Representing spatial uncertainty and allowing for probabilistic topological functions with SUFF, an extension to GeoSPARQL

By Nicholas Car, for GeoLD, 2024

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Outline

1. SUFF*'s purpose & motivation
2. Overview GeoSPARQL
3. Description of SUFF
4. Plans for the future

* *Spatial Uncertainty for Features & Functions specification*

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SUFF's Purpose & Motivation

GeoSPARQL does not specifically cater for fuzzy (uncertain) geometries or probabilistic topological functions. SUFF is a GeoSPARQL extension that does.

The need for fuzziness is encountered regularly in spatial data work: many projects need to represent it in position and working with such data requires probabilistic topological functions.

Examples:

- Australian Indigenous (Aboriginal) peoples' traditional land areas;
- mineral occurrence areas;
- informal, named geographical objects;
- and species distribution maps

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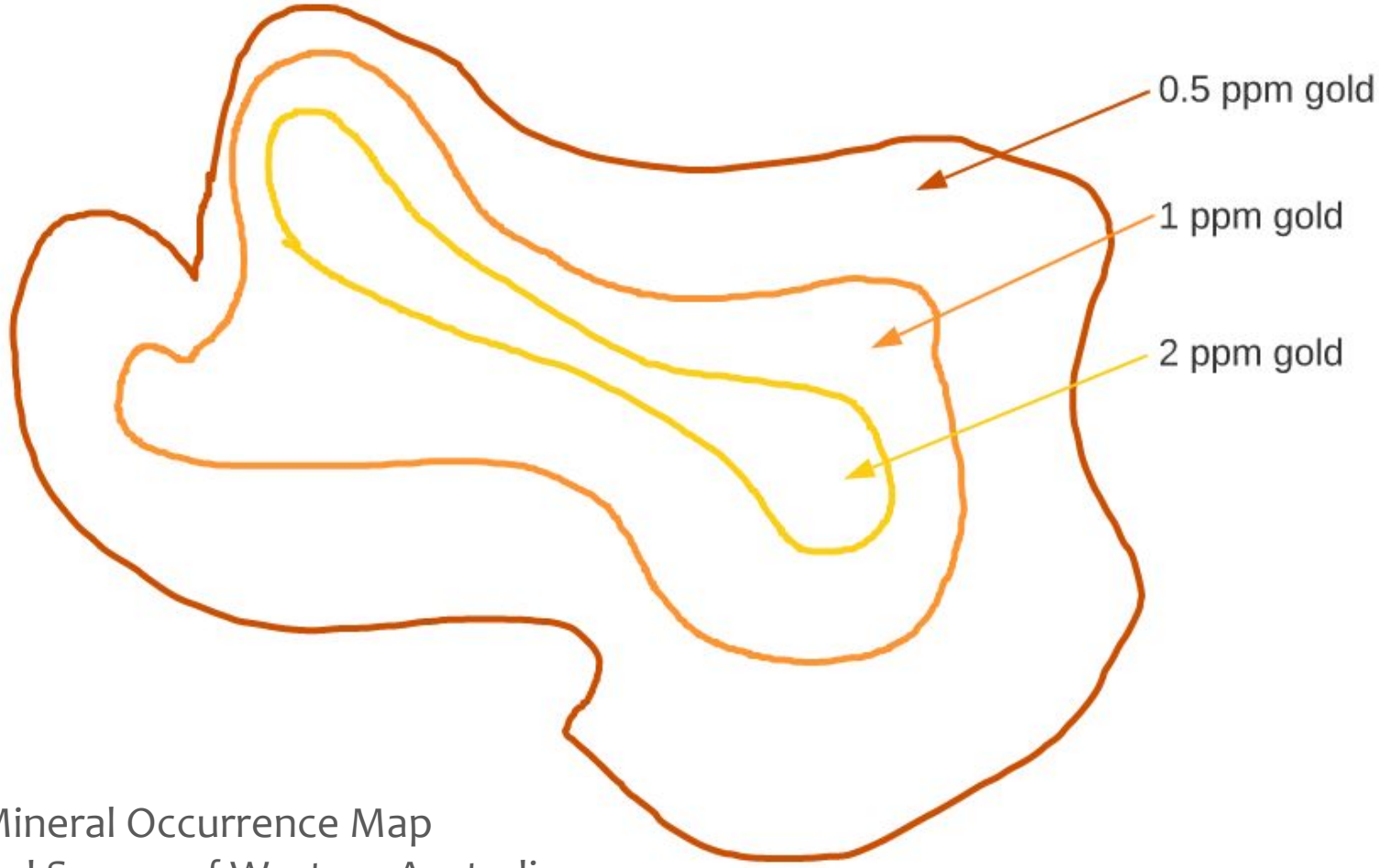
Australian indigenous tribal homelands, approximated from place names
- Nola Turner-Jensen, 2024



