

GIS today is characterized by

1. Different actors in data collection & distribution
2. an increasing number of geo-applications, product types, and formats
3. duplication and difficulties in having access to data even within /across departments and organizations
4. Diverse data encodings
5. Different data meaning

Need for harmonization on an operational level: technical, contextual & organizational

1. Technical (machine to machine, software module interaction, API, format...)
2. Semantic
 - (Understanding concepts, terms...)
 - Inter-disciplinary (special vocabularies)
3. Political/Human
 - Government (policy, training...)
 - Legal (ownership, responsibility...)

Definition of Interoperability: the ability of two or more systems or components to exchange information and to use the information that has been exchanged.

The ability of GIS information systems to:

1. “freely exchange all kinds of spatial information about the Earth and about the objects and phenomena on, above, and below the Earth’s surface; and
2. Cooperatively (over networks) run software capable of manipulating such information” (ISO19101:2001)

SDI (spatial data infrastructure)

SDI is a data infrastructure implementing a framework of geographic data, metadata, users and tools that are interactively connected in order to use spatial data in an efficient and flexible way.

SDI – why: For effective & efficient organization of geo information

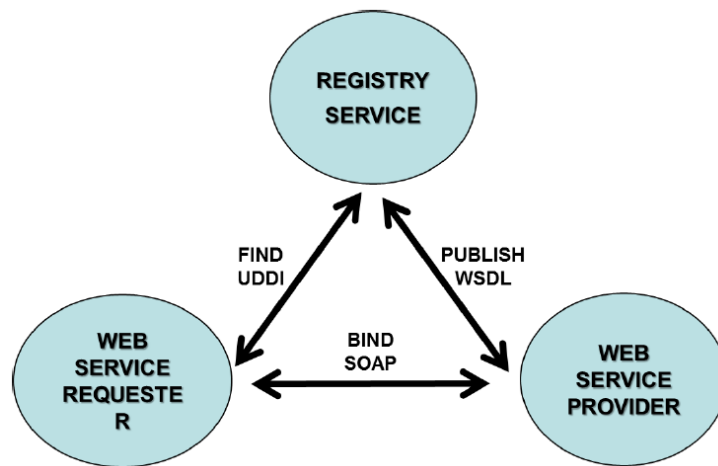
1. improve data access
2. improve data reuse
3. make information readily available
4. ensure that investments for data collection and management result in a growing pool of information

Decomposition of a Spatial Data Infrastructure (SDI)

- Standards
- Access, technology
- Content (data)
- Organization
- Education

SOA: Service Oriented Architecture, Publish – Find – Bind Principle

- Publish resource descriptions (using Web Services Description Language - WSDL) so that they are accessible to the potential users (publish);
- Discover resources in Universal Description Discovery and Integration (UDDI) registries according to specific search criteria (find), and
- Interact with the resource provider to access the needed resources (bind).



SOAP: Simple Object Access Protocol

REST: software architectural style, a set of rules that a RESTful based (software)

1. Lightweight alternative to SOAP
2. REST's principle (Source: Tilkov, 2007):
 - Give everything on the web an ID: URL (Uniform Resource Locator)
 - Link things together: hyperlinks
 - Use standard methods
 - Resources with multiple representations
 - Communicate stateless

