

Malaysian Land Administration Domain Model Country Profile

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Abstract

Land administration is a process of recording and disseminating information about the association between people and land. To administer land matters in Malaysia, the Department of Surveying and Mapping Malaysia uses *eKadaster* and Land Office has *eTanah* which are different in e-Systems. Currently, Malaysia does not have a standard model for land administration and standardisation is one of the important aspects in a land administration process. This paper proposed a country profile model using international standards based on Land Administration Domain Model. This paper also attempted to generate strata object model via Land Administration Domain Model which would be useful for Malaysia and countries with similar land administration systems. In this proposed model, spatial data modelling using secondary data from the aforementioned two land administration units in Malaysia and Unified Modelling Language application were used to develop the conceptual and the technical models. The developed model was evaluated and verified by the Department of Surveying and Mapping Malaysia and Land Office. These units agreed and were satisfied because the model fits their requirements by being more comprehensive as it included three-dimensional lots and two-dimensional topology. In addition, the proposed model facilitated the management of spatial and non-spatial objects such as customary areas, reserved lands, lots, strata objects, utilities and the related attributes to be better managed by the two units. The development of Malaysian Land Administration Domain Model country profile is unique because it can support a very wide range of spatial units. Furthermore, the model was developed to help establish a national Spatial Data Infrastructure. To conclude, the developed Malaysian Land Administration Domain Model is a standardised model that could be used for local and international exchange of information concerning land administration matters.

Keywords: LADM, country profile, cadastre, registration system, land administration

1. Introduction

According to ISO 19152 (2012), Land Administration Domain Model (LADM) is an important model to create “standardized information services in an international context, where land administration domain semantics have to be shared between regions, or countries, in order to enable necessary translations”. There are many different reasons to adopt International Organization for Standardization (ISO 19152), LADM, such as allows meaningful exchange of data (within country, Spatial Data Infrastructure (SDI) setting, but also between countries); covers complete land administration spectrum: survey, cadastral maps, rights, restrictions, responsibilities, mortgages, persons (individuals of groups); allows integrated 2D and 3D representation of spatial units. Literature shows that many countries propose their own profile based on LADM such as Portugal, Korea, Japan, The Netherlands, Australia/Queensland, Cyprus and others. Malaysia is one of the potential candidates towards LADM-based country profile. This paper describes the conceptual model of the Land Administration Domain Model (LADM), in particular the parties, the rights, restrictions and responsibilities (*RRRs*) and the relationship with spatial data in Cadastral. This paper aims at presenting the concepts of LADM for the Malaysian LADM country profile to harmonize 2D and 3D land registration in Malaysia.

2. Objective

The objective of this research is to propose a country profile for 2D and 3D cadastral registration based on LADM specification for Malaysia.

3. Land Administration Domain Model (LADM)

3.1 Overview of the LADM

The product of the LADM is a conceptual model. The LADM consists of three main packages and one sub-package. A group of classes, with a particular class of cohesion is called a package and it has its own namespace. The maintenance of different organizations is facilitated by packages. The comprehensive model can be performed through a shared set of geo-information systems at different locations, which supports data maintenance and provides elements of the model. The model can also be performed by one or more maintenance organizations, operating at local, regional or national level. The maintenance organizations may be different, with different approaches but still can keep the same standard (ISO 19152, 2012).

The overview of packages with their classes is illustrated in Figure 1. Party Package, Administrative Package and Spatial Unit Package are the three main packages. Meanwhile, Surveying and Representation is a sub-package of the Spatial Unit Package. The LADM classes are prefixed by *LA* (i.e. Land Administration) to differentiate them from other classes in the ISO geographic information series of standards.

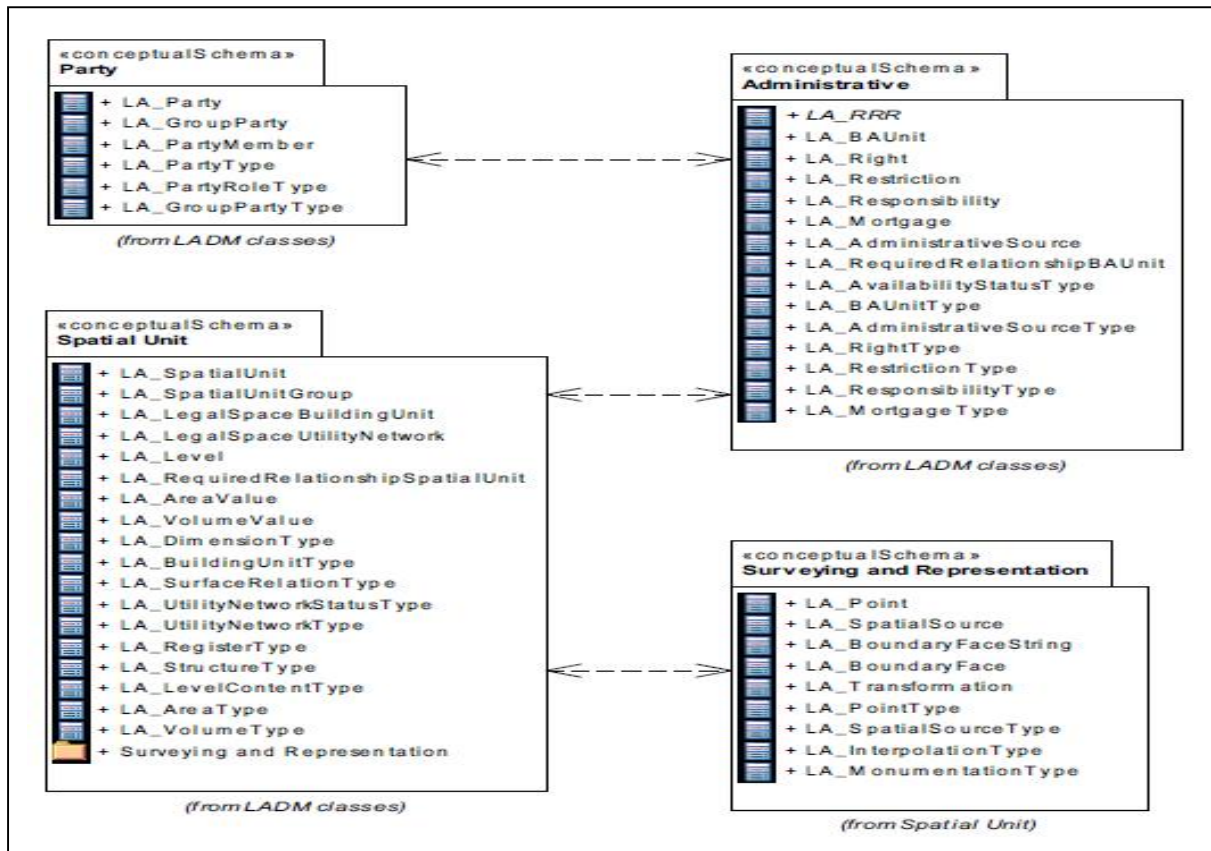


Figure 1. The LADM overview packages with their classes (ISO 19152, 2012)

The beginning of the development of LADM was at the FIG Congress held in Washington DC in April 2002. In September 2002 at the meeting of the Open GeoSpatial Consortium (OGC) in Noordwijk, 1st version of LADM was presented. After that, Van Oosterom and Lemmen (2003) presented 2nd version of the LADM in a workshop on Cadastral Data Modelling at the ITC in Enschede. During Digital Earth in Brno, 3rd version of the LADM was presented (M.P.J.M. Lemmen and C.H.J. Lemmen, 2003) and was called the Core Cadastral Domain Model (CCDM).