Dummy Mineral Occurrence Map
- Geological Survey of Western Australia

GeoSPARQL in overview

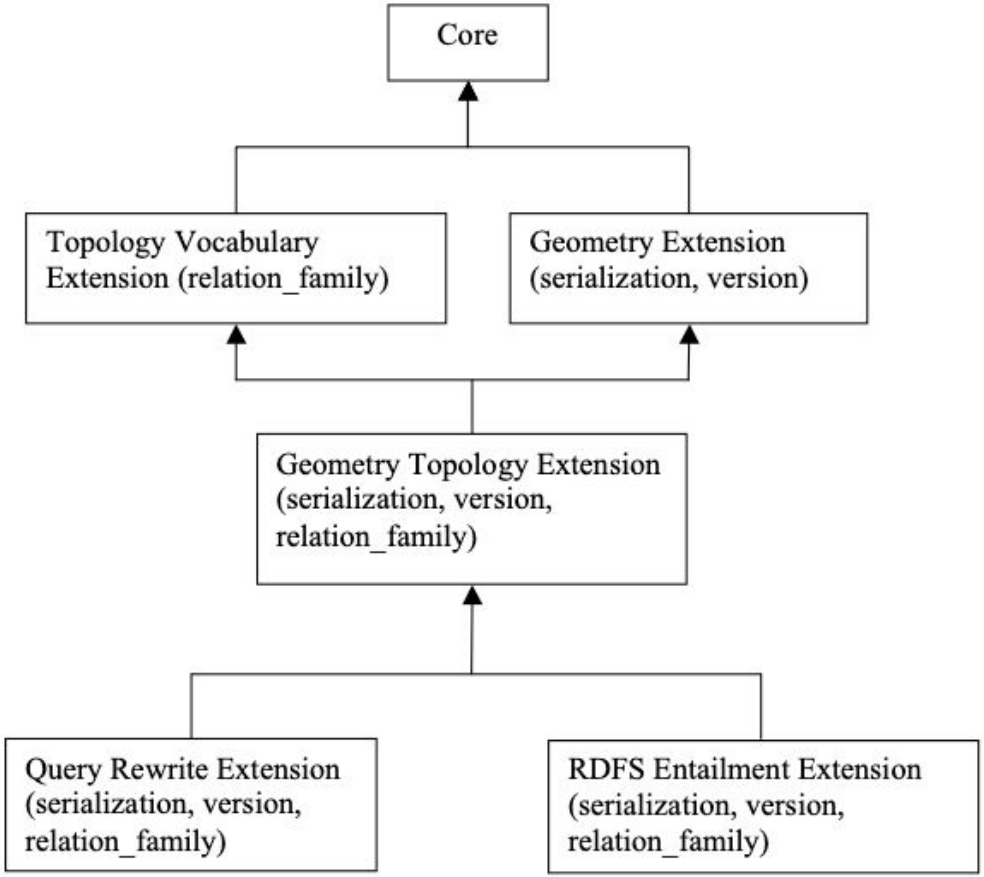
GeoSPARQL contains a small spatial domain OWL ontology that allow literal representations of geometries to be associated with spatial features and for features to be associated with other features using spatial relations.

