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Class Diagrams for Abstract Data Types

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Outline

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Motivation

Illustration. The Stack ADT

Example. The RailGround Case Study

Motivation. Visualisation for ADTs

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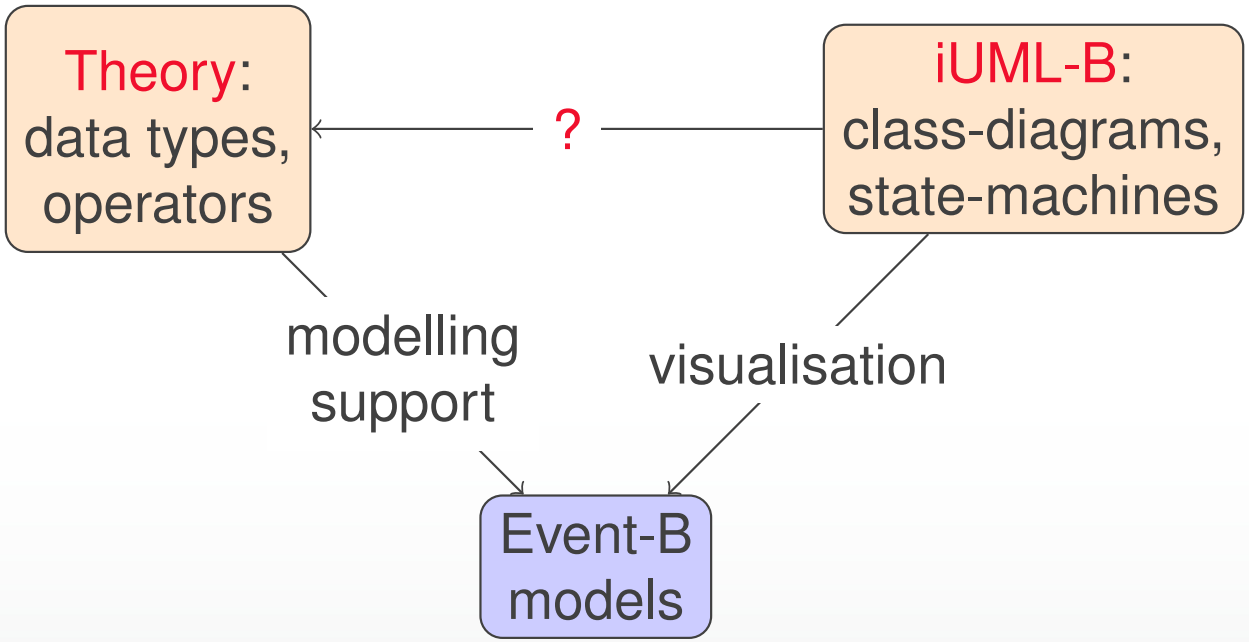

The Aim

Aiding design of ADTs using class diagrams.

Illustration. Stack ADT

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Stack ADT

- Polymorphic datatype.
- `emptyStack`: denotes an empty stack.
- `top`: takes a non-empty stack `st` and returns `st`'s top element.
- `pop`: takes a non-empty stack `st` and returns a stack where `st`'s top element is removed.
- `push`: takes a stack `st` and an element `e` and returns a stacks where `e` is added to the top of `st`.

Illustration. Stack ADT

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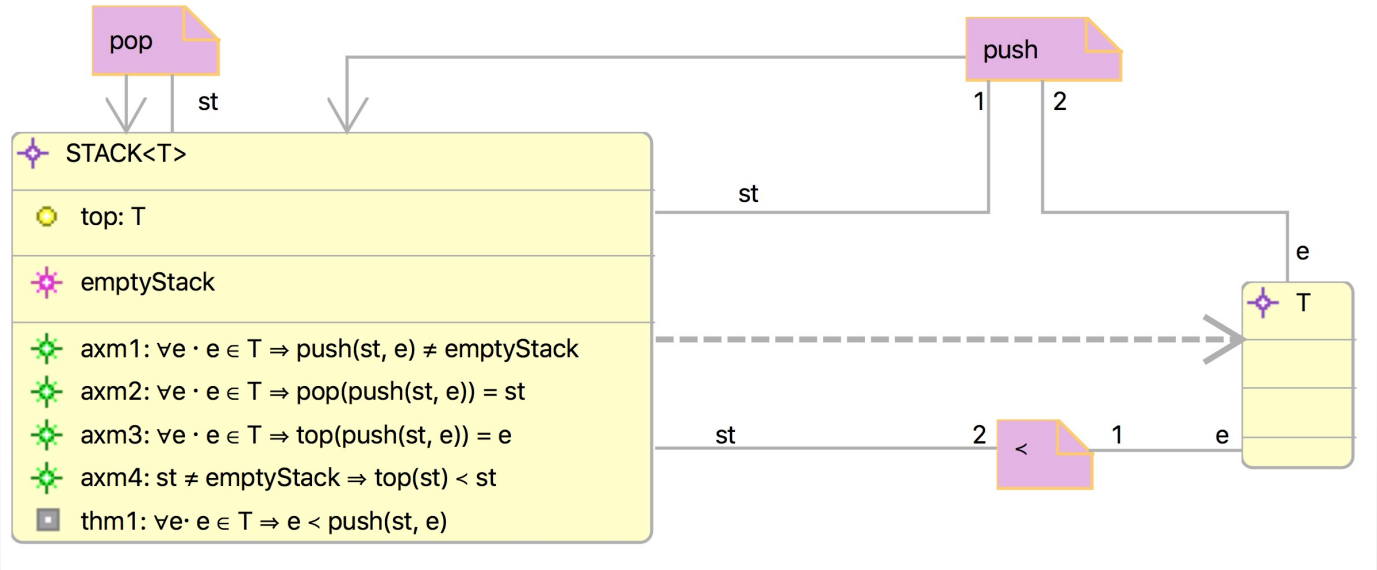

