Geospatial Data and Processing in Apache Projects

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APACHECON North America
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Geospatial in Apache Projects

- Apache projects implementing geospatial
- Space, time, coordinates, grids,
- Geospatial APIs and Encoding standards
- Geospatial coordination activities

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ApacheCon Geospatial Tracks

- ApacheCon Big Data 2016 – Vancouver
  - Geospatial track
  - Geospatial BoF
  - mailing list established: geospatial@apache.org.
- ApacheCon Europe 2016 – Seville
  - Geospatial Track
- ApacheCon NA 2018 – Montreal
  - Geospatial Track today
  - Geospatial BoF – this evening

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Open Source Geospatial

- Apache Projects in Geospatial Tracks 2016 & 2018
  - SIS, Calcite, Lucene, Solr, Marmotta ,
    Open Climate Workbench, SDAP, Druid, OFBiz
- Apache Projects extended for geospatial
  - Spark (GeoSpark*), Accumulo (Geowave, Geomesa),
    Jena / Fuseki, UIMA (Baleen)
- Open source organizations focused on Gespatial
  - Location Tech, OS Geo
- Companies offering geospatial OS
  - MapD, Google, Esri, Bentley, Cesium, others

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Open Source and Open Standards

- Use of open consensus standards in OS:
  - Increases code quality
  - Reduce development effort
  - Stable and proven APIs and encodings for interoperability
  - Interchangeability of software components

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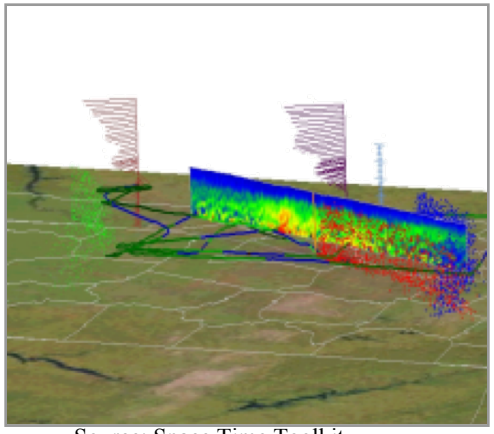
The OGC Mission

Global forum of developers and users of spatial data products and services

Open international standards for geospatial interoperability.



Source: Space Time Toolkit

Source: One Geology

Source: 3d Stadtmodell Berlin

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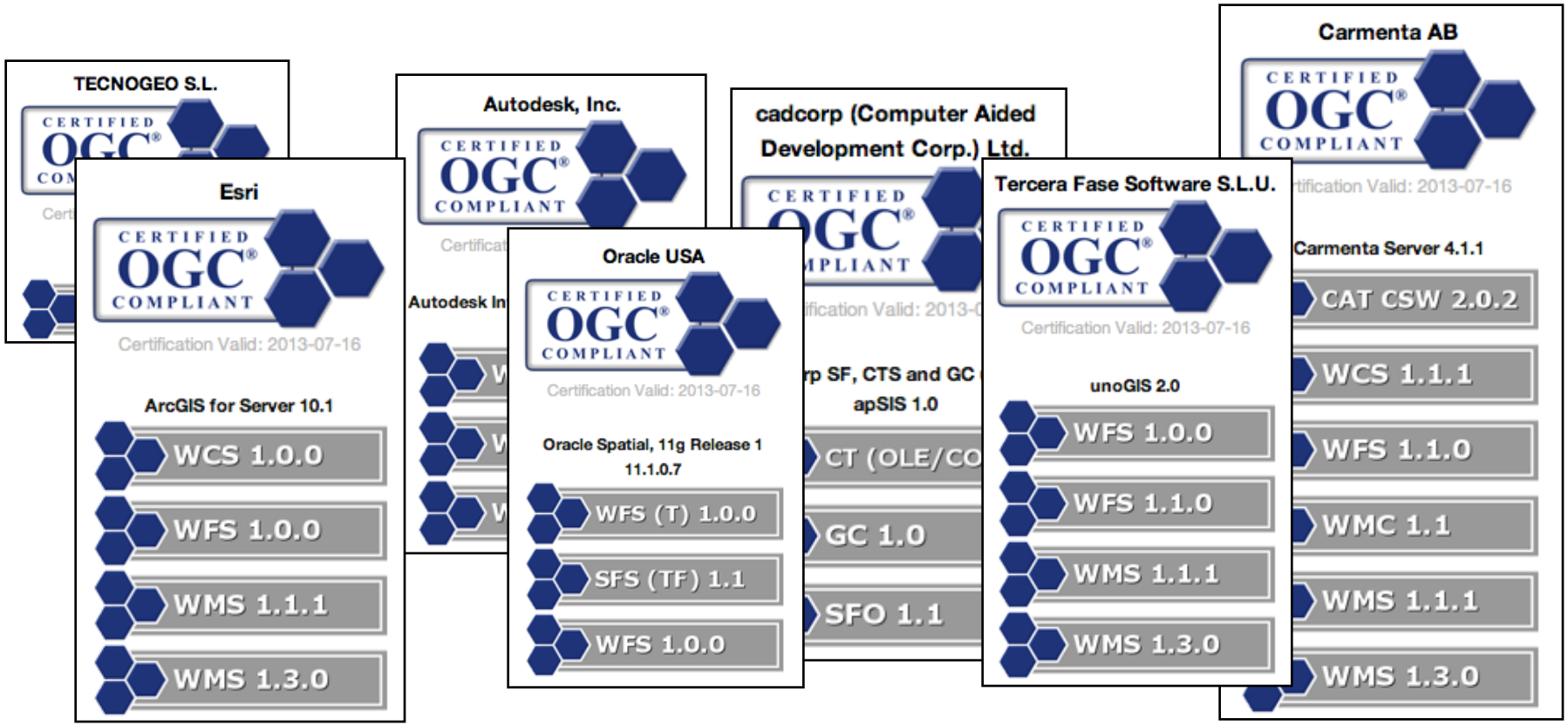
900 implementing products



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http://www.opengeospatial.org/resource/products/compliant

GEOSPATIAL APIS AND ENCODING STANDARDS

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In the beginning…

All was simple, everyone agreed:
the world was flat.

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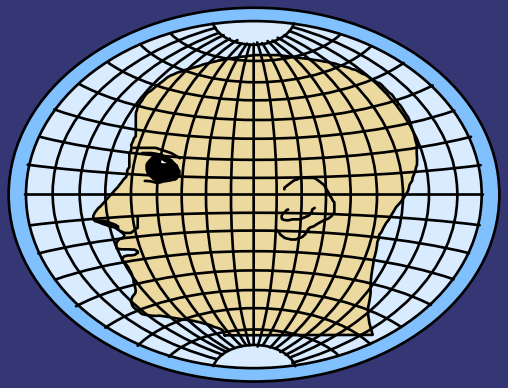
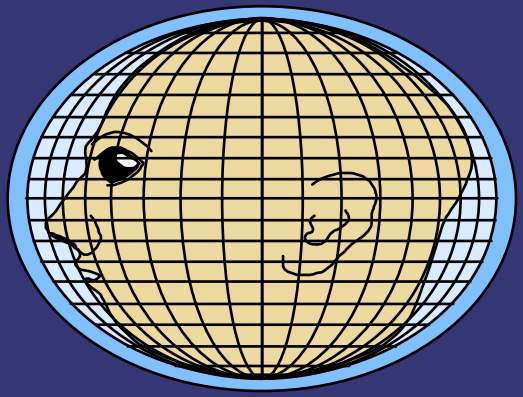
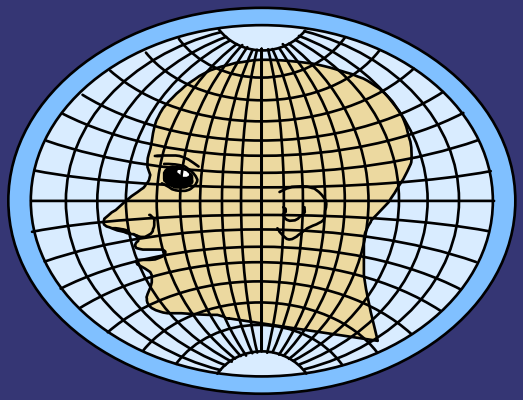
Forcing the Earth to appear flat requires suboptimal choices



