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ClearSy

BART – Automatic Refinement in B

REQUET
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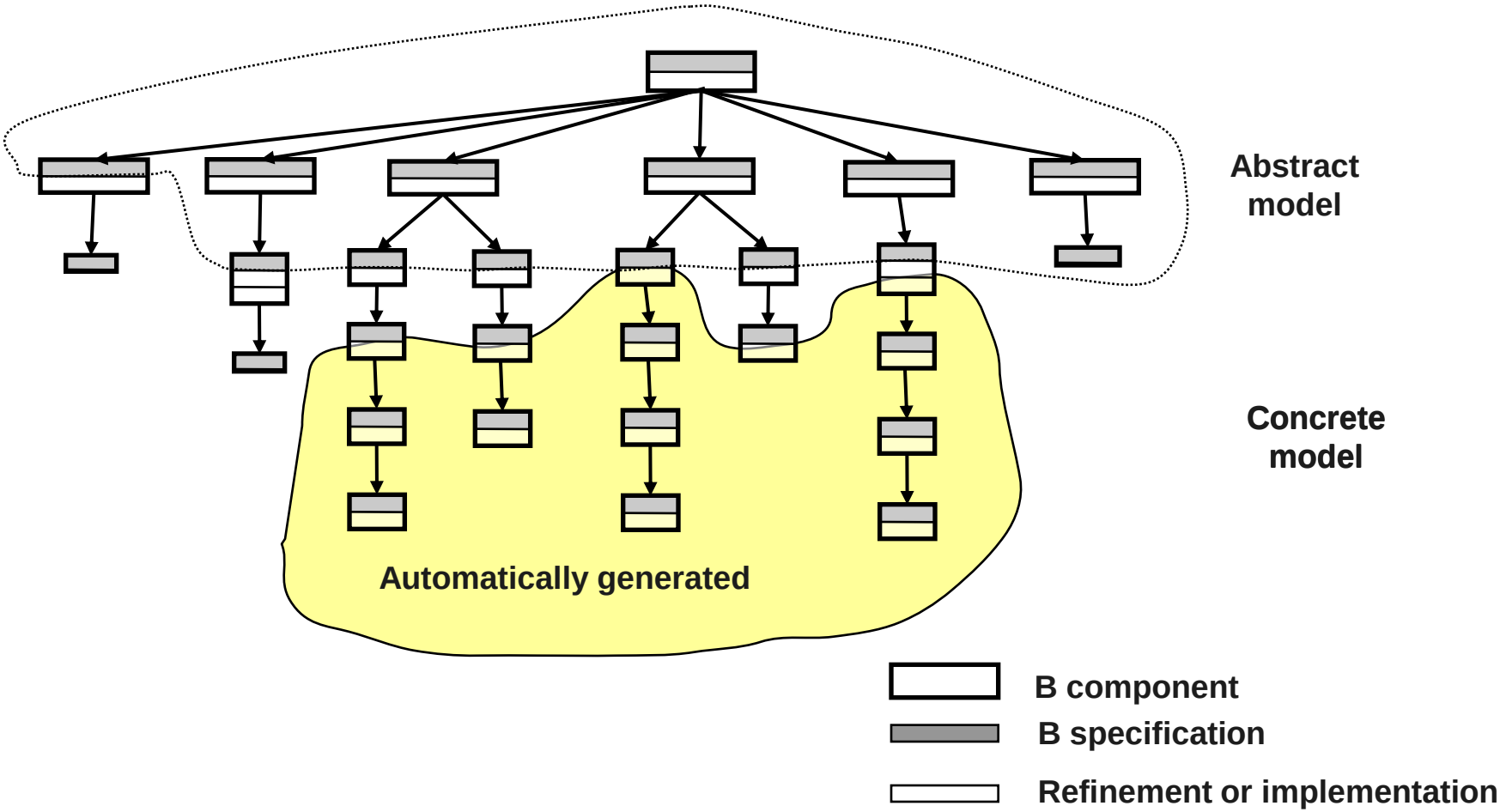
Introduction

- Typical B development
  - Abstract model: describes the requirements of the software
  - Concrete model: refinement of the abstract model, describing the implementation
- Aims of automatic refinement
  - Automatically generate the concrete model (or part of it) from the abstract model

Example project



Why use automatic refinement?

- Productivity
  - Security Critical Software usually requires twice more workload
  - Automatic refinement can divide the workload by two
    - Automatic generation of the concrete model
    - Model easier to validate
  - CSC software developed with non CSC budget
- Allows focusing the work on the “interesting” parts of the development
  - Writing the specification, optimization of the software, etc...

History

- 1997: Matra Transport International (Siemens Transportations Systems) develops internally a tool called edithB still in use in the company
  - 1999: FM'99 Workshop : Automatic refinement
- 2008: ClearSy develops BART in order to allow the community to benefit from automatic refinement tools
  - 2009: Atelier B 4.0 with integrated BART tool

