



Evolution of Environmental Information Models

Reusable properties bound to a persistent URI



Introduction

- Standardization of data models essential for reuse of environmental information
- Existing standards are being extended independently, leading to new discrepancies
- How to enable evolution of environmental information models while maintaining harmonization
- Analyzed at Workshop on EIM at ISESS 2015, requirements defined

Background

- Access to Environmental Information (2003/4/EC)
- OGC/ISO Standards (191XX) provide basis
- Extended for 34 thematic areas by INSPIRE (2007/2/EC), still semi-harmonized
- INSPIRE being extended for
 - EU Reporting Obligations
 - MS Requirements
 - Thematic Requirements

State of the Art I

1. Definition of data structures directly in XML.

Examples:

a) Geography Markup Language (GML; ISO 19136)

2. Definition of individual defined concepts that can be combined to data structures. Examples:

a) Clinical Data Interchange Standards Consortium (CDISC) foundational standards supporting clinical and non-clinical research processes;

b) Darwin Core standard for biodiversity observations.

State of the Art II

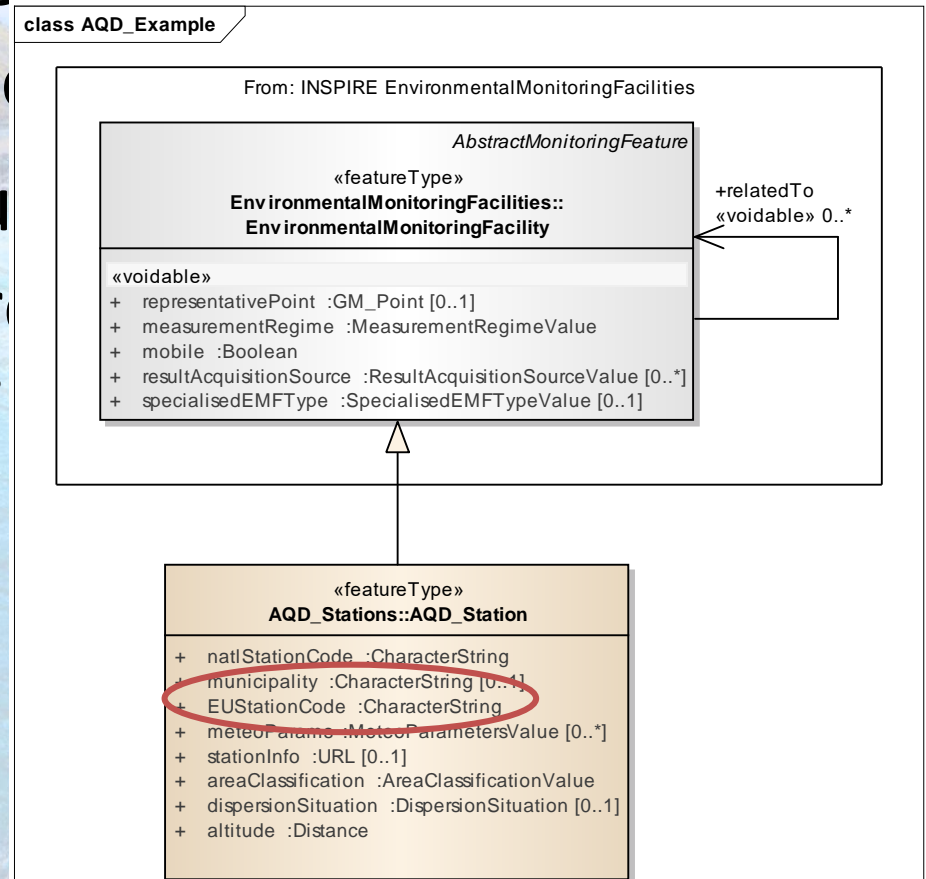
3. Definition of data structures in Unified Modelling Language(UML), provision Extendible Markup Language (XML), sometimes JSON. Examples:
 - a) Most ISO/OGC standards and extensions, i.e. INSPIRE;
 - b) American National Information Exchange Model (NIEM).
4. Definition of data structures using semantic technologies (Resource Description Framework (RDF) and Web Ontology Language (OWL))
 - a) Open Biomedical Ontology (OBO);
 - b) The Extensible Observation Ontology (OBOE).