GeoSPARQL also contains SPARQL extension function definitions that can be used to calculate relations between spatial objects.

Several other supporting assets are also contained within GeoSPARQL such as vocabularies of Simple Feature types and data validators.

Nicholas J. Car, Timo Homburg, Matthew Perry, John Herring, Frans Knibbe, Simon J.D. Cox, Joseph Abhayaratna, Mathias Bonduel: OGC GeoSPARQL - A Geographic Query Language for RDF Data. OGC Implementation Standard OGC 22-047, Open Geospatial Consortium (2023), http://www.opengis.net/doc/IS/geosparql/1.1

GeoSPARQL in overview - modules



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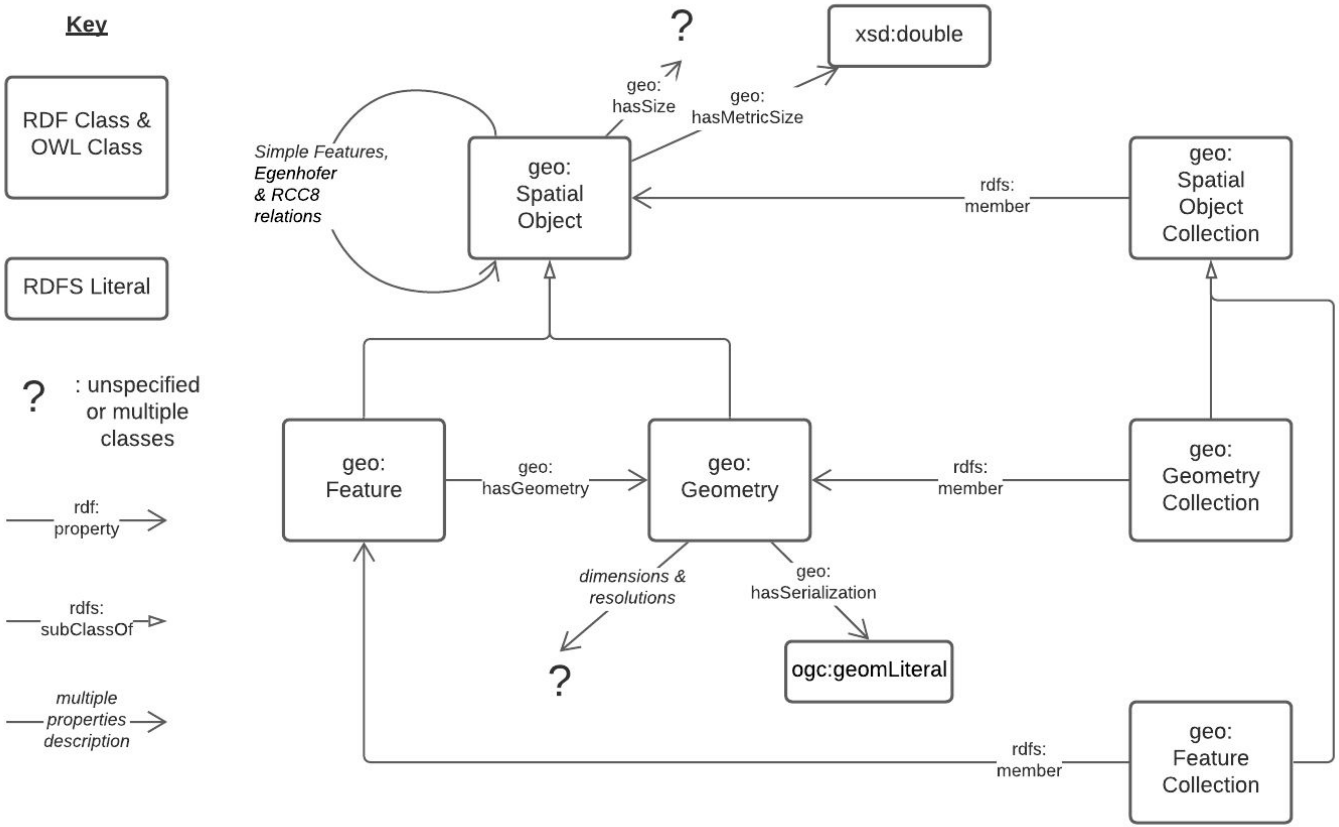
GeoSPARQL in overview - ontology



