IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 4, No 2, July 2011
ISSN (Online): 1694-0814
www.IJCSI.org

Enhanced-Location-Dependent Caching and Replacement Strategies in Mobile Environment

Kahkashan Tabassum[1] , Mahmood Quadri Syed[2] and Dr. A. Damodaram[3]

[1]Associate Professor, Department of Computer Science Engineering, Muffakham Jah College of Engineering,
Osmania University, Hyderabad-500155, Andhra Pradesh , India

[2]Student, Department of Computer Science Engineering, Muffakham Jah College of Engineering,
Osmania University, Hyderabad-500155, Andhra Pradesh , India

[3]Professor, Department of Computer Science Engineering, JNTU, Kukatpally ,
Hyderabad-500085, Andhra Pradesh , India

Abstract

Mobile computing has developed a lot during recent years. Location dependent services are most popular services that the mobile communications support. Still caching is a critical issue that plays a vital role in improving these services. In this paper, we examine cache invalidation and cache replacement strategies in mobile environment under a geometric model which uses semantic caching. An existing caching efficiency criterion called CEB (Caching Efficiency Based) Scheme has been enhanced in this paper. The new scheme is called Enhanced CEB (E-CEB). The existing replacement schemes such as PA and PAID has also been enhanced to get better throughput. We have conducted a series of simulation experiments to study the performance of the algorithm. The experimental results show that the new criteria are effective.

Keywords: *Mobile computing, location-dependent information, cache replacement, cache invalidation, semantic caching.*

1. Introduction

Studies in computer hardware technology and wireless communication networks have evolved into the result of *mobile* computing. The ability to move has given rise to classes of applications for mobile environments. Location Dependent Information Service (LDIS) is a service where information provided to users is based on their current location and is the part of applications which are getting popular day-by-day [5], [8], [21]. Location is an important characteristic of information for representing, storing, and querying location-dependent information. Location dependent data (LDD) is the data whose value is to be determined from the present geographical location of the mobile user from where the query originates. In a location-dependent query, a location is needed to be specified explicitly or implicitly. A location model depends heavily on the underlying location identification technique employed in the system. The available schemes for determining locations can be classified into two basic approaches Symbolic Model .and Geometric Model**.** In the former the location space is divided into disjoint zones and each zone is identified with a unique name. Examples are Cricket and the cellular infrastructure. In the latter a location is specified as a 3 -dimensional coordinate, e.g., GPS.

Mobile clients in wireless environments suffer from scarce bandwidth, low quality communication, weak and intermittent connectivity, frequent network disconnections, and limited local resources .Also, contacting the server for data is expensive in wireless network and may be impossible if client is disconnected[10]. Data caching on mobile clients has been considered an effective solution to improve system performance and facilitate disconnection [1][2].There are two common issues involved in client cache management: a cache invalidation scheme maintains data consistency between the client's cache and the server; a cache replacement policy determines which data item(s) should be deleted from the cache when the cache does not have enough free space to accommodate a new item[1][2][20]. Researchers in have contributed towards cache management for LDD. In three cache invalidation schemes were proposed based on geometric model: Polygonal Endpoints (PE) Scheme, Approximate Circle (AC) Scheme and Caching-Efficiency-Based (CEB) Method[27].CEB is based on caching efficiency and it balances the overhead and the precision of valid scope that is to be sent to mobile client along with response data. PA and PAID were the cache replacement schemes that were proposed in a previous which took factors like probability, area of valid scope and distance in to consideration[27].

In this paper, we have enhanced the CEB scheme so that it becomes more accurate. We have taken two new things into considerations for choosing a candidate valid scope. The new scheme E-CEB is aiming at more accuracy. We have introduced an additional factor for cache replacement apart from existing ones.

2. Related Work

Data Caching at mobile clients is a necessary for increasing system's performance in a mobile environment [1] [2].In this section we will see the existing systems present which are based on cache invalidation and replacement strategies in mobile environment.