Globular projection

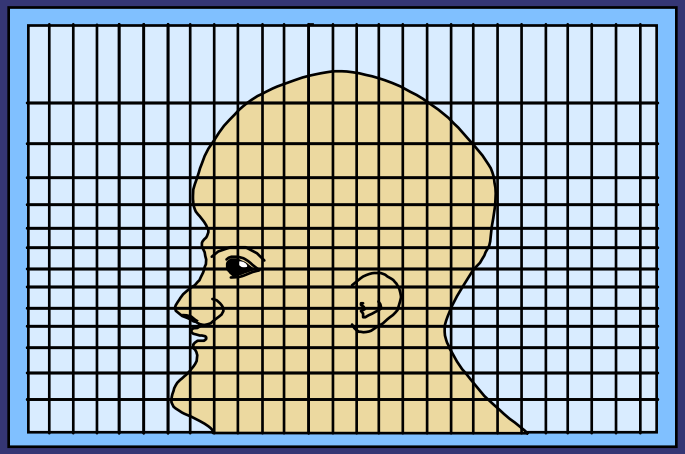
Orthographic projection



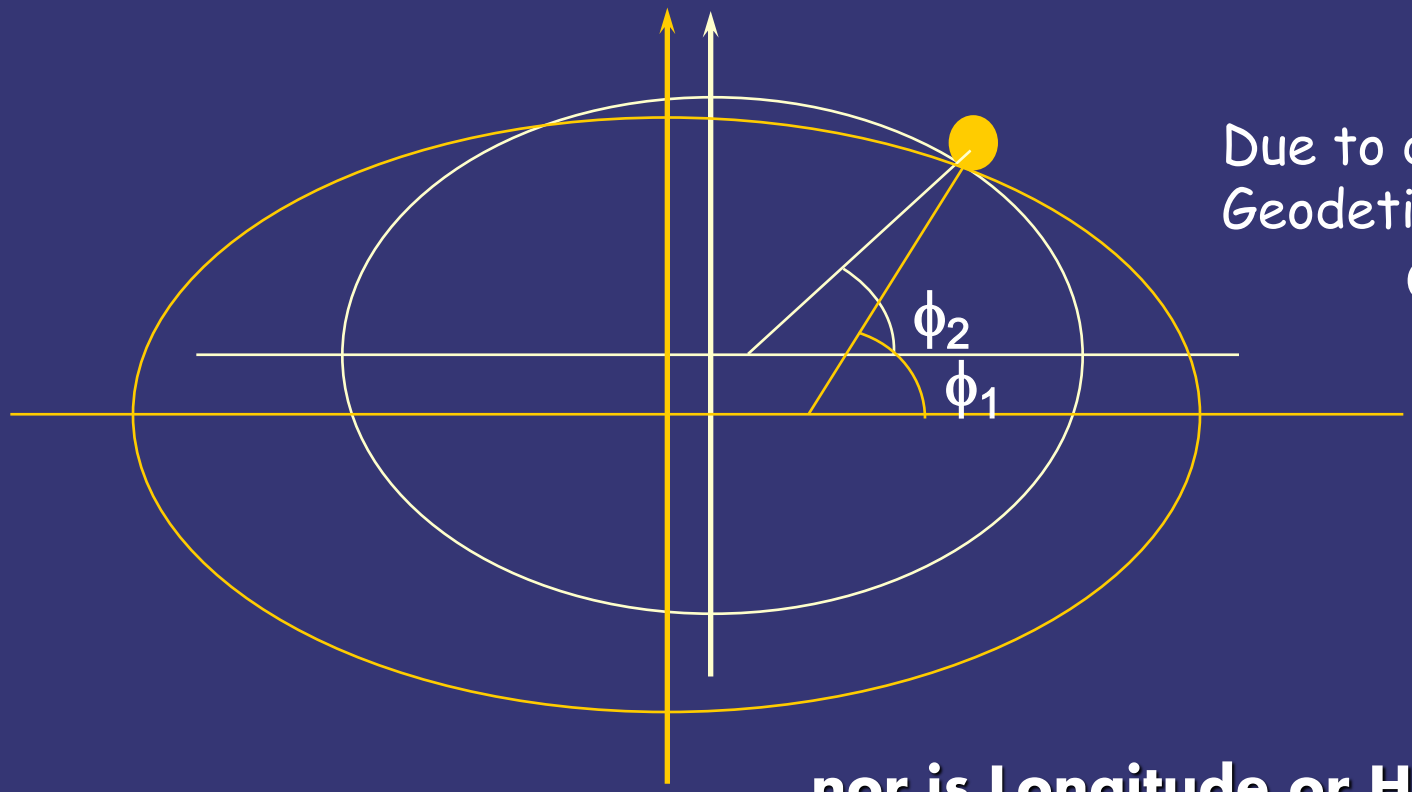


Stereographic projection

Mercator projection



The world is sort-of a sphere
So, latitude is not unique

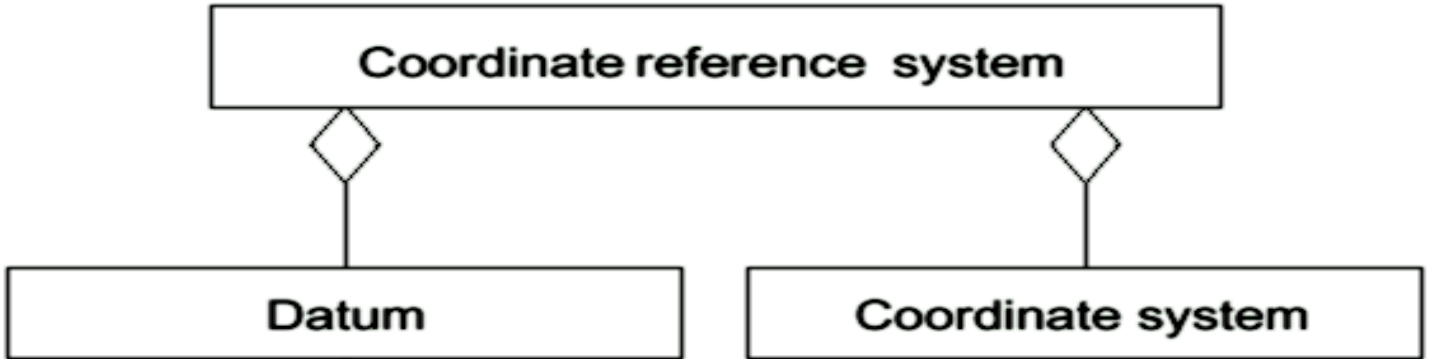


Due to different
Geodetic Datums:

$$\phi_1 \neq \phi_2$$

...nor is Longitude or Height unique

Coordinate Reference Systems



- Coordinate
  - one of a sequence of N numbers designating the position of a point in N-dimensional space
- Coordinate Systems
  - Cartesian 2D and 3D
  - Spherical (3D), Polar (2D)
  - Cylindrical
  - Linear - along a path
  - Ellipsoidal

- Coordinate Reference System
  - coordinate system related to real world by a datum
- Examples
  - Geographic
  - Geocentric
  - Vertical
  - Engineering
  - Image
  - Temporal
  - Derived CRS, e.g., projections

Reference ISO 19111 and OGC Abstract Spec Topic 2

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CRS implementation is confused, but its getting better

- Problems:
  - CRS was not specified
  - CRS was specified but axis order was confused
- Sources:
  - Original ISO/OGC CRS WKT specification
    - Did not define axis order
    - Mutated in the field to deal with other problems
  - People ignored CRS definitions
- Imminent release of **OGC CRS WKT 2.0.1**
  - **"Well known text representation of coordinate reference systems"**
  - Release for Public RFC after updating to 18-010rx

http://www.opengeospatial.org/standards/wkt-crs

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CRS WKT EXAMPLE: Dynamic CRS , ellipsoidal 3D coordinate system

```
GEOGCRS["WGS 84 (G1762)",
  DYNAMIC[FRAMEEPOCH[2005.0]],
  TRF["World Geodetic System 1984 (G1762)",
    ELLIPSOID["WGS84",6378137,298.257223563,LENGTHUNIT["metre
    ",1.0]]],

  CS[ellipsoidal,3],
    AXIS["(lat)",north,ANGLEUNIT["degree",0.0174532925199433]],
    AXIS["(lon)",east,ANGLEUNIT["degree",0.0174532925199433]],
    AXIS["ellipsoidal height (h)",up,LENGTHUNIT["metre",1.0]]

  ID["EPSG",4269],
  REMARK["1986 realisation"]
```

