Modernizing Natural Resource Management in Minnesota

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SUMMARY

Thomson Reuters is currently in the final stages of implementing a modern land administration system in Minnesota Department of Natural Resources (MN DNR). The use of automation technology is expected to improve the management and administration of over 5 million acres of public lands and mineral interests underlying more than 10 million acres of land, while helping to preserve ecological and historical resources as well as develop mineral, timber and other natural resources for the benefit of Minnesota schools and universities.

At Thomson Reuters we embraced the Land Administration Domain Model (LADM) from its early days and support this standard in our land administration software. In recent years, especially with the completion of ISO approval process, the standard model found much wider acceptance in the industry. While LADM's comprehensive representation of land information is beneficial for providing a common starting point in new land information system designs it makes transition from other proprietary data models challenging, especially in the cases when the legacy data is fragmented, incomplete or unreliable. Additional challenges arise when administrative records are not fully and uniquely related to spatial data.

MN DNR has started automating land administration using information technology in mid-1980s by building in-house land information management applications on IBM AS/400 platform. Given the level of mainstream technology capabilities of that time, the system focused on administrative data and did not include support for storing and maintaining spatial information. This forced extensive use of Public Land Survey System (PLSS) grid references to identify approximate parcel location, which, in turn, resulted in artificial spatial fragmentation of real interests represented in the legacy data. Additionally, inability to determine overlapping or coinciding interests using only a PLSS designation would also affect the use of LADM to its full potential.

These data-related challenges, if not properly identified and addressed, would limit the benefits of transitioning to LADM as the information would become more complex to query, analyze and maintain. This article shares the author's experience applying LADM to automate administration of land and mineral properties, describe challenges and lessons learned and discuss potential approaches to the transition to LADM, potential pitfalls and model extensions.

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1. INTRODUCTION

The MN DNR land administration system project converged a variety of factors and backgrounds that affected the choices and approaches taken to design data models, interpret, as well as map and convert information. These design decisions were driven by seemingly unrelated or loosely related topics like history, information technology, surveying and mapping, and real property law. It is my anticipation that some, perhaps minimal, insight into this context will be required to appreciate the origin and weight of the challenges that were encountered within this project. Thus, by the way of introduction, I would like to offer a quick overview of these areas.

1.1 History of State Lands in MN

In the old days, when the American colonies had just separated from Great Britain the explored and claimed lands were, to a large degree, confined to the original 13 states. Each of these states, by a mere virtue of their sovereignty, took ownership of all vacant and unclaimed land within its borders. At the end of American Revolution the United States acquired a title, for the benefit of all the states, to the region that was organized as the Northwest Territory, which in due course of history became the states of Indiana, Ohio, Illinois, Michigan, Wisconsin and the part of Minnesota east of the Mississippi River. Further, lands that currently constitute the territory of Minnesota west of the Mississippi River were acquired by the United States as part of the Louisiana Purchase of 1803 and additional portions became part of the US after settling its northern boundary with England in 1818. All these lands were surveyed and mapped by the US General Land Office (GLO) [now Bureau of Land management (BLM)], which created the initial parcel subdivision and designation now known as the Public Land Survey System (PLSS).

All this turbulent history placed public lands into Federal ownership. State ownership of land started building up via Congressional grants, such as the Morrill land grants of 1862 and 1890, that placed certain public lands under state ownership to help funding public schools and universities. Additionally, tracts of mostly swamp and overflowed lands were granted to the state for reclamation and improvement. These grants vested full fee simple absolute ownership into the state.

The state land acquisition ownership continued to expand through the acquisition of private lands through funding programs directed towards natural resource preservation as well as private grants by individual land owners and environmental conservation organizations. Interests acquired by the state through these programs vary from ownership to easements to less durable interests, such as leases. Additionally, the state continues to acquire interest in forfeited lands.

Minnesota statutes prevent the state from alienating mineral rights in state lands when the land is sold into private ownership. This fact results in a division of the bundle of rights when state lands are transferred. Both private and state ownership of minerals is still common as mineral rights could be transferred from the Federal government into private ownership when the land was claimed and purchased.

