Consistent Broadcast of Location Aware data on Replicated Mobile Database Environment(CBLD)

Dr. S.Abirami[1] Dr. K.Chitra [2]
Asst. Prof , Dept.of CA&IT [1]
Thiagarajar college(Autonomous)
Madurai-9,Tamil Nadu

Asst.Prof, Dept .of Computer Science [2]
Govt.Arts college,Melur
Madurai, Tamilnadu

Abstract

Consistent broadcast of location dependent data becomes very popular in recent years. Location dependent data services (LDIS) provide convenient and current data access to the mobile clients. Mobile clients may receive inconsistent data because of overlapped execution of broadcast and update transactions on server data or the data inconsistency may occur due to the location changes of mobile clients. Preserving consistency while broadcasting the location dependent data with the minimum resources of mobile clients is the major research issue. In our paper, we have proposed on demand based location aware data broadcasting algorithm using replicated mobile databases for temporal and non temporal databases. To enforce the data consistency and to reduce the resource utilization of mobile clients, we have used compression and decompression mechanism for client server communication. By considering the direction movement of mobile clients and the distances of data items from the service points, the current data broadcast of is achieved in our approach.

Key Words : **Location dependent data base, Mobility aware data, Replicated Database, Cache Consistency, Data Dissemination.**

1. INTRODUCTION

The innovative mobile technologies direct the people to do everything from anywhere with their mobile phones. To get improvement in business sectors and to cover wide range of customers, most and of the E-commerce based application are developed to satisfy the requirements of mobile clients. A new kind of information service called location dependent information service (LDIS) plays the major role in mobile computing environment. Finding the nearest hotels, petrol bunks for the current location of mobile clients, getting current local news and current weather information are the examples for mobile LDIS. These types of LDIS provide convenient and current data access [1][2] to the mobile clients. The information on server can be delivered to the mobile clients using data broadcast approach or on demand delivery method [3][5]. The data broadcast approach disseminates the data from the server continuously to all mobile clients without any requests. But in on demand data delivery, data will be delivered only for the requested clients. To get the current location based information, we have followed the above two models (on demand data broadcast) in our data dissemination approach.

Retrieval of inconsistent data would degrade the entire system is performance [4][9].The data inconsistency may occur due to the overlapped execution of update and broadcast transaction [6][7] otherwise the changes in location of mobile clients may leads to data inconsistency [8]. Our proposed approach is implemented to retain the consistency on location dependent data broadcast for the above two situations. The server workload can be shared by the implementation of replica server. The replica servers provide speedy data access and improve the entire system performance .But the consistency preservation in replicated database environment is an additional burden. In our approach, one server is designated as master server and replica servers are designed as broadcast servers. We have followed single master log based [10] propagation between replica and master server.

The database stored on master server can have temporal or non temporal data [11][12]. In temporal database, values of data items are allowed to update frequently. We have designed our algorithm for these two types of databases (Temporal and Non temporal databases). To get location aware information service, the currently broadcasted data have to be cached on mobile client. The cache should be maintained effectively and the cached data have to be invalidated properly for retaining data currency. It improves data access and reduce the communications among the mobile clients and server [13][14].

Our proposed algorithm caches the most recently broadcasted data and replaces the data which are irrelevant to the current location and to the direction of client movement. The following section-2 describes the related work and their limitations. Section-3 presents our location aware data dissemination system model. The different phases of our proposed algorithm are described in section-4. The performance analysis of proposed system is described in section-5. Conclusion and future enhancements are specified in section-6.

2. Related Work

Effective cache replacement algorithm (MARS) for location dependent data is proposed in [15].When the cached data is invalid or cache is invalid, by considering spatial and temporal properties the cached item will be replaced by this algorithm. It provides the location dependent data access through on demand data requests. MARS employs cost based approach for cache replacements. The cost is calculated using spatial and temporal scores. The data item with the minimum score will be ejected by this algorithm. Since it takes both temporal and spatial properties for cache management, effective cache replacement of location dependent data is achieved .But the data consistency mechanisms for dynamic data are not discussed.