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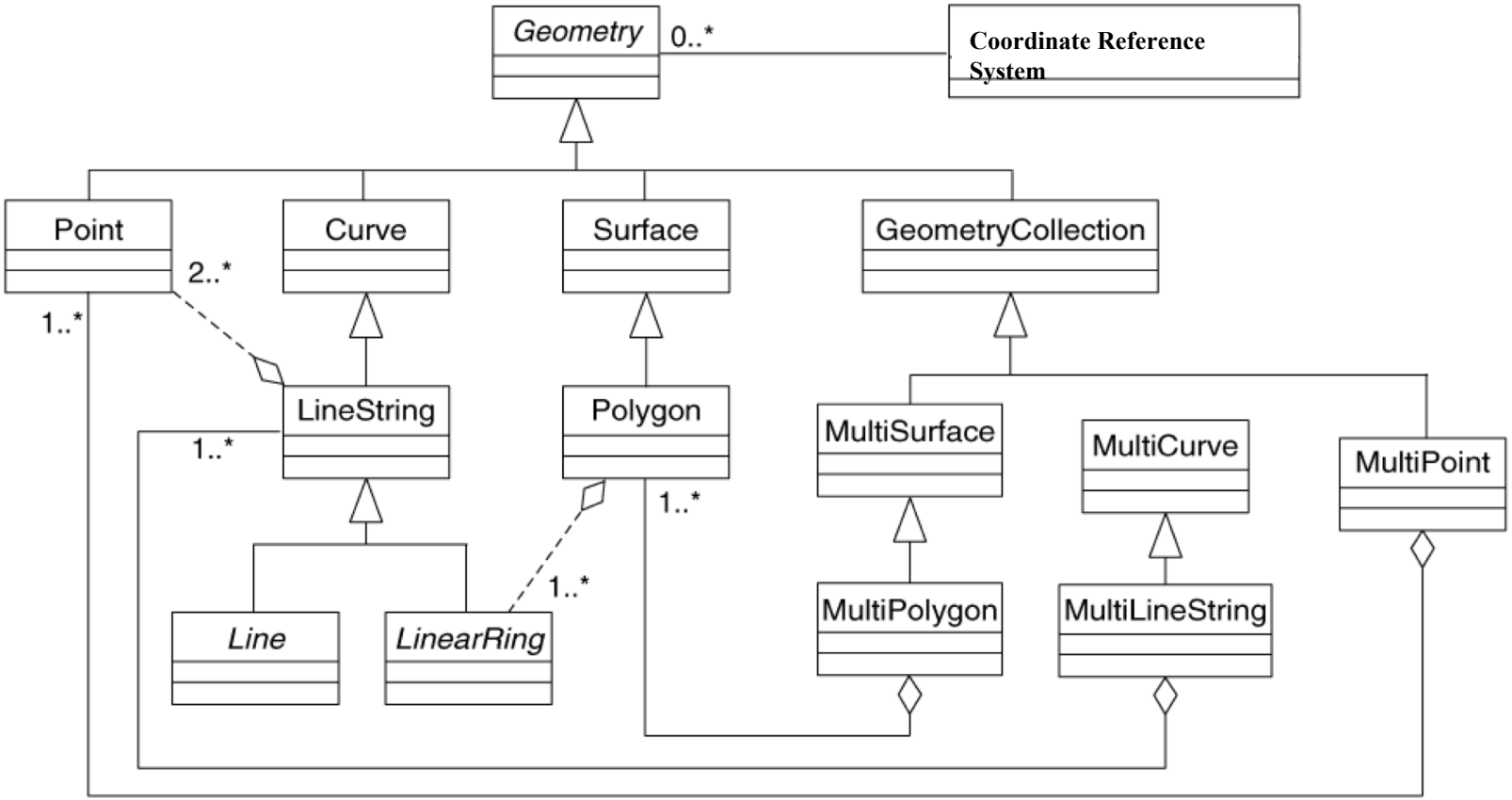
Simple Feature: Geometries



OGC simple features geometries restricted to 0, 1 and 2-dimensional geometric objects that exist in 2-dimensional coordinate space (R2)

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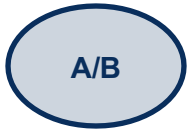
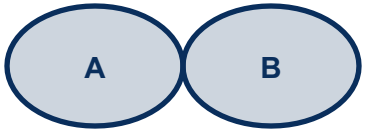
http://www.opengeospatial.org/standards/sfa

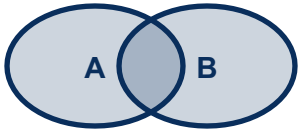
Simple Features: Relations



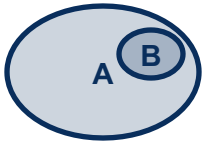
Equals



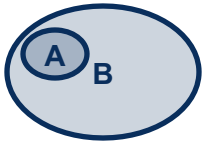
Touches



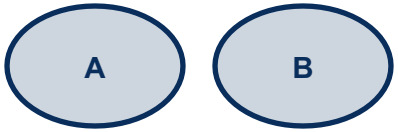
Overlaps



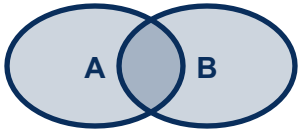
Contains



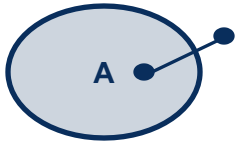
Within



Disjoint



Intersects



Crosses

Defined in Simple Features Access

http://www.opengeospatial.org/standards/sfa

Also defined in GeoSPARQL

http://www.opengeospatial.org/standards/geosparql

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GeoSPARQL for Geo Relations

```
ogcf:relate(geom1: ogc:WKTLiteral, geom2: ogc:WKTLiteral,
            patternMatrix: xsd:string): xsd:boolean

ogcf:sfEquals(geom1: ogc:WKTLiteral,
              geom2: ogcf:WKTLiteral): xsd:boolean

ogcf:sfDisjoint(geom1: ogc:WKTLiteral,
                geom2: ogcf:WKTLiteral): xsd:boolean

ogcf:sfIntersects(geom1: ogc:WKTLiteral,
                  geom2: ogcf:WKTLiteral): xsd:boolean

ogcf:sfTouches(geom1: ogc:WKTLiteral,
               geom2: ogcf:WKTLiteral): xsd:boolean

ogcf:sfCrosses(geom1: ogc:WKTLiteral,
               geom2: ogcf:WKTLiteral): xsd:boolean

ogcf:sfWithin(geom1: ogc:WKTLiteral,
              geom2: ogcf:WKTLiteral): xsd:boolean

ogcf:sfContains(geom1: ogc:WKTLiteral,
                geom2: ogcf:WKTLiteral): xsd:boolean

ogcf:sfOverlaps(geom1: ogc:WKTLiteral,
                geom2: ogcf:WKTLiteral): xsd:boolean
```

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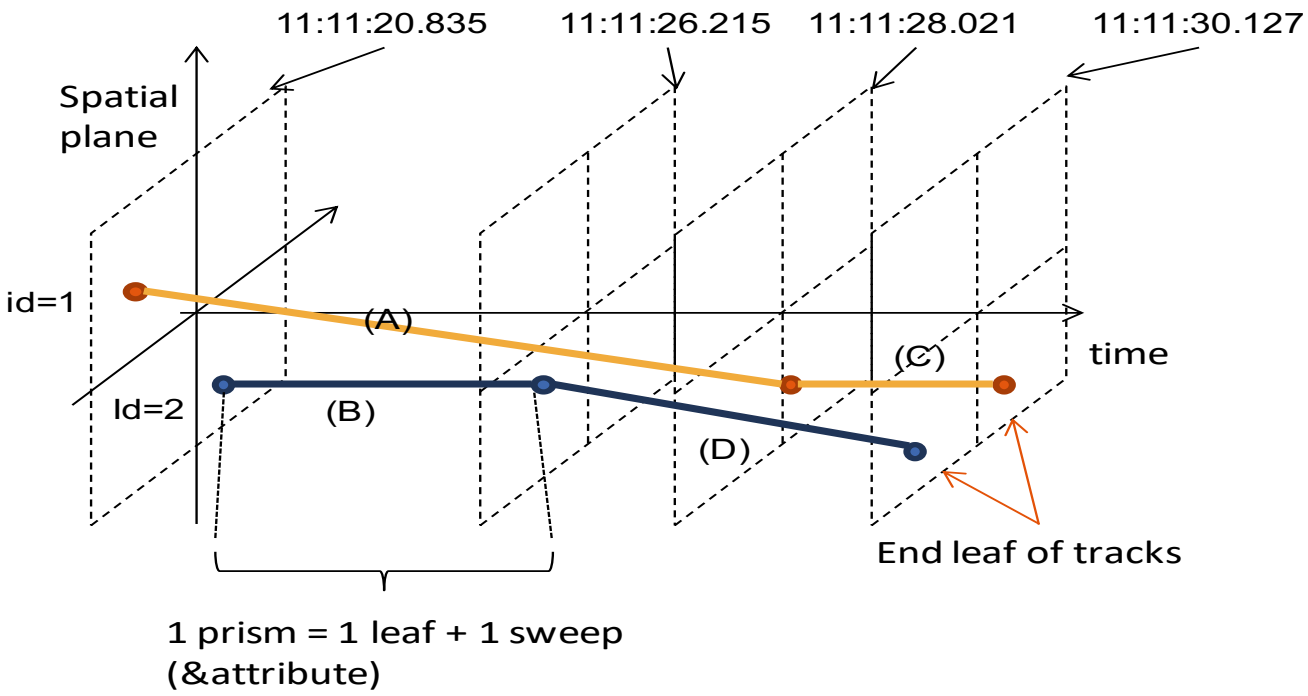
Spatial Temporal Geometry



