DISTRIBUTED CADASTRAL SYSTEMS

FIG Core Cadastral Domain Model Version 1.0

FIG 2002 Congress in Washington was presented with a proposal to develop a (shared) Core Cadastral Domain Model, the FIG CCDM. Such a model broadly covers land registration and cadastre and provides an extensible basis for an efficient and effective cadastral system. Development proceeds based on a model-driven architecture, enabling communication among parties using a shared, model implied ontology. After four years of development, the authors here present CCDM Version 1.0.

Important considerations during the design process were that the model should cover the most common aspects of cadastral registration all over the world and should follow international ISO and OGC standards, whilst remaining as simple as possible so as to be useful in practice. There is alignment with FIG Cadastre 2014: these guidelines giving an excellent start for implementing a cadastral model that is closer to unambiguous system implementation and information exchange. However, the generic set of guidelines requires specialisation. This is the aim of the FIG Core Cadastral Domain Model (CCDM) here presented in Unified Modeling Language (UML).

Core of CCDM

The relationship between land and people via rights is the foundation of every land administration. In addition to (informal) rights, real-estate objects can have restrictions or responsibilities that may be related to persons. No direct relationship between Person and RegisterObject exists in the CCDM; they are linked via Right Restriction Responsibility (RRR). After analysis of registration needs in many countries, specialisation was developed for the three (abstract) classes as presented in Figure 1, showing the core of the CCDM in a UML class diagram. Whilst it remains core, implementation of the CCDM in a specific country or region may require additional attributes, operators, associations and even introduction of complete new classes. Furthermore, a subset of the CCDM classes alone may be used for a specific implementation; there are many options.

Distributed Systems

The CCDM contains both legal/administrative object classes, such as persons, rights and geographic description of real-estate objects. The model will most likely be implemented as a distributed set of (geo-) information systems, each supporting maintenance activities and information supply of parts of the dataset represented in this model (diagram) and thereby using other parts of the model. This emphasises the relevance of the model: different organisations have their own responsibilities in data mainten-ance and supply and have to com-
municate on the basis of stand-
ardised processes in so-called â€˜value addingâ€™ production chains. In trying to understand the model one should not view it as a whole but look rather at the UML â€˜packagesâ€™ or coherent parts, as shown colour-coded in Figures 2 to 4. Here yellow represents Legal/administrative aspects (Figure 2); green, Person aspects (Figure 2); blue, Immovable Object specialisations (Figure 3); pink, Surveying aspects (Figure 4) and purple, Geometric/Topological aspects (Figure 4). Distinguishing packages like this carries advantages including the ability to present the CCDM in comprehensive parts, maintenance and development of packages as independent parts, and the possibility of using a package to implement one type of functionality; basic packages could be implemented by software (GIS) suppliers.

Yellow Package

Specialisation classes of â€˜Personâ€™ are NaturalPerson and NonNaturalPerson: organisations, companies or government departments. GroupPerson is a third specialisation intended to represent communities, co-operations and other entities representing social structures. The main class in the yellow package is the abstract class RRR, with specialisations Rights, Restrictions and Responsibilities. In principle, all RRRs are based on a LegalDocument. Each jurisdiction has a different â€˜land tenure systemâ€™ reflecting social relationships in rights and restrictions to land. The variety of rights is quite large within most jurisdictions and there may be considerable differences in meaning between similar rights under differing jurisdictions (perhaps areas with customary tenures). Because property and ownership rights are based on (national) legislation, â€˜lookup tablesâ€™ (catalogues) may offer support. Relating to a region, â€˜Customary Rightâ€™ or â€˜Informal Rightâ€™ can be included. â€˜Rightâ€™ is compulsory association between RegisterObject and Person, whereas association is not compulsory in the case of â€˜Restrictionâ€™ and â€˜Responsibilityâ€™. The class RRR allows for the introduction of â€˜shares of rightsâ€™. One or several mortgages is vested on a (set of) Right(s). The mortgagee is connected to the Mortgage as MoneyProvider; one of the specialisations of Person. The fact that all the different (public and private law) RRRs find their basis in some kind of establishing or transacting document is represented by connecting them to LegalDocument, a specialisation of the abstract class SourceDocument, such as SurveyDocument. The Conveyer is responsible for drafting the document.

