

The seminar 07: Modelling architecture of the multi-agent system

Objectives of the seminar: to introduce the StarUML tool, to learn to develop entity diagram and society diagram, i. e.:

- to set up the AML project and create the structure of the project,
- to develop entity types, i. e.:
 - agent types,
 - environment types,
 - resource types.
- to specify relations between entity types,
- to specify organisation unit types,
- to create entity role types,
- to create social associations and their types,
- to create social association “Play association”.

Update: 18. 9. 2018

Theoretical background for the AML and StarUML

AML (The Agent Modelling Language) is the conceptual language used for conceptual modelling of multi-agent systems (MAS). Traditional conceptual languages used in software engineering are not well suited for representation of the MAS, because they do not use the concept of an intelligent agent. The main aim of the AML is the following according to the [1]: *“To design and specify a semi-formal³ visual modelling language, called Agent Modelling Language (AML), for specifying, modelling and documenting systems in terms of concepts drawn from MAS theory.”* The AML is based on the UML 2.0 and extends this language with the new 11 diagrams. These diagrams are categorized according to the specification of the metamodel of the AML. The AML offers the diagrams for modelling:

- architecture of the MAS,
- mental aspects of the MAS,
- behaviour of agents,
- ontologies,
- management of MAS-based models.

The StarUML 5.0 is the open-source CASE tool, that is primarily used in software engineering during a design and an analysis of a software with the UML 2.0. The plugin for the AML can be used as the extension for the StarUML 5.0. You can download the StarUML on the following web address: <http://sourceforge.net/projects/staruml/>. This software with the AML plugin is available in the Ukazky directory (Husakova.Martina).

Introduction into the application domain




Football is a very popular sport that is in the centre of the interest of researchers in the artificial or computational intelligence. Researchers investigate various algorithms that can be used for coordination and cooperation of robotic soccer players. The main aim of this seminar will not be to model completely the football, but to show how the AML can be used for modelling particular parts of the football.

Our MAS will use the environment – football pitch where the artificial intelligent soccer players will play the football. The amount of players is not specified. The MAS consists of two football teams. Soccer players of the same team cooperate with each other towards the fulfilment of the goal – to score. These soccer players use the soccer ball and a talent 😊.

Entity diagram

Entity diagram extends the UML Composite structure diagram. The main aim of the diagram is to model entity types and relations between them. This diagram offers the basic view on the structure of the MAS. Modelling of the internal structure of the autonomous and non-autonomous entity types is the second purpose of the entity diagram. Behaviour, social interactions, social roles and services are properties of intelligent agents that are closely related to the internal structure of agents. Building of this diagram is the first step in the investigation of the fundamental rules of the investigated system. The entity diagram is based on the usage of the following three entity types that are briefly described in the following table 1:

Table 1: Entity types

Name	Nature	StarUML toolbox	UML element	Visual representation	Example
Agent type	Autonomous	(AML) architecture	UML class		Person Animal Chemical substance
Resource type	Behaviour				Reservoir Ball
Environment type	Autonomous				School Firm Soccer pitch

Practical modelling: StarUML

1. Run the StarUML and build the new AML project.

Choose the Start/StarUML.exe in the START menu of the OS WIN. The new window (New Project By Approach) appears after that. Choose the modelling style (approach) in this screen. If the AML profile is available, AML profile is one of the option in the window, see fig. 1. Click on the AML Approach option and select OK. The new AML project is set up.

