DSLs an overview

A holistic look at domain specific languages

About the session

The session is about expressive and extensible systems in general, and how DSLs in particular fit in the context of expressivity and extensibility.

Core technical concerns discussed here

Expressivity

```
The ability of the system to express arbitrary domain specific computation.
```

Extensibility

```
The ability of the system to extend it's capability without modifying the core software.
```

How can you create an expressive system?

By designing systems that has one or more of the following design.

- Plugin architecture
  - Host language plugins
  - Guest language plugins
- Internal DSLs
- External DSLs
- Visual DSLs

How can you create an extensible system?

By designing a system with a plugin architecture and one or more of the following design.

- Plugins in host language
    - Host language
    - Internal DSLs embedded in host language
- Plugins in guest language
    - Scripting language
    - Internal DSLs
    - External DSLs
    - Visual DSLs

Structural equivalence in expressiveness and extensibility

Technically the ability to capture computation dynamically in a system warrants a mechanism to execute it and such a mechanism should follow design by contract idiom, roughly something like resolve(), execute(), and cleanup() is the bare minimum abstractions required, which is nothing but an implicit plugin interface.

Given a pluggable interface the mechanism for extensibility is equivalent to the mechanism for expressivity, only the intent varies. Hence the structural equivalence.

Vectors concerning design choice (I)

Host language plugin

- Developers are encoding the computations.
- Domain object model created in host platform is both sufficient and necessary for expressing computations.
- Skill set of the team authoring plugins are in the host language.
- Doesn't require the dynamism of a scripting language.
- Empirically proven performance advantage.

Vectors concerning design choice (II)

Guest language plugin

- Developers are encoding the computations.
- Host platform object model is both sufficient and necessary for expressing computations.
- Skill set of the team authoring plugins are not in the host language.
- Flexibility of the guest language type system seems attractive for rapid prototyping and development.

Vectors concerning design choice (III)

Internal DSL

- Developers are encoding the computations.
- A domain specific abstraction is necessary for capturing the intended semantics.
- Domain specific abstraction can be embedded within a general purpose language.

Vectors concerning design choice (IV)

