Quality Measurement over Quality Data Reuse in Cellular Networks
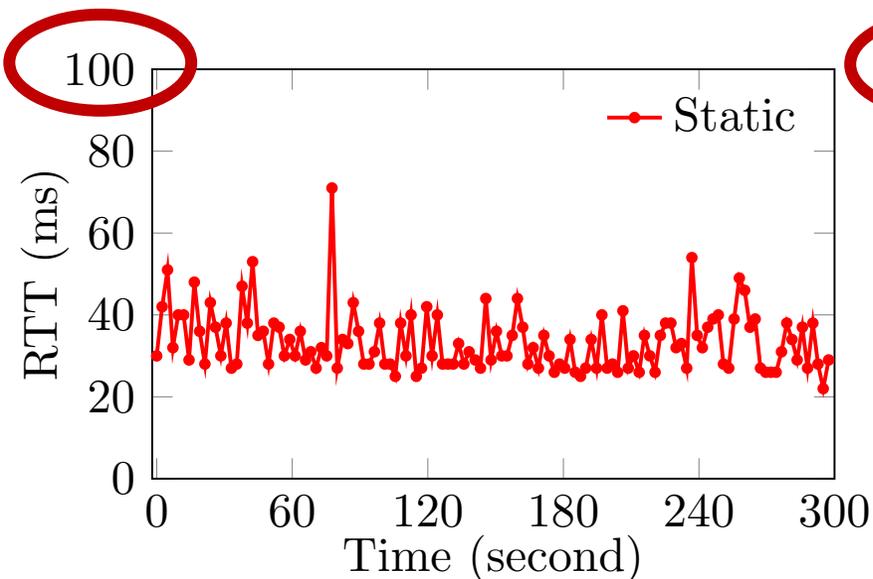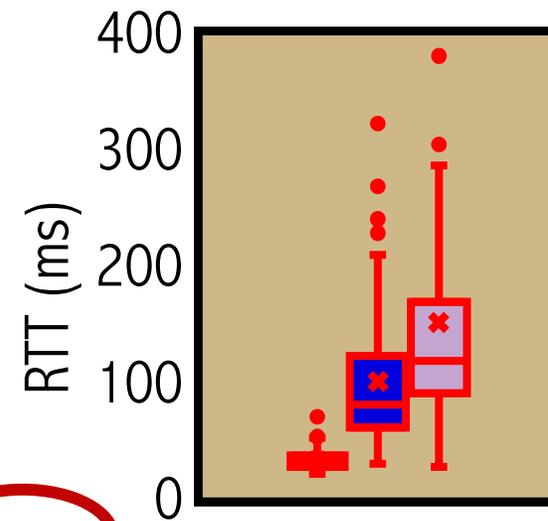
Zizheng Liu, Chunyi Peng

Department of Computer Science, Purdue University
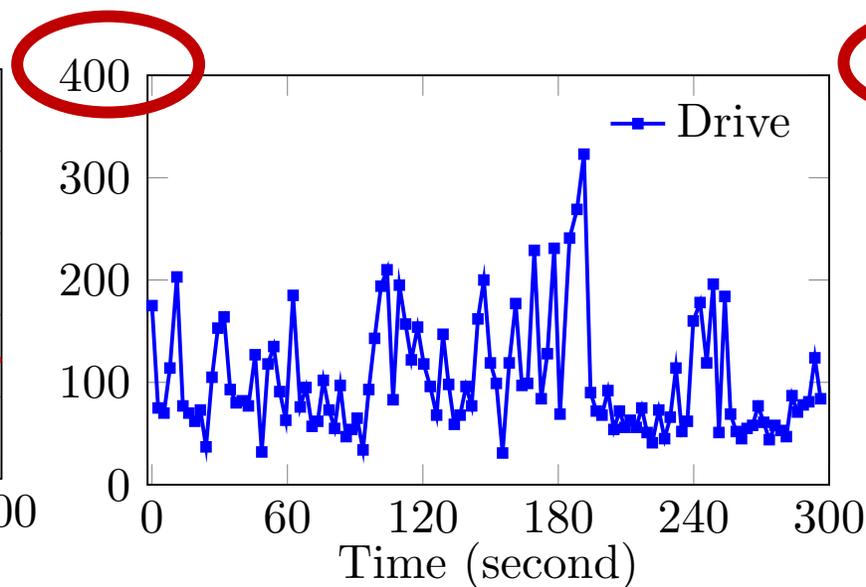
Example on latency measurement

