

Abstract Syntax and Name Resolution

Tijs van der Storm



Centrum Wiskunde & Informatica

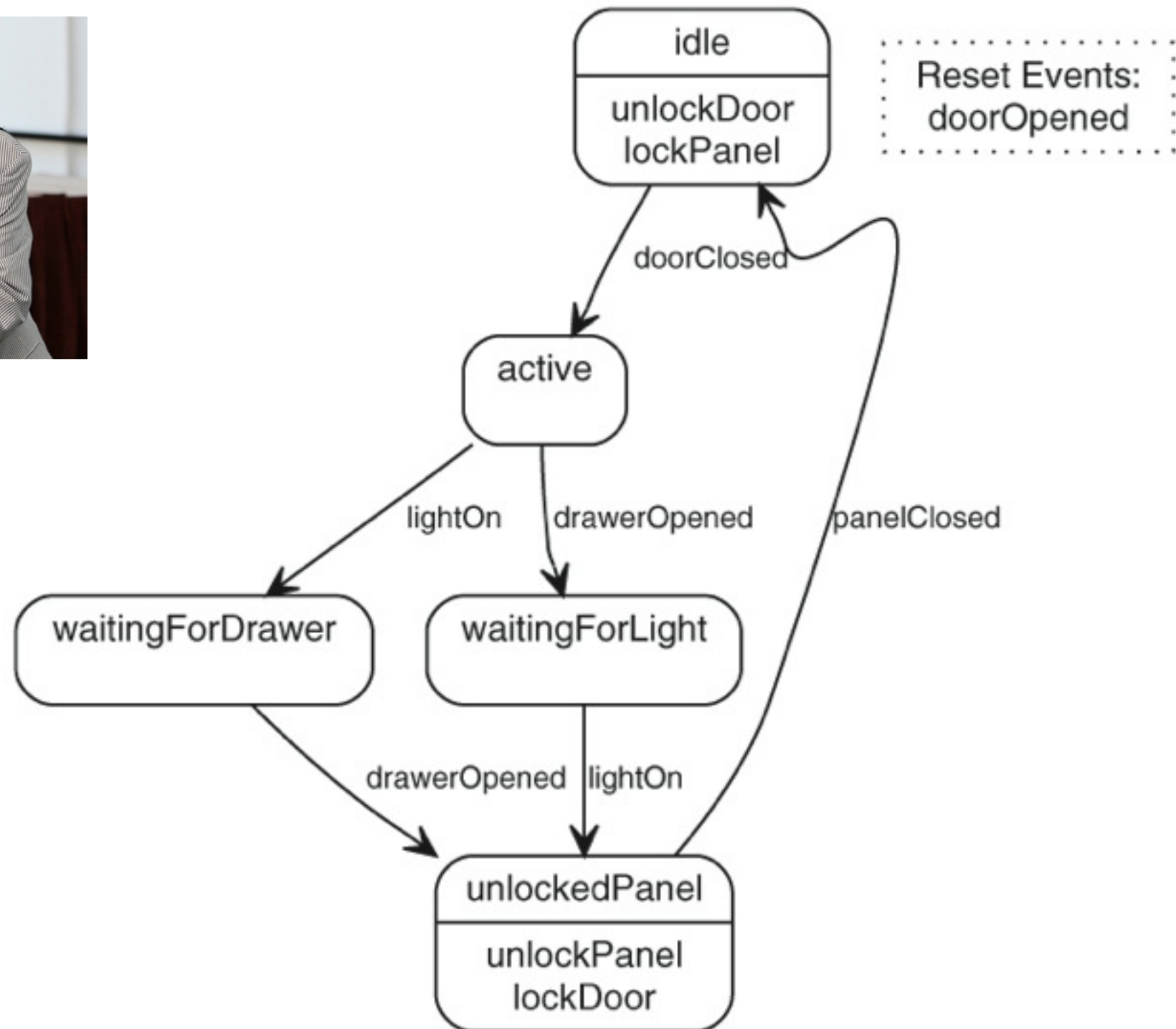


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Recap

- Context-free grammars to define syntax
- Parser generator: Grammar \rightarrow Parser
- Parser: Text \rightarrow Concrete syntax tree
- Today:
 - abstract syntax representations
 - name resolution

