CSEDU 2018
10TH INTERNATIONAL CONFERENCE ON COMPUTER SUPPORTED EDUCATION

A Model-Driven Engineering process to support the adaptive generation of learning game scenarios

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LIUM
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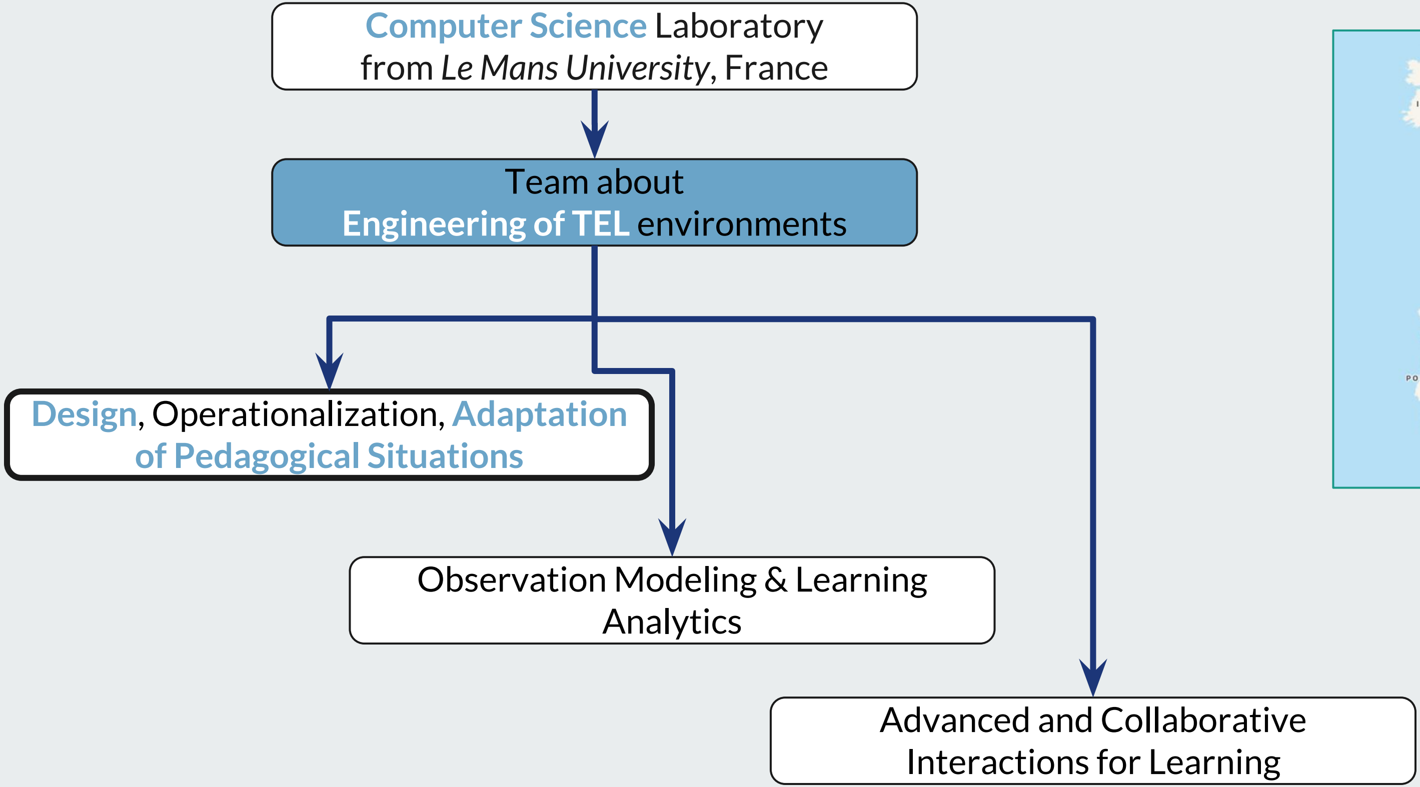
About us



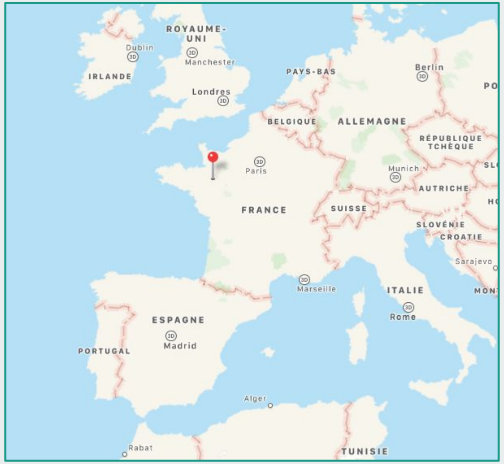
Computer Science Laboratory from *Le Mans University*, France

