A dynamic data model for mobile GIS

Wenzhong Shi a,c,⁎, Kawai Kwan a, Geoffrey Shea a, Jiannong Cao b

a Advanced Research Centre for Spatial Information Technology, Department of Land Surveying & Geo-Informatics, Hong Kong
b Department of Computing, The Hong Kong Polytechnic University, Hong Kong
c Key Lab of Land Use, Ministry of Land and Resources, Beijing, China

A R T I C L E   I N F O

Article history:
Received 12 February 2008
Received in revised form 23 March 2009
Accepted 25 March 2009

Keywords:
Dynamic data model
Dynamic database
Mobile GIS

A B S T R A C T

A fast response time is a major objective for Mobile Geographic Information System (GIS) applications. This study provides a solution for improving the performance of response time by a dynamic data model. A conceptual dynamic data model is proposed, which covers (a) "position" information of selected geographic objects relevant to the GIS user's interest within his current location, (b) the selected attribute information in which the mobile GIS user is interested. In this approach, first, the attribute information is selected through a validating process making use of the temporal and attribute filters. Second, a specially designed dynamic database is employed to enable the implementation of the conceptual dynamic data model. This dynamic database is continually updated in accordance with the spatial, temporal and attribute constraints specified for the conceptual model. This design of a dynamic data model increases the availability of spatial data to mobile GIS users by providing up to date accurate information relevant to the area of interest, in a limited communication bandwidth. Third, an experimental study has been conducted and the results demonstrate that by using a dynamic database the response time can be reduced to one-third of that of a conventional database. The response time performance can be further improved as the size of the database is increased.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

Mobile Geographic Information System (mobile GIS) is an integrated technology which combines mobile computing, the Internet and GIS. Mobile GIS has been applied in areas, such as location-based services. With a mobile GIS, users can access personally selected spatial, temporal and attribute information unhindered by location limitations. Spatial query and spatial analysis is no longer necessarily limited to a fixed environment and can be accessed in any time and at any place.

With the rapid development of spatial data capture technologies (such as high resolution satellite images and Lidar) and spatial data modeling methods (such as extending two-dimensional methods to three- and four-dimensional modeling methods), the size and accuracy of the spatial database has been increased dramatically (Mok et al., 2004). A research study of system load testing by Kwan (2003), concluded that, of one thousand web pages, only 15% of websites worked properly and in accordance with their stated aim. It was concluded that an efficiency bottleneck, impeding the use of these websites, occurred in four areas: (1) database (27%), (2) network (25%), (3) application server (23%) and (4) web server (20%). This research indicates that the greatest limitation in the distribution of geographic information over Internet and wireless environments is the difficulty in handling large amounts of spatial data and the high cost of processing spatial data. A way to improve or overcome the problems is to enhance spatial data interoperability (Vckovski, 1999). The particular research objective of this study is the development of a dynamic database design with the aim of improving the performance of the existing spatio-temporal data databases. The overall performance of a database, enabled by such a development, should improve response time and user satisfaction on information searching.

Much research, in computing science, focuses on new technologies to improve web performance, by means of the use of such as lowering web latency and alleviating server bottlenecks. For example, Liu et al. (2001) suggested a world wide web (WWW) hierarchical, distributive and hybrid caching system in an attempt to (1) reduce latency when obtaining documents, (2) decrease the network traffic on the server side and (3) lower the service content requirements provided, by introducing, such as, routing, replacement decision and cache coherence mechanisms. Pun-Cheng and Shea (2004) presented a similar idea to deliver nine tiles of a Hong Kong base map using the classic web application model. The work carried out by Zhou et al. (2002) produced a spatial database using vector data as the basic element.
for web-based applications. The model used a conventional Relational Data Base Management System (RDBMS) on the server side to manage spatial data. A map was generated on demand using the data retrieved from the server-side spatial database management system. However, mobile environments introduce many new challenges to this mobile GIS field.

In the field of User-adaptive Maps, Zipf (2002) suggested that user models and context knowledge have to be exploited in order to provide a system based on user preferences and interests, and able to generate dynamic tourist maps, in accordance with a wider range of variables. Carboni et al. (2002) pointed out that map provisioning for mobile devices requires the implementation of a complex infrastructure.

Extensive research on location-based services has focused on delivering proximity information or service according to the user’s current position. For example, Hinze and Voisard (2003) proposed a system that can deliver tourism information based on location, time, and the profile of mobile users. This system only conveys a small static amount of maps expressed, to the user, in simple image format.