Federation of International Surveyors (FIG) submitted a proposal to develop an International Standard for the Land Administration domain to the ISO/TC211 on Geographic Information in 2008 and the proposal gained a positive vote from the TC211 member countries and started to work on the standard development. On November 2012, it was finally accepted as an ISO standard and formally published by ISO on the 1st December 2012.

3.2 Packages of LADM

The main packages of LADM are Party, Administrative and Spatial Unit. The sub-package is the Surveying and Representation. The basic class *LA_Party* is the main class of the Party package. A party can be a normal person, juridical person or a group of persons that can be identified in a transaction of rights relative to a Basic Administrative Unit (BAUnit). *LA_GroupParty* is a specialization of *LA_Party*. A party may participate in a group of party and a group of party may be a party. There is an optional association class called *LA_PartyMember*

between *LA_Party* and *LA_GroupParty* (Figure 2).

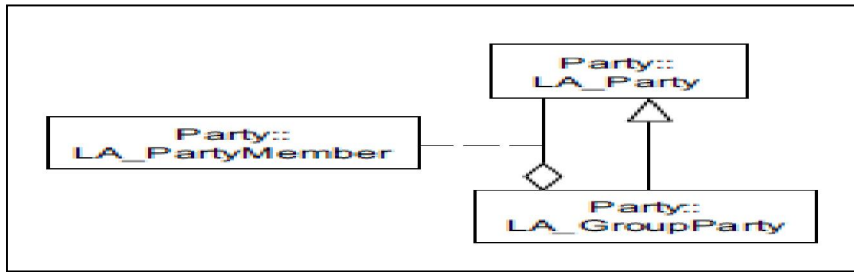


Figure 2. Party package (ISO 19152, 2012)

The Administrative package describes the administrative part of a land administration system and consists of two main classes which are *RRR* and *BAUnit* (Figure 3). The *RRR* class is an abstract class of Rights, Restrictions and Responsibilities (i.e. formal or informal entitlements). Special restriction of the ownership right is called *LA_Mortgage*. This conveys the property by a debtor to a creditor. The conveyance of a property serve as a security for a financial loan, usually the property is refunded to the debtor on full reimbursement of the debt.

The *BAUnit* is defined as numerous spatial units, belonging to a party, having the same right. The right shall be homogeneous to the whole *BAUnit*. Basically, all rights, restrictions and responsibilities come from an administrative source (i.e. *LA_AdministrativeSource*). Class *LA_RequiredRelationshipBAUnit* allows for creating instances of relationships between *BAUnits*. Relationships can be legal, temporal, or of a spatial nature.

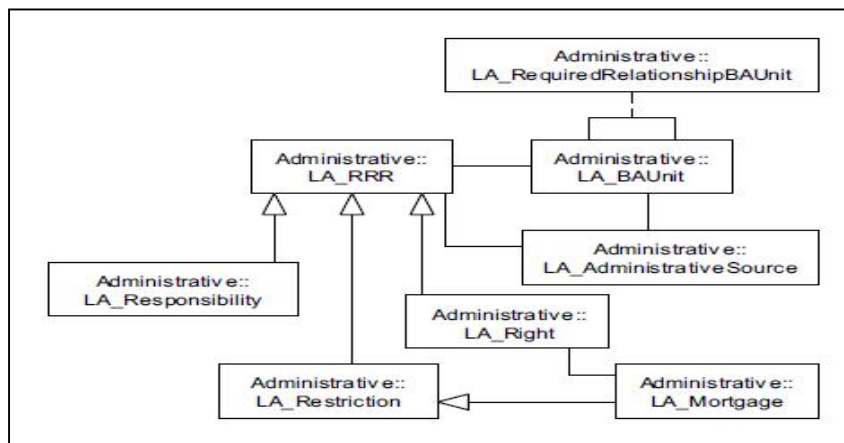


Figure 3. Administrative package (ISO 19152, 2012)

The Spatial Unit package presents the physical objects of a land administration system. The basic class *LA_SpatialUnit* is the main class of the Spatial Unit package. *LA_SpatialUnit* is also known as *LA_Parcel* (Figure 4). The spatial unit class corresponds to the boundaries of a single area or volume of land or water. It is used to support the creation and management of the *BAUnit* and can be specialized as a *LA_LegalSpaceUtilityNetwork* and *LA_LegalSpaceBuildingUnit*. Meanwhile, the spatial unit group class forms a collection of spatial units and the *LA_Level* class regroups the spatial unit with the same topologic, geometric, and thematic coherence.

The required relationships are explicit spatial relationships between spatial units (i.e. *LA_RequiredRelationshipSpatialUnit*). Sometimes there is a need for these explicit spatial relationship if the spatial units inaccurate enough to give consistent results and applying geospatial overlaying techniques.

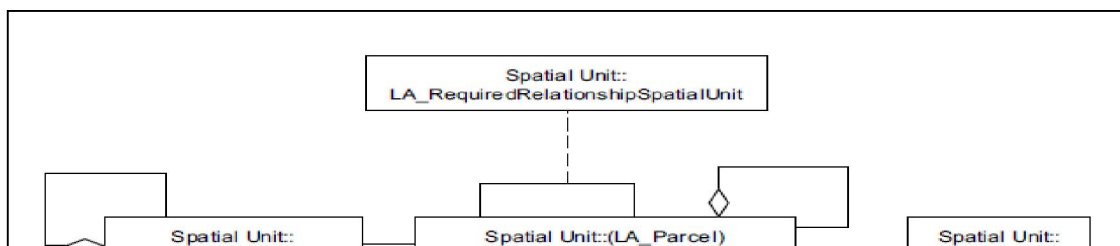


Figure 4. Spatial Unit package (ISO 19152, 2012)

Spatial representation can be described in the Surveying and Representation sub-package (Figure 5). A set of lines which represents 2D boundaries of the spatial units is termed as *LA_BoundaryFaceString*. The *LA_BoundaryFace* class is used to show 3D spatial units. For example, to form a closed or bounded volume in height and depth. The spatial representation of the spatial units could be referred by using *LA_Point* class. *LA_Point* class can be used to define *LA_BoundaryFaceString* or *LA_BoundaryFace* classes. *LA_Point* also is associated to *LA_SpatialSource*. The class *LA_SpatialSource* relates to survey documentation, which contains all documents linked to a survey.

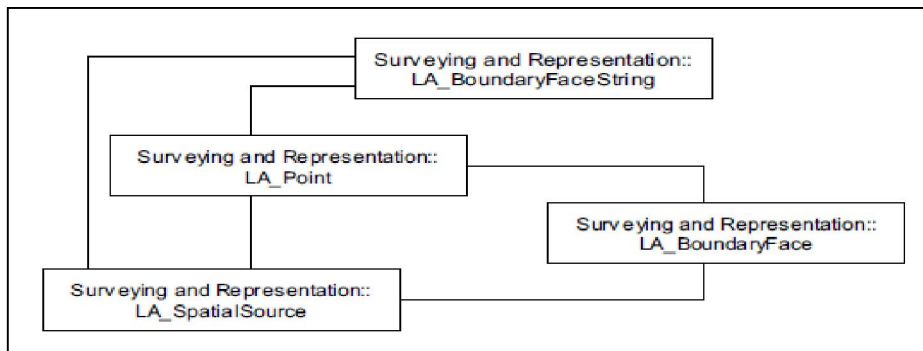


Figure 5. Surveying and representation sub-package (ISO 19152, 2012)

3.3 Basic Classes of LADM

Basically, there are four basic classes of the LADM (Figure 6) which are;

- i. *LA_Party* - Parties are an instances of this class.
- ii. *LA_RRR* - Rights, restrictions and responsibilities are an instances of this *LA_RRR* subclasses.
- iii. *LA_BAUnit* - Basic administrative units are instances of this class.
- iv. *LA_SpatialUnit* - Spatial units are instances of this class.

