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# LA-GPS : A Location-Aware Geographical Pervasive System

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**Abstract**— The advancement of mobile information systems is going in parallel with Geographical Information Systems where they both meet in providing location-aware services. New systems are providing a new pervasive GIS dimension where access to geographical attributes is being possible “anytime, anyplace and anyhow”.

In this article, we propose a system that provides mobile users with a service that corresponds not only to their requests but also to their preferences, location and querying time. Finally, we project the query results to construct a GIS map layer that is added to original GIS area map in order to provide more indications to the path that the user should follow in order to reach the demanded service.

## I. INTRODUCTION

In the age of mobility and ad-hoc networks, many challenges arise. In order to meet these challenges, pervasive services were introduced to provide users maximal access to information at anytime, anywhere and anyhow [6].

Pervasive Computing allow computing elements to disappear from the user’s consciousness while functioning homogeneously in the background of his environment [11].

Pervasive systems are considered as location-aware systems that take into account the user profile, his preferences, his location and the surrounding environment. Location is fundamental to the way we as humans understand and operate in this world [15]. Usually, it is very important to know where we are in relation to the place where we want to go and the most efficient way of achieving this.

Most leading computer systems now recognize the importance given to location and spatial information by their clients. Therefore, they are providing tools to facilitate the storage, retrieval and analysis of location meta-data.

With the development of computer and network software and hardware, especially Internet building, GIS has got a lot of new features to fit Web applications. GIS technology integrates common database operations such as query and statistical analysis with unique visualization and geographic analysis benefits offered by maps. GIS usually provides numbers of tools for people to get more useful geographic information.

In this article, we present LA-GPS; a Location-Aware Geographical Pervasive System that allows users to demand for a location-aware service that is adapted to their preferences location, and querying time. Our system will be projecting the querying results on a GIS map layer in order to

offer further services like the navigation path the user should take to reach the service.

Our article will be organized as follows: First, we’ll present a state of the art about GIS mobility and Mobile - GIS related works. Then, we’ll introduce our contribution

## II. STATE OF THE ART

### A. GIS mobility

GIS is a computer system capable of integrating, storing, editing, analyzing, sharing, and displaying geographically-referenced information. In a more generic sense, GIS is a tool that allows users to create interactive queries (user created searches), analyze the spatial information, edit data, maps, and present the results of all these operations.

Since 1990, geospatial information technologies and mobile wireless Internet have been rapidly developed. It is easy to see that the integration of geospatial information and mobile Internet is inevitable, which is simultaneity driven by market demands and technologies [9].

In the Mobil applications, we need to talk about “location services”. A location service, in the broadest sense, is any service or application that extends spatial information processing, or GIS capabilities, to end users via the Internet and/or wireless network [5]. The OGC defines location services as follows: “... location (application) services are any application software services that access, provide or otherwise act upon location information.” [13].

These location applications has to work on mobile intelligent terminals, and brings new dimension “at any time, any place” to access geospatial and attribute information in GIS. It is called Mobile Geographic Information System (Mobile GIS). Mobile GIS offers another new perspective for the use of GIS and further extends the “office” GIS works in mobile environment [16]. Mobile GIS was early applied to assist office and collect data in the field [8].

The Mobile Geographic Information Service is a geospatial service system providing service wherever and whenever is needed. It defines an “interactive” model between the user and the actual world, which can provide different information service dynamically to individual users at different times, and in different places. When the same mobile user is interacting with the model, his view will change along with his type of role and the environment [12].

Mobile Geographic Information Service is the combination of all the GIS applications with easy-to-use mobile devices to provide information wherever and whenever is needed (For example, putting spatial information into the dashboards of vehicles, and in the hands of those in the street or out in the field). It is giving service providers and emergency responders real-time location information (not positioning) that enables them to offer rapid response, targeted, relevant assistance and better services [10].

So, Mobile Geographical Service is not a simple conventional GIS modified to operate on a smaller computer, but a brand-new system architecture using a fundamentally new paradigm [2]. It extends unlimited information on the Internet and the powerful service functions of GIS to mobile devices. It can also provide mobile users with geospatial information services. At this time, it would be built on the new integration. Mobile GI Service creates a new channel of business practice, and thousands of potential applications and services can also be developed.

As a kind of mobile information service, Mobile GI Service should have the following features: mobility, real-time online service, non-structural data contents, be people-oriented (supporting the nature language query and output, most wireless communication methods, and variability of mobile terminals), and have the ability to present remotely sensed images [9].

#### B. Mobile - GIS related work

There are some research projects or groups dealing with geoinformation issues in mobility, e.g. the DeepMap project [14], the EC CRUMPET project [1] or the LoL@ project [4]. However, most of these projects put the emphasis on IT and telecommunication technology.

