The GenW2 Framework: An Architecture for Mobile GIS and Mapping Scenarios

Ramya Venkateswaran, Pia Bereuter,
Dirk Burghardt and Robert Weibel
University of Zurich
Department of Geography
Winterthurerstrasse 190
8057 Zurich (Switzerland)

INTRODUCTION

The GenW2 project (Generalization for portrayal in Web and Wireless mapping) has recently started and aims at developing new methods for web and wireless mapping with the main focus on integration of heterogeneous information and on-the-fly map generalization in a mobile context. The poster discusses the first step of a proposed methodological framework for future mobile GIS and mapping scenarios.

MOTIVATION

In contrast to a desktop system, a mobile system has to face other challenges like limited processing power, display capacity, less bandwidth on wireless connections (Peng and Tsou, 2003), the changing position of the user (Shiode et al., 2004; Jiang and Yao, 2006) and the changing context in a dynamic environment (Reichenbacher, 2004; Jiang and Yao, 2006). Considering these characteristics we propose the GenW2 framework, streamlined to work in a mobile scenario. In short, the main objective of this framework is to propose a methodology or workflow of a "mobile GIS" environment and to bring together the concepts, components and best practices in the domain with the challenges of this specific environment in mind. Furthermore, this framework serves as a blueprint for future research within the GenW2 project.

STATE OF THE ART

Multiple-representation databases (MRDBs) represent data in different levels of detail (LOD). The use of additional databases, combined with mash-up services with data from the web helps to derive personalized services. These highly heterogeneous datasets need integration, pre-generalization and harmonization of data into the MRDBs (van Oosterom 2005; Burghardt et al. 2004; Edwardes et al. 2005; Sester and Brenner 2004, Follin et al. 2005).

Change of scale and content need to be sufficiently fast on the mobile display, thus requiring powerful algorithms for on-the-fly generalization (Weibel and Burghardt, 2008).

The OpenGIS Service Architecture (Open Geospatial Consortium, 2002) has established a detailed conceptual framework for developers to follow a standard to process geographic data and have a similar environment over the last few years. Early work using the OGC Service Architecture is described by Lehto and Sarjakoski, (2005). Other efforts for an extensible and generic GIS based framework are proposed by Luaces et al. (2005) and a framework to support interoperability by Stoimenov and Djordjevic-Kajan (2002).

PROPOSED FRAMEWORK

The GenW2 framework (figure 1) combines the components needed to work in a mobile environment. Although independently operational, it is intended to work with the OpenGIS Service Architecture. The components deal with efficient processing and organization of the load and personalized data handling, generation and representation. The framework extends the server-client architecture in that is now commonly used in Mobile GIS by introducing additional functionality. The server's database in this case is more integrative, and uses data from MRDBs and different dynamic data sources, along with extracted information from web mashups. The client is more user-adaptive and by taking into account the user profile, context and habits and different adaptive filters, it improves on-the-fly generalization by informing about specific contextual information.

As a test case we are in the process of implementing a "User Adaptive Trip Planner". The planner implements parts of the proposed framework, mainly in the field of filters and data integration methods. Data is extracted from different web sources with the help of extraction algorithms that use keywords and search patterns. The profile filter along with the interface then streamlines the extracted information into an "adaptive" map representation.

