Measuring Video-Conferencing Performance on Ark

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Oliver Michel, Bashayer Alharbi[1], Kyle Jamieson[2]

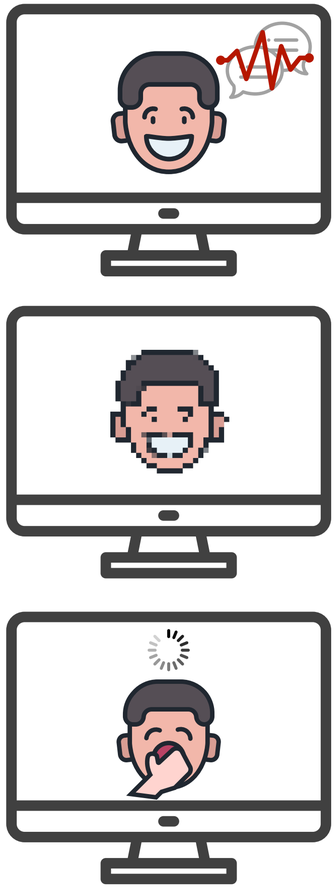
ILLINOIS TECH

1 University of Colorado Boulder

2 PRINCETON UNIVERSITY

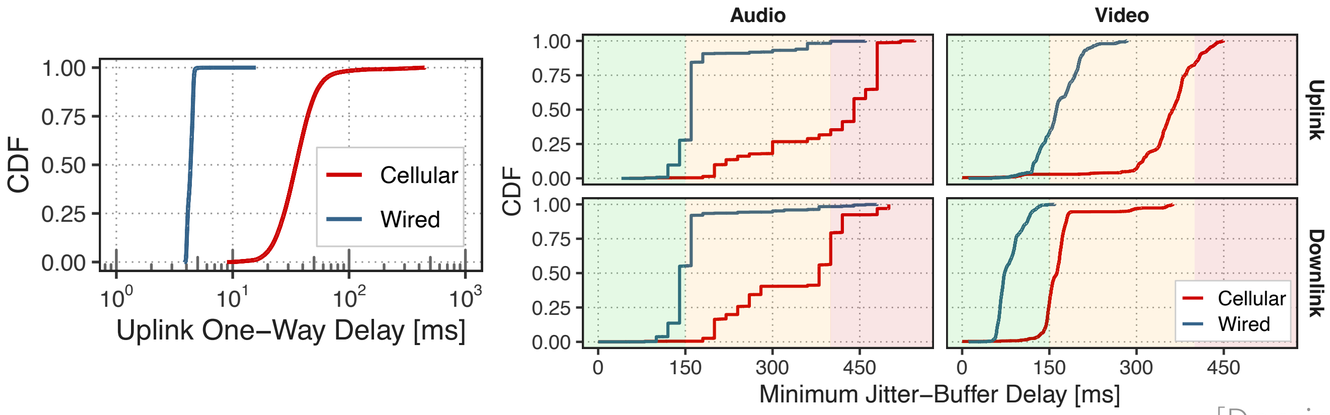
Video Conferencing and Beyond

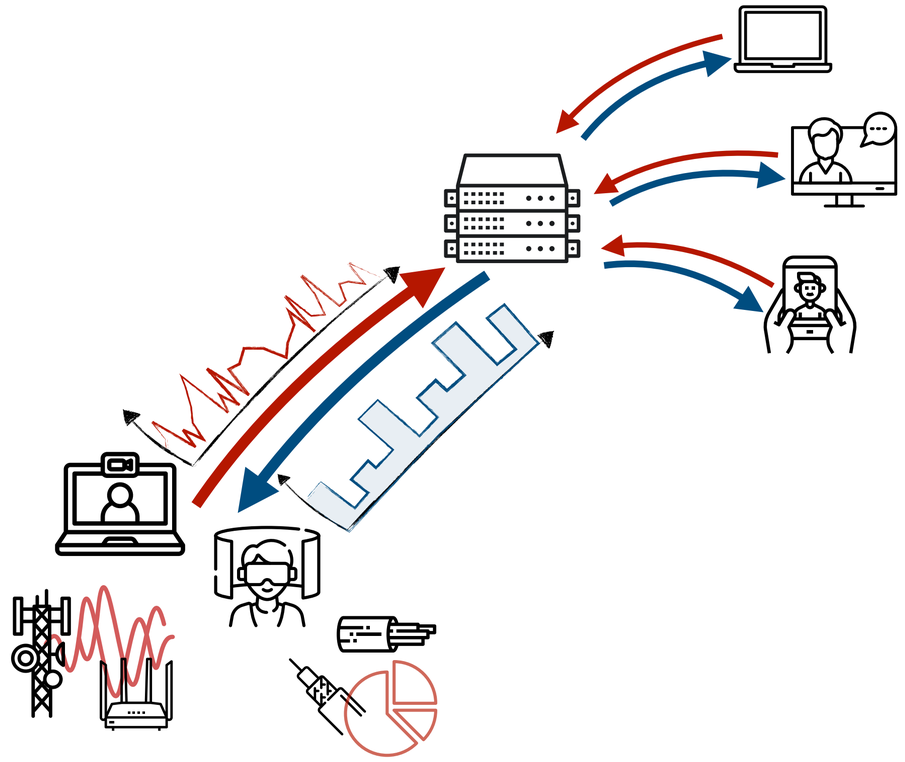
- Essential application across many industries
- Continued market growth
  10.6 billion USD (2022) → 19.1 billion USD (2027)
- Real-Time Communication (RTC) more widely used
  AR/VR, GenAI, Remote Control, Telemedicine, …
- Remains challenging to deliver consistently high QoE
  [Yi+24, Yi+25, MacMillan+21]



Access Networks challenge Real-Time Communications (RTC)

- RTC Applications rely on uplink just as much as on downlink
- Traverse (often wireless) access networks twice
- Access networks characterized by rapidly varying capacity and delay due to multiplexing, scheduling, and physical-layer effects



