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Carrier Interconnect in the Edge Computing Age

Meeting Edge-Native Applications Needs

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AGENDA:

- The Edge Computing Legacy Interconnect Problem
- Options, Trade-offs and Test Results
- Recommendations and Conclusions

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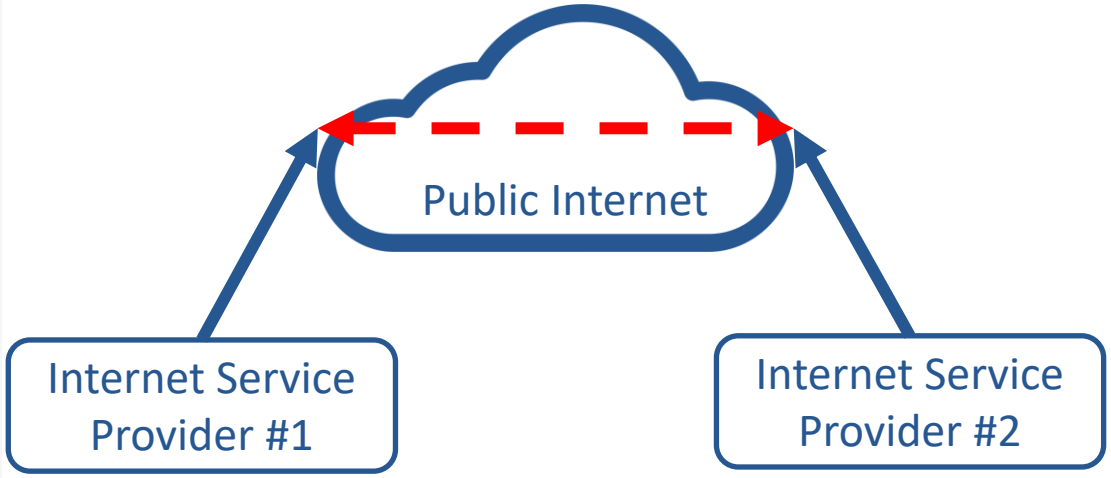
THE PROBLEM

Where Are Today's Interexchange Points? (IXPs)

Internet Exchange Points



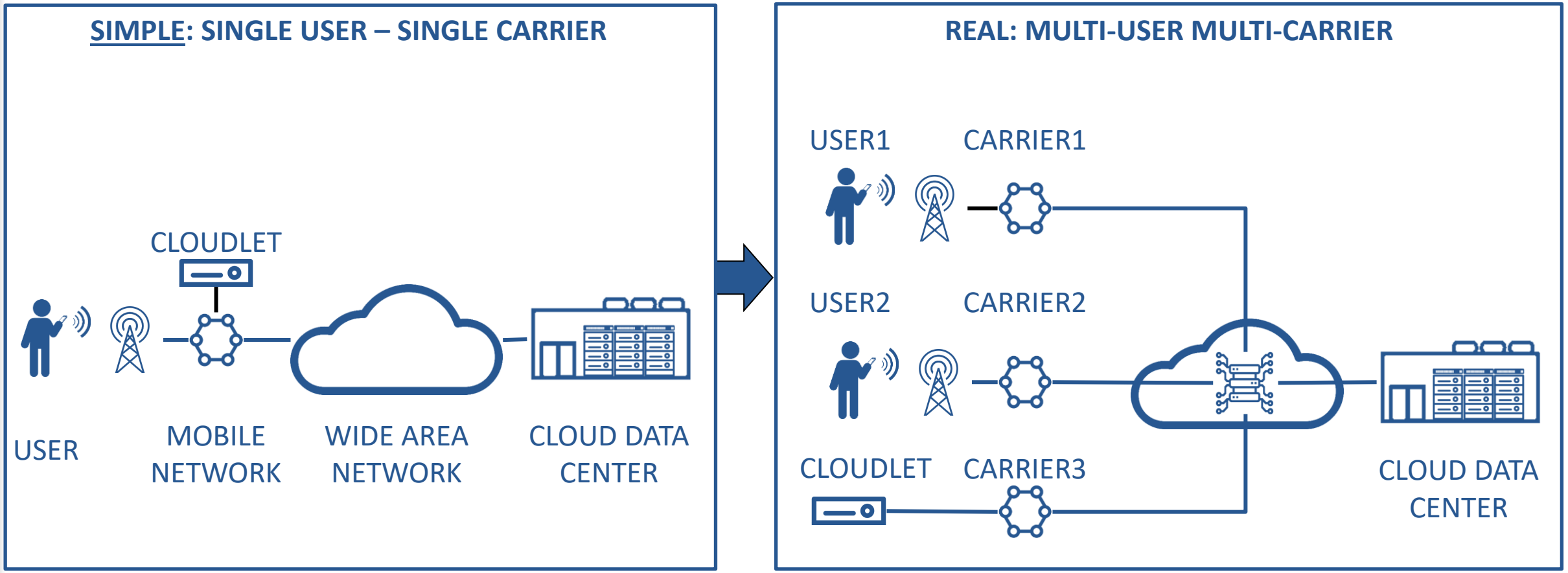
Source: https://www.internetexchangemap.com/

