Data Management issues

In

Location Dependent Services

Next few slides…

- **Location Based Services**
- Challenges
- Why Caching ?
- Terminologies
- Existing Caching Techniques
- Drawbacks
- Proposed system

Location- Dependent Information Services (LDIS)

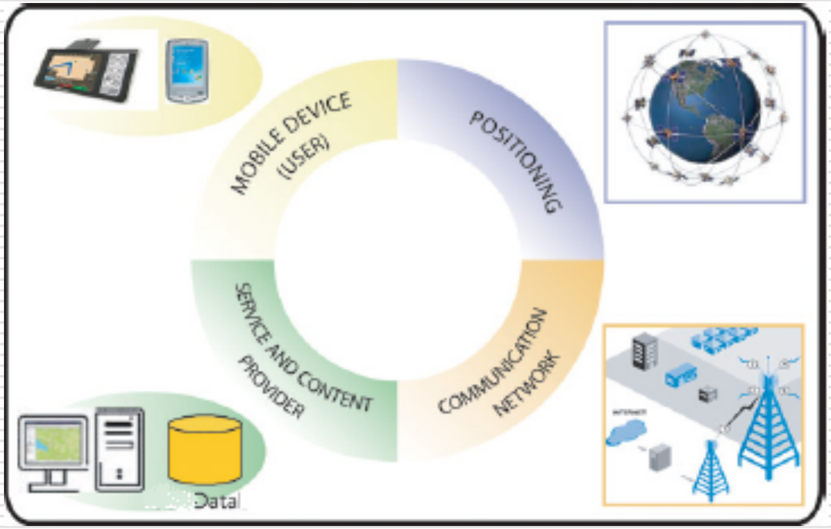
Provide services based on the geographical location of users.

Application Opportunities

- Mapping, navigation, and directions applications
- Workforce-tracking and management applications
- Entertainment and gaming applications
- “Finder” applications - find services in the local environment
- Weather applications
- Reminder applications to prompt users when they reach particular locations
- Information services
  - stock quotes
  - nearest cash ATM

Enabling Technologies

- Wireless Networks
- Mobile Devices
- Positioning Technologies
- Database Systems



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What makes LDIS Challenging?

- User Movement
- Mobile Environment Constraints
- Spatial Property of Queries

User Mobility

- Continuous querying leads to high work load
- Results may be invalid due to high movement

Mobile Environment Constraints

Characteristic of Wireless Communication

- Frequent Disconnections
- Expensive
- Relatively unreliable
- High bandwidth Variability
- Scarcity of Bandwidth

Characteristic of Mobile Devices

- Limited memory
- Limited computational power
- Small screen
- Limited battery Life
- Variability in resources
- Frequent location updates

Location Dependent Data (LD)

- The class of data whose value is functionally dependent on location.
- location determines the current value of the data.

Examples: City code

Location Independent Data (LID)

- The class of data whose value is functionally independent of location.
- Value of the location does not determine the value of the data.

Example: name, account number

Location Dependent Queries

- Data objects are associated with location
- Query predicates based on location
- Query result depends on location and time

