ING Bank Loans in Clafer

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Abstract

The purpose of this paper is to demonstrate how complex concepts can be modeled by using the Clafer modeling language. More specifically in this paper i discuss the procedure, the methods, the solutions and the outcome analysis of modeling the ING Bank Loans by using the Clafer. Initially i provide a brief description of the Clafer in order to provide the appropriate theoretical background. At next i provide the initial analysis of this project and briefly discuss the necessary information regarding to the structure of the Loans. The purpose of this step is to clarify and sort out the loan variants in order to make the modeling procedure easier. The next step is to translate this "informal" language to Clafer language in order to construct the desired model and be able to generate valid instances of this model by using the on-line ClaferIDE tool. Finally the analysis of the model is performed and the conclusion of this study is presented.

Introduction

Clafer is a textual language which is used in concept modeling and specification of software product lines [2]. It has the ability of providing a uniform syntax and semantics to class and feature models and its goal is to make lightweight modeling more accessible to a wider range of users and domains, including enterprise systems. Moreover, Clafer has several applications and it can be used for Domain and structural modeling. Clafer models can encode feature, class,and meta-models which contain complex constraints. The language provides model verification and validation. The tool has the ability of testing the consistency of models; check if given examples correspond to correct instances of models and derive multiple examples from models. For this purpose the Clafer to Alloy Translator is used. The translator-compiler takes a Clafer model and transforms it to corresponding Alloy model. This happens in order to give precise semantics to the language by preforming semantic analysis and establishing a mapping to Alloy. The translator comprises of lexer and parser of layout resolver which makes a Clafer model shorter and easier to read by reconstructing the code. In this paper i analyze the modeling of the ING Bank Loans by using Clafer. At this point i would like to mention that this work is an outcome of the available information on the official website of the ING Bank and especially on the "Lending" page. The acquired knowledge and information is completely based on the on-line information which is provided by the ING Bank. Furthermore, information was taken from the electronic brochure of the ING Bank that can be found on the website. More specifically, for information like the calculation of the permissible duration of the repayment periods, the repayment methods, the calculation of the acceptable amount of money to borrow and the interest rates which correspond to each case, the on-line simulators of ING can be used. The Uniform resource locators that have been used for deriving the information are presented in a following section.

Initial analysis of the concept

The initial analysis of the concept is based on reading the source, taking notes and writing down in a direct form the ways that the variant loans can be expressed and demonstrated. For this stage is efficient to write down as much information as it is possible. Clafer supports note taking during conversations, reading, and workshops. Moreover, Clafer models can initially be written on a piece of paper, a whiteboard, or in any text editor. Afterwards this "informal" information can be translated to a more formal Clafer model. The purpose of this analysis is to collect and enumerate all possible loans provided by the bank and model them according to their features, properties and concept. Moreover it is important to collect and clarify all the applicable restrictions of the loans and translate them into the form of Clafer constraints. The Figure 1 presents the available loans to be modeled from ING Bank.

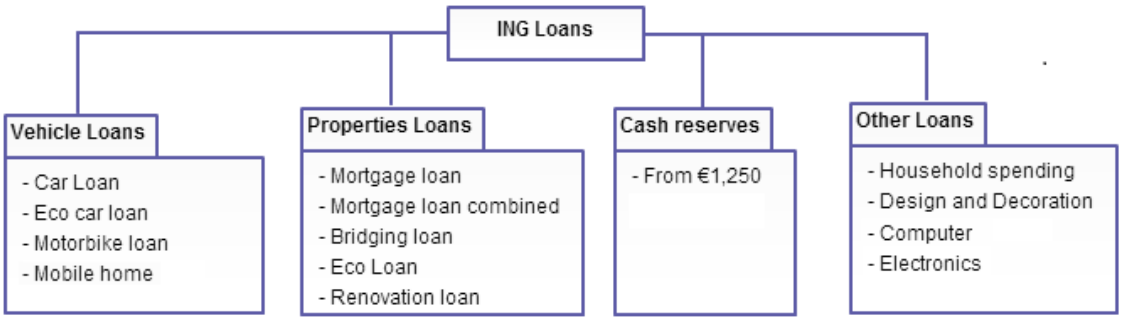

Figure 1: Loans available from ING Bank

Furthermore, the following table demonstrates the grouping of the information regarding to the available loans and their attributes as they are presented in the website. First the information regarding to the Vehicle Loans is analyzed.

Vehicle Loans	
Attributes	Description
Proposal	String value. It represents the proposal of each loan.
Repayment Period	Integer value. Specifies the permissible boundaries of the duration of each repayment period. It depends on the loan.
Chronology	It specifies the age of the vehicle. According to the value of different rules are applied. There are 3 acceptable values: - New vehicle - Second-hand vehicle less than 2 years old - Second-hand vehicle more than 2 years old
Vehicle type	It specifies the type of the vehicle. There are different rules in the loans for each vehicle. There are 4 acceptable values: Car, Motorbike, Eco Car and Mobile home.
Amount to borrow	Integer value. It represents the minimum and maximum amount to be borrowed. This amount belongs to the range of [2000, 125000] euros.

Fees	String value. This attribute refers to additional fees of the loan. In the case of the Vehicle loans it has two values/attributes: Management fees and Service fees.
Interest Rate	This attribute varies regarding to the Repayment Period of the loan and the age (Chronology) of the vehicle. The interest rates for all cases can be found on the website of ING Bank and can be seen by using the online vehicle loan simulator.

