10 Hierarchies in Subdivision Processes

Gerhard Navratil and Andrew Frank

ABSTRACT

Comparison of cadastral processes in different countries creates different results based on the level of detail. Sub-processes, which are comparable at one level of detail, may show significant differences when adding detail. In this chapter we investigate how to structure the processes hierarchically so that we can model and compare them.

The basic assumption to obtain a hierarchy is that we can separate objects of the real world, socially constructed objects, and intentions of cognitive agents. This separation emerges from the 5-tier ontology (Frank, 2001). In each of these tiers the subdivision is treated differently. We identify the differences between the tiers and show how to model the objects.

1. INTRODUCTION

Land administration requires different kinds of processes. Areas of land, usually called ‘parcels’, need an identifier to separate them from each other and to attach attributes to them. The parcel provides spatial reference for these attributes. One of the attributes is the legal situation: ownership and encumbrances. The processes are needed to update these attributes and to restructure space by changing the shape and number of the parcels.

Comparison of these processes throughout Europe is difficult. Even if the processes look similar on a general level they may become incomparable when looking at their details. This became evident during the comparisons performed within the COST action G9 (Vaskovich, 2004).

The goals of cadastral systems are similar in all countries: society needs a system providing information on land ownership and offering additional information required by other processes within society, e.g. taxation of land. The physical elements are similar, too. Land is the main focus of land administration and documents provide evidence. Still, there are major differences between the systems. Bogaerts and Zevenbergen presented a list of alternatives, which lead to different systems (Bogaerts & Zevenbergen, 2001). The choices determine the system and depend heavily on the philosophy of the society. Societies based on trust in the honesty of citizens create systems based on trust, whereas societies with less trust create more rigorous systems.

Zevenbergen presented a systems approach to deal with these differences (Zevenbergen, 2003). The comparison of processes requires a method to separate between elements that are equal in all systems and elements that are different. The method should have a clear concept of separation between those groups. The way the systems approach was applied did not provide such separation. Therefore we use a hierarchical approach in this work. The hierarchy separates physical objects, social context, and actors. The hierarchy is based on the 5-tier ontology (Frank, 2001). Each of the hierarchical levels has a different structure. The physical objects follow physical law, whereas the social context is defined by social behaviour. Actors usually follow both physical laws and social roles. In addition, they have goals they want to reach. The physical laws are the same in all cadastral systems, whereas the social behaviour is different. This provides a strict separation, which can be used to structure the processes.

In section 2 we start with a brief overview on the use of hierarchies in modelling. It shows the wide range of possible applications for hierarchies and shows our motivation to apply

hierarchies for the problem at hand, the comparison of cadastral processes. Section 3 introduces the ontological framework and connects the problem of subdivision to it. The result is an ontological hierarchy of the subdivision process. Section 4 contains a discussion of the different levels of the hierarchy. An example for modelling the levels physical objects and social context in section 5 shows the advantage of this separation when modelling systems from different societies. Section 6 discusses connections and dependencies between the levels and, finally, section 7 presents our conclusions.

2. HIERARCHIES AND THEIR APPLICATION

Hierarchies are a common way to structure information. Hierarchies provide a representation for different levels of detail or different viewpoints. Buildings, for example, can be represented in different levels of detail. The simplest form in 3D is a cube. Adding the general layout of the roof increases the detail. Further refinements may include roof details, façade structures, windows, doors, internal walls, interior decoration, etc. The different representations sorted by the level of detail contained by the model form a hierarchy. Buildings can be structured based on function, too. We can separate public and private buildings and further split the latter class into apartments, factories, and shops and offices. Finally, hierarchies can represent different steps in a process. The life of a building, for example, consists of planning, constructing, using, and removing the building. Each of these phases has a different treatment and legal terms. Since these phases structure the life of the building they form a sequence, which is a simple form of hierarchy. In the following sections we will see examples for the application of hierarchies to structure knowledge.

An important application of hierarchies in computer science is storing spatial data in a database. File structures on the physical level of computer memory or hard disks are sequential. Thus, access times for elements in the database depend on the position of the element if the simplest access method, sequential access, is used. In this case each access process starts with the first entry and the file is read until the needed entry is found. Indexing structures have been introduced to cope with the problem of access times. Spatial indexing is even more difficult than indexing in linear structures since there is no predefined order. One solution to this problem is the quadtree structure, where the area covered by the database is separated recursively into four parts. The advantage of hierarchical approaches for storing spatial data is their ability to focus on the interesting subsets of the data (Samet, 1990).

