GeoSPARQL and 3D

The road ahead

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What is GeoSPARQL?

- Semantic Web Standard by the Open Geospatial Consortium (OGC)
- Core Ontology for representation of
  - Geospatial Features
  - Geometries
  - Their attributes
  - Their relations towards each other
  - Their serializations
- Extension to the SPARQL query language:
 - Query geometries and their relations

Background

- 2012: GeoSPARQL 1.0 released
- 2019: Efforts to reestablish GeoSPARQL working group
- 2020: Charter and Working Group start
- 2021: GeoLD Workshop: Ideas towards GeoSPARQL 1.1
- 2022: MDPI Paper: GeoSPARQL 1.1: Motivations, Details and Applications of the Decadal Update to the Most Important Geospatial LOD Standard
- 2023: Approval of GeoSPARQL 1.1 by OGC
- 2024: Formal publication
- Now: Gathering requirements and demands for the next iteration of GeoSPARQL
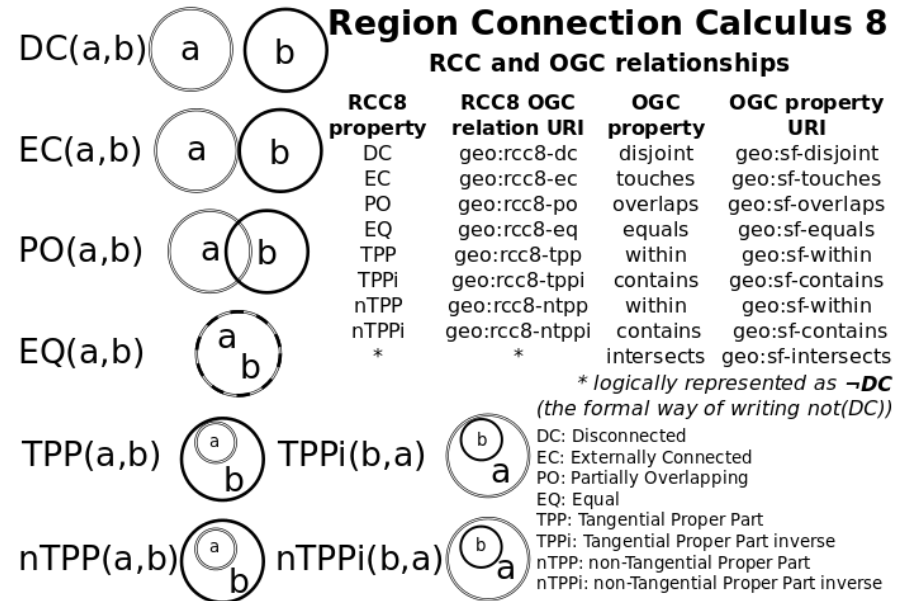
GeoSPARQL 1.0 Ontology

- Core Ontology for geospatial features and geometries
- Simple Feature Vocabulary for Geometry Types
- Geometry Serializations (WKT and GML)
- Properties for Geometry Relations:
  - Egenhofer Relations (DE-9IM)
  - RCC8 Relations
  - Simple Features Relations
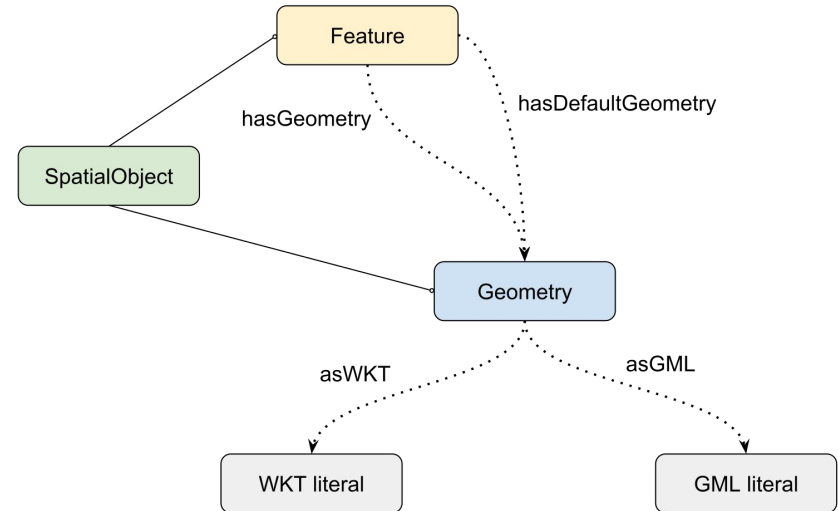
[GeoSPARQL 1.0 Documentation]