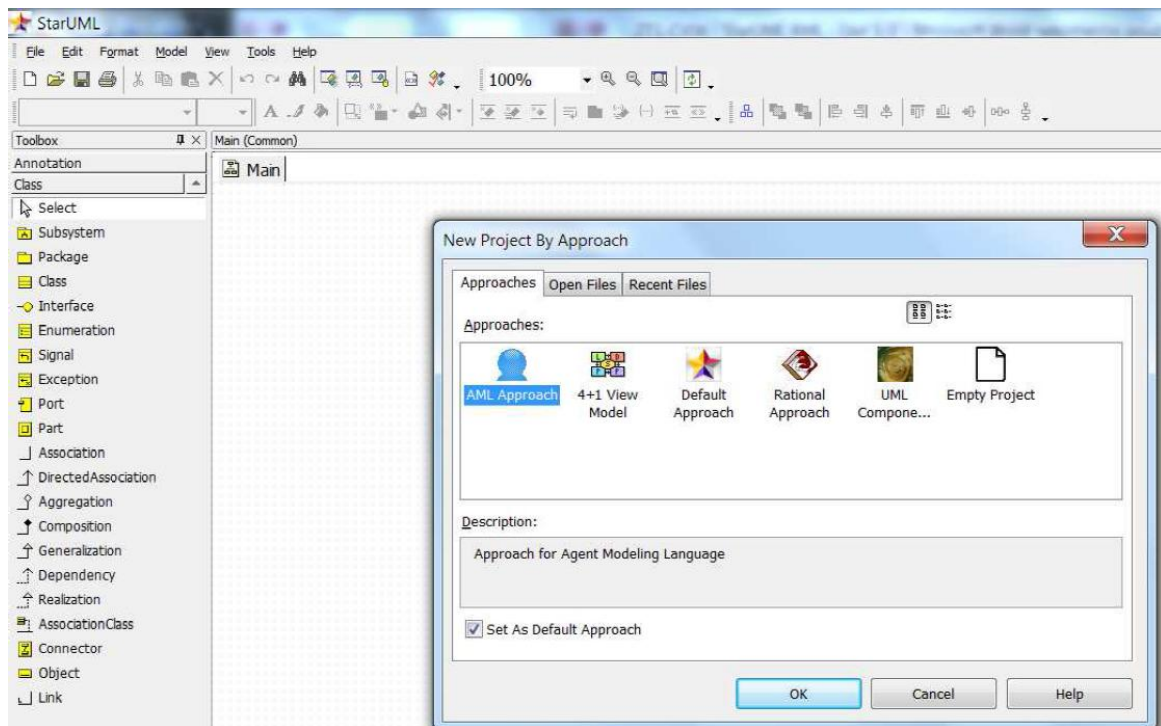


Figure 1: The new AML project

If the AML profile is not available in this screen, go to the main menu of the StarUML and select the item Model/Profiles, see fig. 2. The working space should appear after that. This working space consists of the main menu and a couple of various toolboxes. Toolboxes offer various elements for modelling particular aspects of the investigated system. Toolboxes are categorised according to the purpose. You can see only two toolboxes on the fig. 3: Annotation and Class. Try to find out for which purposes these two toolboxes exist. The Model Explorer is on the right side of the working space. The Model Explorer offers the views on your system. Diagram Explorer is the second tab offering the list of created diagrams. If you want to model in the AML language, you have to have toolboxes of the AML profile. You can expand one of the views in the Model Explorer, e. G. Logical View/Behaviour Decomposition Model and with double-clicking to choose the AML diagram Behaviour Decomposition Model, see fig. 3.