The next category of loans that is modeled is the Property loans. This category contains more complicated rules and restrictions that are modeled in the form of constraints. The following table presents the required information about the Property Loans that can be written down. This information needs to be analyzed for the modeling procedure.

Property Loans	
Attributes	Description
Proposal	String value. It represents the proposal of each loan.
Term	This attribute distinguishes the loans in long-term loans and short-term loans.
Repayment Period in Years	Integer value. Specifies the permissible boundaries of the duration of each repayment period in years. The range of values depends on the loan. For example the repayment period of every mortgage loan belongs to the range of [1, 30] years.
Loan Type	It specifies the type of the property loan. According to its value different rules are applied. There are 6 acceptable values: Mortgage Loan, Combined Loan, Bridging Loan, Renovation Loan, Eco Loan.
Amount to borrow	Integer value. It represents the minimum and maximum amount to be borrowed. This amount must be greater than 2500 euros and it can be expressed in tens, hundreds regarding to each loan.
Loan formula	This attribute "connects" all the attributes and represents the form of each loan. Every property loan has its own formula attribute (Combined loan formula e.g.).
Interest Rate	This attribute varies regarding to the Repayment Period of the property loan. The interest rates for all cases can be found on the website of ING Bank and can be seen by using the online loan simulator.
Fixed and Variable Interest Rate	This attribute varies regarding to the type of the property loan. The interest rate can be fixed for the lifetime of the loan or it can contain a variable interest rate with different kinds of variability.
Fluctuation	This attribute refers to fluctuation of the interest rate in the case of Variable Interest rate. The fluctuation range depends on the type of the Variable Interest loan.
Borrowers	String value. This attribute refers to permissible number of borrowers for each loan. For example in the case of mortgage loan the number of borrowers must be 1 or 2.

Guarantees	This attribute specifies the available guarantees that are bounded with the loans. There are three available guarantee methods provided for each mortgage loan: Mortgage Guarantee, Notarial mandate Guarantee and Grant a mortgage Guarantee.
Repayment types	This attribute specifies the available repayment methods of each mortgage loan. There are three available repayment methods: Fixed monthly installments, Periodic Capital Amortization and Full Repayment of the capital upon maturity.
Eco Loan Purpose	This attribute refers to the purpose of the Eco property loan.
Fees	String value. This attribute refers to additional fees of the loan. In the case of the property loans it has the value/attribute: Dossier fees.

The next category of loans that is modeled is the Other loans. This category contains more simple rules. The following table presents the required information about this category of loans that can be written down. This information needs to be analyzed for the modeling procedure.

Other Loans Formula	This category of loans contains some sub-categories which are presented as attributes in the Clafer model. The values are: Household spending, Electronics, Computer, Design and decoration.
Amount to borrow	Integer value. It represents the minimum and maximum amount to be borrowed. This amount must be greater than 2000 euros and less than 50000.
Repayment Period in months	Integer value. Specifies the permissible boundaries of the duration of each repayment period in months. The range of values belongs to the range of [6, 180] months.

The last category of loans to be modeled that is analyzed, is the Cash Facility loans. The following table presents the required information about this category of loans that can be written down.

Other Loans	This category of loans contains some sub-categories which are presented as attributes in the Clafer model. The values are: Household spending, Electronics, Computer, Design and decoration.
Amount to borrow	Integer value. It represents the minimum amount to be borrowed. This amount must be greater than 1250 euros.
Repayment Period	Integer value. Specifies the permissible boundaries of the duration of each repayment period in years. there are two available options: Once per year and once per 5 years.
Fees	String value. This attribute refers to additional fees of the loan. In the case of the Vehicle loans it has two values/attributes: Arrangement fees.

Translation to Clafer language

The initial analysis of the concept is done and the next is to translate this "informal" information to Clafer language. The Clafer language is a lightweight modeling language that aims in the improvement of the understanding of a problem domain. It also gives the opportunity of modeling complex concepts by supporting some features like inheritance, reference, cardinalities, group cardinalities and the performance of constraints. These features are used in this step for the construction of the Clafer model. One of the required steps for this procedure is the identification of commonalities in order to group the common attributes and exploit the feature of inheritance. Moreover at this point we need to distinguish between the abstract Clafers and Concrete Clafer of the Clafer model. The abstract Clafers are used to create models that represent abstract concepts and they can be used as superclasses for the inheritance of the common attributes. The inheritance in these cases can be declared by writing ":" between the superclafer and the subclafer. Furthermore, the set of abstract clafers composes the metamodel of the domain. The Concrete clafers are used for modeling concepts and representing variabilities among them. Typically a single concrete clafer model represents several configurations. Concrete clafers are used to capture several configurations in a single model and for producing instances. Variabilities in the structure of concrete Clafer models come from the declaration of cardinalities and/or group cardinalities. Cardinality is as single number or an interval that follows clafers name. It specifies how many instances of a given clafer can appear as children of the instance of the parent clafer. The default cardinality value of all Clafers in a model is equal to 1..1 or simply 1. Furthermore at this stage its necessary to decide about the possible constraints that can be applied to every Clafer model/sub-model. The performance of the constraints requires the declaration of the values that get involved in it. Clafer supports the declaration of a value of primitive value types such as integer, string, enumeration. Finally the inheritance must be performed in an efficient way in order to reduce the size of the code as much as possible and keep the Clafer model clear, direct and efficient. The Clafer Model of the ING Bank Loans is presented in the Appendix Clafer Loans model at the end of this paper. Finally we can see that the indentation is crucial for the Clafer model and especially for distinguishing between the parent-children relation.

