Domain-Specific Languages

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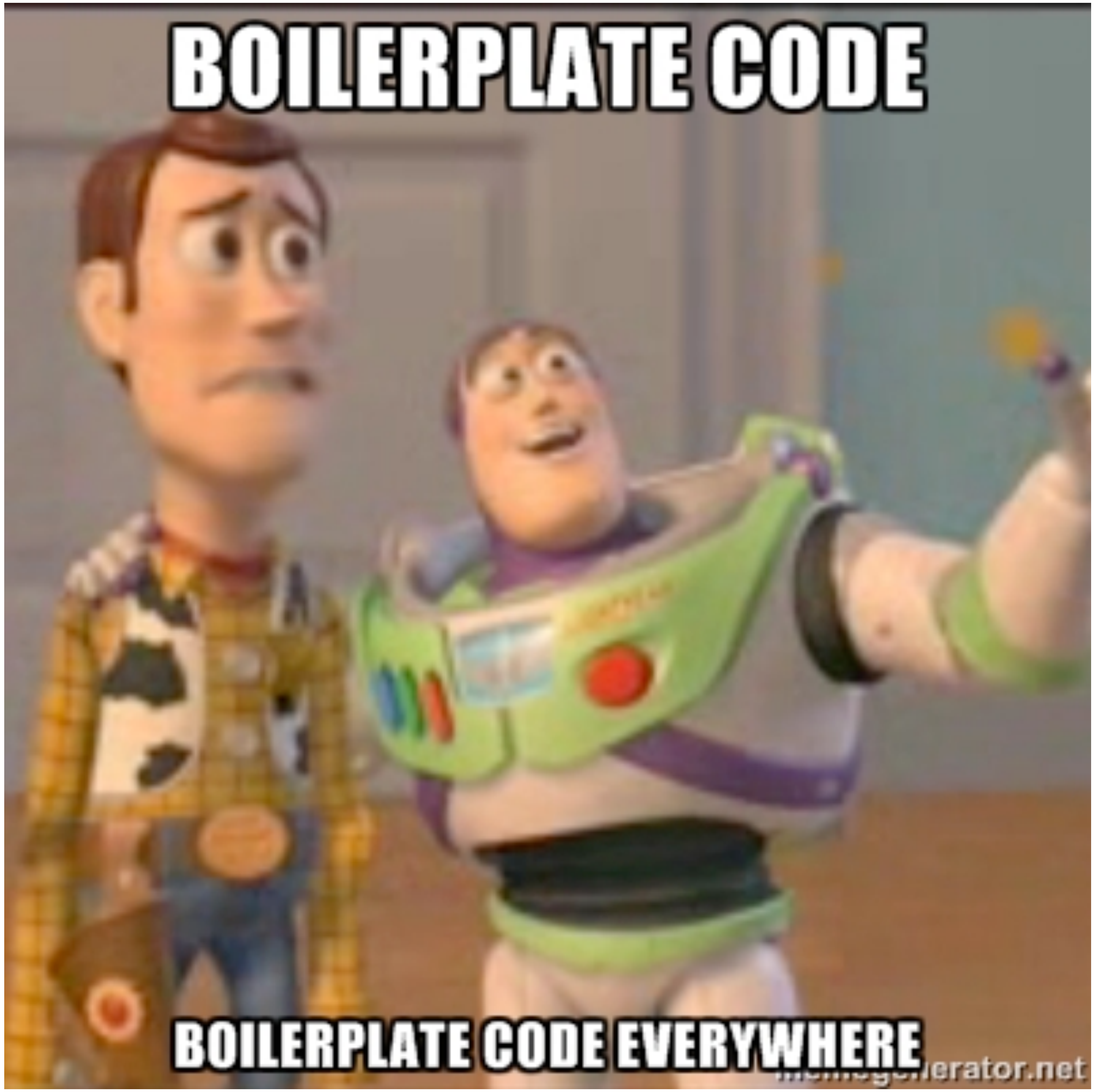
university of groningen

Programming?


BOILERPLATE CODE
BOILERPLATE CODE EVERYWHERE

A programming language is low level when its programs require attention to the irrelevant

Alan J. Perlis, Epigrams on Programming, *ACM SIGPLAN Notices* 17 (9), September 1982, pp. 7–13

Some facts

Fact 41. Maintenance typically consumes 40 to 80 percent of software costs. It is probably the most important life cycle phase of software.

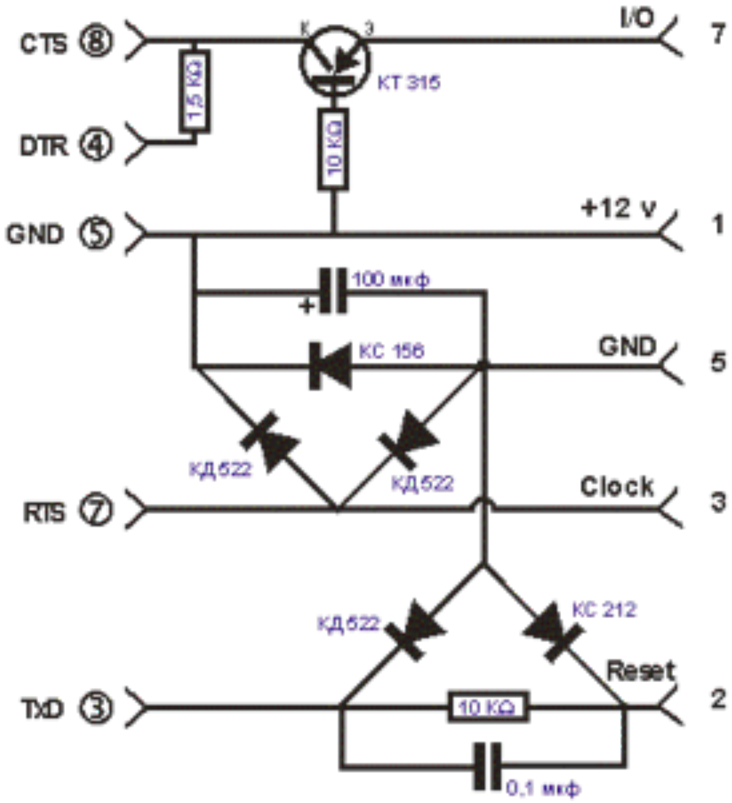
Fact 44. Understanding the existing product is the most difficult task of maintenance.

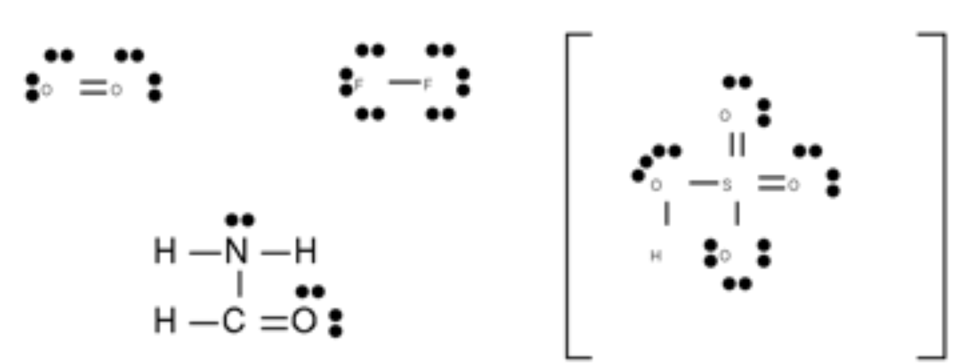
Fact 21. For every 25 percent increase in problem complexity, there is a 100 percent increase in solution complexity.

Domain Specific Languages!

Robert Glass, *Facts and fallacies of Software Engineering*, Addison-Wesley 2003

Domain specific languages

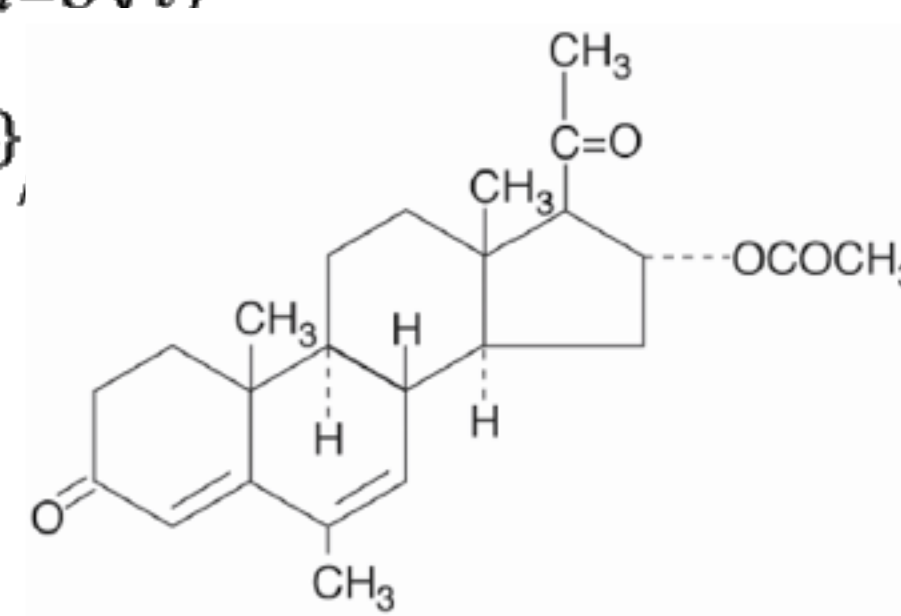




$$c_t = S_t N(h) - Xe^{-rt} N(h - \sigma\sqrt{\tau})$$

where

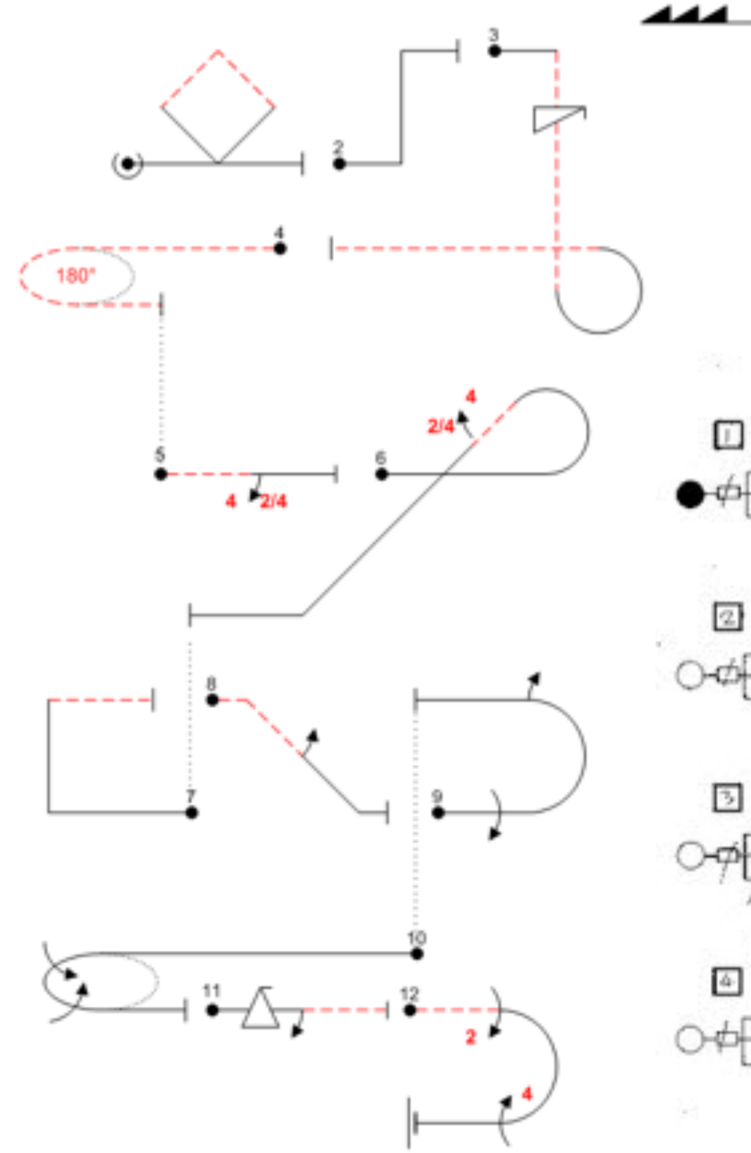
$$h = \{\ln(\frac{S}{X}) + r\tau + \frac{\sigma^2\tau}{2}\}$$

