

Towards platform specific energy estimation for xDSMLs

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What's wrong with IT energy consumption ?

It's expensive

For every \$1.00 spent on hardware, \$0.50 is spent on power & cooling.

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This is expected to grow even more by 2030: up to 23% of total greenhouse emissions !

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Reducing energy consumption

Hardware level		Software level	
Clock gating	Adapt clock signal to circuit activity	CPU offloading	Offloads heavy calculations to cloud
CPU throttling	Adjust CPU frequency on-the-fly	Approximate computing	Reduce QoS with a soft error tolerance
Voltage scaling	Adjust CPU voltage on-the-fly	Energy types	New type systems aimed towards energy efficiency
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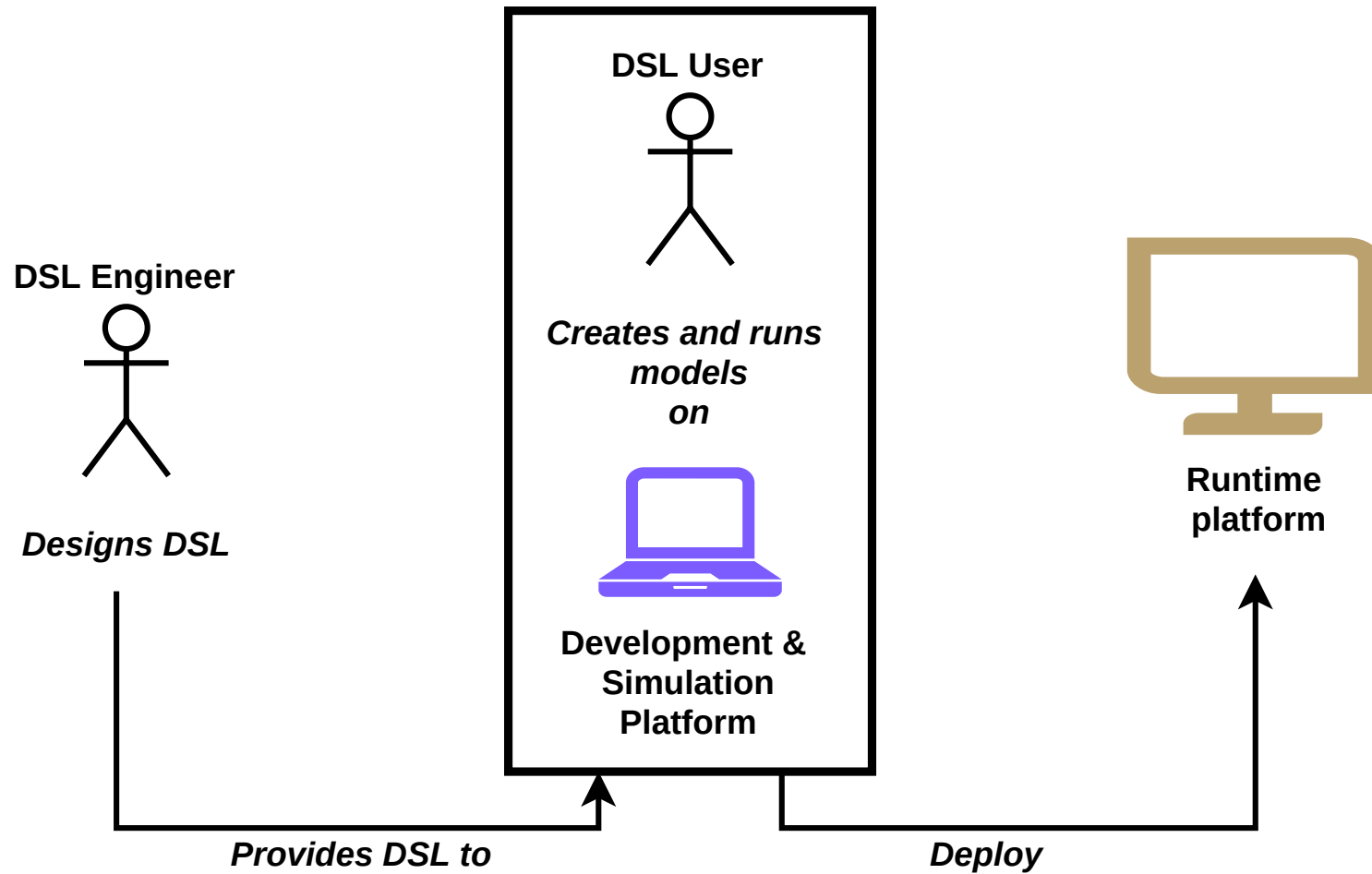
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Software-level techniques require developer's implication!

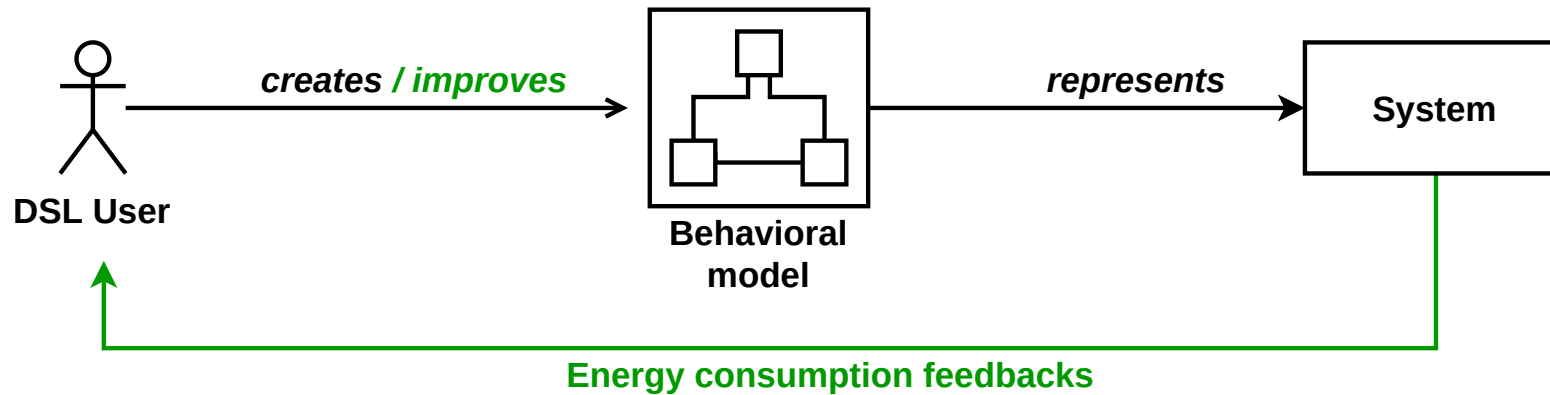
What about energy optimization for DSLs ?

Considered modeling scenario



Energy consumption and xDSMLs

The model describes the **behaviour of the system**. Improving the model can improve the **system's energy consumption**.



Measuring energy consumption of Runtime systems

- Power-meters

Require **heavy** analysis for correlating metrics with a running programs.

