The LADM Valuation Information Model based on INTERLIS

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Key words: ISO 19152:2012 Land Administration Domain Model (LADM), LADM Valuation Information Model, INTERLIS, Immovable Property Valuation

SUMMARY

The geometric, legal, physical, economic, and environmental characteristics of property units are utilized in valuation activities. Property valuation registries and databases are supposed to record these characteristics in relation to property units that are subject to immovable property valuation. Moreover, the links between valuation registries and the other land administration registries such as cadastre, land registry, building and dwelling should be specified. Apart from procedural valuation standards, there is no internationally accepted data standard that defines the links and semantics of property valuation databases. The ISO 19152:2012 Land Administration Domain Model (LADM), as an international land administration standard focuses on legal requirements, but considers out of scope specifications of external information systems including valuation and taxation databases. A recently started joint activity under International Federation of Surveyors (FIG) Commission 9 (Valuation and the Management of Real Estate) and FIG Commission 7 (Cadastre and Land Management) has developed an information model for the specification of valuation information maintained by public authorities especially for property taxation.

This paper investigates the use of INTERLIS tools for the technical implementation of the Valuation Information Model, which has been developed as a valuation extension of ISO 19152:2012 Land Administration Domain Model (LADM).

INTERLIS is a Swiss standard that enables modelling and integration of geographic data sets. It provides a conceptual schema language that can be used to specify a data model in a neutral system environment, similarly, class diagrams of the Unified Modeling Language (UML). It is compatible with international standards like UML, XML and GML. INTERLIS also provide some tools for the implementation of conceptual models into technical models. The core LADM, a number of the ISO191xx base models and some LADM country profiles were already expressed in INTERLIS standard.

This paper presents definition of classes, code lists and constraints of the LADM Valuation Information Model and its Turkish Country Profile in INTERLIS. It also discusses possible advantageous of INTERLIS tools (UML editor, compiler, checker, validator and loader) such as system neutral data exchange format, compatibility with relevant international standards, reusable and extensible conceptual schema language, and automatic translation from the conceptual model to physical model.

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1. INTRODUCTION

Immovable property valuation is performed by public sector actors for several land management activities, such as property taxation, expropriation or compulsory purchase of land, land readjustment and land consolidation. Therefore, appropriate systems are needed for fair and timely valuation of tenure rights for land and immovable property. The geometric, legal, physical, economic, and environmental characteristics of property units are utilized in valuation activities. Property valuation registries or databases are supposed to record these characteristics in relation to property units that are subject to immovable property valuation. Moreover, the links between valuation registries and the other land administration registries such as cadastre, land registry, building and dwelling should be specified for constructing the spatial data infrastructure. Apart from existing valuation standards that focus more on concepts and terminology of value, valuer, and valuation practices, there is no internationally accepted data standard that defines semantics of property valuation registries and the links between valuation registries and the other land administration registries. The ISO 19152:2012 Land Administration Domain Model (LADM), as an international land administration standard focuses on legal requirements, but considers out of scope specifications of external information systems including valuation and taxation databases. A recently started joint activity under International Federation of Surveyors (FIG) Commission 9 (Valuation and the Management of Real Estate) and FIG Commission 7 (Cadastre and Land Management) has developed a conceptual model for the specification of valuation information maintained by public authorities especially for property taxation.

A conceptual model identifies the objects of the chosen domain, their characteristics, the associations among them, constraints and the operations on each. The conceptual model makes data modeling independent from implementation specific issues, like changes in physical storage and performance tuning (Keller, 1999, p. 50). From the given conceptual schema and with the help of binding rules, the corresponding physical schema can be directly derivable based on a Conceptual Schema Language (CSL) or a Data Description Language (DDL). The strengths and limitations of a proposed conceptual model can be exploited with the transformation of a conceptual model into a physical database (e.g. PostgreSQL and Oracle Spatial 11g) or a data exchange format (e.g. XML/XSD, GML) or a graphical user interface. There are a number of tools available for automating this transformation and several of these are applied by the INTERLIS.

INTERLIS is a national standard (SN 312031) implemented by the Swiss Federal Directorate for Cadastral Surveying. The INTERLIS standard can be employed for data modeling, spatial data exchange, and integration of data model geographic models (KOGIS, 2006). It was initially designed for land administration, but it is not restricted to land administration data

modeling. Due to its flexibility, it has become part of the Swiss Federal Act on Geoinformation in 2007. The conceptual schema language of the INTERLIS provides precise description of the international data standards and it can be utilized for generating its corresponding technical implementation and load some geographical data afterwards (Germann et al, 2015). In other words, it automatically converts conceptual schema definitions into computer-processable format.

There are a number of implementations of INTERLIS in the land administration domain, as LADM based country profiles of three countries, namely Switzerland, Greece and Colombia, were developed for INTERLIS (Kalogianni et al, 2017). The present paper investigates the use of INTERLIS tools for the technical implementation of the Valuation Information Model, which has been developed as a valuation extension of ISO 19152:2012 Land Administration Domain Model (LADM). Moreover, these tools are also employed for implementation of the Turkish Country Profile of the LADM Valuation Information Model (Kara et al, 2018b). The INTERLIS tools (UML editor, compiler, checker, validator and loader) are investigated to assess benefits and drawbacks in the translation from the conceptual model to physical model. Moreover, the potential of INTERLIS regarding the unification of legal and physical objects related to property valuation is assessed.