Illustration. Stack ADT

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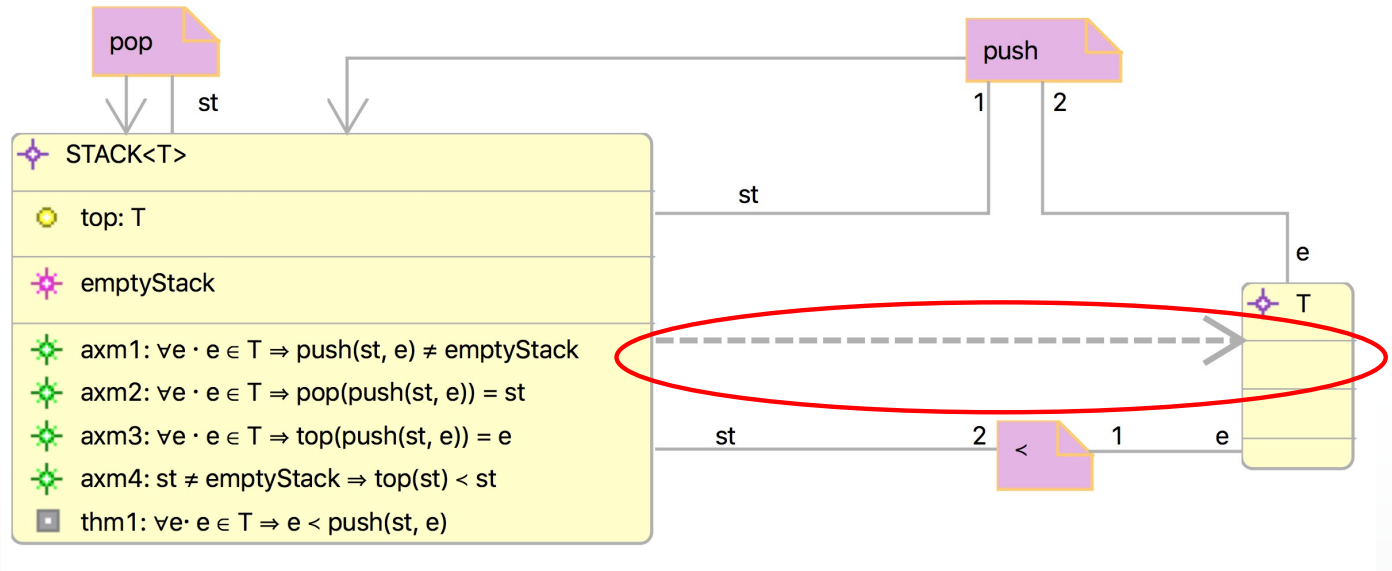

- `STACK` is polymorphic with `T` is the type parameter.

```
1 theory STACK<T>
```

Illustration. Stack ADT

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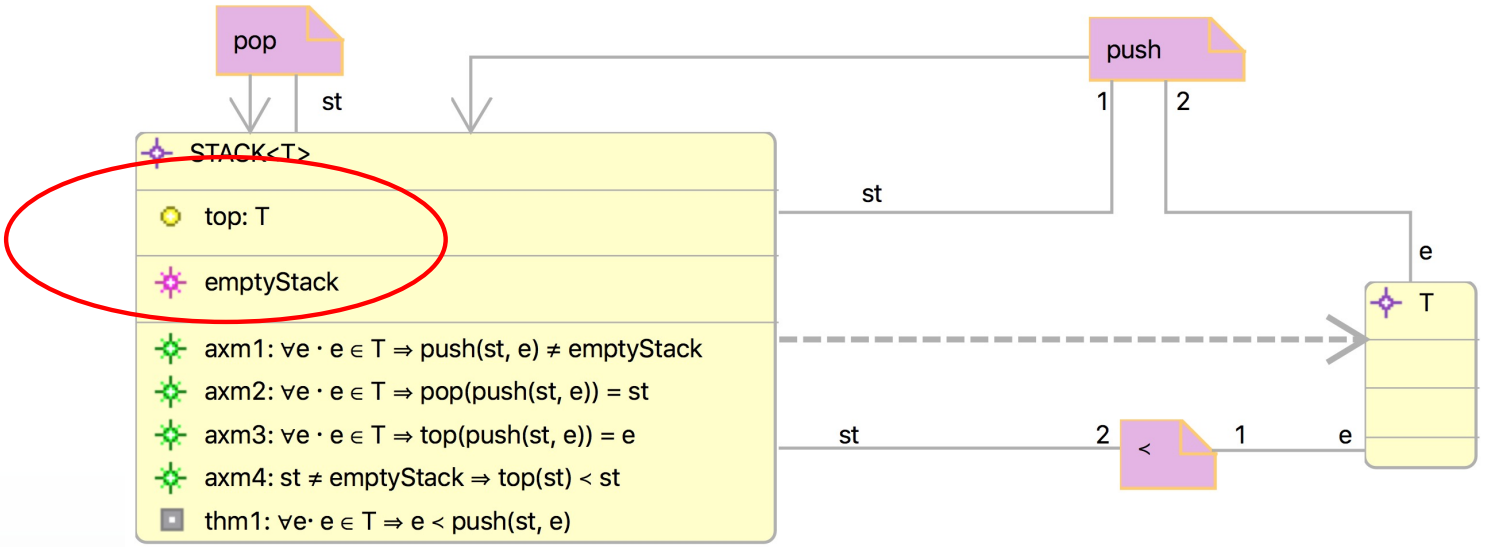