E.g., Find the cheapest hotel here ….(Planar) Point query

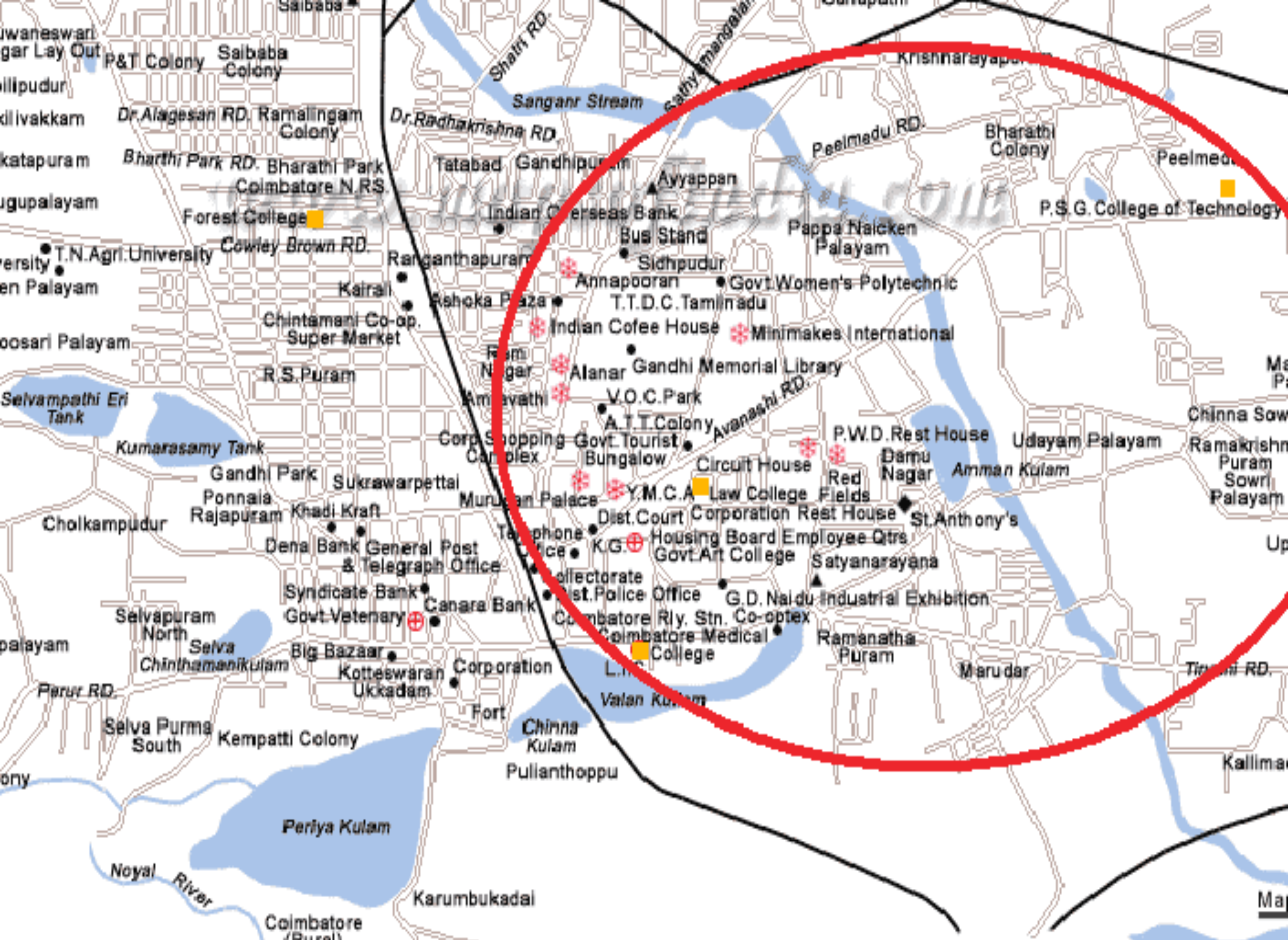
- E.g., Find all hotels within 5 miles….. Window query
- E.g., Find the nearest hotel to me …(K-)nearest-neighbor search

Query Types

- Mobile clients ,querying static objects
- Stationary clients, querying moving objects
- Mobile clients, querying mobile objects

Differ from Temporal Queries

- Highly Dynamic
- Multiple answer sets depending on   location/time
- The mobility of clients
- Location of client may be part of the query itself
- May depend on direction of movement
- The mobility of data objects
- Locations of data objects change (e.g., cars)


Saibaba
Sanganr Stream
Shatri RD.
Sathy Mangalam
Ganapathi
Krishnarayapuram
uwaneswari
gar Lay Out
P&T Colony
Saibaba Colony
ilipudur
Kilivakkam
Dr.Alagesan RD.
Ramalingam Colony
Dr.Radhakrishna RD.
Peelmedu RD.
Bharathi Colony
Peelmedu
katapuram
Bharthi Park RD.
Bharathi Park
Tatabad
Gandhipuram
Ayyappan
Coimbatore N.RS.
ugupalayam
Forest College
Indian Overseas Bank
Bus Stand
P.S.G. College of Technology
Pappa Naicken Palayam
T.N.Agri.University
ersity
Cowley Brown RD.
Ranganthapuram
Sidhpudur
Annapooran
Govt.Women's Polytechnic
en Palayam
Kairali
Ashoka Plaza
T.T.D.C.Tamilnadu
Chintamani Co-op. Super Market
Indian Cofee House
Minimakes International
oosari Palayam
Ram Nagar
Alanar
Gandhi Memorial Library
R.S.Puram
Selvampathi Eri Tank
Amaravathi
V.O.C.Park
Avanashi RD.
A.T.T.Colony
Kumarasamy Tank
Corp.Shopping Complex
Govt.Tourist Bungalow
P.W.D.Rest House
Udayam Palayam
Chinna Sow
Ramakrishn Puram
Sowri Palayam
Gandhi Park
Sukrawarpettai
Circuit House
Damu Nagar
Red Fields
Amman Kulam
Ponnaia Rajapuram
Murugan Palace
Y.M.C.A.
Law College
Cholkampudur
Khadi Kraft
Dist.Court
Corporation Rest House
St.Anthony's
Telephone Office
K.G.
Housing Board Employee Qtrs
Dena Bank
General Post & Telegraph Office
Govt.Art College
Satyanarayana
Collectorate
Up
Syndicate Bank
Dist.Police Office
G.D.Naidu Industrial Exhibition
Selvapuram North
Canara Bank
Govt.Vetenary
Coimbatore Rly. Stn.
Co-optex
palayam
Selva Chinthamanikulam
Coimbatore Medical College
Ramanatha Puram
Big Bazaar
L.I.C.
Kotteswaran
Corporation
Marudar
Tiruchi RD.
Perur RD.
Ukkadam
Valan Kulam
Fort
Selva Purma South
Kempatti Colony
Chinna Kulam
Pullanthoppu
Kallimad
ony
Periya Kulam
Noyal River
Karumbukadai
Coimbatore (Rural)
Map

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- Challenges
- **Why Caching ?**
- Terminologies
- Existing Caching Techniques
- Drawbacks
- Proposed system

Why Caching ?

