VL OpenGIS

Spatial Data Infrastructures & Cloud Computing

24S 856.164 | 12 March 2024| 08:30 – 10:00

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Open GIS: Need for harmonization

- Spatial data helps organizing and integrating data
- Value is added by putting data in context
- Discovery, access, use and exchange of spatial data must be optimized
- Data sharing helps getting the “Big Picture”

This can be achieved by a **spatially enhanced harmonized information broker**, supported through modern approaches for **spatial information management**.

Spatial Data Infrastructures
Need for harmonization

- Spatial information is an integral part of day-to-day work and decision making.
- There is an increasing demand for mobile use of spatial applications.
- There is significant potential for more extensive cross-divisional spatial information sharing to optimize data exploitation and investments in future data acquisitions.
- There are still challenges for searching, accessing and ordering high-quality spatial information.
- **Need for harmonization on an operational level**
  => technical, contextual & organizational

Open GIS: Spatial data Infrastructures(SDI) - Definition

- A 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.
- A spatial data infrastructure (SDI) is comprised by **technology, policies, standards, human resources** and related activities necessary to *acquire, process, distribute, use, maintain,* and *preserve* spatial data.

(White House 2002)

- A spatial data infrastructure (SDI) A SDI is a coordinated **series of agreements on technology standards, institutional arrangements, and policies** that enable the discovery and use of geospatial information by users and for purposes other than those it was created for.

(Kuhn 2005)

Open GIS: Spatial data Infrastructures(SDI) – Definition (with technology focus)

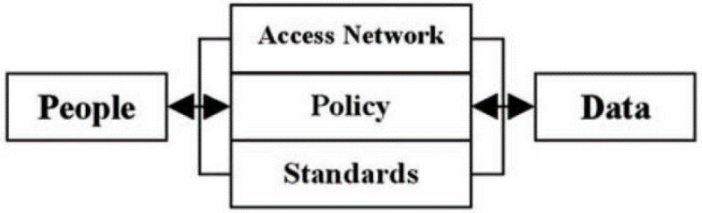
- “The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general.”

(The SDI Cookbook http://www.gsdi.org)

- „Spatial Data Infrastructure (SDI) is/are Internet-based platform(s) that will make it easier for us to search and find geodata that may be relevant for our work and be collected, stored or published by other organizations“

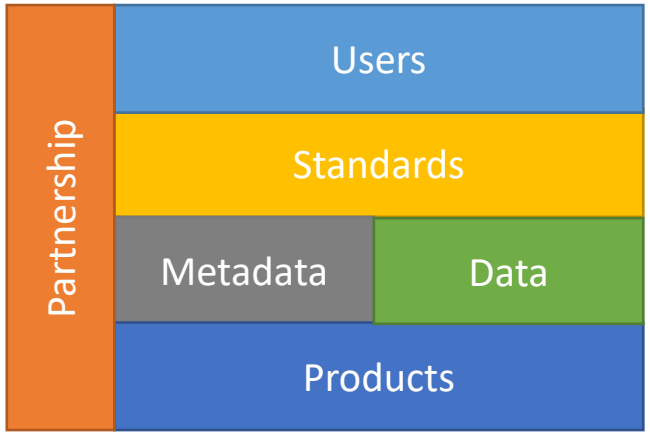
(ESRI – INSPIRE Directive)

Open GIS: Standards, Architectures and Services
SDI -Definition Summary



(Rajabifard et al, 2002)

- Spatial Data Infrastructure (SDI)
  - is a data infrastructure implementing a framework of **geographic data, metadata, users and tools**
  - are interactively connected in order to use spatial data in an efficient and flexible way.
- Shifting the GIS paradigm to
  - share, access, analyze and exploit spatial information
  - across communities and
  - technical IT platforms



SDI consists of interrelated, but autonomous components:

Open GIS: SDI - why

- For effective & efficient organization of geoinformation
  - improve data access
  - promote data reuse
  - make information readily available
  - ensure that investments for data collection and management result in a growing pool of information
- ways of leveraging spatial information
  - Change from monolithic IT-systems towards distributed architecture
  - are becoming independent of computing platforms
  - geo-portals serve as gateways to spatial-information

Open GIS: SDI - Characteristics

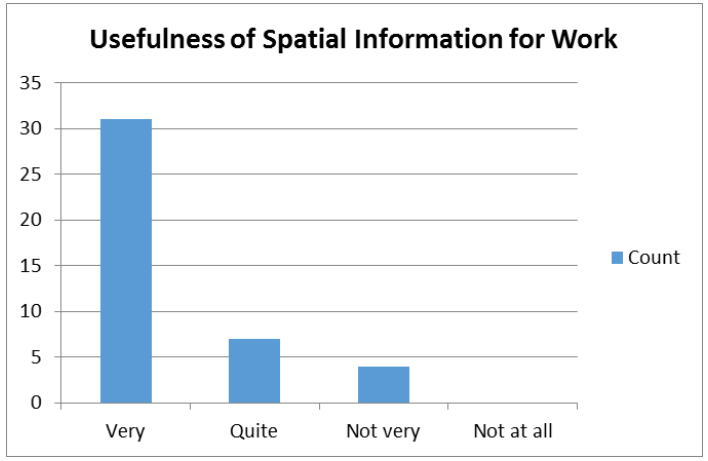
- Geodata infrastructure = Spatial data Infrastructure
  Geographic information infrastructures = geodata **&** user oriented distributed geographic information services
  - structured organization of geodata and geographic information services
  - based on a common technical infrastructure (IT-technologies) bringing in **interoperability**
  - usage of internationally accepted standards for technological interoperability based on Open Geospatial Consortium (OGC) and ISO standards as **lingua franka** to guarantee interoperability
  - integration of legal requirements (cadastral laws, INSPIRE directive) and global initiatives (GEOSS) → definition of **common semantics** harmonized organizational concepts

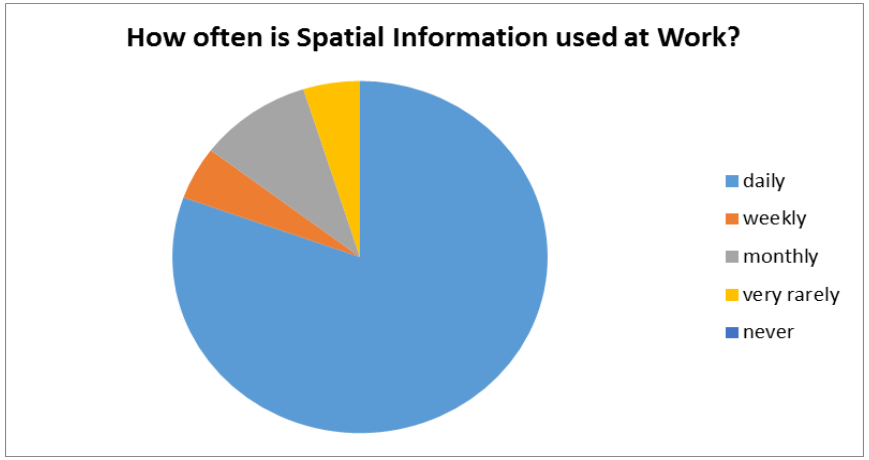
Open GIS: SDI - Benefits & opportunities

- Cooperation and sharing are the keys to success
- Many suppliers of data are essential, everyone has important data that are useful for others
- Reduce costs for data collection and maintenance by reducing minimizing redundant work
- Improve availability and access to data
- Increase efficiency, consistency and quality of services
- Learn from each other, cooperate by creating shared SDI's
- Facilitate combination of data from different sources
- Support the development of e-governance
- Support the development of GI-business

Open GIS: Value of SDIs

- Estimations on the **awareness, importance** and **requirements** and use of spatial data for the work
  - Usefulness of spatial information for work?
  - How often spatial information is used for work?





Results of GIS expert interviews on national level (Twining No.: GE11/ENP-PCA/OT/12, 2014)

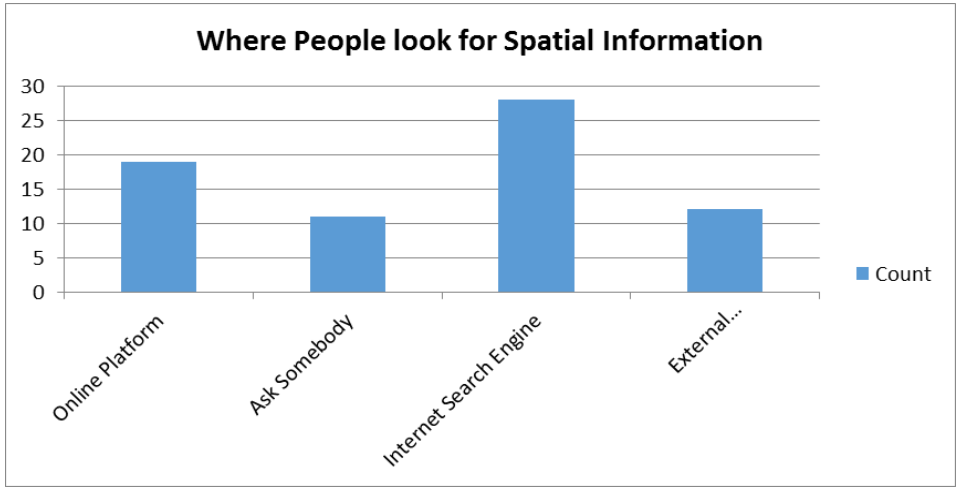
OpenGIS
Where to look for data?

