

LOW-COST MOBILE WIRELESS GIS

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ABSTRACT: This paper proposes a general framework for a low-cost mobile wireless geographical information system to facilitate dynamic near real-time server access from remote locations. For instance, one targeted application is the monitoring of environmental and natural disasters. While current systems are based on dedicated hardware and/or utilise high-quality imagery, the depicted solution targets a more cost effective solution. This does not render established systems redundant, but rather extends the application range. In particular, a system was developed which integrates the retrieval of satellite image data available free-of-charge on the Internet with remote access from resource limited handheld devices.

1. INTRODUCTION

Examples for wireless applications accessing GIS databases are increasingly to be found in the consumer market, where the term *location-based service* is used more frequently. Unlike the profession segment with its strict requirements in precision, the developments in the low-end market are driven by free-of-charge services with instances like Google Earth and Wikimapia. However, behind these for the user inexpensive services, actual profitable aspects are hidden in the form of advertising, customer profiling etc. In this context it is less the actual access to the data that has to be paid (either directly or indirectly), but the presentation.

The objective of this paper is to illustrate the design and implementation of a homogenous framework that utilises existing, freely available data and which provides access through remote wireless clients. Other approaches for the access to remote sensed imagery by handhelds have been well described in several publications with applications in weather observation, responsive ambulance assistance, planning and surveying etc. (Derekenaris et al., 2001; Wu et al. 2003; Zingler et al., 1999). A prime example for a server-based architecture accessed by wireless handheld devices can be found in (Tsou, 2004a; Tsou, 2004b). However, to be the best knowledge of the authors, so far no effort was undertaken to integrate these systems with sources of manifold and *free* data.

One of the main problems is to locate useful imagery in a highly medium like the Internet. Manual approaches are inefficient and the utilisation of generic search engines like Google and AltaVista does not provide satisfactory results. However, this problem can be tackled by employing specialised web crawlers that retrieve relevant data based on a content analysis of the imagery. Once found and analysed the extracted information can be archived and utilised for later queries by the clients. It is worthwhile noting that this approach does not suggest storing the actual image data since this would violate possible copyrights and ownerships.

The remaining part of this paper is organised as follows: Section 2 provides a system overview which shows the developed system as a whole. In the following Sections 3, 4, and 5 the individual sub-systems, i.e. the web crawler, the indirect access to Google Earth, and the integration of the wireless clients, are illustrated. Finally, Section 6 concludes this paper.

terms of further traversal (Sedigh and Roudaki, 2003). A schematic overview of VirtSat and its components is presented in Figure 2. Additional information regarding the implementation of VirtSat is described in (Bretschneider et al., 2006).

Several techniques were implemented in order to reduce the percentage of unsuccessfully visited websites. First of all following links within the current domain is given priority based on the assumption that a URL which was considered as likely to contain satellite imagery should be analysed prior to other sites. Secondly, positive as well as negative keyword lists are utilised, which hold words that identify terms like the names of satellites and unlikely terms, respectively. Instances for the latter case are “gambling”, “sex” etc.

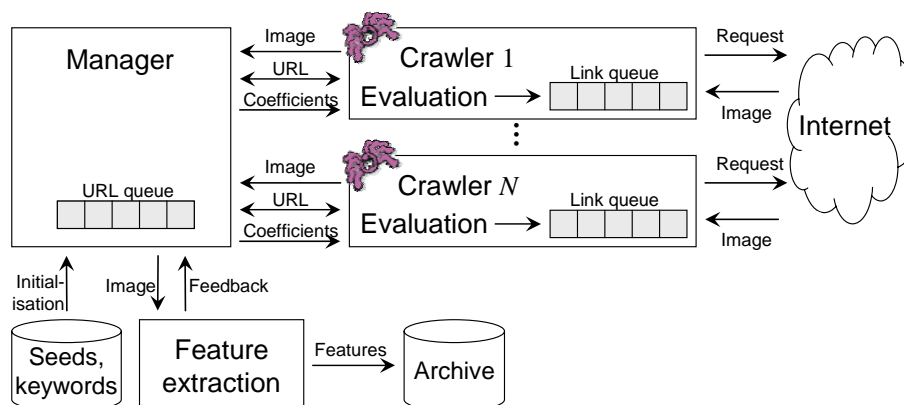


Figure 2: Flowchart for data access and analysis performed by VirtSat

All shown queues in Figure 2 are organised dynamically, i.e. a continuous re-evaluation of the contained link/URL relevance is performed. While the order in the manager queue is based on the importance of all URLs, the crawlers’ queues are organised with respect to the significance of links within a URL. The ranking is performed based on previous retrievals from the same Internet location, the matching of keywords, the duration since the last visit, the ranking of other websites referencing the current site, and an actual image content analysis. A dedicated approach was derived, which estimates the semantic meaning of an image based on previously learned semantics. A detailed description of the approach can be found in (Li and Bretschneider, 2005; Li and Bretschneider, 2006).

