WiScape

A Case for Client-Assisted Approach to Monitoring Wide-Area Wireless Networks

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Motivation

- One way to monitor wireless performance
  - Carrying out drive-by measurement test

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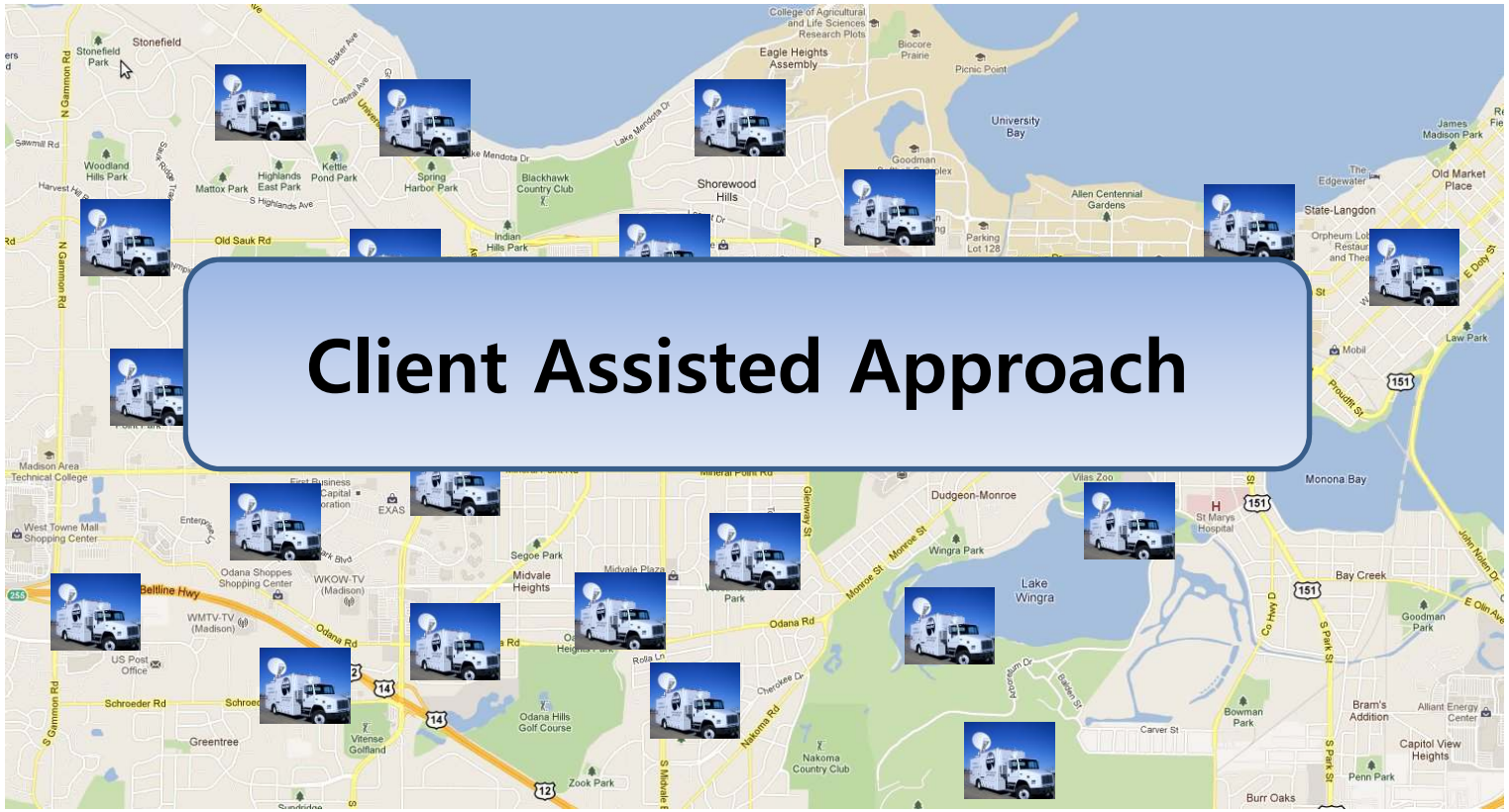

Client-Assisted Monitoring

- Collecting measured samples from multiple clients

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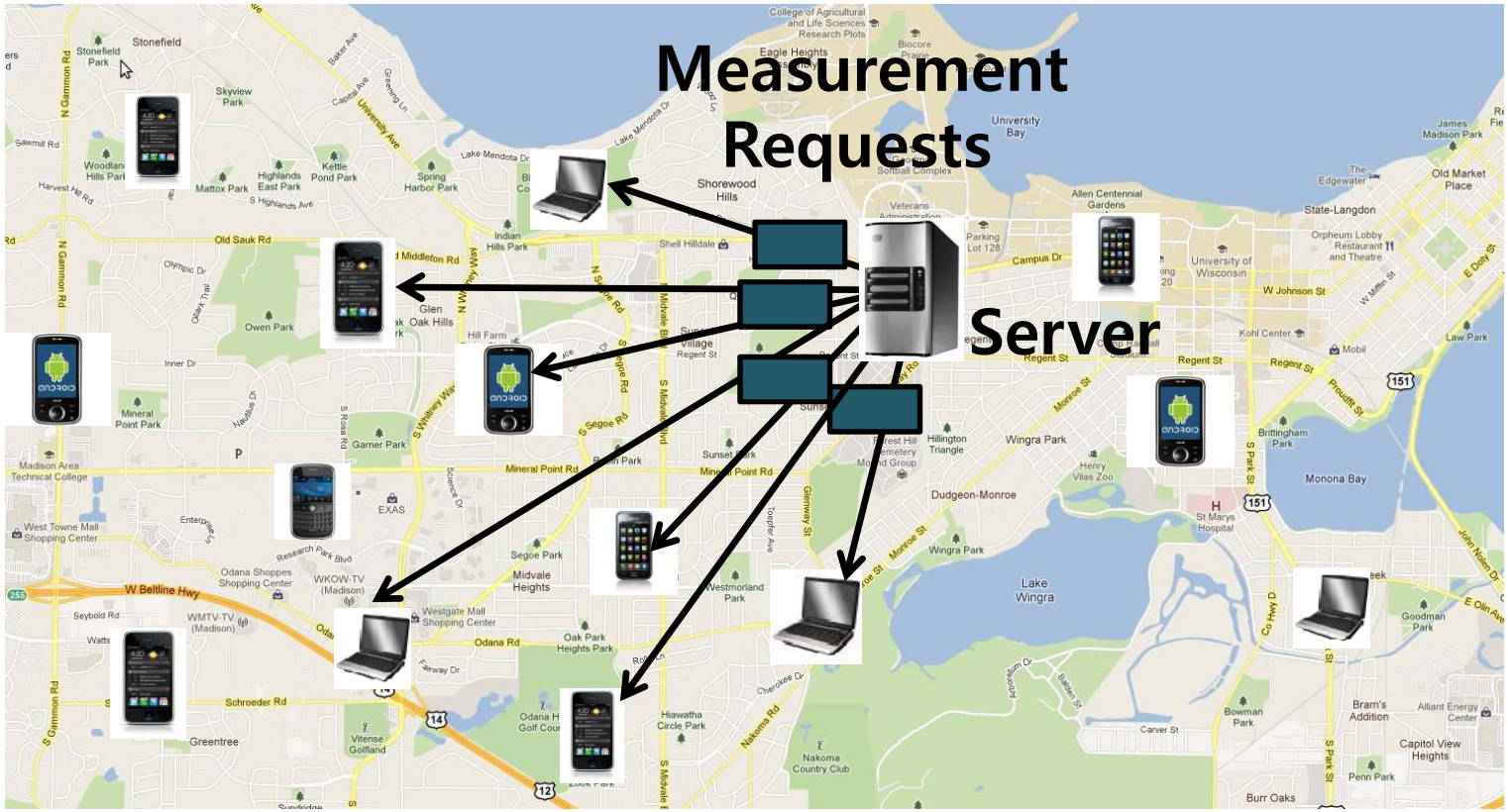

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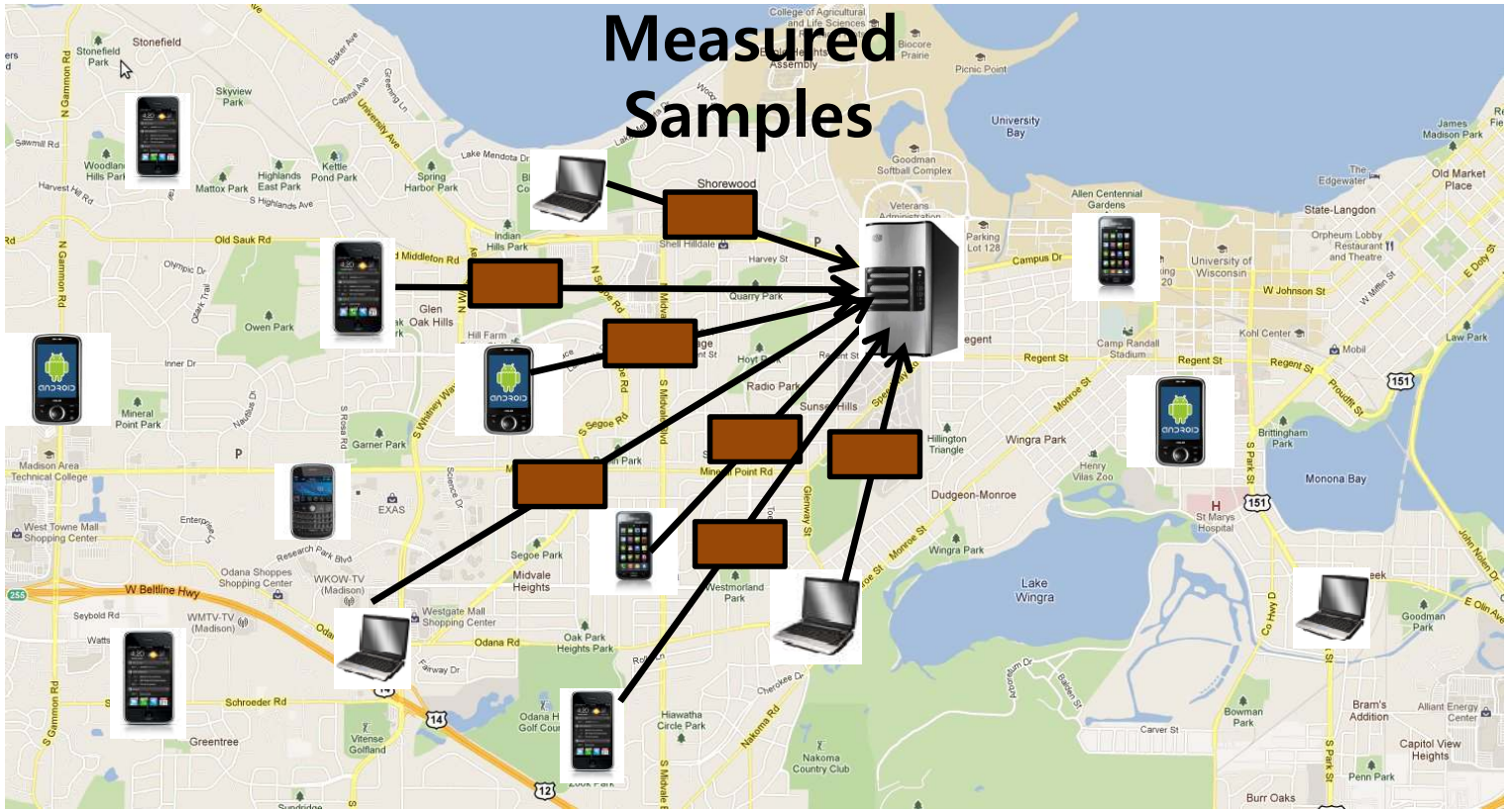
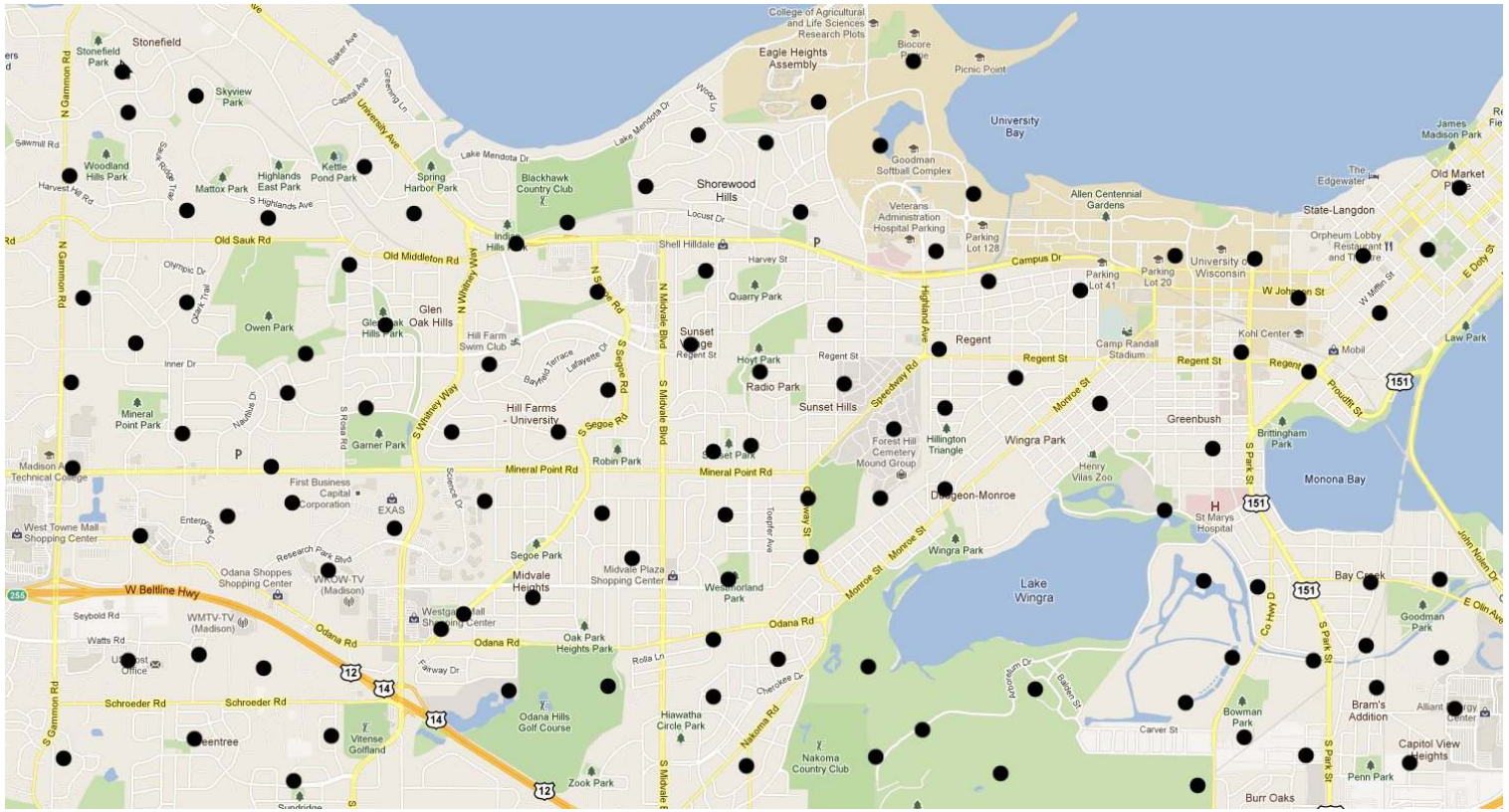