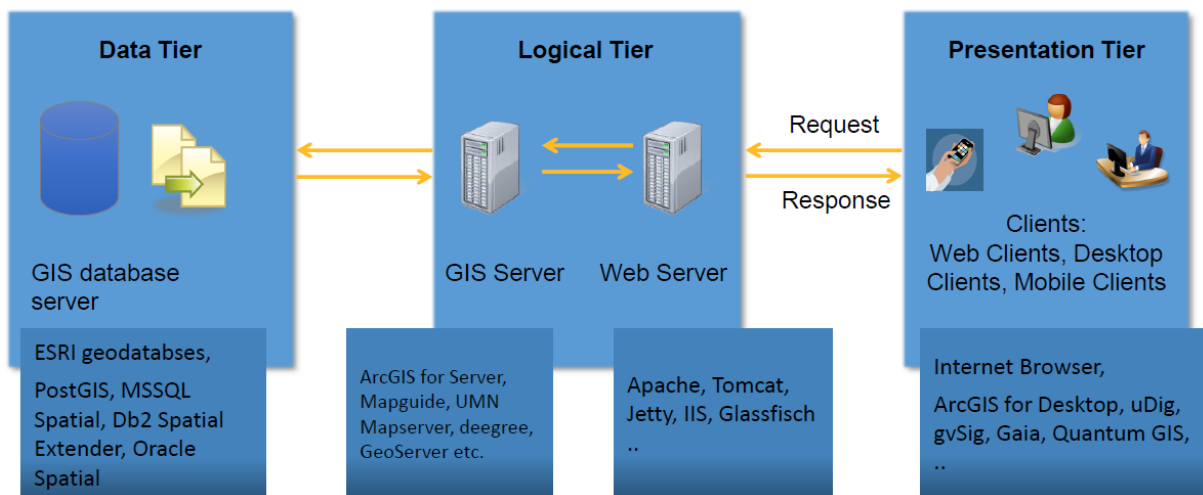
Service oriented GIS

Advantages:

1. For effective organization of geodata
2. Consume, instead of storing your own
3. Reduction of redundant data-storage
4. Cross platform - Independent from operating-system, programming language, programming-environment
5. Online community

Disadvantages: Dependence on server and Internet availability

1. Presentation Tier – Client
 - Browser
 - Client-Application
2. Logical Tier - Server
 - Webserver
 - Mapserver
 - Geoportals
3. Data Tier
 - Databases
 - Remote data
 - WFS, WCS, SOS

