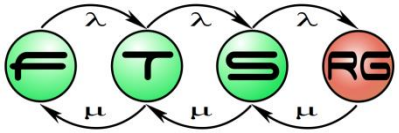
Modeling Environments, Code Generation

Budapest University of Technology and Economics
Fault Tolerant Systems Research Group



Content

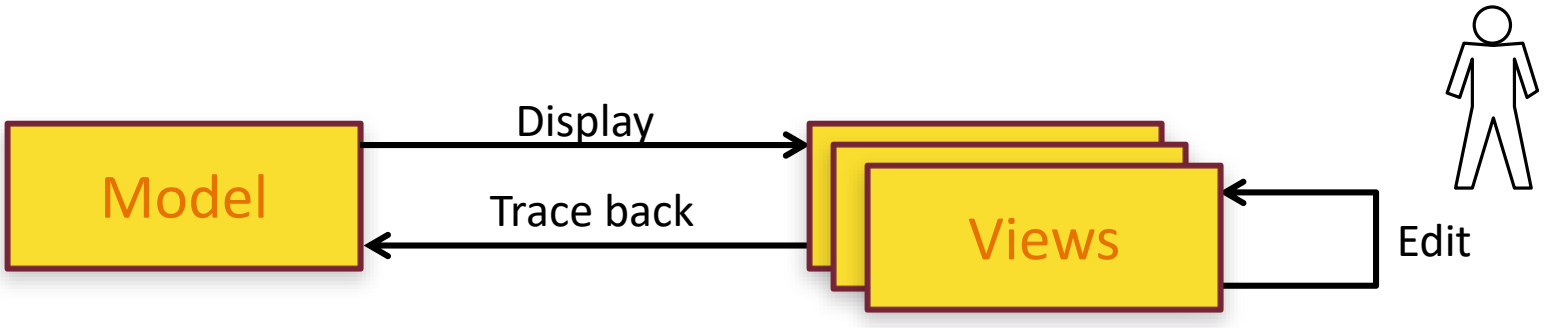
Functions

Modelling Environments

Code Generation

FUNCTIONS OF MODELLING ENVIRONMENTS

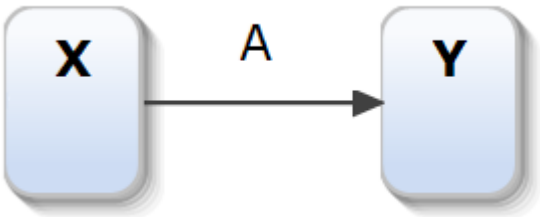
Functions of Modelling Environments