- Improves data accessibility
- Minimizes access costs.

Cache Management

- Cache Prefetching
- Cache Invalidation
- Cache Replacement

Cache Prefetching

- The Data required is predicted based on the user demands and client’s movements
- Cache repository will consist of data required for high update intensive transactions.

Cache invalidation

- Cache inconsistency can occur due to temporal and location - dependent updates.

  - Temporal-dependent invalidation

  - Location-dependent invalidation

Cache Replacement…

- Process
  - - Flush out cache chunks
  - - Write back to the server or drop
  - - Increase in communication overhead
- Objective
  - Provide a high hit rate
  - Perform as few replacements as possible.

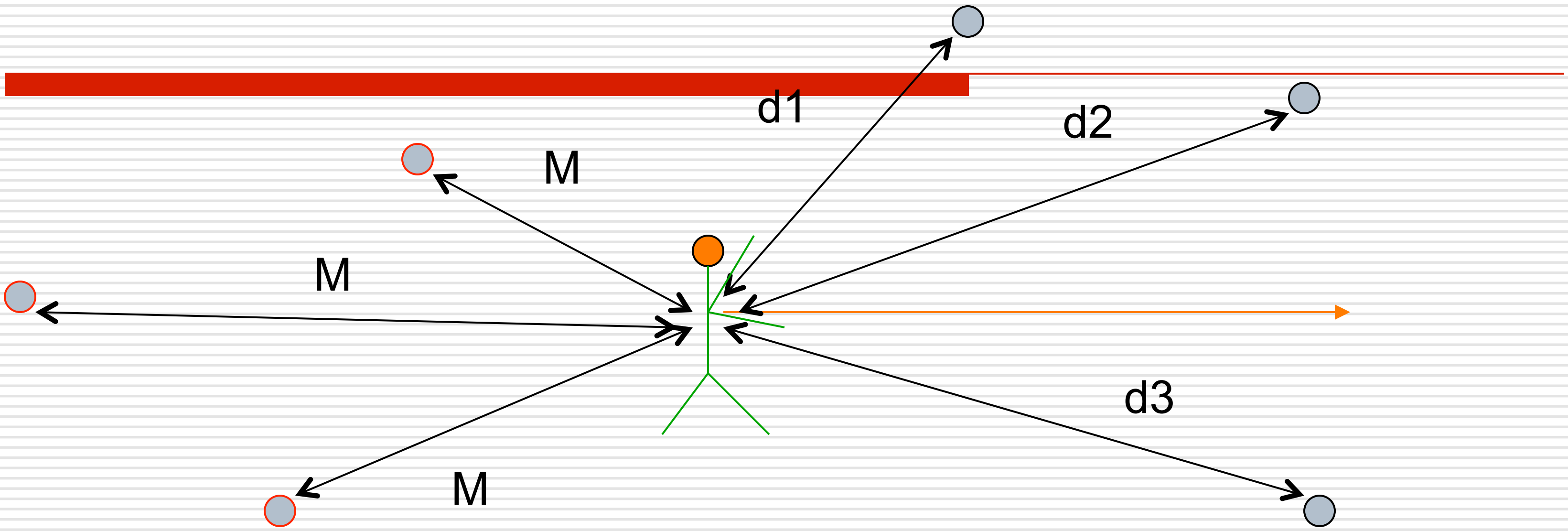
Existing Cache Replacement Strategies

- Euclidean
- Manhattan
- Farthest Away Replacement (FAR)
- Probability Area Inverse Distance (PAID)

Drawbacks

- Rely on the temporal locality of client' s access pattern.
- Evict only the most unlikely data item from the cache.

Farthest Away Replacement (FAR)



M--very large

Probability Area Inverse Distance (PAID)

The Cost function $c_{i,j}$ for data value *j* of item *i* is defined as:

$$c_{i,j} = \frac{P_i \times A(v'_{i,j})}{D(v'_{i,j})}$$

Where

P_i Access probability of item *i*

$A(v'_{i,j})$ Area of the attached valid scope $v'_{i,j}$

$D(v'_{i,j})$ Distance between the current position and valid scope $v'_{i,j}$

DrawBacks of PAID

- Does not consider the randomness of user movement
- Does not consider data updates
- Does not give the user an option to choose his object of interest

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Weighted Angular Distance Based Cache Replacement Strategy

- Temporal locality,
- Location of data,
- Location of the client
- Direction of the client' s movement
- User Preference

- Remove a set of data items and replace them with a corresponding number of data items which are more likely to be used.