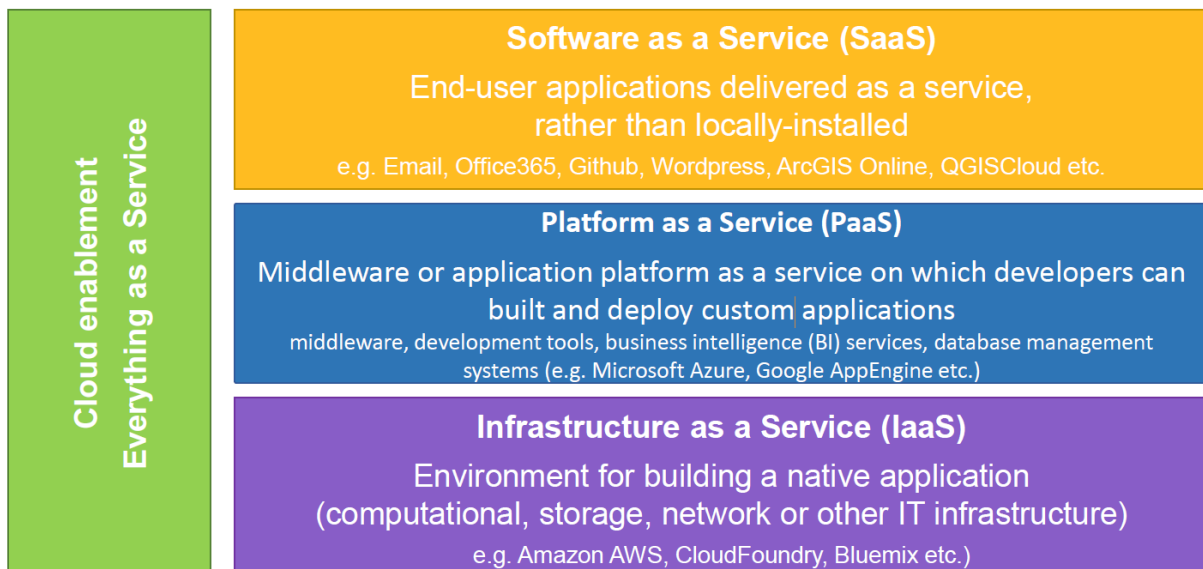


Cloud Computing

IaaS: Infrastructure as a Service

PaaS: Platform as a Service

SaaS: Software as a Service



Geodatabase

Why need Geodatabase

1. Store a rich collection of spatial data in a centralized location.
2. Apply complex rules and relationships to the data.
3. Define advanced geospatial relational models (e.g., topologies, networks).
4. Maintain integrity and Backups of spatial data with a consistent, accurate database.
5. Work within a multiuser access and editing environment. (Authorization & Authentication)
6. Integrate spatial data with other IT databases.
7. Easily scale your storage solution
8. Support custom features and behavior.
9. Leverage your spatial data to its full potential.

View services support the

1. visualization of spatial data sets and
2. offer the possibility to navigate in them,

3. display them enlarged / reduced, to move the map,
4. to overlay data, to query based on x, y and to optionally display legend information

WMS (Web Map Service):

Map-like views of pre-rendered information: HTTP queries to an OGC WMS server return pre-rendered images (layers) from different sources to be layered on top of each other in the client application

1. GetCapabilities

https://geoservices.bayern.de/wms/v2/ogc_dop80_oa.cgi?REQUEST=GetCapabilities&SERVICE=WMS&VERSION=1.1.0

2. DescribeLayer

<http://localhost:8080/geoserver/topp/wms?service=WMS &version=1.1.1 &request=DescribeLayer&layers=topp:coverage>

3. GetMap

<http://com.esri.wms.Esrimap?SERVICE=WMS&VERSION=1.1.1&REQUEST=GetMap&LAYERS=Oceans,Countries,Cities&STYLES=&SRS=EPSG:4326&BBOX=-124,21,-66,49&WIDTH=600&HEIGHT=400&FORMAT=image/png>

4. GetFeatureInfo

http://<hostname>/<deploy_name>/com.esri.wms.Esrimap?SERVICE=WMS&VERSION=1.1.1&REQUEST=GetFeatureInfo&SRS=EPSG:4326&BBOX=-117,38,-90,49&WIDTH=600&HEIGHT=400&QUERY_LAYERS=States&X=200&Y=150

WMTS (Web Map Tile Services):

A WMTS enabled server application can serve map tiles of spatially referenced data using tile images with predefined content, extent, and resolution.

1. GetCapabilities

2. GetTile

http://www.maps.bob/maps.cgi?service=WMTS&request=GetTile&version=1.0.0&layer=etopo2&style=default&format=image/png&TileMatrixSet=WholeWorld_CRS_84&TileMatrix=10m&TileRow=1&TileCol=3

3. GetFeatureInfo

GeoJson

```
{
  "type": "FeatureCollection",
  "features": [
    {
      "type": "Feature",
      "properties": {},
      "geometry": {
        "type": "Point",
        "coordinates": [
          110.74218749999999,
          63.54855223203644
        ]
      }
    },
    {
      "type": "Feature",
      "properties": {},
      "geometry": {
        "type": "Point",
        "coordinates": [
          88.9453125,
```

```

        61.270232790000634
      ]
    }
  }
]
}

```

WFS (Web Service Specifications):

specifies the behaviour of a web feature service that provides **transactions on and access to geographic features** in a manner independent of the underlying data store. It specifies **discovery operations, query operations, locking operations, transaction operations and operations to manage stored parameterized query expressions**.

Web Feature Service defines protocols for requesting as well as (optionally, WFS-T) inserting and modifying GML (Geography Markup Language) Features (Geospatial objects) through HTTP requests. GML Features are geospatial objects semantically describing realworld entities, like Meteorological objects (fronts, precipitation areas), weather observation readings, observation stations or roads.

Operations:

- GetCapabilities

All OGC Web Services (including WFS) are self-describing which means that the clients are able to request information about the service details. The response of GetCapabilities request is an XML document that describes the service capabilities.

