Ubiquitous cartography

—by Georg Gartner

In the late 1980s, Mark Weiser, a technologist at the Xerox Palo Alto Research Center, created the term "ubiquitous computing." In his disquisition on "T*he Computer for the 21st Century*," Weiser (1991) assumed that in the near future, a great number of computers will be omnipresent in our everyday life and that they will soon be interconnected in an ubiquitous network. Especially in the last decade this concept gained in importance not only in computing but also in other disciplines (Baard 2002). Recently, geo-scientists have discovered the possibility of using the omnipresent computer landscape for exploring our spatial environment and established mapping as a part of the ubiquitous computing concept.

DEFINITIONS, AIM AND BASIC ELEMENTS

Fairbairn (2005) explains the term "ubiquitous cartography" as a technological and social development, made possible by mobile and wireless technologies, which receives, presents, analyses, and acts upon map data distributed to a user in a remote location. Furthermore he predicts that this new approach to maps will revolutionize the way many people interact with maps. To Ota (2004) "the definition of ubiquitous mapping is that people can access any map at [sic] anywhere and anytime through the information network" (pp. 167). Morita (2005) uses the term "ubiquitous mapping" to refer "to the use and creation of maps by users anywhere and at anytime" and notes that it "…is strongly influenced by advances in information technology, such as the development of wireless systems, high-density data storage, and broadband communication, which can be seen as stimulation and facilitation of dynamic and personalized mapping."

By extension we can define ubiquitous cartography as the study of how maps can be created and used anywhere and at anytime. Underlying this definition is the assumption that there is something special about real-time, *in-situ* map production or a use that differentiates it from more traditional cartographic activities.

As is often the case with rapidly emerging technologies, a generally accepted ontology that clearly defines what ubiquitous cartography is and is not has not been developed. From Morita's definition, however, we see that context—a unique combination of place, time, and user—drives *in-situ* map production and, thus, we can view ubiquitous cartography as an umbrella term for several related technologies, including location-based services (LSB), TeleCartography, and mobile cartography.

MAIN RESEARCH THEMES

The development of ubiquitous cartography is enabled and pushed by major technological developments, including:

- Telecommunication infrastructure (such as 3G wireless networks);
- Smart environments (such as defined by Weiser as a "physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives and connected through a continuous network");
- Near field communication infrastructure (using technologies such as WLAN, Bluetooth, ZigBee, RFID etc.); and
- Smart devices (e.g. iphone and gphone).

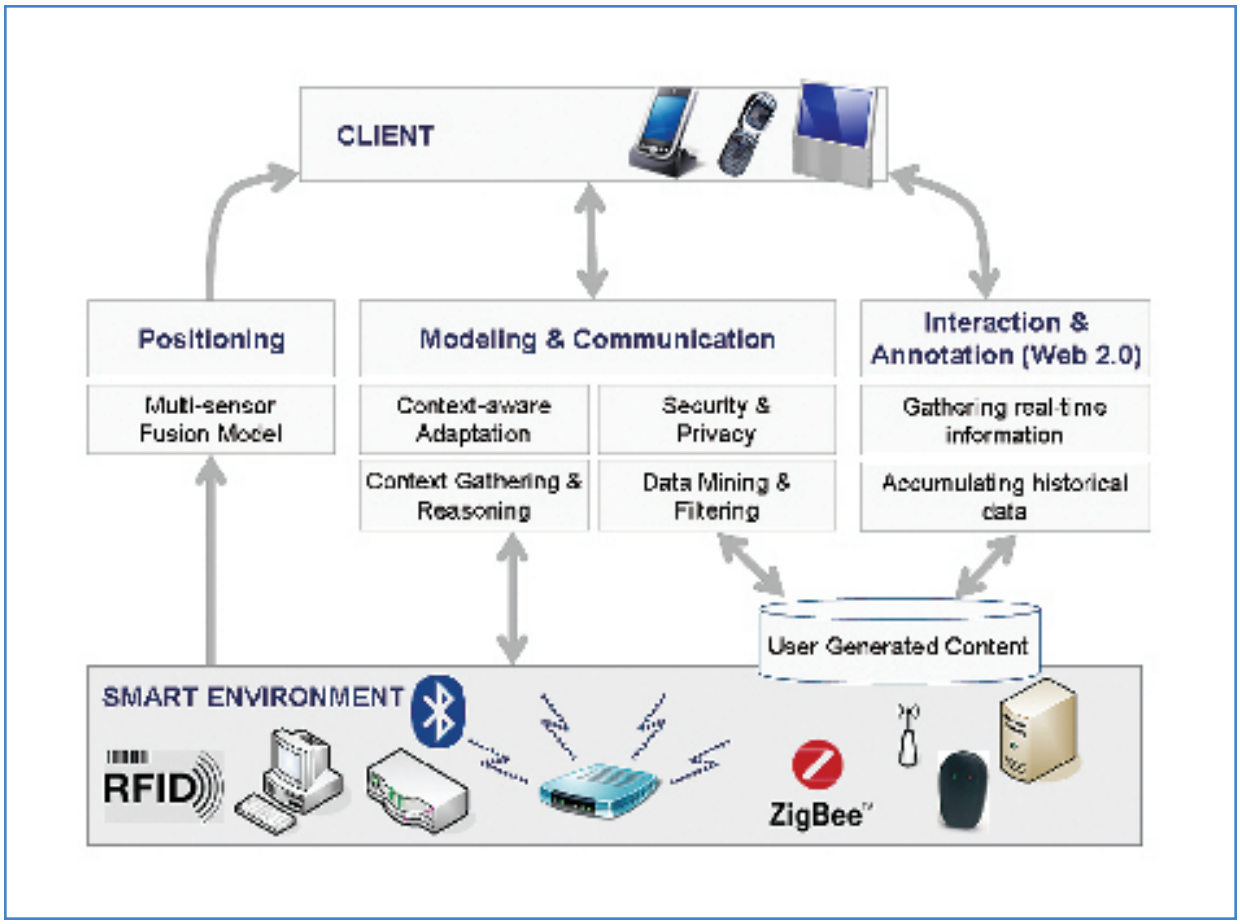
Additionally, the availability of spatial data (either commercial, free, or volunteered) is increasing and leads again to a push in an interest in contemporary web mapping applications, including mobile services and ubiquitous applications. To develop ubiquitous applications successfully, research needs to focus on a number of priority areas.

