Introducing Location-Based Mass Collaboration Systems

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Abstract

Geographical data has long played an important part in information systems. Two recent technological advancements present new opportunities for location-based information systems: the first is web-GIS tools and location-based services and the second is online mass collaboration. Building on these advancements, we propose a new class of information systems: location-based mass collaboration systems. In this paper we explore this new area by: explaining the working of location-based mass collaboration systems, discussing key design principles, and describing one specific implementation: WikiGIS. We believe that the potential for this new type of systems is enormous, and call for further research in the area.

1. Introduction

In modern life, location-related information and geo-referenced media are indispensable. Traditionally, location-based information systems (namely Geographical IS; GIS) were used and maintained by few application experts. Now, we are witnessing a paradigm shift, fuelled by two fundamental technological trends. The first trend relates the ability to collect spatial information. Technological advances such as Global Positioning System (GPS), Radio Frequency Identification (RFID), high-resolution imaging satellites, and wireless sensor networks, have made cheap and reliable spatial data collection a reality. The second trend relates to the emergence of mass collaboration platforms (Tapscott & Williams 2006), which allow large distributed groups to co-create information-based products. Wiki technology (Leuf & Cunningham 2001) is an example of such a mass collaboration platform, and Wikipedia is an example of a specific application. When combined, these two trends make it now possible to mass collaborate around geo-spatial information. In recent years, we have begun witnessing the first examples for applications of this type, e.g. Google Earth and Maps, Microsoft Live Local Search, and Yahoo! Maps. These applications – often referred to as Web-GIS – provide large groups of users open access to spatial information, thus enhancing dissemination, exploration, visualization, and analysis of spatial data (Dragicevic, 2004). However, these applications are still very limited in their ability to support collaboration.

This study is part of a wider program to design a novel location-based mass collaboration platform, which would utilize web 2.0 massively distributed collaboration tools, and would allow virtual groups to produce high-quality information goods. To date, we have taken preliminary steps towards this goal, and have developed a prototype system – termed WikiGIS – that demonstrates the design principles for location-based mass collaboration applications.

2. Related Works

Traditionally, decision support systems were designed to be used by a single executive. With the shift towards flatter organizations and more collaborative environments, group decision support systems (GDSS) emerged, allowing more views to be brought to the table, and thus improving decision quality and increasing group involvement (DeSanctis & Gallupe 1987). Still, collaboration was restricted to a small group of decision makers, and these groups often suffer from the social biases inhibiting face-to-face deliberation. Emerging collaboration technologies, such as discussion forums and wikis, represent a fundamental change, opening the deliberation process to the public, thus attracting large user groups, increasing the pace in which information is gathered, and enhancing deliberation and decision-making processes (Sunstein 2006).

Geographical information, similarly to other information types, has traditionally been managed by few application specialists. In recent years there has been effort to open access to location-based data processing, the most noticeable efforts being collaborative GIS[1] (Balram & Dragicevic 2006) and collaborative mapping (Novak & Voigt 2006). *Collaborative GIS* is a class of collaboration applications that allow to process geospatial information. In a sense, it a location-based GDSS, allowing users to contribute information and supporting the aggregation of opinions. However, Collaborative GIS applications remain centralized: they are geared towards a well structured decision making process, are moderated by an external facilitator, and maintain a rigid social structure (i.e. roles are predefined and bottom-up participation is restricted; Dragicevic and Balram 2004). *Collaborative mapping*, on the other hand, is the collective creation of real world spatial models by large virtual groups (Gillvary, 2006). Its advantage is in open access, which increases participation and information sharing. However, current collaborative mapping applications are limited in their sense-making and decision-support capabilities: they do not provide spatio-temporal data analysis tools, mechanisms for filtering-out low-quality information, tools for aggregating the multitude of information pieces, or methods for resolving conflicting opinions. Figure 1 compares these two applications.

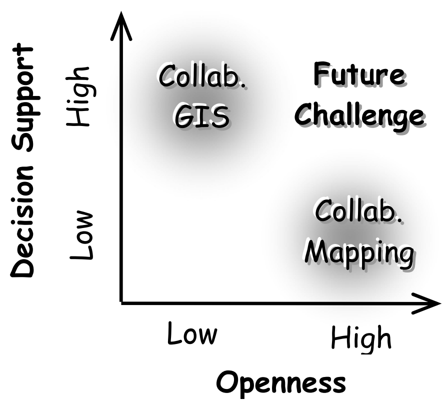

Figure 1: mapping Collaborative GIS and Collaborating mapping

The existing gap – and challenge for the future – is to combine collaborating GIS and mapping into a location-based mass collaboration platform, which is open and decentralized, yet provides the necessary aggregation mechanisms for creating high-quality information goods. Such a platform could serve numerous applications; some examples include participatory journalism, emergency response and disaster recovery, wikis of locality, forestry and agriculture, and environmental monitoring.