There are two types of invalidation methods [22][23]. One is temporal dependent invalidation and second is Location dependent invalidation. In temporal dependent invalidation, the server keeps track of the update history and sends periodic updates in the form of invalidation reports (IR) to the client by periodic or aperiodic broadcast of messages[2][4][11][12]. In Location dependent invalidation, a previous data that is stored in the cache becomes invalid when the client moves to another new location. Semantic data caching has been used where the location of the data should be associated with the information in the cache [6][15]. Cache replacement policies for mobile environment were first examined during the broadcast disk project [1][13]. Pix policies, Min-Saud, Gray scheme are few cache replacement strategies which take data access probability in to consideration [20]. Few data distance based cache replacement policies like Manhattan distance and FAR have been proposed [6][15].

3. System Model

We think of a cellular mobile network which is similar to the mobile computing infrastructure [2]. It has two different sets of components: mobile clients and fixed hosts. Some of the fixed hosts, called mobile support stations (MSSs), are augmented with wireless interfaces. An MSS can communicate with mobile clients within its radio coverage area, called a wireless cell. Mobile clients and the fixed data servers can communicate with each other through wireless channels via MSSs.

A mobile client can move freely from one location to another while retaining its wireless connection. Seamless Hand-off from one cell to another is assumed. The information system provides location-dependent services to mobile clients. We refer to the geographical area covered by the system as the service area. A data item can show different values when it is queried by clients at different locations. Note that, in this paper, we distinguish data item value from data item, i.e., an item value for a data item is an instance of the item valid for a certain geographical region. For example, "nearest restaurant" is an item and the data values for this item vary when it is queried from different locations. In this paper, we assume a geometric location model, i.e., a location is specified as a two-dimensional coordinate. Mobile clients can identify their locations using systems such as the Global Positioning System (GPS) [9]. We are now going to introduce two definitions: valid scope and scope distribution. The valid scope of an item value is defined as the region within which the item value is valid. The set of valid scopes for all of the item values of a data item is called the scope distribution of the item. A mobile client can cache data values on its local disk or in any storage system that survives power-off. In this paper, data values are assumed to be of fixed sizes and read-only so that we can omit the influence of data sizes and updates on cache performance and concentrate on the impact caused by the unique properties of location-dependent data.

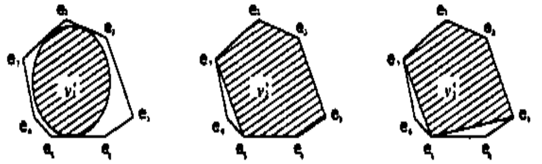
4. Existing System

Baihua Zheng, Jianliang Xu, and Dik L. Lee proposed three schemes for valid scope representation for cache invalidation namely Polygonal Endpoints (PE), Approximate Circle (AC) and Caching Efficiency Based (CEB) scheme. In the same paper, two cache replacement policies were also proposed namely PA and PAID [27].

4.1. Cache Invalidation

The PE scheme records all the endpoints of a polygon to record its valid scope [27]. But as the number of endpoints of the polygon increase, the overhead also increases. More memory is required to store the endpoints in the cache which affects its performance.

The AC scheme takes a inscribe circle in the polygon which requires just a center point and a radius which takes less memory when compared to PE scheme [27]. But this scheme fails when the polygon is thin and long as the inscribe circle cannot cover the maximum area of the polygon.



(a) v_1' inscribed circle of v (b) v_2' $p(e_1,e_2,e_3,e_4,e_5,e_7)$ (c) v_3' $p(e_1,e_2,e_3,e_5,e_7)$

Fig 1. Example of possible candidate valid scope {v=p (e1….e7)}

Due to these problems a new scheme CEB was introduced which balanced the overhead and precision of valid scopes [27]. It takes a valid scope and determines all possible candidate valid scopes and chooses the best candidate valid scope which maximizes the efficiency. The first candidate valid scope is a inscribe circle. To obtain other candidate valid scopes it goes through a series of iterations. During iterations, it uses a greedy approach and eliminates a single point at a time in the polygon to obtain sub polygon. Assume that the valid scope of a data value is v, and v^1i is a sub region contained in v. Let D be the data size, A (v^1i) the area of v^1i, and O (v^1i) the overhead needed to record the scope v^1i [27]. The caching efficiency of the data value with respect to a scope v0i is defined as follows [27] :

$$E(v^1_i) = \frac{A(v^1_i)/A(v)}{(D+O(v^1_i)/D} = \frac{A(v^1_i)D}{A(v)D+O(v^1_i)} \qquad (1)$$