Geometric location model based cache invalidation and replacement policies (PA, ACCEB) are proposed in [16]. Polygonal end points (PE) scheme stores all the end points of polygons represents the valid scope. If the system is larger, it's performance may becomes poor. In Approximate Circle approach (AC) valid scope is estimated b center of inscribed circle to minimize the overhead. It's effectiveness would be very less when the polygon size is larger. The third approach Cache Effective Based (CEB) method calculate the cache efficiency based on data size, data area, overhead to record the scope. It highly reduces the overhead in cache invalidation. Two other schemes PA (Probability Area Inverse Distance),PAID (Probability Access In) .PA calculates the cost for replacement based on access probability and valid scope. In PAID distance factor is also included for computing cost value. Though these mechanisms provide efficient cache management, it doesn't deal the updates to the data items.

Three algorithms bit vector with compression (BVC), grouped bit vector with compression (GBVC) and the implicit scope information (ISI) are proposed in [17]. These three strategies perform cache validation of location dependent data and the organization of validation information. In BVC validity information is attached to a data item value. It includes the complete set of cells in which the data value is stored on cache but the size of BVC vector is equal to the number of cells in the system. Whenever a data item is required for invalidation, the client transaction verifies the broadcasted CID (Cell associated an ID) value. But BVC may lead to the overhead in invalidation process when the system size is larger. The second algorithm reduces the overhead by maintaining the validity information of each data item value only for some of adjacent cells. But if the group size is larger, maintaining validity information leads to overhead. This larger size of validity information may need higher network bandwidth and cache memory. The third scheme (ISI) minimizes the size of validity information by arranging the scope distribution of all items sequentially on server. Still these schemes effectively performs invalidation, they need more network communications.

Enhanced CEB (E-CEB) is and the replacement policy, PA (Probability Area) for location depended data and PAID (Probability Area Inverse Distance) are also extended in [18]. In CEB scheme, the valid scope of date items is considered as inscribe circle and sub polygons. If the system is larger, it increases the overhead and it covers only the smaller valid scope area. But in extended CEB another criteria called median circle (A circle whose radius is between inscribe circle and outer circle radius) is included along with the existing one for the selection of best valid scope. For efficient cache replacement, a new factor data size is included in the cost function of PA and PAID algorithms. These extended algorithms keep the larger data items in cache to reduce the overhead in replacement. Cache management for the temporal data base is not taken into the account by these approaches.

Efficient cache replacement for retaining cache consistency is proposed in [19].On demand based multicast data dissemination for location dependent mobile environment is addressed. The proposed data dissemination method based on special node DTA (Dynamic Transmitting Agent). The Dynamic selection of DTA depends on access rate of mobile node, energy level and the distance among the nodes in network. The proposed replacement policy ejects the data based on retrieval delay, update rate, access probability, and size of data and the cost of invalidation. The proposed approach maintains the strong consistency by selecting stable, highly powerful mobile host to deliver invalidation messages to the peer nodes on network. When a node is disconnected, after getting connection, it has to poll nearest DTA rather than the server for validation. Though these approaches reduce the client server communications, but the direction of client movement is not considered for efficient data dissemination.

The proposed approach in [20] uses fixed host (base station) for storing the cache, instead of caching in mobile clients. A cache manager module retrieves the data from server and controls the operations on cache. It is loaded in fixed host. It monitors the validity of cached data and sends the invalidation when ever data is updated. It reduces the network communication overhead. All the mobile clients can access the data item within PLP. If there is any update requests or PLP of any data expires, it will be invalidated with the change in PLP. If the requested data is in the cache and the value of PLP is valid then it allows the data access by changing the value of PLP, otherwise the data will be fetched from server. If there is any update request, it will be performed locally, and then the invalidation message also sends to the affiliated transactions then the update request given to the server. On server side, if there is any data request, they will be broadcasted. When the server receives update request, the update process will be executed by sending the invalidation messages. It reduces the overhead of mobile clients in cache and replacing the data items. But these types of data caching is not fit for location dependent information services.