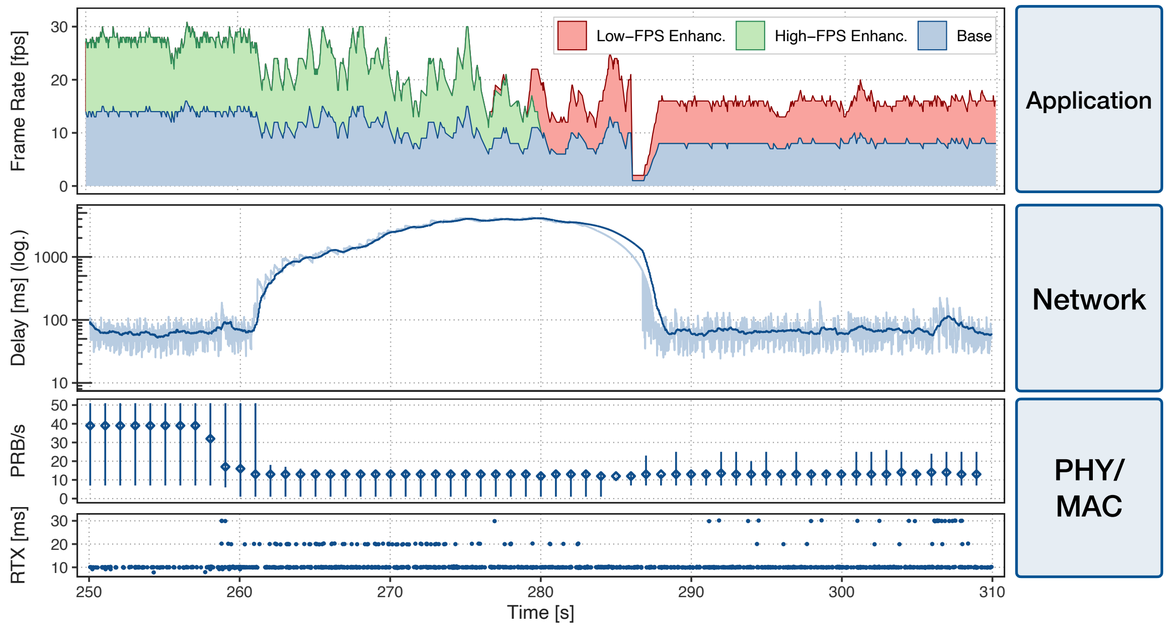


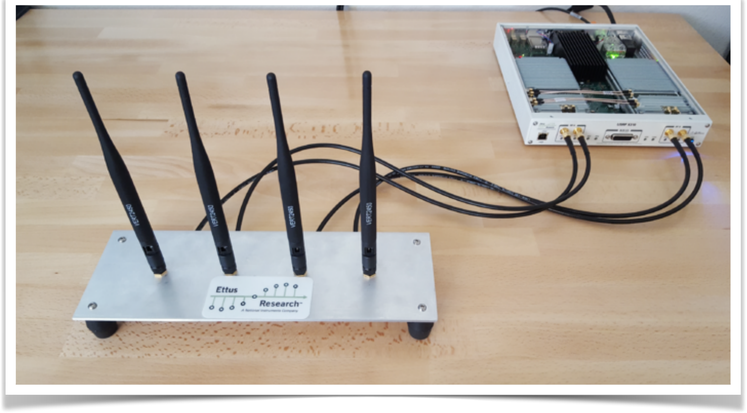
[Domino IMC '25]

RTC Measurement Setups are complex

[Athena HotNets '24]

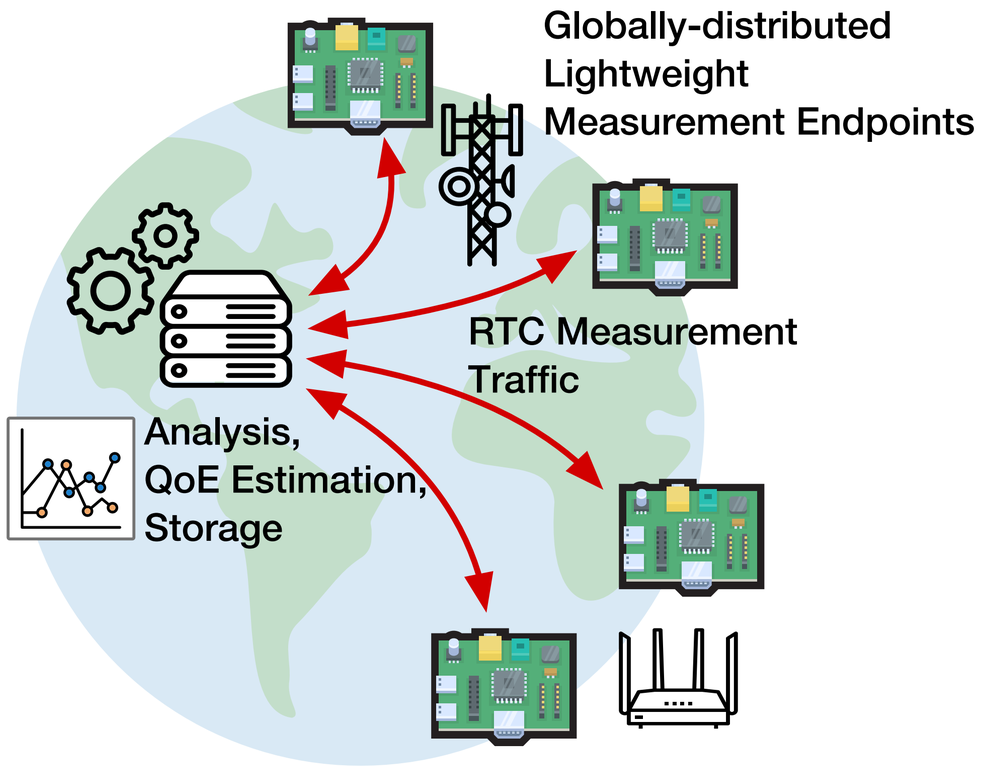
- Cross-layer performance measurements require complicated setups, including
  - Media annotated with QR codes
  - Clock synchronization
  - Multiple packet captures
  - Software-defined radio instrumentation to decode 5G control channels
- Measurements to not scale outside of a lab, require expensive, complex setups, and expertise to perform measurements