Requirements to URI-Properties

1. A URI-Property must be uniquely identifiable through an URI
2. The datatype of a URI-Property must be tightly coupled with its definition
3. The semantics of a URI-Property must be tightly coupled with its definition
4. A URI-Property must be persistent. We shall define persistence in analog manner to the definition used for Global Unique Identifiers (GUIDs) referencing data: A URI-Property may not be redefined with different semantics while retaining the same URI; while the definition of a URI-Property may at some point no longer be available, the reuse of the URI is not allowed.

Working Example

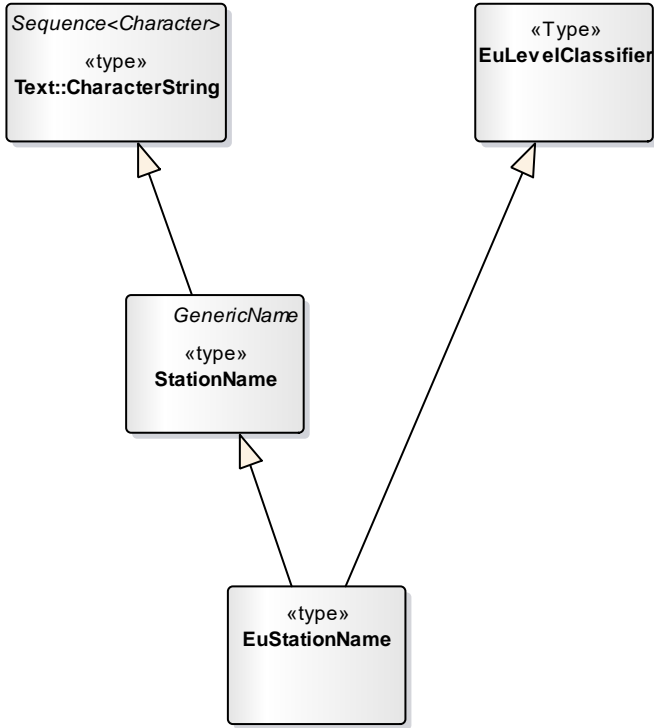
- Example from the European Air Quality reporting model, extended from INSPIRE Environmental Monitoring
- Addition of an attribute Station Code will be reported across environments