3. System Design

Accessing location aware data employs on on-demand data delivery. In our algorithm, the server broadcast the location aware data on broadcast channel. The mobile client's current location and data request would be given to the server through uplink channel. It broadcast the current data to all requested mobile clients until they were disconnected from the network. The broadcasted data would be cached by the appropriate mobile clients (Using Cell ID). Whenever the location of a mobile client is changed, it's CID ,compressed data about direction movement of the mobile client (Including current location) will be given to the server automatically. By decompressing the received data, server would broadcast the required data items relevant to the current location along with the CIDS.

On client side, the received data from the broadcast channel can be cached or cancelled by verifying the current location. Whenever the current location is not changed the broadcasted data will be cached, otherwise the mobile transaction has to issue a pull request along with new location information immediately. Our proposed model is designed with replicated database environment to provide fast data access. Here the master server is responsible for executing update transaction and propagating them to replica. Here all replica server can broadcast the current data to any mobile client. The database stored on master server can be temporal or non temporal. The following figure.1 shows our system model.

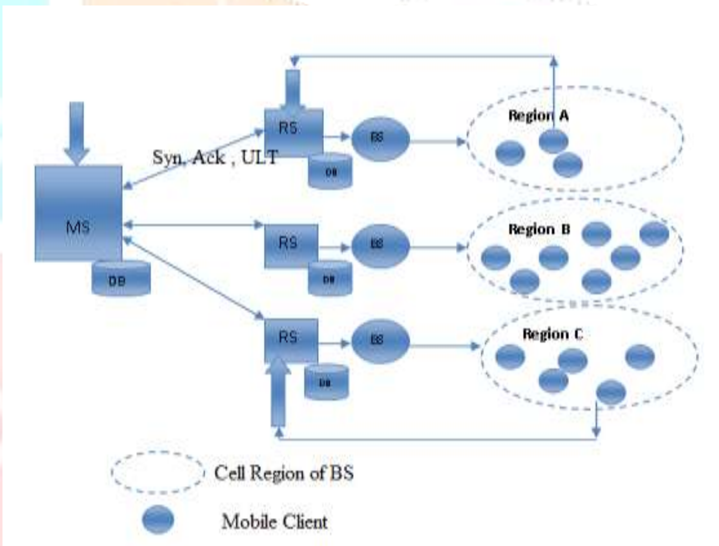

Figure.1 System Model

3.1 Properties of our algorithm

Our proposed data dissemination method broadcast the location dependent data with the following properties,

- We are caching three most recently visited places (Including current location) in compressed form to predict the direction movement of mobile clients.
- Individual mobile clients are identified by unique cell identifier (CID) on wireless network.
- We have assumed that, the current location of mobile clients received from mobile clients using GPS(Global Positioning System).
- The server would broadcast the data item values related to the current location whenever it is changed.
- Cached data items are validated without any invalidation messages.
- Ack and syn mechanisms are used to enforce the synchronization among master server and replicas when the master server is updated.

4. Location dependent data dissemination algorithm.

This algorithm disseminates the current and consistent data to the mobile clients according to their location. Here on demand broad cast method is used to broadcast current data. The requested data closer to the current location will be cached on mobile client and it is invalidated by decompressing the cached content without any server communication. We have designed our approach for temporal as well as non temporal databases. Whenever the database is highly dynamic Syn, Ack signals are used between master and replicas to enforce the data consistency. The update transactions (Either from external devices or from the administrator) will be given to the master server through Queue and the data access requests will be given to the replica servers through uplink channel using another Queue. Our proposed approach is designed with the following three modules,

- Master Server Module
- Broadcast replica module
- Client module

4.1 Master Server Module

This phase is responsible for executing and propagating update transactions. It arranges the data item values in several regions based groups. Each data item on a region keeps region ID, place ID, place, distance to facilitate quick data access. The master server stores temporal or non temporal databases. Based on the type of data , the master server does the process differently.

