YYT-C3001 Management of environmental data and information

Learning session 2: Spatial data modeling and management (starts at 14.15)

Aalto University
School of Engineering

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10.9.2020

Contents of this lecture

Enabling technologies

The structure of a spatial data service

- **Client side – Desktop GIS or browser**
  - Visualization of spatial data
- **GIS server**
  - Data delivery
  - Data storage and databases
  - Data storage formats
- **Data delivery from provider to server**

Learning goals for this lecture

To learn what are the basic building blocks of a spatial data service (on conceptual level)

To understand how data is delivered from a web service to a desktop GIS and to a web browser

What is the difference between these two approaches

How a spatial data service works as a part of a larger spatial data infrastructure

Note

The discussion today is about how to use spatial data that is stored in a server (somewhere off-site). Data that has been downloaded and can be used locally is out of scope.

Using local data is in many cases easier than connecting to a server, if you use desktop GIS. But not always.

Overview of a spatial data service

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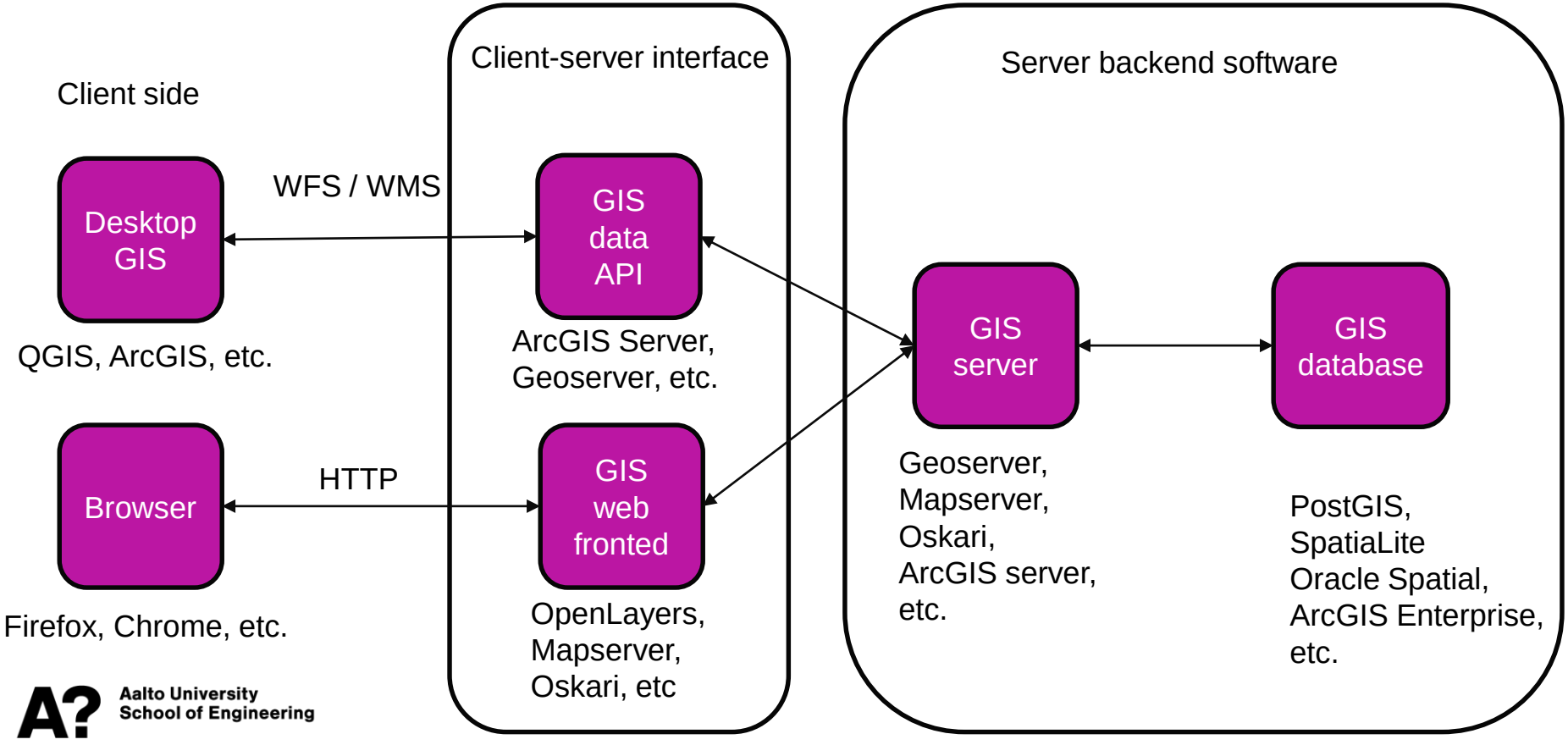
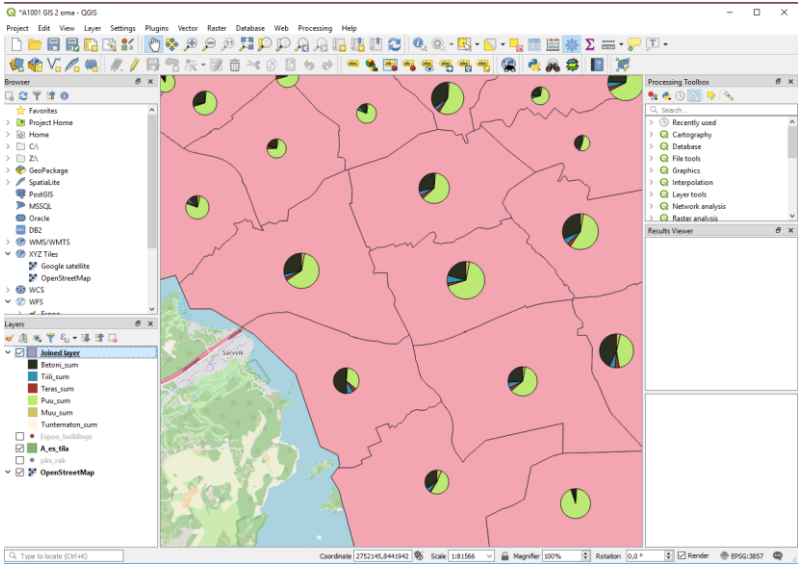
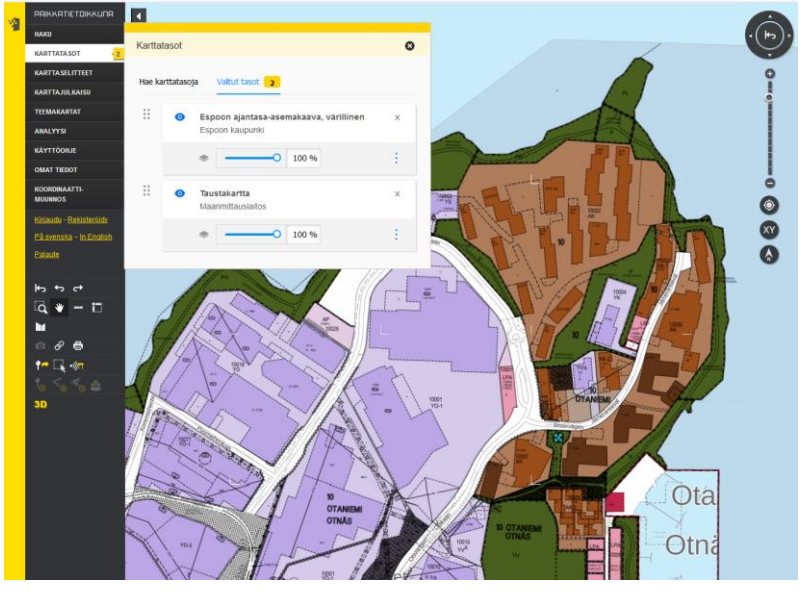
Spatial data service (rough outline)