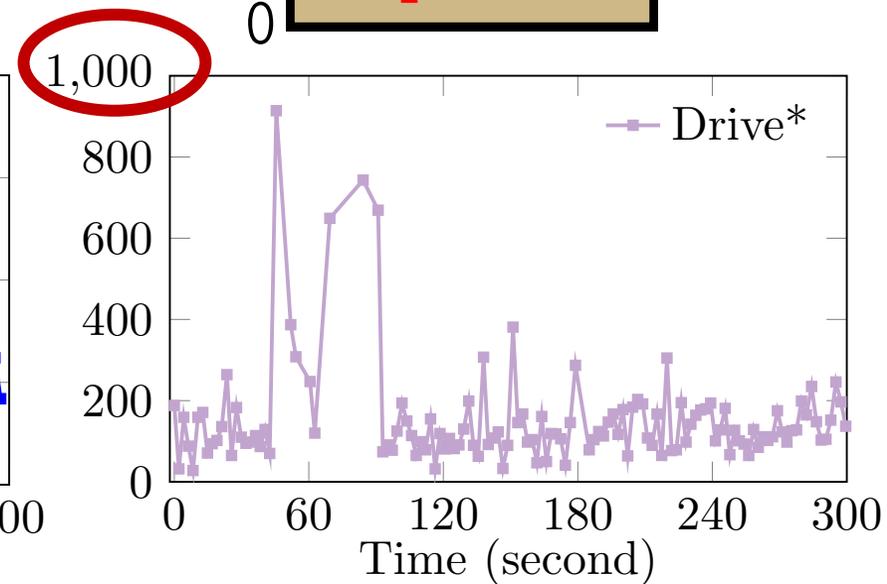AT&T (4.5G), April 2, 2021 @ West Lafayette, IN

Latency = RTT of ping google.com

(a) Static (at home)

(b) Drive (~20mph)

(c) Drive* with heavy traffic

What have we learned regarding 4.5G latency in the wild?

Measurements are biased

- Affected by a number of explicit and implicit experiment settings
  - Controlled (explicit)
    - Automated exp programs, e.g., test traffic, network settings and operations at test equipment, …
    - Manual operations, e.g., test locations/routes, driving speed, hours of a day, …
  - Uncontrolled (implicit)
    - Network elements beyond our test equipment, e.g., dynamic traffic loads at base stations
    - Uncontrolled factors at test equipment, e.g., accompanying foreground and background traffic in user study
- Particularly in cellular networks: wireless and mobility
- Scale (big data) needed to combat the bias
  - Choice of network operators and measurement companies

What we can do? (What we are good at?)

What we have

What we want

Small Medium Large Super-Large

Scale

High

+ Controlled
+ Fully adopted
+ Web-domain,
SIGMetrics, ACM.

Papers at IMC, SIGCOMM, NSDI,
MobiCom, MobiSys,
SIGMETRICS, PAM research
types)

