Version 1.0 of the FIG Core Cadastral Domain Model

Christiaan LEMMEN and Peter VAN OOSTEROM, the Netherlands

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SUMMARY

At the FIG Congress in Washington in 2002, the proposal was launched to develop a (shared) core cadastral domain model; the FIG CCDM (van Oosterom and Lemmen, 2002). After the launch several specific international workshops have been devoted to the development of this topic, various organizations have been involved (Open GeoSpatial Consortium - OGC, International Organization for Standardization - ISO/TC211, UN-Habitat, Inspire), MSc/PhD students, researchers and international experts have devoted a significant part of their research to cadastral modeling (Joao de Hespana, Arbind Tuladar, Vladimir Stromcek, Tryggvi Ingvarsson, Young-Ho Lee, Wilko Quak, Paul van der Molen, Jantien Stoter, Jaap Zevenbergen, Hendrik Ploeger, Claudia Hess, Marian de Vries, Clarissa Augustinus, Louis Hecht, Jürg Kaufmann, and many others), resulting in a series of versions of the CCDM published in different magazines, proceedings and journals; the most recent version is called the Moscow-version (van Oosterom et al, 2006).

A standardized core cadastral domain model (CCDM), covering land registration and cadastre in a broad sense (multipurpose cadastre), serves at least two important goals: (1) avoid reinventing and re-implementing the same functionality over and over again, but provide a extensible basis for efficient and effective cadastral system development based on a model driven architecture (MDA), and (2) enable involved parties, both within one country and between different countries, to communicate based on the shared ontology implied by the model. The second goal is very important for creating standardized information services in an international context, where land administration domain semantics have to be shared between countries (in order to enable needed translations). Important conditions during the design of the model were and still are: should cover the common aspects of cadastral registrations all over the world (has been verified via several case studies; e.g. Netherlands, El Salvador, Bolivia, Denmark, Sweden, Portugal, Slovak Republic, Greece, Australia, Nepal, Egypt, Iceland, and several African and Arab countries), should be based on the conceptual framework of Cadastre 2014, should follow the international ISO and OGC standards, and at the same time the model should be as simple as possible in order to be useful in practice.

Note: There is alignment with the FIG Cadastre 2014 (Kaufmann and Steudler, 1999). In short one could state that FIG guidelines in Cadastre 2014 give an excellent start for implementing a cadastral model. However, it is a generic, or abstract, set of guidelines, which must be further refined into a more specific model. This is the aim of the FIG Core Cadastral

Domain Model. One could compare these two levels with the abstract and the implementation level of specification within Open Geospatial Consortium (OGC).

Besides the three well-known concepts, RegisterObject (e.g. Parcel), Person (natural, non-natural and group) and RRR (Right, Restriction, Responsibility), at the class level the model also includes immovables such as Building and OtherRegisterObject (geometry of easement, like a right of way, protected region, legal space around utility object, etc.) and the following concepts: SourceDocument such as SurveyDocument or LegalDocument (e.g. deed or title), and Mortgages. At the attribute level of the model the following aspects are included: SalePrize, UseCode, TaxAmount, Interest, Ranking, Share, Measurements, QualityLabel, LegalSize, EstimatedSize, ComputedSize, TransformationParams, PointCode, and several different date/times. The model supports the temporal aspects of the involved classes and several levels of Parcel fuzziness: Parcel (full topology), SpaghettiParcel (only geometry), PointParcel (single point), and TextParcel (no co-ordinate, just a description). The geometry and topology (2D and 3D) are based on the OGC and ISO/TC211 standard classes. The model is specified in UML class diagrams and it is indicated how this UML model can be converted into a XML schema, which can then be used for actual data exchange in our networked society (interoperability).

After four years, this paper now presents version 1.0 of the FIG CCDM, to indicate that this is the first truly mature version of the CCDM. New elements are: introduction of interface objects (SheetOfRegistry, CadastralMap), times series for valuation attributes, ParcelComplex has been replaced by the more generic ImmovableComplex, Units in Buildings have been specialized into IndivudualUnits and SharedUnits, Parcel has a new (optional) attribute Rural_Urban, and several refinements around the SurveyPoint are made (e.g. indication of Geodetic control points, possible multiple coordinates for points, supporting multiple reference systems). It will be named the Munich-version and besides this paper, the intention is the deliver detailed FIG publication at the 2006 Congress. This publication will include many examples of the CCDM 'at work'.

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INTRODUCTION

The relationship between real estate object (e.g. parcels) and persons (sometimes called 'subjects') via rights is the foundation of every land administration. Besides (informal) rights, there can also be restrictions (or responsibilities) on real estate objects, which can be related to persons. So the class RRR (Right, Restriction, Responsibility), has specializations Rights, Restrictions and Responsibilities. A person can be involved in any number of RRRs and an RRR can involve exactly one person.
In the model there is no direct relationship between Person and RegisterObject, but only via RRR. The CCDM is presented in Unified Modeling Language, UML (Booch, Rumbaugh, Jacobsen, 1999). Figure 1 shows the core of the model in a UML class diagram.

