GeoS4S Module OpenGIS and Spatial Data Infrastructure

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Abstract
Worldwide, a novel trend shifting paradigms towards opening - to share, access, analyse and exploit spatial information across communities and technical platforms - can be observed. This opening technically driven by leveraging service-oriented (geographic) information infrastructures which are used to create nationally and internationally connected spatial data infrastructures (SDI). To achieve this goal, efforts are being joined across the globe to create technical standards for managing, sharing and exchanging geo-information. Additional efforts are also put into enhancing the semantic interoperability of geo-information content using harmonized data specifications.

Key Words: Open, Spatial Data Infrastructure, Data Sharing, Services, Opengis, WebGIS, OGC, WMS, WFS

1. Introduction

The Internet and the latest Information and Communication Technologies (ICT) changed the way in which we interact with spatial information and created the premises for developing what is known today as Online GIS or Web GIS. This new GIS paradigm exposes GI content and tools over the web, contributing to GIS democratization. According to Craglia (2010) the frameworks for data sharing where data collected by others can be searched, retrieved and used comprise the Spatial Data Infrastructure. Therefore the SDI host data and its documentation (Metadata) and support the discovery, the evaluation and usage of these geo-datasets (Nebert, D. D., 2004) using service oriented architectures.

1.1 Module Description

In this context, Spatial Data Infrastructure (SDI) provides the foundation for geographic resources discovery and usage across networks. Therefore the module provides the architectural introduction and foundation on interoperability - general organizational concepts and methods as well as technical implementation strategies for organizing, deploying and leveraging geographic information. Based on the fact that information can best unleash its power when put together according to their contexts in time and space the module is addressing the technical requirements and needs for opening and connecting spatial and non-spatial data and information resources (Toth et al., 2012). It introduces the technological advances and standardization efforts that enable GI resources (vector data, raster data, tools, maps) sharing and integration across distributed platforms.

Spatial data sharing and integration rely on the standards and specifications developed by the International Organization for Standardization (ISO) with its Technical Committee 211 (TC211) and Open Geospatial Consortium (OGC/OpenGIS). The following OpenGIS Specifications will be discussed in this module: Geography Markup Language (GML) is the standardized data encoding format used to share spatial data; Web Map Service (WMS) specifies the interface to share georeferenced map images over the web; Web Feature Service (WFS) allows a client to retrieve and modify geospatial data encoded in the GML format based on XML ; Metadata standards and Catalog Services standards used to store, search and discover metadata items in a standardized way; Web Coverage Service (WCS) allows a client to retrieve and modify raster data; Web Processing Service (WPS) specifies the rules for sharing spatial analysis processes over networks.

1.2 Learning Outcomes

- to outline the key technologies behind the Open GIS/distributed infrastructures;
- to explain the role of web services in developing distributed infrastructures;

- to list the organizations responsible for developing standards in the GIS context
- to define Spatial Data Infrastructures (SDIs) and their role in spatial data exchange and integration;
- to publish and consume standardized OpenGIS web services in different applications (desktop and web clients)