The remaining part of the paper is organized as follows: The INTERLIS standard and tools are presented in Section 2. This section also examines the previous implementation of INTERLIS in the geographic domain. Section 3 gives an overview of the LADM Valuation Information Model and the Turkish Country Profile. The INTERLIS implementation of the LADM Valuation Information Model and the Turkish Country Profile is presented in Section 4. The strengths and limitations encountered during implementation are also discussed in this section. The last section suggests further research and concludes the present paper.

2. A STANDARD FOR LAND ADMINISTRATION INTERLIS

INTERLIS is an object-oriented conceptual schema language (CSL), which is being used to define data models in textual form with a rigid computer readable syntax (COGIS, 2006). Geographic data can be documented in a comprehensive, system-neutral manner with the model-based approach of the INTERLIS. It provides a framework to storing features, updates and graphic presentations of standards definitions (Keller, 1999). An implementation of any INTERLIS data model is done in several steps, namely, data modeling, model validation, translation of conceptual model to technical, data validation, and data acquisition (Jenni et al, 2017). INTERLIS provides wide range of free tools for the implementation of conceptual data models, namely, INTERLIS/UML-editor, INTERLIS-Compiler, INTERLIS SQL DB, INTERLIS Validator, and other supplementary tools.

INTERLIS/UML-editor is used to visualize INTERLIS data models as UML diagrams. It is also used to generate INTERLIS data models files (*.ili) from the UML diagram definitions. Since the INTERLIS data models files is an ASCII file, it can be read and modified in any ASCII editor. It is compatible with the international standards such as UML, XMI Rational Rose, XML schema and GML schema.

The syntactic and semantic compliance of a newly created INTERLIS data model is validated with the INTERLIS-Compiler (ili2c). The correctness of INTERLIS data model files (*.ili) can be checked with this tool. The INTERLIS checker tool can also be used to create XML schema, GML schema and XML-based exchange format (XTF files) of the validated INTERLIS data model.

INTERLIS provides a number of tools for translation of the INTERLIS data model files to the relational databases. The translation of the INTERLIS data model to a database is a so-called object-relational mapping (O/R mapping). There are a number of tools (INTERLIS SQL DB – ili2db) of INTERLIS that can be used for the O/R mapping, automatically. For example, the ili2ora tool can be used for converting INTERLIS data models to the ORACLE database. Similarly, the ili2pg and ili2gpgk tools can be used for the translation to PostgreSQL/PostGIS and OGC Geopackage, respectively. Moreover, ili2geodb (loader for ESRI GDB), ili2mdb (loader for Microsoft Access), and ili2mssql (loader for Microsoft SQL server) were developed as a part of the ili2db project. It is noted that the these tools not only deals with the translation of INTERLIS data model definitions to the relational databases, but also load INTERLIS data into the databases and extract INTERLIS data from the databases. Moreover, these tools support not only 2D geometry types, but also 3D geometry and topology.

The data validation tool of INTERLIS (iliValidator) is one of the big advantage of the INTERLIS. It gives an opportunity for validating model compliancy of data against its conceptual data model (Germann et al, 2014). The errors in validation are logged in a simple ASCII log file or in an INTERLIS transfer file. This tool can also be used as programming library for integrating the data validation in existing software, web services and/or existing processes (Jenni et al, 2017). The validator also offers the possibility of validating complex spatial and non-spatial constraints.

An INTERLIS plugin for the QGIS software, the project generator plugin, was developed in last year. This tool can be employed for generating physical models from INTERLIS models and capturing, importing, editing and exporting data to INTERLIS transfer files (XTF) (Kalogianni et al, 2017). Another tool of INTERLIS is the Reader/Writer to FME (ili2fme). This tool is used in order to read and write INTERLIS models to the Feature Manipulation Engine (FME) and write data in different data exchange format via appropriate mapping parameter.

There are a number of features that make INTERLIS unique. For example, the INTERLIS data model can be directly processed in open and closed source software tools by means of the wide range of free INTERLIS tools. The relational and object-oriented data models can be described in a system neutral way. It is possible to quality check spatial data including geometric attributes against INTERLIS data models with constraints. 3D geometry types are supported by INTERLIS data model including ISO 19107 GM_Solid. Topological relationships and constraints can also be included in INTERLIS conceptual language. INTERLIS automatically converts the code list classes to the databases. Moreover, both logical and spatial constraints expressed in the INTERLIS conceptual schema language can also be automatically converted to the databases.