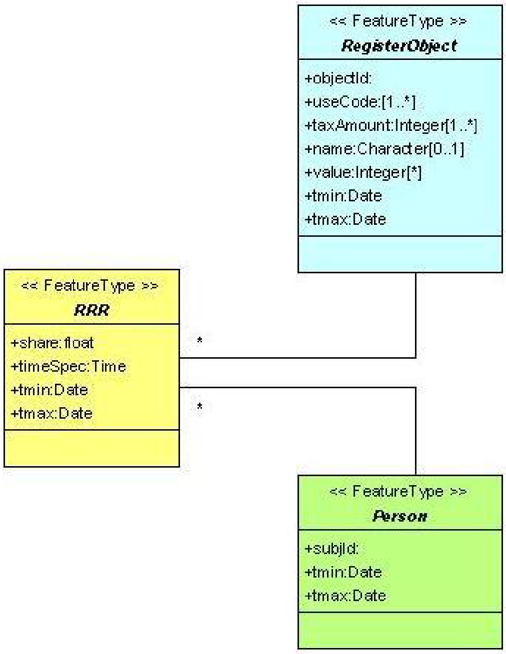

Figure 1: Core of the CCDM: Person, RRR (Right, Restriction, Responsibility) and RegisterObject

The CCDM contains both legal/administrative object classes like persons, rights and the geographic description of real estate objects. This means in principle that data could be maintained by different organizations. The model will most likely be implemented as a distributed set of (geo-) information systems, each supporting the maintenance activities and the information supply of parts of the dataset represented in this model (diagram), thereby using other parts of the model. The model can also be implemented for one or more maintenance organization(s) operating at national, regional or local level. This underlines the relevance of the model: different organizations have their own responsibilities in data maintenance and supply and have to communicate on the basis of standardized processes in so called value adding production chains.

One should not look at the whole model at once as the colors are representing UML 'packages' or coherent parts of the model:

- Yellow: legal/administrative aspects, (figure 2a)
- Green: person aspects, (figure 2a)
- Blue: immovable object specializations, (figure 2b)
- Pink: surveying aspects and purple: Geometric/topological aspects (figure 2c).

See figures 2a, 2b and 2c representing the complete model (including its 'packages') at the end of this paper.

The advantages of distinguishing several packages are: being able to present the CCDM in comprehensive parts, maintain and develop packages independently, possibility to use a package to implement one type of functionality. The idea is that basic packages could be implemented by software suppliers, e.g. GIS suppliers.

It should be noted that though this is the core cadastral domain model, it has not the intention to be complete for one specific country. It is very likely that additional attributes, operators, associations and perhaps even complete new classes are needed for a specific country or region. Further it has to be noted that only a subset of the CCDM can be used for a specific implementation; there are many optionalties.

RegisterObject has a number of specialization classes, in this case two: Immovable and Movable. The Movable objects, such as airplane, ship, train, and car are outside the scope of the model.

1. SPECIALIZATIONS OF IMMOVABLE

The Immovable objects are further refined into two main categories: land, or in 3D space, objects (the 'parcel' family in 2D and 3D in 'light blue') and the other objects (in 'blue'). In this version 1.0 of the CCDM Parcels can be (optional) urban or rural. The specializations of the Immovable class are represented in the 'light blue' and 'blue' package; see figure 2b. The different types of land (space) objects include: RegisterParcel, SpaghettiParcel, PointParcel, TextParcel, ImmovableComplex, PartOfParcel.

These classes can all have actual instances and these instances somehow describe a piece of land (2D) or space (3D). The other immovable register objects (blue) include: Building, Unit, NonGeoRealEstate and OtherRegisterObject. All these specializations of Immovable have associations with one or more Persons via the RRR class. There are parts, called ServingParcels in the model, which only have direct associations with two or more RegisterParcels. Characteristic is that it serves a number of other RegisterParcels, and that it is held in joint ownership by the owners of those RegisterParcels.

Parcels can be aggregated to AdminParcelSets, e.g. a section, a polygon, a municipality, a planning area. This class contains a method for area calculation. An AdminParcelSet can be an aggregation of other AdminParcelSets. In implementations of the CCDM this can be related to identifications.

In the UML class diagram RegisterParcel, ServingParcel and NPRegion are specializations of the topologically structured Parcel, which all-together form the partition (subdivision without gaps and overlaps) of the territory where land administration applies. The Parcel-family of classes is shown in Figure 2b.

A ImmovableComplex is an (optional) aggregation of Immovables. A ImmovableComplex situation might occur in a system where a set of Immovables (e.g. a Unit -see below-, a Building and a Parcel) has a legal/customary meaning. A ImmovableComplex is in itself an Immovable which can be related to a RRR. ImmovableComplex replaces ParcelComplex in earlier versions of the CCDM – as it was under development at that time.

A RegisterParcel can also be subdivided in two or more PartOfParcels. This case could occur when 'preliminary' RegisterParcels are created during a conveyance where the RegisterParcel will be split and surveying is done afterwards. It could also be helpful to support planning processes, based on cadastral maps, where establishment of RegisterParcels in the field is done later in time. Or in case where a RegisterParcel is determined from aerial or space imagery.

The model also offers the possibility to represent parcels not only based on a topological structure (in 2D or in 3D), that is, a set of cells without overlaps and without gaps, but also in alternative ways. A land (or space) Immovable/RegisterObject could (initially) be represented with a textual description (label), a single point or a spaghetti polygon, which is not (yet) adjusted with its neighbors in a topological structure. Spaghetti polygons can overlap each other and can be identified. In this way a land administration 'territory' can be covered by two types of regions:

1. Regions based on parcels with a topological structure, and
2. Regions not (yet) based on parcels with a topological structure.