GeoSPARQL 1.0 Query Language

- Topological relations as query functions
  - RCC8
  - Egenhofer Relations (DE-9IM)
  - Simple Features Relation
- Some functions of the SF family:
  - geof:buffer
  - geof:distance
  - geof:envelope
  - geof:dimension
  - geof:union
- GeoSPARQL 1.0 only supports **2.5D** geometries

Region Connection Calculus 8
RCC and OGC relationships

DC(a,b)

EC(a,b)

PO(a,b)

EQ(a,b)

TPP(a,b) TPPi(b,a)

nTPP(a,b) nTPPi(b,a)

RCC8 property	RCC8 OGC relation URI	OGC property	OGC property URI
DC	geo:rcc8-dc	disjoint	geo:sf-disjoint
EC	geo:rcc8-ec	touches	geo:sf-touches
PO	geo:rcc8-po	overlaps	geo:sf-overlaps
EQ	geo:rcc8-eq	equals	geo:sf-equals
TPP	geo:rcc8-tpp	within	geo:sf-within
TPPi	geo:rcc8-tppi	contains	geo:sf-contains
nTPP	geo:rcc8-ntpp	within	geo:sf-within
nTPPi	geo:rcc8-ntppi	contains	geo:sf-contains
*	*	intersects	geo:sf-intersects

* *logically represented as ¬DC (the formal way of writing not(DC))*

DC: Disconnected
EC: Externally Connected
PO: Partially Overlapping
EQ: Equal
TPP: Tangential Proper Part
TPPi: Tangential Proper Part inverse
nTPP: non-Tangential Proper Part
nTPPi: non-Tangential Proper Part inverse

GeoSPARQL 1.1 Ontology

- **New Classes for Collections**
    - SpatialObjectCollection
    - FeatureCollection
    - GeometryCollection
- **New Literal Types**
    - GeoJSON Literal (only WGS84)
    - KML Literal
    - DGGS Literal
- **New Measurement Properties**
    - has{Metric}Area
    - has{Metric}Length
    - has{Metric}PerimeterLength
    - has{Metric}Size
    - has{Metric}Volume
- **Geometry Relation Properties**
    - hasCentroid
    - hasBoundingBox
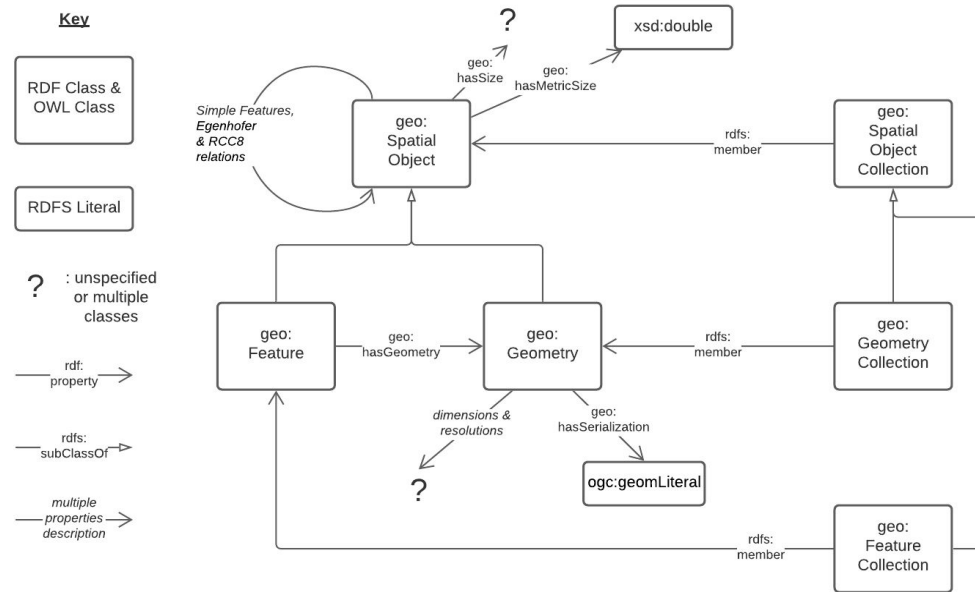
[GeoSPARQL 1.1 Ontology]

