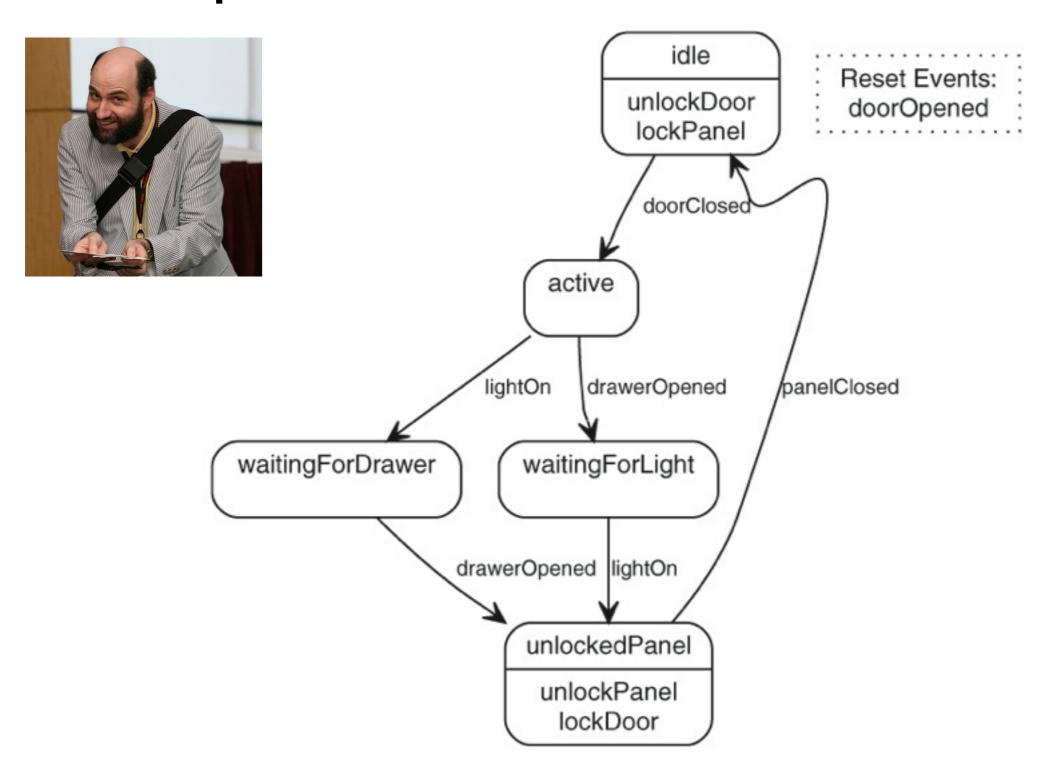
# Structure: Syntax and Name Resolution

Tijs van der Storm





### Example: state machines



```
events
 doorClosed D1CL
 drawerOpened D2OP
 lightOn L10N
 doorOpened D10P
 panelClosed PNCL
end
resetEvents
 door0pened
end
commands
 unlockPanel PNUL
 lockPanel PNLK
 lockDoor D1LK
 unlockDoor D1UL
end
state idle
 actions {unlockDoor lockPanel}
 doorClosed => active
end
```

```
state active
drawerOpened => waitingForLight
lightOn => waitingForDrawer
end
state waitingForLight
lightOn => unlockedPanel
end
state waitingForDrawer
drawerOpened => unlockedPanel
end
state unlockedPanel
actions {unlockPanel lockDoor}
panelClosed => idle
end
```

#### Grammars

```
standard
              module Syntax
              extend lang::std::Layout;
                                                   Layout
  start
              start syntax Controller =
symbol
                 controller:
                    Events events
                                            subelement
                    ResetEvents? resets
production
                                               labels
                    Commands? commands
   label
                    State+ states;
              syntax Events
                = @Foldable "events" Event* "end";
              syntax ResetEvents
enable
                = @Foldable "resetEvents" Id* "end";
folding
              syntax Commands
                = @Foldable "commands" Command* "end";
```

Lexical syntax

lexicals don't get layout

```
follow restriction
```

character class

```
lexical Id

= ([a-zA-Z][a-zA-Z0-9_]* !>> [a-zA-Z0-9_])

Reserved;
```

keyword reservation

keyword Reserved

```
= "events"
```

l "end"

l "resetEvents"

