Techniques for Acquisition of Moving Object Location in LBS

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Key words: LBS (Location-Based Services), MODB (Moving Object Database), Moving Object, Acquisition of Location.

SUMMARY

The types of service using location Information are being various and extending it's domain as wireless internet technology is developing and it's application part is widespread, so it is prospected that LBS (Location-Based Services) will be killer application in wireless internet services. This location information is basic and high value-added information, and this information services make prior GIS (Geography Information System) to be useful to anybody. The acquisition of this location information from moving object is very important part for these LBS. After this, when LBS is familiar to everybody, we can predict that LBS system load is so heavy for the acquisition of so many subscribers and vehicles. Moving object database (MODB) system manages objects like subscribers and vehicles that are moving and have telecommunication terminal checked one's location. MODB is consists of 4 part, moving object location acquisition part, moving object location storage part, moving object query processing part, and moving object application part. In this MODB system, acquisition of moving object location part must provide guarantee location information as well as reduce telecommunication overhead.

In this paper, we study of problems in acquisition a huge number of moving objects location and design some acquisition strategies to reduce telecommunication overhead. And after implementation these strategies, we estimate performance of this system and quality of information.

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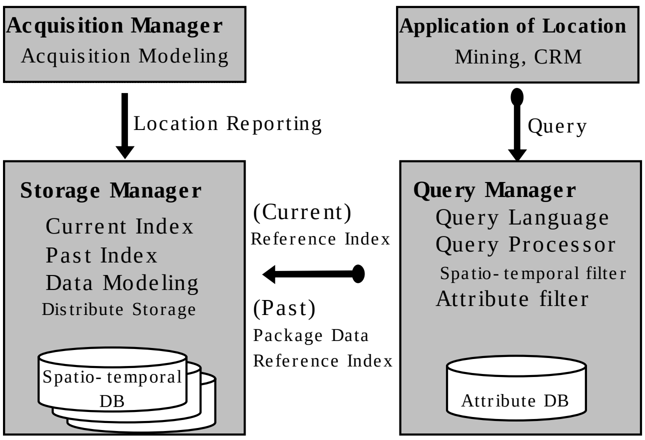
1. INTRODUCTION

As wireless Internet technology is developing and its application part is widespread, as services using by user's mobility are extending. Location-based services are services using by real time information of moving object location. This location information is basic and high value-added information, and this information services make prior GIS (Geography Information System) to be useful to anybody. LBS (Location-based services) platform makes this location-based services enable and can be storing, managing this moving object locations basically. And there will be optimal, shortest path service, dynamic tracking for vehicle, searching geographical contents nearby moving objects, spatiotemporal analysis, map matching between electronic map data and GPS (Global Positioning System) data, spatiotemporal moving historical data mining in kinds of LBS. Moving object is that continuously change its position and shape as time goes by [10]. The MODB (Moving object database) is core part of LBS platform and presently, is managing current moving object locations and serves current location services. But after this, MODB will manage not only current locations but also past locations and serve high value-added services using by this current/past locations. And when LBS are familiar to everybody, we can predict that LBS system load is so heavy for the acquisition of so many subscribers and vehicles. Because of this reason, function of acquisition of moving object locations between LBS platform and mobile telecommunication network is very important in MODB parts. So, in this MODB system, acquisition of moving object location part must provide guarantee location information as well as reduce telecommunication overhead.