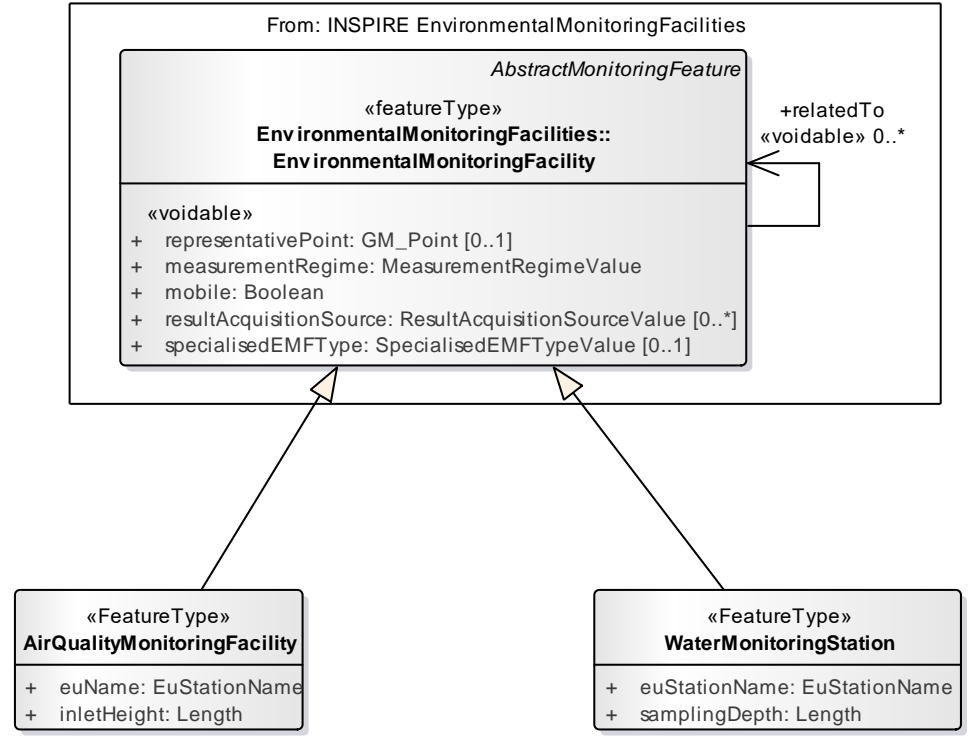
Analysed Approaches

- Data Types
- Interfaces
- MOF Level Adjustment of UML
- Stereotypes

GML DataTypeBaseGML



GML DataTypeUsageGML



```

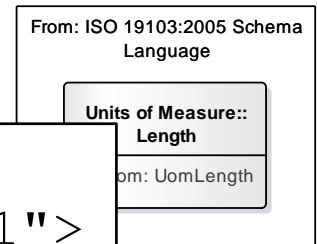
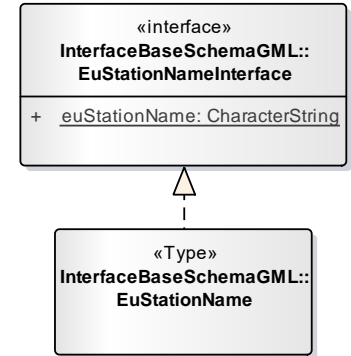
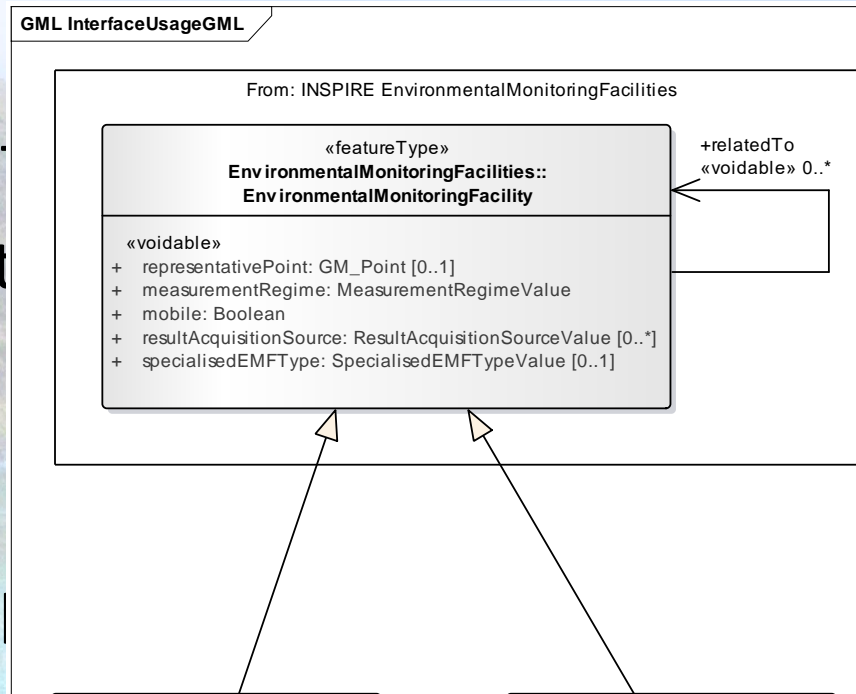
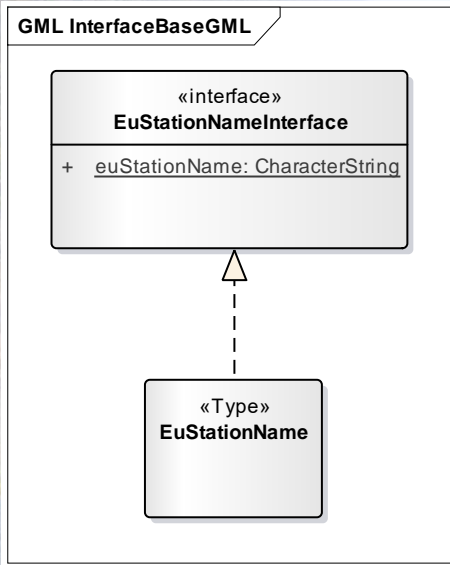
<dtf:euName>
  <dt:EuStationName gml:id="AT_AQ_Station1">
    <gml:name>
      AT_AQ_Station1
    </gml:name>
  </dt:EuStationName>
</dtf:euName>
  
