

Enabling Web-based, Real-time Geographic Information Systems through Service-Oriented Sensor Networks and Semantic Integration of Spatial Data

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Abstract: Geographic information systems (GISs) are computer systems that capture, manage, integrate, analyze, and display spatial data. Most existing GISs are desktop applications. They do not support a distributed, Web-based sharing of GIS data and are, therefore, unable to answer complex queries that require the automatic integration of several heterogeneous, spatial and non-spatial data sets that may originate from different Web-accessible sources. Also, most existing GISs operate on existing data; they are unable to acquire and process spatial data originating from real-time data acquisition infrastructures with stringent resource constraints (e.g., energy, bandwidth) such as wireless sensor networks. Addressing these two key challenges is fundamental to achieve the vision of Web-based, real-time GISs (WRT-GISs).

In this talk, we present our contribution in building WRT-GISs. Our work focuses on two requirements for WRT-GISs: (i) support for semantic integration of heterogeneous spatial data and (ii) support for real-time data acquisition and processing. To address the first requirement, we developed a peer-to-peer collaborative GIS framework where users share spatial and non-spatial data. In this framework, users semantically register their spatial data through ontologies and specialized markup languages such as GML (Geography Markup Language) and GeoSciML (Geosciences ML). Users may submit complex queries to a semantically-enabled query engine that is able to discover data sets relevant to the query and to integrate these data sets to generate the query's result. We implemented this framework in our DIA (Discovery, Integration, and Analysis) system, a Web-based GIS that provides a knowledge sharing environment for Earth sciences.

In addition to semantic integration, future GISs must also acquire and process real-time spatial data originating from sensor networks efficiently while being designed and implemented independently from those networks. For this, we introduced the idea of service-oriented sensor-actuator networks (SOSANETs), a novel architecture for programming and querying open, interoperable, application-independent sensor networks. Unlike in traditional sensor networks where the same generic or application-specific code is loaded on sensor nodes at deployment time, each node in a SOSANET may run a different code than other nodes. A node's code consists of a collection of services. SOSANETs provide the benefits of both application-specific SANETs (e.g., energy efficiency, scalability) and generic SANETs (e.g., reusability), and avoid most of their limitations. This service-oriented design model is very suitable for WRT-GISs. For example, as it decouples applications from sensor networks, this model enables a single GIS to use several SOSANETs and enables several GISs to simultaneously use the same SOSANET. We implemented a prototype SOSANET, called TinySOA, on top of TinyOS 1.1.15. We will describe TinySOA and show the architecture of a Web-based, real-time GIS that combines DIA and TinySOA. We will conclude with some challenges and future research directions in the area of WRT-GISs.

Biography: Abdelmounaam Rezgui is a PhD candidate in the Dept. of Computer Science at Virginia Tech. He received his MS in computer science from Purdue University. Abdelmounaam is an instructor in the Dept. of Electrical and Computer Engineering at Virginia Tech. While working on his PhD, he was a researcher in the Dept. of Geosciences at Virginia Tech. His research interests include Web-based GISs, semantic integration of spatial data, interoperability of GIS database systems, Web services, and routing and query optimization in sensor networks. Abdelmounaam authored more than 30 book chapters, journal papers, and conference papers. He served as a PC member in ACM SAC's special track on handheld computing (2005, 2006) as well as a panel member in the 2007 NSF International Workshop on Theoretical and Algorithmic Aspects of Sensor and Ad-hoc Networks (WTASA). Abdelmounaam is a member of the IEEE and Upsilon Pi Epsilon.