Maps are an example of a hierarchy based on the level of detail. The level of detail increases with the scale. A map of 1:10,000 contains more detail than a map of 1:25,000 or 1:50,000. The representation between these maps changes. Separate buildings may be represented by a common symbol or the shape of the building may be simplified. Sometimes buildings may be completely removed from the map. Timpf discussed these changes within the hierarchy for buildings and street networks (Timpf, 1997; 1998).

Hierarchies in wayfinding processes have been discussed extensively in literature. Timpf, Volta, Pollock & Egenhofer (1992) described a conceptual model for wayfinding with three levels of abstraction. They separated planning level, instructional level, and driving level. The planning level uses abstract street graphs, where each intersection is represented by a point. The instructional level requires more detail to produce driving instructions. Lastly, the driving level uses direct observation to select a lane if there is more than one. The driving level deals with real objects whereas the other levels use abstractions of these objects. An ontology for this hierarchical process and a discussion on the connection to the granularity of graphs has been presented by Timpf & Kuhn (2003).

Car pointed out the influence of hierarchies in road networks on wayfinding tasks (Car, 1993). Generalisation of the methodology led to the theory of hierarchical spatial reasoning (Car & Frank, 1994; Car, 1997). An implementation of the concepts showed a considerable increase in performance for the computation of shortest paths if compared with the traditional Dijkstra approach (Dijkstra, 1959; Car, Mehner & Taylor, 1999).

Also closely connected to wayfinding processes is the mental map of the street graph. An empirical study by Casakin, Barkowsky and Klippel showed that test subjects used main roads as a framework when asked to draw a schematic road map (Casakin, Barkowsky & Klippel, 2000). The test subjects had to eliminate roads to simplify the network. Most of the eliminated streets were unimportant streets such as dead ends. The test subjects avoided removing main roads. The authors concluded that the relative hierarchical level of roads influenced the inclusion or exclusion of streets and that hierarchy influences the mental representation. Voicu described a computational model for working with a hierarchical cognitive map (Voicu, 2003).

Hierarchies have also been used successfully to structure representations of space for building robots. Kuipers developed a spatial semantic hierarchy consisting of the sensory level, the control level, the causal level, the topological level, and the metric level (Kuipers, 1996; 2000). The hierarchy consists of multiple interactive representations, both qualitative and quantitative. Each level has its own representation. This allows us, for example, to compose uncertainties into components that can be handled by the different representations. The concept has been used with different robots, as reported by Kuipers (2000).

The examples show that hierarchies are a useful tool for structuring information and decisions. Hierarchies are used to structure processes, representations and classifications. We have even seen evidence that the human wayfinding process is hierarchically structured. Even ontologies, as the science of what is, use a top-level ontology and therefore a hierarchy to combine different ontologies (Smith, 2003).

3. SUBDIVISION PROCESS IN AN ONTOLOGICAL FRAMEWORK

Ontology is a specification of concepts that occur in a domain (Kuhn, 2000). It answers the question “what is here?”. While philosophers tend to find a solution to fit all situations, ontologies in computer science are used as a concept to describe models. Ontology here is a description of what is included in the model and what is ignored.

3.1 5-Tier Ontology

Frank proposed a tiered ontology to describe phenomena in the real world (Frank, 2001). The ontology consists of 5 tiers:

- Tier 0: Physical environment
- Tier 1: Observations of the environment
- Tier 2: The world of objects
- Tier 3: Socially constructed reality
- Tier 4: Subjective reality of cognitive agents.

Tier 0 describes the physical environment we live in. The underlying assumption is that there is only one single physical environment. Tier 1 contains the results of observing tier 0. The separation of these two levels dates back to the Greek philosopher Plato. Plato pointed out the necessity to separate reality from our knowledge of it. Frank assumes that each point in space

and time has determined properties and that space and time are the fundamental dimensions of this reality. The observations and thus the knowledge about the world will be incomplete since it is impossible to observe all properties for all points in space and time.