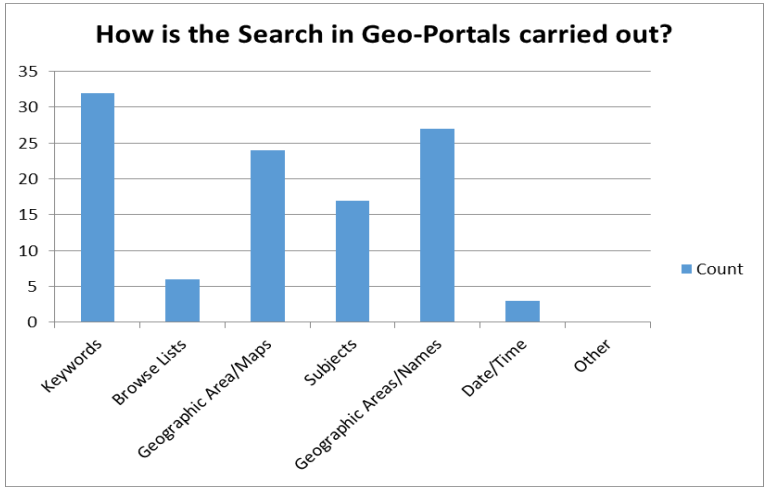
- You all used GIS data already. - How do you get GIS data, how do you find it?

- https://www.menti.com/gpb6trjq7o
- www.menti.com code: **76 52 52 8**

Open GIS: Value of SDIs

- Experiences with regard to **discovery, accessibility** and **exchange** of spatial data.
  - Where people look for spatial information?
  - How people search for geoinformation?

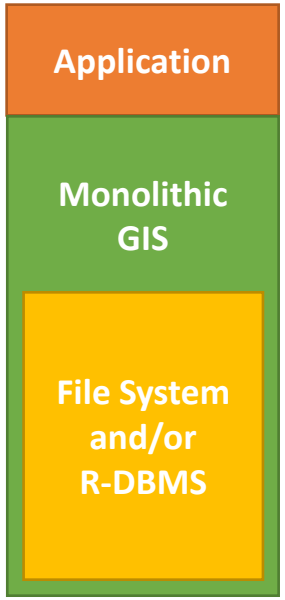




Results of GIS expert interviews on national level (Twining No.: GE11/ENP-PCA/OT/12, 2014)

Open GIS: SDIs - Architectural foundation

- Data-exchange-format era
  - GIS ported to PC systems
  - GIS used on monolithic computer systems (stand-alone)
  - Data exchange performed via proprietary file-basedexchange interfaces
  - No exchange possibility for GIS functions, programming interfaces did not exist



Open GIS: SDIs - Architectural foundation

- GIS interoperability era
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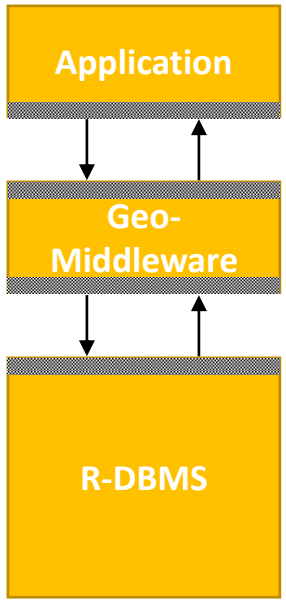
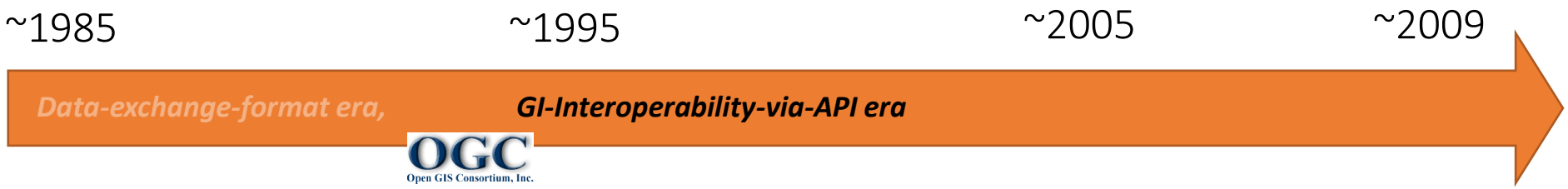
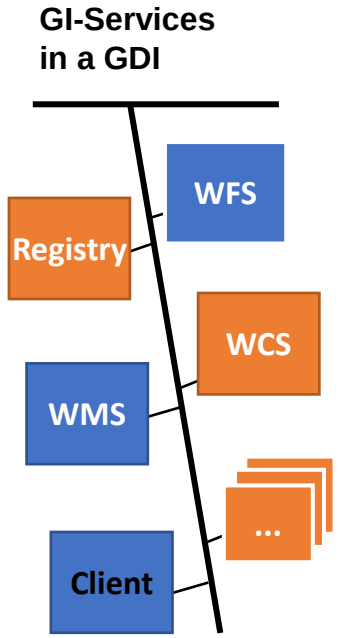
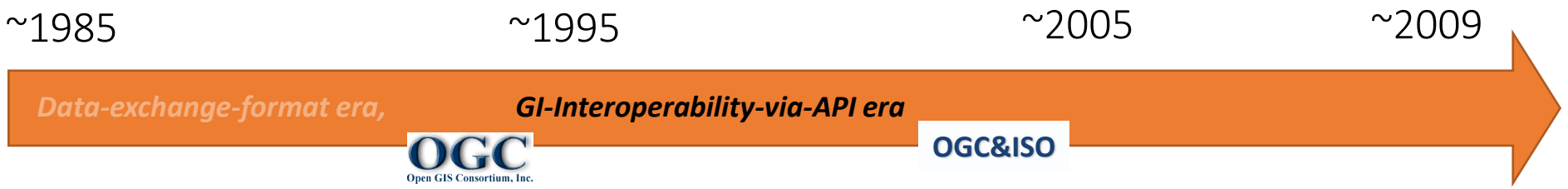




Open GIS: SDIs - Architectural foundation

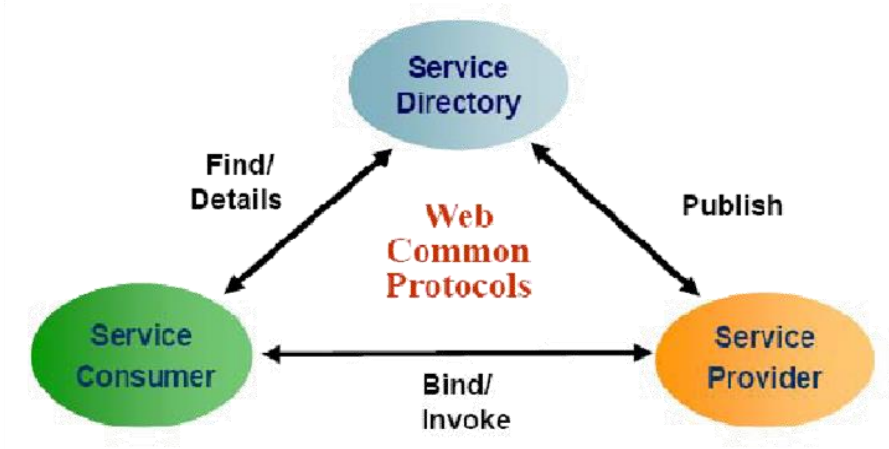
- GIS interoperability era
  - GI-services based on Distributed Computing Platforms (DCP) und protocols (z.B. CORBA/IDL, WEB/HTTP - Spatial Web)
  - GI-services expose clearly defined GIS-functionalities
  - GI-services are standards based and support interoperability
  - GI-services are stateful (e.g. processing services) or stateless (e.g. tile services)
  - GI-services are organized in infrastructures and might be chained





Open GIS: SDIs - Architectural foundation

- Technical Viewpoint: Distributed Service Architecture
  - change of paradigms from desktop processing of file-based data towards online data access and data processing
  - more and more data and applications are made available online via geo-services, following the concept of a service-oriented architecture (SOA).
  - This service-oriented paradigm is based on three operations: to publish, to find and to bind.
  - **Geoportals serve as service broker**



Open GIS: SDIs - Components

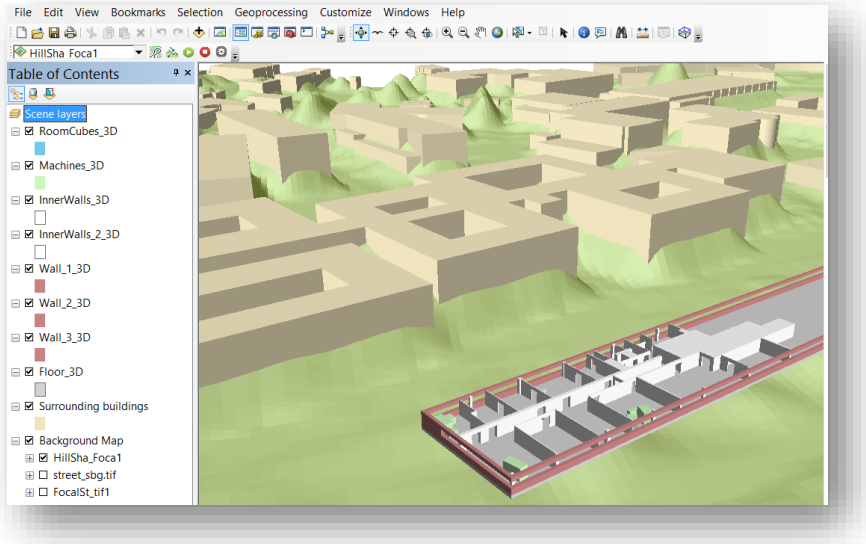
- Institutional Arrangements
  - mechanisms created to enable key stakeholders to collaborate and engage actively in the planning and implementation of the SDI.
- Framework Data
  - set of continuous and fully integrated spatial data that provides context and reference information.
  - Framework datasets are expected to be widely used and generally applicable,
- Policies strategic- or operational-level instruments that help facilitate the development or use of an SDI.
  - Strategic policies address high-level issues (e.g., enforcing compliance with certain standards and procedures)
  - Operational policies address topics related to the lifecycle of spatial data and help facilitate access to and use of spatial information