Algorithm used in Selection of the Best Valid Scope for the CEB Method:

```
Input: valid scope v =p(e1,……..,en) of a data value;
Output: the attached valid scope  $v^1$, $v^1$cv; Procedure:
$v^1_1$ := the inscribed circle of p(e1;……….; en);
$v^1$:= $v^1_1$ ;Emax := E ($v^1_1$);
$v^1_i$ = p(e1;………..; en);
i := 2;
while n – i ≥ 1
    //{containing at least three end-points for a polygon}
    if E ($v^1_i$)i > Emax then
        $v^1$:= $v^1_i$; Emax: = E ($v^1_1$);
    end if
    if n - i > 1
        $v^1_{i+1}$ := the polygon that is deleted one endpoint
        From $v^1_i$ while being bounded by v and has the
        Maximal area;
    end if
    i := i +1;
end while
output $v^1$.
```

4.2. Cache Replacement

The various cache replacement schemes that have been proposed up to now were mostly base on probability. The data items that have the least access probability will be from the cache. Here two new factors were introduced namely valid scope area and data distance. The Valid Scope Area is the area within which the data value is valid. The Data Distance is the distance between current location of the user and the valid scope of the data value. The Probability Area (PA) scheme calculates the product of access probability and area of valid scope of data item [27].

$$c_{ij} = P_i \,.\, A\,(v^1_{ij}) \qquad (2)$$

Probability Area Inverse Distance (PAID) scheme calculates the product of access probability with area of valid scope of data item and divides this value with the data distance [27].

$$c_{ij} = \frac{P_i \,.\, A\,(v^1_{ij})}{D\,(v^1_{ij})} \qquad (3)$$

There are two variations of PAID namely PAID-U and PAID-D. In PAID-U, it directly calculates the distance without considering the current direction of movement [27]. In PAID-D, it calculates the distance considering the current direction of movement of the user. The valid scope area can be obtained easily as it is attached with the data value. The data distance can be calculated by taking a point of a polygon as a reference point and calculating distance between user's current location and the reference point. The probability can be calculated as follows [27]

$$P_i = \alpha \,/\, (t_c - t_i{}^1) + (1 - \alpha)\, P_i \qquad (4)$$

Where t_c is the current time, t_l is the time of last access and α is a constant factor to weight the importance of the most recent access in the Probability estimate [27].

5. Enhanced CEB (E-CEB)

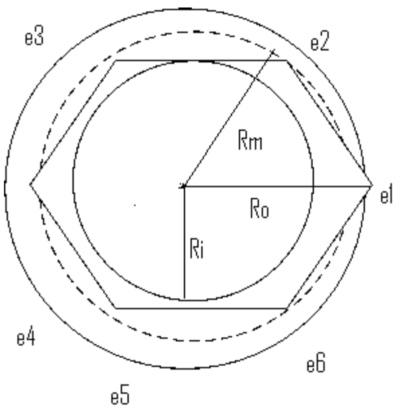


Fig 2: Median Circle of valid scope {v=p (e1….e7)}

Improvement to CEB is E-CEB.it adds a new candidate valid scope to the existing CEB scheme. In the CEB scheme, the candidate valid scopes were a inscribe circle and the sub polygons. Apart from these two, we have added a new candidate valid scope called a median circle. The median circle is the circle whose radius is between the inscribe circle's radius and the outer circle radius. The problem with inscribe circle is it covers less valid scope area when the polygon is thin and the outer circle covers area which is outside the valid scope area. So, In these cases a median circle can be efficient. We can obtain a radius of median circle by

$$R_m = R_i + \frac{R_o - R_i}{2} = \frac{R_o + R_i}{2} \tag{5}$$

Where R_o is the radius of outer circle and R_i is the radius of inscribe circle. R_m is the radius of the required median circle

Algorithm used in Selection of the Best Valid Scope for the E-CEB Method:

Input: valid scope v =p(e1,……..,en) of a data value;
Output: the attached valid scope v^1, $v^1 \underline{c} v$; Procedure:

```
$v^1_1$ := the inscribed circle of p(e1;……….; en);
$v^1 := v^1_1$ ;Emax := E ($v^1_1$);
$v^1_2$ := the median circle of p(e1;……….; en);
if E ($v^1_2$) > Emax then
    $v^1 := v^1_2$; Emax: = E ($v^1_2$);
end if
$v^1_i$ = p(e1;………..; en);
i := 3;
while n – i ≥ 1
    //{containing at least three end-points for a polygon}
    if E ($v^1_i$) > Emax then
        $v^1 := v^1_i$; Emax: = E ($v^1_1$);
    end if
    if n - i > 1
        $v^1_{i+1}$ := the polygon that is deleted one endpoint From $v^1_i$ while being bounded by v and has the Maximal area;
    end if
    i := i +1;
end while
output $v^1$.
```

The efficiency is calculated the same way it was calculated in CEB.

6. Enhanced Cache Replacement Policies.

The existing cache replacement policies i.e., PA and PAID has been enhanced to accommodate a new factor data size, which is taken into consideration whenever an item has to be removed from cache.

Data Size: The data size refers to the size of the data stored in cache. If the data with larger size is removed from cache and is required again then it becomes a overhead to again record the larger value in the cache all over again. So the data which is smaller in size should be removed instead of data which is larger in size, So as to reduce the over head and increase the performance.

The PA scheme has been enhanced to incorporate data size alongside with probability and area of valid scope. The cost function for a data value j of an item i is

$$c_{ij} = \frac{P_i \,.\, A\,(v^1_{ij})}{D_s} \tag{6}$$

Where P_i is the access probability of item I, A **(v^1_{ij})** is the area of the attached valid scope **v^1_{ij}** for data value j and D_s is the Data size.

The PAID scheme has also been enhanced to accommodate the data size factor, Area of valid scope, probability and distance. The cost function for a data value j of an item i is

$$c_{ij} = \frac{P_i \,.\, A\,(v^1{}_{ij})}{D(v^1{}_{ij}).\, D_s} \qquad (7)$$

Where P_i is the access probability of item I, A **($v^1{}_{ij}$)** is the area of the attached valid scope **$v^1{}_{ij}$** for data value j, Ds is the Data size and D ($v^1{}_{ij}$) is the distance.

As the data is stored in cache, acquiring data size will not be an issue here. Hence, the data size is obtained by checking the amount of memory it takes in cache.

7. Simulation Model

In this section, we describe the simulation model use to assess the performance of the proposed strategies. Our simulator is developed in java.

7.1. System Execution model

The cellular network consists of cells and provides seamless handoffs from one cell to another cell. The network can be assumed as a single large service area. The service area is portrayed as a rectangle of fixed size of Size. The database contains ItemN items and every item may have ScopeN different values for different client locations within the service area. Every data value has a size of DataSize. Double precision floating point number is used to represent two dimensional coordinate system and radius. The uplink channel is used by the client to query the server and the downlink channel is used by the server to respond to the query.

7.2. Client Execution Model

Table 1: Configuration Parameters of the Client Execution Model

Parameter	Description
QueryInterval	size of the rectangle service area
CacheSizeRatio	number of data items in the database
ParaSize	number of different values at various locations for each item
Θ	size of a data value
α	bandwidth of the uplink channel

Client is designed to have an independent Process: query process. The query process repeatedly generates queries for different data items. After the present query is completed, the client waits for an exponentially distributed time period with a mean of QueryInterval before the next query is issued. To respond to a query, the client's cache is checked first. If the data value for the requested item with respect to the current location is found, then no need to go all the way to the server and get back the answer. Otherwise, the client gives the query and its current location to the server and retrieves the data from the server through the downlink channel. The client is assumed to have a fixed size cache, which is a CacheSizeRatio ratio of the database size. In order to be just with different caching schemes, the cache contains both the space needed for storing item and the space available for storing data. Each cached parameter occupies ParaSize bytes.