Positioning

The required level of accuracy produced by positioning systems depends on the service to be provided; it is contextually dependent. Some applications can be supported by simply knowing the telecommunication cell from which the user is calling; positional accuracy of between 50 and 100 meters is possible in urban areas (see Retscher 2002). With ubiquitous mapping and telecartography also comes the need to track people within structures (i.e., through buildings and underground transportation systems). To be able to do this, satellite-based positioning (such as GPS) needs to be augmented with additional technologies, including WiFi, Bluetooth, or RFID signals (Retscher 2008).

Context-aware adaptation

Attaching context to location is an explorative, multi-media, user-driven activity accomplished through access to files and analytical tools stored on a handheld computer or distant computer servers. This rich, context-specific interaction made possible by mobile computing technologies should reduce the cognitive burden placed on users as they attempt to use cartographic materials to understand the world in which they are situated. In context-aware adaptations, the focus shifts from a carto-centric to a user-centered or egocentric view (Meng 2005).



Sensitivity to real-time context is largely what differentiates ubiquitous from traditional forms of mapping, and it requires us to rethink fundamental cartographic concepts (Reichenbacher 2003; Armstrong and Bennett 2005; Bennett et al. 2007). The contextualization of the user, however, challenges researchers to conceptualize cartographic software as more than automated mapmaking.

We must also think specifically about how to model mobile users within dynamic environments and carefully consider how this complex setting affects the processes of map production and use. Currently, adaptation to user context is often limited to user profiles selected in advance from a list or entered manually by the user. Machine intelligence, user perception, spatio-temporal data models of discrete and continuous phenomena, context representation, and context sensing (e.g., position, light levels, travel speed, and weather conditions) are all areas for future research.

Map communication

Mobile cartographic technologies simultaneously constrain and expand the options available to cartographers as they attempt to communicate information about geographic phenomena. Cartographers are constrained, for example, by the limited display and computational capabilities of mobile computing devices. On the other hand, cartographers are no longer limited to the static presentation of geographic pattern on hard-copy media.

New cartographic presentation forms designed specifically for small-screen displays are being developed to facilitate the construction and communication of maps on mobile devices. Klippel (2003), for example, has conducted research on the use of "focus-maps." Research is also being conducted on display technologies. Wearable computers and AR allow for a conflation of the real and digital world.

Collaborative filtering and web mapping 2.0

Ubiquitous cartography is expected to introduce also the Web 2.0 era. Many users are not satisfied with being passive consumers of information; they want to be active contributors. By enabling user-generated content, users can share their personal experiences with others, which will fulfill users' intrinsic desire to communicate these experiences

(to friends, or even with other tourists they do not really know) and thus provide other users with new experiences. The challenge remains to use collaborative filtering methods in order to design smart applications which recommend relevant information.

Security and privacy

The ability to link individual identity to location, time, and context is what drives location-based services. However, as an ever-growing body of research reminds us, capturing this information presents a very real threat to individual privacy (Armstrong, 2002; Monmonier, 2002; Miller 2005, Goodchild 2009). Concerns about the loss of privacy in the context of LBS range from malicious intrusions into an individual's personal information or physical space to the more subtle and slow erosion of our collective sense of privacy as we willingly increase our use of these technologies for convenience, knowledge, or pleasure (Curry 1998; Onsrud et al. 1994; Armstrong and Bennett 2005). As Chang et al. (2006) illustrate, the perception of privacy is correlated with an individual's willingness to adopt LBS. However, there is often a positive relationship between the amount of personal information an individual provides to a LBS and the quality of service provided.

CONCLUSIONS

In the last few years, a significant amount of research and development has taken place in the context of location based services, and this research is now being supplemented and expanded with the help of ubiquitous methods. Associated concepts are enabling a revolution in mapping and navigation. Yet research is still in the early development stage, and many new challenges still confront the research community.

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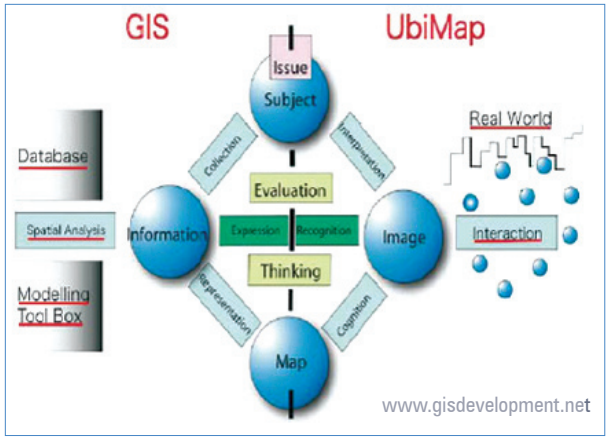

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