Terminologies and Assumptions

Geometric Model

- 2D or 3-D coordinates,
- e.g., the latitude/ longitude pair
- Compatibility across heterogonous systems

Symbolic Model

- Logical, real-world entities
- Bus stop number, train station name
- Coarser location granularity
- Suitable for LBS applications due to semantics

Service Area : the geographical area covered by the mobile system

Terminologies

Data instance

location-dependent queries return different results, each result is called a data instance

Valid scope

the area within which a data instance remains valid

Can be seen as an implicit property associated with a query result.

Spatial Scope

the area where the query result remains valid.

Temporal Scope

the period of time when the query result remains valid.

Contextual Attributes Scope for context-aware applications

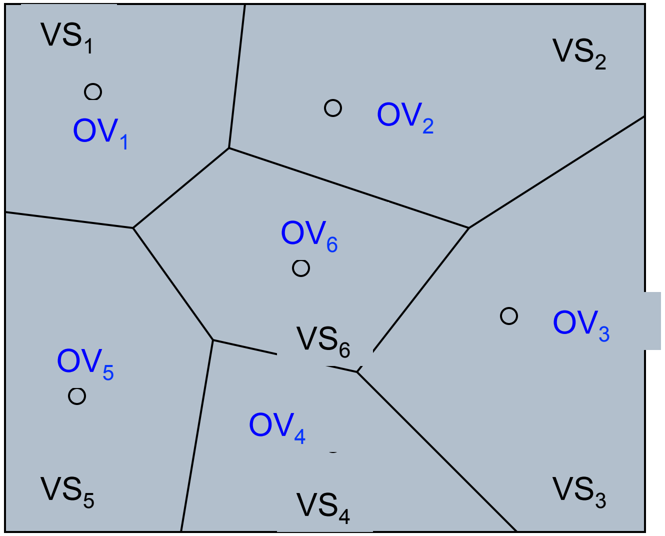
e.g., temperature range

Valid Scope

The valid scope is defined as the region within which the item value is valid.

For Data Item i

Item Value	Valid Scope
OV_1	VS_1
OV_2	VS_2
OV_3	VS_3
OV_4	VS_4
OV_5	VS_5
OV_6	VS_6



… Valid Scope

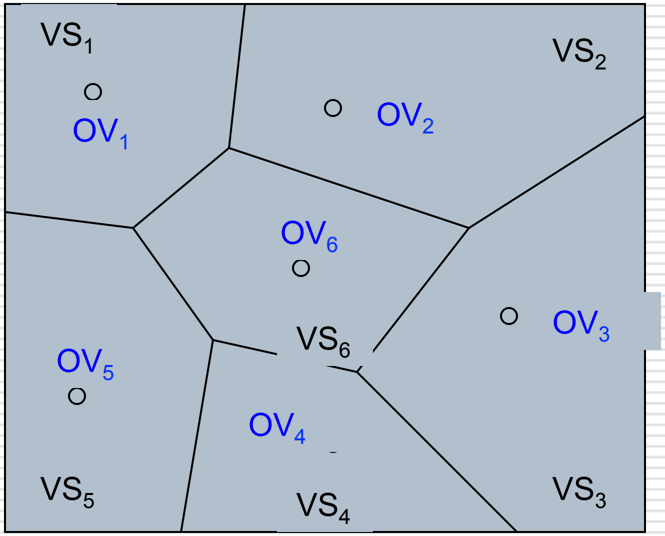
- Refers to the geometric area of the valid scope of a data value.
- Indicator of the access probabilities for different data values.
- Larger the valid scope area of the data, higher the probability of access

Scope Distribution

It is the set of valid scopes for all items values of a data item.

For Data Item i, scope distribution SD_i :

$SD_i = \{VS_1, VS_2, VS_3, VS_4, VS_5, VS_6\}$



Voronoi Diagrams …

The Voronoi diagram of a point set is the collection of regions that are closer to one point than to any other point.

…Voronoi Diagrams

- Area of valid Scope is generated based on the *Voronoi diagram*.

- A Voronoi diagram divides a space into disjoint polygons

- The nearest neighbor of any point inside a polygon is the generator of the polygon.

Voronoi Polygons

A set of limited number of points, called *generator points*, in the Euclidean plane

Associate all locations in the plane to their closest generator (s).

The set of locations assigned to each generator forms a region called *Voronoi polygon* or *Voronoi cell*, of that generator.