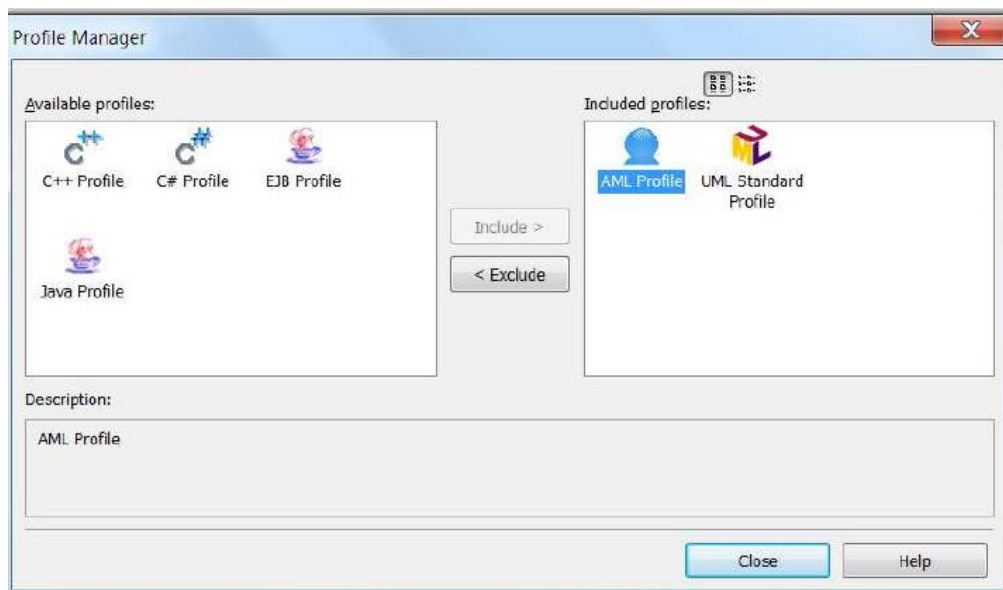


Figure 2: Selection of the AML profile in the Profile Manager

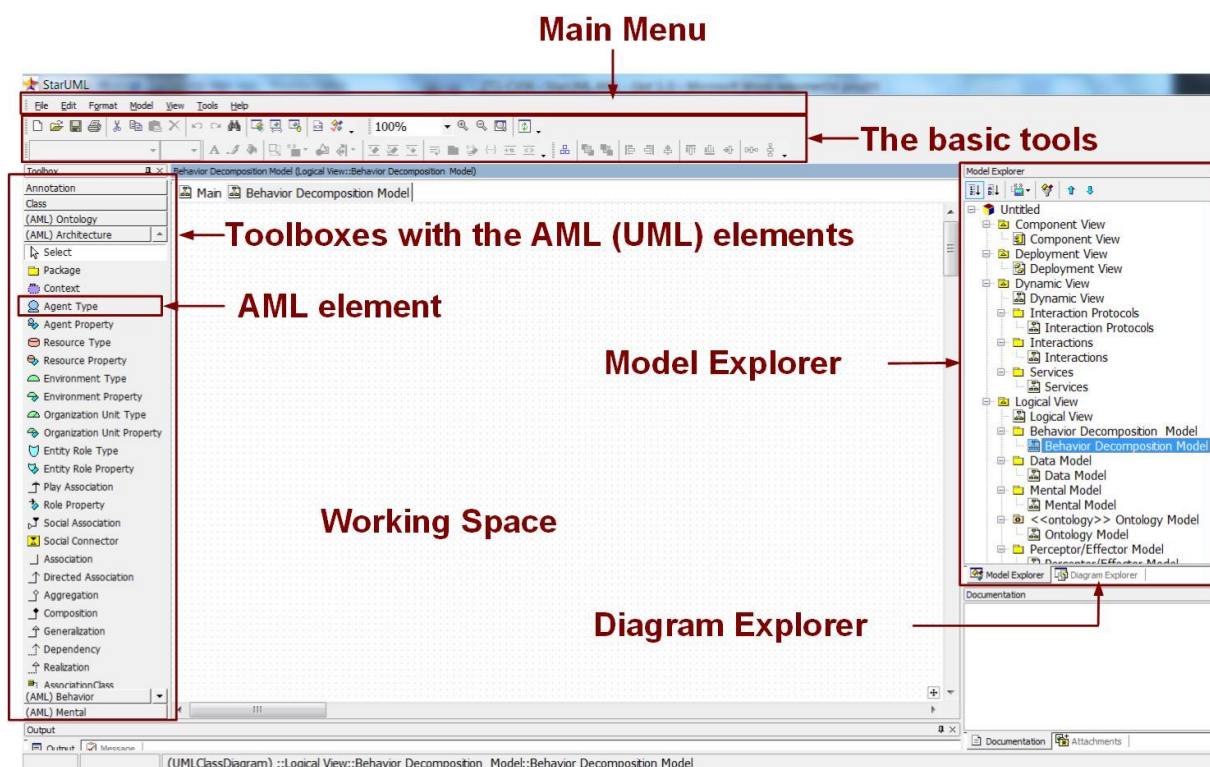


Figure 3: StarUML

2. Specify the suitable structure for our AML project.

StarUML offers predefined structure for our project. This structure is not completely suitable for our purposes, because all AML diagrams are not going to be created. We will mainly focus on the AML diagrams, not UML diagrams. We will customise the structure of the AML project with the assistance of the Model Explorer according to the fig. 4. Particular packages (Architecture, Behaviour, Mental aspects, Model management, Ontology) will correspond to the views on the investigated system. These views will contain models with AML diagrams and elements.

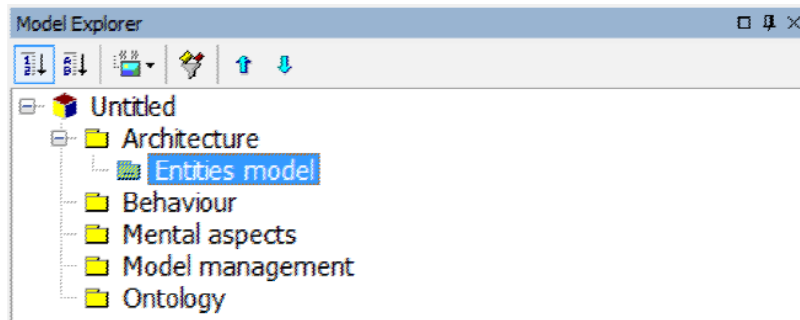


Figure 4: Customised structure of the AML project

How to customise the structure of the AML project? Select the root element (Untitled) with the right click of the mouse and invoke the context menu where you select the Add/Package. Select this new package and do the same step, but select the Add/Model instead the Add/Package. Entities model will be the new name for this package, see fig. 4.

Practical modelling: Entity diagram

We will demonstrate the usage of the entity diagram with the robotic soccer application domain, see the chapter *Introduction into the application domain* above.

3. Create the new entity diagram.

Select the Entities model in the Model Explorer. Invoke the context menu with the right click of the mouse. Select the Add diagram/Agent diagram. The new AML toolbox Architecture appears on the left side of the working space. Typical UML-based elements appear also in this toolbox. You can use them also in your AML projects.

Our entity diagram will contain the following entity types:

- Person (agent type),
- Ball (resource type),
- 3DSpace (environment type),
- Pitch (environment type).

4. Create the new entity type, i. e. agent type.

Ensure that the toolbox (AML) Architecture is visible on the left side of the StarUML. Select the Agent Type element and click into the working space of the StarUML. The new entity type will create, i. e. agent type that has default name. Give the name Person for this agent type, instead of the default name.

5. Change the visual style of the entity type, i. e. agent type.

Select the agent type Person. Choose the Stereotype display icon with the item Decoration in the “Basic tools” menu, see fig. 5. Select the style for the AML elements where the stereotype is visible each time. The stereotype obviously depicts which entity type is located on the work space. Properties of particular UML (AML) elements can be set up by the context menu that is visible after the right click of the mouse or on the right side of the working space - Properties section (under the Model Explorer). These properties can be changed only if the element is chosen.

