

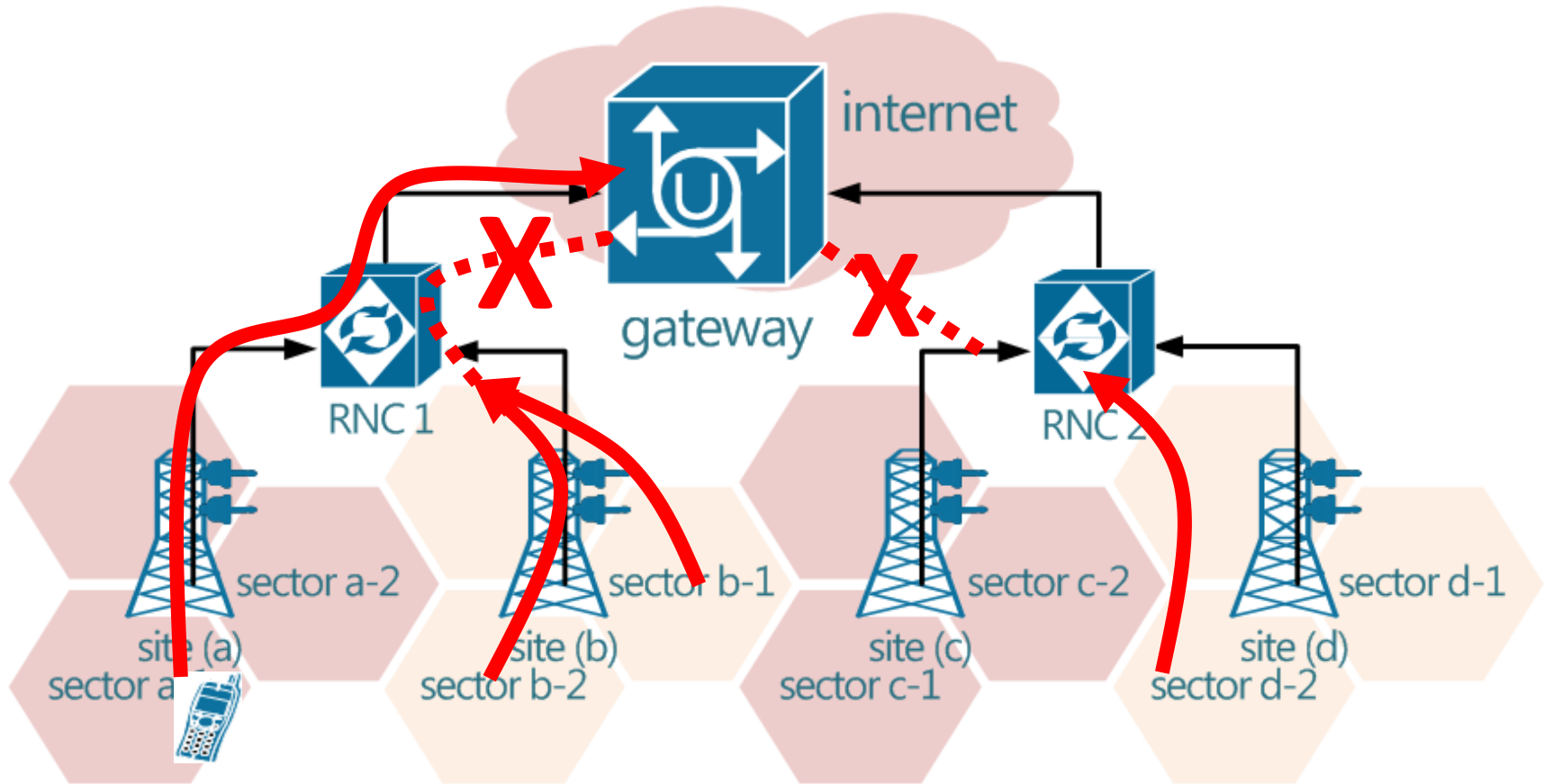
AccuLoc: Practical Localization of Performance Measurement in 3G Networks