Carrier Peering Points

Source: OEC Blog -- http://bit.ly/387qNVa

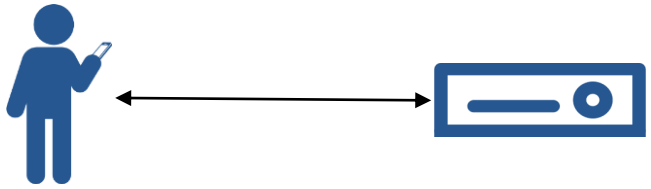
Not Designed for Edge Computing

IXP Placement Matters

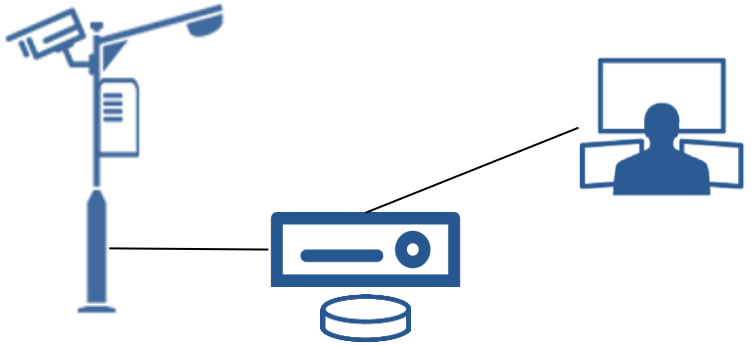


IXP Location Impacts Application Viability

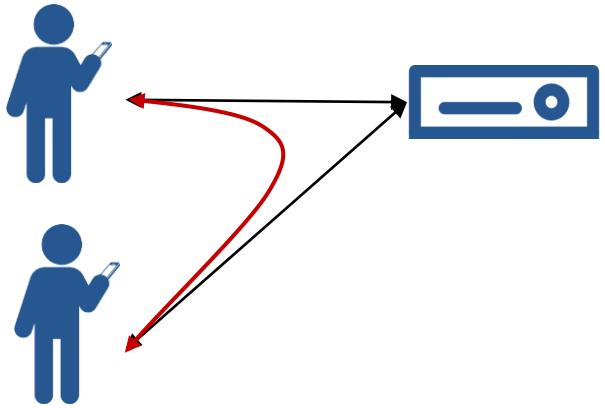
And, Application Requirements Vary Greatly



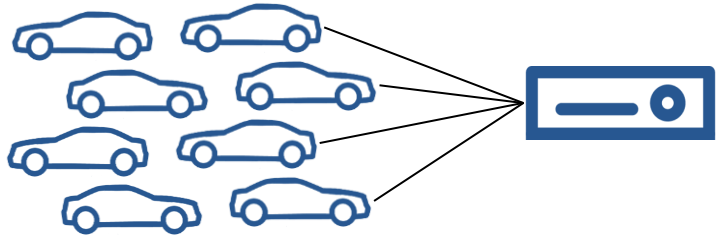
SINGLE USER INTERACTIVE



EDGE ANALYTICS



MULTI-USER-INTERACTIVE



IOT SENSOR

Application Differences in:

- Up & downstream dataflows
- Packet sizes & freq
- Numbers of devices
- Compute requirements
- Storage requirements
- User experience metrics
- …

Optimal IXP Placement Depends on Application Experience Metrics

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THE TEST

CARRIER IXP LOCATION STRATEGY WITH:

LOWEST COST AND ACCEPTABLE USER EXPERIENCE

Measuring User Experience: OpenRTIST

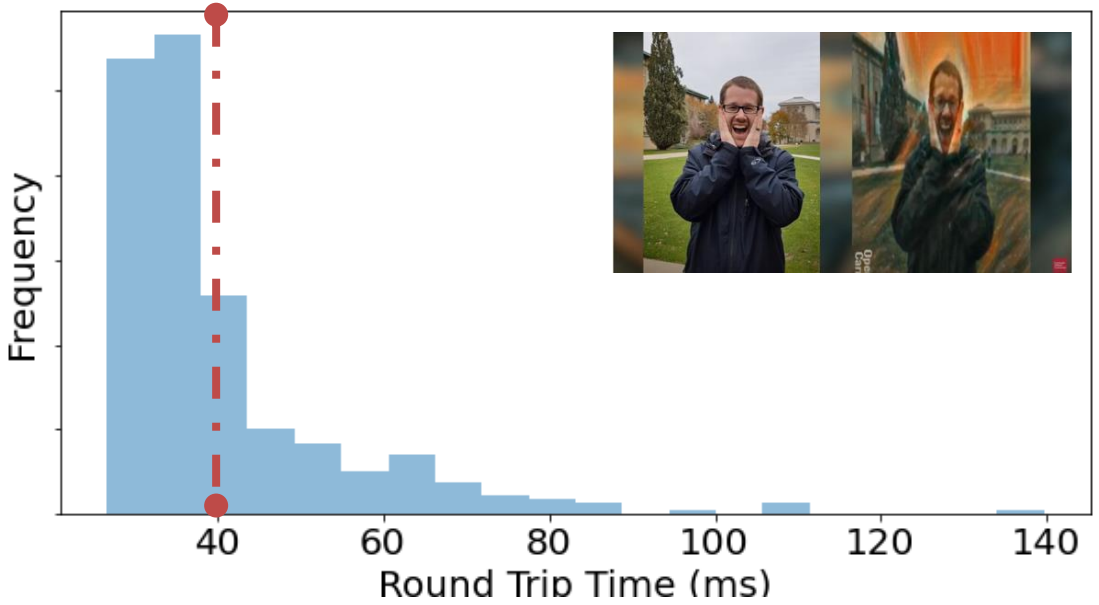
Subjective
Visual Quality
Responsiveness
Measure: User MOS, etc.

Objective
Framerate
Round Trip Time
Measure: FPS and RTT

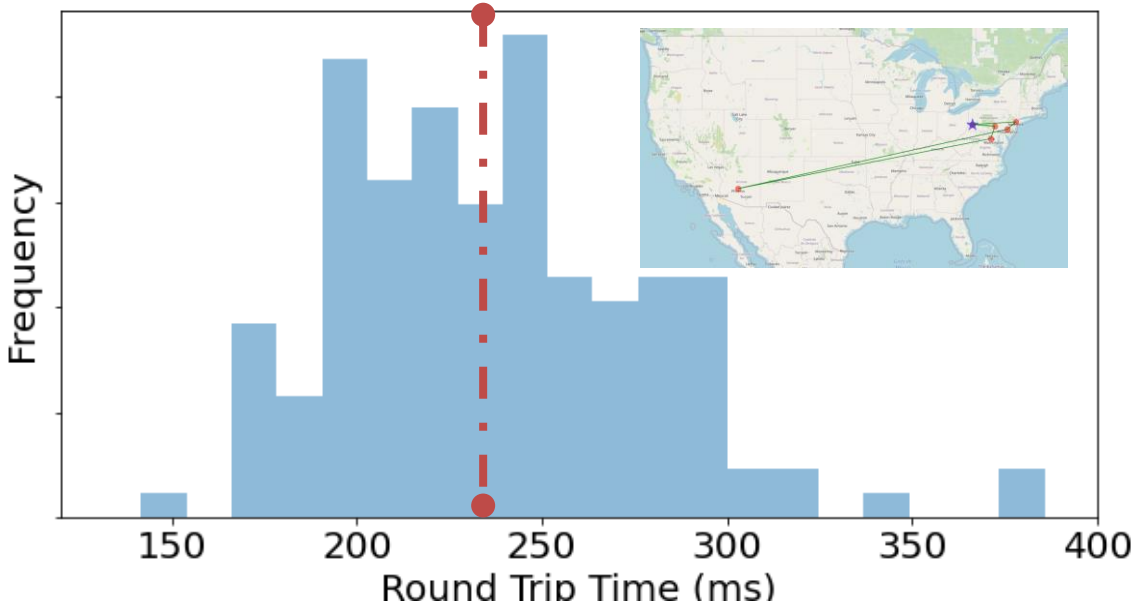
Acceptability Criteria
RTT < Max(RTT)
With User Acceptable Quality