Model compilation

The next step for this study is to transfer the Clafer language model which is demonstrated in the Appendix Clafer Loans Model into the on-line ClaferIDE tool which can be found on the Clafer home page. This transformation aims to perform the compilation, the analysis and the instance generation of the model. The model can be transferred to the text editor which is presented in the left-hand side of the interface (Input Clafer Model and Options) of the on-line ClaferIDE and by clicking on "Compile" the model can be compiled. The ClaferIDE supports error detection and it provides the user with the appropriate information is the case of error occurrence. This happens in the Right-hand side column of the interface (Output). In the middle column (Compiled Formats) of the interface it is possible to choose the compiled format of the Clafer model. The available options are the generation of HTML code, XML code, javascript code, Alloy model and produce the corresponding graph of the model. Moreover in the middle column in the "Instance Generator" is possible to choose the instance generator (Alloy-based instance generator or Choco-based instance generator) in order to generate the instances of our model. Finally the right-hand side part of the interface (Output) is the part where the instances of the model are generated and the part that the information about the model (e.g. the number of concrete and abstract Clafers, the cardinalities etc) are demonstrated. The following figure presents the ClaferIDE interface.

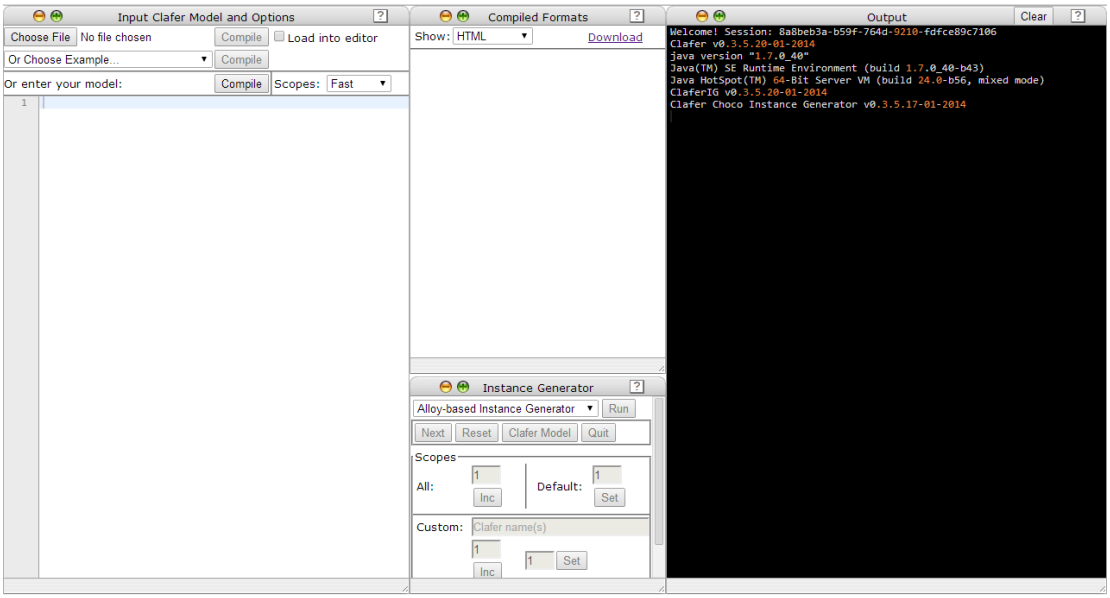

Figure 2: ClaferIDE interface

Instance Generation by using Alloy

For the generation of instances, the on-line ClaferIDE tool is used and especially the instance generator for the production of valid configurations. Initially as we can see in the following figure (Figure 3) the model can be compiled successfully (”Compiler¿ success”) and the tool provides some simple analysis according to the structure of the model (e.g. the number of the concrete and abstract Clafer, the number of references and constraints).

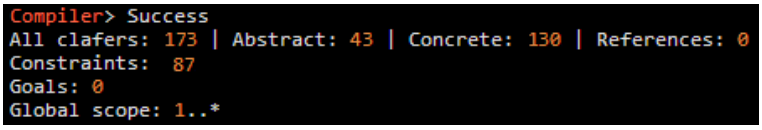

Figure 3: ClaferIDE tool analysis

The next step is to use the Clafer to alloy translator for generating valid instances of the model. For this step the on-line tool ClaferIDE is used again. The tool is using the Clafer Instance Generator which is an interactive tool that generates instances of Clafer models, shows counter examples and conflicting constraints. After the compilation of the meta-model, multiple instances can be generated. The following figures demonstrate some possible instances of the model (Figure 4 and Figure 5). In the two generated instances different scenarios are demonstrated. In the first case (Figure 3) we ca see a Property loan available from the ING bank and more specifically a Mortgage loan with variable interest rate. The interest rate in this case is 3,6%, the repayment period is three years and the number of borrowers is two. This is a completely valid and acceptable loan instance according to the ING website. In the second case (Figure 4) an instance of a property Combined loan is demonstrated. The interest rate in this case is 4,4% the repayment period of the loan is one year, the number or borrowers is two, the

amount to be borrowed is 25.200 and finally the percentage of the Bullet loan is 64% while the percentage of the Traditional loan is 36%. This is also a valid and acceptable loan instance according to the information provided by the ING website.

```
ClaferIDE> Running the chosen instance generator...
claferIG> Loan_Type
  Properties_Loans
    mortgage_Loan
      Variable_Rate
        Annual_Variability
          Interest_360
            Repayment_Period_in_Years = 3
          Proposal = "The interest rate may be adjusted every year"
        fluctuation = "The fluctuation cannot be more than 3% and there is no lower floor"
      Periodic_Capital_Amortization
      Grant_a_mortgage_Guarantee
      number_of_borrowers = 2

claferIG>
```