1.2 Role of the Department of Natural Resources

The department defines its mission (MN DNR, 2013) as “to work with citizens to conserve and manage the state's natural resources, to provide outdoor recreation opportunities, and to provide for commercial uses of natural resources in a way that creates a sustainable quality of life”. This multi-faceted mandate drives somewhat conflicting objectives but allows for balancing the use of land for various purposes such as commercial use of natural resources and their conservation.

In addition to its natural resource management role the department administers the land granted to the state in trust for the benefit of public schools and universities. This role has the objective of using land assets to provide sustainable long term revenue to the state’s public education system. This precipitates the need for commercial use of these lands and often includes forestry and timber production, agriculture, and mineral and aggregate material extraction.

1.3 History of MN DNR land information systems

The department started digitizing and automating land information in the 1980’s with the use of IBM AS400 mid-range computers. The information management system supporting management of real property was initially rolled out between 1986 and 1989 and currently runs on IBM i5 model 515.

The system tracks real estate interests currently or previously administered by the DNR as well as real estate transactions, billing and payment information. Over time, it organically grew to include inventory of mineral assets, valuation information for land that is subject to payments in lieu of property tax (PILT), and substantial additional information in support of the business processes in the organization. Most of this development was carried out by the department’s application support staff maintaining and programming the application using RPG programming language.

Besides the land records database described above, the department created and currently maintains a number of small independent databases and applications to support many other areas of its business.

MN DNR has extensive history managing spatial data and applications. GIS operations, however, developed somewhat independently of land records management and the spatial data collected and maintained did not include consistently collected delineation of transacted real estate. Historical land inventory, for the most part, is delineated by the corresponding PLSS subdivision (typically a quarter-quarter-section) while more recently transacted parcels have their true boundaries delineated more precisely. Where possible, the parcel boundary would be correlated with the GIS data maintained by the local government within each county.

1.4 Modernization of land information

In 2009 the Minnesota Department of Natural Resources engaged in a multiyear effort to modernize its land records process and information systems. At the center of this effort the department set the replacement of its aging Land Records and Mineral Rights information system with a new system that would also provide additional functionality and capabilities. These additional capabilities include business process reengineering and automation, and consolidation of some smaller disparate datasets into the central repository, which would include tabular data and electronic documents, as well as close integration of spatial information into the information system and organizational business processes. By selecting Thomson Reuters software solution the department became an early adopter of LADM standard, which at the project inception, still was in its draft form. While following a draft standard is often associated with the risks of changes having to be introduced into system designs, it helped to promulgate the LADM concepts within the organization and helped to build organizational knowledge.

2. LEGACY LAND INFORMATION MODEL

The information model of the legacy information system was developed by the department's application development team over a number of years. While being an independent design effort, it, similarly to many other land information systems, operates with many concepts and notions described by LADM such as interests, interested parties, documents, etc. The model, however, has significant differences in design, implicitly and explicitly represented concepts and classes, definition and semantics of data structure and elements. This makes data mapping and transformation transitioning to LADM non-trivial, requiring a choice from multiple different options. This section provides an overview of the legacy data model as well as highlights of several areas requiring special consideration.

2.1 Conceptual data model

For the purpose of this discussion the legacy data model is represented conceptually with only some classes and attributes represented on diagrams. The core portion of the data model related to real property interests is depicted in Figure 1.

