Nailing the reality with GeoMedia: location-aware multimedia tags

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ABSTRACT

In this article we present a work in progress dedicated to location-based multimedia messaging. Unlike Post-Its, virtual notes preserve privacy, can be remotely put to any place and do not clutter the environment. In contrast with other location-based messaging systems working with plain text notes, GeoMedia supports rich multimedia content such as high-resolution images, audio and video. Multi-sensor positioning system used in GeoMedia works both indoors and outdoors and provides better accuracy and coverage than traditional methods like GPS.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Communications Applications; D.2.11 [**Software Engineering**]: Software Architectures; K.4.2 [**Computers and Society**]: Social Issues

Keywords

location-awareness, location-based services, virtual notes, mobile applications

1. INTRODUCTION

Post-It notes are a popular mean of near-field communication, suitable for both personal and group messaging. They serve as reminders, to-do lists, can be used to write short notes, etc. However, their usage is limited in many ways: Post-Its can contain only text or small hand-drawings, they are static, they can be seen by anyone nearby, they can be attached only to an appropriate surface and only in the user's nearest vicinity (at a hand reach).

In this project we present the concept of virtual Post-Its that are free from most of the described limitations. They can be remotely attached to any place in the world, present both text and multimedia content, made available only for a specific person, a group of people with a common profile

or to everybody, preserving the privacy of communication in each case.

The paper is organized as follows. Section 2 provides a review of related work. Section 3 introduces the architecture of the GeoMedia system and its prototype. Section 4 concludes and describes the directions of future work.

2. RELATED WORK

A number of works has been dedicated to context-aware messaging. Due to the multidimensional nature of context (location, time, activity, etc.), the scope of the projects varies depending on the context features they use.

Stick-e Notes project [2, 7] was one of the first efforts in the area. The authors introduced the general idea of context-aware notes, discussed its challenges and possible applications. They described notes as SGML files containing a document (text) and the context in which the note should be triggered. The user was supposed to carry a PDA[1] equipped with GPS[2] module or other location-sensing technology; the notes could be either downloaded from Internet or beamed between users. Unfortunately, the system lacked practical implementation.

ComMotion [6], Place-Its [8] and PlaceMail [5] presented location-based messaging and reminder applications. These works differ by the positioning technologies they use, message types, and target platforms. Place-Its and PlaceMail allow the user to choose arbitrary location using GSM[3] Cell-ID and GPS positioning, respectively. ComMotion, in turn, offers a choice from user's personally important places. The place learning algorithm utilizes GPS signal loss in buildings; if the signal is lost for more than 10 minutes, the location is considered as an important place. Unfortunately, any single positioning technology has its limitations (low accuracy of GSM, low coverage of Wi-Fi, indoors performance of GPS). GeoMedia, in turn, uses multi-source localization provided by PlaceLab framework [4], which offers good accuracy and almost ubiquitous coverage. Although PlaceLab requires calibration for Wi-Fi and GSM positioning, on-going calibration efforts in many cities make it a good candidate for localization system.

Related projects also differ by supported content types. Place-Its deliver only text notes, while PlaceMail and ComMotion also support voice messages (and voice-based user interface). Such a simple content might have been to a large

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[1]Personal Digital Assistant
[2]Global Positioning System
[3]Global System for Mobile communications

extent determined by slow WAP[4] and GPRS[5] connections. However, current 3G mobile networks support high-speed transfers. Our project utilizes wide-band connectivity to quickly deliver rich multimedia content, including high resolution images, audio and video.

PlaceMail authors have identified that in order to ensure appropriate delivery time, the system must be able to predict user's path. Our system keeps track of user position and builds movement profile, which enables the system to predict user location and pre-load large content accordingly. This can be achieved only if the user always carries the mobile device. Thus, we share the Place-Its and PlaceMail approach and implement the mobile part of the system on a cellular phone, which people usually keep nearby.

GeoNotes project [3], while similar in nature, is different by its focus. The authors addressed social implications of location-based messaging, such as motivating user to create content and filtering excessive messages. GeoMedia, in turn, focuses on two different aspects: possible benefits of location-aware *multimedia* messaging, and methods for inferring and predicting user position and activities.

