Building mbeddr:
An Experiment in Language Engineering

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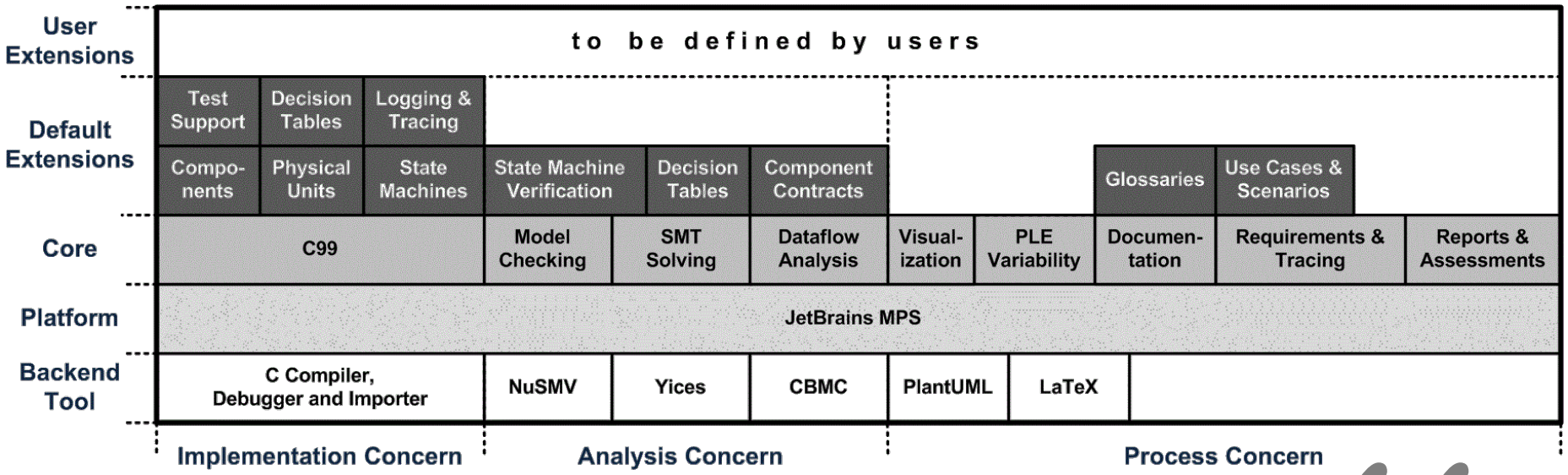
mbeddr

An extensible set of integrated languages for embedded software engineering.



“Specific Languages”

mbeddr

StateMachines – tutorial – [~/Documents/mbeddr/mbeddr.core/code/applications/tutorial]

```
#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 bef
  state airborne {
    on next [tp->alt == 0 m && tp->speed == 0] -> crashed
    on next [tp->alt == 0 m && tp->
    [on next [tp->speed > 200 mps &
    [on next [tp->speed > 100 mps &
    on reset [ ] -> beforeFlight
  } state airborne
  state landing {
    on next [tp->speed == 0 mps] -> landed
    [on next [tp->speed > 0 mps] -> landing { points--; }] -> imp
```

Error: type int16/[m / s] is not comparable with (uint8 || int8)

```
alt                    ^DataStructures.Trackpoint.alt (Member)
crashNotification      ^StateMachines.FlightAnalyzer.crashNotification (OutEvent)
id                     ^DataStructures.Trackpoint.id (Member)
speed                  ^DataStructures.Trackpoint.speed (Member)
time                   ^DataStructures.Trackpoint.time (Member)
x                      ^DataStructures.Trackpoint.x (Member)
y                      ^DataStructures.Trackpoint.y (Member)
```

```
#constant TAKEOFF = 100; -> implements PointsForTakeoff
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[verifiable]
exported statemachine FlightAnalyzer initial = beforeFlight
```

	next(Trackpoint* tp)
beforeFlight	//[Here is a comment on a transition.]
	[tp->alt == 0 m] -> airborne
airborne	[tp->alt == 0 m && tp->speed == 0] -> crashe
	[tp->alt == 0 m && tp->speed > 0 mps] -> lan
	[tp->speed > 200 mps && tp->alt == 0 m] ->
	[tp->speed > 100 mps && tp->speed <= 200 mp
	tp->alt == 0 m] -> airborne
landing	[tp->speed == 0 mps] -> landed
	[tp->speed > 0 mps] -> landing -> implements Sh
landed	

```
alyzer initial = b
```

	next(Trackpoi
beforeFlight	[tp->alt > 0
composite state airborne initial = flying {	[onTheGround