Open GIS: SDIs - Components

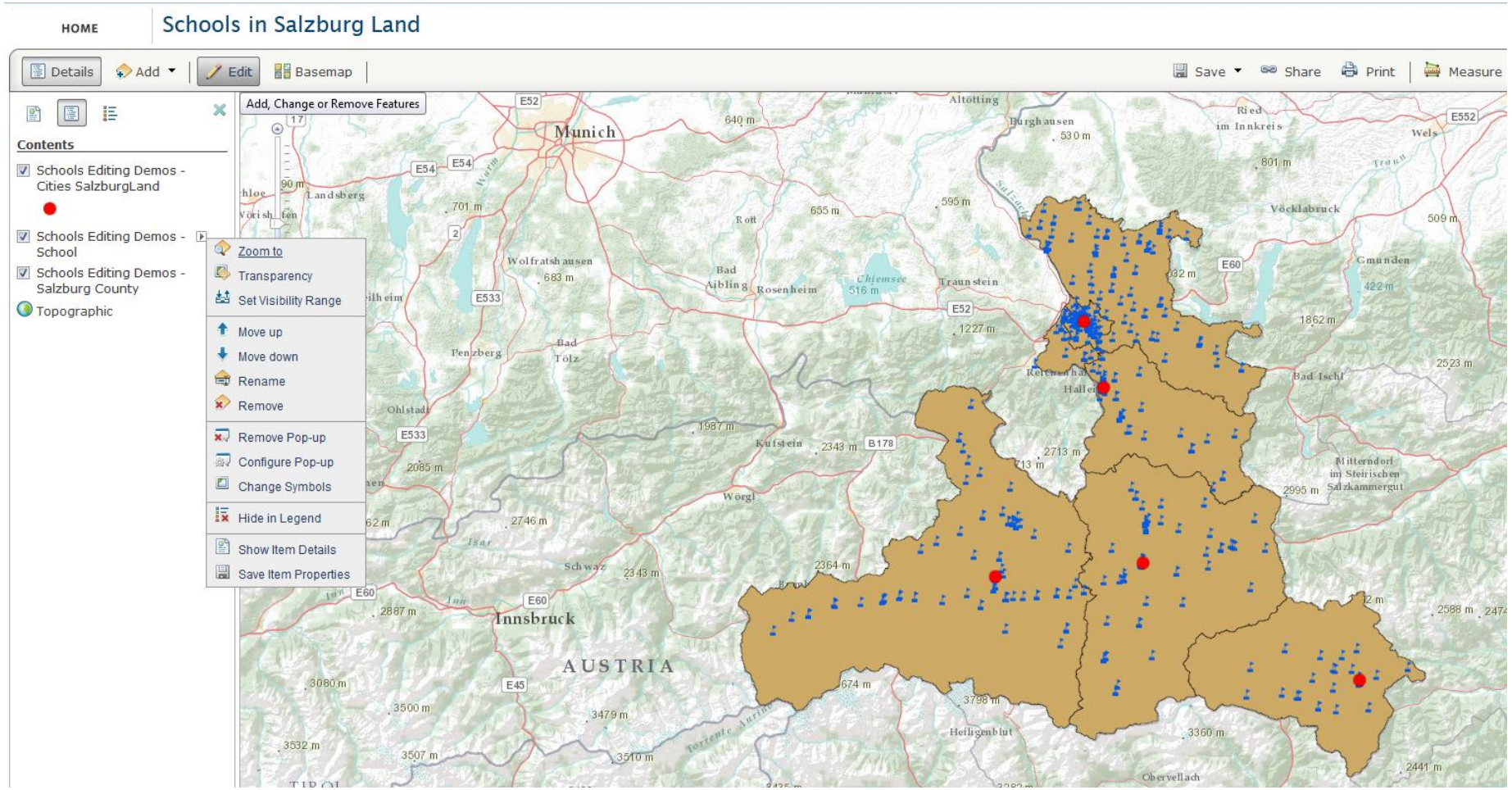
- Standards
  - Spatial standards are technical documents that detail interfaces or encodings, data specifications etc. to address specific interoperability challenges.
- Technologies
  - technological architecture of an SDI is composed of a network of physical servers /cloud services that provide Web services

Types of GIS
Desktop GIS

- Locally installed information system
- Offers huge amount of functionalities, like …
  - data creating
  - data editing
  - coordinate transformations
  - data storing
  - spatial analyzing
  - queries and selections
  - visualizing
- Examples
  - Open Source: QuantumGIS, GRASS GIS, JUMP, SAGA GIS, …
  - Commercial: ESRI ArcGIS, GeoMedia, Manifold, …



Types of GIS
Desktop GIS to Online GIS



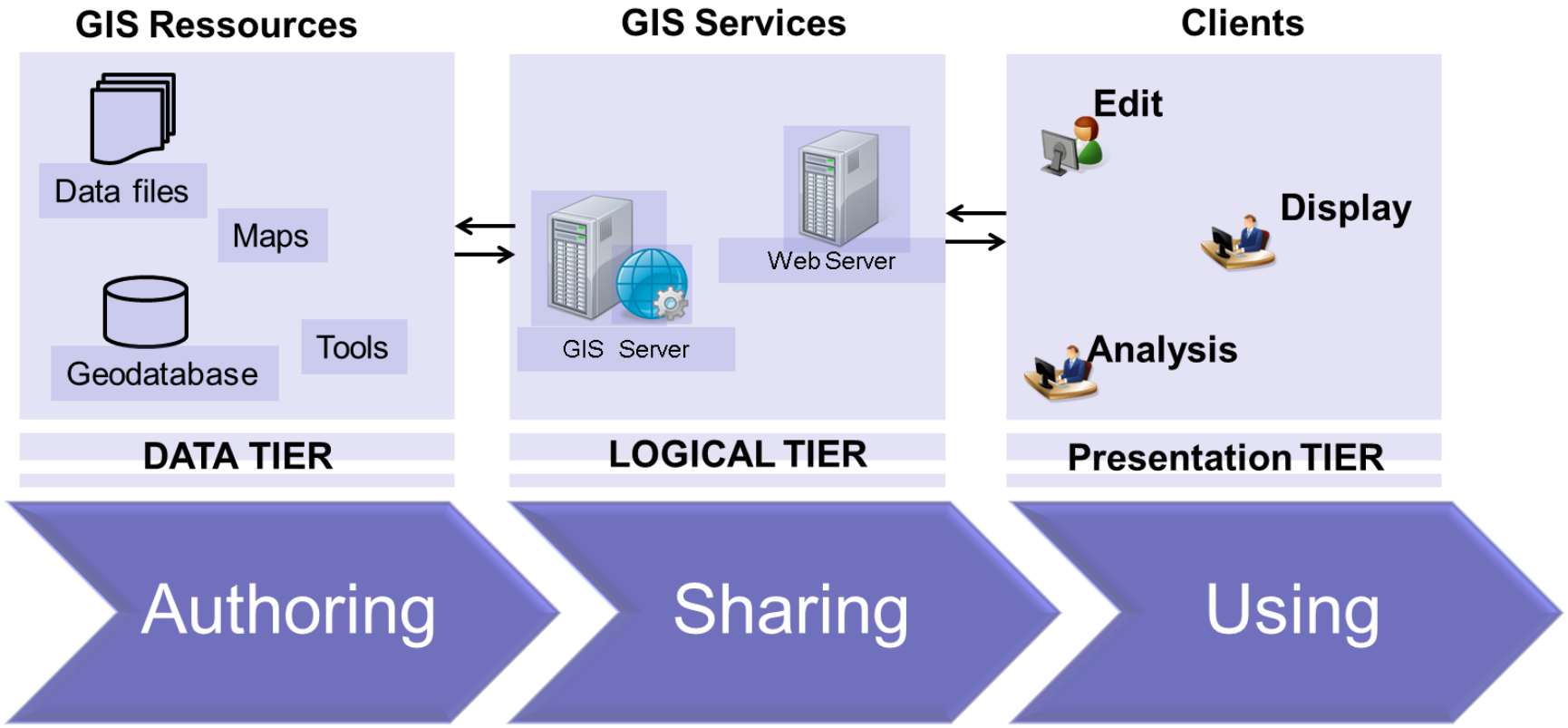
Types of GIS
Service oriented GIS - advantages

- For effective organization of geodata
- Consume, instead of storing your own
- Reduction of redundant data-storage
- Cross platform - Independent from operating-system, programming-language, programming-environment
- Online community
- Disadvantages:
  - Dependence on server and Internet availability

Web Services

- “A Web Service is a software system designed to support interoperable machine-to-machine interaction over a network” (W3C, 2004)
  - Interface to application functionality accessible through a network
  - Intermediary between data/applications and users
- A Service is a set of interfaces provided by an entity
  - The service provides a functionality that distinguishes the entity from other entities [ISO19119:2015].
  - In this context, an entity is a server on the web, that provides a service, in most cases via HTTP.