- `emptyStack` is constant `STACK`
- `top` is a "query" operator returning an element of type `T`

```
1  emptyStack: "STACK<T>"
2  top(st : "STACK<T>"): "T"
```

Illustration. Stack ADT

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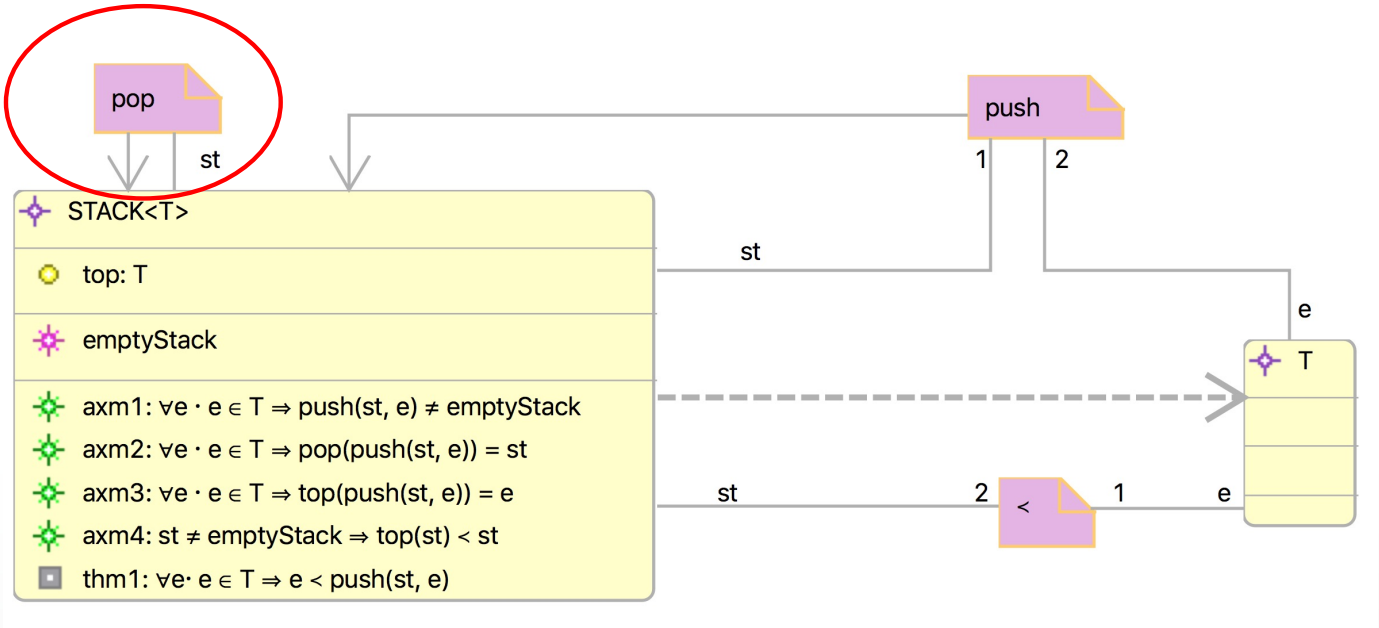

- `pop` is an operator with one input (`st`) and one output (of type `STACK<T>`)

```
1   pop(st: "STACK<T>"): "STACK<T>"
```