<https://data.stadt-salzburg.at/geodaten/wfs?service=WFS&version=1.1.0&request=GetCapabilities>

- DescribeFeatureType

Through this operation the clients access the information about the GML schema of the geographic features published as WFS. This operation offers the users the possibility to send proper feature retrieving requests or to know how to create a new feature.

[https://data.stadt-](https://data.stadt-salzburg.at/geodaten/wfs?service=WFS&version=1.1.0&request=DescribeFeatureType&typename=o)

[salzburg.at/geodaten/wfs?service=WFS&version=1.1.0&request=DescribeFeatureType&typename=o](https://data.stadt-salzburg.at/geodaten/wfs?service=WFS&version=1.1.0&request=DescribeFeatureType&typename=o)
gdsbg:baumkataster

- GetFeature

Allows the clients to retrieve feature instances. In addition, the client can constraint the query spatially and non-spatially (using logical or comparison operators defined by the OpenGIS® Filter Encoding Implementation Specification).

[http://zgis221.geo.sbg.ac.at/geoserver/wfs?service=WFS&version=1.1.0&request=GetFeature&type](http://zgis221.geo.sbg.ac.at/geoserver/wfs?service=WFS&version=1.1.0&request=GetFeature&typename=topp:states)
name=topp:states

There are two types of WFS:

READ ONLY WFS & WFS-Transactional (WFS-T)

WFS-T enables the clients to interact with data dynamically by performing the **CRUD** operations:

- Insert operation enables users to insert new feature;
- Update operation enables user to update the features;
- Delete operations enables users to delete features;
- Other vendor specific operations.

FME (Feature Manipulation Engine)

FES (Filter Encoding Standard) defines the fundamental operation of querying

- performed on a set of data or resources
- in order to obtain a subset of the data

OGC Filter Encoding Is used for querying in order to obtain a subset of the data which contains certain desired information that satisfies some query criteria

```
select * from roads where roadtype = 1
```

```
<Filter>
  <PropertyIsEqualTo>
    <PropertyName>roadtype</PropertyName>
    <Literal>1</Literal>
  </PropertyIsEqualTo>
</Filter>
```

Metadata

Metadata are

- Data / information or “metadata” about the data.
- Providing information about one or more aspects of the data
- Give a summary of the detailed data and leads to it
- Necessary for a user to be able to find those data sets and services to decide whether

Why to use metadata?

- Expansion in the use of Geographic Information
- Geospatial data is imperfect
- Geographic Data is expensive

A metadata standard is simply a common set of terms and definitions known as elements that describe an information resource

The information included in the standard has to support the following data or services use (OGC, 2007):

- Discovery – data needed to identify and locate the sets of geographic data that exist for a geographic location.
- Access – data needed to acquire an identified set of geographic data.
- Fitness for use – data needed to determine, if a set of geographic data meets the user’s need and to supports in applying the geographic information appropriately.
- Transfer – data needed to get a copy of a set of geographic data

Dublin Core: universal description of resources

DCMI (Dublin Core Metadata Initiative)

- Provides simple standards to facilitate the finding, sharing, and management of information.
- uses both HTML and RDF/XML for structuring information and Z39.50 for search and retrieval
- One of the DCMI elements is coverage. DCMI Coverage is the spatial or temporal topic of the resource, This DCMI element supports only a basic geospatial definition.

The DCMI 15 elements:

1. Contributor – “An entity responsible for making contributions to the resource.”
2. Coverage – “The spatial or temporal topic of the resource, the spatial applicability of the resource, or the jurisdiction under which the resource is relevant.”
3. Creator – “An entity primarily responsible for making the resource.”
4. Date – “A point or period of time associated with an event in the lifecycle of the resource.”
5. Description – “An account of the resource.”
6. Format – “The file format, physical medium, or dimensions of the resource.”
7. Identifier – “An unambiguous reference to the resource within a given context.”
8. Language – “A language of the resource.”
9. Publisher – “An entity responsible for making the resource available.”
10. Relation – “A related resource.”

