MINOTAURUS: A Distributed Multimedia Tourism Information System

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Abstract

The rapidly expanding technology of mobile computers, wireless data networks, vehicle navigation, multimedia and database systems has caused the development of powerful mobile information systems. These systems, consisting of a portable computer (Laptop, PDA), have large storage capacities, capabilities of wireless connection to a worldwide information network and provide to their users many functionalities like access to WWW, shopping, banking, reservations and other transactions.

This paper presents such a mobile system named **Minotaurus** which combines the above technologies to achieve the development of a mobile, multimedia tourist information system.

1. Introduction

The system's objective is to overcome the existing problems of traditional tourist information systems using modern technology, aiming to eliminate and resolve most of them. The baseline functionality that the system provides to its users has been categorized in:

- Presentation of historical, tourist and geographic information about the areas a user wishes to visit.
- Providing road-level navigation assistance through the display of the vehicle's position onto a geographical map when the user travels.
- Presentation of data stored in Remote Information Servers accessed through the Internet from wherever the user might be, using location-transparent methods.

In contrast to existing Tourist Information Systems, **Minotaurus** has substantial advantages. The most important issue is the *ease and speed of access* to the tourist-related information since the platform being used allows the user to carry the system inside his car in full effect.

The wireless modem being used over Mobile Telephony network enables the user to obtain access to a vast amount of data through a connection to a remote Information Server, and the WorldWideWeb (WWW). Thus, the system is *unrestricted with respect to the amount of information it can provide* to the user, while still *being portable*.

Yet another advantage of **Minotaurus** is the usage of a GPS device, that introduces the notion of vehicle navigation in Tourist Information Systems. The GPS device is used for the display of the user's geographic position, assisting him during his excursions.

Last but not least, the system uses a well-defined structure based on Relational Data Base Technology and also provides a visual presentation using Multimedia Technology.

In the rest of this paper we will describe the architecture of **Minotaurus**, its basic characteristics, the functionality it provides and finally, the Client and Server components. We will mention the contribution of this work and we will conclude with plans for future work and possible improvement.

2. The *MINOTAURUS* architecture

In this section we'll describe the architecture of the **Minotaurus** system, its components and their attributes. **Minotaurus** consists of two parts: the **Information Service System** and the **Mobile Information Stations [6]**.

The **Mobile Information Stations** are portable systems which travelers and tourists can use during their vacations or tours in order to obtain access to valuable information. This portable system contains 3 components (Figure 1):

- A portable multimedia computer (Laptop).
- A Global Position System (GPS) receiver.
- A wireless modem.

The portable multimedia computer is the basic component of a Mobile Information Station. It runs the application software (**Minotaurus Client**) which is responsible for the presentation of the tourism information, manages the interface with the other peripheral components and handles the interaction with the user. It also contains large storage mediums (Hard Disks, CD-ROM) for storing the tourist multimedia data.

GPS is a satellite positioning system based on the NAVSTAR/GPS [8][13] project of the U.S. NAVY. In a few words, the GPS receiver consists of a PCMCIA card and a special antenna that receives specific signals from the GPS satellites. The PCMCIA card processes the satellite signals and can compute quite accurately (100 meters precision) the geographic position (latitude, longitude, height) of the Mobile Information Station every 1 sec.

Finally, the wireless modem consists of a mobile telephone and a PCMCIA cellular data card. It is used to establish communication connections between Mobile Information Stations and Information Service System through modern cellular data communication networks. **Minotaurus** uses these connections to successfully access dynamic information stored in remote service systems. Dynamic information is time-dependent (changes continuously) and cannot be stored in the storage media of the Mobile Information Stations.