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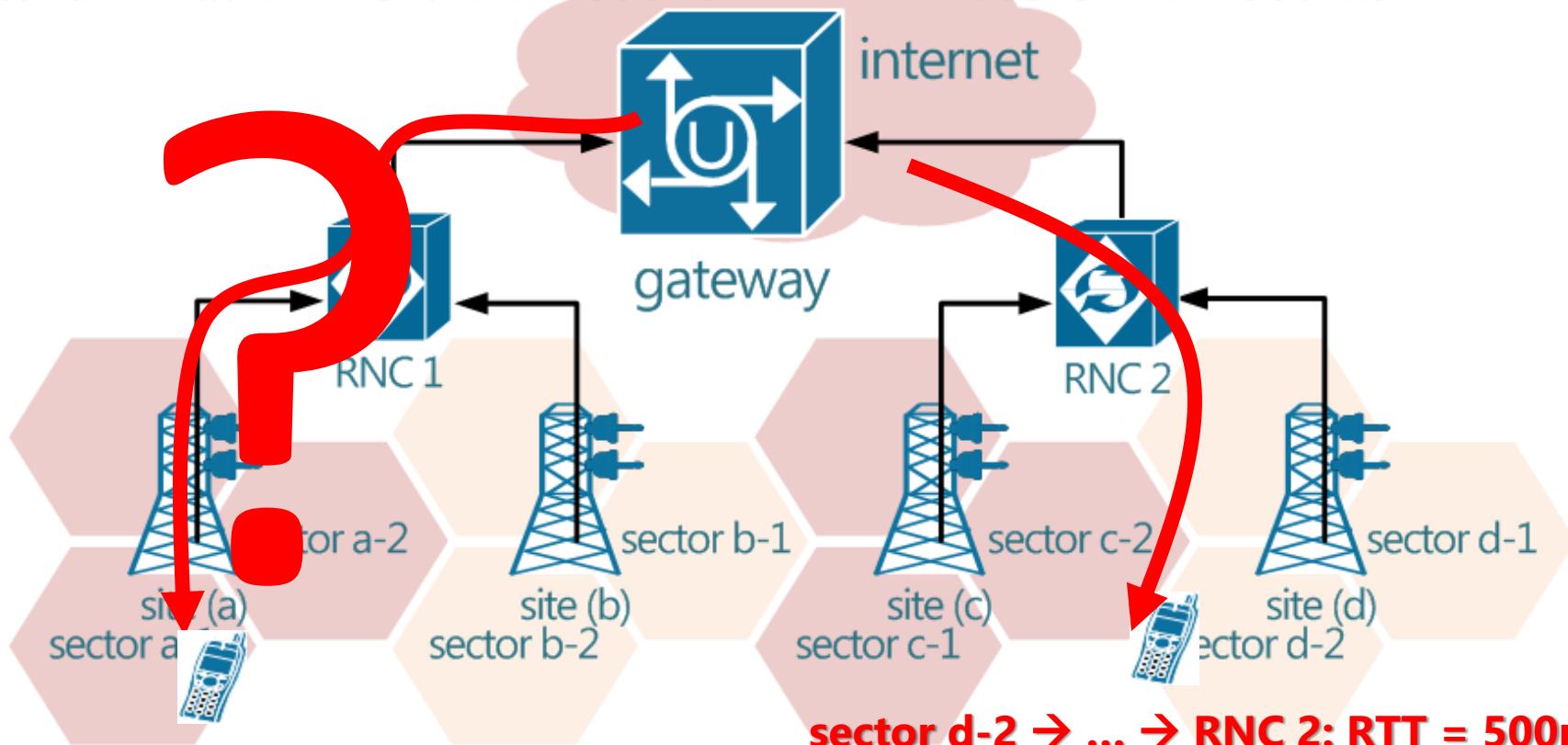
Visibility of Device in Cellular Network



Which Sector Has High RTT?

sector a-1 → ... → RNC 1: RTT = 500ms

user's RTT = 500 ms



sector d-2 → ... → RNC 2: RTT = 500ms

Problem Statement: Accurately Localize Performance Measurement

- **How inaccurate** is the current performance measurement localization?
- How to make performance measurement localization be **more accurate**?
- Expected benefits for cellular network operators
 - Assign measured performance to the correct network elements
 - Monitor the health of individual network elements
 - Detect/identify performance anomaly