Together those regions cover the whole territory.

The object class Parcel is therefore also specialized into NonPlanarRegion (NPRegion). A NonPlanarRegion is a region without topological structured data. Note that the NPRegion itself does not have any associated Person (or RRR), that is, it is not a RegisterObject. On the other hand, the land objects in Immovable class include the following specializations: TextParcel, PointParcel and SpaghettiParcel. These three 'alternative' non-topology representations of a land object can only exist in NPRegion areas. A parcel may change its presentation over time from TextParcel (e.g. associated to Person or RRR later in time), to PointParcel to SpaghettiParcel to RegisterParcel. However, this does not need to be the case in situation that the TextParcel, PointParcel or SpaghettiParcel fulfils the needs. Perhaps, the text, point and spaghetti representation of a parcel should be interpreted as a parcel description with a certain fuzziness (all 'fuzzy faces' belonging to the same 'conceptual' partition of the surface).

As mentioned above, the other immovable register objects, the non-land (or space in 3D) subdivision objects, include: Building, Unit, NonGeoRealEstate and OtherRegisterObject (see figure 2b). In the CCDM there is no explicit association between Building and a Parcel as this can be derived from the geometry and topology structures. In case this would not be possible, for example because a TextParcel (without geometry) is involved, an explicit association could be added in that specific country or area. Unit and Building are specializations of Immovable (this is new in version 1.0 of the CCDM, in earlier versions Unit was associated to Building only). A Building is composed out of several Units. Note that a Unit is intended in the general sense, not only unit for living purposes, but also for other purposes, e.g. commercial. In other words, all building units with legal/registration significance are included here.

Futher note that ImmovableComplex allows to relate one right to e.g. a combination apartment Unit, parking place and another Unit in the building.

A Unit has as specializations SharedUnit and IndividualUnit. In such a way an apartment could be represented as an IndividualUnit, the common area's (treshold, stairs, corridors, elevator, roof,…) as a SharedUnit. A Unit is associated to SurveyPoint and so a link to 3D geometry is established. SharedUnit, Individual Unit and the association Unit and SurveyPoint are new functionalities in version 1.0 of the CCDM.

In most cadastral systems a restriction is associated to a complete RegisterObject (RegisterParcel) and this is also reflected in the presented model: a Person can have a Restriction (specialization of RRR) on a RegisterObject. Note that OtherRegisterObjects are modelled as closed polygons in 2D or polyhedrons in 3D and there is no explicit topology between OtherRegisterObjects, that is, they are allowed to overlap. Typical examples of OtherRegisterObjects are: geometry of an easement (such as 'right of way'), protected region (as a consequence of sustainable management of national resources or nature preservation), legal space around a utility object.

RegisterObject contains attributes required for valuation purposes: arrays of values attributes with linked dates (of observation) are included now.

The class NonGeoRealEstate can be useful in case where a geometric description of the RegisterObject does not (yet) exist. E.g. in case of a right to fish in a commonly held area (itself depicted as a ServingParcel), where the holder of the fishing right does not (or no longer) hold rights to a land parcel in the area.

2. SURVEYING CLASSES

Object classes related to surveying are presented in pink color; see figure 2a, 2b, 2c. A cadastral survey is documented on a SurveyDocument, which is a (legal) source document made up in the field. This document may contain signatures; in a full digital surrounding a field office may be required to support this under the condition that digital signatures have a legal support. Otherwise paper based documents (which can be scanned of course) should be considered as an integral part of the cadastral system. Files with terrestrial observations - distances, bearings, and referred geodetic control- on points are attributes of SurveyDocument, the Measurements. The individual SurveyPoints are associated with SurveyDocument. One SurveyDocument can be associated with several SurveyPoints. The SurveyPoints form the metric foundation of both the topology-based objects and the non-topology-based objects.

In case a SurveyPoint is observed at different moments in time there will be different SurveyDocuments. In case a SurveyPoint is observed from different positions during a measurement there is only one association with a SurveyDocument. One of the attributes of a SurveyPoint is the pointCode, which indicates the type of SurveyPoint; this could for example be a Geodetic Control Point (GCP). If the 'same point' is resurveyed several times and the location does change significantly the there are two options in the model: replace the old SurveyPoint with a new SurveyPoint (with a new id) and all associated classes (Building, but also Parcel node, edge,..) must be updated in order to refer to this new id. An alternative is to make a new version of the old SurveyPoint (keeps same id, but gets different timestamps). The associated classes do not have to be updated, only the SurveyPoint itself: new time stamp, better, better coordinate and association to new SurveyDocument. Pervious locations of a specific SurveyPoint can be found via its id, which remains the same. In general the second option is preferred in case the location of the SurveyPoint is changed as this offers all the functionality with a relative small adjustment in the data set. Further, instead of a resurvey there could also be other reasons for changing coordinates, for example map improvement or switching to a different coordinate reference system (or new calculation of same reference system). Note that in version 1.0 of the CCDM indication of Geodetic control points, possible multiple coordinates for points, supporting multiple reference systems are supported.