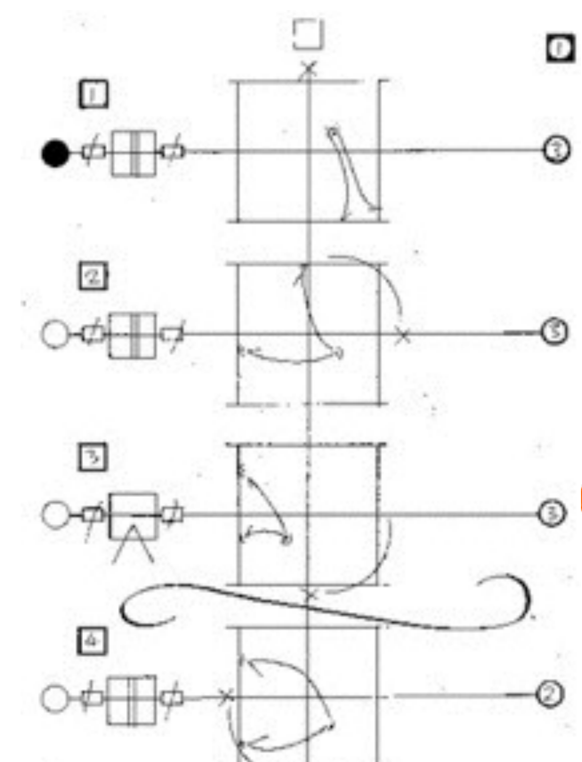


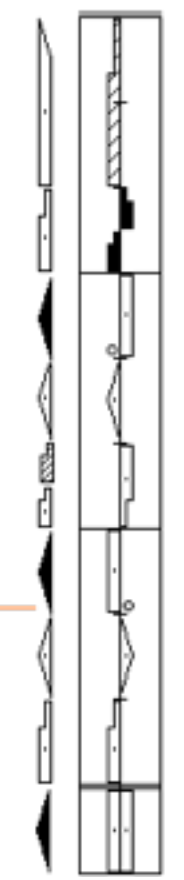
Domain specific languages

```
E|-------------|------------|-------------|------------|
B|-------------|------------|-3---3--0----|-1---1------|
G|-0-2--0------|-0-2-0------|-------------|--------0---|
D|--------2----|-------2----|-------------|------------|
A|-------------|------------|-------------|------------|
E|-------------|------------|-------------|------------|
```


```
White:  G. A. Anderssen
Black:  J. Dufresne
Opening:  Evans Gambit
Location: Berlin, 1854
      White          Black
     -------        -------
 1.  P-K4           P-K4
 2.  Kt-KB3         Kt-QB3
 3.  B-B4           B-B4
 4.  P-QKt4         BxKtP
 5.  P-B3           B-R4
 6.  P-Q4           PxP
 7.  O-O            P-Q6
 8.  Q-Kt3          Q-B3
 9.  P-K5           Q-Kt3
10.  R-K1           KKt-K2
11.  B-R3           P-Kt4
12.  QxP            R-QKt1
13.  Q-R4           B-Kt3
14.  QKt-Q2         B-Kt2?
15.  Kt-K4          Q-B4?
16.  BxQP           Q-R4
17.  Kt-B6 ch!      PxKt
18.  PxP            R-Kt1
19.  QR-Q1!         QxKt
20.  RxKt ch        KtxR
21.  QxP ch!        KxQ
22.  B-B5 dbl ch    K-K1
23.  B-Q7 ch        K-B1
24.  BxKt mate
```







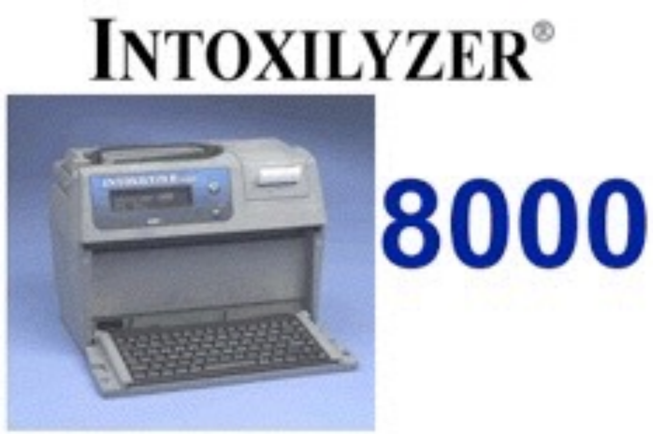
Observations

- Special purpose
- Restricted
- Concise
- Expert usage
- Formalized
- Textual or graphic or combination

General purpose languages (GPLs)

DSLs

Programming



Domain Programmer Code

Programming

Domain Programmer Code

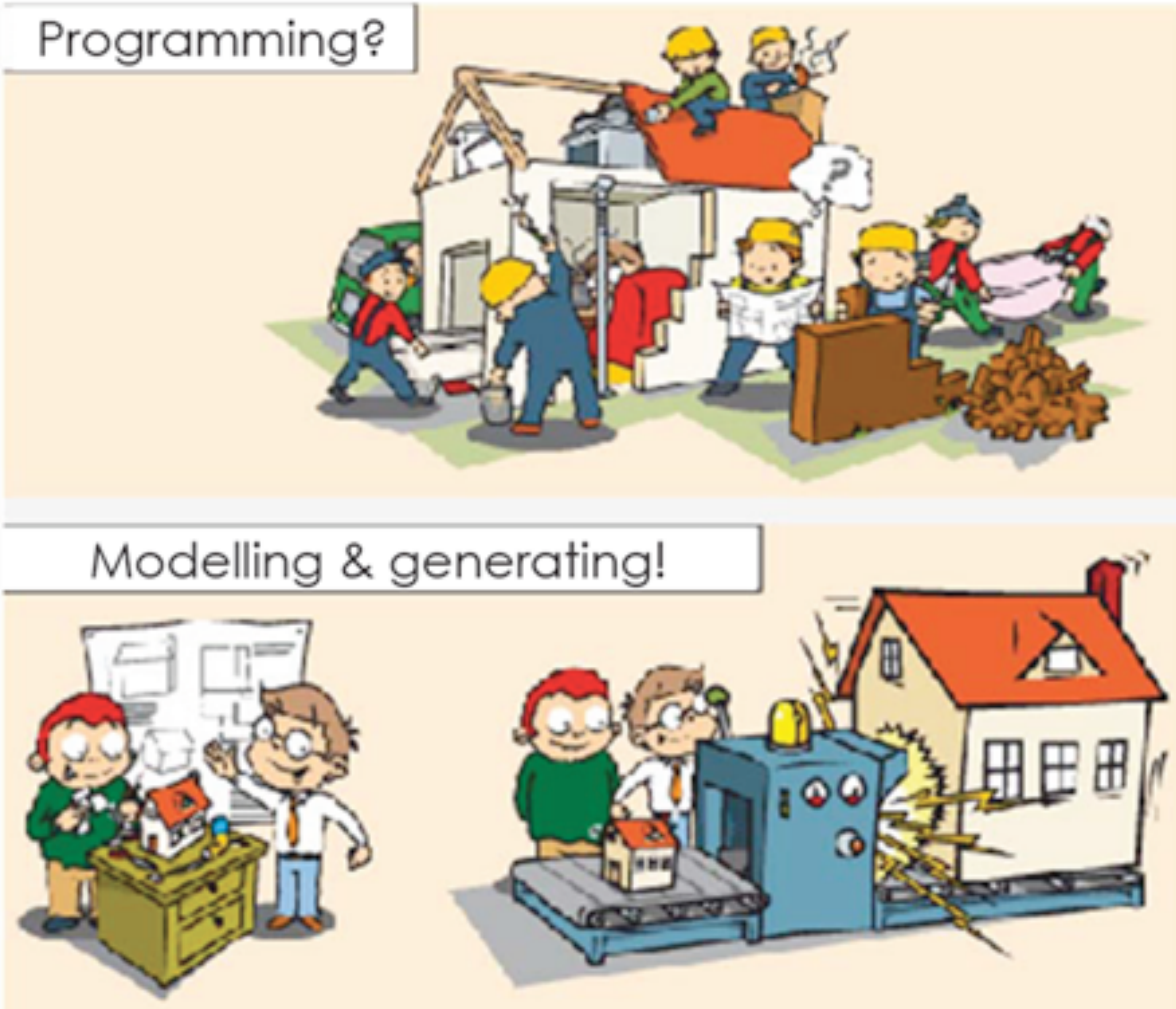
Programming is “lossy”

- encoding
- obfuscating
- encrypting
- dispersing
- tangling
- distorting

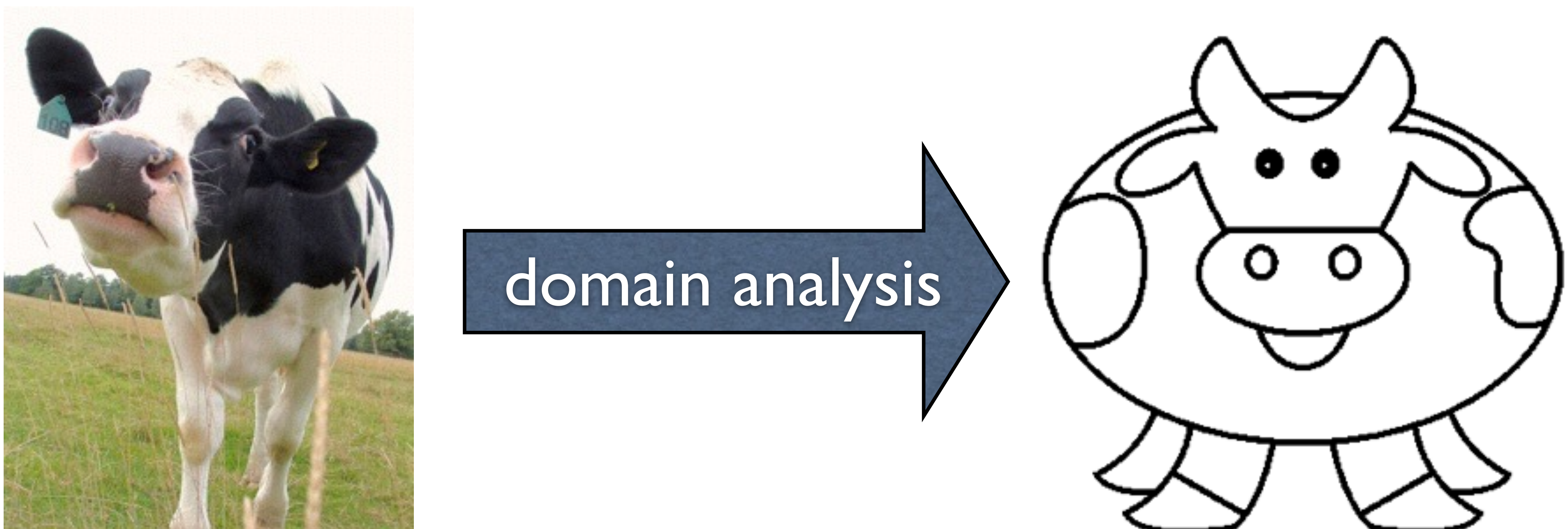
Cognitive distance

The problem

- a lot of code,
- low level code,
- characterized by lack of abstraction
- encoding domain knowledge
- and encoding design knowledge