Illustration. Stack ADT

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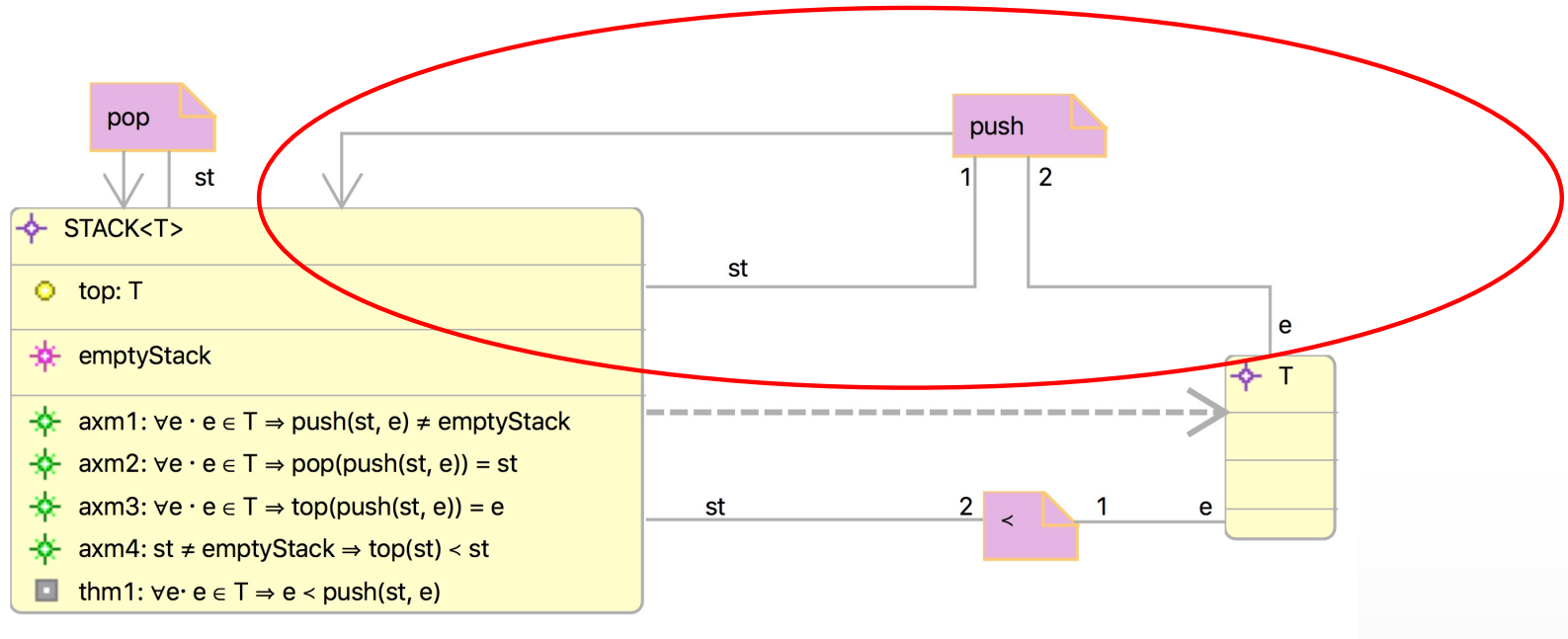

- `push` is an operator with two inputs (`st` and `e`) and one output (of type `STACK<T>`)

```
1   push(st: "STACK<T>", e: "T"): "STACK<T>"
```

Illustration. Stack ADT

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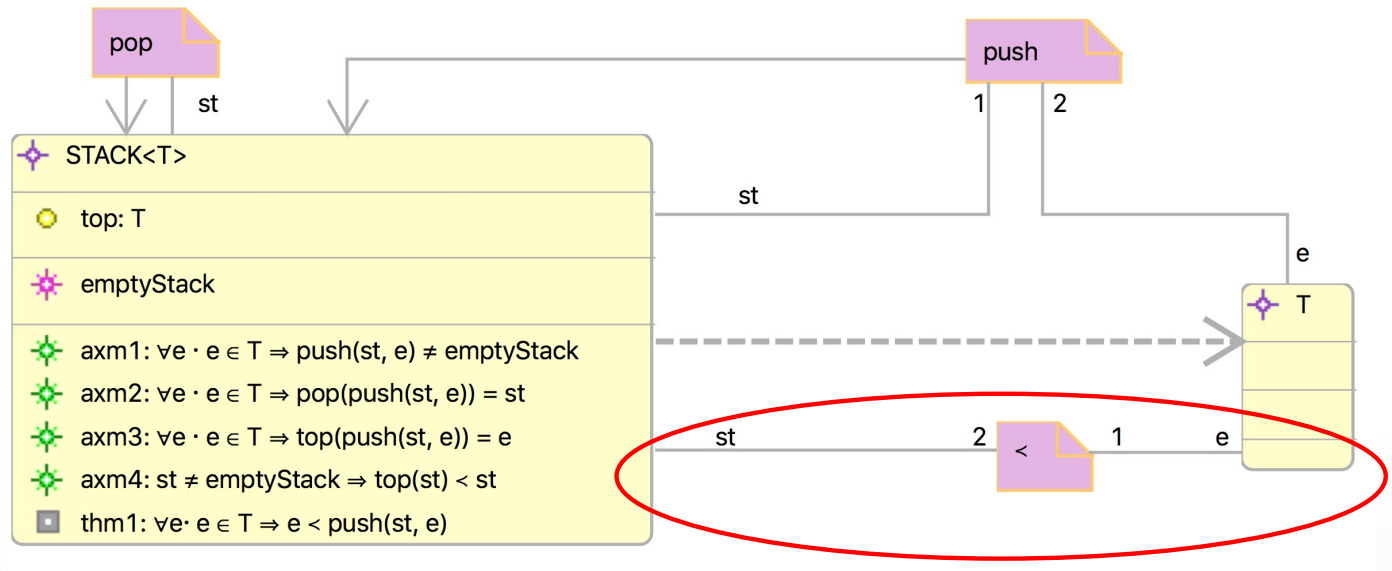