Figure 4: Instance of Property Loan 1

```
ClaferIDE> Running the chosen instance generator...
Loan_Type
  Properties_Loans
    Combined_Loan
      Variable_Rate_Bullet
        Annual_Variability_Bullet
          Interest_440
            Repayment_Period_in_Years = 1
          Proposal$1 = "The interest rate may be adjusted every year"
        fluctuation = "The fluctuation of the Bullet loan cannot
                       be more than 3% and there is no lower floor"
      Proposal$2 = "The Bullet Loan covers up to 65% of the value
                    of the asset you want to purchase"
        Bullet_Loan_Persentage = 64
        Traditional_Loan_Persentage = 36
      Loan_Borrowers
        number_of_borrowers = 2
      Amount_to_borrow_in_hundreds = 252

claferIG>
```

Figure 5: Instance of Property Loan 2

At next, two more loan instances are presented. The Figure 6 demonstrates an instance of a loan that belongs to the category Other Loans. As we can see the purpose of the loan is "house holding spending" the amount to be borrowed is 4.000 and there are no arrangement fees for this type of loan. Similarly Figure 7 demonstrates a scenario of a Vehicle Loan. More specifically is a loan for a second-hand car less than two years old, the repayment period of the loan is 84 months while the amount to be borrowed is 9.000. Moreover we can see that there are no management fees or service fees for these type of loan and that the chosen method of repayment is the Semester repayment. Both instances are valid and acceptable regarding to the current rules of the bank.

```
ClaferIDE> Running the chosen instance generator...
Loan_Type
    Other_Loans
      Household_spending
        Proposal = "Wedding? Communion? Holidays? Give
        yourself unforgettable moments without having
        to make sums all the time! You pay back at your
        own pace"
      Arrangement_fees = "no arrangement fees"
      Borrowed_Amount_in_thousands = 4

claferIG> claferIG>
```

Figure 6: Instance of Other Loans

```
ClaferIDE> Running the chosen instance generator...
Loan_Type
  Vehicle_Loans
    Car
      Interest_275
      Second_hand_less_than_2years
      Repayment_Period_in_months = 84
    Amount_to_borow_in_thousands = 9
    Description = "The ING Car Loan is an instalment loan
        for buying a new or second-hand vehicle. This could be
        a car, an Eco car, a motorcycle or a mobile home"
    Semester_Repayment
    Management_fees = "no management fees"
    Service_fees = "no service fees"

claferIG> claferIG>
```

Figure 7: Instance of Vehicle Loan

Finally, by using the ClaferIDE tool we can translate the Clafer language model to HTML code, XML code, javascript code, Alloy code and produce the corresponding graph of the model.

Instance verification

The ClaferIDE tools gives the opportunity to check the consistency of the model instances and supports their verification. In this way, is possible to check if an instance of a model is valid. This procedure initially can be done by providing the text editor with the instance to be checked. The next step is to compile the model in order to verify that is a syntactically approved model. If the compilation if successful, the instance generator will be able to produce the first instance of the model by clicking on "Next". In the case that the instance of the model is acceptable, we can see the generated instance in the "Output" interface in the right-hand side of the ClaferIDE (like in figures 4, 5, 6 and 7). In the case that the instance of the model is not acceptable, the instance generator provides information related to the invalidity of the model and the violation of the constraints. The following figure (Figure 8) presents one case where the instance of the model is invalid. For this example an instance of Vehicle Loan is used which is also presented in the Appendix Invalid Instance.

```
Vehicle_Loans : Amount_Vehicles

    [Description = "The ING Car Loan is an instalment loan
    for buying a new or second-hand vehicle. This could be
    a car, an Eco car, a motorcycle or a mobile home"]
    Instance_Car_Loan : Interest_Car
    [Amount_to_borow_in_thousands=5]
    [Repayment_Period_in_months = 10]
    [Chronology => Second_hand_more_than_2years]
```

Figure 8: Invalid instance of the model

As we can see, the above instance describes a vehicle loan and more specifically a car loan. By applying some constraints, the validity of the model can be checked. This instance represents a Car loan where the amount of money to be borrowed is 5.000, the loan is for a second-hand car more than two years old and the repayment period is ten months. According to the Clafer model (Appendix Clafer Loans Model) the repayment period cannot be less than 12 months and more than 180 months. The repayment period attribute of this instance violates the rule about the repayment period that has been declared in the Clafer model. This fact implies that this instance is an invalid instance of a loan although the two other constraints do not violate the model rules. The instance generator produces the following output (Figure 9) for the above instance:

```
The following set of constraints cannot be satisfied in the current scope.
(Hint: use the setUnsatCoreMinimization command to minimize the set of constraints below)
  1) Repayment_Period_in_months = 10 (line 96, column 6)
Altering the following constraints produced the following near-miss example:
  1) removed Repayment_Period_in_months = 10
Vehicle_Loans
  Instance_Car_Loan
    Interest_750
    Second_hand_more_than_2years
    Repayment_Period_in_months = 80
  Amount_to_borow_in_thousands = 5
  Description = "The ING Car Loan is an instalment loan
    for buying a new or second-hand vehicle. This could be
    a car, an Eco car, a motorcycle or a mobile home"
  Yearly_Repayment
  Management_fees = "no management fees"
  Service_fees = "no service fees"
```

Figure 9: Instance Generator output

As we can see, the constraint of the Repayment_Period_in_months can not be satisfied and its value is removed and replaced by an acceptable value.