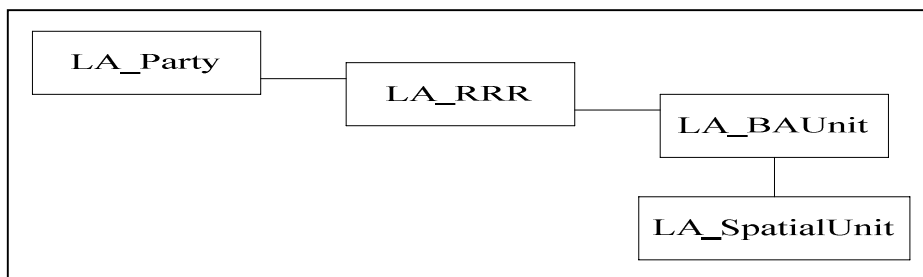


Figure 6. Basic classes of LADM (ISO 19152, 2012)

3.4 2D and 3D Spatial Unit Based on LADM

The spatial units are a flexible concept to illustrate the geometry of an objects in reality, different types of spatial units are supported in LADM (Lemmen, Van Oosterom, Eisenhut, & Uitermark et al., 2010). This type of spatial unit is used if the representation is allowed to have incomplete boundaries and hanging lines. A collection of spatial units with a thematic, geometrical and topological coherence is called a 'level'. The level can be organized on the basis of the geometrical or topological structure of the spatial units, This occurs when the data collected was at different times using different data acquisition methods (Figure 7).

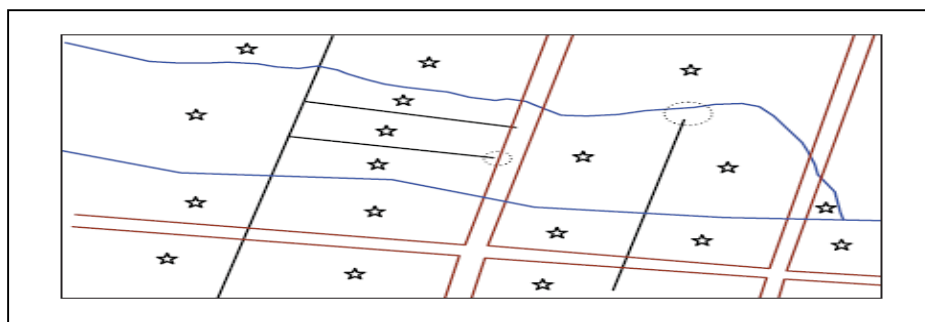


Figure 7. Line based spatial units (ISO 19152, 2012)

3.5 Geometry and Topology Classes

Object classes describing geometry and topology are *tp_node*, *tp_edge* and *tp_face*. Geometry in LADM is based on survey points (mostly after geo-referencing, depending on data collection mode: tape, total station, Global Navigation Satellite System (GNSS), etc.) and is associated with the classes *tp_node* and *tp_edge* to describe intermediate shape points between nodes, metrically based on survey points.

Basically, lots have a 2D or 3D geometry. 2D lot geometry can be defined by a minimum of 3 horizontal planar survey points. For 3D geometry, volume is defined by a minimum of 4 non-planar survey points such as the tetrahedron which is the simplest 3D volume.

The lot corresponds one-to-one to the 'tp_face' in a topological structure. The face is bounded by its edges in 2D. The edge is related one-to-one to a lot boundary, which may contain non-geometric attributes. Each edge has a beginning node and ending node represented in 'tp_nodes'. Furthermore, an edge may also have some intermediate points. Both intermediate points and nodes are associated with survey points. The topological primitives *tp_nodes*, *tp_edge* and *tp_face* have a method (operation) called 'create view' which can be used to obtain a full metric representation. Furthermore, there are also 'create view' methods presented within the area and volume property classes to return the whole and clear geometry respectively *gm_surface* and *gm_volume*. For *gm_volume*, this will result in a tetrahedron.

4. The Creation of Malaysian Country Profile

4.1 Overview of Malaysian Land Administration System

The Malaysian land administration system is based on the Torrens system. The main objective of the Torrens system is to make the register of the documents of title as a conclusive evidence of land ownership. Once a person's title is registered in accordance with the prescribed registration procedures, the person in whose favour the dealing is registered will become the indefeasible proprietor or interest holder to the exclusion of all others. Under Torrens system, for each parcel of land or lot, there is one document of title, namely Register Document of Title in Malaysia. This document has all the essential legal information about the title. This original document is kept in a register maintained by the relevant land office, and duplicate is issued to the registered proprietors for the time being. In Malaysia, Department of Survey and Mapping (JUPEM) is responsible for managing and maintaining the cadastral system. JUPEM deals with the cadastral survey to determine the dimension, size and location of the properties. JUPEM is also responsible for preparing Certified Plan, producing and managing the spatial component including the surveying and mapping of the cadastre parcels. The administrative (legal) data, is the responsibility of the land offices in State level. The land office deals with ownership registration, i.e. who owns the RRRs. Both organizations have their own information management systems: *eTanah* and *eKadaster* in land office and JUPEM respectively (Tan and Looi, 2013).

4.1.1 *eTanah*

Ministry of Natural Resources and Environment (NRE) creates an integrated computerized system, i.e. Electronic Land Administration System (*eTanah*) to realize the computerization of the overall management and administration of land. *eTanah* is planned to improve the delivery of land administration and management services in Peninsular Malaysia using an integrated ICT infrastructure.

The main objective of *eTanah* is to develop a complete system in land offices in order to modernize all activities that are related to land and to realize the implementation of electronic government in the public sector. In addition, the mission of *eTanah* is to implement a National Land Administration System via ICT towards improving the growth of national development. It is an integrated and a fully computerized system to administer land offices in

order to increase the quality of service delivery to the public for all land related dealings. *eTanah* also enables the public to make payments online and print the payment receipts, checking details on their own land and so on.

4.1.2 *eKadaster*

The vision of the Malaysian government is to become a developed country by the year 2020 which encompasses the realization of an efficient public delivery system at various levels. Since 1995, JUPEM has embarked on a modernization program that saw the dramatic computerization of both field and office processes of its cadastral survey division. The digital cadastral database was created by capturing the surveyed accurate information of all land parcels. The *eKadaster* project is under the 9th Malaysian Development Plan (2006-2010). This has been approved to be implemented by the Department of Survey and Mapping Malaysia (JUPEM) and aims to achieve a fully digital Malaysia by 2015.

Under the *eKadaster* project, a comprehensive nationwide readjustment of the meshwork of parcels was carried out based on a new geocentric datum. A dense network model known as the Coordinated Cadastral System (CCS) of Real Time Kinematic Global Positioning System (RTKGPS) permanent stations has been established to provide precise geocentric positioning and implemented through the *eKadaster* project (JUPEM, 2009).