Challenge: Complexity, Cost & Capability

- Complexity
 - No Infrastructure/protocol supports
- Cost
 - Collecting/delivering RNC events consumes significant resource
- Capability
 - RNC events are limited to only certain RNCs

AccuLoc: Leverage Mobility Patterns

- **Key:** user mobility patterns are restricted and predictable
 - Users usually move around within a small set of sectors
 - Sectors are correlated if always visited by the same users
- Infer mobility patterns – identify top correlated sectors
 - BIGRAPH: a snapshot of RNC events
 - HANDOVER: lightweight handover counters
 - Compatible to all RNCs
- Localize performance measurement based on mobility patterns

Previous Studies

- Mobility patterns discovery
 - Understanding Individual Human Mobility Patterns [*Gonzalez et al. Nature'08*]
 - Mobility Detection Using Everyday GSM Traces [*Sohn et al. UbiComp'06*]
 - Extracting a mobility model from real user traces [*Kim et al. INFOCOM'06*]
- Cellular network characterization
 - Metastability of CDMA Cellular Systems [*Antunes et al. MobiCom'06*]
 - Profiling Users in a 3G Network Using Hourglass Co-Clustering [*Keralapura et al. MobiCom'10*]
 - Mobility: A Double-Edged Sword for HSPA Networks [*Tso et al. MobiHoc'10*]

Outline

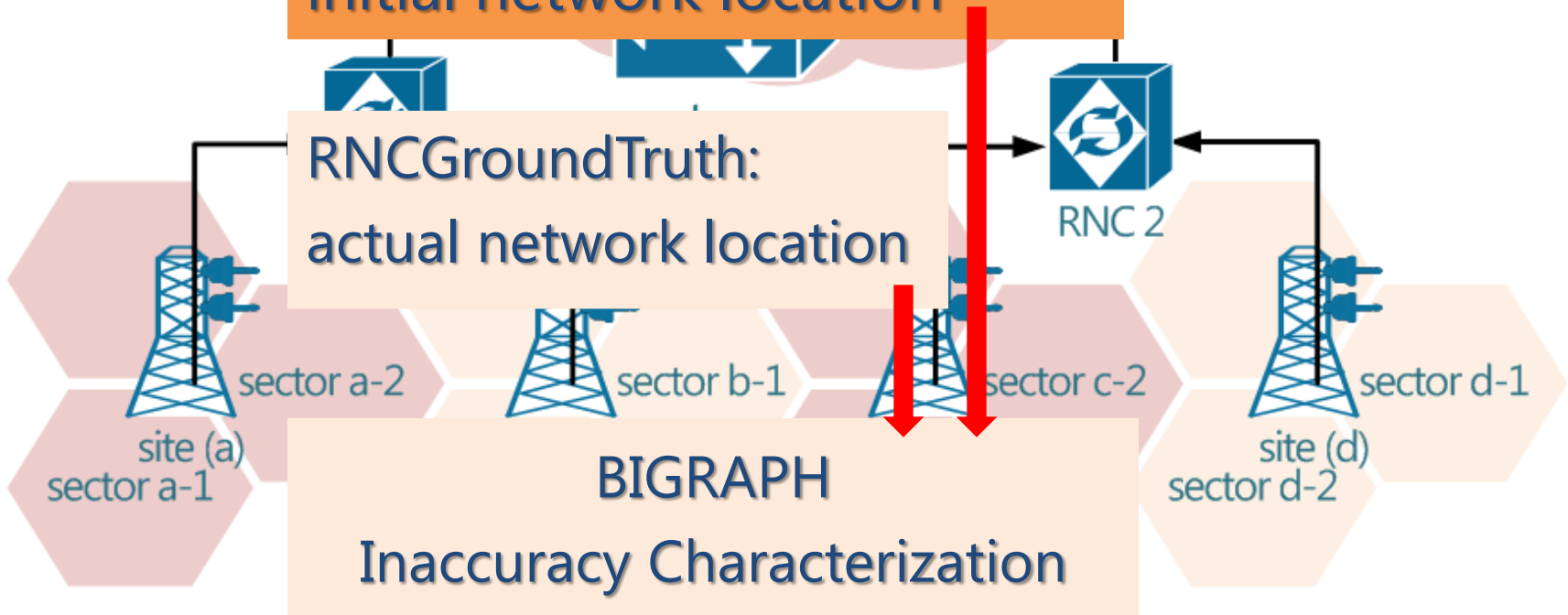
- Introduction
- **Data sets**
- Inaccuracy of the current performance measurement localization
- AccuLoc: infer/leverage mobility patterns
- Adopt AccuLoc in performance anomaly detection

