# CSE 6488: Mobile Computing Systems

## A Fully Distributed Spatial Index for Location-based Wireless Broadcast Services

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# Motivation of DSI



- Motivation
  - To supports location-based services in wireless data broadcast systems
  - To address inherited deficiencies of tree indexes
    - Problem1. Must wait for the arrival of the root node
    - Problem2. The search has to be stopped if index node is lost

# Index Structure of DSI

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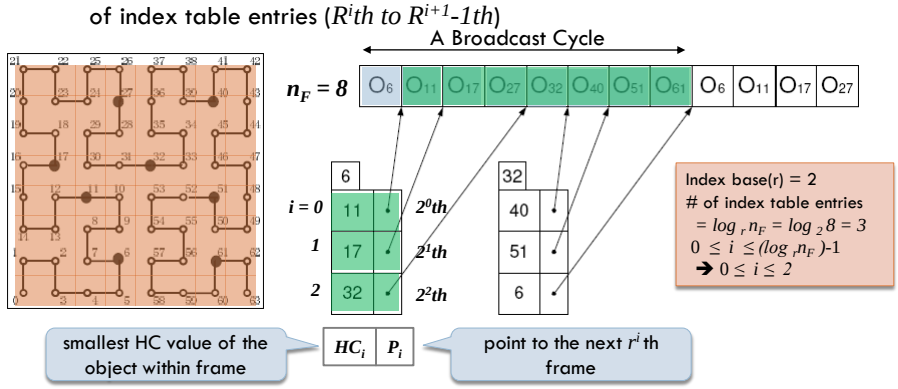
- Basic Idea
  - Divide the whole set of data objects into $n_f$ frames and associate with each frame an index table
  - The number of frames covered is exponentially increased with the order of index table entries ($R^i th$ to $R^{i+1}$-$1th$)




# Energy Efficient Forwarding(1)

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- EEF is
  - Efficiently reach a frame containing the data object of a given location
- Steps of EEF (given a target point, p)
  - Compute the HC value of p, ($HC_p$)
  - Tunes into the broadcast channel (Initial probe)
  - Comparing $HC_p$ with $HC_i$ maintained in the index table
  - Client follows the pointer $P_i$, where $HC_p \in [HC_i' , HC_{i+1}')$

# Energy Efficient Forwarding(2)

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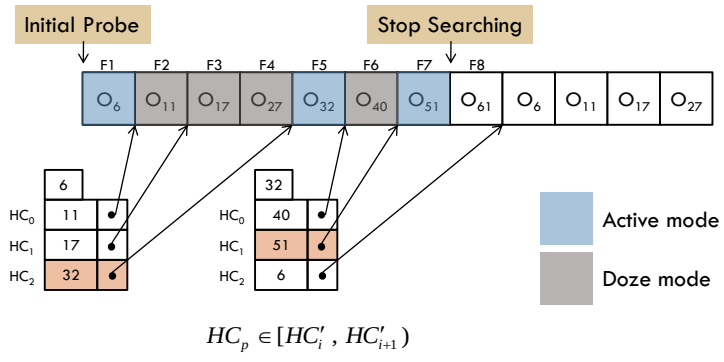
- Example (find $O_{51}$)
  - $HC_p$ = 51




$$HC_p \in [HC_i' , HC_{i+1}')$$

# Window Queries(1)

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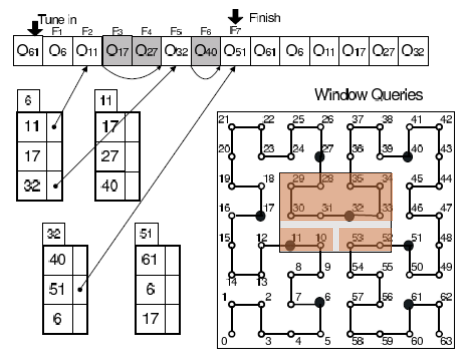
- Window query
  - returns all the data objects associated with locations within a given query window W
- Steps of Window query
  - Detects all the intersections between the HC and W

Target segment H
= [10,11] [28,35] [52,53]