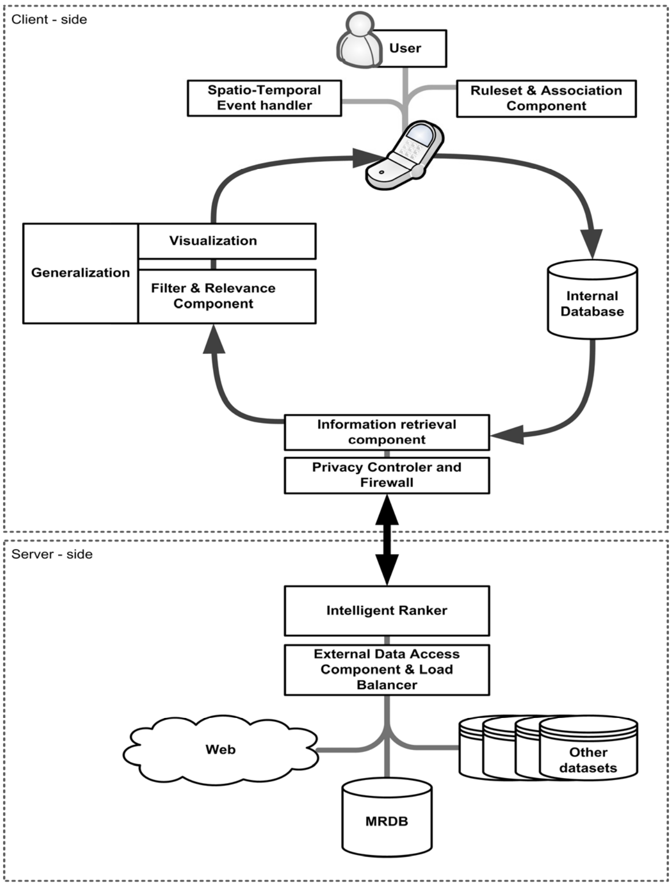

***Figure 1*:** The GenW2 Framework.

Server

The server handles various methods of data integration, extraction and structuring along with issues of load balancing of requests and initial relevance ranking of data to provide services for a mobile client (i.e. user).

Since mobile applications demand up-to-date and globally informed data, a single data source may not suffice, as storing all information on a single database is inefficient. Hence, the framework suggests a combination of a basic MRDB, a dynamic mashup of web data, and different static data sources. This results in an up-to-date and globally informed data source. Methods to extract data through automated wrappers (Crescenzi et al., 2001) can be used and extended. Also, instead of pre-generated wrappers, generation of automated wrappers (Zhao et al., 2005), to perform extraction is suggested.

The load balancer contains computational intelligence to manage, balance and direct any incoming queries or requests from multiple clients. Similar to the Apache HTTP Server Project, different methods of load balancing are proposed.

The external Data Access Component (DAC) extracts data through various methods, communicates with data sources of different formats and finally preprocesses and formats any data, before presenting it to the ranker. For this purpose it is broken up into smaller components namely - Communicator, Mashup and Data Retrieving Component, and Preprocessor. The components and organization suggested in the particular framework take suggestions in architecture and workflow management from the OpenGIS Service Architecture (Open Geospatial Consortium, 2002) and also follow certain postulates proposed in the OpenGIS Service Architecture, Topic 12. The proposed frameowork also builds on previous experience in building and implementing a service-oriented architecture for a map generalization system (Burghardt et al., 2005; Neun et al., in press).

The Intelligent Ranker then performs a relevance ranking on the results and records obtained from the DAC. The mobile device possesses limited processing power and memory, hence incomplete, irrelevant and incorrect data are ranked low or eliminated. The relevance ranker decides to rank results according to physical and personal relevance (Saracevic, 1996; Raper, 2007; Reichenbacher, 2007). The relevance ranker present in the client also performs this process.

Client

The client side handles on-the-fly generalization and personalization of data, for a client with a user in a mobile scenario.

The visualization changes with user input, spatio-temporal events, rulesets or tasks. The user's inputs and movements are analyzed to discover emerging patterns as associations or rulesets.

With the help of learning algorithms and data clustering rulesets are derived to allowing the data to organize itself (Ashbrook and Starner, 2003; Kohonen, 1998). The resulting dynamic rulesets directly map to the user's actions and profile. Data access is then facilitated by efficient data structures.

The information retrieval component sends conditional requests controlled by the Privacy Controller (Duckham et al., 2006) to the server, for additional data.

During generalization, learning filters handle the selection of relevant data according to current or future context. They analyze data and derive new datasets. Different filters and their combination rank the data according to their relevance. A possible set of filter categories is presented below:

- Spatial filters analyzes derives proximity and further spatial characteristics. (Mountain and MacFarlane 2007)
- Temporal filters derive patterns from timeline of movements and events (Zhaoet al., 2008).
- Network filters analyze personal relations and other graph like structures (Strogatz 2001).
- Profile filters look at similarities between users to derive local interest groups using Web2.0 and social networking applications.
- Hierarchy filters order the dataset by hierarchies inherent in the data, e.g. considering administrative units (Burghardt 2004).
- Semantic filters order and analyze the datasets for its semantics (Reichenbacher, 2004).
- Pattern filters search for movement pattern (Laube et al., 2007; Brimicombe and Li, 2006).
- Device filters handle device settings and constraints.

CONCLUSION

We have presented the conceptual framework for flexible web and wireless mapping used in the GenW2 project, extending a mobile GIS server-client architecture by additional functionality. On the server-side the framework features *ad hoc* data integration from heterogeneous data sources, combined with dynamic mashup services. On the client-side intelligent filters in conjunction with generalization, personalization and visualization are there to deliver on-the-fly map generation on mobile displays. The GenW2 project has only recently started and hence the framework also provides the setting for our future research. The next steps consist in analyzing the requirements for *ad hoc* data integration on the server-side and formalizing different filters of the types described above.

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