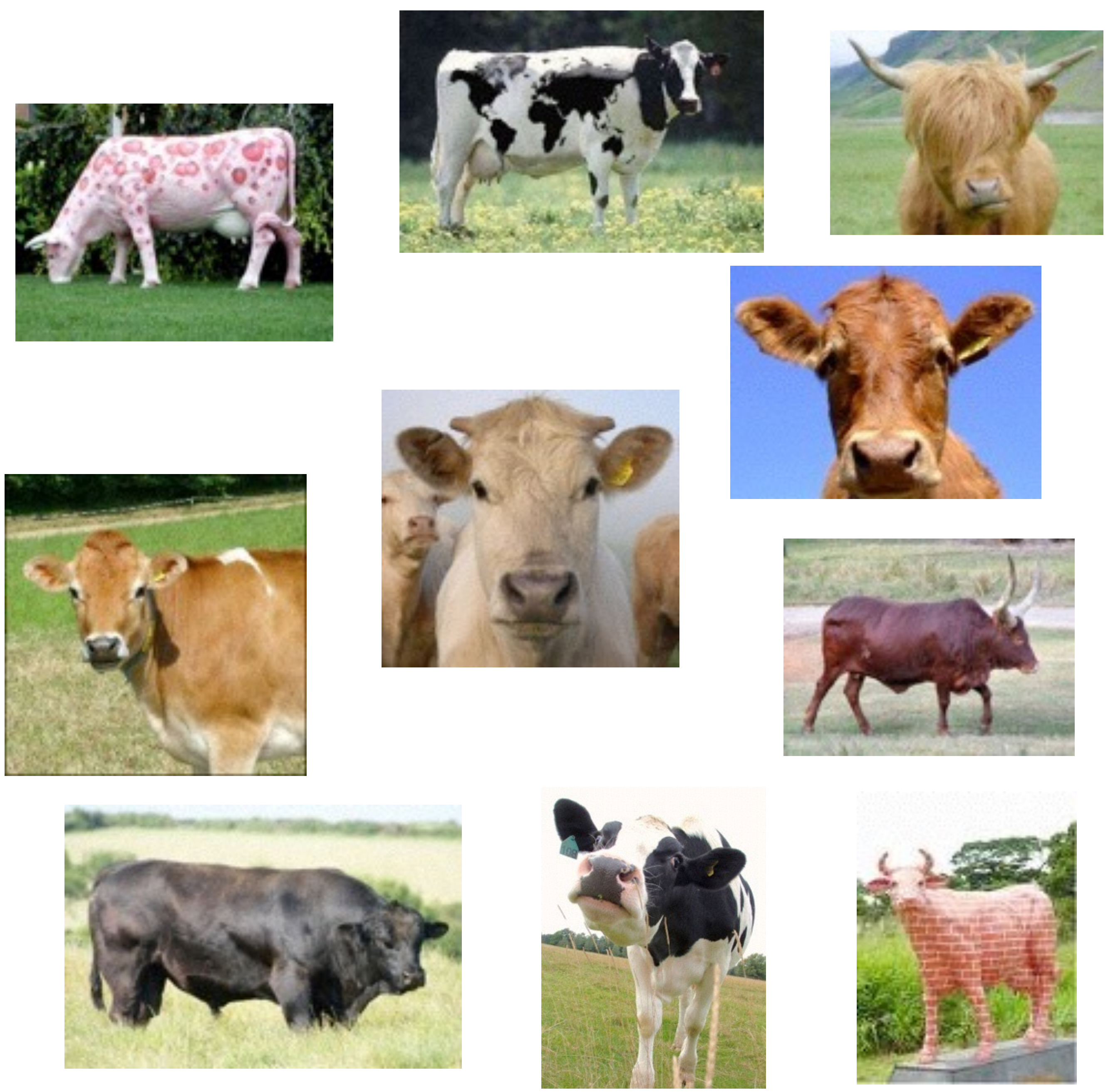

Programming?
Modelling & generating!