- $\prec$ is a predicate with two inputs (`e` and `st`) stating that `e` is in the stack `st`.

```
1   ≺ (e: "T", st: "STACK<T>") infix
```

Illustration. Stack ADT

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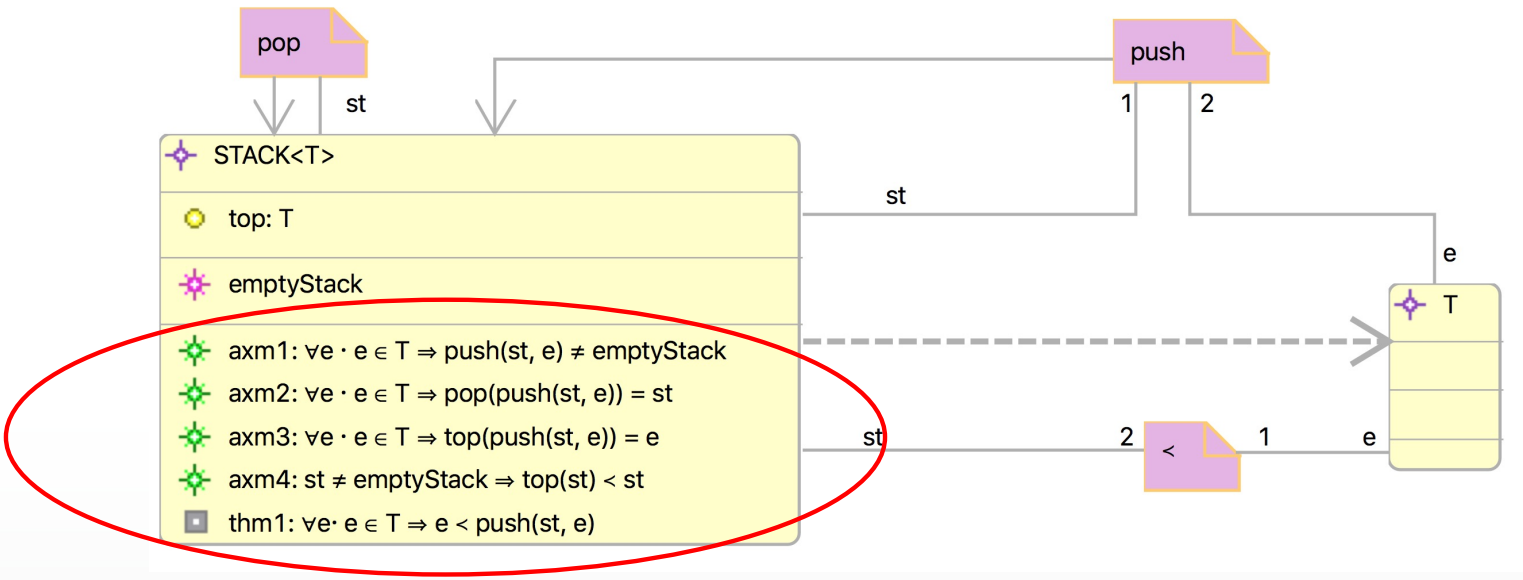

- Axioms are lifted to all instances of the `STACK` datatype, e.g.,

```
1 @axm1: "∀ st·  st ∈ STACK ⇒
2         (∀ e · e ∈ T ⇒ push(st, e) ≠ emptyStack)"
```