```

3:2005 Schema
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Interfaces



- Visually chal

```

<inf:euName>
  <in:EuStationName gml:id="AT_AQ_Station1">
    <gml:name>
      AT_AQ_Station1
    </gml:name>
  </in:EuStationName>
</inf:euName>
    
```

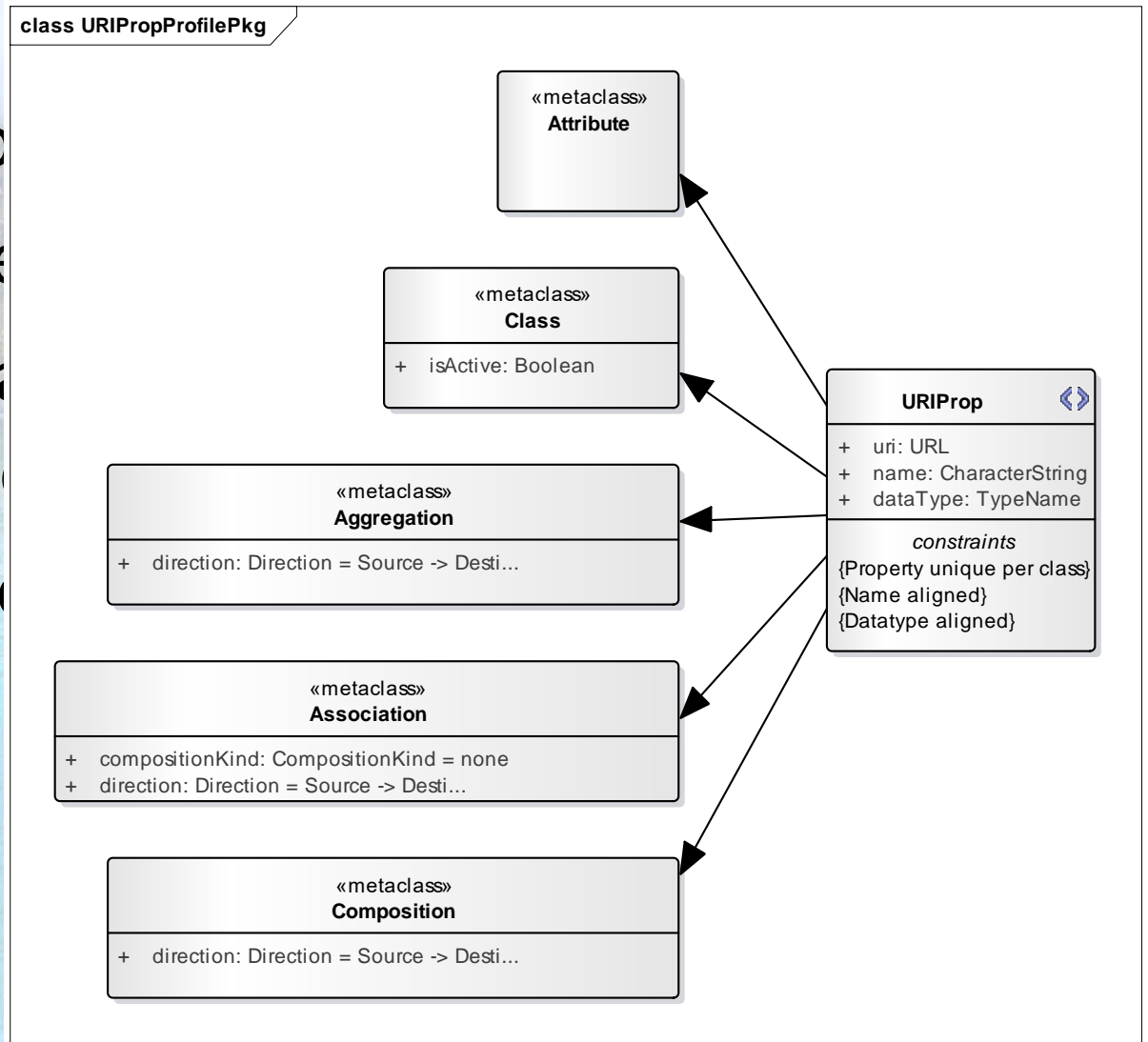
MOF Level Adjustment of UML

- Not possible, as both attributes and associations have a minimal cardinality of 1 in the MOF definition
- Workaround by defining a placeholder class for definition
- Not further explored as stereotype solution fulfilled all requirements