3. GEOMETRY AND TOPOLOGY: IMPORTED OGC/ISO TC211 CLASSES

Object classes describing the geometry and topology are presented in purple; see figure 2c. The CCDM is based on already accepted and available standards *on geometry and topology* published by ISO and OGC (ISO, 1999a, 1999b, OpenGIS Consortium 1998, 2000a, 2000b, 2000c and 2000d). *Geometry* itself is based on SurveyPoints (mostly after geo referencing, depending on data collection mode: tape, total station, GPS, etc) and is associated with the classes tp_node (topology node), tp_edge (topology edge) and tp_face (topology face, only in 3D case) to describe intermediate 'shapes' points between nodes, metrically based on SurveyPoints.

Parcels have a 2D or 3D geometric description. In 2D a geometry area is defined by at least 3 SurveyPoints, which all have to locate in the same horizontal plane (of the earth surface). In 3D a geometry area is defined by at least 4 non-planar SurveyPoints; this would result in a tetrahedron, the simplest 3D volume object.

Parcels have a 2D or 3D geometric description. The 2D or 3D (ISO/OGC) topology structures are valid at every moment in time. There are never gaps or overlaps in the partition. However, to edges belonging to different time spans (defined by tmin-tmax) may cross without a node. The temporal topology must also be maintained: that is no time gaps or overlaps in the representations. Therefore the structure is based on spatio-temporal topology.

Current cadastral registration systems, based on 2D topological and geometrically described parcels, have shown limitations in providing insight in (the 2D and 3D) location of 3D constructions (e.g. pipelines, tunnels, building complexes) and in the vertical dimension (depth and height) of rights established for 3D constructions (Stoter and Ploeger , 2002; Stoter and Ploeger, 2003; Stoter, 2004). 2D and 3D are treated in the same manner throughout the model; not only for Parcels but for all types of Immovable's. It is important to realize that there is a difference between the 3D physical object itself and the legal space related to this object. The CCDM only covers the 'legal space'. That is, the space that is relevant for the cadastre (bounding envelope of the object), which is usually larger than the physical extent of the object itself (for example including a safety zone).

4. PERSON

'Person' (see figure 2a) has as specialization classes NaturalPerson or NonNaturalPerson like organizations, companies, co-operations and other entities representing social structures. Further there can be a third specialization: GroupPerson. The difference between the NonNaturalPerson and the GroupPerson is that the first is intended to represent instances such as organizations, companies, government institutes (with no explicit relationships to other Persons), while the second is intended to represent communities, cooperation's and other entities representing social structures (with possible explicit relationships to other Persons, optionally including their 'share' in the GroupPerson and associated RightsOrRestrictions to RegisterObjects). Note that a GroupPerson can consist of all kinds of persons: NaturalPersons, NonNaturalPersons, but also of other GroupPersons. In case of more informal situations the explicit association with the group member Persons is optional. Further, a Person can be a member of 0 or more GroupPersons. The composite association between GroupPerson and Person could be developed into an association class 'Members', in which for each Member certain attributes are maintained; e.g. the share in the group and the start and optionally end date of the membership.

5. LEGAL/ADMINISTRATIVE CLASSES

Object classes presented in yellow cover the refinements in the Legal/Administrative side; see figure 2a. The main class in this package is the abstract class RRR with specializations Rights, Restrictions and Responsibilities. In principle, all RRRs are based on a

LegalDocument as source. The essential data of a LegalDocument are can be represented in the classes RRR and Mortgage. A single legal document may even create of mix of these three types. In the other direction, a RRR or Mortgage is always associated with exactly one LegalDocument as its source. Of course it is possible to describe more the one Mortgage in one LegalDocument.

Each jurisdiction has a different 'land tenure system', reflecting the social relationships regarding rights (and restrictions) to land in that area. The variety of rights is already quite large within most jurisdictions and the exact meaning of similar rights still differs considerably between jurisdictions (which could be area's with customary tenures).

The aforementioned rights are primarily in the domain of private law. Usually the rights are created after an agreement between the person getting the right and the person (e.g. the land owner) who restricts his right by the newly created right. The rights and restrictions usually 'run with the land', with means that they remain valid even when the land is transferred after the rights was created (and registered). This is called a right *in rem* in many jurisdictions.

Because property and ownership rights are based on (national) legislation, 'lookup tables' can support in this. 'Customary Right' related to a region or 'Informal Right' can be included; from modeling perspective this is not an item for discussion. Of course, for the actual implementation in a given country or region, this is very important.

In addition to those private law restrictions, many countries also have public law restrictions, which are usually imposed by a (local) government body. The 'holder' of the right is a fake Person (either 'the government' or 'society-at-large') and usually they are primarily seen as restrictions. Some of them apply to a specific RegisterObject (or right therein) or a small group of them, for example most pre-emption rights, or the duty to pay a certain tax for improvements on the road, or the duty to repair damage or perform belated maintenance.
Each non-ownership Right by a third part (be it government or a private Person) causes a Restriction. These Restrictions have their own place in the CCDM: they are modeled as views. That is, not intended to be stored, but to be derived on demand when needed.

Right (a specialization of the abstract super class RRR) is compulsory association between RegisterObject and Person, where this is not compulsory in case of 'Restriction' and Responsibility (the other specializations of RRR). The class RRR allows for the introduction of 'shares of rights' in case where more than one Person holds a undivided part of a 'complete' Right (or Restriction or Responsibility). Object classes presented in yellow cover the refinements in the Legal/Administrative side; see figure 2a.