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Measuring energy consumption of Runtime systems

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- **Specialist** Providing energy consumption feedbacks requires the help of a specialist.
Exp

- **Middleware & Application-level energy monitoring**

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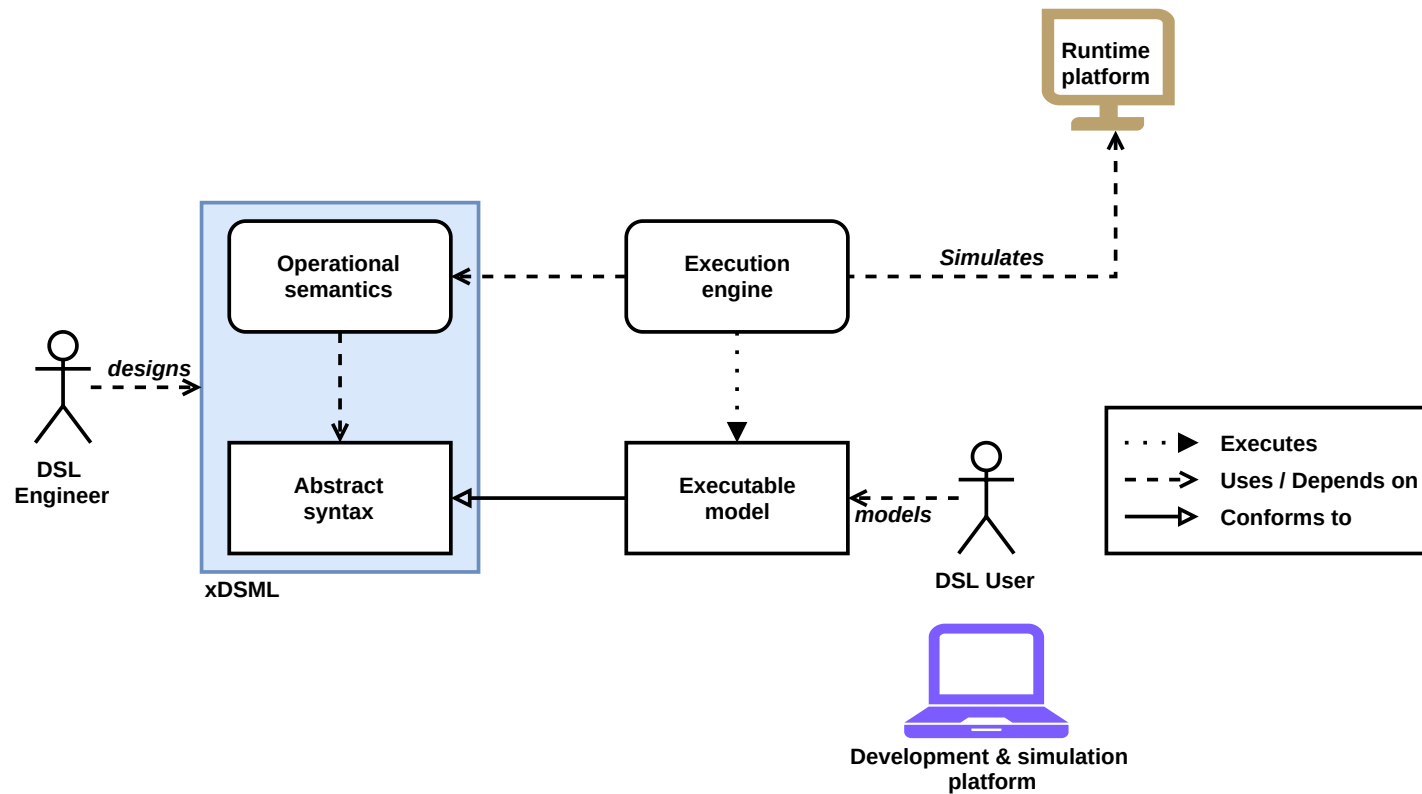
Research question

How to provide **energy consumption feedbacks** of runtime platform without energy measurement tooling and expertise?

