STDCS: A Spatio-Temporal Data-Centric Storage Scheme For Real-Time Sensornet Applications

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Outline

- Introduction
- Related Work
- Spatio-Temporal Data-Centric Storage Scheme (STDCS)
- Experimental Evaluation
- Conclusion

Introduction

- Sensor networks in the future will consist of globally deployed sensors providing real-time geo-centric information to users.
- Users issue ad-hoc queries asking for real-time data generated by sensors falling in a particular area.

Introduction

- There may exist some hotspots , where most of the mobile users issue queries to a small number of sensors.
- Traffic skewness and hotspots can result in the early death of battery-operated sensors.
- The major design goal for STDCS is load-balancing.

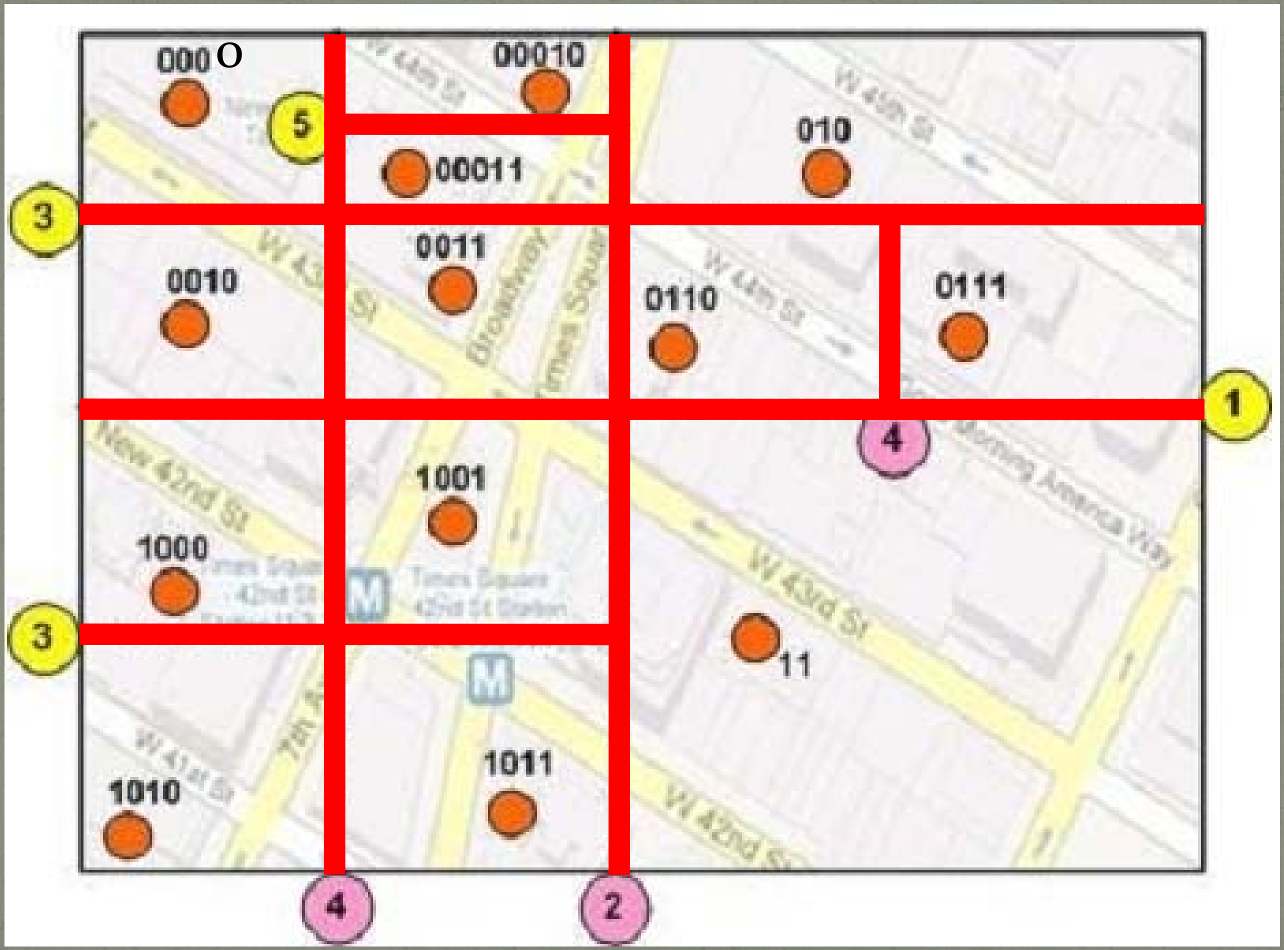
Related Work

- Date storage:
  - Use a base station to store all the data.
  - Local storage.
  - In-network Date-Centric Storage.
    - Hash table
    - K-d tree
- Load balancing:
  - Decomposing storage hotspot.
  - Avoiding hotspot.