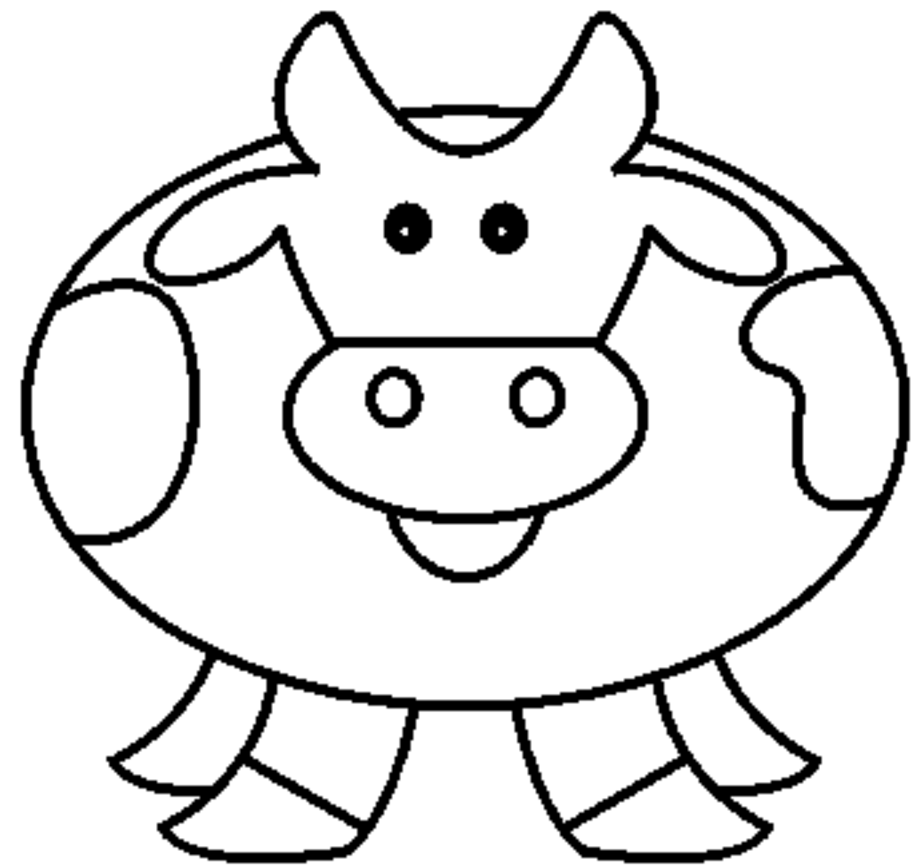
Modeling the domain



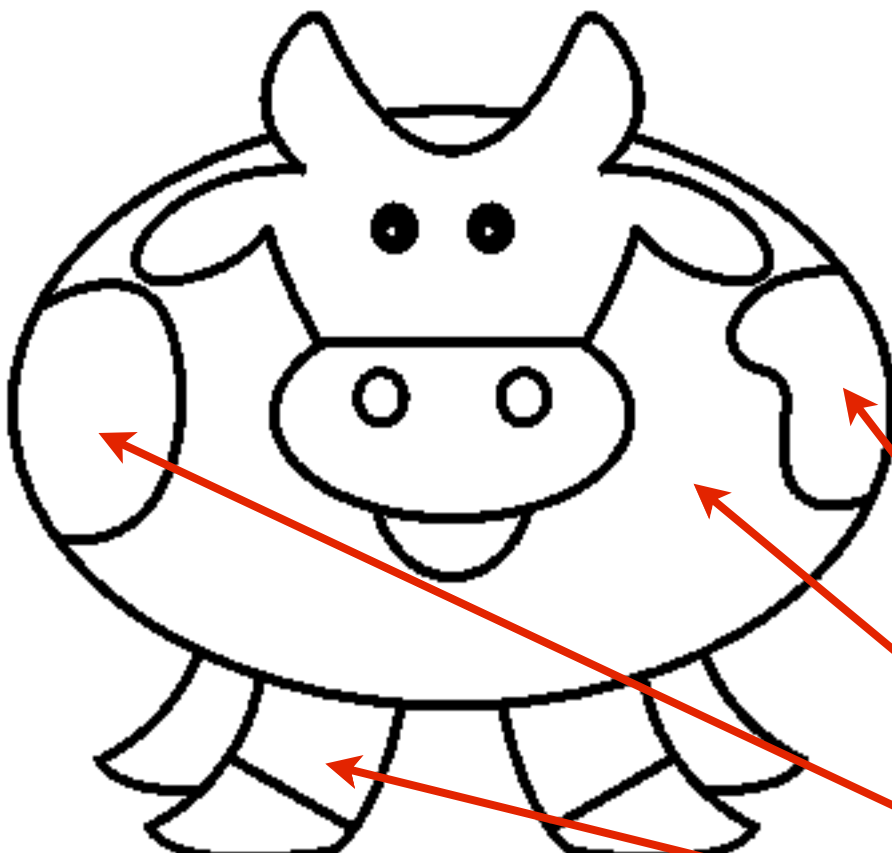
Ceci n’est pas une vache

System families





Domain Specific Language

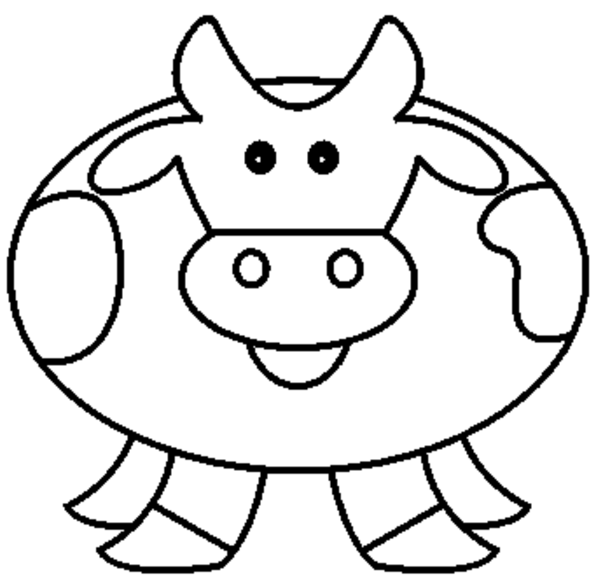


=

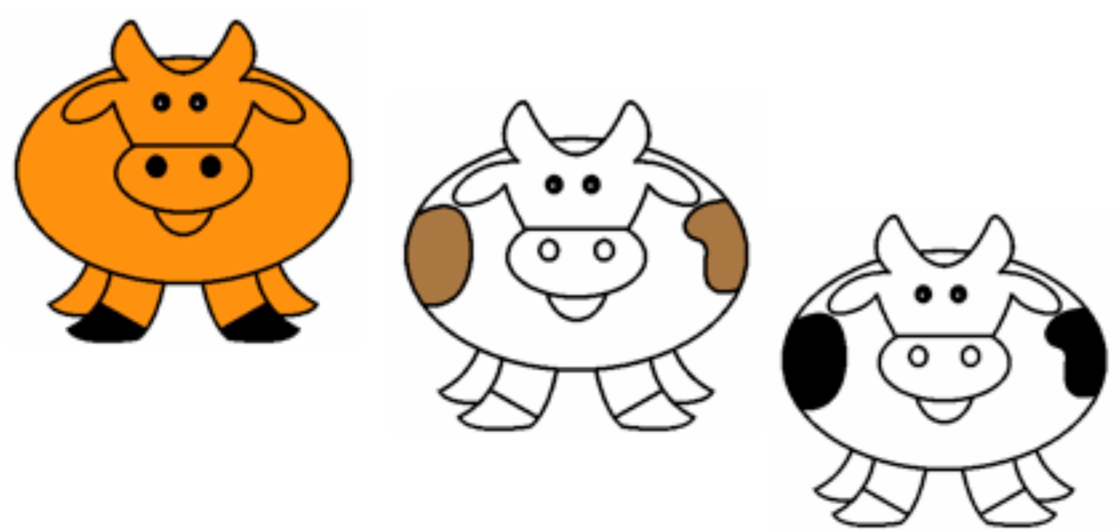
formalized notation capturing "Cows"

variation points

Domain Specific Languages

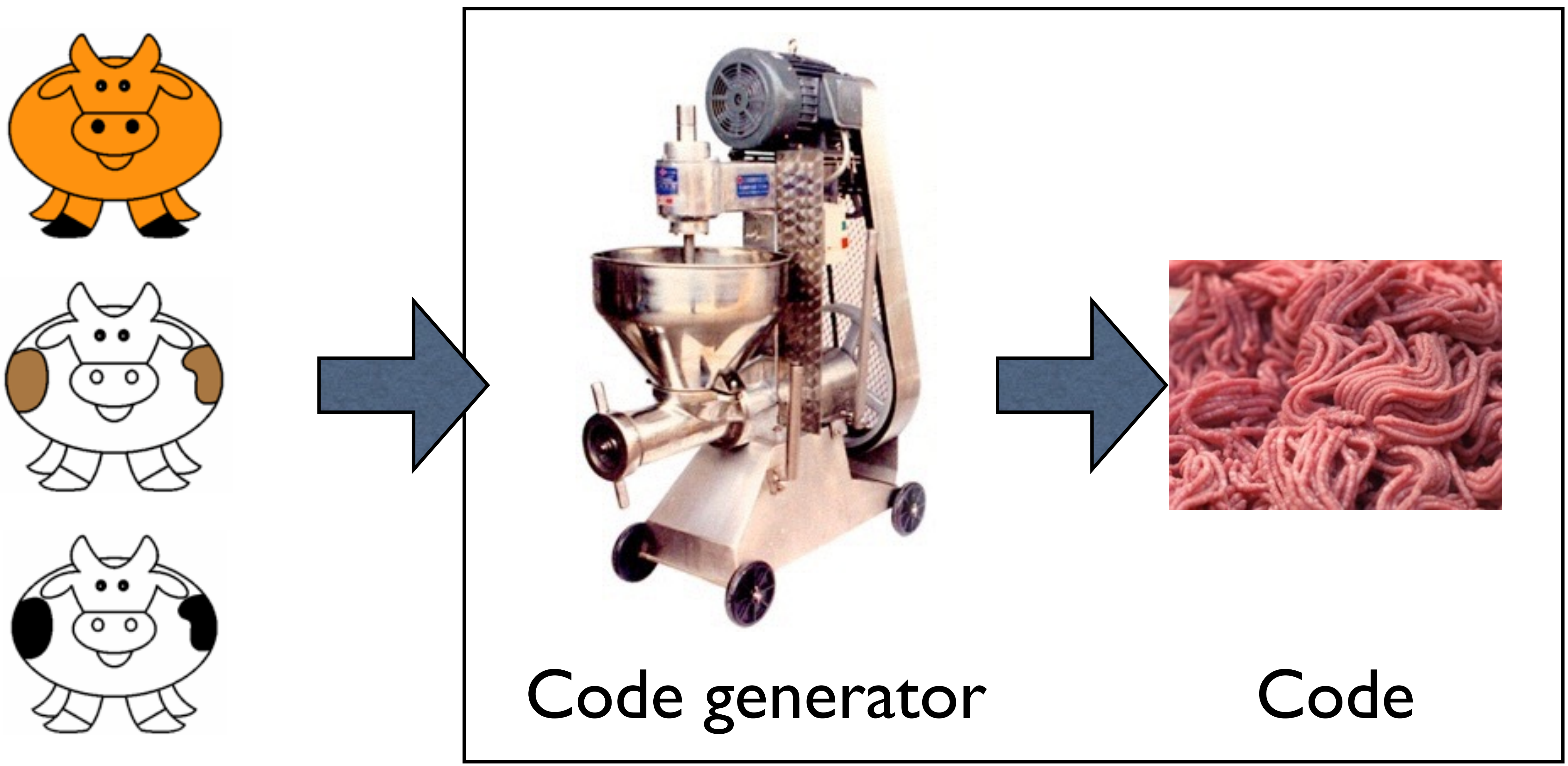


= grammar, template, metamodel

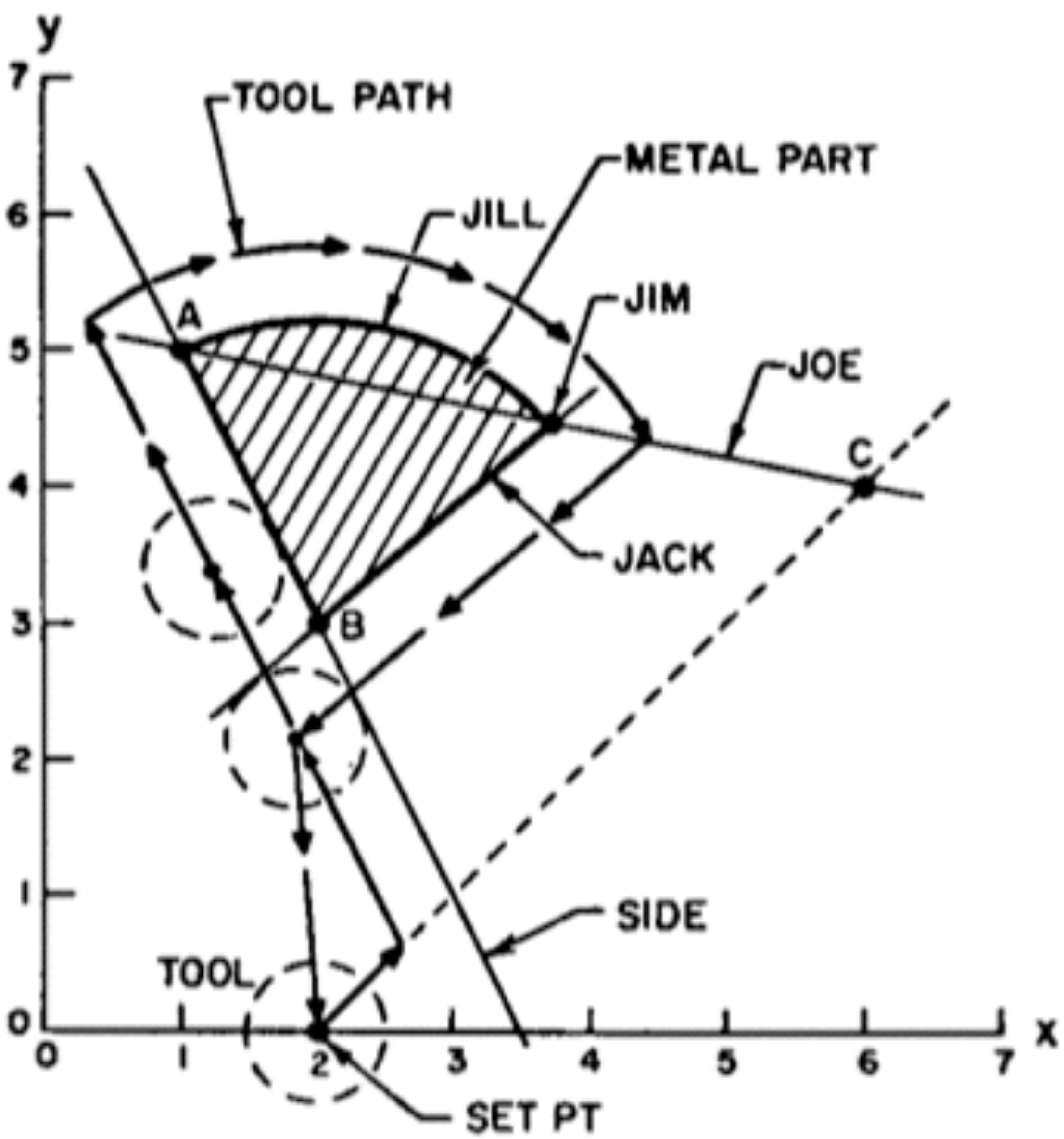


= sentence, instance, model

Code generation



APT: numerical control




```
A       =  POINT / 1, 5
B       =  POINT / 2, 3
C       =  POINT / 6, 4
           TL DIA / +1.0, INCH
           FEDRAT/ 30, IPM
SET PT  =  FROM, POINT/ 2, 0
           IN DIR, POINT/ C
SIDE    =  GO TO, LINE / THRU, A, AND, B
           WITH, TL LFT, GO LFT, ALONG/ SIDE
JILL    =  GO RGT, ALONG, CIRCLE/ WITH, CTR AT, B, THRU, A
JOE     =  LINE / THRU, A, AND, C
JIM     =  POINT / X LARGE, INT OF, JOE, WITH, JILL
JACK    =  LINE / THRU, JIM, AND, B
           GO RGT, ALONG/ JACK, UNTIL, TOOL, PAST, SIDE
           GO TO/ SET PT
           STOP, END, FINI
```

from the '50s (!)