RailGround

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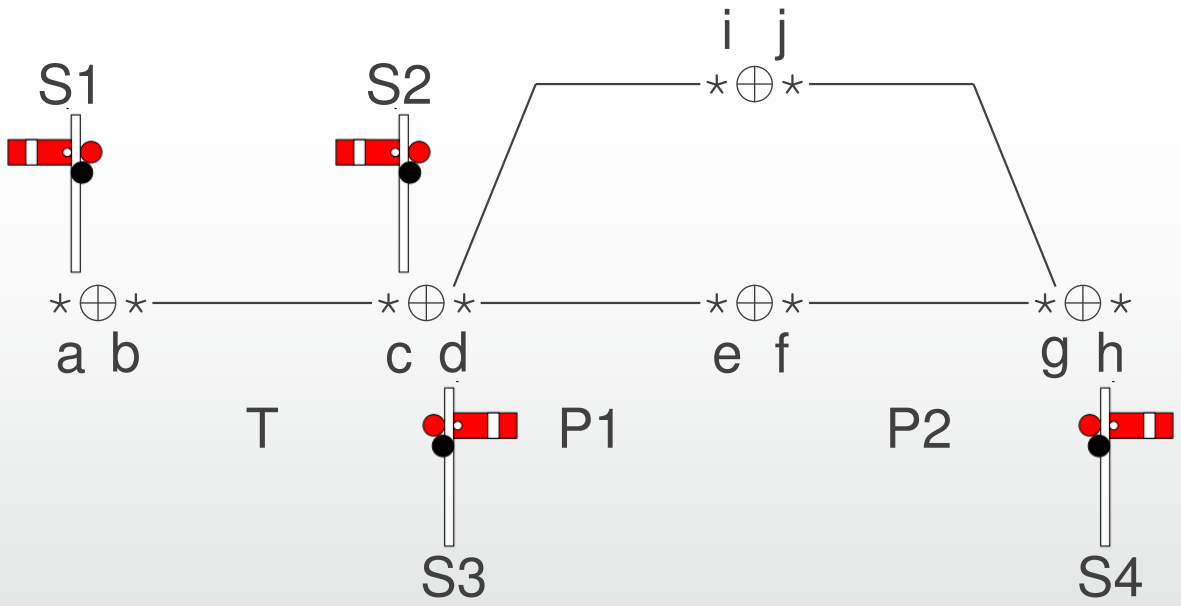
- A formal model of a (simplified) railway interlocking system.
- Provided by Thales Austria GmbH.
- Research on formal validation and verification of railway systems.



RailGround. Concepture Entities

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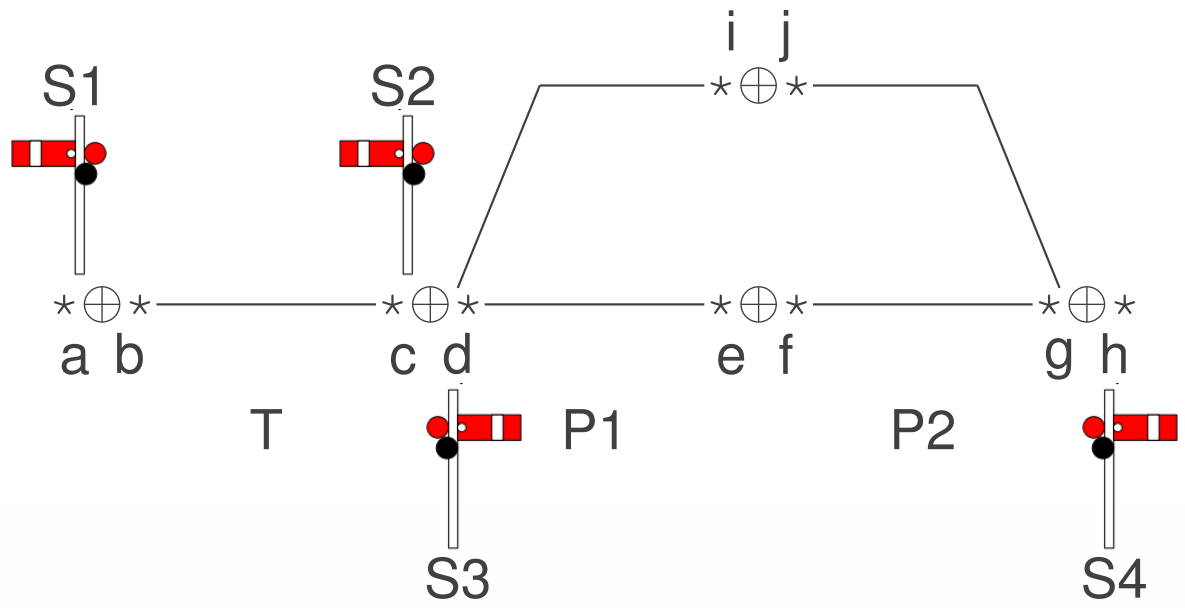

- Rail Elements: `T`, `P1`, `P2`
- Rail Connectors: `a, b, c, ...`
- Segments: `bc, de, di, ...`
- Paths/Route: `[bc,de,fg], [bc, di,ig], ...`
- Vacancy Detection: correspond to a set of segments
- Signals: `S1, S2, S3, S4`

Refinement Strategy

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- **M0**: To abstractly specify active routes in the system, focusing on the collision-free property
- **M1**: To introduce the life-cycle of routes by specifying requested routes.
- **M2**: To formalise the rail elements and the link between rail elements and paths.
- **M3**: To specify the element positions and their association with the rail elements.
- **M4**: To introduce the track vacancy detection mechanism.
- **M5**: To introduce the signals protecting the trains' movement.