3. GEOMEDIA SYSTEM

The GeoMedia system distinguishes two types of users: stationary and mobile ones. Stationary users are provided with a web interface which displays a world map and a number of marked locations on it. A *location* is defined by a pair of coordinates and a name (e.g., "Shopping mall"). Each location has a number of virtual stickers associated with it. A *sticker* contains a multimedia file (e.g., a photo of avocado), its description (e.g. "Buy me an avocado, please. It looks like this one.") and priority level (e.g., "high"). Stationary users can modify and add new locations, as well as upload new stickers. The stickers can be addressed to a specific person, to a group of people or made public.

Mobile users are equipped with location-aware devices that have Internet connectivity. The device periodically updates the system with the user's current position, and receives a list of nearby locations and stickers attached to them. When a new high-priority sticker is detected nearby, it is automatically downloaded and presented to the user; low-priority stickers can be received manually by user's request. In order to avoid abuse, the user can configure criteria of automatic downloading (e.g. "only high-priority messages addressed to me" or "any message addressed to public"). The activity inference and prediction module is responsible for building user movements profile and using it to predict future context of the user. It is a part of the future work.

The architecture of the system is presented on Figure 1. Both stationary and mobile clients communicate with the system by HTTP[6] via web front-end. The Map Builder module takes map image from an online service, e.g. Google Maps, and overlays it with location markers. When the user selects a location, a list of associated stickers is displayed. The user can then upload a new sticker, and it will be attached to the selected location. For the mobile user, the process is more straight-forward: given the coordinates, the system generates an XML file with a list of locations and associated stickers is some vicinity of the user; basing on

this list the mobile client downloads and displays stickers. However, the mobile part of the system presents a number of challenges, such as localization accuracy, limited resources, slow connections, privacy concerns, etc; we discuss them in the next few sections.

3.1 Localization

There is no universally suitable positioning technology. GPS provides accuracy better than 10m, but only outdoors and with non-obstructed view of sky. Median positioning error of a state-of-the-art Wi-Fi positioning system can be less than two meters, but Wi-Fi coverage is very limited in less populated areas and developing countries. GSM-based solutions provide almost ubiquitous coverage as a trade-off for low accuracy (hundreds of meters). Bluetooth can be used for sub-room level positioning, but stationary Bluetooth-enabled devices are not currently wide spread.

A sensor fusion framework, e.g. PlaceLab [4], can unite the advantages of different methods. Such frameworks usually provide more accurate localization than any single method they utilize. Also, the availability of positioning information is higher, due to the joint coverage of used localization technologies.

3.2 Privacy

Privacy is a common concern for a location-aware application. User location is crucially important information for our system to function; in order to benefit from the service, the user has to give away some part of his/her privacy. However, there are a number of ways in which the user can control the flow of private data. Firstly, all location estimations are done locally on the device and sent to the network only upon user's consent at the beginning of the session. The user can decide to be anonymous and thus receive only public messages. In other cases, the coordinates sent to the system have an embedded distortion which parameters are configured by the user and also reported to the system. Thus, the system never knows the true position of the user, while the mobile client provides full-quality service by adjusting information about nearby stickers to the user's true position.

3.3 Content adaptation

Limited resources and different device capabilities are two of the major challenges of mobile computing. Although many modern cellphones can play audio and video, supported formats vary widely. The system must determine capabilities of the mobile device (display resolution, supported formats, etc) and optimize sticker content accordingly. Large images should be resized to fit to screen; rare formats should be converted to those supported by the device; if the device does not support video playback, the system should send at least the audio part of video clip. Content adaptation done by the Content Optimizer module both enables support of various client devices and saves network traffic.