Case a) Non temporal database stored on MS

In case of non temporal **database**, the MS send the entire content of database to all Replica at once.

Example

When the petrol bunks information (Addresses) is stored on master server, it will not be frequently changed. For each Bunk address, the nearest place, place IDS, distances, region ID will be stored on database for immediate data access. Then entire content of MS data base will be copied to the replica at once.

Case b) Temporal database stored on master server.

The dynamic databases can be updated frequently either by external sensor device or by the administrator of a particular system. Then the MS does the following,

- All update requests will be given to the MS through Queue to avoid preemption then MS retrieves each update request sequentially
- MS send SYN1, set of data IDs (Place IDs their values to be updated) for all Replicas to lock them from broadcast transaction
- Receive ACK1 from all replica servers, execute and commit update transaction send update log transaction to all replicas
- Receive ACK2 from all replica servers, send SYN2 to rebroadcast the updated data item values.

Example

When the weather data base is stored on master server, it will be frequently updated by sensor device. The weather value of a particular place, place ID, region ID will be stored the master server to provide fast access. When the Weather values of particular places are updated, MS has to lock those data IDs from the broadcast transaction to preserve consistency. The MS sends data IDs, Syn1 signal to all replicas to block them. After receiving Ack1 from all replica servers, the update transaction would be executed. Then MS sends update log transaction to all replicas. After receiving Ack2, it sends Syn2 signal for all replicas to rebroadcast the newly updated weather values.

4.2 Broadcast Replica Module

It is responsible for consistent broadcasting of location dependent data. All the replica servers maintains their own set of CIDs, data IDs who were all issued pull request for data access until the mobile client is in connected network. The Data access request from the mobile clients will be given to the particular replica server through Queue. Based on type of data stored on database replica server performs differently. In all cases, if there is any higher priority data request is in the Queue then it will be executed first.

4.2.1 Non Temporal Databases

Whenever the static database is stored on replica server database, the data access requests from the mobile clients will be given to the particular replica server using queue based on cell region. Then the replica server retrieves each data request sequentially from the Queue. If there is any higher priority data request (to invalidate cached data item) on queue, they will be executed immediately by replica server. Then the replica server do the following

- Receive CID, compressed data. Then replica server decompress it to get the information about current location and the already visited places
- Retrieve the nearest three unvisited data item values (Addresses of nearest hotels, Distances) from the database according to the current location if found
- Otherwise (If there is no nearest data item values in forward direction) retrieve most two visited data item values and one unvisited data item value with their distances
- Broadcast CID, compressed form of data item values with their distances on broadcast channel.

Example

When the hotel information data base is stored on MS, it will not be frequently updated If there is any query request (Nearest hotels) issued by the mobile clients, replica server have to receive CID, compressed data about current location and the most two visited places if any. Then it decompress the data and it will retrive the nearest three hotel addresses (Service points) and their distances (not in unvisited place list) from the database for the current location. If there is no nearest service points then BRS would return two already visited places and one unvisited place along with their distances. BRS broadcast CID, compressed form of service points(Hotel addresses) ,distances on broadcast channel.

4.2.2 Temporal Data Bases

If highly dynamic data is stored on master server, the execution of update transaction on MS should be synchronized with all replicas to preserve consistency. Then replica server performs as follows,

- If there is any SN1 signal from MS, replica server set LI for locking the data values from the broadcast transaction. Then replica sever broad cast the CID and Null data for ID list where the IDs are used by CIDs. (To indicate that these are in current update transaction). Then replica server send Ack1 to Master Server
- If there is any update log transaction, it will executed by all replica then Ack2 would be given to MS
- If there is any Syn2 from MS, replica server would rebroadcast the compressed form of newly updated data items which are currently used by the MC
- When there is no update transaction requests, the replica servers broadcast the list of requested data item in compressed form based on their current location. The replica server receive cell IDs(CID) of requested mobile clients, compressed data (Current location of mobile client) from the queue. Then the replica retrieve the data item value from the database for the current location. Then broadcast CID, compressed data item values on broadcast channel.

