Toward Location-based Services using GPS-based Devices

Monica Vlădoiu and Zoran Constantinescu

Abstract—**We present here our work on developing ePH, which is a framework for building of a dynamic user community that shares public interest information & knowledge, which is accessible through always-on context-aware services (location-based included). We introduce here unde.ro, a geo-spatial search and tracking environment that has been developed to support ePH, and gipix-102B, a GPS-based module for location-based services. ePH aims to be a framework around a user-centred digital library that stores regional information and knowledge and that boosts a self-developing community of transnational users around it. The content will be accessible through always-on contextual services. The users can get it or enhance it, according to their location: at home or office by using a computer, on road with a specific GPS-based device in the car, or off-line, off-road via mobile phone. The content will include: public interest information (drugstores, hospitals, general stores, gas stations, entertainment places, restaurants, travel and accommodation, weather, routes etc.), historical/touristic/cultural information and knowledge, users' personal "war stories" (tracks, touristic tours, impressions, photos, short videos and so on), and users' additions, comments or updates. We develop (open source) the ePH system for our county of origin and will provide an easy-to-use how-to recipe to clone it for other regions.**

Index Terms—**context awareness, GPS-based devices, internetworking heterogeneous wireless/wireline networks, location-based services, wireless/mobile networked applications**

I. Introduction

The information and knowledge within our world are constantly growing and becoming more and more complex. Not only communications revolutionize, but also our perceptual reaction to the environment in which we live, our construct of reality, and the nature of knowledge. Through the satellite related-technologies, location-based services and personal mobility can be easily sustained. User location is an important dimension in this new data-service world – "it has the potential to make mobile services more relevant to users as information is adjusted to the context" [1]. The information and knowledge presented to users should be tailored accordingly with their context, being it personal or environmental. In case of a context-aware tourist guide, personal context can consist of "the visitor's interests or the visitor's current location", whilst environmental context could include: the time of day, or the opening times of museums [2]. Moreover, wireless has the potential to change the e-services in three directions: accessibility, alerting and averting, and updating [3]. The use of mobile devices and infrastructure is making possible to access information from any location at any time [4]. The junction of mobile and web service technologies provides for the development of new hybrid services (that span many communication infrastructures) [1]. In many circumstances, information and knowledge are socially constructed and the IT mediated communication has allowed complex social networks to become a leading form of social organization [5]. That is why the communities will play a significant role in the consolidation of our growing Information and Knowledge Society.

We present here our ongoing work on developing ePH - a framework for building of a dynamic user community that share public interest information and knowledge that is accessible through always-on, context-aware services (location-based included) [6]. We introduce here unde.ro [7], a geo-spatial search and tracking environment that has been developed to support ePH (using Google Maps), and gipix-102B, a GPS-based module for location-based services. The main goals of this project are to construct a user-centred Digital Library (DL) that stores regional information and knowledge and to boost a self-developing community of transnational users around it. The DL's content will be accessible through contextual services that are always available. In the first stage, the DL will contain public interest information (pharmacies, hospitals, general stores, gas stations, infotainment, restaurants, travel and accommodation, weather, routes etc.), historical or cultural knowledge, and touristic information about a particular county. The ePH services will be personalized and context-aware (geo-location, around a situation, an idea or an entity etc.).

The users will be allowed to manipulate freely the content for their personal interest. They can access it or enhance it, according to their location: at home/office with a computer, on road by using a specific GPS-based device in the car, or off-line/off-road via cell phone. Users can make additions, comments, or updates. The user-generated content will be personalized, as users can upload their personal "war stories" (tracks, touristic tours, impressions, geo-tagged photos, short videos/audios etc.). More, the whole ePH system will subscribe to the users' needs, goals and abilities.

Manuscript received March 22, 2008.

