GeoS4S Module Real-Time Geospatial Applications

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Abstract
The data we are typically using in geographic information systems is typically somewhat 'outdated', as soon as it gets created. The spatial data we are using represents typically a specific state of a place or area in the physical world at a certain moment in time. These data is very valuable for a vast amount of spatial analysis and applications but is not in sync with the 'current' situation on site (Artz, 2013). Combining new location aware Internet of Thing technologies (IoT) and GIS data shared via Spatial data Infrastructures give us now opportunities to integrate up-to-date ness into our GIS applications and to reflect its current status. These applications are being characterized by a continuous stream of events including position, phenomenon values (e.g. temperature, humidity etc.) flowing from sensors or data feeds interlinked with building-plans, basemaps etc.

Key Words: Real-Time GIS, Internet of Things (IoT), Sensor, Networks, OGC SOS, OGC SWE, Collective Sensing, Privacy, MQTT, SensorThings API

1. Introduction

The provision of (near-)real-time information becomes a critical task for various societal areas including environmental monitoring, disaster management, development of early warning system, human health, public security. The advancements of communication technologies such as Internet, wireless communication networks or web services enabled the development of intelligent geo-application for data collection in the field and real-time monitoring of various environmental conditions such as precipitation, humidity, temperature, pressure or pollution. The following concepts will be introduced in this module: Internet of Things, (Geo) sensors & sensor networks, OGC Sensor Web Enablement specifications, Collective sensing, privacy & security considerations and the trending 'streaming analytics'.

1.1 Module Description

Real-time GIS enabled platforms are capable of integrating location aware streaming data sent out from sensor systems in different data formats with other geospatial information. The incoming data therefore has to be sent in near-real time either as streaming service (through push operation) or is being shared as standardized feature service (e.g. OGC WFS) which can be polled in a defined interval by the client. The module therefore addresses the new The Internet of Things (IoT) paradigm which has been defined as a *„world-wide network of interconnected objects uniquely addressable, based on standard communication protocols"*(Ortiz et al., 2014). Connecting a vast amount of every day's objects, which have been assigned an IP address via internet. With these smart objects (e.g. sensor networks, smart devices, beacons etc.) it is possible to sense, collect, transmit and/or to process information about e.g. the physical environment to facilitate the development of 'smart cities, agriculture, manufacturing etc.

The module will explain the protocols and technologies for enabling the autonomous communications between various sensors. The subsequent lessons will introduce the concepts of real time GIS, the concepts of observations defined by the ISO 19156 Observations & Measurements (O&M) standard and explain the important standards of the OGC Sensor Web Enablement (SWE) initiative like the OGC Sensor Observation Service (SOS) and the sensorThings API introduced in 2016. The closing lesson discusses the role of real-time location aware applications, the collective sensing approach and introduce related privacy and security considerations.

1.2 Learning Outcomes

- to define the concept of Internet of Things and enabling technologies;
- to explain the role of sensor networks to address various environmental and disaster monitoring and management issues;
- explain and make use of sensor network and used communication protocols like MQTT
- to explain the role of OGC Sensor Web Enablement (SWE) specifications and sensorThings API for integrating different data sources streaming in near real-time geo-applications
- to embed location aware near-real-time data services in user-friendly geo-applications;

2. Module Structure

2.1 Module Overview

This module consists of 15 lessons with slides and accompanying notes in total which amounts to a minimum of 150 hours of effort required for studying the core material. Most of the lessons equal to about 4 to 5 hours, excluding reading material, lab exercises and assignments. Some other lessons are more challenging and for the study or their core material more time (~ 10 -15 hours each) is required. The module is intended to provide credit equivalent to 6 ECTS. The module materials are designed to be used flexibly, in either a traditional classroom setting or for on-line study. The module also includes six (6) exercises for self-assessment by the students and four (4) assignments for evaluation and grading by the teacher / instructor.

2.2 Summary of Lesson Content

This section briefly presents the content and goals of each lesson.

