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Modeling Geometry and Reference Systems on the Web of Data

Raphaël Troncy¹, Ghislain A. Ateazing¹ and Nathalie Abadie²

¹ EURECOM, Sophia Antipolis, France,
<raphael.troncy@eurecom.fr>

² COGIT-IGN, Paris, France, <nathalie-f.abadie@ign.fr>

Abstract. For many years now, the web of data has been dominated with the use of only one Coordinate System (CRS), namely WGS84, to represent the localization of geographic objects on Earth. Reasons for its adoption is the simplicity of the vocabulary (few core classes and properties) and the fact that the vocabulary is described in a W3C namespace. Nowadays, with the Open Data movement, more and more publishers including governments and local authorities are releasing legacy data that is often geolocalized in a different coordinate system. For example, IGN in France in releasing data that is geolocalized using Lambert93, a Lambert conformal conic projection (LCC) when objects are localized on the France metropolitan area. In this paper, we propose two vocabularies that take into account geometries defined in different coordinate systems. We provide as well mappings with existing vocabularies to ensure compatibilities with existing implementations. Finally, we provide a REST service that supports the conversion of coordinates between several CRS.

Keywords: Ontology modeling, Geographic data, Coordinate systems, Geometry vocabulary, Linked Data, REST service

1 Identification and Description of CRS

The EPSG registry³ identifies various coordinates systems. The Open Geospatial Consortium (OGC) recommends to use URI to identify coordinate reference systems under the uri <http://www.opengis.net/def/crs/>. For example, the WGS84 coordinate system is identified by OGC with <http://www.opengis.net/def/crs/OGC/1.3/CRS84> while the authority EPSG will identify CRS under the uri <http://www.opengis.net/def/crs/EPSSG/0/4326>.

In France, the National Geographic Institute (IGN) is also maintaining a registry of several coordinate systems (Figure 1). Each system is described within an XML file⁴ following the ISO 1911 standard. The URI scheme is defined as follows: [http://registre.ign.fr/\[authority\]/\[registry\]/\(\[version\]\)?/\[type_of_resource\]/\(\[parent_identifier\]\)*/\[resource_identifier\]](http://registre.ign.fr/[authority]/[registry]/([version])?/[type_of_resource]/([parent_identifier])*/[resource_identifier]). For example: <http://registre.ign.fr/ign/IGNF/crs/RGF93EQGPFR>.

³ <http://www.epsg-registry.org/>

⁴ <http://bibliothecaires.ign.fr/geoportail/resources/IGNF.xml>

We have developed a complete vocabulary for defining CRS. We will use the prefix `ignf` to refer to this vocabulary which is available at <http://data.ign.fr/ontologies/ignf#>⁵.

REGION	COORDINATE SYSTEM	ELLIPSOID	PROJECTION SYSTEM	ALTIMETRY SYSTEM
FRANCE METROPOLITAN	RGF93	IAG GRS 1980	Lambert 93 and CC 9 Zones	
MAYOTTE	RGM04 (ITRF2000)	IAG GRS 1980	UTM 38 South	SHOM 1953
GUYANE	RGFG95	IAG-GRS 1980	UTM 21 22 North	
MARTINIQUE	WGS84	IAG-GRS 1980	UTM 20 North	
GUADELOUPE	WGS84	IAG-GRS 1980	UTM 20 North	
LA RÉUNION	RGR92	IAG-GRS 1980	UTM 40 South	GGR 99
NOUVELLE-CALÉDONIE	ITRF90	IAG-GRS 1980		
POLYNÉSIE	RGPF	IAG-GRS 1980	UTM 5, 6, 7 and 8 South	Tahiti IGN 1966
WALLIS ET FUTUNA	MOP87	International 1924		
SAINT-PIERRE ET MIQUELON	RGM01 (ITRF2000)	IAG GRS 1980	UTM 21 North	Danger 1950
ILE CLIPPERTON	Marine 1967	International	UTM 12 South	

Fig. 1. Coordinate Reference System used in France. Source: <http://geodesie.ign.fr/>

2 A Vocabulary for Geometries

We have already surveyed in [1] numerous vocabularies for representing geographical features and their geometries, either using a literal à la WKT or a structured representation à la NeoGeo. We have developed a new vocabulary that re-uses and extends the existing vocabularies for representing geometries, namely:

- <http://www.opengis.net/ont/geosparql#> (prefix `gsp`⁶. This vocabulary provides the basic concepts to represent geographical data such as `SpatialObject`, `Feature` or `Geometry`. A `Feature` is linked to a `Geometry` via the relation `gap:hasGeometry`. The geometries are strings typed as `gmlLiteral` or

⁵ The vocabulary is temporary available at <http://www.eurecom.fr/~atemezin/datalift/ign-onto/ignfv2.rdf>

⁶ All prefixes used in this paper are in line with the prefixes recommended by the Linked Open Vocabulary (LOV) initiative

`wktLiteral`, corresponding respectively to the properties `asGML` and `asWKT`. The vocabulary contains also spatial functions.

- <http://www.opengis.net/ont/sf#> (prefix `sf`): This vocabulary describes the standard Simple Features for SQL of OGC. The class `sf:Geometry` is a subclass of `gsp:Geometry`.

The extensions are the following:

- Links between geometries and instances of different type
- the representation of geometries in a more structured way
- the integration of coordinate reference systems

We will use the prefix `geom` to refer to the vocabulary we propose available at <http://data.ign.fr/ontologies/geom#>⁷. In the GeoSPARQL standard, the property `gsp:hasGeometry` links a resource of type `gsp:Feature` to a resource of type `gsp:Geometry`. In our case, we left the domain empty to accept any type of resource links to a geometry. We use the property `geom:geometry` to link a resource to a given Geometry.

The naming convention used for the `geom` vocabulary follows the terms used by the SimpleFeatures vocabulary, the glossary of multilingual terminology of ISO/TC 211, available at <http://www.isotc211.org/Terminology.htm>.

Axiom 1 *A resource of type `geom:Geometry` should be associated to only one resource of type `ignf:CoordinatesSystem` via the property `geom:crs`.*

Alignments: `geom:Geometry` is a subclass of both `sf:Geometry` and `ngeo:Geometry`. It contains in addition the property `geom:crs`.

Axiom 2 *A POINT is a subclass of a GEOMETRY.*

Axiom 3 *The instances of the class `geom:Point` are associated with the instance of only one `ignf:CoordinatesSystem` via the property `geom:crs`. An instance of a Point has only one coordinate X and coordinate Y. The coordinates are `xsd:double` and use respectively the following properties:*

- `geom:coordX` which refers to, in a particular CRS, the longitude of a point and within a projection coordinate system (CS), the value of false easting of a point.
- `geom:coordY` which refers to, in a particular CRS, the latitude of a point and within a projection CS, the value of false northing point.

On the current usage of positioning on the web of data, it is assumed that the coordinates should be in WGS84, and hence the definition of the point. However, publishers might have data in different CRS according to the location. Thus, our proposal is to define a more generic class for a point with the benefit of choosing the CRS of the underlying data.

⁷ The vocabulary is temporary available at <http://www.eurecom.fr/~atemezin/datalift/ign-onto/GeometryV8.ttl>

```

geom:Point a owl:Class;
rdfs:label "Point"@en, "Point"@fr;
rdfs:subClassOf geom:Geometry;
owl:equivalentClass
  [a owl:Class ;
    owl:intersectionOf
      ([a owl:Restriction;
        owl:onDataRange xsd:double;
        owl:onProperty geom:coordY;
        owl:qualifiedCardinality "1"^^xsd:nonNegativeInteger]
      [a owl:Restriction;
        owl:onDataRange xsd:double;
        owl:onProperty geom:coordX;
        owl:qualifiedCardinality "1"^^xsd:nonNegativeInteger])
    ] ;
rdfs:subClassOf sf:Point.

```

Listing 1.1. Definition in Turtle of the axiom defining a POINT.

3 A REST Service for Converting Geo Data

As we have seen, geo data interpretation relies on a coordinate system, and while the WGS84 standard is the de-facto standard for GPS devices, many other coordinates systems are in used. For example LAMBERT 93, RGM 04 or RGR 92 are respectively used to locate points of interests in France continental, Mayotte or La Reunion. We have developed a REST service that is capable of transforming one dataset using a particular coordinates system into another one. The algorithms implemented are the ones described at <http://geodesie.ign.fr/index.php?page=algorithmes> and available within the standalone Circé software⁸. The REST service is available at <https://github.com/vienlam/Geo>.

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