Increasing attention has been given to provide Web services on the Internet. For example the related GIS technologies have been applied in e-commerce for the construction industry (Kong et al., 2003, 2004). The work in Berger et al. (2003) provides general frameworks specifically for Web services on mobile devices in the e-commerce environment. This system does not consider the spatial database component, such as maps, in the system design.

Mobile GIS information provision is governed by two primary technical objectives: (a) fast response and (b) accurate information in the widest sense. The mobile GIS user wants to acquire precise information regarding his specific query within the shortest possible time. However, the existing large databases and limited wireless communication bandwidth negatively affect the full achievement of these objectives and hence provides strong research motivation into technologies to improve both response time and the provision of the desired accurate information concerning spatial, temporal and attribute domains. Take, for example a tourist’s desire to visit the Hong Kong History Museum. From a mobile GIS, he can find the location of the Museum. He can successfully take public transport to reach the Museum. However, on arrival he could find the Museum closed. In the above example, mobile GIS should provide users with not only the right location information but also precise temporal and attribute information, if a truly satisfactory service had been procured.

The research presented in this paper, as indicated above, aims to provide a solution in the form of the development of a dynamic data model which would enable the enhancement of the ability of mobile GIS technology to provide the user with faster response time and updated temporal and attribute information, as a normal part of a location-based service.

2. Conceptual dynamic data modeling

In general, a geographic information system manages the following: (a) spatial information, (b) temporal information, (c) attribute information and (d) topological relations. Spatial information describes the location and shape of geographic objects in which the user is interested. Attribute information describes the property, quality and characteristics of geographic objects. Temporal information describes the changes over time in geographic objects, while topologic relations describe the topological relationship between geographic objects.

2.1. A conceptual spatio-temporal model

The data elements of GIS can be described based on set theory. A set is a collection of definite, distinguishable objects, described as a whole. An attribute set can be described as a set of the properties of geographic objects. The notation for the attribute set would then be, for example,

\[ A = \{a_1, a_2, \ldots, a_i, \ldots, a_n\} \]

where \(a_i\) is the attribute element and \(i = 1, 2, \ldots, n\).

A spatial set can be defined as a set of two- or three-dimensional spatial elements on the location, shape or even relationships among the geographic objects. The notation of a spatial set is

\[ S = \{s_i : f(s_i) \in A, 0 < i < \infty\} \]

where \(s_i\) is the \(i\)th spatial object, \(f(s_i)\) the attribute function of the object \(s_i\) and with the attribute properties belonging to \(A\), and \(A\) the full attribute set of the objects.

A temporal set can be defined as a set of temporal elements of geographic objects. The members in a temporal set may include, for example, a temporal object, a function over time or another set of a temporal set. Temporal dimension can be viewed as a dimensional extension to the spatial dimension of geographic objects.

A spatio-temporal model can thus be described as a set of spatial objects with temporal and attribute properties. The notation for the spatio-temporal model is

\[ ST = \{s_i(t) : f(s_i(t)) \in A, 0 < i < \infty, -\infty < t < \infty\} \]

where \(s_i(t)\) refers to a spatial object at time \(t\) and \(f(s_i(t))\) refers to the function for the attribute of the spatial object \(s_i\) at time \(t\) and with its the attribute belongs to set \(A\).

2.2. Temporal and mobile properties in GIS

2.2.1. Temporal property

In a temporal GIS, temporal change refers to spatial or attribute changes of geographic objects, over a period of time and within a certain geographic area. For example in Fig. 1, focus is on the representation of the area of buildings on the map. There is only one building block within the area, bound by a dotted line at time \(T_1\) (Fig. 1(a)), while there are three buildings in the area at time \(T_2\) (Fig. 1(b)). Additionally, the area of buildings is divided into two parts (with spatial change) and the number of buildings increased from 1 to 3 (attribute change).

In Fig. 1, the temporal change description focuses on a specific area, such as the building area, the area covered by a map sheet or several map sheets. Within the specific area, there are spatial or attribute changes of geographic objects over a period of time. This is the temporal change normally modeled by a temporal GIS.

2.2.2. Mobile property

One property considered by a mobile GIS is the movement of the user from one place to another over periods of time. Thus the positions of (1) geographic objects and attributes of those objects, in relation to the user and (2) the instant location keep changing in line with the GIS user’s movements. However geographic objects in the real world may or may not change during this period of time.