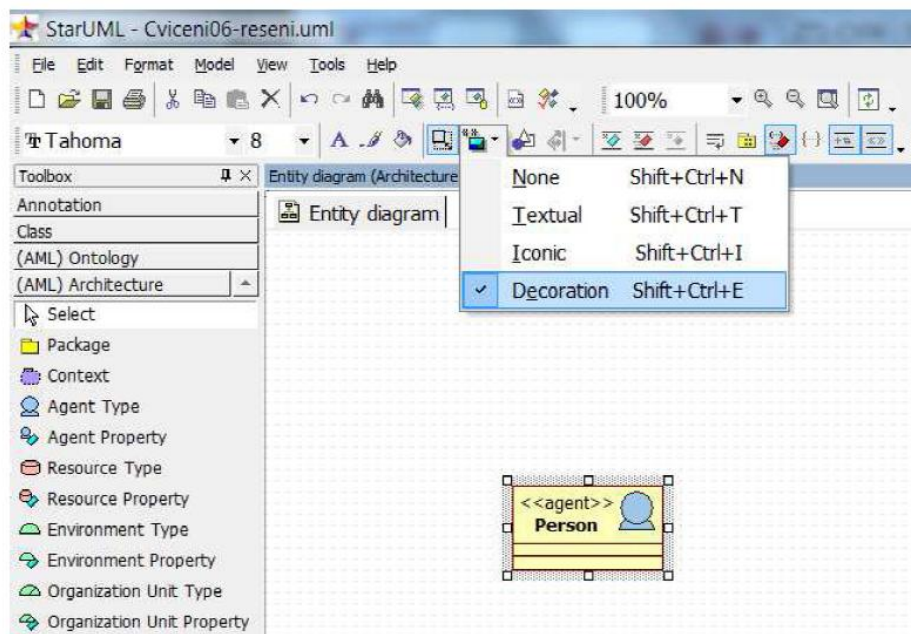


Figure. 5: Change of the appearance of the entity type

6. Create the other entity types: Ball, 3DSpace and Pitch, see the step 4.

7. Change the visual style of these new AML elements, see the step 5.

8. Add the new UML class 3DObject and Goal into the work space.

Choose the toolbox Class from the toolbox palette. Choose the element Class. Click into the work space and create the new UML element – the UML class – 3DObject. Create the UML class Goal in the same way.

9. Model the relations between created classes.

Specification of relations between classes is very simple. Choose the suitable relation from the toolbox Class or (AML) Architecture. Create the relation by drawing between classes in the working space. The fig. 6 depicts the inheritance relation and aggregation relation.

10. Set the cardinality and roles (the space and object) for the aggregation relation existing between the 3DObject class and 3DSpace class.

Choose the aggregation relation in the working space. Set the suitable cardinality in the panel Properties/Multiplicity (Model Explorer section) for the both sides of the aggregation relation. Set the roles for both sides of the aggregation relation in the same panel Properties – field Name.

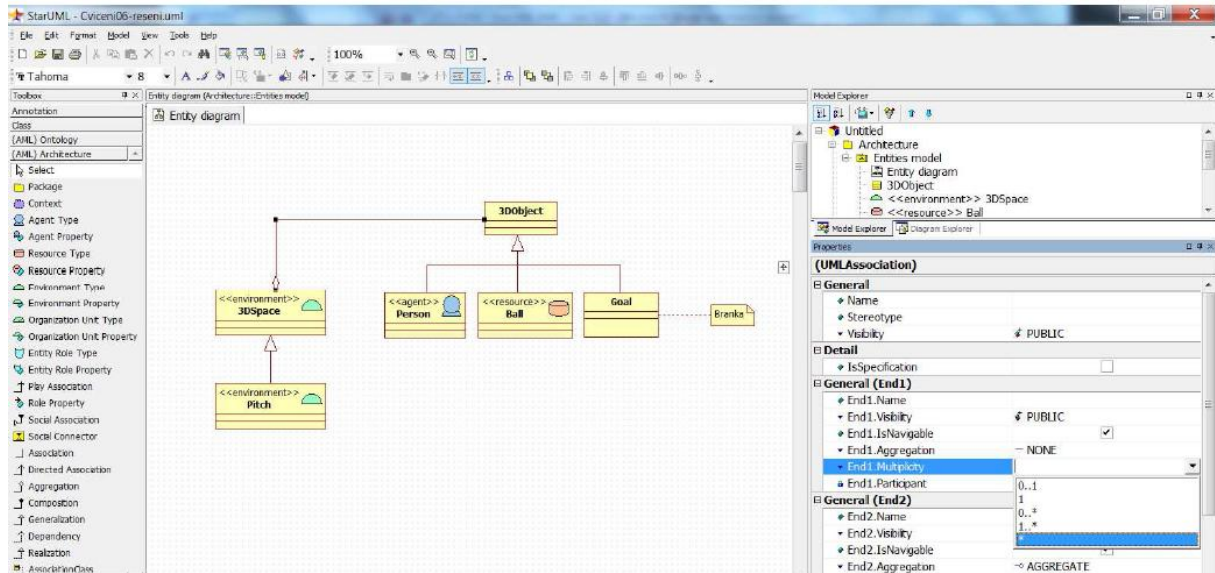


Figure 6: Properties of the aggregation relation (3DSpace and 3DObject)

11. Create the association class 3DPlacement for the aggregation relation (3DSpace and 3DObject).

Create the UML class, see the step 8, and give the name 3DPlacement. Choose the toolbox Class or (AML) Architecture and element Association Class. You will almost automatically create the relation between 3DPlacement and aggregation existing between 3DSpace and 3DObject, see fig. 7.