PhantomNet

Quantity

Trace

PAWR

Medium

MobiLab

Infrastructure for Studying and Improving the Design of Mobile Computing Systems

PhoneLab

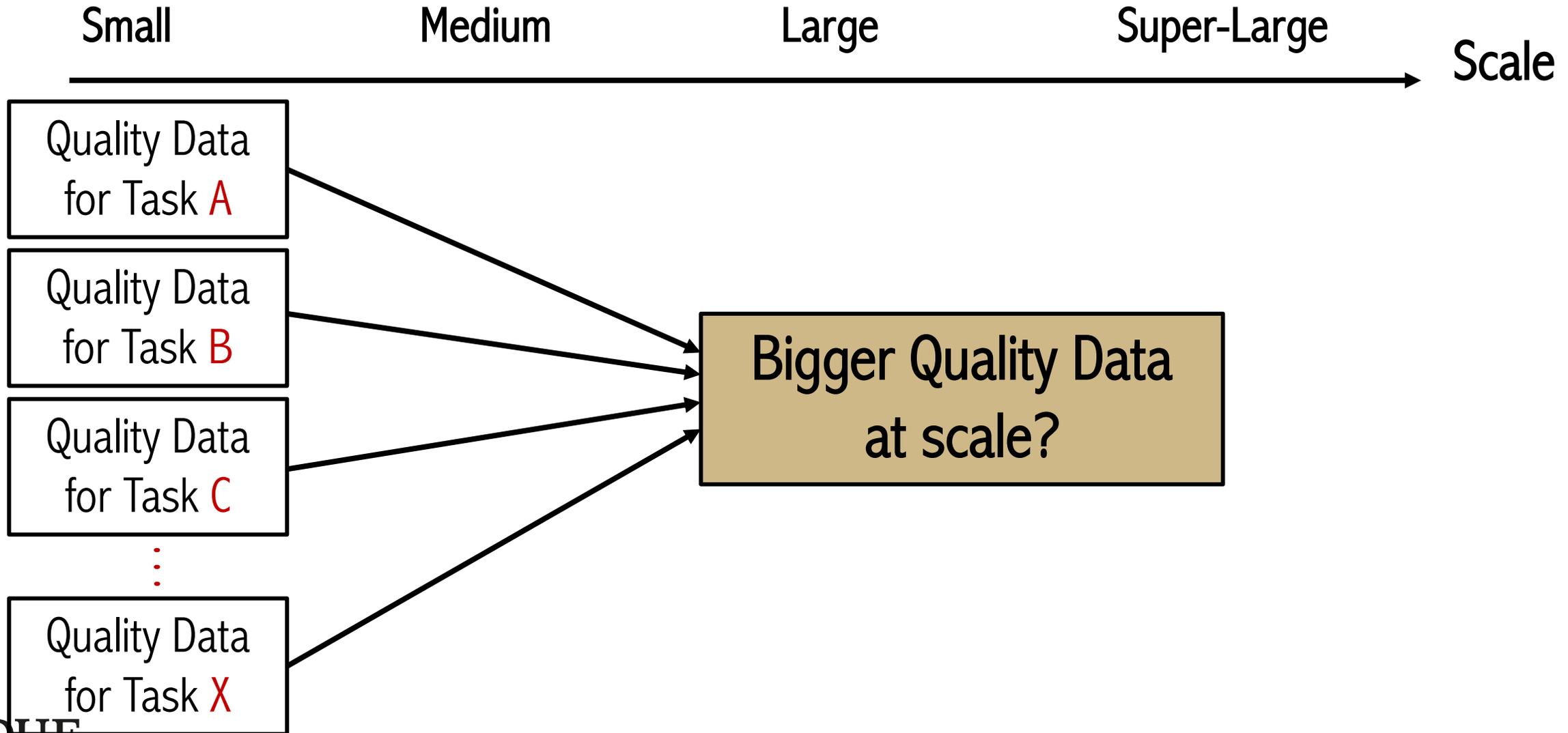AT&T

verizon

OpenSignal

...

T·Mobile·

OOKLA
SPEEDTEST

Google

Low

Quality

MI-LAB

- Uncontrolled
- Largely closed
- Poorly-documented
- Limited types (e.g., speedtest)

Quality data reuse?