- *Lesson 1: Internet of Things* - This lesson outlines the concept and enabling technologies for Internet of Things (IoT), describes what smart objects are and discuss the main challenges related with IoT.
- *Lesson 2: Smart applications* – The lesson explains how IoT technologies contribute to the realization of smart applications (smart cities, smart house, smart grid, smart health, smart agriculture etc.), describes the concepts of smart city, smart health, smart house and smart agriculture
- *Lesson 3: Communication technologies and Protocols for IoT* – This lesson explain technologies behind the autonomous communications between various sensors and gives an introduction to the the key wireless sensor networking technologies
- *Lesson 4: Real Time GIS and Internet of Things* – This lesson explains the main concepts and benefits of of real-time GIS, introduces the concept of 'observations' and provides examples of real-world applications.
- *Lesson 5: OGC Sensor Web Enablement (SWE)* – Subsequent to the introductory lessons this lessons provides a comprehensive introduction to the concept behind the OGC Sensor Web Enablement (SWE) Initiative and describes the conceptual schema encoding for observations specified by OGC Observation and Measurements (O&M)
- *Lesson 6: OGC Sensor Observation Service (OGC SOS)* – This lesson introduces the OGC Sensor Observation Service and describes and explains the OGC SOS Operations (Core & Extensions)
- *Lesson 7: SensorThings API & MQTT* – Explanation of the OGC sensorThings API and introduction to the MQTT communication protocol.
- *Lesson 8: Operations Dashboard for ArcGIS – This lesson* explains Explain the key functionalities of the Operations Dashboard for ArcGIS and explains how to develop new Operation View Dashboard for monitoring live stream gauges.
- *Lesson 9: Semantic Sensor Web* - This lesson explains semantic web technologies and the importance of semantic sensor web technologies to integrate and distribute sensor data
- *Lesson 10: Mobile real time geo applications development* - This lesson highlight the main benefits of Mobile GIS and explain the underlying technological advances that triggered the development of mobile GIS. Additionally it introduces Collector for ArcGIS to develop mobile apps
- *Lesson 11: Real-time Indoor (Outdoor) positioning* - This lesson explains the main challenges related to real time indoor positioning and navigation and describes existing indoor positioning technologies (RFID, Wi-Fi, BLE etc.)
- *Lesson 12: Real time geospatial application for disaster management* - This lesson explains the role of real time applications to manage and monitor natural disasters such as earthquakes or flooding.
- *Lesson 13: Collective sensing* - This lesson introduces the collective sensing concept and describes the advantages and limitations of sensor network data to get insights into human behaviour.

- *Lesson 14: Security and data privacy issues in the context of real time geo-application* - This lesson explains the main data security concepts with regard to real-time GIS applications (Authentication, Authorization & Accounting), introduces the 'privacy' concept and discusses the security and data privacy challenges in the context of real time geo-applications.
- *Lesson 15: Future Directions – Streaming analytics* - This lesson highlights the future trends in the real-time geospatial applications development – Streaming Analytics and describes the key capabilities of the GeoEvent Server Role of Esri ArcGIS Server

3. Exercises

The module provides six (6) exercises for self-assessment by the students to supplement the lecture content, deepen students' understanding, and develop their practical skills.

- Exploring RFID and beacons technologies (Lesson 3)
- Interacting with real time data using web map application hosted on ArcGIS Online Platform (Lesson 4)
- Exploring various sensor platforms (Lesson 5)
- Interacting with real time data using Dashboard for ArcGIS (Lesson 8)
- Developing a mobile web application using ArcGIS Collector (Lesson 10)
- Discuss the main security and privacy issues related to real time geospatial applications (Lesson 14)

This module assumes some prior knowledge of GIS software and introduces to the use of real-time GIS software (ESRI ArcGIS Geoevent Server Role, ArcGIS Collector, ArcGIS Dashboard & Open Source 52 North for Sensor Observation Service (SOS) and Node Red), therefore some of the activities will be easier if students have some exposure to IT and programming concepts.

4. Teaching and Learning System

The learning and teaching strategies will follow student centred mode. Through the lectures, additional reading material and exercises, the students will acquire advanced theoretical knowledge about real-time GIS, IoT and related issues. Through the exercises, the students will develop skills to use geospatial techniques for establishing, querying and leveraging real-time GI services and applications. The students will get practice into the main steps required to use and create real-time GIS applications using both open-source and proprietary software. On completion of this module, the students will be able to develop their own real-time GI applications using IoT resources published as standardized sensor web services.

As part final part of the exercise lessons, the students are required to do presentations about the results of their work. Students subsequently ask questions and shall give comments. The teachers also take part in the discussion and give their opinions. The teaching and learning system can be conducted in a classroom or an internet platform with teachers and students.

5. Evaluation System

The evaluation system consists of five assignments, lab exercise work, and participation in discussions. Grading criteria are as follows: (out of 100pts in total):

- Assignment 1 " Strengths, weaknesses, opportunities and threats (SWOT) analysis of the Internet of Things ": 20 pts (Lesson 3)
- Assignment 2 " Developing a dashboard for visualization real time data using Operations Dashboard for ArcGIS application ": 30 pts (Lesson 8)
- Assignment 3 " Summarize the main advantages of semantic web technologies in an essay of maximum 1500 words ": 20 pts
- Assignment 4 " Developing a mobile application dedicated to a topic of your choice where at least one of the used data is real time data ": 30 pts (Lesson 10)

6. Additional Notes

The lectures and geo-related laboratory exercises in this module jointly linked together. For all students with background knowledge of geography and IT, it is recommended to start with the lessons from the beginning to the last one. Many of the lectures are built upon knowledge created by the prior lessens.

Some exercise in this module require the installation of additional software products. Many of these products are open source. For commercial software trial licenses can be obtained. Additionally it is recommended that the students already have in-depth GIS knowledge to achieve the goals for this module. For the students with advanced skills it is recommended that they establish a full real-time GIS services infrastructure on a system of their own. The intention of this module is to train students with advanced scientific literacy. After learning this module, it is hoped that each student can resolve real-time GIS questions in a technologically advanced and logical way.

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