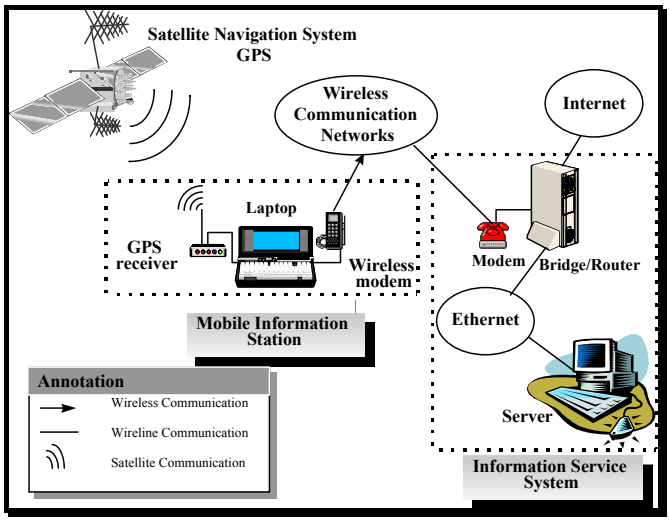


Figure 1. The **Minotaurus** architecture

The **Information Service System** is a centralized information system responsible of processing and servicing of the requests sent from Mobile Information Stations for presentation of dynamic tourist information.

The Information Service System consists of three components :

- A bridge/router.
- A master desktop computer.
- A set of secondary desktop computers.

The bridge/router is a **base station [6]** responsible of establishing the wireless communication between the Information Service System and the Mobile Information Stations.

The master desktop computer is the basic component of a Information Service System. It runs the software (**Minotaurus Server**) which is responsible of receiving requests from the Mobile Information Stations, and servicing them appropriately. Each request is transformed to one or more SQL queries which are then forwarded to a relational DBMS for processing. The results are retrieved and sent back.

The set of secondary computers is used to constantly update the database with the dynamic information. It constitutes a local network along with the master computer.

Finally, the communication between the three components mentioned above, is established using a traditional Ethernet-based LAN. Some alternative solutions could be ISDN, ATM or other networks. On the other hand the communication between the Information Service System and the Mobile Information Stations is established using cellular communication networks like GSM-900 and DCS-1800.

3. The *MINOTAURUS* Client

The **Minotaurus Client** is the software application running on the Mobile Information Stations. It exports the functionality of **Minotaurus** to the users. The Minotaurus Client consists of three subsystems :

- The Geographical Position Display (GPD) subsystem, which is responsible for the accurate display of the geographical position of a Mobile Information Station onto a digital map of the area where the user is currently moving.
- The Static Tourism Information Presentation (STIP) subsystem, which is responsible for the presentation of multimedia tourist information to users.
- The Dynamic Information Management (DIM) subsystem which is responsible for the management of the communication establishment between the Mobile Information Stations and the Information Service System for access to dynamic tourist information and of presentation of information to users.

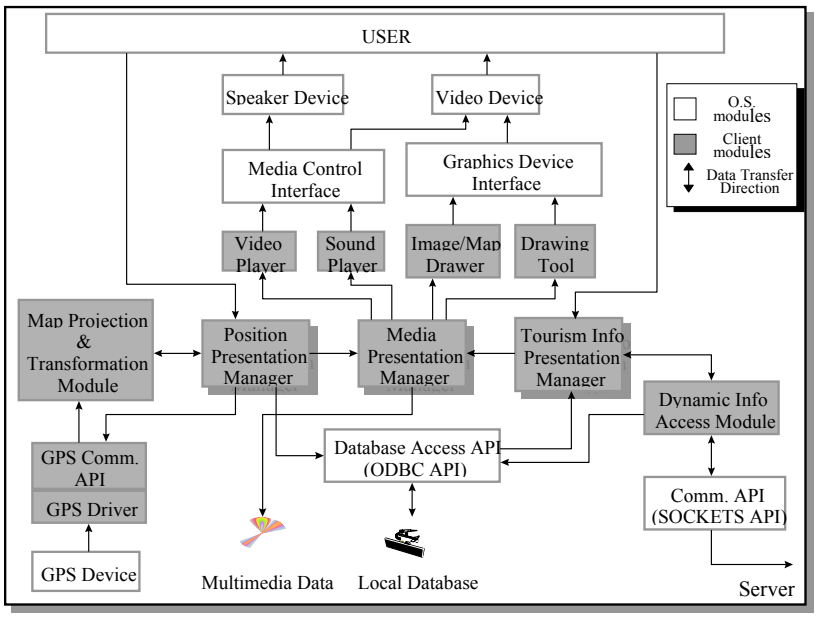


Figure 2. The Minotaurus Client architecture

In the following sections will describe the three subsystems and the software architecture (Figure 2) of Minotaurus Client.