Stereotypes

URIProp stereoc

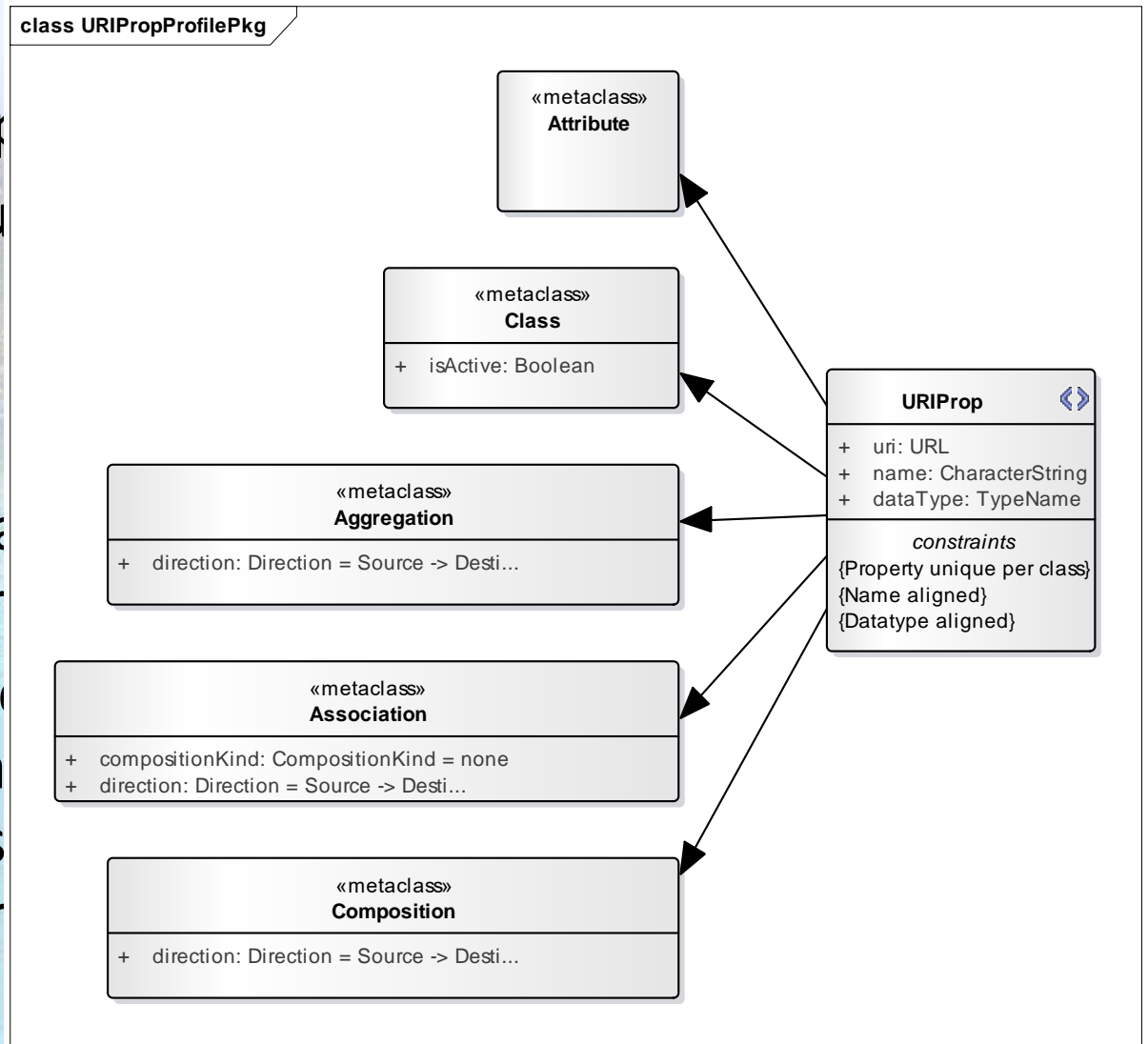
- URI: a unique
- Name: the na
- association r
- Datatype: the
- the target of