4.1.3 Strata Title

The Register Document of Title has all the essential legal information about the title. Strata title was first introduced into Malaysia by way of certain sections of the National Land Code 1965 (Act 56). In the course of time, it was decided that it would be best to replace the existing provisions of the National Land Code, which relate to strata title with comprehensive Act. Thus in 1985, the Strata Title Act was passed.

The latest update that will bring about a significant change to the landscape of strata developments and common property management comes in the form of the Strata Titles (Amendment) Act 2013 (STAA 2013), which has come into force in June 2015. The amendments under STAA 2013 include the introduction of the Electronic Land Administration System of Strata Titles, the designation of limited common property, and the creation of one or more subsidiary management corporations to represent the different interests of parcel proprietors.

The management corporation is a body corporate of which all proprietors are automatically members, and it has the responsibility of administering the strata scheme, including looking after maintenance of the common property, enforcing by-law and collecting levies from the proprietors to finance necessary expenditure. Proprietors' voting rights and liability to contribution for expenditure are assessed according to their share units or unit entitlements.

Thus, each individual proprietor of a parcel has the advantage of title to his own property, which he may deal with freely in the same way as an ordinary Torrens title property. He has part ownership of the common property with other proprietors and must contribute to expenses, and the scheme in principle is free from the major disadvantages associated with previous methods of ownership of high-rise property.

The proprietors need to get, keep and preserve strata title of their units for the following reasons:

- i. As ultimate proof of ownership.
- ii. As a dealing instrument for instances of charging to banks for loans.
- iii. To facilitate disposal should they wish to sell
- iv. To be able to initiate and get involved when the Management Corporation is formed by proprietors of the units in the sub-divided building or land to maintain and manage the property.
- v. As a final proof of the built-up area of the unit and ultimately, the appointment of the share in the total aggregate units.

Figure 8 illustrates the various types of strata objects in Malaysia. A parcel in relation to a subdivided building, means one of the individual units comprised therein (apartment or condominium), which is held under separate strata title. An accessory unit means a unit shown in a strata plan, which is used or intended to be used in conjunction with a parcel. A common property means so much of the lot as is not comprised in any unit (including any accessory unit). A limited common property means common property designated for the exclusive use of the proprietors of one or more strata lots. A land parcel means a unit delineated within the lot (in which is comprised a building of not more than four storeys) which is held under a strata title and which may have shared basement, accessory unit and common property.

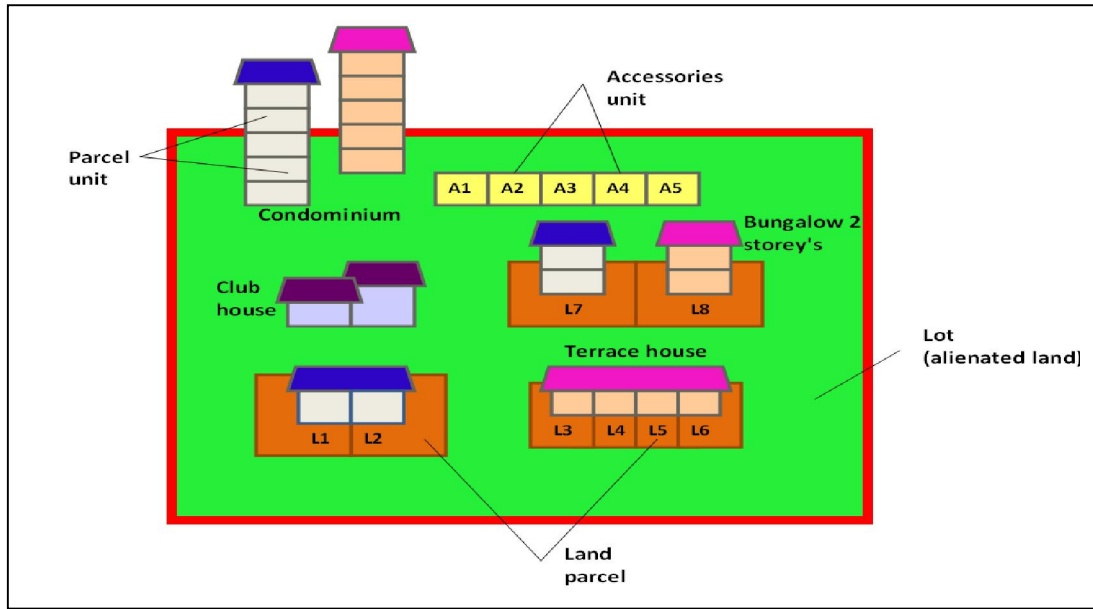


Figure 8. Various cadastral objects related to strata in context of one lot

4.2 Development of Malaysian Country Profile

The development of Malaysian Country Profile is based on the data sources that are obtained from Land Office and Department Survey and Mapping (JUPEM). Administrative data is collected from the Land Office while spatial data is obtained from JUPEM. Administrative data contains ownership of lots and strata title for building. The spatial data for this research contains National Digital Cadastral Database (NDCDB) model for lots and Strata XML model for building. The development of Malaysian Country Profile is also based on the User Requirement Analysis (URA) from JUPEM and Land Office officers.

The URA of this LADM country profile has been established from workshops and meetings organized between JUPEM's core group on cadastre and 3D GIS LADM group of University Technology Malaysia (together with TU Delft) on 7th-8th November 2013. Many suggestions and views were gathered and discussed during the workshops. All the suggestions were incorporated in the conceptual and technical models of the country profile.

Based on the earlier works and publications (Abdul Rahman, Teng, & Van Oosterom, 2011; Tan and Looi, 2013; Zulkifli, Abdul Rahman, & Van Oosterom, 2013), which have taken initial steps towards a Malaysian country profile, this research further develops the model. Figure 9 and 10 give an overview of the developed model. In this research, *MY* is the prefix for the Malaysian country profile, covering both the spatial and administrative (legal) data modelling. For the first time, the Malaysian country profile is now based on the inheritance of the LADM classes. To illustrate the inheritance from the LADM classes, the *MY* classes have either in upper right corner the corresponding *LA* class name in italics or have the explicit inheritance arrow shown in the diagram. All classes in Malaysian model are derived directly or indirectly (via the inheritance hierarchy) from LADM classes.