3.1 The Geographical Position Display subsystem

The Geographical Position Display (GPD) subsystem is the component of Minotaurus Client which undertakes the display of the position of a Mobile Information Station onto a digital geographical map of the area the user is currently moving.

In order to display the user's position, GPD uses the GPS receiver and executes the following procedure (Figure 3):

- GPD communicates with the GPS receiver every 1 sec and receives the computed position of the Mobile Information Station. This position is described in an elliptic geographical coordinate system named World Geodetic System - 84 (**WGS-84)** [14].
- GPD transforms the position's value as measured by the GPS receiver from elliptic to Cartesian coordinates system using the *Universal Trancator Mercator* **(UTM)** projection method [2].
- GPD transforms the value of the user's position from the Cartesian **UTM** coordinates system to the Cartesian image coordinate system (Pixel coordinates) using the *Mapping Polynomial with Control Points* algorithm and *Resampling* methods. These methods improve the quality and the precision of the digital map removing the distortions caused by scaling, rotation, shearing, reflection, warping but not the ones caused by random errors.

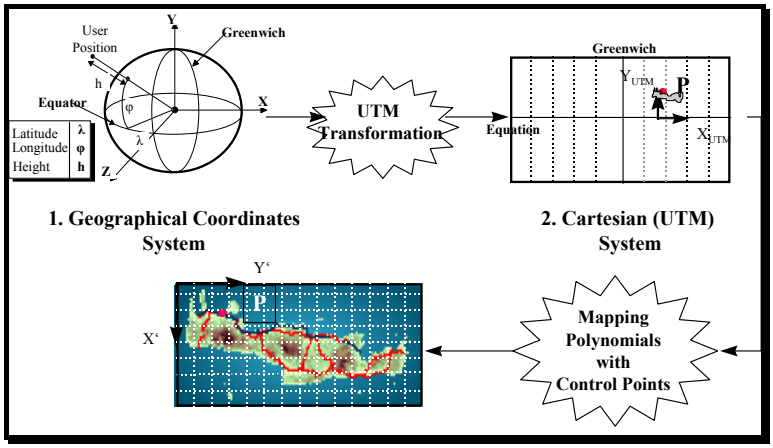


Figure 3. The Geographical Position Display on Digital Map Method

The whole procedure of Mobile Information Station position display is managed by the *Position Presentation Manager* (PPM) module. PPM not only controls the communication between Minotaurus Client and GPS device via the *GPS Comm. API* module and the projection and transformations of the initial values from GPS receiver via the *Map Projection & Transformation* module but it is also responsible for the access of digital maps from the Mobile Information Station local multimedia database and the display on the screen of the mobile computer.

3.2 The Static Tourism Information Presentation subsystem

The Static Tourism Information Presentation subsystem (STIP) undertakes the management and servicing of the user requests for *static* tousist information presentation. This information which describes historical and tourist sites or geographical areas of general interest via multimedia (texts, photos, maps,

audio and video), doesn't require continuous updates and is stored in the secondary storage of the Mobile Information Stations (CD-ROM).
The STIP's basic operations are :

- The processing of the user requests for tourist information presentation.
- The formulation and execution of the appropriate SQL queries to the relational DBMS of the system.
- The final visual presentation of the information to the user.

The *Tourism Info Presentation Manager* (TIPM) is responsible of the management of the procedure for tourist information retrieval. Specifically, after receiving the user requests for information presentation, TIPM processes it and creates the appropriate SQL queries to retrieve the information from the local database in Mobile Information Stations. The SQL queries are executed via the *Database Access API* module and the SQL results are returned to the TIPM.
Then, TIPM informs the *Media Presentation Manager* (MPM) to undertake the final visual information presentation to the user. The MPM uses one of the modules *Video Player, Sound Player, Image/Map Drawer, Drawing Tool* to handle different media types. In the first three cases, MPM accesses the multimedia database of the Mobile Information Station and provides the corresponding data files to the Multimedia Players. In the last case, text or the attributes of the graphical objects are sent to the MPM by TIPM in order to be displayed.