Team about Engineering of TEL environments

Design, Operationalization, Adaptation of Pedagogical Situations

Observation Modeling & Learning Analytics

Advanced and Collaborative Interactions for Learning



Outline

Research context: the *Escape It!* project

Research problem: generating adapted learning scenarios

State-of-the-art

Research proposition: an MDE approach and process for dealing with the generation of adapted scenarios

Application: to the *Escape It!* serious game

Conclusions

Further works

Research context: the *Escape it!* project

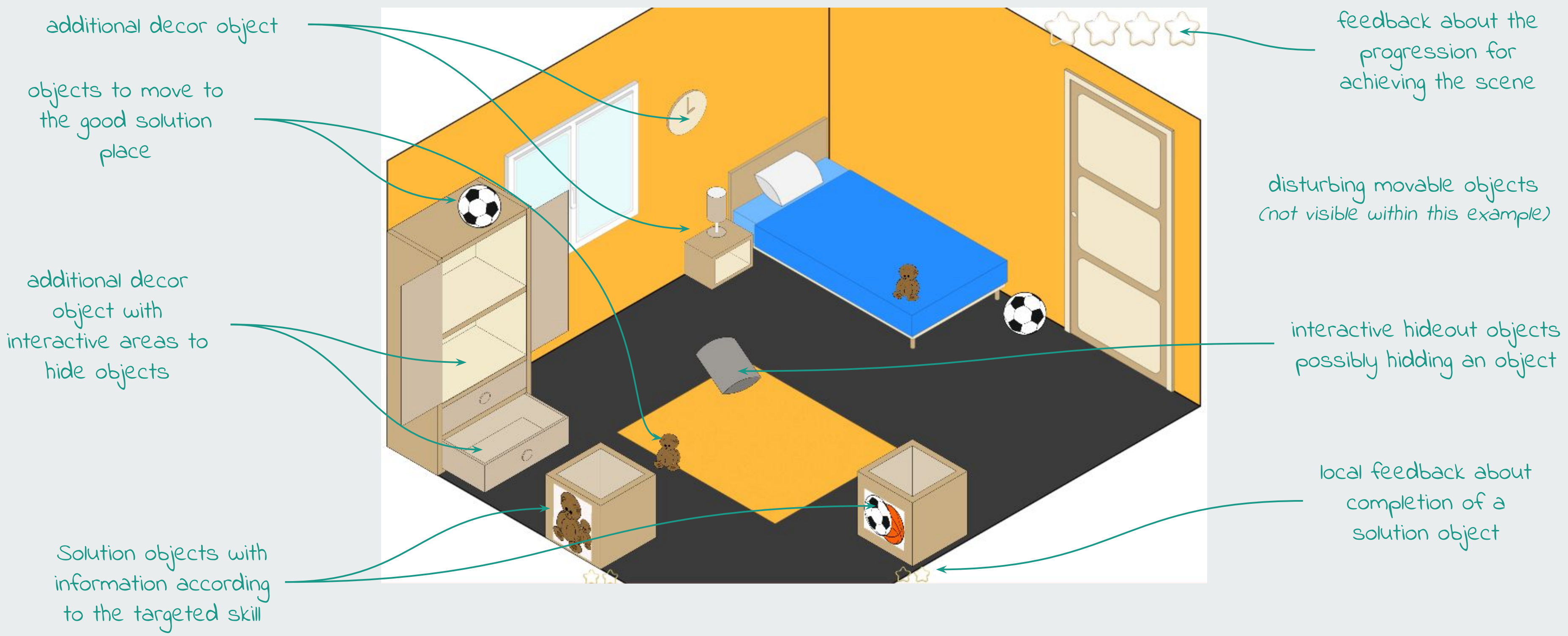
- Objective
  - to design and develop a mobile serious game to train visual skills for children with Autism Spectrum Disorder
    - B3 skill = matching an object to an identical object,
    - B8 skill = sorting several objects into different categories
    - ...
  - mechanics from ”escape-room” games (opening a locked door to escape a room)

children has to solve numerous puzzles requiring observation and deduction

game scenario =
ordered sequence of *scenes*

scene =
description of components / locations / other informations required for the *game engine* at *runtime*