Uses of automatic refinement

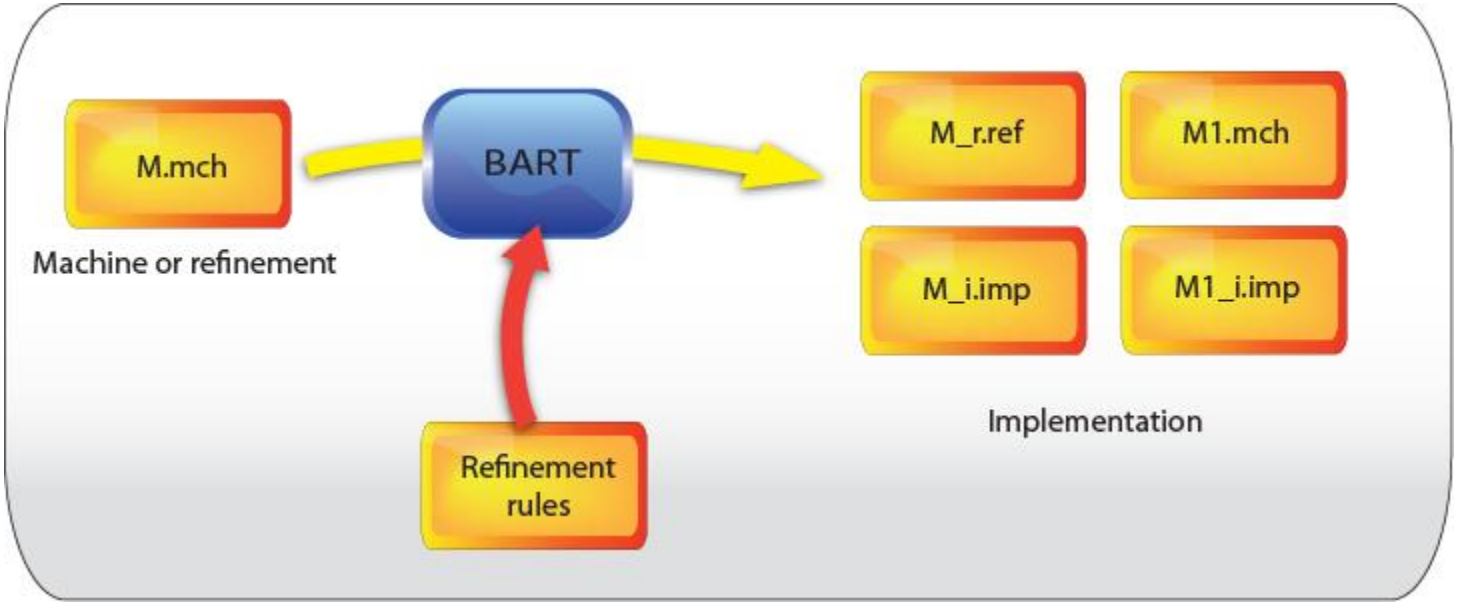
- Used worldwide for several metros
- Biggest implementation: Val de Roissy Shuttle
  - Alarm control unit: 265 kloc B model (40 kloc handwritten), 186 kloc Ada code
  - Section automatics pilots: 67 kloc B model, 50 kloc Ada code

The BART tool

- Automatic refinement tool integrated in Atelier B
  - Open-Source tool
- Uses refinement rules to refine the components
  - The user can add new rules on a project and component basis
    - In the case where no existing rule is provided
    - To implement more efficient refinement
- The generated components still have to be proved
  - Makes BART a non-critical tool
  - Simplifies adding rules
    - An incorrect rule will generate non-proveable code

Working principles

- Input: complete set-theoristic model of a software
- Output: refinements and implementations



- Refinement engine: applying transformation rules

```
RULE assign_a_bool_subset_b_c_11
REFINES
    @a := bool(@b <: @c-@d)
REFINEMENT
    @a := bool(@b <: @c & @b /\ @d = {})
END;
```

```
RULE assign_a_bool_belongs_b_c_16
REFINES
    @a := bool(@b|->@d : @c*@e)
REFINEMENT
    @a := bool(@b:@c & @d:@e)
END;
```

BART usage

- Handles concrete refinements only
  - Requires an abstract machine detailed enough
  - Does not replace proof or specification refinements
  - The input model should be deterministic
- Provides an automatic and an interactive mode
  - Automatic mode: allows automatically applying the rules
  - Interactive mode: used to add rules when the default rules do not succeed
    - Allows inspecting the different rules that are applied
    - After the rules have been added interactively, the automatic mode is used

Using BART in a project

- Using BART usually means writing refinement rules instead of refinements
  - Rules written using the interactive mode
  - Default set of rules usually not enough/suitable for large projects
  - Rules can be kept and reused for later projects
- Refinement rules have to be written
  - On a project basis (rare)
  - For specific components (often)

Writing refinement rules

- Adding rules on a project basis
  - In the case where the specification is written in a different way than expected from the default rules
  - Typically an expert activity
- Adding rule for specific components
  - When the default rules cannot refine the component
  - When the default refinement is not efficient enough
    - Adding optimisations
    - Using a better refinement scheme

Refinement rules

- Refinement rules applied by pattern-matching
- Three main types of rules
  - Variable rules, for data refinement
  - Operation rules, for algorithmic refinement
  - Initialisation rules, specific case of algorithmic refinement
- Rules contains
  - A pattern, indicating the kind of element that can be refined
  - Guards, that indicates whether a rule can be applied or not
  - A refinement pattern, that indicates the resulting refinement

Conclusion

- Automatic refinement can improve productivity by
  - Automatizing repetitive tasks
  - Leading to simpler proofs
  - Simplifying reusing of known refinement patterns

- BART
  - Integrated in Atelier B 4.0
  - Open-Source Tool
  - Supported by grant No ANR-06-SETI-015-03 awarded by “Agence Nationale de la Recherche”
  - Part of RIMEL project: “Incremental refinement of event models”

Demo

- Refinement of a small project with BART

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Thanks

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