No dedicated, exactly same measurements throughout five years

A: Web-latency analysis [ICCCN'18]

B: Handover config [IMC'18]

C: Across-the-US drive tests(2019)

D: Low-latency VR [SIGMETRICS'18]

D: Missed speed [MobiCom'20]

E: signaling latency [MobiCom'17]

Web browsing (bing.com)

Data collected:
- E2E latency from web SDK
- Pcap files
- Mobileinsight logs
- Phone info

Dataset:
- WeiVR in 2017
- Primarily in LA
- Five US carriers
- Mainly in 2017 - 2018
- Globally

Ping Google.com

Data collected:
- E2E latency
- Pcap files
- Mobileinsight logs
- Phone info

Dataset:
- MobiVR in 2017

File downloading

Any traffic (radio link establishment and handover)

[MobiCom'21] Li et. al, Experience: A Five-Year Retrospective of MobileInsight, 2021

Not fully reusable, but partially

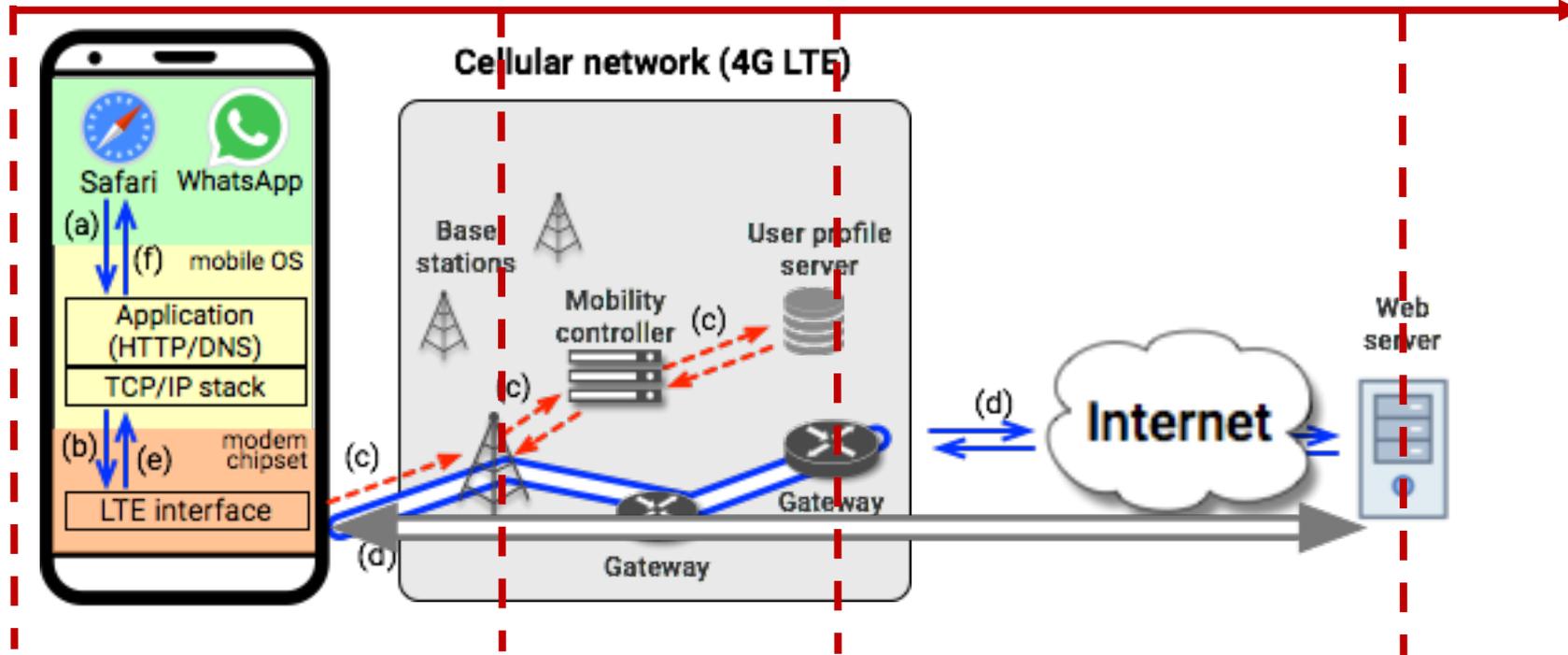|	
A: Web-latency analysis [ICCCN'18]	Web browsing (bing.com) E2E latency: ~ 473 ms
B: Handover config [IMC'18]	Ping Google.com No E2E latency
C: Across-the-US drive tests(2019)	Ping Google.com E2E latency: ~ 50-70ms with good coverage
D: Low-latency VR [SIGMETRICS'18]	Mobile VR E2E latency: ~ 83 ms (DL: < 15ms, UL: < 1ms)
D: Missed speed [MobiCom'20]	File downloading No E2E latency
E: signaling latency [MobiCom'17]	Any traffic No E2E latency Radio link establishment: ~ 170ms