I "state"

l "actions";

keyword class

# 

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ge(9,10), range(12,13), range(32,22))), vont-follow(lite'/'/'))], {}), [ppp](regular(\texture liter)); (fort-follow(liter)', liter)-(liter)); (fort-follow(liter)); (fort-follow

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(39,3,<3,15>,<3,18>)]) [@loc=|project://MissGrant/input/missgrant.ctl|(38,4,<3,14>,<3,18>)]) [@loc=|project://MissGrant/input/missgrant.ctl|(38,4,<3,14>,<3,18>)]])
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star(sort("WhitespaceOrComment")), {\not-follow(\char-class([range(9,10), range(12,13), range(32,32)])), \not-follow(lit("//"))})], {}),
[appl(regular(\iter-star(sort("WhitespaceOrComment"))), [appl(prod(label("whitespace", sort("WhitespaceOrComment")), [lex("Whitespace")], {}),
[appl(prod(lex("Whitespace"),[\char-class([range(9,10),range(12,13),range(32,32)])],\{\}),[char(10)])[@loc=|project://MissGrant/input/
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class([range(9,10),range(12,13),range(32,32)])],{}),[char(32)])[@loc=|project://MissGrant/input/missgrant.ctl|(43,1,<4,0>,<4,1>)]])[@loc=|
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project://MissGrant/input/missgrant.ctll(42,2,<3,18>,<4,1>)],appl(prod(label("event",sort("Event")),
[label("name",lex("Id")),layouts("Standard"),label("token",lex("Id"))],{}),[appl(prod(lex("Id"),[conditional(seq([\char-
class([range(65,90), range(97,122)]), conditional(\iter-star(\char-class([range(48,57), range(65,90), range(95,95), range(97,122)])), {\not-
follow(\char-class([range(48,57), range(65,90), range(95,95), range(97,122)]))))), {delete(keywords("Reserved"))})], {}))
[appl(regular(seq([\cline{c}]),conditional(\cline{c})),conditional(\cline{c})
class([range(48,57), range(65,90), range(95,95), range(97,122)])), {\not-follow(\char-
class([range(48,57), range(65,90), range(95,95), range(97,122)])))), [char(108), appl(regular(\iter-star(\char-
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star(sort("WhitespaceOrComment")), {\not-follow(\char-class([range(9,10), range(12,13), range(32,32)])), \not-follow(lit("//"))})], {}),
[appl(regular(\iter-star(sort("WhitespaceOrComment"))), [appl(prod(label("whitespace", sort("WhitespaceOrComment")), [lex("Whitespace")], {}),
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missgrant.ctl|(56,1,<4,13>,<5,0>)]])[@loc=|project://MissGrant/input/missgrant.ctl|
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class([range(9,10), range(12,13), range(32,32)])], {}), [char(32)])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]])[@loc=|project://MissGrant/input/missgrant.ctl|(57,1,<5,0>,<5,1>)]]]]
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project://MissGrant/input/missgrant.ctll(56,2,<4,13>,<5,1>)],appl(prod(label("event",sort("Event")),
[label("name",lex("Id")),layouts("Standard"),label("token",lex("Id"))],{}),[appl(prod(lex("Id"),[conditional(seq([\char-
class([range(65,90), range(97,122)]), conditional(\iter-star(\char-class([range(48,57), range(65,90), range(95,95), range(97,122)])), {\not-
follow(\char-class([range(48,57),range(65,90),range(95,95),range(97,122)]))})]),{delete(keywords("Reserved"))})],{}),
[appl(regular(seq([\char-class([range(65,90),range(97,122)]),conditional(\iter-star(\char-
class([range(48,57), range(65,90), range(95,95), range(97,122)])), {\not-follow(\char-
```

# non-terminals map to data type

# bstract syntax

list[str] actions,