3.3 The Dynamic Information Management subsystem

The Dynamic Info Access Module subsystem (DIAM) is responsible of managing the communication between the Mobile Information Stations and the Information Service System. Furthermore, it is responsible of the presentation of *dynamic* tourist information to the user.
The term *dynamic* is used to describe the time-dependent and time-varying tourist information such as news, weather forecasts, cultural and special events, time schedules of excursions with various transportation media, reservations in hotels and flights etc.
This information is stored into the database of the Information Service system in order to be easily updated. The Mobile Information Stations retrieve it using wireless, cellular communication networks (e.g. GSM 900). Cellular communication networks do have several disadvantages [1][9]:

- Low transmission rates (up to 9600 bps).
- Relatively high cost, compared to traditional networks (wired).
- Low connection quality (It is quite common to face difficulties in connecting to the server, while the connection itself suffers from noise which can frequently cause disconnections).

As a partial solution to these problems, we propose a caching technique: small-size databases are kept locally (on the client's side) and their content is

updated by downloading the dynamic data from the centralized database located at the Information Service System. Each time the Client Application is executed on the Mobile Information Station, a connection is established between the Mobile Information Stations and the Information Service System, through which the local database's content is updated to reflect the latest state. This method allows us to:

- Minimize the duration of the connection to the Information Service System in order to minimize the related economic cost.
- Minimize the time delays related to the service of the user's requests, since the network is bypassed and data is now accessed from the local database.

However, this method may face data inconsistency problems. The majority of the dynamic data mentioned –such as weather forecasts, sport and cultural events, trip schedules etc.– changes slowly, allowing us to update the local caches on a regular yet in-frequent basis. By convention we've decided to update the local cached on a daily basis, during low-rush or no-rush hours as far as the system's workload is concerned (e.g. early in the morning).

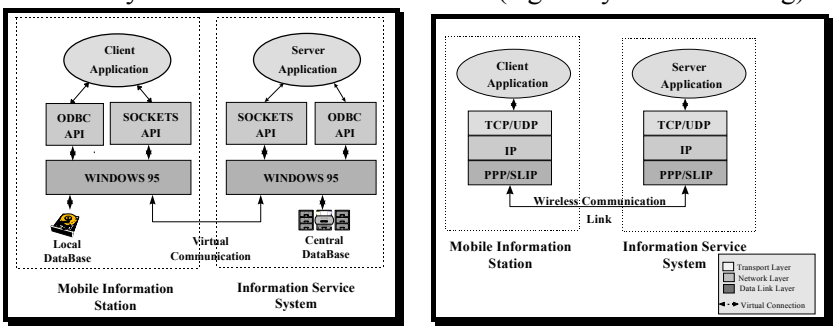


Figure 4. The Client - Server Communication

On the contrary, this method is not sufficient for frequently changing information, such as reservations-related information. To solve this issue, the system has no alternative to accessing the Information Service System directly, in order to serve specific user requests.

Access to the dynamic information is managed by the *Dynamic Info Access* module. When the DIAM receives a request for dynamic data by the Tourism Info Presentation Manager, either retrieves the related information from the local (to Mobile Information Station) database if it is up-to-date, or manages the remote communication establishment and the transmission/reception of data between the Mobile Information Station and the Information Service System.

The fundamental characteristics of wireless communication between the Mobile Information Stations and the Information Service System (Figure 4) are:

- Client- Server architecture [4][7].

- TCP/UDP transport protocols for the end to end communication management [13].
- IP network protocol for the transmission over heterogeneous communication networks.
- SLIP/PPP data-link protocols for point to point communication between the Mobile Information Stations and the base station in Information Service System [12].
- Cellular PCMCIA Data Card and modems for the physical transmission of data.