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 ten (10) exercises for self-assessment by the students and five (5) 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: From Maposaurus to OpenGIS standardized geo-spatial web services* - This lesson outlines the key of service-oriented GIS technologies, describes web service concept and explains the the Open GIS approach.
- *Lesson 2: Requirements on standardisation & interoperability for sharing geospatial resources* – The lesson explains the concept of interoperability and standardisation with regard to technical, organisational/social and legal requirements, explains Service Oriented Architecture (SOA) approach together with its underlying principles, advantaged and disadvantages. Additionally it lists existing organizations responsible for developing standards within GIS domain (e.g. Open Geospatial Consortium (OGC), International Organization for Standardization (ISO) with its technical committee TC211.
- *Lesson 3: Web Services* – This lesson explain the client-server interaction in distributed architectures, describes the key characteristics of Simple Object Access Protocol (SOAP) and Representational State Transfer (REST) protocol.
- *Lesson 4: Spatial Data Infrastructure* – This lesson explains the main concepts and benefits of creating and maintaining SDIs and describes the common goal of existing SDI Initiatives and their importance for developing a spatially enabled society. Explain the role of open data and open government data initiatives to develop intelligent geospatial applications.
- *Lesson 5: Spatial Data Infrastructures Online* – Subsequent to the SDI lesson this lesson introduces to some of the existing SDI initiative at global, regional and national level like EU INSPIRE, data.gov etc.
- *Lesson 6: eXtensible Markup Language (XML)* – This lesson introduces the basic concepts of eXtensible Markup Language (XML) to encode and transfer data over the web
- *Lesson 7: Metadata and Web Catalog Services* – Explanation of the role of metadata for sharing spatial data across distributed networks, listing of the main metadata standards on spatial datasets and services and outline of the concept and role of Catalog Services for Spatial Data Infrastructure (SDI) initiatives
- *Lesson 8: Spatial Data Infrastructure – This lesson* explains the main concepts and benefits of creating and maintaining SDIs. Additionally the lesson lists the main components of Spatial Data Infrastructure (SDI).
- *Lesson 9: Geography Markup Language (GML)* - This lesson explains the role of the Geography Markup Language (GML) to encode spatial data, describe the main GML specifications and gives an introduction to the differences between GML profiles and GML applications.
- *Lesson 10: Web Feature Service (WFS)* - This lesson explains the OGC Web Feature Service (WFS) specification and gives an introduction to understand the syntax of OGC WFS requests.
- *Lesson 11: Web Feature Service Filter Encodings* - This lesson gives an introduction to the OGC Filter Encoding specification (FES) being used by various standards like OGC WFS and OGC SOS and geives examples on how to use FOS WFS filters to select spatial data.
- *Lesson 12: Web Coverage Service (WCS)* - This lesson explains the coverage representation model, describes the OGC Web Coverage Service (WCS) specification, its extensions and the OGC GML Application Schema for Coverages 1.0.

- *Lesson 13: Web Processing Service (WPS)* - This lesson describes the advantages and disadvantages of Web Processing Service (WPS) for processing/analysing spatial data online and explains WPS specifications defined by OGC
- *Lesson 14: Tile specifications* - This lesson gives an introduction to the OGC Web Map Tile Service 1.0 (WMTS) specification and describes the Mapbox Vector Tile Specification.
- *Lesson 15: Additional Important Geodata exchange standards* - This lesson introduces additional important geodata standards like the OGC KML specification, the OGC GeoPackage format for geospatial information and the Internet Engineering Task Force (IETF) RFC 7946 GeoJSON specification.

3. Exercises

The module provides ten (10) exercises for self-assessment by the students to supplement the lecture content, deepen students' understanding, and develop their practical skills.

- Discussion of The Role of Spatial Data Infrastructures (Lesson 4)
- Encode spatial data in eXtensible Markup Language (XML) format (Lesson 6)
- Installing Tomcat and GeoServer open-source software (Lesson 8)
- Loading data to GeoServer and publishing Web Map Services (WMSs) using GeoServer (Lesson 8)
- Data visualization using Styled Layer Descriptor (SLD) specifications (Lesson 8)
- Defining a simple GML schema and GML instance file (Lesson 9)
- Querying WFS using GET and POST requests (Lesson 10)
- Publishing Web Feature Service (WFS) using GeoServer (Lesson 10)
- OGC Web Feature Service (WFS) & QGIS Client (Lesson 10)
- Publishing/Working with Web Coverage Service (WCS) using GeoServer (Lesson 12)

This module assumes some prior knowledge of GIS software and introduces to the use of GIS server software (ESRI ArcGIS Server, ArcGIS Online & Open Source Geoserver), 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 OpenGIS, Spatial Data Infrastructures and related issues. Through the exercises, the students will develop skills to use geospatial techniques for establishing, querying and leveraging SDI services. The students will get practice into the main steps required to publish OpenGIS web services using both open-source and proprietary software. On completion of this module, the students will be able to develop their own applications using GI resources published as standardized 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 "Sharing Spatial information across distributed infrastructures": 20 pts (Lesson 3)
- Assignment 2 "Metadata and data discovery": 20 pts (Lesson 7)
- Assignment 3 " OGC Web Map Service (WMS)": 20 pts (Lesson 8)
- Assignment 4 " Styled Layer Descriptor (SLD)": 20 pts (Lesson 8)
- Assignment 5 "OGC Web Feature Service (WFS)": 20 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. Most 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 SDI framework 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 SDI questions in a technologically advanced and logical way.

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