The LADM ISO 19152 and a number of ISO 19100 series standard including ISO 19107, ISO 19115, and ISO 19156 were described with INTERLIS by the Swiss Land Management (SLM). The second version of the INTERLIS data model of LADM was described in the context of the Project 'Modernization of Land Administration in Colombia'. The second version LADM described in INTERLIS and the second version of ISO 19107 in INTERLIS supports both 2D and 3D geometries (Jenni et al, 2017). Moreover, the second version of INTERLIS data model of LADM includes more code lists and structures (e.g., Image, ExtArchive), and more constraints in some classes (e.g., LA_SpatialUnitGroup and LA_BAUnit) (Kalogianni et al, 2017). There are also a number of country specific developments of INTERLIS in land administration domain. LADM based country profiles of three countries, namely Switzerland, Greece and Colombia were developments in INTERLIS. In Switzerland, INTERLIS is currently being used to describe more than 160 data models of the Swiss National Data Infrastructure, including core cadastral data model, utility services and urban planning (Germann et al, 2015). The INTERLIS tools were assessed for creating a relational database for the representation of a wide range of different types of spatial units including 2D and 3D and aiming to establish an appropriate basis for the National Spatial Data Infrastructure (NSDI) of Greece (Kalogianni et al, 2015; Kalogianni, 2016; Kalogianni et al, 2017). LADM Colombia Country Profile was described using the conceptual schema language of INTERLIS, as well as the development of additional open source software tools (e.g. PostgreSQL, Geoserver, Leaflet, and Drupal) that support the countrywide implementation of the standard in the Modernization of Land Administration project of Colombia (Jenni et al, 2017).

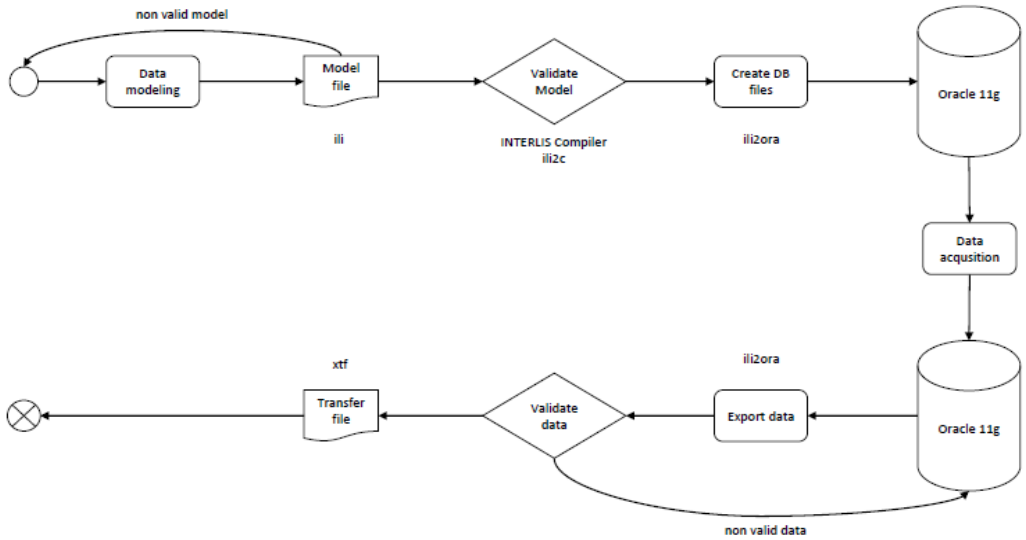


Figure 1. Workflow for implementation of a conceptual model with INTERLIS tools *(edited Jenni et al, 2017)*

Figure 1 above presents the workflow for implementing a new conceptual model based on INTERLIS tools from data modeling to data exchange. In this study, LADM based Valuation Information Model and Turkish Country Profile are described in INTERLIS data model. After that, a prototype is developed in ORACLE database with using INTERLIS tools. In other words, INTERLIS UML Editor, INTERLIS Compiler, and 'ili2ora' tool for converting

INTERLIS data models to the ORACLE database is used in the context of this research. Next section gives a brief information on LADM Valuation Information Model and its Turkish Country Profile.

3. AN OVERVIEW OF LADM VALUATION INFORMATION MODEL AND TURKISH COUNTRY PROFILE

This section provides a brief overview of LADM Valuation Information Model and Turkish Country Profile. More detailed description of the LADM Valuation Model is presented in Kara et al (2017, 2018a) and of the LADM Valuation Model Turkish Country Profile in Kara et al (2018b). Figure 2 presents the LADM-based Valuation Information Model that also modeled time series data, labelled with the prefix VM_ and developed through the specification of the ExtValuation class of LADM.