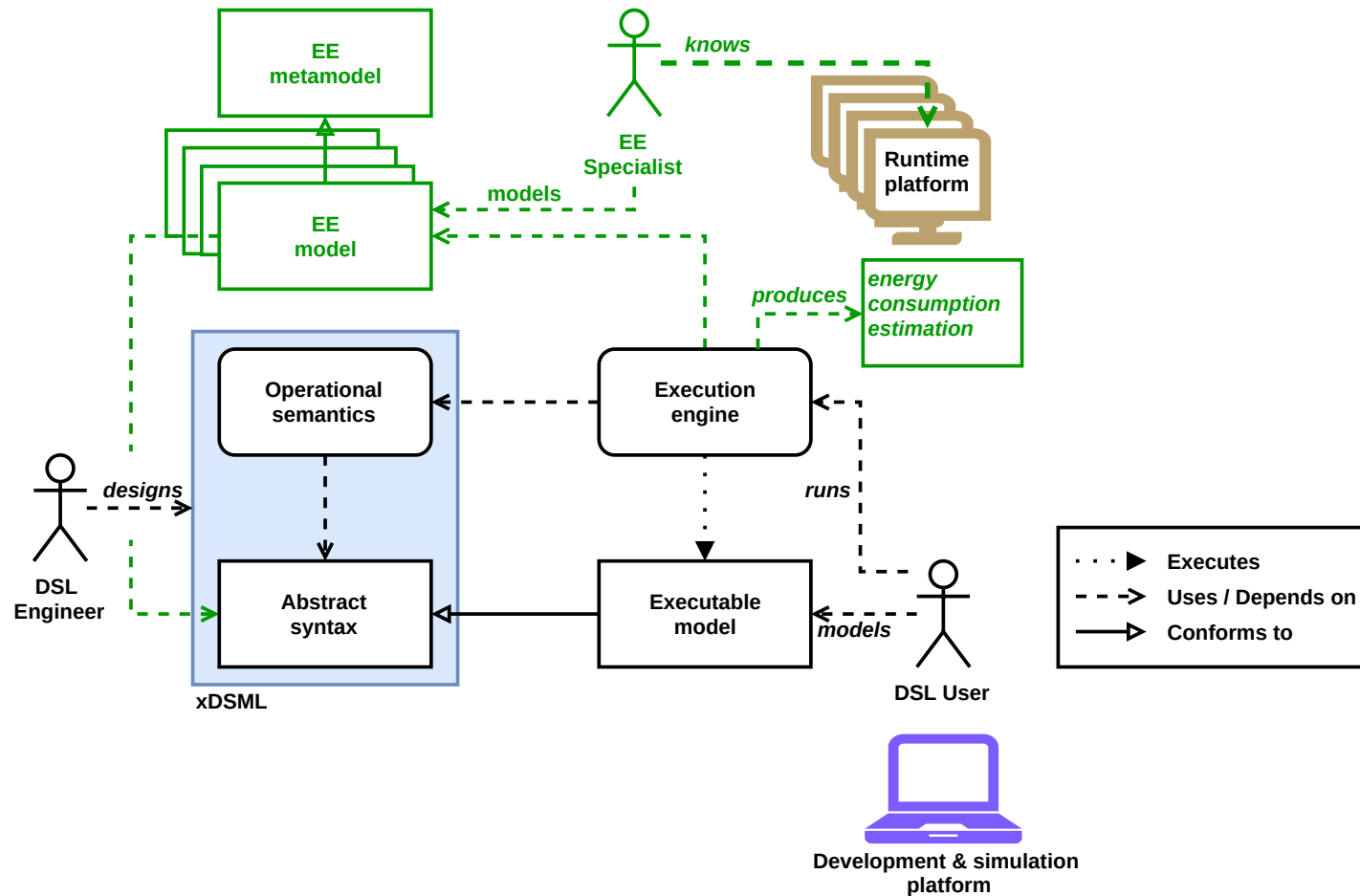
Our contributions

- 1 A DSL for **specifying energy-consumption** estimation formulas.
- 2 An **extension of the GEMOC modeling workbench** to provide energy consumption estimations of runtime system to DSL Users.

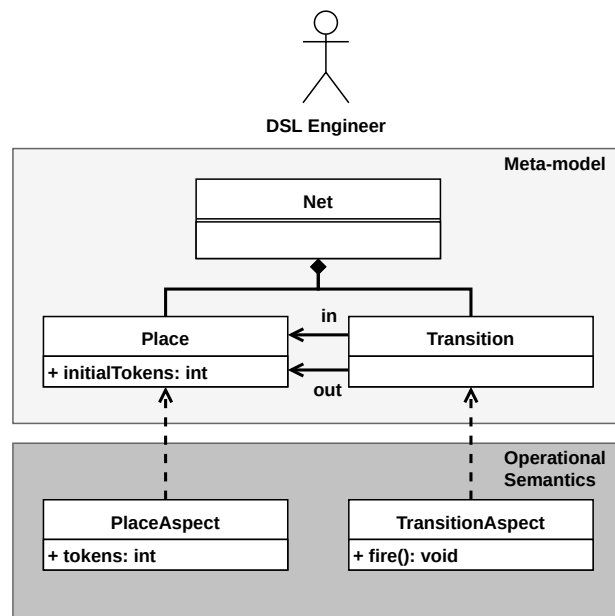
Energy-consumption feedback for xDSMLs end-users



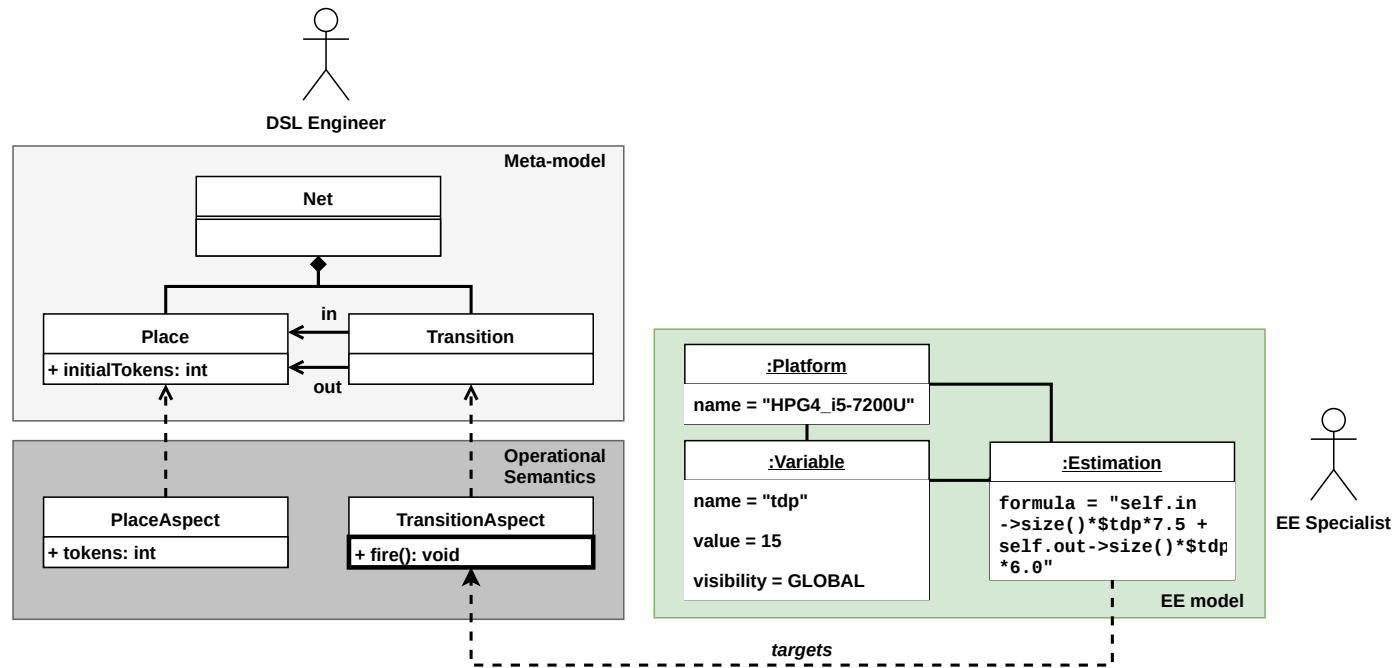
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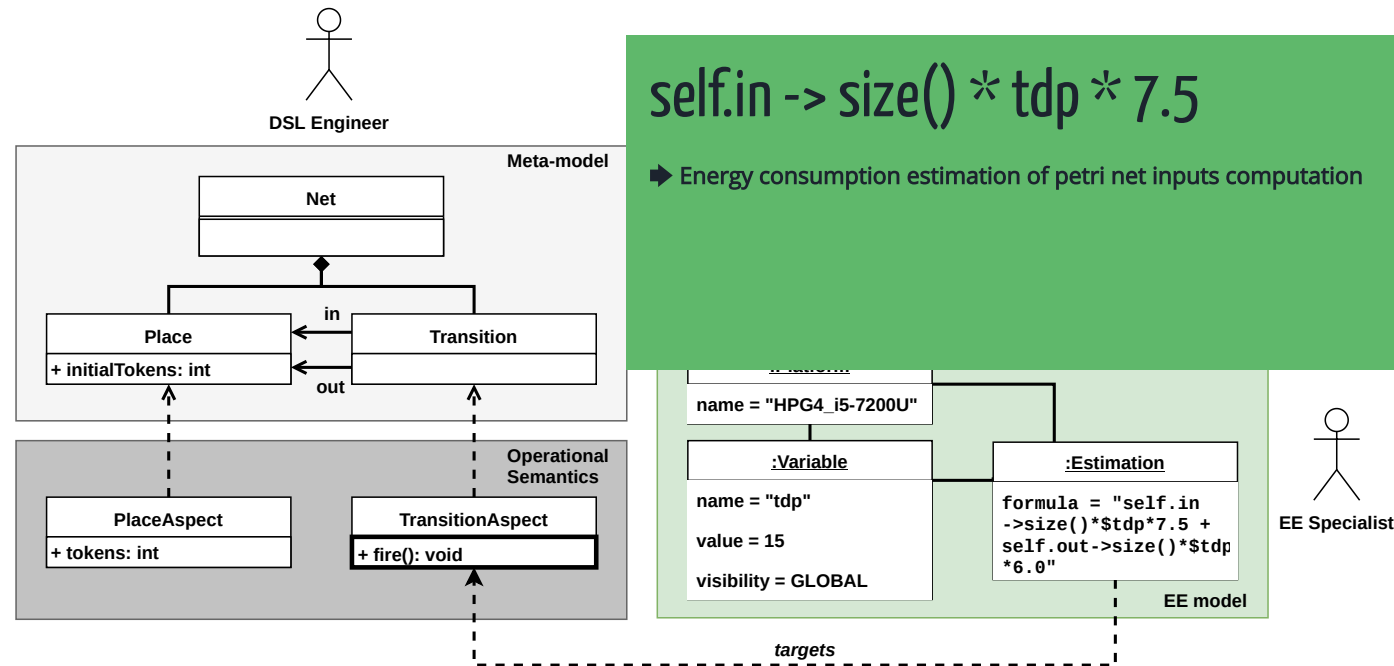
Example: Petri net modeling scenario