Data Sets

IPFlowRecords:
end-to-end perf. measurement

PDPSetupLocations:
initial network location

RNCGroundTruth:
actual network location



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Localization Inaccuracy

- Network location has levels of precision, i.e., sector/site/RNC) level
 - The sector-level accuracy is ~30%
 - The RNC-level accuracy is ~70%

Lessons from Inaccurate Localization

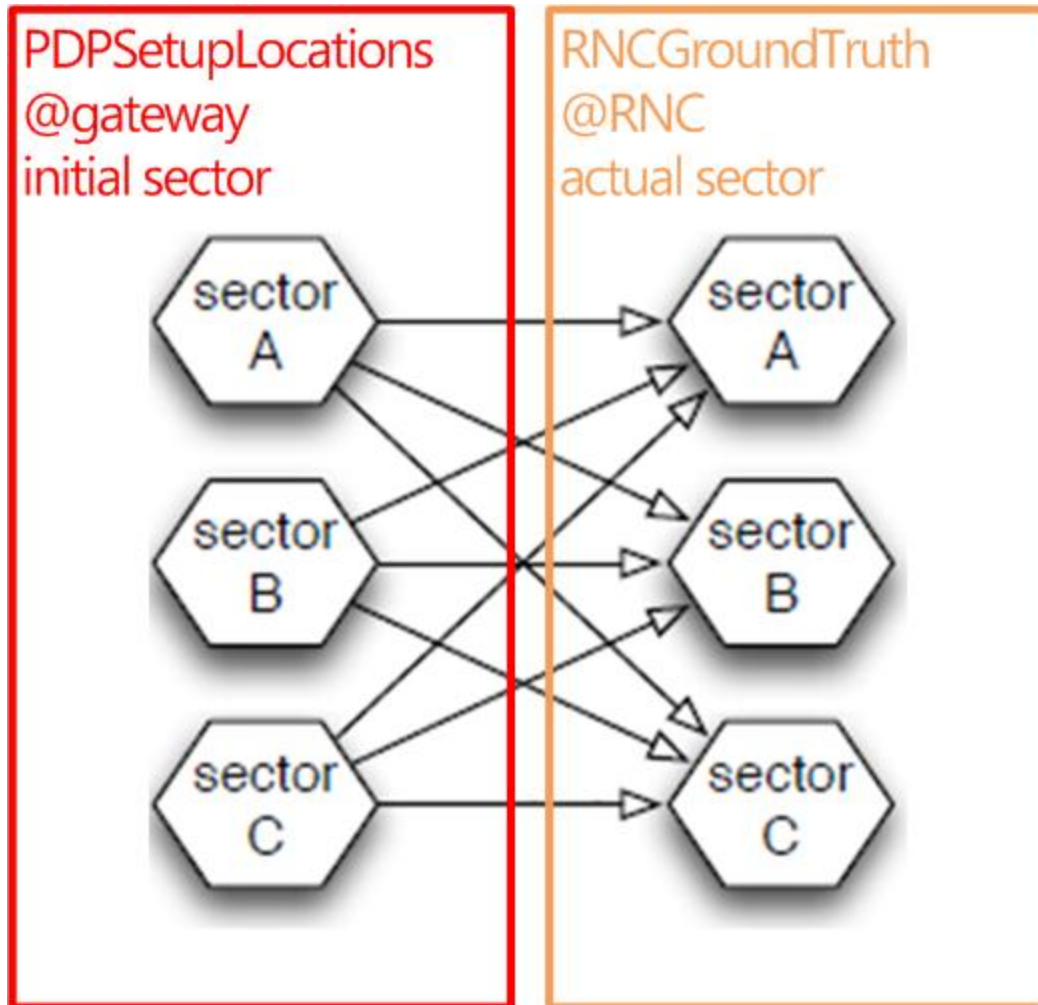
- Accuracy at higher aggregation levels (i.e., site/RNC) is low
- Mobility patterns cannot be captured by such static clusters as site/RNC