11. Rights – “Information about rights held in and over the resource.”
12. Source – “A related resource from which the described resource is derived.”
13. Subject – “The topic of the resource.”
14. Title – “A name given to the resource.”
15. Type – “The nature or genre of the resource.”

CSW (OGC Catalogue Service Web)

Catalogue services support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects.

Operations:

- GetCapabilities

allows CSW clients to retrieve service metadata from a server

<http://ispacevm22.researchstudio.at/geoplatform/csw/discovery?Request=GetCapabilities&Service=CSW&Version=2.0.2>

- DescribeRecord

allows a client to discover elements of the information model supported by the target catalogue service. The operation allows some or all of the information model to be described

- GetRecords

Search for records, returning record IDs

- GetRecordById

Query subset of the GetRecords operation based on recordID

- GetDomain

Used to obtain runtime information about the range of values of a metadata record element or request parameter

Open

Open means anyone can freely access, use, modify, and share for any purpose

An open work must satisfy the following requirements in its distribution:

1. Open License or Status
2. Access
3. Machine Readability
4. Open Format

Open Works – Licenses

The license must not limit, make uncertain, or otherwise diminish these permissions except by the following allowable conditions:

1. **Attribution Redistribution** include attribution of contributors, rights holders, sponsors, and creators
2. **Integrity** may require that modified versions of a licensed work carry a different name or version number
3. **Share-alike** distributions of the work to remain under the same license
4. **Notice provide** recipients with access to the preferred form
5. **Non-aggression** require modifiers to grant the public additional permissions (for example, patent licenses) as required for exercise of the rights allowed by the license

Open Government data Principles (US)

1. Complete
2. Primary
3. Timely
4. Accessible

5. Machine processable
6. Non-discriminatory
7. Non-proprietary
8. License-free

The European PSI Directive

Main Objectives

- To stimulate the further development of a European market for services based on Public Sector Information
- to enhance the cross-border use and application of PSI in business processes, including publishing
- to strengthen competition in the internal market
- To address divergence as to reuse rules between Member States.

Public sector bodies have to

- Make information re-usable for commercial or non-commercial purposes under non-discriminatory conditions.
- Process requests and provide access within 20 days (or 40 if request is complex); justify negative decision and inform about how to appeal.
- Charge no more than cost of reproduction, provision and dissemination; publicise charges and indicate calculation basis on request processes, including publishing
- Publish licenses in digital format
- Facilitate search for information preferably online (e.g. portal).

Public sector bodies may not

- Unnecessarily restrict reuse for re-use or be used to restrict competition.
- Grant exclusive rights, unless necessary, subject to review every 3 years

Public sector bodies do not have to

- Make information available that is excluded by virtue of access regimes in the Member States
- Adapt formats or provide translations

RDF (Resource Description Framework)

RDF is a modeling framework designed for knowledge representation on the World Wide Web.

RDF extends the idea of linking resources on the web by giving a URI (Uniform Resource Identifier) to describe

RDF stands for:

- Resource: Everything that can have a unique identifier (URI), e.g. pages, places, people, dogs, products...
- Description: attributes, features, and relations of the resources
- Framework: model, languages and syntaxes for these descriptions

INSPIRE (INfrastructure for SPatial InfoRmation in Europe)

Objectives: Make relevant, harmonized spatial data available for Community Environmental Policy (formulation, implementation, monitoring and evaluation)

- To better enable the Commission and Member States to prepare, implement and monitor environmental policies

- However, the infrastructure will create a 'platform' (infrastructure) which can be used for many other purposes
- INSPIRE does (only) address spatial data of public administrations, that is already (or will be in future) available in a digital format.
- INSPIRE is complementary to related policy initiatives, such as the Directive on the re-use of public sector information (Directive 2003/98/EC) and the Directive on public access to environmental information (Directive 2003/4/EC).