```
data Command = command(str name, str token);
data Event = event(str name, str token);
data Transition = transition(str event, str state);
```

list[Transition] transitions);

int/real/bool

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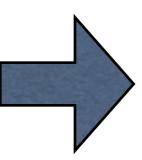
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]])[@loc-lproject:/Missfarnit/input/missgarant.ctli /Missfarnit/nput/missgarant.cli/473,2,435,9,636,0>],appl(prod(lt("end"),[)char-class([range(101,101)]),\cl tespoceDrCamment")),[lex("Mitespoce"),{}]),[appl(prod(lex("Mitespoce"),[\char-<66.6,476,0)])]]Miss[aminst-/Missfarent (input/missarant)

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# "Implode"

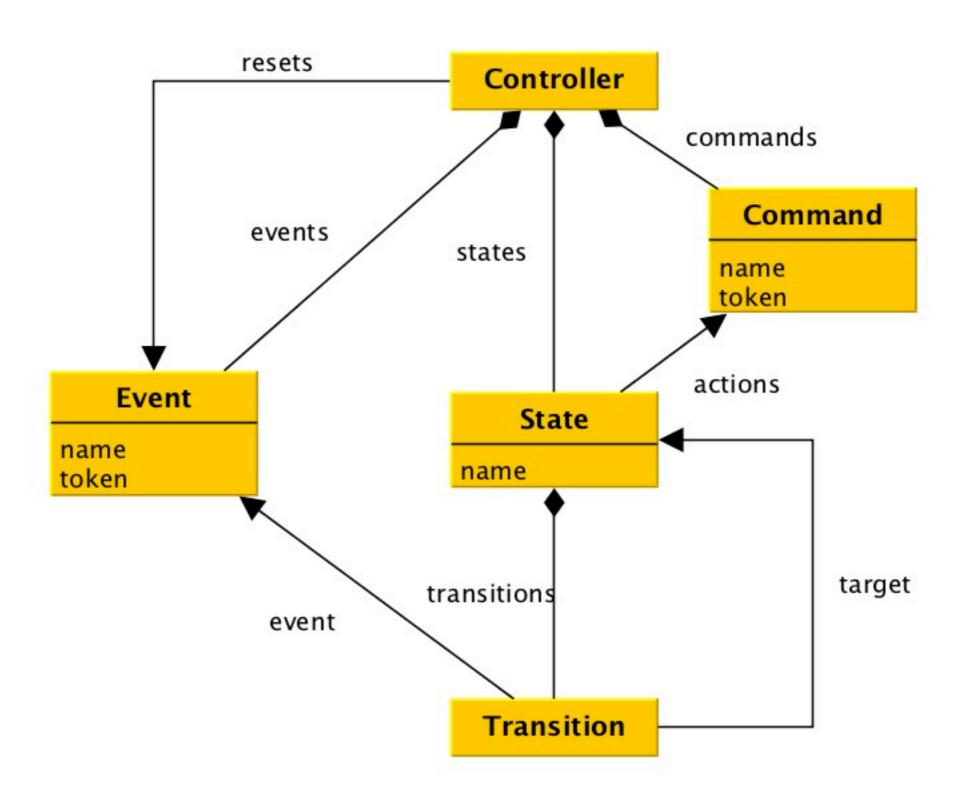


