Domain Specific Modeling

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Abstract. For centuries people from da Vinci to Einstein have created models to help them better understand patterns and processes in the world around them. Nowadays computers and smartphones make it easier for both novices and domain experts to build and explore their own models and learn new scientific ideas in the process. Domain Specific Modeling can support both experts and novices in building models for different domains. There are approaches (e.g. Mindstorms,Starlogo) that enable novices with few or even no programming skills at all to implement their own models. Domain Experts an the other hand may use modeling languages (e.g. SimuLink,BPMN) designed for a domain to create models, which allows them to focus on domain-specific problems instead of implementation-specific details like supported language features of a programming language. We will therefore give an overview over different domain-specific modeling langues for both, novices and experts as well as present a toolchain for creating modeling languages.

1 Introduction

For centuries people from da Vinci to Einstein have created models to help them better understand patterns and processes in the world around them. Nowadays computers and smartphones make it easier for both novices and domain experts to build and explore their own models and learn new scientific ideas in the process. Domain Specific Modeling can support both experts and novices in building models for different domains. There are approaches (e.g. Mindstorms,Starlogo) that enable novices with few or even no programming skills at all to implement their own models. Domain Experts an the other hand may use modeling languages (e.g. SimuLink,BPMN) designed for a domain to create models, which allows them to focus on domain-specific problems instead of implementation-specific details like supported language features of a programming language. We will therefore give an overview over different domain-specific modeling langues for both, novices and experts as well as present a toolchain for creating modeling languages.

- can help experts and novices builing Models for different domains
- enables novices with few or even no programming skills at all to implement their own models (e.g. MindStorm,Starlogo)
- supports domain experts by setting focus on the domain-specific problems (e.g. SimuLink,BPMN)

1.1 Foundation

Model

- What is a model? (Definition [Stachowiak] + some Explanation)
- Abstraction: Remove details which do not serve the purpose
- Homomorphism: Statements on model elements hold for real world entities
- Pragmatics: Model has some purpose
- + example (novice) house Made of LEGOS → Model for a “real” house / building
- + example (expert) blueprints from an architekt → different model, but represents same object in real world
- Abstraction brings representational bias
- → electric cable installations, water pipes cannot be “expressed” in lego but they can with blueprints
- → lego allows 3D Modeling while Blueprints cannot (oonly via 2d projections/ optical illusions)

Domain

- novice and expert have different views on the same thing but use different models / languages
- both models may be used in the context of a domain (Architekture)
- What is a Domain? (Definition + some Explanation)

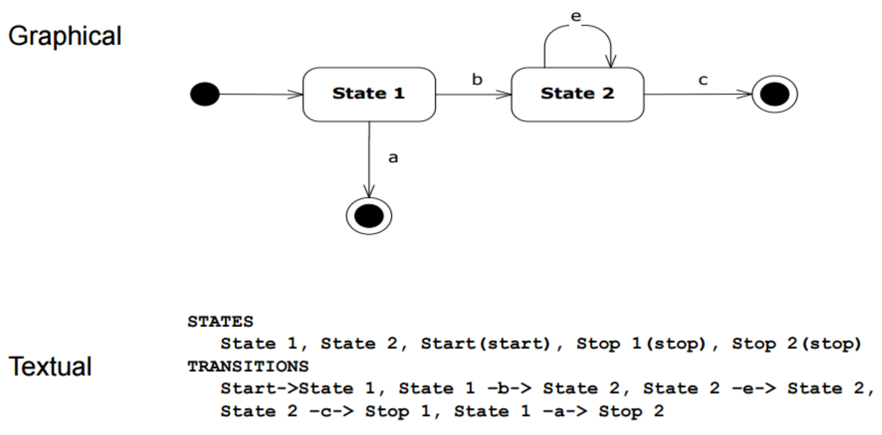
1.2 Domain Specific Languages

- different approaches : Graphical Modeling Languages, Textual Modeling Languages
-
- examples (domain experts): BPMN , SimuLink
- examples (novice): STARLOGO

2 Existing Modeling Languages

2.1 StarLogo TNG

- is a client-based modeling and simulation software
- enables secondary school students and teachers to model decentralized systems through agent-based programming
- facilitates the creation and understanding of simulations of complex systems
- graphical programming blocks instead of text-based computer code



```
STATES
   State 1, State 2, Start(start), Stop 1(stop), Stop 2(stop)
TRANSITIONS
   Start->State 1, State 1 -b-> State 2, State 2 -e-> State 2,
   State 2 -c-> Stop 1, State 1 -a-> Stop 2
```

