Scientific Report

Ontology Engineering for the Comparison of Cadastral Processes

Short Term Scientific Mission at
the Royal Institute of Technology,
Stockholm

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1 Motivation

The Short-Term Scientific Mission (STSM) "Ontology Engineering for the Comparison of Cadastral Processes" aimed at supporting the analysis of similarities and differences between national cadastral processes. The ontology-based methodology from Bamberg University was intended to be further developed and adapted to the cadastral domain. The STSM was used to discuss the methodology with cadastral domain experts and to evaluate it with cadastral process models for property transfer. It was held at the Royal Institute of Technology, Stockholm, 03/04/05 – 08/04/05. This institute was chosen as visiting university in order to integrate the ongoing work on the analysis and description of cadastral processes from Stockholm and the approach to a formal comparison from Bamberg University.

First steps in the comparison of cadastral processes have already been made within the research activities of the COST Action G9 "Modelling Real Property Transactions". Several national cadastral transactions of different types, above all property transfer and subdivision have been analyzed. Marina Vaskovich for instance provided a textual and formal description of national process models for England/Wales and Denmark (Vaskovich 2003, 2004). This STSM evaluates the ontology-based approach with the models for property sale in England/Wales and Denmark developed by Marina Vaskovich during previous STSMs in the COST Action G9. She presented initial comparisons of the process models during a working group meeting. The initial comparison by Marina Vaskovich analyzed commonalities of the process models based on their textual descriptions. Until now, no formal comparison of national cadastral transactions has been made and a methodology for such comparison is missing. A formal comparison should ensure that only such models of national processes are compared which represent the transaction at the same level of detail. Some process models look at a rather abstract level to be "identical" but reveal to be very different when they are compared on the basis of a more detailed representation. Furthermore, we are interested in the degree of conformity or similarity between the cadastral processes of two countries. Such detailed knowledge would permit to explain why two national cadastral systems are closer to each other than to another national cadastral system.

The remainder of this scientific report is structured in the following. Section 2 describes the ontology-based methodology and presents the steps necessary to obtain a formal ontology model of national processes. The subsequent section discusses the iterations in which the ontological process model is refined on the basis of the relationships computed by an ontological reasoner. Differences and similarities are analyzed in this section based on reasoner results. Section 4 evaluates the presented approach. Future cooperation between Bamberg University and the Royal Institute of Technology based on the results from this STSM are discussed in section 5. The conclusion summarizes the research carried out during the STSM.

2 Ontology-Based Comparison of Cadastral Transactions

2.1 Overview of the Ontology-Based Methodology

A formal approach to the comparison of cadastral process models has to take into account that until now, no reference processes exist for the different types of cadastral transactions. Therefore, process models have to be compared pair wise. A reference process for cadastral transactions would permit to compare national processes only with the reference process and to infer differences between national processes based on their individual comparisons with the reference process. Direct comparisons of national models will become very time consuming if the number of analyzed and thus comparable process models increases. The presented approach does not rely on such reference process but wants to support the development of a reference process. A formal comparison of several national cadastral processes constitutes the basis for the inductive development of reference processes for different cadastral transactions.

In the following, a methodology for an ontology-based comparison is presented. In contrast to comparisons based on textual descriptions, this approach compares formal ontology models which consistency can be checked by ontological reasoning. Ontology modeling languages offer a higher expressiveness than object-oriented modeling languages like UML. In our example that means that the ontology model integrates the activity diagrams and the textual descriptions in one model. Correspondences are computed between the national process models by the reasoner.

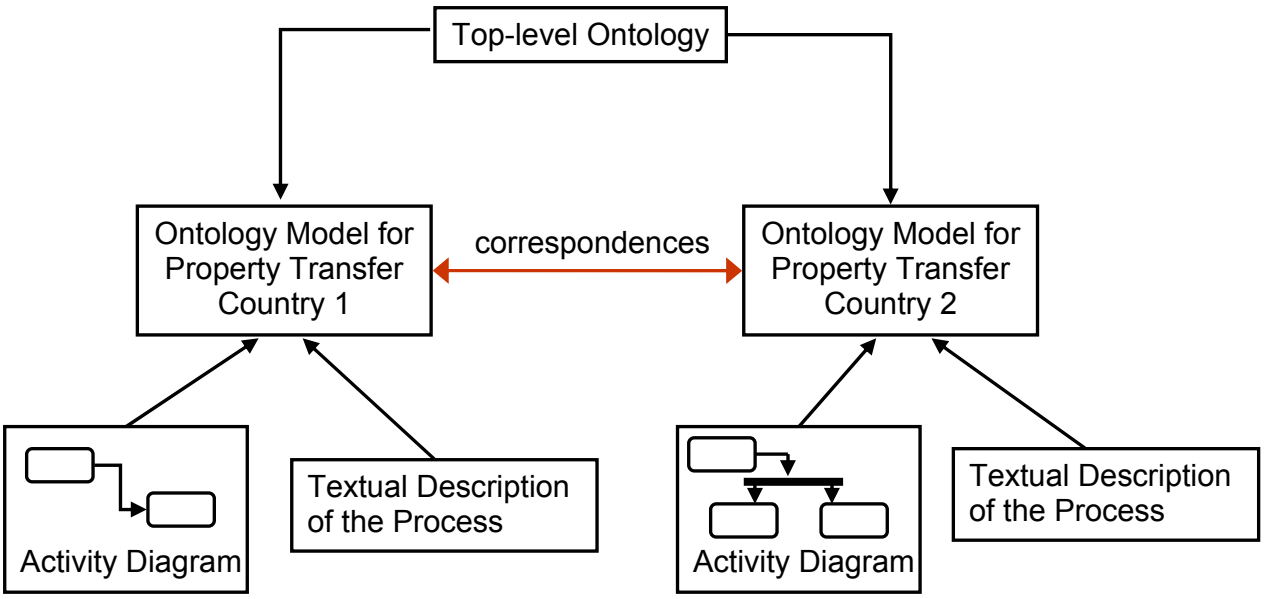


Figure 1 – Ontology-based Comparison

Figure 1 gives an overview of the ontology-based comparison of cadastral transactions. A top-level ontology defines the basic concepts and properties that are used for the description of the

national process models. The ontology models of the national processes are modeled on the basis of the descriptions of the national processes and their activity diagrams. A reasoner computes the relationships between both models which will be interpreted by domain experts and knowledge engineers.

During the STSM, we proceeded in the following: We started with the definition of a top-level ontology. Then we transferred the national models (activity diagrams and descriptions) into the ontology models. These ontology models were adapted on the basis of the results computed by the reasoner. In two iterations, we refined the models in order to represent the national cadastral transactions correctly.

2.2 The Top-Level Ontology

2.2.1 The Purpose of the Top-Level Ontology

The top-level ontology contains the concepts and properties that will be used for the description of process models. Claudia Hess pre-selected concepts from the glossary of the Workflow Management Coalition as candidates for a cadastral top-level ontology. The Workflow Management Coalition is a non profit organization with the objectives of "advancing the opportunities for the exploitation of workflow technology through the development of common terminology and standards" (Workflow Management Coalition, 1999). These concepts and properties are suited for the description of different types of process models. During the STSM, we discussed the pre-selected concepts and extended the top-level ontology with concepts for the description of cadastral processes.