The set of Voronoi polygons associated with all the generators is called the Voronoi diagram with respect to the generators set.

The Voronoi polygons of a Voronoi diagram are collectively exhaustive because every location in the plane is associated with at least one generator.

The polygons are also mutually exclusive except for their boundaries.

The boundaries of the polygons, called *Voronoi edges*, are the set of locations that can be assigned to more than one generator. The Voronoi polygons that share the same edges are called *adjacent polygons* and their generators are called *adjacent generators*.

Voronoi

The Voronoi polygon and Voronoi diagram can be formally defined as:

$P = \{p_1, ..., p_n\} \subset \Re^2,$ where

$2 < n < \infty$ And $p_i \neq p_j$ for $i \neq j,\ i, j \in I_n = \{1, ..., n\}.$

The region given by

$$VP(p_i) = \{p \mid d(p, p_i) \leq d(p, p_j)\} \text{ for } j \neq i, j \in I_n$$

where *d*(*p; pi*) specifies the minimum distance between *p* and *pi* is called the *Voronoi Polygon* associated with *pi*, and the set given by:

$$VD(P) = \{VP(p_1), ..., VP(p_n)\}$$

Properties

- Property 1:
- The Voronoi diagram of a point set *P*, *V D*(*P*), is unique.

- Property 2:
- The nearest generator point of *pi* (e.g., *pj*) is among the generator points whose Voronoi polygons share similar Voronoi edges with *V P*(*pi*).

Weighted Angular Distance Based Cache Replacement Strategy

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Cost Function

$$c_{i,j} = \frac{P_i . A_{i,j}}{\alpha_d . D(V_{i,j}) + \alpha_\theta . \theta(V_{i,j})} \times \frac{1}{v}$$

- *P* - access probability,
- *A* - valid scope area,
- *D* - beeline distance
- *θ* - angle of bearing,
- *ad* and *aθ* - beeline and bearing coefficients
- *v* denotes the supplement variable.

Access Probability

- Probability of a particular data item being queried again within the same valid scope.
- Exponential aging method. (Two parameters are maintained for each data item i)
- (*Pi*) Running probability
- (*tlast, i*) Time of the last access to the item

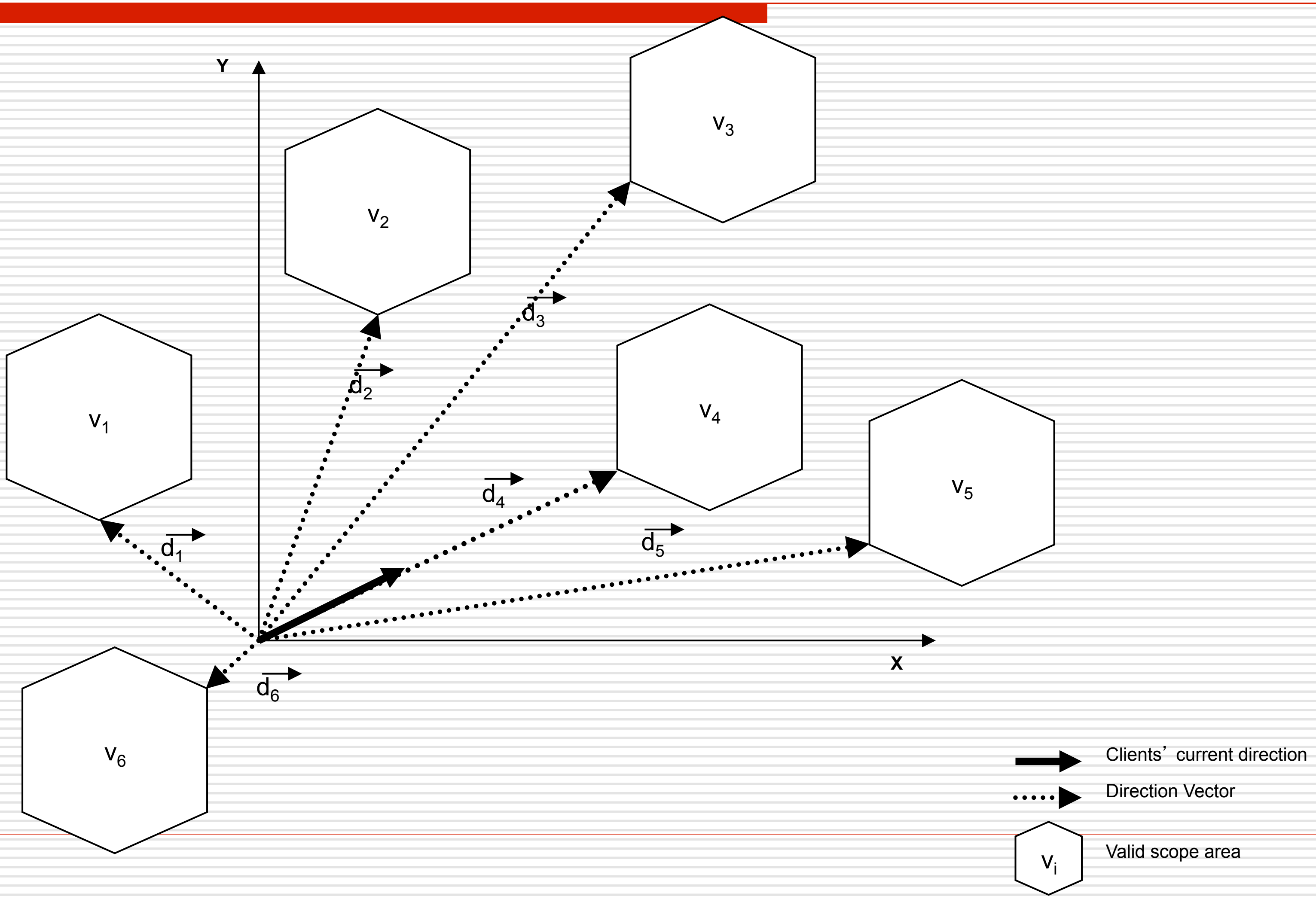
$$P_i = \frac{\alpha}{(t_{current} - t_{last,i})} + (1-\alpha)P_i$$