The client side

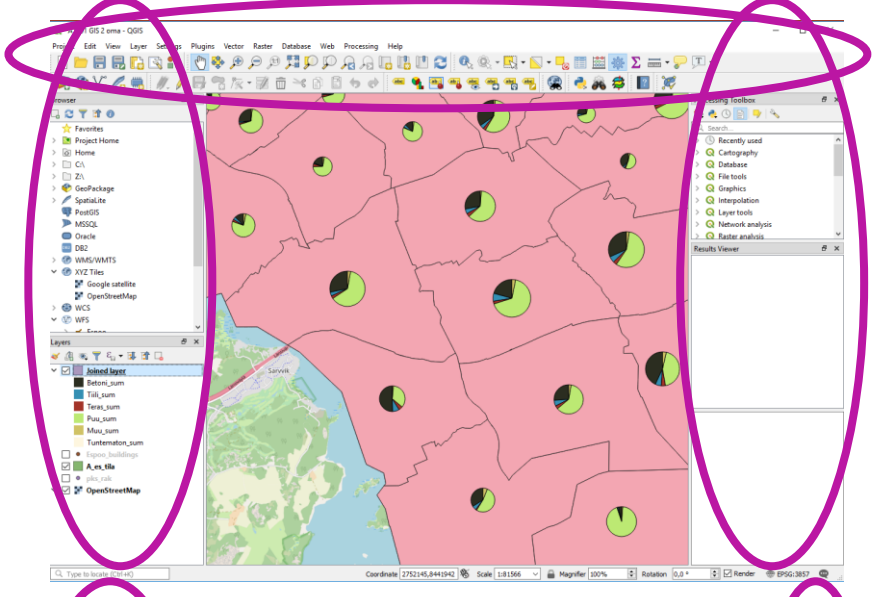
- **Desktop GIS is software designed for managing analyzing, and visualizing spatial data**
  - Can fetch spatial data from service and uses it locally
- **Web browser is software designed for showing and navigating web pages**
  - Fetches and represents web pages (spatial data visualizations)
  - Can do local processing (according to server-side instructions) and pass processing instructions to the server





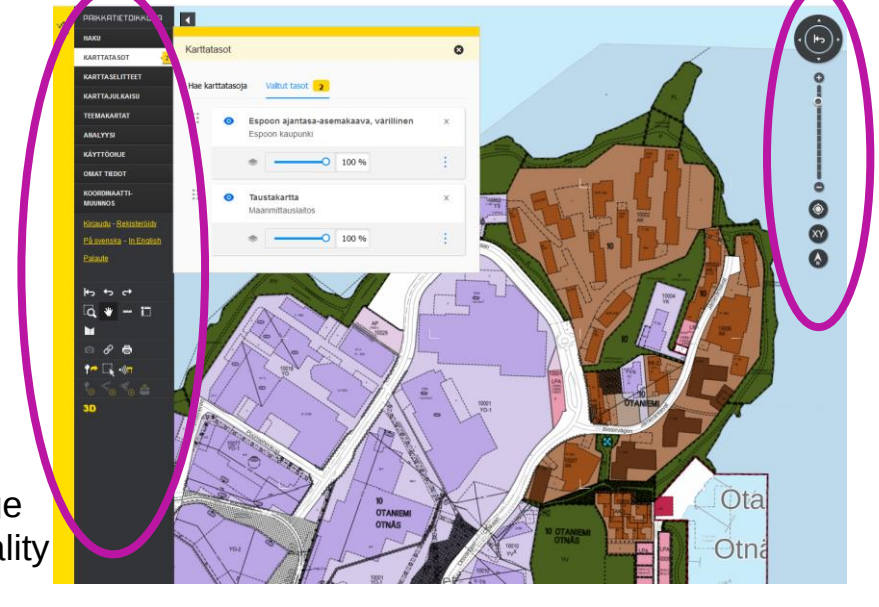
The client side

QGIS functionality

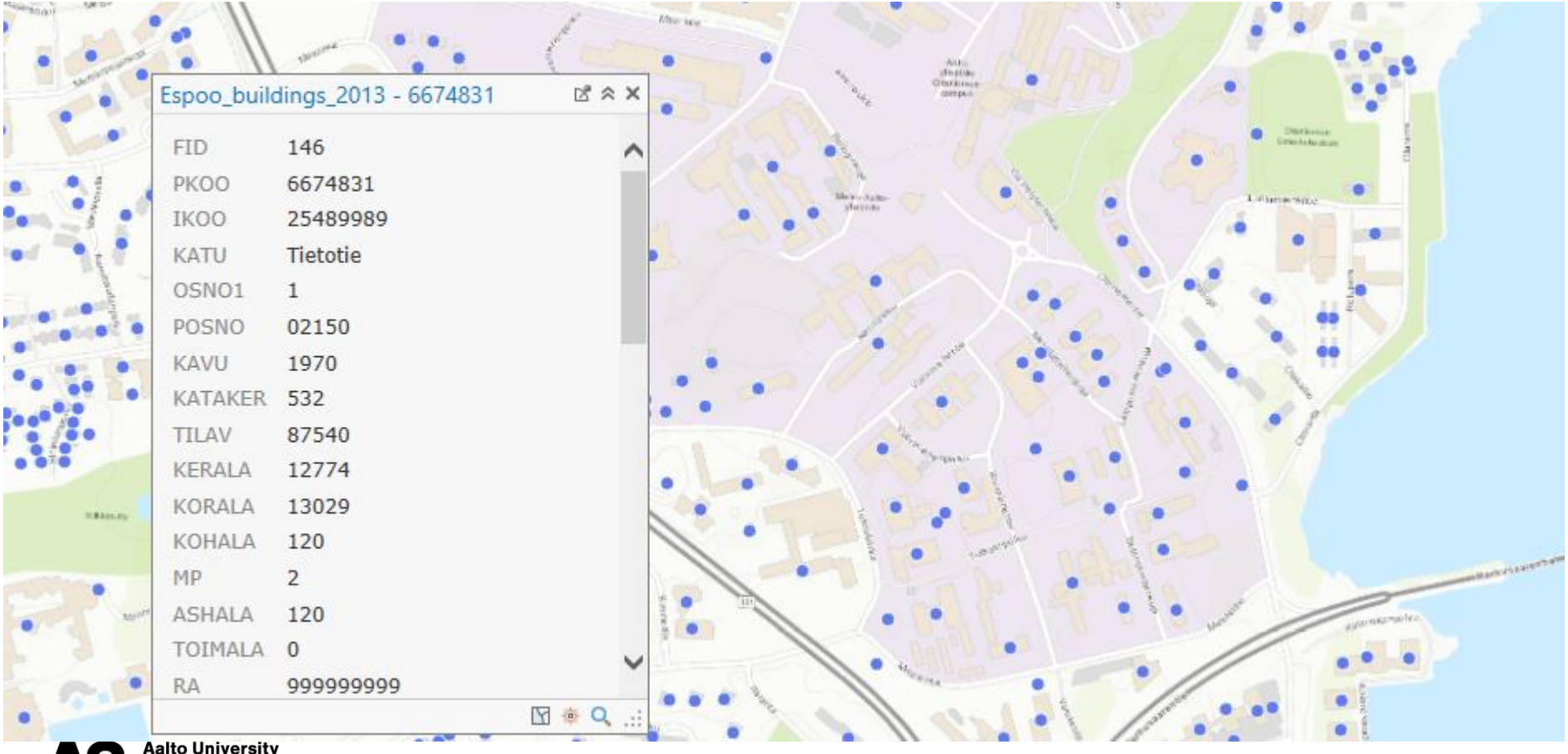


- **Desktop GIS has primarily client-side functionality**
  - what can be done depends on the data and the desktop GIS software in use
- **Web browser provides functionality defined by the website**
  - Functionality can be on the client side, but what can be done depends on the server