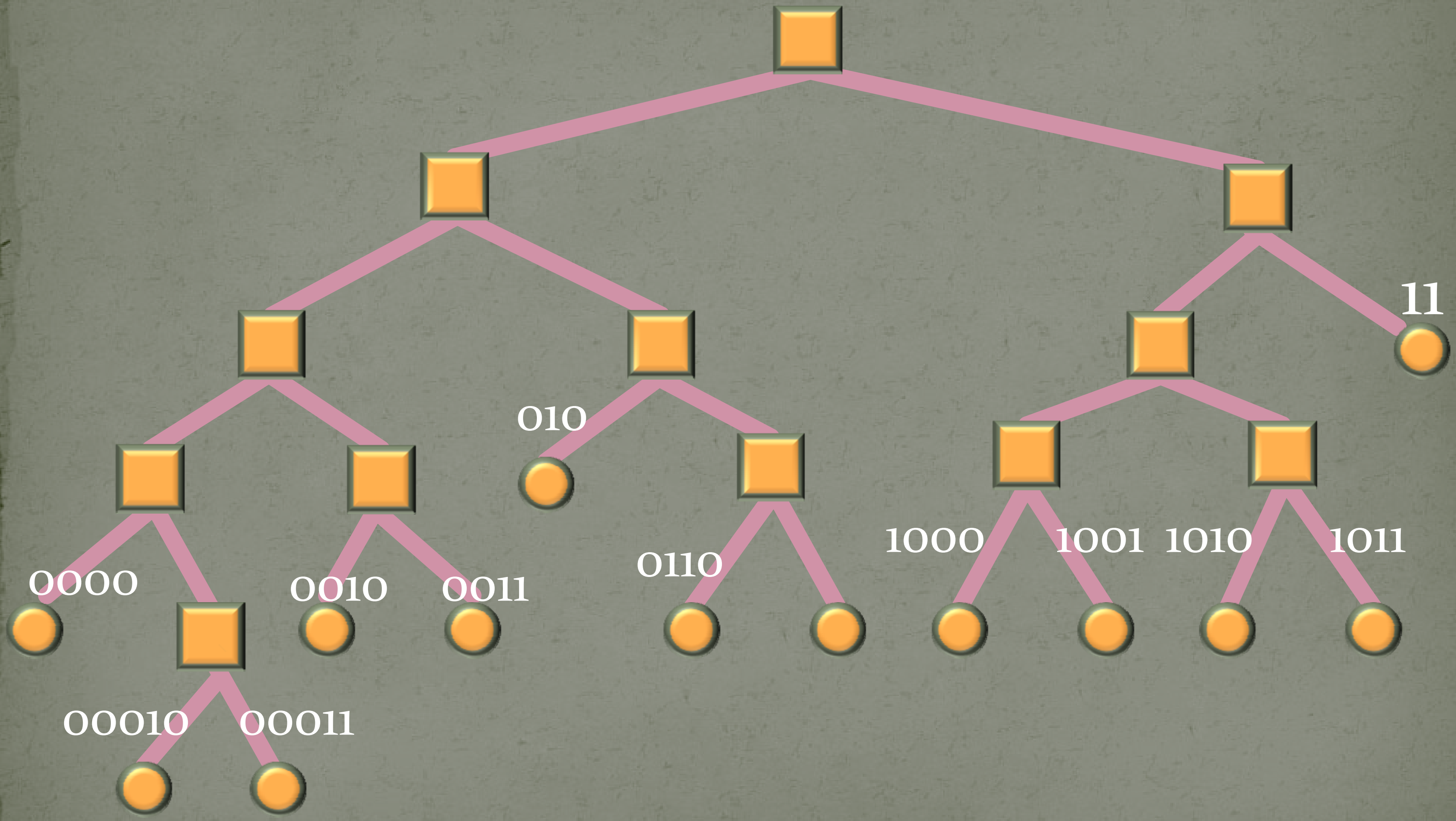
Spatio-Temporal Data-Centric Storage Scheme (STDCS)

- Local Virtual Address Assignment.
- The spatio-temporal data indexing.
- The point-to-point Delivery of Readings.
- Query Processing.
- Adaptive Hotspot Decomposition.