Development of Theories

Paths

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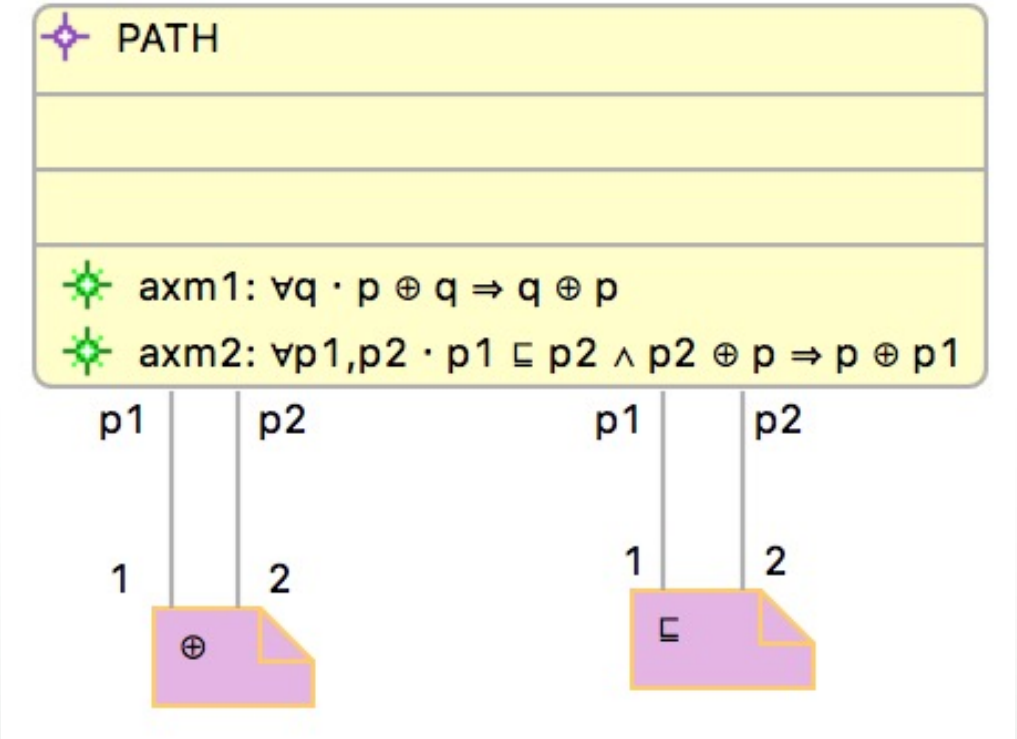

- $p \oplus q$: Paths p and q are disjoint.
- $p \sqsubseteq q$: p is a sub-path of q.

Development of Theories

Rail Elements

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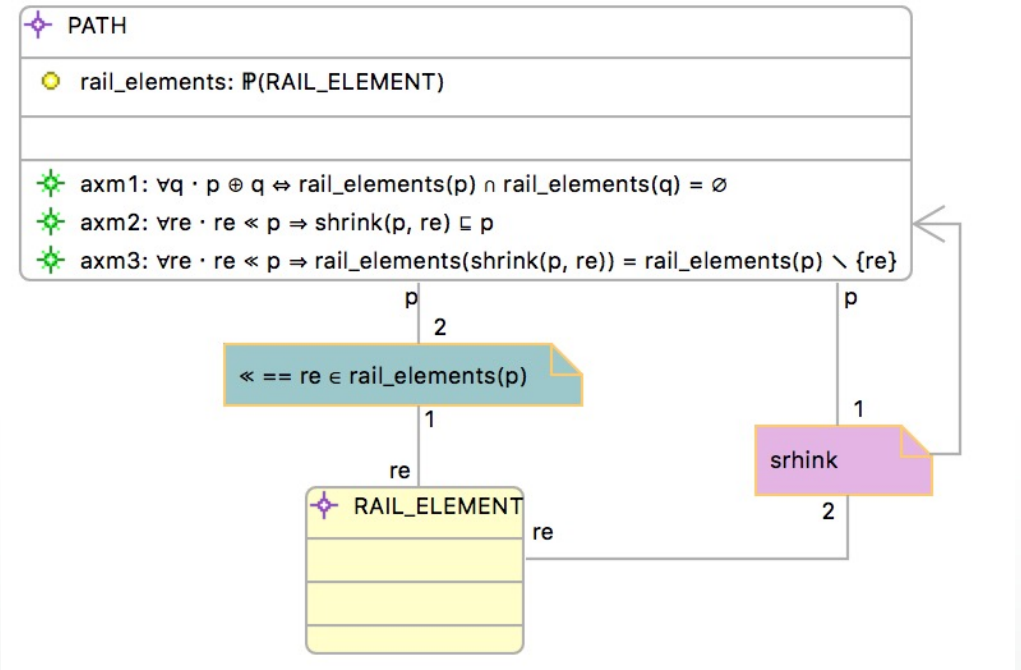

- `rail_elements(p)`: Returns the set of element of a path `p`
- `shrink(p, re)`: Remove element `re` from path `p`.
- `re ≪ p` (direct definition): Element `re` belongs to path `p`.