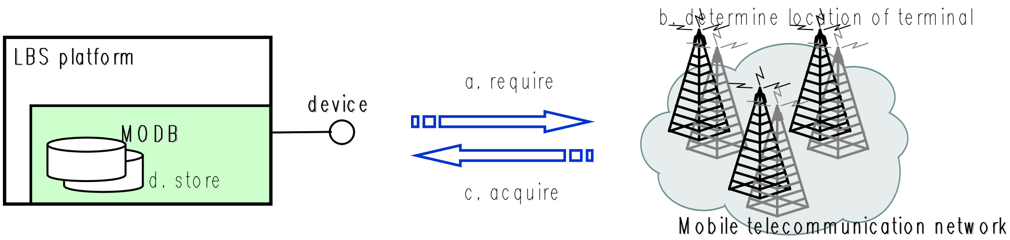
Picture 1 MODB Architecture

Picture 1 shows MODB (Moving Object Database) architecture. It consists of 4 parts, moving object location acquisition part, moving object storage part, moving object query processing part, moving object application part. The acquisition manager acquires moving object location real time and minimizes telecommunication traffic overhead simultaneously. After acquiring information, acquisition manager reports that information to storage manager. Then storage manager distributes current locations and past location to various multiple database system and constructs current memory spatio-temporal index and past disk spatio-temporal index. The query manager retrieves moving object locations through spatio-temporal filter and attribute filter by query language. The application part makes application system like spatio-temporal data mining and CRM (Customer Relationship Manager) using by this stored information.

After this, if the number of moving object in MODBs grows as several million, it takes so much time to acquire location of object and store those in MODBs. Examply if the number of moving object is one million and acquisition interval is one minute, the times of acquisition and storage space is required like below.

- acquisition count per 1 day = 1,000,000 * 1440 = 1,440,000,000 times
- space per 1 day = 1,000,000 * s * 1440 = 1.44 * s G bytes (s = size of moving object)

If LBS platform couldn't acquire location of one million moving objects within one minute because of telecommunication overhead, it can't guarantee the performance of system and quality of information. So, it is useful to adjust flexibly acquisition interval of moving object location. Picture 2 shows flow of acquiring moving object location from mobile telecommunication network, and storing those to database.



Picture 2 The flow of acquiring location of moving object

There are several system overhead in acquiring location of moving object between mobile telecommunication network and LBS platform listed by below.

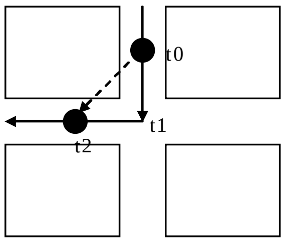
- a, c : telecommunication overhead for acquiring location of moving object.
- b : internal signal traffic overhead for determining location of terminal
- d : filtering steps overhead before storing information and construction overhead moving indices

So, we have researched the techniques of minimize telecommunication overhead (a,c) in acquiring location of so many moving objects and therefore we can minimize other overheads in moving object database and mobile telecommunication network (b, d).

In this paper, we study of problems in acquisition a huge number of moving objects location and design some acquisition techniques to reduce telecommunication overhead. And after implementation these strategies, we estimate performance of this system and quality of information. In the beginning, we will observe relate work in section 2. In section 3, we make sure some acquisition model for moving object location and benchmarking of this model. In section 4, after implementing this system, we examine experiment result. And last, we conclude this research.

2. RELATED WORK

The techniques of managing location of wireless mobile phone have been researched for long time in wireless mobile telecommunication environment. Also database part, it have been researched formed of moving object database, spatiotemporal database. Specially, in wireless mobile telecommunication, it is researched to determine position of hand terminal and paging, location update methods are researched to minimize signal transfer overhead. In database, moving object data model, spatial, temporal indices, uncertainty management, query processing are researched for LBS [6]. First, in wireless mobile telecommunication network, there are methods of location update, named time-based location update [1], distance-based location update [2,3,4], movement-based location update [5]. And it is important to adjust trade-off between terminal paging and location update to enhance performance of system in wireless mobile telecommunication environment. Second, in database, data modeling, query expression, indexing research parts are related with existing researches part of spatial database, spatiotemporal database. In data modeling, it have been researched to focus on moving object data types, operators [6,14]. In query expression, it have been researched to extend SQL in legacy relational database [23] and the FTL (future temporal logic) expression has been researched to maintain dynamic functional attributes [6,14,15,17]. And indexing part has been researched about extension of spatial indexing R-tree in GIS [25,26,27]. In uncertainty part, it defines errors of measuring instrument to determine object location and location sampling [14]. The sampling problem is that if system acquires object location frequently, then sampling error rate is lower and quality of information is batter, but system performance is poor and storing space is very huge [17]. Picture 3 shows sampling error. The sampling error rate is higher in acquiring the time t0, t2 than in acquiring the time t0, t1, t2.