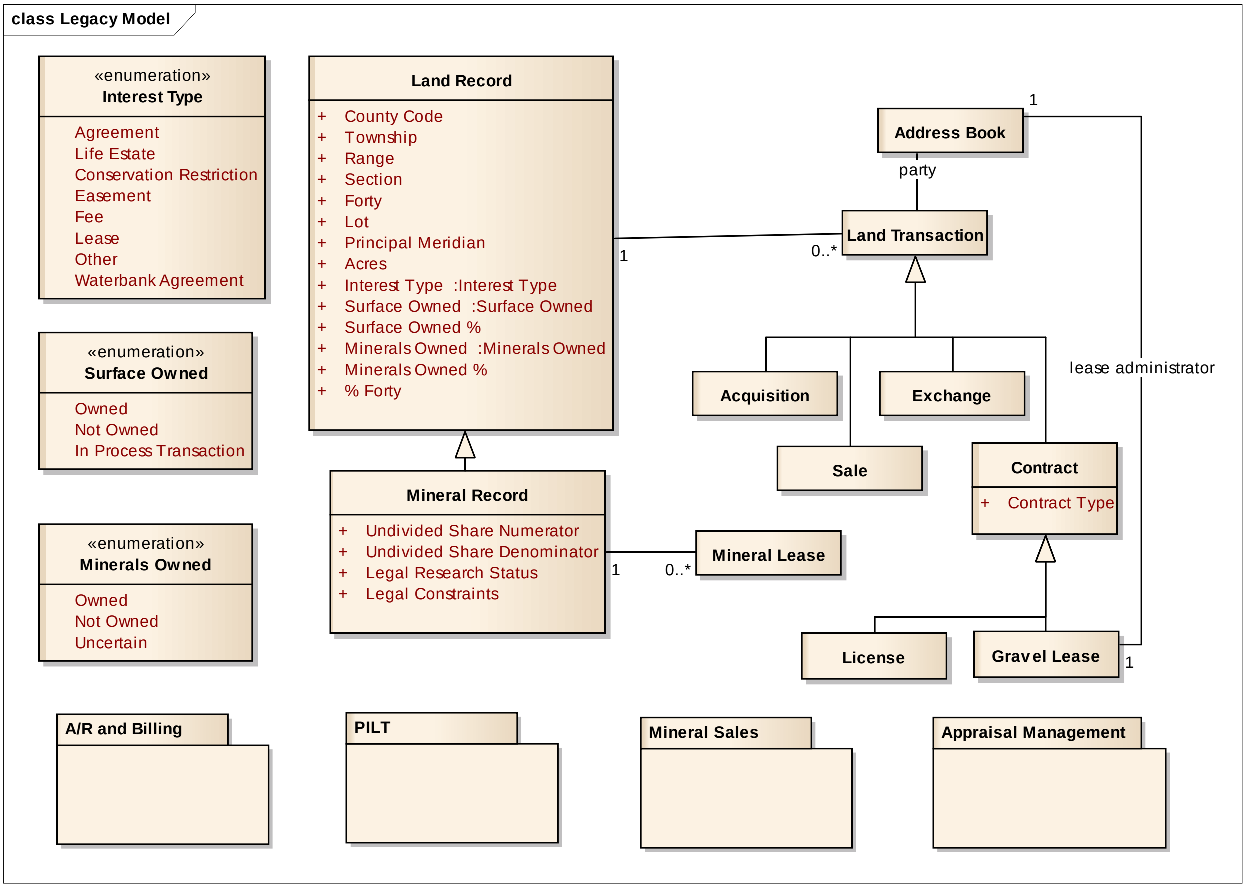

Figure 1. Simplified conceptual data model of the Legacy Land Records System

The legacy *Land Record* class semantically represents a real property interests that currently are or were previously possessed or administered by the DNR. The interest type describes the interest in the real property that was acquired or administered by the DNR. It is not representative of other interests that might have been granted to other parties. The latter are represented under *Sale* and *Contract* trees of the *Land Transaction* hierarchy. Coincidentally, easement (servitude) interests that are granted to third parties are represented in the legacy model similarly to contracts, while easement interests granted to the DNR are reflected under land record hierarchy as part of the real property inventory data. This design appears to be a reflection of agency-centric view of the real property inventory that is discussed later in this section. Such a unidirectional view of land information is common to land administration systems focusing on automating administration of land assets of one agency or organization, in contrast to the omnidirectional view of information found in information systems dealing with title registration.

It can be seen that information about mineral (sub-surface) interests (*Mineral Record* class) and contracts encumbering these interests (*Mineral Lease* class) is somewhat separate from the rest of the real property information. Such design reflects the fact that support for tracking mineral interests was added to the data model later as the system evolved through years of its use. It should also be noted that as part of this evolution, the share of interest for minerals became represented as numerator and denominator supplementing the percentage value, which is inadequate for representing small fractions of undivided mineral interests commonly acquired by the State through forfeiture.