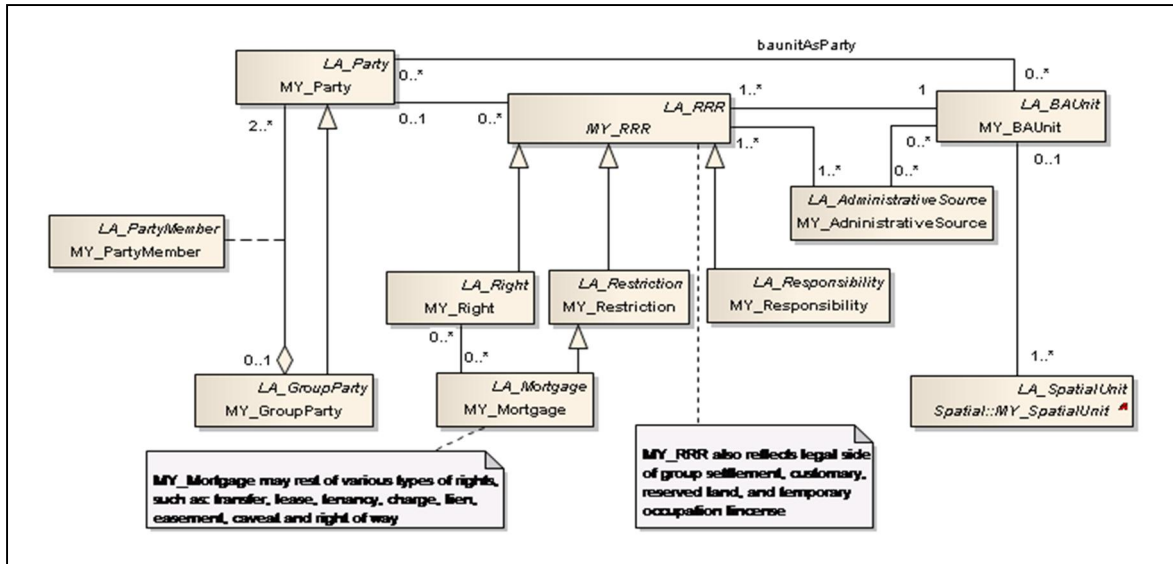


Figure 9. Overview of administrative (legal) part of Malaysian LADM country profile

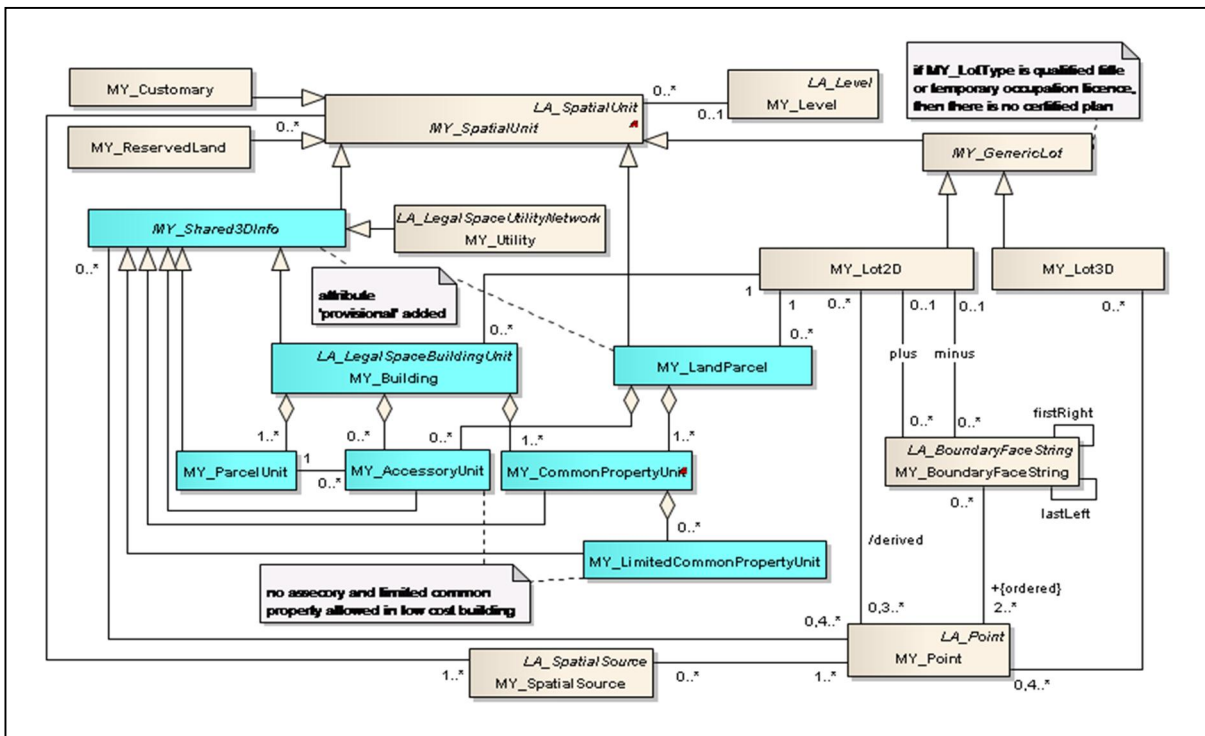


Figure 10. Overview of spatial part of Malaysian LADM country profile

(Blue is used for strata related classes)

4.2.1 Administrative (legal) Part

The legal part of Malaysian LADM country profile contains Party and Administrative package. Main class of the party package is *MY_Party* class with its specialisation *MY_GroupParty*. There is an optional association class called *MY_PartyMember*. Basically, a party is a person or organisation that plays a role in a rights transaction. The organisation can be a company, a municipality or a state. A group party is any number of parties, forming together a distinct entity. A party member is a party registered and identified as a constituent of a group party. This allows the documentation of information to a membership (holding shares in right).

The administrative package concerns the abstract class *MY_RRR* (with its three concrete sub-classes *MY_Right*, *MY_Restriction* and *MY_Responsibility*), *MY_Mortgage*, *MY_BAUnit* and *MY_AdministrativeSource*.

A right is an action or activity that a system participant may perform on or using an associated resource such as ownership, customary, easement and tenancy rights. The rights may be overlapping or may be in disagreement. A restriction is a formal or informal entitlement to refrain from doing something. For example, it is not allowed to build a house on a piece of land or not allowed to transfer the title to other parties within some period of time. A responsibility is a formal or informal obligation to do something such as the responsibility to maintain a monument or a building. The instance of class *MY_Mortgage* is a mortgage. *MY_Mortgage* is a subclass of *MY_Restriction*. *MY_Mortgage* is also associated with *MY_Right* class. The mortgage can be associated to zero or more rights.

A *BAUnit* is an administrative entity consisting of zero or more spatial units (parcels) against which one or more unique and homogeneous rights, restrictions or responsibilities are associated to the whole entity as included in the Land Administration System. An example of a *BAUnit* is a basic property unit with two spatial units with same RRRs attached (e.g. Federal Land Development Authority-FELDA). A settler can have two spatial unit (i.e. residential and farm land) with same RRRs attached. A *BAUnit* may play the role of a *party* because it may hold a right of easement over another, usually neighbouring, and spatial unit.

One of the important foundations of LADM is the fact that all information in the system should originate from source documents and that the association to the source document is explicitly included. In case of administrative source documents (usually titles) there are associations with rights, restrictions (including mortgage) and responsibilities (RRR) and basic administrative unit. *MY_AdministrativeSource* associates with *MY_RRR* and *MY_BAUnit*. The LADM Malaysian country profile uses *sID* for administrative source. Basically, *sID* for administrative source is title number.

Except source documents, all classes in LADM (and therefore also all derived classes in Malaysian country profile), are a subclass of *VersionedObject* and inherit all the *VersionedObject* attributes (Figure 11). The class *VersionedObject* is introduced in the LADM to manage and maintain historical data. As source documents cannot change, only new source documents can arrive, they are not versioned. The current land administration system in Malaysia does not yet support full history management, so this is a significant change. It is not only an important change for the land administration system itself, but it is also crucial for the future Malaysian information infrastructure, as others might need the functionality to refer to historic versions of land administration objects.