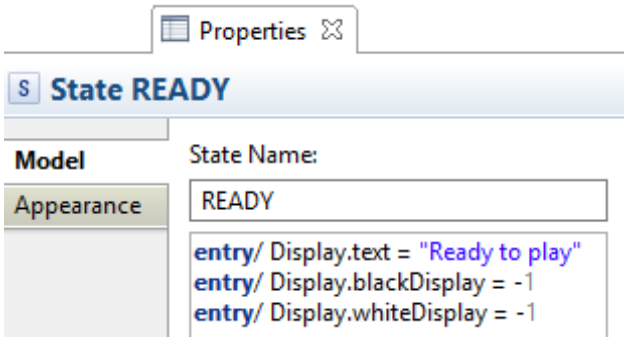
Textual

Demo
internal:
event A
event B

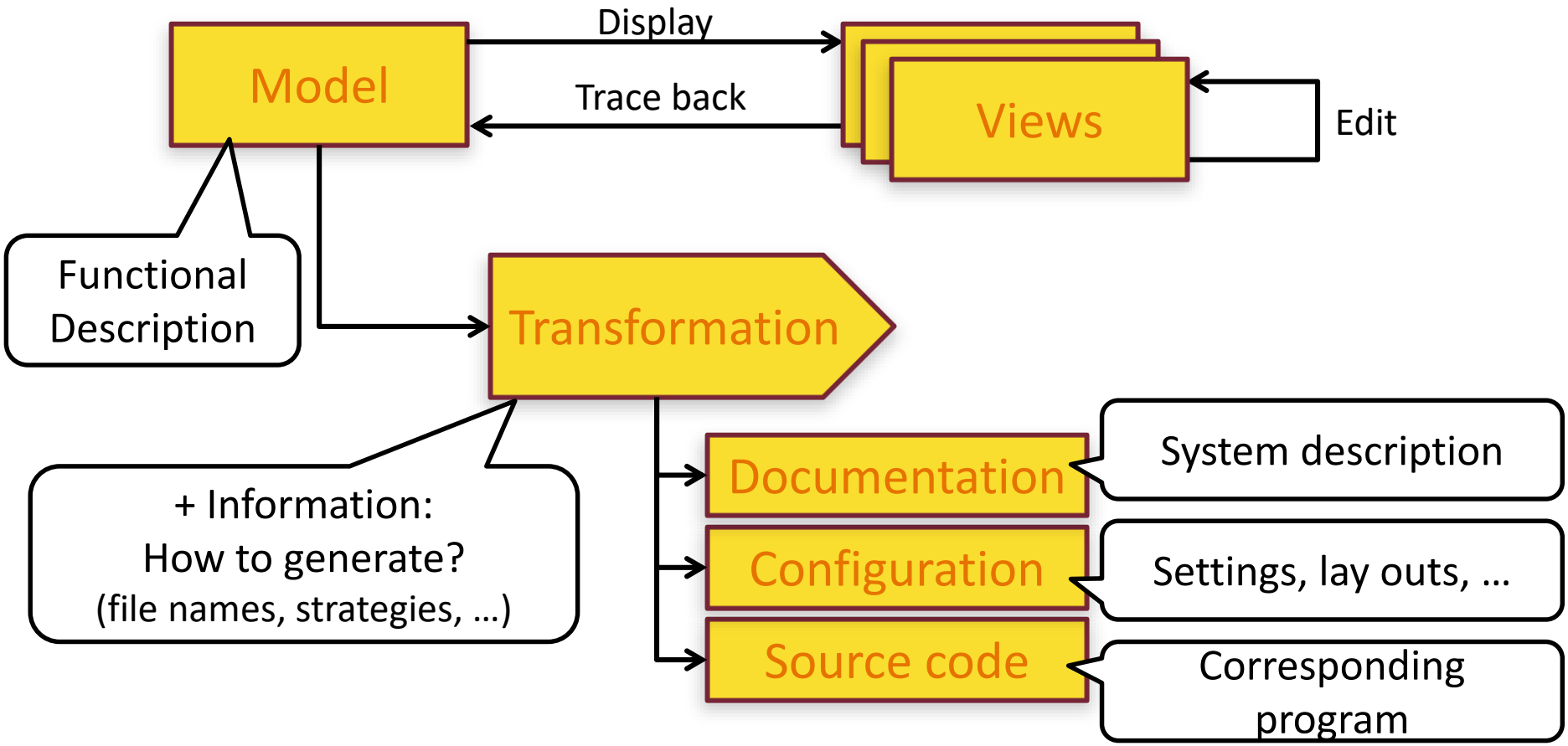
Graphical



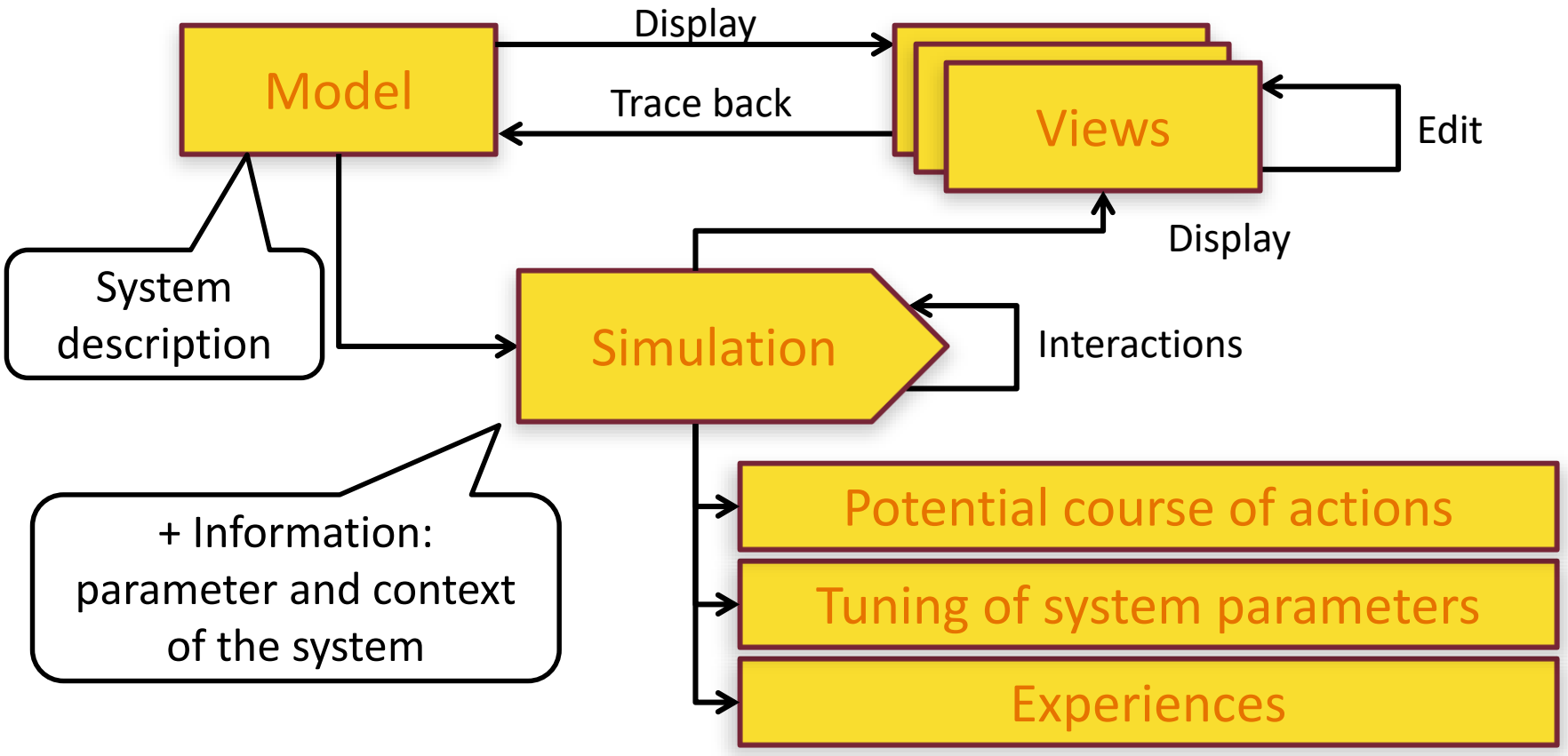
Structured Interfaces



Functions of Modelling Environments



Functions of Modelling Environments

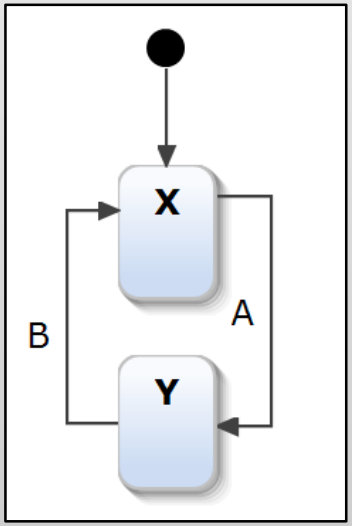


MODELLING ENVIRONMENTS

Modelling Functions of Yakindu

Concrete syntax