GeoSPARQL 1.1 Query Language

Main updates of query functions:

- Spatial Aggregate Functions
  - geof:aggBoundingBox, geof:aggBoundingCircle, geof:aggCentroid, geof:aggConcaveHull, geof:aggConvexHull, geof:aggUnion
- Metric Functions
  - geof:{metric}area, geof:{metric}buffer}, geof:{metric}Distance, geof:{metric}Length, geof:{metric}Perimeter
- Coordinate Accessors:
  - geof:minX, geof:maxX, geof:minY, geof:maxY, geof:minZ, geof:maxZ

GeoSPARQL 1.1 SHACL Validation

Introduction of SHACL Shapes for Graph
Validation

- 23 Shape Categories
- Checking consistency of the graph
- No check of Geometry literal contents

[GeoSPARQL 1.1 SHACL Shapes]

Example:

"Each node with an incoming geo:hasGeometry, or a
specialization of it, can have a maximum of one outgoing
geo:asWKT relation."

GeoSPARQL 1.1: Further Updates

- SPARQL Service Descriptions: Exposing GeoSPARQL capabilities to users
- Formal description of the standard (W3C Profiles Vocabulary)
- CQL Mapping for implementers creating middleware
- Official JSON-LD contexts for GeoSPARQL 1.1 and the Simple Features Vocabulary
- GeoSPARQL 1.1 translations into German, Dutch and French (still ongoing)
- Modeling of all GeoSPARQL requirements in RDF

GeoSPARQL 1.2

- An ISO-compatible version of GeoSPARQL 1.1
- Awaiting ISO adoption
- Process can begin now that GeoSPARQL 1.1 is published
- Changes requested by ISO might become a GeoSPARQL 1.1 revision (GeoSPARQL 1.1.1)

GeoSPARQL 1.3 Planned Scope

- Fully-featured 3D support:
  - Query functions for 3D representations
  - Property relations between 3D geometries
  - Vocabulary and relations for different 3D geometry types
- Add Semantics for CRS:
  - Prepare GeoSPARQL for the adoption of a CRS ontology model
  - CRS ontology is in development in parallel
  - Could be adopted as a JSON-LD context for PROJJSON
- Basic description of geometry visualizations
  - Minimum: Literals which express the visualization of geometry instances (e.g. CSS)
  - Better: Classes and concepts for geometry visualizations in certain contexts
- Definition of basic Geometry roles
  - Geometry roles with respect to other semantic things should be describable
- Additions to GeoSPARQL 1.1:
  - Add missing Simple Feature Access Functions to GeoSPARQL
  - Functions for geometry simplifications
  - Concepts for accurracies and tolerances

[GeoSPARQL 1.3 Github Project]

GeoSPARQL 1.3 (Development Version)

- Already there:
    - Complete all Functions in OGC SF Spec (PR #408)
    - Introduction of Geocode Literals (PR #466)
    - Latitude and Longitude Functions (PR #526)
    - More Non-SFA Functions (PR #414)
- In Draft:
    - Basic Feature Style Description
    - Ideas for textures
- Planned:
    - Updated mappings to other ontologies
    - Extension for Geometry Roles (planned)
    - Extension for Fuzzy Geometries
        - Nick presented at GeoLD 2024

Geocode Literal of a GeoHash:

```
PREFIX geo:
<http://www.opengis.net/ont/geosparql#>

<https://w3id.org/geohashes/geohash>
    "r7hue3x9jepv"^^geo:geocodeLiteral .
```

Related Work: Standardization of a CRS Ontology

- Three vocabularies exist ([ISO19111](#), [IGN France](#), [Proj4RDF](#))
- Work on consolidation of vocabularies has started
- Intended results:
  - One CRS core ontology
  - A number of extension vocabularies for CRS parts (e.g. projection types)
  - Convertibility to other CRS formats [PROJ](#), [WKTCRS](#), [PROJJSON](#)
  - Implementation in at least one library/triple store
- Gains:
  - CRSs can be defined alongside data
  - CRS can be provided in RDF
  - Semantics of CRS may be exploited in SPARQL queries

