Survey on Target Tracking in Wireless Sensor Networks

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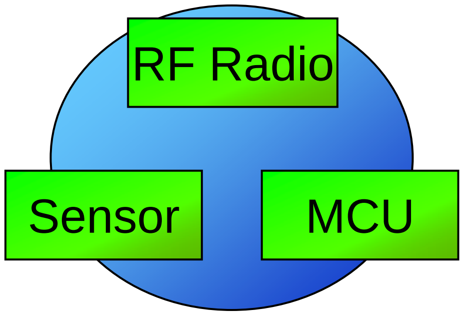
Outline

- Introduction
- Different Approaches of Target Tracking
  - STUN
  - DCTC
  - Dynamic Clustering
    - Acoustic target tracking
    - The continuous objects tracking
  - Dual Prediction-based
- Issues Discussion
- References

Introduction

- Sensor networks usually comprise small, low-power devices
  - Sensing
  - Processing
  - Wireless communication



Sensor Node

- One of their most important applications is target tracking

Introduction

- Target categories
  - individual objects
    - usually have very small size comparing with the large area with sensor network deployed
    - may emit noise, light, and seismic waves etc.
  - continuous objects
    - spreading in very large region with sensor network deployed
    - such as diffused poison gas, biochemical ,and chemical liquid

Introduction

- Tracking applications share several common characteristics
  - Report the location of the target to subscribers
  - The data collected by sensors may be
    - Redundant
    - Correlated
    - Inconsistent
  - collaborate on processing the data

Introduction

- Target Tracking approaches can be classified in the following categories
  - Tree-based
  - Cluster-based
  - Prediction-based

STUN
SCALABLE TRACKING USING NETWORKED SENSORS

- H. T. Kung and D. Vlah. "Efficient Location Tracking Using Sensor Networks." *WCNC*, March 2003.
- Chih-Yu Lin and Yu-Chee Tseng "Structures for In-Network Moving Object Tracking in Wireless Sensor Networks" BROADNETS'04

STUN
SCALABLE TRACKING USING NETWORKED SENSORS

- The method will need to handle a large number of moving objects at once
- Our method uses a hierarchy to connect the sensors
  - The leaves are sensors
  - the querying point as the root
  - the other nodes are communication nodes

STUN - main idea

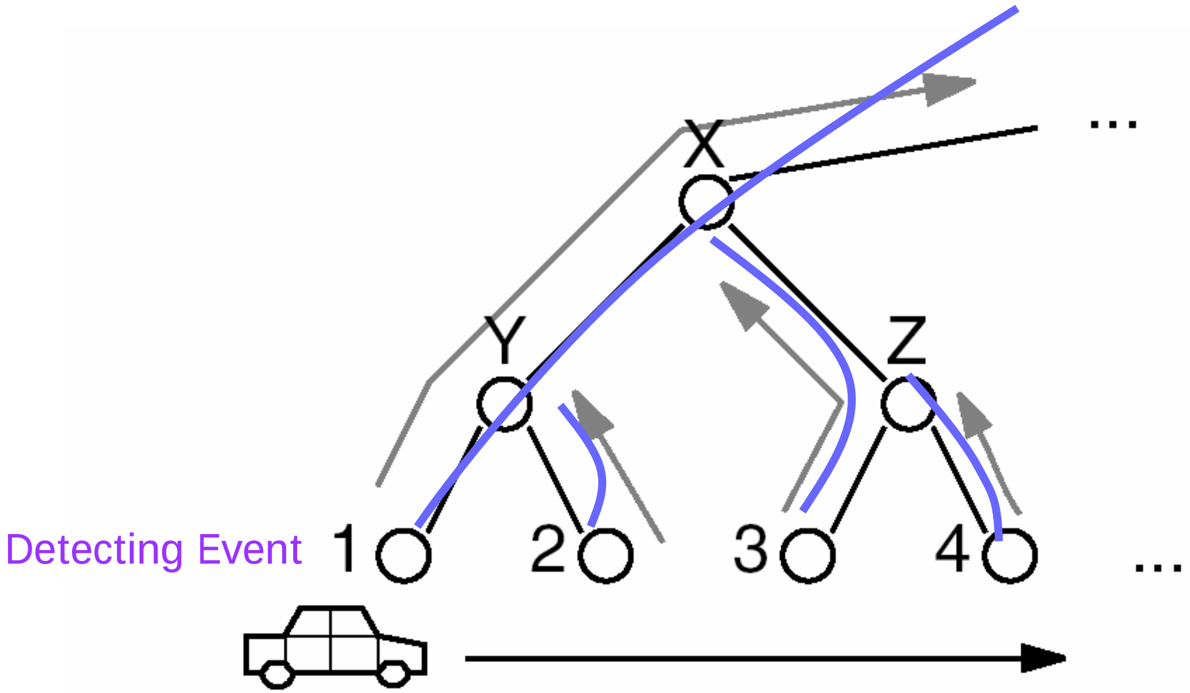
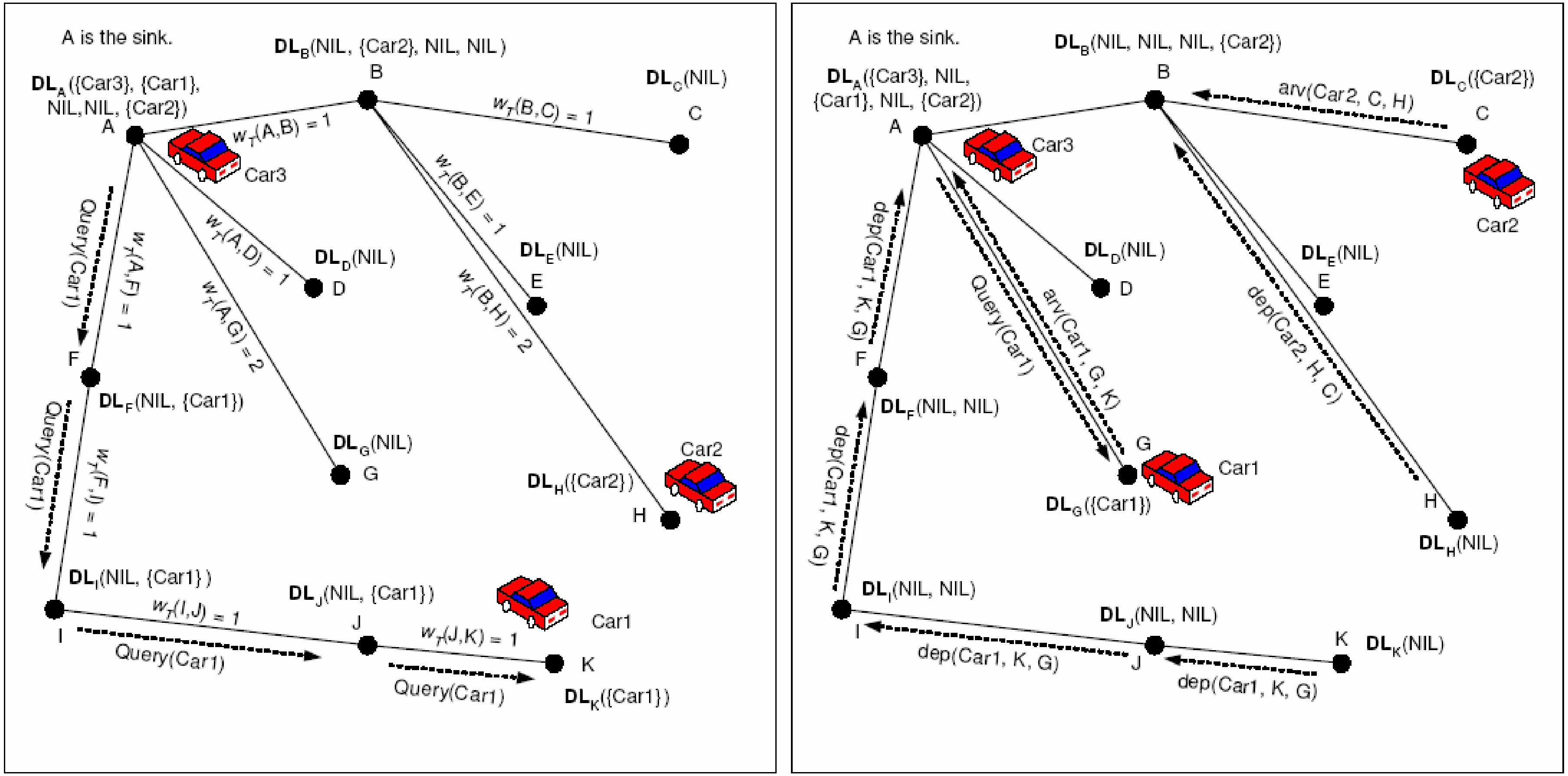