Use Experience Metrics to Assess Acceptability

The Baseline: Real Network with Real Application



Application Round-Trip Time → 40ms

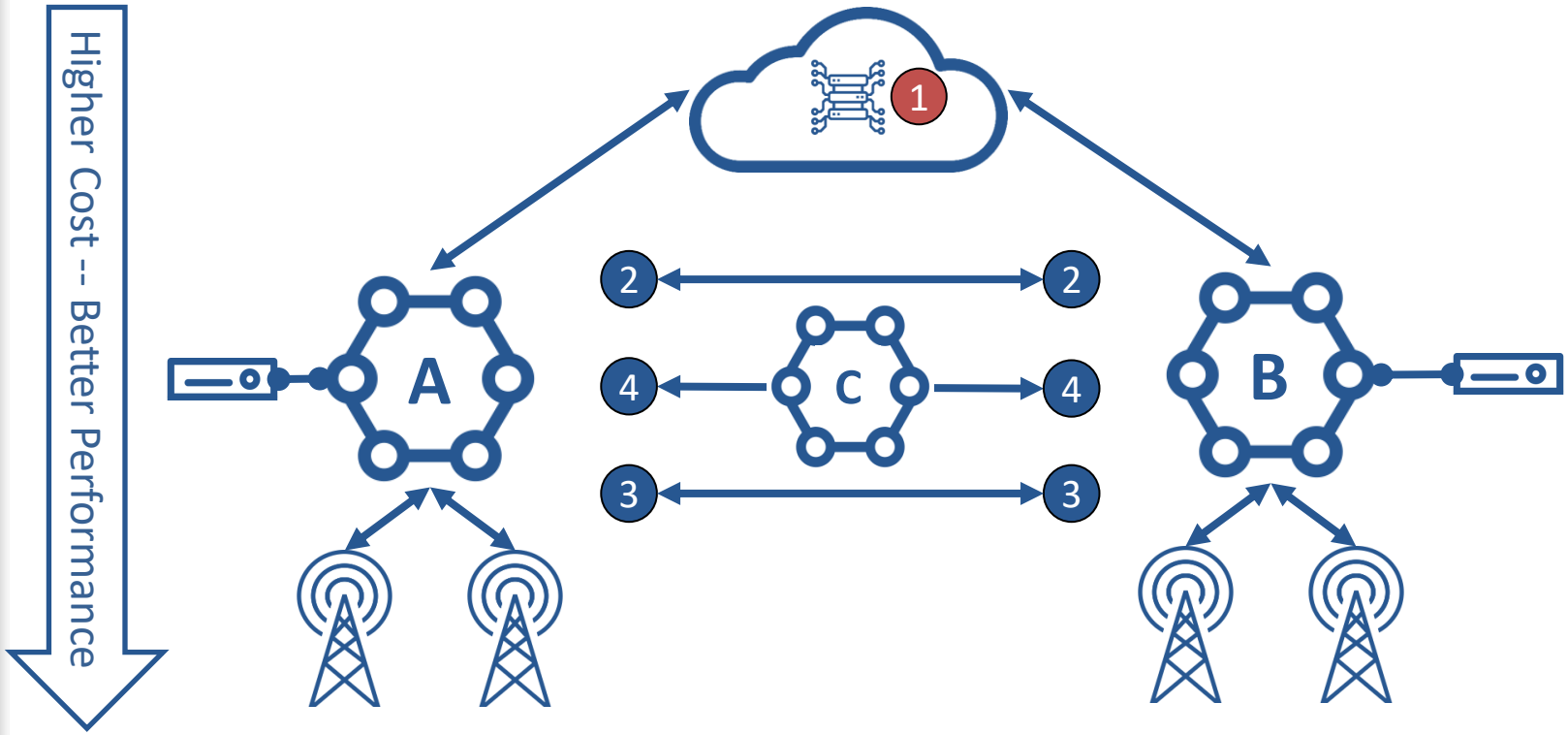


Application + Network Round-Trip Time → 240ms

Source: CMU Tech Report @ https://bit.ly/3qhk15o

Real Network Adds 200ms! Acceptable UX <150ms

The Question: Where Should IXPs Be?