OGC Moving Features Standard

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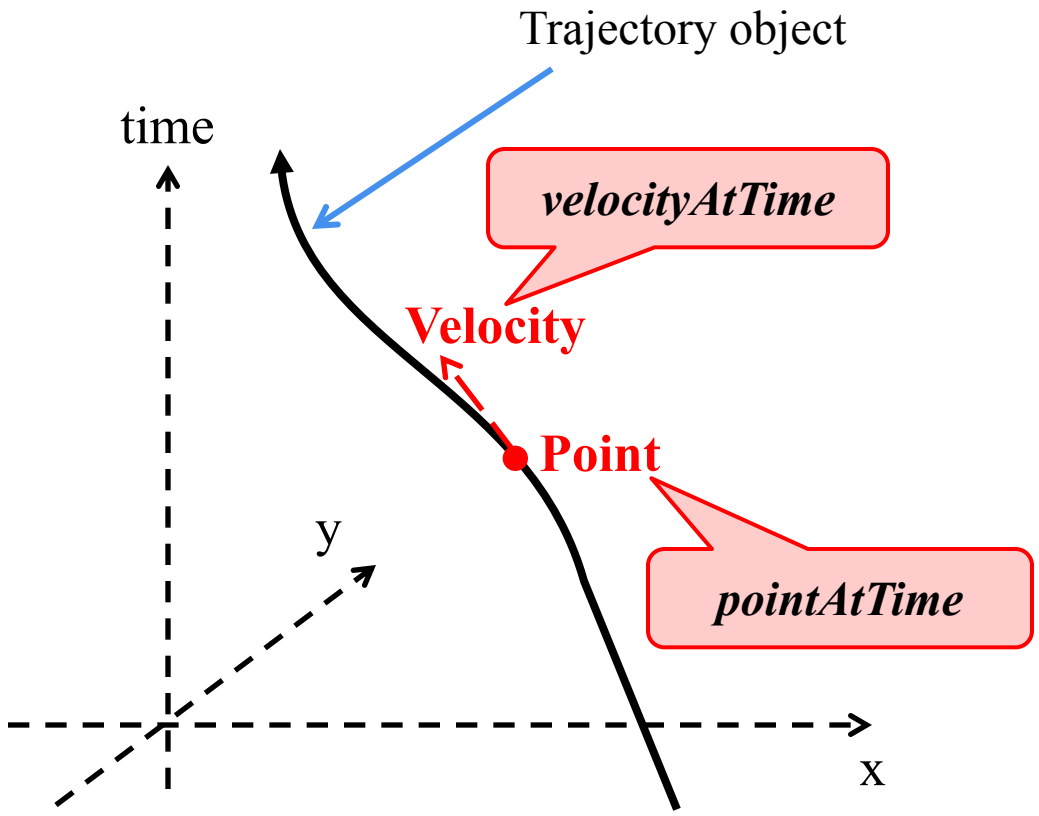
Moving Feature Access - Type A

Retrieval of a feature attribute

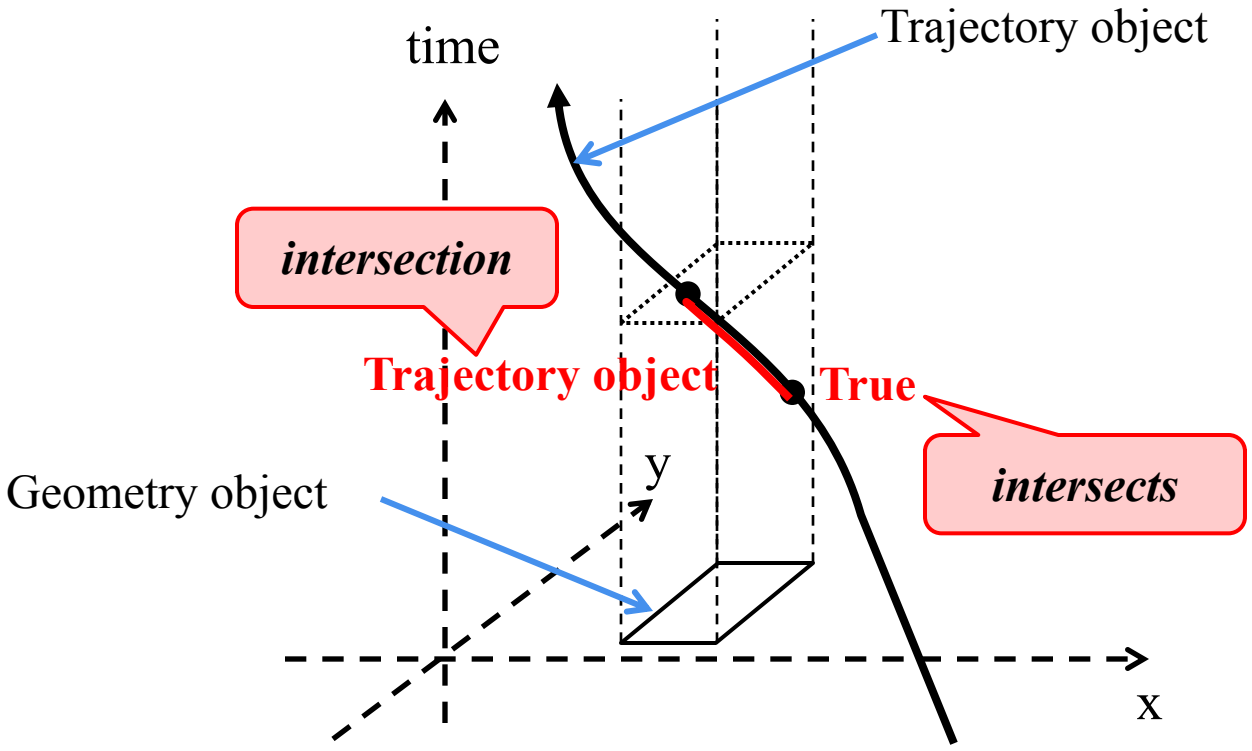
For example, these operations retrieve positions and velocities of a moving feature such as a car, a person, a vessel, an aircraft, and a hurricane.



Moving Feature Access – Type B

Operations between one trajectory object and one or more geometry objects

An example is “intersection” between a geometry object and a trajectory of a moving feature like a car, a person, a vessel, an aircraft, and a hurricane.



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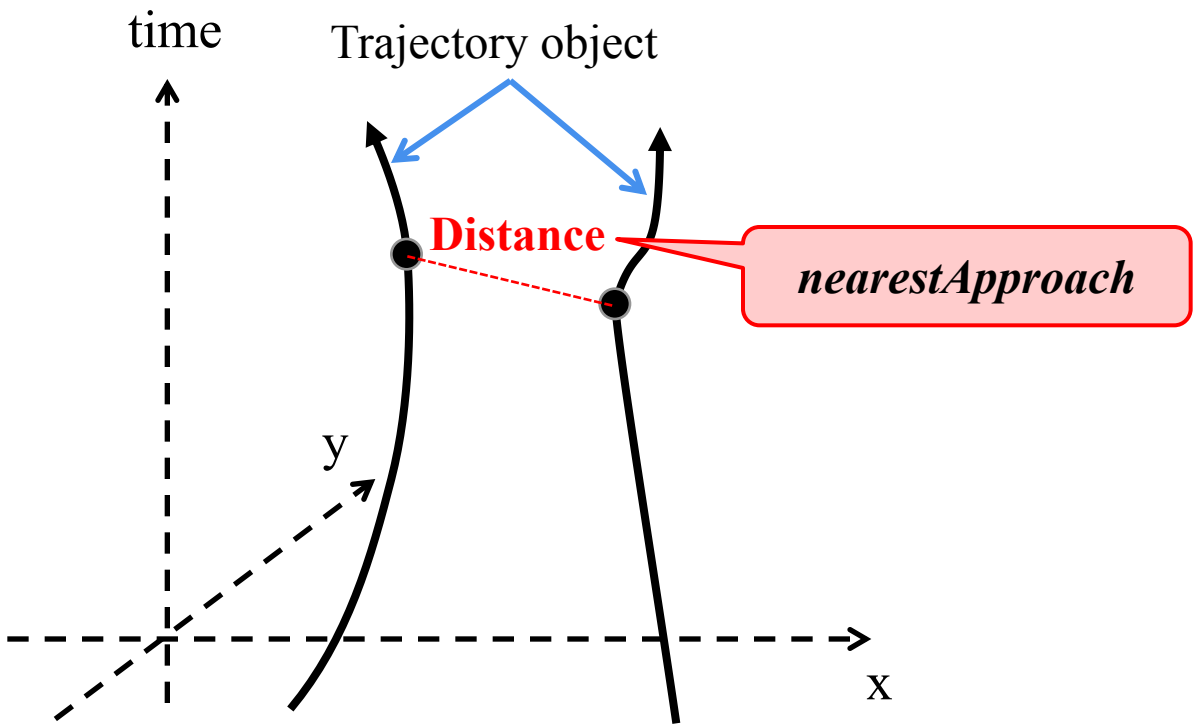
Moving Feature Access - Type C

Operations between two trajectory objects

An example is to calculate a distance of the nearest approach of a trajectory to another trajectory.



