

Review

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Location-based health information services: a new paradigm in personalised information delivery

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Abstract

Brute health information delivery to various devices can be easily achieved these days, making health information instantly available whenever it is needed and nearly anywhere. However, brute health information delivery risks overloading users with unnecessary information that does not answer their actual needs, and might even act as noise, masking any other useful and relevant information delivered with it. Users' profiles and needs are definitely affected by where they are, and this should be taken into consideration when personalising and delivering information to users in different locations. The main goal of location-based health information services is to allow better presentation of the distribution of health and healthcare needs and Internet resources answering them across a geographical area, with the aim to provide users with better support for informed decision-making. Personalised information delivery requires the acquisition of high quality metadata about not only information resources, but also information service users, their geographical location and their devices. Throughout this review, experience from a related online health information service, HealthCyberMap <http://healthcybermap.semanticweb.org/>, is referred to as a model that can be easily adapted to other similar services. HealthCyberMap is a Web-based directory service of medical/health Internet resources exploring new means to organise and present these resources based on consumer and provider locations, as well as the geographical coverage or scope of indexed resources. The paper also provides a concise review of location-based services, technologies for detecting user location (including IP geolocation), and their potential applications in health and healthcare.

Introduction

The concept that location can influence health is well known in medicine. Certain diseases tend to occur in some places and not others. Health information needs and services also vary with location. In fact, different places on Earth are usually associated with different profiles that can also change with time: physical, biological, environmental, economic, linguistic, social, cultural, and sometimes even spiritual profiles, that do affect and are affected by health, disease, and healthcare [1]. Caregivers need to know not only the history of patients they treat

but also information about the social and environmental context within which those patients live. Patients and the public in general also have similar needs that vary with location. The Internet offers a wealth of health information resources that can answer most of the knowledge needs of clinicians and their patients, and the public in general, but also carries with it the risk of overloading them with unnecessary information. A big challenge remains to find and push location-specific knowledge (e.g., local disease rates and guidelines Table 1) to users based on their location and needs [2].

Table 1: Examples of location-specific medical/health information

Examples of Location-specific Medical/Health Information
<ul style="list-style-type: none"> - Local disease rates and information*, maps and guidelines; - Targeted health education; - Addresses of local healthcare facilities; - Local health news; - Local health risks and hazards; - Travellers' health information; - Local drugs/drug trade names and prices (in local currency); - Information whose digital distribution rights are limited to some location(s); - In addition to serving up content (and interface) in language(s) relevant to the viewer's location.

* For example, the most common cause of splenomegaly in Kenya is malaria, while in the UK the most common causes of Splenomegaly are cytomegalovirus infection and toxoplasmosis.

Location-based information means information that is *immediately relevant*, which is the essence of the Semantic Web (the next-generation World Wide Web – <http://www.w3.org/2001/sw/>). Research literature discussing health and healthcare-specific potentials and applications of location-based services is currently very scarce (none in MEDLINE/PubMed as of January 2003).

Throughout this review, the author's experience in designing and implementing a related online health information service, HealthCyberMap <http://healthcybermap.semanticweb.org/>, is referred to as a model that can be easily adapted to other similar services.

The potential and applications of location-based services in health and healthcare

Different user (device) localisation technologies exist today that can locate in real time mobile (wireless) and desktop Internet users to their country, town or city of access, and even to their exact location on Earth (with an accuracy of metres) depending on the technology used. Geobytes, Inc. provides one such technology (see below). Departing from their generic list of applications of user localisation technologies <http://www.geobytes.com/applications.htm>, one can think about the following health and healthcare-specific scenarios:

- Geographical customisation of Web services, Web sites, and e-mail newsletters (personalisation by location), for example to serve up language relevant to the viewer's location, to cite only drugs, drug trade names and their prices as found in the viewer's country, and to deliver local health news, local weather and air quality maps, travellers' health information, and other health content specific to the viewer's location.

- Geographically targeted banner and email marketing and advertising. This can prove very useful to commercial

online health service providers and pharmaceutical companies.

- Web site traffic analysis to determine the geographical provenance of health sites' visitors – Figure 1. This information can then be used to tailor site content to match the needs of actual visitors and the characteristics of their location, as well as to refine site-marketing strategies and monitor advertising campaigns (especially in case of commercial online health services).

Determining the most active countries accessing a site can help prioritising development plans of new health information service interfaces and content in other languages, e.g., French language content and user interface, besides English (giving higher development priority to languages of most active countries). This becomes especially important when development resources (human and financial) are scarce, and to ensure rapid and sustained leadership over competitor services that might be also exploiting the potential of multilingual interfaces and content.

- Fraud detection and user authentication by confirming that users are actually present where they claim they are.

- Digital rights management to ensure compliance with distribution rights of copyrighted health information and media.

Mobile location-based services and their applications in health and healthcare

Besides transmitting real-time information on their precise location, next generation mobile phones currently entering the market (e.g., Microsoft Smartphone – <http://www.microsoft.com/mobile/smartphone/default.asp>) also provide users with wireless Internet access [3]. This makes them very versatile and powerful devices.