- *tcurrent* The current system time
- *a* a constant factor to weight the importance of the most recent access in the probability estimate

Angle of Bearing

- The angular distance (in degrees), θ between the client's current direction and direction vector of a particular valid scope.

$$c_{i,j} = \frac{P_i . A_{i,j}}{\alpha_d . D(V_{i,j}) + \alpha_\theta . \theta(V_{i,j})} \times \frac{1}{v}$$


Y
v_3
v_2
$\vec{d_3}$
$\vec{d_2}$
v_1
v_4
v_5
$\vec{d_4}$
$\vec{d_1}$
$\vec{d_5}$
X
$\vec{d_6}$
v_6
Clients' current direction
Direction Vector
v_i
Valid scope area

Beeline Distance

- The linear distance of a valid scope from the client’s current location. In a location-dependent data service,

$$P_i = \frac{\alpha}{(t_{current} - t_{last,i})} + (1-\alpha)P_i$$

Beeline and Bearing coefficients

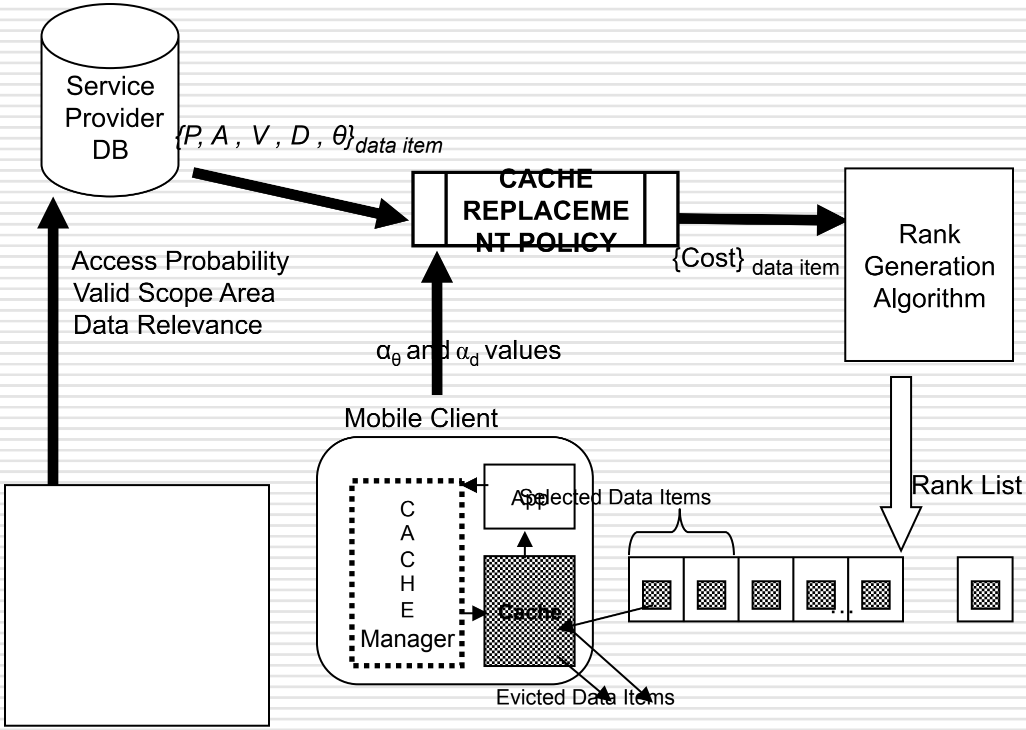
- In location-dependent data services, the beeline distance may gain precedence over the angle of bearing or vice-versa depending on the need and type of service.

$$c_{i,j} = \frac{P_i . A_{i,j}}{\alpha_d . D(V_{i,j}) + \alpha_\theta . \theta(V_{i,j})} \times \frac{1}{v}$$

Supplement Variable

- Relevance of LDD changes dynamically
- V is a measure of data relevance
- Can signify any scenario being just a numerical value.