The *Address Book* class represents the information about interested parties that are related to the interests acquired or granted by the DNR. The legacy design views party relationship rather simplistically only allowing one part per land transaction resulting in the need to use conventions to represent joint owners or groups of individuals involved in a transaction. While being adequate for basic information tracking such a design limits the ability to automate business processes, document composition, and integration with other systems.

2.2 Partial view of the world

As was mentioned earlier in this section, land administration systems supporting estate management activities may not have a universal view of property interests or the property lifecycle. In a typical land registration scenario, one can safely assume that once a property is registered, all subsequent transactions of material significance to property rights would be reflected in the registry.

This assumption does not hold true if the land information system can only be made aware of land transactions in which its host organization is directly involved. This creates a situation where not all current interests can be reflected in the information system. This context is illustrated by Figure 2.

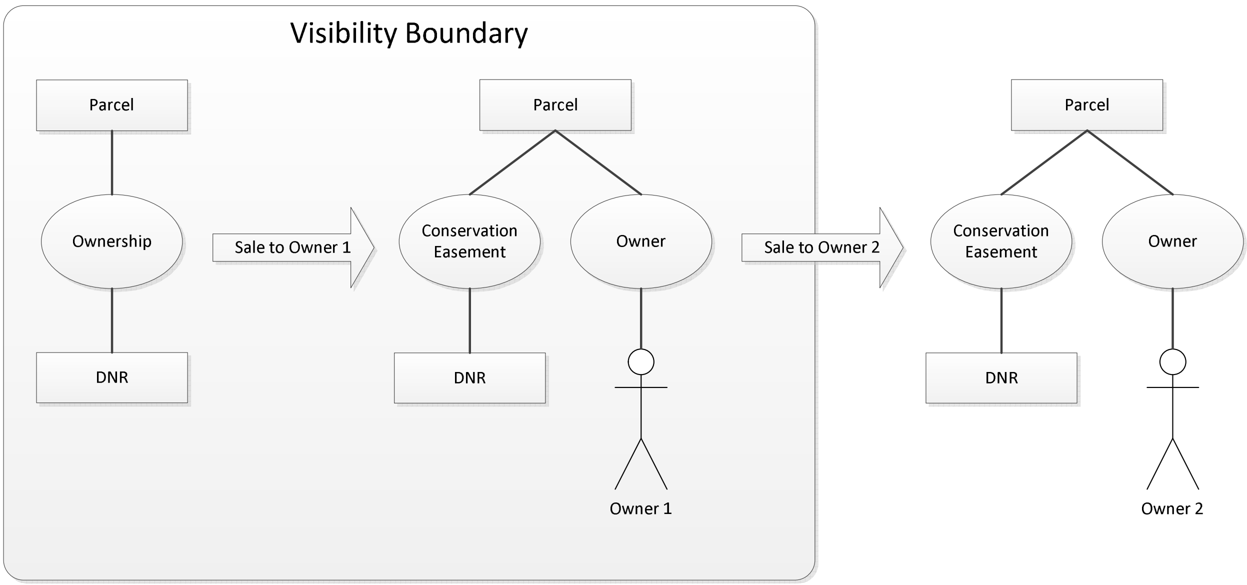

Figure 2. Limited visibility in land administration systems

Additionally, partial information about existing third-party interests may exist until the corresponding title search is carried out where it is not readily available, as in a deed-based environment. This is especially true in the case of mineral interests where identifying if mineral rights are conveyed with a parcel may require navigating a long chain of title.

In the instances where a property object leaves the visibility boundary of the organization it is possible for it to re-enter the visibility boundary upon subsequent land transaction. For example if DNR leased a parcel of land from Owner 1 and after lease termination Owner 1 sells the said parcel to Owner 2 while DNR decides to purchase the land from Owner 2. In this case, a clear identification of the spatial unit would be required, which leads us to the next topic.