External DSL

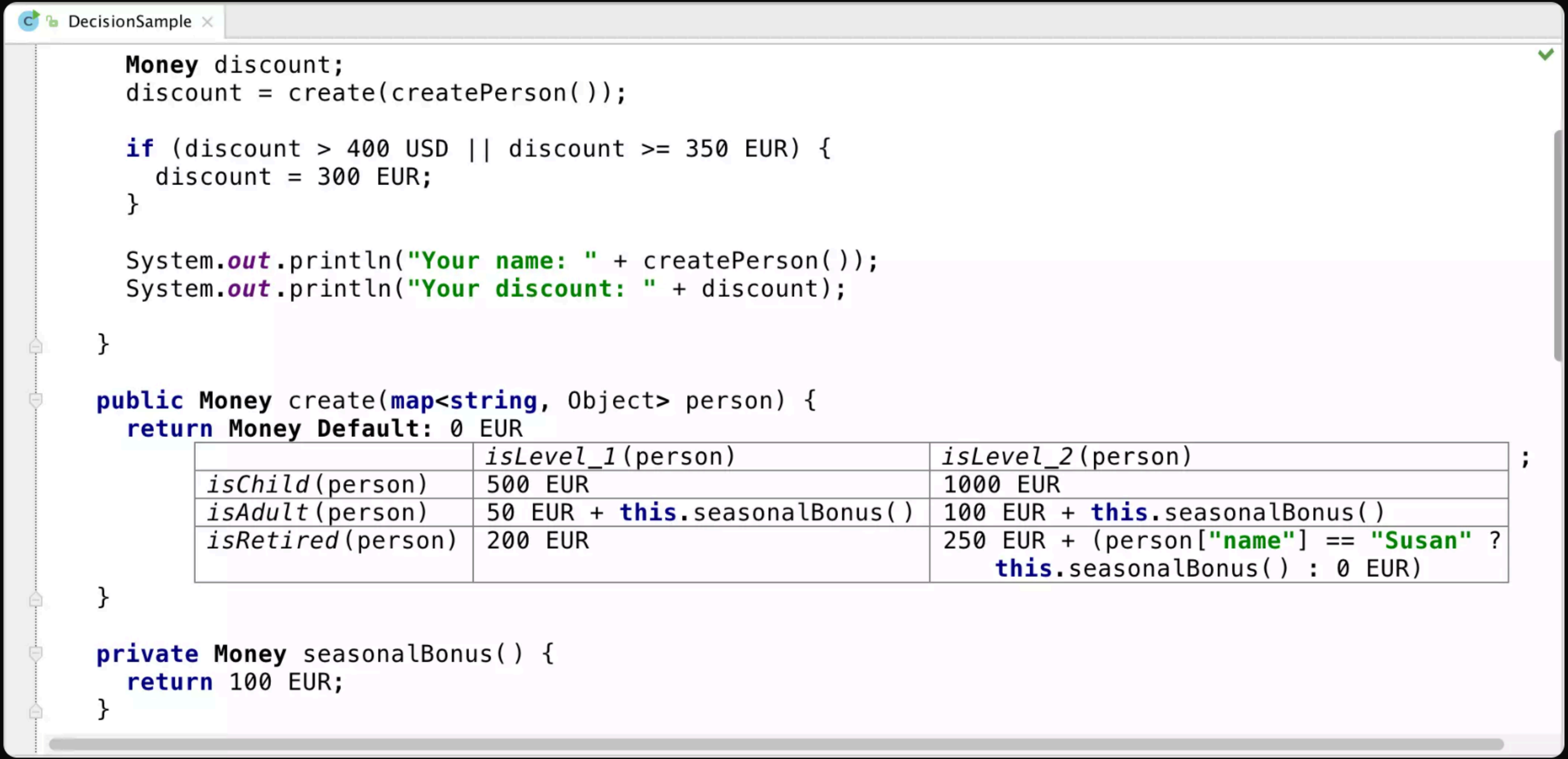
- Non technical domain experts are encoding the computations.
- Embedding domain specific abstractions in a general purpose language limits the expressivity in terms of the coherence with domain ontology.
- Needs domain standardization.
- A domain specific abstraction is necessary for capturing the intended semantics.

Vectors concerning design choice (V)

Visual DSL

- Non technical functional experts are encoding the computations.
- Technical people finds it hard to reason about the computation in a linear text based language.
- Enhanced accessibility to those who are not familiar with conventional coding practices.
- A domain specific abstraction is necessary for capturing the intended semantics.

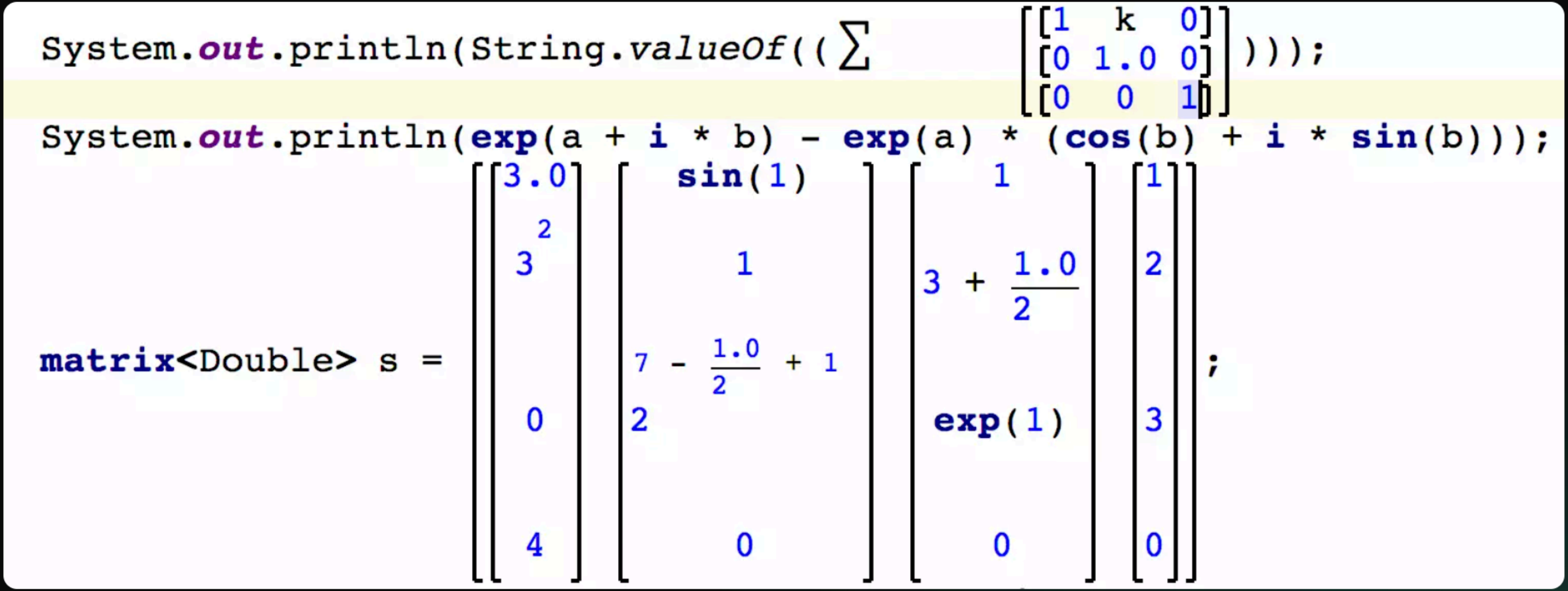
Projectional editing



```
    Money discount;
    discount = create(createPerson());

    if (discount > 400 USD || discount >= 350 EUR) {
      discount = 300 EUR;
    }

    System.out.println("Your name: " + createPerson());
    System.out.println("Your discount: " + discount);

  }

  public Money create(map<string, Object> person) {
    return Money Default: 0 EUR
```