Development of Theories

Rail Positions

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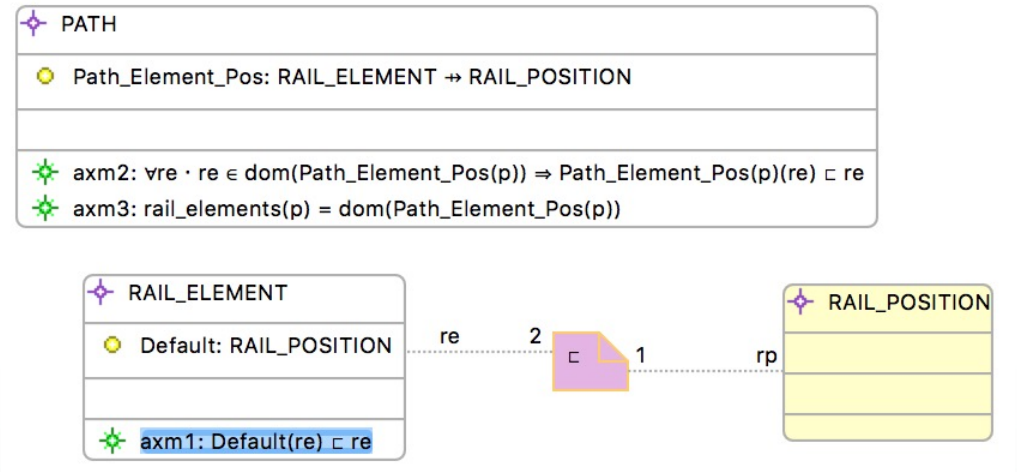

- `rp ⊏ re`: rail position `rp` is a valid for rail element `re`.
- `Default(re)`: The default position for rail element `re`
- `Path_Element_Pos(p)`: the position of the rail elements for path `p`.

Development of Theories

Vacancy Detection

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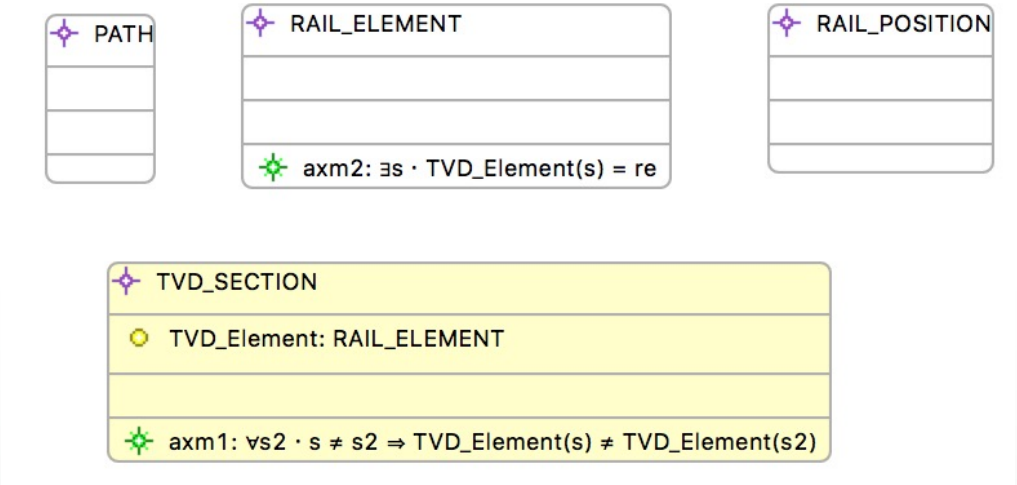

- `TVD_Element(s)`: the rail element corresponding to the TVD section `s`

Development of Theories

Signal

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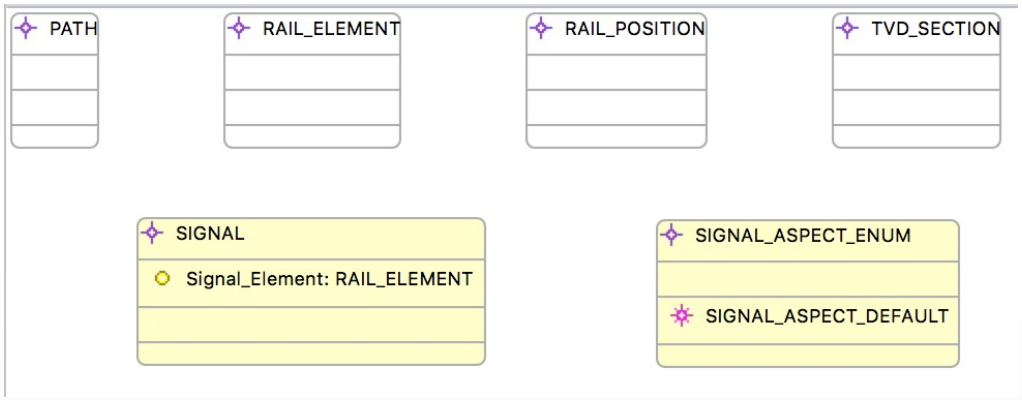

- `Signal_Element(s)`: the rail element that the signal `s` protects.

Summary

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- Classes are linked to data types
- Attributes and associations corresponding to operators.
- Class constraints are axioms on the data types.
- Visiualsation aids the design of ADTs.
- Future work:
  - Tool support
  - Theory instantiation