3.4 Preliminary results

To test the idea, we have implemented a single-user prototype of the proposed system. Server part is running Apache Tomcat and Struts as web front-end; MySQL handles data management and storage. Stationary user's interface (see Figure 2) is based upon Google Maps API, using JavaScript
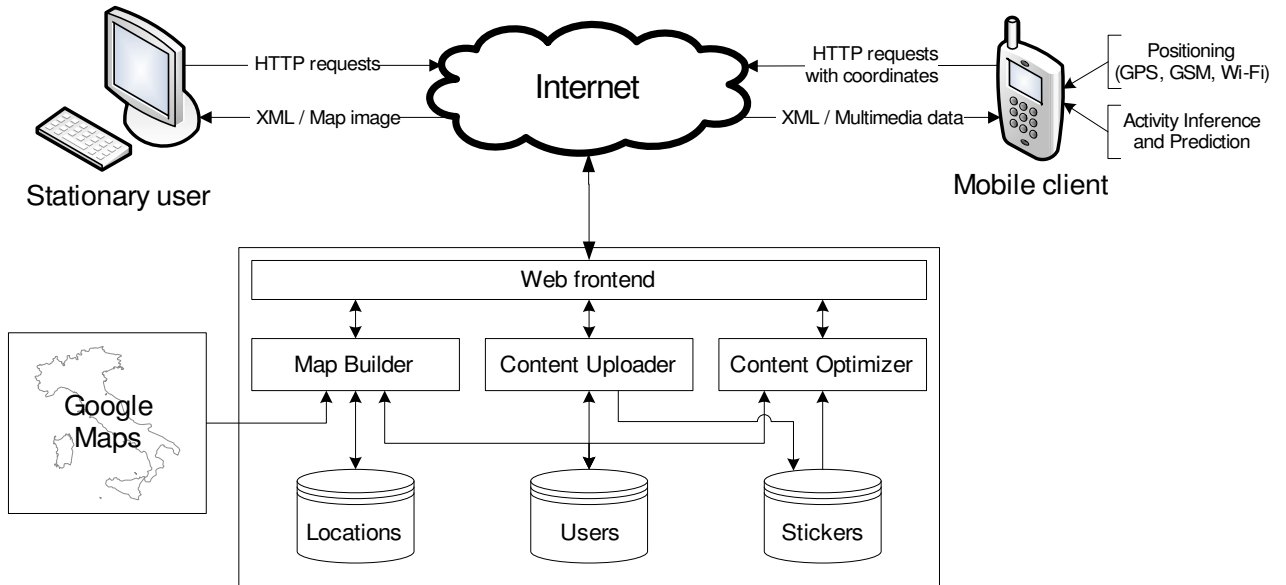
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[4]Wireless Application Protocol
[5]General Packet Radio Service
[6]Hypertext Transfer Protocol
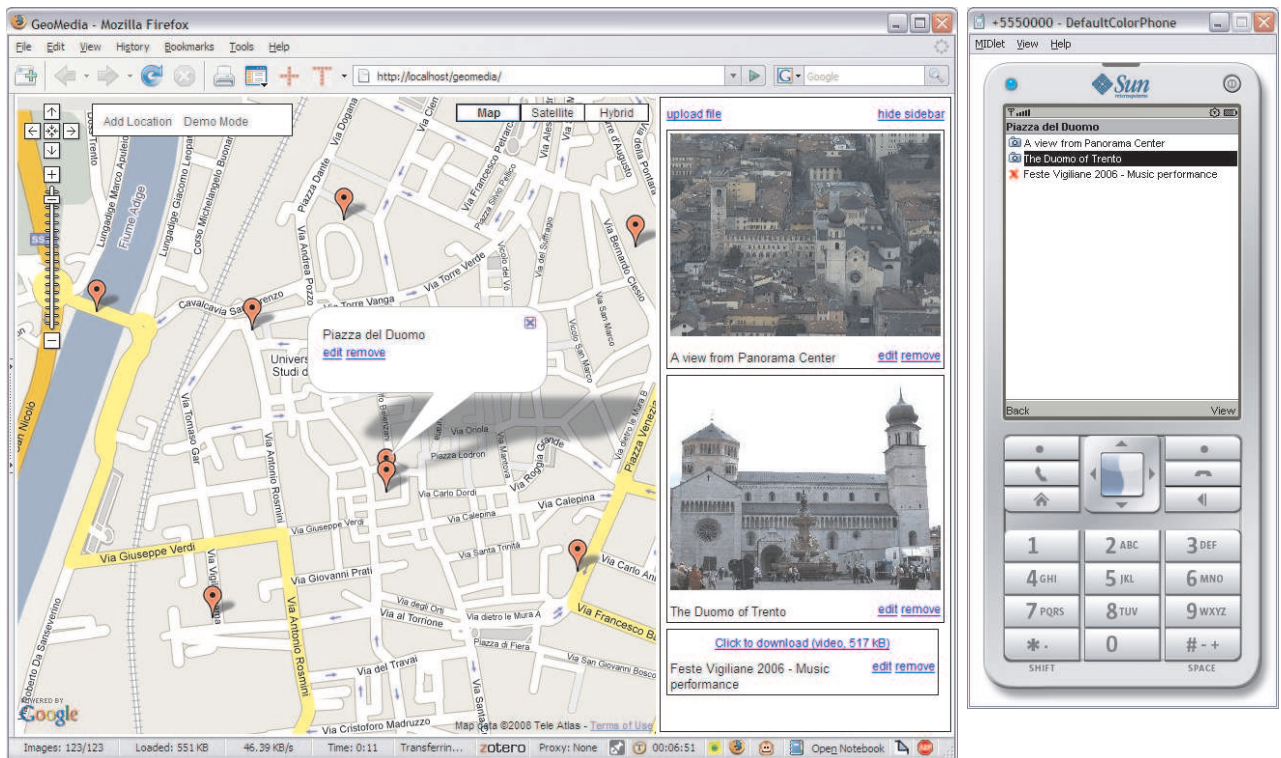
Figure 1: System architecture