The first refinement is the extension of the class RRR (which used to be called RightOrRestrction) to explicitly include Responsibilities as well. In current thinking and literature on cadastral and land administration issues usually the three Rs of Rights, Restrictions and Responsibilities are used. A restriction means that you have to allow someone to do something or that you have to refrain from doing something yourself. Restrictions can both be within private law, especially in the form of servitudes, as within public law, through zoning and other planning restrictions as well as environmental limitations. Responsibilities mean that one has to actively do something. Not all legal systems allow such mandated activities as property rights (rights in rem), and this will also effect the question if they can (and have to be) registered. Obviously their impact can be substantial and their registration makes sense.

The class RRR, used to be presented as an association between Person and RegisterObject. In the current version of the model, this has been replaced by a normal class RRR with associations to both Person (exactly one) and RegisterObject (exactly one) as suggested (Zevenbergen 2004 and Paasch 2004). It is still possible that one RegisterObject is related to several Persons (via RRR associations) and reversibly, that one Person is related to several RegisterObjects (again via RRR associations). There is always at least one instance of Right (subclass of RRR) in which the type of right represents the strongest (or primary) right, for instance customary or statutory ownership, freehold or leasehold. Connected to this strongest right certain interests can be added, or subtracted from this strongest right. A point of discussion is how to represent the subtractions (Restrictions) as they are already implied by a non-primary right of a third party. The fact a neighbor is allowed to walk over your Parcel is an additional Right (appurtenance, positive-side) to the ownership of his property, where it is a Restriction (encumbrance, negative-side) to your property. In the present model both sides are represented, but it is the intention to only store the positive-side and derive (compute) the negative side when needed (compare Zevenbergen 2004).

One or several mortgage(s) is always vested on a (set of) Right(s), and should never be seen as a separate relation between Person and RegisterObject. On the other hand a Mortgage is usually vested as collateral for loan. Therefore the mortgagee, is connected to the Mortgage as MoneyProvider; one of the specializations of Person (see figure 2a, 2b and 2c). Note: Mortgage is associated to a Right and not anymore on a RRR as in earlier versions under the development of the CCDM; simply because a Mortgage on a Restriction or Responsibility has no meaning; this is just a small improvement of the CCDM.

The fact that all the different (public law and private law) RRRs find their base in some kind of establishing or transacting document is represented by connecting them to LegalDocument which is a specialization of the abstract class SourceDocument (as is SurveyDocument). The one responsible for drafting the document is connected to this as Conveyer.

The legal/administrative package as just described is based on the notion of one strongest (primary) right, with other limited rights derived from it. This notion can be found in most continental European countries, but it also fits to the different approach found in the Anglo-American law. That starts from the concept of property rights as ‘estates’ held in the land. Ownership in this approach is often seen as a ‘bundle of sticks’. Separate ‘sticks’ of the bundle can be acquired in different ways, can be held by different persons, for different periods. When a person owns all the rights, he is said to own the fee simple title. When he owns only some of the rights, he has a partial interest. This approach is also used in (Paasch 2004). Further research is needed to ascertain that the CCDM can support land tenure systems based on other legal concepts as well; e.g. as in Arab and/or Islam countries.

Land administration systems that have to underpin customary land tenure systems, informally arranged land use or conflicting claims to rights, and whose objects might not be clearly identifiable (fuzzy), not (yet) clearly identified or whose areas overlap are in need of other classes to allow for those type of situations (van Oosterom et al 2004). Often in such countries or jurisdictions both types of situations (strictly legal and formalized and more fuzzy and informal) are to be found in the same area, and should therefore be able to co-exist in the cadastral system, and thus in the core cadastral domain model.

6. HISTORY AND DYNAMIC ASPECTS

There are two different approaches when modeling the result of dynamic systems (discrete changes in the state of the system): event and/or state based modeling:

- In event based modeling, transactions are modeled as a separate entity within the system (with their own identity and set of attributes). When the start state is known and all events are known it is possible to reconstruct every state in the past via traversing the whole chain of events. It is also possible to represent the current state, and not to keep the start state (and go back in time via the 'reversal' of events).
- In state based modeling, only the states (that is the results) are modeled explicitly: every object gets (at least) two dates/times, which indicates the time interval during which this object is valid. Via the comparison of two succeeding states it is possible to reconstruct what happened as a result of one specific event. It is very easy to obtain the state at a given moment in time, by just selecting the object based on their time interval (tmin-tmax).

The temporal aspect is generalized to a TimeSpec attribute. This attribute is capable of handling also other temporal representation such as reoccurring pattern (every week-end, every summer, etc.) Note that nearly every object inherits the TimeSpec attribute via either RegisterObject, RRR or Person. It would have been possible to introduce a new object (TemporalObject with a TimeSpec attribute) from which in turn these three mentioned classes would inherit their temporal attribute (mainly because of legitability this was not done). In addition to the event and state modeling, it is also possible that the 'parent/child' associations between the Immovables (RegisterObject) are modeled (lineage); e.g. when a cadastral parcel is subdivided. However, as these associations can also be derived from a spatio-temporal overlay, it was decided to not further complicate the model with the explicit parent-child relationships. In case of Person and RRR it does not seam useful or meaningful to maintain lineage at all.