Tier 2 deals with objects. Objects are defined by uniform properties for regions. Since the properties are observed in tier 1 the formation of objects is based on that tier. A definition criterion for objects is that they continue in time. Temporal constructs for objects have been defined by Al-Taha and Barrera (1994), extended by Hornsby and Egenhofer (1997), and formalised by Medak (2001).

Tier 3 describes the socially constructed reality. Socially constructed reality is based on social processes, which may create external names. Examples of external names are 'Gerhard Navratil' and 'Andrew Frank', the names of the authors. According to tier 2 the authors belong to the classes mammal, human being, man, etc. This is not enough for social processes – the tax authority, for example, requires detailed identification in order to tax income. Society has therefore invented external names. Social rules may create facts and relationships between these facts. The facts are only valid within the context of social reality. One institution created by social reality is money (Searle, 1995). A piece of paper with specific properties counts as 'money' in the social context of 'Austria' and some other countries. Outside the corresponding social context this piece of paper cannot be used as money. This context may also change over time (try to pay today with 'Schilling', the Austrian currency until 2000). In general, the status of an object may change if it is used as a social object.

Lastly, tier 4 is the subjective reality of agents. Agents have to make decisions. They use their knowledge of the world to derive other facts and make these decisions. Agents acquire their knowledge gradually through observation. They observe reality directly and obtain observations indirectly from other agents by observation, e.g. by using maps, as shown by Frank (2000). Knowledge is therefore acquired gradually. This may cause problems if a phenomenon changes over time because the knowledge lags behind reality.

3.2 Subdivision Process in the 5-Tier Ontology

Subdivision is only possible if we have objects that can be divided. Thus the process of subdivision can only take place in tiers 2, 3 and 4. We will start with the simplest form, the objects, and then move to the socially constructed reality and the subjective reality.

3.2.1 Subdivision of objects

Subdivision of an object is a process that splits an object into two or more separate objects. Such processes are well known for different kinds of objects. Objects like flour and coffee do not have a fixed shape; we take a quantity and separate it from the rest. The resulting objects again have arbitrary shapes. Objects like cakes, apples and pizza are different; we create physically separated objects by cutting the original object. The shape of the resulting objects is based on the shape of the original object. However, hard objects like apples tend to keep their shape better than soft objects like pizza. Thus a unification of the separated objects is simpler with apples than with pizza.

Subdividing a piece of land is similar to subdivision of apples but there are some important differences. Land is an immovable object. Subdivision of a piece of land must create different pieces of land and these pieces can only be recognised if the boundaries of the objects are clearly visible. It is not possible, as in the case of the apple, to move the piece of land so that the gap between the pieces shows that there are different objects. This must be done by visible marks like fences or walls. The boundaries, however, fit together perfectly.

Figure 1: Subdivision of land by fences in a horseback riding farm.

Figure 1 shows an example of such a subdivision. Horseback riding farms need a large number of separated areas to let horses out of the stables while still keeping them apart to avoid fights. Separation may be carried out using fences, as shown in the above photograph.

3.2.2 Subdivision of socially constructed objects

Subdivision in the socially constructed context must be treated differently. A well-known socially constructed object is money. As a physical object, money is a printed piece of paper or a piece of metal with engraved symbols. Subdivision of a specific amount of money cannot always be done by separating two different amounts. The upper part of Figure 2 shows a EUR 20 banknote. Subdivision into two equal amounts is only possible if there are two banknotes of equal value, as shown in the lower part of Figure 2. Subdividing the banknote cannot be done using a pair of scissors and cutting it into two pieces. This would render the banknote invalid because none of the pieces would bear the necessary marks.

Figure 2: Different banknotes with the same value

An important social construct for land management is the construct of ownership, which creates a link between an object and a person. The person has some power over the object if he is the owner. According to Austrian law, ownership is '*the competence to rule the substance and the use of a thing … and to bar anybody else from substance and use.*'[1] (§354, ABGB 1811). Subdivision of this construct is possible in two ways:

- The object is subdivided and each person becomes owner of one piece. This is possible if the object can be subdivided, e.g. ownership of firewood.
- The right of ownership is shared between the persons. This is necessary if the object cannot be subdivided in a useful way. Subdividing a car between two persons in a way that each person owns a part of the car is not possible if the car is to work properly.