Local Virtual Address Assignment



2-D Tree



Spatio-Temporal Data Indexing

- Determines the storage-sensor of every sensor in the cluster using the virtual address .

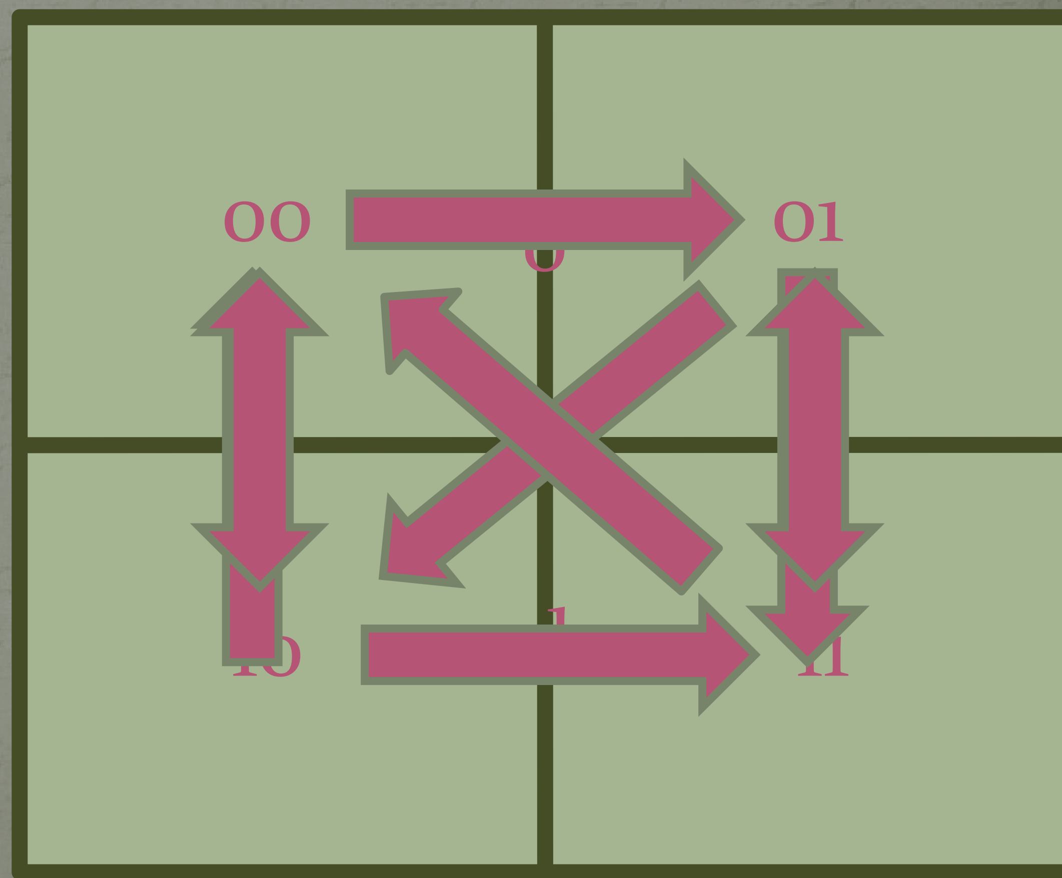
- Two main parameters :
  - prefix : determine the size of subcluster
  - offset : used for change mapping function
    value : 0~2^perfix

Spatial Data Indexing- Subcluster Mapping

prefix = 1 2

offset = 0 1 2

000->100
00 -> 10
0 -> 0
001->101
01 -> 11
1 -> 1
100->110
10 -> 00
111->001
11 -> 01



Spatial Data Indexing- Sensor Mapping

- Case 1 : bit-length of original sensor = storage sensor
  - ex : 10 -> 01

    1010 -> 0110
- Case 2 : bit-length of original sensor > storage sensor
  - ex : 10 -> 01

    1000 -> 010 , 1001 -> 010
- Case 3 : bit-length of original sensor < storage sensor
  - ex : 10 -> 00

    1001 -> 00010 or 00011

Temporal Data Indexing

- *Switching-time* : Determine the duration of the mapping function.