Besides the data modeling aspect of the dynamic processes within the CCDM, one could question how are the functions and processes related to each other? The UML class diagram should further be completed by diagrams covering other aspects, e.g. via state (use case, sequence, collaboration, state or activity) diagrams. Activity diagrams show how processes are related to the information (data) and how one 'flows' from on to the other. In all the other mentioned types of UML diagrams, actors or organizations play an important role and this may be quite dependent on the (national) set-up. The introduction of different 'stages' of a parcel (one-point, image, surveyed), a right (start, landhold, freehold) and a person could further reflect the dynamic nature of the system.

7. INTERFACE OBJECTS

The interface objects CadMap and OwnershipFolio support the generation and the management of products and services. Those classes do not contain attributes in itself but they allow the option to relate e.g. customer (identifier), date etc. This can be useful in the link to CRM, WFM and financial systems.

8. CONCLUDING REMARKS

A Core Cadastral Domain Model has been developed to initiate the standardization of the Cadastral Domain.

A main characteristic of land tenure is that it reflects a social relationship regarding rights to land, which means that in a certain jurisdiction the relationship between people and land is recognised as a legally valid one (either formal or non-formal).

These recognised rights are in principle eligible for registration, with the purpose to assign a certain legal meaning to the registered right (e.g. a title). Therefore land administration systems are not 'just handling only geographic information' as they represent a lawfully meaningful relationship amongst people, and between people and land. As the land administration activity on the one hand deals with huge amounts of data, which moreover are of a very dynamic nature, and on the other hand requires a continuous maintenance process, the role of information technology is of strategic importance.

Those circumstances are even more valid in developing countries. For this reason a specialization of the CCDM is under development in co-operation with FIG and UN-HABITAT: the Social Tenure Domain Model (Augustinus et al, 2006).

The following three figures show the compete CCDM: figure 2a the legal and person part of the model, figure 2b the immovable object classes, and figure 2c the Geometry and Topology classes from ISO TC211.

