GeoSPARQL 1.1: an almost decadal update to the most important geospatial LOD standard

Nicholas J. Car[1 [0000-0002-8742-7730]],
Timo Homburg[2 [0000-0002-9499-5840]], and
Simon J.D Cox[3 [0000-0002-3884-3420]]

[1] SURROUND Australia Pty Ltd., Brisbane Australia &
Australian National University, Canberra Australia
nicholas.car@surroundaustralia.com
https://surroundaustralia.com

[2] Mainz University Of Applied Sciences, Germany
timo.homburg@hs-mainz.de

[3] Commonwealth Scientific & Industrial Research Organisation, Australia
simon.cox@csiro.au

Abstract. The Open Geospatial Consortium published the GeoSPARQL 1.0 standard [5] in 2012 containing multiple parts that define "SPARQL extension functions", "RIF rules"[8], "an RDF/OWL ontology for information based on the General Feature Model" and supporting vocabularies, all for Semantic Web spatial data.

In the 8+ years since its publication, GeoSPARQL has become the most important spatial Semantic Web standard, as judged by references to it in other Semantic Web standards and its wide use in Semantic Web data.

An update to the standard was proposed in 2019 to deliver GeoSPARQL 1.1 in 2021 with a charter[2] to: handle outstanding change requests and source new ones from the GeoSPARQL user community as well to "better present" the standard, that is to better link all the standard's parts and better document & exemplify elements. Expected updates included possible alignments to other ontologies, possible handling of new spatial referencing systems, new geometry representations, and new artifact presentation.

In this paper, we will discuss the submitted change requests and resulting updates to the standard. We will also discuss the theory behind updates and our expectations for GeoSPARQL 1.1's use.

Keywords: GeoSPARQL · GeoSPARQL 1.1 · spatial · geospatial · Semantic Web · RDF · OWL · OGC · Open Geospatial Consortuim · standard.

1 Introduction

2 Motivation to Update GeoSPARQL

Spatial Data On The Web Best Practices [3] GeoSPARQL White Paper [1] https://www.w3.org/2015/spatial/wiki/Further_development_of_GeoSPARQL

3 New features in GeoSPARQL 1.1

GeoSPARQL 1.1 includes non-breaking changes to the GeoSPARQL 1.0 standard.

3.1 New geometry literals

GeoSPARQL 1.1 introduces three new literal types: A GeoJSON[4] literal, a KML[10] literal, and a DGGS[11] WKT Literal.

Listing 1.1. GeoJSON literal example

```
"{\"type\":\"Point\",␣\"coordinates\":[-83.38,33.95]}"
^^<http://www.opengis.net/ont/geosparql#geoJSONLiteral>
```

Since the GeoJSON and KML formats are restricted to be represented in the WGS84 coordinate system only, these restrictions also apply to GeoJSON and KML literals. The DGGS WKT literal

3.2 Spatial aggregate functions

GeoSPARQL 1.1 includes new spatial aggregate functions, which allow for the quick aggregation of different geometry types. While spatial aggregate functions are the norm in many non-semantic geospatial databases such as POSTGIS or Oracle Spatial, at the time of defining the GeoSPARQL 1.0 standard, aggregate functions had not yet been introduced into the SPARQL standard since SPARQL 1.1 [12] was released about one year later. Spatial aggregate functions similar to traditional aggregate functions such as AVG,MAX, or MIN allow to aggregate results of geometry queries, e.g., to create the union out of a set of given geometry literal results. While calculating these aggregates may also be possible outside of the semantic database, the inclusion of the functions provides distinct advantages:

1. No client-side library is needed to create an aggregated geometry result
2. Fewer and more appropriate results can be returned using a spatial aggregate function (e.g., a single union geometry vs. a set of geometries for which to create union externally)
3. Spatial aggregates from different SPARQL endpoints can easily be calculated using federated queries

GeoSPARQL 1.1 defines the aggregate functions *geosf:boundingCircle*, calculating a bounding circle around a set of geometry, *geosf:centroid* calculating the centroid of the set of geometries, *geosf:concatLines* concatenating a set of linestrings that overlap, *geosf:concaveHull* calculating the concave hull of a set of geometries and*geosf:union*, calculating the union of a set of geometreis, in addition to the *geosf:envelope* and *geosf:convexHull* functions already defined in the GeoSPARQL 1.0 standard. Since SPARQL 1.1 these fucntions were also usable as aggregate functions. Spatial aggregate function definitions are accompanied by the functions *geof:maxX*, *geof:maxY*, *geof:maxZ* and *geof:minX*, *geof:minY*, *geof:minZ* which allow to retrieve the minimum and maximum coordinates of a geometry respectively.