2.3 A Case of spatial Myopia

As can be seen from the legacy data model, the real property that is affected by interests represented by class *Land Record* is not defined explicitly but is rather identified by its PLSS designation. This, in essence, describes the corresponding spatial unit as being located within a quarter-quarter-section (an approximately 40 acre part of a 1 square mile section). Such a "fuzzy" or approximate description does not allow to differentiate between adjacent, overlapping or coinciding interests within the same "forty" with the exception of cases when a spatial unit represents the entire "forty", which is not uncommon. This problem of ambiguous spatial reference is illustrated by Figure 3. Other references besides the quarter-quarter-section designation are also used in the historical data but they are prone to the same issue of limited spatial fidelity.

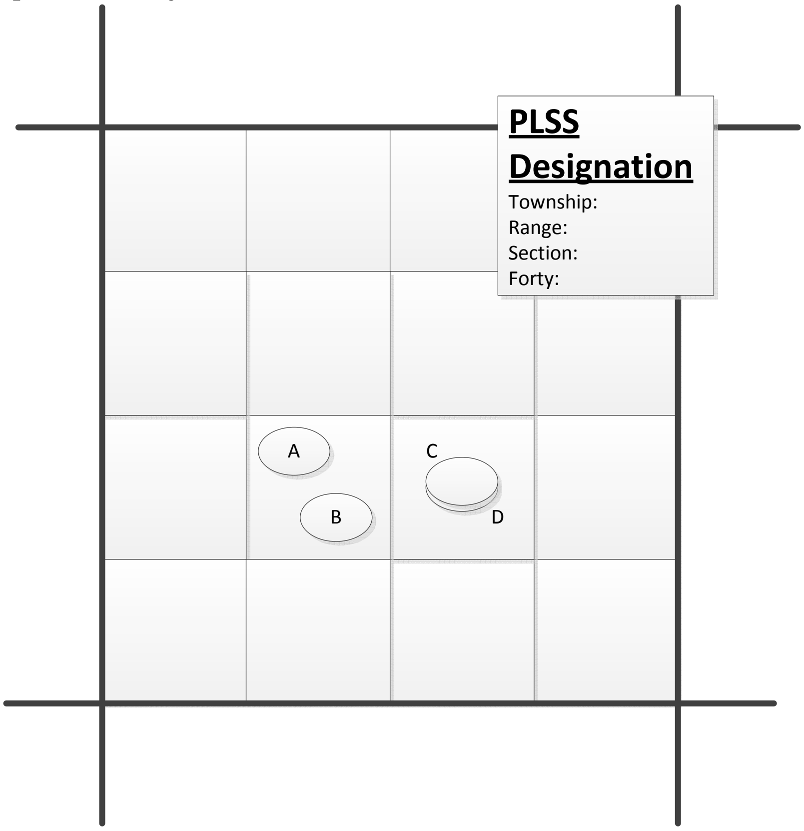

Figure 3. PLSS based Spatial Reference

Nevertheless, the inability to conclusively identify if the interests are related to the same or different areas on the ground results in a limited ability to avoid multiple instances of the *Spatial Unit* class representing the same physical location on the ground. It will become possible to eliminate such duplication once spatial unit geometries are created within the new LADM-based system.

2.4 Interest record fragmentation

Another direct effect of approximating spatial information with PLSS grid references is the necessity to split an interest covering more than a single “forty” into a number of distinct records so that each quarter-quarter section related to the interest would be reflected in the data. This creates fragments that cannot be effectively dealt with as a single item and complicates data maintenance as the information needs to be updated within multiple instances. It also complicates processing subsequent land transactions in the land administration system. This appears to be a common problem, solwing which not only requires unique spatial unit identification but also requires proper interest identification as discussed below.

2.5 Interest aliasing

I use term of *aliasing* to refer to the case of multiple distinct items being represented by the same value similarly to computer graphics and other disciplines. Aliasing results in inability to distinguish or discriminate the original items by looking at the recorded information. This issue is observed not only in regards to the spatial unit identification but also in regards to identifying distinct interests related to the same spatial unit.

