2. Conceptual Modeling in UML

Consider the following description of a **Real Estate** domain.

- Clients buy, sell, let to rent, or rent properties. The following information is of interest for each client: tax code, address, city of residence, and region of residence. Clients can be individual persons (with name, surname, profession, and city of birth), or companies (with budget and number of employees).
- Agents handle transactions, and for each of them the identification number and the city where they are located are of interest.
- Each transaction (with code, date, and value) is handled by exactly one agent and involves exactly one property. It can be either for sale or rent of the property.
    - A rent transaction involves exactly two clients (one who lets to rent, and one who rents the property). The start and end date of rent are of interest.
    - A sale transaction involves exactly one seller and one or more buyers, and for each of the buyers the percentage of the bought value is of interest.
- For each property, the code, address, city of location, square meters, and number of rooms are of interest. Some properties have historical value, and for these also the year of construction is of interest. Other properties are renovated, and for them the year of the last renovation is of interest.
- For a city, the region might be of interest.

Given the above description, do the following:

Exercise 2.1 [5 points] Model the real estate domain in terms of a UML Class Diagram.

Exercise 2.2 [5 points] Formalize the UML Class Diagram in first-order logic.

Exercise 2.3 [5 points] If possible, formalize in first-order logic the following additional constraints (which are not directly expressible in UML):

1. A client cannot be involved in a sell transaction both as seller and as buyer of the same property.
2. A client cannot rent and let to rent the same property (in different transactions).
3. For each city in which a property is located, the region must be specified.
4. The identification number of an agent is unique within the city in which he is located.
5. The code of a property is unique within the region in which it is located.
6. The code of a transaction is unique within the region in which the corresponding property is located.
7. Each city should be of some interest, i.e., it should be the residence or birth city of some client, or the location of an agent or of a property.
8. An agent can handle a rental transaction only if the city of the agent coincides either with the city of the involved property, or with the city of residence of one of the clients involved in the transaction.
9. For a property, there cannot be two overlapping rental periods.
10. For every rented property, there is continuity in the rental periods, i.e., from the start date of its first rental to the end date of its last rental, the property is rented every day.

Exercise 2.4 [5 points] Formalize the UML Class Diagram in Description Logics, using reification where necessary. Choose a minimal set of constructors for the DL so as to make the formalization possible.

Exercise 2.5 [5 points] If possible, formalize the constraints specified in Exercise 2.3 using DLs. (possibly with identification constraints).

Exercise 2.6 [5 points] How can the notion of identification constraint be extended so as to make it possible to formalize constraints 5 and 6 of Exercise 2.3. Provide a possible syntax of such extended identification constraints, and define their formal semantics.

Submission deadline: April 1, 2015, 20:30 by email to Guohui Xiao.