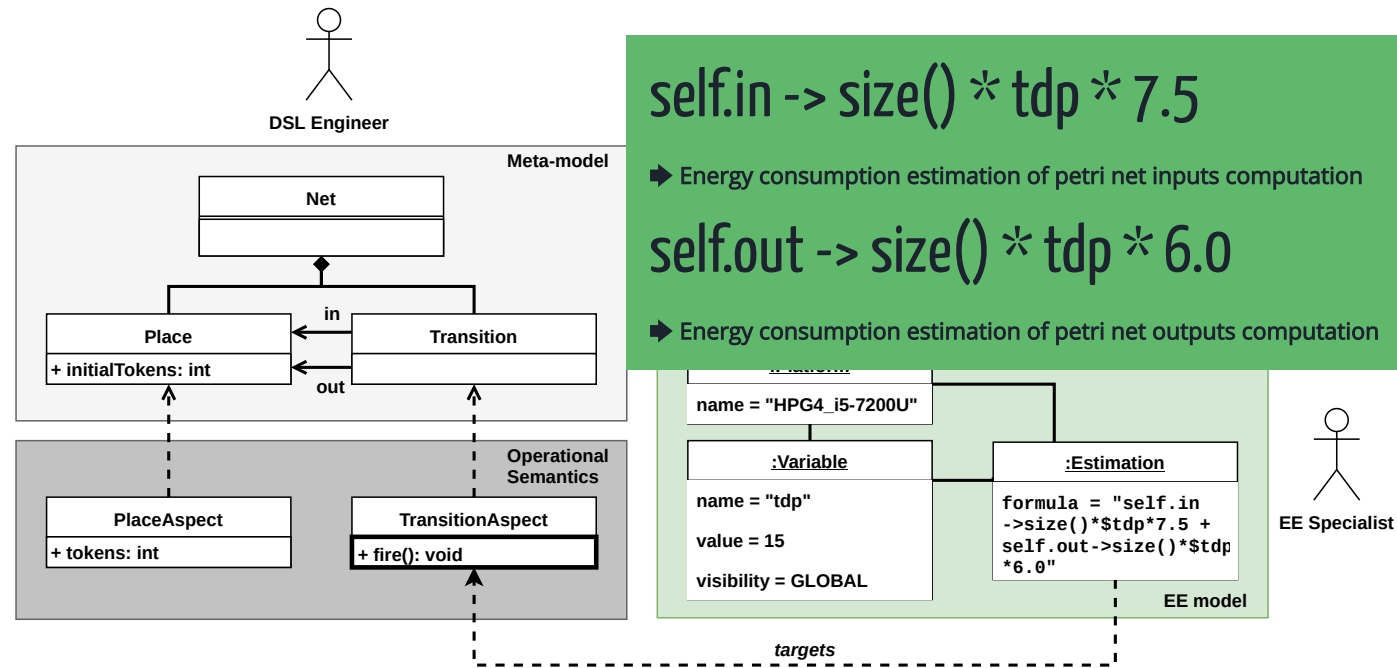
Example: estimating Petri Net energy consumption



