Extensible Visual Constraint Language

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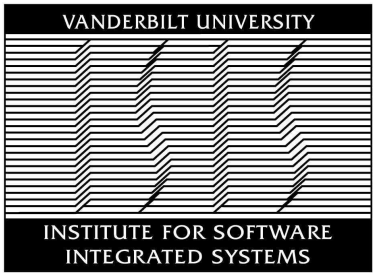


Background

Constraints

- Well-formedness rules for a DSML
- Typically written in OCL or Microsoft Formula

WebGME

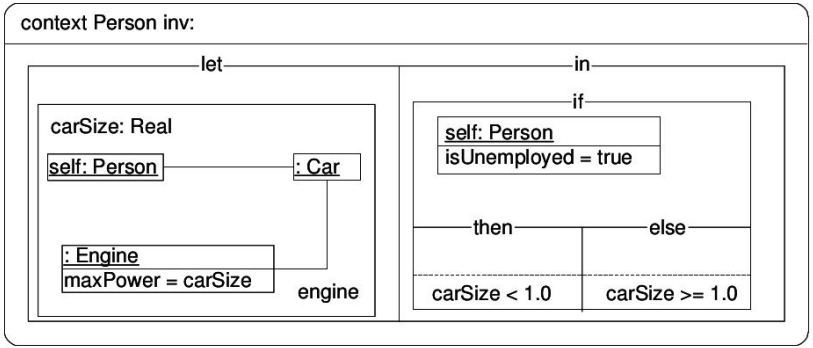
- Next generation of the GME
- Runs in a web browser
- Component based
- Provides:
  - Scalability
  - Real-time collaboration
  - Version control
  - Custom data visualizations

Related Work

Other Visual Constraint Approaches

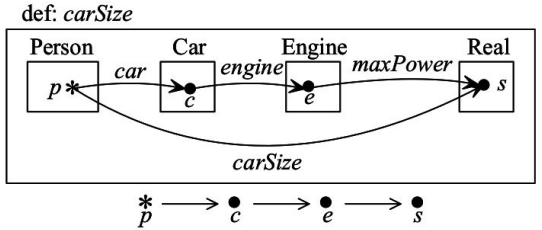
Visual OCL

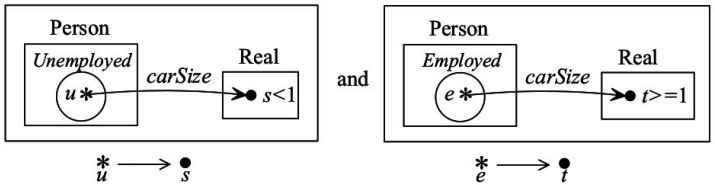
- Logical, typed, object oriented
- Adheres to UML for simplicity



Constraint Diagrams

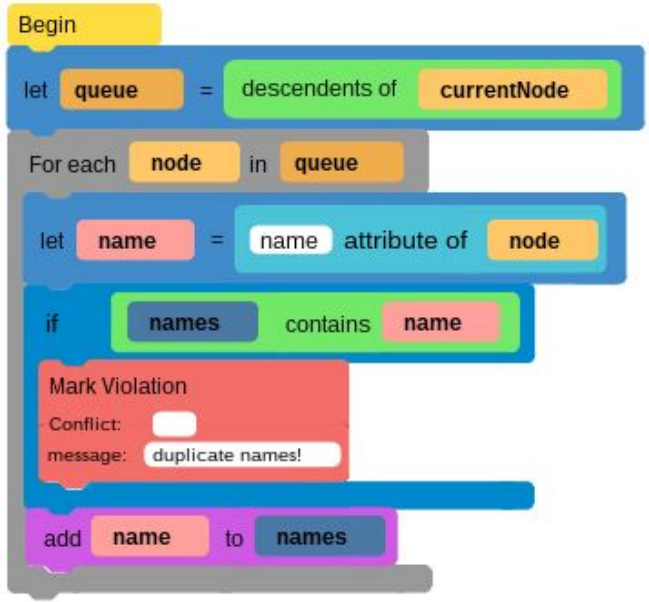
- Logical, typed, object oriented
- Similar to Euler diagrams
- More compact than Visual OCL





Extensible Visual Constraint Language

- Inspired by Scratch from MIT
  - Explicitly focuses on making programming more accessible
  - Imperative
- Implemented as a DSML
  - Supports domain specific customization
- Supports evaluation in distributed environment