LaTeX: document preparation

```latex
\subsection{Application à un exemple: la coévolution proies-prédateurs}
    \subsubsection{Étape 1: Modèle écologique et stationnarité}
Nous nous intéresserons dans ce cas au modèle simple de Lotka-Volterra,
énoncé par le système~\ref{eq:lotka_volterra}.

Dans ce modèle de base, il faut introduire une dépendance au trait sujet
à évolution qui nous intéresse. Ici, nous considérons la taille
corporelle $x$ comme trait d'intérêt et supposons que la compétition
intraspécifique, $\alpha$, et la prédation, $\beta$, en dépendent ainsi:
\begin{eqnarray}
    \alpha(x_1)&=&\alpha_0+\alpha_2(x_1-x_{1_{0}})^{2}\\
    \beta(x_1,x_2)&=&\beta_0
\exp\left[-\left(\frac{x_1}{\beta_1}\right)^{2} +
2\beta_3\left(\frac{x_1}{\beta_1}\right)\left(\frac{x_2}{\beta_2}\right)
- \left(\frac{x_2}{\beta_2}\right)^{2}\right]
\end{eqnarray}

\begin{figure}[p]
    \begin{center}
        \includegraphics[width=0.45\textwidth]{figures/func_alp}
        \includegraphics[width=0.45\textwidth]{figures/func_bet}
        \caption{Les fonctions choisies pour $\alpha$ et $\beta$}
    \end{center}
\end{figure}
```

VHDL: hardware description

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.STD_LOGIC_ARITH.ALL;
use IEEE.STD_LOGIC_UNSIGNED.ALL;

entity ClkDiv is
    Port (  InByte : in STD_LOGIC_VECTOR(3 downto 0);        --<-- Seq_CPLD
            RegSel : in STD_LOGIC_VECTOR(1 downto 0);        --<-- Seq_CPLD
            RegStrb : in STD_LOGIC;                          --<-- Seq_CPLD
            MClk : in  STD_LOGIC;                            --<-- OSC
            SeqReset : in STD_LOGIC;                         --<-- Power Monitor
            ADC_Clk : out STD_LOGIC);                        -->-- ADC
end ClkDiv;

architecture Behavioral of ClkDiv is
   signal   ADC_div :      STD_LOGIC_VECTOR(5 downto 0) := "001111";
   signal   ADCClk :       STD_LOGIC := '0';
   signal   ClkSel :       STD_LOGIC_VECTOR(2 downto 0) := "100";

begin
```

Risla: financial products

Time to market went down from 3 months to 3 weeks.

Developed at CWI

```
product LOAN

declaration
  contract data
    PAMOUNT : amount                 %% Principal Amount
    STARTDATE : date                 %% Starting date
    MATURDATE : date                 %% Maturity data
    INTRATE : int-rate               %% Interest rate
    RDMLIST := [] : cashflow-list    %% List of redemptions.

  information
    PAF : cashflow-list              %% Principal Amount Flow
    IAF : cashflow-list              %% Interest Amount Flow

  registration
    %% Register one redemption.
    RDM(AMOUNT : amount, DATE : date)
```

QL

```
form Box1HouseOwning {
  "Did you sell a house in 2010?" hasSoldHouse: boolean
  "Did you by a house in 2010?" hasBoughtHouse: boolean
  "Did you enter a loan for maintenance?" hasMaintLoan: boolean
  if (hasSoldHouse) {
    "Private debts for the sold house:" privateDebt: money
    "Price the house was sold for:" sellingPrice: money
    "Value residue:" valueResidue = sellingPrice - privateDebt
  }
}
```

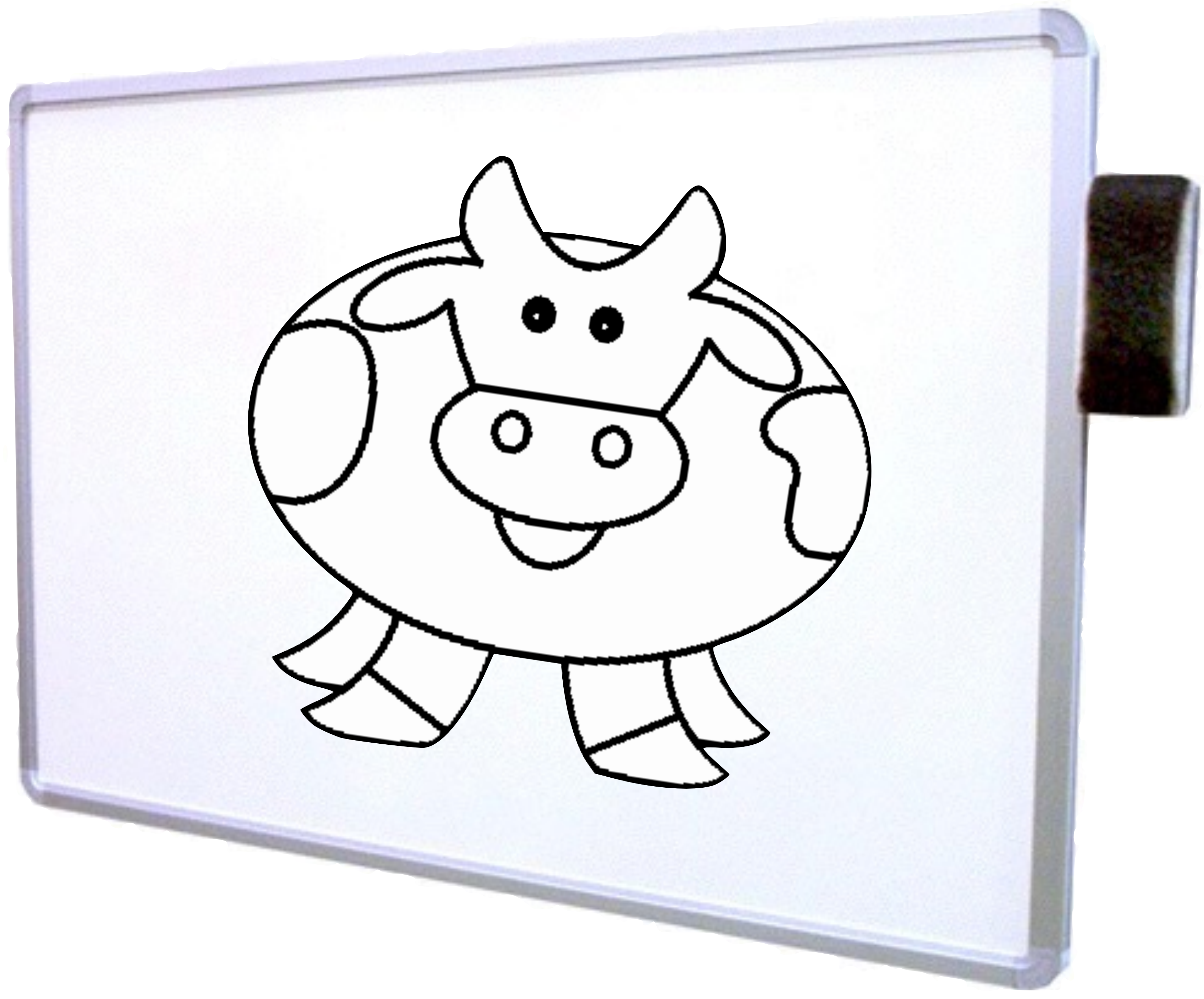
Other examples

- Make: software building
- Dot: graph visualization
- SQL: relational querying
- SWUL: Swing GUIs
- HTML: hypertext
- CLOPS: commandline options
- GNUPlot: plotting
- R: statistics
- CML: kernel config
- Lex: lexical scanning
- Excel: spreadheets
- Rascal: meta-programming
- ...

Domain-specific languages

- Better languages, for specific domains
- Capture families of systems
- Higher level of abstraction
- Focus on “what” vs “how”
- Reuse designs, not just code
- Language workbenches (e.g., Rascal)

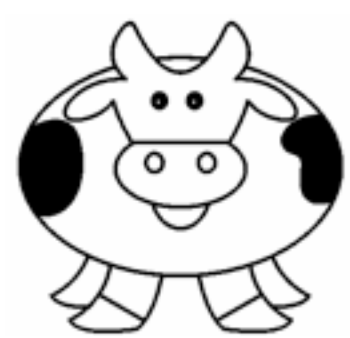
DSL Implementation



DSL Code

```
cow
  spots false
  color orange
end
```

```
cow
  spots true
  color brown
end
```



```
cow
  spots true
  color black
end
```

Internal DSLs

```
cow
  spots false
  color orange
end
```

```
new Cow()
  .spots(false)
  .color("orange")
.end();
```

```
(cow
   spots #t
   color 'orange)
```

```
cow do
  spots false
  color :orange
end
```

Advantages

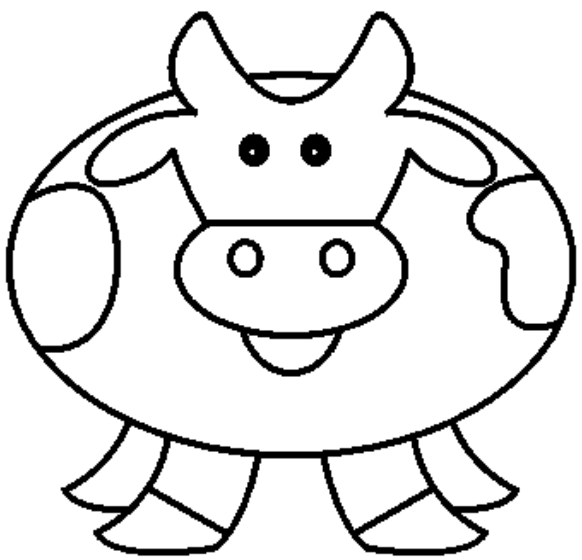
- No need to write/maintain parser
- Host language available if needed
- Use of existing tools (IDE) etc.

Drawbacks

- Restricted to host language
- Less static checking
- Fewer opportunities for optimization

External DSLs

Repetitio



```
Cow   ::= "cow" Prop* "end"
Prop  ::= "horns" Bool
        | "spots" Bool
        | "color" Color
Bool  ::= "true" | "false"
Color ::= "black"
        | "brown"
        | "orange"
```

literal

alternative

Parser generation

Grammar