Stereotypes

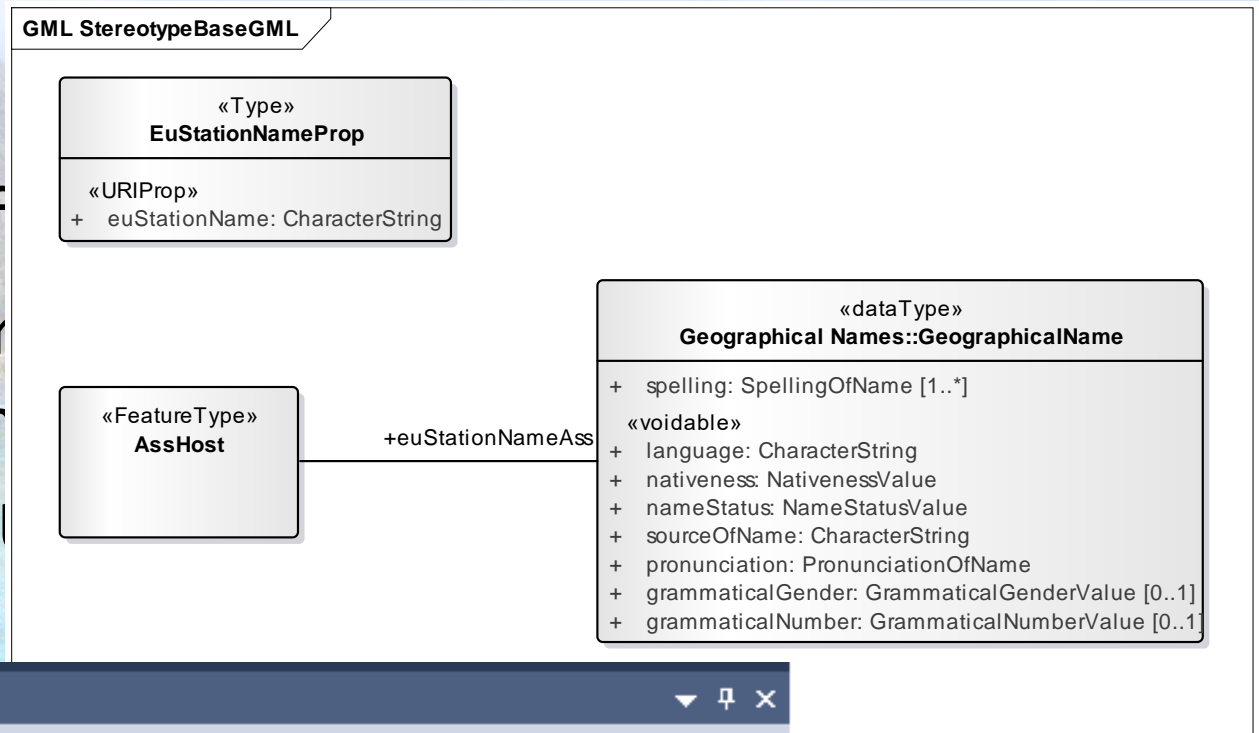
URIProp stereotype

- **Property unique**
occur once per
- **Name aligned:**
as the Name ta
the same as tha
under the refer
- **Datatype align**
same as the Da
in turn be the s
Property under