In Fig. 2, a mobile GIS user has moved from time \(T_1\) to time \(T_2\). His area of interest (surrounded by the dotted line) is the rectangle at the lower left of the map at time \(T_1\) and upper right at time \(T_2\). The geographic objects within the area, \(T_1\) include such as a shopping center and town hall. When the mobile GIS user moves into the location, \(T_2\), the geographic objects within his area
of interest, T₂, are now a lake and forest objects. Hence an object difference is seen between T₁ and T₂, which are different from those in time T₁.

2.3. A conceptual dynamic model for mobile GIS

The change of geographic objects in the real world in a specific area (such as the Kowloon area of the Hong Kong territory) is modeled over a time period (such as from 1980 to 2005) using a traditional spatio-temporal GIS model. However, the aim when modeling, using a mobile GIS, is to reveal the continuously changing images of different geographic objects. Clearly the geographic objects in the real world may or may not themselves actually change during the user’s search. The changes within his area of interest are changes in objects which are only made apparent, as the mobile GIS user moves from one time slot to another.

The new proposed conceptual mobile GIS model, in this study, is specified as follows. Firstly, attribute change, spatial change and temporal change of the mobile GIS model is defined. Spatial change refers to change of location in the area of interest in line with the movement of a mobile GIS user. Attribute change refers to the changes of the attributes of the geographic objects in the different zones as the user moves. Temporal change refers to the time change as the mobile GIS user moves.

The conceptual mobile GIS model can thus be defined as follows:

\[ O_M = \{ t : s_i(t) \in ST, f^*(s_i(t)) \in A; I_1 \leq t \leq I_{n+1}, T_{start} \leq t \leq T_{end} \} \]
where \( s_i(t) \) refers to the \( i \)th geographic object at time \( t \), \( f'(s_i(t)) \) refers to the attribute function of the spatial object \( s_i \) at time \( t \), \( T_{\text{start}} \) and \( T_{\text{end}} \) define the moving time period of the mobile GIS user by its start to end time, \( I_j \) and \( I_{j+n} \) refer to the geographic objects within the mobile user’s area of interest. Finally, \( O_{\text{tr}} \) refers to all the geographic objects, within area of interest, when the mobile GIS user moves from time \( T_{\text{start}} \) to \( T_{\text{end}} \).

### 3. Dynamic database design for mobile GIS model

The proposed conceptual mobile GIS model is implemented in a dynamic database as follows. An open source relational database for handling spatial and temporal data such as PostgreSQL is used. The following two assumptions are made for the dynamic database design. (a) Time is considered one-dimensional and linearly ordered. (b) The areas of interest do not overlap. This means that the geographic objects differ from one area of interest to another.

A series of sub-databases (“Master Database”, Fig. 3, below) for subsequent query are then generated dynamically from the core GIS database, that is, the dynamic database, which is generated continually, based on the instant position and time in line with the mobile GIS user’s movement progress. The contents of this dynamic database (spatial, temporal and attribute information of time and location) change concurrently, when the mobile GIS user moves. It is then stored in the user’s device memory as a virtual database. The database responds to the dynamic change status of the geographic objects and sensates accordingly as the “dynamic database” possessing the characteristics of an active database. The conceptual schema of this dynamic database is depicted in Fig. 3. The master database is generalized by different “scope areas”. Each area is composed of dissimilar spatial objects. “Name” is the internal identifier of spatial objects. “Address”, “Working hours” and “Classification” are attributes of corresponding objects. “Address” is a composite attribute consisting of such as the street number, street name.

The principle of the dynamic database is illustrated by the two examples given below. In the first example, the geographic objects in the real world are not changed. The area of interest of the mobile GIS user changes continually, the associated spatial, temporal and attribute information within each of the areas of interest is updated constantly according to the location and time slot of the mobile GIS user. In the second example, the geographic objects (or the status of the geographic objects) in the real world change in accordance with the movement of the mobile GIS user.

![Conceptual schema of the dynamic database](image-url)
Example I: In this example, a moving mobile GIS user has a spatial query request, which is “to find the location of a Japanese restaurant”. In such a query, the mobile GIS user is required to input his current location and his maximum walking distance to an Internet-ready mobile device. Fig. 4 illustrates the different stages of the dynamic database creation in response to this spatial query, and data volume of the dynamic databases at different stages.