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detection

How BIGRAPH Works

1. Build correlation graph
 - sector \rightarrow vertex
 - likelihood \rightarrow edge
2. Cut correlation graph
 - Goal: minimize edge lost
 - Constraint: cluster size

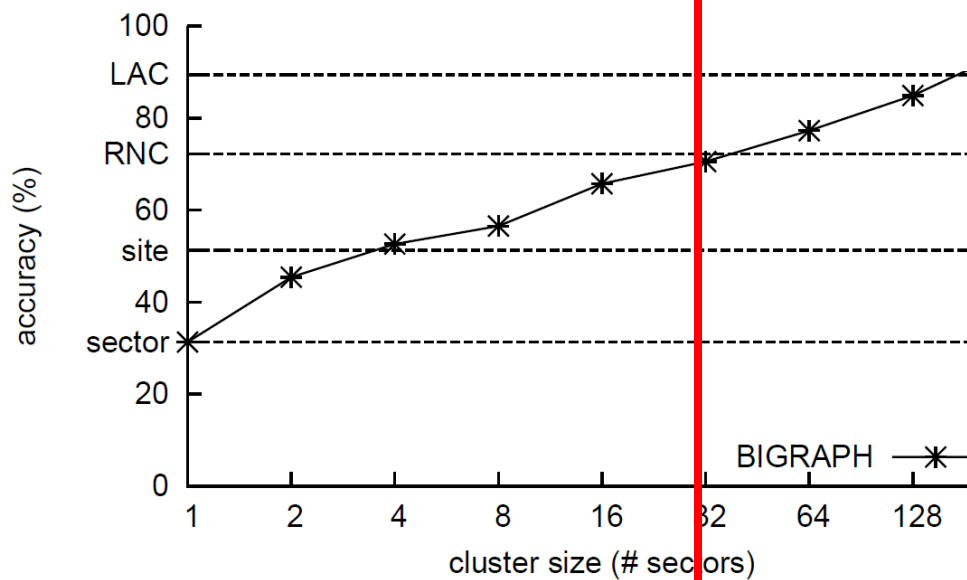
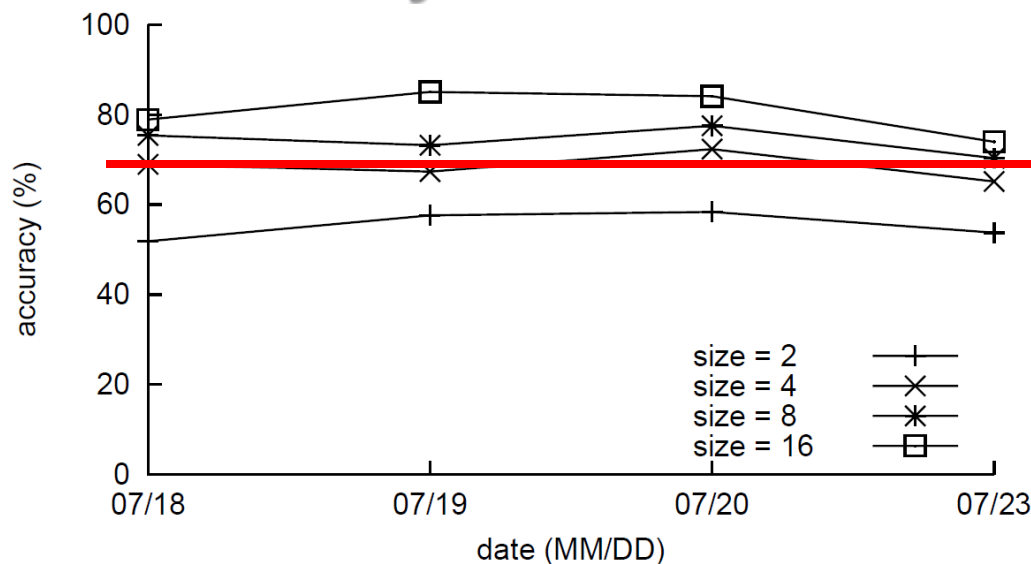


