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mbeddr
An extensible set of integrated languages for embedded software engineering.

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<td>Reports &amp; Assessments</td>
<td>to be defined by users</td>
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</table>
#constant TAKEOFF = 100; >> implements PointsForTakeoff
#constant HIGH_SPEED = 10; >> implements FasterThan100
#constant VERY_HIGH_SPEED = 20; >> implements FasterThan200
#constant LANDING = 100; >> implements FullStop

[verifiable]
exported statemachine FlightAnalyzer initial = beforeFlight {
  in event next(Trackpoint* tp) <no binding>
  in event reset() <no binding>
  out event crashNotification() => raiseAlarm
  readable var int16 points = 0
  state beforeFlight {
    // [ Here is a comment on a transition. ]
    on next [tp->alt == 0 m] => airborne
    exit { points <= TAKEOFF; } >> implements PointsForTakeoff
  } state beforeFlight
  state airborne {
    // [ Here is a comment on a transition. ]
    on next [tp->alt == 0 m && tp->speed == 0] => crashed
    state airborne {
      // [ Here is a comment on a transition. ]
      on next [tp->speed > 200 m/s && tp->speed > 0 m/s] => laned
      on next [tp->speed > 100 m/s && tp->speed <= 200 m/s] => air
      state airborne {
        // [ Here is a comment on a transition. ]
        on next tp->speed == 0 m/s => laned
        on next tp->speed == 100 m/s => air
        state airborne {
          // [ Here is a comment on a transition. ]
          on next tp->speed == 0 m/s => laned
        } state airborne
      } state airborne
      state laned {
        on next [tp->speed == 0 m/s] => landed
      } state laned
    } state airborne
  } state airborne
  state landed {
    ...
Open Source @ eclipse.org
Eclipse Public License 1.0
http://mbeddr.com
itemis France: Smart Meter

First significant mbeddr project
cia. 100,000 LoC
about to be finished
great modularity due to components
uses physical units extensively
great test coverage due to special extensions
ACCEnT
Control.Lab

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LMS is a leading provider of test and mechatronic simulation software and engineering services in the automotive, aerospace and other advanced manufacturing industries. As a business segment within Siemens PLM Software, LMS provides a unique portfolio of products and services for manufacturing companies to manage the complexities of tomorrow’s product development by incorporating model-based mechatronic simulation and advanced testing in the product development process. LMS tunes into mission-critical engineering attributes, ranging from system dynamics, structural integrity and sound quality to durability, safety and power consumption. With multi-domain and mechatronic simulation solutions, LMS addresses the complex engineering challenges associated with intelligent system design and model-based systems engineering. Thanks to its technology and more than 1250 dedicated people, LMS has become the partner of choice of more than 5000 manufacturing companies worldwide. LMS operates in more than 30 key locations around the world.
20+ Projects in various stages by various “Big Name” companies.
The Language Workbench
Open Source
Apache 2.0
http://jetbrains.com/mps
Language Workbench

+ Refactorings, Find Usages, Syntax Coloring, Debugging, ...
Projectional Editing
[Projectional Editing]

Parsing

[Diagram showing parsing process with Concrete Syntax leading to Abstract Syntax Tree]

Projectional Editing

[Diagram showing projectional editing process with Concrete Syntax leading to Abstract Syntax Tree]
[Projectional Editing]  
Syntactic Flexibility

Regular Code/Text

Mathematical

Tables

Graphical
Projectional Editing
Syntactic Flexibility

Regular Code/Text

```c
// A documentation comment with references
to @arg(data) and @arg(dataLen)
void aSummingFunction(int8[] data, int8 dataLen) {
    int16 sum;
    for (int8 i = 0; i < dataLen; i++) {
        sum += data[i];
    }
} aSummingFunction (function)
```

Mathematical

```
double midnight2(int32 a, int32 b, int32 c) {
    return \frac{-b + \sqrt{b^2 - \sum_{i=1}^{4} a \cdot c}}{2 \cdot a};
} midnight2 (function)
```