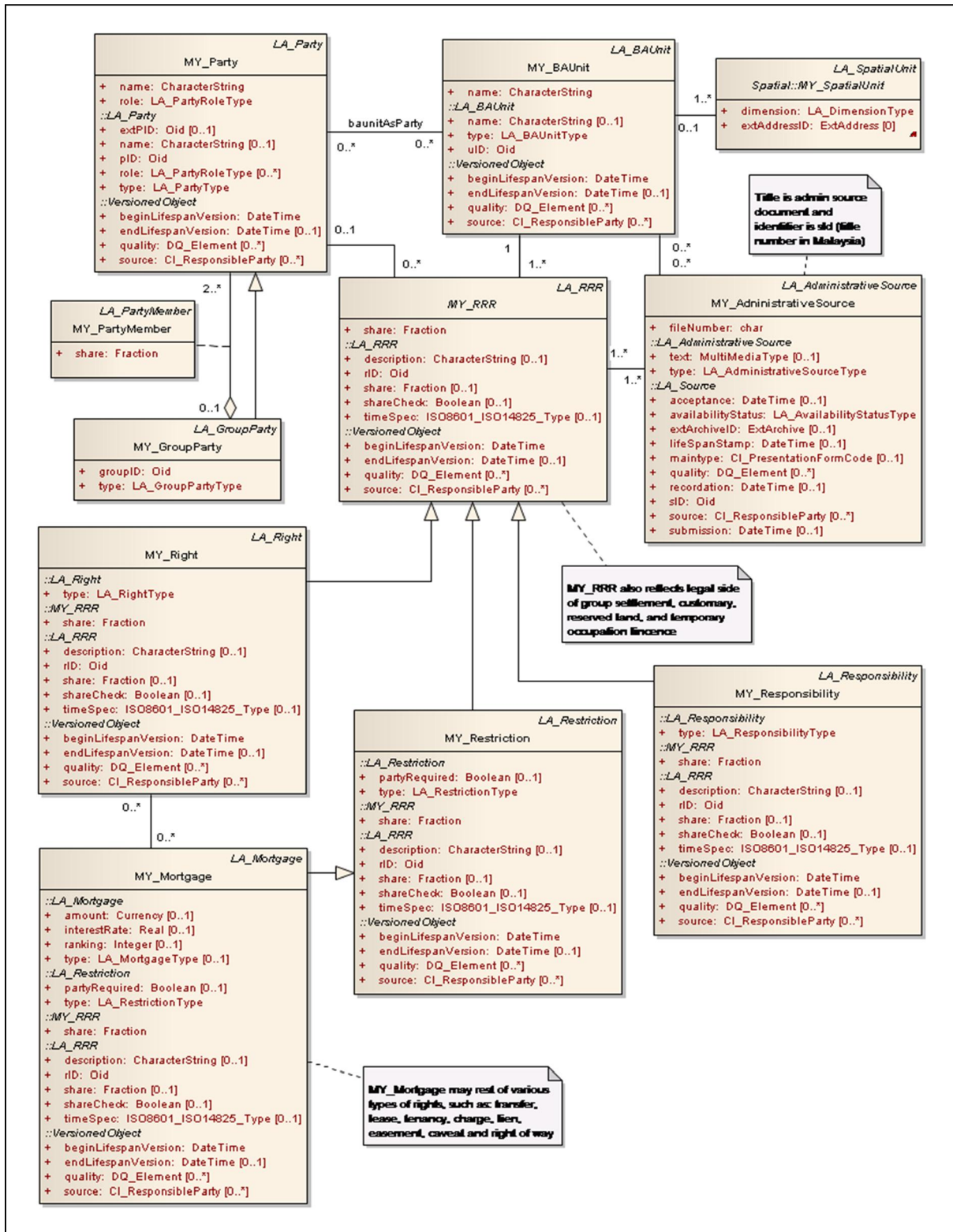


Figure 11. Details of administrative side of model (Mainly showing LADM inheritance)

4.2.2 Spatial Part

In the Malaysian country profile, spatial units can be in 2D or 3D forms. Traditionally, lots (land parcels) are 2D, but the subsurface of lots do already exist with 3D description with volumetric descriptions (without 3D topology). The model has introduced an abstract class *MY_GenericLot* holding the attributes of a lot and this class has two specializations *MY_Lot2D* and *MY_Lot3D*, with their own attributes and structure. Currently *MY_Lot2D* is based on 2D topology with references to shared boundaries (*MY_BoundaryFaceString*).

In the 3D spatial unit, topology is not used: not for lots (*MY_Lot3D*), nor for strata objects. In the model one strata object type remains to be represented in 2D, *MY_LandParcel* (with building no more than 4 storeys). The other strata objects are all proposed to be 3D and therefore inherit from an abstract class *MY_Shared3DInfo*, with strata specializations (and mutual aggregation relationship): *MY_BuildingUnit*, *MY_ParcelUnit*, *MY_AccessoryUnit*, *MY_CommonPropertyUnit* and *MY_LimitedCommonPropertyUnit*. As there can be several *LimitedCommonProperty* in one *CommonProperty*, this is modeled as a part-of relationship to *MY_CommonProperty* (the aggregation class). In the class diagram (Figure 12), the blue classes refer to part of strata objects for a better readability of the model.

Note that there are several abstract classes in the Malaysian country profile as indicated in Italics: *MY_SpatialUnit*, *MY_Shared3DInfo*, *MY_GenericLot*. These classes are only supporting the modelling process, representing shared attributes and structures, and these abstract classes will not get any instances (and therefore no corresponding table in the database implementation). For *MY_Shared3DInfo* there is a geometry attribute (of type *GM_Solid*). Normally the 3D geometry in LADM is represented in *LA_BoundaryFace*, but given the fact that no 3D topology is used there is 1-to-1 association with the spatial unit (one of the specializations of *MY_Shared3DInfo*). So, it could be argued that the proposed country profile is ISO conforming, despite that absence of the class *LA_BoundaryFace*. Figure 12 contains more detailed information concerning the 2D and 3D geometry and topology aspects and the various design decisions for the model.