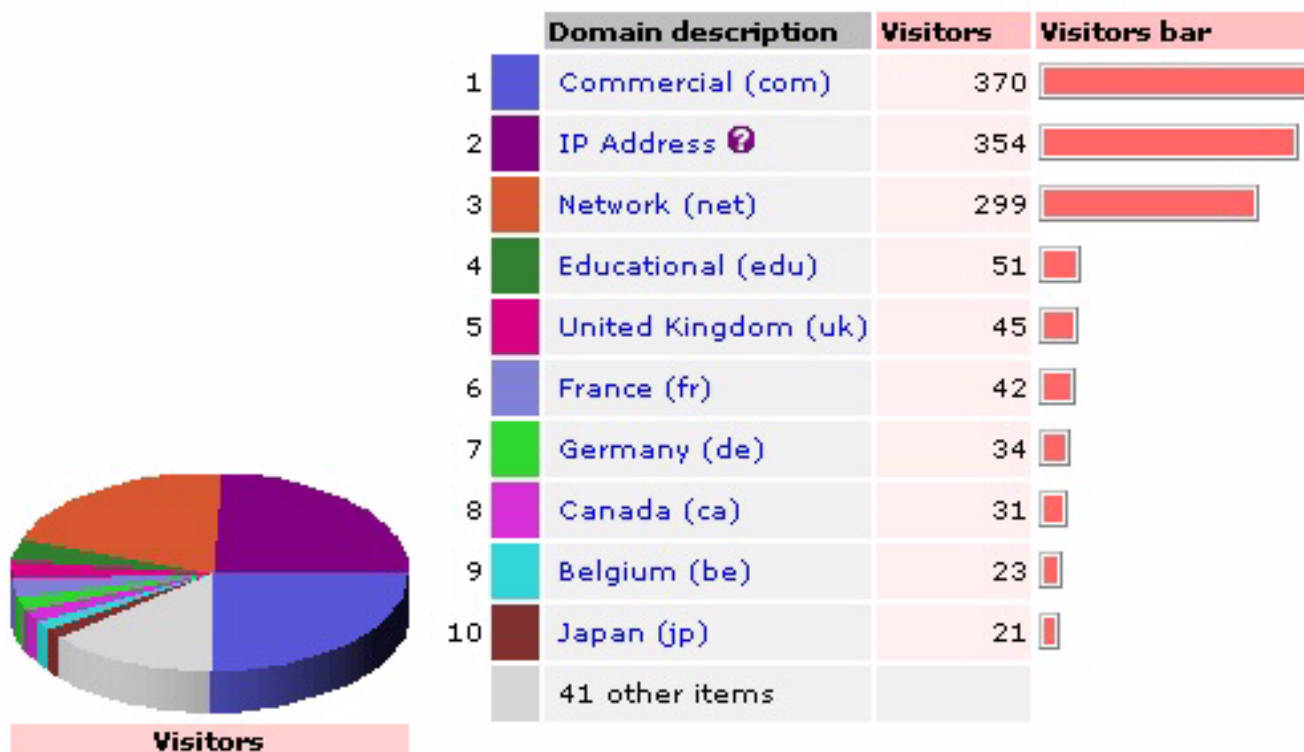


Figure 1
Geographical provenance of HealthCyberMap visitors based on server logs Sawmill 6.3.8 <http://www.sawmill.net> analysis of HealthCyberMap server logs for the period from 18th April 2002 to 1st June 2002 (45 days), showing the geographical provenance of HealthCyberMap visitors during this period. More sophisticated server log analysis tools utilise their own database to resolve visitors' IP addresses into more recognisable and useful provenance data <http://www.netiq.com/support/wrc/geotrends.asp>.

Mobile health applications require an understanding of where consumers are, where they have been and where they are going. Wireless mobile devices can continually transmit device (user) location to such applications, which must then make use of the transmitted information in a sensible way.

According to Berkowitz and Lopez [4], *location-awareness* refers to applications or services that make use of location information provided by suitable devices or software (location need not be the primary purpose of the application or service), while *location-sensitivity* refers to location-enabled mobile devices that can be used by location-aware applications and services such as mobile phones, personal digital assistants and pagers. Such devices rely on GPS (Global Positioning System)/mobile phone-related technologies.

One can also add to the second category of location-sensitive tools any software whose primary function is to de-

tect the locations of "static" Internet users (e.g., in the office or at home) based on their IP (Internet Protocol) address as demonstrated in HealthCyberMap (IP geolocation [5,6] – see below).

Following are some health and healthcare application examples of mobile location-based technologies.

- Health information and service providers can (if needed) react immediately to the changed location of a mobile user by delivering personalised timely information and services for his/her new roaming region [4].

- An online healthcare facility locator service can assist users in finding the nearest hospitals or clinics based on their location and health needs, and even provide them with driving directions and real-time traffic information [4]. For example, a mobile patient checking on the availability of a dental clinic in a given city might access geocoding services that identify the location of the patient and

nearest clinics, and would cull data from real-time booking services to check for clinics' working hours and book a suitable appointment, and from driving directions and real-time traffic information services to route the patient to the clinic.