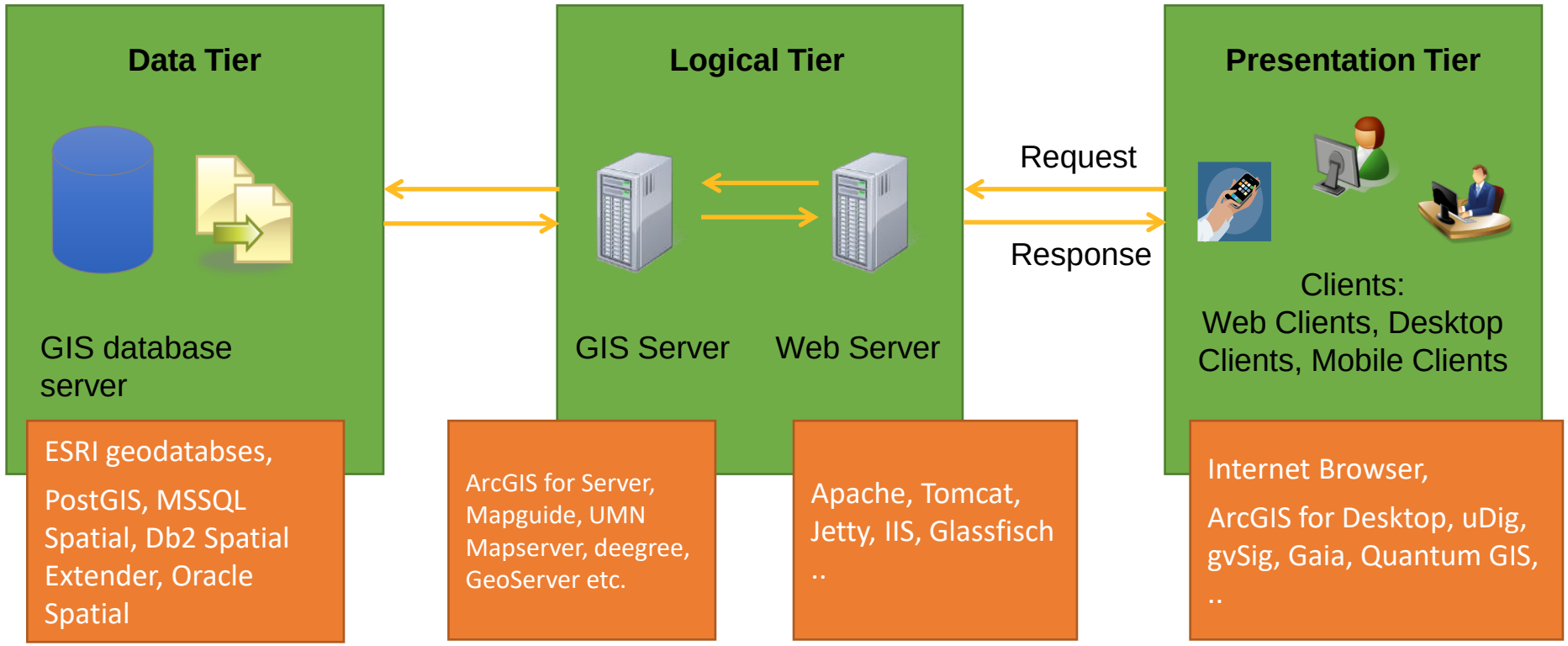
Types of GIS
Desktop GIS to Online GIS



Types of GIS
Client Server architectures

- Presentation Tier - Client
  - Browser (Firefox, Internet Explorer, Opera, Safari)
  - Client-Application (OpenLayers, Mapbender,GeoExt)
- Logical Tier - Server
  - Webserver (Apache Tomcat, Microsoft Internet Information Services – IIS, Jetty)
    - A WebServer is a computer that is set up with software and networking capabilities to deliver Web pages on the Internet or an Intranet.
  - Mapserver (UMN Mapserver, GeoServer)
    - A Web Map Server is a computer which provides a "Map Service" to respond the clients' requests.
  - Geoportals (ArcGIS online, Boundless OpenGeo, Openplans ..
- Data Tier - Databases
  - Databases (Oracle Spatial, MSSQL Spatial, PostGIS, MySQL)
  - Remote data – Download Services
  - Web feature Service, Web Coverage Service, Sensor Observation Service ..

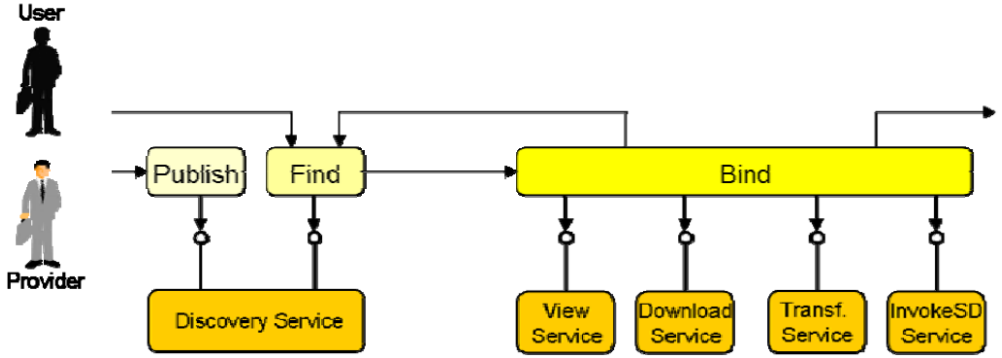
Types of GIS
Client Server architectures



[Source: Fu and Sun, 2011]

Types of GIS
Service oriented GIS

- GIS following the principles of Web 2.0
  - = user generated content + collective intelligence access + web as a platform + mashup style programming + mobile solutions + a rich user experience
- Web based GIS usually offers a distinct/predefined number of functionalities – depending on
  - User requirements /experience
- Consists of components to
  - Manage and store data
  - Publish maps and data from a variety of formats and sources to a Map-Server
  - Build flexible user interfaces and custom workflows in the browser
  - Analyze and publish geospatial data
  - Access and edit data using open standards
  - Leveraging open standards like OGC WMS, WFS, WCS, and others.
  - Performing analysis by e.g. using OGC WPS



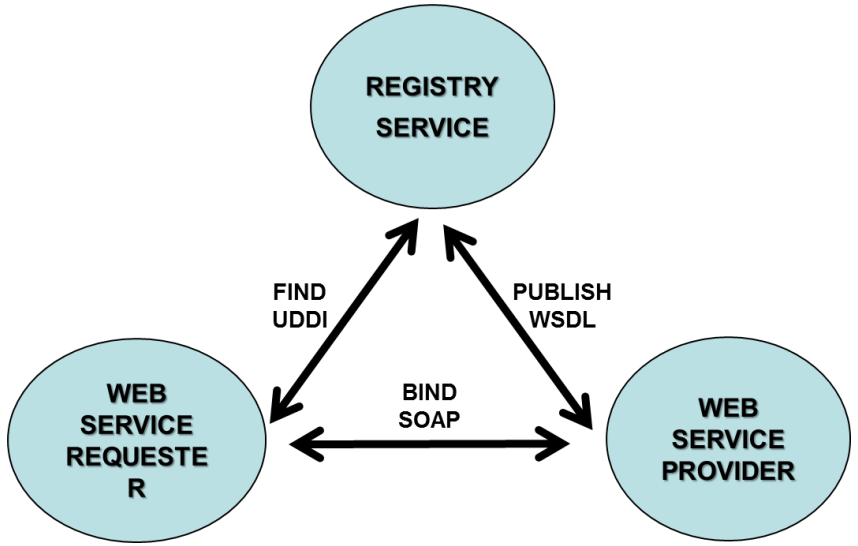
INSPIRE network service architecture, 2008

Service Oriented Architecture
Publish – Find – Bind Principle

- SOA stands for **S**ervice **O**riented **A**rchitecture
- SOA is a design pattern and conceptual methodology for organizing and utilizing distributed functionalities/capabilities
- Framework for developing distributed multi-tier applications
- SOA's characteristics:
  - Modularity
  - Supports loose-coupling:
    - Platform independency
    - reusability
  - No redundancy: scalability, consistency and maintainability