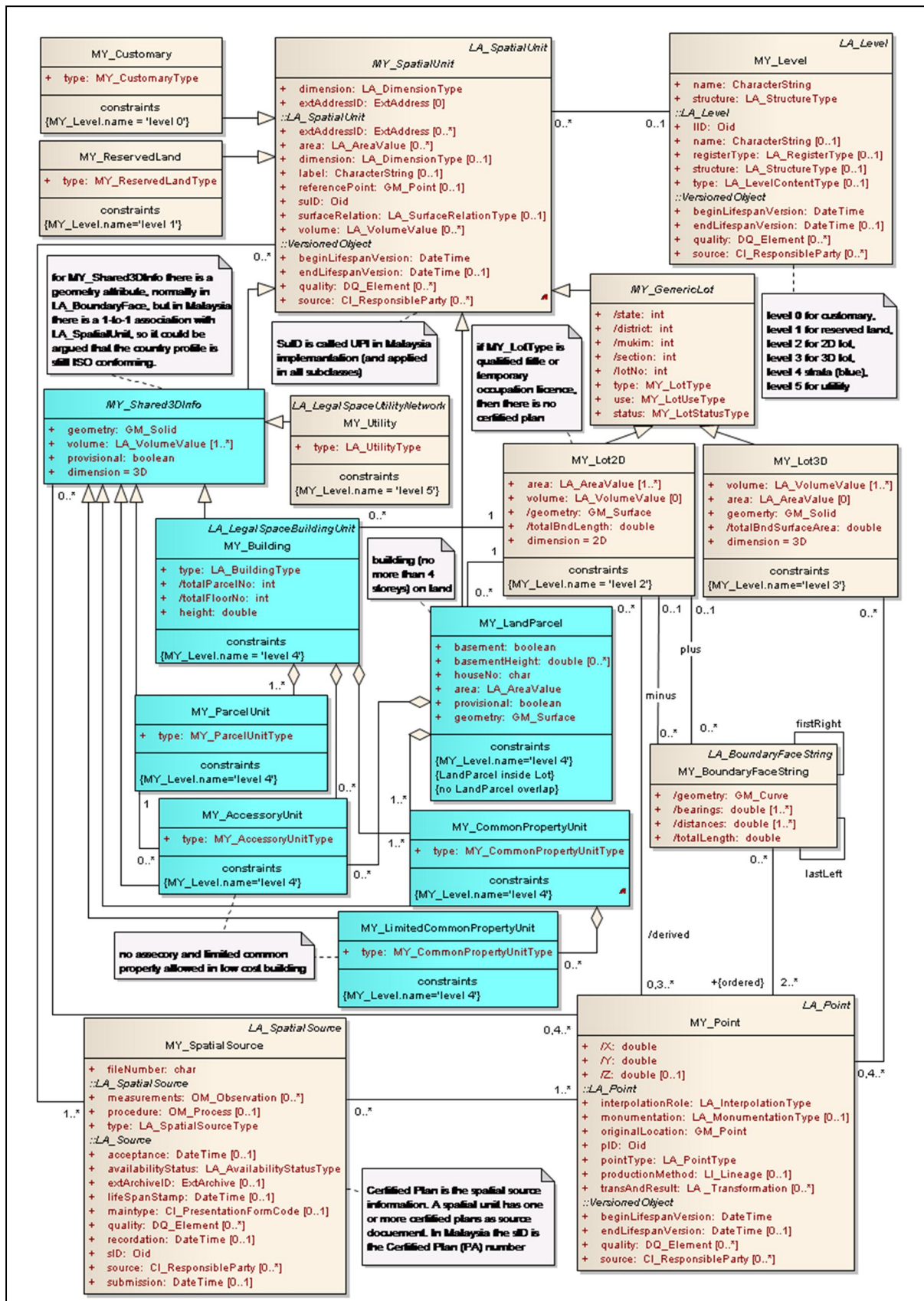


Figure 12. Details of spatial side of model

To make the model comprehensive and future proof, a wide range of spatial units is supported including legal spaces for utilities (3D), customary areas, and reserved land (forest, wildlife areas). It should be noted that reserved land (forest, wildlife), are associated with own RRRs, normally have no overlap, but in some cases overlap can happen depending on state and type. The spatial description of reserved land is by text or sketches, but they may also be surveyed (or a combination with the above).

The various types of spatial units are organized in levels. In this model, *MY_Level* class is used to organize the various types of spatial units. For *MY_Level*, there is a type attribute which describes the level type of the spatial unit. The type of spatial unit includes customary, lots (mixed land and road), building (parts, strata) and utilities. The code list for this attribute can be referred to *MY_LevelContentType*. Basically, *MY_Level* is a collection of spatial units with a geometric or thematic coherence. The following levels are proposed: level 0 for customary, level 1 for reserved land, level 2 for 2D lot, level 3 for 3D lot, level 4 strata, and level 5 for utility. In the involved classes a constraint has been added (third box in class diagram) to make this more explicit. For an example; *MY_Customary* has a constraint: *MY_Level.name = level 0*.

In the case of some special types of lots there may be no Certified Plan; related to Qualified Title (only temporary boundary from sketch/demarcation by settlement officer/pre-computation plan). Also strata with provisional block for building or land parcels for phased development are supported by marking them as provisional via additional attribute. In one scheme for building (3D), it also has provisional block. Based on section 4 of Strata Titles Act 1985 (Act 318), provisional means “in relation to a proposed strata plan, a block in respect of a building proposed to be, or in the course of being, erected, for which a separate provisional strata title is applied for; (b) in relation to an approved strata plan, such a block shown therein, for which a provisional strata title is to be registered; (c) in relation to a book of strata register, such a block shown therein, for which a provisional strata title has been registered”.

In the proposed country profile, there are some attributes, which are repeated after inheriting them from *LA_class*. The reason for this is that they have different multiplicity the same attribute has in the corresponding *LA_class*. For an example, *LA_AreaValue* in *MY_Lot3D* class has 0 multiplicity because this class has no value for area and in *MY_Lot2D* the multiplicity of this attribute is [1..*]: indicating the presence of one or more area values. The original *LA_class* (*LA_SpatialUnit*) for the area attribute has multiplicity zero and more [0..*]. Note that some example area types of *LA_AreaValue* are: *officialArea*, *nonOfficialArea*, *calculatedArea*, and *surveyedArea*.

In case of spatial source documents (usually Certified Plan) there are links with spatial unit and point tables: *MY_SpatialSource* has association with *MY_SpatialUnit* and *MY_Point*. The LADM Malaysian country profile uses *suID* for spatial unit and *sID* for spatial source. Basically, *suID* in Malaysian country profile is based on Unique Parcel Identifier (UPI). *sID* for spatial source is the Certified Plan number. A note has been added in the country profile to indicate this.

In Malaysia there is normally 1 to 1 relationship between *BAUnit* and spatial unit. However, there are some cases where one *BAUnit* (with same RRRs attached) has multiple Spatial Units: a combination of farmland with residential house (Group Settlement Act 1960). Also, some status values of *MY_Lot* (e.g. 10, which indicates charting stage) relate to lots that have yet had RRRs attached, to make this possible, the multiplicity of the association between spatial unit and *BAUnit* is 0..1 (optional) at ‘BAUnit’ side. In the future, the Malaysian land administration system can consider more grouping of spatial units with the same RRRs attached via a single *BAUnit*.

4.2.3 Topology Model

Topological boundaries do not intersect and do meet other boundaries at begin and end nodes. All topological boundaries are used once in positive and also exactly once in negative direction. Unless the boundary is on the edge of the domain, then it is used only once. All associated boundaries together form one or more non-intersecting rings defining at exactly one outer ring (with counter-clockwise orientation) and optionally one or more inner rings (with clockwise orientation). For 2D lots topology is used: based on 3 primitives’ node (point), edge (*MY_BoundaryFaceString*), face (lot). In general, a topological data model manages spatial relationships by representing spatial objects (point, line and area features) as an underlying graph of topological primitives—nodes, edges and faces (Figure 13). Topology is a set of rules and behaviors that model how points, lines and polygons share coincident geometry. For an example, adjacent features, such as two lots, will have a common boundary between them, sharing the same edge. Topology references (in *MY_BoundaryFaceString*) are:

- i. edge-node = *fromNode* and *toNode* (and intermediate points),
- ii. edge-edge = *firstRightEdge* and *lastLeftEdge*, and
- iii. edge-face = *rightFace* and *leftFace*.

Currently JUPEM represents a boundary (edge) with a straight line segment with no intermediate points, but it is proposed in the model to also have potential intermediate points, running from node to node (node=location where 3 or more boundaries meet). It is good to have intermediate points as a boundary, because this will result in less records, a more compact representation with less repeated left/right references (for a chain of straight line segments between two topological nodes, all left/right references must equal).