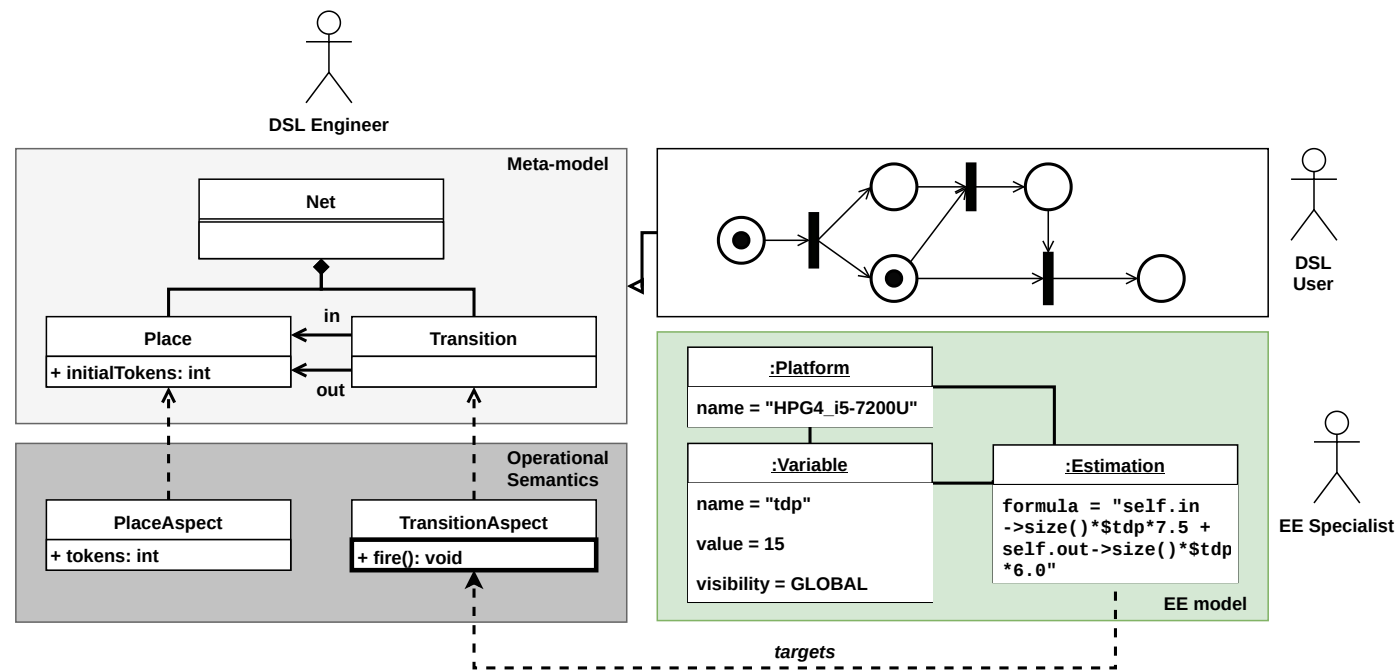
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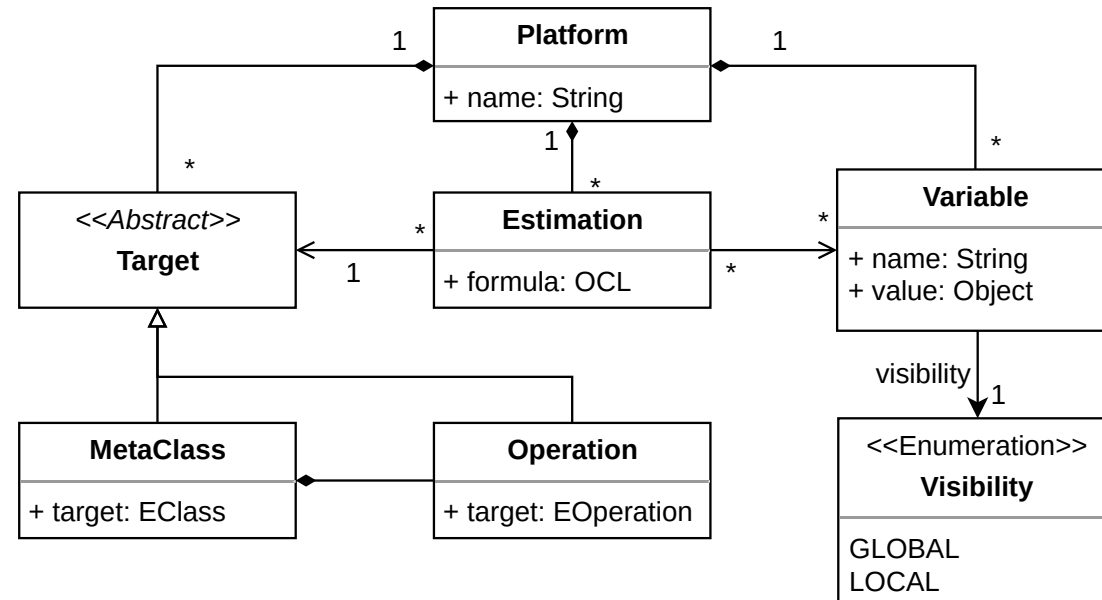
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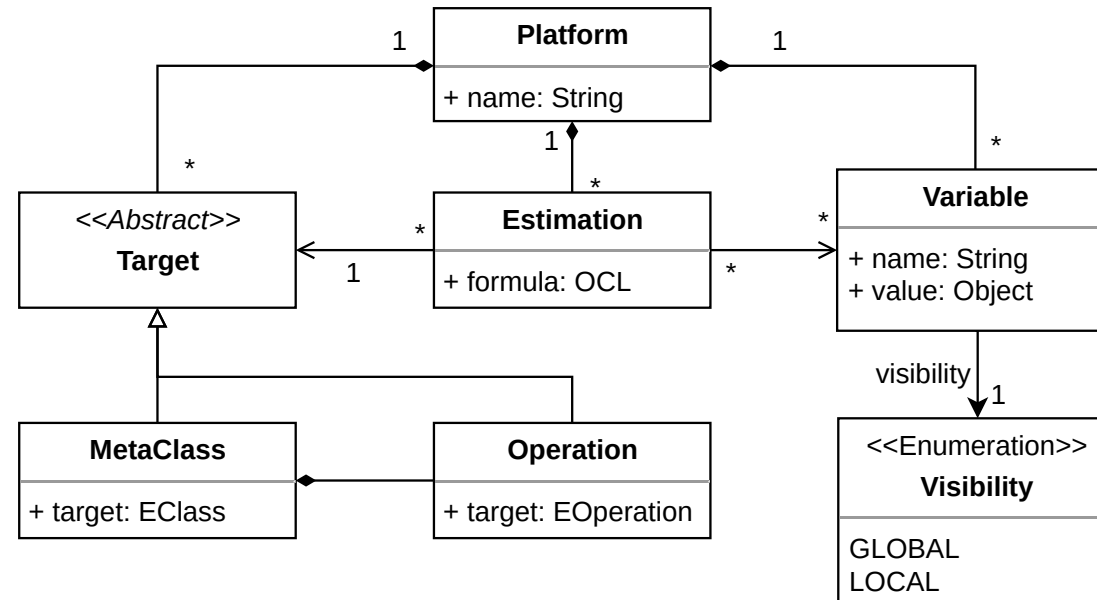
Defining energy estimation formulas

- Role of the Energy Estimation **specialist**.
- Requires a thorough study of the operational semantics.
- Can be **inferred** from multiple model executions with energy consumption measurements.