7.3 Server Execution Model

Server is designed to have a single process that accepts the requests from clients and respond them. The requests are stored in a buffer at the server if necessary and an infinite queue is assumed. The FIFO principle is used in the design. To answer a query, the server uses a planar point location algorithm (pploc) 5 to locate the correct data value with respect to the specified location. As the concern of this paper is the cost of the wireless link, which is more expensive than the wired-link and disk IO costs, the overheads of request processing and service scheduling at the server are assumed to be negligible in the model.

Table 2: Configuration Parameters of the Server Execution Model.

Parameter	Description
Size	size of the rectangle service area
ItemN	number of data items in the database
ScopeN	number of different values at various locations for each item
DataSize	size of a data value
UplinkBand	bandwidth of the uplink channel
DownlinkBand	bandwidth of the downlink channel
F loatSize	size of a floating-point number

8. Performance Evaluation

In this section, the proposed strategies are evaluated using the simulation model described in the previous section. The cache hit ratio, caching efficiency and cost function are used as performance evaluation metrics. The table below shows the default parameter

Table 3: Default Parameter for Execution

Parameter	**Setting**	**Parameter**	**Setting**
Size	4000*4000	*QueryInterval*	50.0s
ItemN	500	*CacheSizeRatio*	10%
ScopeN	110	θ	0.5
DataSize	128 bytes	*F loatSize*	4 bytes
UplinkBand	19.2 kbps	*DownlinkBand*	144 kbps

8.1. Evaluation of Location-Dependent Invalidation Schemes

In this section, we will assess the performance of the proposed scheme E-CEB for valid scope representation during cache invalidation. This section assesses the performance CEB comparatively with E-CEB. The metrics used to compare these location dependent invalidation schemes are cache hit ratio and caching efficiency. The parameters that vary are query interval and data size. In the simulation, if not a single scheme is applied, the cache hit ratio is mostly zero since the probability that the client issues the same query at the same place and that the query result is cached is very low. The proposed invalidation scheme E-CEB improves the cache hit ratio upon CEB. E-CEB is better comparatively than CEB. We can the comparative performance results in the figures shown below which uses the cache hit ratio metric as its primary metric is as follows.

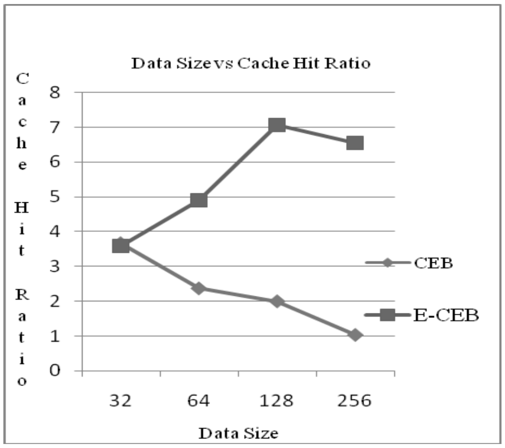


Fig 3. Data Size vs. Cache Hit Ratio

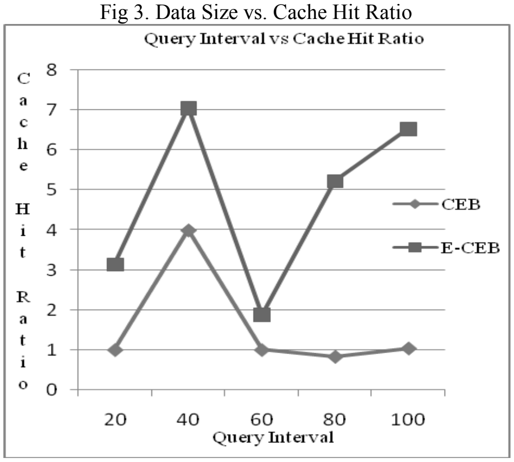


Fig 4. Query Interval vs. Cache Hit Ratio

Another metric used to assess the performance of location dependent invalidation schemes is the caching efficiency criterion. This also shows that E-CEB gives a better performance than CEB as the performance results are shown in the figures 3 and 4 which depict the results. The figure follows