1 As-Is – Distant

But they could be:

2 Central Metro

3 Distributed Metro

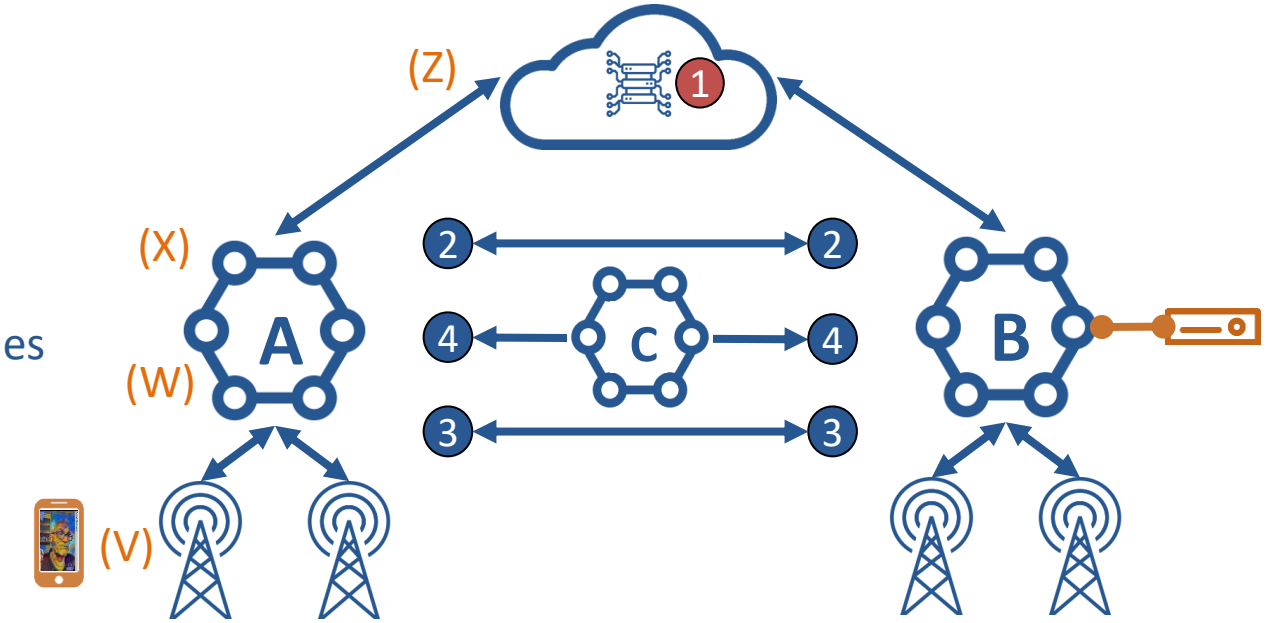
4 Metro Neutral Host

Source: Gerszberg 2019 Blog http://bit.ly/3e9De6

Evaluate Experience Metrics at Different IXP Positions

The Experiment

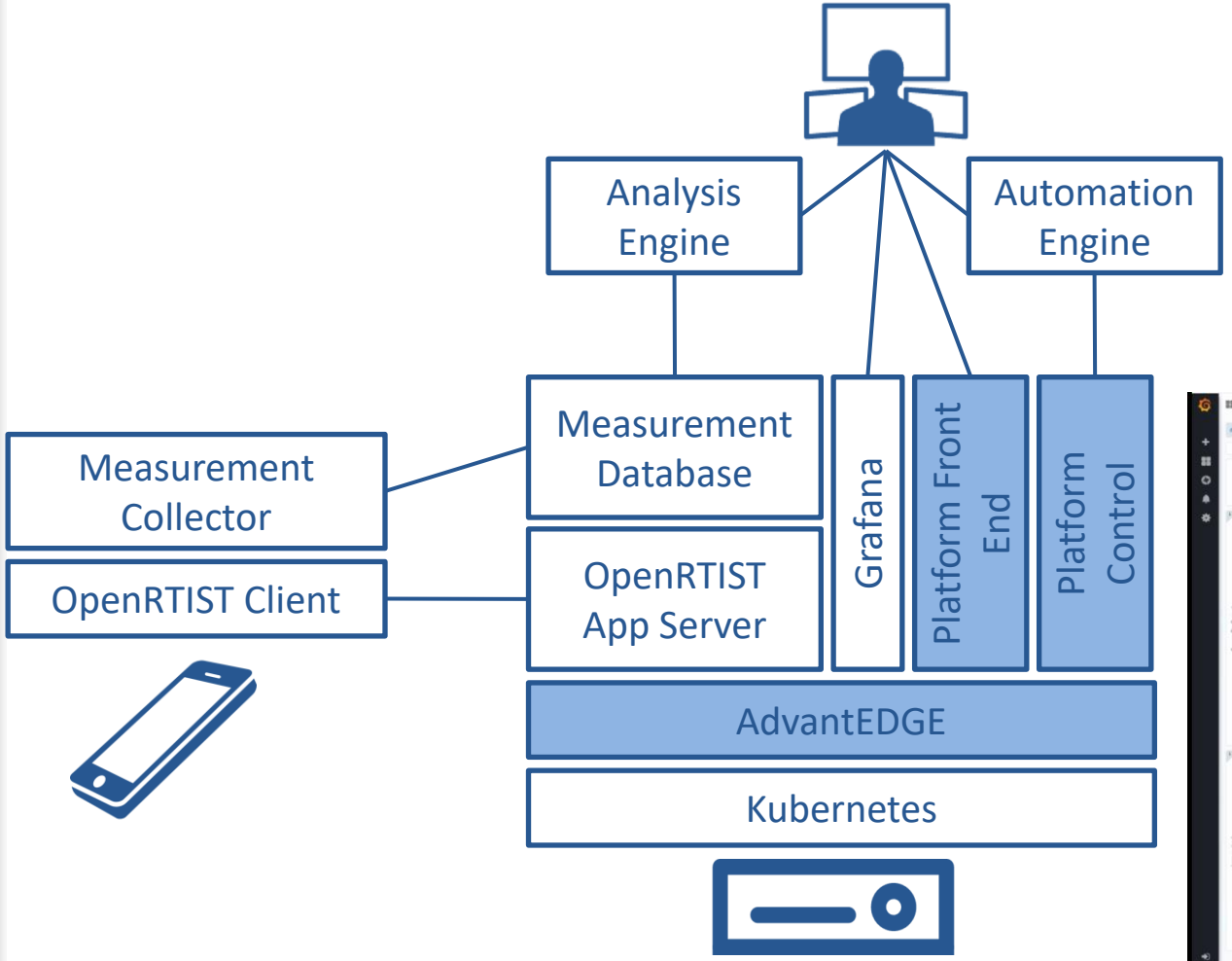
- Execute real client & cloudlet application
- Set configuration to carrier-provided values