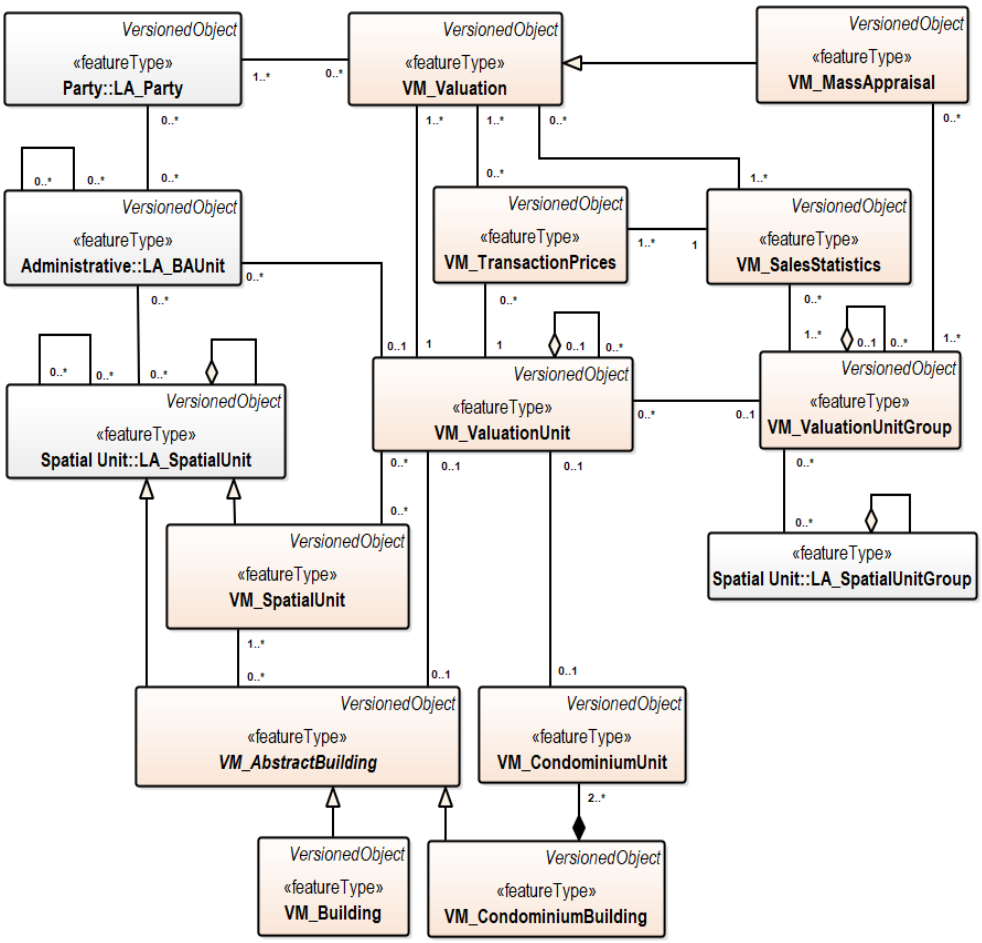


Figure 2. The core classes of LADM Valuation Information Model

The main purpose of LADM Valuation Information Model is to specify semantics of inventories used in immovable property valuation made for public purposes and relations

between them. It has been designed to facilitate recording information in relation to all stages of property valuation applied for recurrently levied immovable property taxation, namely the identification of properties, assessment of properties through single or mass appraisal procedures, generation and representation of sales statistics. It enables the recording of data concerning the parties that are involved in valuation practices, property objects that are subject of valuation, as well as their geometric, legal, physical, economic, and environmental characteristics.