GUIDE is a location-aware multimedia tourist guide that was developed for the City of Lancaster [7]. Another similar system is MOBIS [17], which is a situative guide running on a PDA. MOBIS is designed for indoor use, as for instance to provide information on the exhibits of a museum. MOBIS follows the same approach as the GUIDE system in that it is based on infrared beacons distributed in the environment, which are used as pointers to a specific context that is stored in the PDA's database.

The HIPS system uses sub-notebooks [3], which support a broader range of media content than the PDA used for MOBIS. HIPS takes into account the absolute position, as well as the distance to objects in the exhibition and uses a radio back-channel for downloading information.

Our system LA-GIS provides mobile users with a service that corresponds not only to their request but also to their preferences, location and querying time. Finally, we visualize the query result in the form of a layer that is added to a GIS database.

The user will be provided with a GIS map that is composed of different layers and saved in a GIS database. The system will return to the user the composed map with hotspots containing additional specifications of the service and would offer to provide path that the user should follow to reach the demanded service.

### III. CONTRIBUTION

In this section, we present our system LA-GPS: A Location-Aware Geographical Pervasive System that provides users with services adapted to their preferences, location and querying time. We'll demonstrate the functionality of our system by applying it on a simple use case where a tourist is handling a mobile device and walking around the downtown. The user might think of taking lunch somewhere but as he doesn't know the possible places that exist in the city, he would consult his mobile device as a practical solution.

As the user launches a query demanding a nearby restaurant, our system will provide him with a map containing the different restaurants that takes into consideration his preferences and his context (location, time). As a result, the user might choose a certain restaurant and our system would provide him with a map showing the path he should follow to reach this restaurant. Next, we'll present the different elements of our system.

#### A. LA-GPS : A Location-Aware Geographical Pervasive System

In previous work within the context of mobile information systems, we have noticed that the contributions were either interested in providing users of location aware services or providing them with service corresponding to their preferences.

In our system, we propose to provide users with location-aware and preferences-aware services and then represent these results on a GIS map layer that would help the user to locate a desired service and to visualise the path he should take to reach it.

As we show in fig. 1, a GIS map is composed of different layers. Our system will use an existing GIS map (containing the city street layer, vegetation layer, etc.) and will add a final layer that specifies the location of different restaurants in the treated area. Our system will employ the user query in order to create this layer (dynamic information retrieval).

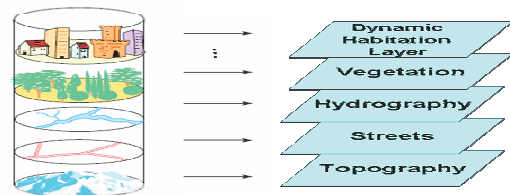


Fig. 1 The multi-layered structure of a GIS map

Our system will function following these steps, see fig. 2:

- 1) *The user launches a query demanding for a service (in our case a restaurant).*
- 2) *Our system will enrich the user query by injecting into it elements like: the user's preferences, the location coordinates and the time.*
- 3) *After representing the new query, the system consults the database of existing restaurants, taking into consideration: the user preferences (restaurant type, meal serving hours,*

budget prices, etc.), the user location (X,Y,Z) coordinates and the time (in order to see if the restaurant is serving food at this time).

4) As the system restores the list of relevant restaurants, it will use the location coordinates of these restaurants in order to set their locations on our dynamic layer that would be added as final layer to the GIS map.

5) The system will return to the user the composed map which will be presenting the retrieved results as **hotspots**.

6) As the user chooses a restaurant link, our system will provide him with the restaurant information and would propose to show him the path that he should take to reach it.

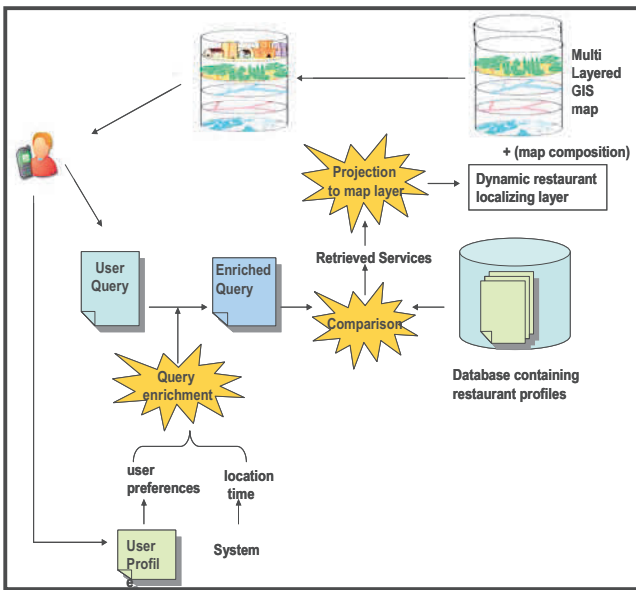


Fig. 2 Our proposed Location-Aware Geographical Pervasive System

### B. Main System Components

The most important parts of our contribution are:

#### 1) Context and preferences adaptor :

This component realises 2 steps:

**Query enrichment:** In this step our system will add to the query some elements that would help to restore to the user the restaurants that are not only adapted to his query but also adapted to his preferences, location and querying time. The values of the enriched elements are restored from the system at the querying time.