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II. Location-based Services

Location-based services (LBS) lie between three technologies: newest ICT (mobile telecommunication system and hand held devices), the Internet and Geographic

Information Systems (GIS) with spatial databases [8]. According to the OpenGeospatial Consortium they can be defined as "a wireless-IP service that uses geographic information to serve a mobile user [9]". LBS give the possibility of a two way communication and interaction between the user who can submit to the service provider his or her request of information, his preferences, and her context. This helps the provider of such location services to deliver information tailored to the user needs. The infrastructure to support location-based services includes: mobile devices, communication network, positioning component, service and application provider, and data and content provider [10].

There exist a broad range of different location based services, the main categories being *navigation* (directions, indoor routing, car park guidance, traffic management), *information* (infotainment, travel and tourist guides, travel planner, shopping guides, mobile yellow pages), *tracking* (people, pet, vehicle, product), *games* (mobile games, geocaching), *emergency* (calls, automotive assistance), *advertising* (banners, alerts advertisement), *billing* (location sensitive, road tolling), *management* (facility, infrastructure, customer relationship, fleet, environmental, security – police, ambulance), *leisure* (buddy finder, instant messaging) [10].

Location-based services are different from traditional paper and internet based media (guides, directories, maps etc.) because they are aware of their context of use and can adapt their contents and appearance accordingly. Context is any information that can be used to characterise the situation of an entity (person, place, or object that is considered relevant to the interaction between a user and an application). There are many different types of context, some of the most commonly considered are location, time, task, social or personal context. These relate to where the user is, when s/he is using the service, what s/he is using the service for, who's s/he with, what s/he likes etc. However considerations such as how young the user is, if it's snowing or who the user is with can be equally as important.

III. ePH HIGH-LEVEL ARCHITECTURE

The ePH framework consists mainly from the core digital library and the communities that gravitate around it, i.e. the developers and the users [6]. The rough architecture is depicted in Fig. 1. The Communications Server (CS) provides the support for the always-on kind of service, regardless of the place where the user is when s/he needs that service. The Location Server (LS) makes available the right service according to the location. The current stage of the project is as follows: the geospatial engine unde.ro provides the basic functionality that is needed for ePH, the GPS car device, called gipix-102B, is in prototype testing phase, and the vital cores of both the CS and the LS are functional as well. In parallel with these technical achievements, we have been working on the working model for always-on services, in the context of digital content use and user communities. Also, the dissemination process has already begun through making the site unde.ro known to various kinds of potential users.

ePH users can make various requests for location-based services through the communication server. As the ePH system will have to respond to day-to-day problems, these can be in a large range from virtual tours in a selected region with instructional or educational purposes, as well as with entertainment or informational goals, to issues of e-safety in transport (in a scenario taking place in a remote mountain region, in which the fuel is going down rapidly - the ePH could display on user's car device where the nearest gas station is). Moreover, the car device gipix-102B can show at the same time both the road map and highlight different points of interest (information about the closest gas station, pharmacy, hospital, accommodation etc., historical sites or touristic sights), or provide access to other users' stories about that geo-location. The user can also record his/her own impressions, or geo-tagged photos, etc. to be uploaded at a later time in the DL (when the bandwidth will allow it). S/he may also get in touch with other on-line ePH users who are, at that moment, in the same geographic region (in a vehicle-to-vehicle way). More, the ePH system will be able to select and present the user with various Points of Interest (POI) within a given area (for instance, the drugstores or the general stores).

In order to perform its job, i.e. to make available the right service according to the location, LS uses a GIS Server. This enables the distribution and manipulation of maps, models, tools and specific point of interest within the ePH framework in a way that fits well to users' needs. The GIS Server allows to developers to author cost-effective maps, globes, points of interest and geoprocessing tasks on their desktops and publish them via a server using integrated tools. GIS functions can then be delivered as services throughout the system. The GIS Server provides for GIS capabilities to be delivered to large numbers of users over various networks. Links to other GIS servers are also provided. The database that LS uses contain information about users, POI, cases used in Case-based Reasoning (CBR) etc.