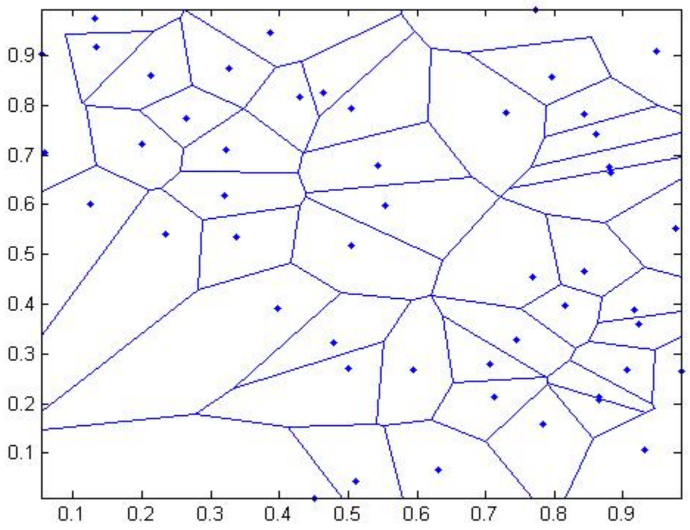
Flow of the proposed cache replacement policy



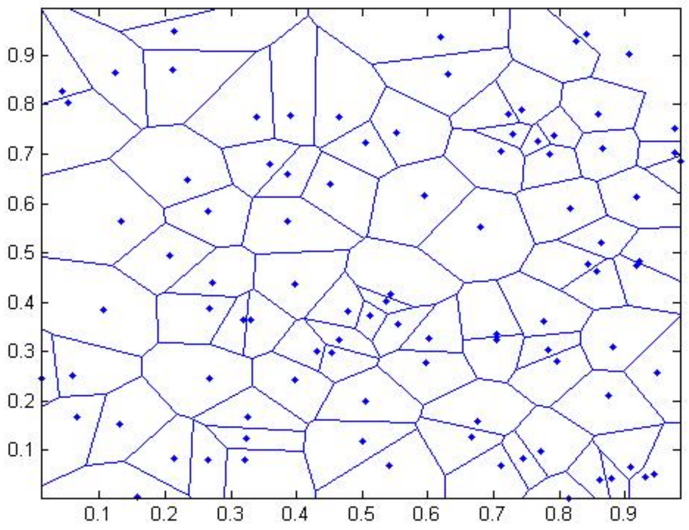
Algorithm

- Input : Rank list, list of current items in the cache
- Output : List of items in the cache
- Procedure :
- **1**: loop i = 0 to all items in the cache
    - Determine lowest ranked item in the cache, Clowest
    - Compare Clowest with the highest ranked item in the rank list, Rhighest.
    - If Rank(Clowest) < Rank(Rhighest) then
        - Replace Clowest with Rhighest
        - Remove Rhighest
    - If Rank(Clowest) >= Rank(Rhighest) then
        - Exit
- End loop