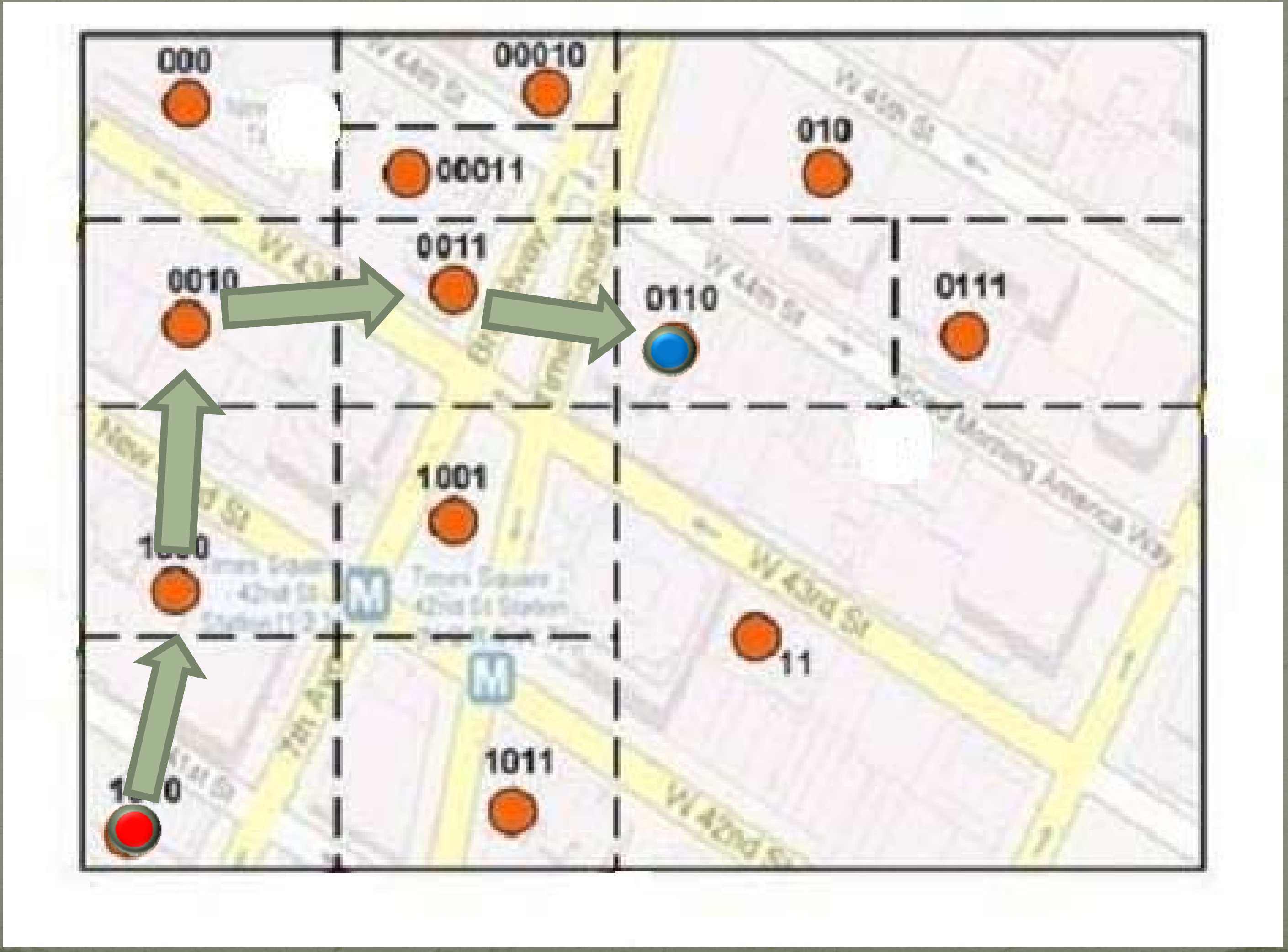
- Partition time into slots , length of slot is equal to *switching-time*.

- At the start of each slot , all sensors change the mapping function by increment the value of offset.