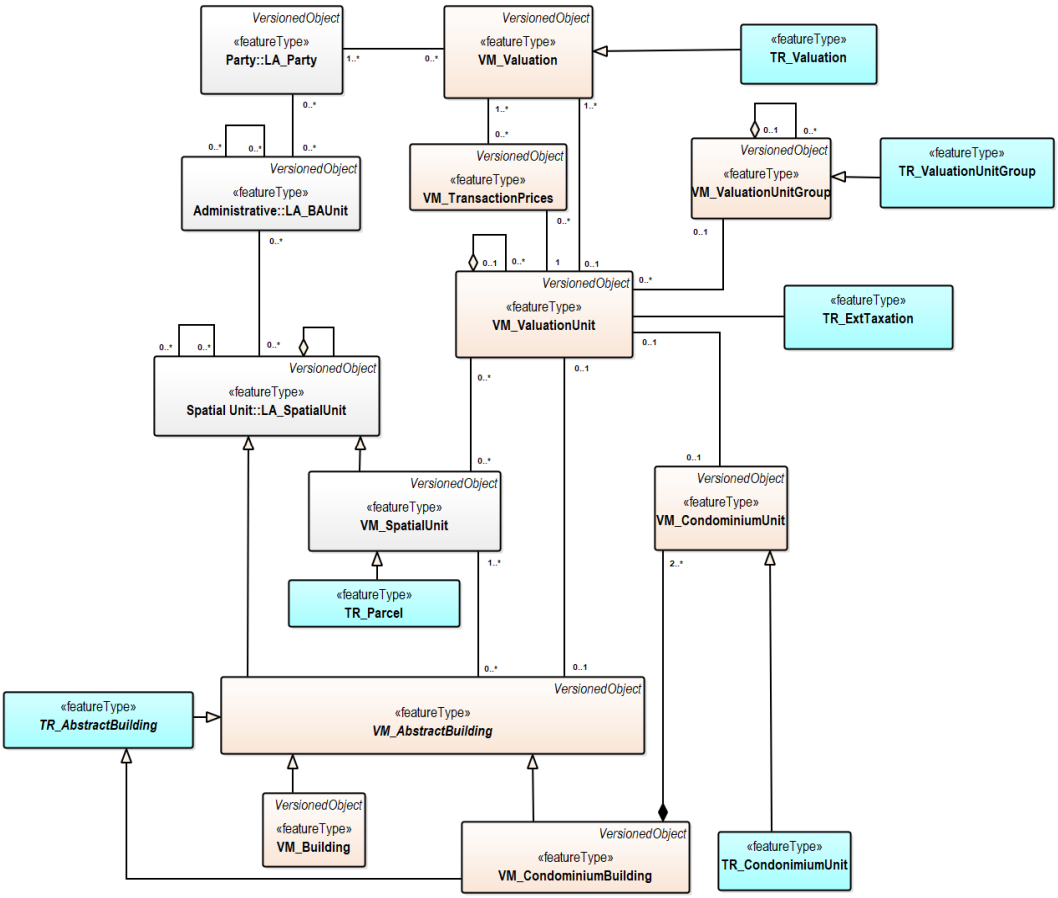


Figure 3. LADM Valuation Information Model Turkish Country Profile

Figure 3 shows classes of LADM Valuation Information Model Turkish Country Profile. In the country profile, 'TR_' prefix is used for the classes of country profile. The turquoise, vanilla and white colored classes present the country profile, valuation information model, and LADM, respectively. For the country profile, the LADM Valuation Model is extended for the country profile with TR_Valuation, TR_ValuationUnitGroup, TR_Parcel, TR_AbstractBuilding, TR_CondominiumUnit and TR_ExtTaxation classes. Moreover, the model is extended with construction type, quality type, elevator, heating/air conditioning, parcel type, parcel unit price per square meter, reassessment rate and date, valuation group type, and valuation party type attributes for completely representing the valuation activities conducted for recurrently levied immovable property taxes in Turkey.

The INTERLIS implementation of LADM Valuation Information Model and Turkish Country Profile are presented in the next section.

4. LADM VALUATION INFORMATION MODEL BASED ON INTERLIS

INTERLIS has some prerequisites for implementing a LADM based model as an INTERLIS data model. Since the LADM is based on the ISO 19000 series standards, including ISO 19107, ISO 19111 and ISO 19115, the INTERLIS definitions of these standards are needed for a new data model implementation. As already mentioned, ISO 19152 LADM and some ISO 19100 series of standards were described as INTERLIS data model by Swiss Land Management. Moreover, INTERLIS description of ISO 19107 and ISO 19152 LADM were improved in the project 'Modernization of Land Administration in Colombia'. In the present study, seven different INTERLIS data models (ISO_Base, ISO 19107_V1, ISO 19111, ISO 19115, ISO 19156, LADM_Base, and LADM_V1) were utilized for creating LADM Valuation Information Model. Figure 4 presents the stack of INTERLIS models that were used to describe the LADM Valuation Information Model and after that the Turkish Country Profile.

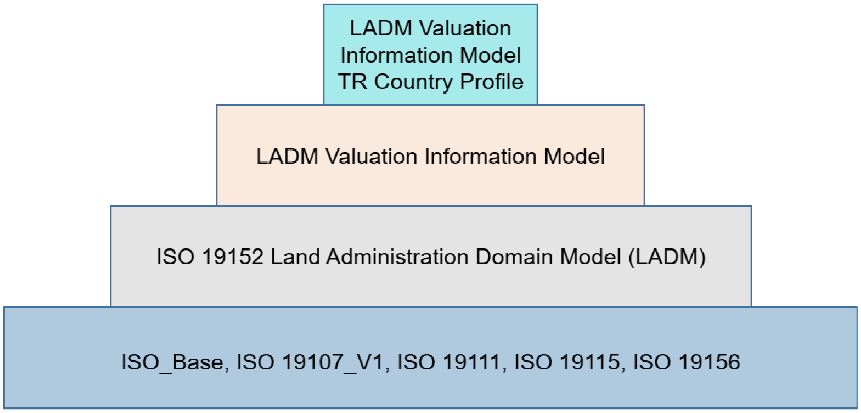


Figure 4. The INTERLIS models used to describe LADM Valuation Model and TR Country Profile

The INTERLIS/UML-editor is used to specify a conceptual model according to an INTERLIS data model. It is used for data visualization and for generating INTERLIS data models. This editor provides a functionality to import an existing UML class diagram in XMI Rational Rose format. Since the LADM Valuation Information Model was designed in the Enterprise Architect software, which does not support XMI Rational Rose format, the import functionality cannot be used. Therefore, all the classes, relations, code lists and constraint of LADM Valuation Information Model were manually described in INTERLIS UML-editor, after importing base INTERLIS data models including ISO 19107 and ISO 19152 LADM.
The conceptual schema languages of INTERLIS and LADM share the same Model Driven Approach (MDA) principles. Therefore, MDA principles were followed when the LADM Valuation Information Model was described in the INTERLIS data model. Figure 5 below presents the VM_Valuation and VM_ValuationUnit UML classes and their INTERLIS description.