Web page functionality



The data you use 1



Geospatial data presentation and visualization

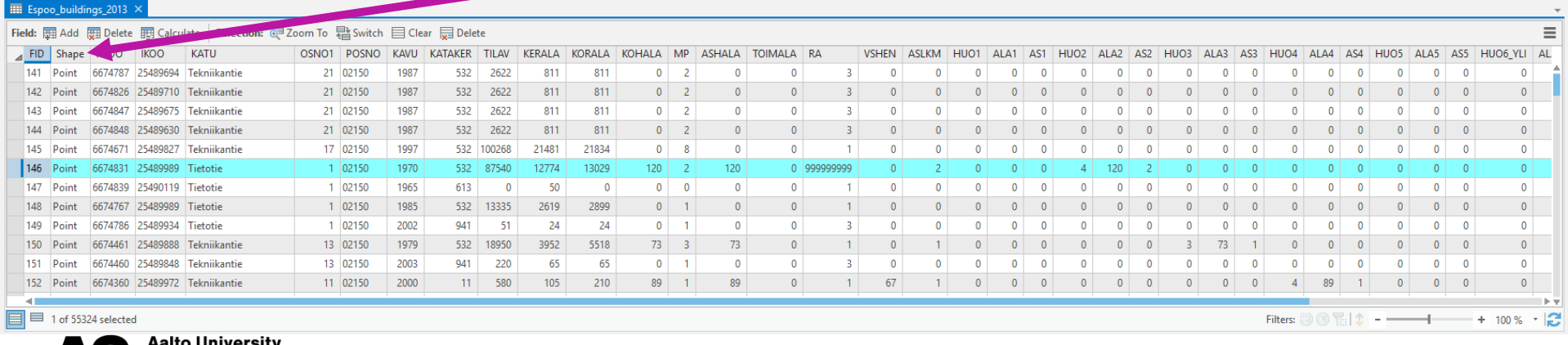
- **Each blue dot in the example represents a building**
  - The dot is a point data element; a coordinate value pair
  - In this dataset, there is no shape associated with a building
- **Each building has a large number of attribute data elements**
- **Together, buildings are a spatial data layer**
  - In the example the layer is stored as a single file on a computer
- **One or more spatial data layers create a spatial dataset**
- **In the example, the spatial dataset is visualized as dots over a background map**

Geospatial data representation: vector data

The building data in the example is in vector data format

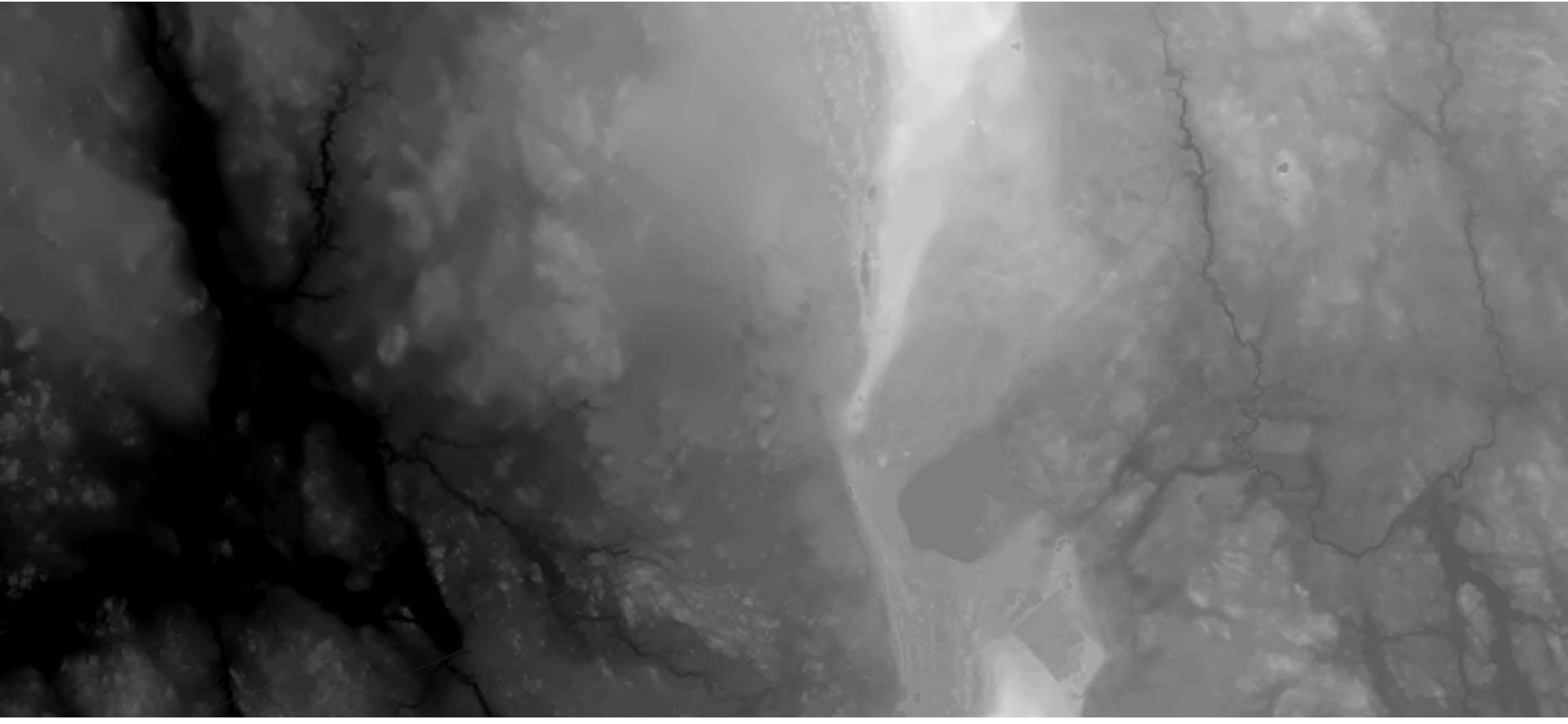
In vector format the data consists of discrete features that have attributes attached to them