Benefits

- Leverages multiple users
  - Covers more area more frequently
- Captures client experiences
- At locations clients care about
- Helps network operators
  - Improves network performance
  - Detects connectivity holes

  → in turn helps users

Challenges of Client-Assisted Monitoring



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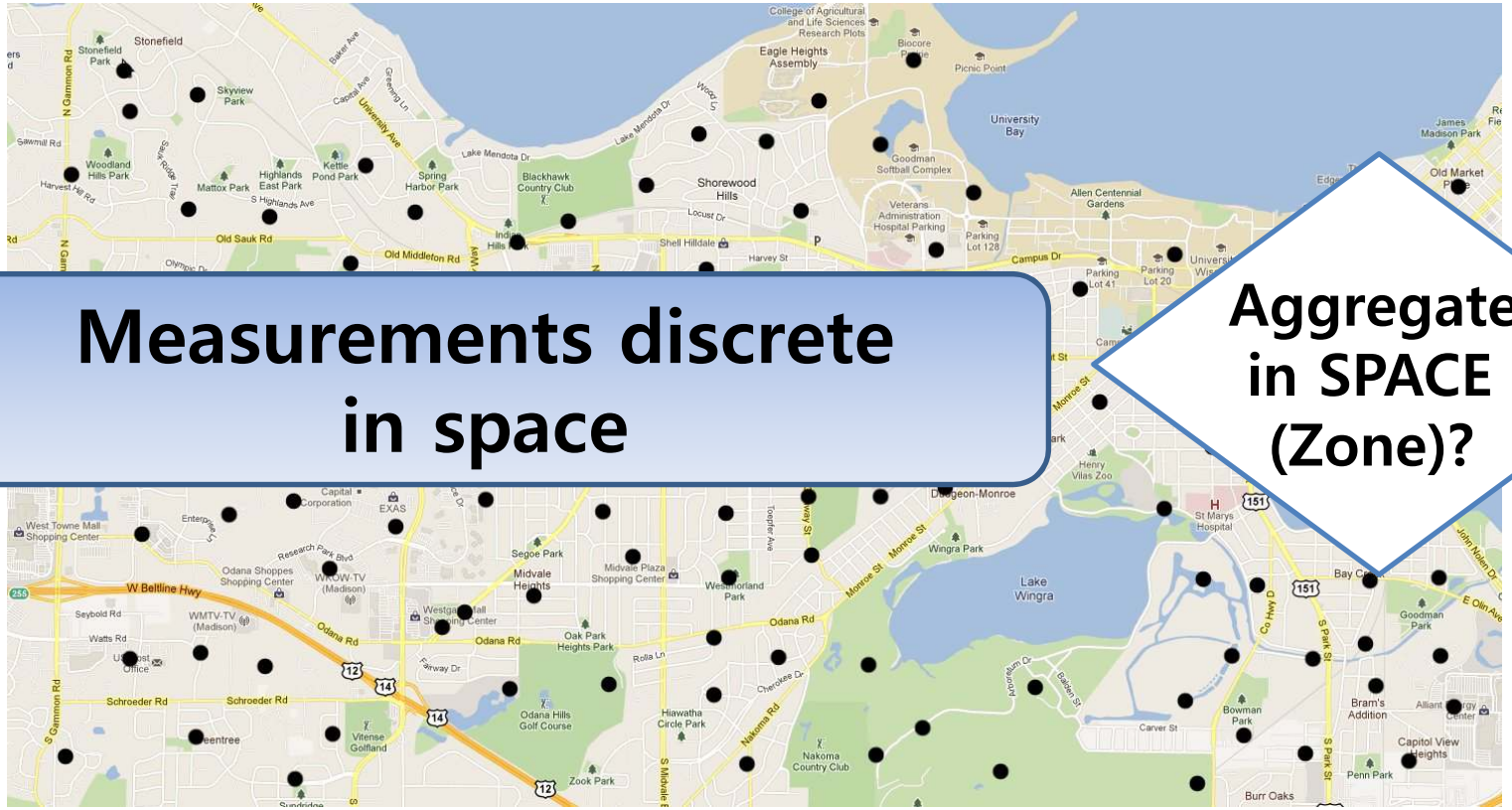

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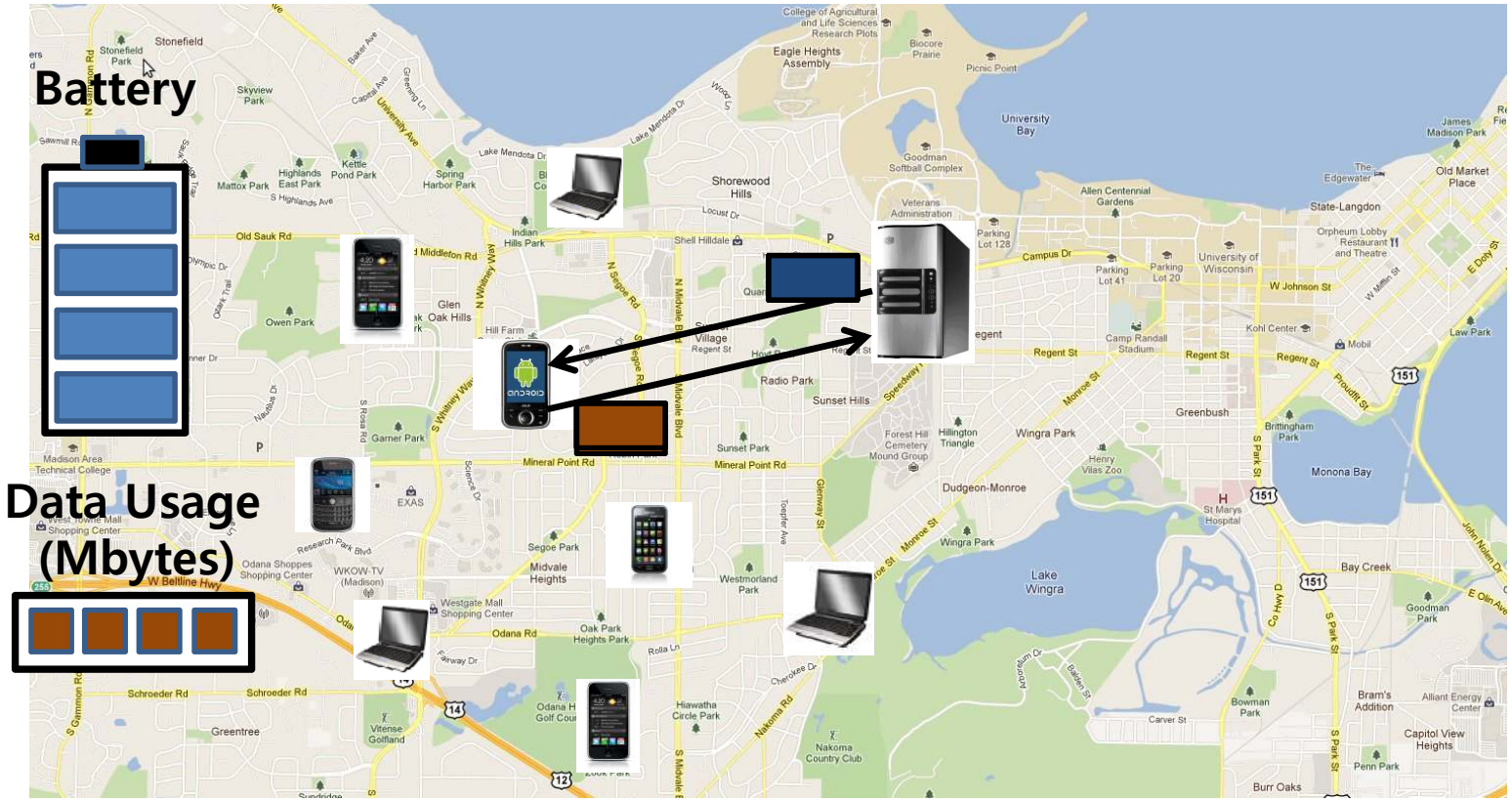

Challenges of Client-Assisted Monitoring

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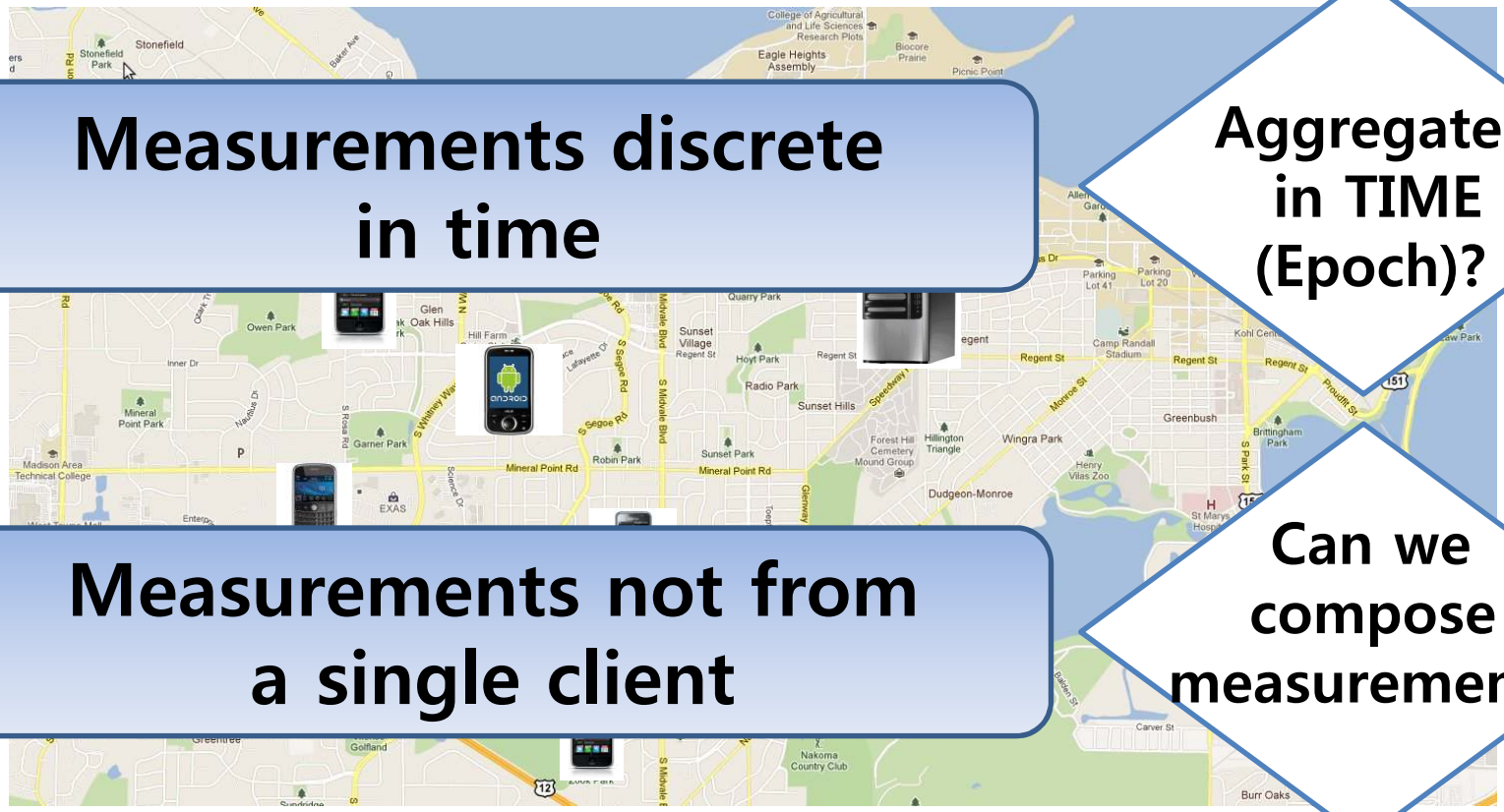

Measurements discrete in time

Aggregate in TIME (Epoch)?

Measurements not from a single client

Can we compose measurements?

Challenges of Client-Assisted Monitoring

Measurements discrete in space

Measurements discrete in time

Measurements not from a single client

Aggregate in SPACE (Zone)?

Aggregate in TIME (Epoch)?

Can we compose measurements?

WiScape

- Characterize the **Wi**reless land**scape** using client-assistance
- Using **small** and **infrequent** amounts of measurement collected by **different users**

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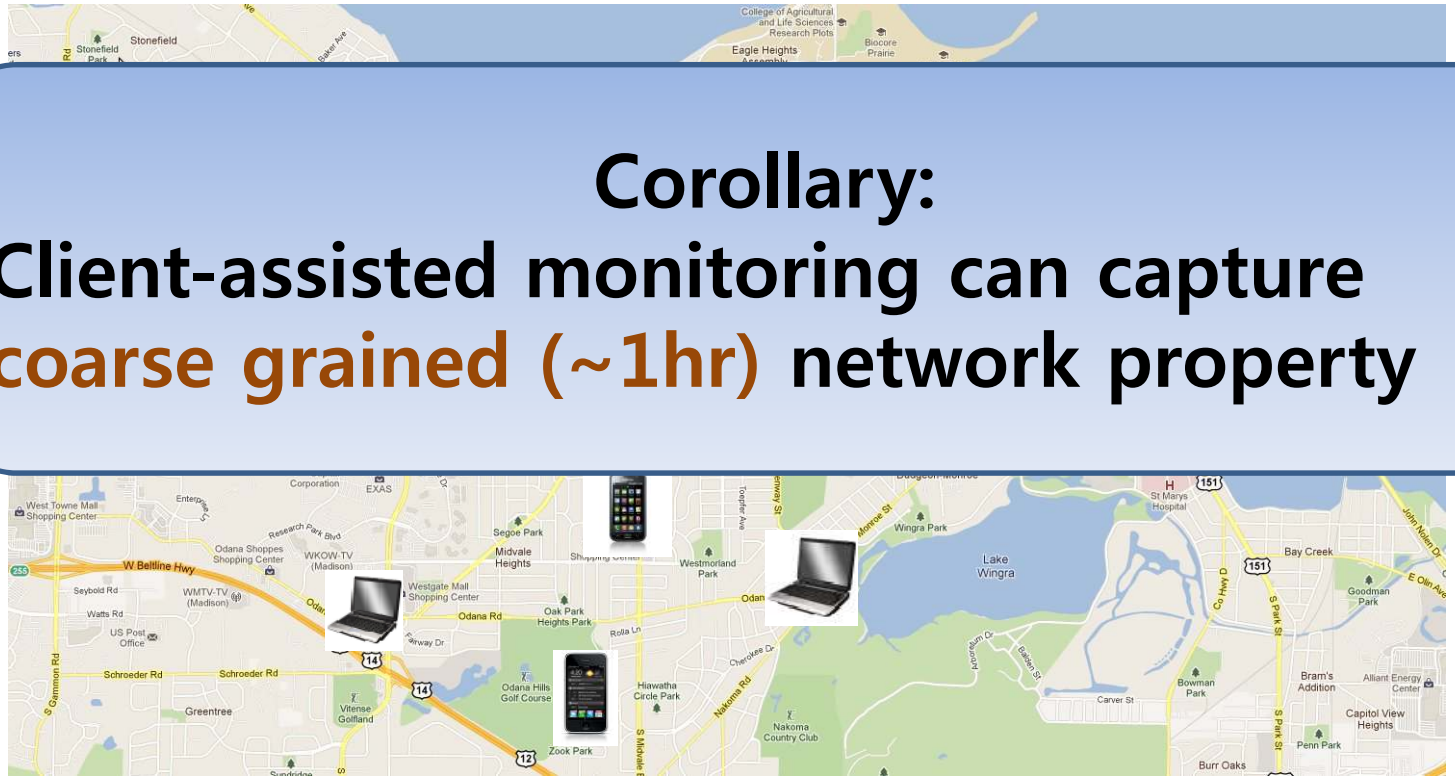