Mobile and Web Servers implement a variety of communication protocols to provide the connection with different types of input devices (mobile phone, gipix-102B, PDA etc.). The Web Server interface has been developed by using Google Maps API. Services Server supplies links to other similar systems (e.g. social networks, data repositories and so on). Besided these servers, CS included modules for content requesting (downloading) and content providing (uploading) that implement primitives for the connection with the location server. *unde.ro* has two main parts: the location server and a CBR engine. The technical limitations of mobile devices call for services that require minimal interactions with the user and adapt their behaviors to the user's expectations. Context-awareness has proven to facilitate personalization of services by enabling the adaptation of the service to the user's situation. However, this adaptation is often carried out by using pre-defined rules that only apply to some contexts. This limitation in location-aware services can be overcome by referring to the previous actions of the user. Metrics to calculate the similarity between the current user's location and the previous ones are needed. Based on these metrics, our system could provide a personalized service by determining the service behavior expected by the user for his or her current (location of) interest [11].

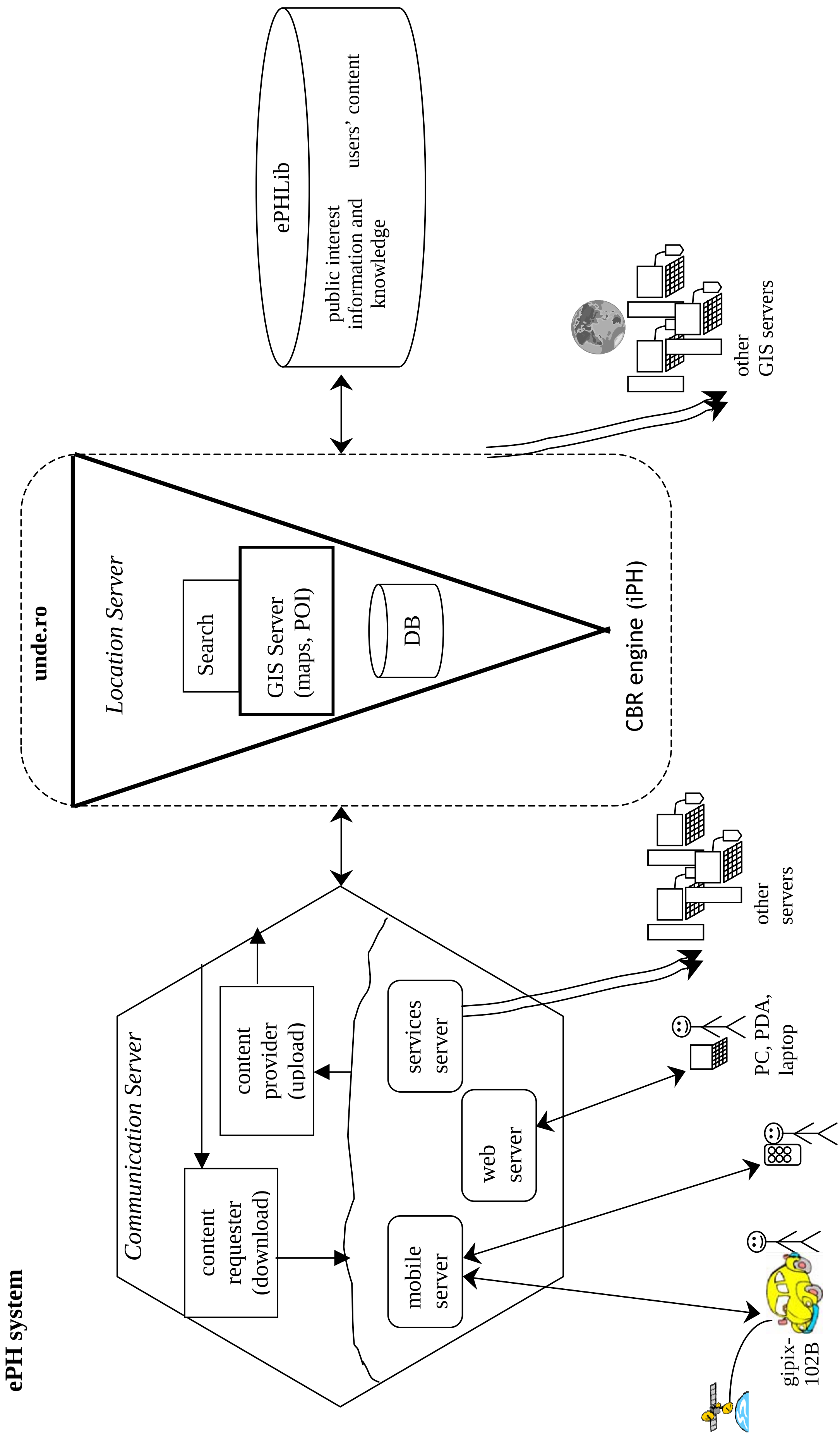

Figure 1: The ePH architecture

The sensing of the context helps to deliver tailored information for a specific user, for instance to a visitor of a National Park as described in [12]. Such a park visitor could be interested in "places where mushrooms did grow in the last years or where the next campfire location is". On the other hand, context sensing rises many privacy concerns if people are tracked by their position or by analysing their references and action history. Such history analysis helps business applications to get a perfect customer model but can raise user fears. Thus, context sensing is closely related to user security and privacy. To reduce user fears s/he should be always informed about the information which is collected and the security of data transfer. Further, LBS user should have an option to decide if context based service features are turned on or off [10].

IV. SOME ePH PRACTICAL RESULTS

Within the two next figures we present some screenshots that have been obtained by using the ePH system in some concrete situations. The former shows a typical tracking screen for a given period: 10.03.2008-21.03.2008 (Fig. 2). 158 records were found for this time range. For each record several information is available: an unique identifier, the start date, the stop date, the duration of the motion, the distance covered and the average speed. Further, there are offered other more sophisticated reports to be displayed after clicking the right icon. The star icon triggers the display of the track on the map, while the blue round icon launch Google Earth and display the track there. By clicking the blurred line the user get access to the graphic on which the speed (v), the altitude (h) and the GPS errors (e) are represented. The three graphics can be displayed one by one or overlaid. On the gray right side there is information that is needed by the ePH admin (the number of taken points – GPS positions, the track displayed in GPX format, some simplified track representations etc.).