	isLevel_1(person)	*isLevel_2*(person)
isChild(person)	500 EUR	1000 EUR
isAdult(person)	50 EUR + this.seasonalBonus()	100 EUR + this.seasonalBonus()
isRetired(person)	200 EUR	250 EUR + (person["name"] == "Susan" ? this.seasonalBonus() : 0 EUR)

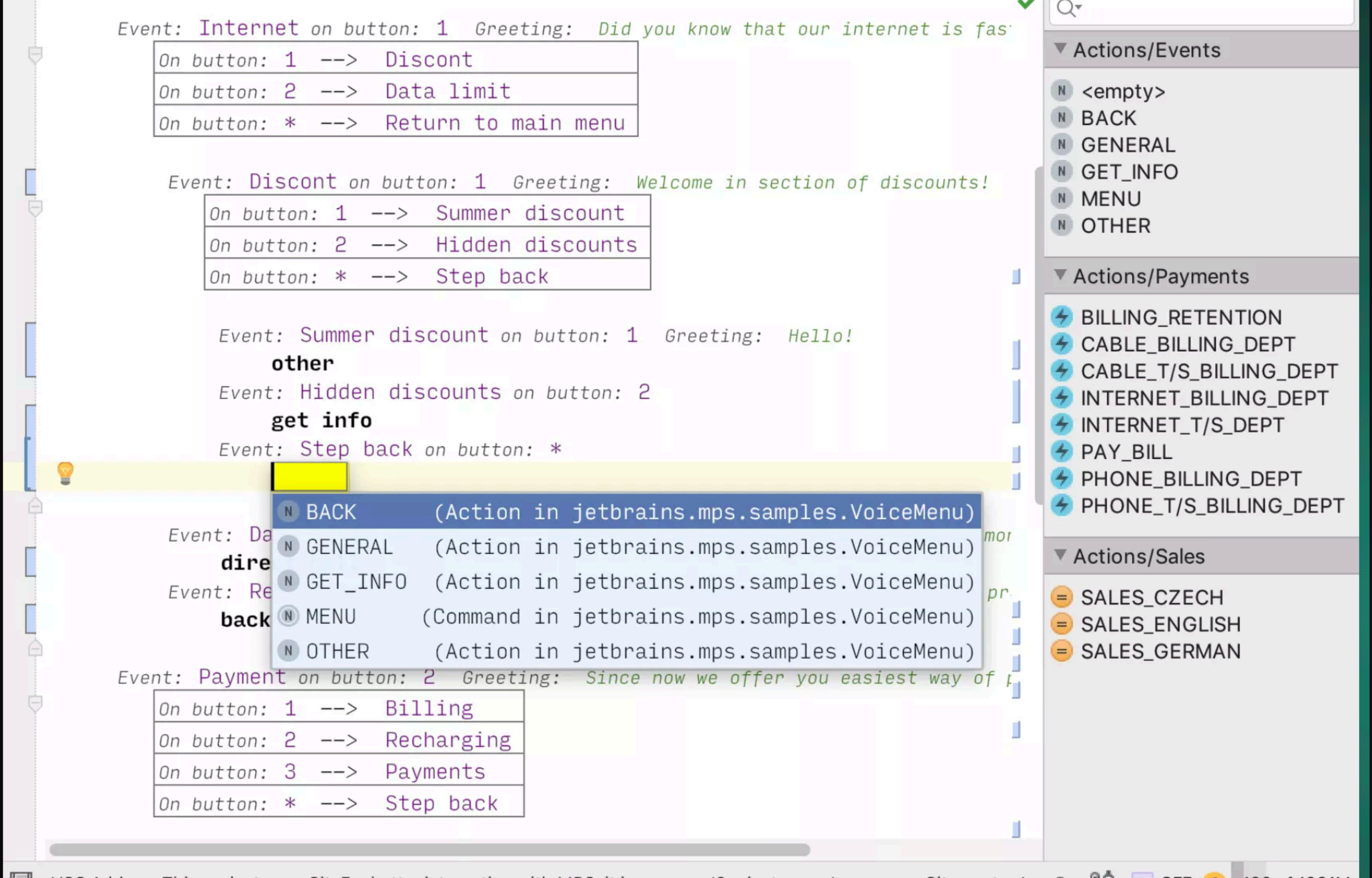
```
;
  }

  private Money seasonalBonus() {
    return 100 EUR;
  }
```