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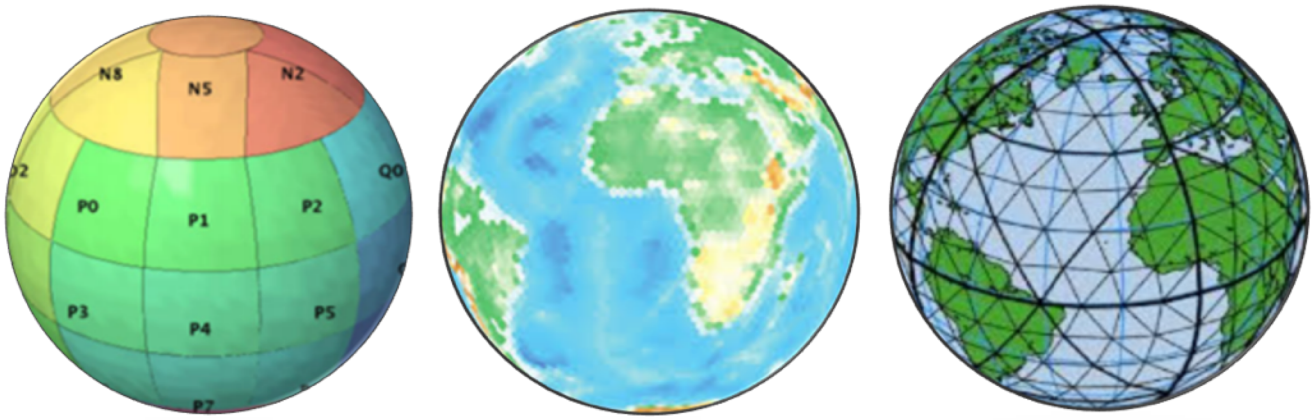
Discrete Global Grid Systems

"…a spatial reference system that uses a hierarchical tessellation of cells to partition and address the globe.

DGGS are characterized by the properties of their cell structure, geo-encoding, quantization strategy and associated mathematical functions."

– OGC DGGS Candidate Standard



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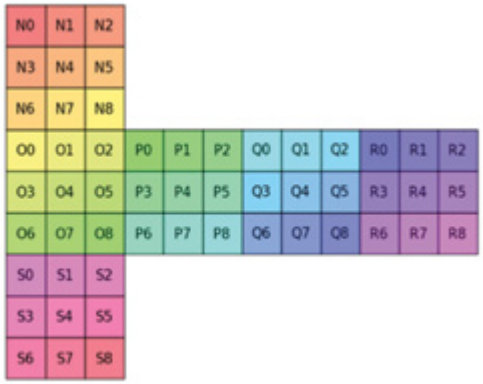
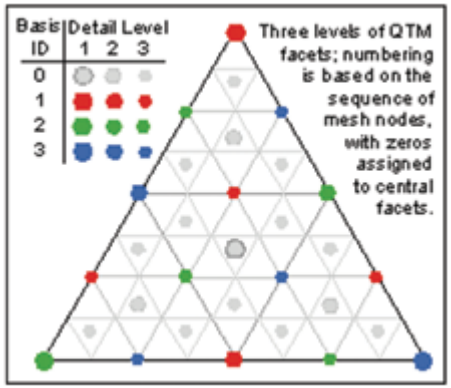
Standardising Discrete Global Grid Systems

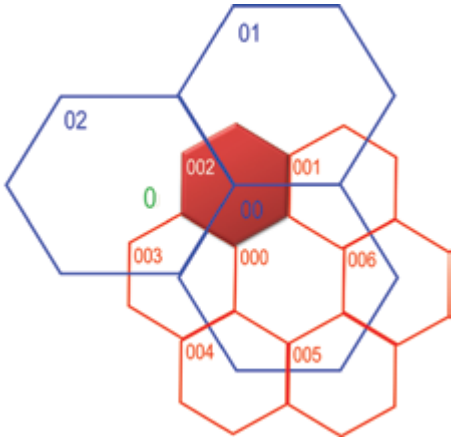
Different Cell Shapes



Square = Familiar



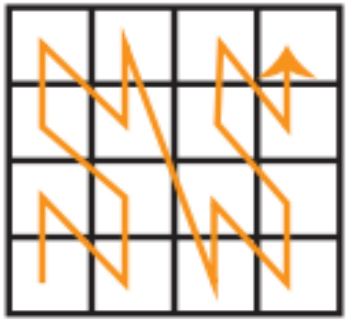
Triangular = Fast

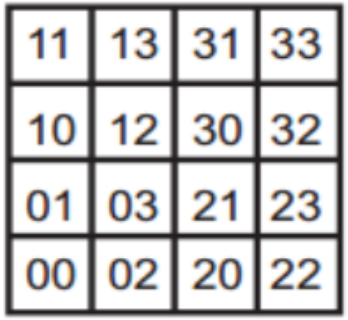


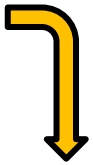
Hexagonal = Fineness of Fit

Unique Cell Indices

- *Hierarchy-based, Space-filling Curve, Axes-based or Encoded Address*







nD Spatial Analyses
↓
1D Array Processes

00	01	02	03	10	11	12	13	20	21	22	23	30	31	32	33

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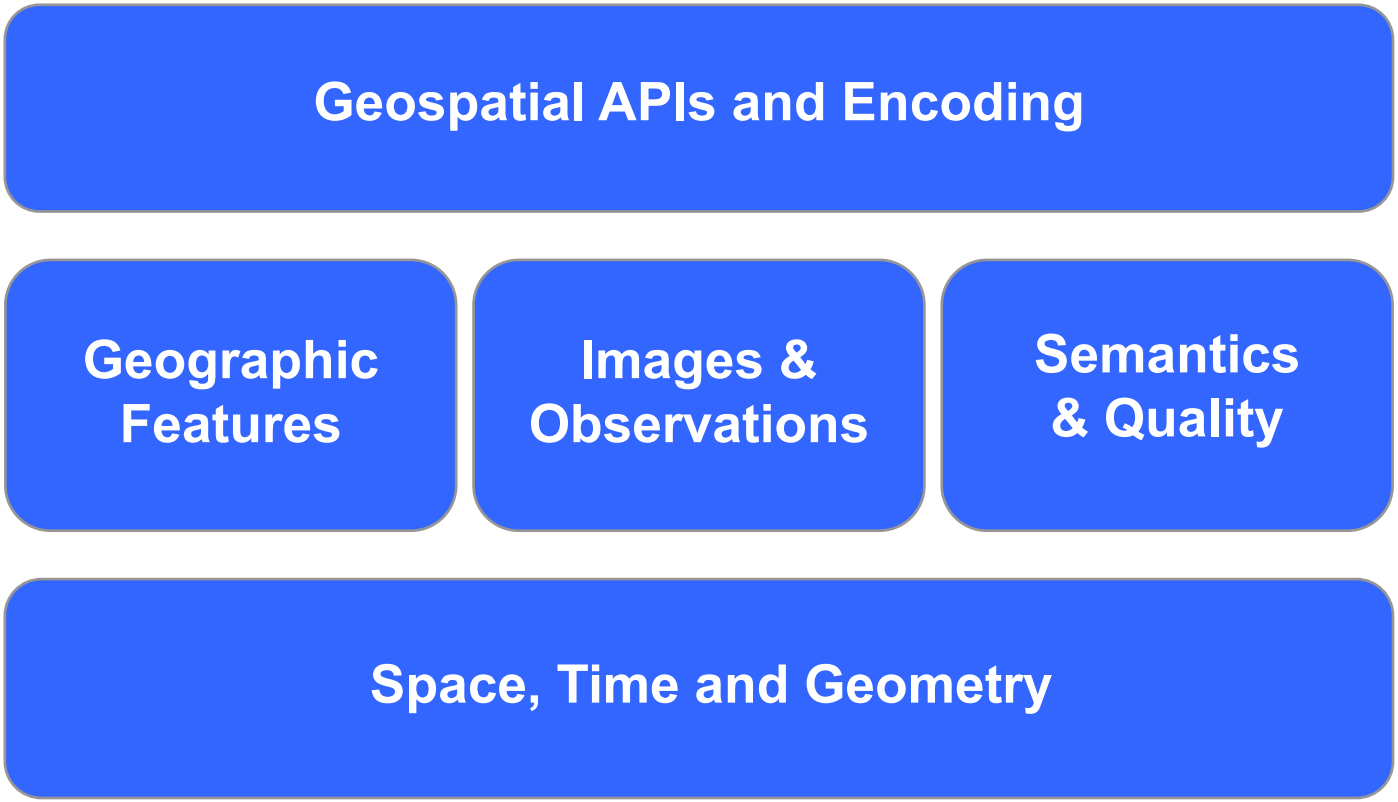
Geospatial APIs and Encoding standards