The later screen illustrates the results of two operations: a track displaying on the map (the purple curved line) and a search for a given point of interest (named "dorneasca") (see Fig. 3). An upside down drop-like cursor can be moved along the track path and the given information will be tailored accordingly. On the right side of the screen there is a small info box, which contains data about instantaneous speed (v), altitude (h), GPS error (e) and track length (d). At the lower part of the screen one can see the speed-height-error graphic that has been drawn for this track (red for speed, green for height and blue for errors). In both screens, from the left upper main menu several options can be selected: positioning, tracks, routes, personal or general points of interest, settings, configuration of users, car devices, vehicles and so on.

V. CONCLUSIONS AND FUTURE WORK

There is a need for always-on services that offer personalised information and knowledge to users, which should provide a seamless user experience, irrespective of the terminal or communication network. More and more information about our environment is available with real-time updates. High added value for user is expected if information can be exchanged between home, car and portable use. There is a strong need to develop harmonised, interoperable, pan-European mobility services, context aware, with reliable contents and wide availability to users and their interfaces [13]. The combination of various services makes up a service-oriented architecture [14]. Location-based services form an important group of mobile information services to be included in this architecture.

The work presented in this paper can prove the potential to accomplish wide deployment of public interest services and to provide for higher mobility of people and increased quality of life, through the provision of accessible and reliable information and knowledge services. Users can benefit from utilizing the ePH framework in various ways [6]: (1) easy-access to useful information or knowledge for anyone, at anytime, from anywhere; (2) easier, safer, quicker, more informed and increased quality services (medical, schools, tourism, stores, gas stations, entertainment, restaurants, travel and accommodation, and so on); (3) bringing historical, geographical and cultural information or knowledge to people in a more attractive and appealing way, given the interest and energy that people spend using PCs and gadgets; (4) potential to boost a virtual community in which people who are interested in some particular topic can share information, impressions, hints, photos etc. and (5) make people more aware of the advantages of using IT for everyday life.