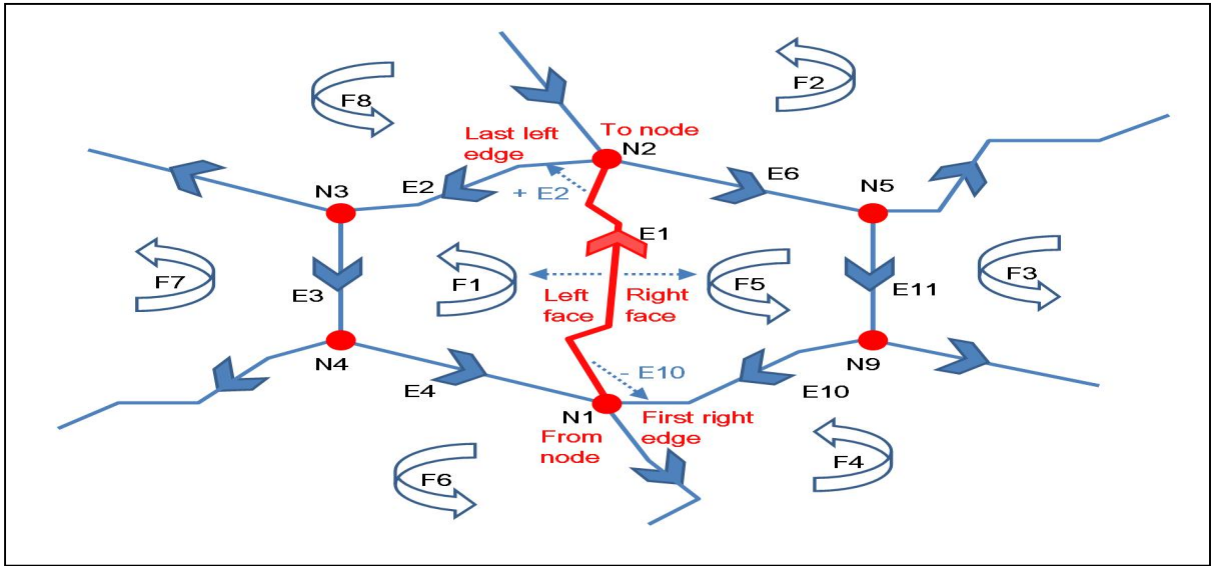


Figure 13. 2D Topology model as used in the Malaysian country profile

4.3 The Technical Model (identifier)

According to LADM, Object identifier (*Oid*) has two parts: the ‘namespace’ and a local *ID*. An example of a possible namespace would be *lot2D.cadastre.jupem.my* (or *point.cadastre.jupem.my*) and by adding this to the local *ID*, it becomes globally unique (as nobody else is allowed to assign *IDs* in this name space). However, within the system of JUPEM (internally), it is not needed to add the namespace (would normally be the same for all objects in the same table). Therefore, internally the local *ID* is enough for the various identifiers values. Next issue is to assign the unique *IDs* for the various types of objects.

The important aspect is that the ‘*ID*’s have to be unique for objects. Note that for a single object there may be multiple versions, which can be differentiated via their *beginDateTime* attribute - part of the Primary Key (PK) together with the *ID*. The identifiers for the land parcels and the various types of (building) units are based on the Unique Parcel Identifier (UPI). The maximum number of UPI for normal lot is 16 characters (JUPEM, 2009). Table 1 shows an example of values of *IDs* for each of the object (spatial unit) type. A more detailed explanation of UPI can be referred to Zulkifli et al., 2013.

Table 1. Example of 'ID's (UPIs) for the main classes

Class	ID
Lot ('Normal' Spatial Unit)	04010800015662
Strata land parcel (building <= 4 storeys)	04010800015662(S)846(L)1
Accessory unit, outside building	04010800015662(S)846(A)1
Common property, outside building	04010800015662(S)846(C)1
Strata multilayer land parcel	04010800015662(S)846(B)ML1(M)0(T)ML1(L)1
Accessory unit, multilayer land parcel	04010800015662(S)846(B)ML1(M)0(T)ML1(A)1
Common property, multilayer land parcel	04010800015662(S)846(B)ML1(M)0(T)ML1(C)1
Strata multilayer land parcel (underground)	04010800015662(S)846(B)ML1(M)0(T)MLB1(L)1
Accessory unit, multilayer land parcel (UG)	04010800015662(S)846(B)ML1(M)0(T)MLB1(A)1
Common property, multilayer land parcel (UG)	04010800015662(S)846(B)ML1(M)0(T)MLB1(C)1
Building - main block (M)	04010800015662(S)846(B)M1(M)A
Building - provisional block (P)	04010800015662(S)846(B)P1
Parcel unit (inside building, condominium)	04010800015662(S)846(B)M1(M)A(T)1(P)1
Accessory unit, inside building	04010800015662(S)846(B)M1(M)A(T)1(A)1
Common property, inside building	04010800015662(S)846(B)M1(M)A(T)1(C)1

5. Conclusions and Recommendations

The LADM is an international standard for the administration of land. This concept is being adopted by several countries to streamline terminologies and enable cross boundary land transaction and acquisition. Referring to conceptual model that is proposed in this research, LADM provides standardized class names for spatial and administrative data. For spatial data class, they have their own standard name called 'SpatialUnit'. In the presented conceptual model, the Malaysian LADM country profile, 'SpatialUnit' has a number of specializations, which are Customary areas, Reserved Lands, Lots (2D and 3D), Legal spaces Building (with various unit types, all in 3D), Land Parcels (strata title, which house no more than 4 storeys, in 2D) and legal spaces Utilities (3D). Building Unit is also divided into three subclasses, which are Parcel Unit, Accessory Unit and Common Property Unit (which has two subtypes: normal and Limited Common Property Unit).

The proposed country profile based on the LADM provides a conceptual model for the 2D and 3D cadastral situations relevant land administration agencies in Malaysia. Strata title and other objects have been enumerated to show how 2D and 3D objects can be registered within the LADM standard. The data model also shows how the two agencies concerned with land administration can be integrated.

LADM can be utilized for 2D and 3D cadastre objects using any UML software tool. In this research, the Enterprise Architect (EA) was used because of the advantage of it having all the ISO models for land administration. It also can perform highly automated transformation of UML diagram, to database tables SQL DDL scripts for data storage or XML schema for data exchange format.

It is good to first experiment with manual transformation from conceptual model to database table, to better assess the issues involved (e.g. define spatial indices/ clustering, transform generic ISO19107 geometry and topology specific database structures, identifiers generated by the system in addition to 'user identifiers', such as UPI, etc.).

The proposed country profile based on the LADM provides a conceptual model for the 2D and 3D cadastral situations relevant land administration agencies in Malaysia. The next steps include a conversion of conceptual model to physical model and development of prototype, using existing sample data from Department of Survey and Mapping and Land Office based on the proposed conceptual model of the Malaysian country profile. The future work may include: Further investigation on the potential use of 3D topology per building, to represent the various units within the building that share faces instead of giving each unit its own 3D geometry which can duplicating the shared faces between neighbours in the database storage; Investigation of potential integration of administrative/legal data (land office) and spatial data (JUPEM) via Malaysian Information Infrastructure (i.e. SDI), with the following two main goals: Consistency of data (data quality aspect) and Combined query (better, more complete services); Exploration the full potential of LADM for the Malaysian Information Infrastructure (i.e. SDI) development.

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