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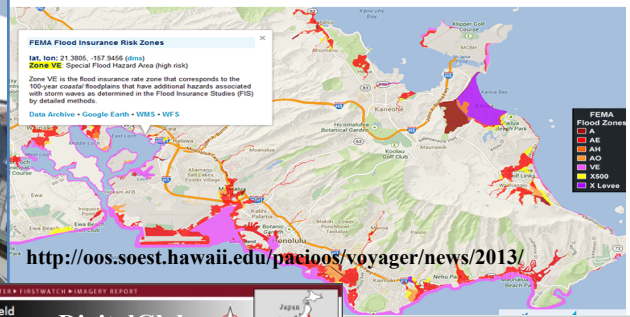
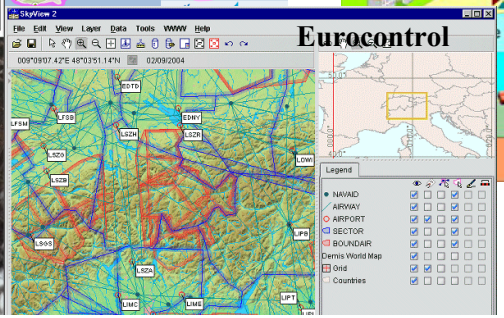
1000s of Services, 100Ks Datasets Worldwide Implement OGC Standards

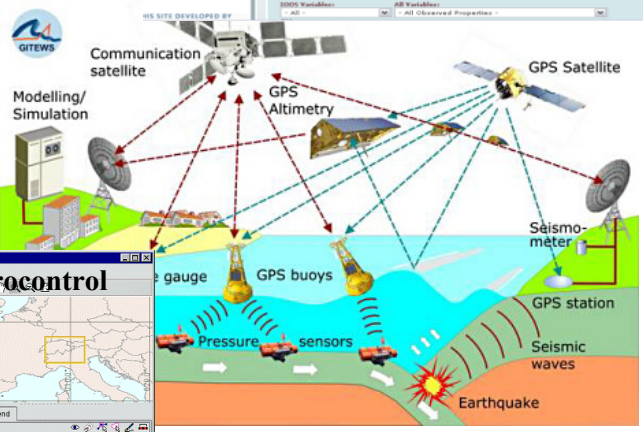
Web Map Service (WMS)
Web Map Tile Servic (WMTS)
Web Feature Service (WFS)
Web Coverage Service (WCS)
KML, GML, GeoPackage
GeoTIFF, NetCDF, HDF



Emergency / Disaster Management



Aviation Flight Information / Safety



Meteorology, Hydrology, Ocean Monitoring

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W3C Working Group Note

TABLE OF CONTENTS

Spatial Data on the Web Best Practices

OGC® Making location count. W3C

W3C Working Group Note 11 May 2017

This version:
https://www.w3.org/TR/2017/NOTE-sdw-bp-20170511/

Latest published version:
https://www.w3.org/TR/sdw-bp/

Latest editor's draft:
https://w3c.github.io/sdw/bp/

Previous version:
https://www.w3.org/TR/2017/NOTE-sdw-bp-20170330/

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OGC/W3C Spatial Data on the Web Best Practice summary

Web principles for spatial data

- Use globally unique persistent HTTP URIs for spatial things
- Make your spatial data indexable by search engines
- Link resources together to create the Web of data

Key spatial aspects

- Use spatial data encodings that match your target audience
- Provide geometries on the Web in a usable way
- Provide geometries on the Web at the right level of accuracy, precision, and size
- Choose coordinate reference systems to suit your user's applications
- State how coordinate values are encoded
- Describe relative positioning

Access

- Use appropriate relation types to link Spatial Things
- Provide information on the changing nature of spatial things
- Expose spatial data through 'convenience APIs'

Metadata

- Include spatial metadata in dataset metadata
- Describe the positional accuracy of spatial data

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Access to Geospatial Resources: WFS 3.0

Table 1. Overview of resources, applicable HTTP methods and links to the document sections

Resource	Path	HTTP method	Document reference
Landing page	/	GET	7.2 API landing page
API definition	/api	GET	7.3 API definition
Conformance classes	/conformance	GET	7.4 Declaration of conformance classes
Feature collections metadata	/collections	GET	7.11 Feature collections metadata
Feature collection metadata	/collections/{name}	GET	7.12 Feature collection metadata
Feature collection	/collections/{name}/items	GET	7.13 Feature collections
Feature	/collections/{name}/items/{fid}	GET	7.14 Feature

information about the API

a dataset with a sub-division into named collections of features

the features

https://cdn.rawgit.com/opengeospatial/WFS_FES/3.0.0-draft.1/docs/17-069.html#tldnr

Only the feature resources are specific to a “feature service”

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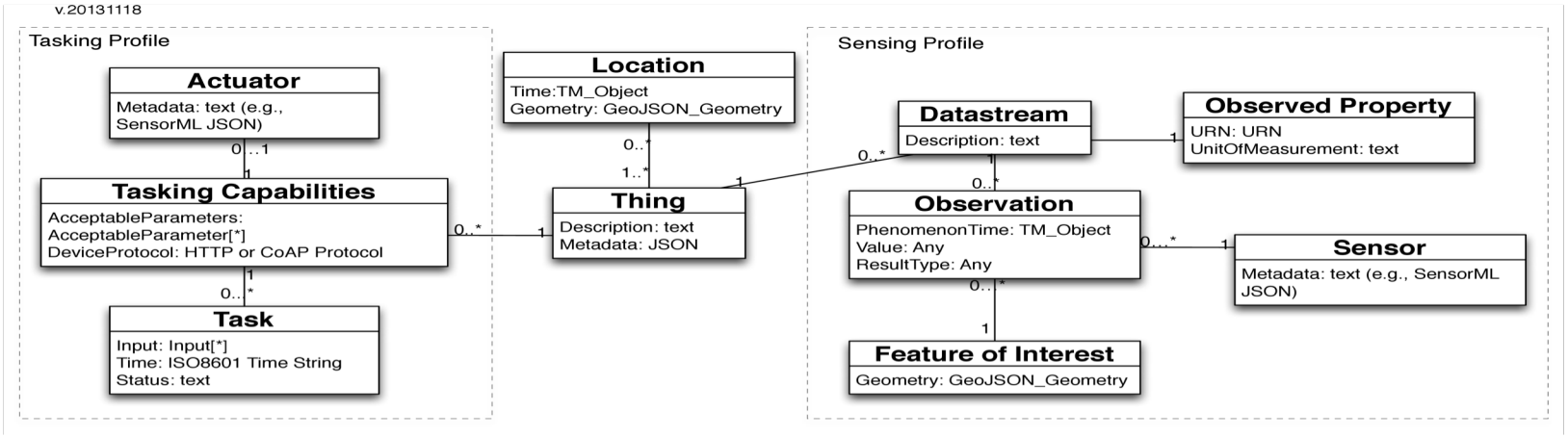
OGC SensorThings for IoT

- Accessing observations from Internet of Things
- Builds on OGC Sensor Web Enablement (SWE) standards that are operational around the world
- Builds on Web protocols; easy-to-use RESTful style
- MQTT for pub/sub



http://www.opengeospatial.org/standards/sensorthings

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GeoPackage

- GeoPackage is a universal file format for geodata.
  - open, standards-based, application and platform independent, and self-describing.
  - Works on any desktop or mobile OS
  - *Connected / limited / disconnected environment use*

- GeoPackage - the modern alternative to formats like GeoTIFF, SDTS and vendor specific