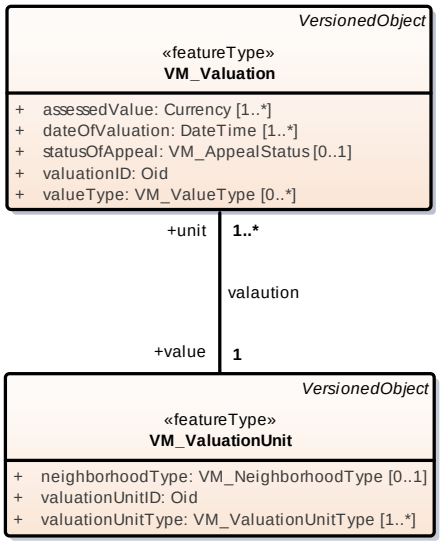
UML Diagram	INTERLIS Description
	**CLASS** VM_Valuation **EXTENDS** LADM_V1.VersionedObject = **assessedValue:** Currency; **dateOfValuation:** XMLDate; **statusOfAppeal:** LIST {0..1} OF VM_AppealStatus; **valuationID:** MANDATORY Oid; **valueType:** LIST {0..*} OF VM_ValueType; **END** VM_Valuation; **CLASS** VM_ValuationUnit **EXTENDS** LADM_V1.VersionedObject = **neighborhoodType:** LIST {0..1} OF VM_NeighborhoodType; **valuationUnitID:** MANDATORY Oid; **valuationUnitType:** LIST {1..*} OF VM_ValuationUnitType; **END** VM_ ValuationUnit; **ASSOCIATION** valuation = unit -- {1..*} TR_ValuationUnit; value -- {0..1} VM_Valuation; **END** valuation;

Figure 5. LADM Valuation Information Model UML class diagram and its INTERLIS description

After the core classes of the model were defined in the INTERLIS/UML-editor, code list classes were described. Code lists are used for expressing a list of potential values. It provides more flexible values than enumerations. Kalogianni et al (2017) proposed a database code list management approach for hierarchical, semantically more meaningful, and extensible code lists. In this approach, code lists are designed as structures with attributes, including an identifier, begin life span version and end life span version. When a code list is extended, the identifier of the parent code list is also included by the child code list.

Constraints in the INTERLIS language can be defined on an object level or a class level (Kalogianni et al, 2015). Moreover, constraints between classes and their instances also can be described in INTERLIS. Constraints expressed in the INTERLIS conceptual schema language can also be automatically converted to the databases. Primary key, foreign key, check constraint and spatial constraint can be defined in a database. Furthermore, some 'soft' exceptions can be defined as constraints in databases, such as exception list, percentage of allowed violations, and conditions when the constraint does not apply (Kalogianni et al, 2017). When the LADM Valuation Information Model was described in INTERLIS, some constraints were defined in the model. For example, if the valuation unit type defined in the VM_ValuationUnit class is condominium, then the VM_CondominiumUnit class should have been created and populated with data, otherwise, VM_CondominiumUnit is unnecessary. A sample INTERLIS conceptual schema language fragment for modelling this 'soft' constraint is displayed:

```
CLASS VM_CondominiumUnit EXTENDS LADM_V1.VersionedObject =
cuID: MANDATORY Oid;
accessoryPart: BOOLEAN;
accessoryPartType: MANDATORY (garage, laundry, shop, other);
condominiumArea: VM_BuildingAreaType;
floorNumber: Integer;
numberOfRoom: Integer;
shareInJointFacility: Fraction;
MANDATORY CONSTRAINT
VM_ValuationUnit.valuationUnitType = “condominium” ;”
END VM_CondominiumUnit;
```

The same methodology was applied when Turkish Country Profile of LADM Valuation Information Model was described in INTERLIS. Figure 6 presents some of the classes and attributes of LADM Valuation Information Model and Turkish Country Profile that defined in the INTERLIS/Editor. Because of limited space, not all the data types, classes and code list are displayed in this figure.