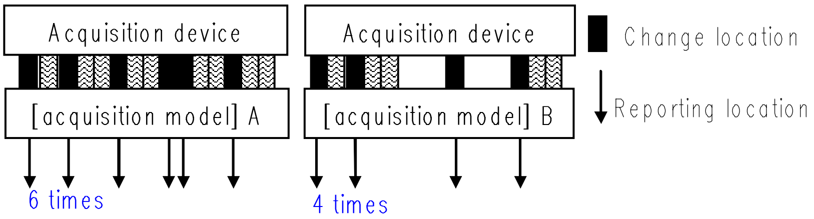


Picture 3 Sampling error

In case acquiring object location in time t0, t2, If there is some request of finding object location in time period [t0, t2], some part of the DOMINO project indicates that it is possible to predict object location using past position, velocity, direction [6,14,17]. In this paper, we announce the acquisition models of moving object that can lessen the time of acquisition of object location, so we reduce uncertainty error rate and database update overhead and enhance overall system performance.

3. ACQUISITION MODEL FOR MOVING OBJECT LOCATION

In this section, we observe acquisition model to reduce acquisition time using past object moving pattern and maintain stable state of MODBs. Picture 4 shows the goal of moving object acquisition model.

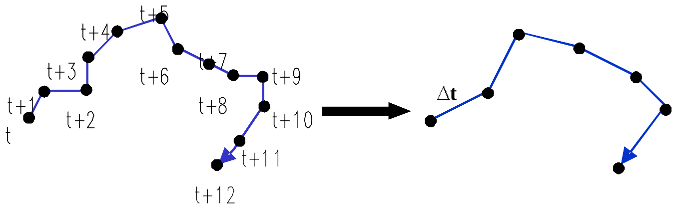


Picture 4 The goal of acquisition model

We design various acquisition model for moving object location with minimum telecommunication traffic overhead. In this section, we design 4 acquisition models and methodology of benchmarking.

3.1 Static acquisition model

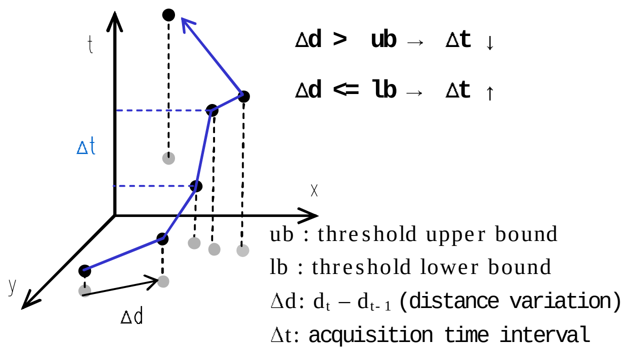
At static acquisition model, all of moving object has same acquisition time period. That is to say, using acquisition time period Δt, it reduces the number of acquisition. This model is effective in case of not large number of moving objects and used more in performance comparison with other models. Generally, we compare other model with this static acquisition model with Δt = 1. picture 5 shows static acquisition model