Example

When the weather information is stored on database, it will be frequently updated on MS. When there is no update transaction on MS, the replica server would receive the requested cell ID(Cell ID), current location from the queue then the replica server retrieve the weather value from the database for the current location of mobile client and broadcast CID, compressed weather value. If there is any

Syn1 signal, then replica set LI with the set of data IDs(Which are in current update process), broadcast these ID list along with CIDs to the mobile clients then send Ack1 to MS. If there is any update log transaction from MS, then replica server has to execute it and send Ack2 to MS. When the replica server received Syn2 form MS, then it rebroadcasts the newly updated weather values in compressed form along with the CIDs.

4.2.3 Replica algorithm

While (true){

If (Data Request) {

- Receive CID, Compressed data
- Decompress the location-ids
    If the CID already existing on database
        Update the current location-id of that CID
    Else
        Insert the CID and its location-id on database
- Retrieve the information for the current location-id based on type of data request
    If location-id is not in block list (LI)
    Compress the location aware information & broadcast it with CID

}

If (Syn1)

{

Set LI as list of Location-ids to block from broadcast transaction .

Send ACK1.

}

If (Update Log Transaction)

{

Execute UT & set UI (Updated information).
Send Ack2.
}

If (Syn2)

{ for each Location-id(x) in LI

If location-id(x) is accessed by any CID on the database

{

Rebroadcast CID, compressed form of UI(x)
}
}
}//while

4.3 Client Module

The client side module is responsible for caching the requested data items and to invalidate the cached data items. Since the client's cache size is very short, we have used compression mechanism to cache the broadcasted data. When the mobile clients open the cache to read the cache content, their content will be decompressed. We have designed the client application for two types of databases (Temporal ,Non Temporal). The client phase performs differently based on types of databases as follows,

4.3.1 Dynamic Data accessed by MC (Not Depend on Direction of movement)

This phase has to send CID, compressed data (current location) to the replica server using uplink channel. Then the client has to cache the requested data item only if the cached current location is not changed. Otherwise this module removes the cached data item value with Null and issues a pull request for new location as the higher priority request to queue of replica server.

Example

When the current weather information for a location is accessed by the mobile client, then CID, compressed form of current location will be given to RS. Then the client can cache the requested weather value only if the cached location is not changed. Otherwise a new pull request for the new location will be given to RS through higher priority Queue request.

4.3.2 Temporal databases(Depend on Direction of movement)

For these of databases, this phase caches the three most recently visited places (Including current) in compressed form. When the mobile clients try to access the dynamic data ,it would send the CID, compressed data(most three visited places) to RS. Then the mobile client can cache their requested data from broadcast channel if the cached current location in not changed. Otherwise the mobile client phase automatically issues a higher priority pull request to RS through Queue.

Example

When the Hospital database is stored on MS, the mobile client may try to access nearest hospital form the current location. This phase has to cache the compressed form of most three visited places on cache. When the mobile client issue a pull request, the broadcasted hospital addresses ,distances and CID can be cached if the cached current location of MC is not changed. Otherwise a new pull request will be given to the RS. In both cases, whenever the current location of MC is changed , this phase automatically issues high priority pull request to RS.

5. Performance Analysis

On analyzing the performance of enhanced LDIS of CIRPT system of providing location aware data service, it is found that the proposed replicated index based location aware data broadcast scheme is studied with the existing approaches of PA (Probability Area), PAID (Probability Area Inverse Distance). The throughput of various size of databases, access time of range of query intervals, cache hit ratio, state access ratio, restart rate are measured to evaluate the performance of the proposed approach.

The proposed location based information service scheme of CIRPT system makes use of java in which, the databases have been designed differently to satisfy the mobile client's requests. In order to satisfy the distance related data requests, this system has been designed with the database of N data item values (Location–ID, information). For each data item (location-ID) there is a set of possible location- ids and their distances to reach that location.