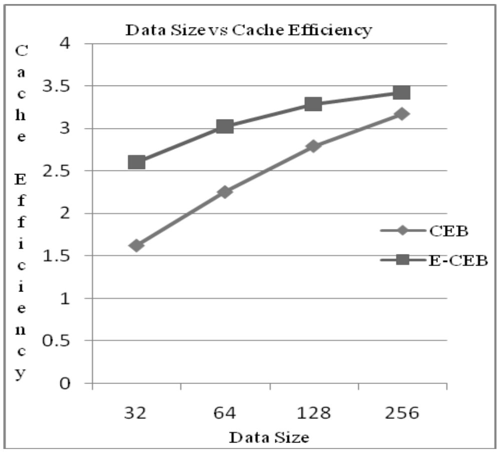


Fig 5. Data Size vs. Cache Efficiency

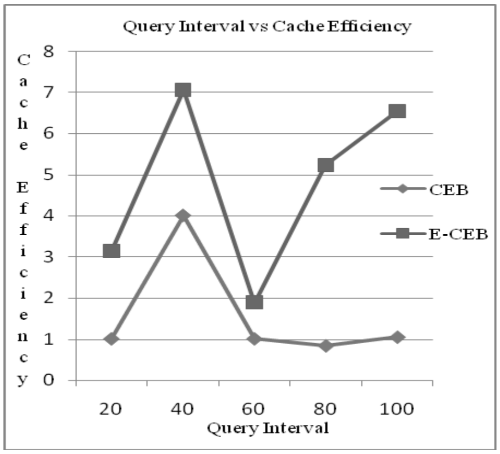


Fig 6. Query Interval vs. cache efficiency

8.2. Evaluation of Cache Replacement Policies

In this section, the proposed cache replacement policies, namely Enhanced PA and PAID is assessed. We compare their performance to the existing policies PA and PAID policies. We use two metrics to assess the performance of the proposed schemes namely query interval and cost function. Query interval is the time interval between two consecutive client queries. In this simulation, we vary the mean query interval from 20 seconds to 100 seconds. If the query interval is increased, every scheme gets a worst performance. This is because, between a longer query interval, the client would make more movements between two successive queries, which means that the client has a lower probability of being in one of the valid scopes of the previously queried data items when a new query is issued.

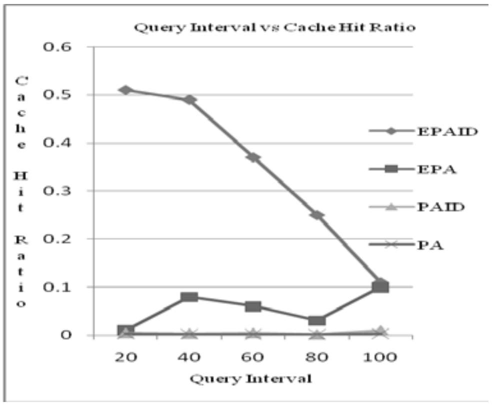
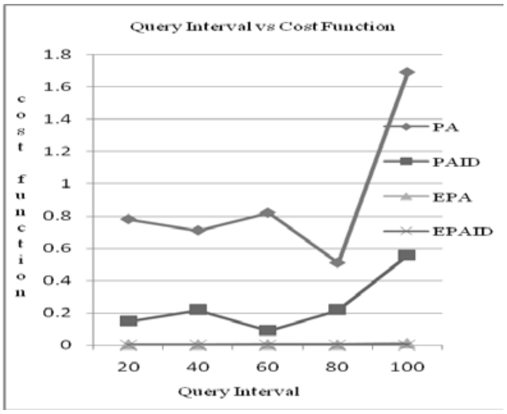


Fig 7. Query Interval vs. Cache Hit Ratio

Another metric that is used to assess the performance of the cache replacement policies proposed in this paper is the cost function. The cost function calculates the overhead of an item being replaced in cache. This criterion also shows a better performance than the earlier schemes. The performance results are shown in fig 6 which is shown below.