```
controller(
    event("doorClosed","D1CL"),
    event("drawer0pened","D20P"),
    event("lightOn", "L10N"),
    event("door0pened", "D10P"),
    event("panelClosed","PNCL")
  ["door0pened"],
    command("unlockPanel", "PNUL"),
    command("lockPanel", "PNLK"),
    command("lockDoor","D1LK"),
    command("unlockDoor","D1UL")
    state(
      "idle",
      ["unlockDoor","lockPanel"],
      [transition("doorClosed", "active")]),
    state(
      "active",
      []
        transition("drawerOpened", "waitingForLight"),
        transition("lightOn", "waitingForDrawer")
      ]),
    state(
      "waitingForLight",
      [transition("lightOn", "unlockedPanel")]),
      "waitingForDrawer",
      [transition("drawerOpened", "unlockedPanel")]),
    state(
      "unlockedPanel",
      ["unlockPanel", "lockDoor"],
      [transition("panelClosed","idle")])
  ])
```

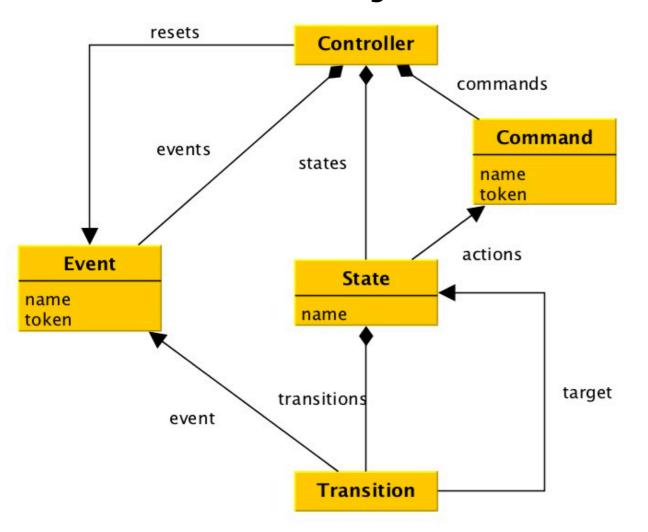
#### Meta Models

- Algebraic data types ("data Expr = ...")
  - Define type of abstract syntax trees
- Meta Models are UML-style class diagrams
  - Define type of of object models
- Both have benefits and disadvantages
- => Technological space (grammarware, modelware)

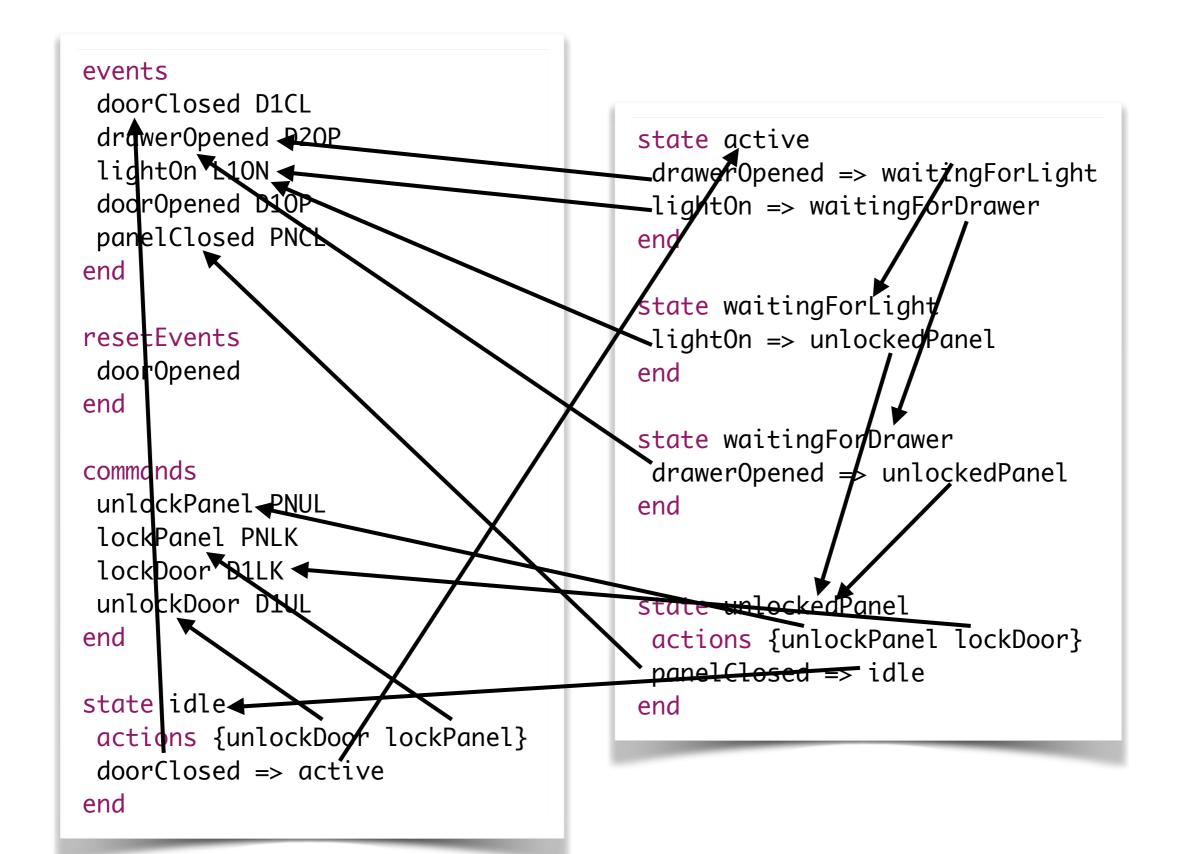
#### State machine meta model



# References: explicit or using symbolic names