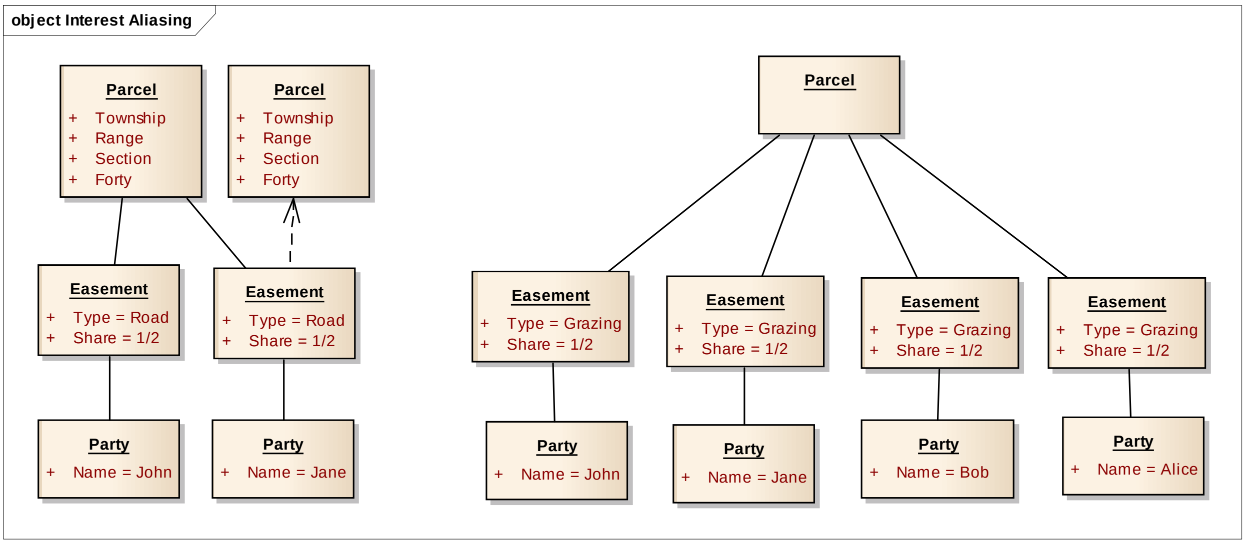

Figure 4. Interest aliasing

Figure 4 illustrates two instances of the interest aliasing related to insufficient spatial unit identification and insufficient interest identification respectively. In the first case, insufficient definition of a spatial unit prevents from determining if the *Easement* instances represent parts of the *same* easement interest or part of two *distinct* easements in the same area. The second case extends this example to illustrate interest aliasing in general that may occur when representing multiple fractional interests of the same type. Even if spatial units are uniquely and precisely defined, it would not be possible to determine which two parties own the shares of the *same* interest.

While the first case is successfully addressed in LADM by explicitly representing the spatial unit instances, the second case is not addressed directly by the model. Model, however, implies that interests can be uniquely identified through their *rID* attribute, which allows grouping parts of the sameinterest. Possible model extension addressing interest aliasing by introducing an explicit representation for the entire interest is described later in this paper.

Providing for grouping of the interest parts into an anchor object representing the entire interest is important in the context of consistently managing lifespan, attributes and objects related to a RRR.

2.6 Common data migration challenges

The issues highlighted earlier in this section represent a small fraction of challenges that land information practitioner faces in each system implementation. Lack of clear identification and differentiation of the instance-level information, frequent use of finer grained objects in legacy data models and other legacy data model design issues hamper data transformation and make LADM transition non-trivial. Common challenges are related to the gathering or re-constituting data in the cases when LADM calls for a single object replacing multiple fragmented instances in the original data design. These are not in any way new problems in the data management world but they always require careful evaluation of transformation approach as well as the approach to post-transformation data validation and verification.

3. TRANSITION TO LADM

This section describes the approach taken to data model transition, design choices and model extensions considered in the process of MN DNR project implementation. Most extensions constitute classes related to capturing detailed information about interests of particular types. For example, type of activities allowed under a lease, payment terms and conditions, valuation details used to determine the rent amount, billing and accounts receivable information, information related to automating work flow and business processes such as user account and job routing information. The core LADM model and concepts confirmed a good fit for land information automation purposes subject to several considerations required to maximize the benefits of LADM-based data organization.