- Simulate IXPs at locations 1-4
- Collect client and network data



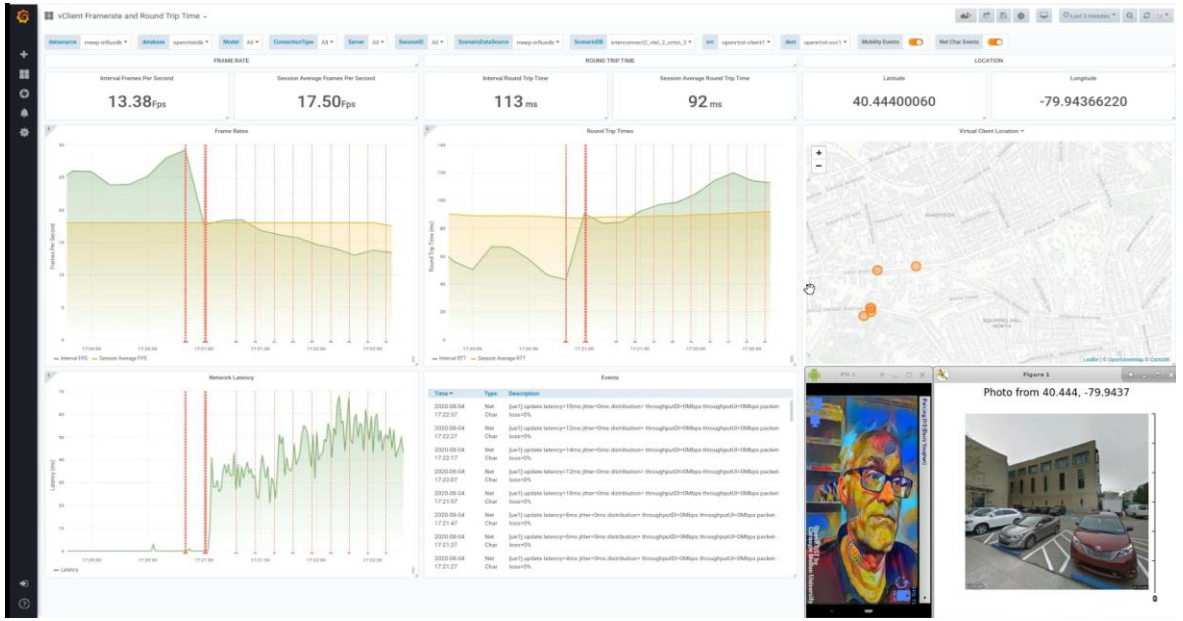
	UE APP	Wireless Link (V)	RAN (W)	Metro WAN (X)	Out of Area WAN (Y)	Interexchange	EDGE APP
Mean Latency	Actual	LTE:3ms; 5G: 1ms	5ms	5ms	20ms-100ms	<1ms	Actual
Jitter	Normal σ = 1ms	Normal σ = 1ms	Normal σ = 1ms	Normal σ = 1ms	Normal σ = 1ms	Normal σ = 0	Actual
Throughput	Actual	1Gbps	1Gbps	1Gbps	1Gbps	1Gbps	Actual