Figure 1: Example of a message-pruning hierarchy. Consider those detection messages from sensors that detect the arrival of the car. Sensor 1's message will update the detected sets of all its ancestors. The messages from sensors 2 and 4 do not update the detected sets of their parents and thus will be pruned there. The message from sensor 3 updates only its parent Z and thus will be pruned at X

STUN - example



STUN - Performance Metrics: Communication Cost and Delay

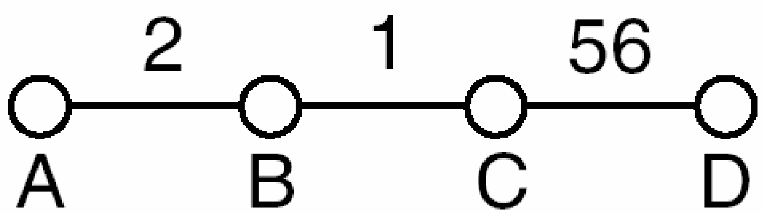
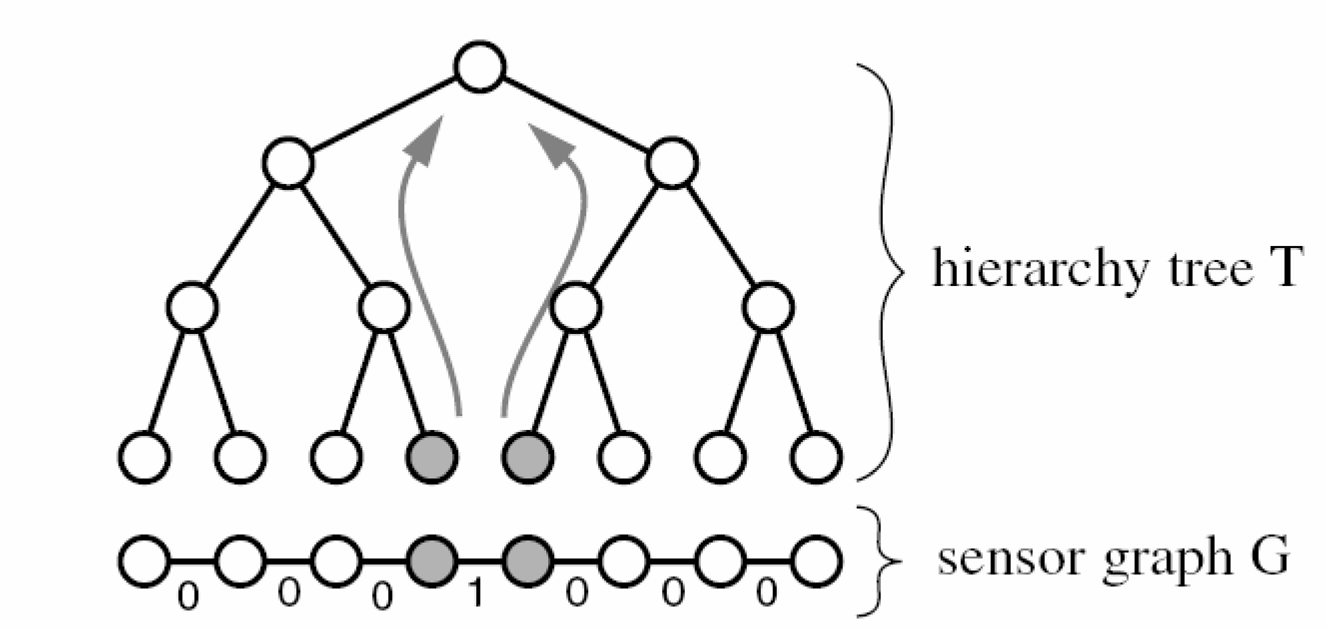
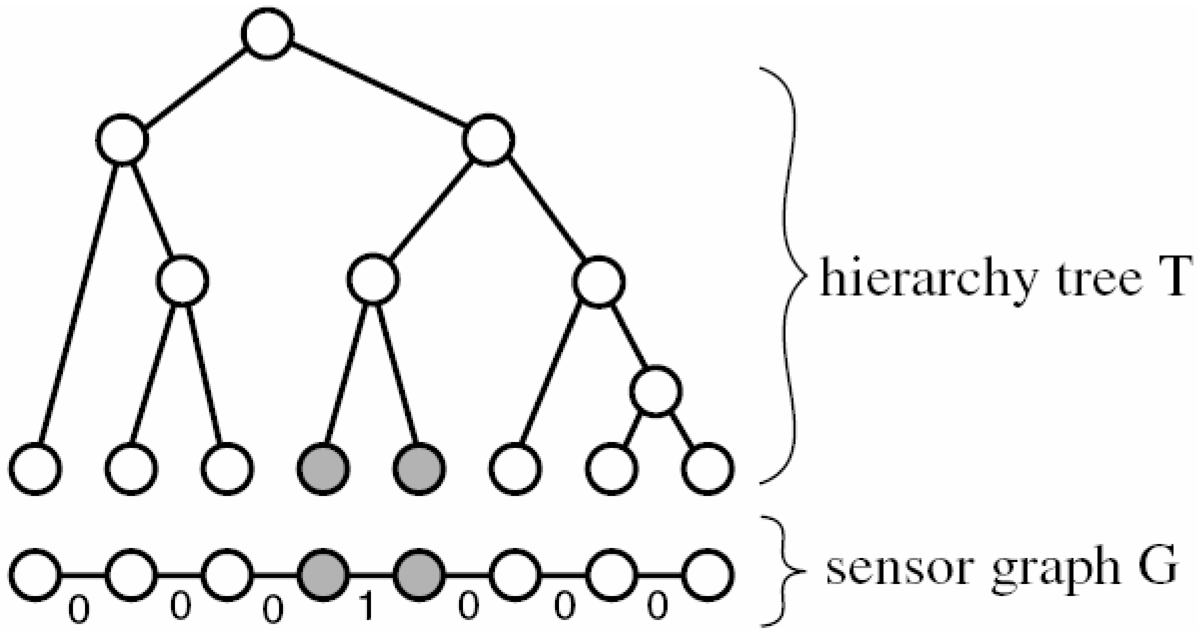


Figure 2: An example 1D sensor graph. Each weight represents the frequency of object movement between a pair of adjacent sensors

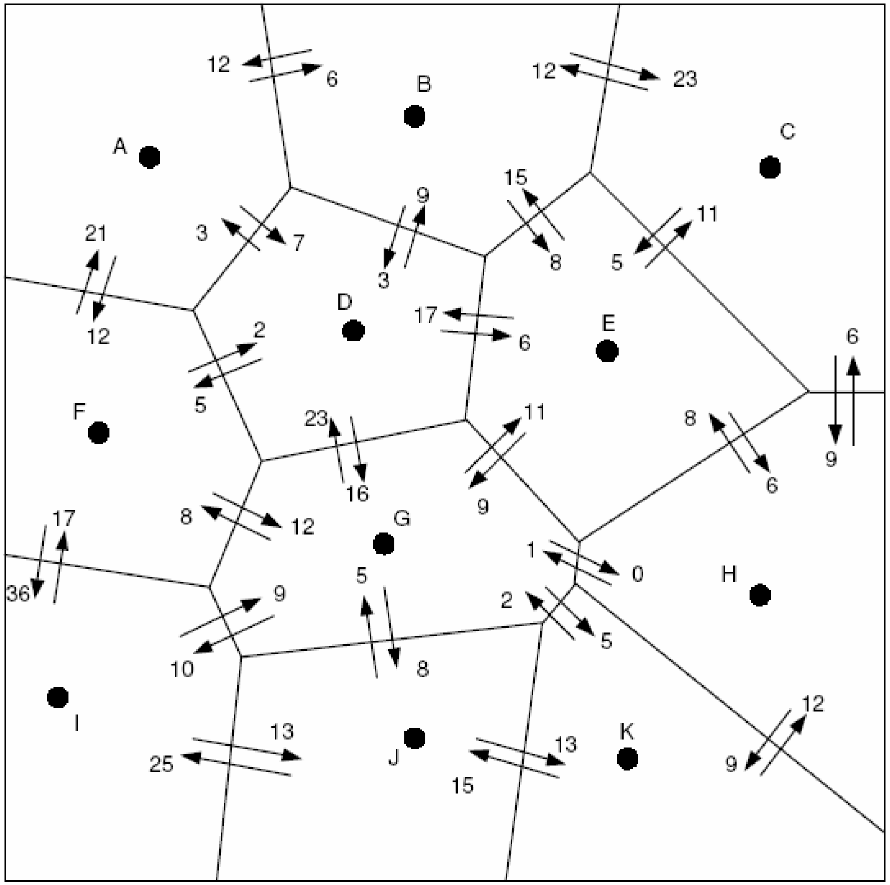
STUN - Performance Metrics: Communication Cost and Delay