- **Features can be points, lines, or areas (polygons)**



FID	Shape	IKOO	KATU	OSNO1	POSNO	KAVU	KATAKER	TILAV	KERALA	KORALA	KOHALA	MP	ASHALA	TOIMALA	RA	VSHEN	ASLKM	HUO1	ALA1	AS1	HUO2	ALA2	AS2	HUO3	ALA3	AS3	HUO4	ALA4	AS4	HUO5	ALA5	AS5	HUO6_YLI	AL
141	Point	6674787	25489694	Tekniikantie	21	02150	1987	532	2622	811	811	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
142	Point	6674826	25489710	Tekniikantie	21	02150	1987	532	2622	811	811	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
143	Point	6674847	25489675	Tekniikantie	21	02150	1987	532	2622	811	811	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
144	Point	6674848	25489630	Tekniikantie	21	02150	1987	532	2622	811	811	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
145	Point	6674671	25489827	Tekniikantie	17	02150	1997	532	100268	21481	21834	0	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
146	Point	6674831	25489989	Tietotie	1	02150	1970	532	87540	12774	13029	120	2	120	0	999999999	0	2	0	0	0	4	120	2	0	0	0	0	0	0	0	0	0	0	
147	Point	6674839	25490119	Tietotie	1	02150	1965	613	0	50	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
148	Point	6674767	25489989	Tietotie	1	02150	1985	532	13335	2619	2899	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
149	Point	6674786	25489934	Tietotie	1	02150	2002	941	51	24	24	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
150	Point	6674461	25489888	Tekniikantie	13	02150	1979	532	18950	3952	5518	73	3	73	0	1	0	1	0	0	0	0	0	0	3	73	1	0	0	0	0	0	0	0	
151	Point	6674460	25489848	Tekniikantie	13	02150	2003	941	220	65	65	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
152	Point	6674360	25489972	Tekniikantie	11	02150	2000	11	580	105	210	89	1	89	0	1	67	1	0	0	0	0	0	0	0	0	0	4	89	1	0	0	0	0	

The data you use 2



Geospatial data presentation and visualization 2

The raster layer in the example represents elevation

- **Each raster cell (pixel) covers a 10m x 10m area**
- **The cell value represents the elevation at that area**
  - Naturally, in real life elevation inside a pixel area can vary

The layer represents one phenomenon (~attribute value) and covers a large geographical area

A background map is not visible since the raster covers the whole area

Geospatial data presentation: raster data

In raster data format, the data consists of a regular tessellation that covers an area

A raster layer represents a continuous phenomenon that can be measured

- **The area is divided into small, regular polygons, typically squares (triangles and hexagons can also be used)**

Each cell (pixel) in the raster represents the value of the phenomenon on the area covered by the cell

If many phenomena are to be covered, several raster layers are required

OID	Value	Count
0	55	6
1	56	266
2	57	2165
3	58	2710
4	59	3210
5	60	7978
6	61	7816
7	62	7517
8	63	5006
9	64	7423
10	65	11426
11	66	9232
12	67	11966
13	68	20004
14	69	29501
15	70	49254
16	71	32345
17	72	42959
18	73	34089
19	74	35847
20	75	41423
21	76	45539
22	77	44626
23	78	42234
24	79	73496
25	80	78952
26	81	72616
27	82	100344
28	83	92785
29	84	102384
30	85	124740
31	86	90894
32	87	123729
33	88	104687
34	89	115389
35	90	167639
36	91	108970

Classroom exercise

Open the Jamboard link (given in Zoom chat)

https://jamboard.google.com/d/1NFVmFa03MafMj54gxsGqNbvfdF1fC2dPxprpQdR7QK4/edit?usp=sharing

I will divide you into breakout rooms for a short group work

Groups will be assigned randomly

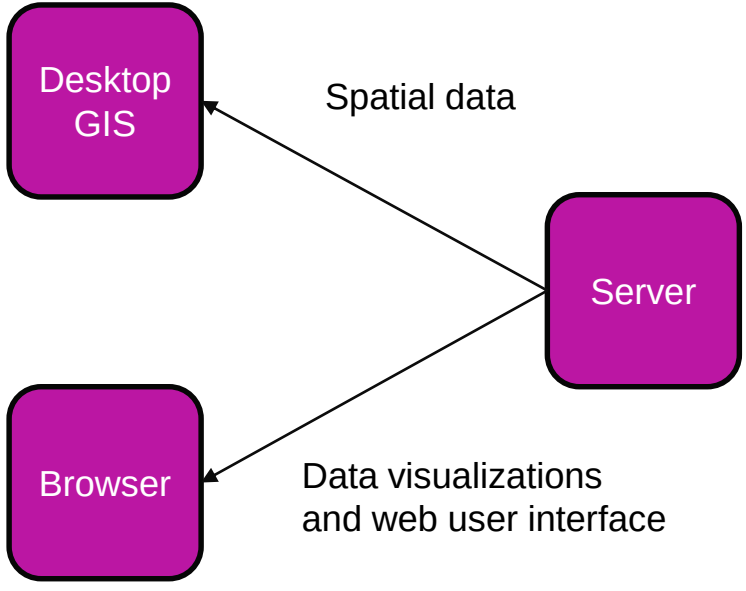
Follow the instructions on the jamboard

You have 10 minutes, after that we will discuss the results

Any questions before we begin?

Spatial data delivery

- The user needs to access the spatial data in order to use it
- For desktop GIS this means the spatial data is transferred to the client
- For web browser this means visualizations are transferred to the client and user interface elements are defined
- The transfer is based on some agreed-upon standard



Spatial data delivery: WFS and WMS

- Spatial data transfer requires different standards for vector and raster data
- Web Feature Service (WFS) defines a service providing individual elements in a data set (vector data)
- Web Map Service (WMS) defines a service providing map images (raster data)

- Additional standards are needed in order to encode the data being transferred
- WFS can deliver vector data elements encoded using Geography Markup Language (GML)
- WMS can deliver raster map elements encoded using GeoTIFF, PNG, or other image format
- There is also a related standard WMTS, which splits raster images into small tiles

WFS and WMS examples

- **WFS**

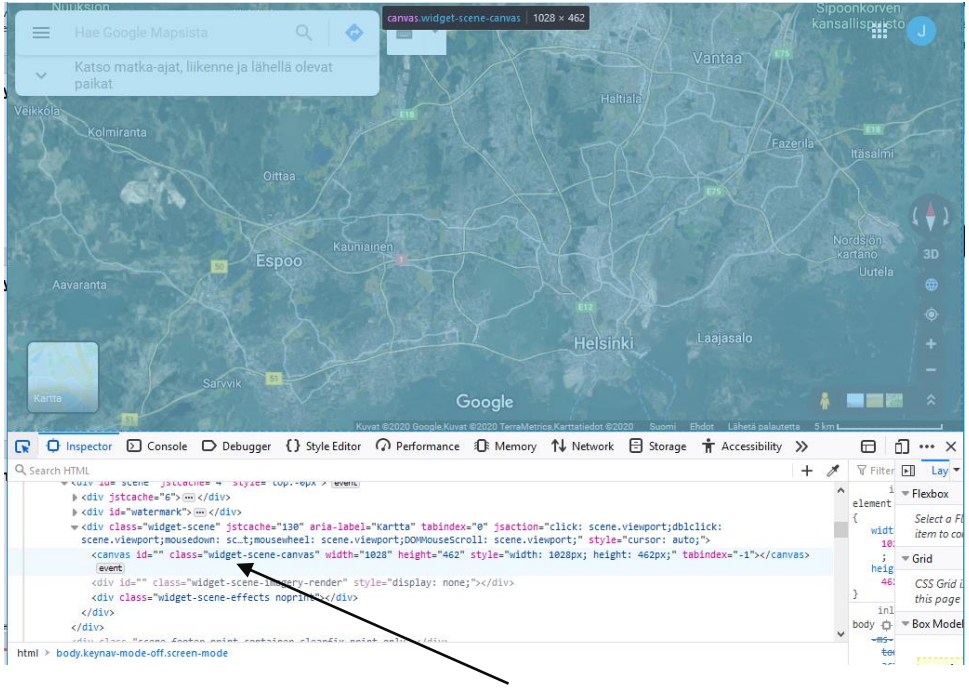
```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns:wfs="http://www.opengis.net/wfs/2.0"
                       xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:gsml="urn:cg
                       xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:base="http:
                       xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:geosolutions=
                       xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:sf="http://ww
                       xmlns:lcv="http://inspire.ec.europa.eu/schemas/lcv/3.0" xmlns:
                       numberMatched="unknown" numberReturned="73" timeStamp="2015-09
                       xsi:schemaLocation="http://inspire.ec.europa.eu/schemas/lcv/3.
  <wfs:member>
    <lcv:LandCoverUnit gml:id="lcu.90">
      <gml:description>VIAREGGIO</gml:description>
      <lcv:inspireId>
        <base:Identifier>
          <base:localId>lcu.90</base:localId>
          <base:namespace>http://it.geosolutions.hale-training</base:namespace>
        </base:Identifier>
      </lcv:inspireId>
      <lcv:geometry>
        <gml:MultiSurface srsName="urn:ogc:def:crs:EPSG::3044">
          <gml:surfaceMember>
            <gml:Polygon>
              <gml:exterior>
                <gml:LinearRing>
                  <gml:posList>4857886.29111215 601905.3493974642
                  4857887.810884466 601856.8903100973 4857887.819975
                  601854.6246530213 4857889.308042958
                  601853.7024644027 4857887.972016796
                  601816.7710701665 4857884.737440859
                  601783.2948182033 4857886.747501158
                  601782.9210170452 4857885.800511726
                  601756.7422173256 4857885.790496408
                  601752.9622890407 4857881.890570495
                  601752.9723048495 4857883.040301406
                  601741.4538185433 4857883.850484745
```