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GeoSPARQL in overview - functions

11. GEOMETRY TOPOLOGY EXTENSION
    - 11.1. Parameters
    - 11.2. Common Query Functions
    - 11.3. Simple Features Relation Family
    - 11.4. Egenhofer Relation Family
    - 11.5. RCC8 Relation Family

Query Function	Defining DE-9IM Intersection Pattern
geof:sfEquals(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(TFFFTFFFT)
geof:sfDisjoint(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(FF*FF****)
geof:sfIntersects(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(FT******* F**T***** F***T****)
geof:sfTouches(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(FT******* F**T***** F***T****)
geof:sfCrosses(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(T*T***T**) for P/L, P/A, L/A; (0*T***T**) for L/L
geof:sfWithin(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(T*F**F***)
geof:sfContains(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(T*****FF*)
geof:sfOverlaps(geom1: ogc:geomLiteral, geom2: ogc:geomLiteral): xsd:boolean	(T*T***T**) for A/A, P/P; (1*T***T**) for L/L

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Description of SUFF

…a Semantic Web model that builds on elements of the GeoSPARQL 1.1 ontology to cater for the representation of spatial uncertainty allowing for deterministic fuzzy visualisations and probabilistic topological functions.

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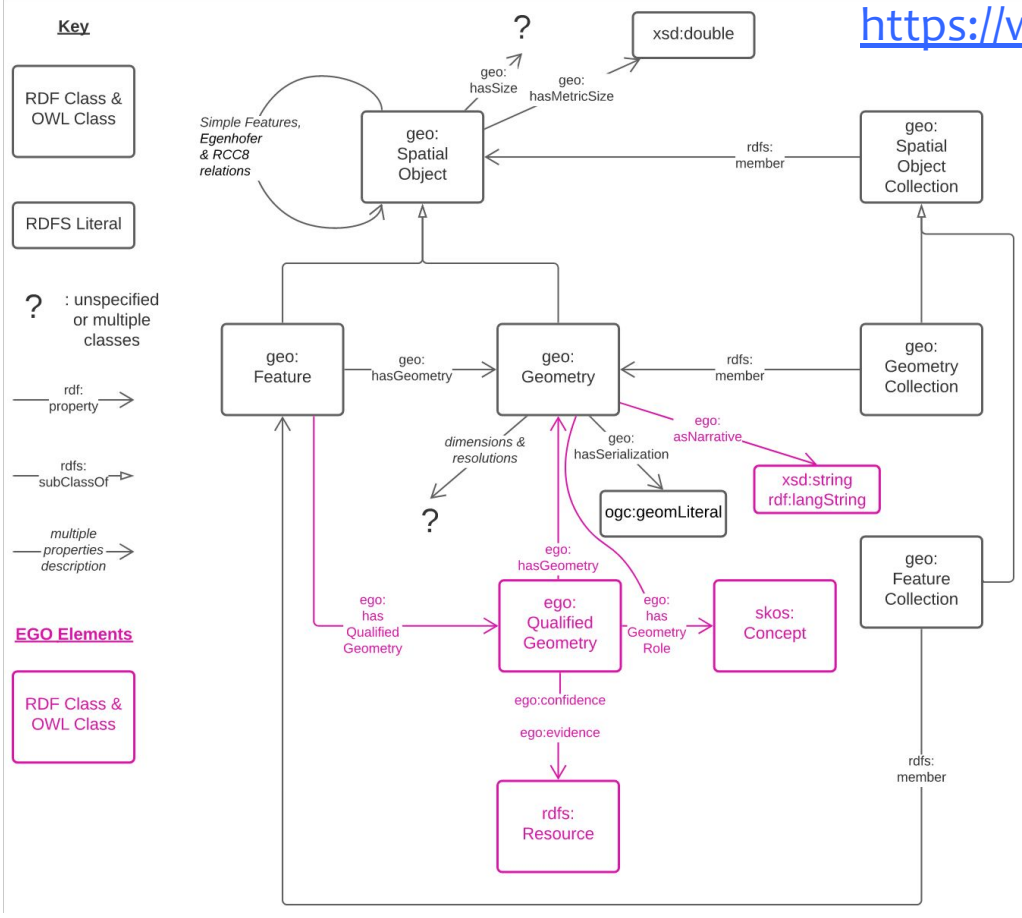
Description of SUFF - history