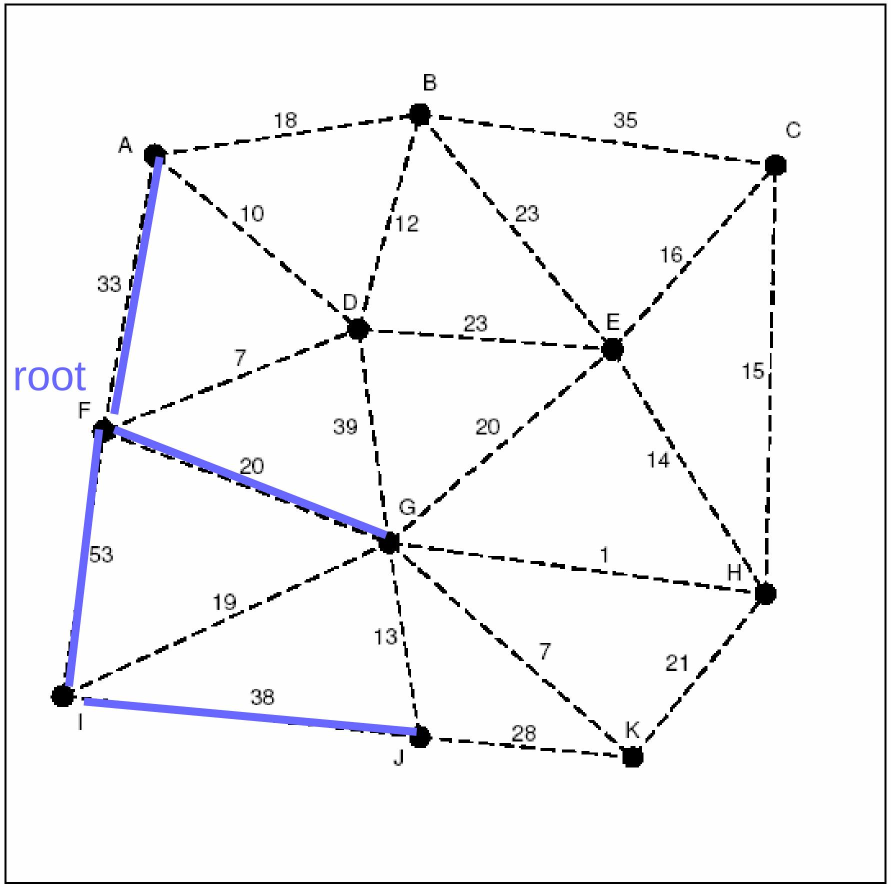


STUN - Performance Metrics: Communication Cost and Delay



STUN - Realize the logical tree





STUN - summary

- Advantage
  - Message pruning
  - routing
- Disadvantage
  - Building the tree (the structures of the tree)

DCTC
Dynamic Convoy Tree-Based Collaboration

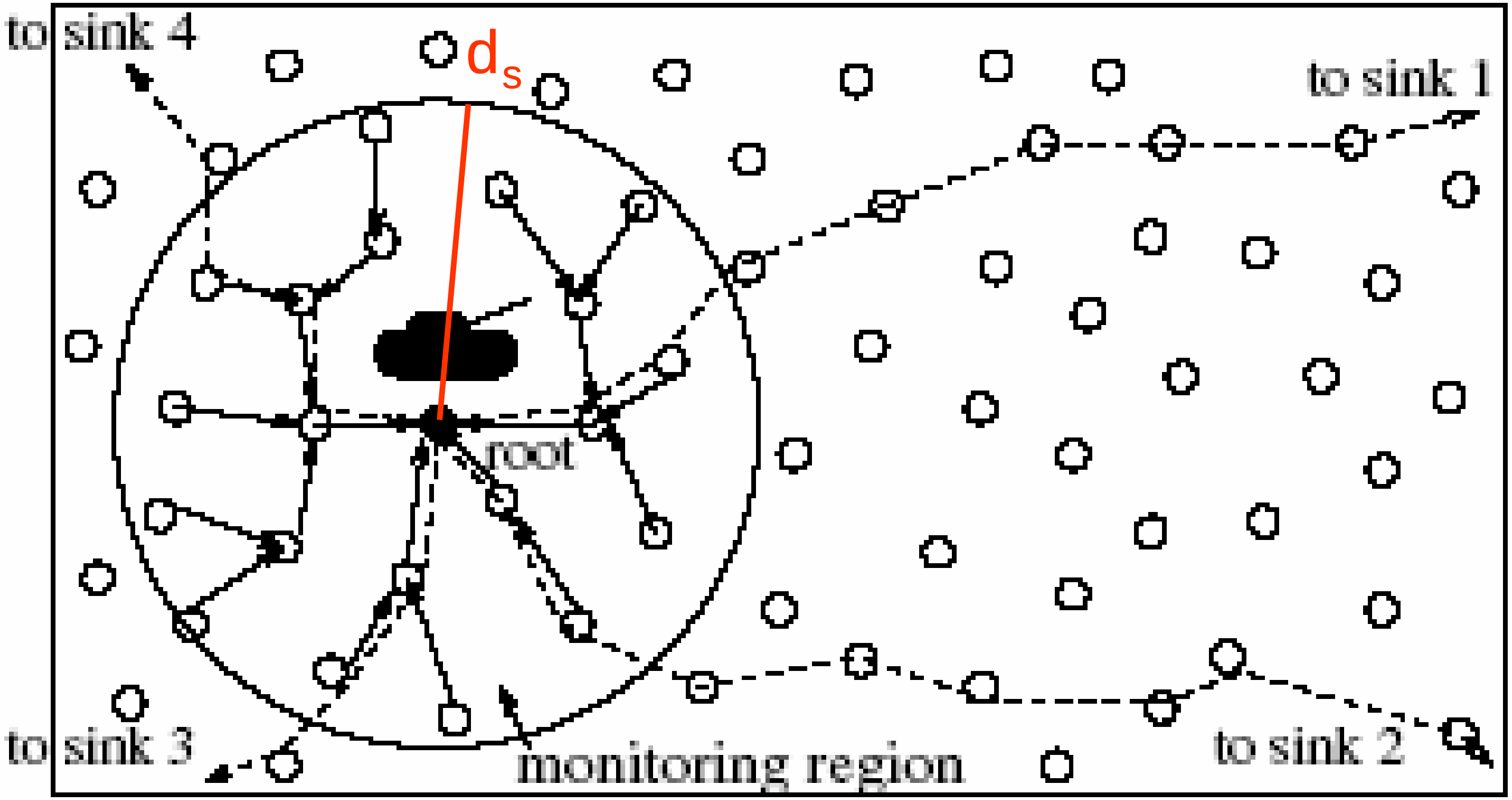
- Wensheng Zhang and Guohong Cao, "DCTC: Dynamic Convoy Tree-Based Collaboration for Target Tracking in Sensor Networks" IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 3, NO. 5, SEPTEMBER 2004
- Wensheng Zhang and Guohong Cao, "Optimizing Tree Reconfiguration for Mobile Target Tracking in Sensor Networks" Infocom 2004