Picture 5 Static acquisition model

3.2 Distance-based acquisition model

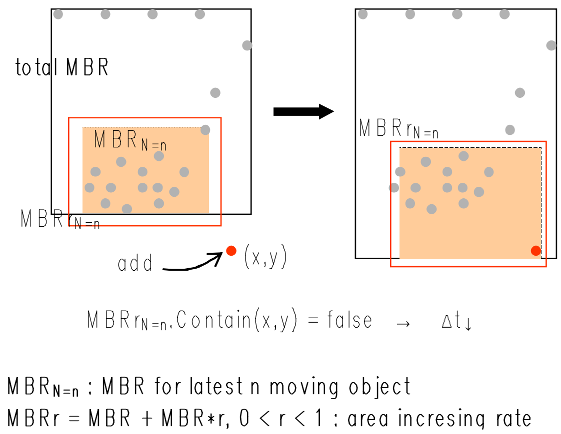
This model is works if moving distance variation is large, acquisition time period will be short, or if small, it will be long. First of all, it is setting up distance variation threshold(ub: upper bound threshold, lb: lower-bound threshold) and every time acquiring moving object location newly, this moving distance variation is compared with ub, lb and so it is controlled the number of acquisition to make stable state of telecommunication traffic. Picture 6 shows distance-based acquisition model.



Picture 6 Distance-based acquisition model

3.3 Group-Based Acquisition Model

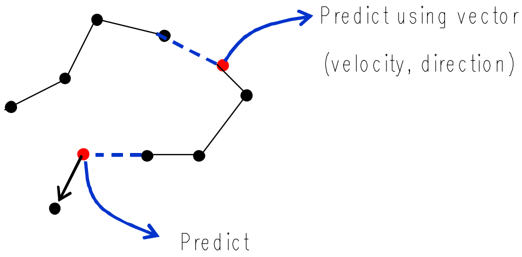
Picture 7 shows Group-based acquisition model. This model, about mo which stays some geometrically area for long time, it makes acquisition time period long until mo leaves that area. So it controls the number of acquisition. We use MBR (Minimum bounding rectangle) for checking whether added moving object is contained by some geometrically area. MBRr is enlarged by increasing rate r (0 < r < 1) of MBR and checks containing newly added moving object. If newly added moving object is contained by MBRr, acquisition time period will be long, if not, it will be short. Important parameters are area increasing rate r and the number of latest moving object which makes MBR. The fourth, picture 6 shows predict-based acquisition model.



Picture 7 group-based acquisition model

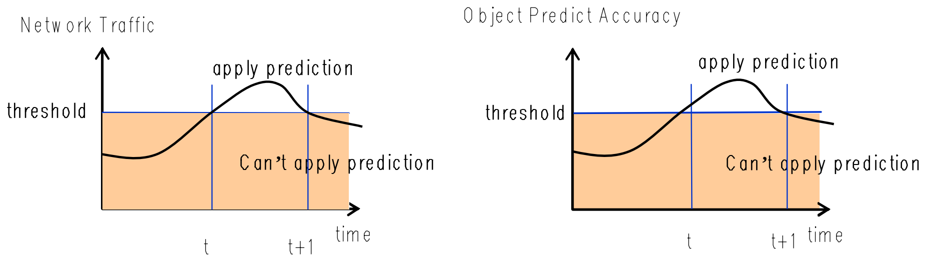
3.4 Predict-Based Acquisition Model

Picture 8 shows predict-based acquisition model. The Predict-based acquisition model predicts next moving object location using start point, direction, velocity. But this model is somewhat dangerous because we couldn't guarantee accuracy rate of prediction. So we use this model when telecommunication traffic overhead is so heavy, otherwise we use other acquisition model. That is to say, after setting up telecommunication traffic overhead threshold, if overhead is over that threshold we use this model. And if current location is predicted some moving objects in this time, then next time location must be acquired by other acquisition model for guaranteeing location information qualities.