Blue Package

Immovable objects, represented in blue in the UML diagrams, consist of two main groups. The first is Objects (the â€˜parcelâ€™ family, in 2D and 3D coloured light blue), which include RegisterParcel, SpaghettiParcel, PointParcel, TextParcel, ImmovableComplex and PartOfParcel. These instances of classes in some way describe a piece of land/space (2D/3D). The second group is Other objects (blue),

which include Building, Unit, NonGeoRealEstate (fishing/hunting rights without specific territory) and OtherRegisterObject, such as utility networks. All these specialisations of Immovable Objects have associations with one or more Persons via the RRR class. Some parts, ServingParcels, have direct associations with only two or more RegisterParcels. They serve other RegisterParcels and are held in joint ownership by the owners of these. Parcels can be aggregated into AdminParcelSets such as section, muni-cipality and planning. A RegisterParcel can also be subdivided into two or more PartOfParcels. This may be of significance for cadastral maintenance processes: future final subdivision. The model enables representation of parcels based not only 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 by a textual description (label), a single point or a spaghetti polygon that is not (yet) adjusted to its neighbours within a topological structure. Spaghetti polygons can overlap each other and be identified. In this way a land administration â€˜territoryâ€™ can be covered by two types of region, those based on parcels with a topological structure and those not (yet) so based. NonPlanarRegion (NPRegion); these often occur where cadastres are under development. A Building is composed of several Units that may be used for living, commercial or other purposes. There are IndividualUnits and Shared-Units, the latter corresponding to common areas and facilities and comparable to ServingParcel. ImmovableComplex allows relating one right to, for example, a combination apartment Unit, a parking place and another Unit in the building. RegisterObject contains attributes required for valuation purposes.

Pink Package
Object classes related to surveying are represented in pink. A cadastral survey is documented on a SurveyDocument: a (legal) source document made up in the field. This may contain signatures; in fully digital surroundings a field office may be required to support this, provided that digital signatures/fingerprints are legal. Files with terrestrial observations - distances, bearings, and geodetic control - on points are attributes of SurveyDocument, the Measurements. SurveyPoints form the metric foundation for both topology and non-topology-based objects. The CCDM supports multiple reference systems, so that points are allowed to have multiple coordinates.

Purple Package
Object classes describing geometry and topology are represented in purple. The CCDM is based on accepted and available standards on geometry and topology published by ISO and OGC. â€˜Geometryâ€™ itself is based on SurveyPoints, mostly after geo-referencing, depending on type of data collection. This may include tape, total station and GPS and is associated with the classes tp_node (topology node), tp_edge (topology edge) and in 3D case tp_face (topology face), to describe intermediate â€˜shapesâ€™ points between nodes, metrically based on SurveyPoints.

Time and Interfaces
The temporal aspect is generalised to tmin/tmax and TimeSpec attributes. The tmin/tmax attributes indicate to which system time-period a version relates. Nearly every object inherits the tmin/tmax attributes via either RegisterObject, RRR or Person. The TimeSpec attribute of the class RRR and all its subclasses is able to handle the user (or valid) temporal representation as a recurring pattern, such as every weekend or every summer. Besides the data modelling aspect of dynamic processes, the relation between functions and processes may be questioned. The UML class diagram should further be completed by diagrams covering other aspects such as via state (use case, sequence, collaboration, state or activity) diagrams. Activity diagrams show how processes are related to the information (data) and how one â€˜flowsâ€™ to another. The introduction of different â€˜stagesâ€™ of a parcel (one-point, image, surveyed), a right (start, landhold, freehold) and a person could further reflect the dynamic nature of the system. Interface objects CadMap and OwnershipFolio support generation and management of products and services. These classes do not themselves contain attributes but allow linking of customer (identifier), date and so on. This can be useful in the link to CRM, WFM and financial systems.

Concluding Remarks
Since launch of the CCDM, international development workshops have been held, various organisations have become involved (Open GeoSpatial Consortium - OGC, International Organization for Standardization - ISO/TC211, UN-Habitat, Inspire) and MSc/PhD students, researchers and international experts have carried out much research. The resulting versions of the CCDM have been published in magazines, proceedings and journals. Land-administration systems do not â€˜just handle geographic informationâ€™; they represent a lawfully meaningful relationship between people, and between people and land. As land-administration activities involve huge volumes of extremely dynamic data, requiring continual maintenance, the role of IT is stra-tegically important, especially in developing countries. A specialisation of the CCDM is therefore under development in co-operation with FIG and UN-HABITAT: the Social Tenure Domain Model.

Further Reading

- Augustinus, C, Lemmen, C.H.J., van Oosterom, P.J.M., 2006, â€˜Social Tenure Domain Model - Requirements from the Perspective of Pro-Poor Land Managementâ€™, 5th FIG Regional Conference, Accra, Ghana.
- Kaufmann, J. & Steudler, D., 1998, Cadastre 2014, A Vision for a Future Cadastral System, FIG, Denmark.
- Oosterom, van, Peter et al, 2004 Proceedings of the Workshop Standardisation in the Cadastral Domain, Bamberg, Germany, 9-10 December 2004, FIG, Denmark.