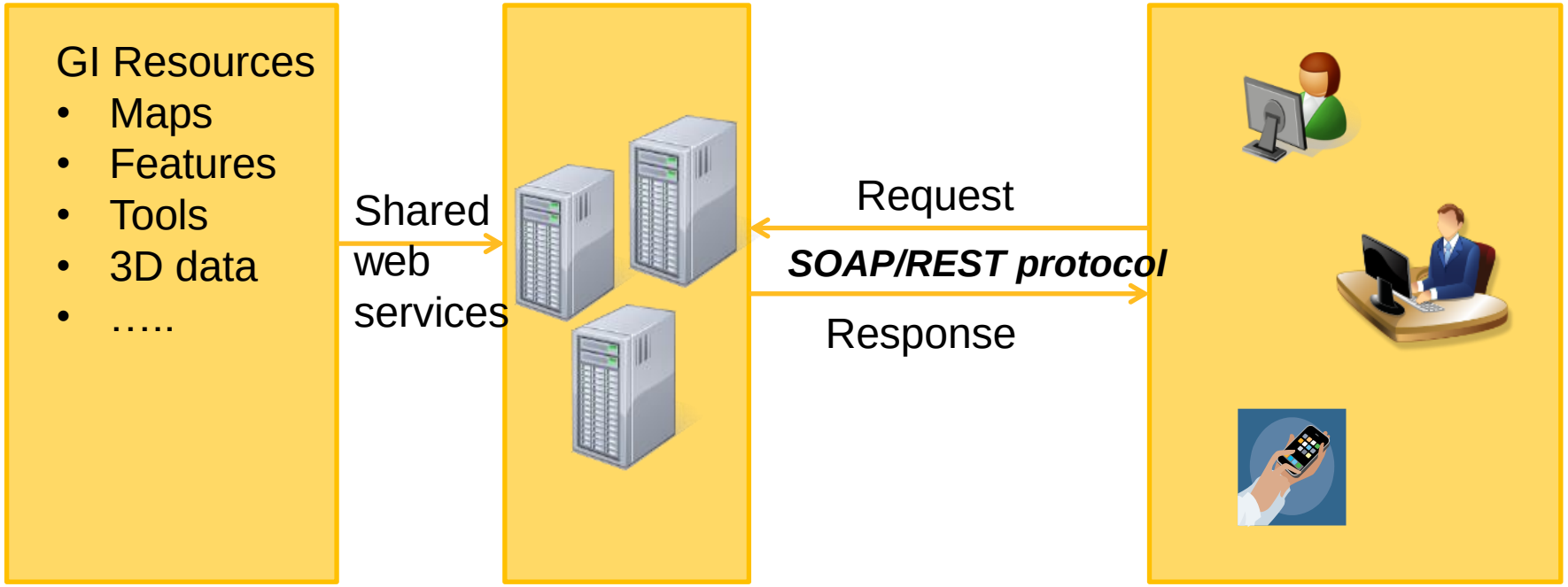
Service Oriented Architecture (SOA)
Publish – Find – Bind Principle

- **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).



Client – Server communication

- Simple Object Access Protocol (SOAP) based web services
- Representational State Transfer (REST)-style Web service

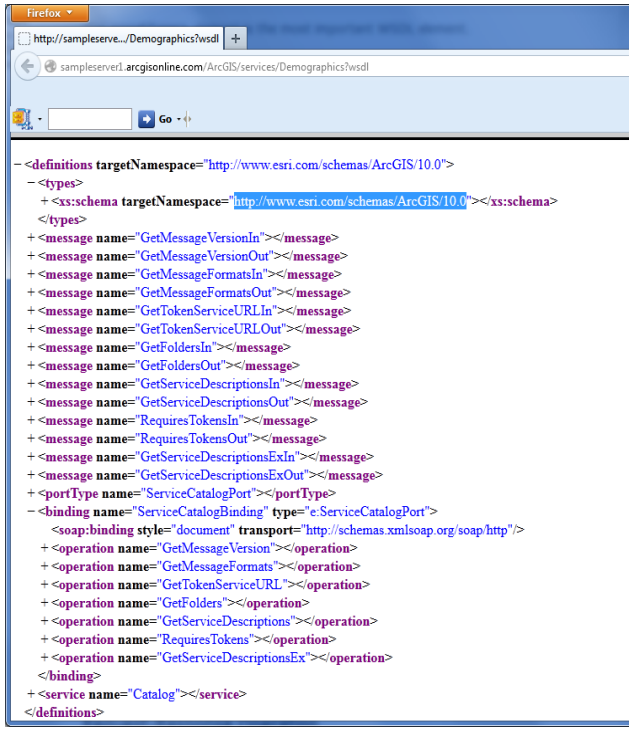


Web Services Protocols
Simple Object Access Protocol - SOAP

- SOAP message example (Source:http://www.w3schools.com/soap/soap_syntax.asp)
- <?xml version="1.0"?>
<soap:Envelope
xmlns:soap="http://www.w3.org/2001/12/soap-envelope"
soap:encodingStyle="http://www.w3.org/2001/12/soap-encoding">
<soap:Header>
…
</soap:Header>
<soap:Body>
<m:GetPrice xmlns:m="http://www.w3schools.com/prices">
<m:Item>Apples</m:Item>
</m:GetPrice>
</soap:Body>
</soap:Envelope>

SOAP & Web Service Description Language (WSDL)

- WSDL is a W3C Recommendation. Web Service Description Language (WSDL) is an XML format for describing the location and operations/methods exposed by (Geo)-Web services.




```
<definitions>
 <types>
     data type definitions.....
 </types>
 <message>
    definition of the data being communicated....
 </message>
 <portType>
    set of operations.....
</portType>
 <binding>
    protocol and data format specification....
 </binding>
</definitions>
```

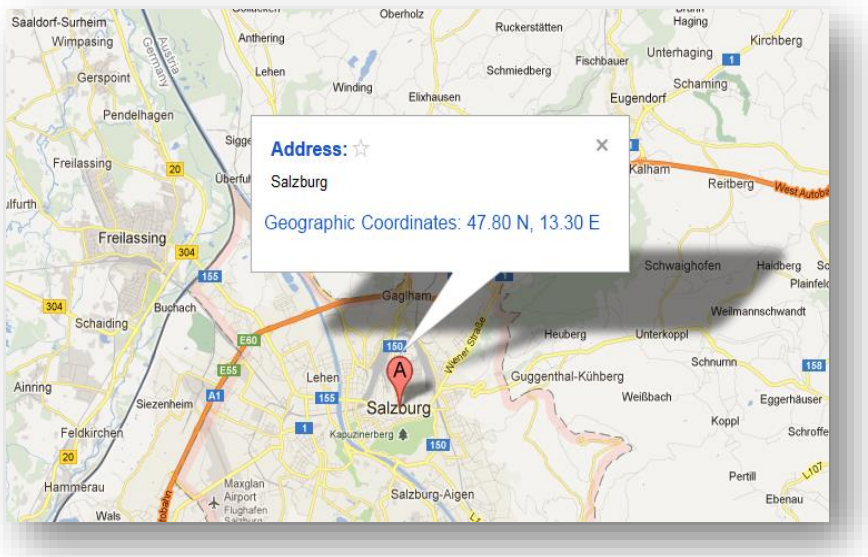
REST – short overview

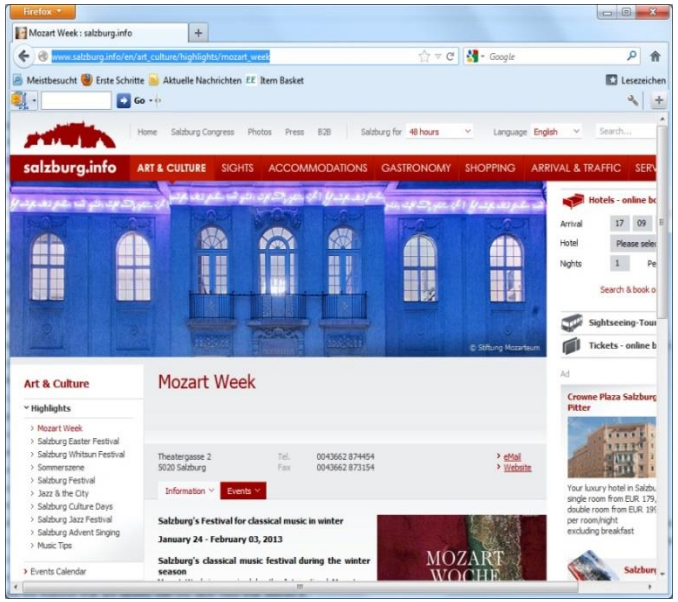
- Definition:
  - a software architectural style that describes how to construct network-based software applications such that they have the best characteristics of the Web". (Roy Fielding)
- REST = software architectural style, a set of rules that a RESTful based (software) architecture should conform to
  - Lightweight alternative to SOAP
  - REST's principle (Source: Tilkov, 2007):
    - Give everything on the web an ID: URI
    - Link things together: hyperlinks
    - Use standard methods
    - Resources with multiple representations
    - Communicate stateless (no session information is retained- every packet of information can be understood in isolation)
- REST describes the location of something anywhere in the WEB from anywhere in the world

REST – operations

- REST architectural style take advantage of simple HTTP for making calls between machines.
- RESTful applications support HTTP requests to
  - Reading a resource
    - GET: read a resource (used mainly for read-only queries)
  - Manipulating a ressource
    - POST: create a resource
    - PUT: update or create a resource
    - DELETE: delete a resource

REST – examples





Geographic Coordinate: 47.80 N, 13.30 E

http://www.salzburg.info/en/art_culture/highlights/mozart_week

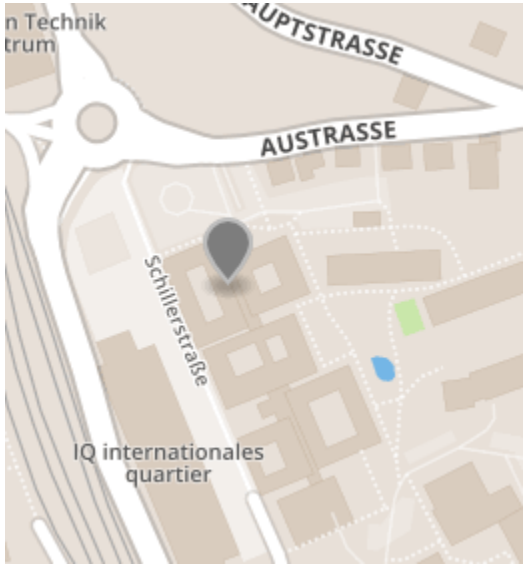
Salzburg City – geographic (unique) identifier

Mozart Week Event – Unique Identifier

REST describes the location of something anywhere in the WEB from anywhere in the world using **URIs** (Uniform Ressources Identification.