$$\texttt{System.out.println(String.valueOf((}\sum \begin{bmatrix}[1 & k & 0]\\ [0 & 1.0 & 0]\\ [0 & 0 & 1]\end{bmatrix}\texttt{)));}$$

```
System.out.println(exp(a + i * b) - exp(a) * (cos(b) + i * sin(b)));
```

$$\texttt{matrix<Double> s = }\begin{bmatrix}\begin{bmatrix}3.0\\ 3^{2}\\ 0\\ 4\end{bmatrix} & \begin{bmatrix}\mathbf{sin}(1)\\ 1\\ 2^{7-\frac{1.0}{2}+1}\\ 0\end{bmatrix} & \begin{bmatrix}1\\ 3+\frac{1.0}{2}\\ \mathbf{exp}(1)\\ 0\end{bmatrix} & \begin{bmatrix}1\\ 2\\ 3\\ 0\end{bmatrix}\end{bmatrix}\texttt{;}$$



```
Event: Internet on button: 1  Greeting:  Did you know that our internet is fas
    On button: 1  -->  Discont
    On button: 2  -->  Data limit
    On button: *  -->  Return to main menu

  Event: Discont on button: 1  Greeting:  Welcome in section of discounts!
      On button: 1  -->  Summer discount
      On button: 2  -->  Hidden discounts
      On button: *  -->  Step back

    Event: Summer discount on button: 1  Greeting:  Hello!
        other
    Event: Hidden discounts on button: 2
        get info
    Event: Step back on button: *

        BACK      (Action in jetbrains.mps.samples.VoiceMenu)
        GENERAL   (Action in jetbrains.mps.samples.VoiceMenu)
        GET_INFO  (Action in jetbrains.mps.samples.VoiceMenu)
        MENU     (Command in jetbrains.mps.samples.VoiceMenu)
        OTHER     (Action in jetbrains.mps.samples.VoiceMenu)
  Event: Da                                                                   mor
      dire
  Event: Re                                                                   pr
      back

Event: Payment on button: 2  Greeting:  Since now we offer you easiest way of p
    On button: 1  -->  Billing
    On button: 2  -->  Recharging
    On button: 3  -->  Payments
    On button: *  -->  Step back
```

How to construct a plugin

The **Design by Contract** approach is a widely used design pattern for developing plugins.