Picture 8 predict-based acquisition model

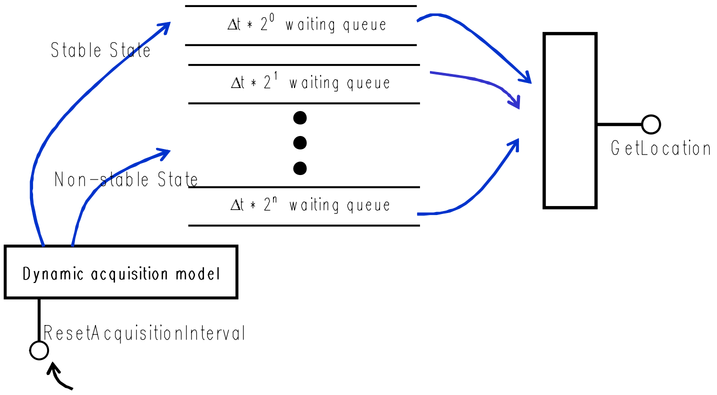
And in this model, all prediction is applied in especially state. That is to say, we consider the state of telecommunication traffic and object predict accuracy like picture 9. As time goes by, when network traffic sate is over some threshold value and simultaneously, each object predict accuracy state is over some threshold, prediction model is applied. The predict accuracy value can be measured as checking aberration of real location and prediction location whenever object location is acquired actually.



Picture 9 apply prediction in state of network traffic and object predict accuracy

3.5 Dynamic Acquisition Model

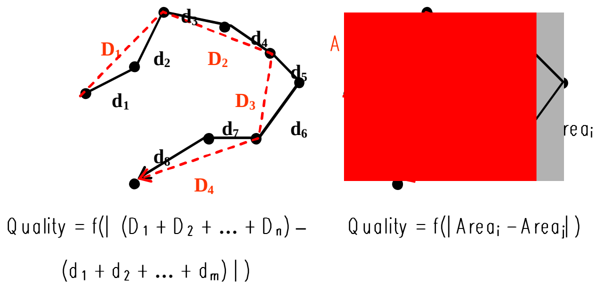
Dynamic acquisition model is applied when system resource(memory, CPU etc) is lacking or telecommunication overhead is grow all at once. If system is maintaining stable state, moving object location is acquired like static acquisition model. Otherwise, it distributes all moving object to several waiting queue properly, which has difference acquisition interval respectivelly, until system is stable state. Picture 10 shows dynamic acquisition model. There are several waiting queue, each queue have different acquisition time interval like $\{\Delta t * 2^0, \Delta t*2^1, \cdots, \Delta t*2^n\}$. And after acquiring location from acquisition device, each moving object reset acquisition interval as state of system, network.



Picture 10 Dynamic acquisition model

3.6 Benchmarking Model

The moving object location acquisition system has various acquisition models and we must be able to guarantee quality of information acquired throughout this various models. So we can suggest benchmarking model for estimating system performance and quality of information. We can estimate system performance as checking the number of acquisition comparatively static acquisition model with $\Delta t = 1$. Picture 11 shows estimation methodologies of quality of information acquired by acquisition model. The absolute difference value of summed up total moving distance and total area of moving objects between static acquisition model with $\Delta t = 1$ and other acquisition model can be measurements of information quality. This value notifies error rate, as minimum as quality is better.