Stereotypes

- Before use, must be defined
 - URI-Property association
 - Values for

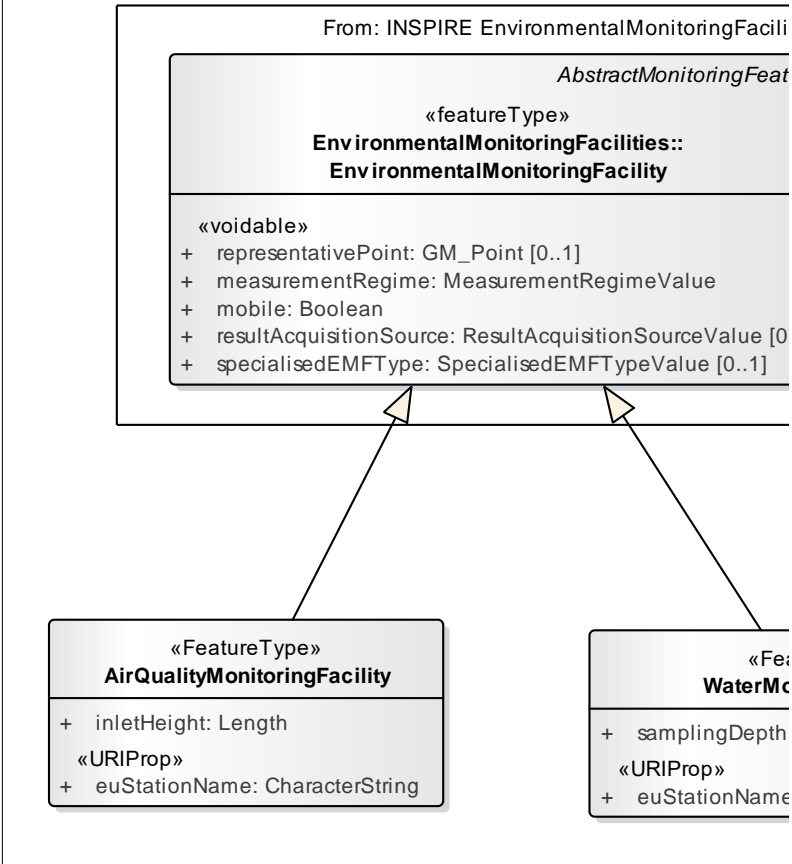


Tagged Values

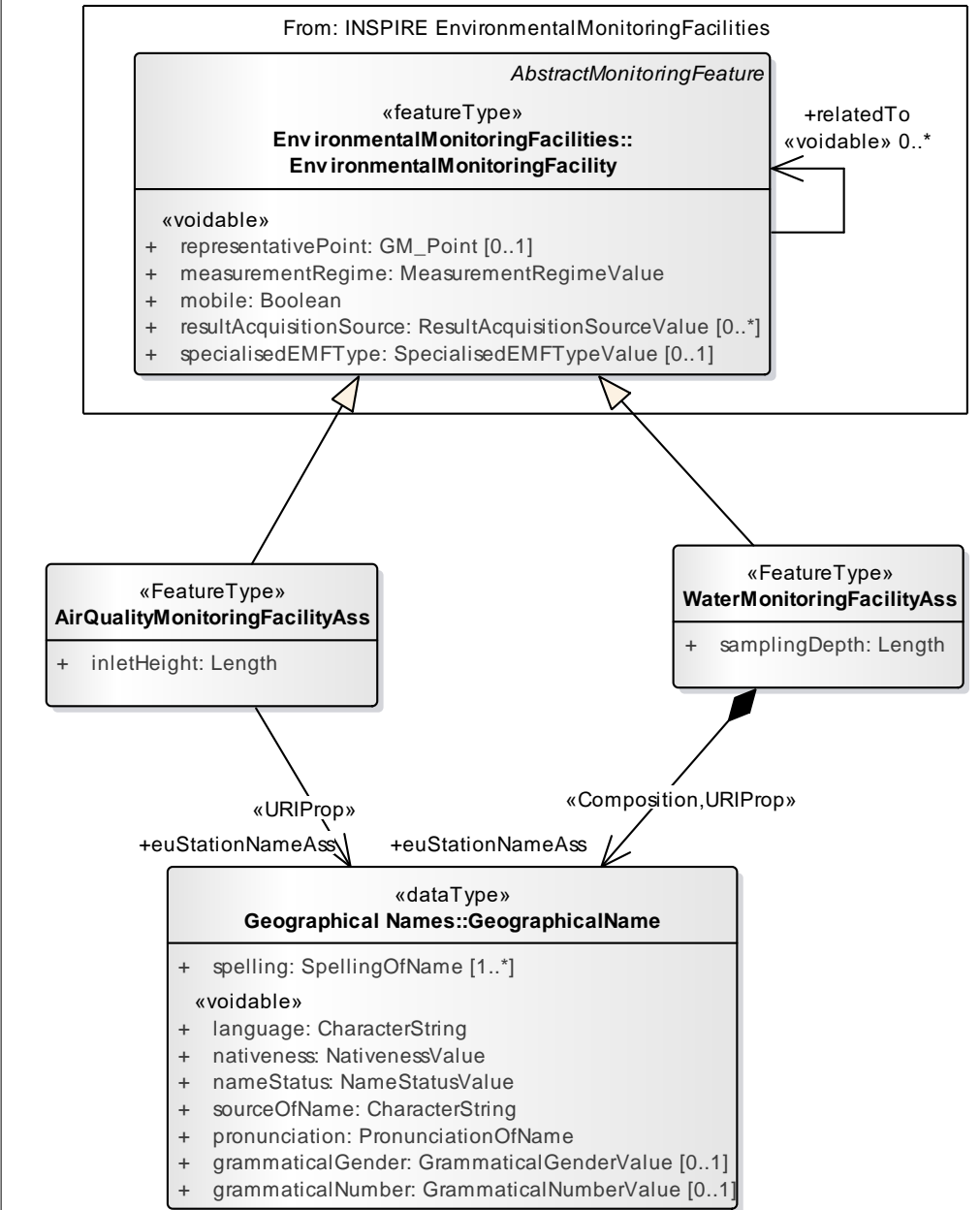
URIPropProfilePkg::URIProp (euStationName)	
URI	http://www.props.eu/euStationName
▶ name	"ISO 10646-2", "euStationName", 50, 13
▶ data Type	"CharacterString"