Example: state machines



events

```
doorClosed D1CL  
drawerOpened D2OP  
lightOn L1ON  
doorOpened D1OP  
panelClosed PNCL
```

end

resetEvents

```
doorOpened
```

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

```
module Syntax  
  extend Lang::std::Layout;
```

standard
Layout

start
symbol

```
  start syntax Controller =  
    controller:
```

production
label

```
      Events events  
      ResetEvents? resets  
      Commands? commands  
      State+ states;
```

subelement
labels

enable
folding

```
  syntax Events  
    = @Foldable "events" Event* "end";  
  syntax ResetEvents  
    = @Foldable "resetEvents" Id* "end";  
  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"  
| "end"  
| "resetEvents"  
| "state"  
| "actions" ;
```

keyword
class

[illegible]

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follow(\char-class([range(48,57),range(65,90),range(95,95),range(97,122)]))})]),{delete(keywords("Reserved"))})],{}),
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non-terminals
map to data type

abstract syntax

```
data Controller
= controller(list[Event] events,
             list[str] resets,
             list[Command] commands,
             list[State] states);
```

regulars (+/*/?)
map to lists

productions to
constructors

```
data State
= state(str name,
        list[str] actions,
        list[Transition] transitions);
```

lexicals to str/
int/real/bool

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

“imprudence”

controller{

event("doorClosed", "D1CL"),
event("drawerOpened", "D2OP"),
event("lightOn", "L1ON"),
event("doorOpened", "D1OP"),
event("panelClosed", "PNCL")

},
["doorOpened"],
[
command("unlockPanel", "PNUL"),
command("lockPanel", "PNLK"),
command("lockDoor", "D1LK"),
command("unlockDoor", "D1UL")

],
[
state("idle",
["doorClosed", "lockPanel"],
[transition("doorClosed", "active")]),
state("active",
[],
[
transition("drawerOpened", "waitingForLight"),
transition("lightOn", "waitingForDrawer")

]),
state("waitingForLight",
[],
[
transition("drawerOpened", "waitingForLight"),
transition("lightOn", "waitingForDrawer")

]),
state("waitingForDrawer",
[],
[
transition("lightOn", "unlockedPanel")],
state("unlockedPanel"),
[transition("panelClosed", "idle")])

state{

"waitingForDrawer",

[],

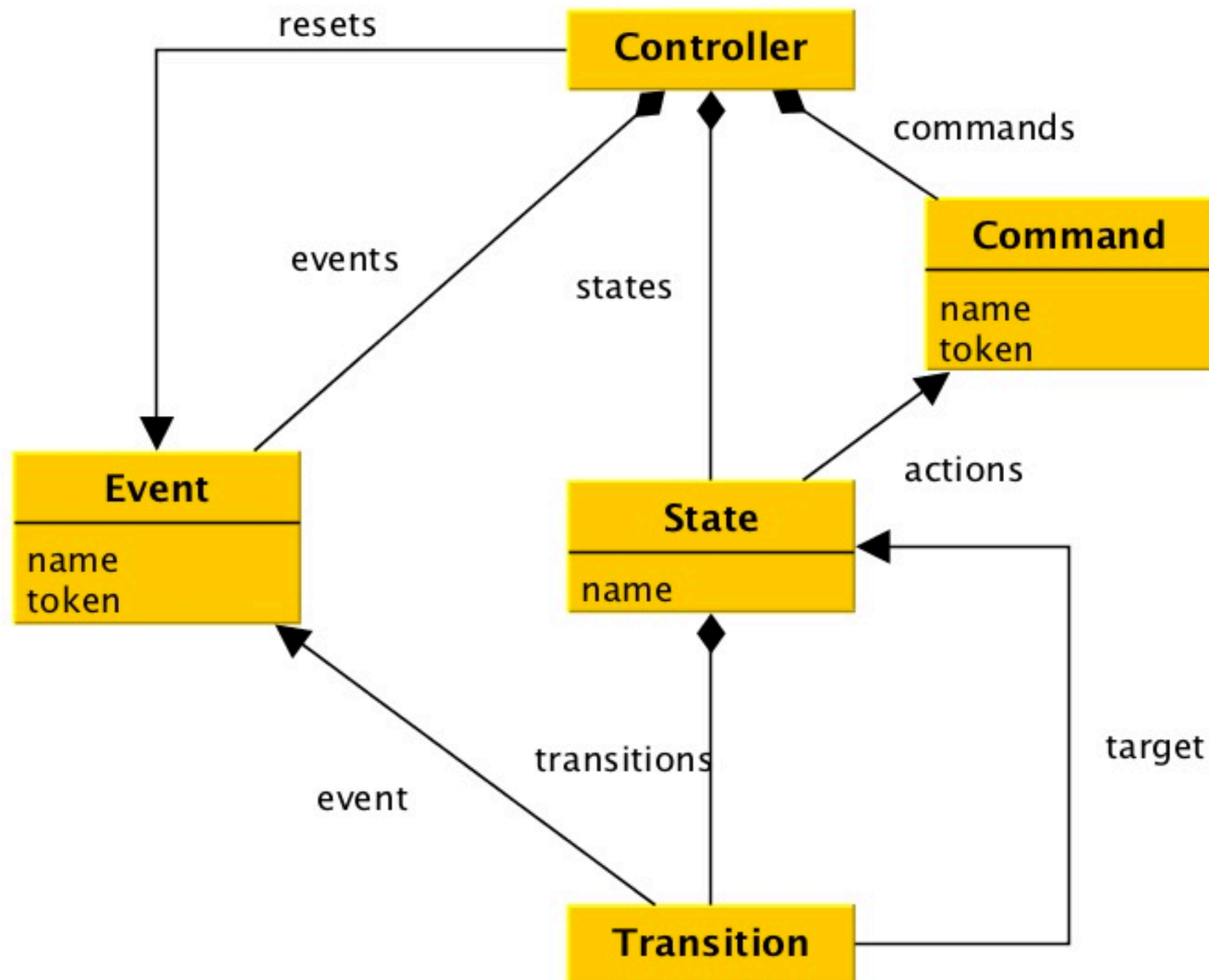
[
transition("lightOn", "unlockedPanel"),
[transition("drawerOpened", "unlockedPanel")],
state("unlockedPanel"),
[transition("panelClosed", "idle")])