PURDUE
UNIVERSITY
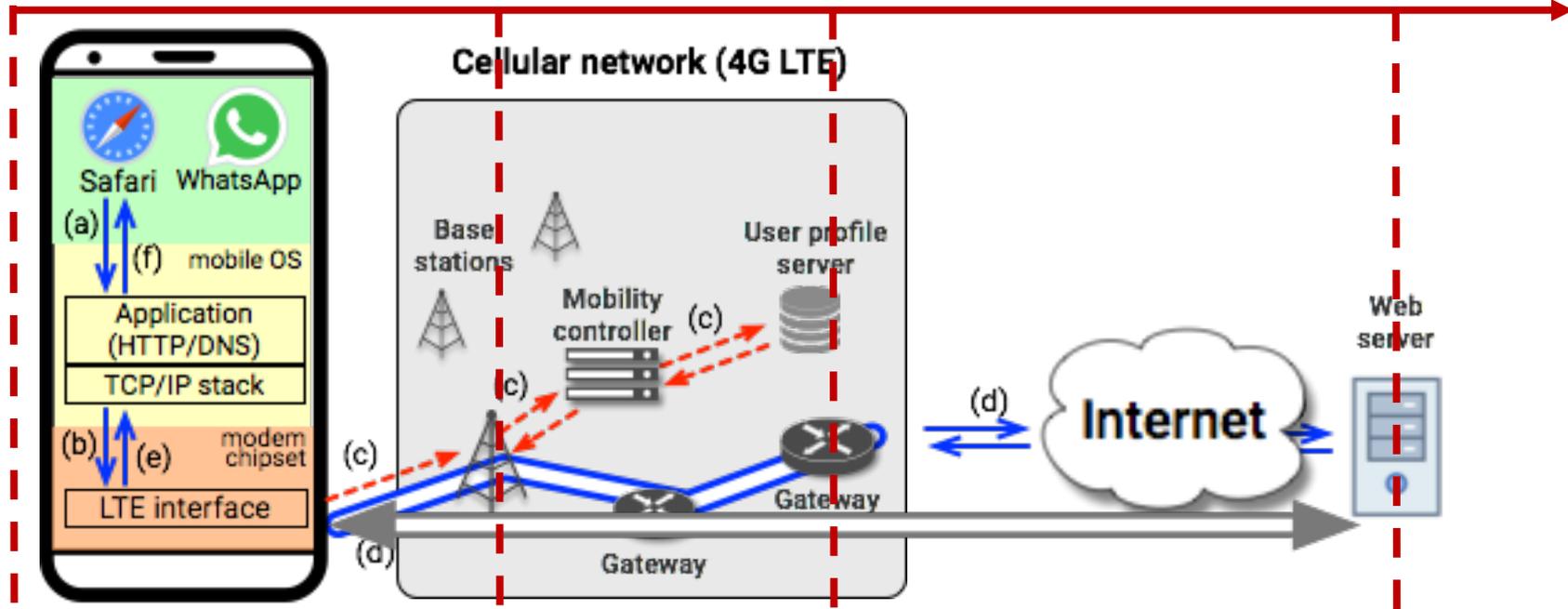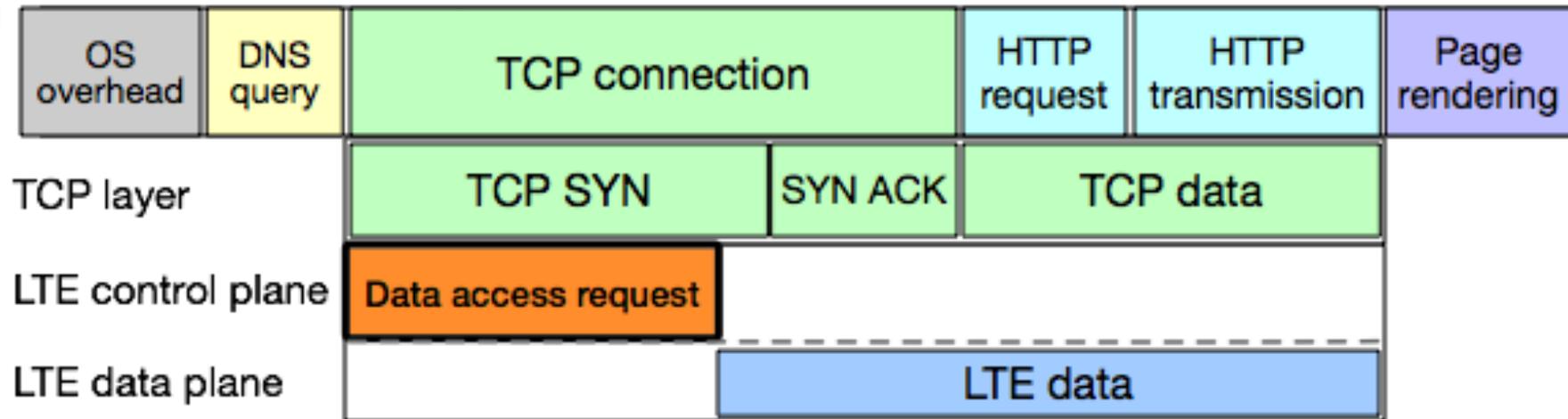
E2E latency breakdown