[CRS Ontology Position Paper]

Timeline:

- From September: Regular Meetings
- End of the year: First release
- Spring 2025: Prototype and Review of the proposal
- Spring/Summer: Begin standardization process if needed

GeoSPARQL 1.3: 3D Work

- Goal: Fully-featured 3D support
- To be done:
  - Define relations between 3D geometries
  - Define query functions for 3D relationships
- Initial survey on related work in 3D relations is underway
- Challenges
  - Contact target communities to supply requirements
    - You!
  - Which data formats are relevant to cover?
  - What logic can be used to define the function set?

[Issue #518: Describe conceptual handling of 3D]

3D Use Cases: Artifacts

- 3D Artifacts (Meshes)
- Annotations in 3D (Volumes)
- Alignment to [IIIF 3D specifications](#)
- Georeferenced artifacts
- Relations between parts of 3D meshes and relations to other 3D meshes in the same coordinate space (possibly scene graph)
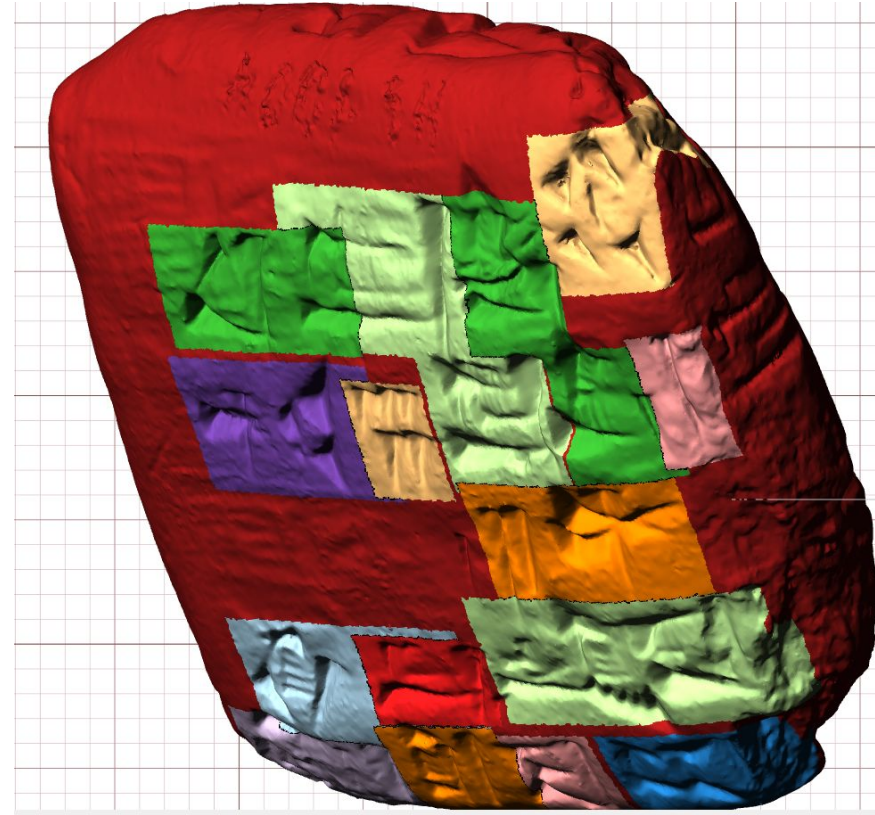
More proposed use cases

- ANZ 3D Cadastre: 3D geometry representation, topological relations
- Stratigraphy: Specilised 3D topological relations
- Soil Modelling: Specialised 3D topological relations
- Archaeology: Specialised 3D topological relations
- **Building modelling: 3D geometry representation and topological relations**

[Issue #519: Demonstrate 3D handling for different communities]

Your input

- What do you expect from the GeoSPARQL 3D extension?
- How do you think GeoSPARQL should integrate with Linked Building Data?
- How can we help?
- Let us discuss!

Template for 3D use cases will be published

- Inputs will be the basis of us consolidating the vocabulary and query functions
- You are very welcome to join us in the standardization effort

Thank you very much for your attention