How we built it and what we have learned

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An extensible set of integrated languages for embedded software engineering.

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"Specific Languages"
#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
    [tp->alt == 0 m & & tp->speed == 0] => crashed
    exit { points <= TAKEOFF; } implements PointsForTakeoff
  } state airborne {
    [tp->speed == 0 m & & tp->speed == 0] => crashed
    on next [tp->speed > 200 mps & & tp->speed > 0 mps] => landed
    on next [tp->speed > 100 mps & & tp->speed <= 200 mps] => landed
    on next [tp->speed == 0 mps] => landed
    on next [tp->speed == 0 mps & & tp->speed < 0 mps] => landed
    beforeFlight {
      type int16[m/s] is not comparable with (uint8 || int8)
    } state airborne {
      [tp->alt > 0] => airborne
      [tp->speed == 0 mps] => landed
      on next [tp->speed == 0 mps & & tp->speed == 0] => crashed
    }
  } state landing {
    [tp->speed == 0 mps] => landed
    [tp->speed == 0 mps] => landed
    [tp->speed == 0 mps] => landed
  } state beforeFlight {
    [tp->alt == 0 m] => airborne
    [tp->alt == 0 m & & tp->speed == 0] => crashed
    crashNotification ^StateMachines.FlightAnalyzer.crashNotification (OutEvent)
    ^DataStructures.Trackpoint.alt (Member)
    ^DataStructures.Trackpoint.id (Member)
    ^DataStructures.Trackpoint.speed (Member)
    ^DataStructures.Trackpoint.time (Member)
    ^DataStructures.Trackpoint.x (Member)
    ^DataStructures.Trackpoint.y (Member)
  }
  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
cia. 100,000 LoC
about to be finished
great modularity due to components
uses physical units extensively
great test coverage due to special extensions
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20+ Projects in various stages by various “Big Name” companies.

Approach also used in other Domains

Insurance, Finance
The Language Workbench
Open Source
Apache 2.0
http://jetbrains.com/mps
Refactorings, Find Usages, Syntax Coloring, Debugging, ...
Projectional Editing
[Projectional Editing]

Parsing

Concrete Syntax

Abstract Syntax Tree
[Projectional Editing]

Parsing

1. Concrete Syntax
2. Abstract Syntax Tree

Projectional Editing

1. Concrete Syntax
2. Abstract Syntax Tree
Projectional Editing

Syntactic Flexibility

Regular Code/Text

Mathematical

Tables

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
Transformation
Constraints

In One File
Type System
Transformation
Constraints
Syntax
IDE

50+ extensions to C
10+ extensions to requirements lang.
Fundamentally it was a success.
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Research Project Completed
Fundamentally it was a success.

Research Project Completed
Lively OS project
Fundamentally, it was a success.
Research Project Completed
Lively OS project
Paying customers
Fundamentally it was a success.
Research Project Completed
Lively OS project
Paying customers
Expanded to other domains
Fundamentally it was a success.

Research Project Completed
Lively OS project
Paying customers
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Learned a lot
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Research Project Completed
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Learned a lot
Fundamentally it was a success.

Research Project Completed
Lively OS project
Paying customers
Expanded to other domains
Learned a lot
Papers + my PhD
Fundamentally it was a success.

Research Project Completed
Lively OS project
Paying customers
Expanded to other domains
Learned a lot
Papers + my PhD
New Research Opportunities
Fundamentally it was a success.

But there were Problems/Challenges/Lessons Learned
Good Experience.
Good Experience.

Neutral Observation
Good Experience.

Neutral Observation

Problem/Challenge
4 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 and config of the analysis is still an issue. (leaky abstraction)
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 (and type systems).
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 JetBrains to resolve them.
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 (because of bugs)
Cross-model generation not possible – being worked on right now.
Ability to create additional language aspects missing (you can existing ones)
Debugger definition separate from generator; leads to duplication
Tracing back from the generated code to the model is not always consistent; problems for debugger and analysis.
many aspects of language definition too „procedural" and hence hard to analyze.
Due to the open world assumption of MPS, there is a "feeling of incompleteness" in 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 [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!
itemis France

• **Company profile**
  - Founded in 2008
  - Based in Issy-les-Moulineaux
  - 7 employees
  - Jeune Entreprise Innovante

**Focus**
- Model-driven tools
- Embedded systems
Internship („stage“): Smart Metering

**Context**

- 3-phase smart meter for Saudi Arabian market
- Measurement of electrical energy consumption, data analysis, automatic meter reading
- Fully developed by itemis France (hardware, software, casing)

**Internship task**

- Development of advanced smart metering functions (multi-tariff support, consumption profiles, etc.)
- Integration on embedded target (Texas Instruments MSP430)
- Using mbeddr and C
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