At a code level, we define an interface that each plugin must implement. This interface serves as a 'contract' that ensures each plugin adheres to a standard structure and behavior.

```
public interface PluginInterface {
    boolean preExecute(Context context);
    boolean execute(Context context);
    boolean postExecute(Context context);
}
```

Components of a plugin

When designing a plugin with a Design by Contract approach, the following components are typically involved:

- Plugin interface.
- Plugin Invoker.
- Discovery mechanism.
- Context Object.
- Plugin implementation.

Plugins demonstration

This demonstration will be a host and guest language plugin adapted from the .Net Design Patterns by Praseed Pai and Shine Xavier.

An Example internal DSL for SQL - JOOQ

```
// Fetch a SQL string from a jOOQ Query in order to manually execute it with another tool.
DSLContext create = DSL.using(conn, SQLDialect.MYSQL);
Query query = create.select(BOOK.TITLE, AUTHOR.FIRST_NAME, AUTHOR.LAST_NAME)
                    .from(BOOK)
                    .join(AUTHOR)
                    .on(BOOK.AUTHOR_ID.eq(AUTHOR.ID))
                    .where(BOOK.PUBLISHED_IN.eq(1948));

String sql = query.getSQL();
List<Object> bindValues = query.getBindValues();
```

DSLContext - the main abstraction of the library that implements the fluent interface.

External DSL design (I)

External DSL follows a proper programming language design.
It requires all the infrastructure a general purpose language requires.

Standard compiler pipeline will consist of the following

- Lexer
- Parser
- Semantic Check
- Optimizer
- Transcompiler or Compiler (Depends on the target)

External DSL design (II)