- **WMS**

Sources: https://geoserver.geo-solutions.it/educational/en/complex_features/landcover/lcv_query.html
https://www.fonecta.fi/kartat

Spatial data delivery - browser

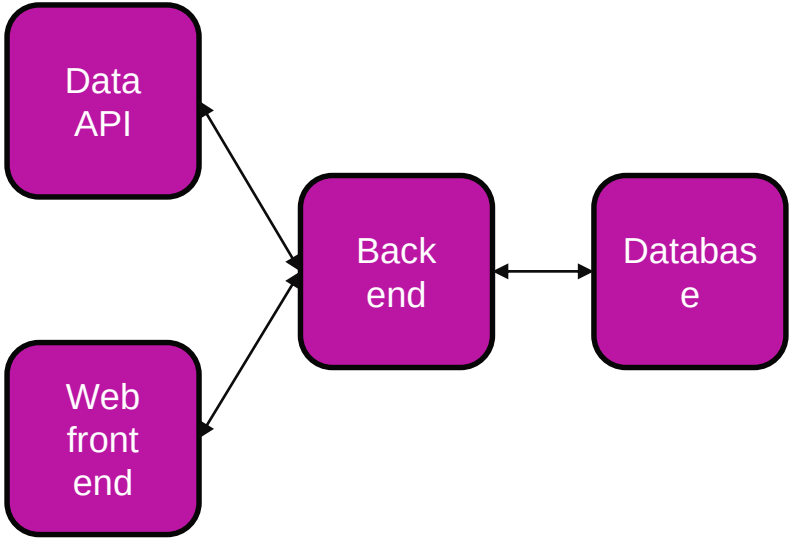
- **Browser shows graphics**
- **One way is to use the** <canvas> **html element and** JavaScript **for populating it**
- **The server backend data can be exactly the same as in a WFS/WMS service**
  - The method for delivery and available functionality differ



Note the <canvas> element. Actual details of what happens inside this element depends on the JavaScript used

Spatial web server

- **A desktop GIS can typically fetch data from a web service via WFS, WMS, or another standard interface**
- **A web browser requires a web front end, which defines how the data is presented on the browser**



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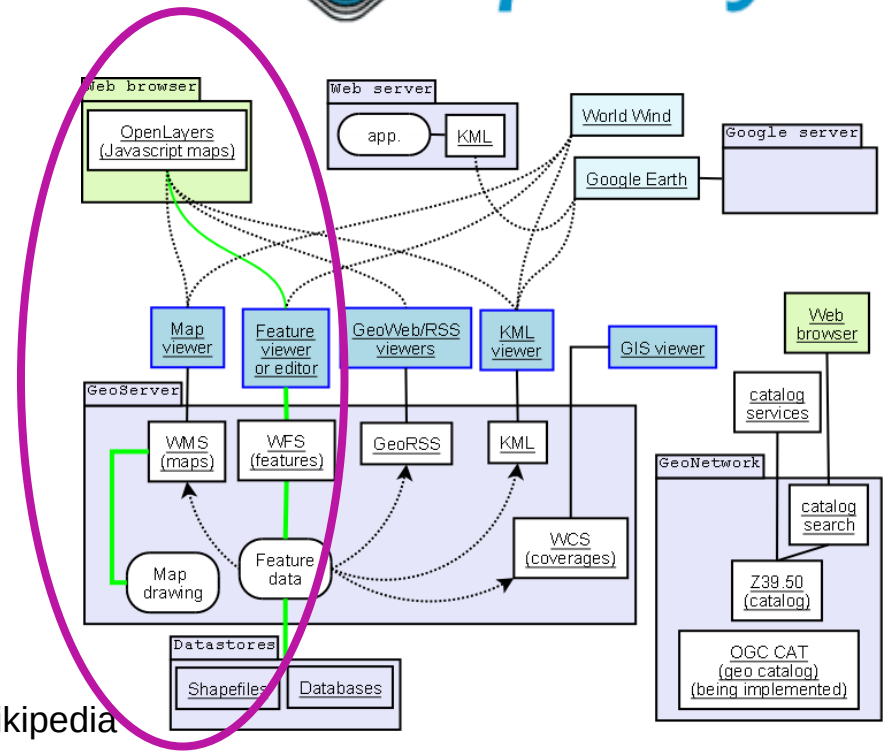
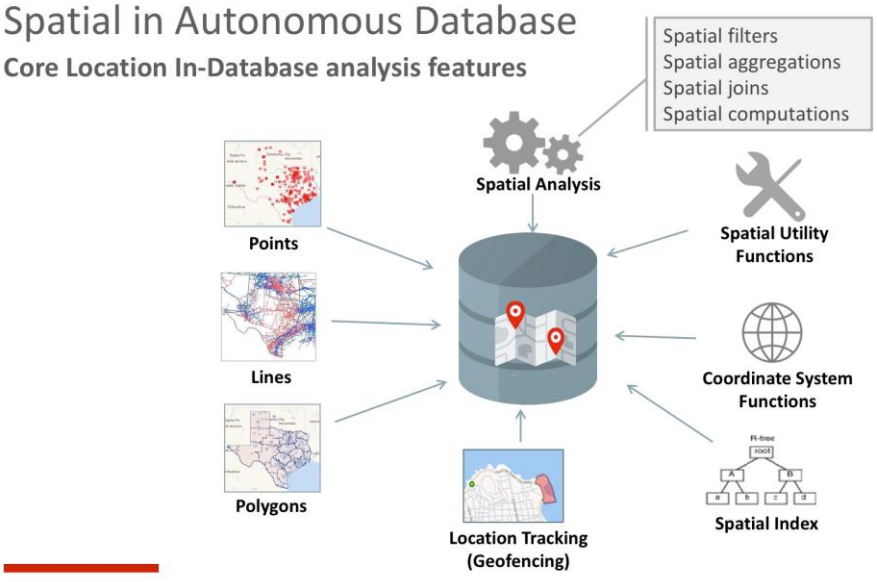