```
Cow   ::= "cow" Prop* "end"
Prop  ::= "horns" Bool
        | "spots" Bool
        | "color" Color
Bool  ::= "true" | "false"
Color ::= "black"
        | "brown"
        | "orange"
```

yacc
bison
lemon

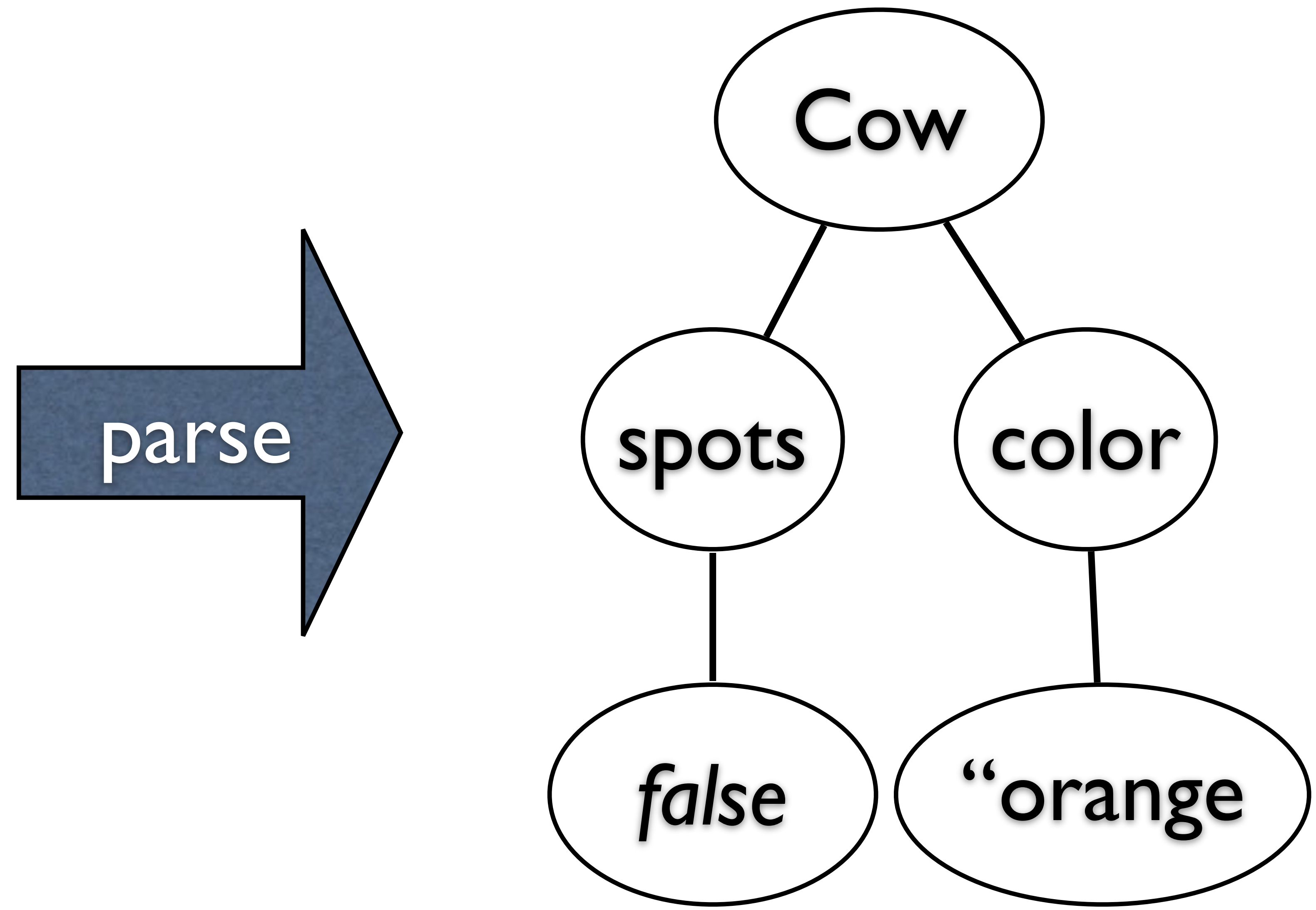
javacup
antlr
Rats!

Parser

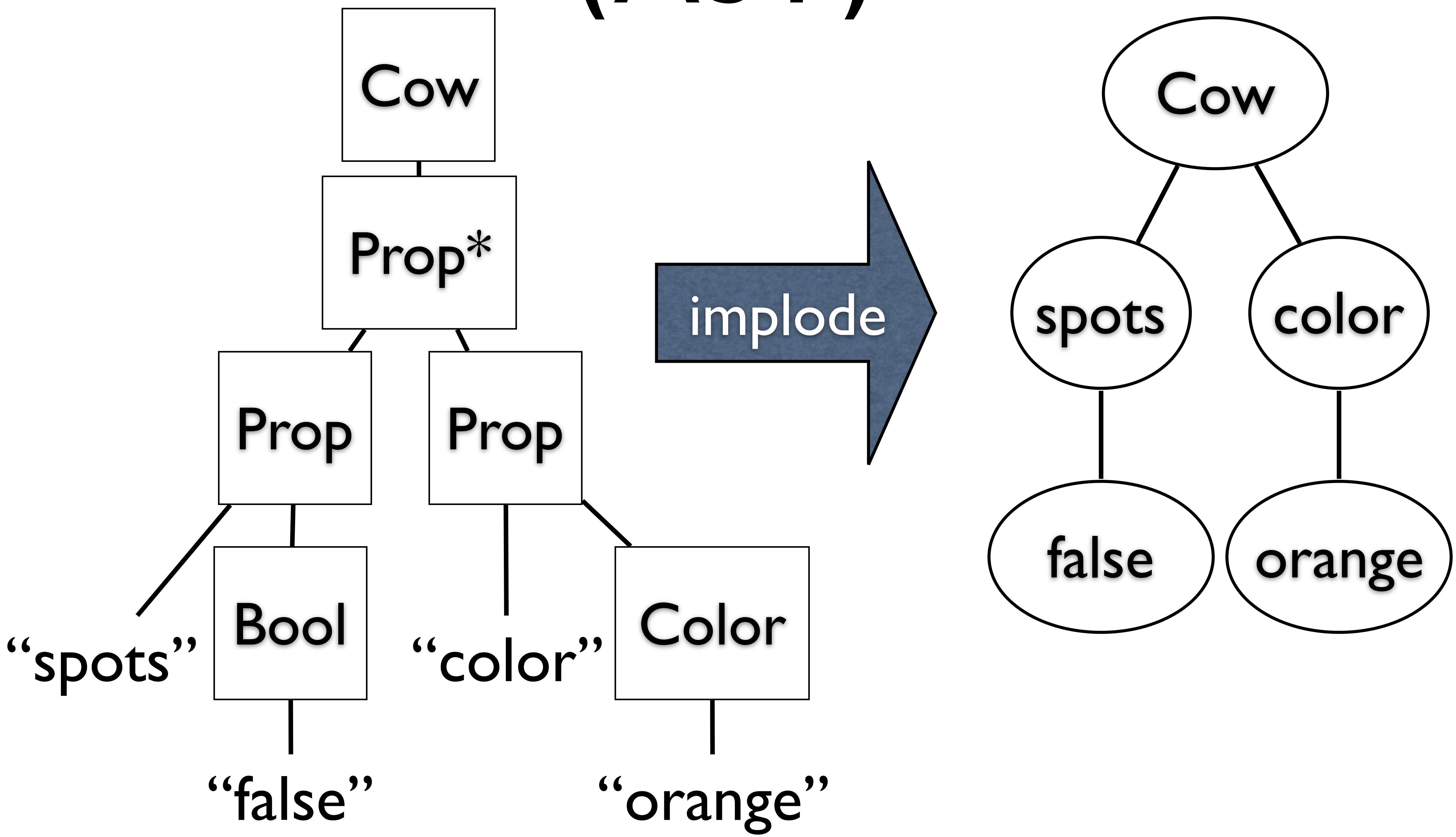
`parse.exe`

Parsing