Research context: Anatomy of a scene



additional decor object

objects to move to the good solution place

additional decor object with interactive areas to hide objects

Solution objects with information according to the targeted skill

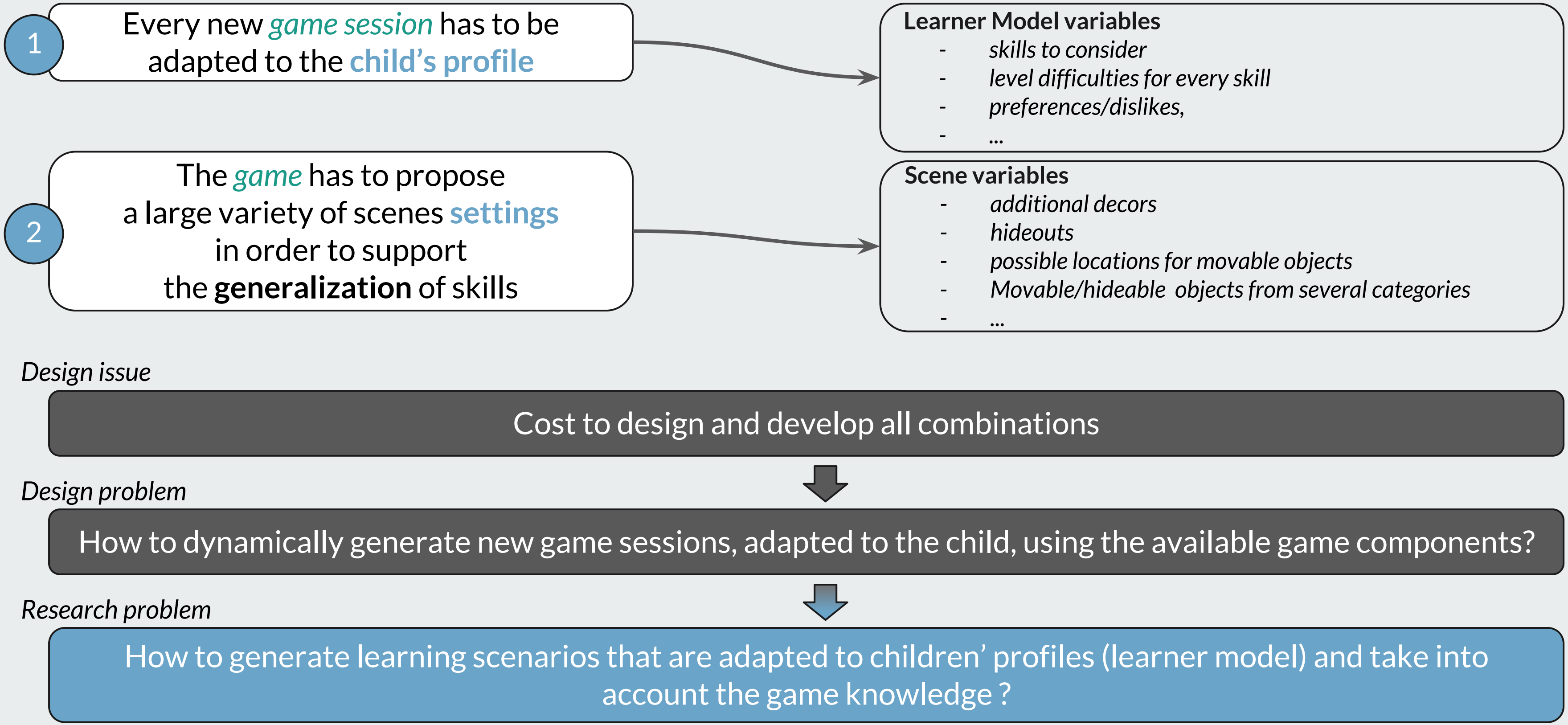
feedback about the progression for achieving the scene

disturbing movable objects (not visible within this example)

interactive hideout objects possibly hidding an object

local feedback about completion of a solution object

From Design problem to Research problem



1 Every new *game session* has to be adapted to the **child's profile**

Learner Model variables

- *skills to consider*
- *level difficulties for every skill*
- *preferences/dislikes,*
- *...*

2 The *game* has to propose a large variety of scenes **settings** in order to support the **generalization** of skills

Scene variables

- *additional decors*
- *hideouts*
- *possible locations for movable objects*
- *Movable/hideable objects from several categories*
- *...*

Design issue

Cost to design and develop all combinations

Design problem

How to dynamically generate new game sessions, adapted to the child, using the available game components?

Research problem

How to generate learning scenarios that are adapted to children' profiles (learner model) and take into account the game knowledge ?

State-of-the-art

- Adaptive serious games usually have specialized, *ad hoc*, approaches, where game components are adjusted to encourage training of a specific skill => **rare generic or reusable design framework**
- Adaptivity research results depend on
    - the **targets**: game mechanics, AI, narratives, content, etc.
    - the **methods**: bayesian networks, ontologies, neuronal networks, rules-based systems, procedural algorithms, …
- Very close and interesting results from CLES project [Sehaba & Hussan, 13]
    - a **generic architecture** (GOALS) for **personalizing** a **serious game scenario** according to **learners' competencies** and interaction traces
        - 3-layers architecture & process to generate 3 successive scenarios: conceptual, pedagogical and serious game scenarios
    - focus on techniques to update learner profile using interaction traces [Hussaan and Sehaba, 2016]
        - Does not tackle explicitation and formalization of game components, generation rules, ...
    - experts involved during requirements and validation of generated scenarios
        - not during specification

Research problem: revised

How to generate learning scenarios adapted to children' profiles (learner model) and taking into account the game knowledge ?