, Fig 8. Query Interval vs. Cost Function

9. Conclusions

In this paper we have introduced various location dependent cache invalidation strategies. We have introduced a new scheme called Enhanced CEB (E-CEB) for cache invalidation and we have enhanced the existing cache replacement schemes PA and PAID. In E-CEB, we have introduced a concept called median circle. Among all the candidate valid scopes the median circle is also taken as a candidate valid scope. The median circle is the circle whose radius is in between the inscribe circle and outer circle of the polygon. The result shows that the E-CEB scheme with median circle is effective. We have also introduced a new factor in the existing PA and PAID cache replacement scheme. The new factor introduced was the data size. The data size refers to the size of data items stored in cache. The data with large size should be kept in the cache in order to avoid the over head of recording it again in the cache. The experimental results show that the Enhanced version of PA and Paid is very cost effective and show better results. Hence, we conclude that the proposed location dependent caching strategies for cache invalidation and cache replacement are effective and show better results.

References

[1] S. Acharya, R. Alonso, M. Franklin, and S. Zdonik, “Broadcast Disks: Data Management for Asymmetric Communications Environments,” Proc. ACM SIGMOD Conf. Management of Data, pp. 199-210, May 1995.
[2] D. Barbara and T. Imielinski, “Sleepers and Workaholics: Caching Strategies for Mobile Environments,” Proc. ACM SIGMOD Conf. Management of Data, pp. 1-12, May 1994.
[3] M. Berg, M. Kreveld, M. Overmars, and O. Schwarzkopf, Computational Geometry: Algorithms and Applications, chapter 7. New York: Springer-Verlag, 1996.
[4] G. Cao, “A Scalable Low-Latency Cache Invalidation Strategy for Mobile Environments,” Proc. Sixth Ann.

ACM/IEEE Int'l Conf. Mobile Computing and Networking (MobiCom 2000), pp. 200-209, Aug. 2000.

[5] K. Cheverst, N. Davies, K. Mitchell, and A. Friday, "Experiences of Developing and Deploying a Context-Aware Tourist Guide: The GUIDE Project," Proc. Sixth Ann. ACM/IEEE Int'l Conf. Mobile Computing and Networking (MobiCom 2000), pp. 20-31, Aug. 2000.

[6] S. Dar, M.J. Franklin, B.T. Jonsson, D. Srivatava, and M. Tan, "Semantic Data Caching and Replacement," Proc. 22nd Int'l Conf. Very Large Data Bases (VLDB '96), pp. 330-341, Sept. 1996.

[7] Spatial Datasets, http://dias.cti.gr/~ytheod/research/datasets/ spatial.html, 2002.

[8] M.H. Dunham and V. Kumar, "Location Dependent Data and Its Management in Mobile Databases," Proc. Ninth Int'l Workshop Database and Expert Systems Applications, pp. 414-419, Aug. 1998.

[9] I.A. Getting, "The Global Positioning System," IEEE Spectrum, vol. 30, no. 12, pp. 36-38, 43-47, Dec. 1993.

[10] T. Imielinski and B.R. Badrinath, "Mobile Wireless Computing: Challenges in Data Management," Comm. ACM, vol. 37, no. 10, pp. 18-28, 1994. 1152 IEEE TRANSACTIONS ON COMPUTERS, VOL. 51, NO. 10, OCTOBER 2002

[11] J. Jing, A.K. Elmagarmid, A. Helal, and R. Alonso, "Bit-Sequences: A New Cache Invalidation Method in Mobile Environments," ACM/Baltzer J. Mobile Networks and Applications (MONET), vol. 2, no. 2, pp. 115-127, 1997.

[12] A. Kahol, S. Khurana, S.K.S. Gupta, and P.K. Srimani, "A Strategy to Manage Cache Consistency in a Distributed Mobile Wireless Environment," IEEE Trans. Parallel and Distributed Systems, vol. 12, no. 7, pp. 686-700, July 2001.

[13] S. Khanna and V. Liberatore, "On Broadcast Disk Paging," SIAM J. Computing, vol. 29, no. 5, pp. 1683-1702, 2000.

[14] J. O'Rourke, Computational Geometry in C, chapter 5. Univ. of Cambridge Press, 1994.