2.2.2 Candidate Concepts for the Cadastral Top-Level Ontology

Activity

An activity describes a piece of work that constitutes one step within a process. In property transfer, such activity would for example be '*signing the sale contract'* or '*mortgage negotiation'*.

As the concept *activity* represents the basic unit of a process model, we decided to include it in our cadastral top-level ontology. The activities that are modeled in the ontology model can directly be taken from the UML activity diagrams. We recommend to use a consistent naming of the activities in the process models, e.g., based on what is done in the activity.

Actor / (Organizational) Role

A group of participants exhibiting a specific set of attributes, qualifications or skills can be called *actors*. As they act in a certain role when doing the work specified in an activity, the term *role* is often used. In the models, it is possible to indicate for each activity the actor who is performing

that activity. In cadastral processes for instance, owner, buyer, legal experts and surveyor are involved.

We decided not to include this concept into the current top-level ontology in order to keep it as simple as possible and to allow for the identification of equivalent activities even if they are accomplished by actors in different roles. However, this concept can be used in future comparisons.

Document

An activity can result in a document on which the participants of an activity agree on. A document might be a contract, a report etc. In the context of cadastral models, a document is for example the sale contract.

This concept should be considered in the top-level ontology. In order to take into account that an activity produces not necessarily a document, i.e. something written, but could also result in a decision or an oral agreement, the concept is called *result* instead of *document*.

Function

The purpose of an activity is called *function*. In the cadastral processes, the function of an activity might be to protect the seller's interests. We included this concept into the cadastral top-level ontology as it seems suited for the comparison. Activities might have the same function but fulfill it in a completely different way. Such differences are worked out by our comparison.

Pre- and Post-Conditions

A pre-condition is a decision criterion on whether an activity may be started. In the cadastral processes, an activity normally starts when the previous activity has completed with a certain result, e.g., a decision or a contract. We decided not to include the pre-condition in the current modeling in order not to emphasize the probably different order of activities in different countries. However, it might be included in future versions.

A post-condition is a decision criterion on whether an activity is completed. It is not necessary in the cadastral process models as one activity follows directly from the completion of another activity by the production of a document. This is represented by the result of an activity.

Deadline

The deadline requires that a certain activity is completed after a certain time span. This concept would be interesting when processes of a very different efficiency are analyzed. It could be used to detect the activities that slow down the complete process. In the current modeling, this concept was not defined in the top-level ontology.

2.2.3 Basic Concepts and Properties for the Top-Level Ontology

Concepts	Activity, Function, Result
Properties	hasFunction (domain: activity, range: function), resultsIn (domain: activity, range: result)

2.3 The Development of the Ontology Models

2.3.1 Worked Example

We decided to take the process models for property transfer in Denmark and England / Wales as example processes for the ontology-based comparison. These countries offer the advantage that activity diagrams and textual descriptions are available. Due to the restricted time during a STSM, we preferred to concentrate on the analysis of two countries and to refine their models in several iterations instead of including a larger number of process models. Such first evaluation of the ontology-based comparison of cadastral processes seemed feasible within a STSM with two national process models.

2.3.2 Development of the Ontology Model

We started with the process model for England / Wales and modeled all the activities from the UML activity diagrams as activities. Then we identified for each activity its function(s) and result(s) based on the descriptions of the cadastral transactions. Functions and results intended to be reused in the description of the Danish property transfer process. Therefore, they were modeled as general concepts which were applicable to different countries. They were named independently of national particularities. In the next step, we transferred the activity diagram and the textual description of Denmark into an ontology model. As far as possible, we reused the already defined functions and results. If necessary, we added new functions and results to the top-level ontology. In the top-level ontology, we structured functions and results in a hierarchical way.

Table 1 and Table 2 show the resulting definition of functions and results for each activity. Concepts which are specific for a certain country, like the activities, include in their name the respective country, e.g., DK for Denmark and EW for England / Wales.

Activity Denmark	**Function**	**Result**
DK_Advertising	FindingABuyer	BuyerAndSellerBrought-Together
DK_PreContractNegotiation	ConfirmingIntentionsFor-	LegallyBindingOralSale-

	PropertyTransfer	Agreement
DK_CollectingLegal-InformationOnProperty	CollectingInformationOn-PropertyForBuyer	ReportOnProperty
DK_PropertyExamination	QualityControlOfProperty	BuyersKnowledgeOn-Property
DK_MortgageNegotiation	GetFormalMortgageOffer	FormalMortgageOffer
DK_SaleContractPreparation	PrepareDocumentsForSale	SaleContract, ContractNote, SalesReport
DK_SaleContractSigning	OfficialTransferOfRightsOn-Property	SignedLegallyBindingSale-Contract
DK_UpdatingTaxRegister	ObtainKnowledgeAbout-PropertyTransferForTaxation	SaleContractWithTaxed-Value
DK_ApplicationForProvisional-Registration	AskForSecurityOfTitle, GuaranteeTransfer-CompletionToSeller	SaleContractTransferredTo-LandRegistry
DK_VerifyingApplicationFor-Registration	CheckOfLegalRequirements	EndorsedSaleContract, ProvisionalRegistration
DK_MortgageContractSigning	GuaranteeMortgageToBuyer	SignedMortgageContract
DK_PaymentOfPurchaseSum	GuaranteePurchaseSumFor-Seller	CompletePurchaseSumOn-LegalExpertsDepositAccount
DK_ApplicationForFinal-Registration	CompleteSecurityOfTitle	LandRegistryInformedBy-LegalExpert
DK_FinalRegistration	SecurityOfTitle	SecuredTitle
DK_CompletingProperty-Transfer	CompleteExchangeOfAssets	CompletePurchaseSumOn-SellersBankAccount, CompletionStatement, EndorsedSaleContractTo-Buyer, TitleOnPropertyToBuyer

Table 1 - Property Transfer in Denmark: Activities, Functions and Results

Activity England / Wales	**Function**	**Result**
EW_ProvisionalMortgage-Negotiation	GettingPromiseForFuture-Mortgage	ProvisionalMortgage-Certificate
EW_Advertising	FindingABuyer	BuyerAndSellerBrought-Together
EW_PreContractNegotiation	ConfirmingIntentionsFor-PropertyTransfer	OralSaleAgreement
EW_PropertyExamination	QualityControlOfProperty	HomeBuyerReport, BuildingSurvey
EW_TitleInvestigation	CollectingInformationOn-PropertyForBuyer	FormOnProperty, ReportOnProperty
EW_MortgageNegotiation	GetFormalMortgageOffer	FormalMortgageOffer
EW_SaleContractPreparation	PrepareDocumentsForSale	SaleContract

