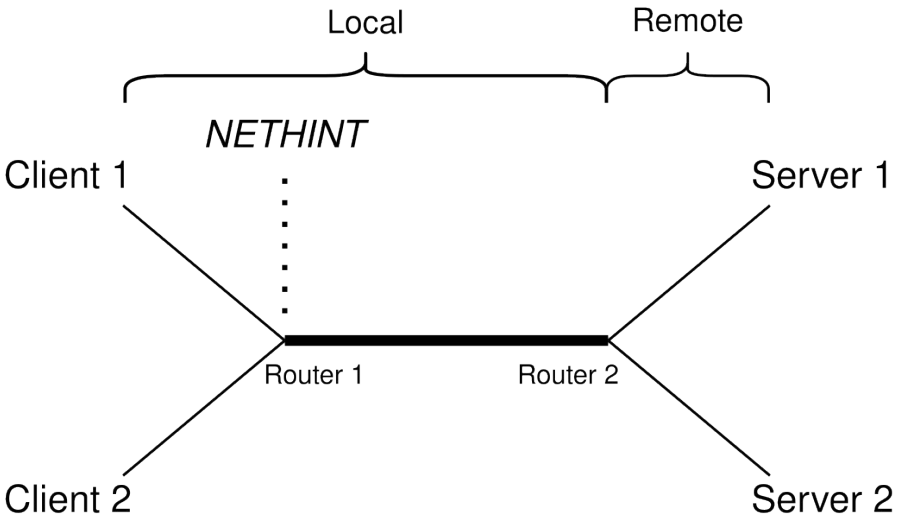
Wireless: Added Challenges

- Capacity
- Interference and collisions
- 802.11 performance anomaly
  - Sending rates
  - Airtime Fairness Queuing



Tests and Results

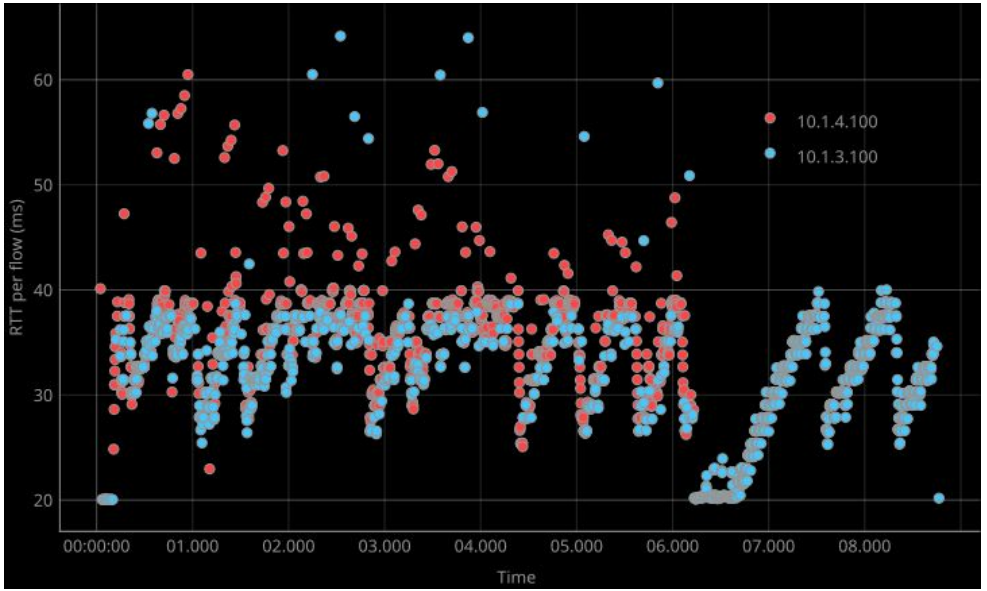
- Emulated
  - BDP
  - Bottleneck situations
- Local wireless