Ownership of land can be subdivided in both ways. Shared ownership allows all owners to use the land. Additional agreements may regulate the use so that each of the owners can actually use the land. However, it is also possible to subdivide the land itself and create separate parcels. When speaking of subdivision of land we refer to the second possibility.

3.2.3 Subdivision in the subjective reality

Subjective reality as a mental model of the world comprising knowledge, emotions and intentions may differ from the socially constructed reality in several ways. Firstly, subjective reality cannot be communicated directly. Frank discussed the difficulties of communicating knowledge for mental maps in navigation processes (Frank, 2000). The limited possibility to compare the subjective reality with the socially constructed reality leads to deviations between those two. Secondly, our knowledge about the world as a part of subjective reality may be incomplete or inaccurate and thus conclusions drawn from it may be wrong. A typical example of inaccurate knowledge is the assumption of a straight boundary line where other evidence, including cadastral maps, shows a curved line. The reason for the incompleteness and inaccuracy is that we gain knowledge by observation, which is subject to errors. Thirdly, our intentions are usually different from those of society. The subjective view has the benefits

[1] Orig.: „Als ein Recht betrachtet, ist Eigenthum das Befugniß, mit der Substanz und den Nutzungen einer Sache nach Willkühr zu schalten, und jeden Andern davon auszuschließen."

of the subject as the point of interest, whereas society tries to keep peace between the subjects forming the society. The target functions or intentions are thus different.

It may happen that subjective realities contradict each other. A boundary dispute is one such situation. Each subject has its own subjective reality and within this reality the parcel owned by the respective person has a specific boundary. Neighbouring parcels share a common boundary and must not overlap. Boundary disputes emerge if the boundaries derived from the subjective realities do overlap.

The intention of a subject within a subdivision process appears to be to perform the subdivision. This, however, is not completely true. The subdivision provides a benefit for the user and this benefit must comply with the intentions of the subject. Let us assume that the owner of a parcel wishes to build a house on his parcel. In some countries this may require a building permit, which is connected to fees whose amount depends on the size of the parcel. The owner will try to minimise the size of the parcel if saving money is one of his intentions. The owner will have to subdivide the parcel to fulfil his intention.

The owner of a parcel is typically not the only person involved in a subdivision process. Other persons may be neighbours, surveyors, lawyers, administrative bodies, etc. Each of these subjects has their own subjective realities and different intentions. The easiest cases are surveyors and lawyers: they want to earn money. In the other cases, hidden intentions may be involved. A neighbour, for example, may intend to build, too, and could require a specific shape and position of the boundary to do that. The process of subdivision must be structured in a way that takes care of all those intentions to fulfil the intention of society – keeping the peace.

4. THE HIERARCHIES FOR THE SUBDIVISION PROCESS

As shown in the last section, the result of a subdivision process differs between the ontological tiers. The important tiers are the world of objects, the socially constructed reality, and the subjective reality. The objects in the land administration are boundary markers, pieces of land, and documents as sheets of paper with text, graphics and signatures. The socially constructed objects are documents as legally valid contracts, parcels and rights. The result in the subjective reality is a change in the social environment that corresponds with the intentions of the subjects.

The results in the subjective reality can be created in different ways. The process in Slovenia is different from the process in Sweden and England. Descriptions of processes in various countries do exist (Dixon-Gaugh, 2004; Mikkonen, 2004; Sismanidis, 2004; Vaskovich, 2004; Zevenbergen, 2004). Questions can be used to structure the steps in the subdivision process. A simple list of such questions could be as follows:

- Do I need to tell someone that I want to subdivide? Whom?
- Do I need a document? Who may create it?
- Do I need a boundary description? How detailed? Who may do it?
- Do I have to consider encumbrances? How? Do I need experts?
- Do I have to consider other rules? Which ones? How? Do I need experts?

This list illustrates the complexity of the process. Different subjects may be included in the process to deal with specific parts. The answer to the first question, for example, may be to inform the land register. The land register (or the clerk who processes the case) is then a subjective agent with his own view. This view should correspond with the view of the land register as an organisation. Errors occur if the views do not correspond.

The answers to the questions also define the objects necessary for the process. The document itself is an object from the real world. A restriction concerning the possible creators separates the socially constructed object from the real world object. In the following sections we assume that we need a document and this document must be registered to create a subdivision.