- Helping ambulance and rescue teams precisely and quickly locate and track people who are in a medical emergency, injured, or lost, and also for ambulance fleet management. New FCC rules (Federal Communications Commission – <http://www.fcc.gov/911/enhanced/>) mean that GPS receivers will very soon become an integral part of all mobile phones.

- Mobile patient monitoring and automated emergency calls with very precise information on patient location if the system detects any medical problem requiring intervention. It should be also possible to transfer all monitoring data to a secure Web-based patient record accessible from anywhere in the world [3]. Digital Angel Technology <http://www.digitalangel.net/> belongs to this category of services.

- Sampling real-time data on environmental exposure to irritants and pollutants with information on the individual's physical reactions in different situations and locations. One practical application of such exercise could be to send alarm messages to mobile asthmatic patients if they start moving to low air quality locations within large cities [3].

Important issues related to location-based services

User devices used to access a service might change with location, e.g., a desktop or laptop computer at home or in the clinic and a more limited mobile device on the road. The drawback of the small size of mobile devices is that display is considerably smaller and input much more difficult (e.g., no full-scale keyboard). Location-based services must take into consideration the input and output characteristics of different user devices by carefully choosing, personalising and formatting the content to display on such devices [4].

Location capability also poses service providers with the challenge of responsibly handling consumers' personal privacy, especially if they use cookies to track their users [3,4,7]. Services should publish their Privacy Policy and respect consumers' choices in this regard. See for example HealthCyberMap's Privacy Statement <http://healthcybermap.semanticweb.org/privacy.htm>.

Experience from HealthCyberMap: first steps toward developing a customisable location-based medical/health information service

HealthCyberMap <http://healthcybermap.semanticweb.org/> is a geographic information system (GIS)-driven Web-based directory service of health resources that explores new means to organise and present health and healthcare related information on the Internet based on consumer and provider locations, as well as the geographical coverage or scope of indexed resources. It tries to develop an online information service that should ultimately allow better presentation of the distribution of health and healthcare needs and Internet resources answering them across a geographical area. The service is aimed to provide better support for informed decision-making by the public, patients and their caregivers.

HealthCyberMap geographical mapping of medical health information resources

Location-based services draw heavily on GIS and geoinformatics [3] as illustrated in the "dental clinic" example above. Another novel use of GIS is to map conceptual spaces occupied by collections of medical/health information resources as demonstrated in HealthCyberMap [8]. Besides mapping the semantic and non-geographical aspects (e.g., subject or topic) of these resources using suitable spatial metaphors (e.g., human body maps – <http://healthcybermap.semanticweb.org/bodyviewer/>), HealthCyberMap also maps some geographical aspects of these resources – Figure 2. The resultant maps can be classified as conceptual information space maps and can be used as navigational aid for browsing mapped resources [9].

Two geographical aspects of health information resources are considered in HealthCyberMap, namely coverage and provenance. Coverage deals with the spatial extent or scope of the content of a given resource (this aspect is important if we want to be able to select resources that are appropriate for a particular user location). Provenance refers to the geographical location (city/country) of a resource publisher or author(s), whichever is more relevant, and can be very useful as an index to information resources and for some kinds of studies [10,11] – Figure 2. Coverage and provenance are not necessarily the same as the physical location of hosting servers, e.g., a British Patient Support Group offering UK-specific advice on some condition might have its Web site hosted on a server in Arizona, US; however, the site remains more relevant to patients and their caregivers living in the UK.

Technologies for detecting user location

To begin developing a location-based service we have to adopt a method for detecting user location. A user's location can be collected through a Web form that the user fills (can be also used to collect other user information/