Point-to-Point Delivery of Readings

- Each intermediate node computes the Least Common Ancestor(LCA) in the 2-d tree between itself and this destination.
- LCA is defined as the most-significant non-matching bit between their bit-codes.
- Determines the sending direction based on the value of the bit.

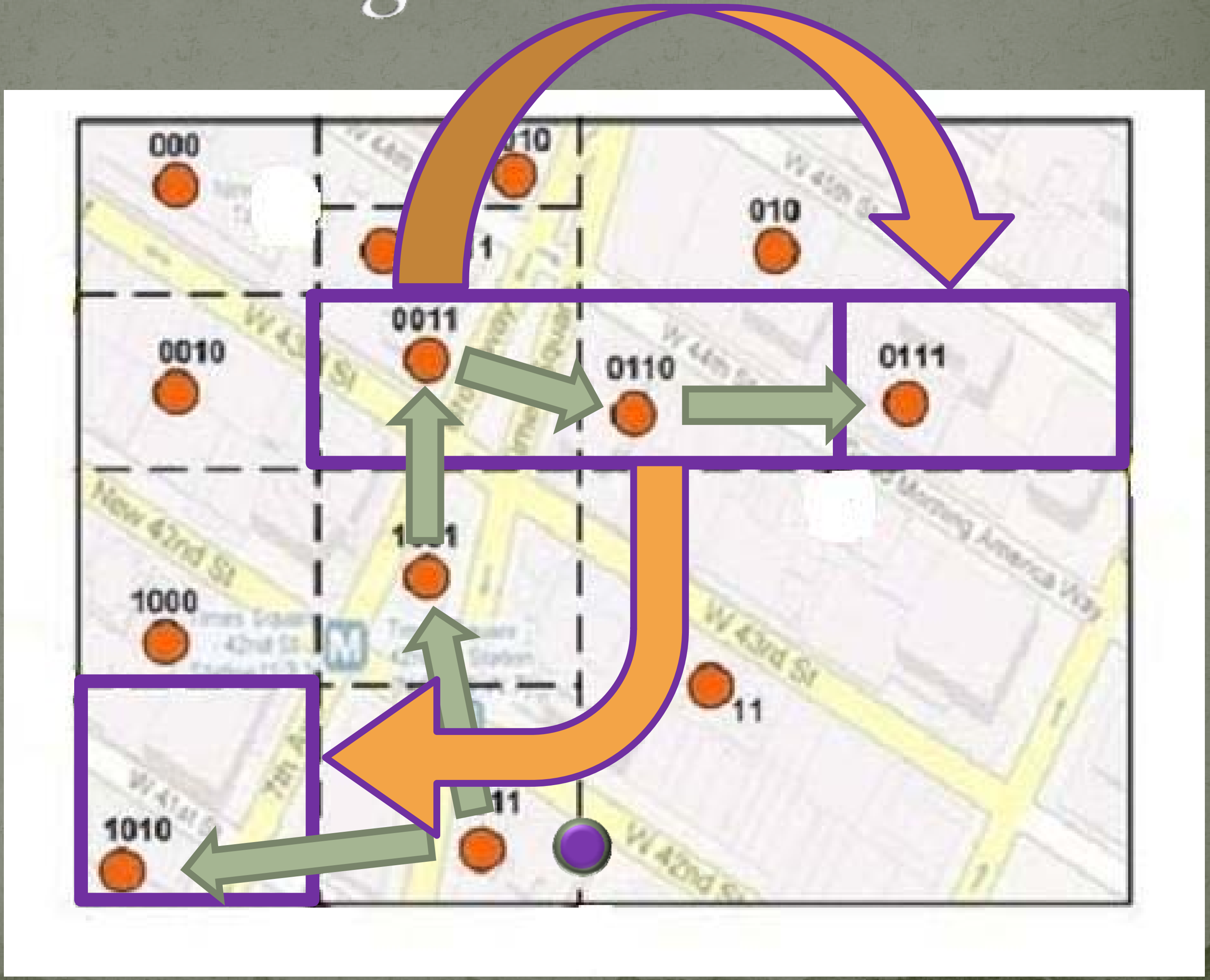
Point-to-Point Delivery of Readings



Query Processing

00 -> 01

01 -> 10



Adaptive Hotspot Decomposition

- Keeping track of the hotspot distribution in the cluster and dynamically changing the value of switching_time.
- Collecting feedback about query load encountered by all sensors.