Use Real Application and Configuration Data on Emulated Network

The Environment: Living Edge Lab Simulation Framework



- AdvantEDGE emulation platform
  - w/Grafana Dashboard and InfluxDB data repository
- Instrumented OpenRTIST client
- Automation engine
- Analysis engine



Framework to Measure the IXP Placement Impact

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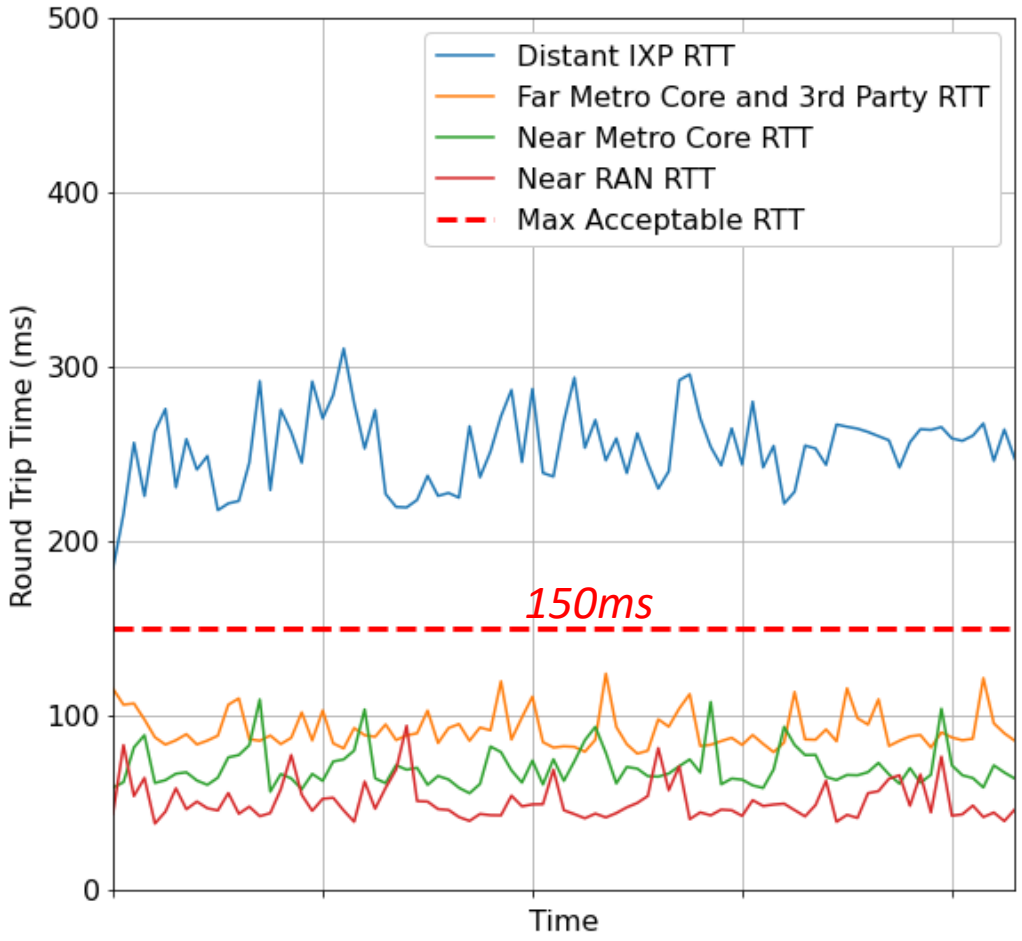
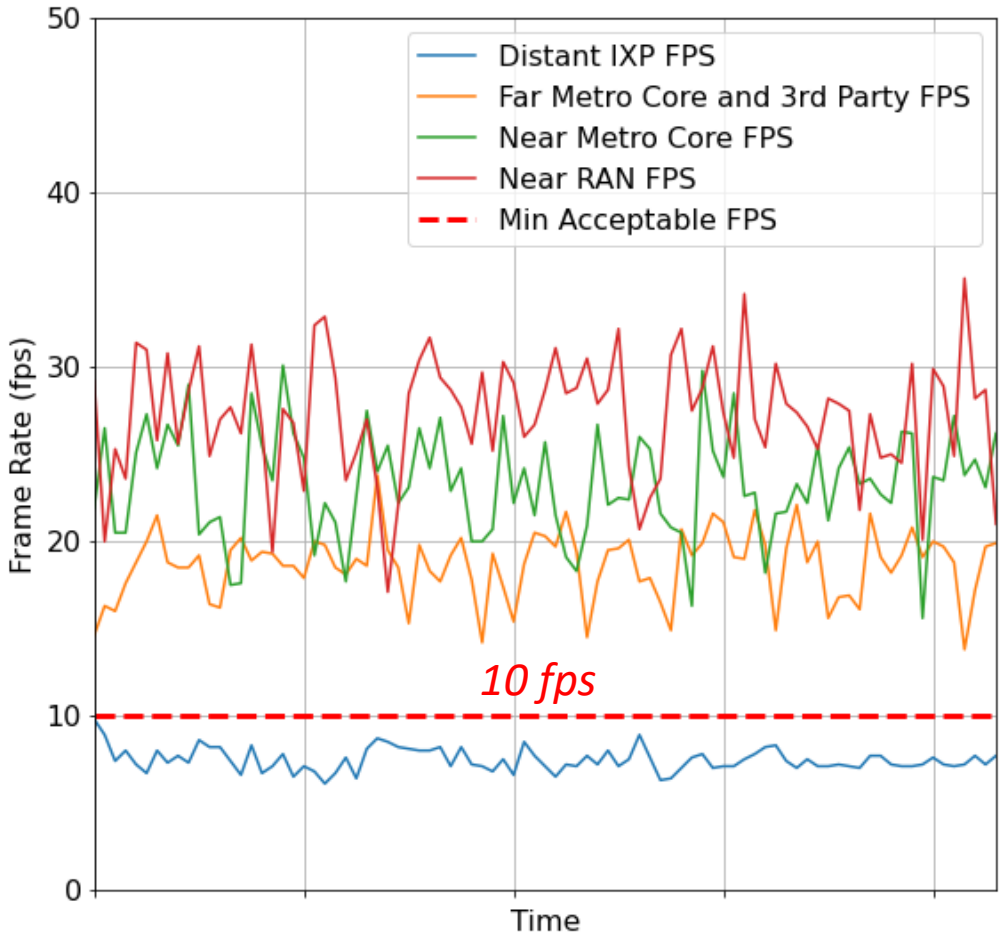
IXP Test Results