4.1 Creating the physical objects

The first task for subdivision is evaluating the extent of the piece of land under consideration (the object) as far as necessary. These boundaries are often fiat boundaries and need not be defined by qualitative heterogeneity (Smith & Varzi, 2000). Boundary markers may have to be located (by observation) and old maps may need to be inspected to check the position of these markers. The basic assumption here is that the physical reality does not change significantly between the placement of the boundary markers and the subdivision and thus problems like landslide are ignored. Sometimes there may not be enough physical evidence to define the boundary. In this case an agreement between the involved landowners will be necessary to specify the boundaries and thus locate the social object parcel in the real world. Evaluating the extent of the parcel is thus a social process. The result, however, is a physical piece of land with its boundaries shown in the real world; as such, it is a physical object.

Subdivision of the piece of land must start from the marked points and the result is then fixed by placing new boundary markers. In a strict sense a subdivision splits a piece of land into several pieces such that the pieces can be treated separately, e.g. they can be sold. Excluding the case of shared ownership, the decision is made by a single person based on his intentions. The decision on where to place the internal boundaries thus includes no social agreement. These internal boundaries are then marked by placing walls, fences or stones connected by (invisible) straight lines. The process of subdivision thus creates separated pieces of land as real objects. The old boundaries have been defined by social processes and thus represent social agreement. The new ones are based on the owner's intention. However, the new pieces of land are not social objects yet, since social objects require the completion of a social process. In this case it includes documentation and (eventually) registration.

The creation of documents and descriptions may be necessary to provide evidence for the enforcement of property rights (Stubkjær, 2003). Seen as a physical object, a document is a sheet of paper with text or graphics on it. In the first case it is a text document, otherwise it is a map. Other elements like signatures or markings will be necessary to indicate the creators of the document.

Entries in databases and books are physical objects, too. A land register consists of a set of entries in a database representing the legal situation for each parcel. Traditional land registers use books and the entries are written in the book. Each entry is a part of the object 'land registry book' and can be seen as a separate object. Digital land registers use databases to store the entries. This changes the storage medium only. Since the medium still has a physical representation, the entries are physical objects.

4.2 Creating the social objects

The pieces of land created by subdivision as physical objects are not yet social objects. The piece of land is called a parcel if it is a social object. A parcel is the representation of a piece of land that is subject to any system granting ownership. The process of creation must be a process of the social reality. The processes of creating and changing parcels are the processes of the cadastre as discussed throughout the COST action G9 project (Stubkjær, 2002).

Applying these processes separates the social object ‘parcel’ from the physical object ‘piece of land’.

In the previous section the necessity of having documents was discussed. Documents contain elements like signatures, text, graphics and markings. Documents must be produced following legal procedures to become a social object. This includes the elements entered on the paper, the order in which the elements are attached, and the agents involved in the creation process. A document is valid if all requirements are met. A document where the text was added after the signatures, for example, will be illegal because the signatures prove that the signatory agrees with the contents of the document; this is at the very least in doubt if the text is added after the signatures. It may also be important that a notary, a licensed surveyor, or a court creates a document. For example, in Austria only a court may create documents for expropriation.

Finally, it may be necessary to have proof of the legal situation of a parcel. This can be done by registration in a public register. Acquisition of ownership on land in Austria consists of two steps: firstly, buyer and seller set up a sales contract and, secondly, the contract is registered at the land register. Only with the second step does the buyer become owner of the parcel (within the Austrian jurisdiction; in other jurisdictions ownership may be conveyed among the parties concerned). Another method would be having a document proving the right of ownership. The possession of this document proves the ownership if the document only exists once.

Each of these cases is regulated by society. Since social regulations are often written down in laws, these texts provide the basis for the processes. However, in some cases the practice emerges from missing legal regulations. Title insurance may be necessary to minimise the risk of the buyer if there is no official proof of ownership. Insurance companies try to minimise their own risk and thus collect purchase documents and other documents affecting ownership of land. These customs will not be defined in law texts, but in internal papers of private companies. Still, the buyer will follow the processes if his costs are less than the risk he takes if he does not follow the rules of the process.