REST – resources‘ formats examples

- XML
- csv
- HTML
- JSON & GeoJSON
  - https://geojson.io/



GeoJSON format (JSON format for spatial information)

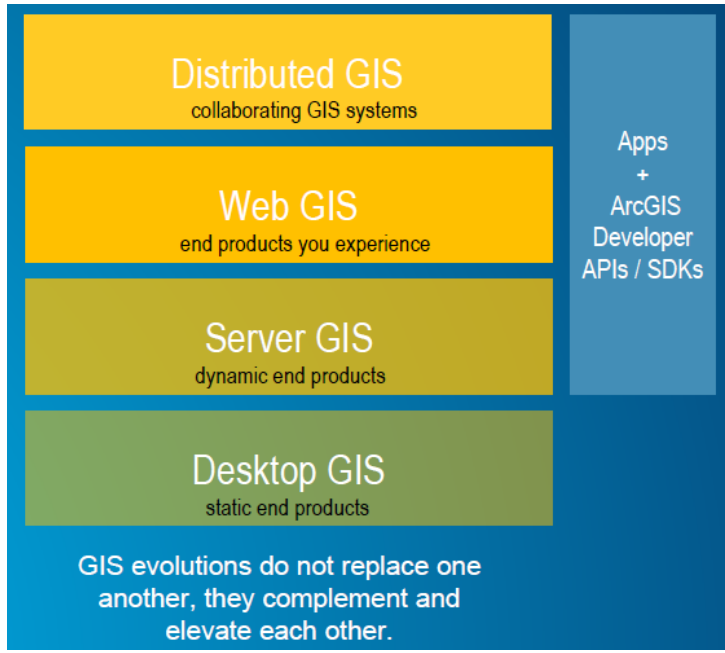
```
{
 "type": "FeatureCollection",
 "features": [
  {
   "type": "Feature",
   "properties": {},
   "geometry": {
    "type": "Point",
    "coordinates": [
     13.039290904998778,
     47.82362946557738
    ]
   }
  }
 ]
}
```

REST – summary

Identification of resources	Everything is an URL
Manipulation of resources through representations	Exchange standard formats using standard verbs/operations
Self-descriptive Messages	Every request asks the full question, every response includes the full answers
Hypermedia as the engine of application state	Hyperlinks

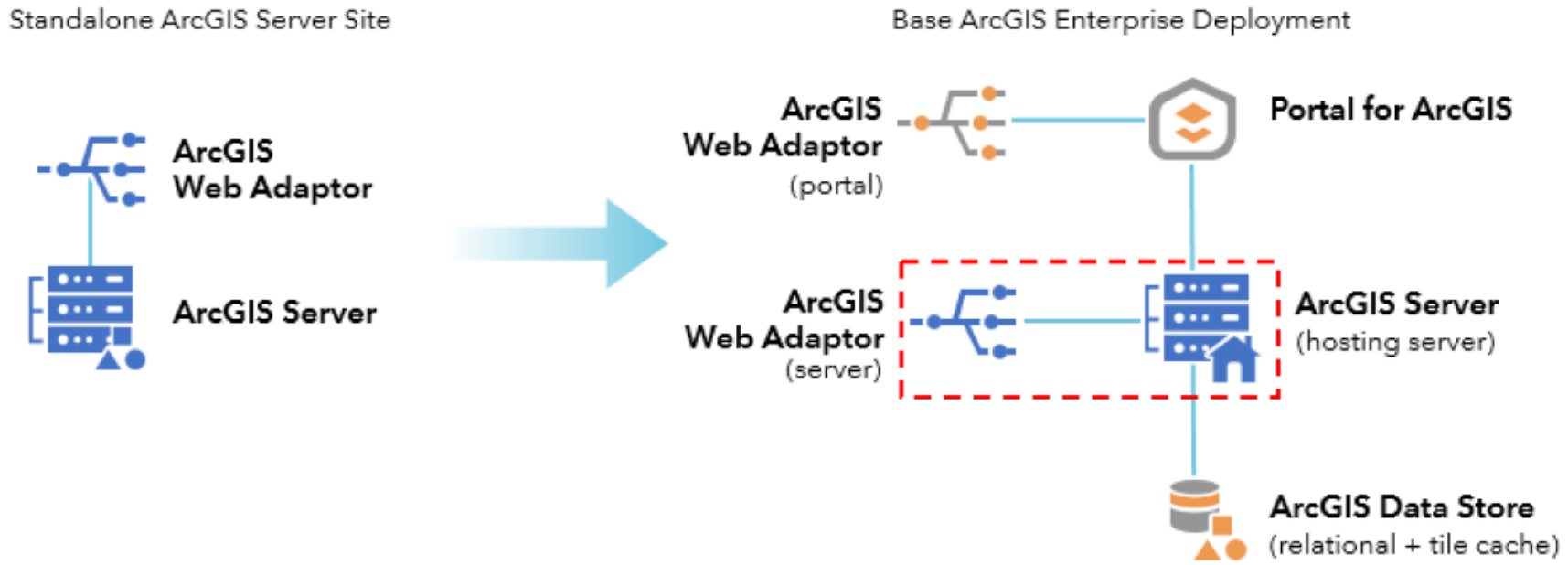
Source: http://www.intertwingly.net/blog/2198.html