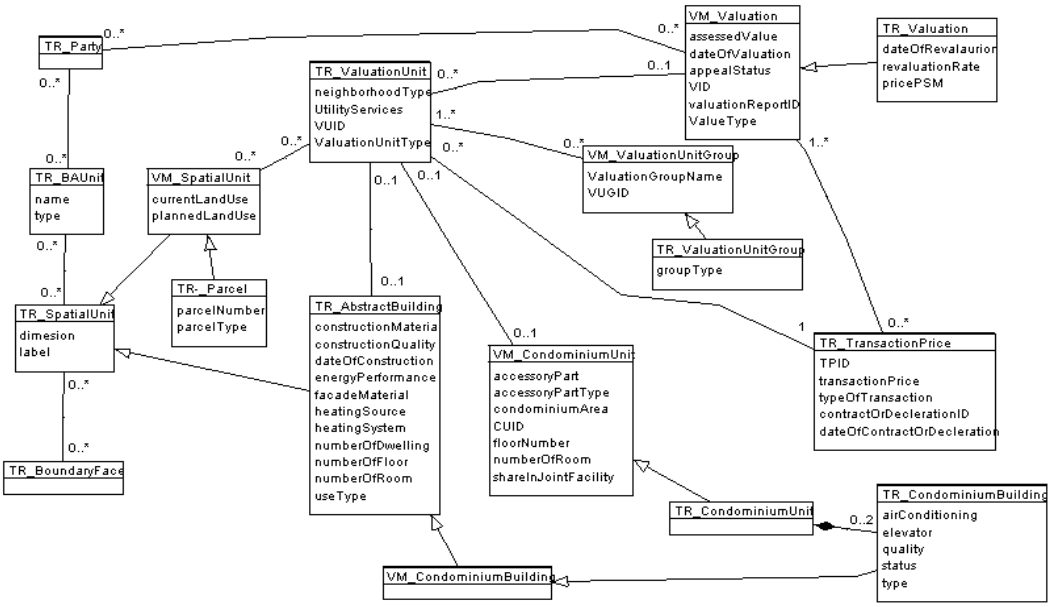


Figure 6. Proposed LADM Valuation Information Model and Turkish Country Profile

After the classes, attributes, code lists, and constraints of the LADM Valuation Information Model were described in the INTERLIS/Editor, the model was exported as an INTERLIS (*.ili) file. Then, the LADM Valuation Information Model and all the other INTERLIS models (ISO_Base, ISO 19107_V1, ISO 19111, ISO 19115, ISO 19156, LADM_Base, and LADM_V1) on which it is based were imported in the INTERLIS-Compiler tool (ili2c) in order to check their correctness. The INTERLIS-Compiler checks the structural correctness of the newly created INTERLIS data models and then provides a data exchange format, such as XML schema and GML schema. In the phase of quality check, a number of structural errors were found in the Valuation Model such as missing commas and TOPIC with no End statements. After these errors were corrected by means of the error massages of INTERLIS-

Compiler, the quality check of the newly created INTERLIS models succeeded as seen in Figure 7. Then, the INTERLIS-Compiler were used to automatically create XML schema and GML schema files for each one of the imported INTERLIS models, LADM Valuation Information Model and Turkish Country Profile.

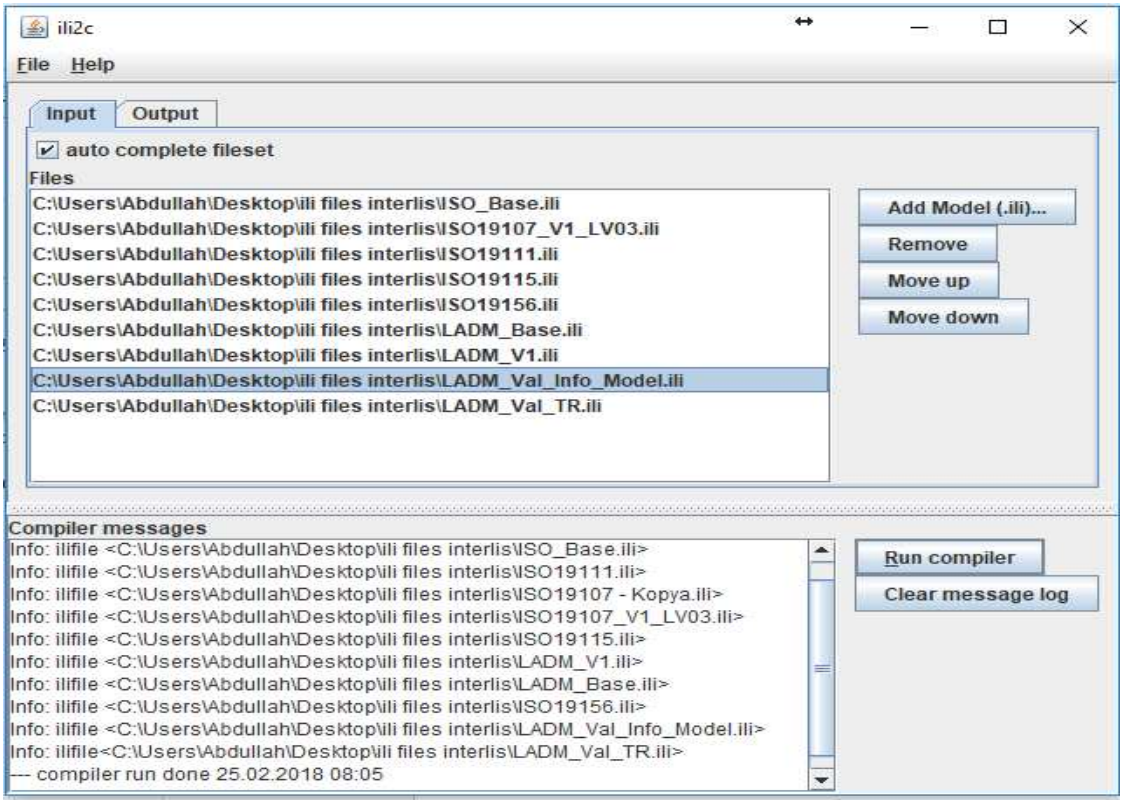


Figure 7. INTERLIS compiler tool (ili2c) for checking correctness of new INTERLIS files

INTERLIS provides some tools for the automatic translation from INTERLIS conceptual schema files to relational databases. In this study, the ORACLE database was chosen since it provides the wide range of advantages such as rich geometry types and automatically created indexes. Therefore, ili2ora tool was used for converting INTERLIS files of the LADM Valuation Information Model and its Turkish Country Profile to the ORACLE database. Firstly, an empty database schema named LADB was created in ORACLE 11g. Then connection between the database and INTERLIS was created with the ili2ora tool. Figure 8 shows the connection between ORACLE database and INTERLIS. After that, all the INTERLIS files (e.g. ISO_Base, LADM_Base, LADM_V1, andLADM_Val_Info_Model, erc.) were imported to the ORACLE one by one. As stated by Kalogianni (2016), deriving a physical model from the conceptual using INTERLIS tools is a repetitive and circular process, since some errors occurred during the mapping form the INTERLIS files to ORACLE SQL. For example, IMPORT statements in the INTERLIS files were not processed by ili2ora and it creates confusions since the data types defined in one INTERLIS files could not use by another file. The rendering of relations between classes in database is another limitation of the ili2ora tool. The relations between classes defined in INTERLIS files (e.g. association

relation) were not mapped to the ORACLE database. Although the most of the Primary Keys (PK) were automatically converted into ORACLE database schema, Foreign Keys (FK) and indexes were missing in the created database. Therefore, some manual fine-tuning was needed when creating an ORACLE database from INTERLIS files together with the INTERLIS tools.