Picture 11 measurements of information quality

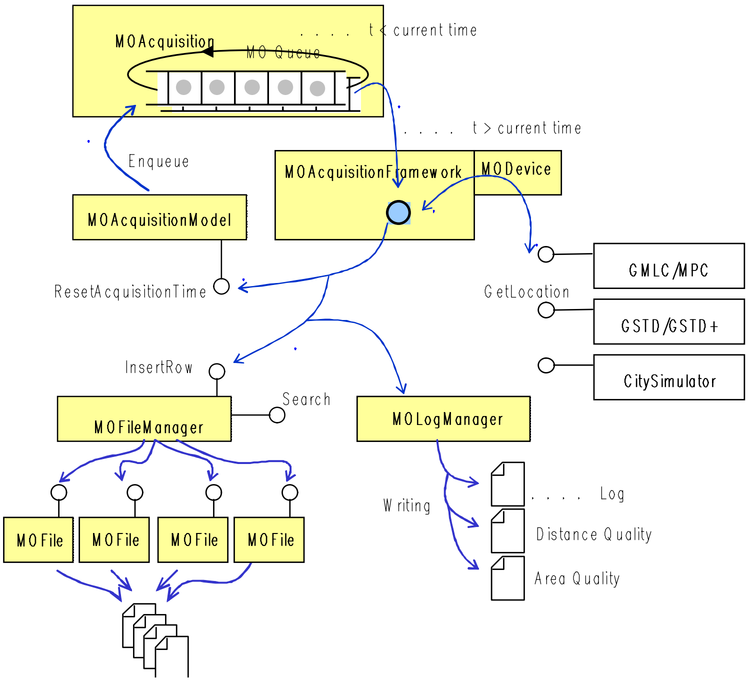
4. IMPLEMENTATION AND EXPERIMENT RESULT

In this section, we implement moving object acquisition system that is part of sub-system of moving object database system. And after this, we estimate system performance and quality of information. Picture 12 shows moving object location acquisition system components. More detailed classes are,

- MOAcquisition class : this has one more waiting thread queue and manages them
- MOAcquisitionModel class : this is abstract class and there are static, distance-based, group-based, predict-based, dynami acquisition model class derived from this, and has

main interface of ResetAcquisitionTime which after acquiring location, reset next acquisition interval before enqueueing each object to waiting queue in MOAcquisition class.

- MOAcquisitionFramework class : this has thread pool and guarantees simultaneously several acquiring locations of objects.
- MODevice class : this class actually acquires object locations with real time from GMLC (Gateway Mobile Location Center) [21] or MPC (Mobile Positioning Center) [19], GSTD/GSTD++ [28,29], Citysimulator (IBM) [23] and so forth
- MOFileManager class : this manages reading/writing information to binary formed file
- MOLogManager class : this is monitoring system status.

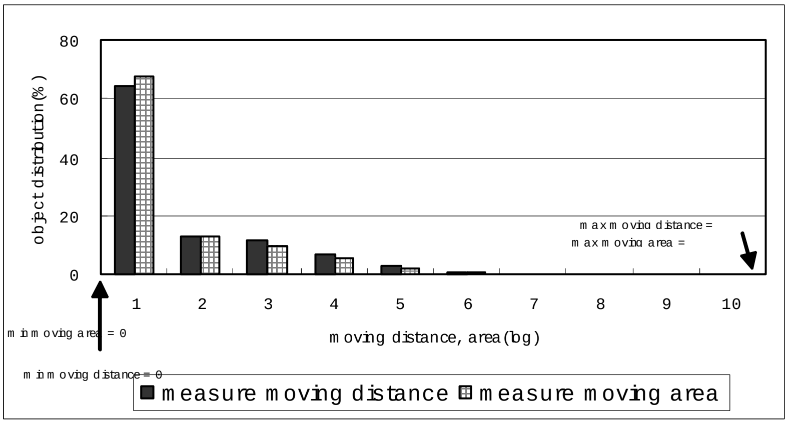


Picture 12 moving object acquisition system components

And this system is operating like below sequence.

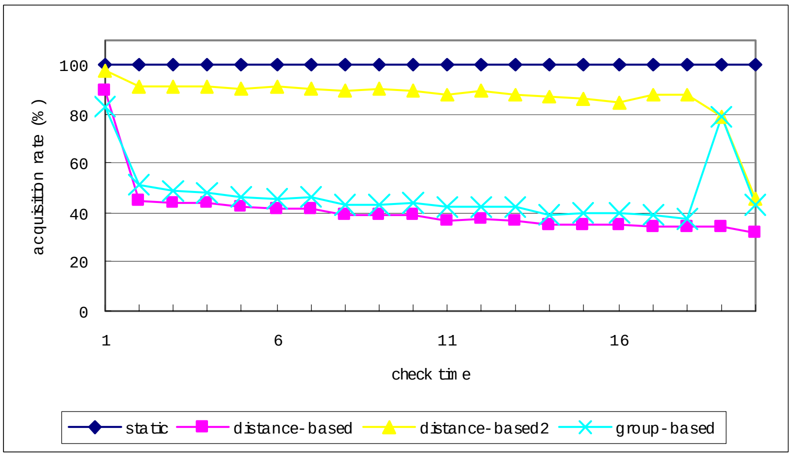
- At time of acquiring location, each moving object is dequeue from waiting queue in -MOAcquisition class, and transfered to thread pool of MOAcquisitionFramewrok class.
- Moving object is dequeue from thread pool one by one, transfered to MODevice class.
- Using GetLocation interface, moving object is acquired actually.
- Storing acquiring information to file throughout MOFileManager, MOLogManager classes.
- Reset next acquisition time of each object as acquisition model.
- Enqueuing each moving object to waiting queue in MOAcquisition class