(for the User)

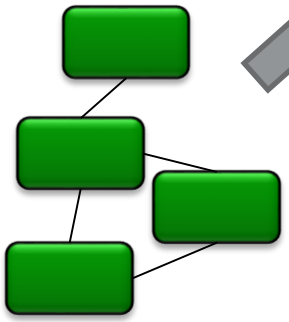
Graphical:



Textual:

Demo
internal:
event A
event B

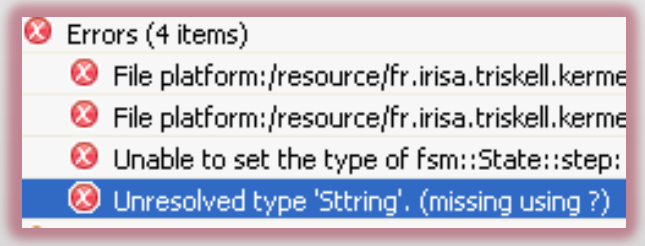
Syntax → Semantics



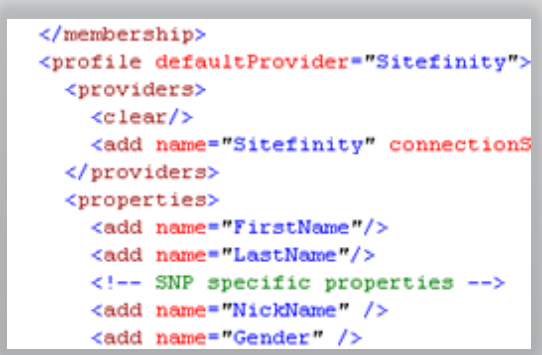
Model
(Abstract syntax)

Modelling functions

Model verification



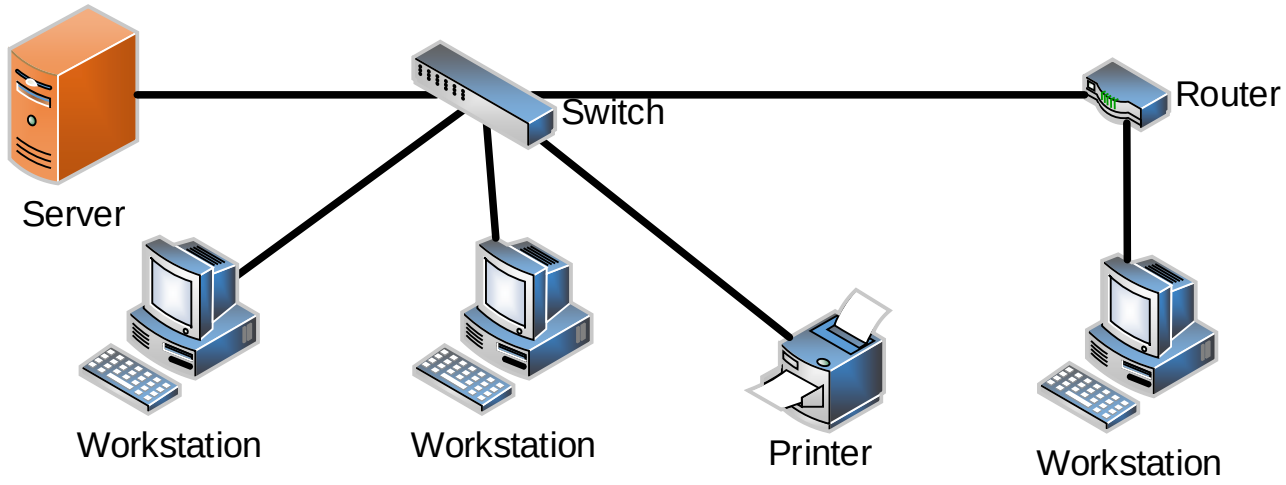
Code generation



(Source code, documentation, configuration)