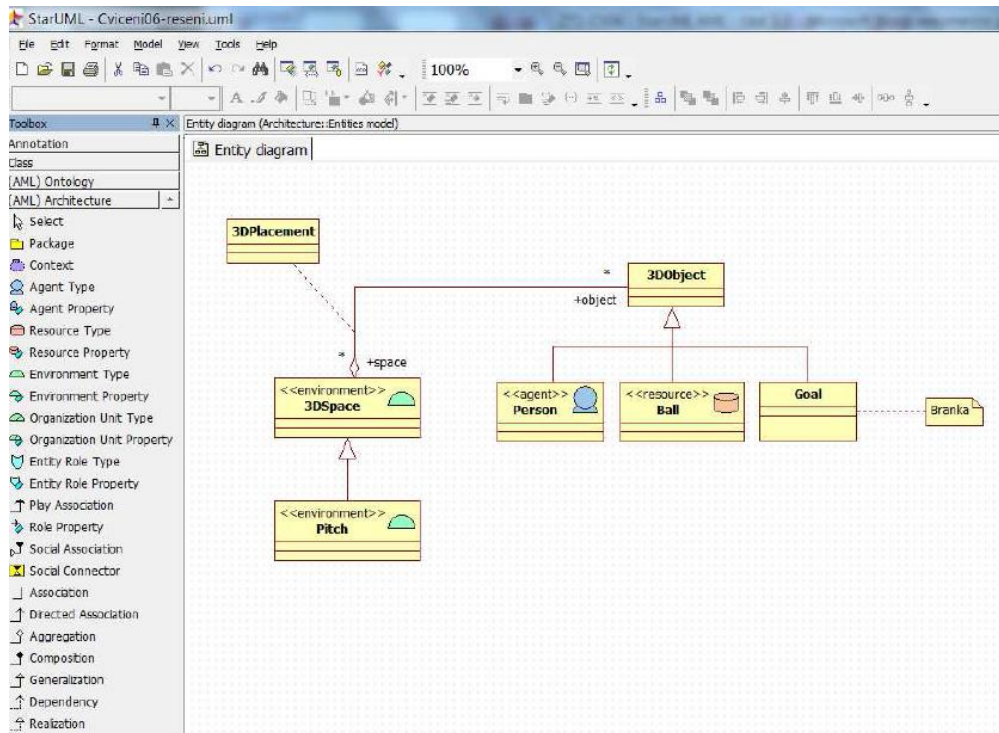


Figure 7: Association class 3DPlacement for the aggregation existing between 3DSpace and 3DObject

12. Define the attribute shape for the UML class 3DObject and the attribute position for the UML class 3DPlacement.

Double-click on the element 3DObject in the work space. The icons for adding attributes and methods (operations) appear on the right side of the selected class, see fig. 8. The icon for changing the visibility of the selected class appear on the left side of the class. Attributes and methods (operations) can be set up in the Properties panel (Model Explorer), see fig. 8.

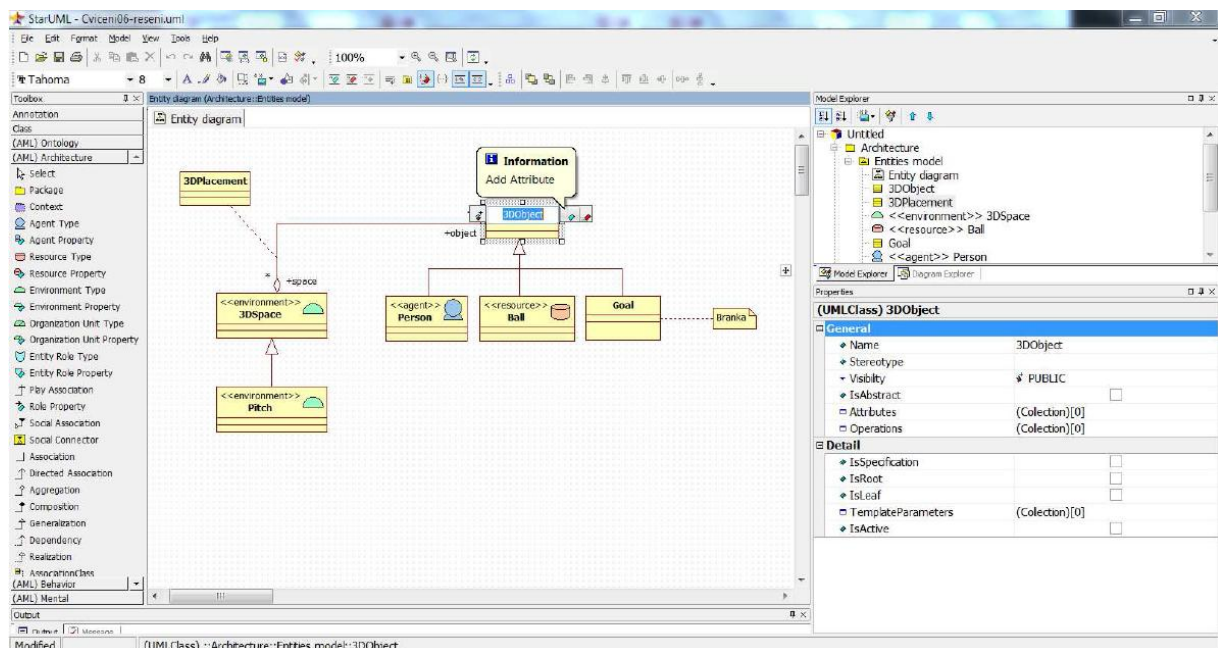


Figure 8: Definition of attributes for the UML (AML) class

13. Define the new attribute for the environment type Pitch. This attribute will define that the Pitch contains unlimited amount of players.

Select the element Environment Property from the toolbox (AML) Architecture. Click on the element that should have this attribute, i. e. Pitch. The new rectangle representing attribute for the Pitch appears inside the class Pitch. Set up the particular properties for this class in the Properties panel, e. g. Name – Person, Stereotype – ag (agent property), Visibility - Private, Type – Person and Multiplicity - *. Change the visual style of this attribute, see the step 5. It is not necessary, but you can hide attributes section or methods section in the class, see the fig. 9.