Figure 2: Interfaces of web and mobile client applications

for GUI[7] management and AJAX[8] for asynchronous communication with the server. Side panel displays the list of stickers associated with selected locations, and provides an interface for sticker upload. Only images are displayed directly in the browser, other types of content can be downloaded and viewed by third-party applications.

The mobile client is implemented in Java 2 Micro Edition (J2ME) and runs on any MIDP2-enabled[9] phone (Nokia E61i in our case). The current implementation uses Java Location API and GPS to obtain user position; later on we plan to adapt PlaceLab framework. User position is sent to the server via Wi-Fi, 3G or GPRS connection every 5 s, which provides a reasonable trade-off between network load and system responsivity. Privacy of the positioning data is secured by JSR-179[10] (Java Location API) regulations [1].

4. CONCLUSION AND DISCUSSION

This paper presented a work in progress dedicated to location-aware multimedia notes. Virtual notes are free from the limitations of traditional paper-based stickers: they can be attached to any place on the map, addressed to an individual or to a group of people, contain rich and dynamic content.

The prototype of the system has revealed a number of issues and challenges. One of them is the transfer rate of GPRS connection which is too slow for multimedia content delivery. Wi-Fi and 3G networks alleviate the problem, but their coverage is still somewhat limited. As a result of narrow GPRS bandwidth, stickers' content can be delivered too late, when the user has moved far away from the marked location. A possible solution is based on the assumption that the user behaviour is mostly routine and conforms to some pattern. Thus, it might be possible to build user's movement profile by constantly observing device location, and then use this profile to predict future position of the user. This would enable the system to pre-load data efficiently and ensure on-time message delivery. Basing on daily movement patterns, it could be possible to recognize higher-level features of the context, such as user familiarity with the environment, is he/she walking or driving, a forecast of data connection quality, etc. Such context features can considerably increase the flexibility of the system and make conditions of message delivery even more personalized and fine-tuned.

Currently we are analysing the types of activities that can possibly be inferred from user's current location and movement history. The future work will deal with design of appropriate recognition techniques, considering the probabilistic nature of location estimates and their varying accuracy. The developed methods will be incorporated into the system and tested therein.

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[7]Graphical User Interface

[8]Asynchronous JavaScript and XML

[9]Mobile Information Device Profile

[10]Java Specification Requests