Abstract Syntax

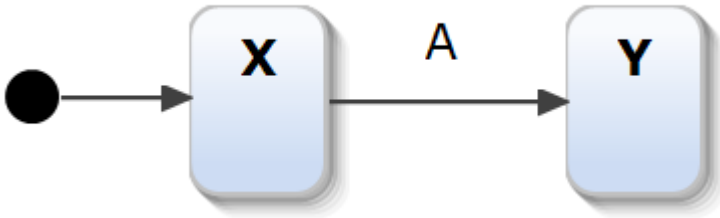
- **Definition:** Structural model of the system model under editing
  - Structural model of a model ???
- Will be maintained by the modelling environment
- Memory aid: structural model = **Graph**
  - **Graph of nodes, edges, properties**



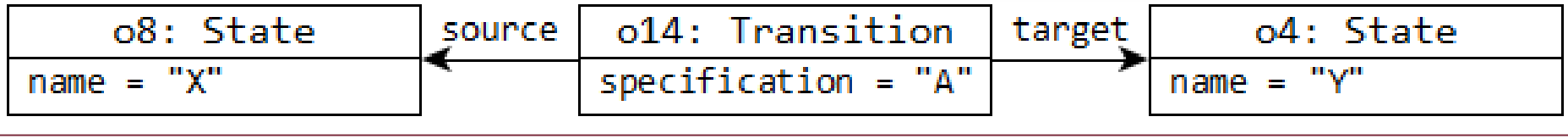
Example – Abstract Syntax: Yakindu

Question:
How would you implement a modelling environment tool?

Example: Yakindu Model



Abstract Syntax



Example – Abstract Syntax: Yakindu

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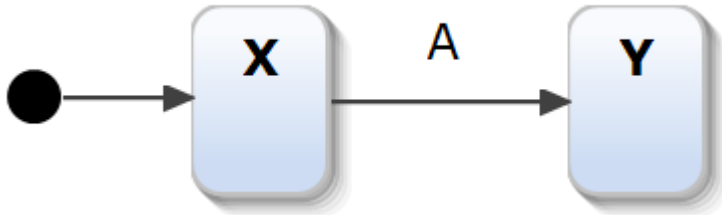
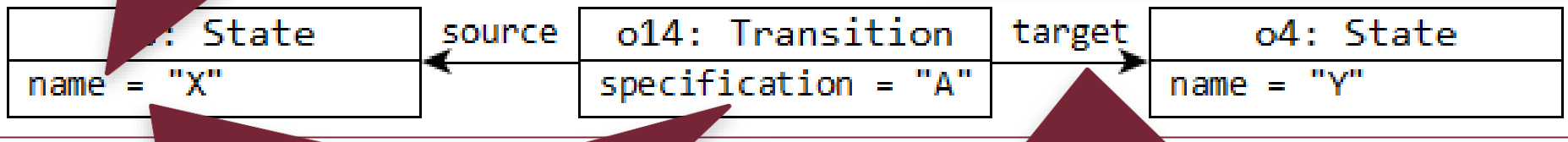
Example: Yakindu Model



Names are stored as strings

```
name = "X"
```

Abstract Syntax



Model elements as objects

Relations as references

Answer: It is a simple object-oriented program with some extra functions

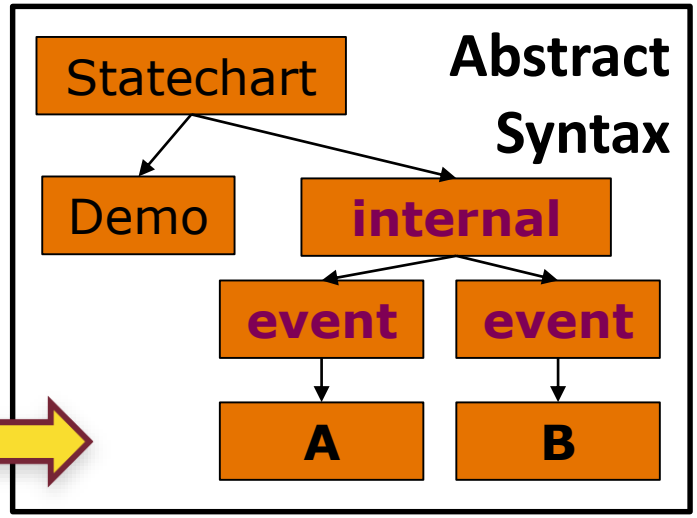
Concrete Syntax: Textual Syntax

- **Goal:** representation⇔ the model behind
- Textual syntax (e.g. programs)
  - Task: Text → Model
  - Rule based (otherwise it would be hard!)

```
Demo
internal:
event A
event B
```

