FORMALIZING IMPLEMENTABLE CONSTRAINTS IN INTERLIS LANGUAGE FOR MODELING 3D LEGAL RRR SPACES AND 3D PHYSICAL OBJECTS

Eftychia Kalogianni
Efi Dimopoulou
Peter van Oosterom
Wilko Quak

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INTRODUCTION

RESEARCH DESIGN & BACKGROUND INFO

LADM - CONCEPTUAL MODEL - INTERLIS - CONSTRAINTS

INTERLIS IMPLEMENTATION

CONCLUSIONS & FUTURE WORK
Representing vertical development

Technological Opportunities

Information integration

Smart data for smart cities

More than 3D data, 4D, 5D,...
Legal ≠ Physical Reality

Today:
Visualizing ownership boundaries alone cannot solve existing ambiguities & will not reduce boundary confusion among owners.

[Aien et al., 2015]

[Stoter et al., 2012]
Conceptual model (legal reality) described in UML diagrams

Technical model (physical reality) described in INTERLIS language

Model described in INTERLIS language

INTERLIS quality check

INTERLIS Database generation

Populate database with use cases

Validation of the database/ final schema

Visualization of legal & physical in 3D environment

Query the database
**Legal Reality**

- Cadastral data models
  - LADM, ePlan

**Physical Reality**

- Virtual 3D City Models
  - CityGML, IFC

**Real World**

- 3D Property & Ownership interests
- 3D physical objects: buildings, pipelines, etc.
✓ 3D Cadastral Data Model [3DCDM], Aien et al. (2013)

✓ CityGML Application Domain Extensions [ADE]
  ✓ Dsilva et al (2009) - [CityGML for cadastral purposes];
  ✓ Çagdas (2013) - [CityGML for immovable property taxation];
  ✓ Rönsdorf et al. (2014) - [CityGML – LADM];
  ✓ Gozdz et al. [2014] - [CityGML – LADM];
  ✓ Van den Brink et al. [2014] - [CityGML – IMGeo];

✓ extension to Unified Building Model (UBM) for integrating IFC & CityGML - (El-Mekawy & Östman, 2012)

✓ LADM – OWL, Soon et al. [2014]

✓ IndoorGML – LADM, Zlatanova et al. [2016]

✓ 3D city models – 3D cadastres: taxation, valuation, Isikdag et al. [2014]

✓ Cadastral extension IFC, Atazadeh et al. [2016]
3 CONCEPTUAL MODEL-INTERLIS-CONSTRAINTS

LADM - 3D MLAS PROPOSED FOR GREECE

INTERLIS LANGUAGE & TOOLS

CONSTRAINTS
Cadastral data models

- **The Core Cadastral Data Model** (Henssen, 1995)
- **FGDC** (FGDC, 1996)
- **ArcGIS Parcel Data Model** (Meyer, 2001)
- **Legal Property Object** (Kalantari et al., 2008)
- **E-PLAN** (ICSM, 2009)
- **LADM - ISO19152** (Lemmen, 2012)

“The nice thing about standards is that you have so many to choose from”

[Andrew S. Tanenbaum]

**LADM - ISO 19152**

- Model Driven Architecture
- Flexible and Extensible model
- Distinguishes and Links legal and physical objects with External Classes
- Supports Both 2D and 3D cadastral registration

**class Figure 1. Core classes of LADM**

[Lemmen C., 2012]
- Versioned object: State based modeling - - 4D
- External classes: linking legal - physical aspects
- “LA_Level” concept
Towards the development of the prototype:

1. **Transformation on conceptual schema level**
   - Re-design the model in INTERLIS
   - Solutions from the literature

2. **Conceptual model based on LADM in EA model**
   - XMI
   - Rational Rose XMI
   - Compatibility problem

3. **INTERLIS**
   - INTERLIS Database schema (constraints supported)

4. **Populate database with real data**

5. **Validation of the database/ final schema**

6. **Transfer format**
   - [IFC, CityGML, InfraGML]
INTERLIS

- National (Swiss) Standard
- Conceptual Schema Language,
- Object Relational modeling language
- Neutral Transfer Format (XML-based),
- Formal specification of constraints,
- Automated quality control of the data,
- Long-term availability (archiving data)
- Interoperability between information systems

A data exchange mechanism for LAS

[Cogis, 2006]
Constraints should always be validated.
HARD

- Should always be TRUE
- If NOT the transaction should be cancelled

SOFT

- May NOT always be True
- If they are Not True they can be included in an exception list

SOFT constraint + exception list = HARD constraint

FALSE OR presence at the exception list = TRUE
4. INTERLIS IMPLEMENTATION

INTERLIS TOOLS

MODEL DESCRIBED IN INTERLIS

CONSTRAINTS IMPLEMENTATION
Already described **ISO models** from Swiss Land Management Group

**Neutral vendor format** – **Explicit formulation of constraints**

```
INTERLIS 2.3;

CONTRACTED MODEL LADM_GR (en)

AT "http://www.gdmc.nl/
VERSION "2015-11-30" =

IMPORTS UNQUALIFIED ISO_Base;
IMPORTS UNQUALIFIED ISO19107;
IMPORTS UNQUALIFIED ISO19111;
IMPORTS UNQUALIFIED ISO19115;
IMPORTS UNQUALIFIED ISO19156;
IMPORTS UNQUALIFIED LADM_Base;
IMPORTS UNQUALIFIED LADM;
```
CONTRACTED MODEL LADM_GR (en)