INSPIRE Components

- general provisions
- metadata
- interoperability of spatial datasets and services
- network services (discovery, view, download, transform, invoke)
- data sharing and re use (policy) a
- co-ordination and complementary measures

GDPR (EU General Data Protection Regulation)

The GDPR makes organizations accountable for personal data protection

Action:

- The pseudonymisation and/or encryption of personal data.
- The ability to ensure the ongoing confidentiality, integrity, availability and resilience of systems and services processing personal data.
- The ability to restore the availability and access to data in a timely manner in the event of a physical or technical incident.
- A process for regularly testing, assessing and evaluating the effectiveness of technical and organisational measures for ensuring the security of the processing.

Personal data

Personal data is defined in both the Directive and the GDPR as any information relating to an person who can be identified, directly or indirectly

Profiling

Profiling is defined as "any automated processing of personal data to determine certain criteria about a person"

WMS Operations

- GetCapabilities : Get View Service Metadata (defined in the [ISO 19128] WMS standard)
- GetMap: Get Map (defined in the [ISO 19128] WMS standard)
- Link View Service:

As stated in INSPIRE Network Service regulation, the Link View Service operation allows a Public Authority or a Third Party to declare a View Service for the viewing of its resources through the Member State View Service while maintaining the viewing capability at the Public Authority or the Third party location. • Furthermore, the Link View Service parameter shall provide all information about the Public Authority's or Third Party's View Service compliant with this regulation, enabling the Member State View Service to get a map from the Public Authority's or Third Party's View Service and to collate it with other maps. The operation returns a map as WMS.

WMTS Operations

- GetCapabilities : Get View Service Metadata (defined in the [ISO 19128] WMS standard)

- GetMap: Get Map (defined in the [ISO 19128] WMS standard)
- Link View Service:

WCS (Web Coverage Service)

WCS offers multi-dimensional coverage data for access over the Internet

WPS (Web Processing Service)

WPS is a generic interface, in the sense no specific processes, data input or outputs are defined. Standard defines “generic mechanism that can be used to describe and web-enable any sort of geospatial process”

- GetCapabilities: provides typical discovery and binding mechanism following the OGC model. In addition of the traditional service description, the list of supported process, including identifier and brief description, is provided.
- DescribeProcess: returns, for a given process identifier, a detail process description (ProcessDescription) in term of data input description (InputDescription), output results description (ProcessOutputs) and process capabilities, that are, at the time being, ability to provide a status and/or store processing results.
- Execute enable to request execution of a given process on data defined in the Data Input request parameter. Optionally, a Response Form could be provided to describe wished type of response. By default, service return all responses described in the Process Description

SWE (OGC Sensor Web Enablement)

The OGC's Sensor Web Enablement (SWE) standards enable developers to make all types of sensors, transducers and sensor data repositories discoverable, accessible and useable via the Web.

OGC Sensor Web Enablement (SWE) Initiative

SWE comprises two models specifications: information and interface models. Information model standards:

- Observations and Measurements (O&M)
- Sensor Model Language (SensorML)

Descriptions of sensors themselves, which are encoded in the Sensor Model Language (SensorML), and the measured values in the Observations and Measurements (O & M) encoding format.

SOS (Sensor Observation Service)

SOS is a web service to query/write real-time sensor data and sensor data time series and is part of the Sensor Web

Terms:

- Measurement
- Observed Property
- Procedure
- Sensor

Operation:

- GetCapabilities
- GetObservation
- DescribeSensor

Enhanced Operations Extension:

- GetObservationById
- GetFeatureOfInterest

Transactional Extension:

- InsertSensor
- DeleteSensor
- InsertObservation

Result Handling Extension:

- InsertResult
- InsertResultTemplate
- GetResultTemplate
- GetResult

sensorThings API – Vocabulary

Thing

Location

HistoricalLocations

DataStreams

Sensors

ObservedProperties

Observations

FeatureOfInterest

MQTT = MQ (Message Queue) Telemetry Transport

The MQ Telemetry Transport (MQTT) protocol is a lightweight publish/subscribe protocol flowing over TCP/IP for remote sensors and control devices through low bandwidth, unreliable or intermittent communications.