Fig. 1: comparison between textual modeling language and graphcal modeling language for the same model

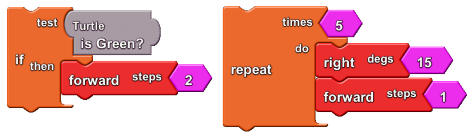


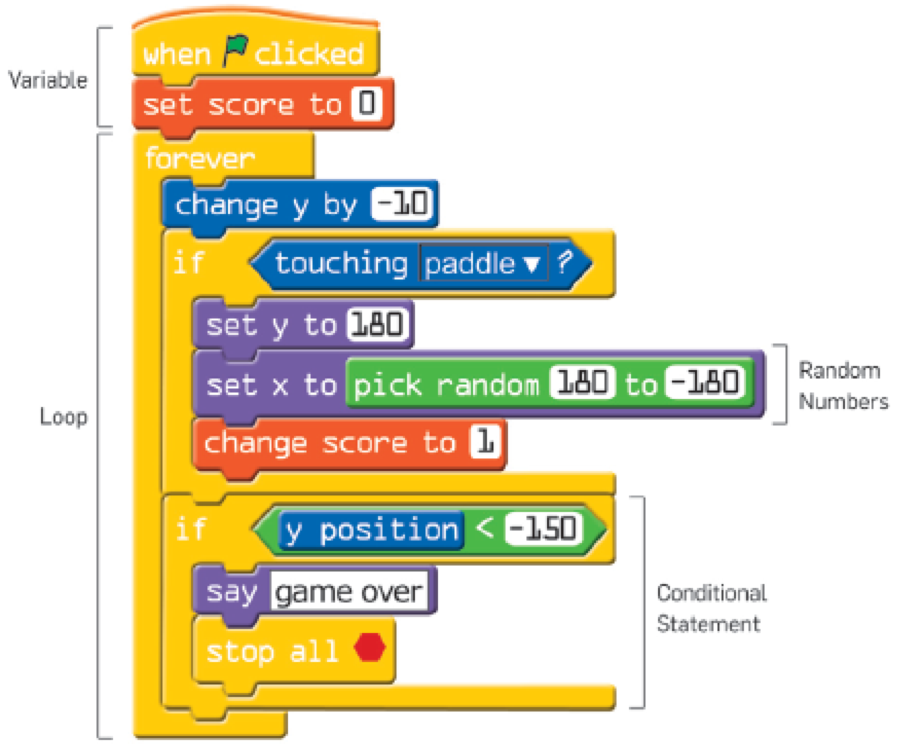
Fig. 2: StarLogo TNGs graphical programming blocks. Example if (left) and repeat (right) blocks are shown. The if block commands a Turtle agent to take two steps forward if it is green; the repeat block commands an agent to repeat five times the sequence of turning right 15 degrees and taking one step forward.

2.2 Snatch

- Graphical Modeling Language (similar to StarLogo)
- developers goal: "make it easy for everyone, of all ages, backgrounds, and interests, to program their own interactive stories, games, animations, and simulations, and share their creations with one another"

2.3 PhyDSL

- textual modeling for (simple) game dev domain
- based on EMF
- allows codegeneration from the created models
- mobile gameplay definition sections:
  - static actor definition
  - environment and layout definition
  - activities definition
  - scoring rules definition

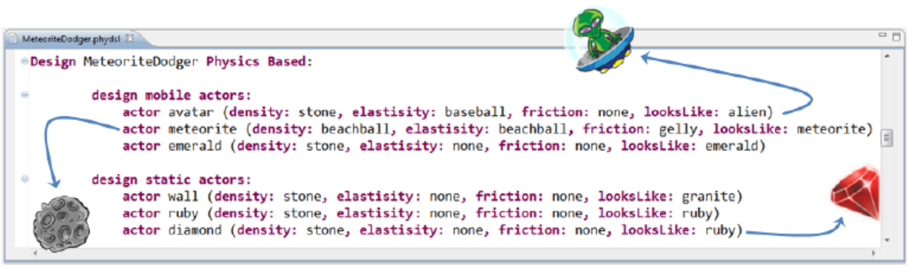


```
when [flag] clicked
set score to 0
forever
    change y by -10
    if <touching paddle ▾ ?>
        set y to 180
        set x to pick random 180 to -180
        change score to 1
    if <y position < -150>
        say game over
        stop all
```

Fig. 3: Sample Scratch script (from Pong-like paddle game) highlighting computational and mathematical concepts

2.4 Lego Mindstorms

- EV3 Programmer App or Computer Software for programming lego robots in a graphical syntax
- action blocks (Green), flow blocks (Orange), sensor blocks (Yellow), data operation blocks (Red), advanced blocks (Dark blue)
- programms are executed on the EV3 P-brick.