Tables

<table>
<thead>
<tr>
<th>alt</th>
<th>spd &gt; 0</th>
<th>spd &gt; 100</th>
<th>otherwise 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>== 0</td>
<td>10</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>&gt; 0</td>
<td>30</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>&gt; 100</td>
<td>50</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

Decide (function)

Graphical

```
Cst.Customer

Contract
starts: date
ends: date
```

```
Tariff
attributes
```

cust 1

```
trf 1
```

Tariff
attributes
[Projectional Editing]
Language Composition

Separate Files

Type System
Transformation
Constraints

In One File

Type System
Transformation
Constraints
Syntax
IDE
Projectional Editing
Language Composition

Separate Files
- L2
- L1

Type System
Transformation
Constraints

In One File

Type System
Transformation
Constraints
Syntax
IDE

50+ extensions to C
10+ extensions to requirements lang.
Version 3.1.2 released recently:
Better Performance, Graphical Editors
Better Tables, Tooltips, Better Console
3

Bottom Line
Up-Front
Fundamentally it was a success.
Research Project Completed
Lively OS project
Paying customers
Expanded to other domains
Learned a lot
New Research Opportunities
Papers + my PhD
Fundamentally it was a success. But there were Problems/Challenges
Good Experience.

Neutral Observation

Problem/Challenge
Lessons: mbeddr-related
Default extensions are useful, in particular components, state machines and units.
Easy and useful to add customer specific extensions.
The non-code languages (Req, PLE, Doc) are more useful and important than we initially thought.
RCP version of MPS crucial for end users. We had underestimated this.
Decided not to make extensions BL independent, they are actually C extensions and cannot be used with other base languages.
mbeddr requires a fundamental change in how people develop software. Makes it hard to "sell".
Integration with analysis tools work and is useful, but performance of the analysis is still an issue.
Do more verification on code level than on model level because of consistency problem with code.
Writing optimizing generators is hard.
Underestimated importance of style of generated code.
Some extensions had to be redone (units) because we didn't get them right the first time.
Splitting C into several languages not so useful – dependencies!
Some of our "C cleanups" were not sustainable.
Importer more challenging than expected (because of #preprocessor)
5 Lessons: MPS-related
Modularity works in principle and practice
MPS’ approach scales to non-trivial and many languages.
Flexible notations actually work and are useful in practice.
Decoupling Notation from Language works.
MPS is easily extensible with new notational styles.
Editor Usability less and less of a Problem as MPS evolved/s.
VCS integration works well (diff/merge)
MPS can be extended with the same means – bootstrapped.
Language Testing works well enough to stabilize non-trivial languages.
MPS also supports debugging of DSLs – even though we had to extend the mechanism
MPS had quite a number of bugs and a few conceptual problems. We worked with JB to resolve them. Generally worked well, though.
Type system is the most challenging aspect of language definition.
No direct support for detecting semantic interactions between languages
Modularity:
Sometimes base language requires change (introduction of abstract class or interface)
Model Migration upon language change is sometimes tedious. To be fixed in 3.2
Renaming languages is sometimes painful.
Cross-model generation not possible – being worked on right now.
Ability to create additional language aspects missing.
Debugger definition separate from generator; leads to duplication
Tracing back from the generated code to the model is not consistent; problems for debugger and analysis.
many aspects of language definition too „procedural" and hence hard to analyze. Eelco's stuff.
Due to the open world assumption of MPS, there is a "feeling of incompleteness" aspects like e.g. in lifting analyses results.
6 Lessons: Life in General
A government project that really worked together on one tool – rare!
mbeddr was only possible because of a highly motivated small team.
mbeddr was only possible because of itemis support.
mbeddr was only possible because of support.
Underestimated "overhead": installer, docs, ...
Not enough time for refactorings - as usual.
More and more team leading and organization for me and Bernd.
The best 3 years in my professional life so far.
Thank you!