Adaptive Hotspot Decomposition

- Each senor keep tracking of its Average Querying Frequency(AQF).
- One sensor acts like a central authority initiates a BFS query collecting the AQFs of all sensors.
- Based on this distribution , it determines whether a hotspot exists or no, as well as how severe is the hotspot.

Adaptive Hotspot Decomposition

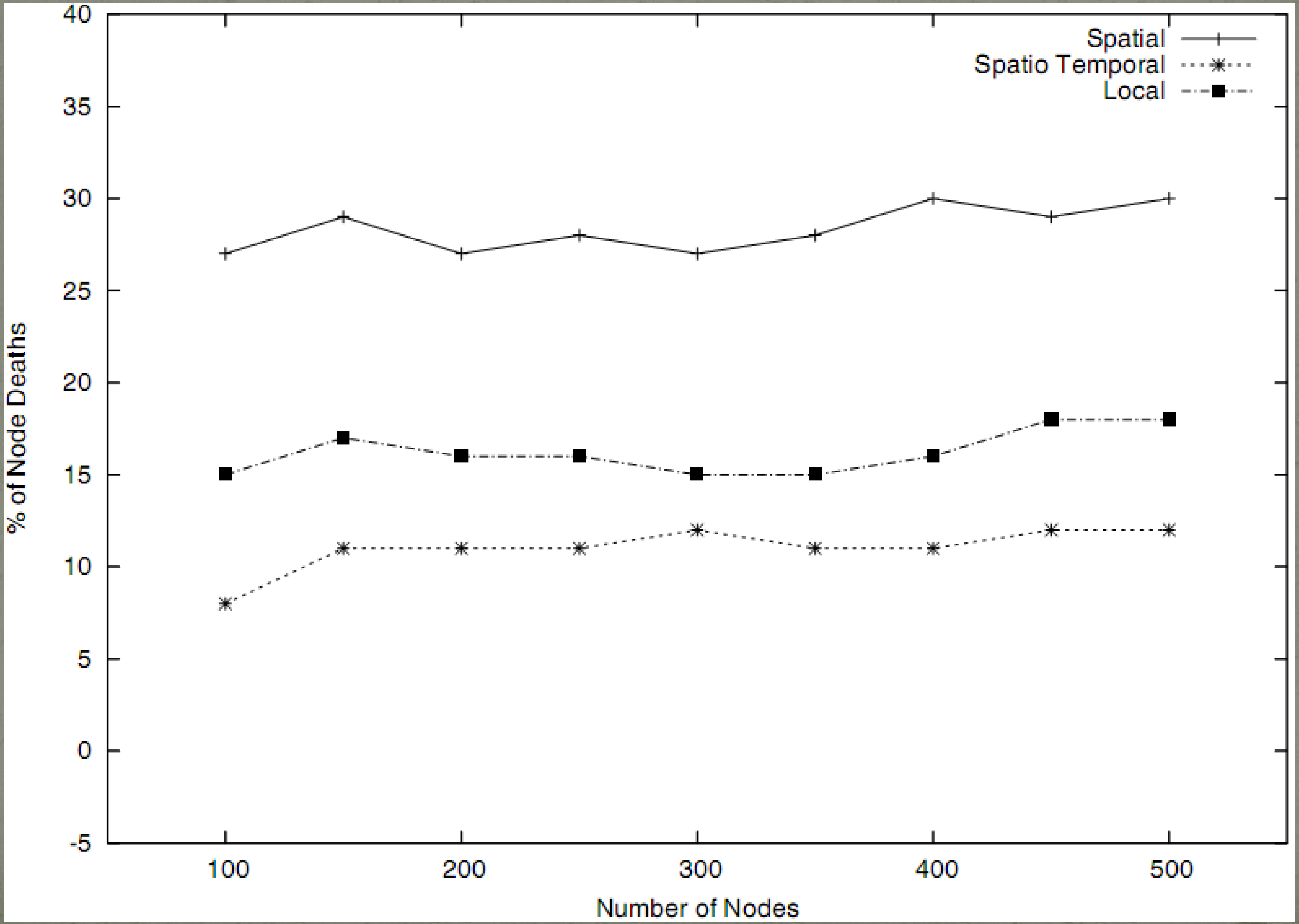
- Case 1 : A hotsopt takes place in a small area.
  - Decrease the value of the switch_time.