# Window Queries(2)

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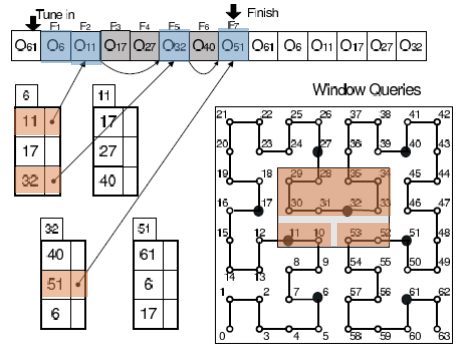
- Window query
  - returns all the data objects associated with locations within a given query window W
- Steps of Window query
  - Client scans each entry and follows the pointer $P_i$ with the range $[HC'_i , HC'_{i+1})$ overlapping with segment of H

| Target segment H = [ ] | 52,53] |
|---|---|




# K-NN Queries(1)

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- Basic Idea
  - To determine a search space based on the partial knowledge of object distribution obtained from index
  - Search space will continuously shrink as more knowledge of the data distribution is obtained
- Properties
  - Initial search space ➔ whole spatial region
  - draw a circle centered at query point p, include at least k data objects
  - How to determine the search space
    - Conservative Approach
    - Aggressive Approach

# K-NN Queries(2)

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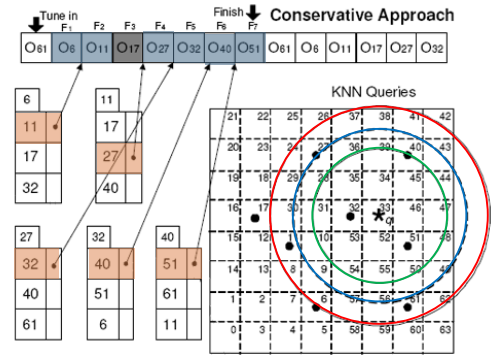
- Conservative Approach
  - Retrieves a data object if it may potentially be in the answer set
  - Have small access latency but high energy expense

ex. $k = 3$, a given query point $p = 33$.

$kNN = \{6, 11, 32\}$ from $O_6$ index frame
$kNN = \{27, 32, 40\}$ from $O_{11}$ index frame
Ignore $O_{11}$ and Skip $F_3(O_{17})$
$kNN = \{27, 32, 40\}$ from $O_{27}$ index frame
$kNN = \{32, 40, 51\}$ from $O_{32}$ index frame
$kNN = \{32, 40, 51\}$ from $O_{40}$ index frame
$kNN = \{32, 40, 51\}$ from $O_{51}$ index frame

Access Latency = 7 frames.
Tuning Time = 6 frames.




# K-NN Queries(3)

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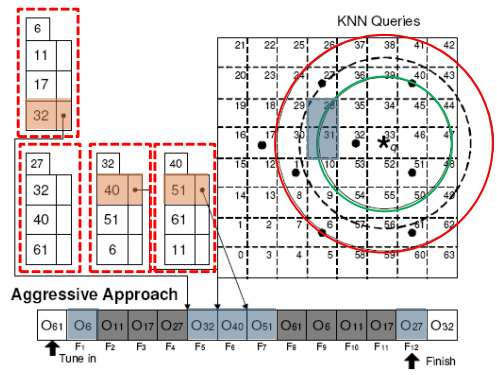
- Aggressive Approach
  - Access index table closer to the query point in order to shrink the search space more rapidly
  - Have small energy expense but high access latency

ex. $k = 3$, a given query point $p = 33$.

$\{6, 11, 17, ?, 32, ?, ?, ?\}$ from $O_6$ index frame
Skip $O_{11}$, $O_{17}$, $O_{27}$.
$\{6, 11, 17, ?, 32, 40, 51, ?\}$ from $O_{32}$ index frame
$\{6, 11, 17, ?, 32, 40, 51, 61\}$ from $O_{40}$ index frame
$\{6, 11, 17, ?, 32, 40, 51, 61\}$ from $O_{51}$ index frame
Skip $O_{61}$, $O_6$, $O_{11}$, $O_{27}$.
$\{6, 11, 17, 27, 32, 40, 51, 61\}$ from $O_{27}$ index frame

Access Latency = 12 frames.
Tuning Time = 5 frames.



# Advantage & Disadvantage

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- Advantage of DSI
  - Fit the wireless broadcast environments
  - Allows query processing to start very quickly
  - Very resilient under error-prone
- Disadvantage of DSI
  - How to determine an optimal exponential base(index base)