Now, we estimate system performance and quality of information. We generate moving object data set using CitySimulator (IBM) which can generate large data set of setting parameters - the number of moving objects and the number of rotation – flexibly. We use experimental data set which has 100,000 moving objects and infinite rotates. And we use 5 acquisition models, which are static acquisition model, distance-based acquisition model, distance-based2 acquisition model, group-based acquisition model, predict-based acquisition model, dynamic acquisition model. The distance-based2 acquisition model is intelligently distance-based acquisition model. Picture 8 shows moving object dataset status. The Graph shows that most of the objects have a little movements and moving area like human's movement.



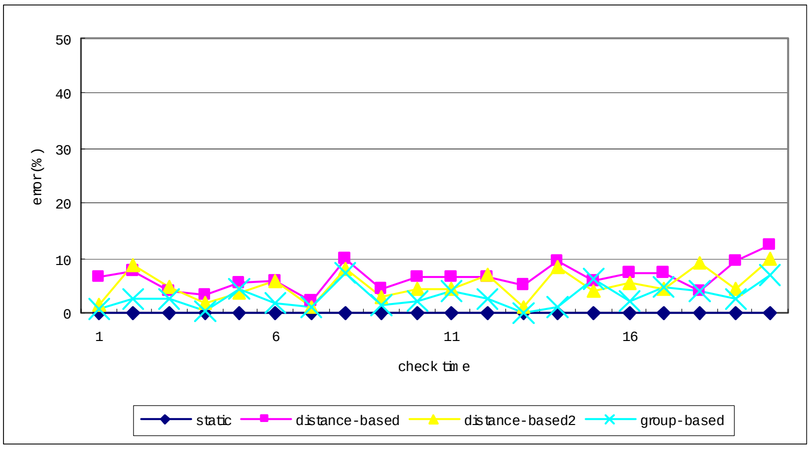
Picture 13 Moving object data set status

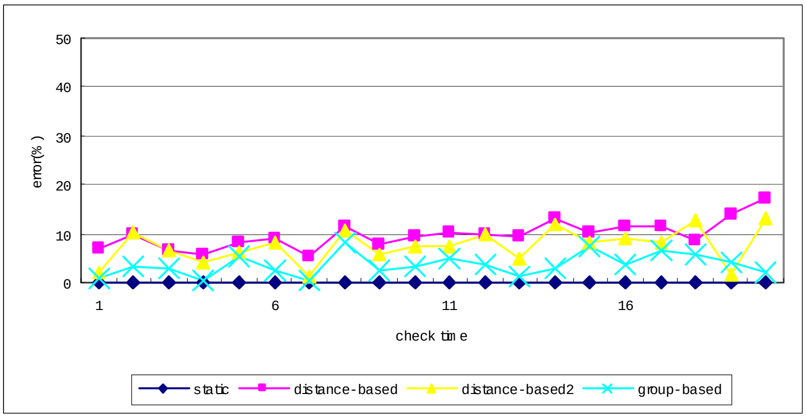
Picture 14 shows the number of acquisition of each model. Graph shows that all of models keep status telecommunication traffic overhead fewer than 70%. We set init-acquisition interval = 5 second and set lower bound, upper bound using 5 times acquiring information, and set acquisitionIntervalSteps = {Δt * 1, Δt * 2,, Δt * 3 , Δt * 4 , Δt * 5} and construct MBR using 5 times acquiring information and MBR rate r = 0.2.