3.3 Extensions of the GeoSPARQL ontology

GeoSPARQL 1.1 extends the GeoSPARQL ontology by adding a new class geo:SpatialMeasure. This class represents a measurement such as a volume, length, or area associated with a measurement amount and a measurement unit. It acts as a range of three newly defined properties geo:hasArea, geo:hasLength, geo:hasVolume which make these attributes of a geometry better accessible using SPARQL. Finally, GeoSPARQL 1.1 adds the geo:inCRS property, which allows querying the coordinate reference system of a given geometry without the need to analyze geometry literal serializations. The property allows for the definition of a CRS as a URI. It paves the way for a future definition of coordinate reference systems fully in RDF as anticipated for GeoSPARQL 2.0.

I created a graphic (geold_ontology.graphml) containing geo:SpatialObject, geo:Feature, geo:SpatialMeasure using the yEd Editor (https://www.yworks.com/products/yed) . If you find it useful we can extend it.

4 Modernizing the documentation of GeoSPARQL

4.1 Profile

5 Conclusions

5.1 Future Work

GeoSPARQL 1.2, GeoSPARQL 2.0?

- GeoSPARQL extension ontologies: CRS systems
- GeoSPARQL 1.2: More literals?
- GeoSPARQL 2.0: Full featured support for 3D, simple features functions, coverages?

6 First Section

6.1 A Subsection Sample

Please note that the first paragraph of a section or subsection is not indented. The first paragraph that follows a table, figure, equation etc. does not need an indent, either.

Subsequent paragraphs, however, are indented.

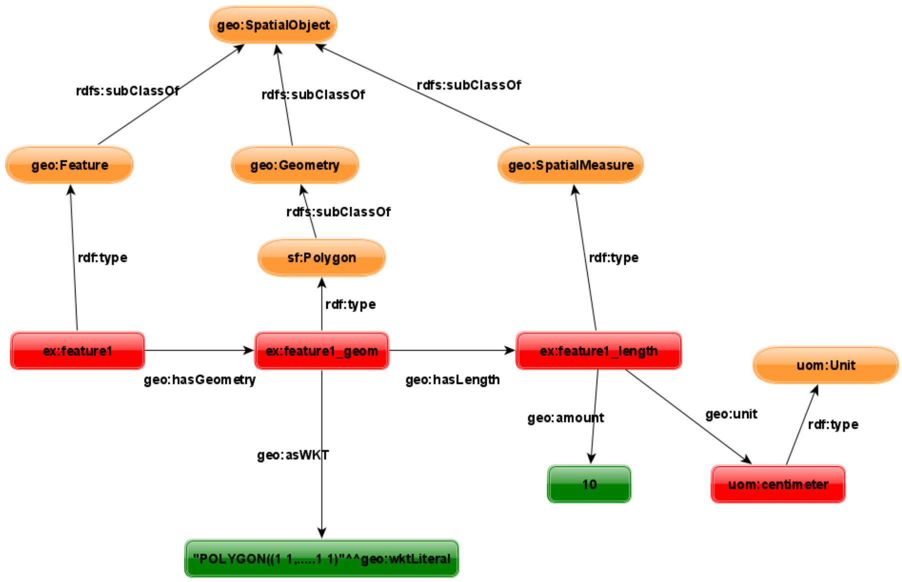

Fig. 1. GeoSPARQL 1.1 ontology including one example feature

Sample Heading (Third Level) Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.

Sample Heading (Fourth Level) The contribution should contain no more than four levels of headings. Table 1 gives a summary of all heading levels.

Table 1. Table captions should be placed above the tables.

Heading level	Example	Font size and style
Title (centered)	**Lecture Notes**	14 point, bold
1st-level heading	**1 Introduction**	12 point, bold
2nd-level heading	**2.1 Printing Area**	10 point, bold
3rd-level heading	**Run-in Heading in Bold.** Text follows	10 point, bold
4th-level heading	*Lowest Level Heading.* Text follows	10 point, italic

Displayed equations are centered and set on a separate line.

$$x + y = z \tag{1}$$

Please try to avoid rasterized images for line-art diagrams and schemas. Whenever possible, use vector graphics instead (see Fig. 2).