Future Work and Proposals

The current version of the on-line ClaferIDE tool contains an editor, a compiler, and an instance generator. It would be useful and efficient if the ClaferIDE tool could provide to users a graphical modeling environment. A graphical environment could improve the understanding of Clafer models, it would make their construction a more simple and direct procedure and it would make concepts like inheritance and cardinality declaration more clear to the users since it would provide some visual aids for these features. Moreover another future work could be

the development of a compiler capable of generating abstract syntax diagrams out of the corresponding Clafer language models.

Evaluation and Conclusions

The Clafer language is a lightweight modeling language that offer the opportunity of modeling complex concepts like e.g. the modeling of bank loans. Clafer is a simple textual modeling language that someone can be familiar with easily and fast. Its syntax is simple and its basic characteristic is the integration of feature and class modeling. The language can be used for making a concept more clear and improving the understanding of the problem domain. Clafer is undoubtedly a simple, flexible and powerful enough language for concept modeling. Its flexibility and the fact that composes a powerful modeling language is an outcome of its features. Clafer language supports features like hierarchy and inheritance. This fact helps in the reduction of the size of the model by grouping the nationalities and at the same time it makes it more direct and flexible to changes. Clafer language also supports cardinality and group cardinality declaration. In this way the relations between the different objects of a Clafer model can be can specified and the number of instances of each Clafer object can be declared. Furthermore the language supports the performance of complex constraints in order to apply the desired restrictions and rules to Clafer models. Clafer provides a simple and easy syntax for applying constraints. Finally it provides reference support and this fact make the language more flexible. The online ClaferIDE tool which was used for this project, provides features like the translation of the Clafer language to Alloy language in order to generate model instances. In this way is possible to check the validity and consistency of models and if given samples are correct instances of Clafer models. Moreover the ClaferIDE tool can support error detection and it provides some simple analysis of Clafer models. Finally it can translate the Clafer language to HTML code, XML code, javascript code, Alloy model and produce the corresponding graph of the model.

References and Guides

1. Clafer homepage: http://www.clafer.org

2. Attributed Feature Models in Clafer, Kacper Bak, Generative Software Development Lab, University of Waterloo, Canada.

3. Clafer: a Unified Language for Class and Feature Modeling, Kacper Bak Generative Software Development Lab ,University of Waterloo, Canada

4. Domain Concept Modeling Using Clafer, A Tutorial By Michal Antkiewicz Version 9.2, Mar 20, 2012

5. Scotiabank Mortgages in Clafer, Draft v. 3 April 24, 2011 By Michal Antkiewicz

6. Example-Driven Modeling Using Clafer, Michal Antkiewicz, Kacper Bak, Krzysztof Czarnecki, Zinovy Diskin, Dina Zayan, and Andrzej Wasowski.

Acquired Information URLs:

1. ING Bank lending page: https://www.ing.be/en/retail/lending/Pages/index.aspx

2. ING Bank electronic brochure: https://www.ing.be/SiteCollectionDocuments/Online_credit_Brochure_HYPO_en.pdf

3. ING Bank Interest Rates: https://www.ing.be/private/mainframe2.jsp?op=ratesLoans&lang=en&WT.ac=floatingpage_charges-regulations_mortgagesrates_body_txt

4. Current charges: https://www.ing.be/SiteCollectionDocuments/Tarievenblad_EN.pdf

5. On-line mortgage loans simulator: https://promo.ing.be/loansimulators/aspx?id=QePPS6maXBJZPeWuL6Yq0UlfDmVPYRUs3iYOY1

6. On-line Bridging loans simulator: https://promo.ing.be/loansimulators/index.aspx?id=hPeegOPz4cb_dHizixF9zdMOWG2z6wrpOGlBxt

7. On-line Combined loans simulator: https://promo.ing.be/loansimulators/index.aspx?id=%2Br886zoxJs7yXzAHWVNfH7EqiyBVxLV8yc_sxy

8. On-line Renovation/Eco loan simulator: https://secure.ing.be/ebpubsec/eb/Request?dse_sessionId=FMJQFNEHAWFUEPERBJAJJOGNGCHREABXBBCVGHBP&dse_applicationId=-1&dse_operationName=cloPubSecImmoSimulationFlow&dse_pageId=1&directUC=IMMO&productId=2&refund=false&immoPromo=&appCode=10&referrer=ing.be&userLanguageCode=EN&WT.popupbtn=ecoloan_web&productDetail=ecoImmo&dse_nextEventName=start&dse_processorState=initial&browserAppName=Mozilla%2F5.0+%28Windows+NT+6.1%29+AppleWebKit%2F537.36+%28KHTML%2C+like+Gecko%29+Chrome%2F32.0.1700.76+Safari%2F537.36&browserAppVersion=&sessionType=eBankingAuthent