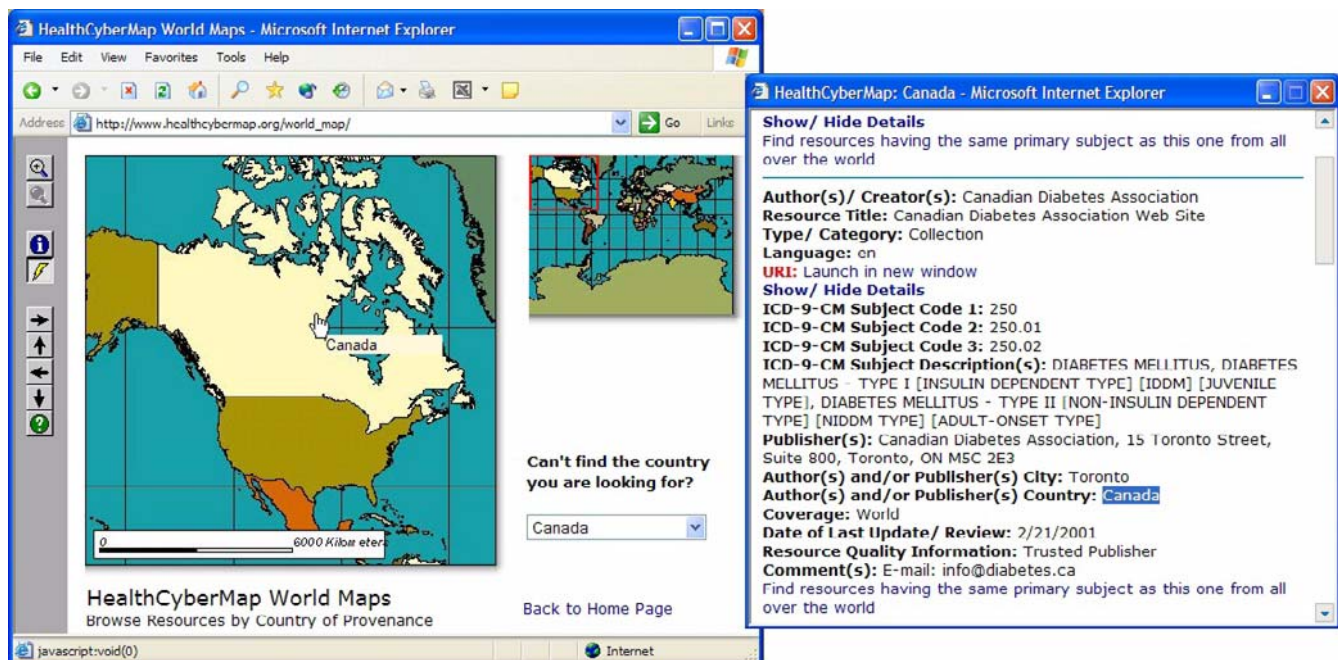


Figure 2
Screenshot of HealthCyberMap World Map Web interface Screenshot of HealthCyberMap World Map Web interface http://healthcybermap.semanticweb.org/world_map/. Health information resources are mapped to countries (of authors/publishers) and their metadata are listed in a separate pop-up text window.

preferences besides location), or automatically detected based on the user's IP address (IP geolocation – [5,6]). Tools exist that allow mapping user IP address to a coarse location (city/country) on Earth (this should be enough for basic geographical customisation purposes of an on-line information service like HealthCyberMap). These tools include:

- Geo-IP <http://geo-ip.com/>;
- Quova GeoPoint <http://www.quova.com/>;
- InfoSplit <http://www.infosplit.com/>;
- Digital Envoy <http://www.digitalenvoy.net>;
- Geobytes' GeoSelect technology <http://www.geoselect.com/>; and
- VisualRoute, a utility produced by Visualware, Inc. <http://www.visualware.com/> – Figure 3.

More information and a demonstration of the last two tools can be found at: <http://healthcybermap.semanticweb.org/ip.htm>.

IP address to city/country mapping is not always successful [5]. Available tools sometimes fail to map a user IP address to a city/country or map it to a wrong location depending on the accuracy and coverage of their underlying lookup databases.

In wireless Internet, mobile devices can continually send their very precise location, e.g., via assisted global positioning services (AGPS – [7]), which can be used in more sophisticated mobile location-based services. However, as outlined above privacy issues must be observed whenever any kind of user location information is gathered (e.g., when a user does not want to reveal his/her location or accept cookies, this should be respected).

HealthCyberMap location-based customisation possibilities

It should be possible to customise (personalise) HealthCyberMap based on a user's geographical location as determined by his/her IP address used to access HealthCyberMap server. Moreover, HealthCyberMap users should be allowed to override this and manually set their preferences (including personal preferences unrelated to location) following "My Yahoo!" <http://my.yahoo.com> and BBC News and Sport (<http://news.bbc.co.uk>