R1 How to explicit and **formalize** domain components (skills, game knowledge, learner model elements..), mapping and generation rules?

R2 How to use these formal models to **drive the generation** of adapted learning scenarios?

R3 How to **involve domain experts** in the explicitation of domain elements & rules and in the validation of generated scenarios?

Research proposition: rationale

- General idea

Adapt the GOALS architecture from [Sehaba & Hussan, 13]

+

Focus on a Model-Driven Engineering (MDE) framework

a research domain promoting an active use of 'executable' models throughout the software development process, leading to an automated generation of the final application)

- Research hypothesis

MDE principles and tools can tackle the **formalization** of the game knowledge (skills, components, etc.), the learner profile, and the learning scenarios as **executable models** : → R1

- **machine-readable** for **driving** the generation activity of learning scenarios → R2
- **human-interpretable** for being **conjointly specified** by computer scientists and domain experts → R3

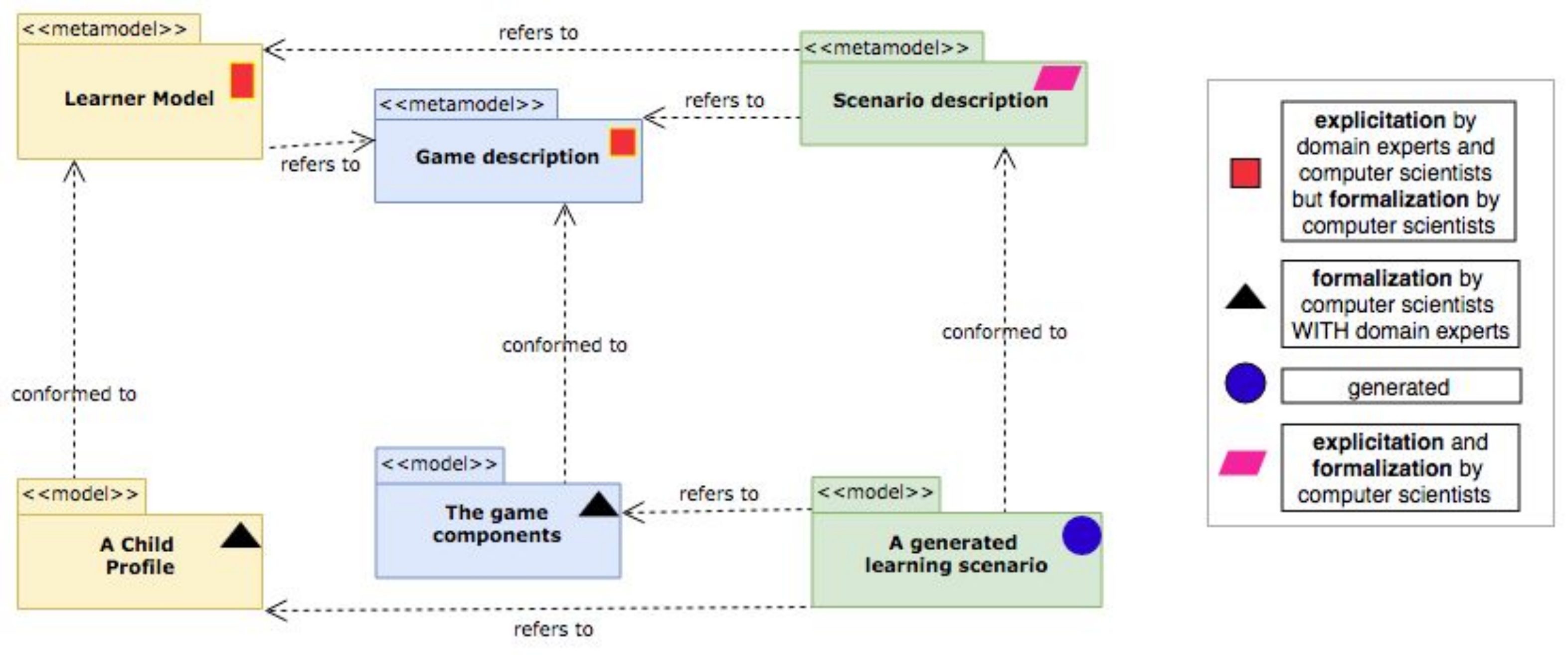
Research proposition: overview

- A 3x3 metamodel-based specification framework
  - 3-incremental perspectives on the resulting scenarios
    - **objective** scenario = selection of the targeted learning objectives according to the user's profile
    - **structural** scenario = selection of learning game exercises or large game components
    - **features** scenario = selection of the inner-resources/fine-grained elements
  - 3-dimensions specifications of domain elements to use and produce

- A dedicated process to involve domain experts in the explicitation/formalization/use/validation of various domain elements

- Using MDE tools
  - to specify metamodels & models
  - to generate domain code for the learning scenario generator