To satisfy **the single information data requests of mobile clients,** the recommended experimental model is designed with the database of N data items (Location-IDs) and their corresponding information.

In order to satisfy the **multiple data request queries**, the system has been implemented with the database of N data item values, with set of possible information related to that location for each data item (location – ID).

This simulation model does not deal with the process of identifying the current location of individual mobile client as it is assumed that the current locations of mobile clients are already cached. Whenever the current location of the mobile clients is cached, the mobile client applications would send an uplink data request to their replica server in compressed form. The clients are assumed to have the same size of cache to have the location-Ids and the location aware information in compressed form. However the selection of cache size depends on database size.

5.1 Experimental Setup

Our system is modeled with a single master server and two replica servers. The master server is responsible for executing update transactions and the replica servers are designed for answering the on-demand requests of mobile clients on broadcast channel through queuing system. Table.1 shows the model parameters and their base values.

Parameters	Base Values
No. of Data items in the Database	1000
No. of Replica Servers	2
Simulation Time	5000Sec
Server Update Transaction Length	1-5
Update Transaction inter arrival time	0.5 Sec- 50sec
No. of Mobile Clients	100
Cache Size	10 % database size
No. of Uplink Channel	1

Table 1. Model Parameters

5.2 Simulation Results

5.2.1. Impact of varying Query Interval

The time interval between two successive client's requests is defined as query interval. The impact of location aware data requests which are issued at different intervals from 20 sec to 140 sec are shown in figure 2. As illustrated, the (PA Probability Area) and their enhanced approaches: PAID-U (Probability Area Inverse Distance-Unidirectional data distances), PAID-D (include direction of distance) are poor in their performances when the interval is longer. The increased number of client's movement reduces the probability of valid scope of previously requested data items. This enhanced replication based broadcast approach of CIRPT caches only the location-ids of current and previously visited locations, since this approach can give consistent cache hit ratio even for the data requests issued at longer query intervals. When the interval is 100 sec, this approach gives the cache hit ratio as 66% (about 69% of PAID-U and it is about 60 % of PAID-D).

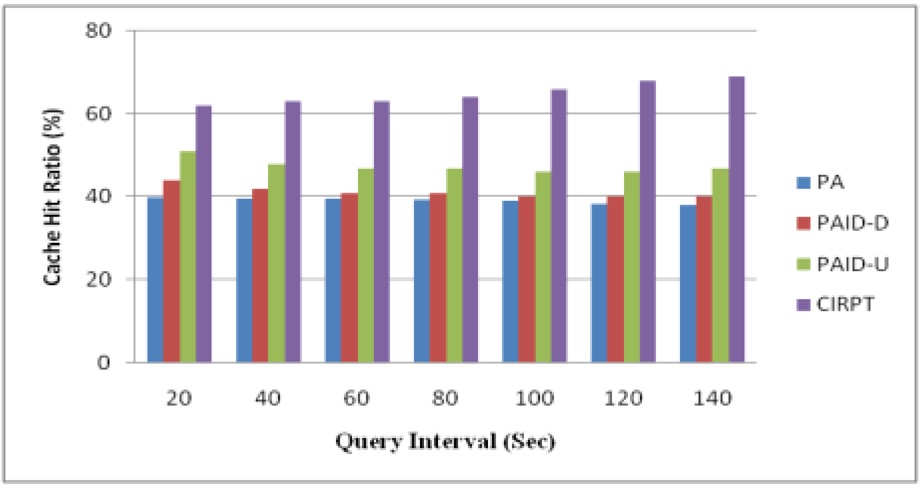

Figure 2. Query Interval (Sec) Vs Cache Hit Ratio (%)

5.2.2 Impact of Concurrent Location Aware Data Read

With the increased number of concurrent requests of mobile clients for their location based data service to the replica servers, the response time for this approach is increased when the database size is 1000 as shown in figure.3 as the system handles the concurrent data requests through queuing system. This throughput is acceptable one for location aware data broadcast approach. Increasing number of replica server improves the throughput for wide range of clients also.