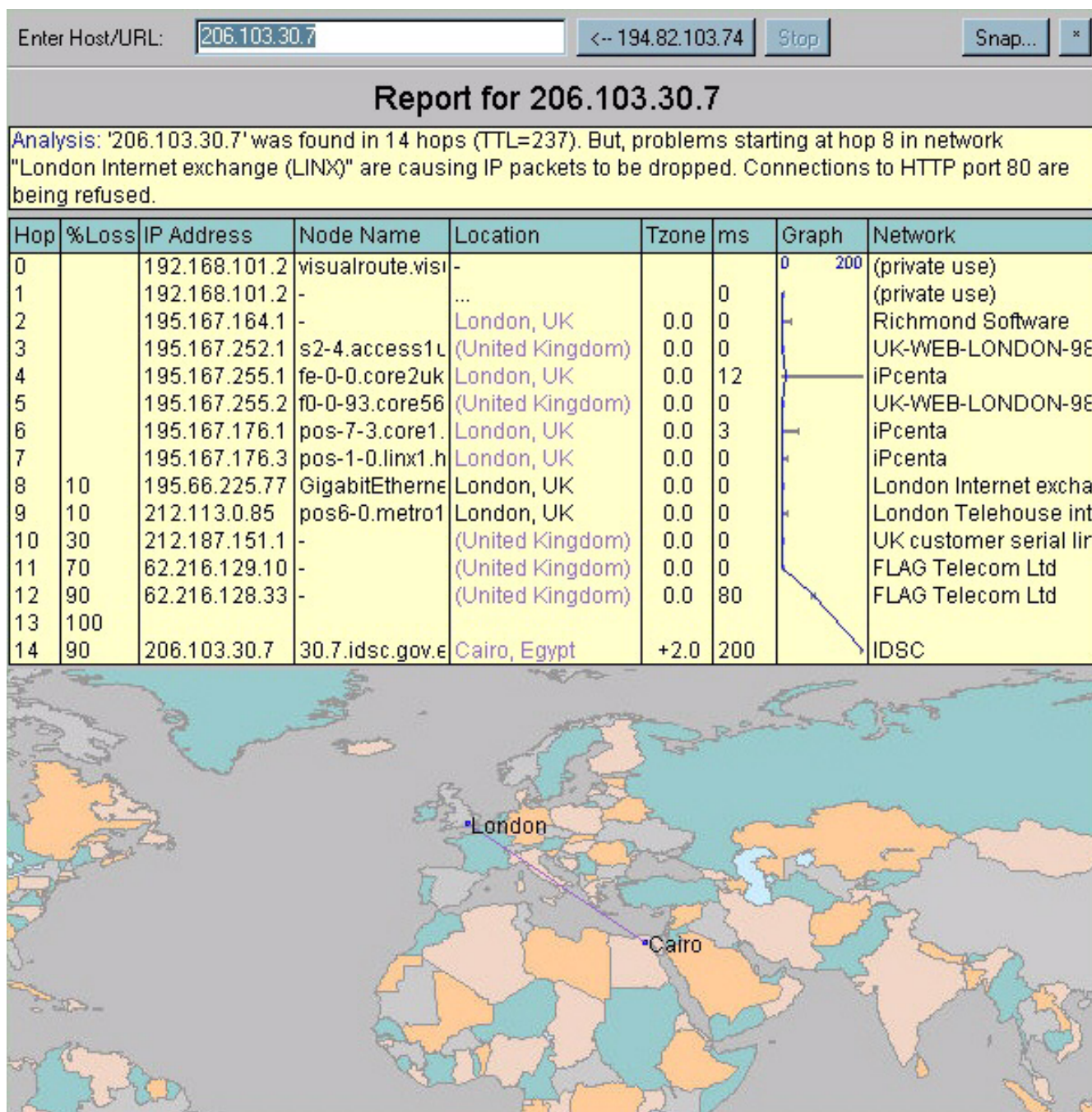


Figure 3
Screenshot of VisualRoute, a graphical traceroute utility Screenshot of VisualRoute, a graphical traceroute utility written in Java by Visualware, Inc. <http://www.visualware.com/>.