Energy estimation meta-model

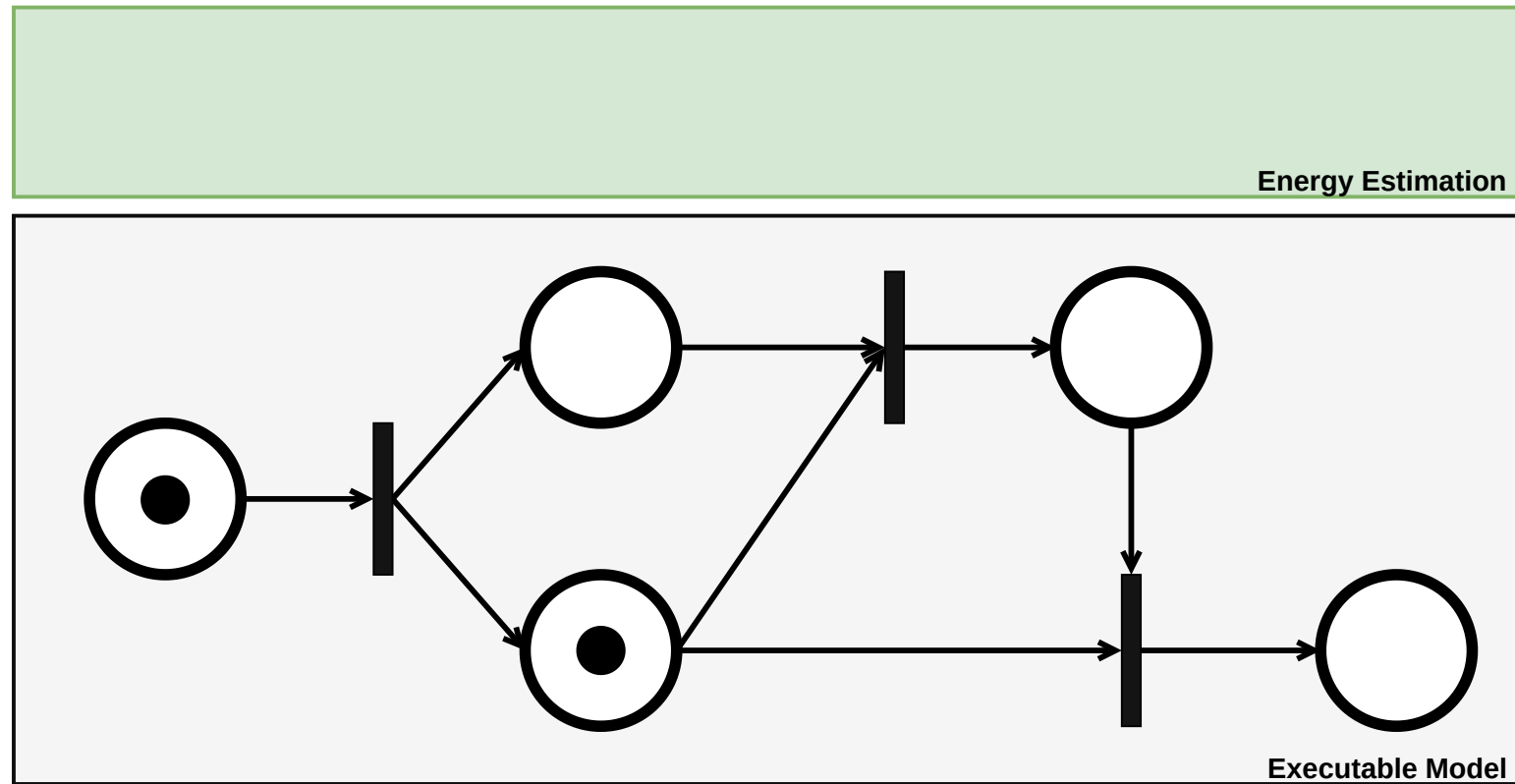


Energy estimation meta-model

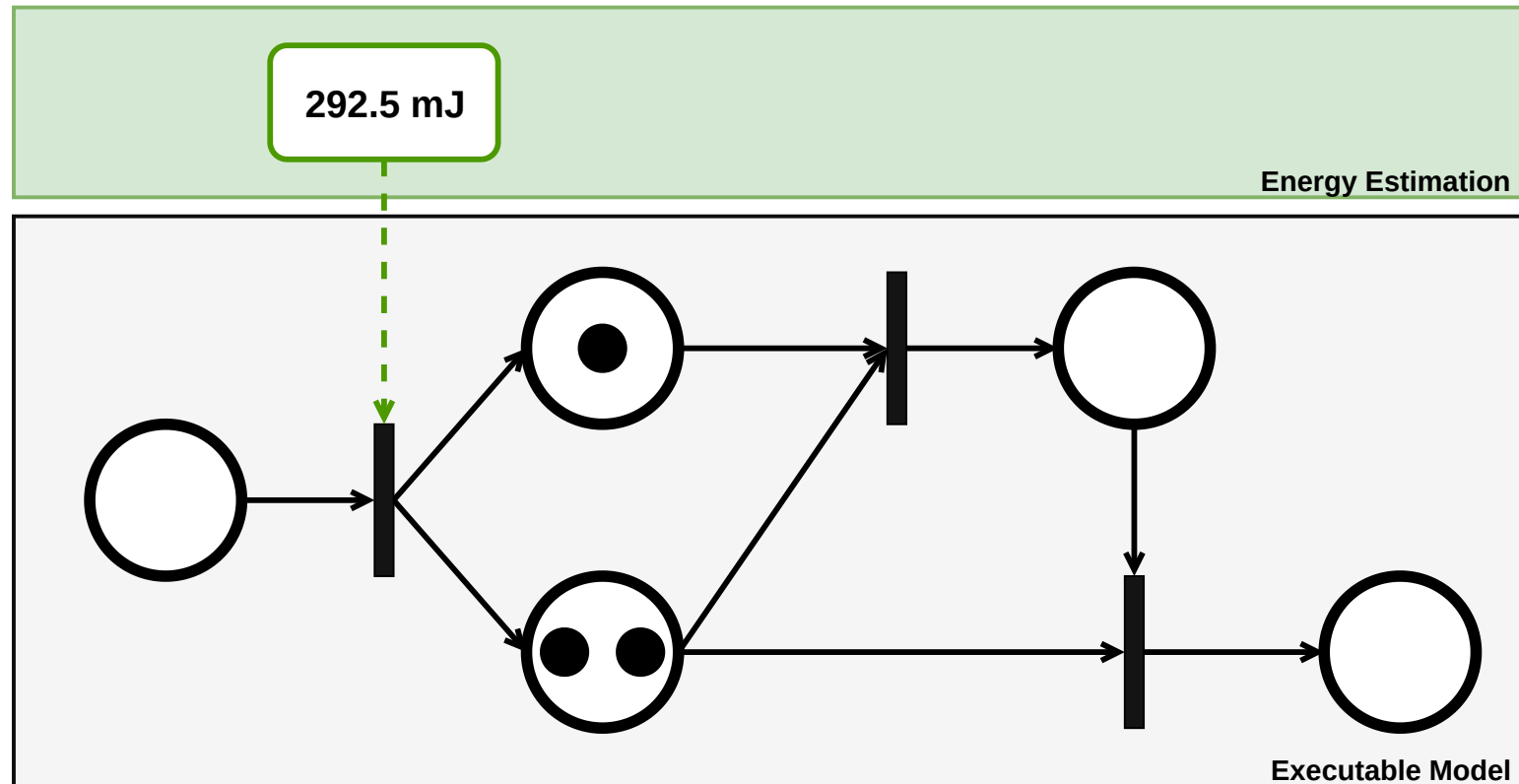


- Formulas are associated to **meta-elements** of a xDSML.
- They should only focus on **one specific platform**.
- Written as OCL Queries, applied to elements of an **executable model** that conforms to the decorated xDSML.