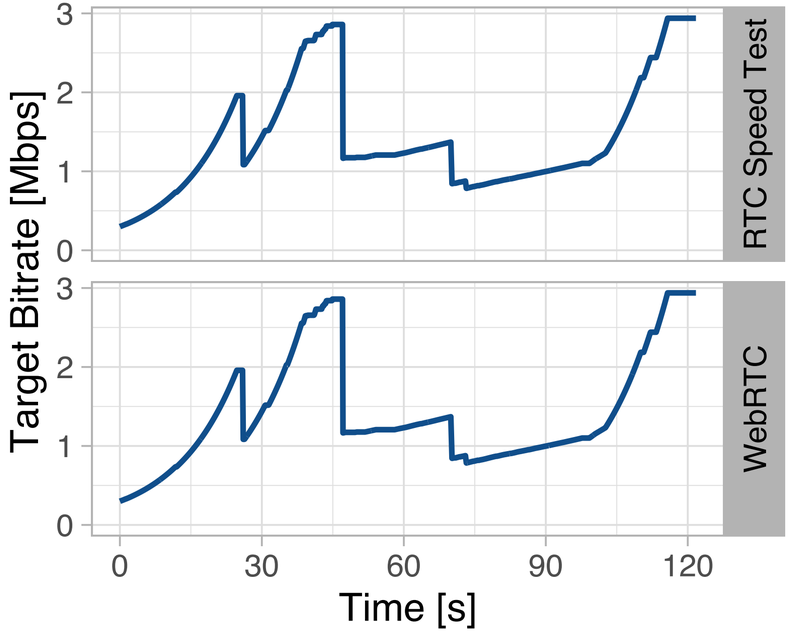
How can we scale RTC Measurements?

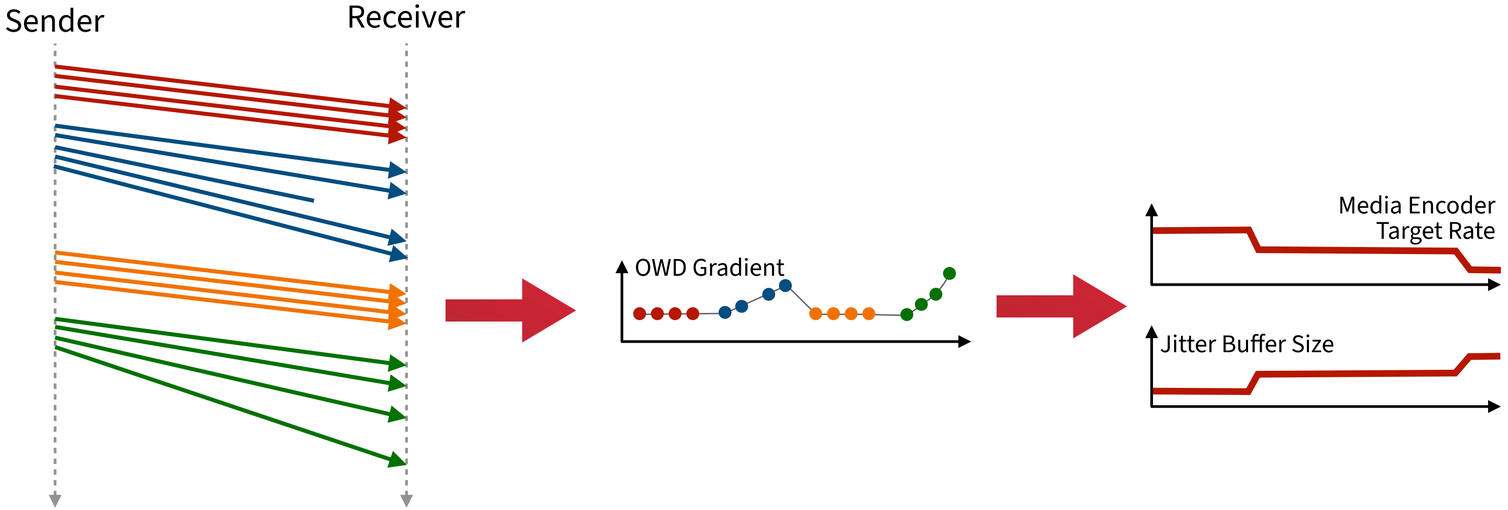
- How can we scale to longitudinal application-specific (here RTC) performance measurements?
  - Global vantage points; over extended periods of time; different access-network technologies
- speedtest.net → bulk throughput and average latency does not accurately characterize RTC QoE
- Ark → cannot run real RTC applications