DCTC

Dynamic Convoy Tree-Based Collaboration

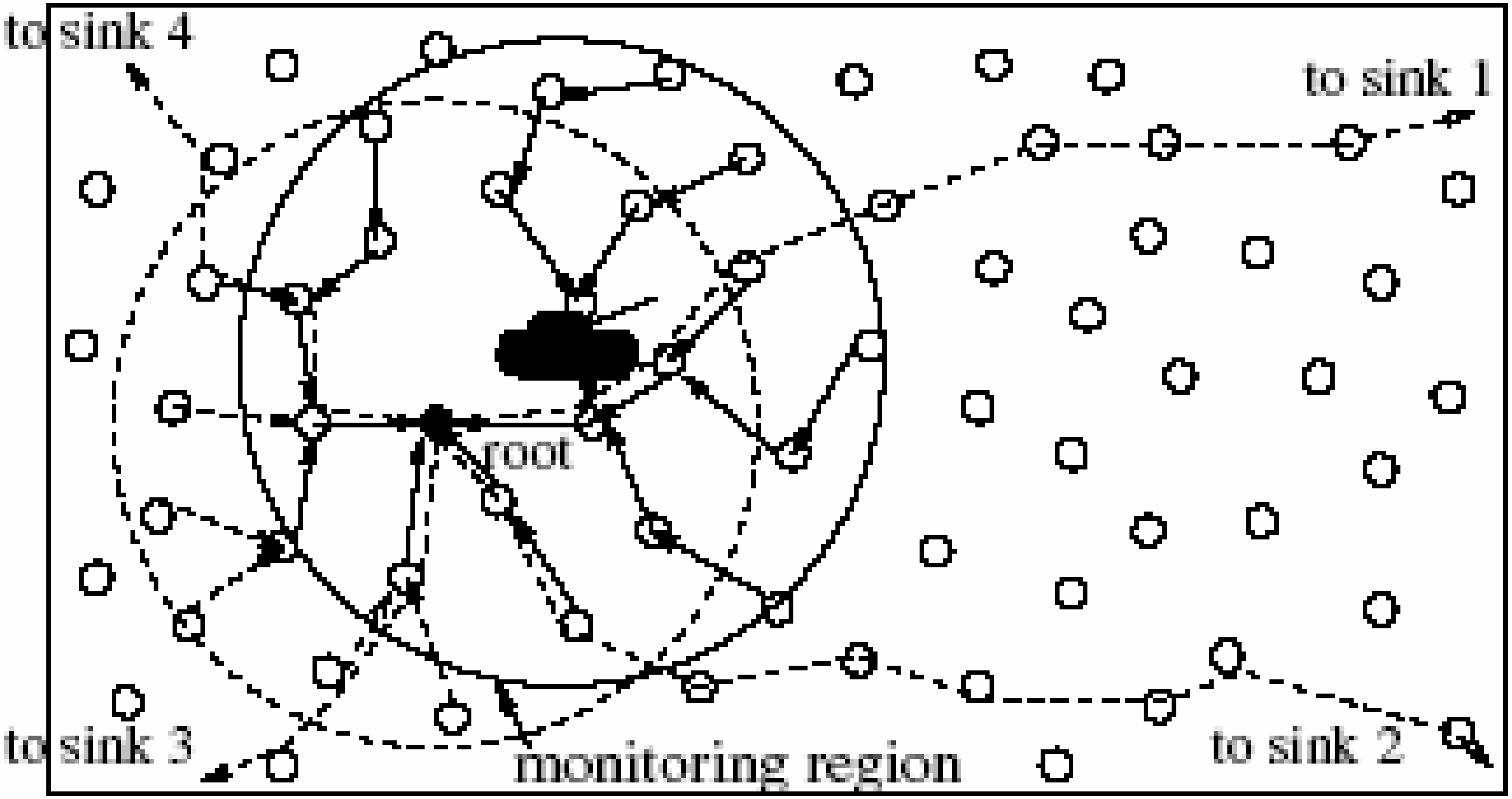
- DCTC relies on a tree structure called “convoy tree”
- The tree is dynamically configured to add some nodes and prune some nodes as the target moves.

DCTC – main idea



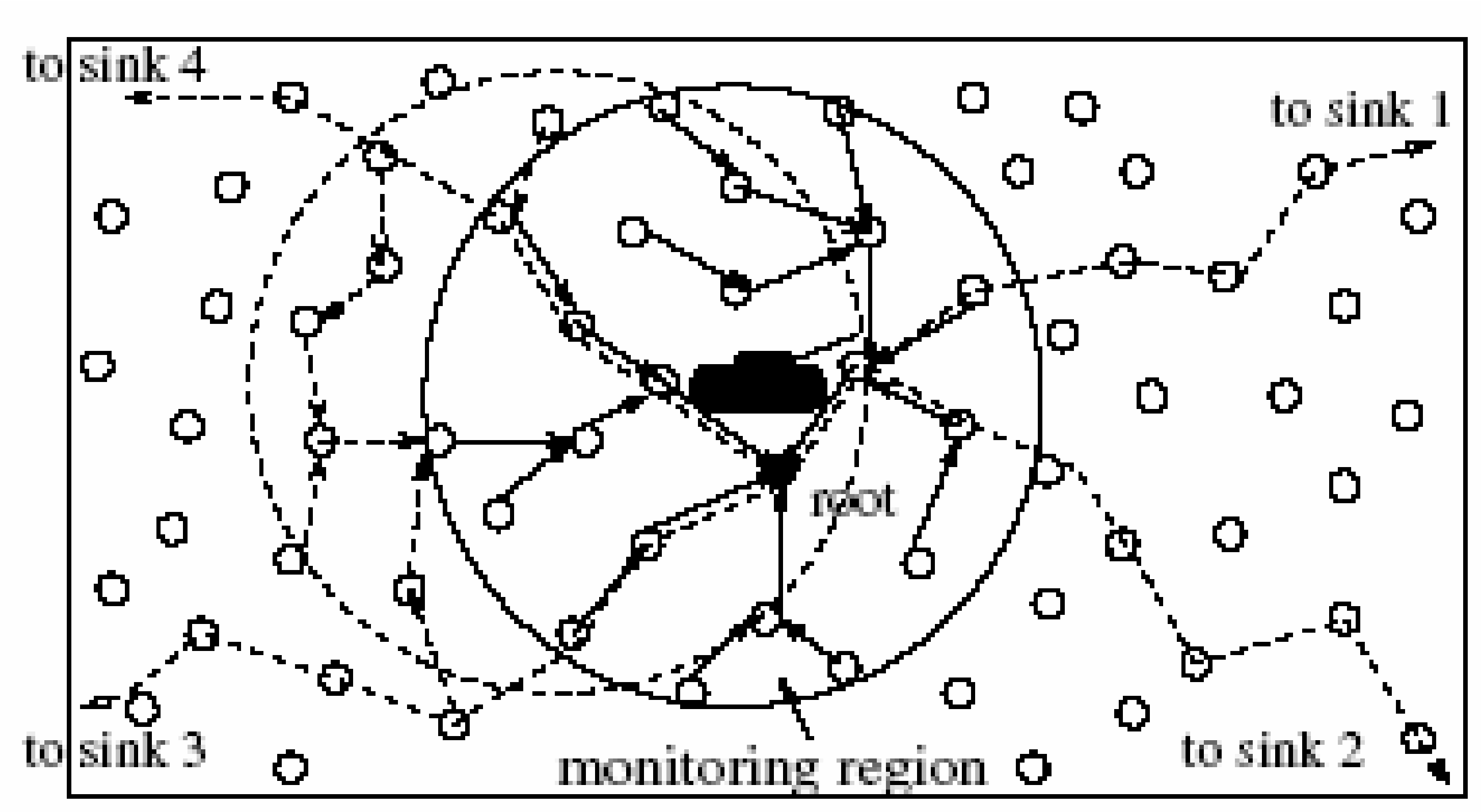
(a)

DCTC – main idea



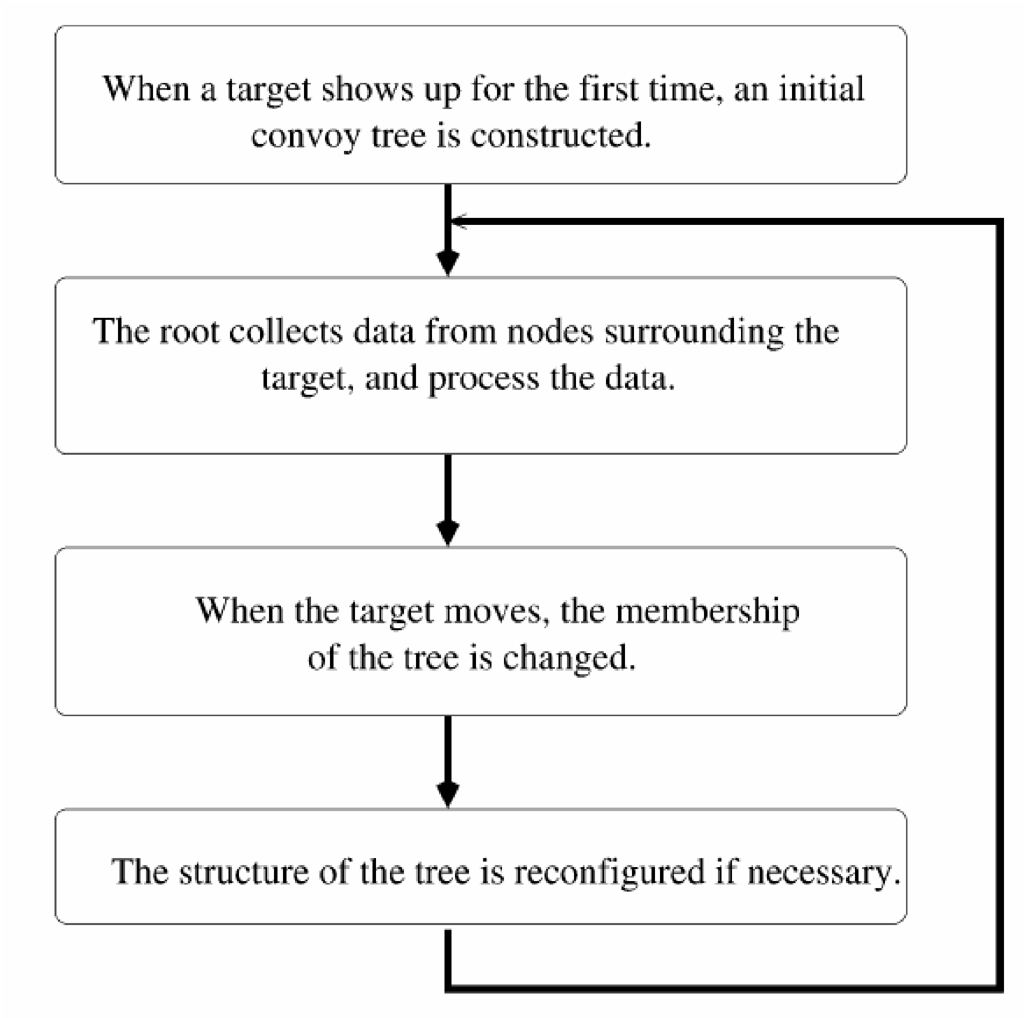
(b)