EW_SaleContractSigning	ConfirmWillToTransfer-RightsOnProperty	SignedNotLegallyBinding-SaleContract
EW_MortgageContractSigning	GuaranteeMortgageToBuyer	SignedMortgageContract
EW_SaleContractExchange	MakeSaleContractLegally-Binding	SignedLegallyBindingSale-Contract
EW_PaymentOfDeposit	GuaranteeTransferCompletion-ToSeller	DepositOnSellersLegal-ExpertsBankAccount
EW_UpdatingTaxRegister	ObtainKnowledgeAbout-PropertyTransferForTaxation	SaleContractWithTaxed-Value
EW_PaymentOfRemaining-PurchaseSum	CompleteTransferOfPurchase-Sum	CompletePurchaseSumOn-SellersBankAccount
EW_ApplicationFor-Registration	AskForSecurityOfTitle, CompleteSecurityOfTitle	SaleContractTransferredTo-LandRegistry
EW_VerifyingApplicationFor-Registration	CheckOfLegalRequirements	EndorsedSaleContract
EW_Registration	SecurityOfTitle	SecuredTitle
EW_CompletingProperty-Transfer	CompleteExchangeOfAssets	EndorsedSaleContractTo-Buyer, TitleOnPropertyToBuyer

Table 2 - Property Transfer in England / Wales: Activities, Functions and Results

The ontology models were formulated with the use of the ontology editor Protégé (http://protege.stanford.edu/). As the include statement for different individual ontologies cannot easily be used in Protégé, we decided to integrate both national models and the top-level ontology in one single ontology model.

2.4 Reasoning on the Ontology Model

Correspondences between the activities of both national models were computed by an ontological reasoner. We used the reasoner Racer (http://www.sts.tu-harburg.de/~r.f.moeller/racer/) which can easily be used in combination with the ontology editor Protégé. The correspondences could be identified without including additional relationships between the models into the ontology model. They could be computed because the terms of the top-level ontology were re-used in both cadastral processes. The types of correspondence that are computed by a reasoner are equivalence and subsumption, i.e. one activity is computed to be more special than another activity.

3 Reasoner Results and Refinement of the Ontology Model

3.1 Interpretation of the Results of the First Iteration

The results of the reasoning in the first iteration are presented in Figure 2. The following section analyzes the results and necessary modification.

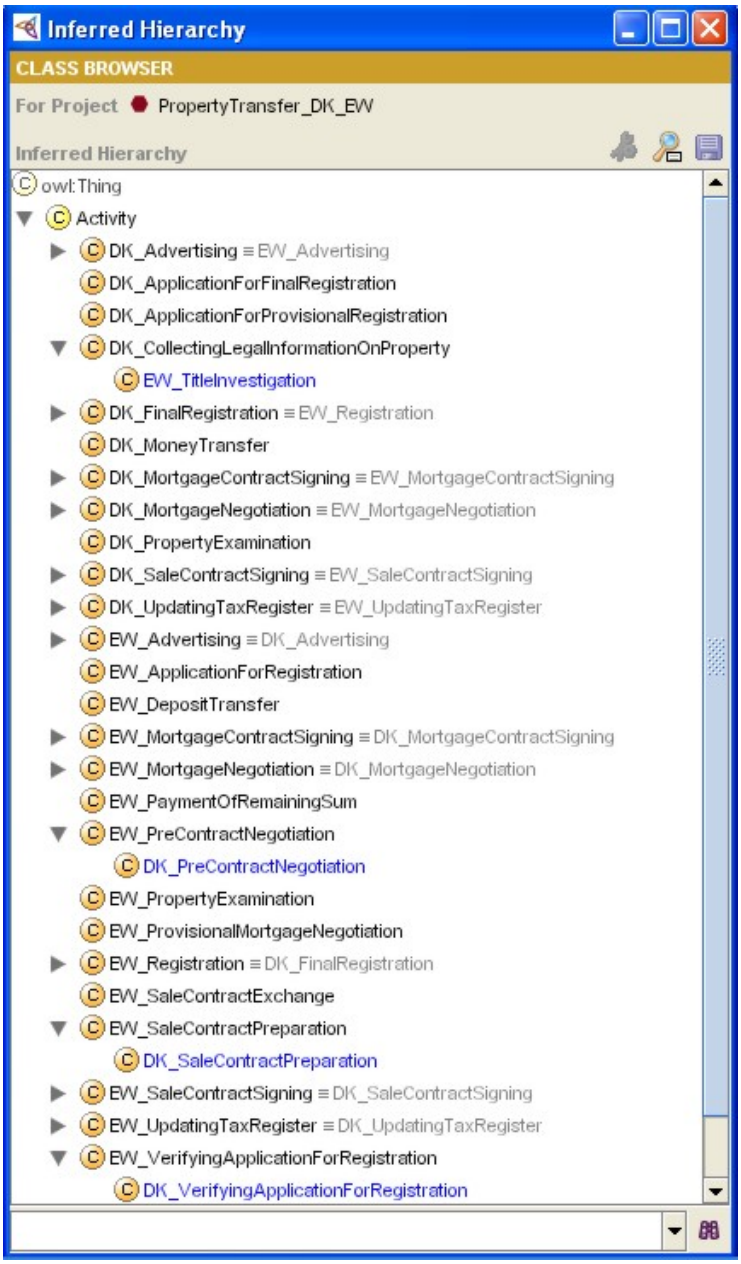


Figure 2 - Inferred Hierarchy in the First Iteration

3.1.1 Phase 1: Pre-Contracting

1. EW_ProvisionalMortgageNegotiation

There is no corresponding activity to EW_ProcisionalMortgageNegotiation in Denmark. In contrast to England / Wales, no certificate proofing that a mortgage will be provided by some bank is required for property transfer in Denmark.

2. DK_Advertising ≡ EW_Advertising

It seems sensible that both activities concerning the advertising of a property which is for sale are identified as equivalent by the reasoner. The advertisement of a property proceeds in rather the same way in both countries.

3. EW_PreContractNegotiation ⊇ DK_PreContractNegotiation

The pre-contract negotiation is more special in Denmark then in England / Wale because the oral agreement poses legal obligations on both parties in Denmark which does not hold for the oral agreement in England/Wales. The Danish case is considered to be more special as it is not the normal case that an oral agreement is legally binding. In most countries, an oral agreement is not legally binding.
In this first modeling, it is not yet considered that the sale agreement can be made in Denmark either oral or verbal. It is only expressed that the sale agreement is an oral agreement with legal obligations.

4. DK_CollectingLegalInformationOnProperty ⊇ EW_TitleInvestigation

The English activity for collecting legal information about the property is more special than the corresponding Danish activity. This computed relationship looks appropriate because in England / Wales more research on the title is required than in Denmark. In England/Wales, a professional should do the title investigation as the English land register is incomplete (it only started in the 1990's), in contrast to Denmark were the buyer himself can examine the state of the property at the land registry. If the buyer wishes, a real estate agent can support him in collecting the legal information. But this is not necessary.

5. DK_PropertyExamination, EW_PropertyExamination

No relationship between the activities on property examination could be identified by the reasoner. However, it should be possible to establish a relationship. The functions of both activities are basically the same. Only results are at a different level of detail because the reports are made by experts (England/Wales: surveyor) and by non-experts (Denmark: buyer), respectively. Due to this, the property examination in England / Wales is more formally than in Denmark. As the buyer himself does the property examination, he is not obliged to provide any

written report about the physical state of the property whereas in England / Wales, the expert responsible for the property examination must provide different documents for the buyer.

In subsequent iterations, a relationship between both activities should be established in such way that property examination in Denmark is more general than in England / Wales.