9. On-line Vehicle loan simulator: https://www.ing.be/en/retail/Pages/carloan-salesflow.aspx

Appendix Clafer Loans Model

```
//——— PROPERTY LOANS ———//
//——— MORTGAGE LOANS ———//

abstract ValueProposal
    Proposal : string

abstract xor Term
    Long_Term
    Short_Term

abstract Borrowers
    number_of_borrowers : integer
        [(number_of_borrowers = 1) || (number_of_borrowers = 2)]

abstract Amount
    Amount_to_borrow_in_hundreds : integer
        [Amount_to_borrow_in_hundreds >= 25]

abstract Repayment_Properties
    Repayment_Period_in_Years : integer

abstract fluctuationValue
    fluctuation : string

abstract xor Variable_Rate_Loan : fluctuationValue
    Annual_Variability : Interest_Annual_Variability
        [fluctuation = "The fluctuation cannot be more than 3 % and there is no lower
        floor"]
    Five_Year_Variability : Interest_Five_Year_Variability
        [fluctuation = "Both the upper and lower rate fluctuation thresholds are set at 5%"]
    xor Initial_Ten_years_and_Five_Years_thereafter
        Fluctuation_plus_5_minus_5 : Interest_Ten_Years_Initial_5
            [fluctuation = "Both the upper and lower rate fluctuation
            thresholds are set at 5%$"]
        Fluctuation_plus_2 : Interest_Ten_Years_Initial_2
            [fluctuation = "The fluctuation cannot be more than 2%
            and there is no lower floor"]

abstract or Guarantees : Borrowers
    Mortgage_Guarantee
    Notarial_mandate_Guarantee
    Grant_a_mortgage_Guarantee

abstract xor Repayment_types : Guarantees
    Fixed_monthly_instalments
    Periodic_Capital_Amortization
    Full_Repayment_of_the_capital_upon_maturity
```

```
abstract xor Loan_Formula : Repayment_types
        Fixed_Rate : Interest_Fixed_Rate
        Variable_Rate : Variable_Rate_Loan

abstract xor Interest_Fixed_Rate : ValueProposal
                [Proposal="The interest rate remains the
                same for the duration of your loan"]
        Interest_370 : Repayment_Properties
                [(1 <= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=5)]
        Interest_410 : Repayment_Properties
                [(6 <= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=10)]
        Interest_445 : Repayment_Properties
                [(11 <= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
        Interest_470 : Repayment_Properties
                [(16 <= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]
        Interest_530 : Repayment_Properties
                [(21 <= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=25)]
        Interest_565 : Repayment_Properties
                [(26 <= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=30)]

abstract xor Interest_Annual_Variability : ValueProposal
                [Proposal="The interest rate may be adjusted every year"]
        Interest_360 : Repayment_Properties
                [(1<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=5)]
        Interest_370 : Repayment_Properties
                [(6<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=10)]
        Interest_375 : Repayment_Properties
                [(11<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
        Interest_380 : Repayment_Properties
                [(16<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]
        Interest_410 : Repayment_Properties
                [(21<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=25)]
        Interest_450 : Repayment_Properties
                [(26<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <= 30)]

abstract xor Interest_Five_Year_Variability : ValueProposal
                [Proposal="The interest rate may be adjusted every five years"]
        Interest_395 : Repayment_Properties
                [(6<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=10)]
        Interest_400 : Repayment_Properties
                [(11<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
        Interest_425 : Repayment_Properties
                [(16<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]
        Interest_440 : Repayment_Properties
                [(21<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=25)]
        Interest_475 : Repayment_Properties
                [(26<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=30)]

abstract xor Interest_Ten_Years_Initial_5 : ValueProposal
                [Proposal="The interest rate is reviewed for the first
                time after 10 years and thereafter every 5 years"]
        Interest_430 : Repayment_Properties
```

```
            [(11<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
        Interest_475 : Repayment_Properties
            [(16<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]
        Interest_505 : Repayment_Properties
            [(21<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=25)]
        Interest_535 : Repayment_Properties
            [(26<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=30)]

abstract xor Interest_Ten_Years_Initial_2 : ValueProposal
        [Proposal="The interest rate is reviewed for the first
        time after 10 years and thereafter every 5 years"]
        Interest_455 : Repayment_Properties
            [(11<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
        Interest_490 : Repayment_Properties
            [(16<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]
        Interest_535 : Repayment_Properties
            [(21<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=25)]
        Interest_565 : Repayment_Properties
            [(26<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=30)]

//————————— COMBINED LOANS ————————————//

abstract xor Variable_Rate_Loan_Bullet : fluctuationValue
        Annual_Variability_Bullet : Interest_Annual_Variability_Bullet
            [fluctuation = "The fluctuation of the Bullet loan cannot be
             more than 3% and there is no lower floor"]
        Five_Year_Variability_Bullet : Interest_Five_Year_Variability_Bullet