```
cow
  spots false
  color orange
end
```

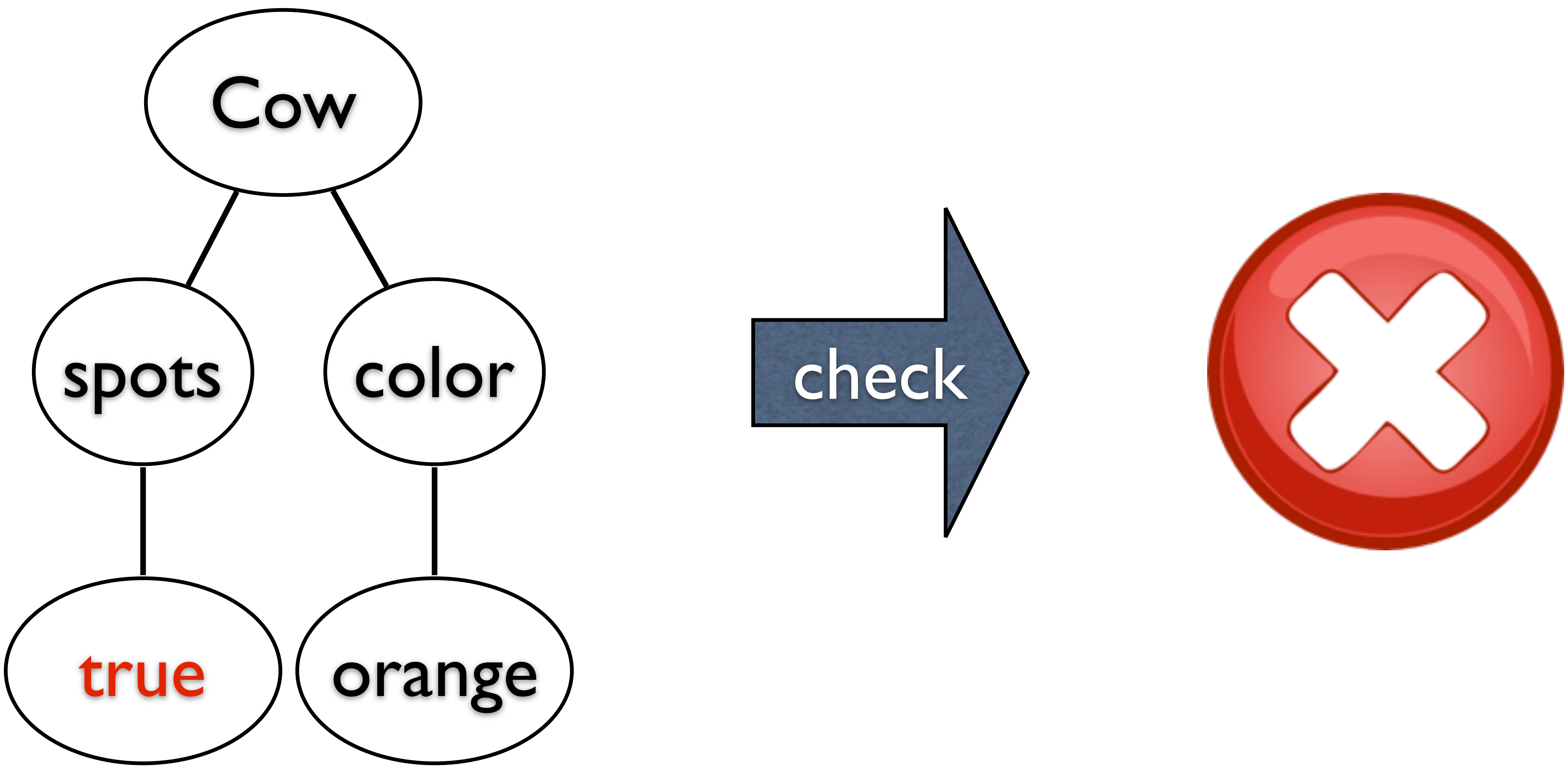


Abstract syntax tree (AST)

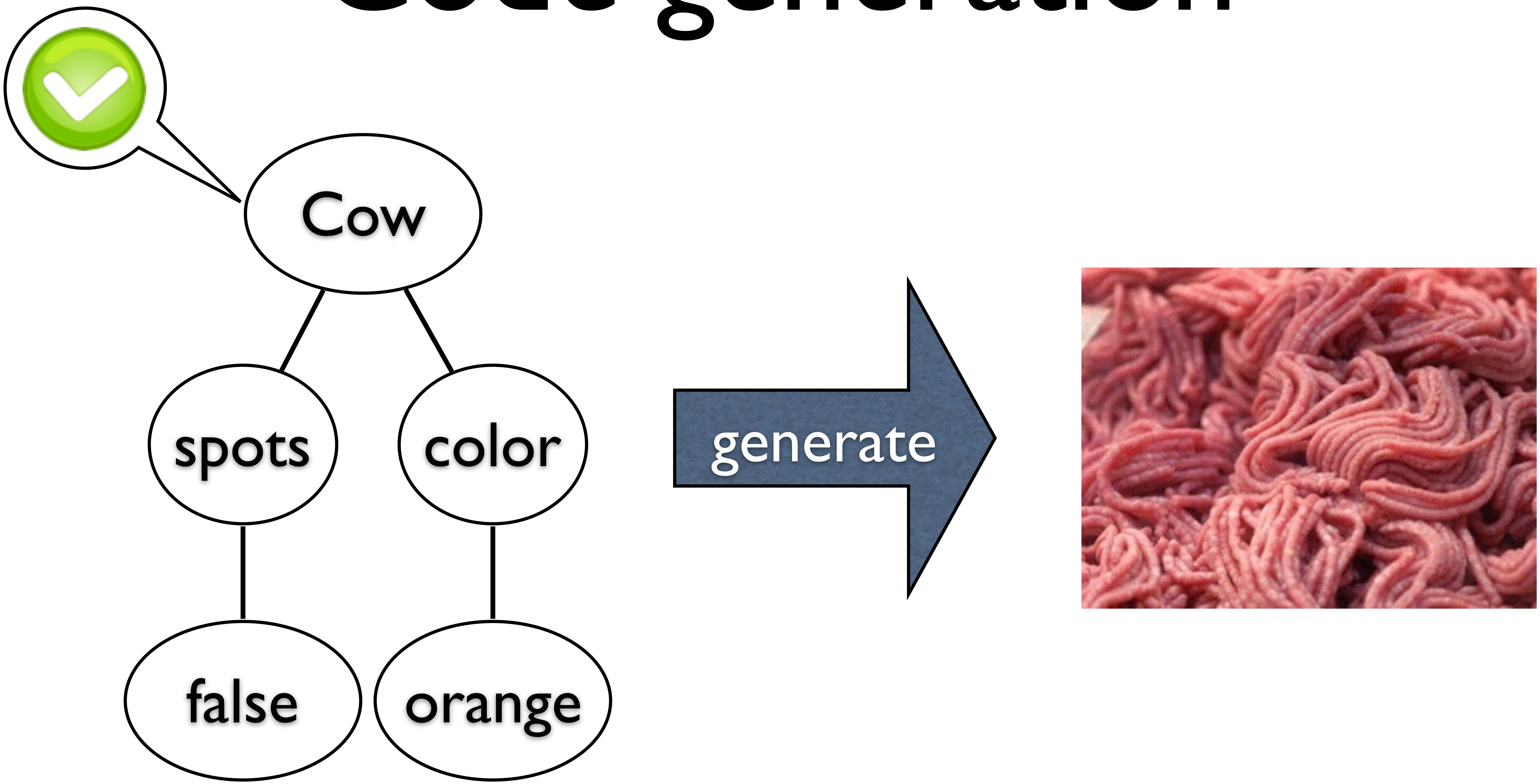


Semantic analysis

Constraint: $spots = \text{true} \Rightarrow color \neq \text{orange}$



Code generation



Tools

- Parser generators
- Attribute grammar systems
- Transformation systems
- Language workbenches

ANTLR

MPS

Rascal

Ensō

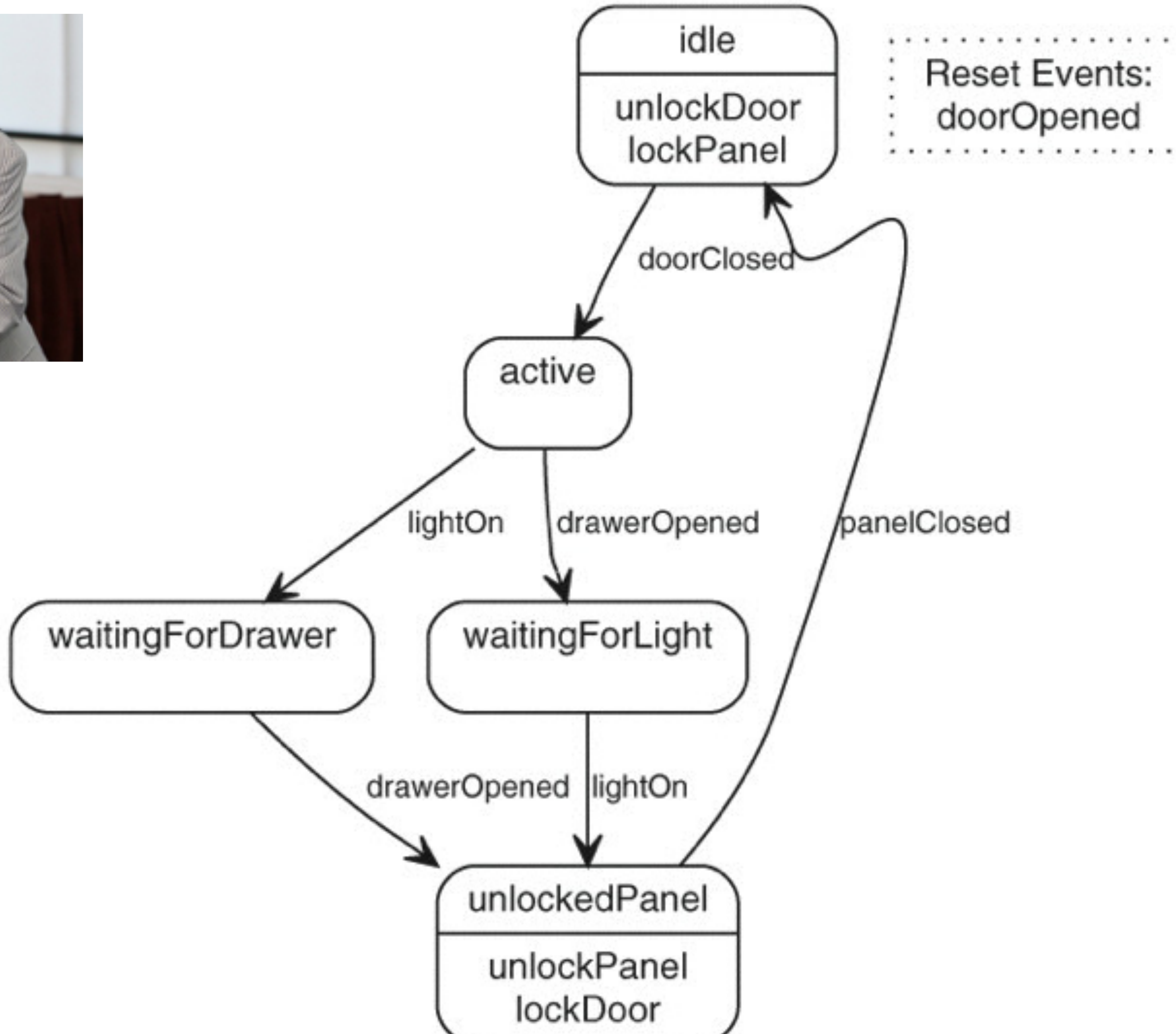
Xtext

Stratego/XT

M "OSLO"


Demo

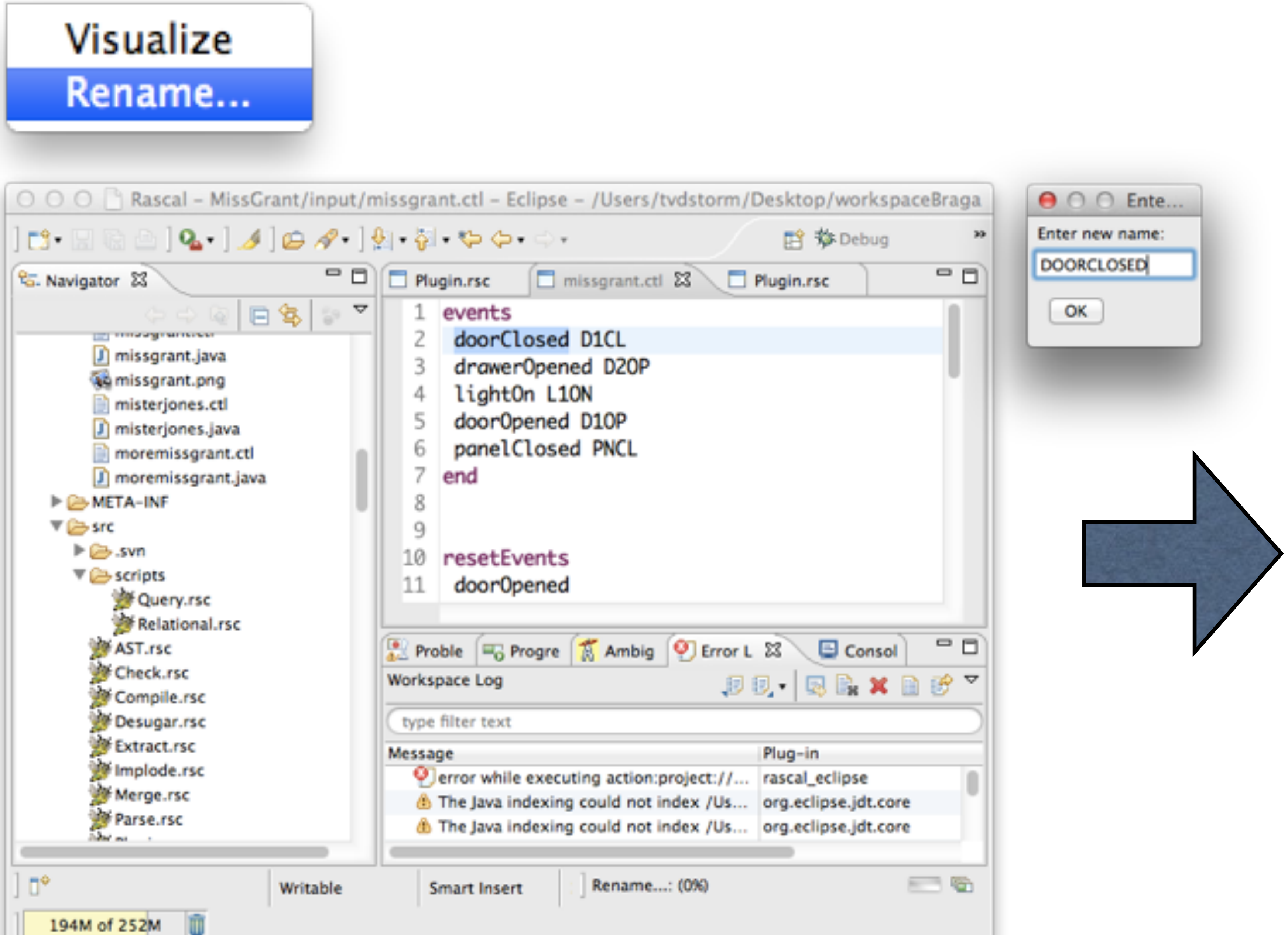
State machines



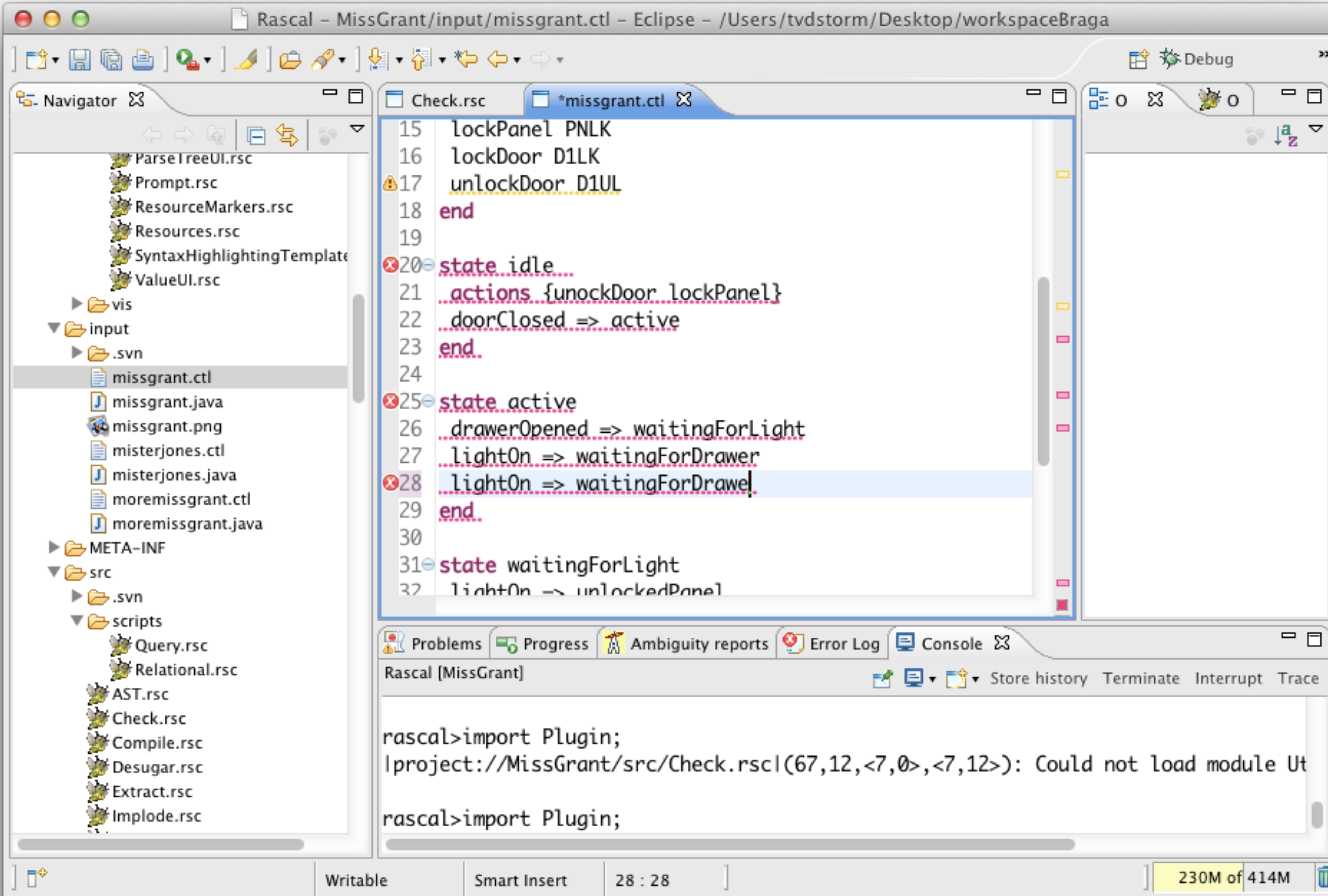
Textual notation