4.3 Fulfilling the intentions

Systems within a society will remain stable over an extended period if they comply with the complex rules, norms and enforcement that constitute the institutional framework. Changes to the system typically consist of small adjustments to the institutional framework (North, 1997;83). The framework is designed in a way that the actors involved gain from it. Although systems are not fully based on self-interest (Mansbridge, 1998), systems where only a few actors win are not stable. We must determine the actors in a subdivision process and look at their intentions to see where they benefit from the processes in a cadastral system. Since the systems throughout Europe are quite different, not all of the agents listed will be part of the process in each country. Nevertheless we can distinguish four different groups of actors with different intentions:

- Owner(s) and person(s) interested in purchase
- Neighbours
- Municipality and government departments
- Experts.

The intention of the owner is to have separated parcels. The reason may be a planned sale, an intention that requires a person interested in a purchase. The owner starts a process that will eventually result in fulfilling his intentions, i.e. a process that produces separated parcels that

he can sell. The user wants this process to be fast and efficient. The intentions of the user are thus fulfilled if the result of the subdivision process is a situation where he can do what he intended to do. Additionally, the costs of the process, both in money and time, should not exceed the benefits to the user. In section 3.2.3 we used the example of the process of granting a building permit. The subdivision in this case is only useful if the reduction of the permit costs exceeds the costs of the subdivision.

The process of subdivision may involve the owners of neighbouring parcels. Subdivision may require a preceding agreement on the position of the boundary. This is only possible if the neighbours are involved in the process. The neighbours want to protect their rights, i.e. they want to protect the extent of their land. The neighbours define the extent of their land based on subjective knowledge. The intention of the neighbours is to protect the subjective position of their boundary.

The municipality wants land to be used effectively. Land is part of the production chain, in addition to capital and labour. In order to strengthen the economy of the area, all parts of the chain should be optimal. The municipality therefore tries to plan the use of land in a way that guarantees maximum effect.

Finally, there may be experts like notaries, lawyers, real estate agents or surveyors involved in the process. Their intention is to make money. However, they may also require the results of the process for future tasks. A surveyor, for example, may need the result of a subdivision process as a starting point for a further subdivision (cf. Stubkjær, 2004). Thus they require the process to be predictable to plan accordingly.

5. FORMALISATION OF A REAL WORLD AND A SOCIALLY CONSTRUCTED OBJECT

A formal description of real world objects and socially constructed objects will clarify the differences. The language used for the formal model is Haskell, a functional programming language (Thompson, 1996; Hudak, Peterson & Fasel, 1997; Bird, 1998; Peyton Jones, Hughes & Augustsson, 1999). The advantage of using a purely functional language is its mathematical correctness and possibility of execution for the result. As an example we will use the creation of documents both as real world objects and socially constructed objects.

Several actions can be performed with documents alone: we can create an empty document, add contents, inspect the contents, and destroy the document. The last action is not useful in the context of land registration because documents provide evidence of the legal situation and destroying the evidence will cause problems. The creation of an empty document is a simple action. Someone prepares an empty sheet of paper of the correct size and thickness. This is done by the function emptyClass. The contents are added sequentially by the function addElement. This task is performed by an agent as expressed in the signature of the function. The opposite action is inspecting the contents, which is provided by getElements. The result here is a list of elements with their respective creators. We assume that the order reflects the order of adding to the document and the first element in the list is the first one added to the document. Removing elements from the document may be possible but is prohibited if we want to create a legally valid document. Therefore we did not include a function removeElement.

```
class Documents a where
  emptyDocument  :: AgentType -> a
  addElement     :: AgentType -> DocElement -> a -> a
  getElements    :: a -> [(AgentType,DocElement)]

data ExpertType = Lawyer | Notary | Surveyor | REAgent
```

```
data AgentType = Owner | Neighbour | Municipality | ExpertType

data DocElement = Text | Graphics | Signature | Marking
```

The list of agent types is restricted to Owner, Neighbour, Municipality, and ExpertType in the formalisation. Experts listed in the model are lawyer, notary, surveyor and the real estate agent. Additional experts can be easily added.

The code above describes a document as a real world object. It does not yet include the conditions to be valid in a social context. The conditions were discussed in the previous section. Three conditions must be met:

- All necessary elements must exist
- The elements must be applied in the correct order
- The creator of the document must be entitled to create such a document.