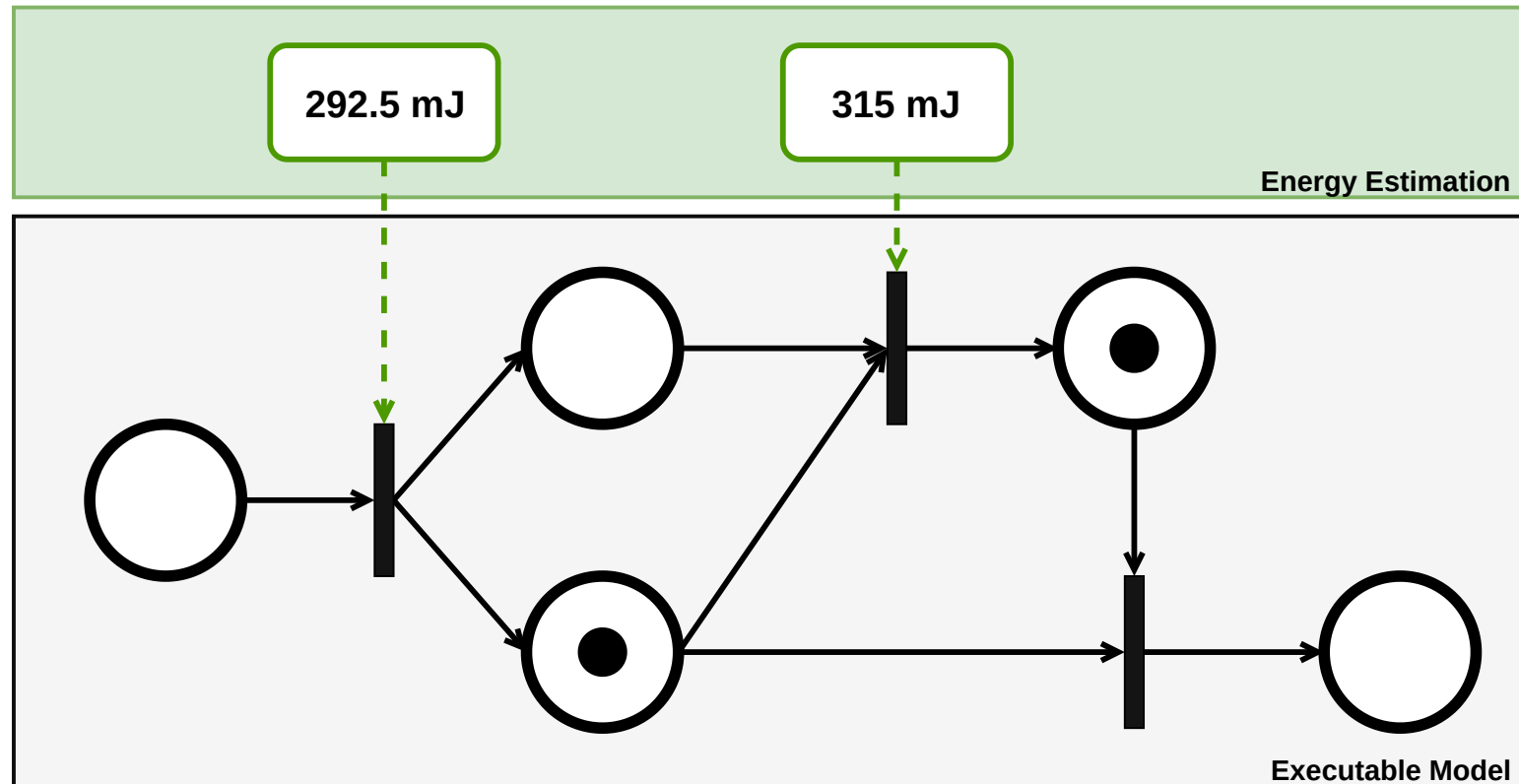
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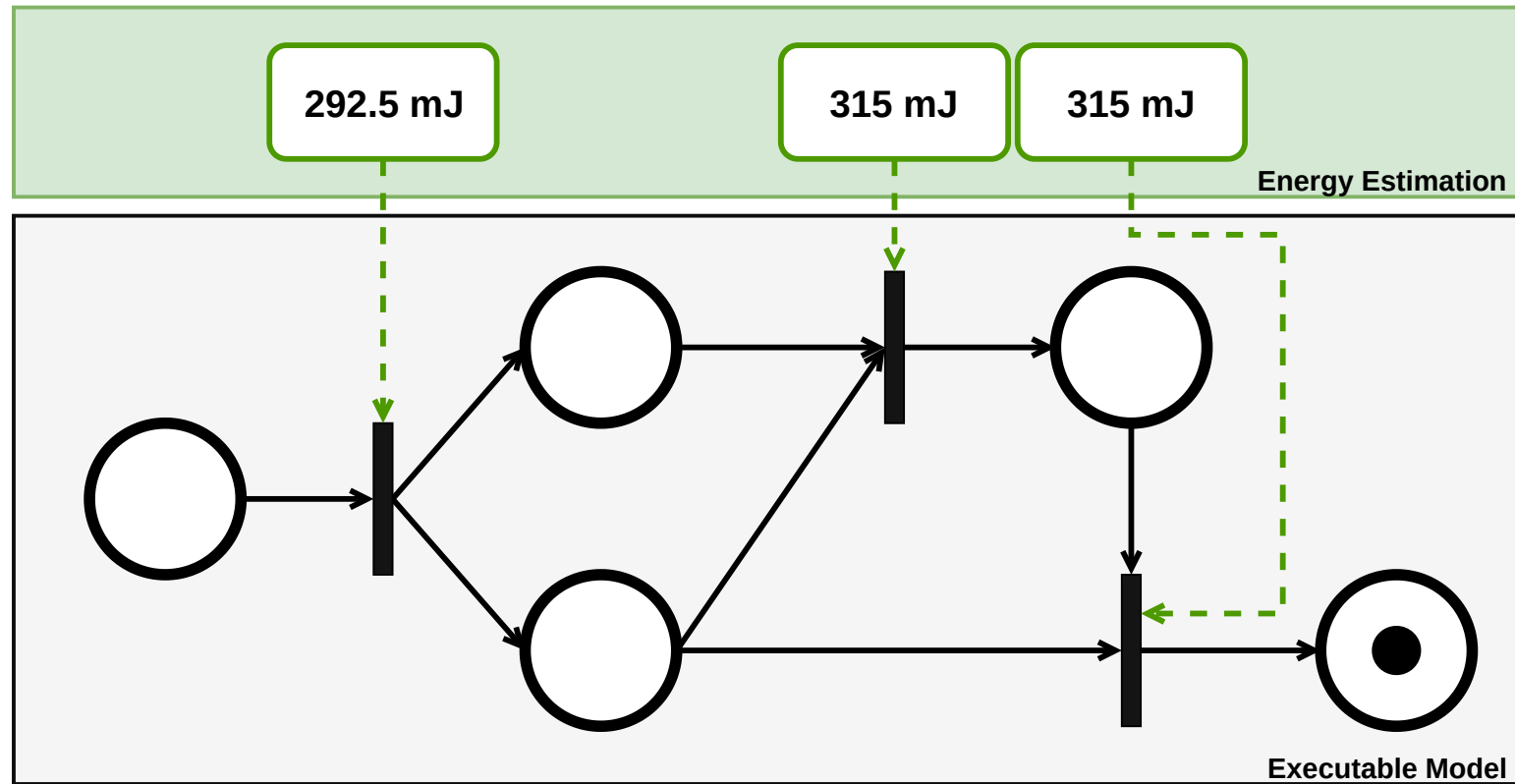
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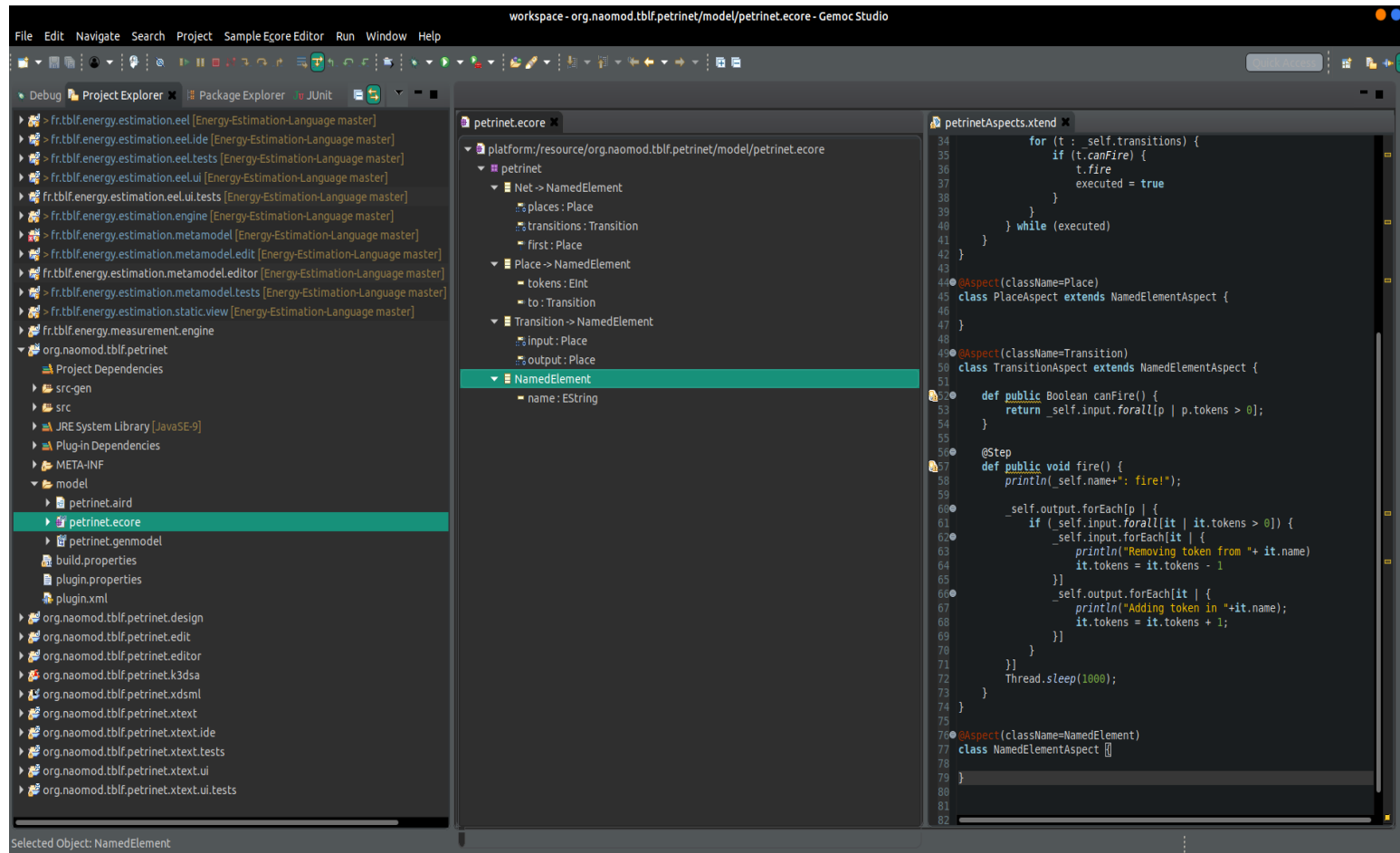
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Extension of the GEMOC modeling workbench