Evaluate BIGRAPH

- Cluster-level localization accuracy changes over the size of cluster
- BIGRAPH's accuracy is 70% (cluster size is 4), which is comparable to the RNC-level accuracy

Evaluation: BIGRAPH's Accuracy over Time

- 1 week: accuracy is consistently high (~70%)

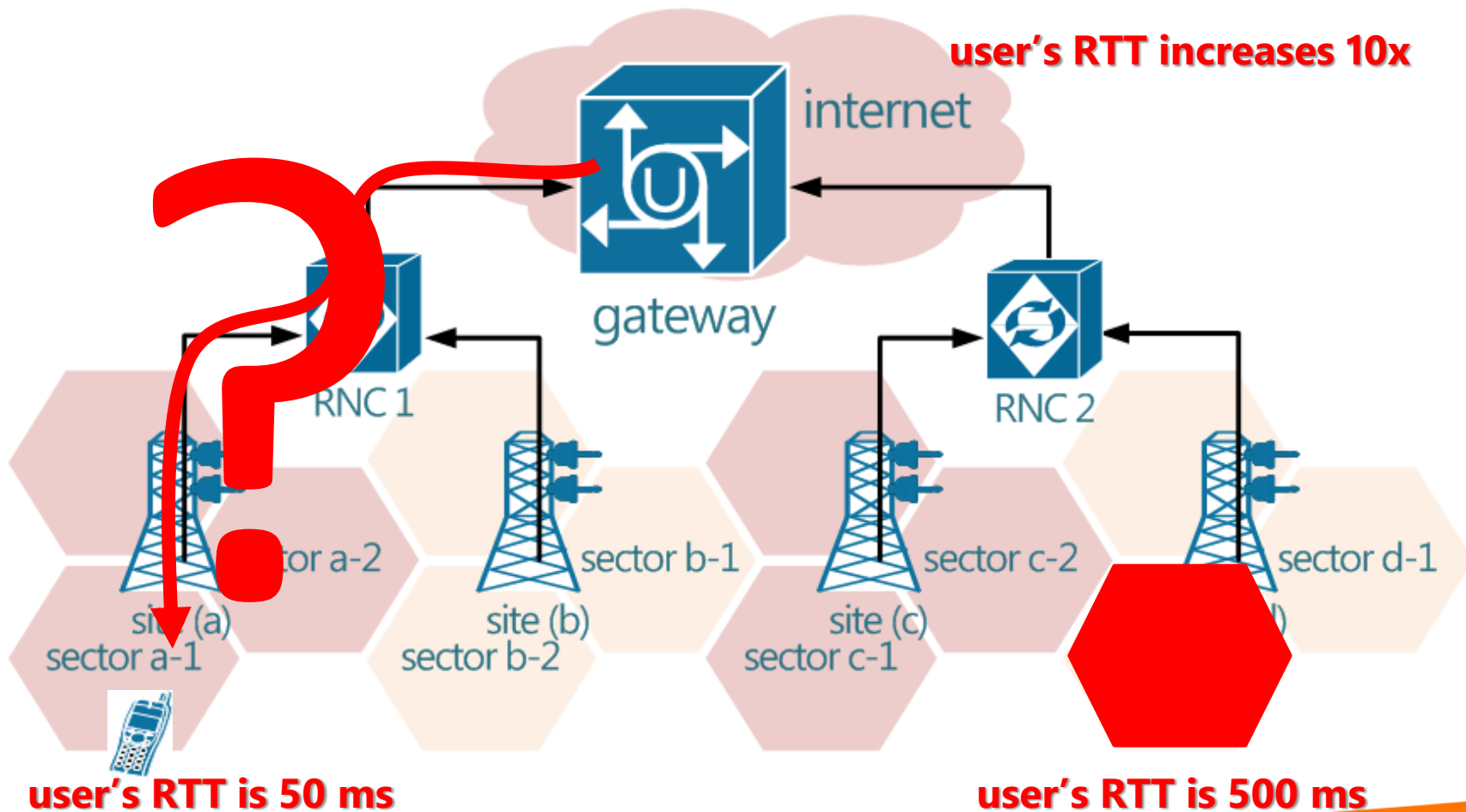


- 5 months: accuracy is still reasonably high
 - BIGRAPH's accuracy is comparable to the RNC-level accuracy (cluster size is 32)