Corollary:
Client-assisted monitoring can capture coarse grained (~1hr) network property

Contributions

- Present a framework for coarse grained monitoring system
- Present applications of coarse grained monitoring of wide-area networks

Outline

- Motivation
- Dataset
- Low overhead client-assisted monitoring
  - Aggregation in space
  - Aggregation in time
  - Composing of measurements
- Applications
- Related work & Conclusion

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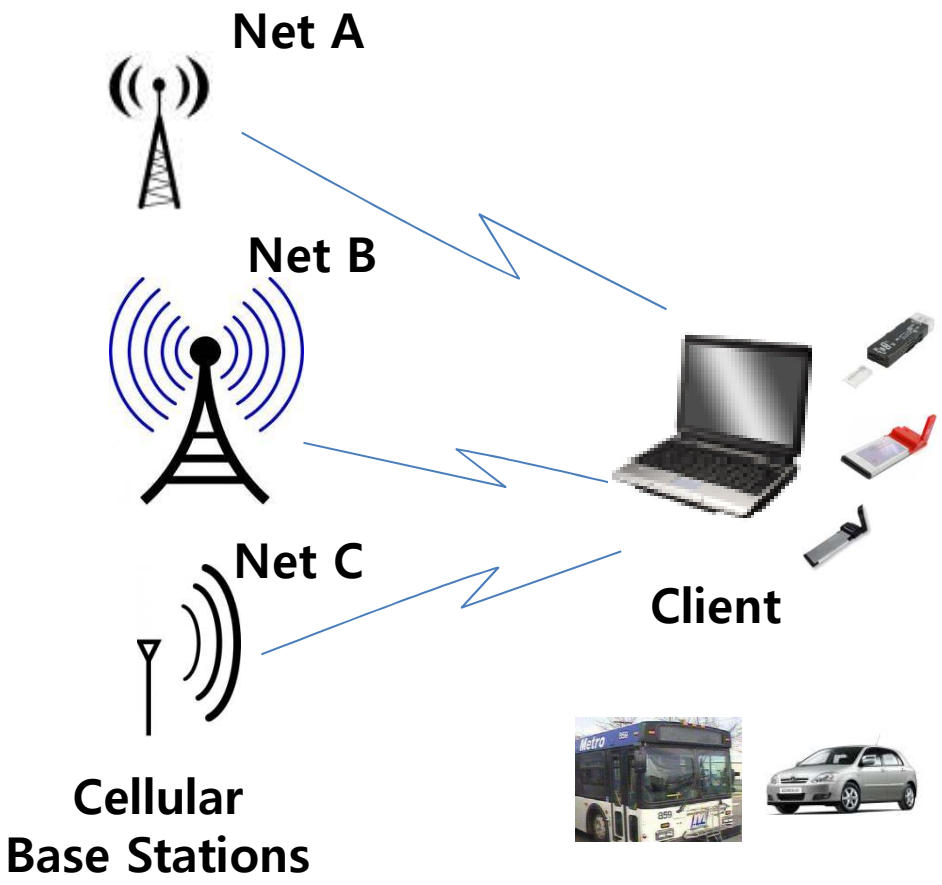
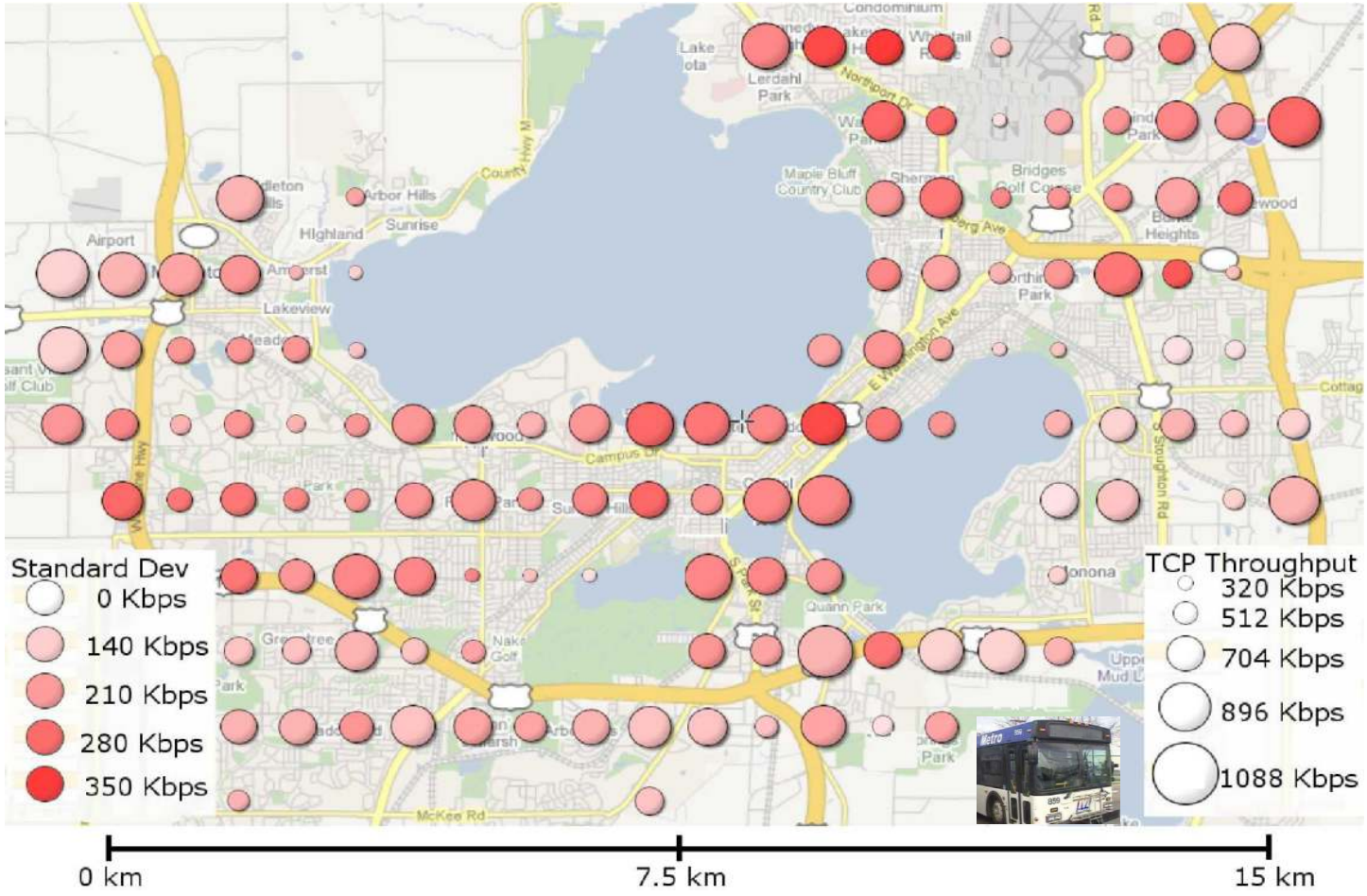
Data Collection Methodology



Measurement Metrics

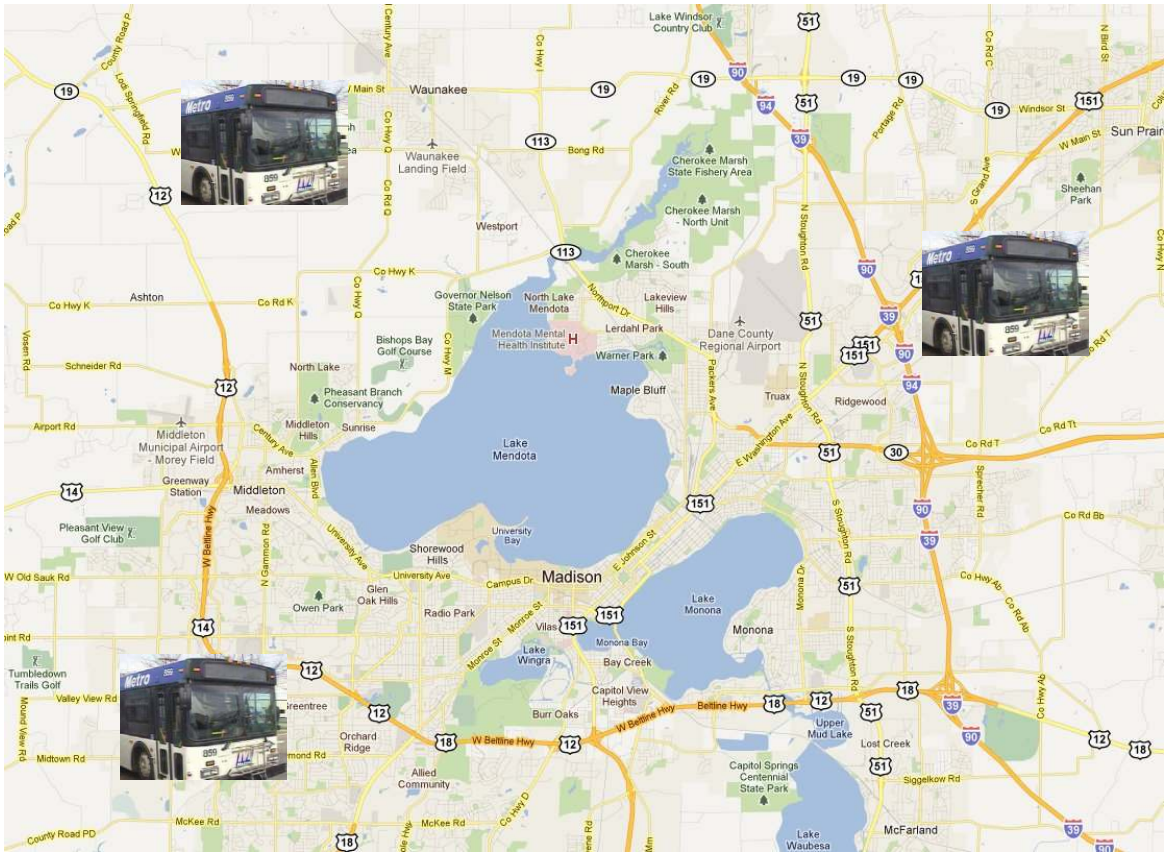
1) TCP/UDP Throughput
2) Jitter
3) UDP Loss rate
4) Latency

Snapshot of TCP performance



- City-wide area, NetB. Circle represents 1.1㎢ area

Vehicular Dataset



155 ㎢ city-wide area in Madison WI

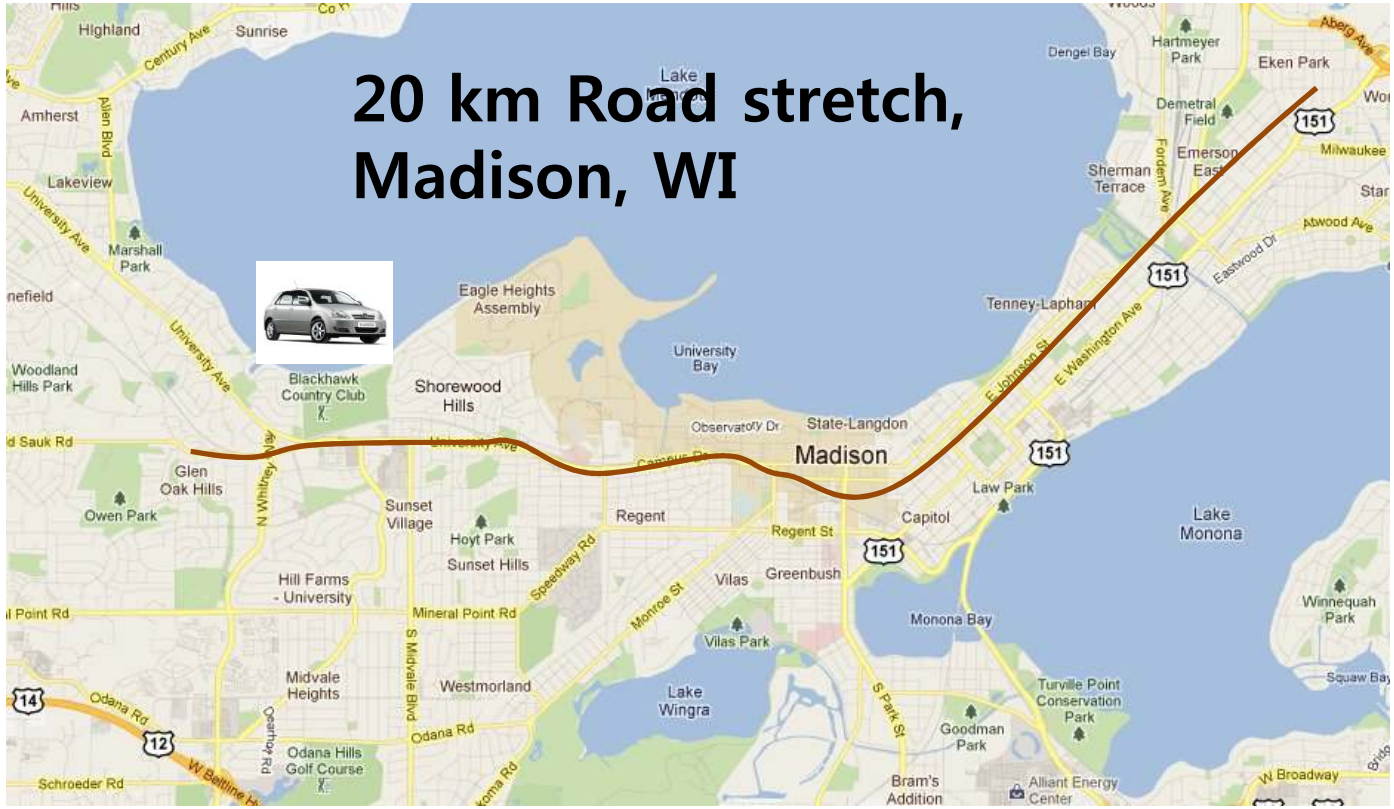
- **Madison Metro buses for 11 month**
- **Net B and C**