Open Source @ eclipse.org
Eclipse Public License 1.0
http://mbeddr.com

itemis France: **Smart Meter**

First significant mbeddr project
ca. 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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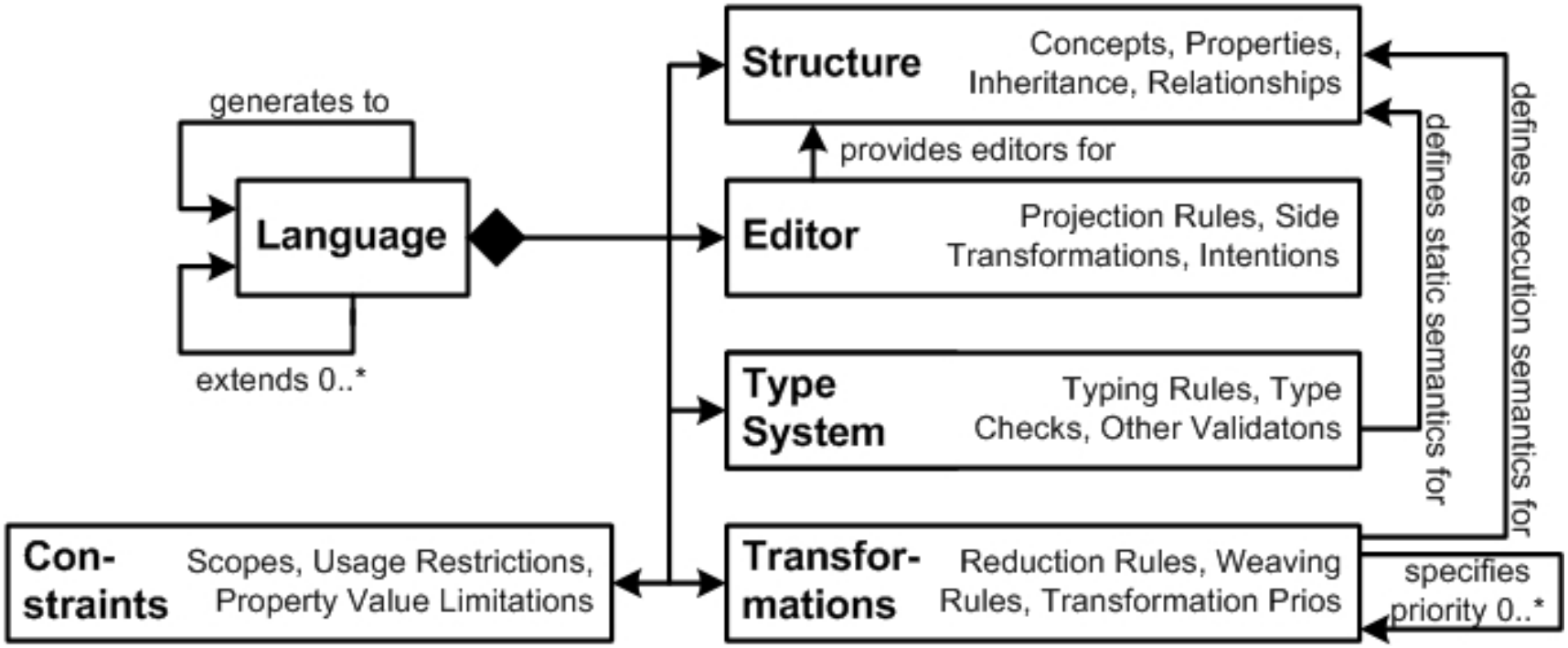
The Language Workbench

Open Source
Apache 2.0
http://jetbrains.com/mps

[Language Workbench]

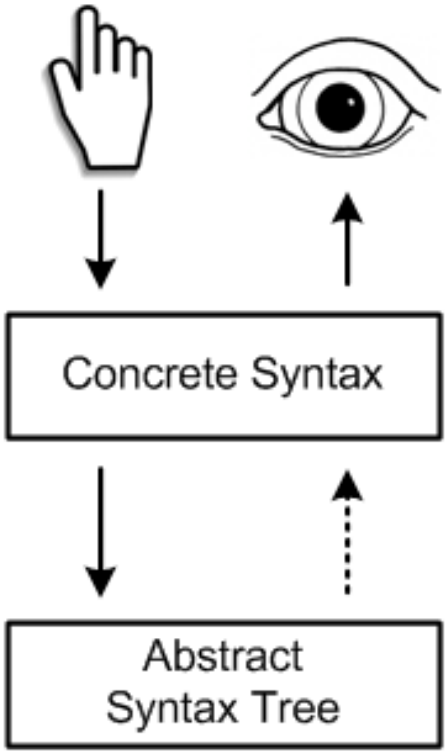


+ Refactorings, Find Usages, Syntax Coloring, Debugging, ...