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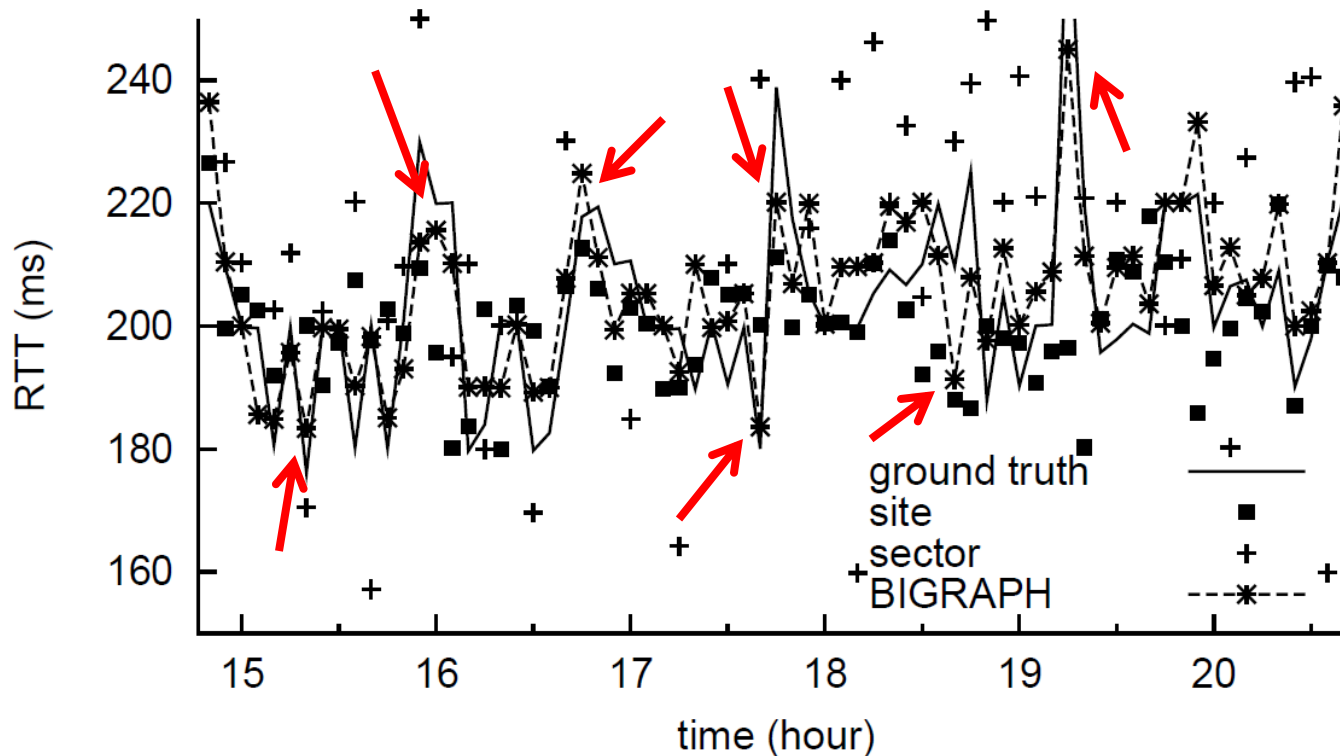
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- **Adopt AccuLoc in performance anomaly detection**

Inaccurate Location's Impact on Performance Anomaly Detection



Detecting RTT Spikes

- “Performance of clusters” captures RTT spikes better



Contribution

- Identified and characterized measurement localization challenge in cellular networks
- Developed AccuLoc, a system to accurately localize performance measurement using mobility patterns
- Applied AccuLoc to performance anomaly detection with good results
- “Accuracy vs. measurement overhead” is a common tradeoff
 - Other types of cellular networks, e.g., EV-DO
 - Future cellular networks, e.g., LTE

Thanks, Questions, & Answers