Vehicular Dataset

240 km road stretch, Madison, WI to Chicago, IL

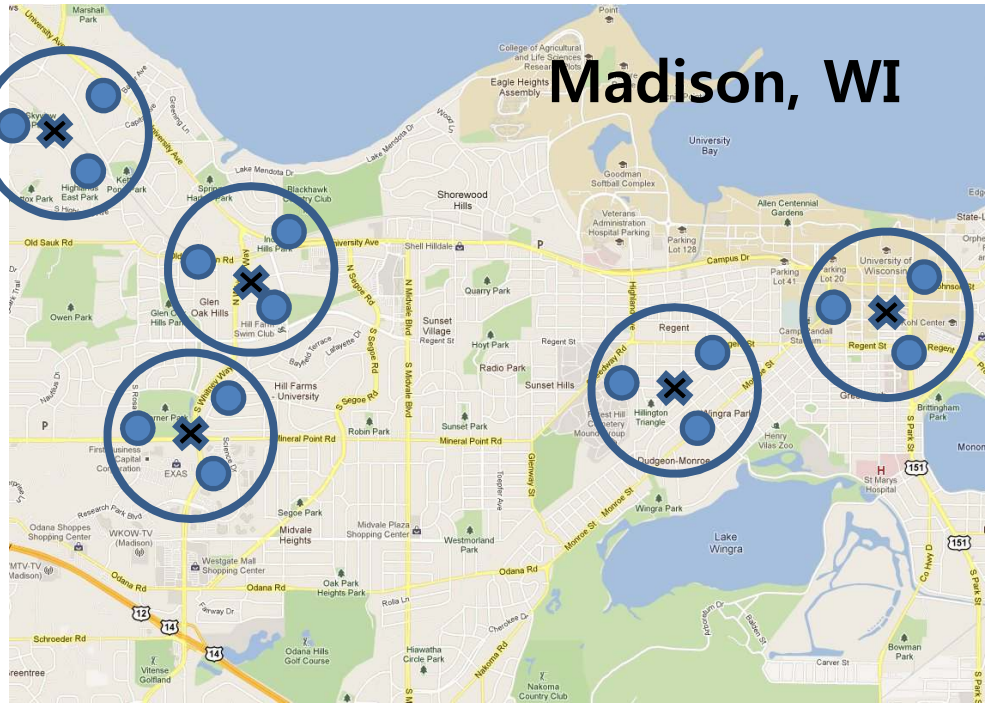
- Collected for 6 month
- Net B and C

Vehicular Dataset



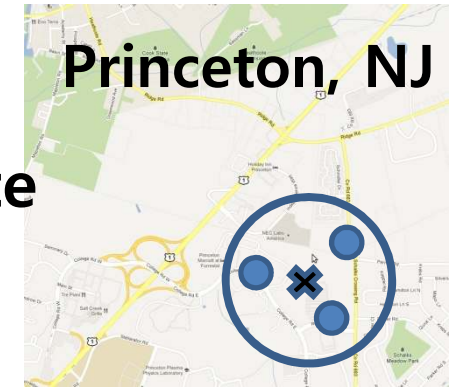
- Active measurement. Collected over 3 month
- Net A,B and C

Static & Proximity Dataset



: Static

: Proximate



Static: 5 Locations in WI, 2 Locations in NJ
Proximity: Vicinity of the static locations
- 5 month in WI using Net A,B and C
1 month in NJ using Net B and C

Dataset

Group	Span	Months	Nets	Location
Static	5 locations 2 locations	5 1	A, B, C B, C	Madison, WI New Brunswick, Princeton, NJ
Proximity	Vicinity of the static locations	5 1	A, B, C B, C	Madison, WI New Brunswick, Princeton, NJ
Vehicular	155 ㎢ city-wide 240 Km road 155 ㎢ city-wide 20km road stretch	6 12 3	B, C B A, B, C	Madison, WI Madison-Chicago Madison, WI Madison, WI

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- Conclusions & Related work

Challenges of Client-Assisted Monitoring

Measurements discrete in space

Measurements discrete in time

Measurements not from a single client

Aggregate in SPACE (Zone)?

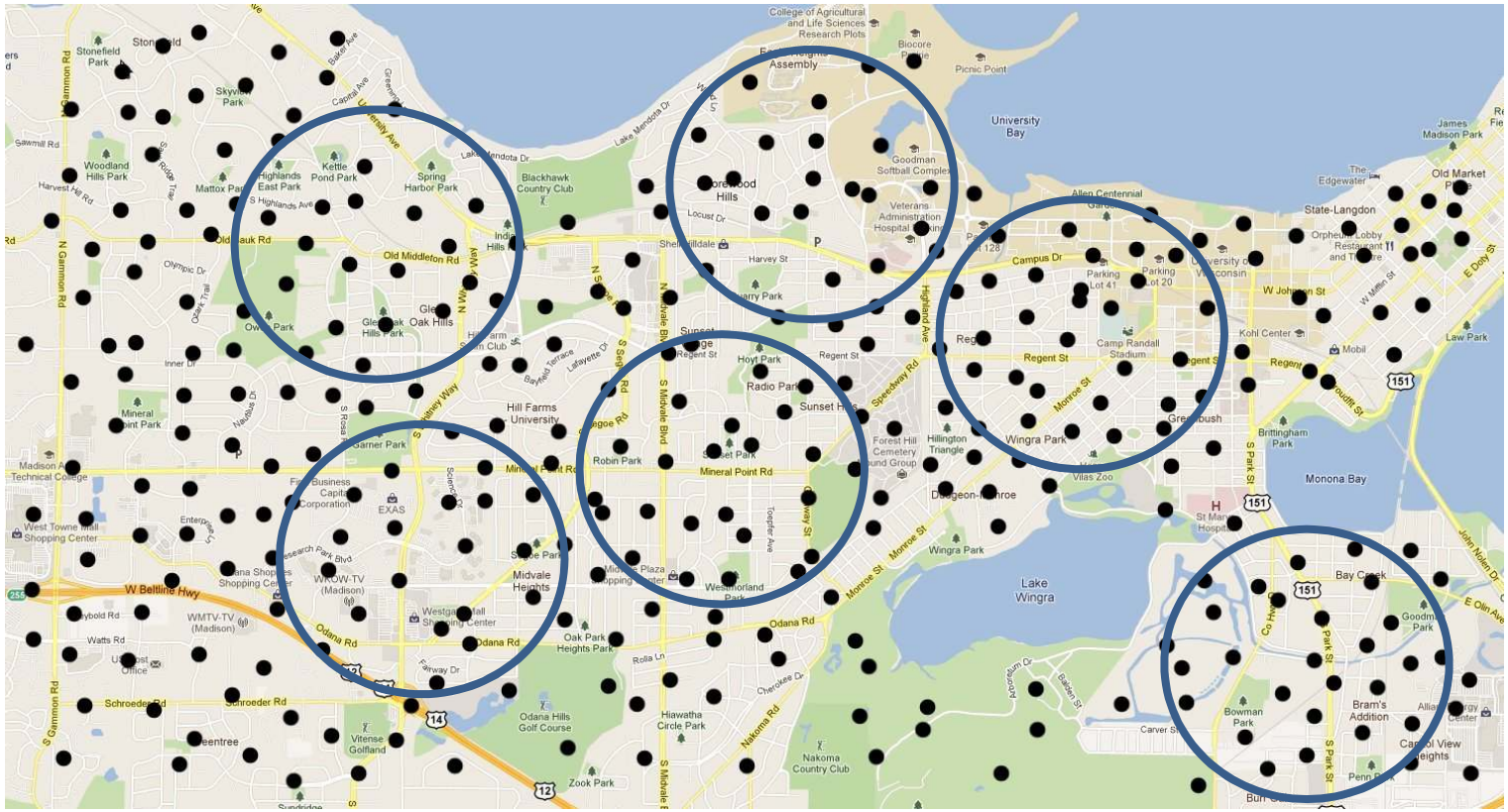
Aggregate in TIME (Epoch)?

Can we compose measurements?

Aggregating in SPACE (Zone)

Zone: a region which is **small** enough to ensure we have **similar performance** but **big** enough to ensure sufficient measurements can be **collected**

Aggregating in SPACE (Zone)



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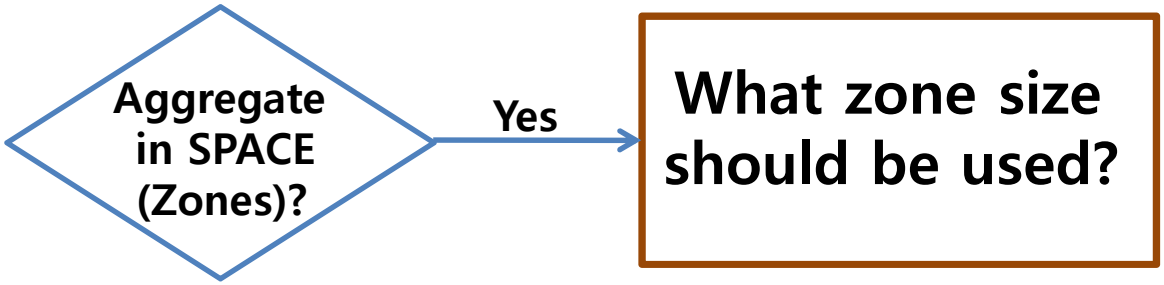

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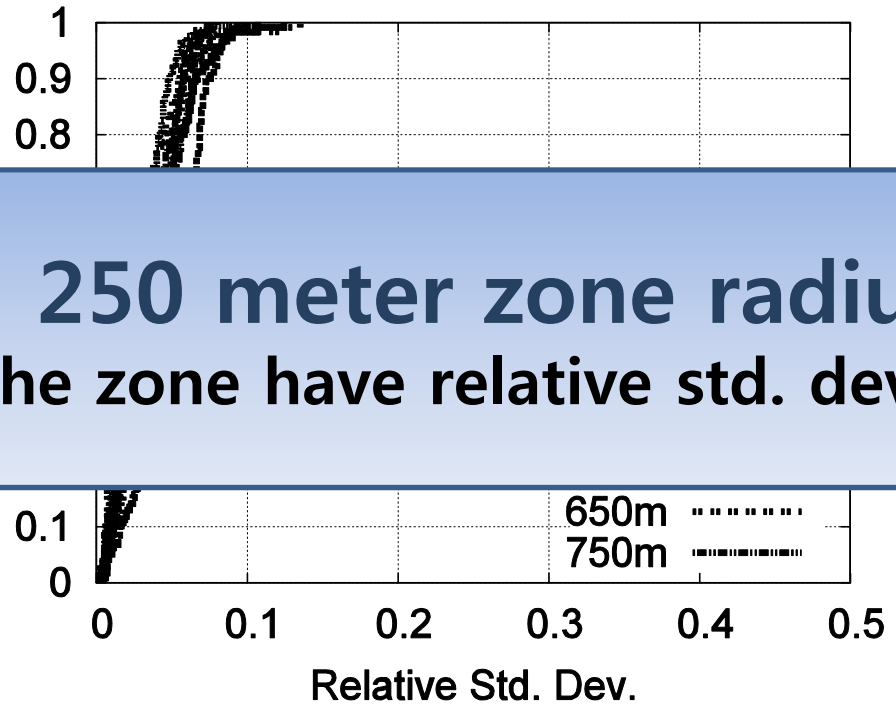
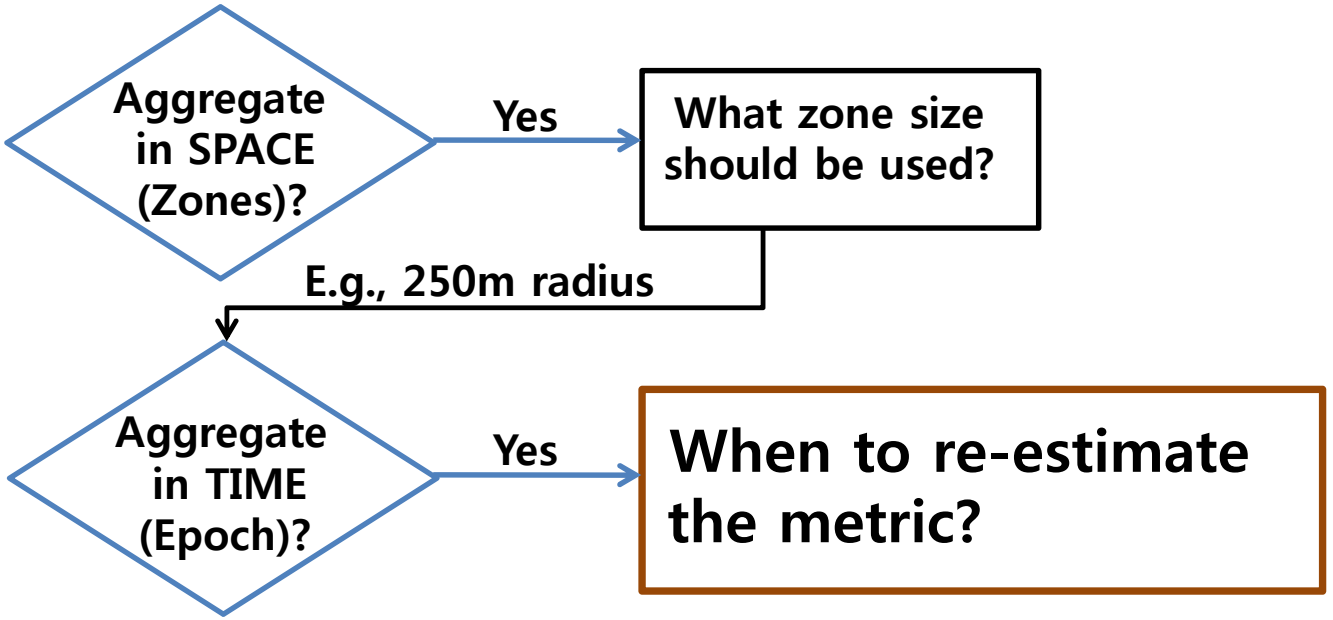


250 meter zone radius

97% of the zone have relative std. dev. < 8%

- **TCP throughput for NetB, collected 155 ㎢ Madison (200~10000 measurements were collected per week at all zones)**
- Relative Standard Deviation
  = standard dev. of samples / mean of samples

WiScape Framework



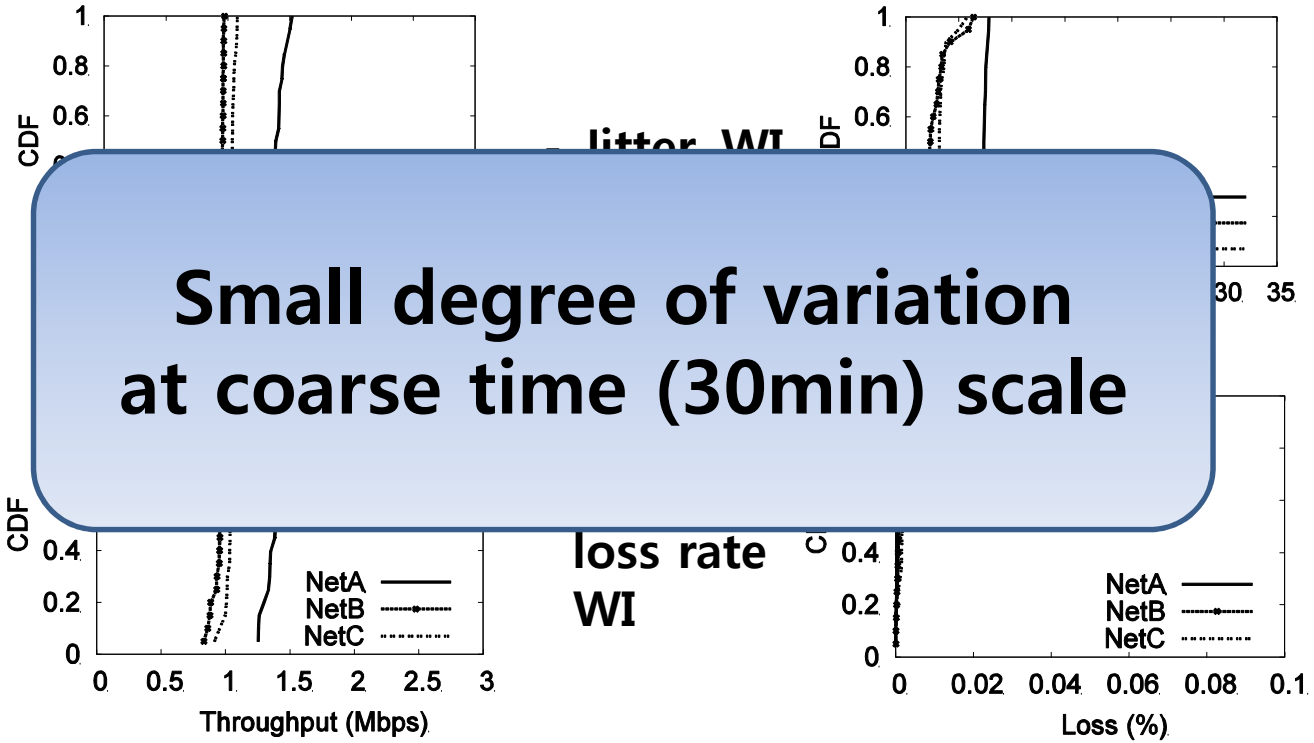
Measurement Metrics
1) TCP/UDP throughput
2) Jitter
3) UDP Loss rate
4) Latency

Aggregating in TIME (Epoch)

- 30 min bins (Coarse time scale)

- TCP throughput WI

- UDP Throughput WI



Small degree of variation at coarse time (30min) scale

- Static-WI/NJ, Net A, B and C

Aggregating in TIME (Epoch)

- 10 sec bins (Fine time scale)
  - Standard Deviation for 10sec/30min time bins

	Net B - WI		Net C - WI		Net B - NJ		Net C – NJ	
	Coarse 30min	Fine 10sec	Coarse 30min	Fine 10sec	Coarse 30min	Fine 10sec	Coarse 30min	Fine 10sec
TCP (Kbps)	33	102	36	96	126	408	167	414
UDP (Kbps)	39	82	38	94	153	429	182	365
Jitter (msec)	1.3	2.1	0.7	1.6	0.5	1.6	0.5	1.0
Loss (%)	~0	~0	~0	~0	~0	~0	~0	~0

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Loss (%)	~0							~0

High degree of variation at fine time (10sec) scale

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  - Standard Deviation for 10sec/30min time bins

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Loss (%)	~0							~0

Degree of variation is zone specific

Aggregating in TIME (Epoch)

- Zone specific epochs

  - Coherence interval of a metric (e.g. TCP throughput, Jitter, etc.) in a given zone.