6. DK_MortgageNegotiation ≡ EW_MortgageNegotiation

This correspondence seems to be reasonable. Differences in the internal workflow of the banks, e.g., the types of documents that are required in order to obtain a mortgage, are not considered in this modeling.

3.1.2 Phase 2: Contracting

7. EW_SaleContractPreparation ⊇ DK_SaleContractPreparation

The preparation of the sale contract in Denmark provides a larger number of documents than in England/Wales. Therefore a subclass relationship is computed by the reasoner. However, the writer of this scientific report has not enough knowledge on the cadastral transactions in both countries to decide whether the content of the sale documents in Denmark and England/Wales is identical or to work out the exact differences. Experts for the national systems should decide whether or not the identified relationship is correct and whether refinements in the results (the type of the documents) are necessary in order to modify the resulting relationship.

8. DK_SaleContractSigning ≡ EW_SaleContractSigning

The identified correspondence between the activities relating to the signing of the sale contract in Denmark and in England / Wales is incorrect. In Denmark, a sale contract is legally binding as soon as it is signed by both involved parties, i.e., after signing the sale contract, involved parties cannot withdraw from the property transfer. In England / Wales however, the sale contracts signed by seller and buyer must be exchanged via the seller's and the buyer's solicitor in order to become legally binding.

Modifications in the ontology model are therefore necessary in order to remove the direct correspondence between DK_SaleContractSigning and EW_SaleContractSigning. Some relationship should instead be expressed between the activity DK_SaleContractSigning and the set of activities EW_SaleContractSigning and EW_SaleContractExchange.

9. DK_UpdatingTaxRegister ≡ EW_UpdatingTaxRegister

The equivalence that is computed by the reasoner for the activities DK_UpdatingTaxRegister and EW_UpdatingTaxRegister is appropriate. The ontology model does not include any detailed knowledge about the way the tax registers work in the different countries. The correspondence is based on the fact that functions and results are identical.

10. DK_MortgageContractSigning ≡ EW_ MortgageContractSigning

The activities representing the signing of the mortgage contract are considered as equivalent in Denmark and in England / Wales. For these activities, it applies the same as for the negotiation of the mortgage contract. The activities abstract from the internal details of the workflows in the banks.

3.1.3 Phase 3: Registration

The way how a property transfer is secured is different in both countries. The following classes therefore show some overlapping in functions and results:

- *DK_ApplicationForProvisionalRegistration,*
- *EW_DepositTransfer,*
- *EW_ApplicationForRegistration,*
- *DK_ApplicationForFinalRegistration.*

However, as they only overlap, no correspondence could be computed by the reasoner. In the following, we analyze the relationships and propose modifications for the next iteration.

11. DK_ApplicationForProvisionalRegistration, EW_DepositTransfer, EW_ApplicationFor-Registration

The reasoner cannot compute any relationship between the activities DK_ApplicationForProvisionalRegistration and EW_DepositTransfer although they have the same function, i.e., to protect the seller that the transfer will be completed in the way that the buyer will pay the complete purchase sum. As results are not related in any way, both activities only overlap in their functions. This is not sufficient for the computation of a correspondence.
The case is similar for the activities DK_ApplicationForProvisionalRegistration and EW_ApplicationForRegistration. Although the reasoner can not compute any relationship between both activities, we can see that both activities overlap in some way because they have the same result, i.e., the transfer of the sale contract to the Land Registry.

It should be checked whether some correspondence could be computed after refining the modeling from the first version of the ontology model.

12. DK_VerifyingApplicationForRegistration ⊆ EW_VerifyingApplicationForRegistration

The subclass relationship between the two activities referring to the verification of the application for a registration of the title is appropriate. The function of both activities, the verification whether all legal requirements are satisfied, is identical. The subclass relationship instead of equivalence is computed due to the fact that the results are different. The case is more special in Denmark because the sale contract is not only endorsed, but also a provisional registration is made.

13. DK_MoneyTransfer, EW_PaymentOfRemainingSum

In some way, both activities have the same function: the purchase sum should be transferred to the seller. However, no matching can be computed as the activities are modeled too differently. Before the next iteration, it should be checked whether a correspondence could be established by a modeling which bridges the gap between both activities and focuses on the similarities.

14. DK_ApplicationForFinalRegistration

This activity was already discussed in the comparison 11: Some overlap could be seen with the activity EW_ApplicationForRegistration, but differences are too significant to compute a correspondence.

15. DK_FinalRegistration ≡ EW_Registration

The equivalence between the activities representing the registration of the title is reasonable as DK_FinalRegistration and EW_Registration have the same functions and results.

3.1.4 Remarks on the First Iteration

During analysis of the results of the first iteration, we noticed that in the current modeling an activity which completes the property transfer is still missing. In an activity diagram, the completion is represented by a specific symbol for the termination. In the ontology model, an activity for the completion with its results is necessary. It will represent not only the symbol used in the activity diagram but also the textual description of the completion and its results.

The results of the first iteration were already promising. In a second iteration, recommendations and necessary modifications identified during the analysis of the results of the first iteration are tried to be integrated in the ontology model in order to improve the modeling and the reasoning results.

3.2 Modifications in the Ontology Model for the Second Iteration

3.2.1 Pre-Contract Negotiation

The current modeling does not yet consider that the sale agreement in Denmark which results of the activity DK_PreContractNegotiation is either oral (legally binding) or written. The ontology model of the first iteration did only include as result of the activity DK_PreContractNegotiation a legally binding oral agreement. This LegallyBindingOralSaleAgreement is a specialization of the

result OralSaleAgreement which is also the result of the corresponding activity in England / Wales (EW_PreContractNegotiation)
.
The possibility to make either a legally binding oral sale agreement or a written sale agreement cannot easily be integrated into the ontology model. Formulating the result as (LegallyBindingOralSaleAgreement OR WrittenSaleAgreement), the computed correspondence would not be any more that the pre-contract negotiation in Denmark is more special than the one in England / Wales due to its legally binding oral agreement. The correspondence would be completely destroyed.

As it is not yet solved how to integrate the possibility of a written sale agreement into the activity DK_PreContractNegotiation, it is not included in the ontology model in order to maintain the correspondence.

3.2.2 Examination of the Property

A relationship between the activities DK_PropertyExamination and EW_PropertyExamination should be established. A correspondence could be obtained by organizing the results, i.e., the informal and formal reports, hierarchically with increasing professionalism. We adopt the following structure:

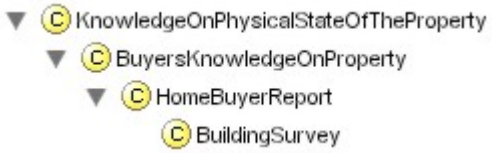


Figure 3 - Results from the Examination of a Property

3.2.3 Signing of the Sale Contract

There is no direct correspondence between the signing of the sale contract in Denmark and England / Wales. Modifications in the ontology model are necessary in order to express the difference between both ways of making the transfer of rights on the property official and legally binding. Ideally, the reasoner would compute a relationship that makes clear that the normal way of signing a sale contract is the Danish way and that the case in England/Wales in which two activities, namely the signing and the exchange of the sale contract, are necessary, is more special than in Denmark.