DCTC – main idea



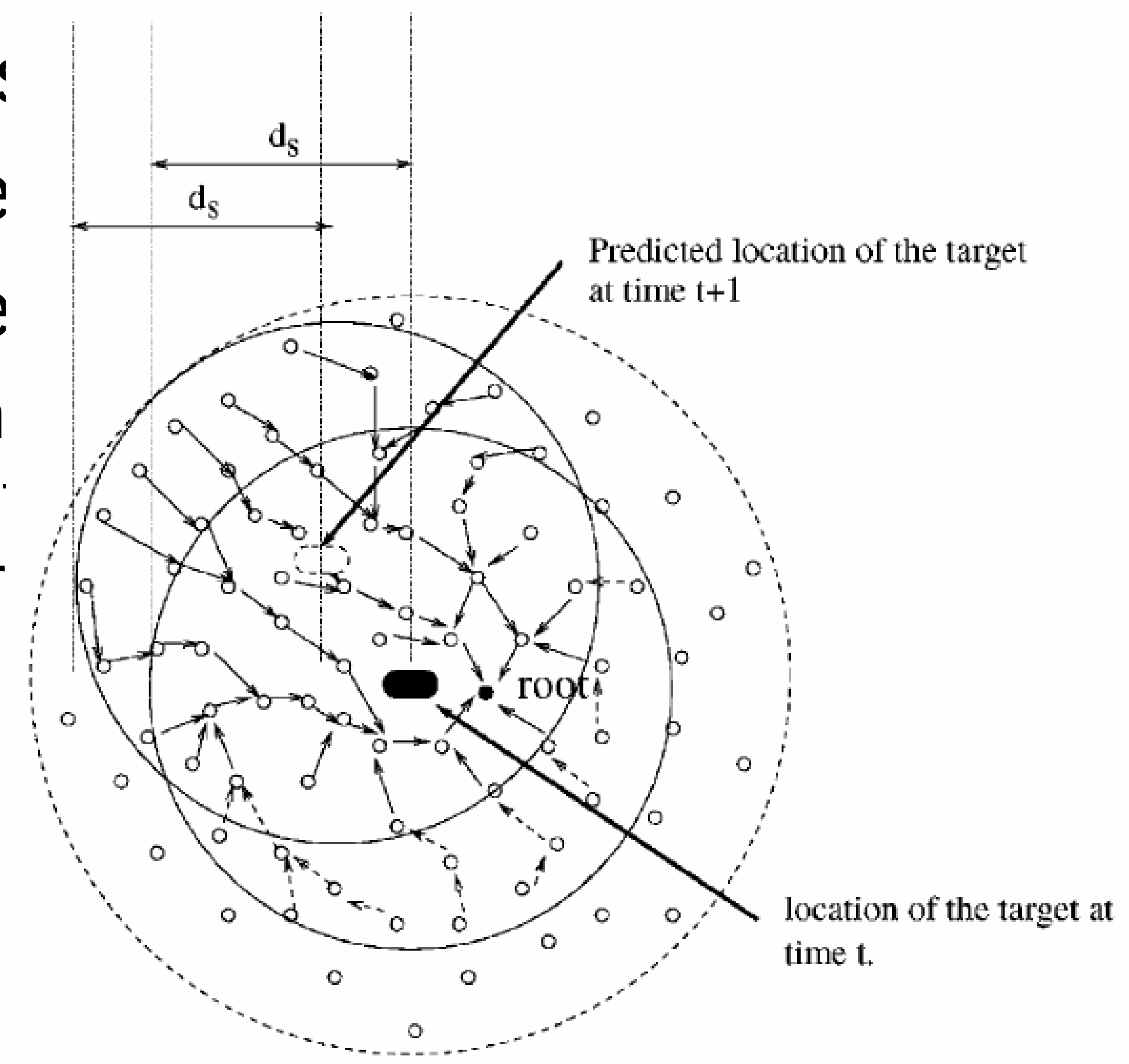
(c)

DCTC – Basic structure



DCTC

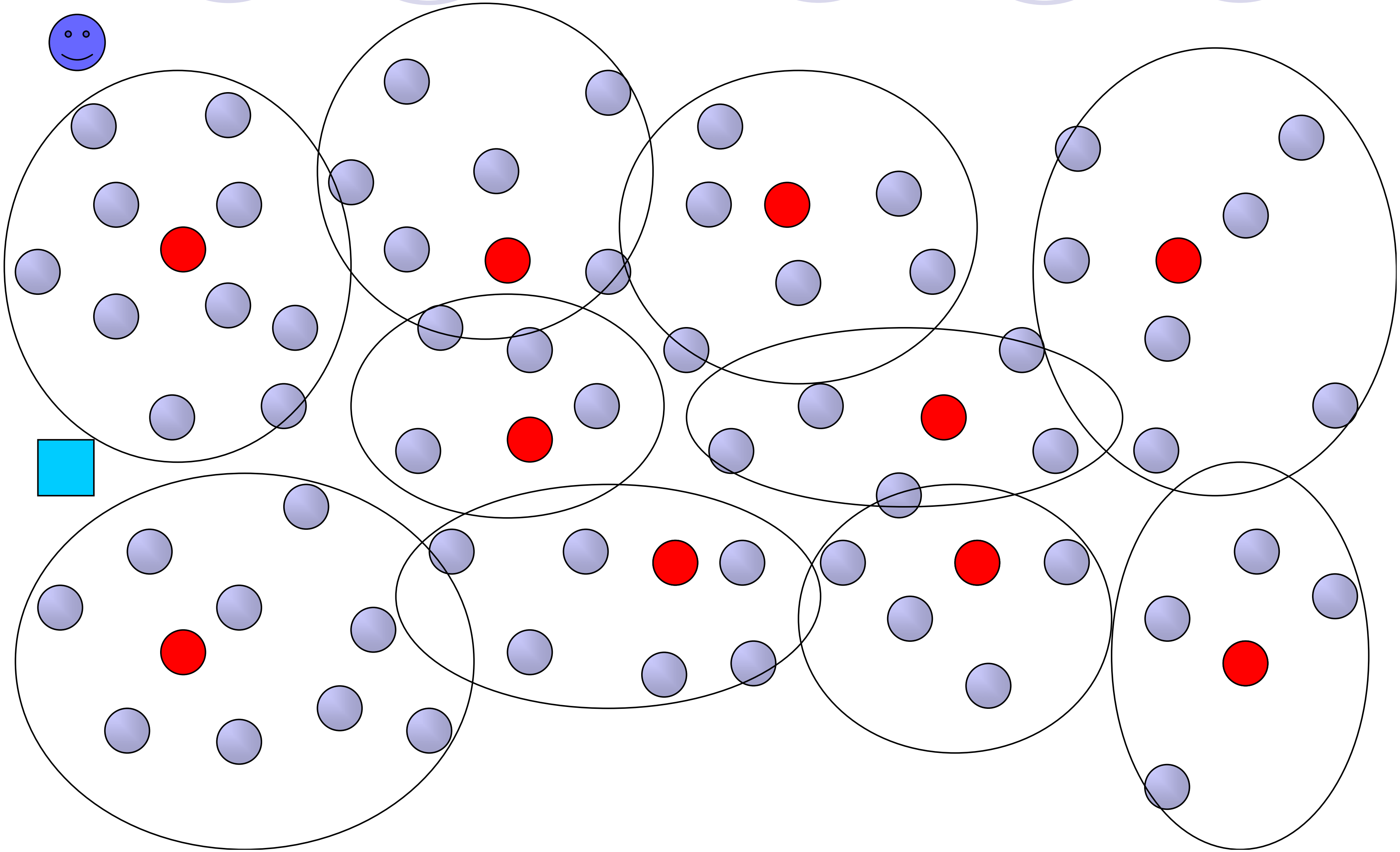
- Con
- Tree
- Tree
  - th ... listance be ... n of the tar