Emulation topology

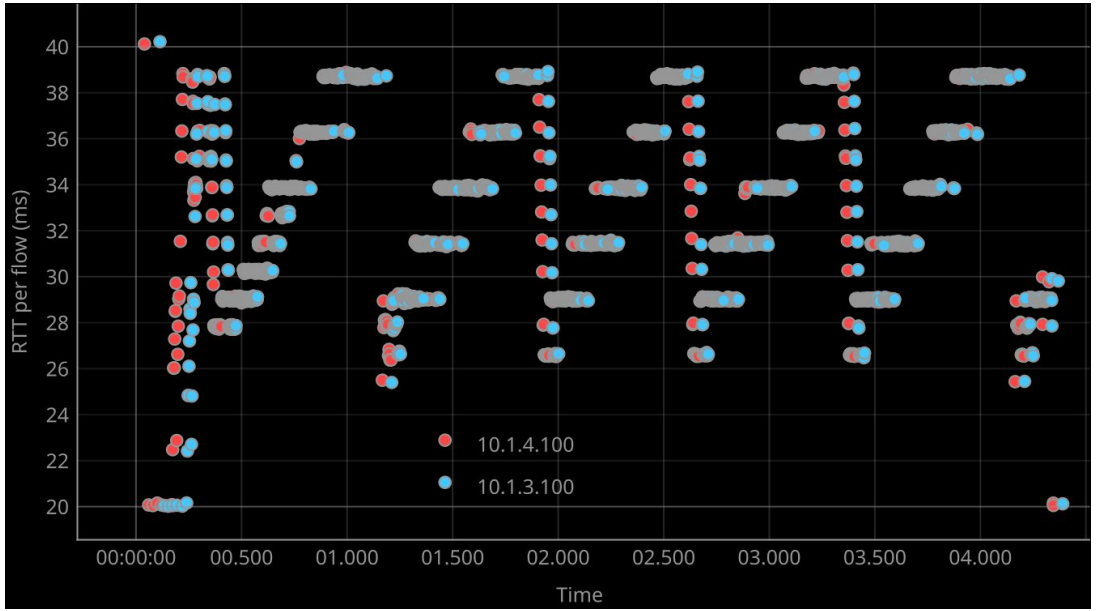
Emulated Tests: Situation 1

- **Local portion** is the bottleneck
- Flows do share delay characteristics to some degree

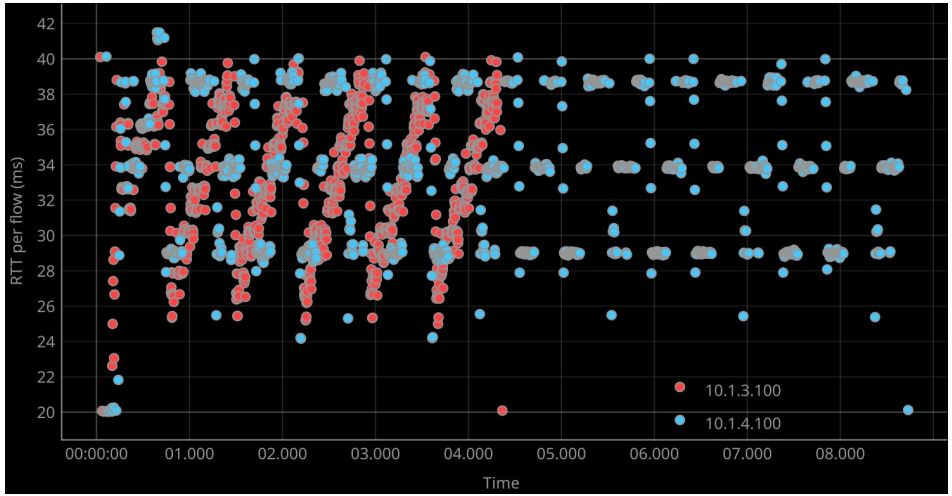


Emulated Tests: Situation 2a

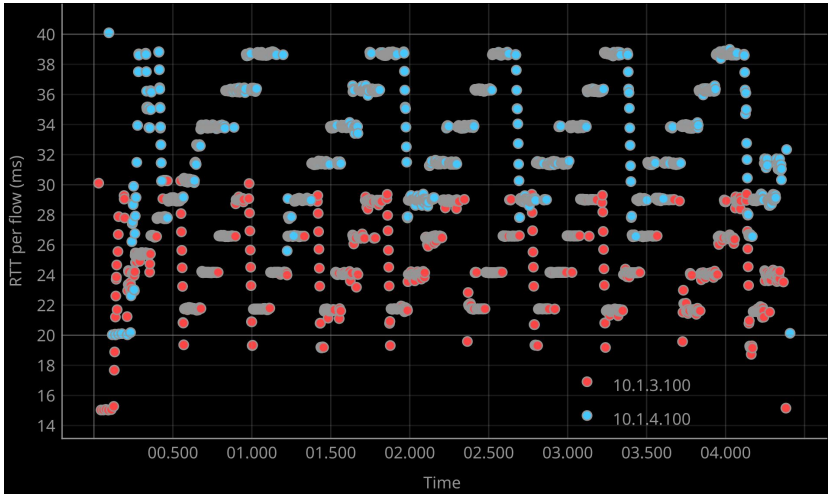
- **Remote portion** is the bottleneck
- Difficult to tell flows apart