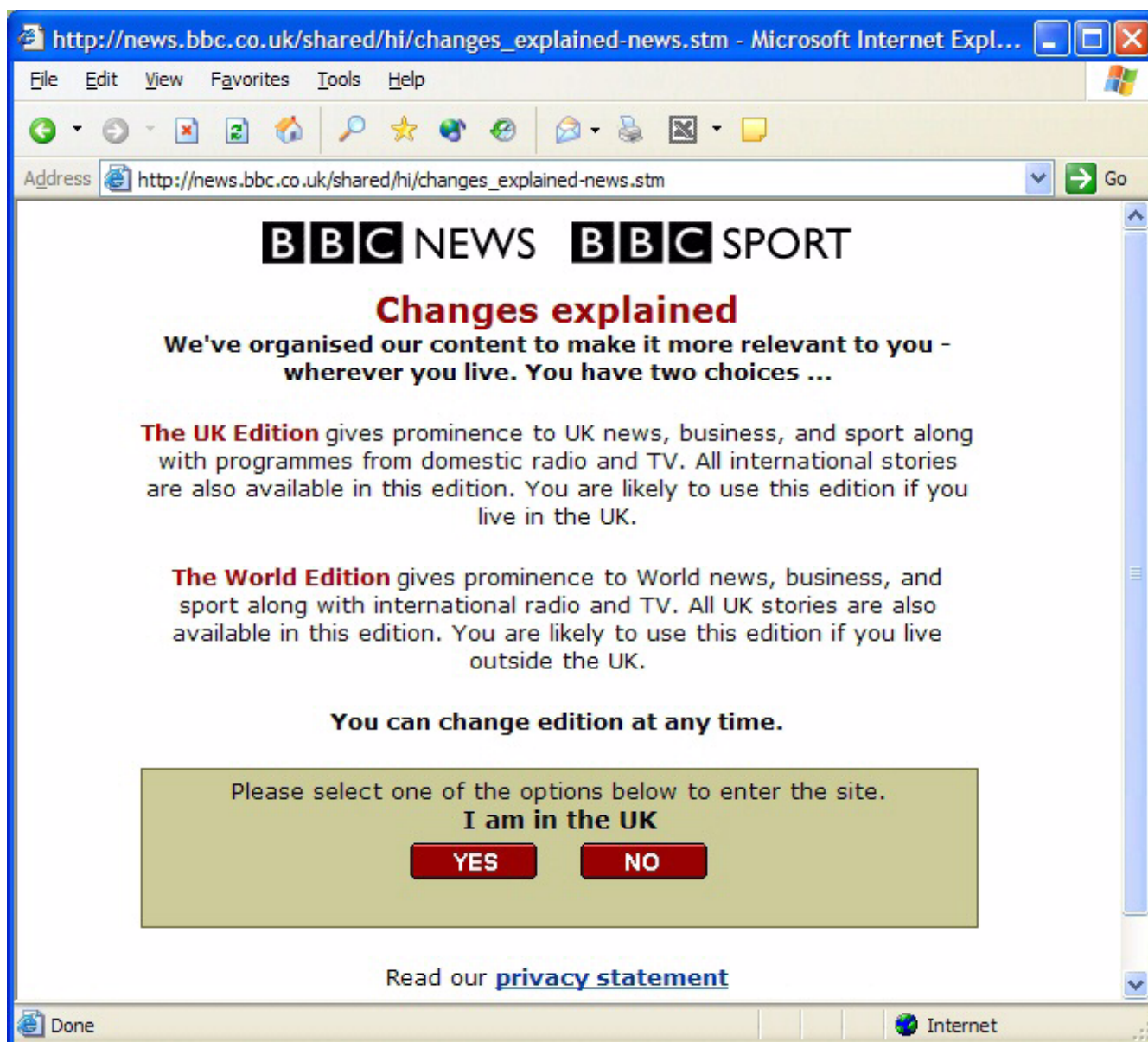


Figure 4
BBC News and Sport location-based content customisation BBC News and Sport location-based content customisation <http://news.bbc.co.uk>.

– Figure 4) examples. A user input form can be used to capture (and store) a user's profile. User's descriptors in this profile can then be used to tailor the content delivered to that user according to some predefined content selection model or rules (Figure 5).

Two main location-based customisation categories are possible:

1. Language and interface customisation:
 - a. Setting HealthCyberMap Web interface language to match user's location language; and
 - b. Retrieving/giving more importance to Web resources in user's location language <http://healthcybermap.semanticweb.org/language.htm> – Figure 6. However, it should be noted that some users might move from their native

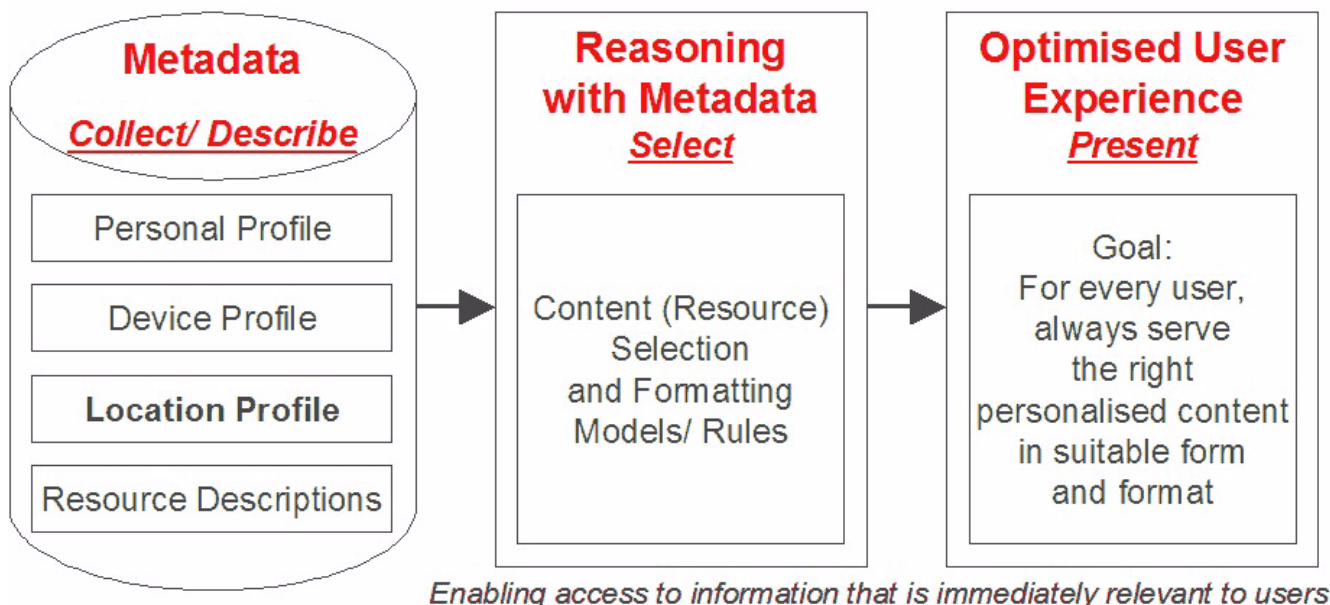


Figure 5
Essential components of a location-based online health information service Essential components of a location-based online health information service.

country to another country, e.g., from the UK to France, either temporarily or permanently. It is not always the case that such users will want the language of HealthCyberMap interface and retrieved resources to be changed to reflect their new location, e.g., from English to French.

2. Content customisation:

Customisation should also (ideally) address any location-specific information needs and match these needs to suitable online resources covering the concerned location and its known health and healthcare makeup (not just its language). This mandates that knowledge about the characteristics and health needs of different locations (location profiles) be available in a form suitable for use by a customisation engine against HealthCyberMap's metadata base of resource pointers to select location-specific information resources (Figure 5).

Customisation parameters

Customisation depends upon many factors and parameters [12]. Some of these have already been discussed above. Following is an incomplete list of parameters that might be relevant to the customisation of health and healthcare information services.