We propose to model the activities related to the signing of the sale contract as presented in Figure 4.
The function OfficialTransferOfPropertyRights is represented in England / Wales by two functions, i.e., ConfirmingWillToTransferRightsOnProperty and MakeSaleContractLegally-Binding. There is no hierarchical relationship between the function OfficialTransferOfRights-OnProperty and the set of functions defined for England / Wales. We cannot say that the OfficialTransferOfRightsOnProperty inherits the properties from the functions ConfirmingWill-

ToTransferRightsOnProperty and MakeSaleContractLegallyBinding. Such modeling would express that the case in England / Wales would be the normal case instead of representing this case as a particular case and of stating the Danish case as the normal one.
The relationship can be described in the following way: The function OfficialTransfer-OfRightsOnProperty has the properties that seller and buyer confirm in a legally binding way that the seller transfers the rights on property to the buyer in exchange of the purchase sum. The function ConfirmingWillToTransferRightsOnProperty shows all the properties of the function OfficialTransferOfRightsOnProperty, except for the fact that it cannot produce a legally binding contract. It requires a second activity to do this, the activity SaleContractExchange which has the function to make the sale contract legally binding.

This situation is called in a logic non-monotonicity. A concept considered to be more special than another one does not has one of the properties of the more general concept. For example, all birds have the property that they can fly, except for the penguin. However, we would normally not like to model that a bird is a special type of penguin, namely one that can fly.
This problem arises not only for the functions of the activities DK_SaleContractSigning and EW_SaleContractSigning as described above, but for the results, too. A signed sale contract has normally the property to be legally binding, except in England / Wales where it must be exchanged.

The non-monotonicity can not be expressed in the ontology modeling language OWL. A logic including non-monotonicity is not any more efficiently computable. That means that it might not be possible to obtain results concerning the correspondences between activities in a reasonable time and maybe not at all.

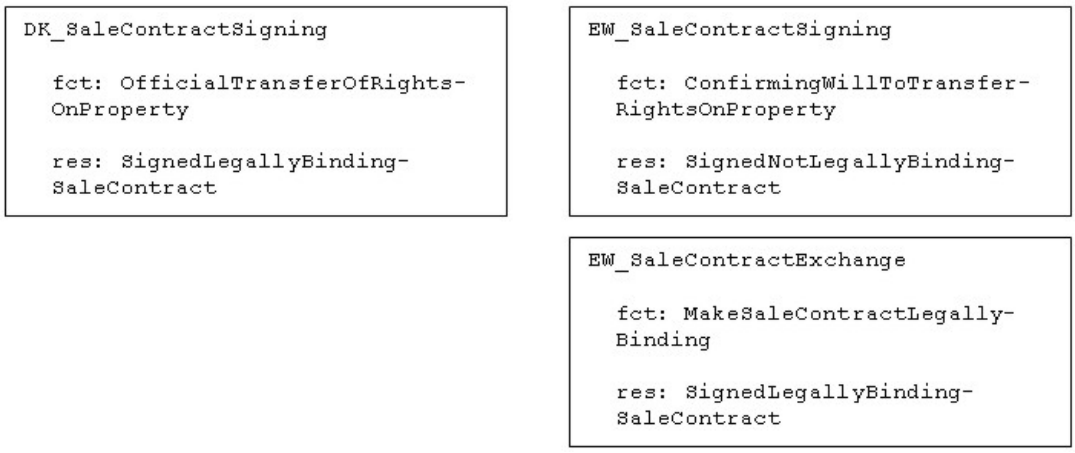


Figure 4 - Proposed Modeling of the Activities describing the Signing of the Sale Contract

The presented modeling seems sensible. However, it does not allow for the computation of any correspondence by the reasoner. Therefore, we discussed different ways of modeling and examined the resulting correspondences. We could not find any modeling that did not have the problem with the non-monotonicity. It looks not feasible to us to modify or reorganize the functions and results in a way that permits the computation that England / Wales has the more special way of signing a sale contract than Denmark.

3.2.4 Securing of the Property Transfer

When thinking about possible correspondences between the activities DK_ApplicationForProvisionalRegistration, DK_ApplicationForFinalRegistration, EW_Deposit-Transfer and EW_Application-ForRegistration, modifications in the modeling were considered as necessary. The modeling in iteration 1 and the matching between functions and results are presented in Figure 5.

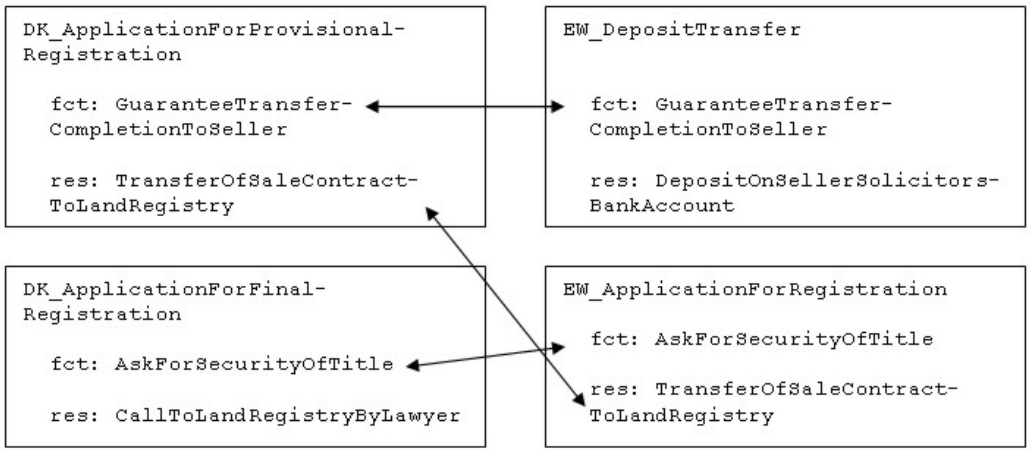


Figure 5 - Securing of the Transfer (Iteration 1)

Besides of a renaming of the concepts which intends to provide a better understanding of their meaning, we decided to make the following modifications: The activity DK_ApplicationForProvisionalRegistration should also include as function that security should be provided to the buyer by asking for the registration of the title. In order to make clear that both activities in Denmark referring to the registration have a different function, the function in the activity DK_ApplicationForFinalRegistration is changed to CompleteSecurityOfTitle. The modification of the function in the activity EW_ApplicationForRegistration follows from the renaming in Denmark.