Emulated Tests: Situation 2b

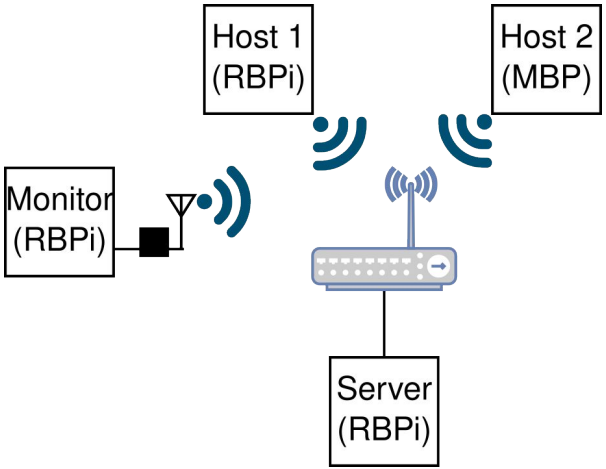


Limited by capacity

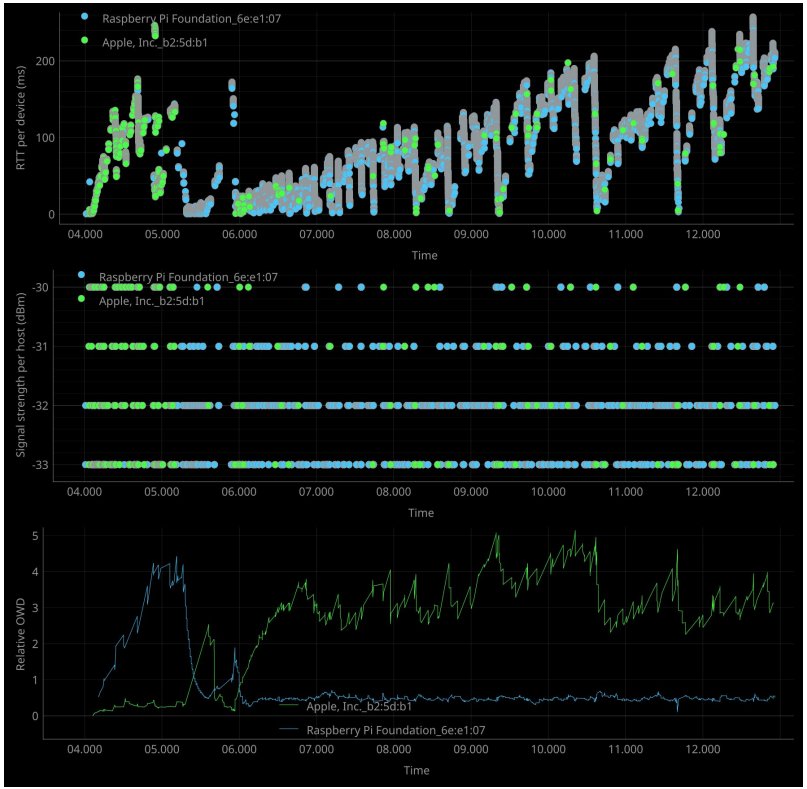


Limited by delay

Local Wireless Test



RBPi = Raspberry Pi. MBP = Macbook Pro.



Two senders each sending 50MB to one server. The OWD "smoothness" is set to 100%, or EWMA $\alpha \approx 0.0075$

Live demo

Conclusion and Future Work

Conclusion

- NETHINT and its capabilities
- Reliable metric sources
- The state of the art

Future work

- 802.11 decryption
- Wireless data rates
- Bottleneck metric
  - Latency over time
  - Low start RTT increase
  - Combining metrics

Thank you!