In-Metro is Necessary and Sufficient for this Application (20-50ms E2E)
Closer is Better but may not Justify Cost

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RECOMMENDATIONS

RECOMMENDATIONS

- Carriers:
  - Edge computing business success of depends on addressing legacy carrier interconnect limitations:
    - Cloudlets and IXPs must be within a region/metro
    - Many apps don't need IXPs at the very edge; Need a business case for those that do
  - IXPs at metro third-party neutral host IXPs are a viable alternative
  - Pay attention to other requirements like lawful intercept and data geofencing
  - Given long planning and implementation cycles, carriers should begin work immediately to rearchitect their IXP approach
- Edge-Native Application Developers:
  - Until networks catch up, app designs must be IXP-Aware and design in IXP location resilience

IXP Placement is a Key Consideration for Edge Cloud Design

For More Information

- Open Edge Computing Initiative:
  - https://openedgecomputing.org, info@openedgecomputing.org and @openedgecomput1
- Blog: "*Connecting the Dots at the Edges*" -- https://bit.ly/387qNVa
  - https://bit.ly/387qNVa and https://www.openedgecomputing.org/connecting-the-dots-at-the-edges/
- Whitepaper: "*How Close to the Edge?*" -- http://bit.ly/3ruDEYQ
- Carnegie Mellon University Living Edge Lab:
  - https://www.cmu.edu/scs/edgecomputing/index.html
- "Walk Down Walnut" Simulation Platform Video -- https://youtu.be/OW1J-J2nWMQ

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THANK YOU