Types of GIS
GIS is evolving – example ESRI

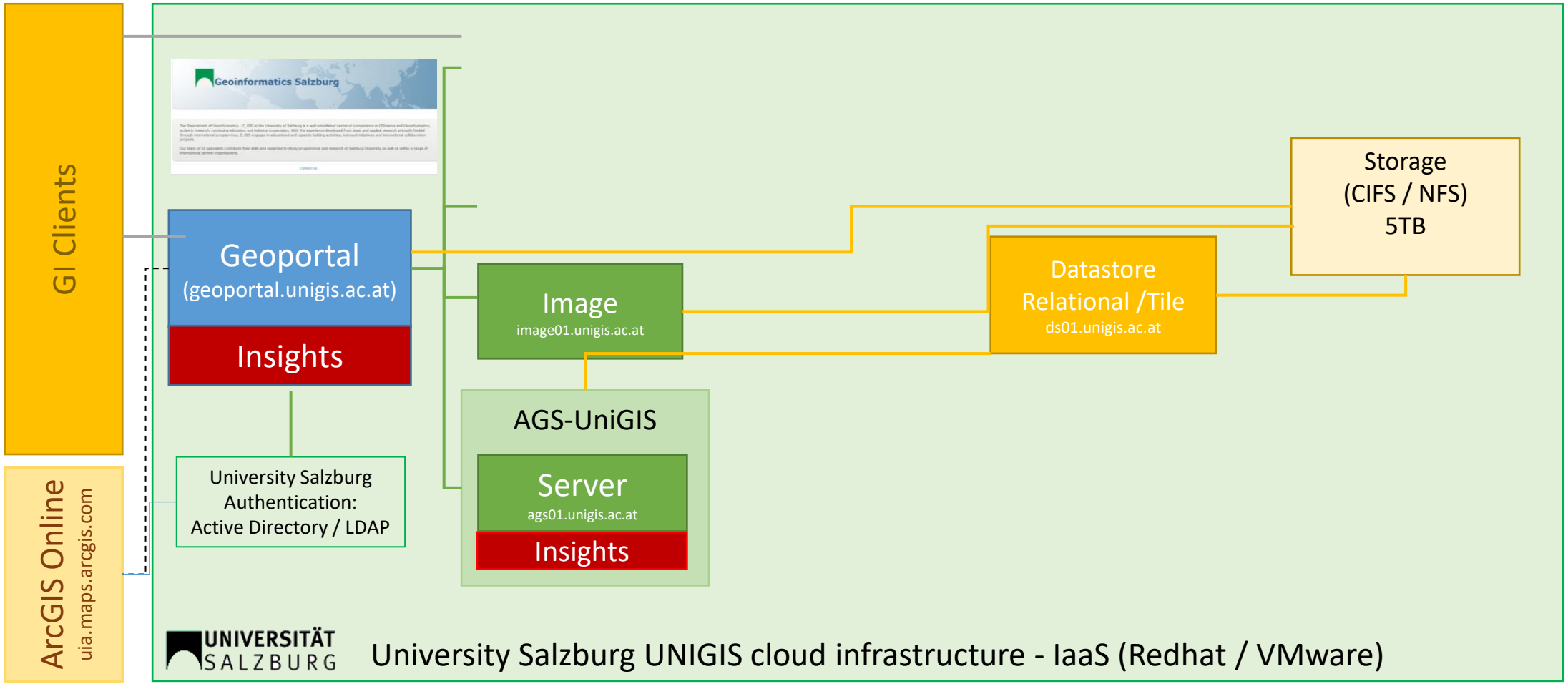


Types of GIS
GIS is evolving – example ESRI

- ArcGIS Server - > ArcGIS Enterprise

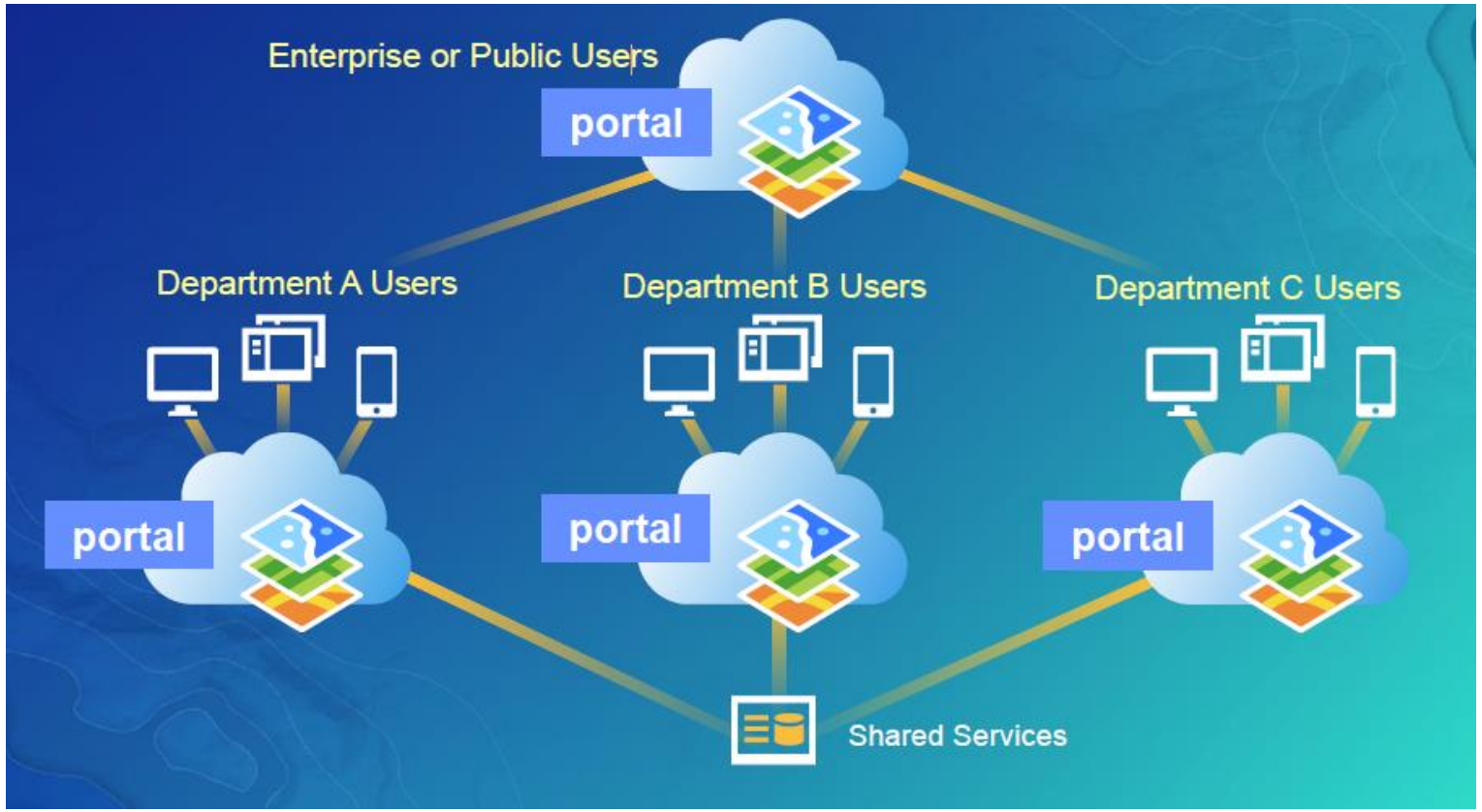


University Salzburg Geoportal
uia.maps.arcgis.com & geoportal.unigis.ac.at



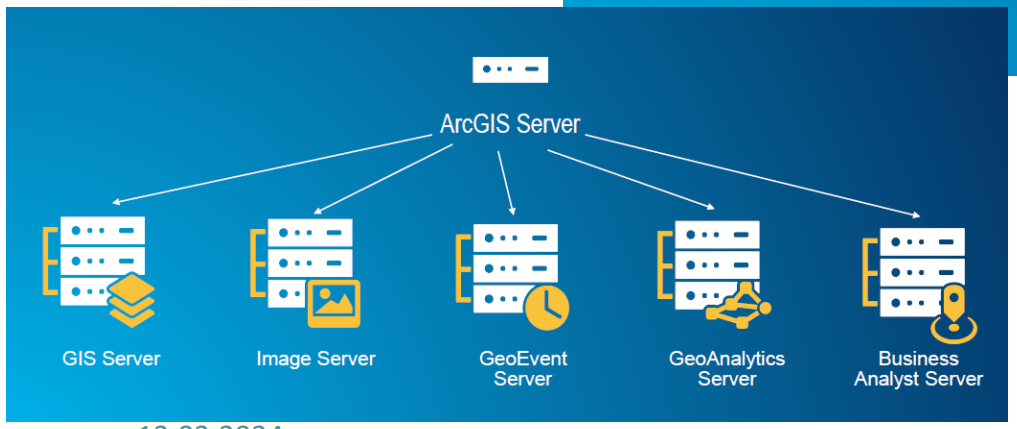
Types of GIS
GIS is evolving – example ESRI

- Distributed Portals



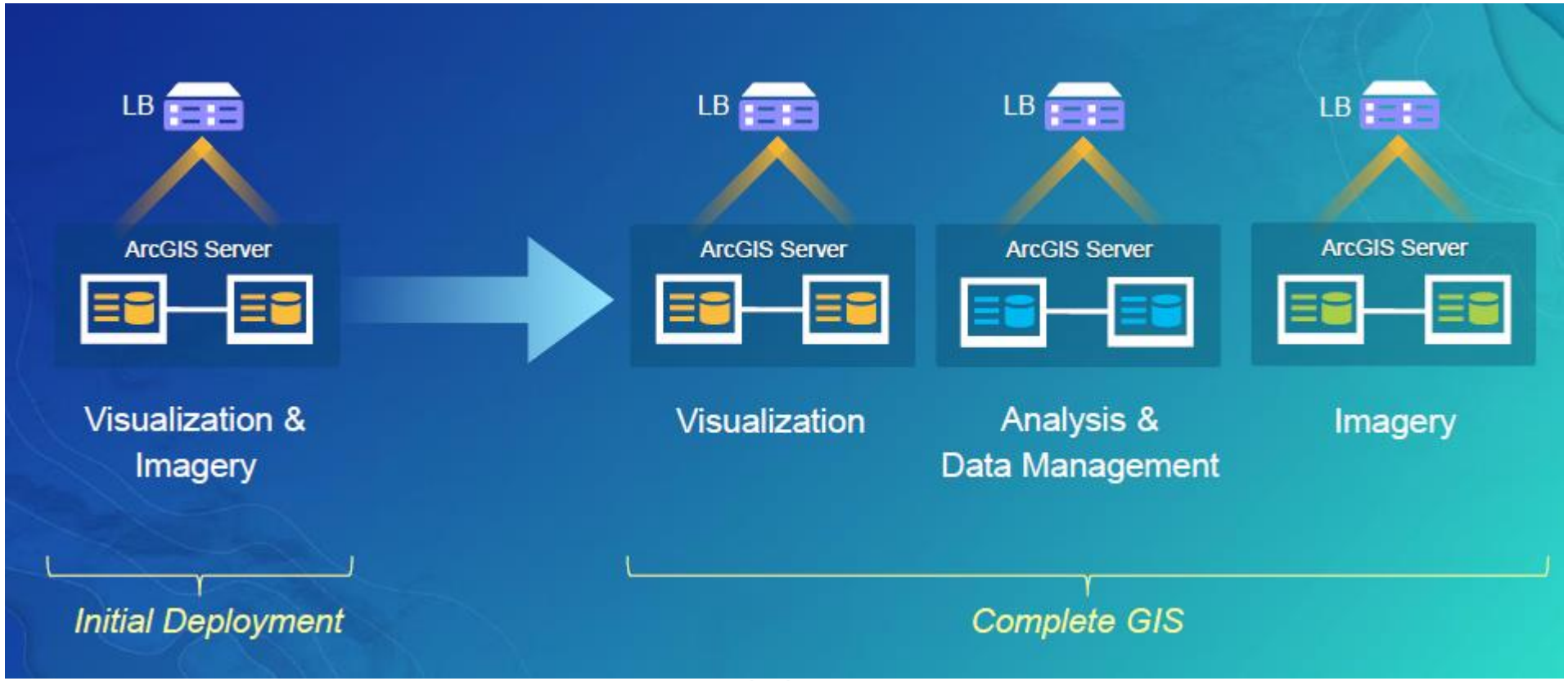
Types of GIS Service oriented GIS
Example ArcGIS Enterprise

- ArcGIS Online /Enterprise base deployment pattern



Types of GIS Service oriented GIS
Example ArcGIS Enterprise

- ArcGIS Online /Enterprise workload separation



Types of GIS
Service oriented GIS – advantages summary

- For effective organization of geodata
- Consume, instead of storing your own
- Reduction of redundant data-storage
- Cross platform - Independent from operating-system, programming-language, programming-environment
- Online community
- Disadvantages:
  - Dependence on server and Internet availability

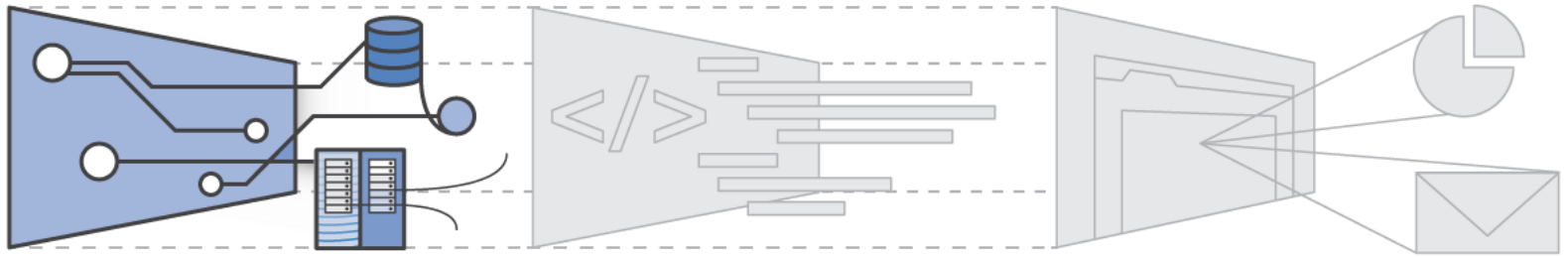
About Cloud Computing

- Pooled computing resources available to any subscribing users
- Virtualized computing resources to maximize hardware utilization
- Elastic scaling up or down according to needed computing resources
- Automated creation of new virtual machines or deletion of existing ones
- Resource usage billed according to the usage