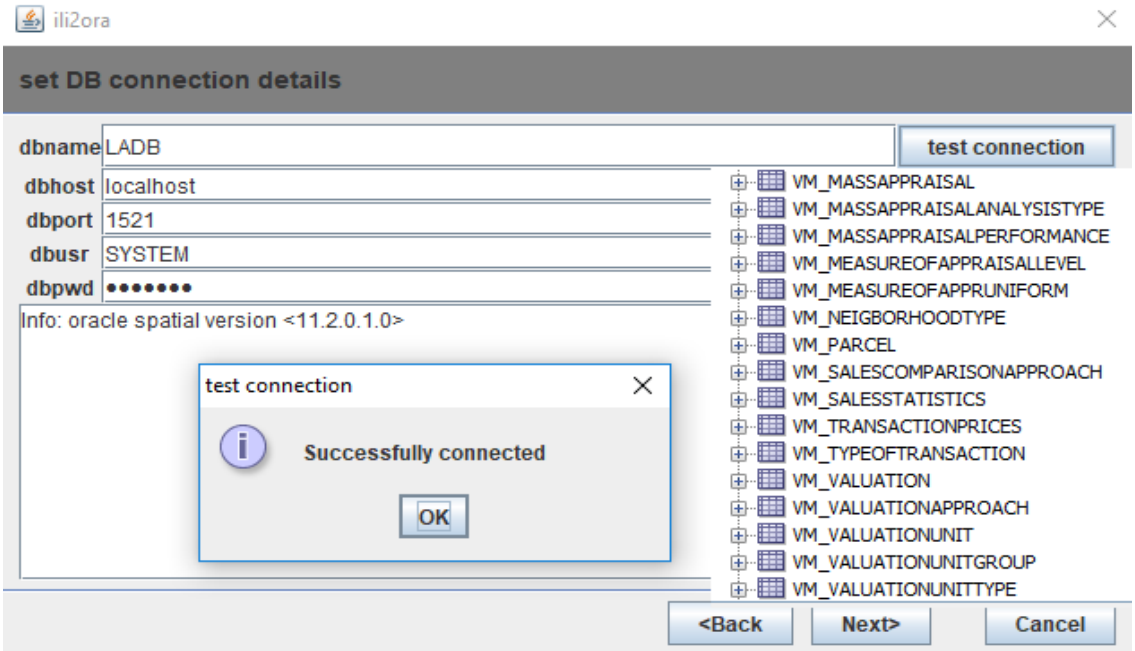


Figure 8. Connection with using INTERLIS ili2ora tool to the empty database

The INTERLIS files (*.ili) of LADM Valuation Information Model and its Turkish Country Profile can be reached at http://www.isoladm.org.

5. CONCLUSION

The use of existing standards and a shared terminology are key challenges for implementation. The INTERLIS tools provide maximum reuse of existing standards for implementing system-neutral and computer-processable database models while using the ISO 19100 series standards together with the ISO 19152 LADM. The use of INTERLIS conceptual language and its corresponding tools creates semantic and syntactic interoperability, both in conceptual and physical models. Moreover, there are also some features that make INTERLIS standard and tools unique, such as 3D geometry including GM_Solid, 3D topology, open source tools, data quality check, and automatic conversion of constraint from conceptual to technical model. The usage of INTERLIS may speed up the prototype implementation processes.

In this study, LADM based Valuation Information Model and Turkish Country Profile was described by means of the INTERLIS data model. The corresponding physical schemas were automatically derived based on the INTERLIS conceptual schema definitions of the models.

The strengths and limitations of the INTERLIS conceptual definitions and tools were investigated. The INTERLIS definitions of ISO 19152 LADM standard, as well as the other ISO 19100 series standards should be improved with further classes, attributes, relations and constraints for more precise modeling, for example, LA_SpatialUnitGroup class should be added the further version of LADM INTERLIS data model. Moreover, some of the INTERLIS tools (e.g. ili2ora) should be improved for the quality of conversion from conceptual to physical model.

It is noted that Kara et al (2018c) presents an ORACLE database implementation for Turkish LADM Valuation Information Model Country Profile. The ORACLE database was manually developed in that study. The manually developed ORACLE database schema is better than the database developed in this study in many ways, for example, (i) defined relations between all classes, (ii) ready for SQL queries, (iii) versioning support (PK of a table consists ID and beginLifeSpanVersion), and (iv) less table created for the implementation and better performance.

Improvement of LADM Valuation Information Model and Turkish Country Profile INTERLIS files, the physical implementation of 3D valuation objects and generation of spatial constraints are determined as future works. Moreover, it should be considered that the INTERLIS conceptual schema definition and tools might be employed for prototype implementation of other standards, for example OGC LandInfra together with the other OGC standards.

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