4. CONTROLLING GOOGLE EARTH – Gobble Google

Google Earth comes with a dedicated client application that allows users to browse satellite imagery. Although other applications can interface with Google Earth and add their data to the display, the other way around, i.e. integration of Google Earth imagery in own applications, is not as straightforward. Hence, the developed approach emulates actions of users. A so-called location controller generates geographical coordinates and passes these to the input field of the client. Thereby only locations of interest, i.e. scenes that show landmass, are queried. The corresponding information is retrieved by a land-sea-mask with a resolution of five minutes. Afterward the client is requested to store the retrieved image on disk.

Since generally the Google Earth client is a user controlled application, no specific feedback regarding the completion of the task is provided. Instead it is assumed that the user recognises the completion once the progressively transmitted image does not change anymore. In the developed framework this behaviour is emulated by polling the storage disk. Once the file size remains constant either the image was transferred completely or the Internet connection is too slow and only limited transmission progress is made. A differentiation between the two cases is

made by analysing the actual image using a template showing the embedded “100%” transmission status. If the template can be matched then the next scene is retrieved, otherwise the application returns to the polling state.

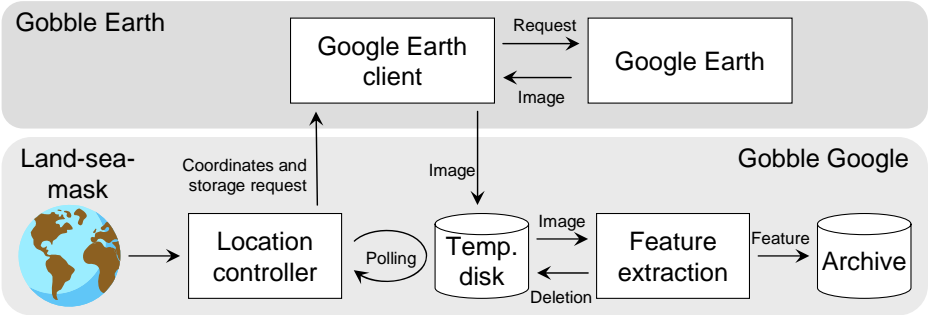


Figure 3: Flowchart for data access and analysis performed by Gobble Google

5. WIRELESS CLIENT INTEGRATION

This section describes a general framework for mobile handheld devices to facilitate near real-time data access to the centralised geographical information system (shown in Figure 1) over wireless networks. The main idea is to use JPEG2000 for the imagery, e.g. high-resolution satellite scenes, as well as for the meta-data simultaneously without deflecting from the GIS typical layer model for data representation. One of the main advantages in this approach is solving the inherent problems in wireless mobile environments, namely limited network bandwidth, restricted memory, and processing speed. An in-depth discussion of the various aspects is given in (Huynh and Bretschneider, 2006).

The proposed system is based on a client-server model with the client and server side components connected over appropriate wireless communication channels, e.g. Internet or general packet radio service (GPRS). The support of separate channels for commands, meta-data and actual imagery allow a flexible simultaneous utilisation of communication links when available. The various functionalities, operations as well as implementation aspects of each system component are shown in Figure 4.