In Stage 1, 10,000 records are recorded in the original database and each row records one spatial object. From Stages 1 to 2, attribute constraint is applied to the spatial query. This is a filtering process and only those records with the fields matching the specified International Specialties, which in this case is “Japanese food” are retained. Furthermore, only those selected fields such as “Name”, “ID”, “Open_time”, “Close_time” and “District” are retained. “ID” is the unique identifier used in the database. “Name” is the name of the restaurant. “Open_time” and “Close_time” indicate the working hours of the restaurant. “District” describes the locations of the districts.

From Stages 2 to 3, spatial constraint is applied. Only those objects within the area of interest of the current position of the mobile GIS user are extracted. These objects are then identified at that specific location and in that specific time slot. At this stage of the dynamic database design and after applying this spatial constraint, only 3000 out of 10,000 possible geographic objects, are retained.

From Stages 3 to 4, temporal constraints are further applied and only 1800 records are retained in the dynamic database. By applying the time constraint, only those “open” restaurants are retained in the current dynamic database and those restaurants “closed”, at that moment, are removed.

The spatial query is applied to the current dynamic database with 1800 records rather than the original database with 10,000 records. The dynamic database generation from Stages 2 to 4 is conducted in accordance with the location of the mobile GIS user.

The following proposed mobile GIS model is applied in the dynamic database creation.

\[
M_{ST} = \{ t : s(t) \in ST, f'(s(t)) \in A; I_j \leq t \leq I_{j+n}, T_{start} \leq t \leq T_{end} \}
\]

The notation representation of events from Stages 1 to 4 in Fig. 4 is given in Table 1. In Table 2, the searching algorithms for each stage are provided.

Example II: In the second example, the geographic objects (mainly the status of the objects) in the real world change from time to time. In this example, the mobile GIS user is searching an optimum path from a specific road network. The network has dynamically changing transportation conditions. The optimum path is defined as the path bearing minimum cost in the broadest sense. For example, the cost of using a road can include distance, time or financial cost. The mobile GIS user is required to input the following three locations to facilitate the search: the starting point, the pass points and the destination. The mobile GIS responds with the optimized path, based on the three given
points and the dynamic changing transportation conditions of the road network.

At time T1, the optimum path from nodes N1 to N3 is the road passing through the road segment C (see Fig. 5(a)) and with the cost CC. The optimum path is determined based on the following facts: (1) the existence of two possible paths from node N1 to N3: (a) the road segment C and (b) the road segments A followed by B; (2) the fulfillment of the following cost estimation: \( C_C < C_A + C_B \). In this case, the cost is estimated based on the time used to pass through the road.

At time T2, there is traffic congestion on the road segment C and the cost required to pass through the road segment thus increases to \( C_C' \). In this time slot, the following condition is fulfilled: \( C_C' > C_A + C_B \). At this time, the optimum path from node N1 to N3 is the road passing through node N1 to N2, and then to N3. And the optimum path passes through the road segments A and B (see Fig. 5(b)).

Fig. 5. (a) The optimum path from node N1 to N3 at time T1. (b) The optimum path from node N1 to N3 at time T2.

The original database with a total of 10,000 records is provided in Stage 1. At this stage, each geographic object is represented, in the database, by one record. From Stages 1 to 2, the attribute constraint applies, and only those fields related to the path measurement are retained in the dynamic database. The retained fields include: “Name”, “ID”, “Type”, “Cost” and “District”. From Stages 2 to 3, the temporal constraint applies, the dynamic changing transport situations are reflected by this constraint and are used in the later optimum path computation. In this particular case, there is no position change of geographic objects in the real world (such as the change of the road network), but the status of the geographic objects (traffic conditions on the road network) are changed from time to time. Events from the Stages 1 to 3 are illustrated in Fig. 6 and Table 3.
Table 3
Notation representation of events from Stages 1 to 3.

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Original Database=A</td>
</tr>
<tr>
<td>Stage 2</td>
<td>A={a_0, a_1, ..., a_n} where a_i is the attribute element that related to the application and there are n+1 number of attribute elements, thus A \subseteq A.</td>
</tr>
<tr>
<td>Stage 3</td>
<td>AT={a(t)</td>
</tr>
</tbody>
</table>

Fig. 6. Dynamic database generation based on attribute and temporal constraints.