[15] Q. Ren and M.H. Dunham, "Using Semantic Caching to Manage Location Dependent Data in Mobile Computing," Proc. Sixth Ann. ACM/IEEE Int'l Conf. Mobile Computing and Networking (MobiCom 2000), pp. 210-221, Aug. 2000.

[16] R. Seidel, "A Randomized Planar Point Location Structure,"ftp://ftp.geom.umn.edu/pub/contrib/comp_geom, 2002.

[17] J.R. Shewchuk, "Triangle: Engineering a 2D Quality Mesh Generator and Delaunay Triangulator," Proc. First Workshop Applied Computational Geometry, pp. 124-133, May 1996.

[18] K.L. Tan, J. Cai, and B.C. Ooi, "An Evaluation of Cache Invalidation Strategies in Wireless Environments," IEEE Trans. Parallel and Distributed Systems, vol. 12, no. 8, pp. 789-807, Aug.2001.

[19] J. Xu, Q.L. Hu, W.-C. Lee, and D.L. Lee, "An Optimal Cache Replacement Policy for Wireless Data Dissemination under Cache Consistency," Proc. 30th Int'l Conf. Parallel Processing (ICPP '01), pp. 267-274, Sept. 2001.

[20] J. Xu and D.L. Lee, "Querying Location-Dependent Data in Wireless Cellular Environments," Proc. WAP Forum/W3C Workshop Position Dependent Information Services, Feb. 2000.

[21] J. Xu, X. Tang, and D.L. Lee, "Performance Analysis of Location-Dependent Cache Invalidation Schemes for Mobile Environments,"IEEE Trans. Knowledge and Data Eng., to appear.

[22] J. Xu, X. Tang, D.L. Lee, and Q.L. Hu, "Cache Coherency in Location-Dependent Information Services for Mobile Environments," Proc. First Int'l Conf. Mobile Data Access (MDA '99), pp. 182-193, Dec. 1999.

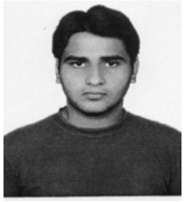
[23] B. Zheng and D.L. Lee, "Processing Location-Dependent Queries in a Multi-Cell Wireless Environment," Proc. Second ACM Int'l Workshop Data Eng. for Wireless and Mobile Access (MobiDE '01), pp. 54-65, May 2001.

[24] B. Zheng and D.L. Lee, "Semantic Caching in Location Dependent Query Processing," Proc. Seventh Int'l Symp. Spatial and Temporal Databases (SSTD '01), pp. 97-116, July 2001.

[25] G.K. Zipf, Human Behaviour and the Principle of Least Effort. Addison-Wesley, 1949.

[26] Baihua Zheng, Jianliang Xu, Student Member, IEEE, and Dik L. Lee "Cache Invalidation and Replacement Strategies for Location-Dependent Data in Mobile Environments"

Kahkashan Tabassum is an Associate Professor in CSED, Muffakham Jah College of Engg. and Tech., Hyderabad, India. She received her Master degree in Computer Science and Engineering in the year 2005 from Jawaharlal Nehru Technological University, Hyd, India. Her area of interests are Database Management Systems, Mobile Computing, Network Security and Data Mining. She teaches and guides projects at B.E. and M.E. level. She is Life member of CSI. She has published 20 technical papers in National, International conferences and journals.



Mahmood Quadri Syed was a student in CSED, Muffakham Jah College of Engg. and Tech., Hyderabad, India. He received his Bachelor degree in Computer Science and Engineering in the year 2011 from Osmania University, Hyderabad, India. His area of interests includes Computer Networks and Mobile Computing.

Dr. Avula Damodaram is the Director of School of Continuing & Distance Education, JNTU, Hyd. He joined as faculty of CSED, JNTU, Hyd in the year 1989 after completing his Ph. D from the same university. Since then he has served the university in distinguished capacities such as Professor, Head of the Department and Vice Principal. He has successfully guided many Ph.D. scholars. His areas of interest include Computer Networks and Mobile Computing. Dr. Damodaram has published 35 technical papers in National and International journals and presented 45 papers at different National and International conferences.