])

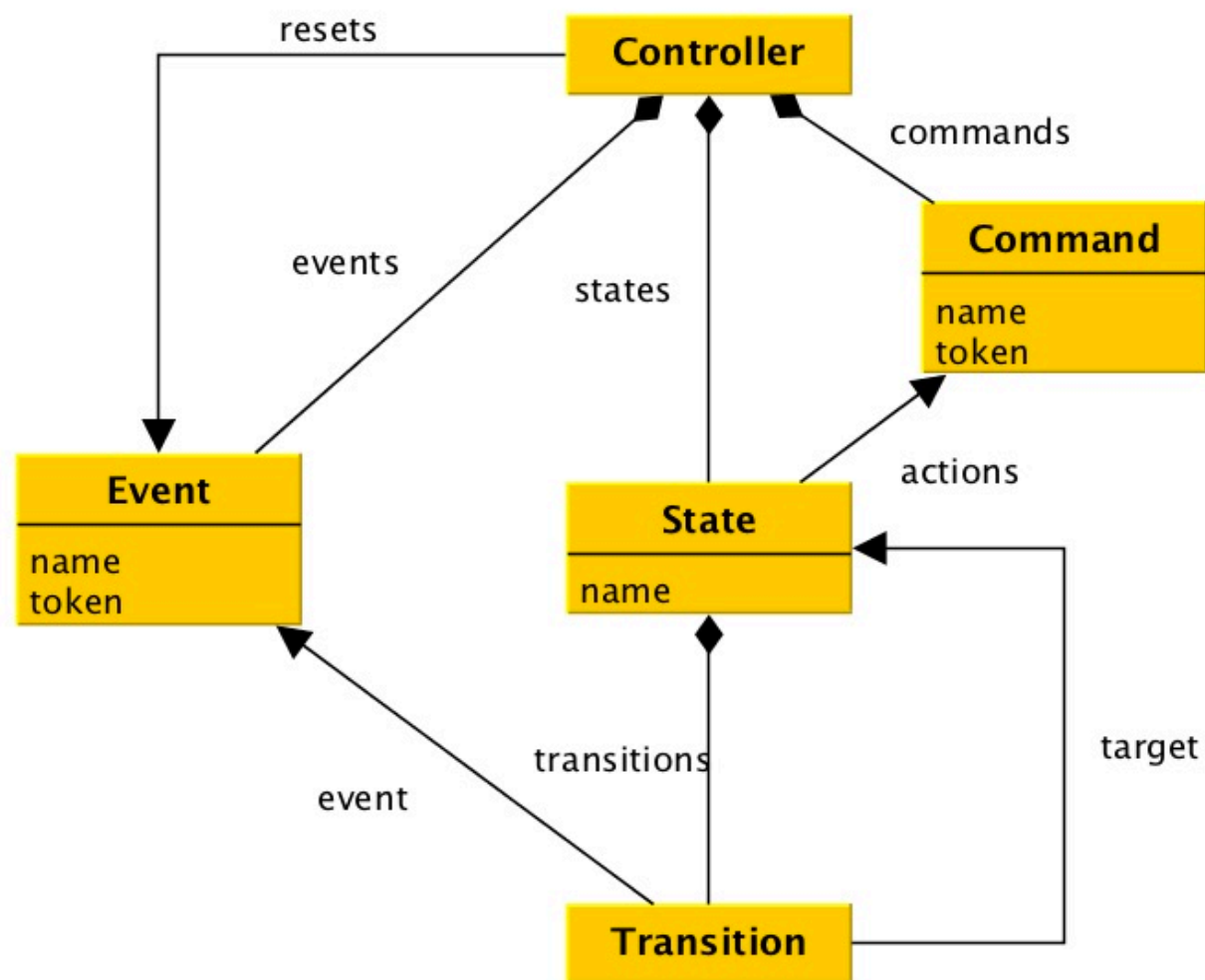
Meta Models

- Algebraic data types (“data Expr = ...”)
 - Define type of abstract syntax *trees*
- Meta Models are UML-style class diagrams
 - Define type of 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);
```


events

doorClosed D1CL
drawerOpened D2OP
lightOn L1ON
doorOpened D1OP
panelClosed PNCL

end

resetEvents