The main challenge we have experienced so far has been the development of the innovative, programmable, GPS-based car device, because gipix-102B has been developed as low cost, so virtually anyone can afford it and enroll within the ePH system. Of course, the system is available to other mobile devices' users, but the full functionality can be obtained only by being always-on with ePH, and that involves having a gipix-device in the car.

The future challenges before us, as we foresee them now, are presented below:

- to extend the system so that it can handle various contexts: where you are (spatial context), whom you are with (social context), and what resources are nearby (information context) etc. In addition to that, technical aspects like communication bandwidth, network, and speed of user have to be considered [15];
- to develop a model for always-on services in the context of digital content use and user communities. To understand the psychology of users, what influences them to join and support a particular community or to behave altruistically or cooperatively, is of major importance;
- to construct the core user-centered digital library, which content must be reliable, accurate, relevant, comprehensive, and free to personal use;
- to create an architecture for connecting various systems together in a multi-service overlay network;
- to ensure the continuity of the service after the project work will be finished, by creating a vivant community that will "survive" to project development end. More, the developers aim to start their own community, as they will provide both a quick how-to for building similar "alive" frameworks and all related software as open source.

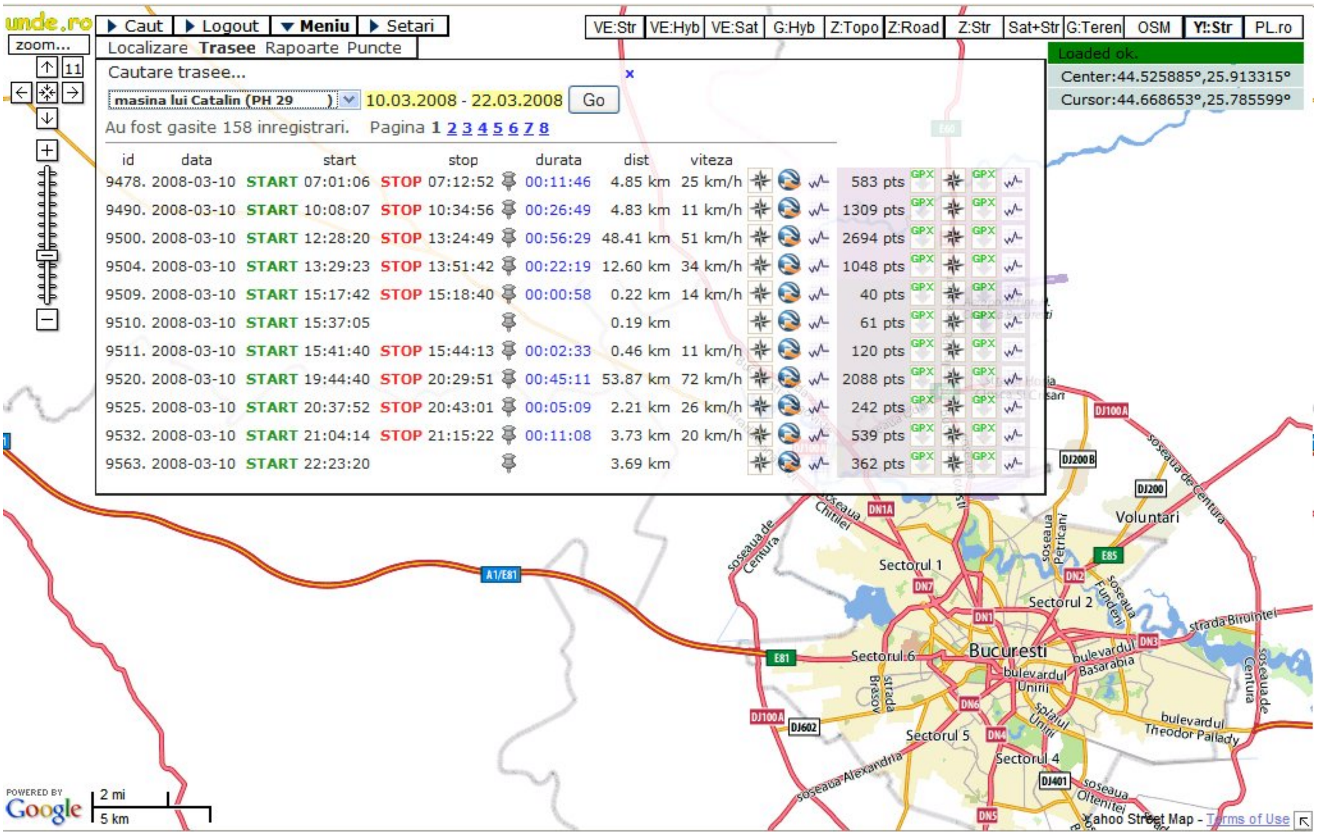

Figure 2: Sample ePH screenshot – Car tracking over a given time period

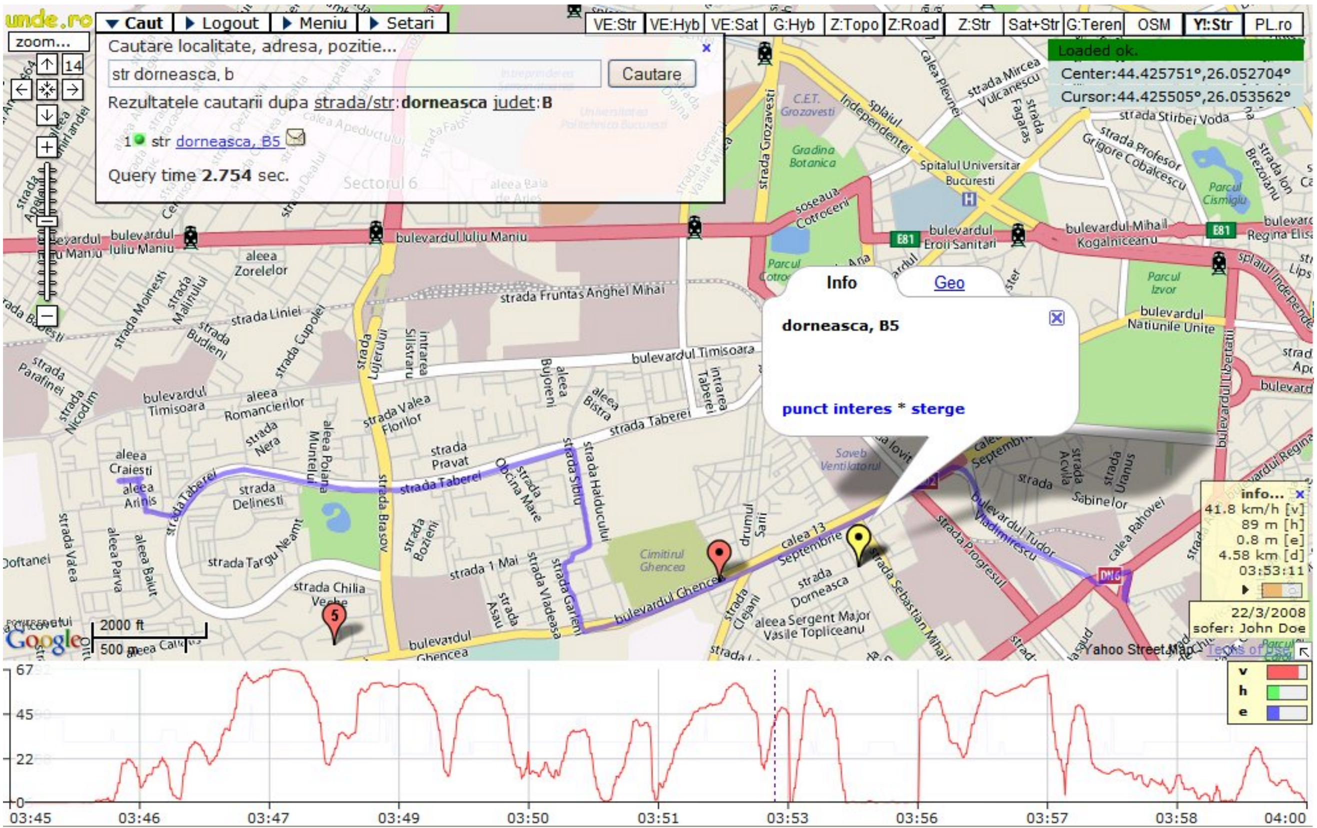

Figure 3: Sample ePH screenshot – graphical car tracking and POI search result

REFERENCES

[1] J. Schiller, A. Voisard, *Location-Based Services,* Morgan Kaufmann, CA: San Francisco, 2004

[2] K. Cheverst, N. Davies, K. Mitchell, A. Friday, "Experiences of developing and deploying a context-aware tourist guide: the GUIDE project", in *Proc. of the 6th Annual Int. Conf. on Mobile Computing and Networking,* August 2000, pp.20-31, Boston, Massachusetts

[3] K. N. Lemon, F.B. Newell, L. J. Lemon, "The wireless rules for e-service", in *e-Service – New Directions in Theory and Practice,* R. T. Rust, P.K. Kannan Eds., New York, M.E. Sharpe, 2002, pp. 200-232

[4] F. Hirsch, J. Kemp, J. Ilkka, *Mobile Web Services: Architecture and Implementation*, Wiley, New York, 2006

[5] B. Wellman, *Networks in the Global Village: Life in Contemporary Communities*, Westview Press, Colorado: Boulder, 1999, p. 356

[6] M. Vladoiu, Z. Constantinescu, Framework for Building of a Dynamic User Community (ePH) – "Sharing of Context-Aware, Public Interest Information or Knowledge through Always-on Services", to be published in *Proceedings of 10th Int. Conference on Enterpise Information Systems*, June, 2008, Barcelona, Spain

[7] unde.ro (2008, March) - A geo-spatial search and tracking environment [online], Available www.unde.ro