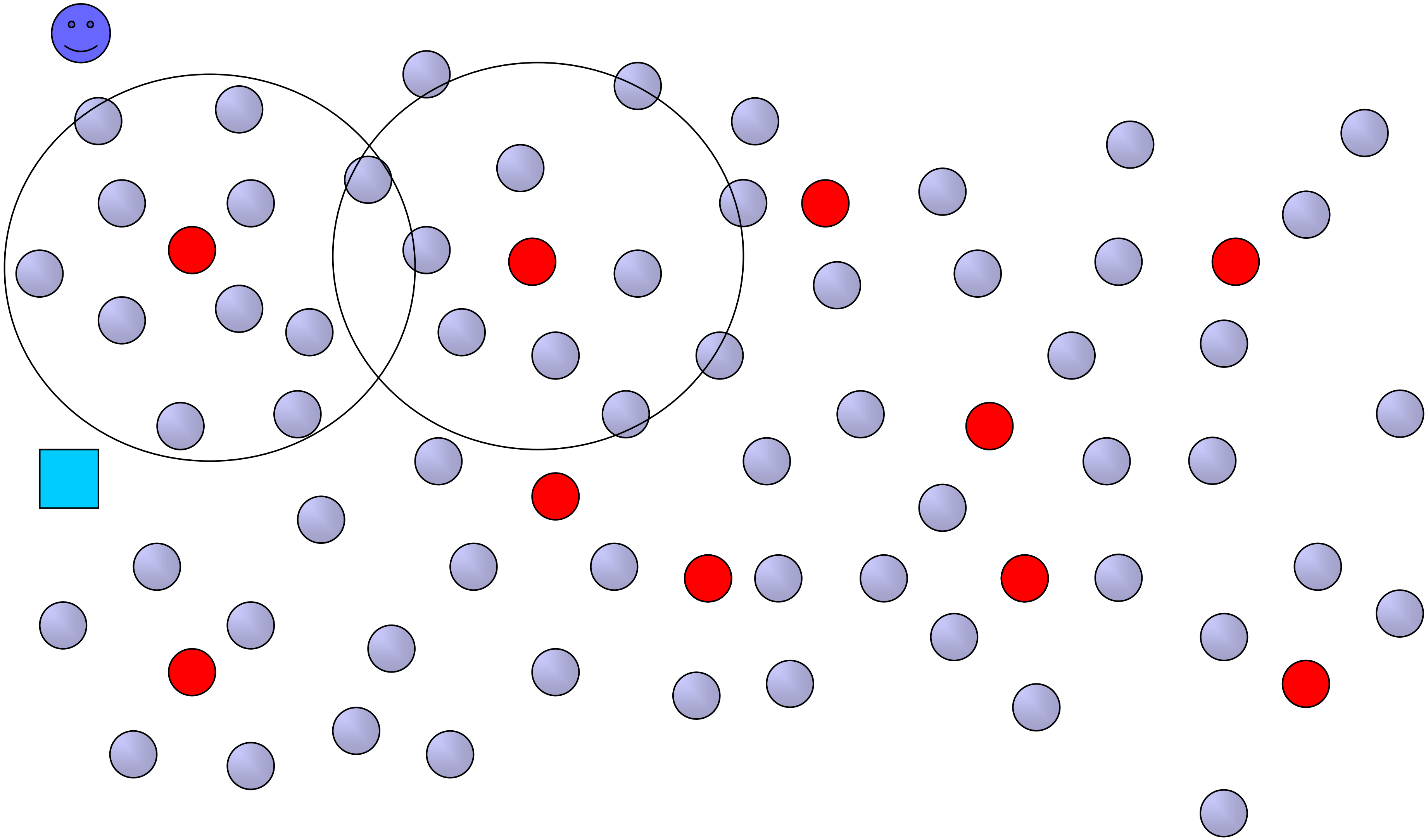
Dynamic Clustering

- Wei-Peng Chen, Jennifer C. Hou, and Lui Sha, Fellow, IEEE "Dynamic Clustering for Acoustic Target Tracking in Wireless Sensor Networks" IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 3, NO. 3, JULY-SEPTEMBER 2004
- Xiang Ji, Hongyuan Zha, John J. Metzner, and George Kesidis , "Dynamic cluster structure for object detection and tracking in wireless ad-hoc sensor networks" ICC 2004

Static clustering



Dynamic Clustering for Acoustic Target Tracking



Dynamic Clustering for Acoustic Target Tracking

- A CH volunteers to become active
  - when it detects that the strength of a received acoustic signal exceeds a predetermined threshold
  - the signal matches one of the signal patterns which the system intends to track.
- The tasks of an active CH
  - broadcasting a packet that contains the energy and the extracted signature of the detected signal to sensors
  - receiving replies from sensors
  - estimating the location of the target based on replies
  - sending the result to subscriber(s).
- Energy-Based Localization
  - The fundamental principle applied in the energy-based approaches is that the signal strength (i.e., energy) of a received signal decreases exponentially with the propagation distance

Dynamic Clustering for Acoustic Target Tracking

TABLE 1
Radio Transmission Range of Berkeley Motes

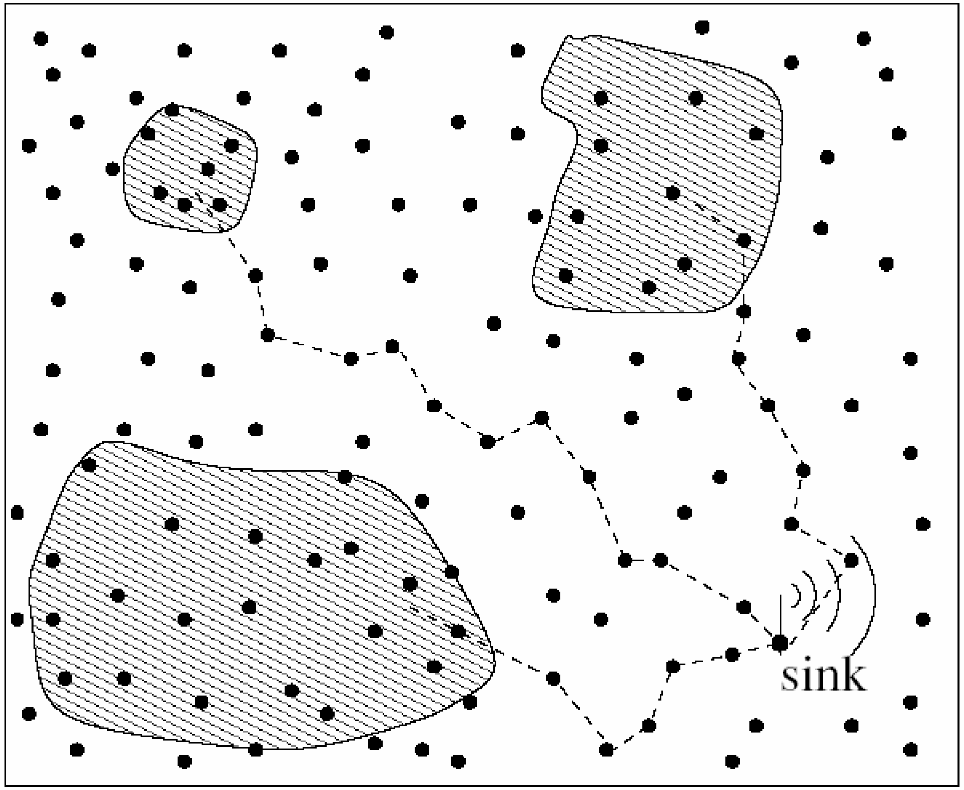
Products	transmission range
MPR300*	30m
MPR400CB	150m
MPR410CB	300m
MPR420CB	300m
MPR500CA	150m
MPR510CA	300m
MPR520CA	300m

Dynamic Clustering for Acoustic Target Tracking

TABLE 2
Sensing Range of Several Typical Sensors

Products	sensing range	typical applications
HMC1002 Magnetometer sensor [20]	5m	Detecting disturbance from automobiles
Reflective type photoelectric sensor [22]	1m	Detecting targets of virtually any material
Thrubeam type photoelectric sensor [22]	10m	Detecting targets of virtually any material
Pyroelectric infrared sensor (RE814S) [21]	30m	Detecting moving objects
Acoustic sensor on Berkeley Motes * [20]	$\sim$ 10m	Detecting acoustic sound sources