The metamodeling framework: 3 dimensions



<<metamodel>>
Learner Model

<<metamodel>>
Game description

<<metamodel>>
Scenario description

<<model>>
A Child Profile

<<model>>
The game components

<<model>>
A generated learning scenario

refers to

refers to

refers to

refers to

refers to

conformed to

conformed to

conformed to

🟥 **explicitation** by domain experts and computer scientists but **formalization** by computer scientists

▲ **formalization** by computer scientists WITH domain experts

● generated

▰ **explicitation** and **formalization** by computer scientists

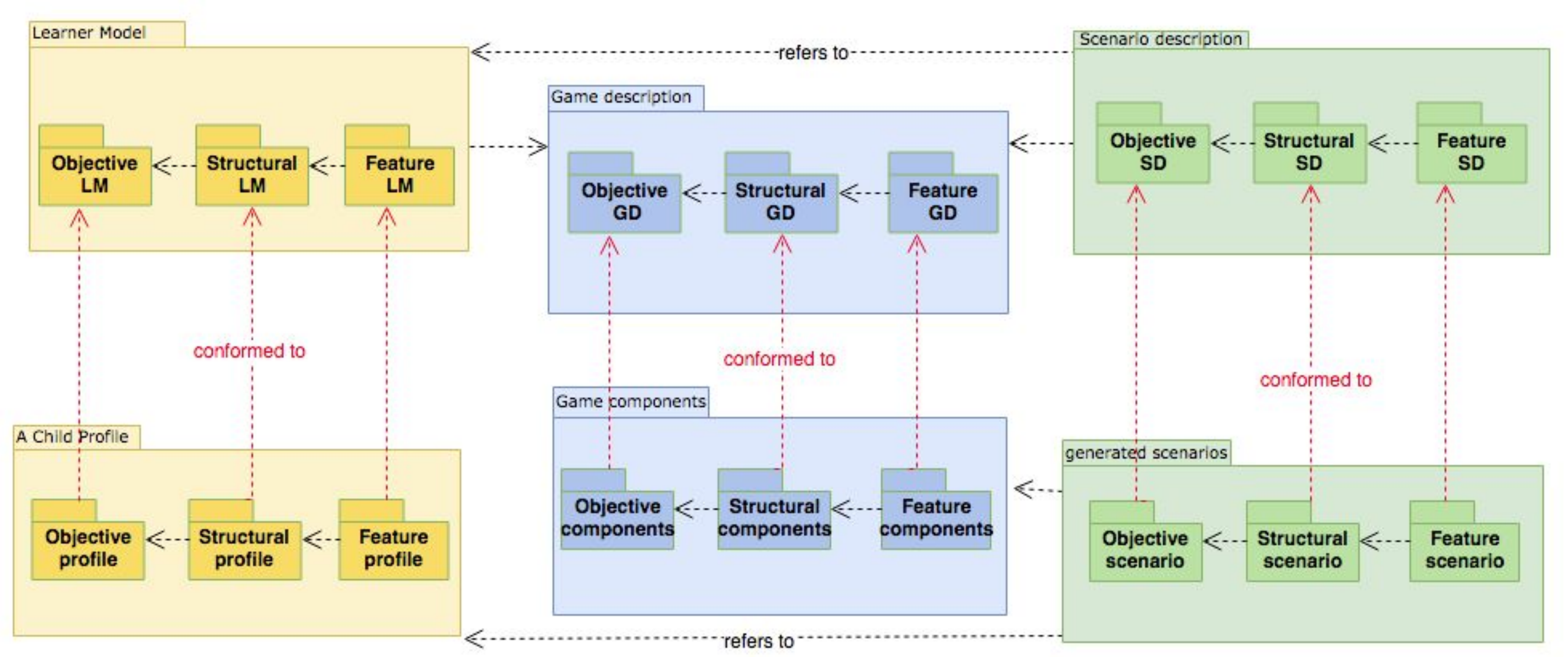
several models

only 1 model !