3. A Motivating Example

In order to better illustrate the applications for location-based mass collaboration platforms, we assume the existence of WikiGIS (described in more detail in subsequent sections) and provide an example in an area of wide interest - environmental monitoring. This specific application was chosen since it relies on geo-spatial information and could benefit from the participation of large user groups.

Consider Judy, who is interested in environmental issues, but is not actively involved in any related organization. Judy has a GPS-enabled cell phone with a camera, allowing her to capture images and short movies. During a weekend hike at a river close to her home, Judy notices an unusual concentration of dead fish that have been washed ashore. Even though Judy is unsure of what the significance of her observations is, she documents the findings by taking a few images. After getting back home, Judy logs into the WikiGIS website and reports her findings. She marks the approximate location of the observations by clicking on the map, describes her findings in a new discussion board post, and uploads the images she has taken. Within a few hours, a number of people respond to Judy's post, by providing comments and rating the correctness of her observation. A few days later, WkiGIS lists more than 50 responses to Judy's post, most of which corroborate her observations; the relevancy rating of the post is now very high. In the two weeks that follow, many other new posts were submitted, describing similar observations at other locations along the river. John, an environmental activist that acts as a volunteer WikiGIS moderator, reviews the evidence. He analyzes the evolution of the responses over time, in terms of location, text, and relevancy, and identifies a clear pattern that connects the various evidence reports. Based on recent pollution history, John believes that the evidence accumulated point to a toxic

[1] Also referred to as "participatory GIS"

spill that originated from a factory upstream. He decides to summarize all the findings related to this case, provides geo-spatial reference by drawing a polygon on the map (thus creating a link to evidence reports in that region) and opens a new wiki page to document his synopsis. The new wiki page is further discussed within the WikiGIS community, and other moderators are contributing to the synthesis of evidence. Within a short time, the authorities are notified and are given access to WikiGIS, so they could explore the evidence. Days later, an investigation against the factory is initiated.

4. Primary Design Considerations

As illustrated in the example above, location-based mass collaboration systems include four fundamental dimensions: (a) social: enabling distributed groups to collaborate, (b) information aggregation: supporting the collection of information elements (in text, audio, or video formats), and the synthesis multiple elements into a coherent information product, (c) spatial: providing geographical reference for information and supporting geo-spatial data analysis, and (d) temporal: time tracking and temporal analysis. Below we outline in more detail the design principles that guided the development of WikiGIS. Please note that Web 2.0 tools (e.g. rating system, wikis) – the theme for WITS'07 – are essential components of the proposed design.

- **Social** – develop a constructive user community by building on the lessons of prior mass-authoring projects (e.g. Slashdot, Wikipedia). Namely allowing users to take control of the application, leveraging on the collective wisdom of the masses (Surowiecki 2005), and providing mechanisms for handling conflict and vandalism.
  - Openness: information gathering is based on a large distributed user community, and thus access to add, change or delete information should be open to public everyone. Higher-level tasks that involve synthesis and sense-making of multiple evidences, as well as quality control and conflict resolution, should be restricted to users that volunteer to take on additional responsibilities (i.e. 'superusers').
  - Democracy: all users' voices carry similar weight in reporting evidence, providing feedback on others' evidence, and everyone has equal opportunity to apply for superusers roles.
- **Information aggregation** – performed in two steps: (a) gathering evidence, and (b) synthesis and sense-making.
  - Gathering evidence: allowing a multitude of opinions and views, and encouraging conflict and contradiction. The underlying assumption is that bringing more views to the table will eventually result in higher-quality decisions. Each contribution of information that is reported by a single user (e.g. an evidence report in the example above) is referred to as an *event*. The technology most appropriate for gathering multiple views is discussion forum, where each event is represented by a discussion thread.
  - Synthesis and sense-making: providing mechanisms that allow users to filter-out low quality information, synthesize multiple evidences into a coherent information product, and resolve conflicting opinions. There are two tools that could support these processes. First, relevancy rating. A rating system allows users to rate the truthfulness of other's contributions, such that each event carries a relevancy scores reflecting its cumulative feedback, and thus allows emphasizing salient events and hiding irrelevant ones. Second, aggregation with wikis. A *case* is the synopsis of multiple events, and each case is discussed in a wiki page that is co-authored by multiple users. Cases, too, carry relevancy, based on the relevancy of events associated with them. Wiki mechanisms for deliberation (e.g. discussion pages), conflict resolution and consensus building (e.g. mediation committees, voting), and quality control (e.g. WatchLists) allow the aggregation of multiple information elements into a high-quality agreed-upon information product.
- **Spatial**:
  - Geographical reference for information: events are represented as points on the map and cases as polygons