- 1 Takes an **energy estimation model** as an extra input.
- 2 An additional execution listener performs energy estimation during the simulation:
 - OCL EE formulas are executed **on the elements of the model**.
- 3 The energy estimation is given as a report to the DSL User.
- 4 Now s/he can improve the executable model in order to **reduce the energy consumption** of the target runtime system.

Implementation: Language workbench



Implementation: Modeling workbench

The screenshot displays the Gemoc Studio IDE interface. The top menu bar includes File, Edit, Navigate, Search, Project, Run, Energy, Window, and Help. The Package Explorer on the left shows a project structure with folders like 'org.gemoc.sample.activitydiagram.sequential.examples' and 'org.naomod.tblf.petrinet.model'. The main editor area is split into two panes. The left pane shows the code for a Platform class:

```
Platform HPG4155200U {
  targets {
    class "org.naomod.tblf.petrinet.Transition" (op "fire")
  }
  estimations {
    target "org.naomod.tblf.petrinet.Transition.fire"
    variables (tdp)
    formula "self.input -> size() * $tdp * 7.5 + self.output -> size() * $tdp * 6.0"
  }
  GLOBAL tdp = 15.0
}
```

The right pane shows the code for a Net class:

```
Net {
  name net
  places {
    Place {
      name p1
      tokens 1
    },
    Place {
      name p2
      tokens 1
    },
    Place {
      name p3
      tokens 0
    },
    Place {
      name p4
      tokens 0
    },
    Place {
      name p5
      tokens 0
    }
  }
  transitions {
    Transition {
      name t1
      output (p2, p3)
    }
  }
}
```

The bottom of the IDE features a Console window with debug output from the Gemoc Engines Status, showing messages like 'Default MessagingSystem console', 'Redirecting System.out and System.err to this console.', and '22:07:07.170 [Worker-0: Decoration Calculation] DEBUG org.eclipse.jgit.util.FS - readpi'. The status bar at the bottom indicates 'Writable', 'Insert', and '12:3'.

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```
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      tokens 1
    },
    Place {
      name p2
      tokens 1
    },
    Place {
      name p3
      tokens 0
    },
  },
}
```

```
org.naomod.tblf.petrinet.impl.TransitionImpl@36f9739b (name: t1) consumed 292.50
t1: fire!
Removing token from p1
Adding token in p2
Adding token in p3
org.naomod.tblf.petrinet.impl.TransitionImpl@648f2942 (name: t2) consumed 315.00
t2: fire!
Removing token from p2
Removing token from p3
Adding token in p4
org.naomod.tblf.petrinet.impl.TransitionImpl@5d66982d (name: t3) consumed 315.00
t3: fire!
Removing token from p4
Removing token from p2
Adding token in p5
```

Conclusion:

- A meta-model for **estimating** the energy consumption of xDSMLs.
- An extension of GEMOC modeling workbench for performing estimations at **runtime**.
- First step towards a better **energy awareness** among xDSMLs users.

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Future work:

- Empirical **evaluation** of the approach
 - Various xDSMLs
 - Various platforms
- Modelling the energy estimations with a dedicated meta-model.
- More research on the automation of the energy-estimation formulas generation.

Thanks !

Contact:

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<https://github.com/atlanmod/energy-estimation-language>