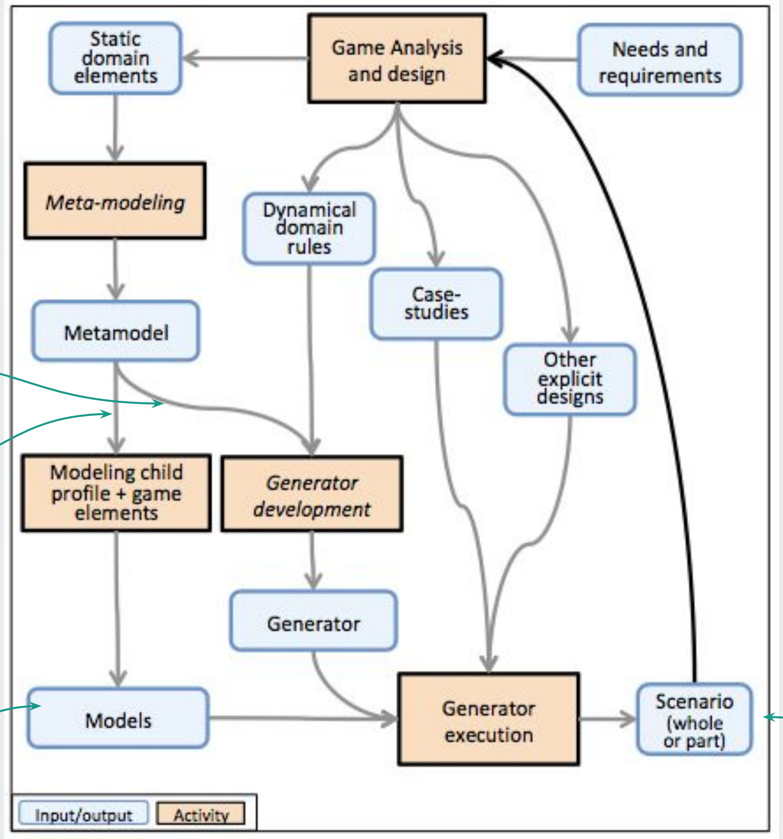
several models (1 by generation)

The metamodeling framework: 3 incremental perspectives

- According to the 3 successive objective, structural and feature scenarios



The metamodeling and modeling process



the *scenario description* metamodel

the *learner model* and *game description* metamodels

One *child profile* and the unique *game components* model

the successive *objective scenario*, *structural scenario*, and *feature scenario*

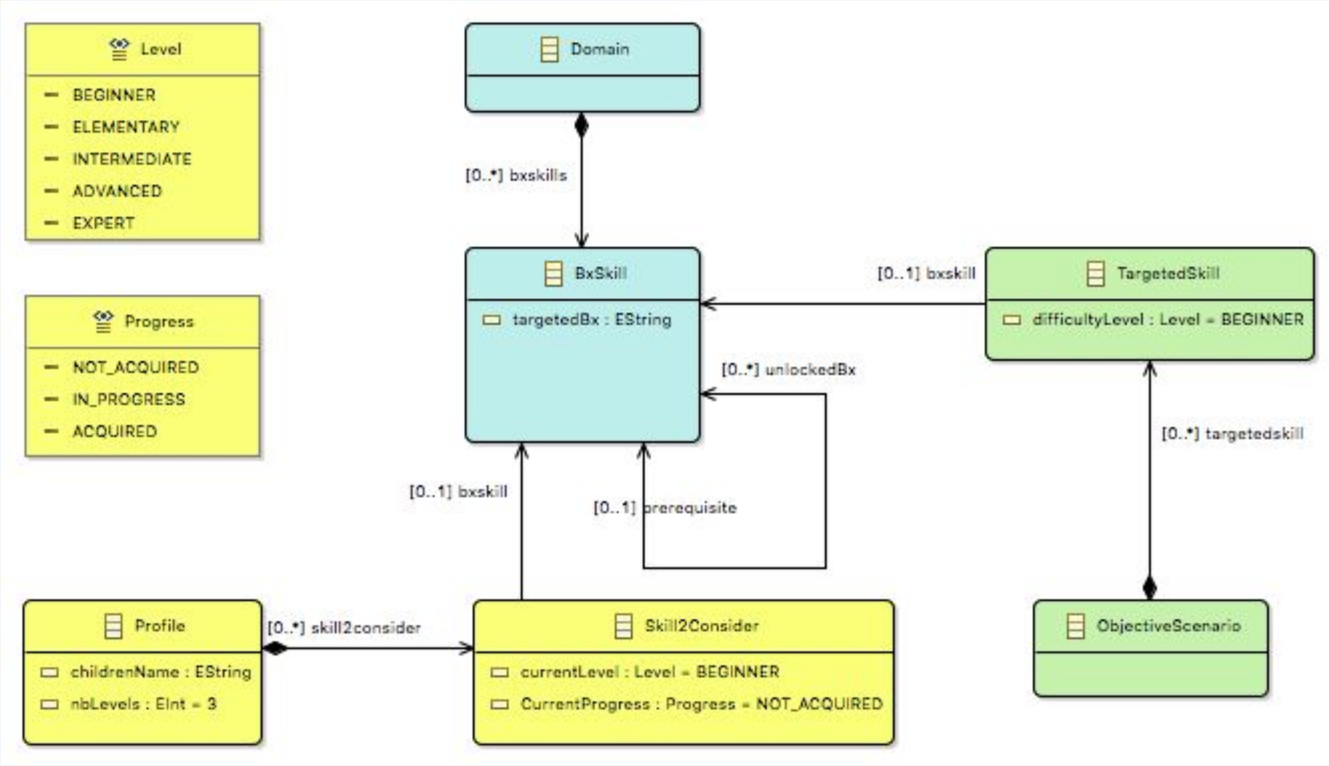
Application to the *Escape it!* project

1. Application of the metamodeling framework
   - Objective scenario => the *N* ordered targeted skills (N = nb of levels to generate for the game session)
   - Structural scenario => the *N* ordered scenes (from one or several themes) dealing with the previous skills
   - Feature scenario => setup details of the *N* ordered scenes in terms of objects and locations