**Query and restaurant meta-data matcher:** Enriching the query with elements that already exist in the restaurant's profile will help to provide common elements between the query and the restaurant meta-data.

In our system, we represent these structures using XML format [18] and in order to respond to the user's demand/request, we precede a matching step that compares the different attribute values. Therefore, the objective of this matching process is to return to the user only the

relevant restaurants that adapt to his preferences, location and time.

#### 2) Dynamic layer designer:

This component processes the list of retrieved restaurants in order to capture the values of the location attribute ((X,Y,Z) coordinates of each restaurant).

As the system extracts these values, it will use a painting function to project these values and precise the location of these restaurants on a new empty layer that we will add to the GIS map.

This layer is dynamic because it contains the user's current query results so each time the user executes a query, the system will map the relevant results on this layer and add it to the different layers to return to the user a complete GIS map.

### C. Main Profiles

In order to provide such a system, we need to represent the following elements:

**The Restaurant Profile:** Describing the meta-data of the different restaurants helps in providing a relevant list of restaurants existing in the querying area. In order to match between the restaurant and query, the restaurant profile should contain the restaurant type, meal serving hours, location, budget prices, payment method, etc. In fig 3, we represent the Restaurant Profile.

```
<RestaurantProfile>
  <StaticCharacteristics>
    <Name> ..... </Name>
    <Address> ..... </Address>
    <Location> ..... </Location>
    <Telephone> ..... </Telephone>
    <FoodType> ..... </FoodType>
    <ServingHours>
      <From>...</From>
      <To>...</To>
    </ServingHours>
    <PaymentMethod> ..... </PaymentMethod>
  </StaticCharacteristics>
  <DynamicCharacteristics>
    <MealOfTheDay>....</MealOfTheDay>
    <Budget> ..... </Budget>
    .....
  </DynamicCharacteristics>
</RestaurantProfile>
```

Fig. 3 XML document representing the Restaurant Profile

**The Enriched User Query:** Nowadays, with the evolution of mobile technologies and the heterogeneity of information sources, user queries are evolving to combine different dynamic elements representing the context such as the location of the user issuing the query, the querying time, etc.

Our works will describe the user demand (in our case: a restaurant) while taking into consideration his preferences (extracted from the user profile), the current querying time and the current user's location (extracted from the device's GPS or the service's GSM).

Next we'll show the Enriched User Query profile, fig. 4:



```

<QueryProfile>
  <UserQuery>
    <keyword> ... </keyword>
    ....
  </UserQuery>
  <Preferences> .... </Preferences>
  <Location> .... </Location>
  <Time> ... </Time>
</QueryProfile>

```

Fig. 4 XML representation of the Enhanced Query Profile

**The User Profile:** In our works, the User Profile is defined to describe the user characteristics and preferences. The representation of the profile is done in an XML. The system allows filling the User Profile by following an explicit procedure at the first sign in (where the user fills in his static characteristics and preferences). In fig 5, we expose the User Profile representation in XML.

```

<userProfile>
  <StaticCharacteristics>
    <FirstName> ..... </FirstName>
    <FamilyName> ..... </FamilyName>
    ....
  </StaticCharacteristics>
  <Preferences>
    <FoodType>.....</FoodType>
    <Budget>
      <From>...</From>
      <To>...</To>
    </Budget>
    <PaymentMethod> ..... </PaymentMethod>
    ....
  </Preferences>
</userProfile>

```

Fig. 5 XML document representing the User Profile

In order to retrieve relevant services, our system will execute a matching process between the Enriched User Query and the different Restaurant Profiles. In order to do this step, the system might do some additional steps for profile processing.

For example: when the user demands for a restaurant, the system will see the current querying time and verify if it exists within the serving hours interval mentioned in the restaurant profile. The same operation will take place in the case of budget verification; where the system will search if the price of the offered meal corresponds to the user's budget.

#### IV. CONCLUSIONS

In this article, we have presented LA-GPS; a system that provides mobile users with a service that corresponds not only to their requests but also to their preferences, location and querying time. The visualization of our system results has used the concept of multi-layered GIS maps in order to provide users with a GIS map containing the results and more indications to the path that the user should follow to reach the demanded service.

Our contribution highlights the evolution of the pervasive GIS dimension where access to geographical attributes is being possible at "anytime, anyplace and anyhow".

Further steps can be added to our research works in order to enrich the context captured adding different elements to it such as the weather status to precise to the user that restaurant serves the meal indoor or out door.

Finally, we intend to generalize the usage of our system to car users by connecting the system with a car navigation system that would enable users to search for a service within a wider geographic area.

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