- *Experience it here:* http://www.ogcnetwork.net/geopackage

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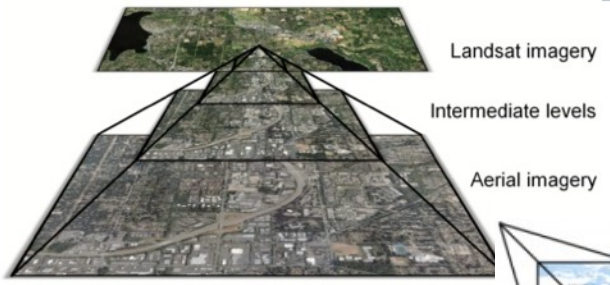
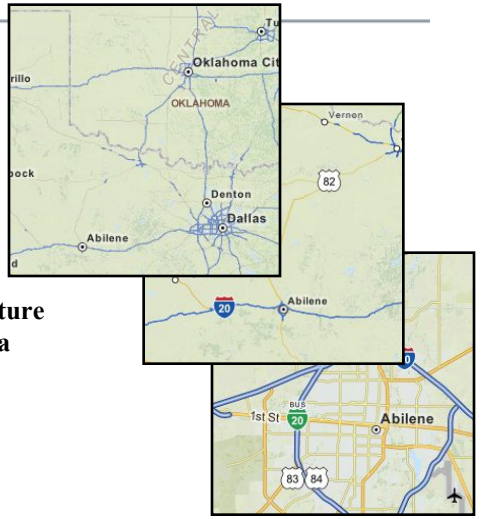
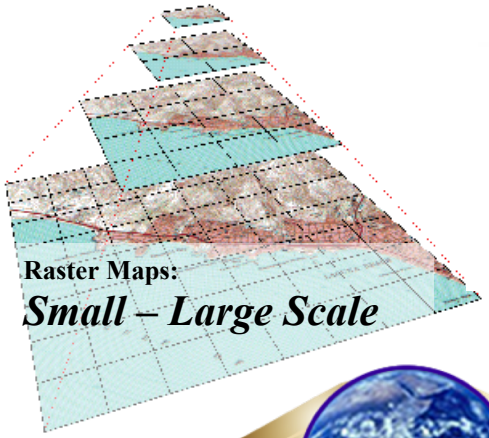
GeoPackage:
Raster Maps, Images and Feature Data in One File



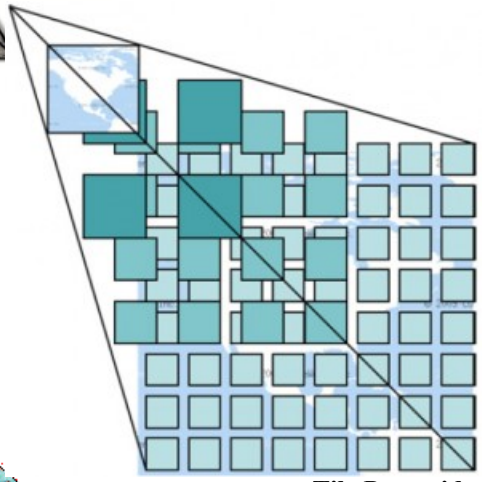
Imagery
Low – High Resolution



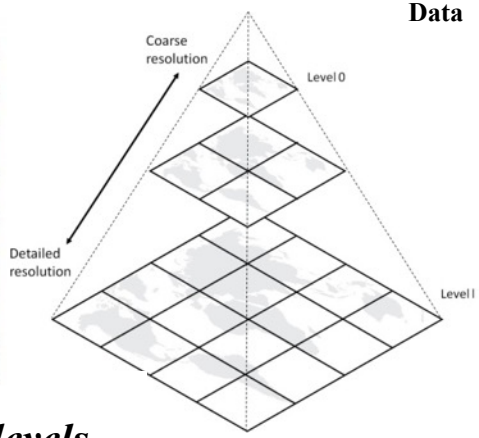
Feature Data



Raster Maps:
Small – Large Scale



Tile Pyramids
24 zoom levels



Single File Sqlite Database
containing all data for direct-use on mobile platforms & handheld devices

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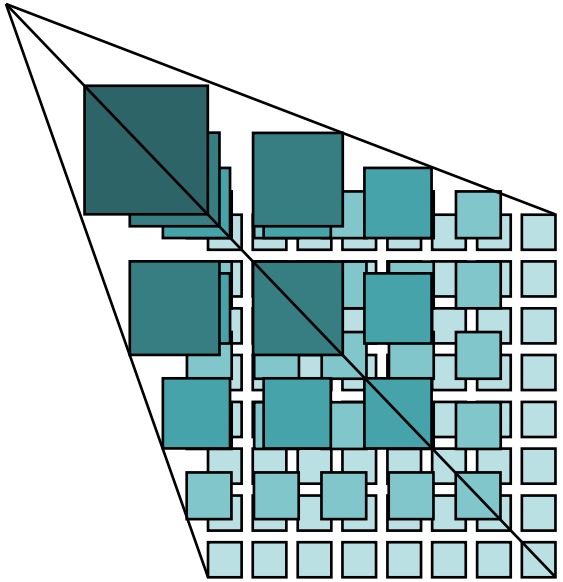
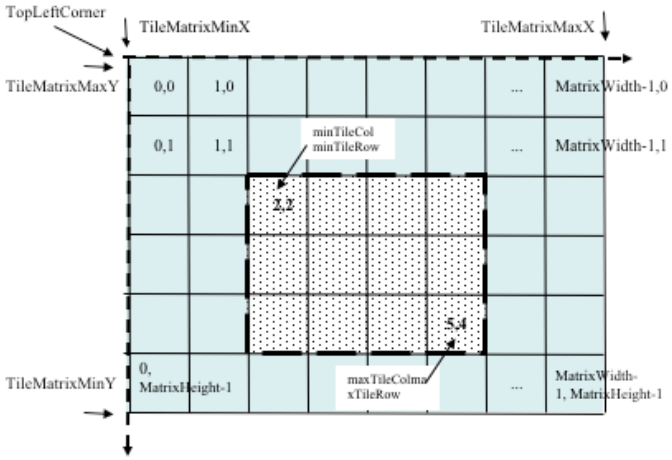
OGC Tile Matrix Set Standard

- Indexes space as regular grids with scales in a CRS
- JSON and XML encodings
- For global projections and specific regions.



Tile Matrix Set originally defined in WMTS
- Being finalized as a stand alone spec
- Reuse in several standards, e.g., GeoPackage

Example of OGC Building Block approach



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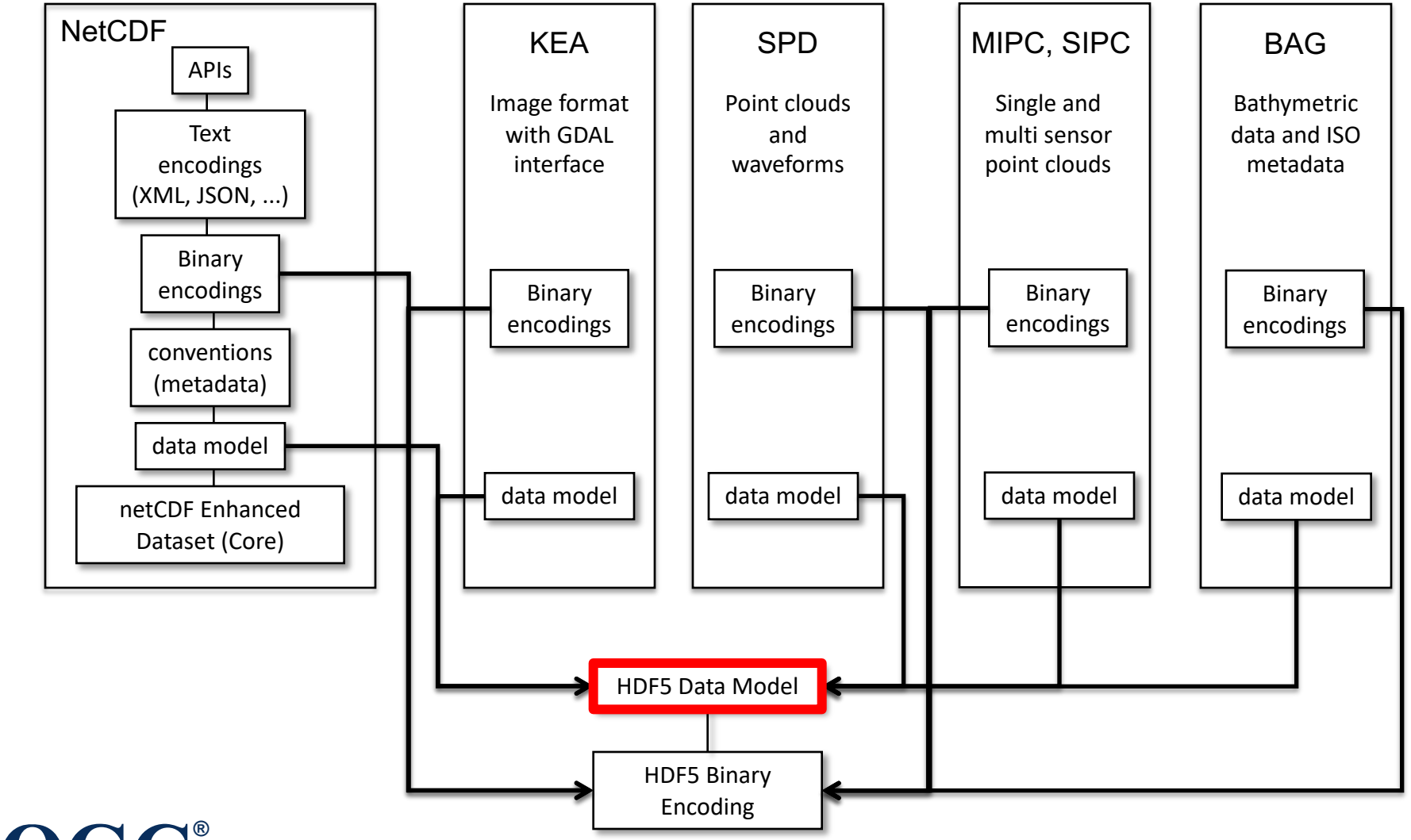
HDF, NetCDF, other large data formats