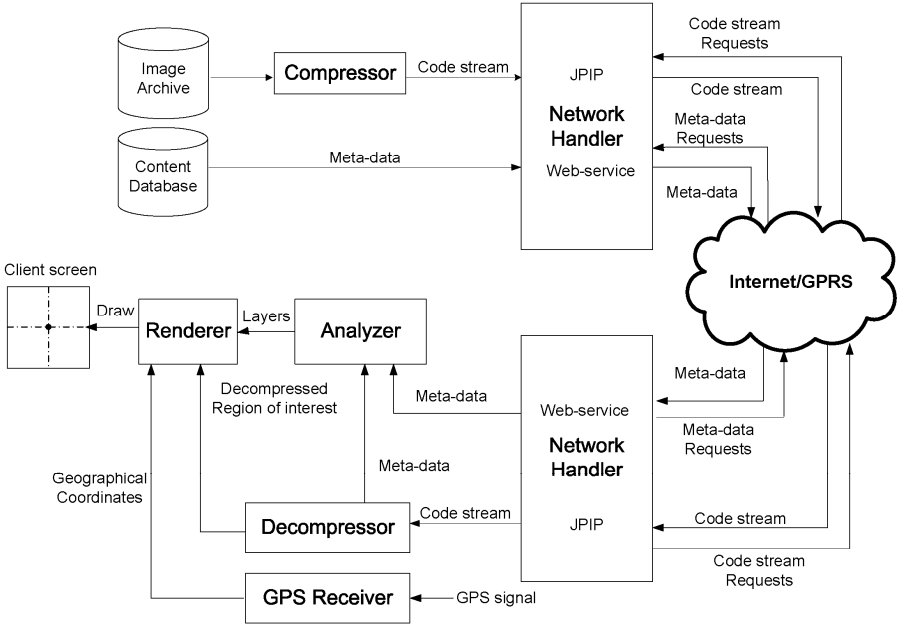


Figure 4: Information flow between server and client side as well as among the various components

After the initialisation of the application, the data analyser module obtains the current position from the GPS receiver module. Based on this position, a series of message is exchanged via the web service channel informing the client about the available satellite image, resolution and available meta-data. Afterwards, the client requests the opening of a channel through the JPEG Internet protocols (JPIP) to obtain the actual code stream for the region-of-interest (ROI). The actual bulk data is handled asynchronously and is decoded interactively. Subsequently a sequence of complimentary meta-data transfers follows transferring additional information in XML format. Further requests through the web service channel may be issued at any point in time. Finally, all data is fed into the analysis module to synthesise and produce the layer representations needed for the renderer module.

A typical user scenario is depicted in Figure 5: A tourist, who is unfamiliar with the locality, travels along the bridge leading to the entrance of Sentosa. After launching the application the GPS-based position is determined, the network connection established, and the corresponding satellite image retrieved from the server. While receiving the data, the concurrent code stream decompression enables the displaying of the surrounding area. Thereby the progressive evaluation enables a constant refinement.

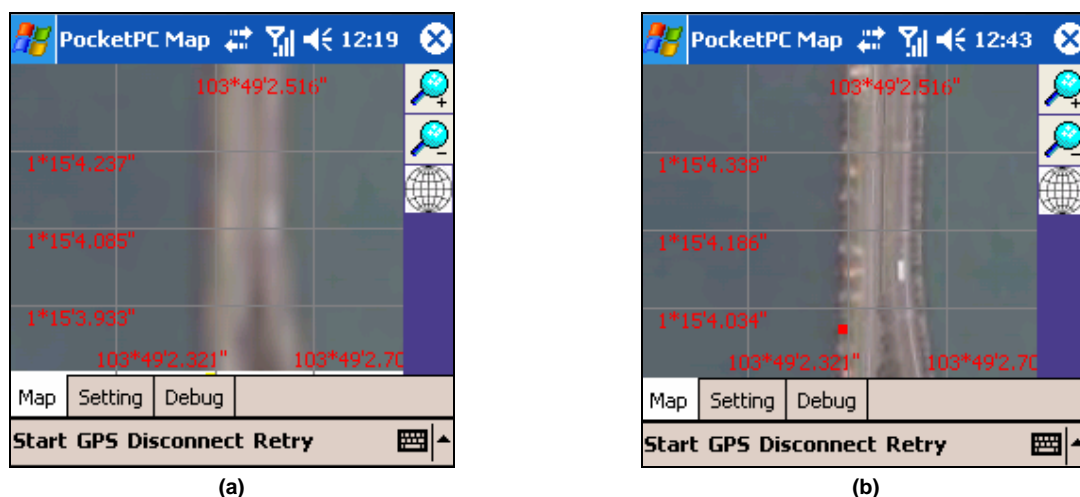


Figure 5: Progressive refinement of ROI within larger satellite image: (a) result for initial coefficient set, (b) final high-resolution image

From the measure transmission results, it can be concluded that the system exhibits a moderated network utilisation and short response time. Though the connectivity using GPRS was not tested explicitly, the results for the wireless connection show that only for very short periods of time burst transfers occur. Given the theoretical bandwidth of 172.2 kb/s and the more realistic value of 40 kb/s, the corresponding data requests would require more time to be satisfied. However, given the general low utilisation over time the scenario would be feasible.

6. CONCLUSIONS

In order to demonstrate and evaluate the proposed framework, a GPS equipped navigation system supporting multi-level resolution views was developed. Access to actual satellite imagery was enabled by locating relevant information on the Internet and storing these details in a GIS database. Instead of even aiming to hold the entire available image data on a centralised server, only descriptors for the scene content as well as features like location etc. were recorded. Hence, queries were satisfied by abstract data retrievals, followed by the actual recovery of the real imagery from the hosting server. The benefits of this iterative approach are the moderate resource requirements as well as the inherent acknowledgment of copyright issues.

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