Use web-latency as an example

Horizontal
Breakdown

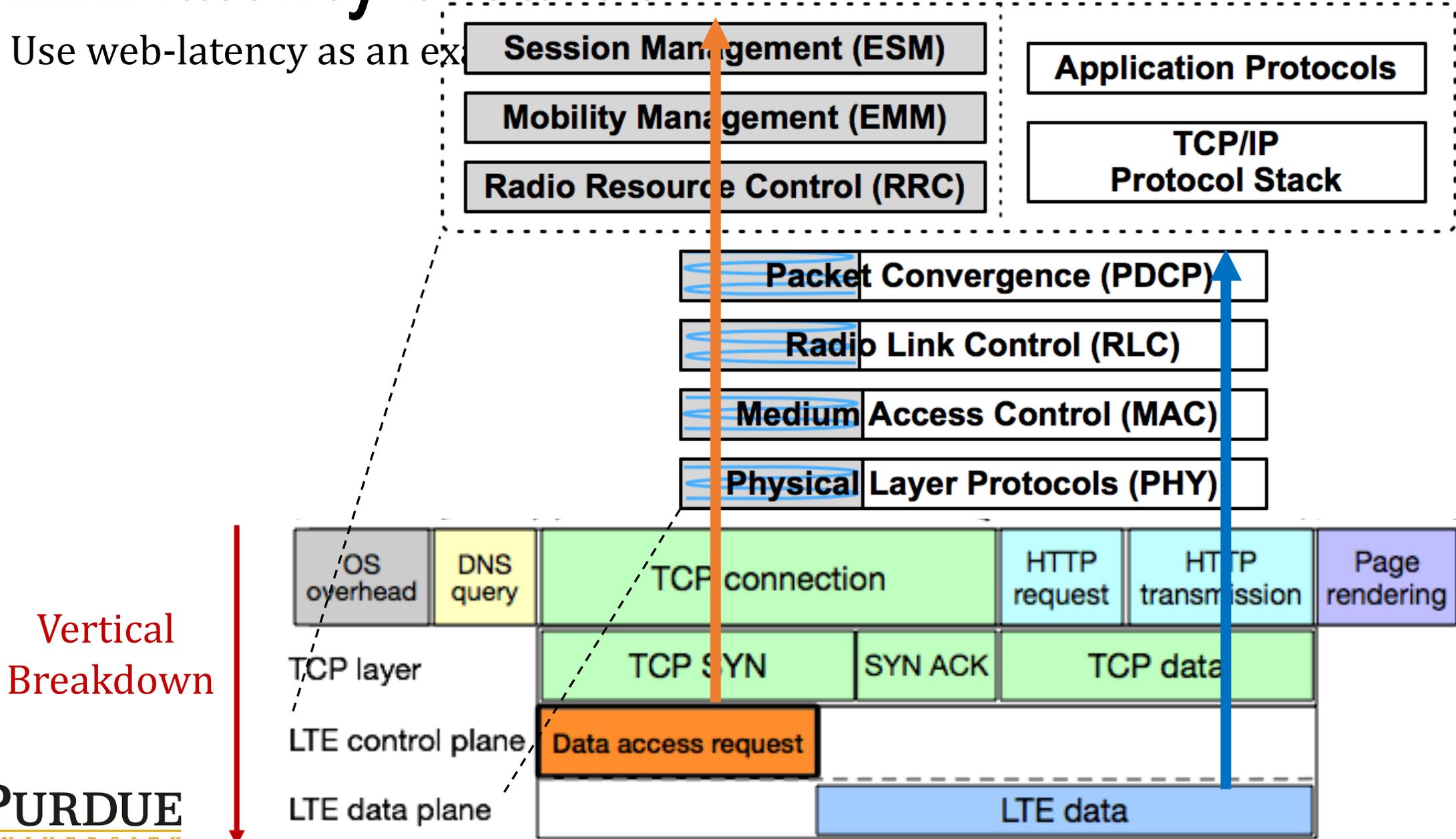# E2E latency breakdown

Use web-latency as an example

E2E latency breakdown

Use web-latency as an ex

Vertical
Breakdown

Data reuse for five-year latency measurement

$$\tau_{e2e} = \sum \tau_i$$

No data reuse for τ_{e2e}, but for τ_i (of research interests)

$$= \tau_{ctrl} + \tau_{data}$$

$$= \tau_{ctrl} + \tau_{radio} + \tau_{higher}$$

- 0ms, if no control-plane signaling in RRC and NAS is needed
- Radio link establishment, if there is no active radio connectivity (RRC state=idle)
- Handover, if there is active radio connectivity but handover is needed (RRC state=active)
- Failure recovering, if failures

Extracted from MobileInsight logs even without no latency measurement records (inferred from cellular network messages exchanged between phones and base stations)

[MobiCom'21] Li et. al, Experience: A Five-Year Retrospective of MobileInsight, 2021