Scope Distributions

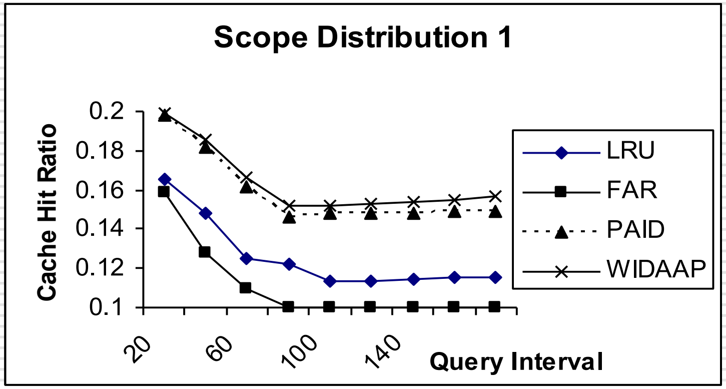


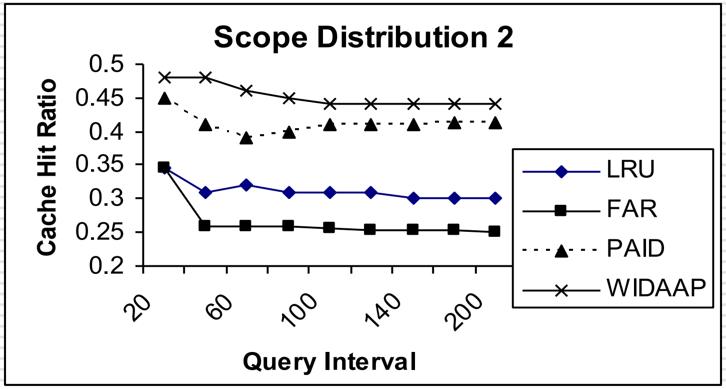
Scope distribution S1



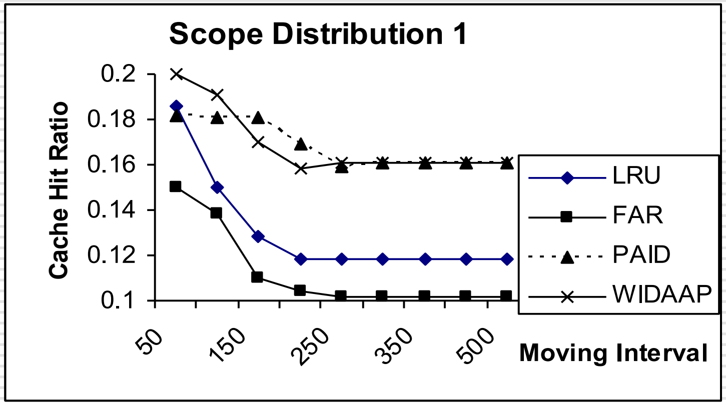
Scope distribution S2

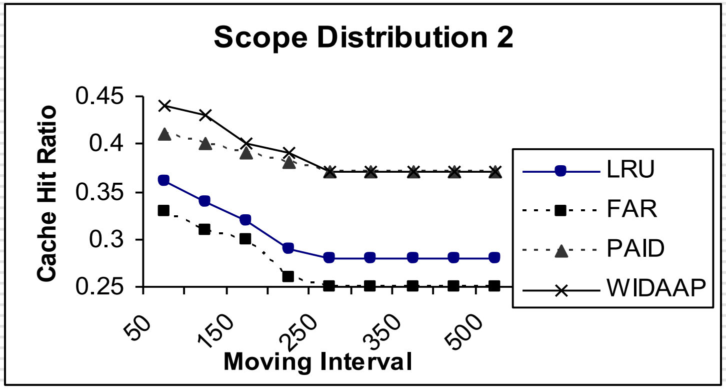
Effect of changing Query Interval



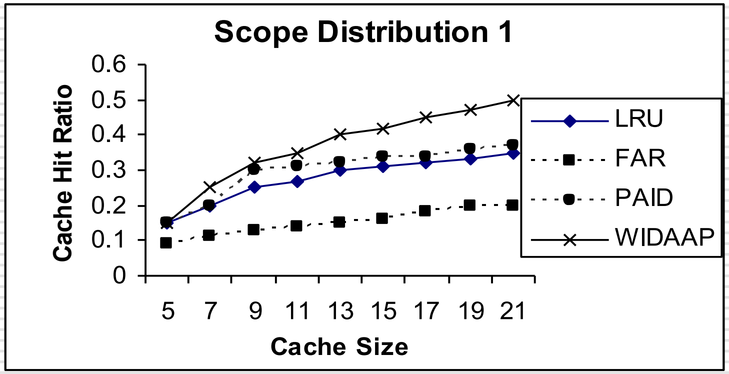


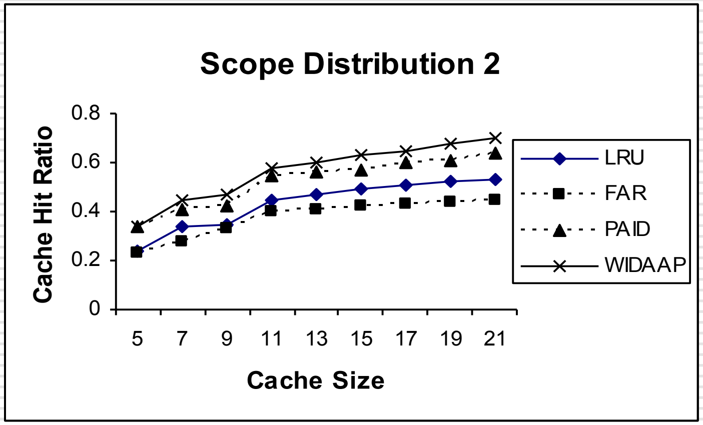
Effect of changing Moving Interval





Effect of Cache Size





Thank You

Cache Replacement

- Cache Replacement Decisions

1. Distance between a client’ s current location and the location of each cached data object
2. Movement direction of mobile clients and the object’ s updates.

- The most common replacement policies are:
- Extensions of traditional replacement techniques
- Key-based techniques use priority factors
- Function-based techniques use time factor