Extended Geometries Ontology (EGO)
https://w3id.org/idn/def/ego



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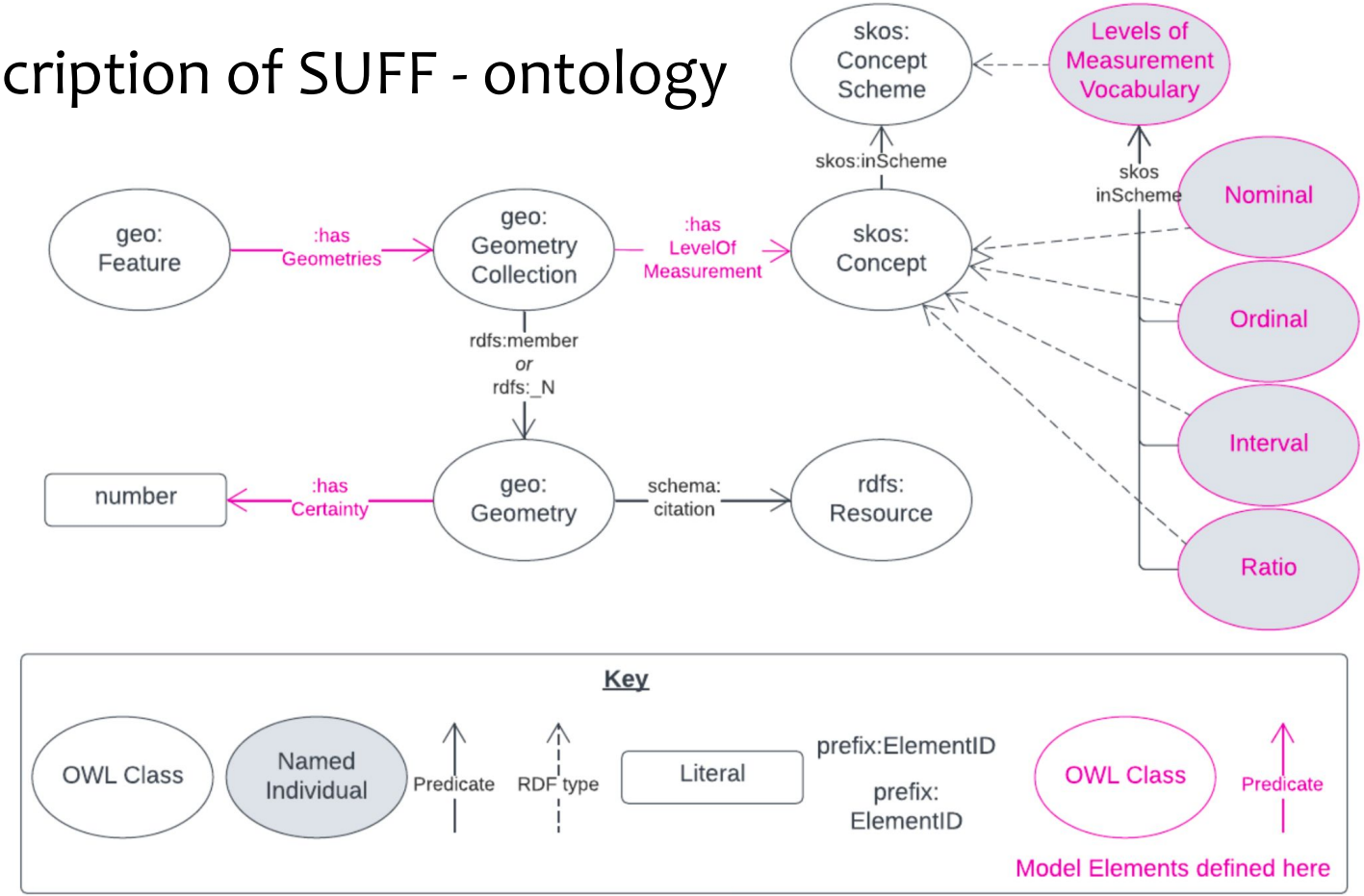
Description of SUFF - outline