[8] N. Shiode, C. Li, M. Batty, P. Longley, D. Maguire, "The impact and penetration of Location Based Services", in *Telegeoinformatics,* H. A. Karimi, A. Hammad, Eds, Florida: Boca Raton, CRC Press, 2004, pp. 349-366

[9] Open Geospatial Consortium (OGC), (2008, March), Open Location Services (OpenLS) 1.1. [online] Available http://www.opengeospatial.org/standards/olscore

[10] S. Steiniger, M. Neun, and A. Edwardes, (2008, March), Foundations of Location Based Services [online], Available www.geo.unizh.ch/publications/cartouche/lbs_lecturenotes_steinigeretal2006.pdf ore

[11] O. Coutand, S. Haseloff, S. Lun Lau, K. David, (2006, June), "A Case-based Reasoning Approach for Personalizing Location-aware Services", in *CEUR-WS Proceedings of 1st Workshop on Case-based Reasoning and Context Awareness (CACOA)* held in conjunction with the 8th European Conference on Case-based Reasoning (ECCBR) [online] Available ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-221/05.pdf

[12] A. –M. Nivala, L. T. Sarjakoski, "Need for context-aware topographic maps in mobile devices", in *Proceedings of ScanGIS 2003*, June 2003, Espoo, Finland, pp. 15-29

[13] European Commission. (2007, April), "Strategic Research Agenda ICT for Mobility" [online]. Available: http://ec.europa.eu/information_society/activities/esafety/doc/esafety_2006/sra_ict_for_mobility_v.3_final.pdf

[14] D. K. Barry, *Web Services and Service-Oriented Architectures: The Savvy Manager's Guide*, Morgan Kaufman, CA: San Francisco, 2003

[15] B. Schilit, N. Adams, R. Want, "Context-aware computing applications", in *Proceedings of IEEE Workshop on Mobile Computing Systems and Applications,* December 1994, Santa Cruz, California, pp. 85-90