  - We re-estimate the metric once every time epoch

Aggregating in TIME (Epoch)

- Allan deviation

  - Determining intervals for over which given metric is most stable

  - Finding the time (coherence) interval at which the difference between bins is minimum

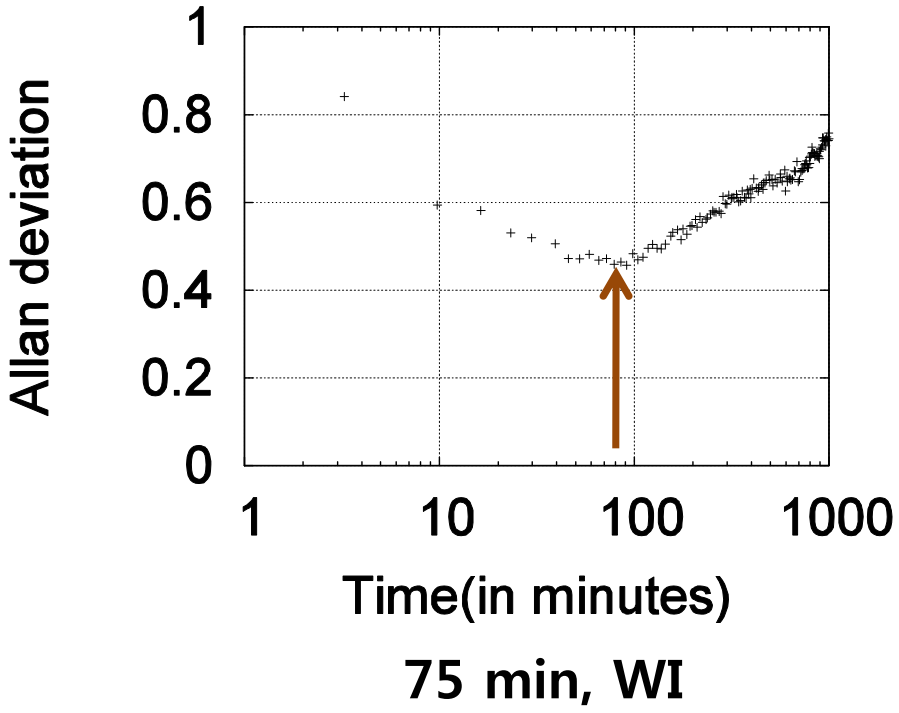
Aggregating in TIME (Epoch)

- Allan deviation

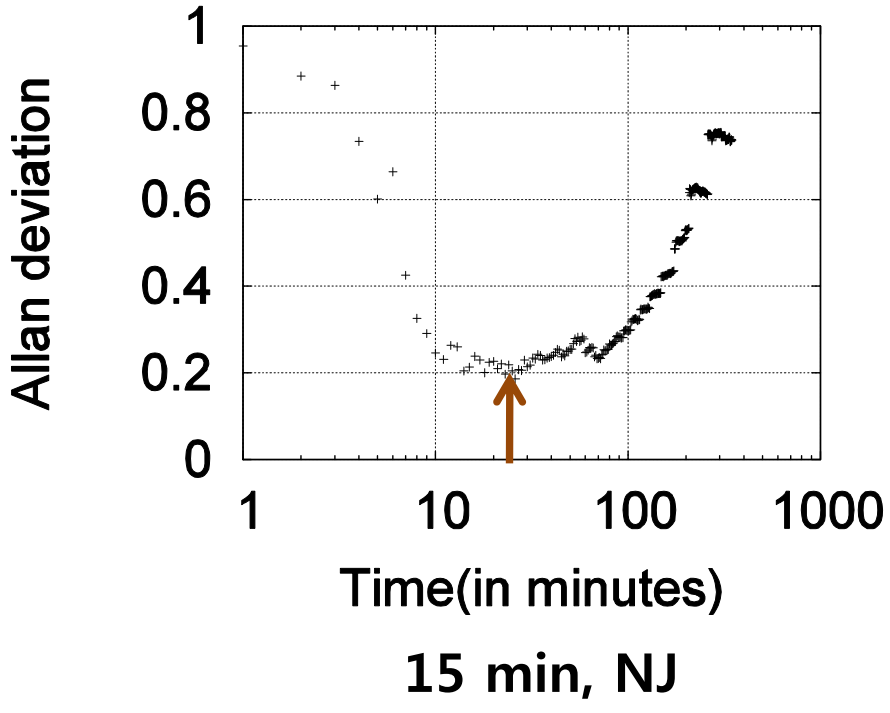
Time duration with the lowest Allan dev. determines the Zone Specific Epoch

Aggregating in TIME (Epoch)

- Zone specific epochs



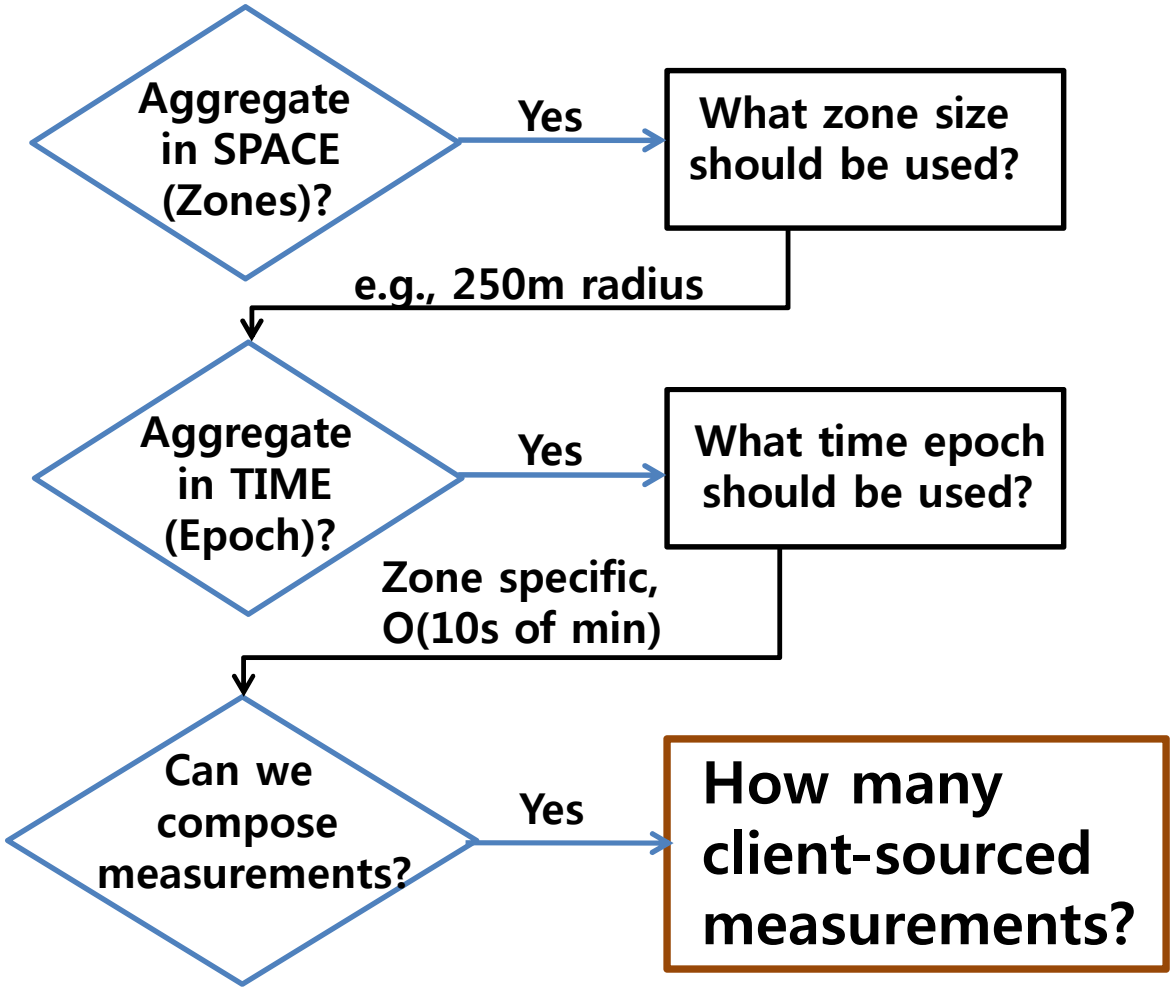
75 min, WI



15 min, NJ

- Proximate-WI/NJ, UDP throughput, Net B

WiScape Framework



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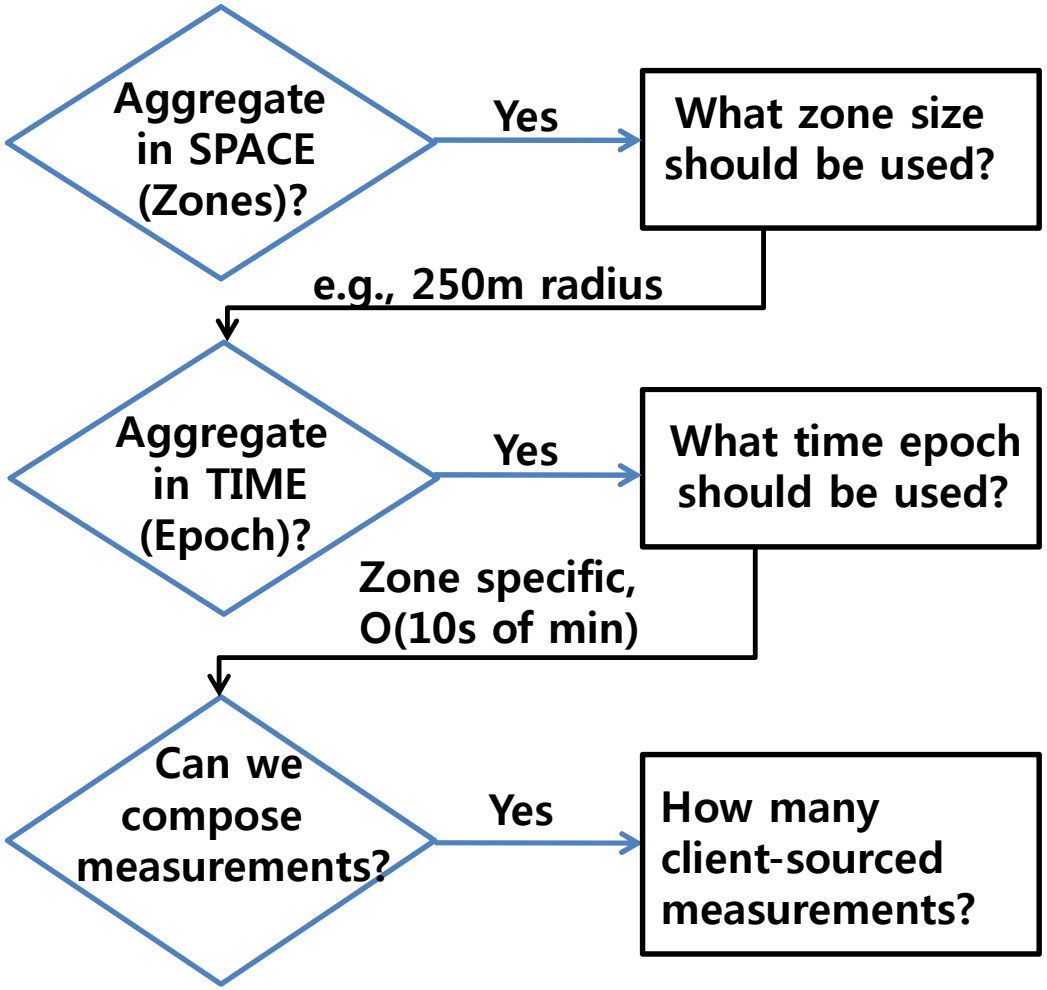
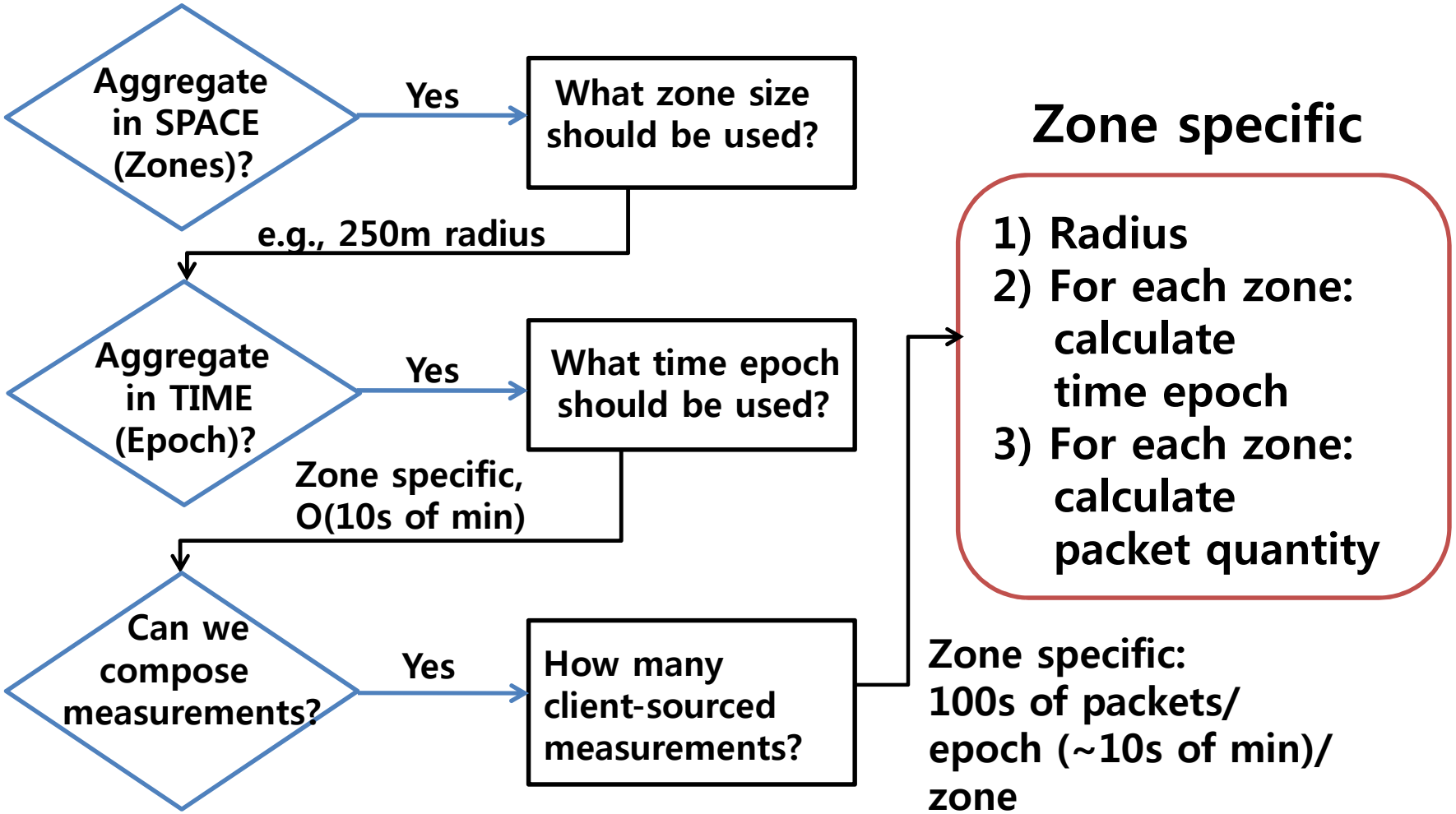