4. The MINOTAURUS Server

The Minotaurus Server is the software application running on the master desktop computer of the Information Service System. Its main purpose is to serve the information requests sent by the Mobile Information Stations to the Information Service System. In this section we briefly discuss the fundamental components of the Server's architecture and their functionality.

The procedure for serving the information requests is comprised of the following steps:

- Reception of the information requests sent by the Mobile Information Stations.
- Analysis and translation of these messages.
- Construction and execution of the appropriate SQL requests to the central Information Service System's database [5].
- Retrieval of the results, construction of the communication messages, and transmission of these messages to the recipients (the Mobile Information Stations).

The *Dynamic Info Access Module* (DIAM) of Server application manages the communication and the message interchange between the Information Service System and the Mobile Information Stations. When DIAM receives an information request from a Mobile Information Station, forwards it to the *Message Translator-Creator* (MTC) module. This module's basic task is to analyze and translate the received messages to a *Message Language*. This language specifies the structure of the messages interchanged between the Mobile Information Stations and the Information Service System.

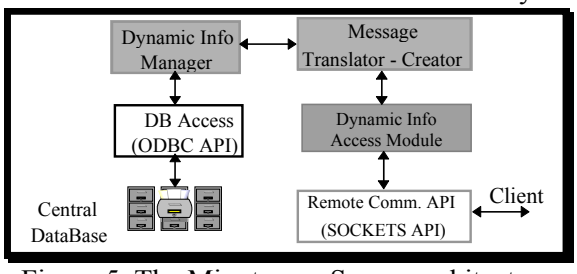
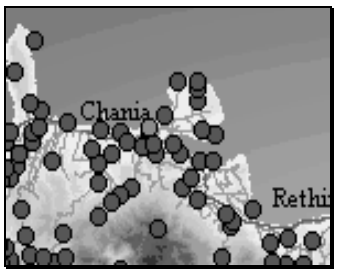


Figure 5. The Minotaurus Server architecture

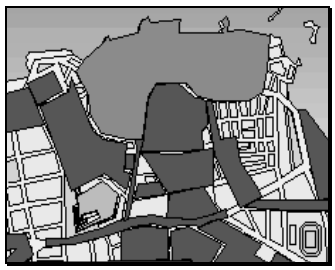
In the next step, MTC requests the Dynamic Info Manager (DIM) to initiate the information retrieval procedure. The DIAM creates the appropriate SQL queries, executes them via the *Database Access API* module and the query results are returned to the DIM. The DIM forwards the results to the MTC module in order to construct the answer message (in order to Message Language). Finally, this message is sent to its recipient via the DIAM.

5. The functionality of MINOTAURUS

In this section we will describe the main features of the **Minotaurus**'s functionality. Specifically, we will present in depth the potential information capabilities provided to the users, as they travel with their vehicles. As previously stated, the **Minotaurus**'s main objective is the presentation of tourist information for a geographic province, an area which is characterized by similar attributes (history, weather, traditions, geographic neighborhood etc.). Such an area is the island of Crete which was used as a pilot-area by the **Minotaurus** project.



The geographic area **Crete**



The area of interest **Chania**

Figure 6. The presentation of the geographic province **Crete**

According to the model of information presentation **Minotaurus** uses [3][10], the geographic province is presented to the users via a set of *Areas Of Interest* and *Sites*. The *Areas Of Interest* can be smaller geographic parts with their own distinct attributes (e.g. towns, villages etc.), while the *Sites* are usually areas with special tourist, historical or geographical interest (e.g. monuments, museums, mountains, gorges etc.).

The *Areas Of Interest* are presented using the map of the geographic province where they belong. The geographic positions of the *Areas Of Interest* are displayed on this map as graphical objects (e.g. circles, polygons). This objects are hotspots. The user can select them with his/her mouse, to visit them and see the information that the system provides for them.