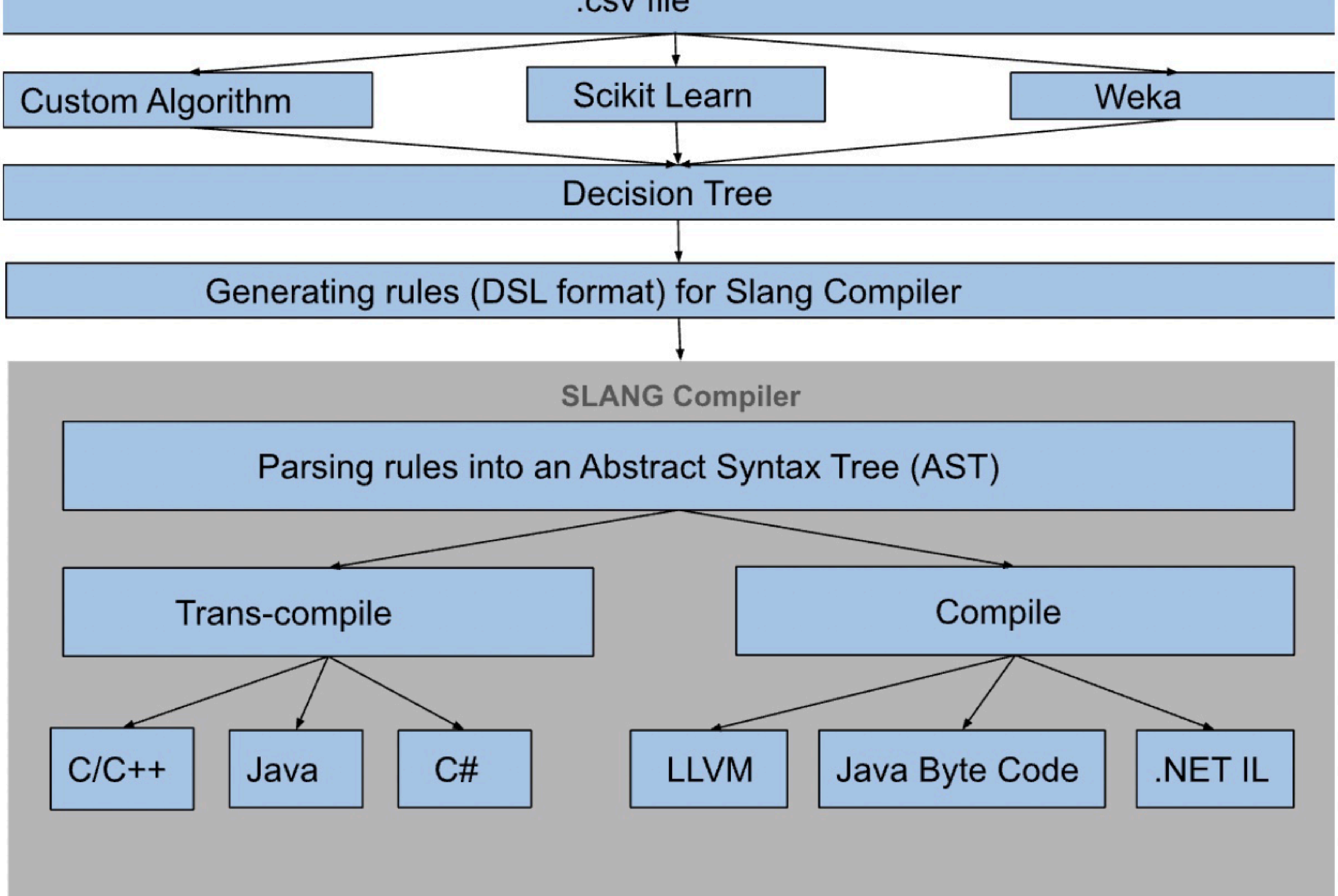
Runtime

- Standard library consisting of domain object models & abstractions on top of it.

Other infrastructure required

- Language Server
- Editor

An example use case



.csv file

Custom Algorithm

Scikit Learn

Weka

Decision Tree

Generating rules (DSL format) for Slang Compiler

SLANG Compiler

Parsing rules into an Abstract Syntax Tree (AST)