- Case 2 : A hotspot may be spanning more than one subcluster.
  - Increase the value of prefix.

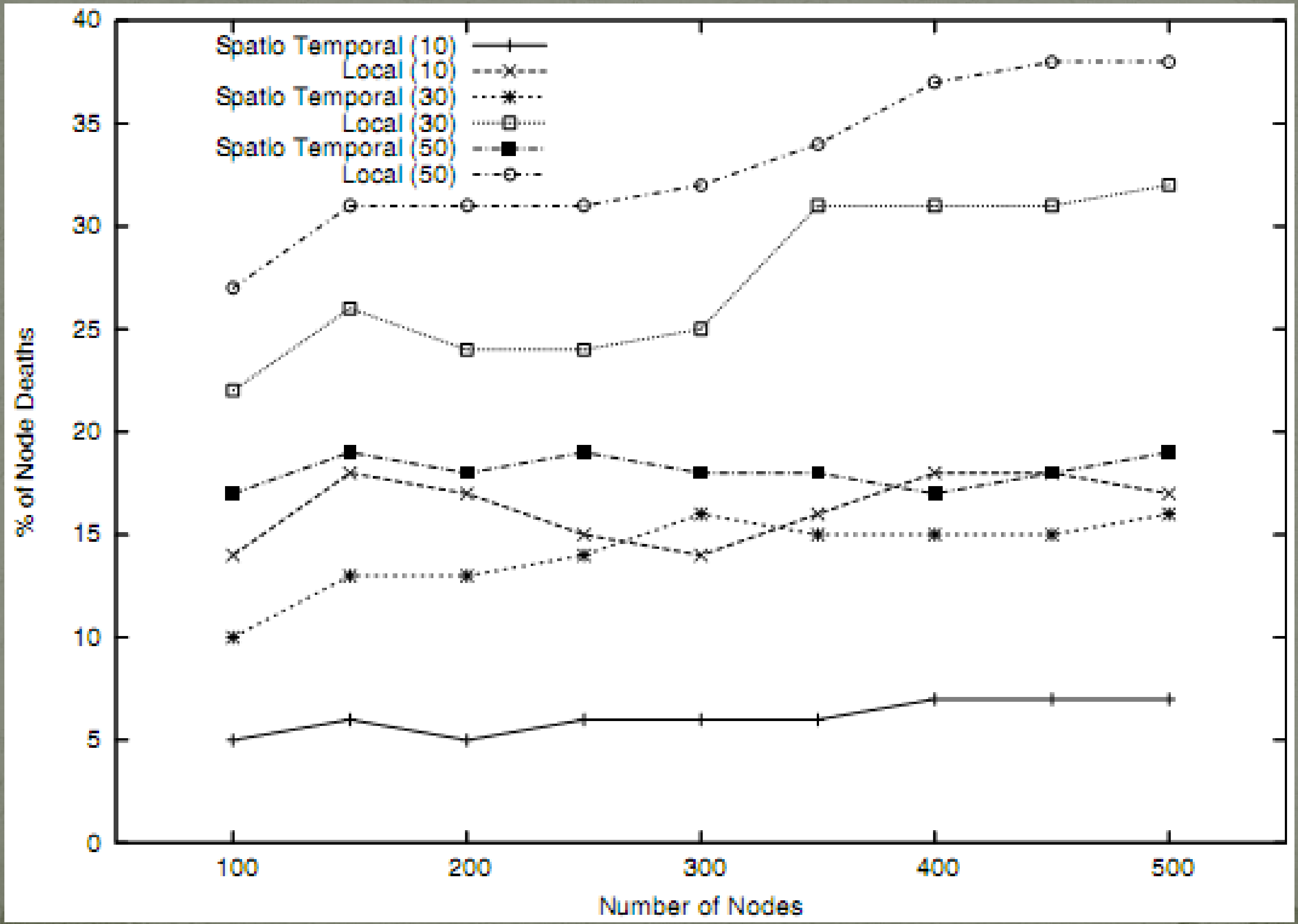
Experimental Evaluation

- Sensors are randomly distributed in 200M x 200M square.
- GPSR as underlying routing protocol.
- Starting energy for every sensor is 30K unit.
- Send and receive cost 1 unit.
- Communication range is 25M.
- 1 query generated every 5 min.
- 10~50 query generated every min for hotspot.