Fig. 7. The logic flow when accessing to dynamic database.
4. Implementation of the dynamic database

4.1. The logic flow of the dynamic database

The logic flow for implementing the dynamic database for mobile GIS applications is illustrated in Fig. 7. This involves at least two important parts. The first part is concerned with creating and updating the original source database to the dynamic database with full GIS datasets. The updating process concerns the constant re-creation of the dynamic database, in order to match instantly with such changes, as indicated above, in the area of interest of the moving mobile GIS user. The second part is the linkage between dynamic database and the mobile applications. After an instant dynamic database is created or updated, mobile GIS
2. Hardware and software configurations

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web server and GIS server</td>
<td>Pentium 4, 2.4 GHz CPU</td>
</tr>
<tr>
<td>Mobile device</td>
<td>Del Am X51V</td>
</tr>
<tr>
<td>Development kits</td>
<td>Windows mobile 5.1</td>
</tr>
<tr>
<td></td>
<td>Microsoft pocket IE</td>
</tr>
</tbody>
</table>

Table 5

Types of International Specialty in the test area in Hong Kong.

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of shops</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beers/wines</td>
<td>362</td>
<td>40.8</td>
</tr>
<tr>
<td>Curry/satay</td>
<td>49</td>
<td>5.5</td>
</tr>
<tr>
<td>Japanese noodles</td>
<td>19</td>
<td>2.1</td>
</tr>
<tr>
<td>Korean BBQ</td>
<td>14</td>
<td>1.6</td>
</tr>
<tr>
<td>Pizza</td>
<td>60</td>
<td>6.8</td>
</tr>
<tr>
<td>Sashimi/sushi bar</td>
<td>48</td>
<td>5.4</td>
</tr>
<tr>
<td>Steak house</td>
<td>42</td>
<td>4.7</td>
</tr>
<tr>
<td>West dessert/drink</td>
<td>120</td>
<td>13.5</td>
</tr>
<tr>
<td>Others</td>
<td>174</td>
<td>19.6</td>
</tr>
<tr>
<td>Total:</td>
<td>888</td>
<td>100%</td>
</tr>
</tbody>
</table>

5. Experimental study

The experiment study is designed to test the performance of the proposed dynamic database for mobile GIS applications. Of particular interest is to assess improvement in response time. The functions to be tested include: (a) a search for three locations of international food specialties a spatial query, and (b) the determination of the optimum path—a spatial analysis. The performance of the system is tested by measuring the time cost for accomplishing the spatial query and spatial analysis.

To operate the experiment, a mobile user was requested to provide (a) an “area of interest” and type of International Specialty required, and (b) his current location, passing point(s) and destination, and (c) the maximum walking distance. Based on the input information, (a) the locations of the preferred restaurants and (b) the optimum path, passing through the passing point(s) from the user’s “start” location to the destination was returned to the mobile GIS user, in answer to his spatial query. A summary of the experiment results and the provision of an analysis on the performance of the test are given as follows.

5.1. Set and index algorithms

The two methods, SET and INDEX, are applied to evaluate the performance of the dynamic database creation and updating methods proposed in this study.

The SET method refers to the collection of similar objects with the same attribute element types. The order of the objects is irrelevant. No attribute elements are duplicated. The INDEX method involves a key to identify unique records. The resulting index field enables a specific record or the sorting of records from the database to be accomplished faster. The algorithms of both the SET and INDEX methods are illustrated as follows. The SET method uses the SQL statement for the establishment of a subset of records fulfilling a pre-set selection condition, while pointers are added to the returned result.

SET method

```
BEGIN
# get the server time
GetCurrentTime
While category != 0 Then
    # create the dynamic database
    CreateSet()
    # SQL search to find out those with 60 minutes left at least before closing
    Select * where Open_time < (Current_time and (Close_time - Current_time)) 60 and Category=particular value
    Category=Category - 1
End
END
```

INDEX method

```
BEGIN
# get the server time
GetCurrentTime
While Category != 0 Then
    GetFirstRecord
    While return != 0
        GetRecordValue(ID, Category, Open_time, Close_time)
        # compare with the current category
        If Category != current
            GetNextRecord
        Else
            # add pointers to the returned result
            Begin
                #do function
                Continue
            End
```