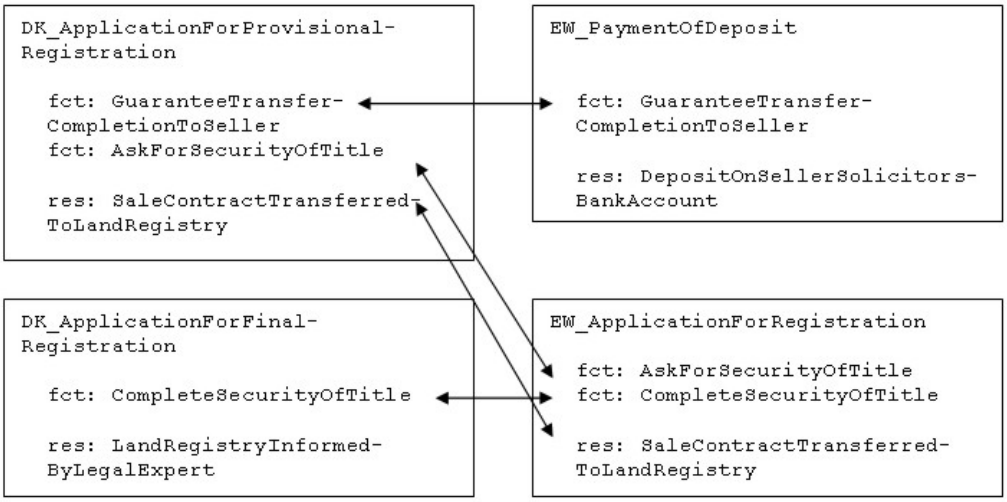


Figure 6 - Securing of the Transfer (Iteration 2)

3.2.5 Payment of the Purchase Sum

We decided not to change the modeling in order to make clear that the transfer of the purchase sum is made in different ways in England / Wales and Denmark. The basic difference between the activities is that the purchase sum is transferred in Denmark not directly to the seller as in England /Wales but it is transferred in a first step to the legal expert's bank account and in later activities to the seller. Therefore results and functions are different.

3.2.6 Completion of the Property Transfer

Two activities DK_CompletingPropertyTransfer and EW_CompletingPropertyTransfer are included in the ontology model. Both activities complete the property transfer and have as results the final documents. They represent the last interaction between buyer and seller.
However, it is not yet included that the endorsed sale contract is send to buyer and seller in England / Wales. Up to now, it is only included that the endorsed sale contract is send to the buyer as it is the case in Denmark, too.

3.3 Interpretation of the Results of the Second Iteration

This section discusses results additional or modified in the second iteration. Activities which remained as in the ontology model of the first iteration will not be considered. The hierarchy inferred by the reasoner is the one shown in Figure 7.

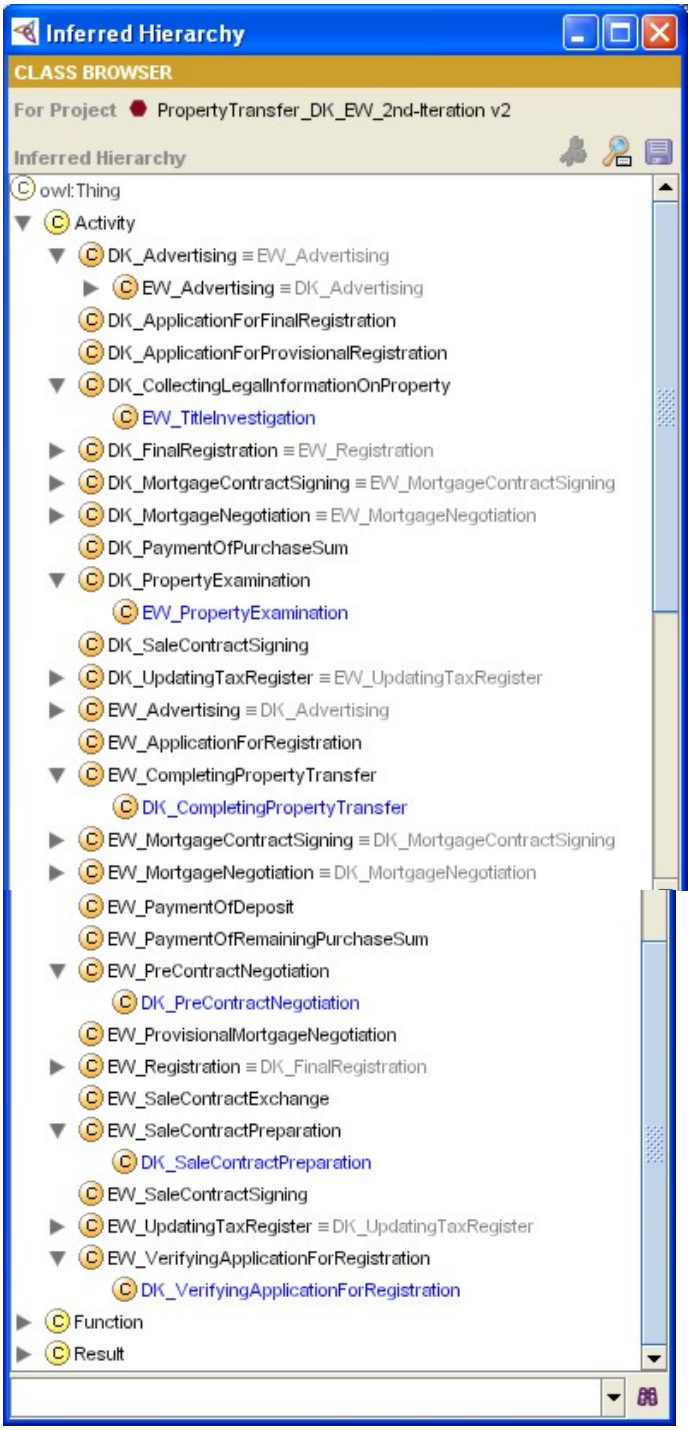


Figure 7 - Inferred Hierarchy in the Second Iteration

3.3.1 Examination of the Property

On the basis of the modifications made in the ontology model for the second iteration, a subclass relationship could be computed between the two activities representing the examination of the physical state of the property. The activity DK_PropertyExamination is computed as more

general than the activity in England / Wales, EW_PropertyExamination because its results are on a more general level. This correspondence is appropriate. No further changes are necessary in both activities.

3.3.2 Signing of the Sale Contract

There is not any more a relationship between the classes related to the signing of the sale contract. This result corresponds with our modeling intentions for the second iteration. However, it is recommended to rethink whether a correspondence could be established in some way between the set of classes related to the signing of the sale contract.

3.3.3 Securing of the Property Transfer

As it could be expected according to the modifications in the ontology model, the reasoner could not compute any correspondence. This result is appropriate as discussed in the previous section.

3.3.4 Completion of the Property Transfer

The correspondence between the activities DK_CompletingPropertyTransfer and EW_CompletingPropertyTransfer are new in the second iteration as both activities were only added during the last modifications in the ontology model. The completion in Denmark is more special as the one in England/Wales because more documents are exchanged and the selling of the purchase sum is only completed at this time by transferring it from the legal expert to seller.

4 Evaluation

The evaluation discusses the research that has been made during the STSM from two points of view. Firstly, the ontology-based approach itself is evaluated. Secondly, the methodology and the results are analyzed according to their usefulness and applicability to the comparison of cadastral transactions.

4.1 Evaluation of the Approach

4.1.1 The Use of a Top-Level Ontology

The top-level ontology constituted the basis for our comparison. The concepts defined in the top-level ontology were used in the modeling of both national process models. This reuse permitted a computation of correspondences between both process models by the ontological reasoner. We recommend using such top-level ontology for each comparison because already its definition and the discussion of the appropriate concepts improve the understanding of the national processes. It clarifies which concepts are important for the process in question.