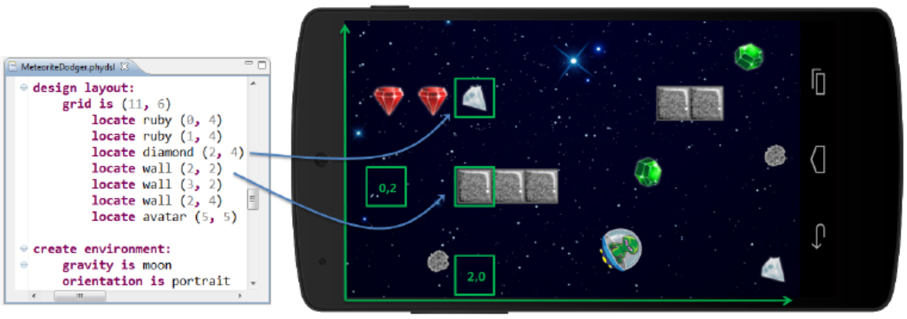


```
Design MeteoriteDodger Physics Based:

        design mobile actors:
            actor avatar (density: stone, elastisity: baseball, friction: none, looksLike: alien)
            actor meteorite (density: beachball, elastisity: beachball, friction: gelly, looksLike: meteorite)
            actor emerald (density: stone, elastisity: none, friction: none, looksLike: emerald)

        design static actors:
            actor wall (density: stone, elastisity: none, friction: none, looksLike: granite)
            actor ruby (density: stone, elastisity: none, friction: none, looksLike: ruby)
            actor diamond (density: stone, elastisity: none, friction: none, looksLike: ruby)
```

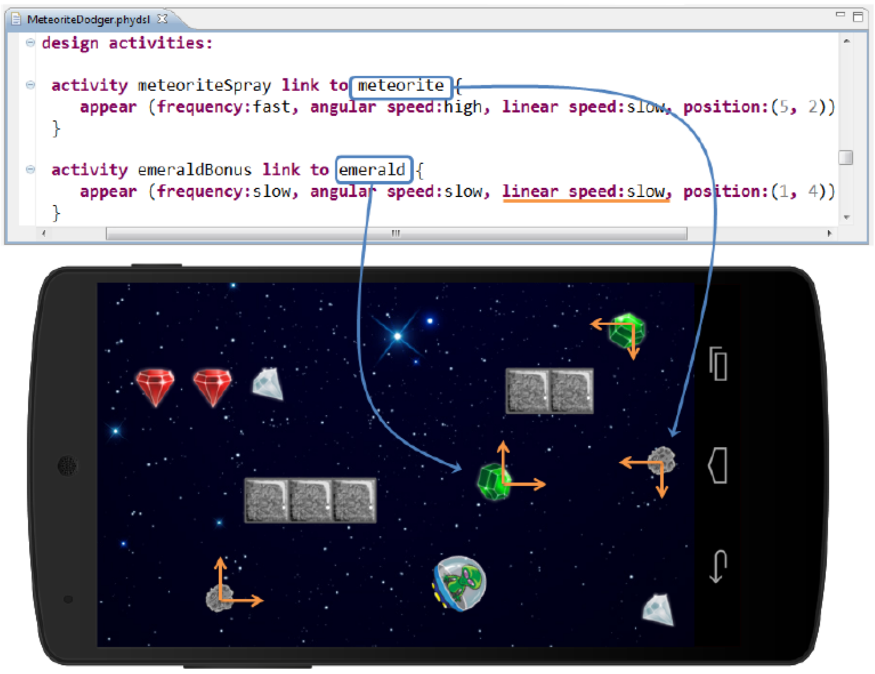
Fig. 4: PhyDSL: static actor definition



```
design layout:
    grid is (11, 6)
        locate ruby (0, 4)
        locate ruby (1, 4)
        locate diamond (2, 4)
        locate wall (2, 2)
        locate wall (3, 2)
        locate wall (2, 4)
        locate avatar (5, 5)

create environment:
    gravity is moon
    orientation is portrait
```

Fig. 5: PhyDSL: environment and layout definition



```
design activities:

 activity meteoriteSpray link to meteorite {
    appear (frequency:fast, angular speed:high, linear speed:slow, position:(5, 2))
 }

 activity emeraldBonus link to emerald {
    appear (frequency:slow, angular speed:slow, linear speed:slow, position:(1, 4))
 }
```

Fig. 6: PhyDSL: activities definition

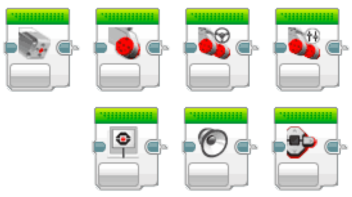


Fig. 7: The action blocks control the actions of the program, e.g. motor rotations, image, sound and the light on the EV3 P-brick.