3.1 Mineral interests

Presentation of mineral interests is sometimes puzzling to newcomers as there is a tendency to look at spatial separation for surface and sub-surface volumes. This, however, is not well aligned with the semantics of mineral ownership that is attached to certain resources within the confines of the parcel with the boundary projecting to the center of the Earth. The ownership of minerals would stay with the same party even after the minerals were extracted from the parcel and placed elsewhere. This concept is also described in numerous LADM country profiles and was recently discussed in (Elia 2013). It calls for mineral ownership representation as a lesser interest within the bundle of rights. The choice of whether an instance of mineral ownership should require presence of fee simple absolute instance and a corresponding surface ownership depends on the scope and function of an individual land administration solution and should be evaluated separately.

3.2 Spatial unit aliasing

The problem of spatial unit aliasing does not have a complete solution until the interest boundaries are reviewed and investigated. Luckily, the extent to which this issue manifests itself through the duplication of some interest records is very small in the case of the MN DNR land records system. Certain heuristics can be used to minimize the number of spatial units that need to be reviewed for adjacency or coincidence.

3.3 Interest aliasing

Interest aliasing is rarely a significant issue in the land registration environment but it gains weight in the case of estates management and land asset management when the information maintained in the system is also used to prepare and perform conveyance or contracting of the individual interests. These individual interests are commonly reflected in the conveyance documents such as deeds, declarations of easement, etc. and often have auxiliary information related to valuation, accounting, etc. associated with them.

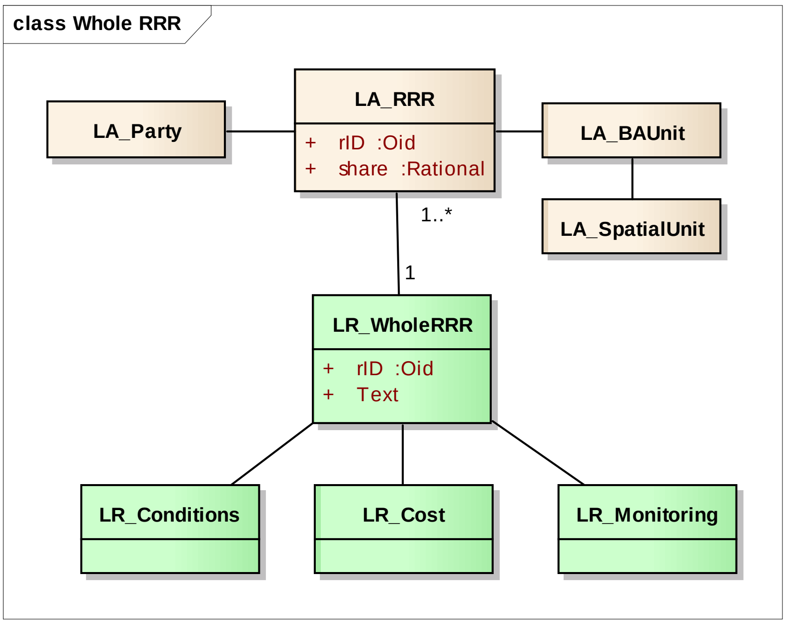

Figure 5. LADM *Whole RRR* Extension

A possible model extension to represent entire interest, with the ability to maintain administrative information related to it, is presented in Figure 5.

Here *LA_WholeRRR* class represents the entire interest and can contain additional attributes, such as easement description from the original conveyance or declaration as well as linking to related data structures required for support of RRR administration.

3.4 Interest and spatial unit fragmentation

Older land information systems that were designed to approximate spatial information by the use of hierarchical or grid-based location attributes commonly have information about real property interests fragmented per each addressable value of the spatial location attribute. This results in a high number of records representing the same interest when this interest is related to a large area of land.

When converting data to LADM these fragments often become represented by the individual *RRR-BAUnit-SpatialUnit* triplets limiting the advantage of having a grouping of spatial units and interests that reduces the number of objects in the database and ultimately simplifies the use of data. It is thus important to consolidate fragmented records as close as possible to a normalized form where basic administrative units represent the *largest possible* administrative entity consisting of zero or more spatial units against which unique and homogenous RRRs are associated to the whole entity.