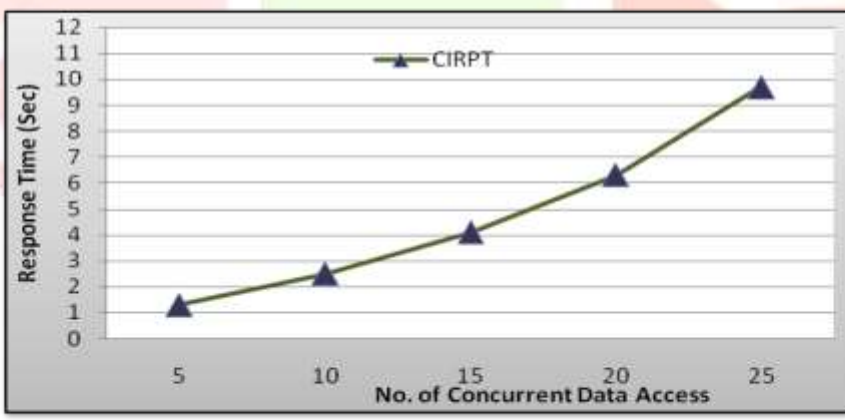

Figure 3. No. of Concurrent Data Access Vs Response Time (Sec)

5.2.3. Impact of Moving Interval

The figure.4 shows that when the client's moving interval is longer, the cache hit ratio of PA and PAID approaches reduces the cache hit as it leave some valid scope. However, the cache hit ratio of this approach is increased. It makes a quick response as it reduces the server workload and minimizes the number of waiting requests in queue also.

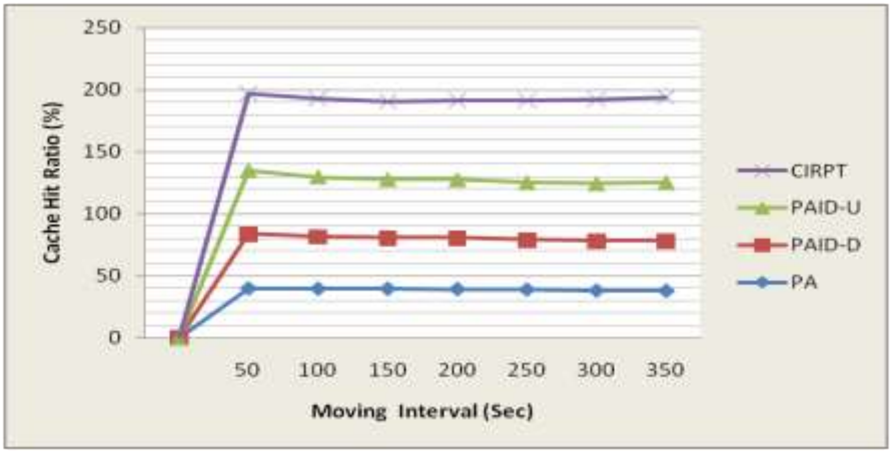

Figure 4. Move Interval Vs Cache Hit Ratio

5.2.4. Impact of Update Interval

The figure.5 reveals that the response time of the proposed approach when server update transactions are executed in different intervals ranges from 1 to 40 seconds. The response time is gradually increased when the update work load is higher because the replica servers need very few milliseconds to verify the active cell identifiers who are all accessing the updated data items. Then the replica servers would rebroadcast the updated data items only to the active mobile clients if they are currently accessing this application. The compression mechanism used to broadcast the information would not cause more delay as already analyzed in section 5.6.4.