Grammar

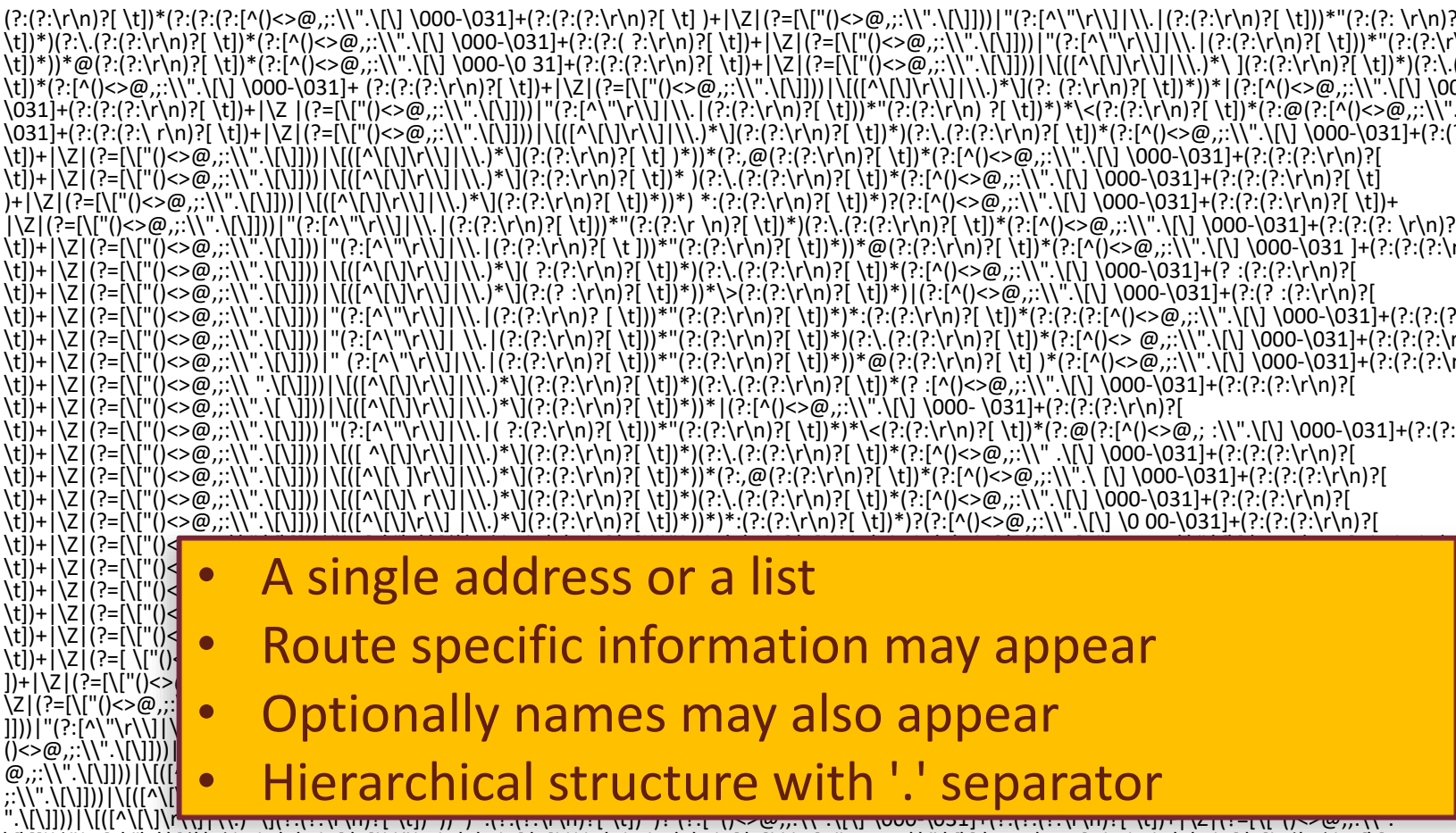
```
<Statechart>::= <Name> <Interface>*
<Interface> ::= ("internal" | <Name>)
                ":" <Event>*
<Event>     ::= "event" <Name>
<Name>      ::= …
```



With **appropriate** technologies (e.g. Xtext) **anyone** can implement **his own** modelling/programming environment!

Counterexample for „appropriate technologies”

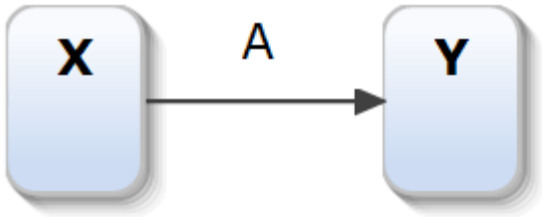
- **Task:** to decide whether a text consists of e-mail addresses



- A single address or a list
- Route specific information may appear
- Optionally names may also appear
- Hierarchical structure with '.' separator

Concrete Syntax: Graphical Syntax

- **Goal:** representation ⇔ the Model behind
- Graphical Syntax (e.g. diagram)
  - Task: Diagram ↔ Model
  - More clear to read, harder to write, rule based



Condition over the Model

Id*: StateVisualisation

Domain Class*: State

Semantic Candidates Expression: [self.eAllContents()/]