```
data Controller
 = controller(list[Event] events,
               list[str] resets,
               list[Command] commands,
               list[State] states);
data State
  = state(str name,
      list[str] actions,
      list[Transition] transitions);
data Command
  = command(str name, str token);
data Event
  = event(str name, str token);
data Transition
  = transition(str event, str state);
```

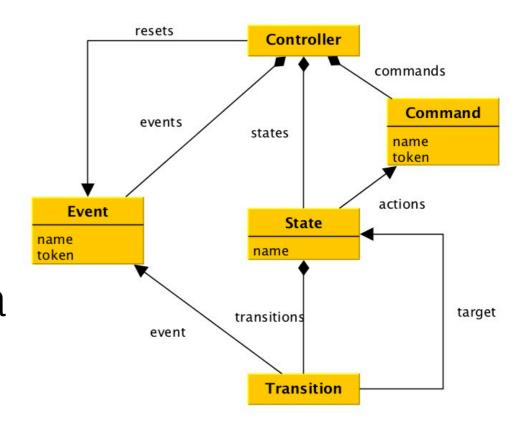


#### Names

- defining occurrence: declaration, or entity, introduction of a name
  - Example: states, events, commands
- · use occurrence: reference, variable use, etc.
  - Example: reference to event/target state in transition, reference to commands in states

### Name resolution

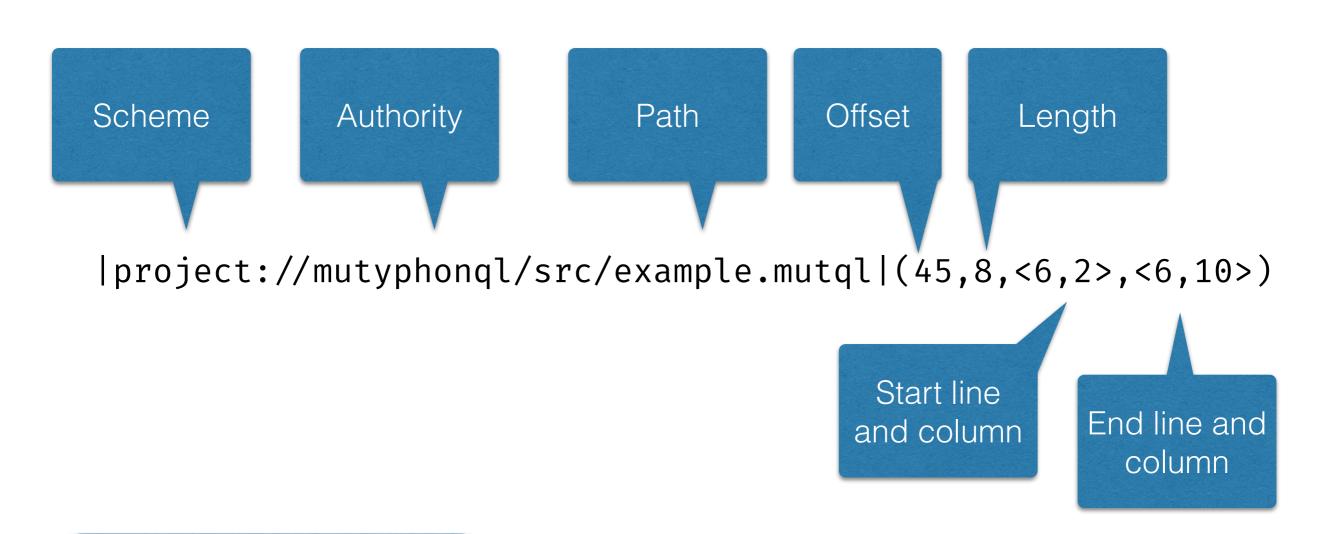
- Finding which use occurrences refer to which defining occurrences
- Recovering the referential structure represented in meta models (roughly)
- IOW: defining the scoping rules of a language



#### Name resolution in Rascal

- Name occurrences (both defining and using) can be identified by source locations
- Source locations are unique: no two name occurrences can overlap.
- So we can use source locations as identities to represent the referential structure of a program.

#### Source locations



NB: clicking on a source location jumps to exact location in an editor

# Reference graphs

- Using source locations as identities of concepts in a language, the referential structure is typically represented as reference graph
- In Rascal: "rel[loc, loc]"
- This can be used to:
  - find naming errors and warnings
  - provide jump-to-definition IDE support
  - use in a compiler to find the declaration of an identifier
  - visualization, etc.

# Next up

- Live coding a simpler state machine example
  - abstract syntax, implode, name analysis
- Providing an introduction to the lab assignment skeleton code for this week.