4. Dataset

In order to reflect the real situation of mobile GIS service in Hong Kong, international food is chosen as a target area for mobile GIS application. The data set for International Specialties (food is one of the included items) is extracted from the Yellow Pages section of the Hong Kong directory, provided by the mobile telephone operator PCCW and Telecom Directories Limited. The dataset was downloaded from the website with the objective of testing the performance of the dynamic database proposed in this study. Nine different types of International Specialties were selected, the restaurant information was input to the original source database as a component of the full GIS data sets. The statistics of the International Specialty are shown in Table 5.
If Open_time < Current_time and (Close_time–Current_time) > 60 Then
  Goto Add_pointer_value
  GetNextRecord
End

Add_pointer_value:
  //write the first record into index table
  If current_record <> first_record Then Do
    //write the ID number of the previous record to pointer field
    SetRecordValues(pointer value=ID value)
  Else
    //write the first record in the index table
    LocateRecord(Index table, field)
  End
End

The time cost for a dynamic database creation and updating is defined as follows. When using the SET method, the average response time measures the average time (in seconds) spent from the moment the dynamic database creation/updating begins until the moment the dynamic database is generated. For the INDEX method, average response time measures the average time (in seconds) spent from the start to the moment all pointers and the index table are generated. The database sizes, for the experimental study, using both methods, vary from 1000 to 75,000 records. Table 6 shows the time cost for the creation/updating of the dynamic database.

Fig. 9 provides the time cost curves by the two different methods: SET and INDEX. The amount of time required increases sharply with the increase of the data volume in the dynamic database by using the INDEX method, whereas the time, when using the SET method, increases slightly with the increase of data volume.

The response time is a critical issue for mobile GIS applications. The above results indicate that the performance, when creating and updating a dynamic database using the SET method is better than that when using the INDEX method. Hence the SET method has been chosen for dynamic database creation and updating.

5.2. The performance of the dynamic database

The performance of the dynamic database is measured by the response time of the database to a spatial query from a mobile GIS user. The response time is defined as the time from the moment the query is sent out till the moment the query results are generated and obtained. For example, a spatial query can be to find Pizza shops within 300m of the current location of the mobile GIS user. The response time is counted from the moment all criteria are entered to the moment the mobile GIS receives the query result, viz the locations of all the Pizza shops in the area.

To compare the performance of the dynamic database and the original source database, the response time of records—from 1000 to 75,000 were tested. The number of records, based on the statistics presented in Table 4, is simulated in Table 7. Table 8 shows the number of records used in response to the spatial query in the original database and that used in the dynamic database.

![Figure 9. Time cost for dynamic database creation and updating by the SET and INDEX methods.](image-url)
Fig. 10 provides two curves that represent the trends of the average response time to the spatial query by using (1) the original database and (2) the dynamic database for various amounts of records.

From Fig. 10, it can be seen that by using the original database, the response time is 4 s for records in the database below 10,000, and with a gradual increase in response time from 4 to 12 s when the records increase from 10,000 to 70,000. On the other hand, by using the dynamic database, the response time is 3 s when records are less than 10,000 in the database, and response time is constantly 4 s when the records are increased from 10,000 to 70,000. From the above experimental results it is found that, the response time is comparable (the difference is less than 1 second) when using the dynamic and the original source databases if the records in the database are small (less than 10,000). However, the difference between among the two can be very large when the number of records is increased—the response time when using the original source database is three times as large as that when using the dynamic database holding records of 70,000. The difference can be even larger when the number of records is further increased. Therefore, it can be concluded that the dynamic database for mobile GIS users is more efficient in terms of response time, particularly when the size of the database is large.

6. Conclusions

This paper has described a dynamic data model for mobile GIS. The dynamic conceptual model considers that the contents in data model change continually. The experimental study has been conducted to test the performance of the proposed dynamic data model and dynamic database. The experimental results have demonstrated that the response time can be reduced to one-third by using a dynamic database compared with response time when using the original source database (70,000 records). This performance can be further improved if database size is further increased.

Currently, heavy database access and the movement of geospatial data via the network are the two major bottlenecks impeding the efficiency of mobile application. Under the limitation bandwidth, the dynamic database is one of the solutions to improve the performance of mobile GIS in terms of response time.
for mobile applications. In addition, it ensures the latest and accurate information is provided to mobile GIS users.

Acknowledgement

The work presented in this paper is supported by The Hong Kong Polytechnic University (Project no. G-YE13) and the Ministry of Science and Technology of China (2006BAJ05A08).

References


Kwan, K.W., 2003. Improving the efficiency of spatial query for Internet/Mobile GIS, MPhil Thesis, The University of Hong Kong Polytechnic University, Hong Kong, 166pp.