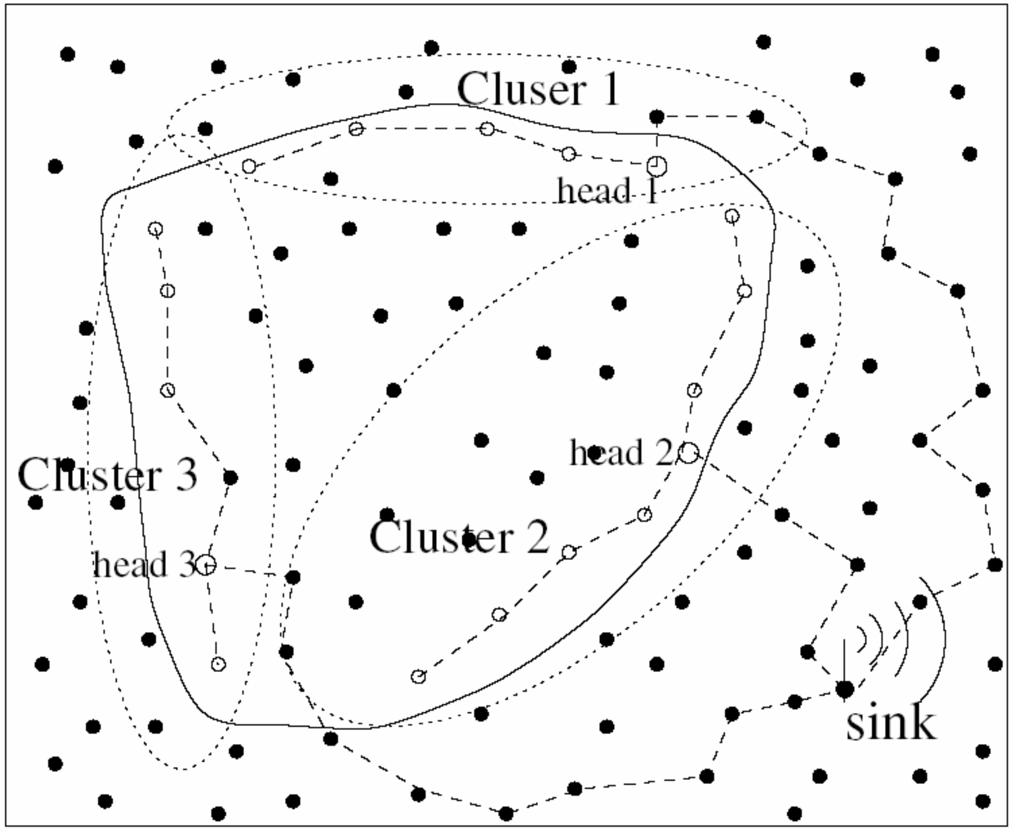
Dynamic Cluster - The continuous objects



- Continuously distributed across a region
- Occupy a large area
- Trend to diffuse, increase in size, change in sharp, split into multiple relatively smaller continuous objects

Dynamic Cluster - The continuous objects

- Object : Tracking boundary

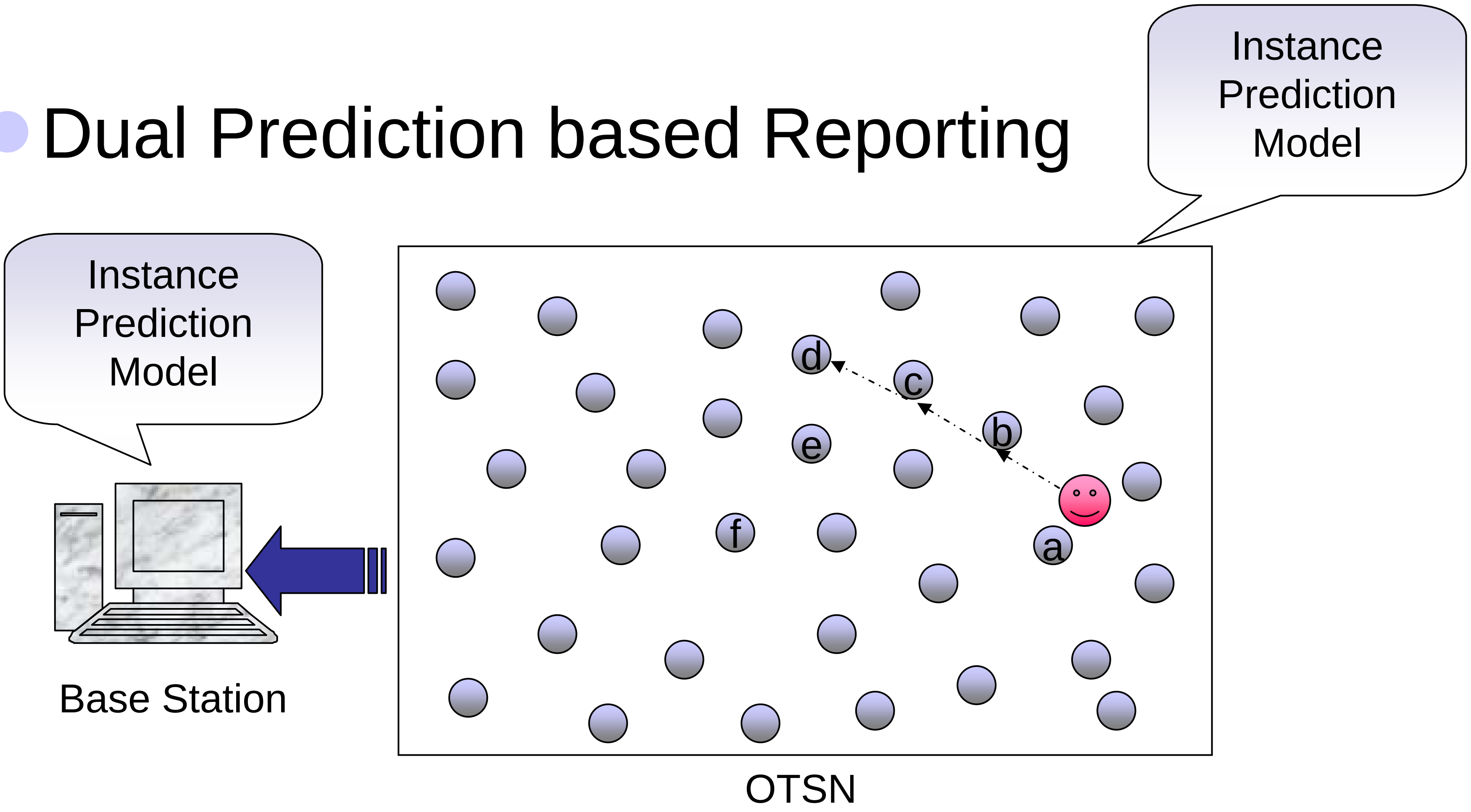


Prediction-based

- Yingqi Xu   Winter, J.   Wang-Chien Lee "Prediction-based strategies for energy saving in object tracking sensor networks" Mobile Data Management, 2004. Proceedings. 2004 IEEE International Conference on
- Xu, Y.; Winter, J.; Lee, W.-C. "Dual prediction-based reporting for object tracking sensor networks" MOBIQUITOUS 2004

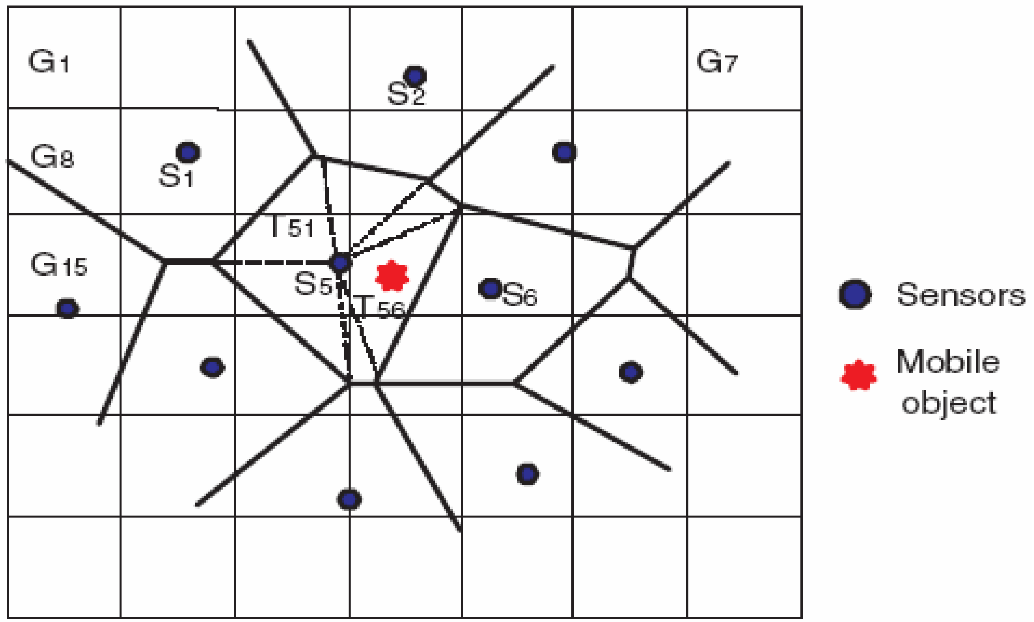
Dual Prediction based Reporting

- Dual Prediction based Reporting



Dual Prediction based Reporting

- Location Models
  - Sensor Cell(SS)
  - Triangle(ST)
  - Grid(SG)
  - Coordinate(SG)