Image: wikipedia

Server – GIS Database

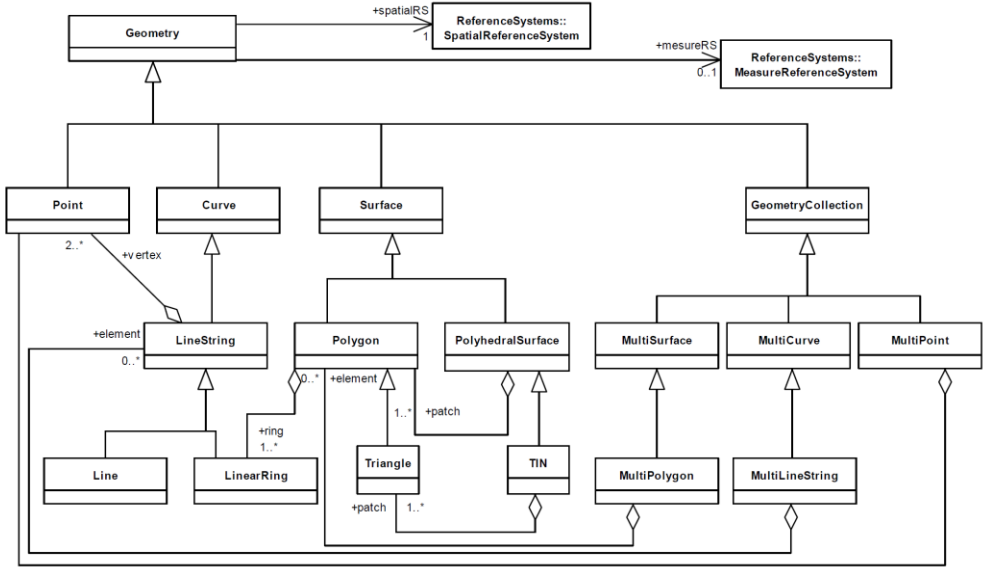
- **The spatial data on a server is stored in a database**
  - **Never** as files on a disk
- **For storing spatial data a spatial database is required**
  - Vector data elements
  - Raster map tile management
- **Most databases these days have spatial data support**
  - Many offer functionality beyond mere efficient storage of spatial data



Picture source: https://blogs.oracle.com/database/autonomous-database-now-with-spatial-intelligence

Spatial data storage standards

- The basis of spatial data storage in databases is – again – standards
- OGC Simple Features, for example, describes how to describe vector data
- The database standards make it easy to convert the data for delivery (e.g. using WFS)



Classroom exercise

We'll continue the classroom exercise

I'll put you back into the break rooms

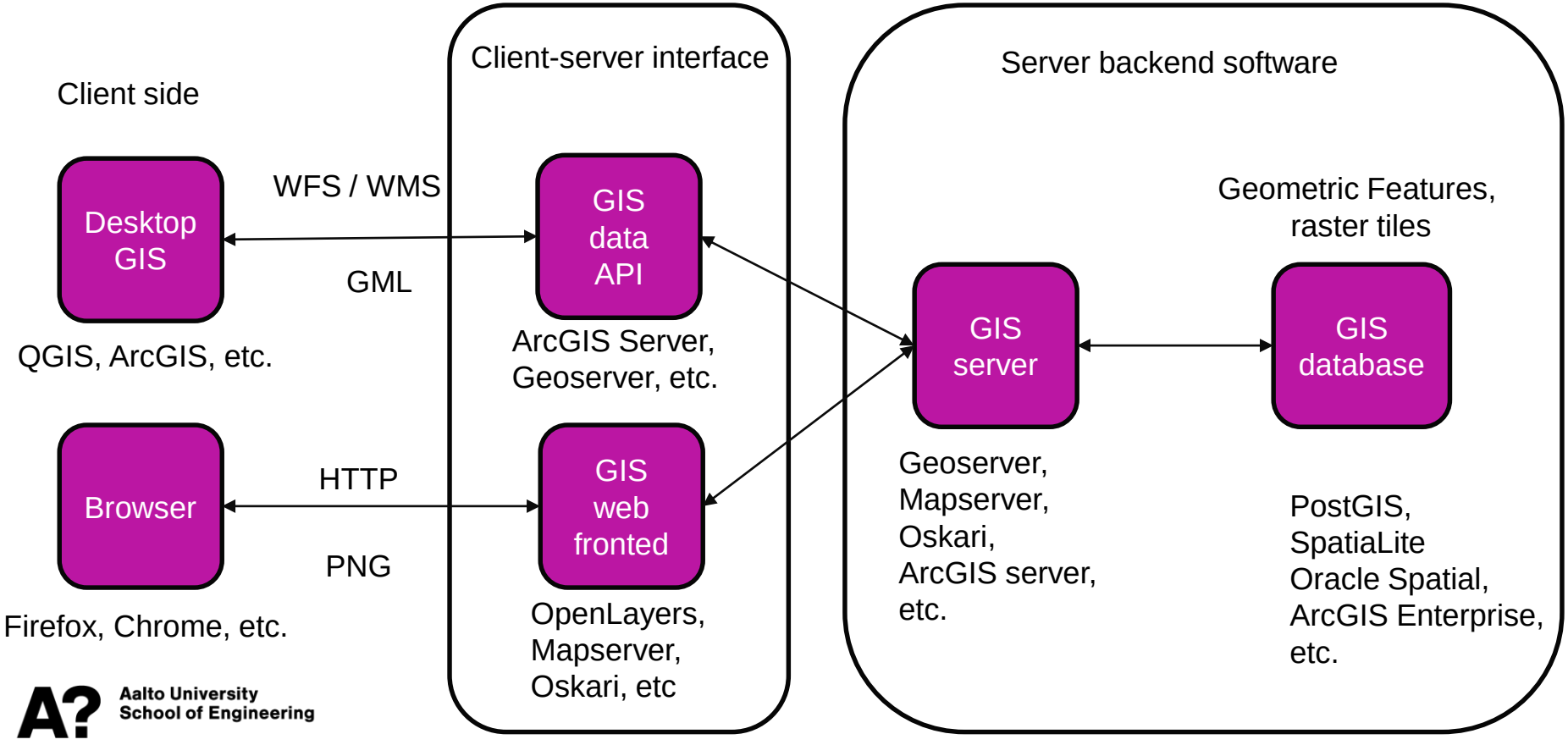
There, see if you can find a way to access the paikkatietoikkuna map layers via interface (WMS/WFS/something else)

If you cannot find a data interface, is there some other way you can access it (aside from paikkatietoikkuna)?

You'll have 10 minutes for this

Any questions before we begin?