```
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
```

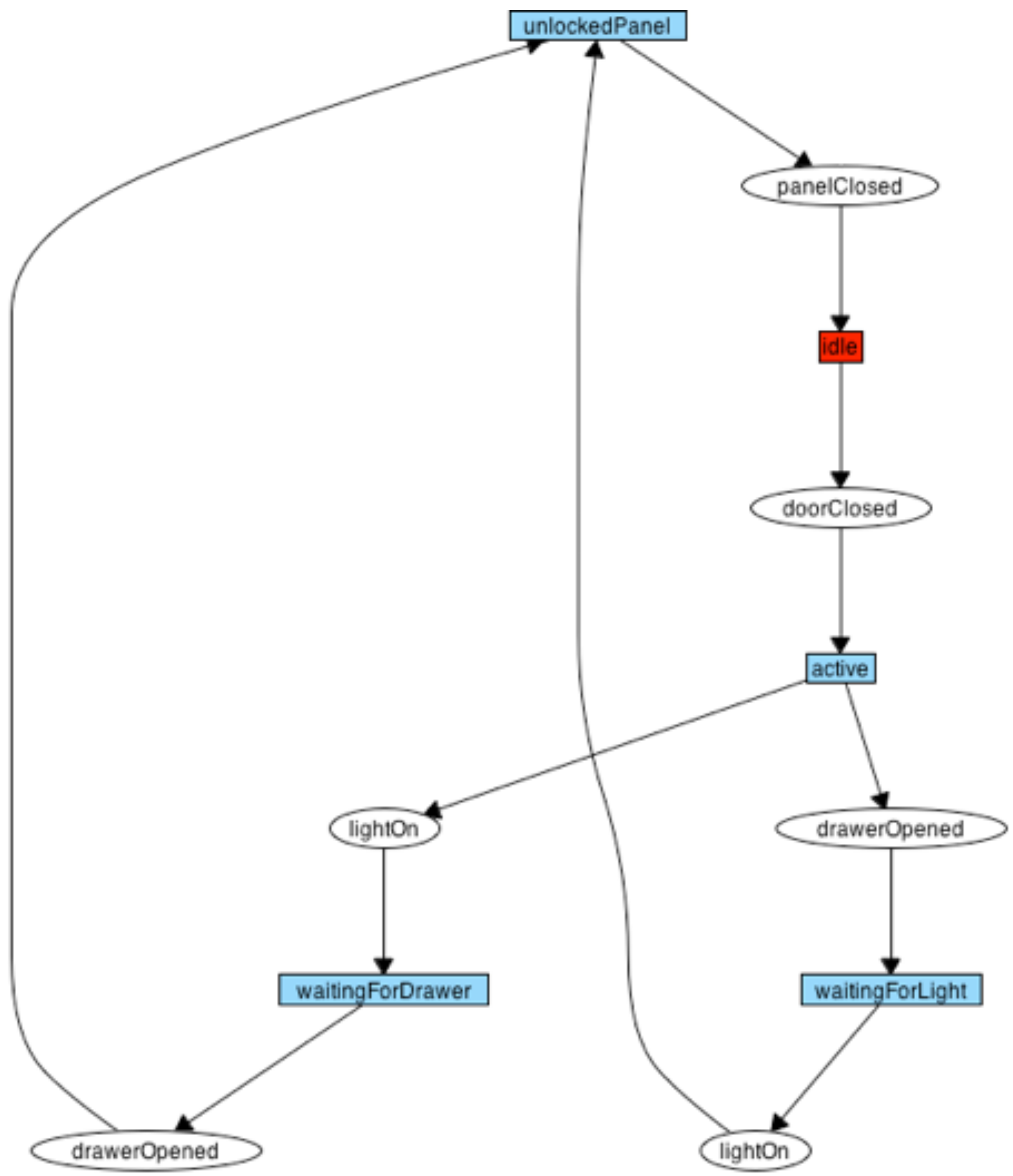



```
events
 DOORCLOSED D1CL
 drawerOpened D2OP
 lightOn L1ON
 doorOpened D1OP
 panelClosed PNCL
end


resetEvents
 doorOpened
end

commands
 unlockPanel PNUL
 lockPanel PNLK
 lockDoor D1LK
 unlockDoor D1UL
end

state idle
 actions {unlockDoor lockPanel}
 DOORCLOSED => active
end
```



Rascal – MissGrant/input/missgrant.ctl – Eclipse – /Users/tvdstorm/Desktop/workspaceBraga
Debug
Navigator
ParseTreeUI.rsc
Prompt.rsc
ResourceMarkers.rsc
Resources.rsc
SyntaxHighlightingTemplate
ValueUI.rsc
vis
input
.svn
missgrant.ctl
missgrant.java
missgrant.png
misterjones.ctl
misterjones.java
moremissgrant.ctl
moremissgrant.java
META-INF
src
.svn
scripts
Query.rsc
Relational.rsc
AST.rsc
Check.rsc
Compile.rsc
Desugar.rsc
Extract.rsc
Implode.rsc
Check.rsc
*missgrant.ctl
15 lockPanel PNLK
16 lockDoor D1LK
17 unlockDoor D1UL
18 end
19
20 state idle
21 actions {unockDoor lockPanel}
22 doorClosed => active
23 end
24
25 state active
26 drawerOpened => waitingForLight
27 lightOn => waitingForDrawer
28 lightOn => waitingForDrawe
29 end
30
31 state waitingForLight
32 lightOn => unlockedPanel
Problems
Progress
Ambiguity reports
Error Log
Console
Rascal [MissGrant]
Store history
Terminate
Interrupt
Trace
rascal>import Plugin;
|project://MissGrant/src/Check.rsc|(67,12,<7,0>,<7,12>): Could not load module Ut
rascal>import Plugin;
Writable
Smart Insert
28 : 28
230M of 414M

Visualization



Code generation

```
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
```

```
public class missgrant {
	public static void main(String args[]) throws java.io.IOException {
		new missgrant().run(new java.util.Scanner(System.in),
				new java.io.PrintWriter(System.out));
	}

	private static final int state$idle = 0;
	private static final int state$active = 1;
	private static final int state$waitingForLight = 2;
	private static final int state$waitingForDrawer = 3;
	private static final int state$unlockedPanel = 4;

	public void run(java.util.Scanner input, java.io.Writer output)
			throws java.io.IOException {
		int state = state$idle;
		while (true) {
			String token = input.nextLine();
			switch (state) {

			case state$idle: {
				unlockDoor(output);
				lockPanel(output);
				if (doorClosed(token)) {
					state = state$active;
				}
				if (doorOpened(token)) {
					state = state$idle;
				}
				break;
			}

			case state$active: {
				if (drawerOpened(token)) {
					state = state$waitingForLight;
				}
				if (lightOn(token)) {
					state = state$waitingForDrawer;
				}
				if (doorOpened(token)) {
					state = state$idle;
				}
				break;
			}

			case state$waitingForLight: {
```

Domain-specific languages

- Better languages, for specific domains
- Capture families of systems
- Higher level of abstraction
- Focus on “what” vs “how”
- Reuse designs, not just code
- Language workbenches (e.g., Rascal)

Take home

- How much code I write is actually relevant for the problem I’m solving?
- What are recurring patterns in the code I’m writing?
- How would I *want* to describe the solution?
- Could I formalize the relevant bits, ... in a DSL?

Thank you

- http://www.rascal-mpl.org
- http://www.cwi.nl/~storm
- storm@cwi.nl
- @tvdstorm