The basic premise of the SUFF Model is that multiple GeoSPARQL Geometry objects can be linked to a Feature to which are different representations of its position which may correspond to different confidences in the position. Differ- ent relationships between the multiple geometries can also be used to allow for different interpretations of their relative confidence of position. These different interpretations are also mapped to specific visualisations so that the relationship from data to visualisation is deterministic.

Description of SUFF - ontology



- https://w3id.org/suff/

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Description of SUFF - Levels of Measurement

Fuzziness in the feature's position is then given by blurring (interpolating) between the individual geometry's boundaries.

Fuzziness in the feature's position is then given by blurring (interpolating) between the individual geometry's boundaries. The manner of blurring can be indicated by linking a concept from the Levels of Measurement vocabulary to the geometry collecting with the SUFF `hasLevelOfMeasurement` predicate and certainty at a particular geometry's boundary may be indicated directly by the data creator using the SUFF `hasCertainty` predicate, or it may be calculated by the geometry's relative position in the collection.

Levels of Measurement vocab:
https://linked.data.gov.au/def/levels-of-measurement

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Description of SUFF - Levels of Measurement

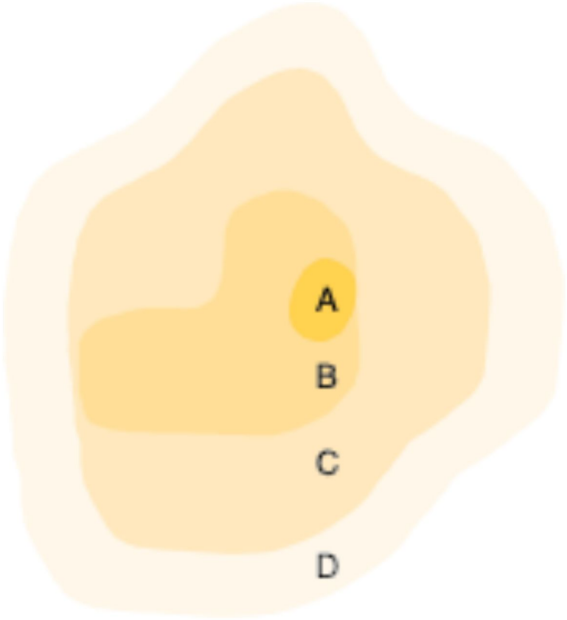
Nominal: Default where each geometry must be assumed to be an equally-weighted estimate of the linked feature's position

Ordinal: If ordering is assigned to the geometries, then the level of the collection is assumed to be Ordinal and estimates of position (geometries) are assumed to be ordered, highest probability to lowest

Interval: Specific values for the probability of each polygon, no zero or 1 probability

Ratio: Specific values for the probability of each polygon with a zero and a 1 given