Trans-compile

Compile

C/C++

Java

C#

LLVM

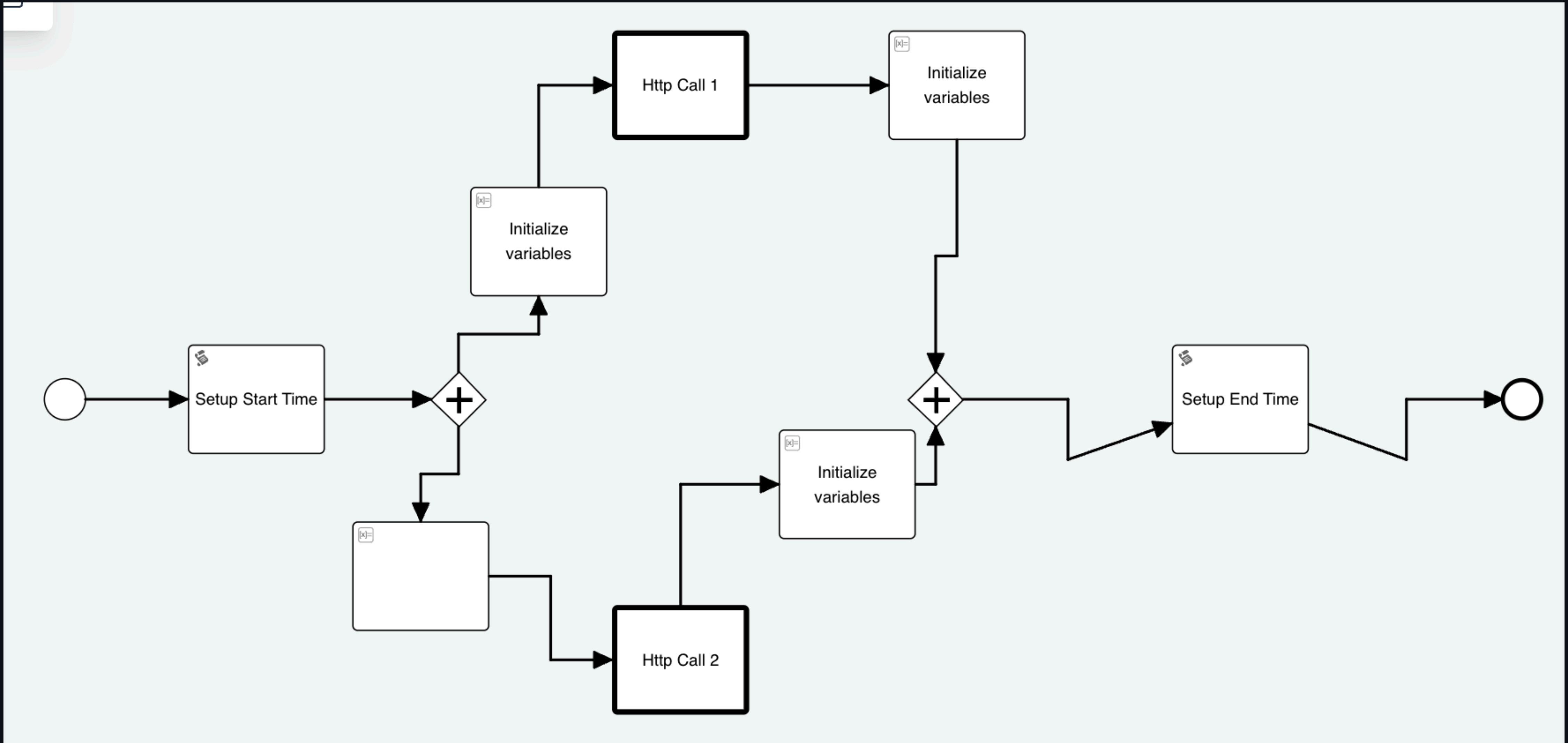
Java Byte Code

.NET IL

Using ANTLR for language design

```
prog:   stat+ ;
stat:   expr ';'                   # ExprStat
    |   'if' '(' expr ')' prog ('else' prog)?  # IfElseStat
    |   'print' '(' expr ')' ';'   # PrintStat
    |   ID '=' expr ';'            # AssignStat
    ;

expr:   expr andOp expr            # And
    |   expr orOp expr             # Or
    |   expr relationalOp expr     # Relational
    |   expr mulDivOp expr         # MulDiv
    |   expr addSubOp expr         # AddSub
    |   '(' expr ')'               # Parens
    |   INT                        # Int
    |   ID                         # Var
    |   '!' expr                   # Not
    ;
```

An example visual DSL



Semantic constructs in a Visual DSL

- Relational expression
- Logical expression
- Module invocation
- If expression (projected construct)
- Loop expression (projected construct)
- ...

Logical and Relational Expressions

```
{
    "id": "outcome",
    "outcome": "Reject",
    "isDefault": false,
    "rules": [
        {
        "rules": [
            {
            "rules": [
                {
                    "field": "firstName",
                    "value": ["Go", "Kevin"],
                    "operator": "isAnyOf"
                },
                {
                    "field": "lastName",
                    "value": "Team",
                    "operator": "is"
                }
            ],
            "combinator": "and"
            },
            {
                "field": "email",
                "value": "goteam@gbgplc.com",
                "operator": "is"
            }
        ],
        "combinator": "xor"
        }
    ]
}
```

Module invocation

```
{
    "id": "node2",
    "type": "module",
    "variantId": "default",
    "data": {
        "grId": "grn:::gbg:design:module:module1@latest",
        "id": "module1",
        "name": "ID3 UK 1 + 1 module",
        "data": {
            "base64File": "@@binary", // Flowable App honoring module spec
            "symbols": [] // variables or state exposed by the module
        }
    }
}
```

If expression

```
{
    "id": "node3",
    "type": "if",
    "expression":  {
        "left": {
            "type": "constantExpression",
            "value": "10"
        },
        "right": {
            "type": "constantExpression",
            "value": "20"
        },
        "operator": "<",
        "leftTargetNode": "node8",
        "rightTargetNode": "node4",
    }
}
```

Loop expression

```
{
    "id": "node4",
    "type": "loop",
    "expression":  {
        "left": {
            "type": "constantExpression",
            "value": "10"
        },
        "right": {
            "type": "constantExpression",
            "value": "20"
        },
        "operator": "<",
        "exitNode": "node6",
        "repeatNode": "node2",
    }
}
```

Thank You

You can find more details in our GitHub repository.

- Presentation
- Presentation Markdown
- Plugin Example, Internal DSL, Compilers - Pull Sub Modules
- Antlr Example