Creation of diagram elements

Label Alignment: Left / Center / Right

Label Expression: feature:name

Label Position: node

Color*: light_blue

Label Color*: black

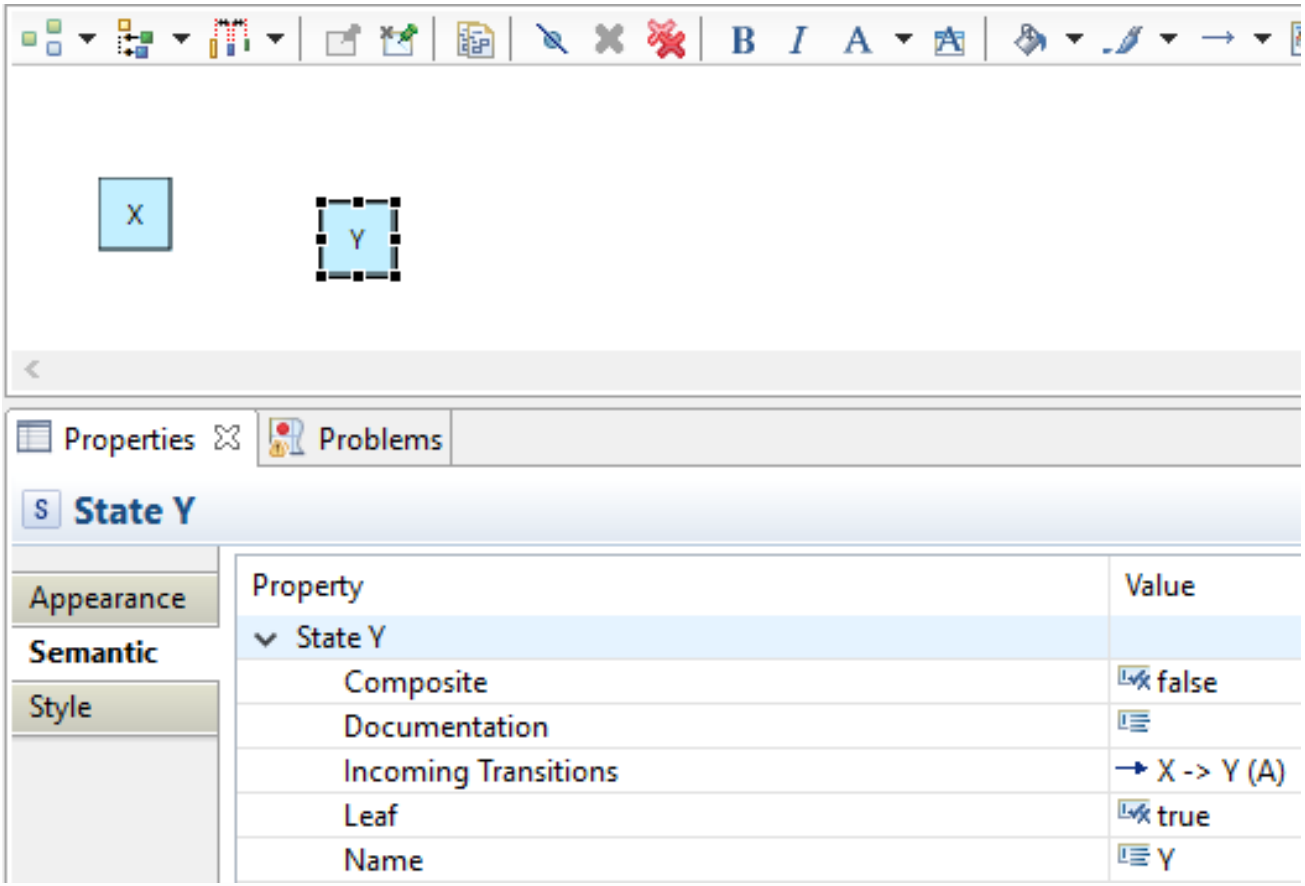
Border Color*: black

Condition satisfied → Diagram element will be created

Diagram will be changed → Model will also be changed

Concrete Syntax: Graphical Syntax

Result:



With **appropriate** technologies (e.g. Sirius) **anyone** can implement **his own** modelling/programming environment!

Model Validation: Syntax Analysis

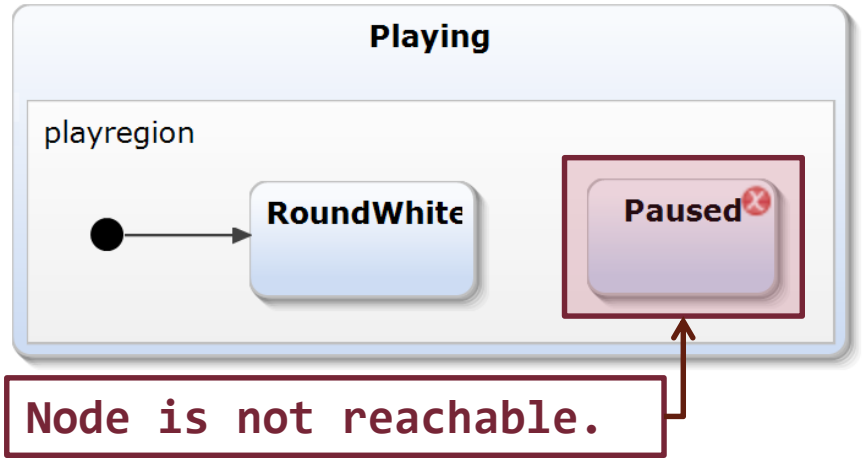
- Syntax analysis: modelling tools connect logically cascading model elements

- Syntax-driven editor
  - Fault during editing→ `Couldn't resolve reference`
  - Advanced editor (offering possibilities for instance)
- Code and diagram together

- Programming: **incorrect** during editing
  Modelling: **correct** during editing

Model Validation: Structural Correctness

- Structural analysis: examining model graph
- Looking for error-patterns during editing
- Unreachable state, for instance:



- Further analysis: missing initial state, deadlock, variable assignment, etc.