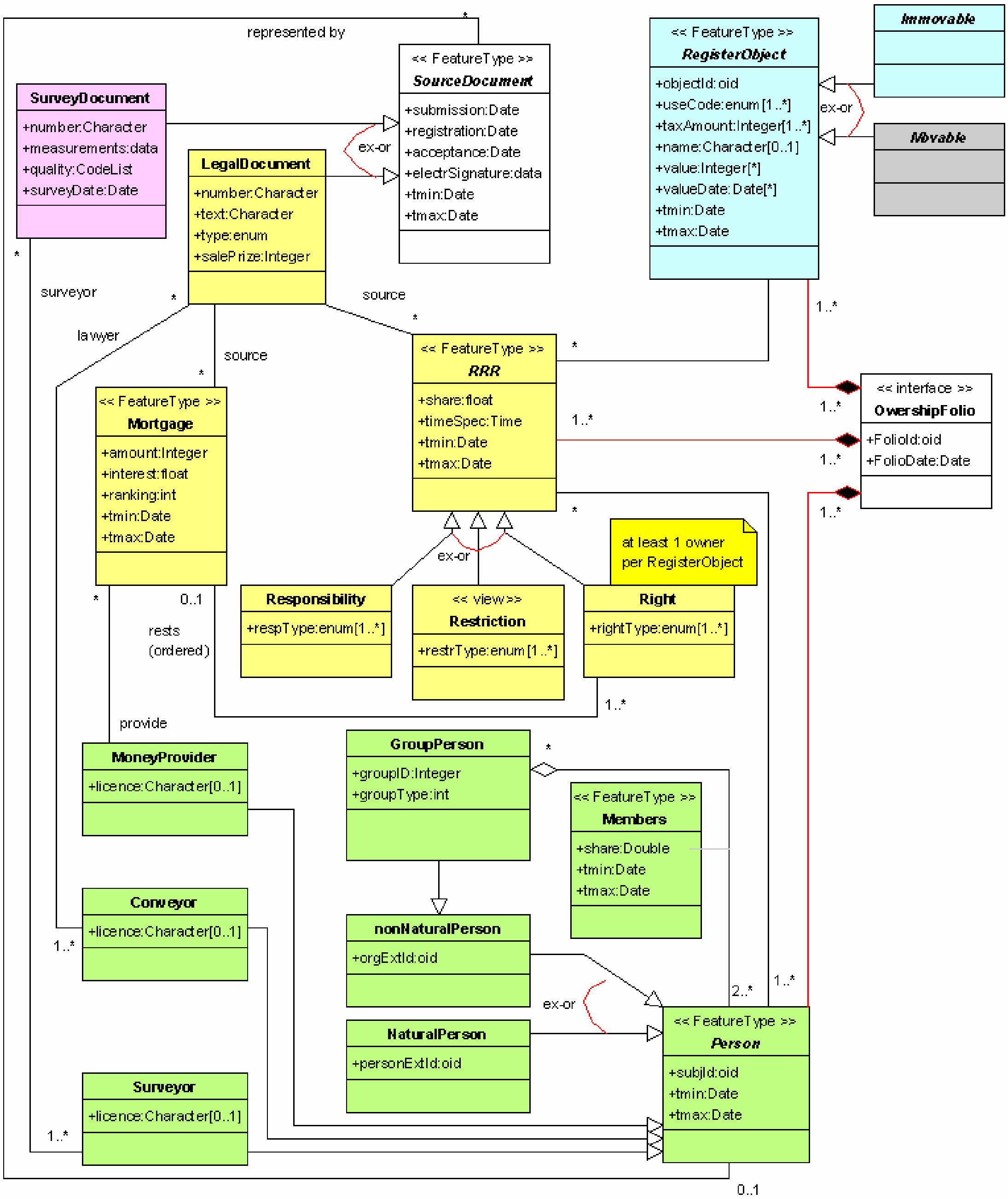

Figure 2a: The legal/administrative and person classes

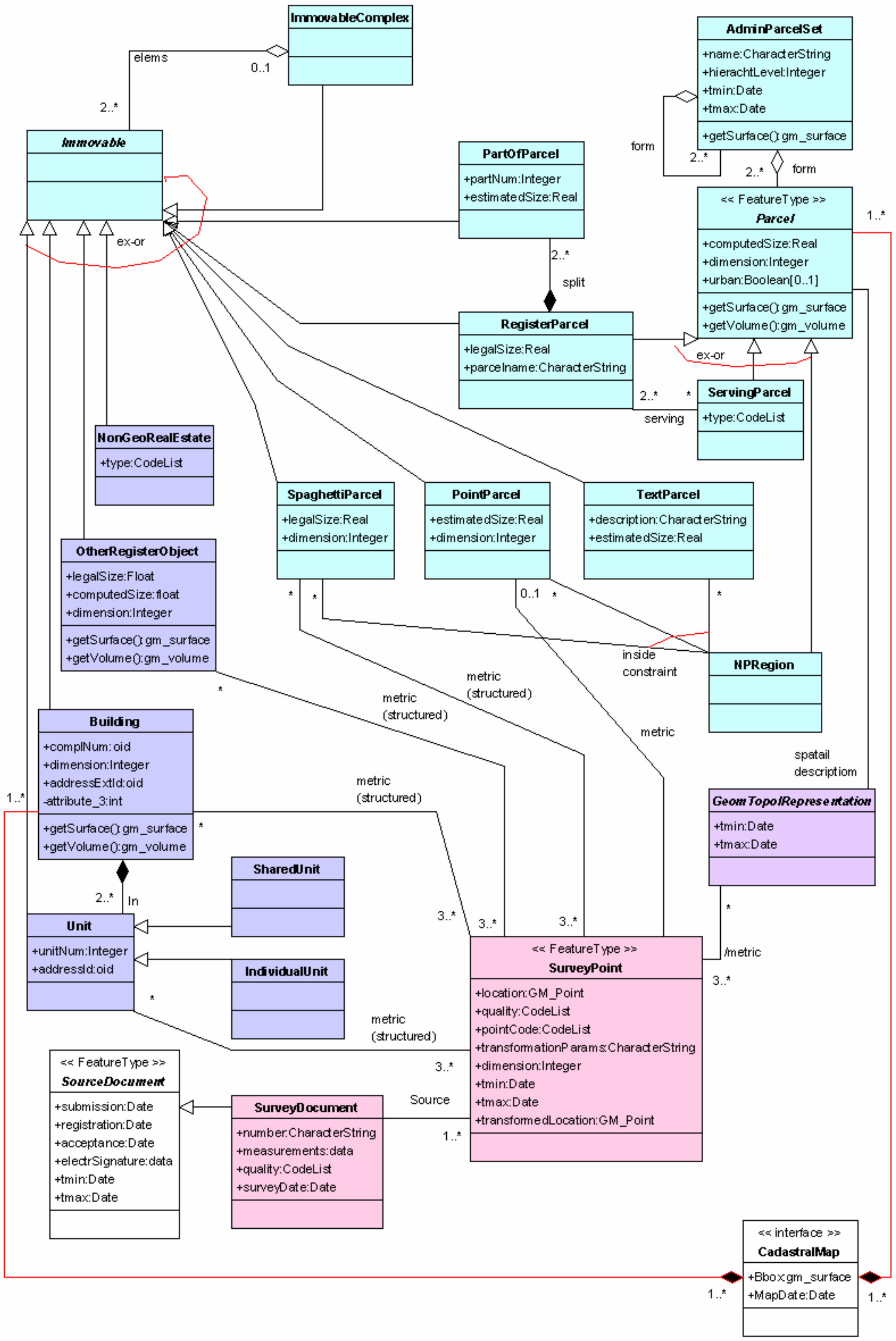

Figure 2b: The different types of Immovable object classes

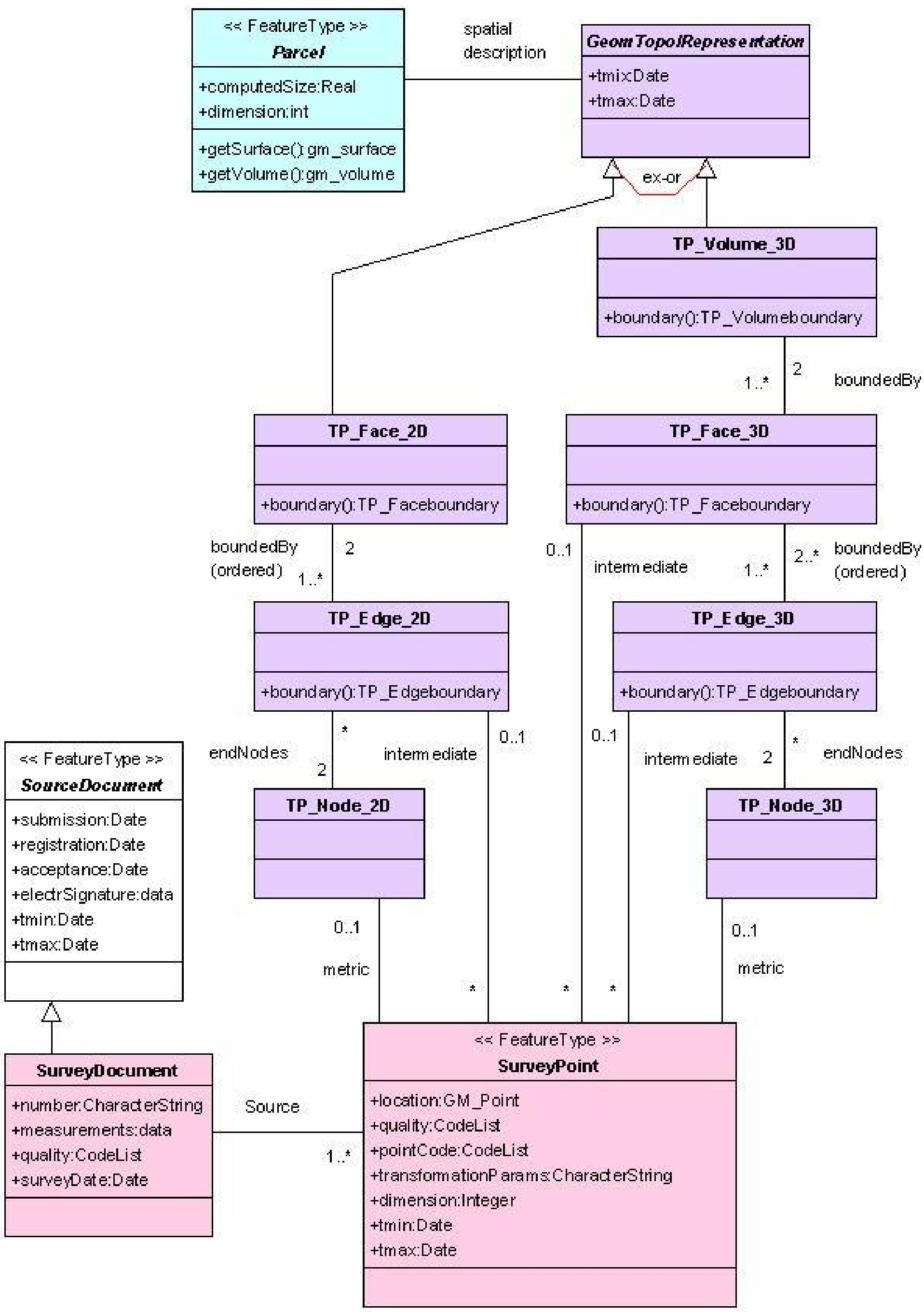

Figure 2c. The Geometry, Topology and some related packages, purple

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BIOGRAPHICAL NOTES

Christiaan Lemmen holds a degree in geodesy of the University of Delft, The Netherlands. He is an assistant professor at the International Institute of Geo-Information Science and Earth Observation ITC and an international consultant at Kadaster International, the International Department of the Netherlands Cadastre, Land Registry and Mapping Agency. He is vice chair administration of FIG Commission 7, ‘Cadastre and Land Mangement’, contributing editor of GIM International and guest editor on Cadastral Systems for the International Journal on Computers, Environment and Urban Systems CEUS. He is secretary of the FIG International Bureau of Land Records and Cadastre OICRF.

Peter van Oosterom obtained a MSc in Technical Computer Science in 1985 from Delft University of Technology, The Netherlands. In 1990 he received a PhD from Leiden University for this thesis "Reactive Data