Architecture

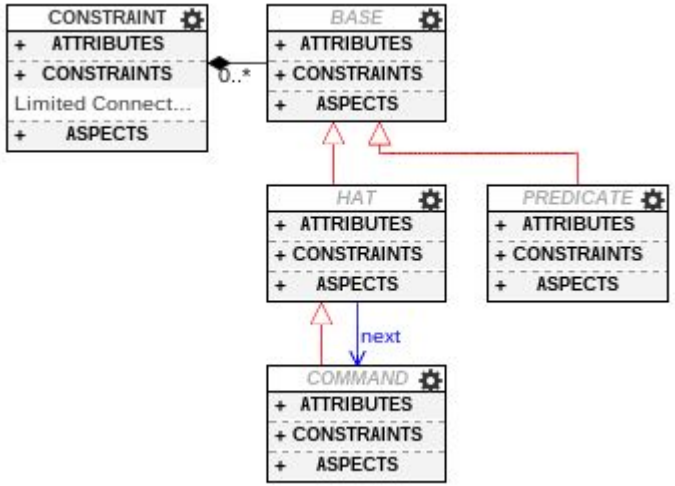
Components

- Composed of 4 main components
  - Metamodel
    - Defines language syntax
  - Model
    - Contains constraint instances
  - Visualizer
    - Provides the Scratch-like representation
  - Compiler
    - Transpiles the visual blocks to asynchronous Javascript
    - Implemented as a WebGME plugin

Language Syntax

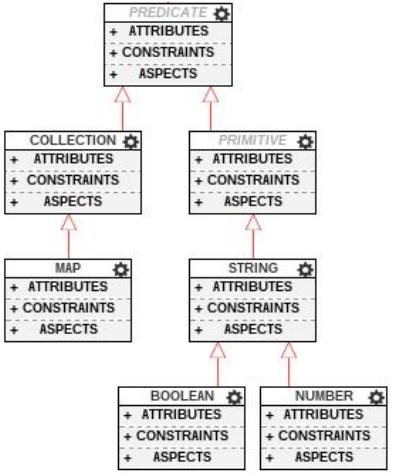
Core Concepts

- Represents the basic structure of the elements
- Blue lines represent pointers in the metamodel
  - The visualizer will interpret these as connected or contained blocks



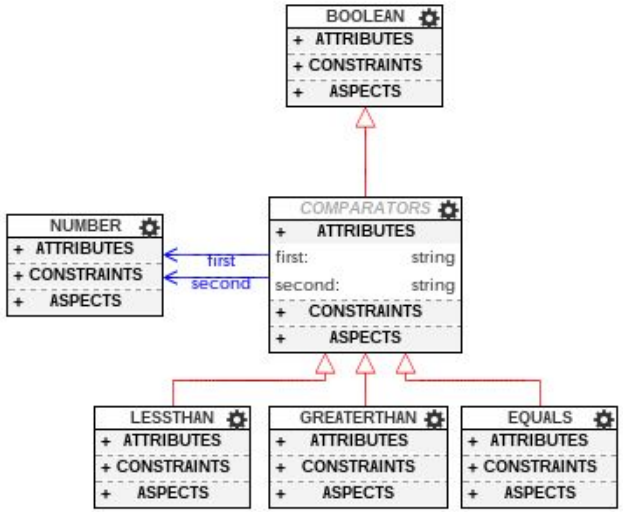
Data Types

- Data types are instances of a *Predicate* block
- Inheritance allows the child block to be implicitly casted to the base block type



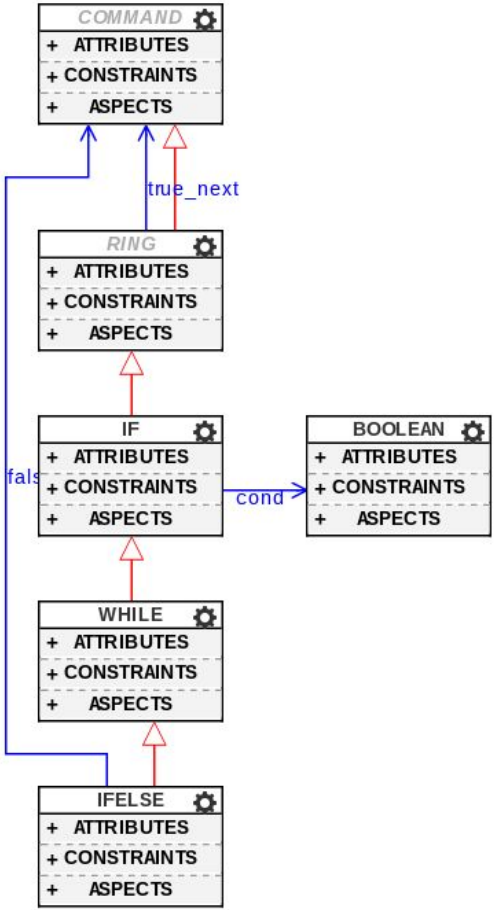
Functions

- Functions inherit from their return type
  - This allows them to be used as their respective return type
- Pointers represent the input for the given function



Control Flow

- Inheritance represents structural similarities
- The “true_next” pointer references the block contained in the parent which is executed if the conditional (target block of the “cond” pointer) is true
- Similarly, the “false_next” pointer references the block to be executed if the conditional is false