Picture 14 Comparison the number of acquisition of location

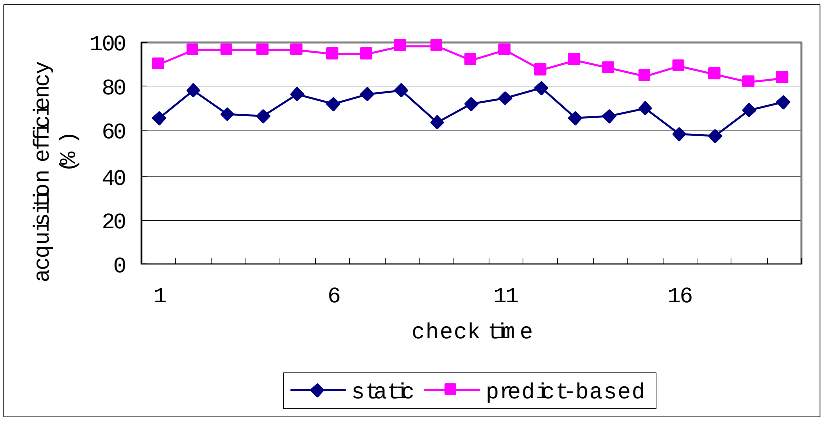
Picture 15 shows the moving distance, moving area error rate of each model. All of models keep status under 20 % error rates. And group-based acquisition model has least error rate.

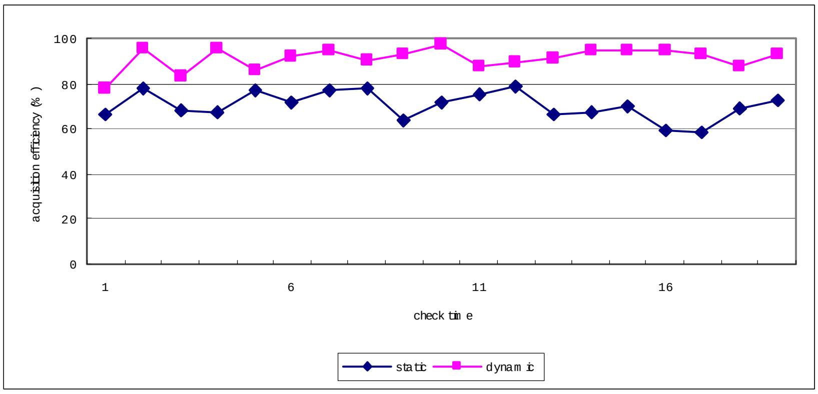




Picture 15 Moving distance, area error rate

Picture 16 shows acquisition efficiency of predict-based, dynamic acquisition model. In predict-based acquisition model, we set init-acquisition interval 3 seconds, then system cann't acquire all location(100,000) for 3 seconds. In this environment, static acquisition model has 60~85% efficiency rate of acquiring. So, predict-based acquisition model can apply in this environment. And we set the threshold of efficiency rate of acquiring to 85 %, predict threshold of accuracy rate to 30%. That is to say, if system has status that efficiency rate of acquisition is lower than threshold-85% and predict accuracy rate is higher than threshold-30%, then predict of location is applied. The efficiency rate of predict-based acquisition model keeps 80~100%. And in dynamic acquisition model, also we set acquisition efficiency rate threshold to 85%, and set of waiting queue are {Δt * 1, Δt * 2,, Δt * 3}. The efficiency rate of dynamic acquisition model keeps 80~100% as well.





Picture 16 The efficiency of acquisition predict, dynamic acquisition model

5. CONCLUSION

In this paper, we have observed moving object acquisition system in MODB and various acquisition models and benchmarking methodologies. And we have estimated system performance and measured quality of information using moving object data sets which are generated by simulators. After this, when LBS is familiar to everybody, these moving object location acquisition model can minimize telecommunication traffic overhead and keep MODB on stable status. As future works, we must study more acquisition model which can be used timely and in various statuses. Also we continuously must estimate system in various data set and various statuses, so make system more stable.

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