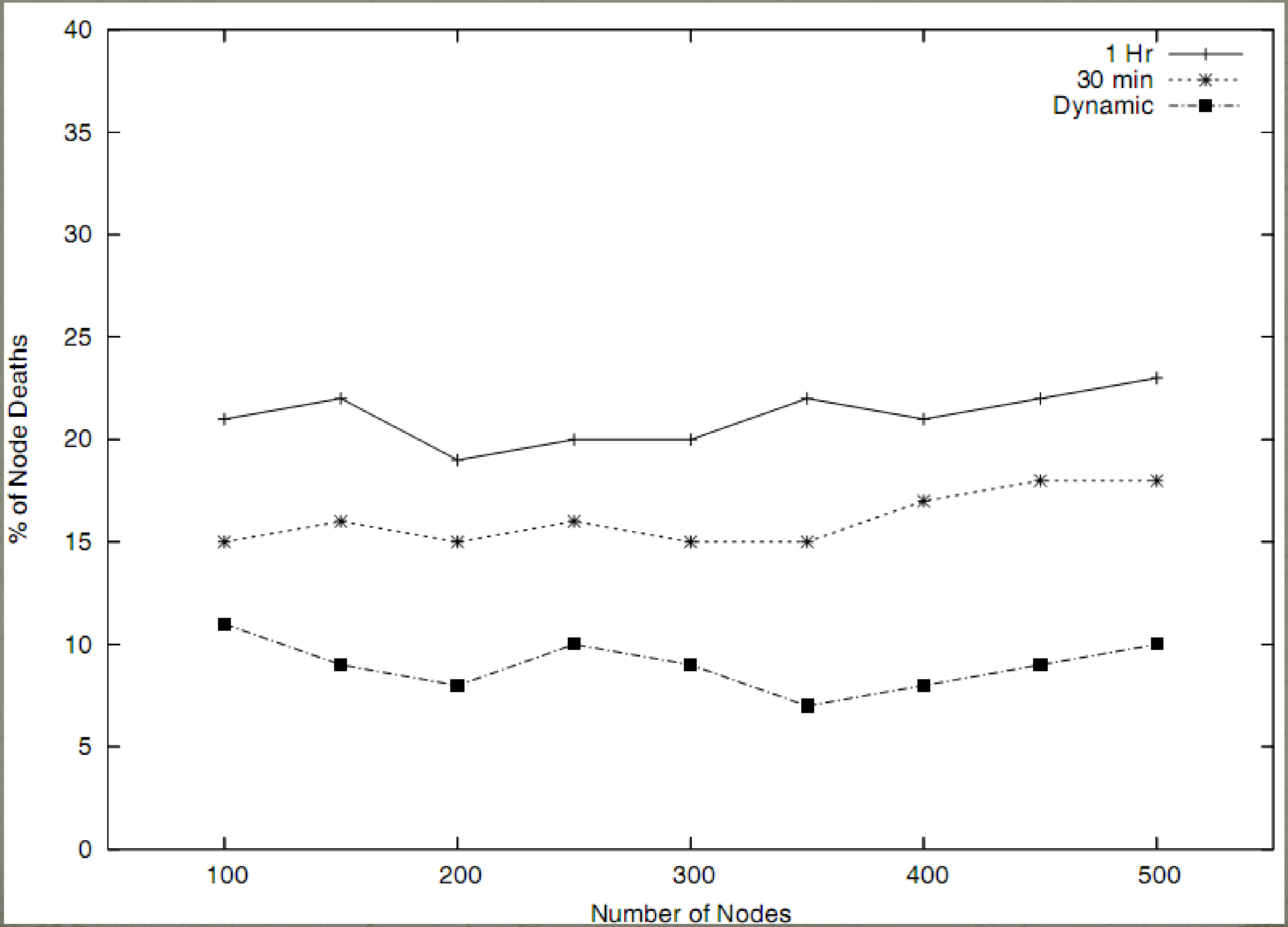
Compare to other scheme



Node deaths vs hotspot levels



Adaptive STDCS performance



Conclusion

- This paper introduces the novel idea of using both the generation time and the sensor location of the sensor readings to achieve load-balancing.

- Through simulation, we showed our scheme's ability to excel versus query hotspots of different sizes when compared to local storage and plain unbalanced spatial indexing.