An *Area Of Interest* is usually composed of a set of smaller *Areas Of Interest* and/or *Sites*. For example, a city consists of a set of districts, roads, squares, described as *Areas Of Interest*, and a set of museums, churches, archeological

grounds, described as *Sites.* They are presented in the map of the city in the same manner as described above (Figure 6).
In short, a tree hierarchy is created with root being the geographical province, nodes the *Areas Of Interest* and *Sites* as leaves.
The complete presentation of the information regarding the *Areas Of Interest* and *Sites* is achieved by using Multimedia (combination of text, photos, sound, video).
In addition, the **Minotaurus** system displays the location of the user as he/she travels along with the tourist information of the area. The user's location is presented as a blinking dot on the digital map of the area (Figure 8).
In summary we achieved:

- Simultaneous display of the user's position and the nearby *Areas Of Interest* on the common geographical map of the area.
- Automatic map interchange when the users arrive/leave at an *Areas Of Interest* which has its own geographical map.
- Automatic notification of the users using text and sound when they approach an *Area Of Interest.*

Also, the system has the ability to access dynamic information stored in remote database systems. The stored information can be:

- Structured data, dynamic information related to the *Areas Of Interest* and *Sites* according to the system's information presentation model. Such information could be cultural, sport, special events etc.
- Unstructured data, general information. These are not related to the geographical province presented and are displayed by a WWW browser.

Finally, the user interaction model [3][10] is used for accessing the tourist information. This model gives significant help to the user as it achieves to:

- Present the information on different levels of detail (e.g. using maps with different scale).
- Present independently the *Areas Of Interest* in the same format with the traditional tourist guides.
- Access information with different ways.
- Show the information perspectives at any point of the user navigation.

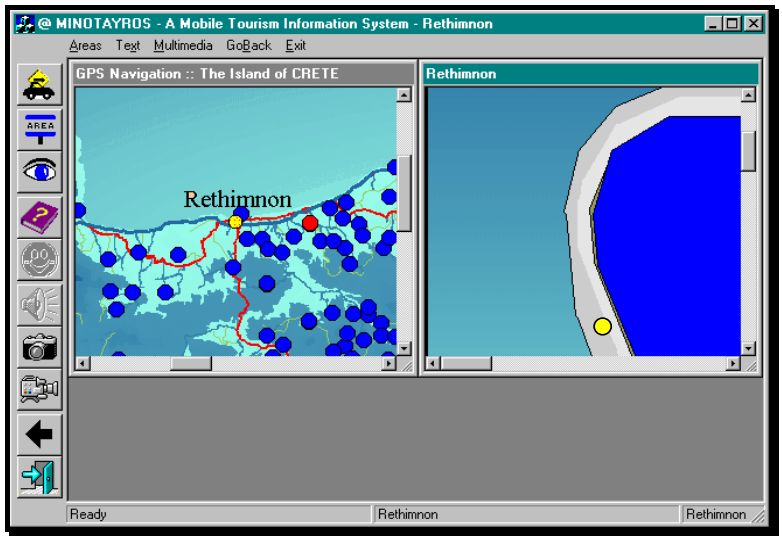


Figure 7. User's Position and Tourist Information Simultaneous Display

Conclusions

In this section we will mention the contribution of **Minotaurus** and in the tourist industry and the computer science, and we will suggest some future extensions.

The most important advantage of **Minotaurus** is the effective integration of three different heterogeneous systems: a GPS-based vehicle navigation system, a multimedia tourist information presentation system and a wireless communication system able to access data from remote database systems. The result of this integration achieves the development of a mobile information system able to replace the traditional tourist information systems. Its main characteristics are:

- The portable platform. In this way users can continuously carry the system inside their car in full effect during their trips.
- The visual information presentation via multimedia (text, photos, sound, video).
- The ease and speed of access to the tourist information.
- The well-defined structure and the independent presentation of the information.
- The unrestricted amount of information which is available to the users via wireless connections with remote databases.

Finally, **Minotaurus** has been developed in a platform which admits many future extensions. The most important of them are the increase of the precision in the GPS-based vehicle navigation system, the use of voice in the user interface, the multilingual support etc. Finally, there are plans for the exportation of the system's functionality into more light-weight platforms (e.g. PDAs).

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