Performance Estimation from Network Measurement

- Actual media not necessarily required to estimate quality (picture quality typically not adjusted)
- Instead: (1) send probes resembling RTC traffic pattern; (2) run application logic to determine achievable rate; (3) estimate expected quality

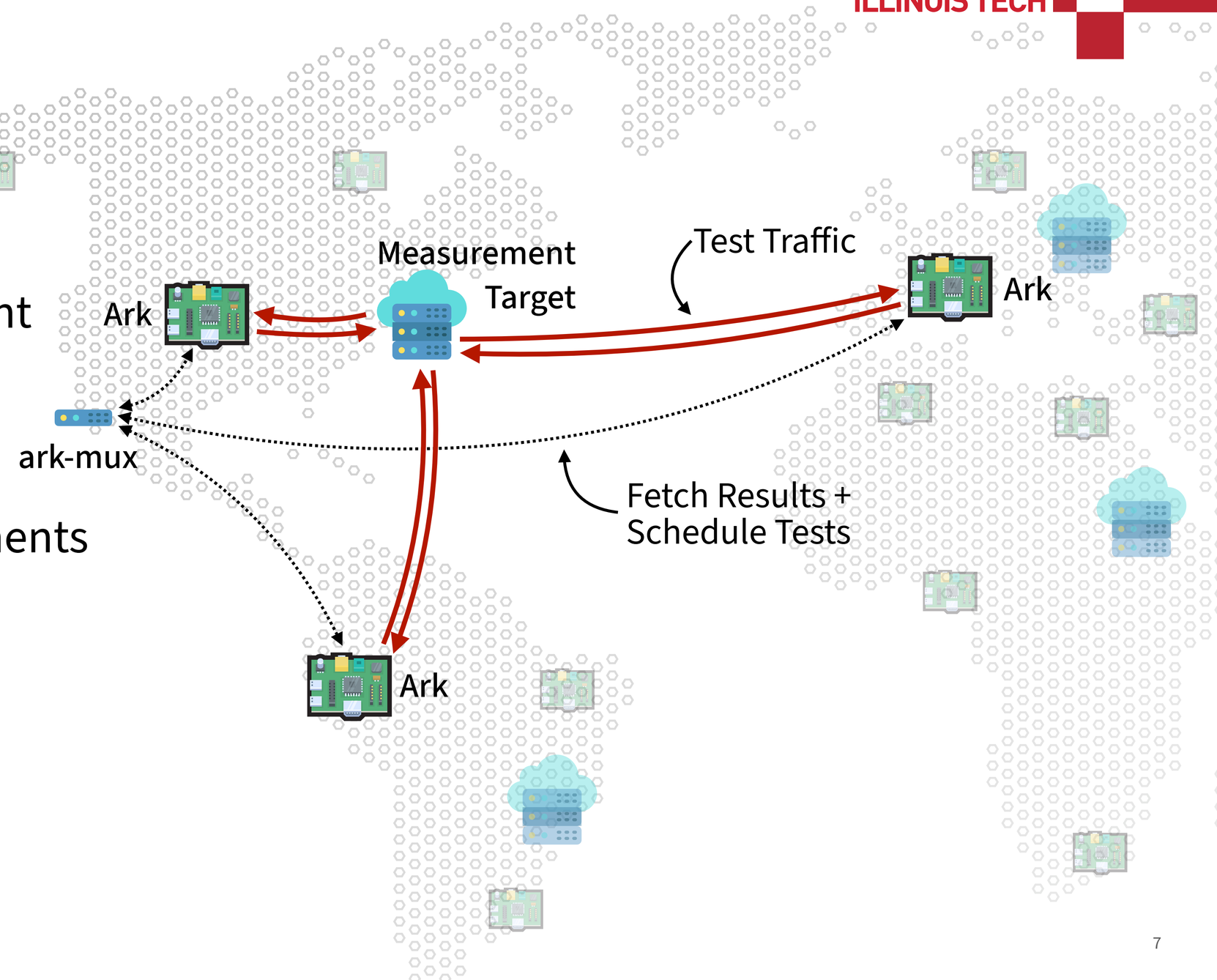




→ Expected latency range
→ Expected resolution/fps range
→ QoE score

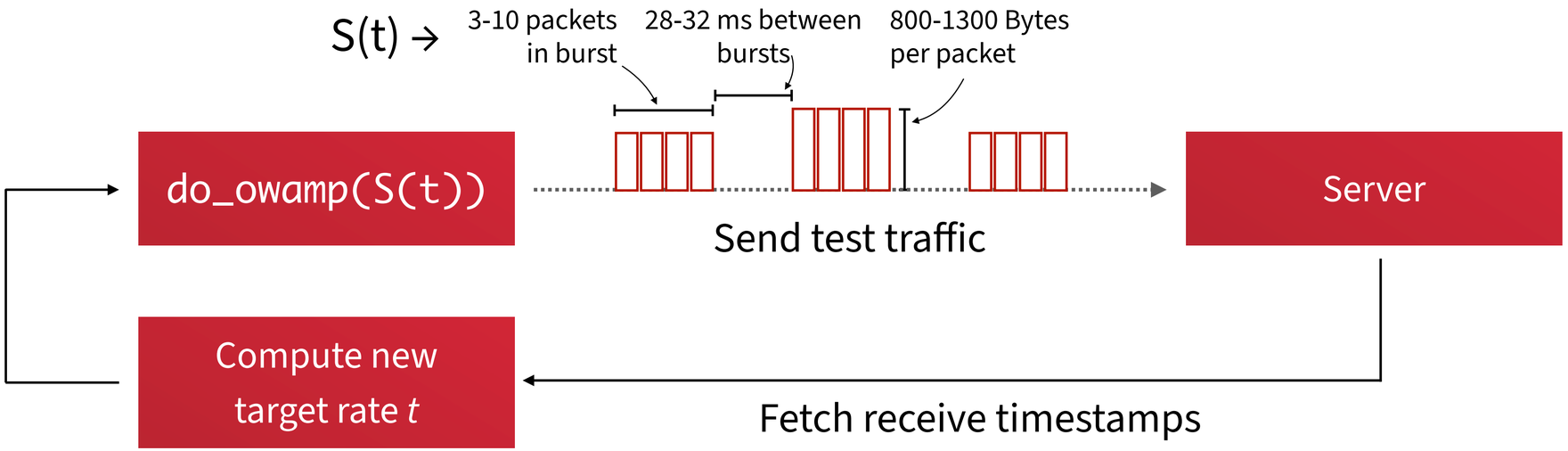
RTC Speed Test on Ark

- Ark nodes and measurement targets in public clouds exchange packet trains
- Ark-Mux collects measurements from nodes and starts new measurement sessions