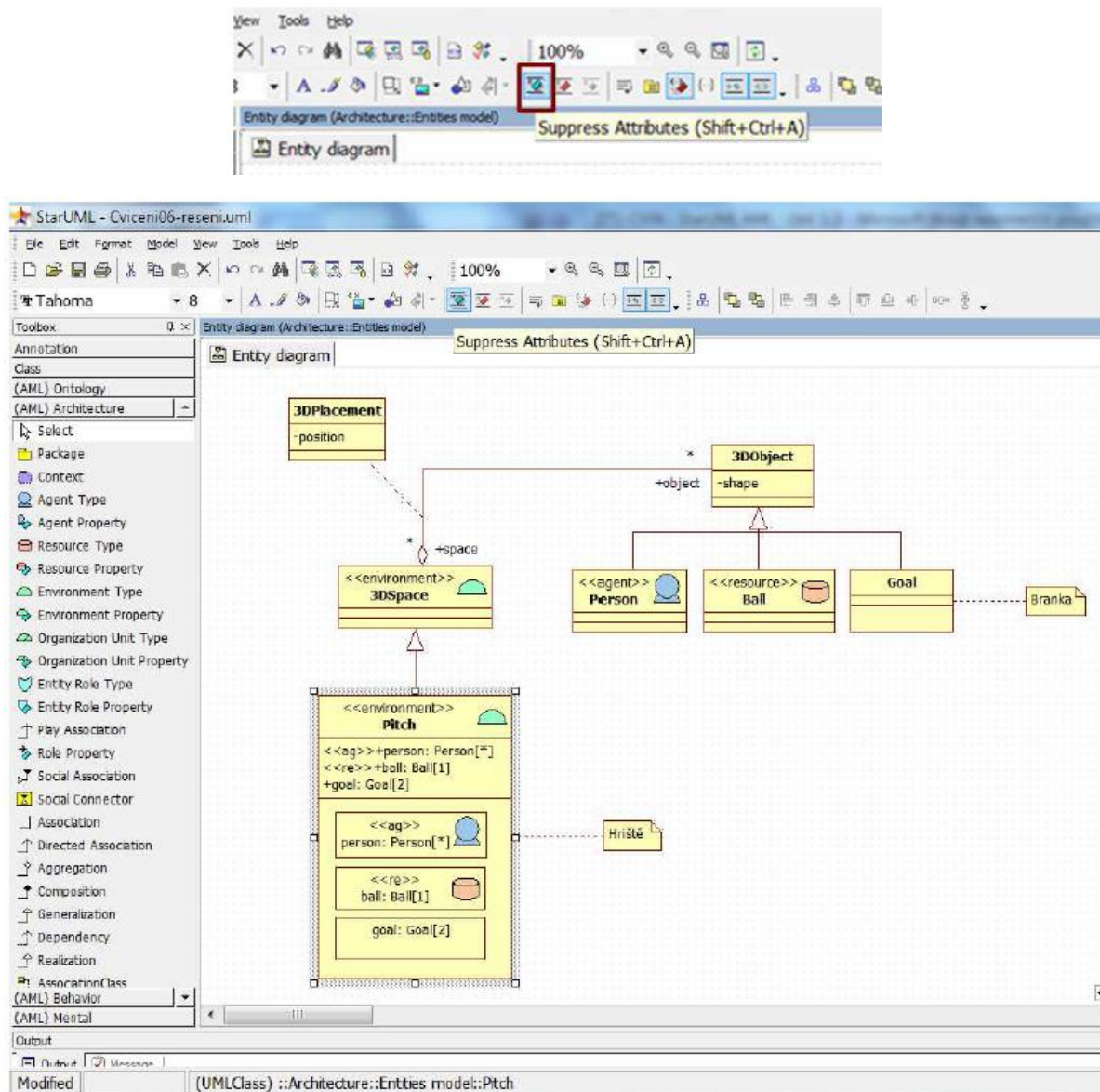


Figure 9: Suppressing attributes and methods (operations)

14. Create the two Goals and one Ball for the environment type Pitch.

See the step 13.

15. Save the AML project

Resulted entity diagram is depicted on the fig. 10.