- **Personal and health profiles:** user role (patient, physician, nurse, etc.); user's demographic and health profiles (might be automatically inferred from his/her health record if linked to HealthCyberMap); health and healthcare makeup of user's location (location can influence health; also disease rates, management guidelines and health information needs vary with location); user address (addresses of health services presented to the user should correspond to his/her address, e.g., address of nearest hospital or pharmacy); user country and region (urban/rural); user's socio-economic group; lifestyle; user dietary style/preferences; user culture; language; literacy; user education; previous knowledge;

- **Computer and Internet profiles (per user):** user computer skills (technophobes/technophiles); user privacy and security needs; user accessibility needs, e.g., large type for sight-impaired patients; user device type, e.g., WAP (Wireless Access Protocol) phone, personal digital assistant, or PC, and device processing power, screen resolution, colour depth, and other display parameters; user agent (browser), supported character encoding sets, supported scripting languages, supported tag sets and data types, and installed plug-ins and versions; available input modalities, e.g., keyboard vs. mouse/pen vs. voice, and

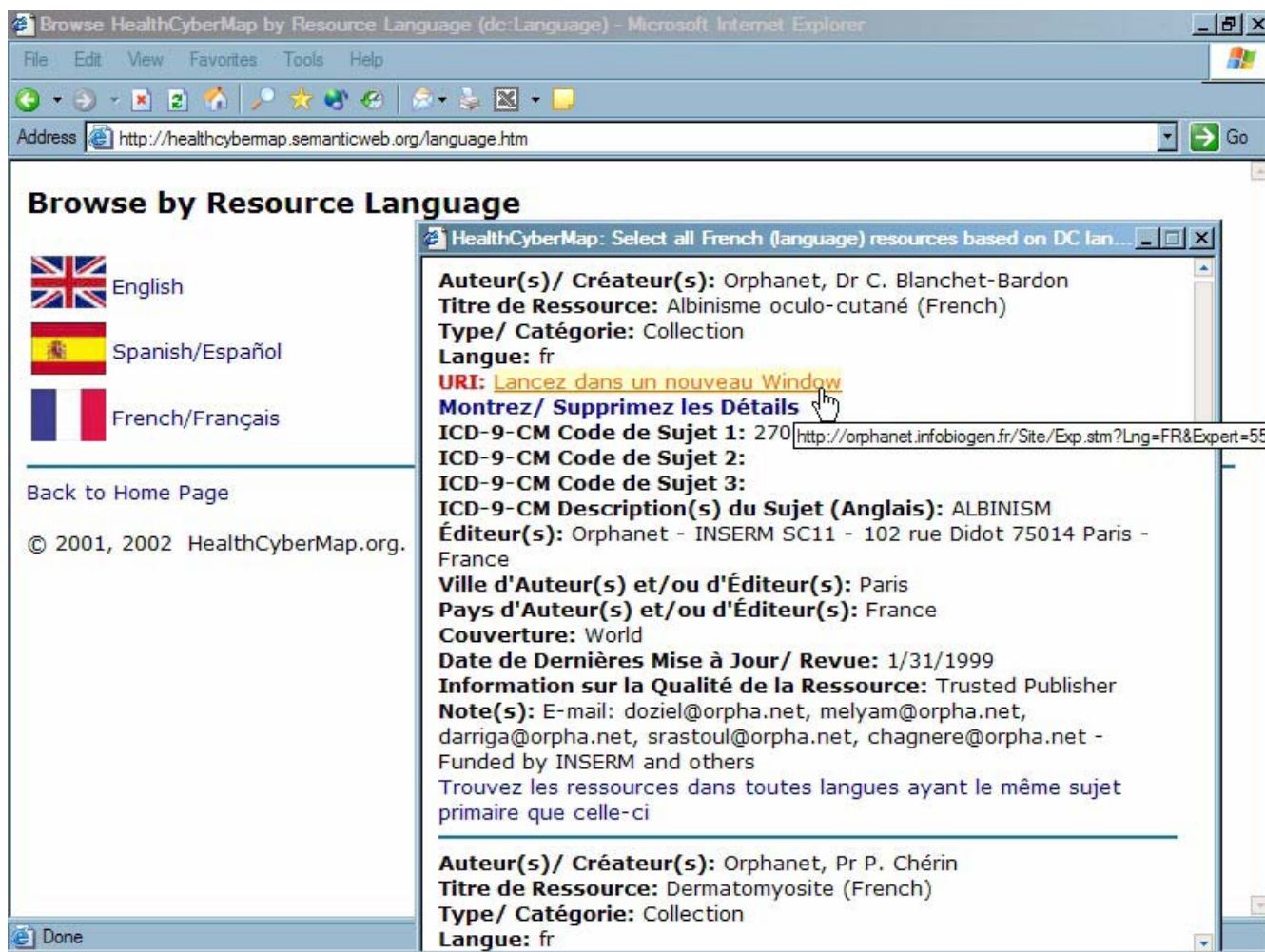


Figure 6
HealthCyberMap pilot French language interface HealthCyberMap pilot French language interface for browsing French language resources <http://healthcybermap.semanticweb.org/language.htm>.

output modalities, e.g., text vs. images/video vs. audio only; network capabilities such as bandwidth; and

- **Other user preferences**, e.g., acceptable language (might differ from actual location language), acceptable cost of content (for paid content) and preferred payment mechanisms, and interface appearance (e.g., choosing a colour theme).