Zone specific: 100s of packets/ epoch (~10s of min)/ zone

[details in paper]

WiScape Framework



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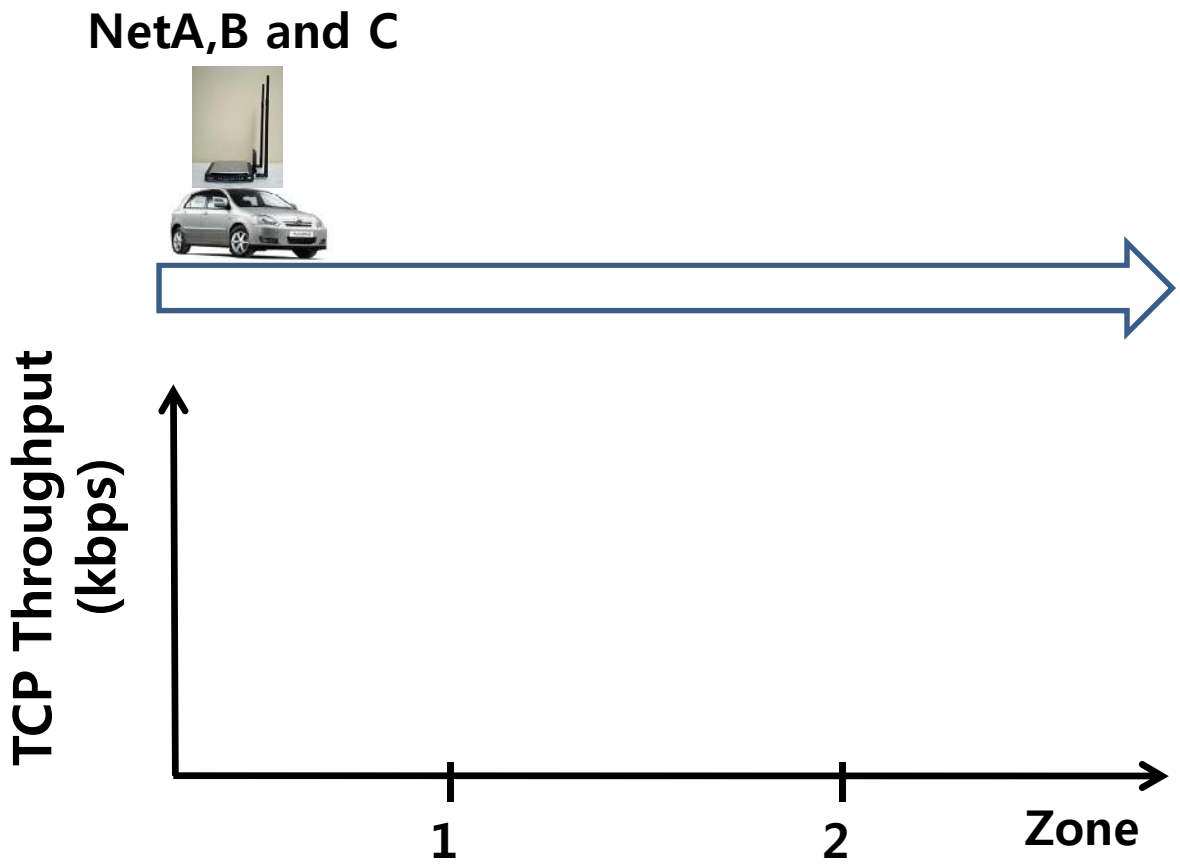
Improving Multi-interface Applications

- Multi Network Interface Systems



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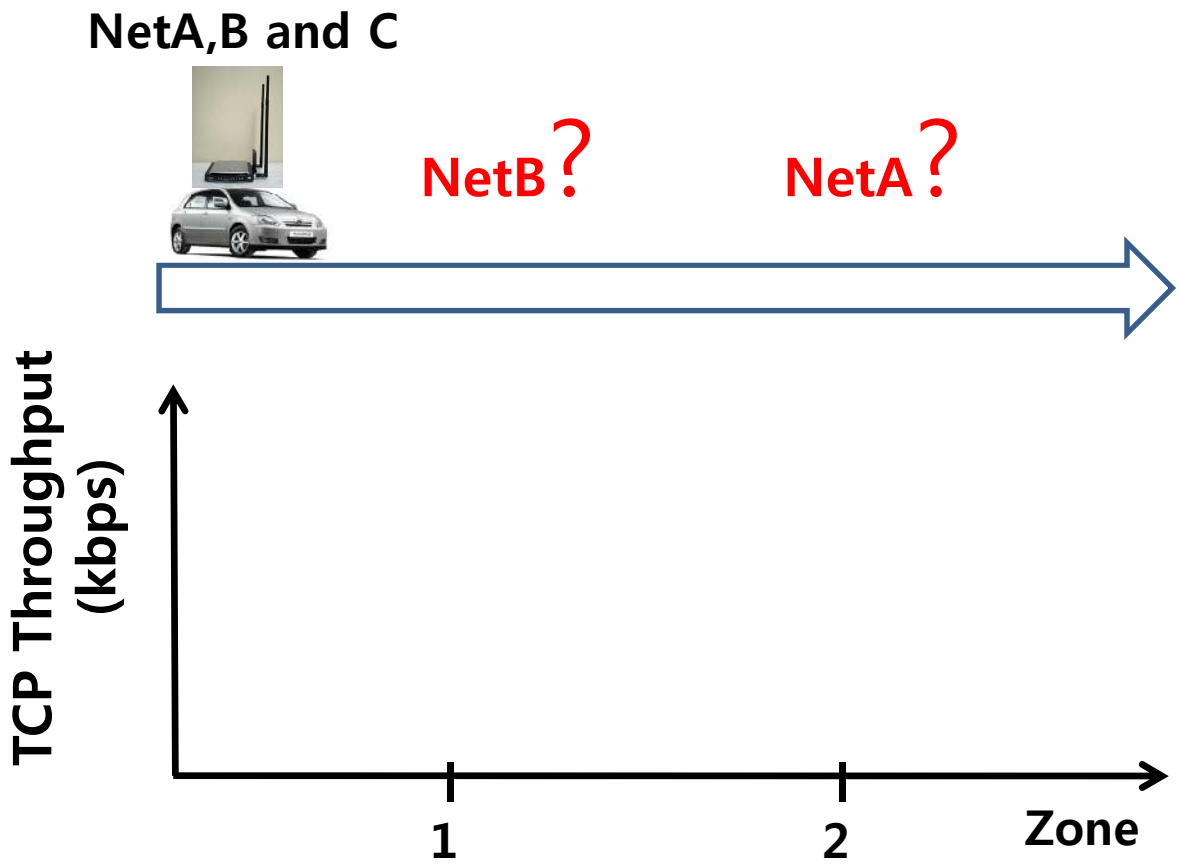
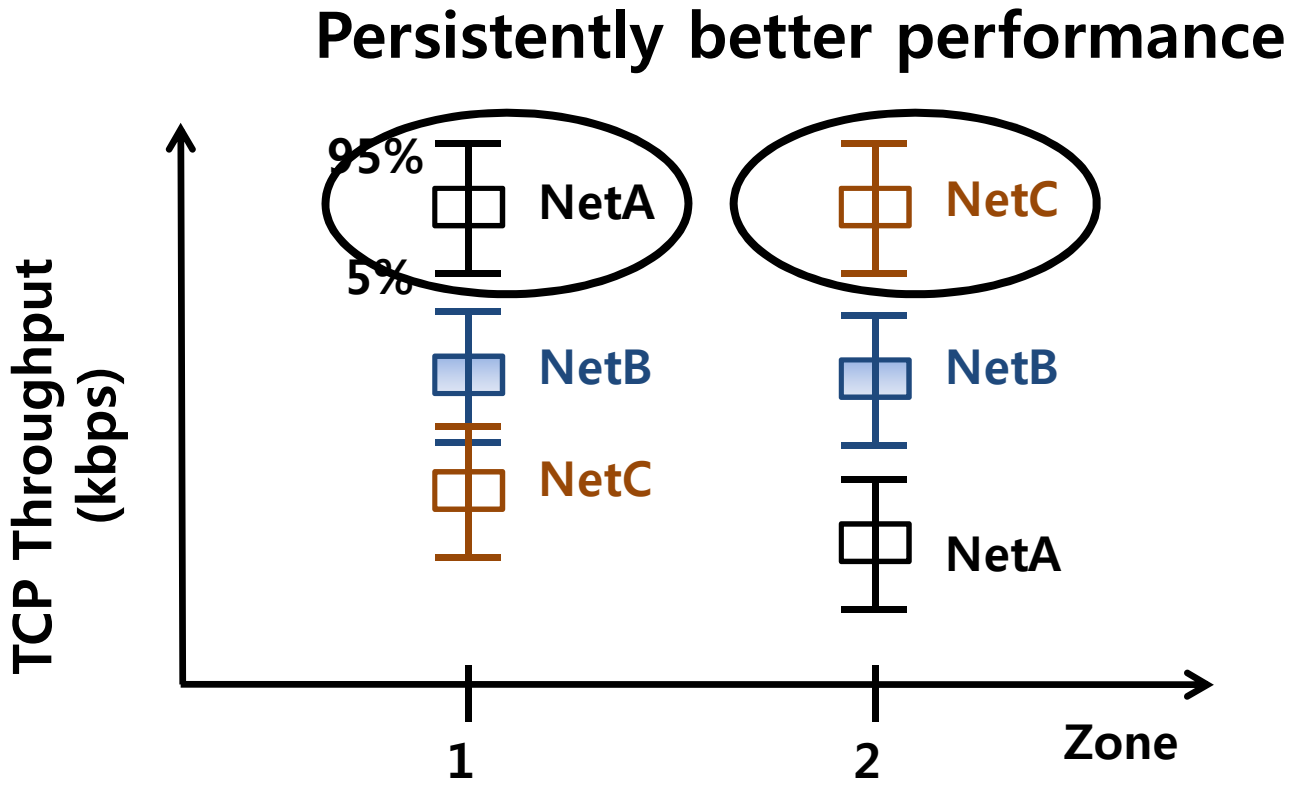
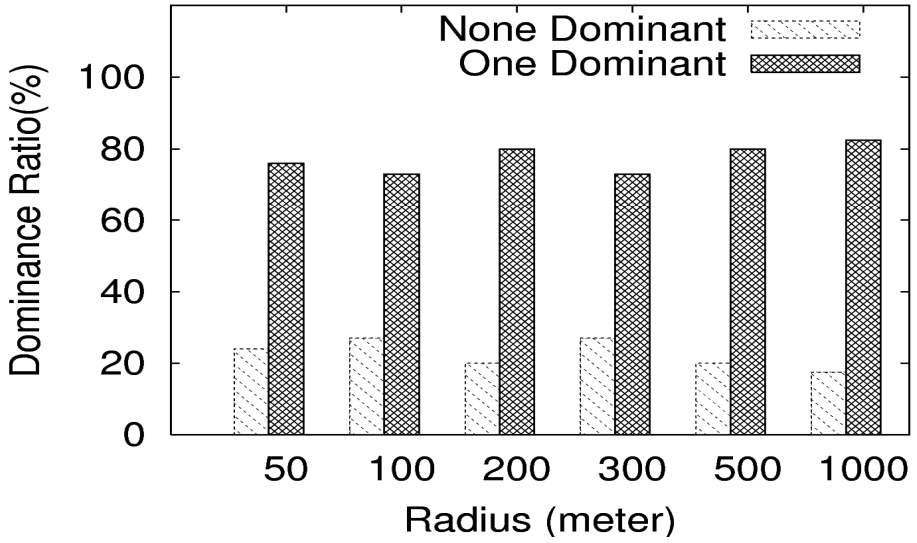