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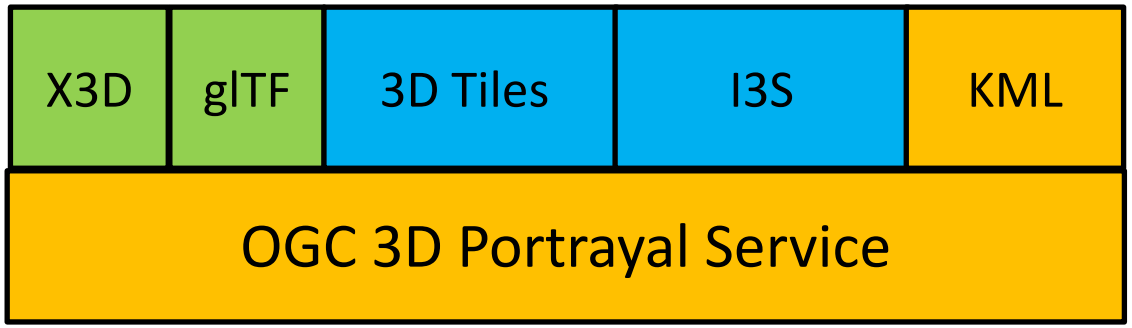
3D Geospatial Visualization

Berlin with 3D and Textures for Visualization

New York City portayal of attributes

The approach: Support multiple 3D data formats



Content Delivery

Query

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ACTIVITIES FOR GEOSPATIAL COORDINATION

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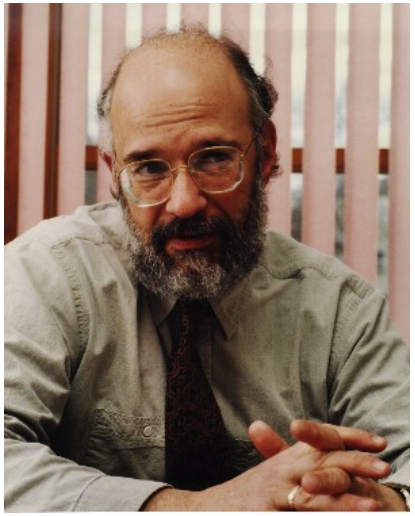
"*Interoperability seems to be about the integration of information. What it's really about is the coordination of organizational behavior*."

David Schell
Chairman (Emeritus)
and Founder OGC



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Geospatial and ASF

- Apache Big Data 2016 – Vancouver
  - geospatial session
  - Geospatial BoF
  - mailing list established: geospatial@apache.org.
- Apache Europe 2016 - Seville
  - Geospatial Track
- ApacheCon NA 2018 - Montreal
  - Geospatial Track today
  - Geospatial BoF – this evening
- Where to?

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Geospatial Track at ApacheCon NA September, 2018

- Which geospatial API for the cloud?
  - Martin Desruisseaux
- Spatial index optimization using Lucene index and GIS query support
  - Jinchul Kim, Navis
- Spatial query on vanilla databases – Apache Calcite
  - Julian Hyde
- Interacting with Billions of National Water Model (NWM) Predictions using Apache Kafka and MapD
  - Aaron Williams, Ben Lewis MapD
- Apache Spark MLib applied to geospatial imagery for flood indication
  - Tom Landry, CRIM
- Geospatial data and processing in Apache projects
  - George Percivall

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APACHECON

Apache Topology T-Shirt

SIS, Calcite, Lucene/Solr, **Marmotta**,
Open Climate Workbench

Incubating: Druid, SDAP

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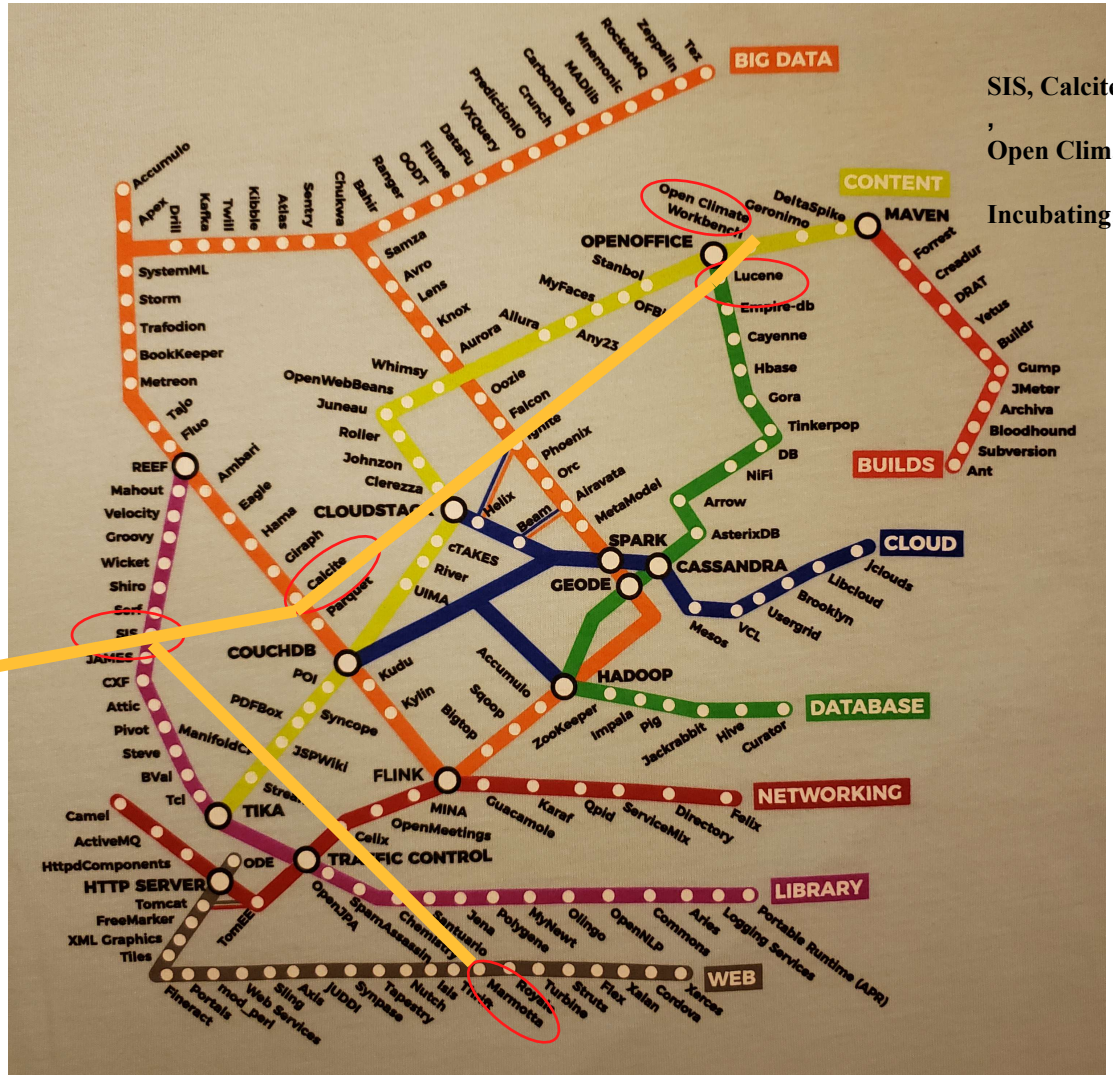
Apache Topology with Geospatial



GEOSPATIAL

SIS, Calcite, Lucene/Solr, **Marmotta**,
Open Climate Workbench

Incubating: Druid, SDAP

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Geospatial Coordination

- Apache Project actions
  - Add “geospatial” as Category in your project’s DOAP file
  - Identify someone from your project to join geospatial@apache
- geospatial@apache.org
  - Geospatial events announcements
  - Communicate new geospatial standards
- Promote your Project if it implements OGC standards
  - http://www.opengeospatial.org/resource/products/registration
  - Reference implementations
- Co-locate Apache Roadshow at an OGC TC Meeting
- Apache VP for OGC relations

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