- Location-based analysis, using the standard functions of Web-based GIS systems: multiple layers of maps, zoom-in and out functionality, panning, area selection, etc.
    - Supporting multiple input modes for geographical reference: clicking on the map area or using location-based devices (e.g. location-enabled cell phone).
- **Temporal**:
    - Events and cases (and the spatial elements associated with them) carry a time stamp.
    - The relevancy of an event depends on its timeliness, as users are commonly more interested in recent events. Thus, a time-decay function is incorporated into the relevancy mechanism.
    - Supporting temporal analysis, such as time-based information filtering and analysis of case evolution. Such an analysis is paramount in environmental monitoring and emergency response applications.

5. The WikiGIS Architecture

In order to explore the technical feasibility and provide a proof-of-concept for location-based mass collaboration applications, we have developed WikiGIS. WikiGIS wraps together three primary components, as illustrated in Figure 2: a web GIS server (GeoServer[2]), a discussion board (phpBB[3]) and a wiki (Twiki[4]). The web GIS server provides the spatial frame of reference and basic GIS functionality, and is responsible for hosting and maintaining the spatial database. The discussion board (used for listing events) and the wiki (used to support cases) are both based on php and share a common database. In order to maintain database consistency, all WikiGIS components are based on the PostgreSQL database engine.

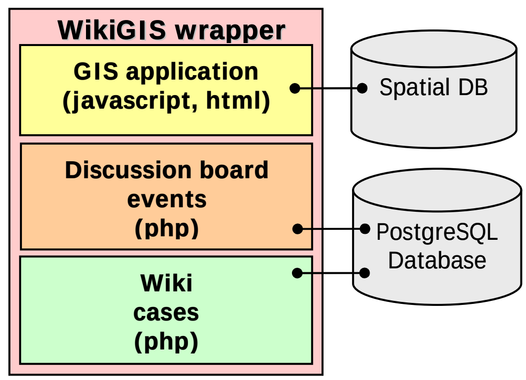

Figure 2: WikiGIS building blocks

At the interface level, the WikiGIS wrapper links all three components together into a single frame, as illustrated in Figure 3. All global functionalities that affect more than one of the applications are performed by the GIS application, which triggers actions in the discussion forum and wiki. For example, when adding an event, the GIS application sends a request to the forum software to generate a new thread and a request to the spatial DB to add the new map feature. The GIS application uses AJAX to communicate with the wiki, discussion forum and Geoserver.

WikiGIS wrapper allows users to seamlessly navigate between the different interface components. For instance, by selecting a polygon (i.e. a case) on the GIS map, the wiki presents the relevant page, and the discussion board lists and the associated events. Geographic information is fully integrated with both the wiki and the discussion board, such that when a wiki page is revised, the geographic representation (i.e. the polygon) can also be edited. The association between cases and events is maintained by the wrapper in a database relation.

6. Conclusion

In this paper we discussed a new class of information systems – location-based mass collaboration systems. Our main contribution is in charting out this new field and outlining primary design considerations. In order to illustrate the architecture of location-based mass collaboration systems, we introduce the WikiGIS prototype. We believe that the potential for location-based mass collaboration

[2] http://docs.codehaus.org/display/GEOS/Home
[3] http://www.phpbb.com/
[4] http://twiki.org/

systems is enormous, and call for further research in the area. Following we point to some possible research directions.