            [fluctuation = "Both the upper and lower rate fluctuation
            thresholds of the Bullet loan are set at 5%"]
abstract Bullet_Loan : Amount
        Proposal : string
            [Proposal="The Bullet Loan covers up to 65% of
            the value of the asset you want to purchase"]
        Bullet_Loan_Persentage : integer
            [(5<= Bullet_Loan_Persentage) && (Bullet_Loan_Persentage <= 65)]
            Traditional_Loan_Persentage : integer
                [Traditional_Loan_Persentage = 100 + (-Bullet_Loan_Persentage)]
        Loan_Borrowers : Borrowers

abstract xor Loan_Formula_Combined : Bullet_Loan
        Fixed_Rate_Bullet : Interest_Fixed_Rate_Bullet
        Variable_Rate_Bullet : Variable_Rate_Loan_Bullet

abstract xor Interest_Fixed_Rate_Bullet : ValueProposal
            [Proposal="The interest rate remains the same
            or the duration of the loan"]
        Interest_480 : Repayment_Properties
            [(1<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=5)]
        Interest_515 : Repayment_Properties
            [(6<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=10)]
        Interest_575 : Repayment_Properties
            [(11<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
```

```
        Interest_580 : Repayment_Properties
                [(16<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]

abstract xor Interest_Annual_Variability_Bullet : ValueProposal
                [Proposal="The interest rate may be adjusted every year"]
        Interest_440 : Repayment_Properties
                [(1<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=5)]
        Interest_470 : Repayment_Properties
                [(6<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=10)]
        Interest_480 : Repayment_Properties
                [(11<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
        Interest_485 : Repayment_Properties
                [(16<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]

abstract xor Interest_Five_Year_Variability_Bullet : ValueProposal
                [Proposal="The interest rate may be adjusted every five years"]
        Interest_490 : Repayment_Properties
                [(6<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=10)]
        Interest_495 : Repayment_Properties
                [(11<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=15)]
        Interest_500 : Repayment_Properties
                [(16<= Repayment_Period_in_Years) && (Repayment_Period_in_Years <=20)]


//——————————BRIDGING LOAN——————————//

abstract Loan_Formula_Bridging : ValueProposal
        [Proposal="The ING Bridging Loan allows you to
        finance the purchase or building of your home with
        the proceeds from the sale of your previous property"]
        Fixed_rate
                Interest_rate_580
        xor Repayment_Period_in_months
                Six_months
                Twelve_months
        Amount_Bridging
                Amount_to_borrow_in_hundreds : integer
                        [Amount_to_borrow_in_hundreds >= 250]


//——————————ECO LOAN——————————//

abstract Amount_in_thousands
        Amount_to_borrow_in_thousands : integer
                [(2<= Amount_to_borrow_in_thousands) && (Amount_to_borrow_in_thousands <=50)]

abstract or Loan_Purpose : ValueProposal
                [Proposal="An ING Real Estate Eco Loan is a personal
                loan with which you can borrow between 2,000 and 50,000
                euros to finance your green improvements"]
        Renewal_and_maintenance_of_old_heaters
        Installation_of_a_solar_powered_water_heating_system
```

```
        installation_of_photovoltaic_panels
        Installation_of_an_air_to_water_heat_pump
        Installation_of_any_system_designed_to_produce_geothermal_energy
        Fitting_double_glazing
        Roof_insulation
        Fitting_thermostatic_valves
        Energy_audit

abstract Repayment_Months : Loan_Purpose
        Repayment_Period_in_Months : integer

abstract xor Fixed_rate_Eco_Loan : Amount_in_thousands
        Interest_525 : Repayment_Months
                [(12<= Repayment_Period_in_Months) && (Repayment_Period_in_Months <=120)]
        Interest_650 : Repayment_Months
                [(121<= Repayment_Period_in_Months) && (Repayment_Period_in_Months <=180)]


//——————————RENOVATION LOAN——————————//

abstract Amount_to_borrow_Renovation
        Borrowed_Amount_in_thousands : integer

abstract Loan_Formula_Renovation : Fixed_Rate_Renovation
        Renovation_Repayment_Period_in_Months : integer
                [(6<= Renovation_Repayment_Period_in_Months) && (Renovation_Repayment_Period_in_Months
<=180)]
abstract xor Fixed_Rate_Renovation : ValueProposal
        [Proposal="The ING Renovation Loan is for all private
        individuals enabling you to borrow 2,000 euros or more
        to carry out your renovation work"]
        Interest_695 : Amount_to_borrow_Renovation
                [(2<= Borrowed_Amount_in_thousands) && (Borrowed_Amount_in_thousands
                < 15)]
        Interest_675 : Amount_to_borrow_Renovation
                [(15<= Borrowed_Amount_in_thousands) && (Borrowed_Amount_in_thousands
                <= 50)]


//——————————OTHER LOANS——————————//

abstract Repayment_Period_Other : Amount_to_borrow_Renovation
                [(2<= Borrowed_Amount_in_thousands) && (Borrowed_Amount_in_thousands
                 <=50 )]
        Repayment_Period_Months : integer
                [(6<= Repayment_Period_Months) && (Repayment_Period_Months <= 180)]

abstract Other_Loans_Fees : Repayment_Period_Other
        Arrangement_fees : string
                [Arrangement_fees = "no arrangement fees"]

abstract xor Others_Loan_Formula : Other_Loans_Fees
```

```
        Household_spending : ValueProposal
                [Proposal="Give yourself unforgettable moments
                without having to make sums all the time! You pay back at your own pace"]