TOPIC SpatialUnit (ABSTRACT) =
DOMAIN

STRUCTURE GR_VolumeValue (ABSTRACT) EXTENDS LADM.Spatial_Unit.LA_VolumeValue =
    volumeSize (EXTENDED): MANDATORY Volume;
    grtype : MANDATORY GR_VolumeType;
END GR_VolumeValue;

CLASS GR_SpatialUnit (ABSTRACT) EXTENDS LADM.Spatial_Unit.LA_SpatialUnit =
    grdimension : LADM.Spatial_Unit.LA_DimensionType;
    grarea : GR_AreaValue;
    grsurfaceRelation : GR_SurfaceRelationType;
    hasTopographicMap: Boolean;
    KAEK: MANDATORY CharacterString;
    label (EXTENDED): CharacterString;
    insideMap: Boolean;
    volume (EXTENDED): LIST {0..*} OF LADM.Spatial_Unit.LA_VolumeValue;
END GR_SpatialUnit;
3D CityModel from Paper
"A methodology for modelling of 3D spatial constraints"

INTERLIS 2.3;

CONTRACTED MODEL CITYMODEL_3D (en)

CLASS CityObject =
  id: MANDATORY int;
  startDate: MANDATORY INTERLIS.XMLDateTime;
  endDate: MANDATORY INTERLIS.XMLDateTime;
  geometry: ISO19107.GM_Object;
END CityObject;

CLASS Building EXTENDS CityObject =
  geometry (EXTENDED): MANDATORY ISO19107.GM_Solid;
  name: string;
  MANDATORY CONSTRAINT

ILIFunction.validateSolidGeometry(geometry);
END Building;

CLASS BuildingParts =
  geometry: MANDATORY ISO19107.GM_Solid;
  theme: MANDATORY string;
  MANDATORY CONSTRAINT

ILIFunction.validateSolidGeometry(geometry);
END BuildingParts;
CLASS GR_Archeological EXTENDS GR_Level =
  archeologicalType : GR_ArcheologicalType;
zones: GR_ArcheologicalZoneType;
END GR_Archeological;

CODE LISTS

STRUCTURE GR_ArcheologicalType =
  ArcheologicalTypeCode_ID: MANDATORY Oid;
  parentCode_ID: Oid referring to GR_SpatialUnit.GR_Archeological.GR_ArcheologicalType;
description: CharacterString;
  !! Possible code list values:
  (ancient_monument, modern_monument, historic_place, archeological_site_traditional_village,
   fortress, movable_objects, theater, public_building, temple, architectural_building, hydric_construction);
END GR_ArcheologicalType;

ENUMERATION TYPES

GR_ArcheologicalZoneType =
  protection_Zone_A,
  protection_Zone_B
);
Constraints should be:

- Defined at a vendor neutral way;
- Set for both legal & physical models (e.g. no time gaps between different property interests, number of shares=1, etc);
- Set also for simple actions preventing problems;
- Maintained and checked by ...

Cross model constraints should be set in order to enforce the integration of legal and physical models
The buffer of the physical object should always be inside the buffer of the legal object.
**INTERLIS**

STRUCTURE GM_Point EXTENDS GM_Object =
geometry: **MANDATORY** Coord3D;
END GM_Point;

**DATABASE**

CREATE TABLE gm_point
(t_id integer NOT NULL,
geometry geometry (PointZ),
Constraint GM_POINT_PKEY (T_tid));

CREATE TABLE gr_legalspaceunfinishedconstruction(
t_id integer **NOT NULL**,
type integer,
startdate character varying(20) **NOT NULL**,
endexpected character varying(20),
CONSTRAINT gr_legalspaceunfinishedconstruction_pkey PRIMARY KEY (t_id),
CONSTRAINT start_end_dates CHECK (endexpected::text >= startdate::text)
)
INHERITS (gr_legalspacebuildingunit);
5 CONCLUSIONS & FUTURE WORK

CONCLUDING REMARKS

RECOMMENDATIONS FOR FUTURE WORK
3D MLAS FOR GREECE

- A step towards the creation of a NSDI
- Levels: unified LAS proposal for Greece
- Link with external registrations
- 3D cases in Greece can be solved
- The development of the prototype helps the assessment of the proposed model

INTERLIS EXPERIENCE

- Directly implementable LADM model which speeds up the technical implementation
- Compatibility problems are faced
- Proposed hierarchical structure for code lists
- Formal specification of constraints

Evaluation of the model

- Conceptual model is validated with real sample data
- Some constraints and associations are not supported
- Linking legal & physical with external classes is succeeded
- 3D geometry is stored in multiple ways -- difficult to validate
- Include **air** as a **level**;
- creation of an **ontology** to define & maintain the values of the code lists;
- establishment of an **organization** at national/international level for maintaining the ontologies;
- **solution to compatibility problems** between INTERLIS and other softwares;
- Provide more INTERLIS tools/manuals in English;
- Create **references** between physical and legal objects;
- further **improvement** of the existing **3D data types**;
- explicit **definition of a 3D PRIMITIVE** (GM_Solid);
- use of actual geometry, topology or bbox?

- **definition of FUNCTIONS, CONSTRAINTS and RULES** to be applied at the data types and **CHECK** their **VALIDATION**;
- creation of the **MAPPINGS** between the **TOOLS** in order to recognize & check the proposed structures;

  - **QUALITY CHECKING** both 2D & 3D representations:
    1. **AVOID GAPS AND OVERLAPPING** between neighboring objects
    2. **VALIDATE** that all the objects are **CLOSED**

- Selection of more coherent datasets to cover a bigger area & investigate the integration of spatial and non-spatial data by performing complicated queries
Questions?

Thank you!

ΣΑΣ ΕΥΧΑΡΙΣΤΩ!