Structures for GIS". From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague, The Netherlands as a computer scientist. From 1995 until 2000 he was senior information manager at the Netherlands’ Kadaster, were he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he is professor at the Delft University of Technology (OTB) and head of the section ‘GIS Technology’. His main research interests are geo-DBMS, generalization, 3D and temporal

GIS, distributed geo-information handling, and cadastral applications. He is European editor for the International Journal on Computers, Environment and Urban Systems CEUS.

CONTACTS

Christiaan Lemmen

Cadastre, Land Registry and Mapping Agency
P.O. Box 9046
7300 GH Apeldoorn
THE NETHERLANDS
Tel.+31.55.5285695
Fax +31.55.3557362
E-mail : chrit.lemmen@kadaster.nl
Web site: www.kadaster.nl

International Institute or Geo-Information Science and Earth Observation
P.O. Box 6
7500 AA Enschede
THE NETHERLANDS
Tel. + 31534874444
Fax + 31534874400
E-mail: molen@itc.nl
E-mail: lemmen@itc.nl
Web site: www.itc.nl

Peter van Oosterom

Delft University of Technology
OTB, Section GIS-technology
P.O. Box 5030
2600 GA Delft
THE NETHERLANDS
Tel. + 31 15 2786950
Fax + 31 15 2782745
E-mail: oosterom@otb.tudelft.nl
website http://www.gdmc.nl