Focus of this presentation because of time constraint

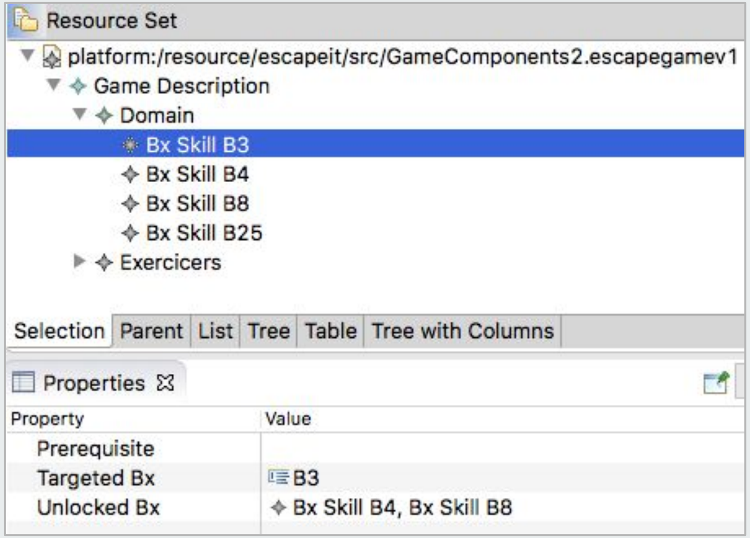
2. Application of the (meta-)modeling process
   - General feedbacks

Application: metamodels for the objective perspective



Application: input models for the objective perspective

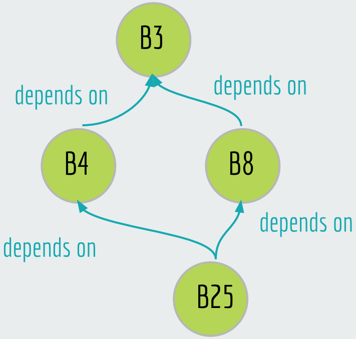
- Specification of the skills tackled by the game



Resource Set
- platform:/resource/escapeit/src/GameComponents2.escapegamev1
  - Game Description
    - Domain
      - Bx Skill B3
      - Bx Skill B4
      - Bx Skill B8
      - Bx Skill B25
    - Exercicers

Property	Value
Prerequisite	
Targeted Bx	B3
Unlocked Bx	Bx Skill B4, Bx Skill B8

tree view model editor from EMF tooling with 'properties' view for editing the selected element

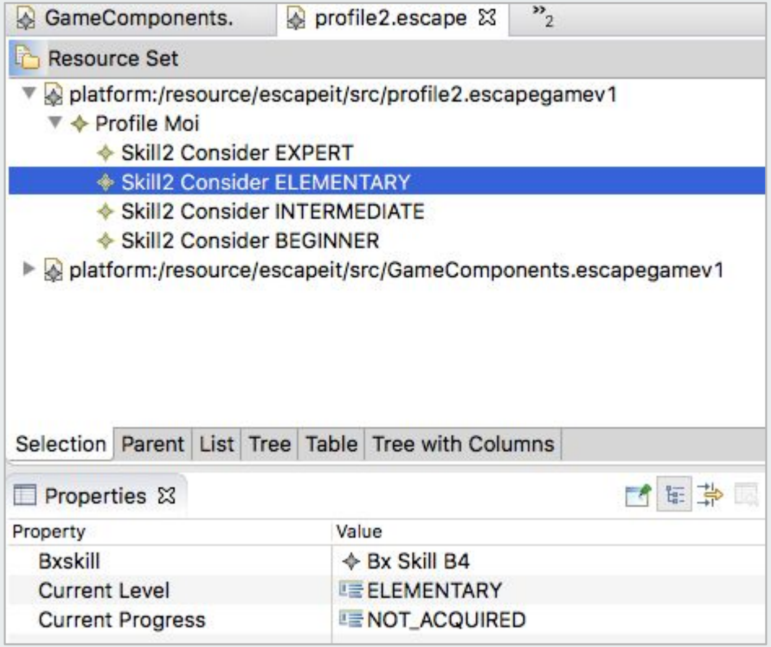


conceptual representation

B3 = matching object to object
B4 = matching object to image
B8 = sorting objects by categorizations
B25 = objects seriation

Application: input models for the objective perspective

- Specification of the learner model



```
▼ platform:/resource/escapeit/src/profile2.escapegamev1
  ▼ Profile Moi
      Skill2 Consider EXPERT
      Skill2 Consider ELEMENTARY
      Skill2 Consider INTERMEDIATE
      Skill2 Consider BEGINNER
▶ platform:/resource/escapeit/src/GameComponents.escapegamev1
```