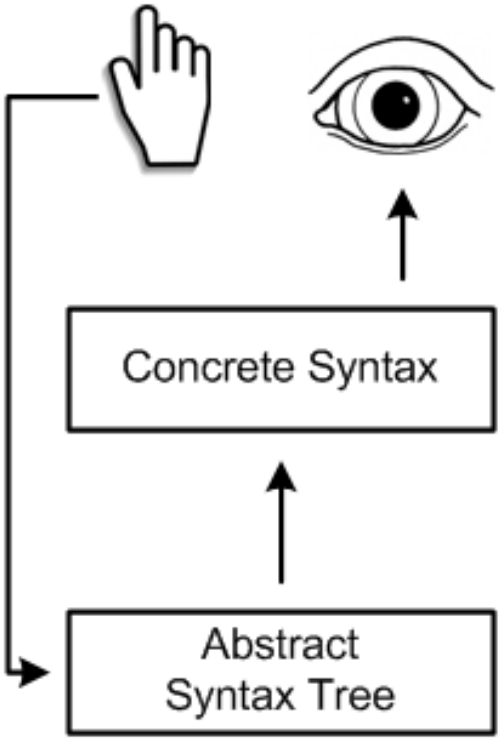
Projectional Editing

[Projectional Editing]

Parsing



Projectional Editing



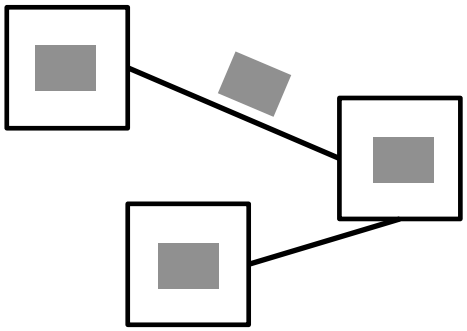
[Projectional Editing]
Syntactic Flexibility

Regular Code/Text

Mathematical

Tables

Graphical



[Projectional Editing]
Syntactic Flexibility

Regular Code/Text

```
//[ 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];
  } for
} aSummingFunction (function)
```

Mathematical

```
double midnight2(int32 a, int32 b, int32 c) {
```

$$\text{return}\ \frac{-b + \sqrt{b^2 - \sum_{i=1}^{4} a * c}}{2 * a};$$

```
} midnight2 (function)
```

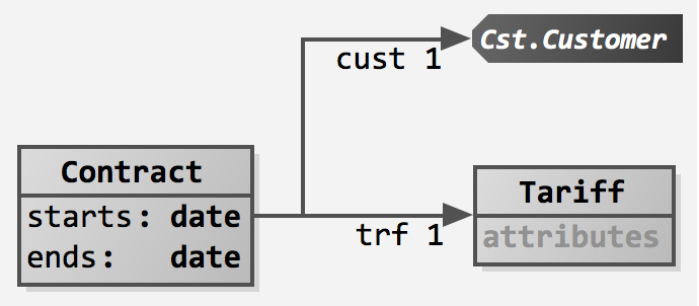
Tables

```
int16 decide(int8 spd, int8 alt) {
  return
```

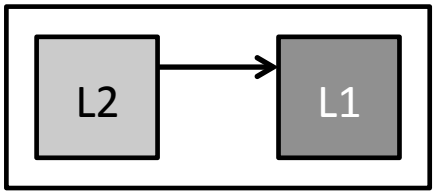
	spd > 0	spd > 100
alt < 0	1	1
alt == 0	10	20
alt > 0	30	40
alt > 100	50	60

```
otherwise 0;
} decide (function)
```

Graphical



[Projectional Editing]
Language Composition



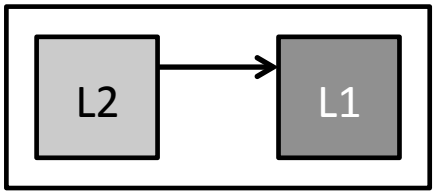
Separate Files

Type System
Transformation
Constraints

In One File

Type System
Transformation
Constraints
Syntax
IDE

[Projectional Editing]
Language Composition



Separate Files

Type System
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In One File

Type System
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mbeddr

50+ extensions to C
10+ extensions to requirements lang.

Version 3.1.2 released recently:

Better Performance, Graphical Editors
Better Tables, Tooltips, Better Console

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Bottom Line Up-Front

Fundamentally it was a success.

Resarch 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

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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)

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Lessons: MPS-related

Modularity works in principle and practice

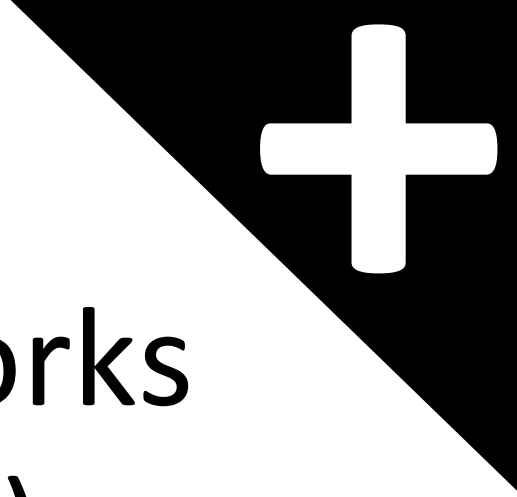
MPS‘ approach scales to non-trivial and many languages.

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 con-ceptual 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 interations 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 onsistent; 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.

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Lessons:
Life in General

A govenment 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 JetBRAINS 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!

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