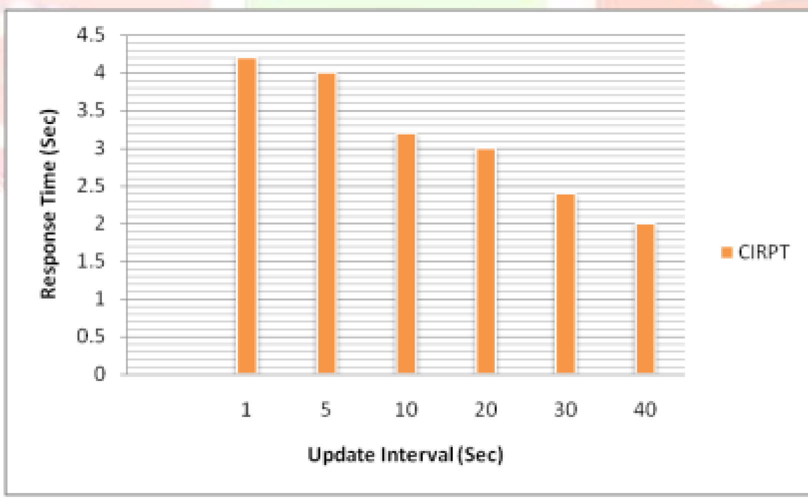

Figure 5. Server Update Interval(sec) Vs Response Time(Sec)

The proposed approach ever broadcasts the consistent data items from the dynamic databases by rebroadcasting the updated data items to the active mobile immediately, which do not restart the transactions due to the data inconsistencies. Thus this approach can give 0% stale access rate and the restart rate as 0 % for any update intervals is shown in figure 6 and 7.

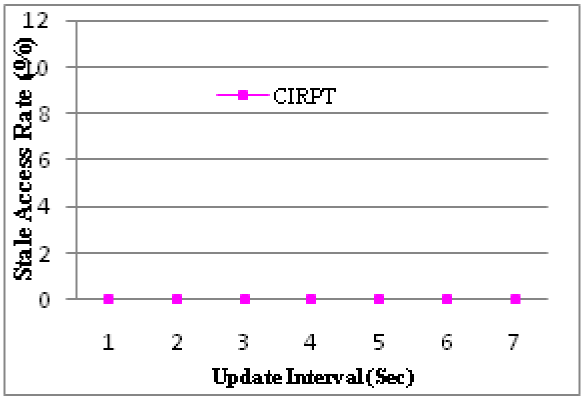

Figure 6. Update Interval(Sec) Vs Stale Access Rate

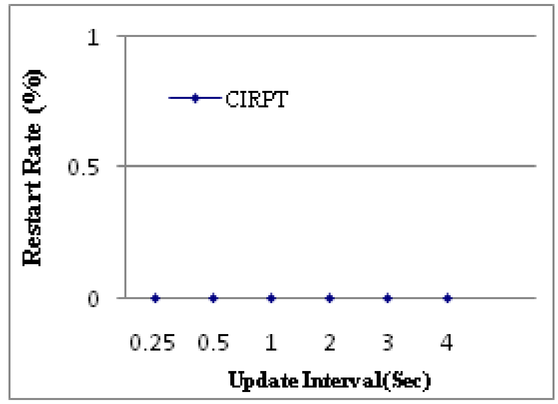

Figure 7. Update Interval(Sec) Vs Restart Rate

The performance analysis of this approach suggests that it can quickly provide the consistent LDIS through minimum communication and power consumption of mobile clients because it provides maximum cache hit ratio and it reduces the data access delay, stale access rate, restart rate with the implementation of replication scheme, queuing and caching mechanisms.

6. Conclusion and Future Enhancements

Consistent data delivery using location aware data caching mechanisms is ensured effectively in our paper. The proposed policy considered spatial properties (Location, distances) for caching current data items and the replacements of irrelevant data. We have designed our model for temporal as well as non temporal databases. We have used compression and decompression mechanisms on cache management to effectively utilize the cache memory. Since we designed the broadcast server as replica in our approach, it provides quick data retrieval to the mobile clients. We maintain the synchronization between the MS and RS through Syn, Ack signals for consistent data broadcast. The proposed approach provide consistent LDIS with the minimum power consumptions (Using caching mechanism) of MC and bandwidth communication (No invalidation Report) efficiently .As a part of our future work, this work can be extend by considering temporal properties in cache replacement decisions and we would like to design this model for the different types of Query systems.

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