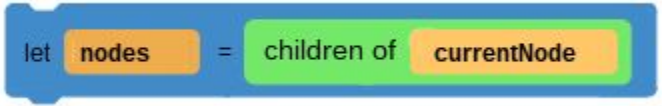
Constraint Generation

Code Generation

- Asynchronous support
  - Hoisting the necessary code into the callback
  - Deterministic evaluation of loops (without causing a stack overflow)
- Additional Features
  - Framework for testing new constraint code blocks
  - Variable hoisting
  - Promotes scalable constraint code
    - Lazy loading of WebGME nodes

Callback Hoisting

- In synchronous code, the generated code for a *predicate* block is the return value of the block
- Example:



```
nodes = getChildren(currentNode);
// next block's code
```

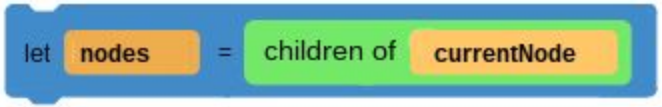
Callback Hoisting

- In asynchronous code, the generated code for a *predicate* block will include the creation of the context in which the return value is defined
- Example:

```
getChildren(currentNode, function(children) {
    {{= RETURN_VALUE.START }}children{{= RETURN_VALUE.END}}
});
```

Callback Hoisting

- In asynchronous code, the generated code for the parent block is hoisted into the correct context (placed around the return value)
- Generated code for command blocks stores the location of the subsequent code
- Example:

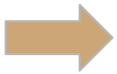


```
getChildren(currentNode, function(children) {
    nodes = children;
    // next block's code
});
```

Deterministic Loops

- Loops are converted to recursive functions
- To eliminate stack overflow, recursive calls are placed in a “setTimeout” call
  - This flattens the call stack
  - Each subsequent call is placed on the event queue at the end of the execution of the prior iteration

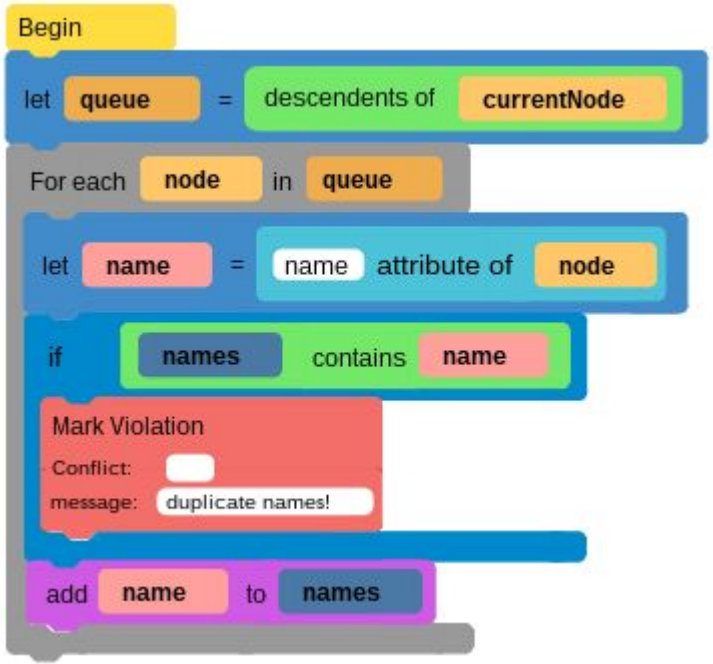
```
while (myConditional) {
  // Executed while
  // "myConditional" is true
}
// Executed once
// "myConditional" is false
```



```
var asyncLoop = function() {
  if (myConditional) {
    // Executed if "myConditional" is true
    setTimeout(asyncLoop, 0);
  } else {
    // Executed once "myConditional" is false
    // Subsequent blocks' code is hoisted here
  }
};
```

Example

Unique Name Constraint




```
function (core, currentNode, callback){
  "use strict";

  var names = [];
  var name = null;
  var node = null;
  var queue = [];

  getNode(currentNode, function(arg0_7){
    getDescendents(arg0_7, function(arg1_6){
      queue = arg1_6;
      var fn_1 = function(){
        var arg1 = Object.keys(queue);
        var arg2 = arg1[0];
        while(arg0_2[arg2] && arg1.length){
          arg2 = arg1.pop();
        }
        if (!arg0_2[arg2]){
          arg0_2[arg2] = true;
          node = queue[arg2];
          getNode(node, function(arg0_4){
            name = core.getAttribute(arg0_4, "name");
            if (names.indexOf(name) !== -1){
              violationInfo = {
                hasViolation: true,
                message: "duplicate names!",
                nodes: null
              };
            }
            if(getDimension(names) === getDimension(name)){
              names = names.concat(name);
            } else {
              names.push(name);
            }
            setTimeout(fn_1, 0);
          });
        } else {
          callback(err, violationInfo);
        }
      };
      var arg0_2 = {};
      fn_1();
    });
  });
}
```

Questions?