What we need: Enable & facilitate quality data reuse

Technically,

- **Breakdown/cause** analysis (decouple reusable components, primary data of measurement and additional data to understand why)
- Design **modular** experiments (with common/standard components)
- Recommend **baseline** experiments
  - Bottlenecks or common interests (e.g., Speedtest, radio link measurement)
  - Recommended exp settings (say, cost-effective, more controlled, extensible)
- Develop **advanced ML** algorithms for domain-specific data reuse (exploiting network models/protocols/functions)
- Share **everything** (primary data, additional data, metadata/exp settings, source codes for data collection and analysis, readme for manual operations, …)
  - Follow community convention/standard

Our attempts towards quality data reuse
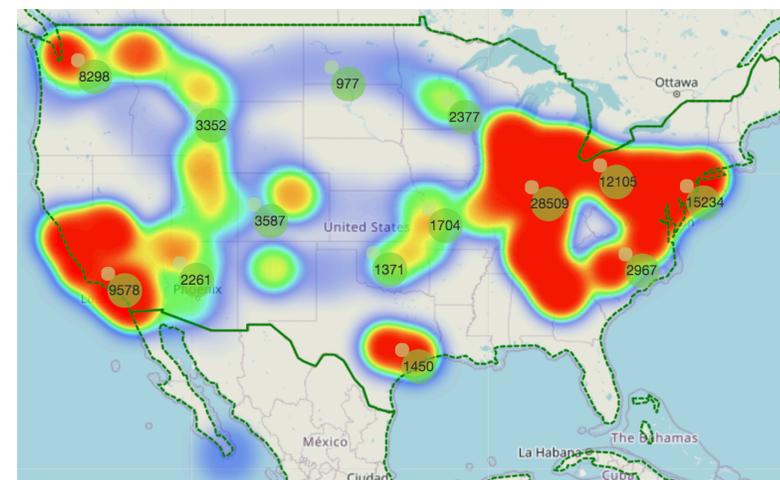
http://milab.cs.purdue.edu/