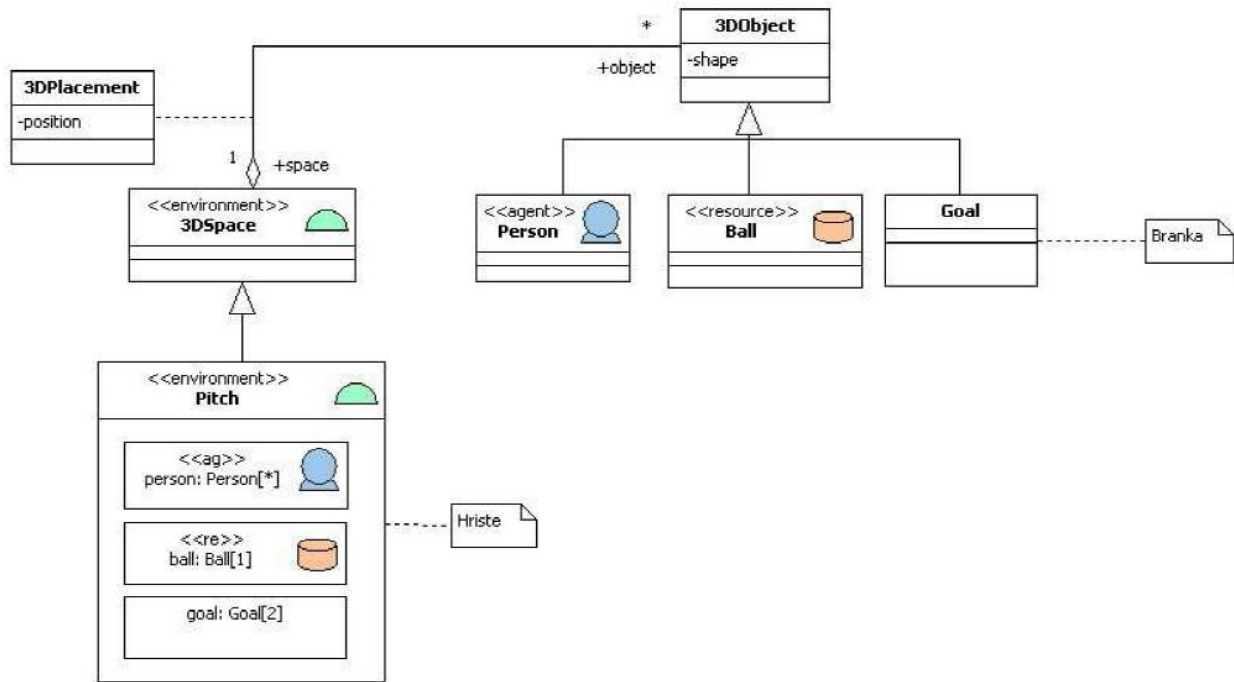


Figure 10: Entity diagram

Society diagram

The AML focuses (besides other things) on modelling social aspects of the MAS in comparison to the UML. These social aspects are modelled with the usage of the Society diagram. Society diagram emphasises representation of social roles, social relations between entity types, membership of social groups and social interactions. Society diagram introduces the following new elements, see overview in the Tab. 2:





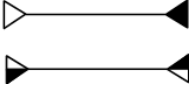
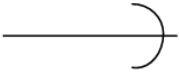
- **Organisation unit type:** It is a special case of the environment type that is used for modelling organisational units, i. e. social communities, organisations, institutions, etc. Visual appearance of the element is similar to the Environment type, see Tab. 2.
- **Entity role type:** It is a special case of the entity type that is used for modelling group of properties, behaviour, relations, interactions, services that are required or offered by these entity types.
- **Social association:** It is used for representation of bidirectional social relations in the form of the UML associations. This element is mainly used for modelling relations between entity role types. The AML distinguishes the following types of social associations:
 - **Peer-to-peer:** the entity types are equivalent

 - **Superordinate-subordinate:** One entity type is in superordinate relation with the the second entity type

- **Play association:** It is a special case of the UML associations that is used for modelling situations when the particular entity type play particular social role. It is used for connecting entity types and social roles of these entity types.

Table 2: Elements of the society diagram

Name	Nature	StarUML toolbox	UML element	Visual representation	Example
Organisation unit type	Type of the environment	(AML) architecture	UML class		Orchestra School Hobby group
Entity role type	Behaviour				Coach Teacher Expert
Social association	Relation		UML association		Teacher teaches student. Conductor conducts orchestra.
Play association	Relation				Student play role of cashier.

Practical modelling: Society diagram

We will create simplified society diagram that will depict the organisational structure of the soccer match. Soccer match ensures organisation of entity types in particular place, time and space. Soccer match is played on the pitch. Football teams are part of the soccer match together with the referee that judges particular soccer teams. Soccer team consists of the coach and team players which cooperate with each other for goal fulfilment. Main goal of the team player is to score. Soccer player can play various roles, e. g. keepers, defenders, midfielders or forwarders.

We use the toolbox (AML) Architecture for modelling society diagram where we select AML elements for modelling society, see tab. 2.

- 16. Add the new model - Society model into your AML project, see the step 2 in case of the Entities model.**
- 17. Add the new diagram – Society diagram into the Society model, see the step 3 in case of the Entities model.**
- 18. Create the organisational structure of the soccer match according to the description that i mentioned above.**

If you create the social association between social roles, it is inevitable to set up the type of this social association (peer-to-peer, superordinate-subordinate). Select the social association and right click. You will see the context menu where choose option Tagged Values. The new window appears where you choose the AML tab. Choose the item sub-super near the field Social Role Kind. This indicates that the Referee will be in the superordinate social role and soccer team will be in the subordinate social role, see fig. 11.