Metadata are important for customisation

Pointers to good quality resources need to be described in a central database and organised in such way to allow a content management and customisation engine to easily and suitably recall and re-use them in different customisation scenarios (Figure 5).

Metadata are information about information. HealthCyberMap metadata base of resource pointers uses fields (elements) from the well-known Dublin Core (DC - <http://www.dublincore.org/>) metadata set scheme for resource description with HealthCyberMap own extensions [13].

A DC language field makes possible the selection of resources based on their language to match a user's preferred language. A DC coverage field is used to store the spatial extent or scope of the content of a given resource; information in this field should help selecting those resources that are appropriate for a user's location. DC cannot be used to describe resource quality or the geographical location of a resource publisher or author(s) (to be differentiated from coverage, although both are ge-

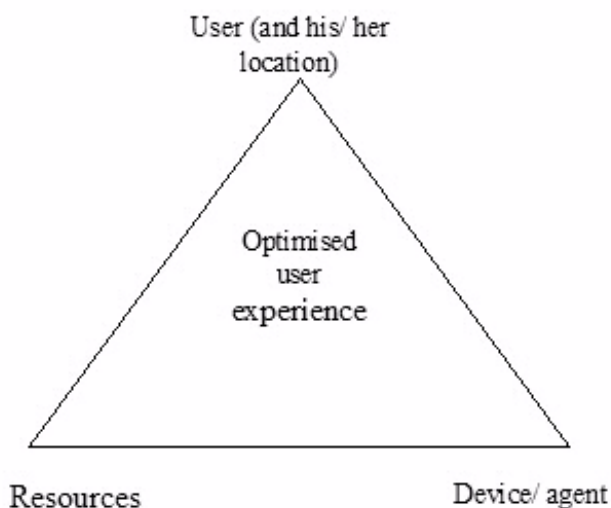


Figure 7
Three interrelated categories of metadata are required for personalised information delivery Three interrelated categories of metadata are required to optimise (personalise) a user's experience.

ographic elements), and so HealthCyberMap had to extend the standard DC elements by introducing its own quality and location elements [13].

Resources can be also selected and classified based on different combinations of two or more DC elements as necessary [14]. This could help filtering and focusing content presented to users in different situations to much smaller, more relevant and more easily manageable sets.

User profiles and device descriptions

Besides collecting metadata describing information resources, two other types of metadata should be gathered, namely user profiles (including user's location profile which directly affects user's health) and device descriptions. An ideal service should be able to reason with all three types of metadata to personalise and optimise a Web user's experience – Figures 5 and 7.

Customisation engine

A customisation engine or content management server will use all collected metadata types to select suitable online resources for a particular user and his/her particular needs at a given time (dynamic match), and also present them in a form that is appropriate for this user and the device he/she is using to access the resources (Figure 5). The content management and customisation engine will depend on a customisation knowledge base or set of rules to

"know" which resource(s) and presentation form are suitable for which situation, location or profiles.

Mapping health problems in HealthCyberMap and identifying information needs and gaps

In addition to mapping medical/health Web resources, an opportunity exists to map health problems and relate them to available online information resources. This can be of great help to healthcare policy makers, planners and managers (helping them make informed decisions). Moreover, any existing knowledge gaps in current Web resources can be identified and health information needs can be efficiently and effectively determined and addressed. For example, we might identify a lack of/a need for adequate Web resources presenting patient education material on a particular health problem. Health and healthcare information providers can then develop any required Web resources or modify existing ones in the light of this information (on current medical/health information needs and corresponding gaps on the Web).

Conclusion

The main goal of location-based medical/health information services is to allow better presentation of the distribution of health and healthcare needs and Internet resources answering them across a geographical area, with the aim to provide users with better support for informed decision-making. To enable proper service customisation, three main types of metadata have to be collected and processed: information resource descriptions, user profiles (including user location profile which directly affects user health), and user device descriptions.

Delivering real-time, location-enhanced and personalised information (i.e., information that is *immediately relevant* to users) can help consumers and providers accelerate and optimise their decision-making process in many medical/health situations and problems. The author believes that the integration of a carefully selected variety of medical/health Internet information services and resources with users' tasks, needs (as determined by users' locations and other parameters), preferences and their device capabilities will enable users to focus more on informed decision-making.

Throughout this review, experience from a related online health information service, HealthCyberMap <http://healthcybermap.semanticweb.org/>, has been referred to as a model that can be easily adapted to other similar services. HealthCyberMap is a Web-based directory service of medical/health Internet resources exploring new means to organise and present these resources based on consumer and provider locations, as well as the geographical coverage or scope of indexed resources.

A general introduction to location-based services, technologies for detecting user location (including tools for mapping user IP address to a city/country – IP geolocation), and their potential applications in health and healthcare was also provided.

Mapping real-world medical/health problems remains the "native" application of GIS in health (compared to mapping conceptual Internet information spaces), and besides its classic benefits [1], it can also inform medical/health information providers to develop any required resources or modify existing ones in light of any identified real-world needs that are unmet by current resources.

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