- Open data (>6.5TB mobileinsight logs, > 3.2TB pcap as 04/02/2021)
- Managed per task (linked with its exp codes, data configuration)
- Simple data reuse showcase enabled (task-dependent)
- Generic data reuse ongoing

Mapview (as Guest)

Datasets in the US
(as of 04/15/2021)

What we need (more)

Immediate actions by the community, e.g.,

- Define standards and recommendations on how to design experiments, annotate data, share artifacts, build benchmarks and streamline common data processing,
- Support and reward such efforts
 - Artifacts Evaluated – Highly Reusable (compliant with recommendation 15.1.0)

Many more in non-technical aspects, e.g., fund, measurement testbeds, industry-academia collaboration, …

Our attempts towards quality data reuse

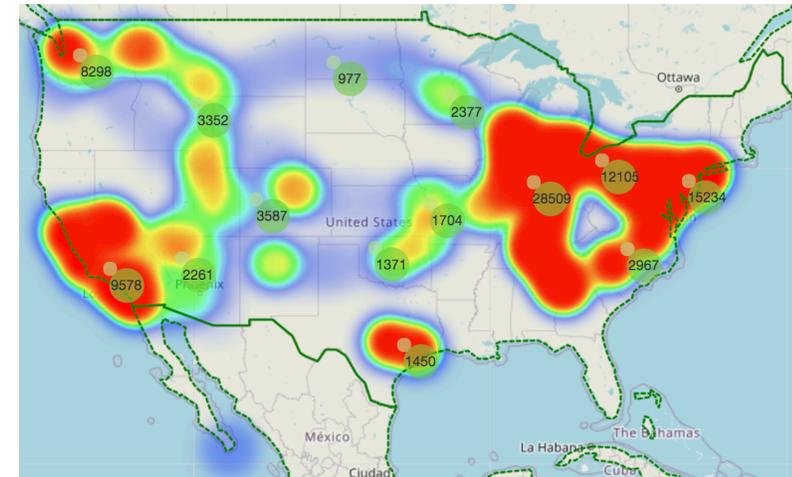http://milab.cs.purdue.edu/

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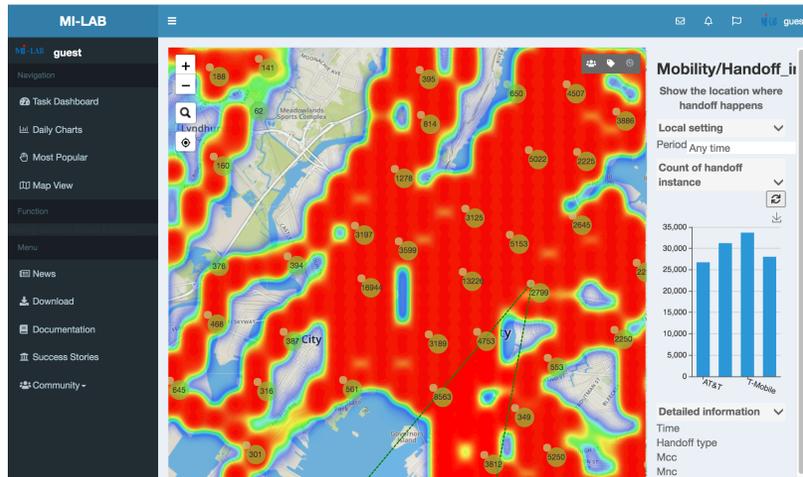
Mapview (as Guest)

US-datasets (as of 04/15/2021)