4.1.2 Ontologies as Modeling Approach for Cadastral Transactions

The approach presented in this work relies on the use of ontologies for the modeling of the national process models. Ontologies represent a formal way to describe process models. They allow for a formal comparison in contrast to previous initial comparisons which were based on a comparison of the textual descriptions.

The chosen level of detail seemed to be appropriate to evaluate the ontology-based comparison of process models. It was possible to compute relationships. However, we identified special cases like the different way of obtaining a legally binding sale contract in Denmark and England /Wales which rise interesting questions on the modeling. Such cases and also the merging and splitting of activities which are described by their functions and results should be examined in future work.

The comparison and the analysis in two iterations offered the possibility to refine the modeling and also to try out the effects of different modeling decisions on the results.

4.1.3 Applicability of the Approach

According to our experiences, it is easy to follow the steps described by the ontology-based methodology, i.e. to start with the top-level ontology, to define the ontology models, to refine the modeling in several iterations and to interpret the correspondences computed by the reasoner. These different tasks are made in a straightforward way. However, the ontology-based comparison requires currently that knowledge engineers and domain experts work together on the

modeling of the process models and the interpretation of the results because until now, ontology editors and reasoner are designed for knowledge engineers. In order to give domain experts the possibility to make an ontology-based comparison by themselves, a tool supporting the modeling, the refinement and the interpretation would be necessary.

4.2 Evaluation of the Results

4.2.1 Chosen Cadastral Top-Level Ontology

The three concepts we defined as basic building blocks for the top-level ontology and from which all other concepts were inferred, permitted us a detailed analysis of the cadastral transaction 'property transfer'. The activities represented in the UML activity diagrams were directly taken over into the ontology model. The concepts 'function' and 'result' allowed for an analysis of the cadastral process models from a point of view which has not explicitly been considered in past work. It was very useful to be able to include more than one function and result to an activity.

The concept 'function' has been proven as valuable because it concentrated our attention to the reasons why some work is accomplished. It is less important who is carrying out a piece of work but why. It might also allow for the identification of useless activities when restructuring a cadastral system.

The quality of the comparison increased by including the results, i.e. the documents or decisions resulting from the work carried out during an activity. Due to the concept 'result', it was possible to show that activities which "do the same" and which could easily be considered as equivalent can produce different results.

In future work, more or different concepts could be considered. The concepts chosen for the comparison depend on the type of difference or similarity that should be analyzed. Surely, the top-level ontology must be extended for the comparison of other national processes and for the comparison of other types of processes such as property subdivision.

4.2.2 Chosen Level of Detail for the Ontology Model

A quite large number of correspondences were computed between property transfer in Denmark and England / Wales. There is a match between 11 of the 16 comparisons that we made. This indicates that we have chosen an appropriate level of detail. The results reflect the commonalities and the differences between property transfers in both countries. If the result only consisted of completely matching activities, it could be the case that the modeling was too abstract and did not go enough in detail to detect the differences.

The preparatory work made by Marina Vaskovich was a good basis for the modeling of the ontology model at an appropriate level of detail. The activity diagram was an important step

before the development of the ontology model as it was decided what should be modeled as activity and which actions refer to the same activity.

4.2.3 Results of the Comparison

The results from the first and the second iteration seem to be correct according to our knowledge. For now, no further modifications are necessary. However, the ontology model is not yet checked by cadastral experts from Denmark and England /Wales, respectively. Included activities, their functions and results are based on the descriptions and models developed during previous STSMs by Marina Vaskovich together with national domain experts. Modifications in the models might be required which could lead to different results in the computations by the reasoner. This discussion can lead to a third iteration with an adapted or extended ontology model. The following table summarizes the results of our comparison.

#	**Property Transfer Denmark**		**PropertyTransfer England / Wales**
1	-		EW_ProvisionalMortgageNegotiation
2	DK_Advertising	≡	EW_Advertising
3	DK_PreContractNegotiation	<	EW_PreContractNegotiation
4	DK_CollectingLegalInformationOn-Property	>	EW_TitleInvestigation
5	DK_PropertyExamination	>	EW_PropertyExamination
6	DK_MortgageNegotiation	≡	EW_MortgageNegotiation
7	DK_SaleContractPreparation	<	EW_SaleContractPreparation
8	DK_SaleContractSigning		EW_SaleContractSigning EW_SaleContractExchange
9	DK_UpdatingTaxRegister	≡	EW_UpdatingTaxRegister
10	DK_MortgageContractSigning	≡	EW_MortgageContractSigning
11	DK_ApplicationForProvisionalRegistration		EW_PaymentOfDeposit EW_ApplicationForRegistration
12	DK_VerifyingApplicationForRegistration	<	EW_VerifyingApplicationForRegistration
13	DK_PaymentOfPurchaseSum		EW_PaymentOfRemainingPurchaseSum
14	DK_ApplicationForFinalRegistration		
15	DK_FinalRegistration	≡	EW_Registration
16	DK_CompletingPropertyTransfer	<	EW_CompletingPropertyTransfer

Table 3 - Results of the Comparison

5 Presentation of the Results and Future Cooperation

The results of this STSM are planned to be presented during the next meeting of the COST Action G9 “Modelling Real Property Transactions” in Thessaloniki (June 2005).
Furthermore, Marina Vaskovich and Claudia Hess are planning to publish two papers together based on the research carried out during this STSM. The papers should have a different focus, one on the cadastral aspects and the other on the support that can be given by ontological modeling and reasoning to comparisons of cadastral transactions.