3.5 Representing uncertain and unknown data

Partial visibility into land information, that was described above as one of the challenges in estates management, precipitates the need to represent uncertain and/or unknown information. This concept relates not only to the information that can potentially be outdated, requiring land administration applications to deal with lapses in information history such as a new property conveyance involving a party different from the owner recorded in the database, but also the interests that may exist in reality but are unconfirmed or unknown to the land administration organization.

While uncertain or unconfirmed interest held by the organization administering real property assets can be modeled by introducing the corresponding *RRR* attribute, a different approach is required to represent the interests that are known to exist but their holder cannot be identified or is not of significance to the organization. For example, it may be sufficient for the organization to know that they do not own mineral interests in a given parcel while the particulars of which party actually owns the minerals may be immaterial for the business of this organization.

One of design choices is to relate such RRRs to a party instance representing a “not me” and ”unknown” objects. In the case of a large number of assets with unknown third party ownership this design may create various data management issues. Using a RRRs attribute to idendicate these related party exceptions may help to simplify the design.

3.6 Spatial units, interests and geometry

The LADM standard clearly defines the basic administrative unit as the entity that associates RRRs to whole spatial units. There are several practical considerations and questions that may arise in this regard. For example, one may be tempted to assume that the RRR is related to an entire Spatial Unit if a smaller unit related to that RRR cannot be readily identified and delineated. This confusion may arise from an ambiguous description as in “shortest distance” or “the least amount of damage” describing an easement and other factors. This inability to delineate a spatial unit upfront does not, however, mean that the RRR is related to the entirety of a parcel or containing spatial unit. After a road is constructed in a manner consistent with “the least amount of damage” description, it can be delineated and reflected.

It follows from the above discussion that a new spatial unit instance should be established whenever new interests related to a *part* of an existing spatial unit are introduced into the database. The lifecycle of a spatial unit object and its geometrical reflection is, however, not the same and in many cases practical considerations of effort, cost and benefit would govern the decision as to when, if at all, geometrical representation should be created for a given spatial unit.

Furthermore, the geometry of a sub-parcel can be fundamentally more complex than the geometry of the parcel. For example, the entire parcel can be adequately described using a 2D boundary line that in actuality describes a 3D volume, which, in turn, may require more complex 3D representation to subdivide vertically. The State of Minnesota has long adopted and codified the legal framework allowing vertical parcel subdivision using strata reference highlighted in (Kaufmann 1998), which is simpler but more limited than a general 3D description.

For example, it may be perfectly feasible to map the boundary of spatial units that have long lasting durable or high-value interests associated with them while the cost of creating geometry for spatial units that are only related to short term lower value contracts as well as resulting business process delays may not be economically feasible.

4. CONCLUSIONS

Through the MN DNR land record system project implementation LADM demonstrated a good fit for practical solutions in estates management domain. Numerous practical recommendations and guidelines can be derived from the results and experience accumulated over the project span. Some of these recommendations and findings are shared with the LADM community in this paper and should contribute to easier and faster adoption of this standard by the industry. By becoming early adopters of LADM, Thomson Reuters and MN DNR are investing in standards based solutions and longevity of data assets as well as higher information fidelity and continuous data quality improvement.

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BIOGRAPHICAL NOTES

Alex Piliptchak, born in Ukraine, studied mathematics and computer science in the University of Kiev and has worked in the software industry for more two decades. Since the late 90s, he has focused on technology application for land information management in support of land tenure, equitable taxation, natural resource management and other adjacent areas. Through many years of work on numerous US-based and foreign projects, Mr. Piliptchak was able to gain a global prospective and experience in the field of land information systems. During his earlier tenure at International Land Systems (ILS), Inc. Mr. Piliptchak supported company's contribution to the work of FIG Commission 7, review and adoption of industry and international standards. Now Mr. Piliptchak is a Senior Director at Thomson Reuters Tax and Accounting Government business providing guidance in product and business development around land administration and cadastre solutions.

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