Observations

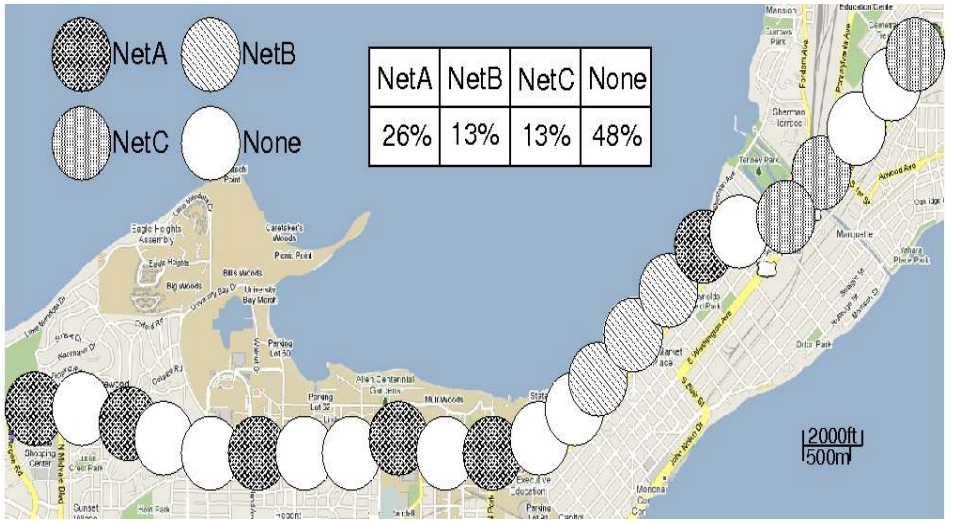


Observations

- Persistently better performance for a zone



- Vehicular traces
Madison-Chicago



- 20 km road stretch
Madison, WI

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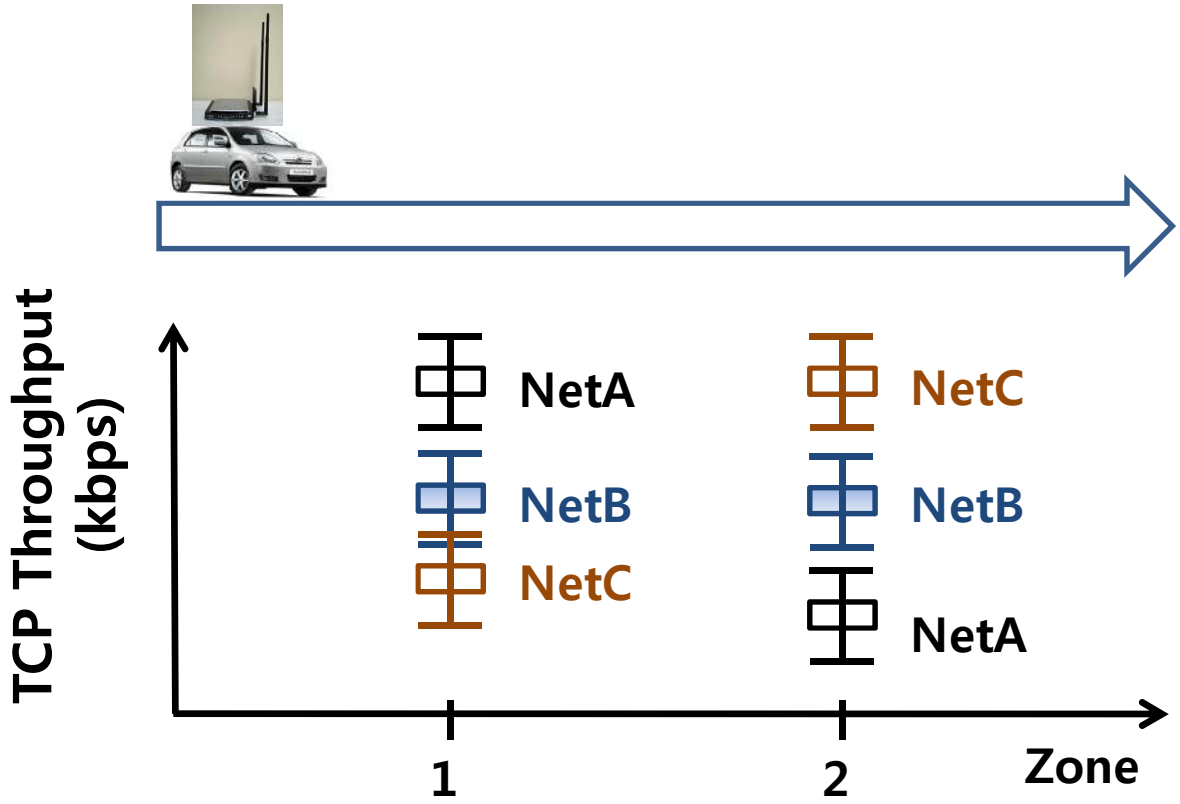

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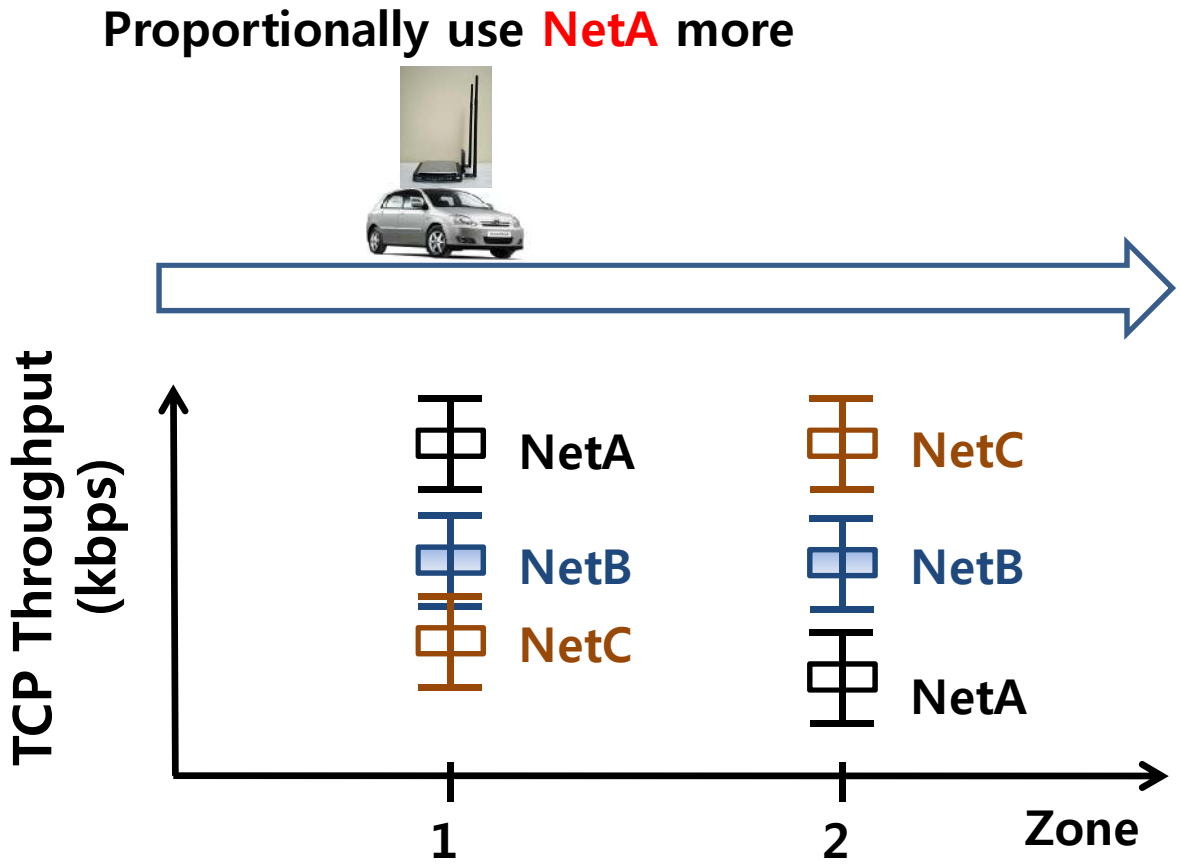

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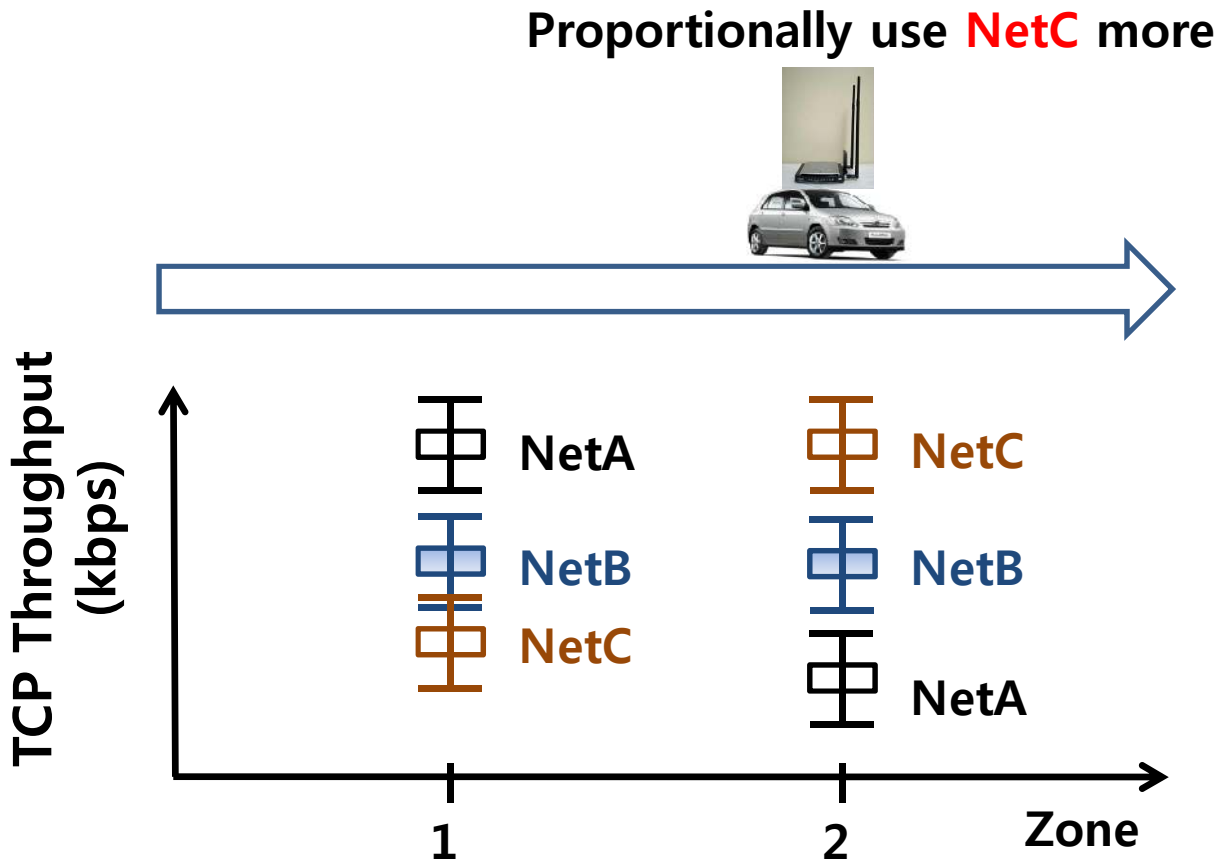

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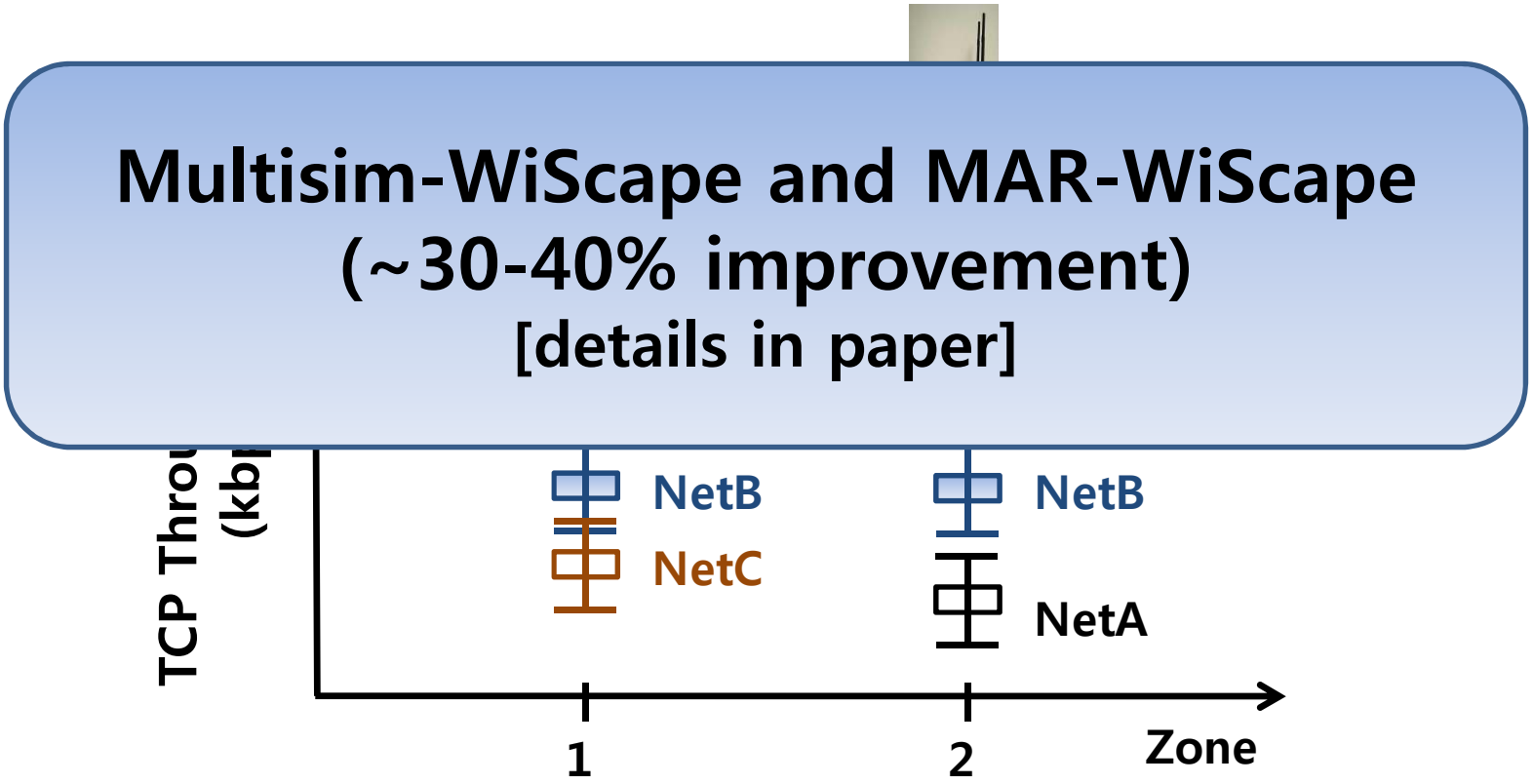
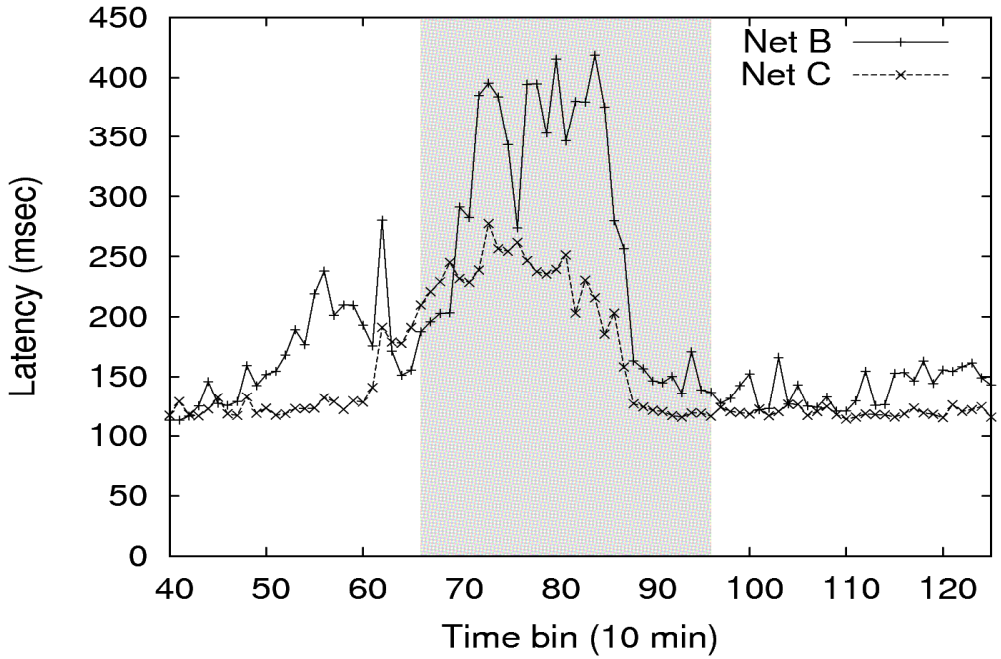