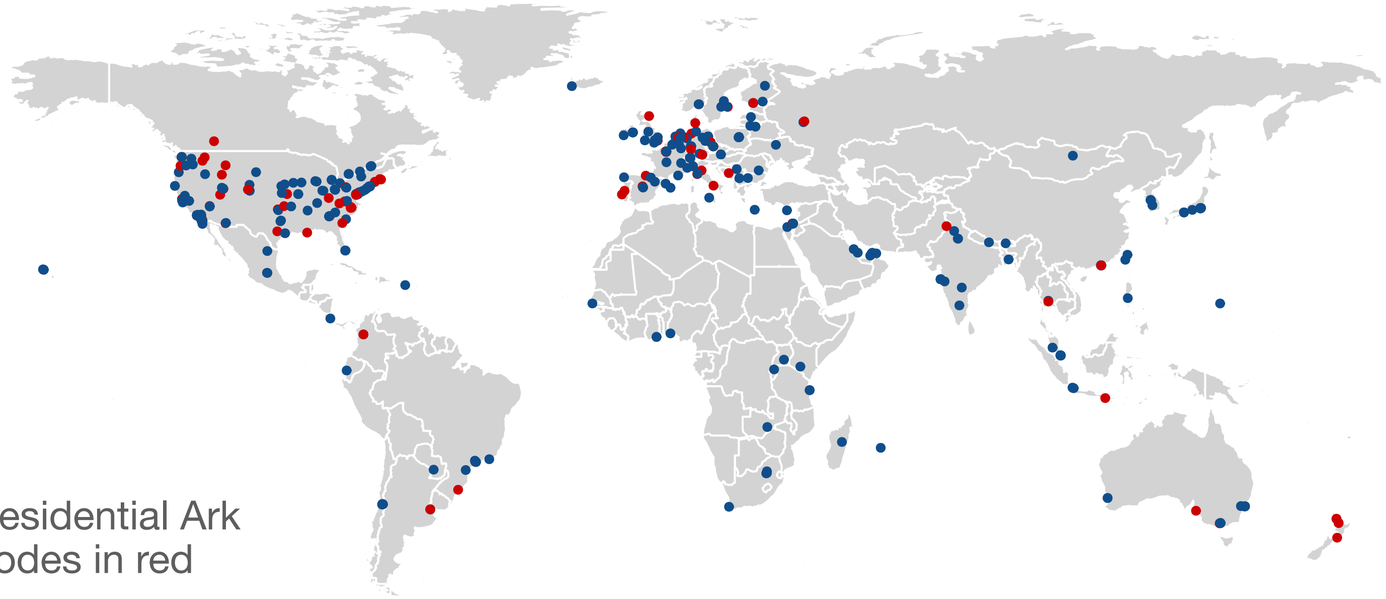
One-Way Active Measurement Protocol (OWAMP)

- One-Way Active Measurement Protocol (OWAMP) [RFC 4656], available in Scamper
- Use Perfsonar OWAMP server



Expanding to more Access & Wireless Networks

- Today, 84 out of 394 Ark nodes in residential networks
- Ideally: Ark nodes in wireless access networks (either residential Wi-Fi or cellular)
- Initial work on equipping Ark nodes with 5G interfaces and Cell Ninja for physical-layer measurements



Residential Ark nodes in red

Raspberry Pi Ark node with 5G interface

Conclusion

Measurement methodology to characterize RTC performance longitudinally and at scale

(1) Design measurement system that estimates QoE-related metrics without running actual media sessions

(2) Build this measurement on top of CAIDA's Archipelago infrastructure using standardized latency-measurement protocols (OWAMP)

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Athena: Seeing and Mitigating Wireless Impact on Video Conferencing and Beyond
Fan Yi, Haoran Wan, Kyle Jamieson, Jennifer Rexford, Yaxiong Xie, Oliver Michel
ACM HotNets 2024

Automated, Cross-Layer Root Cause Analysis of 5G Video-Conferencing Quality Degradation
Fan Yi, Haoran Wan, Kyle Jamieson, Oliver Michel
ACM IMC 2025

Oliver Michel

Assistant Professor,
Illinois Institute of Technology

omichel@illinoistech.edu