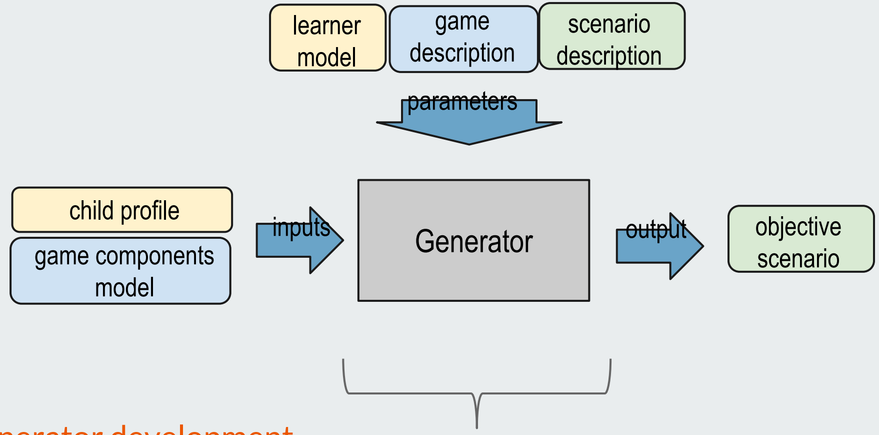
Property	Value
Bxskill	Bx Skill B4
Current Level	ELEMENTARY
Current Progress	NOT_ACQUIRED

tree view model editor using EMF

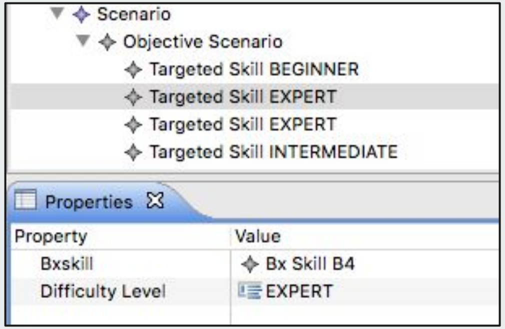
more readable →

Skill	Current level difficulty	Current progress for the difficulty level
B3	Expert	Acquired
B4	Elementary	NAcq
B8	Intermediate	NAcq
B25	Beginner	NAcq

Application: output model (i.e. the objective scenario)



output model viewed using EMF



- Scenario
  - Objective Scenario
    - Targeted Skill BEGINNER
    - Targeted Skill EXPERT
    - Targeted Skill EXPERT
    - Targeted Skill INTERMEDIATE

Properties

Property	Value
Bxskill	Bx Skill B4
Difficulty Level	EXPERT

Generator development

- ➔ ***Java** implementation*
- ➔ *input models are handled by **domain model Java code** generated from ecore metamodels using **EMF tooling***
- ➔ ***hard-coded generation rules** with **randomness** when several choices*

B25 BEGINNER
+ B4 EXPERT
+ B3 EXPERT
+ B8 INTERMEDIATE

readable format

Example of generating rules

- ➔ ***IF N** (number of levels to generate from child profile) **< NBS** (nb of skills from game desc. model) **THEN** pick up randomly N different skills*
  ***ELSE** pick up randomly N different skills, when no more skills start again with initial set of skills*

Validation with domain experts

- Objective
  - verify the generation process => the generator complies with the specified mapping and generation rules
  - validate the mapping and generation rules (independently from the generator)
- Session 1
  - **validation** of various generated **objective scenarios** and **structural scenarios** with mock **children profiles** and **game components models** (mock themes and scenes)
  - **modification** of the **generation rules**
- Session 2
  - **validation** of the generation of **feature scenarios** (regarding mapping and generation rules) with mock input models
  - results visualization improved, for experts:
    - **console-based** generated results
    - + **paper-based prints** of the scene's background, objects, solution objects, hiding objects, etc.

To sum up

- A 3x3 metamodel-based specification framework
  - 3-incremental perspectives on the resulting scenarios
  - 3-dimensions specifications of domain elements to use and produce
- A dedicated process to involve domain experts in the explicitation/formalization/use/validation of various domain elements
- Based on MDE principles & tools
  - to specify metamodels & models
  - to generate domain code for the generator
- Application to the design and development of the *Escape it!* serious game about learning visual skills for children with ASD

Further works

- Research perspectives
  - Improve explicitation and formalization of generation rules (currently hard-coded) also as executable models
    - MDE research issue
  - and experiment impact on the domain experts involvement

in progress

- Engineering perspectives
  - Integrating the generated scenarios in the Unity-based prototype
    - random-based generations of scenarios in prototype 1

DONE : prototype V2
1 scene (bedroom) and 4 skills

  - Adding more playing scenes and other skills
    - Improving modeling of skills requirements

planned

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