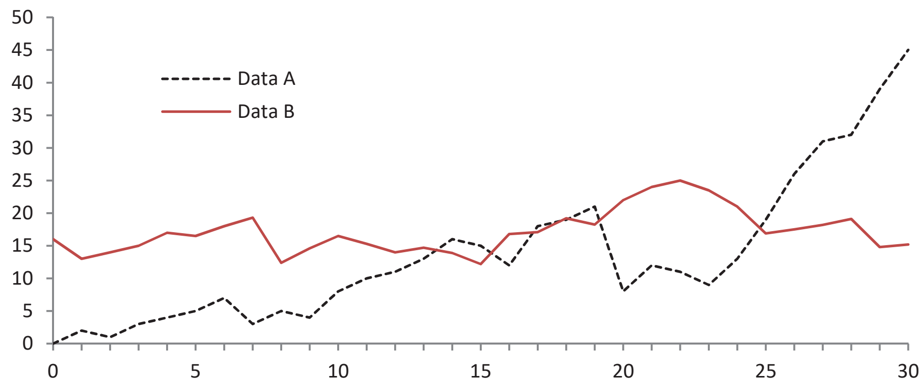

Fig. 2. A figure caption is always placed below the illustration. Please note that short captions are centered, while long ones are justified by the macro package automatically.

Theorem 1. *This is a sample theorem. The run-in heading is set in bold, while the following text appears in italics. Definitions, lemmas, propositions, and corollaries are styled the same way.*

Proof. Proofs, examples, and remarks have the initial word in italics, while the following text appears in normal font.

For citations of references, we prefer the use of square brackets and consecutive numbers. Citations using labels or the author/year convention are also acceptable. The following bibliography provides a sample reference list with entries for journal articles [6], an LNCS chapter [7], a book [**?**], proceedings without editors [9], and a homepage [9]. Multiple citations are grouped [6,7,9].

References

1. Abhayaratna, J., van den Brink, L., Car, N., Atkinson, R., Homburg, T., Knibbe, F., McGlinn, K., Wagner, A., Bonduel, M., Holten Rasmussen, M., Thiery, F.: OGC Benefits of Representing Spatial Data Using Semantic and Graph Technologies (2020), http://docs.ogc.org/wp/19-078r1/19-078r1.html
2. Abhayaratna, J., van den Brink, L., Car, N., Homburg, T., Knibbe, F.: OGC GeoSPARQL 2.0 SWG Charter (2020), https://github.com/opengeospatial/geosemantics-dwg/tree/master/geosparql_2.0_swg_charter
3. van den Brink, L., Barnaghi, P., Tandy, J., Atemezing, G., Atkinson, R., Cochrane, B., Fathy, Y., García Castro, R., Haller, A., Harth, A., et al.: Best practices for publishing, retrieving, and using spatial data on the web. Semantic Web **10**(1), 95–114 (2019)
4. Butler, H., Daly, M., Doyle, A., Gillies, S., Hagen, S., Schaub, T., et al.: The geojson format. Internet Engineering Task Force (IETF) (2016)
5. Consortium, O.G., et al.: OGC GeoSPARQL - A Geographic Query Language for RDF Data. OGC Candidate Implementation Standard (2012)

6. Gonzalez-Beltran, A., Browning, D., Cox, S., Winstanley, P.: Data Catalog Vocabulary (DCAT) - revised edition. W3C Recommendation, World Wide Web Consortium (Nov 2018), https://www.w3.org/TR/vocab-dcat-2/
7. Gregory Todd Williams: SPARQL 1.1 Service Description. W3C Recommendation, World Wide Web Consortium (Mar 2013), http://www.w3.org/TR/sparql11-service-description/
8. Kifer, M., Boley, H.: Rif overview. W3C working draft, W3C,(October 2009). http://www. w3. org/TR/rif-overview (2013)
9. Knublauch, H., Kontokostas, D.: Shapes Constraint Language (SHACL). W3C Recommendation, W3C RDF Data Shapes Working Group (2017), https://www.w3.org/TR/shacl/
10. Nolan, D., Lang, D.T.: Keyhole markup language. In: XML and Web Technologies for Data Sciences with R, pp. 581–618. Springer (2014)
11. Sahr, K., White, D.: Discrete global grid systems. Computing Science and Statistics pp. 269–278 (1998)
12. W3C SPARQL Working Group: SPARQL 1.1 Overview. W3C Recommendation, World Wide Web Consortium (2013), http://www.w3.org/TR/sparql11-overview/