Users play a critical role in mass collaboration projects, and research has begun investigating the impact of various aspects of the user community, for instance group size, diversity (e.g. Arazy et al. 2006), and user motivation (Bagozzi & Dholakia 2006). Another important social aspect is the trade-off between accountability and privacy: on one hand accountability is achieved when each contribution is attributed to a specific user whose identity is known and verified; on the other hand, users' privacy should be protected (Nissenbaum 1996). Furthermore, as location-based mass collaboration system incorporate location into the collaboration process a new dimension of privacy arises, namely the collaborator's exact location (e.g. see works in the context of pervasive computing; Duckham and Kulik, 2005). Since the impact of these different aspects is likely to differ across applications, we propose that research on online user communities be extended to location-based mass collaboration.

On the system side, there are many opportunities for improving the design of the architecture presented here, and these could be explored in future research. Prior research on collaborative systems has investigated design elements such as rating system (Kollock 1999), wikis quality control and conflict resolution mechanisms (Viégas et al. 2007), and user interfaces for collaborative systems (Gutwin & Greenberg 2002). Since location-based mass collaboration has distinct features, we call for future research on these design elements in the current context. We plan to evaluate the usability of the system by working with potential users on a specific application context, and focusing on system effectiveness, efficiency, and user satisfaction.

Finally, there are challenges specific to location-based mass collaboration systems, such as versioning of spatial data elements, integration of geographical and textual features (e.g. automatic extraction of geographical references from text; reflecting multiple viewpoints of an event on the map), and inter-operability with other applications (e.g. employ sensor networks as input; share data with exiting application, for instance in the case of government-run disaster-recovery applications). The advancement of location-based mass collaboration systems warrants future research in these areas.

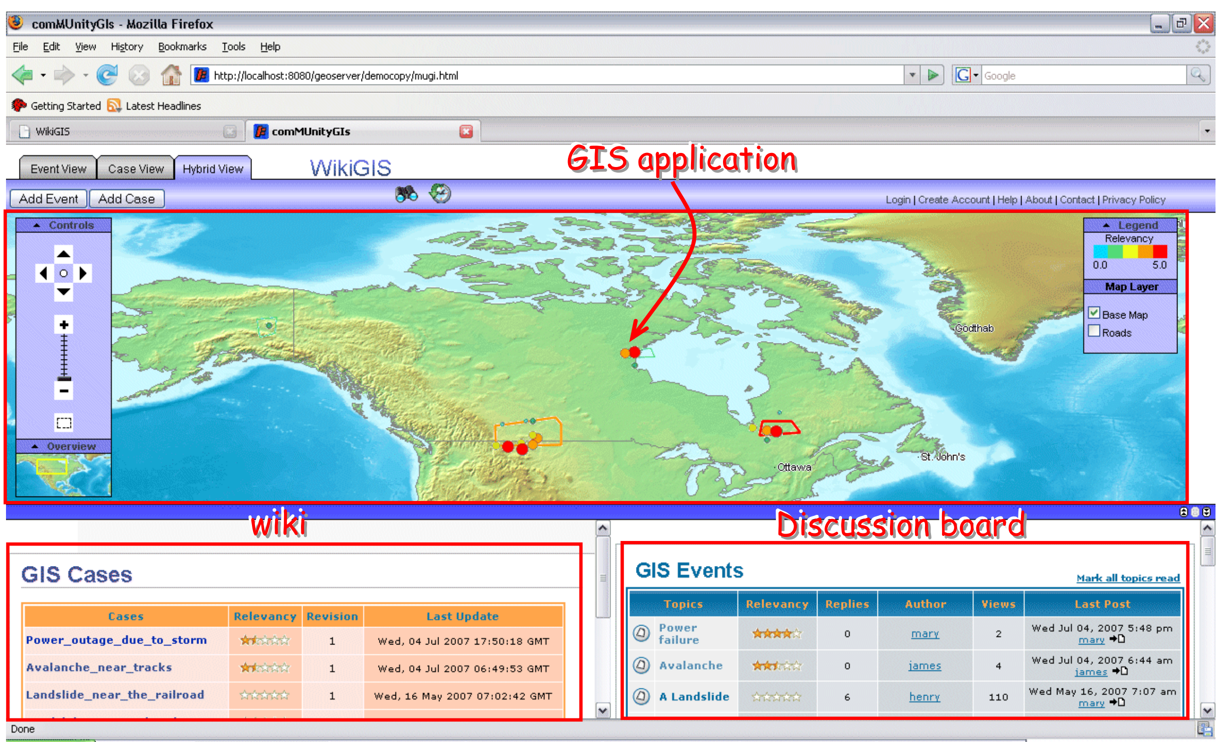

Figure 3: WikiGIS user interface

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