        Electronics : ValueProposal
                [Proposal="Settle your payments in one go and then repay at your own pace"]
        Computer : ValueProposal
                [Proposal="Do you need a computer for your children's school work or just for
                fun? Buy the one you really want at a very competitive rate"]
        Design_and_Decoration : ValueProposal
                [Proposal="Is your television or washing machine broken? Replace them straight
                away without touching your savings"]


//————————————VEHICLE LOANS————————————//

abstract Fees
        Management_fees : string
                [Management_fees = "no management fees"]
        Service_fees : string
                [Service_fees = "no service fees"]

abstract xor Repayment_Method : Fees
        Monthly_Repayment
        Quartely_Repayment
        Semester_Repayment
        Yearly_Repayment

abstract Proposal : Repayment_Method
        Description : string

abstract Amount_Vehicles : Proposal
        Amount_to_borow_in_thousands : integer
                [(2 <= Amount_to_borow_in_thousands) && (Amount_to_borow_in_thousands
                <= 125)]

abstract Repayment
        Repayment_Period_in_months: integer

abstract xor Chronology : Repayment
        New_vehicle
        Second_hand_less_than_2years
        Second_hand_more_than_2years

abstract xor Interest_Car : Chronology
        Interest_225
                [((12 <= Repayment_Period_in_Months) && (Repayment_Period_in_Months
                <= 60)) && ((Chronology => New_vehicle) || (Chronology =>
                Second_hand_less_than_2years))]
        Interest_275
                [((61 <= Repayment_Period_in_Months) && (Repayment_Period_in_Months
                <= 84)) && ((Chronology => New_vehicle) || (Chronology =>
                                Second_hand_less_than_2years))]
```

```
        Interest_750
                [((12 <= Repayment_Period_in_Months) && (Repayment_Period_in_Months
                <= 84)) && (Chronology => Second_hand_more_than_2years)]

abstract xor Interest_Motorbike : Chronology
        Interest_225
                [((12 <= Repayment_Period_in_Months) && (Repayment_Period_in_Months
                <= 60)) && ((Chronology => New_vehicle) || (Chronology =>
                Second_hand_less_than_2years))]
        Interest_750
                [((12 <= Repayment_Period_in_Months) && (Repayment_Period_in_Months
                <= 60)) && (Chronology => Second_hand_more_than_2years)]

abstract xor Interest_Eco_Car : Chronology
        Interest_205
                [((12 <= Repayment_Period_in_Months) && (Repayment_Period_in_Months
                <= 60)) && ((Chronology => New_vehicle) || (Chronology =>
                Second_hand_less_than_2years) || (Chronology =>
                Second_hand_more_than_2years))]
        Interest_255
                [((61 <= Repayment_Period_in_Months) && (Repayment_Period_in_Months
                 <= 84)) && ((Chronology => New_vehicle) || (Chronology =>
                 Second_hand_less_than_2years) || (Chronology => Second_hand_more_than_2years))]

abstract xor Interest_Mobile_Home : Chronology
        Interest_225
                [((12 <= Repayment_Period_in_months) && ( Repayment_Period_in_months
                <= 60)) && ((Chronology => New_vehicle) || (Chronology =>
                Second_hand_less_than_2years))]
        Interest_270
                [((61 <= Repayment_Period_in_months) && ( Repayment_Period_in_months
                <= 120)) && ((Chronology => New_vehicle) || (Chronology =>
                Second_hand_less_than_2years))]
        Interest_750
                [Chronology => Second_hand_more_than_2years]


//——————————CASH RESERVES——————————//

abstract Amount_to_borrow_Cash : ValueProposal
                [Proposal=" The ING Cash Facility, offers you a cash reserve on your
                current account for 1,250 euros or more. It's just the ticket when you
                need money temporarily. You only pay interest on any negative balance"]
        Amount_to_borrow_in_tens : integer
                [125 <= Amount_to_borrow_in_tens]

abstract Loan_Formula_Cash : Amount_to_borrow_Cash
        Repayment_method : Fees
                Once_per_year : Amount_to_borrow_Cash
                        [Amount_to_borrow_in_tens < 30]
                Once_per_5_years : Amount_to_borrow_Cash
                        [Amount_to_borrow_in_tens >= 30]
```

```
//————————-CONCRETE CLAFERS FOR INSTANCE GENERATION————————//

xor Loan_Type
        xor Properties_Loans
                mortgage_Loan : Loan_Formula
                Combined_Loan : Loan_Formula_Combined
                Bridging_Loan : Loan_Formula_Bridging
                Eco_Loan : Fixed_rate_Eco_Loan
                Renovation_Loan : Loan_Formula_Renovation
                Other_Loans : Others_Loan_Formula
        xor Vehicle_Loans : Amount_Vehicles
                        [Description = "The ING Car Loan is an instalment loan
                        for buying a new or second-hand vehicle. This could be
                        a car, an Eco car, a motorcycle or a mobile home"]
                Car : Interest_Car
                Motorbike : Interest_Motorbike
                Eco_Car : Interest_Eco_Car
                Mobile_Home : Interest_Mobile_Home
        Cash_Facility : Loan_Formula_Cash
```

Appendix Invalid Instance

The last part of the Clafer model has to be replaced with the following part:

```
//————————-CONCRETE CLAFERS FOR INSTANCE GENERATION————————//


        Vehicle_Loans : Amount_Vehicles

                [Description = "The ING Car Loan is an instalment loan
                for buying a new or second-hand vehicle. This could be
                a car, an Eco car, a motorcycle or a mobile home"]

                Instance_Car_Loan : Interest_Car
                [Amount_to_borow_in_thousands = 5]
                [Repayment_Period_in_months = 10]
                [Chronology => Second_hand_more_than_2years]
```