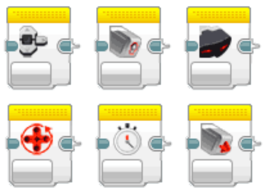


Fig. 8: The sensor blocks allow to read the inputs e.g. from a Color sensor, IR sensor, Touch sensor.

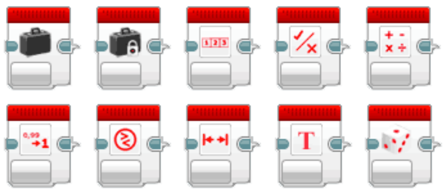


Fig. 9: The data operation blocks let the user write and read variables, compare values for example.

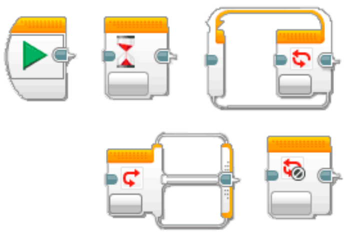


Fig. 10: The Flow blocks control the flow of the program.

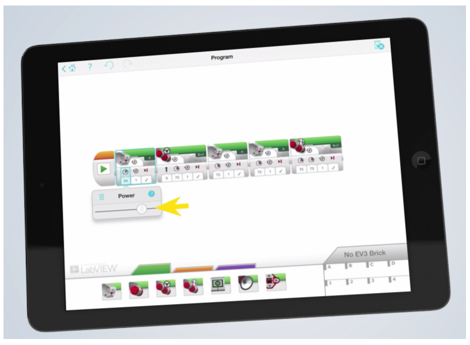


Fig. 11: EV3 Programmer App used to create programms using a graphical syntax based on blocks

2.5 Sensr

– enables people without programming skills to build mobile data collection and management tools for citizen science

3 Creating Domain Specific Models

3.1 Ecplise EMF

3.2 Ecore

– a meta model for describing models and runtime support for the models .

3.3 Xtext

– used to create textual DSLs for ecore (meta-)models designed in EMF
– syntax similar to EBNF
– one rule for each (meta-)model element

```
FSM: “States:” (states+=State (“,”)?)*
“Transitions:” (transitions+=Transition (“,”)?)*;
State: id=ID isStart?=“(start)” isStop?=“(stop)”;
Transition: fromState=[State] “-” (input)? “->”
     toState=[State];
```

Fig. 12: XText Sample Grammar

3.4 GMF

– used to create graphcal DSLs for models described in Ecore
– connects domain model and a graphical model via mapping modell

4 Summary

– DSM allows novices to build and explore their own models and learn new scientific ideas in the process
– domain experts are supported by setting focus on domain specific problems

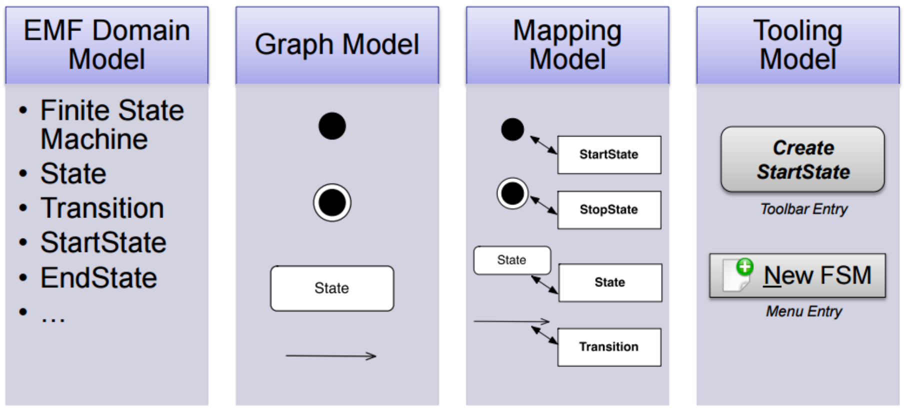


Fig. 13

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