6 Conclusion

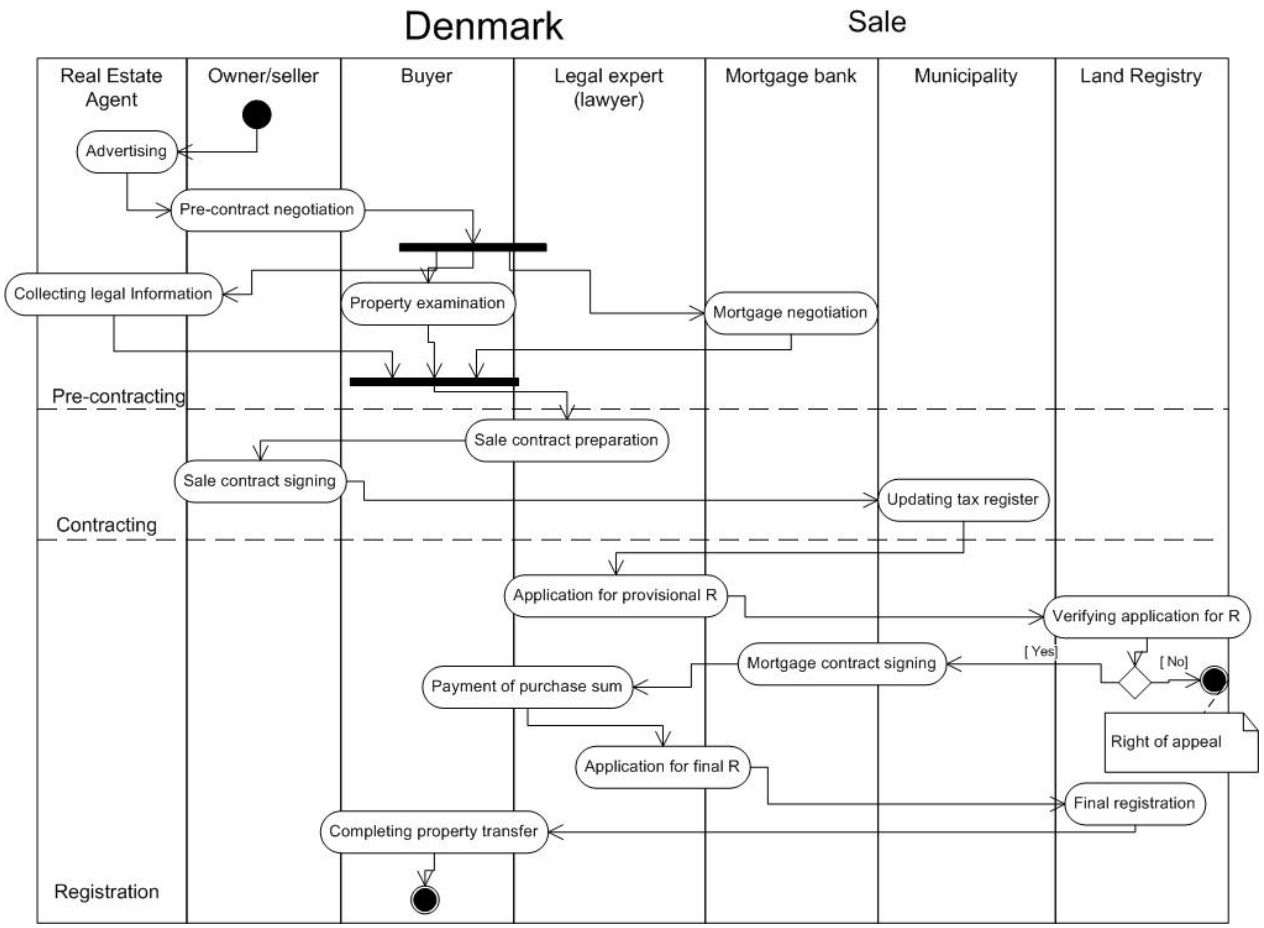
The ontology-based comparison of the processes for property transfer in Denmark and England / Wales provided detailed knowledge about the relationships between the processes in both countries. Even if there might be some modifications or refinements in the ontology model after further discussing it with experts for the national cadastral systems, the chosen cadastral top-level ontology and the resultant level of detail seem to be appropriate.
The ontology-based comparison supports the comparison of cadastral models as it provides a formal language to represent the national process models and reasoning support which permits the computation of the relationships by the reasoner. The correspondences obtained in our examples by the reasoning procedures of the reasoner did not produce any surprising results but they permitted a more comprehensive analysis than a comparison based on the textual descriptions. By its formal way of representing activities and using the concepts from the top-level ontology, the ontology-based comparison depends less on the personal impressions gained by the reading of the descriptions as the initial comparisons based on the textual descriptions. The presented comparison was based on the concepts ‘function’ and ‘result’ due to which a large number of correspondences could be computed. But also small differences could be identified. Future comparisons can use different concepts than the current one and analyze the process models from a different point of view.

The correspondences we obtained between the models for property transfer by the reasoner and the knowledge we gained by the analysis and the interpretation of the results show that the ontology-based methodology supports the comparison of cadastral transactions. In future research, a larger number of national process models should be compared according to the presented methodology. Common activities, their functions and results become apparent because the concepts defined by the top-level ontology are used in all models and corresponding activities are computed by the reasoner. A reference process could result of these comparisons between national cadastral transactions.

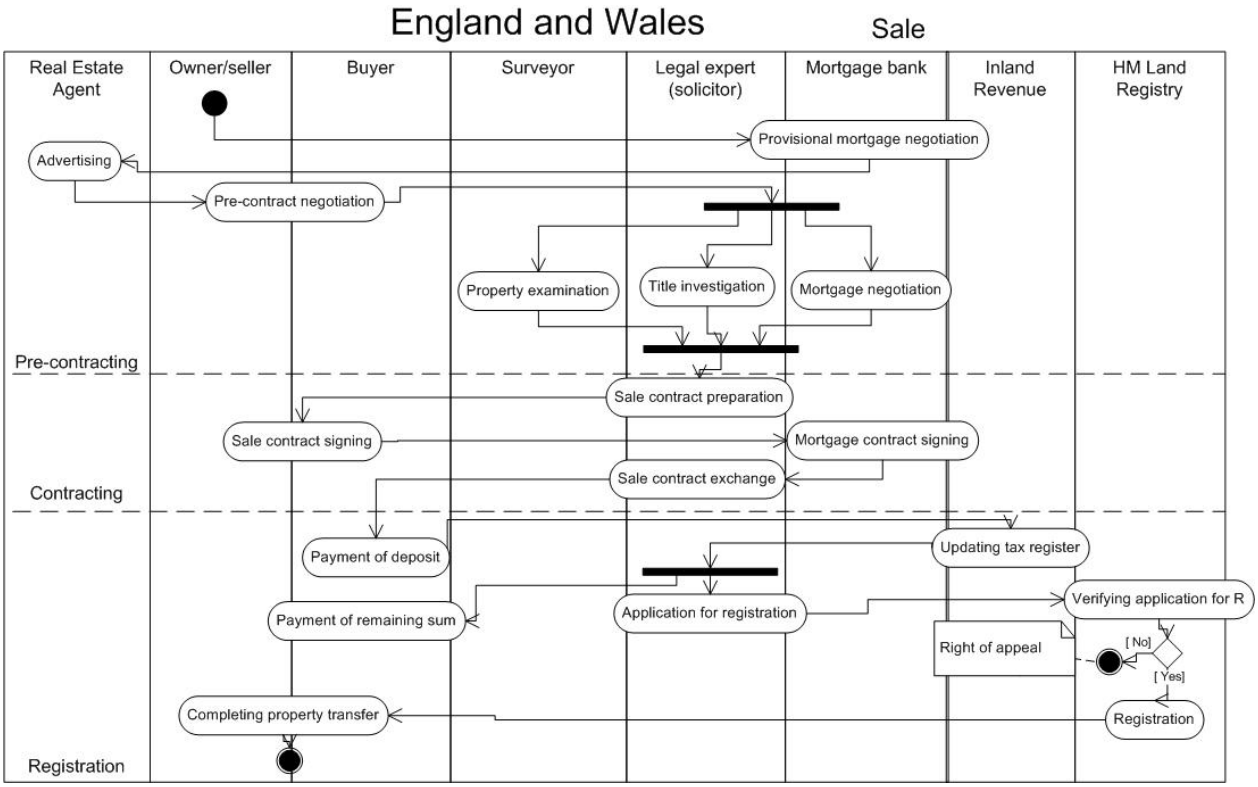
Appendix

The following activity diagrams were modeled by Marina Vaskovich (Vaskovich 2003, 2004) during STSMs in Denmark and England / Wales, respectively. They were modified during the STSM in Stockholm in such way that activities were renamed in order to use as far as possible the same vocabulary in both national models.

Appendix A: Activity Diagram for Property Transfer in Denmark



Appendix B: Activity Diagram for Property Transfer in England / Wales



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