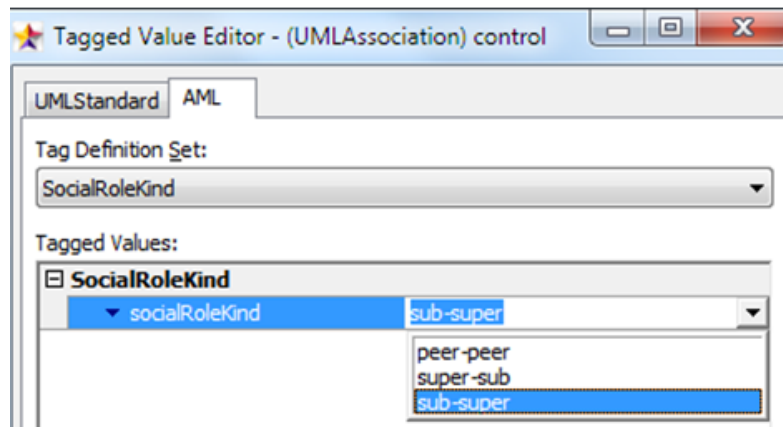


Fig. 11: Type of the social association

19. Compare the result with the diagram on the fig. 12.

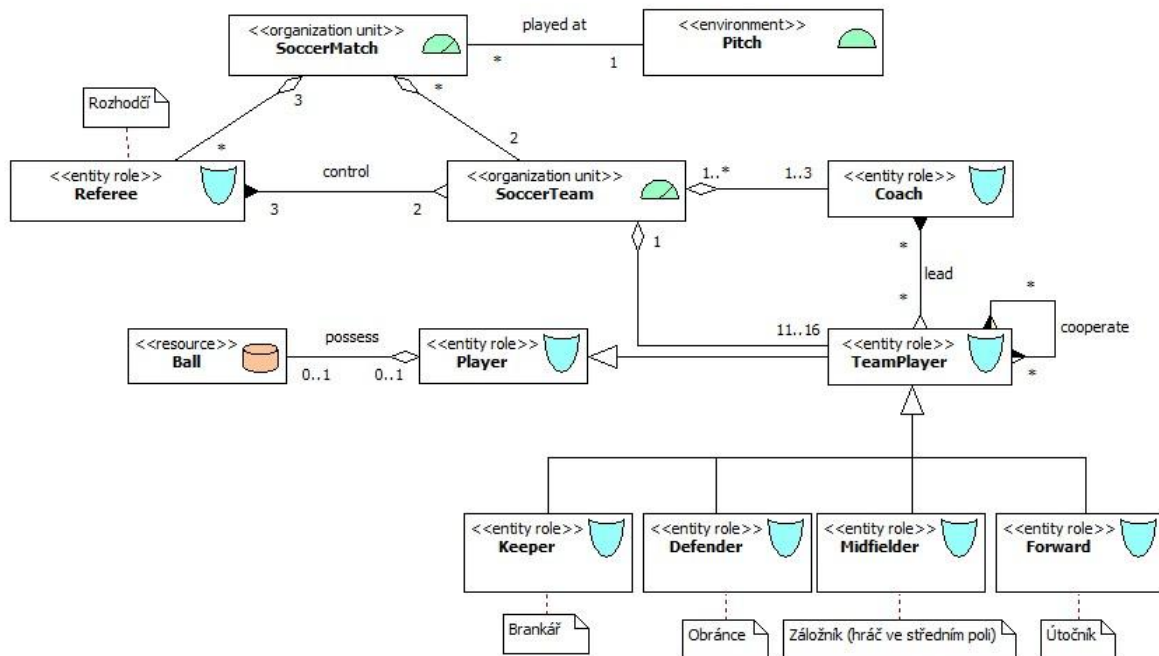


Figure 12: Society diagram – Organisation of the soccer match

20. Represent the following fact in your AML diagram: “Entity type Person play the social role of the Coach, Player or Referee.

Use the AML element Play Association from the toolbox (AML) Architecture for this purpose. Create the new society diagram because of the better readability. Name it as PlayingRoles diagram that add into the Society model “directory”.

Move the agent type Person, social roles Referee, Coach and Player into this new diagram in the Model Explorer. Create the Play association between these AML elements.

21. Compare your diagram with the diagram on the fig. 13.

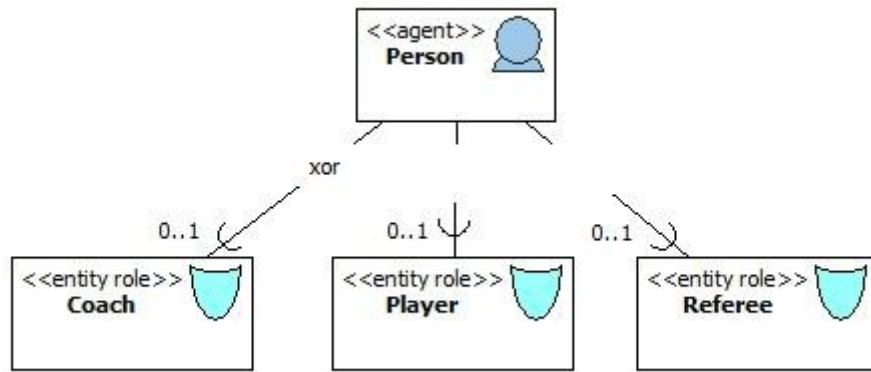


Figure 13: Entity type Person playing various roles

22. Save your AML project.

End of the seminar

Exercises

- Choose your own application domain for which you create simplified entity diagram. This diagram will contain agent type, environment type and resource type with suitable relations between them.
- Choose your own application domain for which you create simplified society diagram. This diagram will contain organisation unit type, entity role type and social association.
- **Homework: prepare the above mentioned diagrams for your project.**

The most important keywords

- StarUML
- Entity diagram
- Agent type
- Environment type
- Resource type
- Society diagram
- Organisation unit type
- Entity role type
- Social association and its types
- Social association Play association

Resources:

[1] Červenka, R. a Trenčanský, I., 2007. The Agent Modeling Language – AML: A Comprehensive Approach to Modeling Multi-Agent Systems Birkhäuser Verlag AG, Basel - Boston - Berlin, 355 p., ISBN 978-3-7643-8395-4.