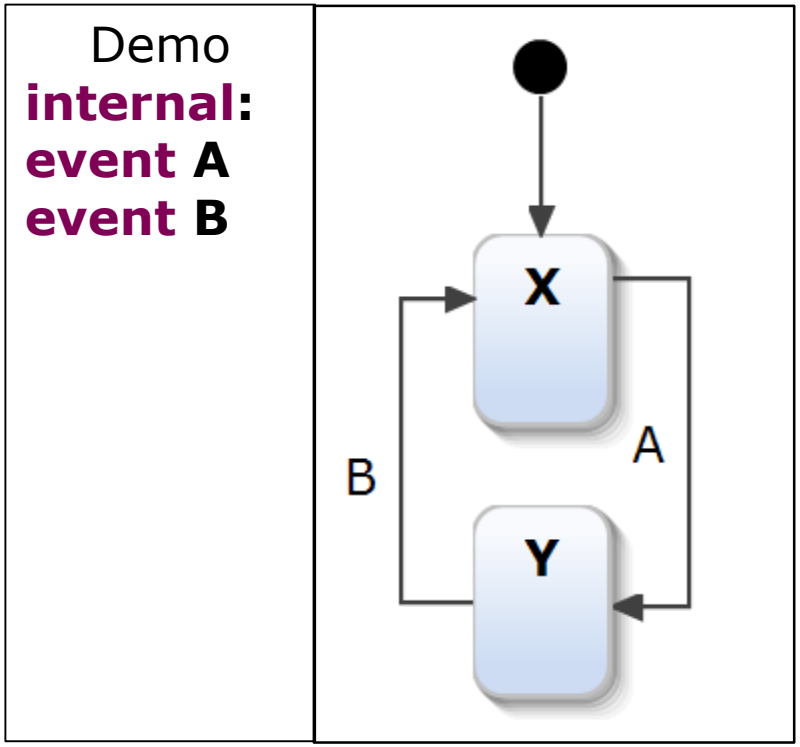
CODE GENERATION

Tasks of the Code Generation

- **Task:** automatic generation of models with *corresponding* behaviour
- Several options → Design decisions
  - **Interpretation:** Model will be loaded and executed
    Program code: Source code will be generated
  - **Programming languages:** Java, C, C++, …
  - **Optimising:** memory vs. processor
    observability vs. performance
  - How can the generated code be extended with manually coded parts?
- Code generator: customizable + extendable

Code Generators – Example

- **Task:**
  Generate C-code for a Yakindu state machine



- Write a function, which:
  → takes a model object
  ← returns a text
- The text will be written is a file „Demo.c”
- It will be compiled (by a C-compiler)

Template Based Code Generator (Xtend)

- Goal: States → Enum

```
enum states {
   StateX,
   StateY
};
```

The output will be collected in a char*, instead %s will the names X,Y be written

- Solution: a C program

```
sprintf(result,
   "enum states {\n\tState%s,\n\tState%s\n};",
   state1->name,
   state2->name);
```

☺ Works immediately!
☹ Unreadable

- Template (Xtend):

```
'''
enum states {
    State«state1.name»,
    State«state2.name»
}'''
```

The variable parts will be indicated

A template will be written

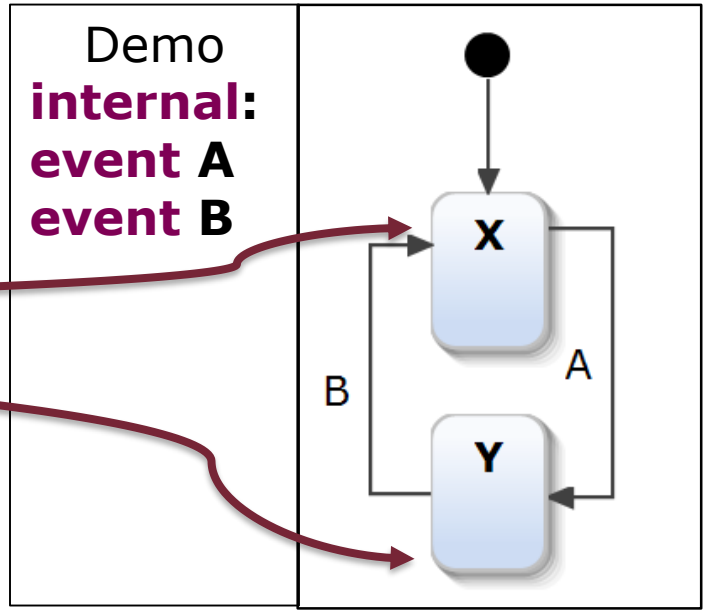
☺ Easier to write
☺ More clear to read
☺ Easier to modify
☹ +1 technology

Code Generator Example – States

- Expected C-code:

```
//States of the statemachine
enum states {
   StateX,
   StateY
};
```