The operation isLegalDocument checks the conditions and returns a Boolean value expressing whether the document is a legal document or not. The document receives the status of a social object only if it passes all the checks. The sequence of checks does not matter. Some checks, however, are easier to perform. The document is not legally valid if it fails at least one check. Therefore the simple checks may be performed first and the most complex checks at the end. This would eliminate illegal documents as early as possible. The following code shows a formalisation of the checks.

```
class (Documents a) => LegalDocs a where
  isLegalDoc     :: a -> Bool
  isLegalDoc d = correctCreator d &&
                 correctContents d &&
                 correctContentOrder d

  correctCreator      :: a -> Bool

  correctContents     :: a -> Bool
  correctContents d =
    ((elem Text cont) || (elem Graphics cont) ||
        ((elem Text cont) && (elem Graphics cont))) &&
    (elem Signature cont) &&
    (elem Marking cont)

    where cont = ((map snd).getElements) d

  correctContentOrder :: a -> Bool
  correctContentOrder d =
    ((remDup.(map snd).getElements) d == [Text,Signature,Marking]) ||
    ((remDup.(map snd).getElements) d == [Graphics,Signature,Marking])

remDup :: Eq a => [a] -> [a]
remDup [] = []
remDup (x:xs) = x:(rd' x xs) where
  rd' l [] = []
  rd' l (a:as) = if a == l then rd' l as else a:(rd' a as)
```

Checking the creator of the document varies significantly with the country and the type of document. In Austria, a subdivision including the creation of an easement requires a surveyor and a notary. The licensed surveyor documents the subdivision, while the notary creates the easement. This is not valid, for example, for Sweden, where the surveyor performs both tasks. Thus the implementation must be done in an instance where the model is applied to a specific jurisdiction.

The contents are similar in all types of legal documents. There must be either text or graphics or a combination of both. This is checked by the expression

```
((elem Text cont) || (elem Graphics cont) ||
((elem Text cont) && (elem Graphics cont)))
```

in the function correctContents. In the case of textual and graphical representation both parts must be congruent. In addition, the document must contain signatures and the markings of the creator.

Checks on the document contents can only check the completeness of necessary data and the logical consistency. It is possible, for example, to check the existence of the necessary data on boundary markers. One test may be to check whether it is specified what kinds of markers have been used. It is not possible, however, to check the correctness of the data without comparing the document with reality. If the document has stones as boundary markers, a formal check cannot decide whether this is true and if the stones are in the correct position. This is the reason why the signatures and markings of the creator are important since he guarantees the factual correctness of the document.

Finally, the elements must be added in the correct order. Text and graphics carry the message of the document. Therefore they must be added first. Later the document is signed by all involved parties, expressing their agreement with the contents. The markings must be added as the last step because the creator of the document is responsible for the correct creation process and thus he finishes the process by providing a marking. The order is checked by correctContentOrder. Since each element may occur more than once, e.g. different pieces of text added by different persons, duplicates are removed by applying remDup. Different occurrences will be reduced to a single occurrence and the test will fail if, for example, text has been added after signing the document.

The other objects from the real world and the social realm can be modelled in a similar way. It is a two-step process for each object: first, the model defines the real world object with its properties and then the conditions for the social object are applied. This separation shows the difference between physical requirements and social context.

6. CONCLUSIONS

We have seen that the process of subdivision in the land administration domain consists of several tiers. On the tier of physical objects, pieces of land are subdivided by erecting fences or other barriers. Other physical objects involved are documents, databases and books, and the entries in them. On the tier of socially constructed objects the physical objects must fulfil special requirements and then receive a new status. A piece of land, for example, becomes a parcel when the social process of subdivision is complete. Finally, the result of the process must fit the intentions of the actors.

The processes within these tiers are different. Cutting a EUR 20 banknote in two pieces creates two different physical objects. The process of subdivision is completely different if we consider that the banknote is a socially constructed object, too. The process of splitting the banknote into smaller pieces works differently.

A comparison of the processes throughout Europe shows similarities and differences on the ontological levels. On a physical level the processes are comparable throughout Europe. The process of separating areas in a horseback riding farm is the same in England, Sweden and Slovenia. The differences between subdivision processes occur only on the social level. The construction of society influences the processes by defining the methodology used. The level of cognitive agents combines both aspects. Cognitive agents have the same intentions everywhere in Europe; they want to secure their rights on land. The number and type of agents involved in the process varies since in some countries notaries do not exist or some experts perform tasks that are shared between agents in other countries.

7. REFERENCES

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