Spatial data service (rough outline)



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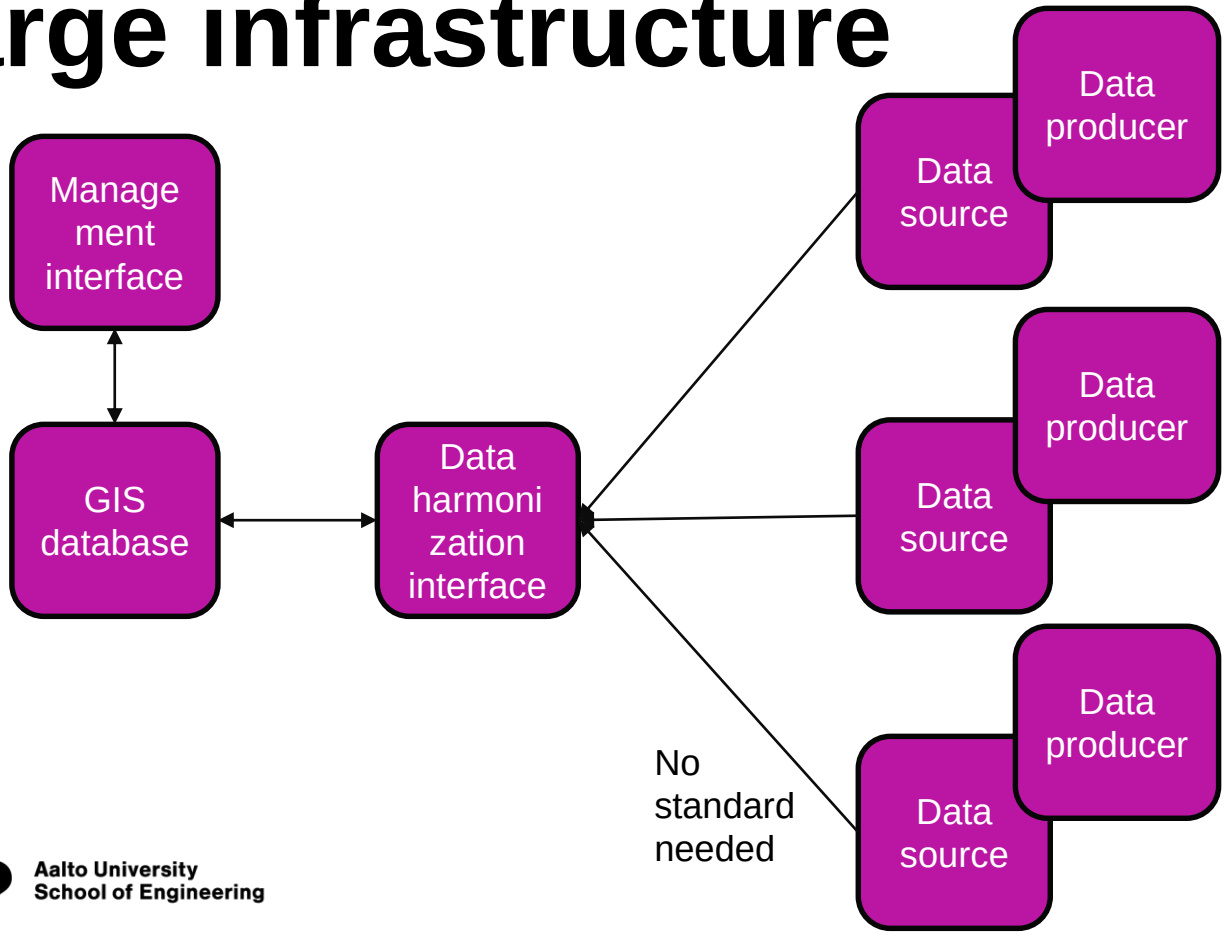
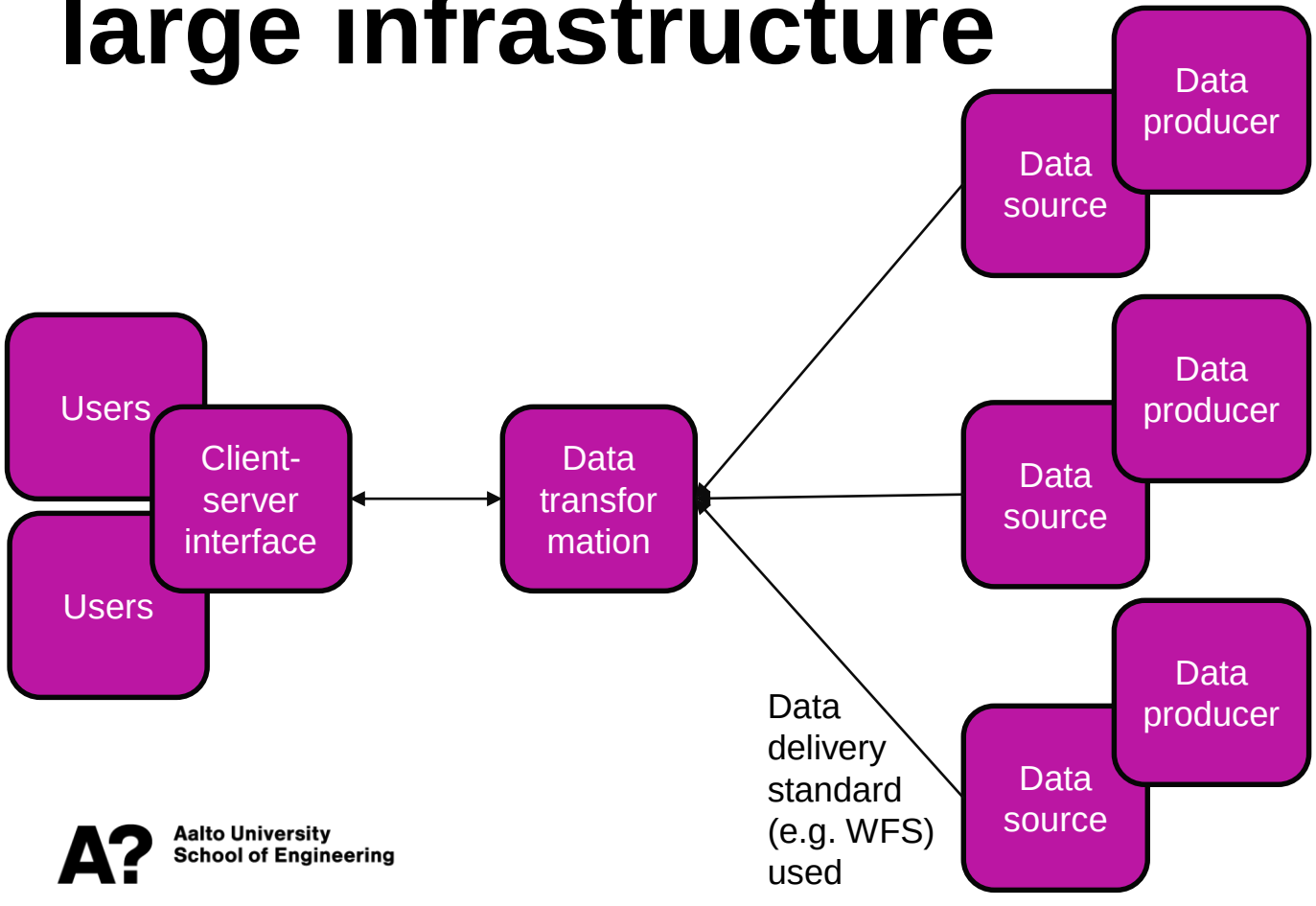
Spatial data service as part of a large infrastructure