Description of SUFF - Levels of Measurement



Nominal

Ordinal

Interval

Ratio

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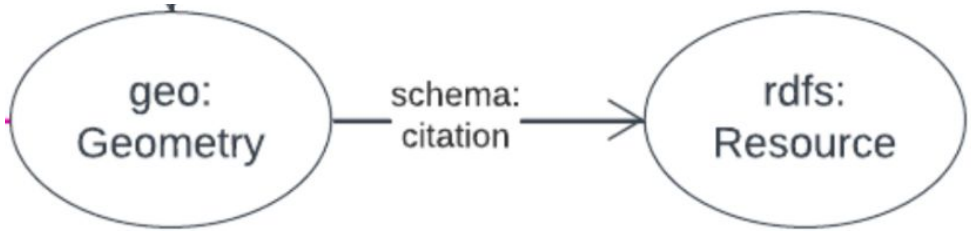
Description of SUFF - Evidence



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Description of SUFF - Functions

```
geof:sfWithin(
    geom1: ogc:geomLiteral,
    geom2: ogc:geomLiteral
) -> xsd:boolean


suff:sfWithin(
    geom1: Feature,    (Geometry)
    geom2: Feature     (GeometryCollection)
) -> xsd:double
```

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Description of SUFF - Functions

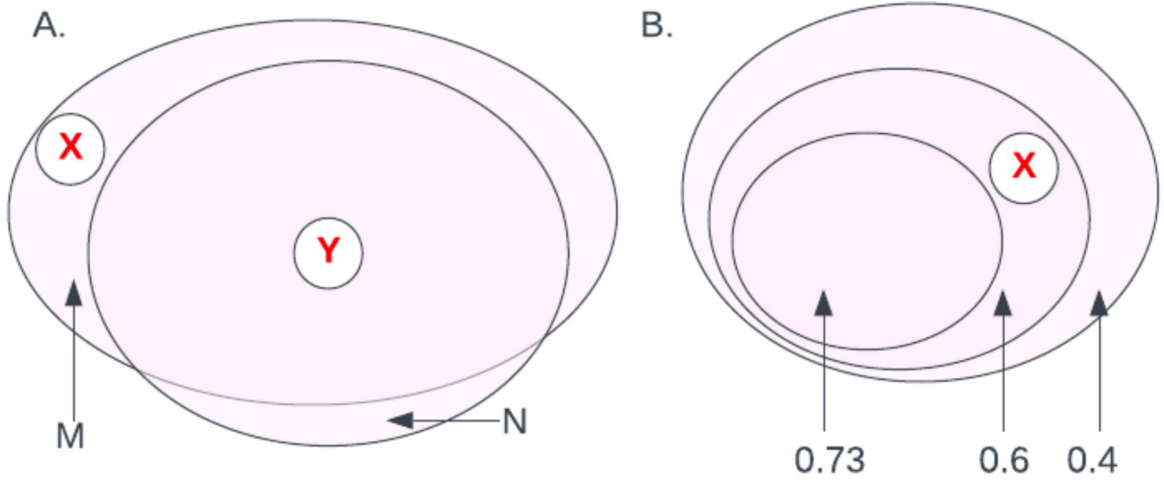

Fig. 3. A: Polygon 'X' is *within* the feature represented with multiple pink geometries with a probability of 0.5 since it is within 1 of 2 geometries and no certainty information is give. Polygon 'Y' is *within* the feature with a probability of 1 since it is within 2 of 2 geometries. B: 'X' is *within* the feature with probability 0.6 since the most certain geometry it is within is that of 0.6.

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Plans for the future

Past

- EGO Ontology
- Test Use
- SUFF

Present

- This conference

Future

- Proposal to GeoSPARQL SWG - June, 2024
- Software creation - by end of July, 2024
- Data testing - June - September, 2024
  - All Levels
  - Topo functions logic & efficiency
  - Opacity rules

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Thanks!

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