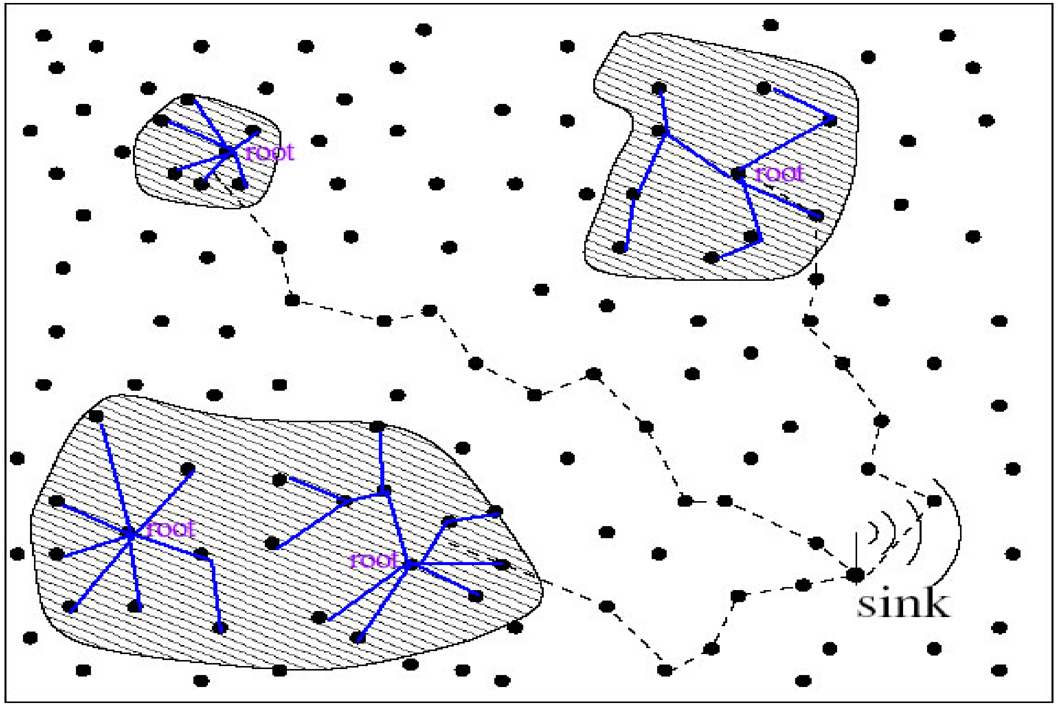


Dual Prediction based Reporting

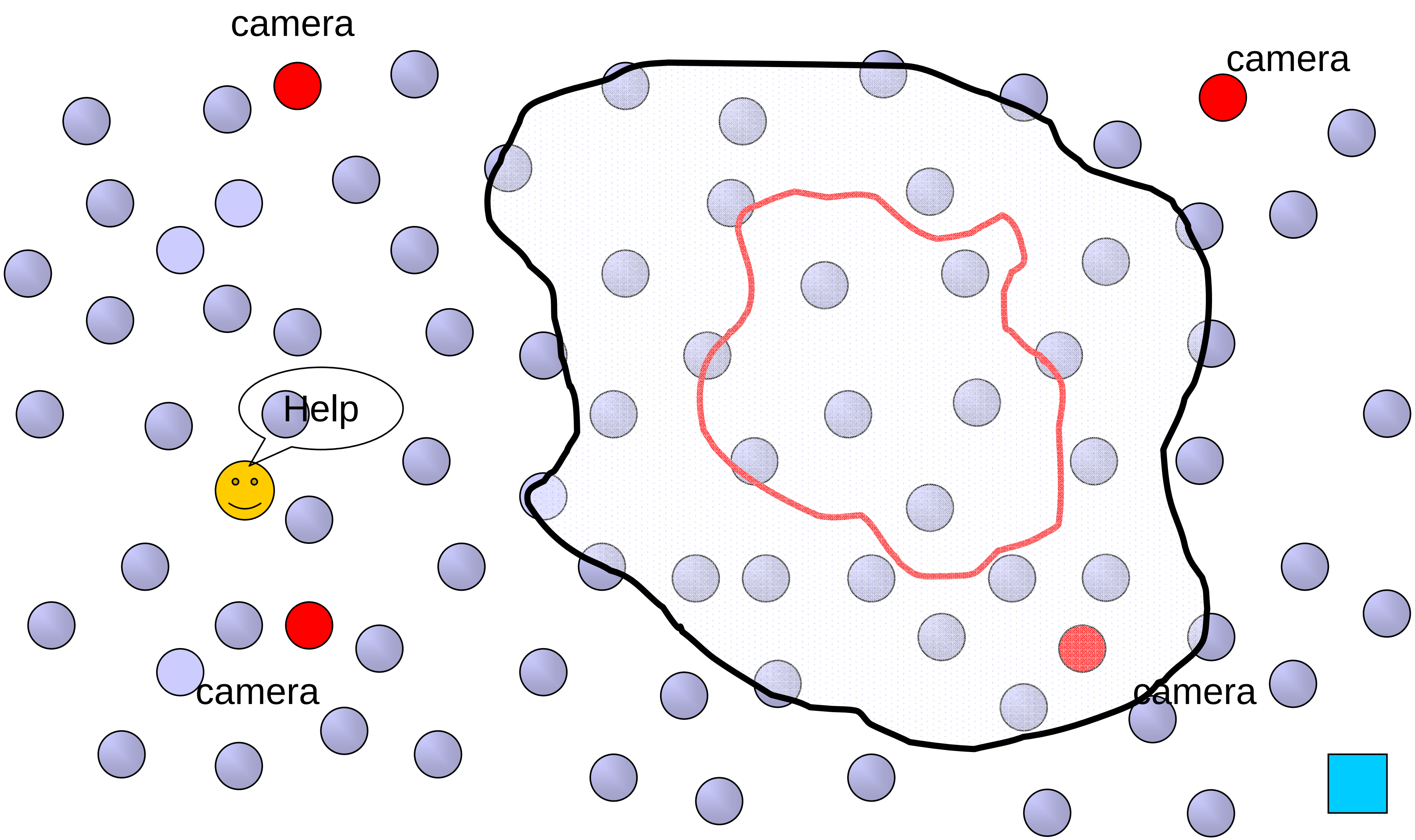
- Prediction Model
  - Heuristics INSTANT
    - Current node assumes that moving objects will stay in the current speed and direction for the next (T-X) seconds.
  - Heuristics AVERAGE
    - By recording some history, the current node derives the object's speed and direction for the next (T-X) seconds from the average of the object movement history.
  - Heuristics EXP_AVG
    - Assigns different weights to the different stages of history.

Issues Discussion

- The continuous objects tracking – not only to track the boundary ,but also to gather the detail of the continuous objects



Issues Discussion - Rescue



Issues Discussion

- Objects tracking
  - Continuous objects – boundary v.s detail
  - Acoustic target tracking - estimating the location of the target and taking the pictures
- QoS – low latency
- Best route

References

- H. T. Kung and D. Vlah. "Efficient Location Tracking Using Sensor Networks." *WCNC*, March 2003.
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THANK YOU

- When a continuous object shows up for the first time, an initial tree is constructed.
- If a sensor detects the emergence of the object in its local area at the current time, the sensor communicates with its one-hop neighboring sensors to query the object detection in its neighboring sensors.
  - if no tree => start tree initiation
  - if tree exist => join to the tree

- The root collects data from nodes in the continuous object, and process the data.
- When the continuous object diffuse (increase in size) or change in shape, the membership of the tree is changed
- The structure of tree is divided if necessary
  – the number of members of the tree
  – the depth of the tree