Observations

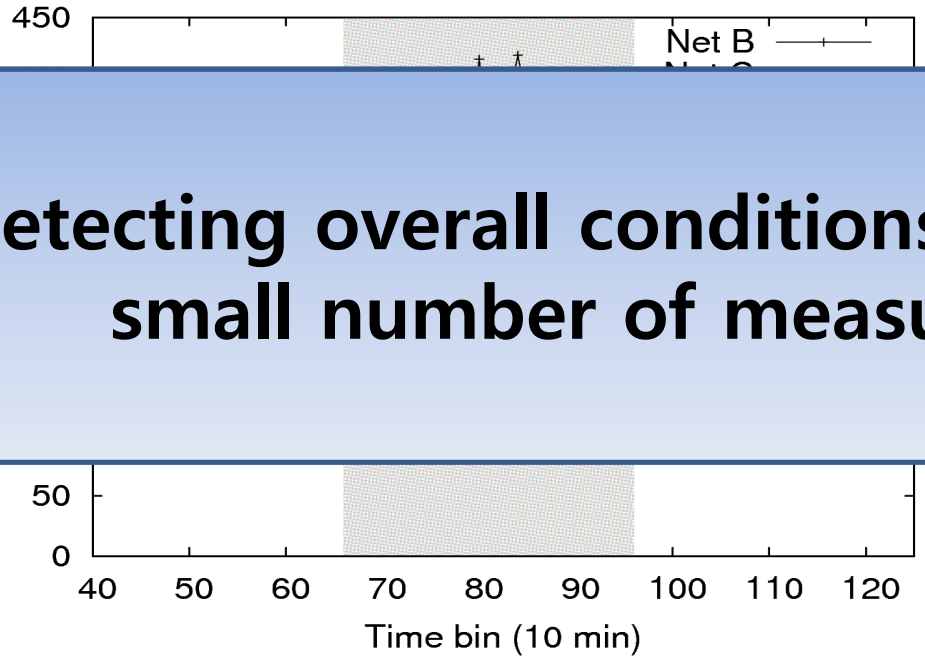
- Identifying locations with variable performance
- Detecting flash crowd



- Game day, Camp Randall, Madison WI

Application for Network Operators

- Identifying regions of high overload quickly
- Detecting flash crowd



Detecting overall conditions quickly with small number of measurements

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Related Work

- Monitoring Cellular Networks
  - Mark the Spot (AT&T)
  - 3G Test (University of Michigan)
  - RootMetrics

Future Work

- Full scalable deployment
- Monitoring dense deployments (NYC, LA, etc.)

Conclusion

- Present a framework for coarse grained monitoring of wide-area network
  - Validate it with data (datasets is available at www.cs.wisc.edu/~yoonj/wiscape/IMC11_Data.html)

- Applications
  - Improving client performance
  - Helping operators

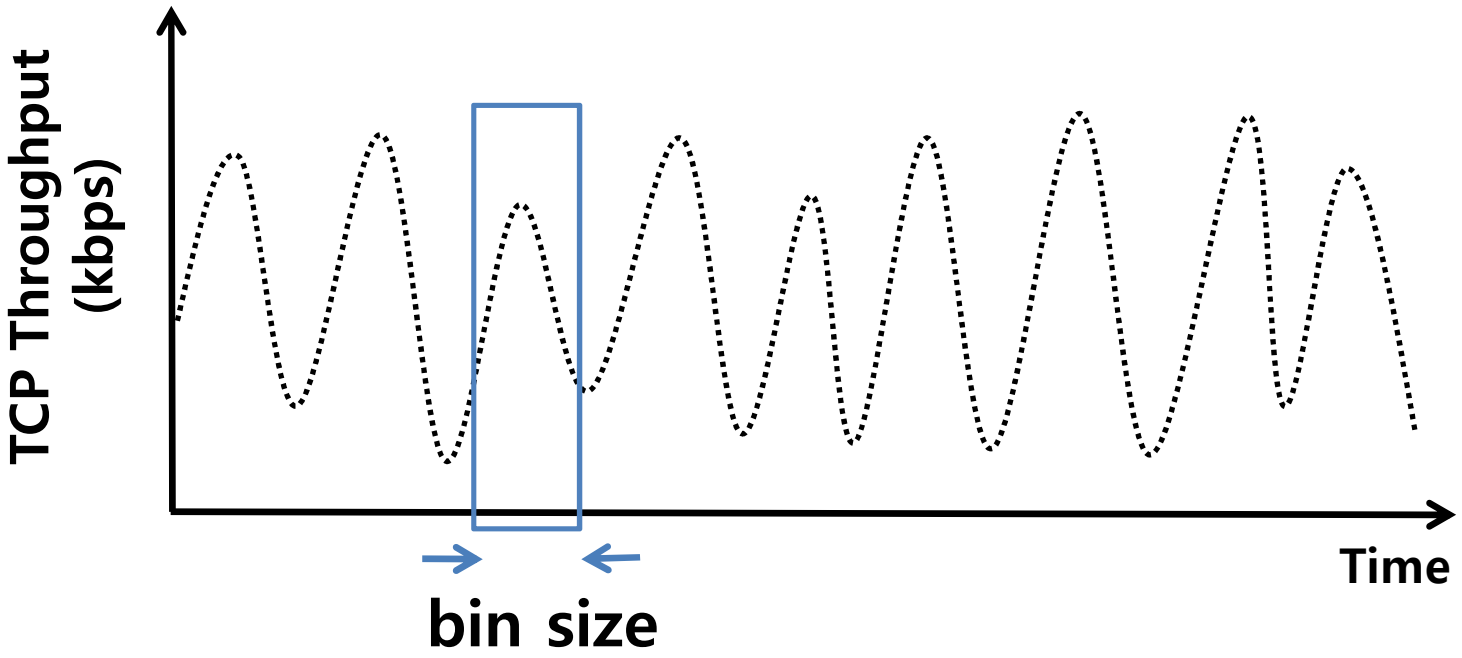
Thank You!

- Questions?

Backup slides

- Backup

Aggregating in TIME (Epoch)



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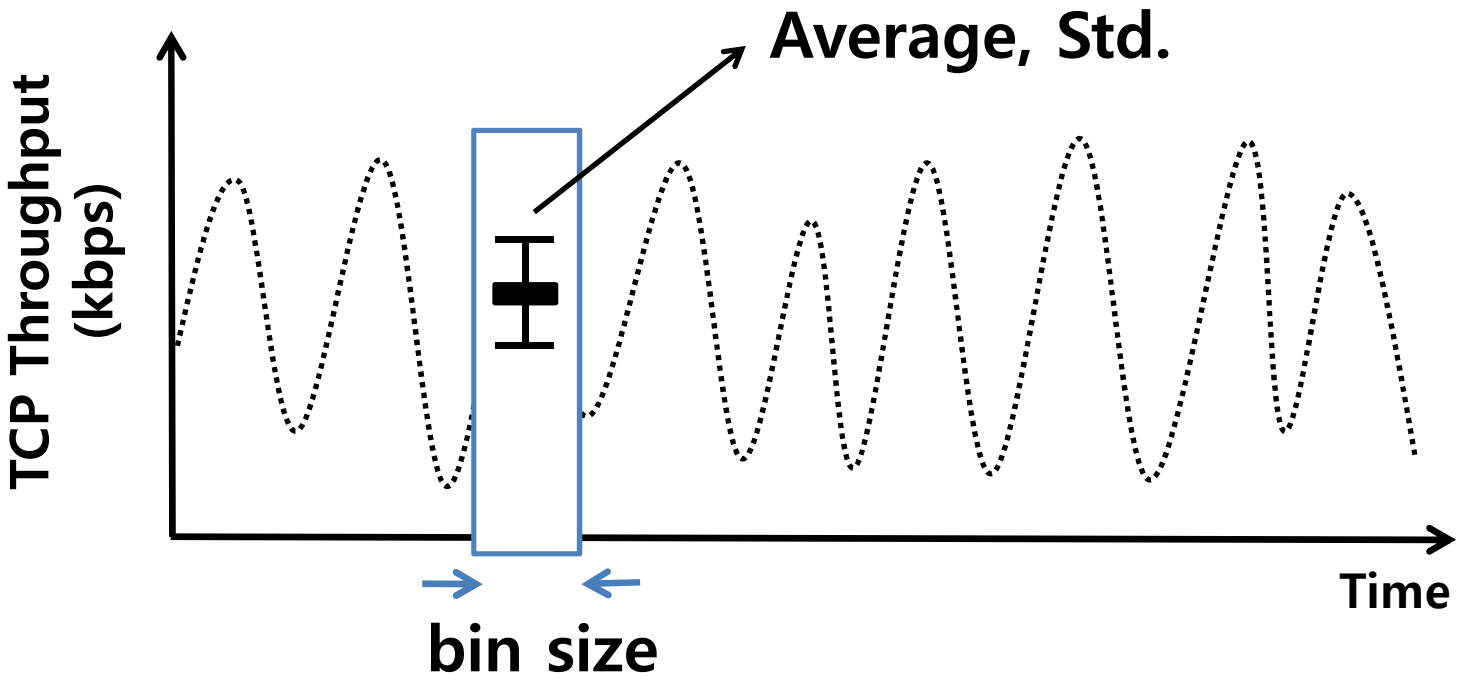
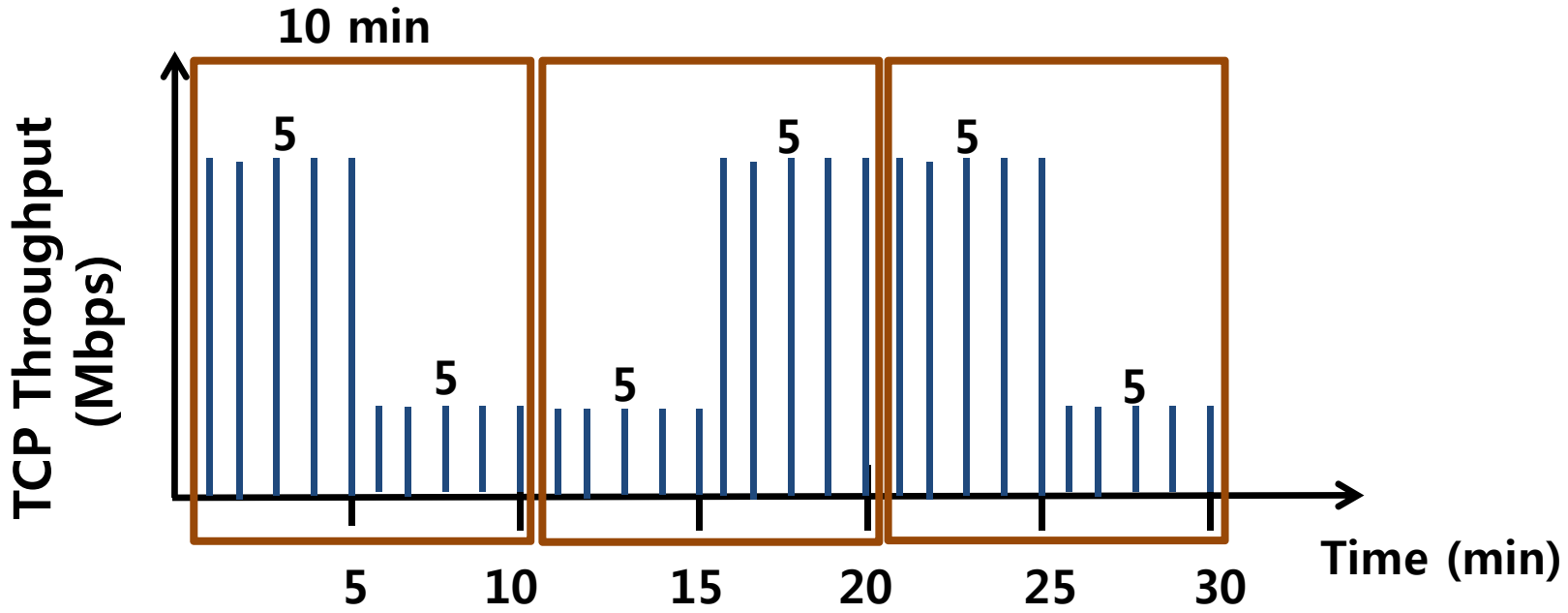


30 min bins: Coarse time scale
10 sec bins: Fine time scale

Aggregating in TIME (Epoch)

- Allan Deviation



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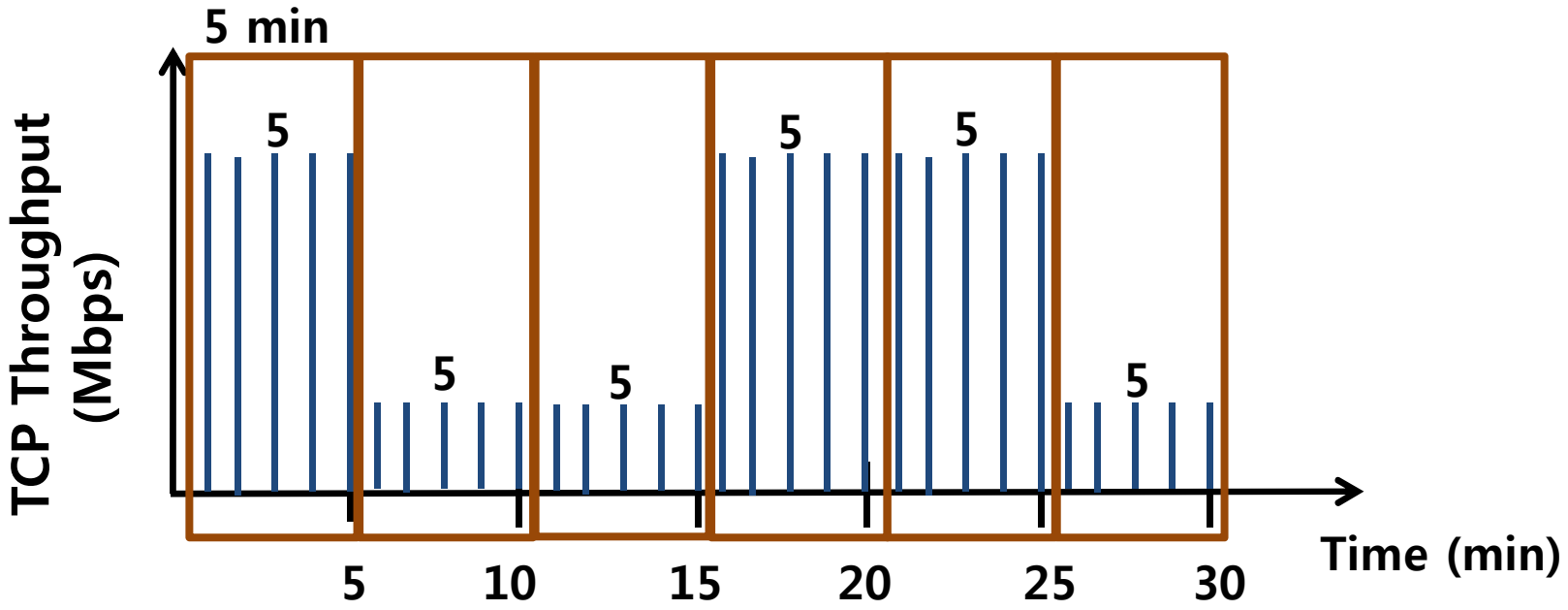

Aggregating in TIME (Epoch)

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