doorOpened

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

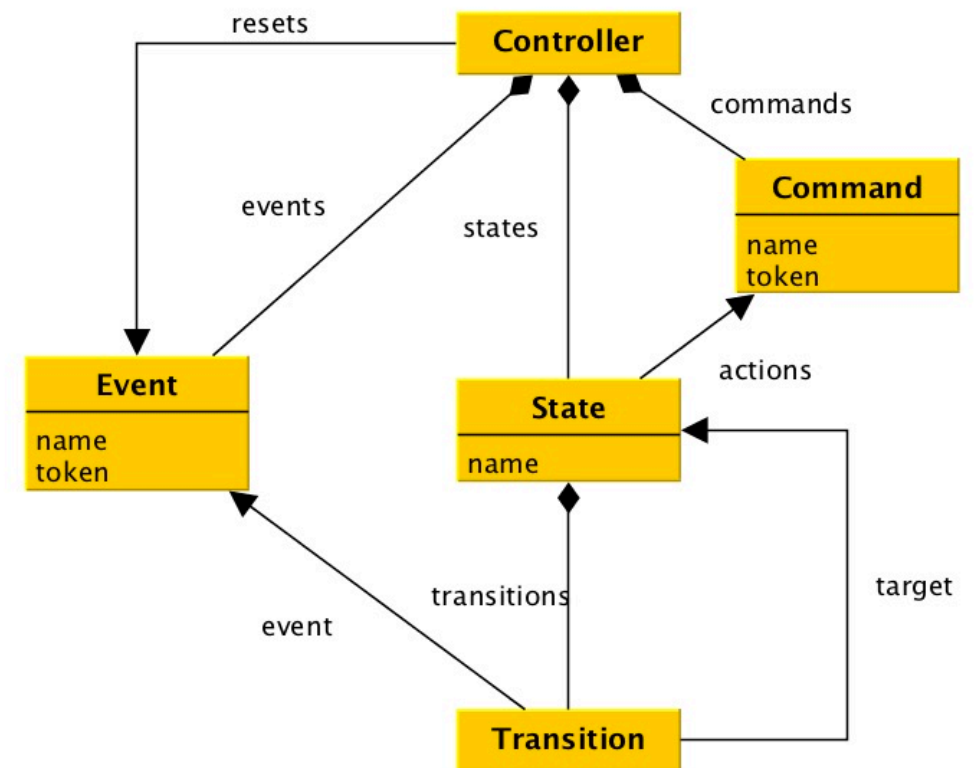
end

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

Scheme

Authority

Path

Offset

Length

|project://mutyphonql/src/example.mutql|(45,8,<6,2>,<6,10>)

Start line
and column

End line and
column

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.