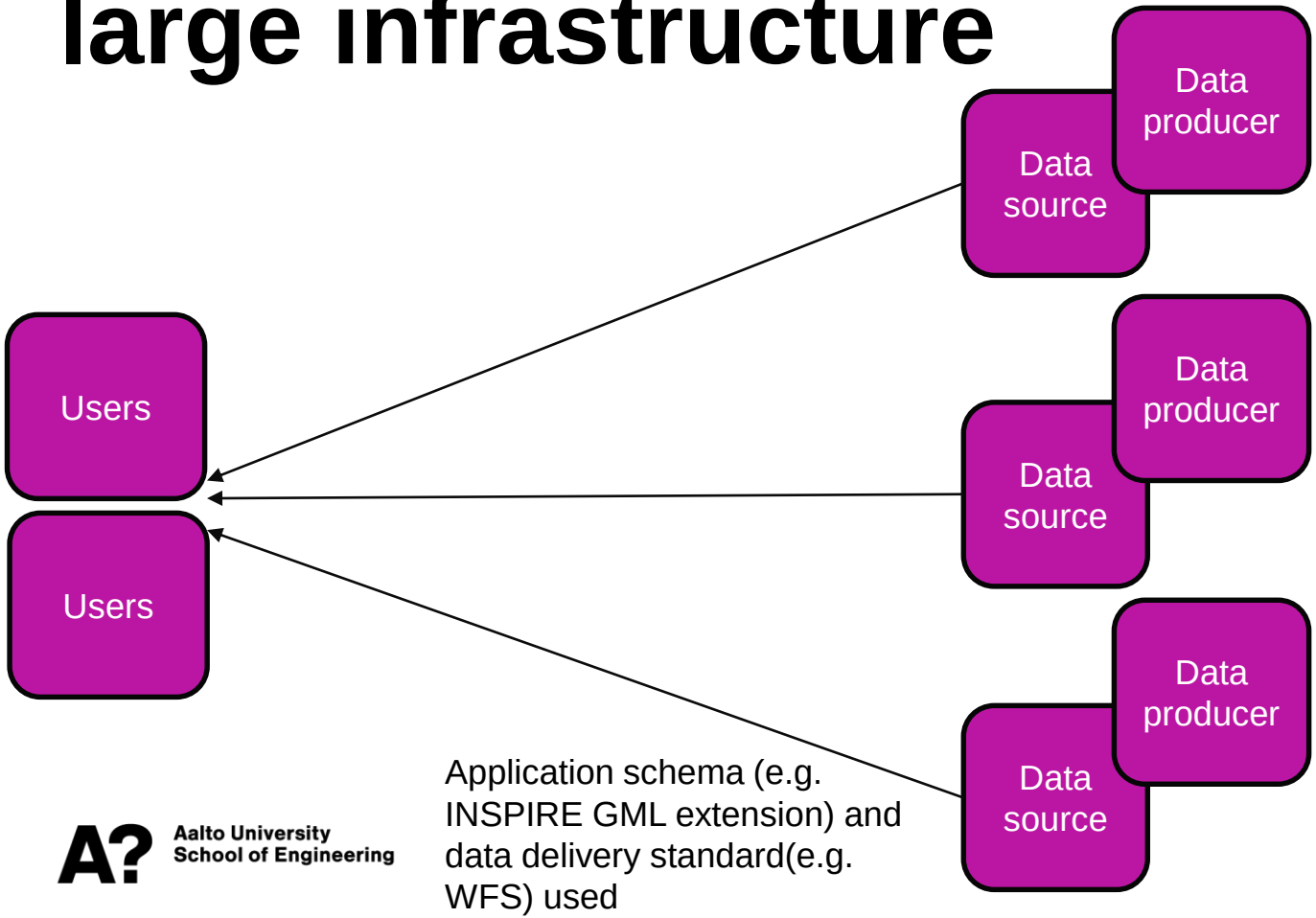
- Data to a specific service may be gathered from a number of data producers
- If the data is gathered to a central database, where all the data is in the same format, it is called **aggregated** data delivery

Spatial data service as part of a large infrastructure



- Data to a specific service may be gathered from a number of data producers
- If the data is gathered to a central database, where all the data is in the same format, it is called **aggregated** data delivery
- If data is transformed on-the-fly into a given format when requested by a user, it is called **brokered** data delivery

Spatial data service as part of a large infrastructure



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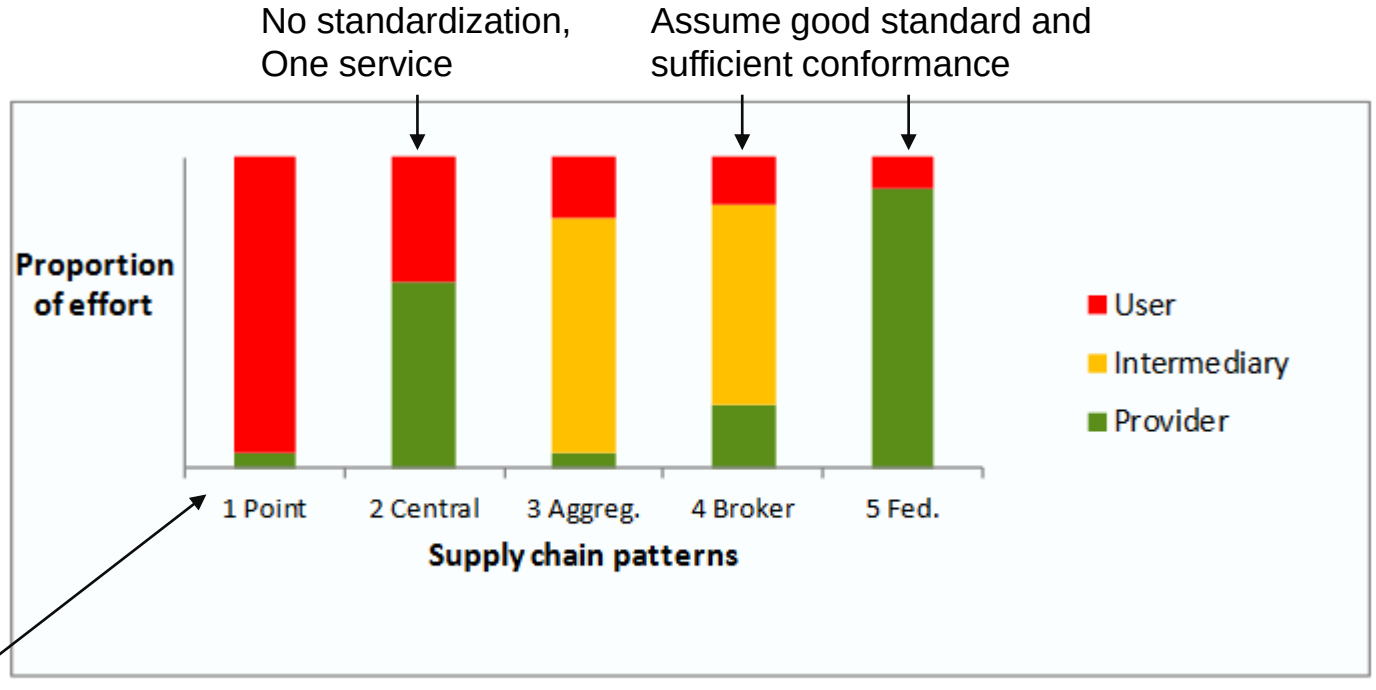
- If the data is gathered to a central database, where all the data is in the same format, it is called **aggregated** data delivery
- If data is transformed on-the-fly into a given format when requested by a user, it is called **brokered** data delivery
- When all data sources share the same standard, it is called **federated** data delivery

Application schema (e.g. INSPIRE GML extension) and data delivery standard(e.g. WFS) used

Comparison of the different chains



No standardization,
No common services

Figure 6 Relative costs of data production for stakeholder by pattern type

Source: Box et al. (2015): A Data Specification Framework for the Foundation Spatial Data Framework

For the next time…

Do the first exercise round. You can get help on Monday at 14-16 in Teams.

You can also post questions to the teams channel Exercises at any time. We'll answer any questions posted there as soon as we're able.

Continue writing the learning diary

You can also take a look at the National Land Survey (maanmittauslaitos) web page, if you want. Focus on the "Maps and spatial data" and "E-services" –sections of the page.