Possible states:
listed as an Enum



- Template:

```
//States of the statemachine
enum states {
«FOR state : states»
   State«state.name»,
«ENDFOR»
};
```

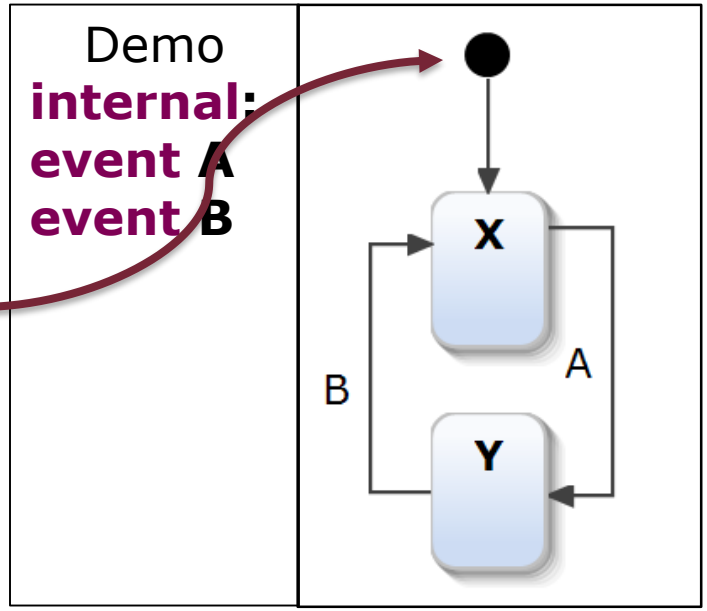
1. We iterate through all states
2. Their names will be written (separated by commas):
   `State«Name»` e.g.: `StateX`

Code Generator Example – Initial State

- Expected C-code:

```
// The current state
// First = entry state.
enum states actualState = StateX
```

current state = initial state



- Template:

```
// The current state
// First = entry state.
enum states actualState = State«findEntry(states).name»
```

1. We search for the initial element
2. Its name will be written

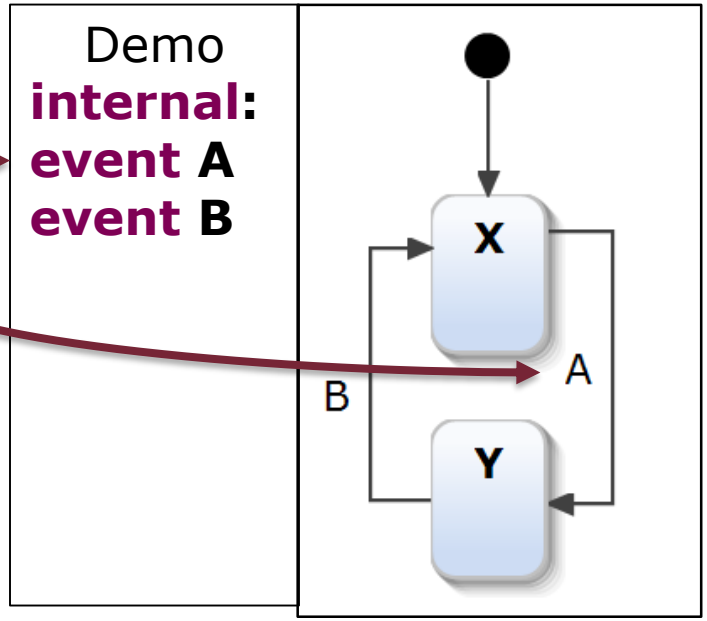
Code Generator Example – State Transitions

- Expected C-code:

```
// Execute "A" event
void doA{
switch(actualState) {
        case StateX:
            actualState = StateY;
            break;
        case StateY:
            break;
    }
}
```

A / X → Y

A / -



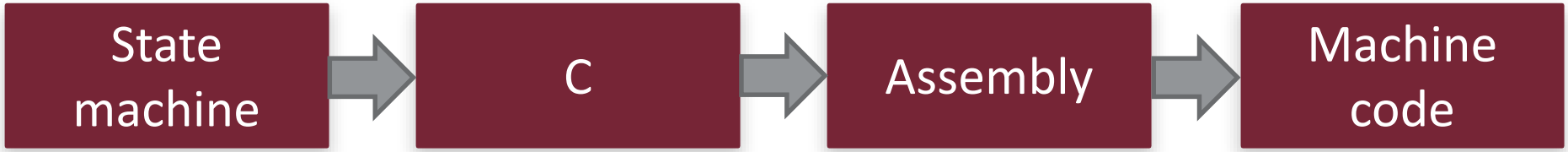
- Template (sketch):

1. For each event a function `do«NameOfEvent»`
2. Its content corresponds to the transitions (with guard, action)

For a (simple) state machine the code generator is nothing more than this!

Code Generator – Summary

- Code generation = translation
- Same steps:



- Working in the domain of the problem: Produktivity ++
- Many boring, complex coding automatized: Performance ++
- Checking in the domain of the problem: Reliability ++
- Projects at our research group: up to **95%** generated code

Code Generator – Summary

- Code generation = translation
- Same steps:

State machir

Prophecy:
yesterday design pattern →
today function of the code generatores →
tomorrow element of the modelling languages

achine code

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