> "**Cloud computing** *is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal effort or service provider interaction*" (Mell and Grance, 2011)

Cloud Computing – Service models
IaaS

- Infrastructure as a Service (IaaS):
  - provision processing, storage, networks, and other fundamental computing resources to maximize hardware utilization
  - consumers are able to deploy and run arbitrary software, which can include operating systems and applications
  - provides access to networking features
  - provides access to computers (virtual or on dedicated hardware)
  - Provides data storage space - Resource usage billed according to the usage



amazon web services™

IBM Bluemix

Image source (2017): https://aws.amazon.com/types-of-cloud-computing/?nc1=h_ls

Cloud Computing – Service models
PaaS

- Platform as a Service (PaaS):
  - is a complete development and deployment environment in the cloud hosting consumer-created or acquired applications
  - resources enable you delivering simple to complex apps and solutions based on programming languages, libraries, services, and tools supported by the provider
  - It is designed to support the complete web application lifecycle: building, testing, deploying, managing, and updating
  - to move development service capabilities to the cloud

Google app engine

Image source (2017): https://aws.amazon.com/types-of-cloud-computing/?nc1=h_ls

Cloud Computing – Service models
SaaS

- Software as a Service (SaaS):
  - access to application software and databases -> "on-demand software" (e.g. Office365, ArcGIS Online, Geonode etc.)
  - providers manage the infrastructure and platforms that run the applications and cloud users access the software from clients
  - is usually priced on a pay-per-use basis or using a subscription fee
  - The service provider manages the hardware and software and ensures the availability and the security

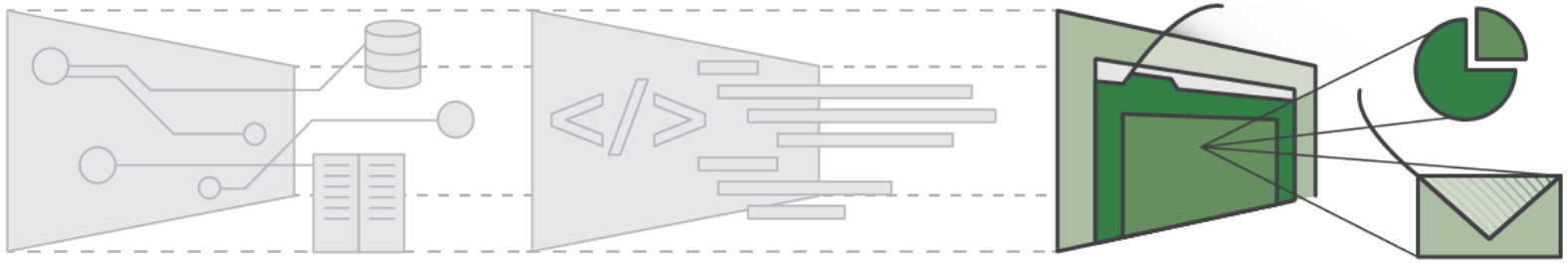
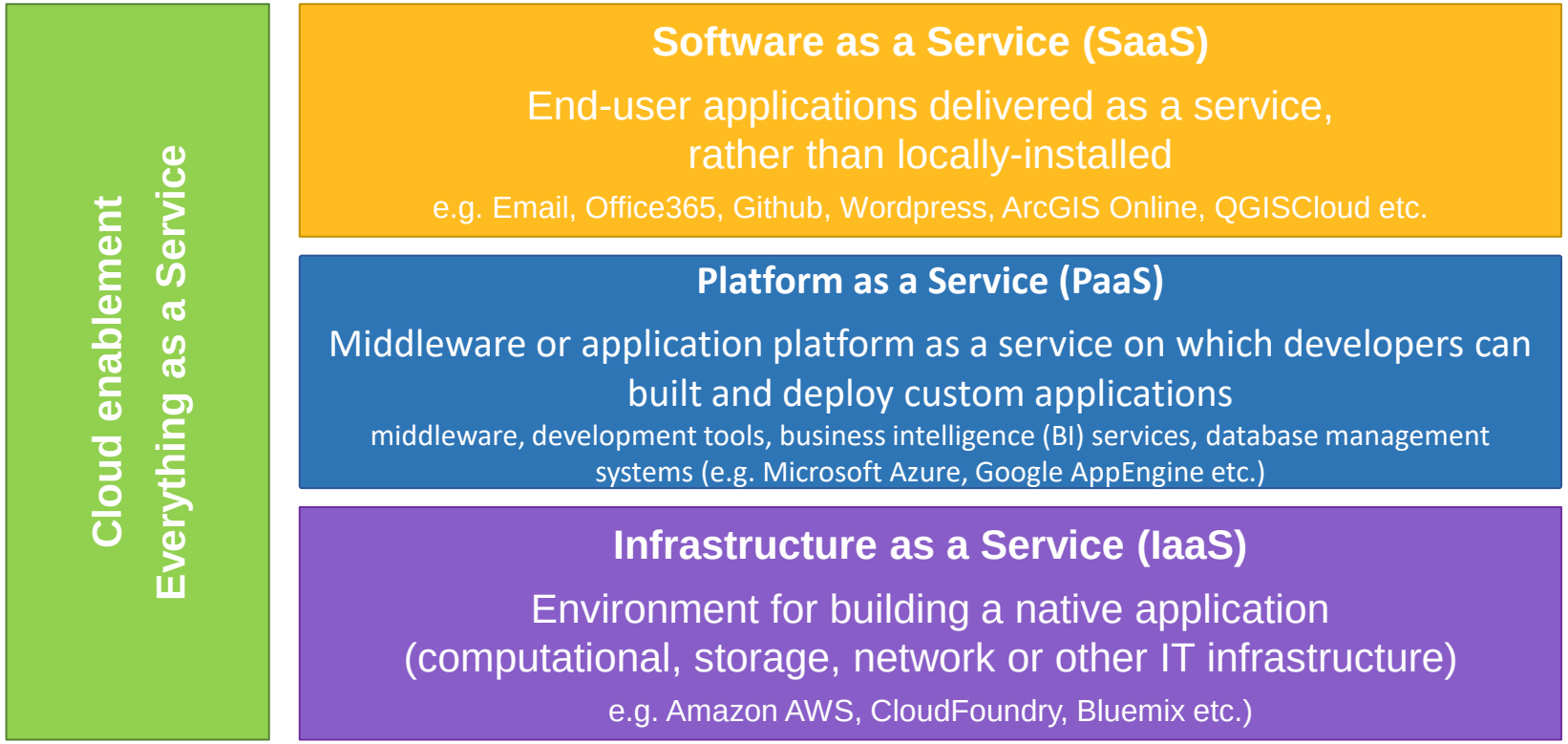


Image source (2017): https://aws.amazon.com/types-of-cloud-computing/?nc1=h_ls

Cloud Computing Service Models Summary



[Source: Rosenberg and Mateos, 2011, modified]

Cloud Computing
Deployment models

- Cloud deployment:
  - A cloud-based application is fully deployed in the cloud and all parts of the application run in the cloud.
- Hybrid deployment
  - is a way to connect infrastructure and applications between cloud-based resources and ‘local/private’ existing resources
- On-Premises (private cloud) deployment
  - using virtualization and resource management tools (e.g. OpenStack, Ubuntu Bare Metal, VMWare etc.

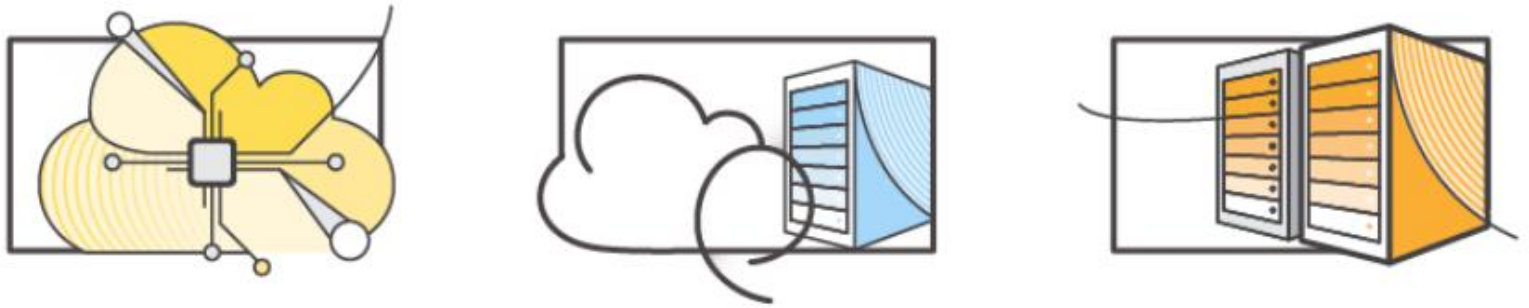


Image source (2017): https://aws.amazon.com/types-of-cloud-computing/?nc1=h_ls