Stere

GML StereotypeUsageGML



GML StereotypeUsageAssSchemaGML



Stereotypes

- S
- [
- N
- E

```
<xs:element name="euStationNameAss" >
  <xs:annotation>
    <xs:appinfo
      source="http://www.props.eu/euStationNameAss">URI-
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="gml:AbstractMemberType">
        <xs:sequence minOccurs="0">
```

```
<xs:element ref="st:euStationName"/> physicalName"/>
```

```
<xs:sequence>
  <xs:attributeGroup
```

```
<xs:element ref="st:euStationNameAss"/>
```

```
source
  </xs:extension>
```

```
URI
  </xs:complexContent>
```

```
<st:euStationName>AT_AQ_Station1</st:euStationName>
```

```
</xs:sequence>
</xs:element>
```


Stereotypes

- Through tight binding of URI-Property to URI, semantics can be externalized (reference via external ontology)
- URI visible in AML Schema via appinfo element
- Easy usage in XML Schema through element reference
- Definition is agnostic of final serialization form → open towards RDF
- Integration into UML tools essential for wider uptake → currently requires discipline from data modellers

Analysis against requirements

Requirement Approach	URI Coupling	Data Type Coupling	Semantics Coupling	Persistence
Data Types	x	~	~	x
Interfaces	x	~	~	x
MOF Adjustment	x	x	x	x
Stereotypes	✓	✓	✓	✓

Standards Extension Process

The following requirements have been identified:

- Data modelers must be able to **define** and **publish** new URI-Properties;
- Data modelers must be able to **identify** existing URI-Properties, and **incorporate** them into their data models;
- Optionally, a **refactoring** process could be foreseen to allow for **merging** of URI-Properties in the case of inadvertent redundancies.

Semantic Implications

- Stereotype based URI-Properties raise attributes to First Class Citizens
- Alignment between URI-Properties and RDF Predicates allows for linkage UML – RDF/OWL
- Allows UML specification for serialization towards semantic technologies
Missing Link between UML and Semantics
- Should be further explored with W3C

Summary and Outlook

- Stereotype based URI-Properties most viable against requirements
- URI-Property Stereotype would need to be formalized, i.e. In ISO 19118 standard
- Support would need to be integrated into:
 - UML modelling tools (i.e. Enterprise Architect)
 - Encoding tools (i.e. ShapeChange)

Thanks for your attention!

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