Domain-Specific Languages

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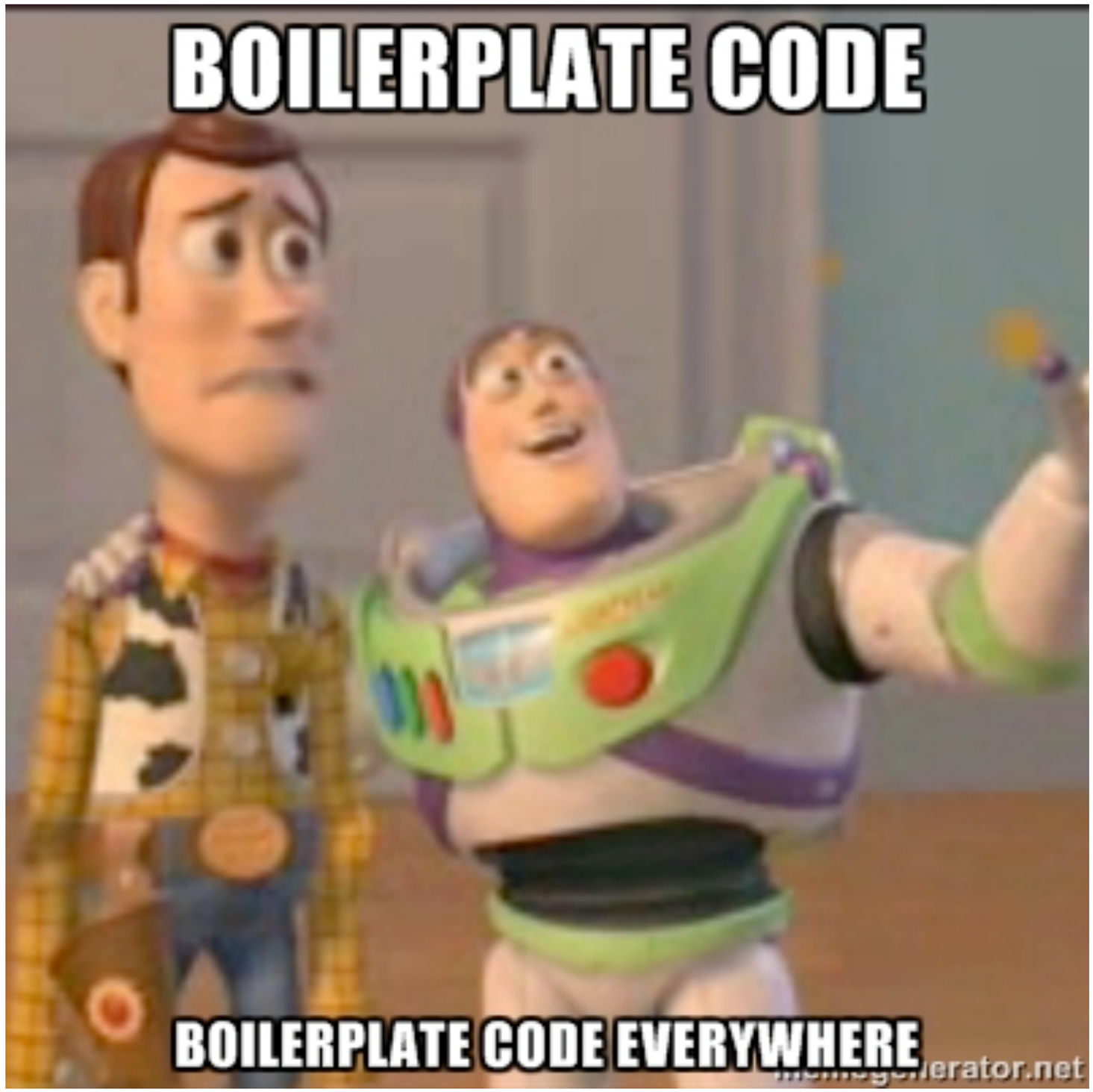
Programming?


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.

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

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Domain Specific Languages!

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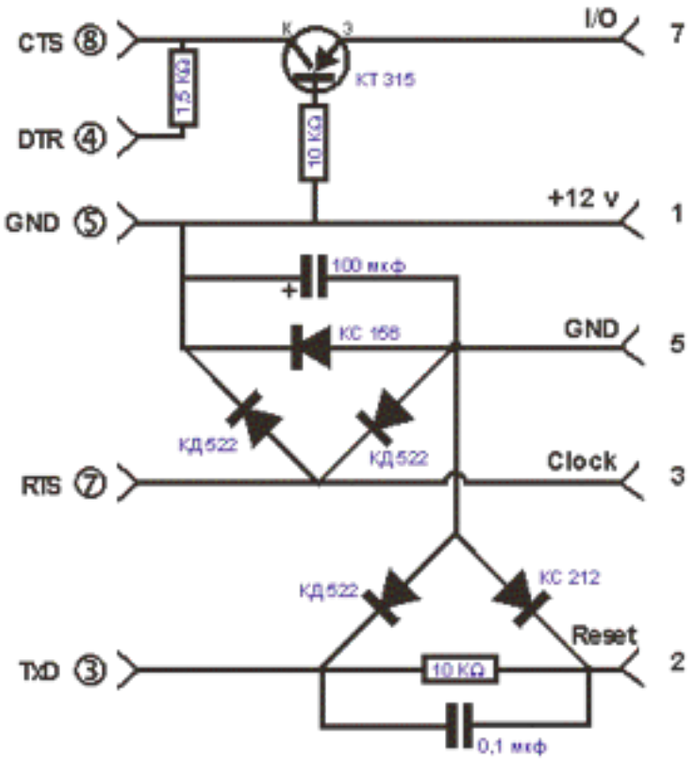
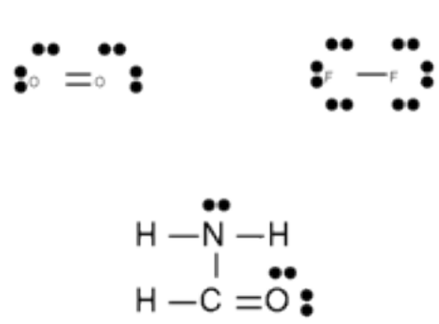
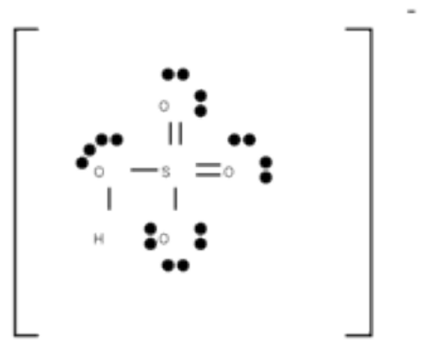
Domain specific languages



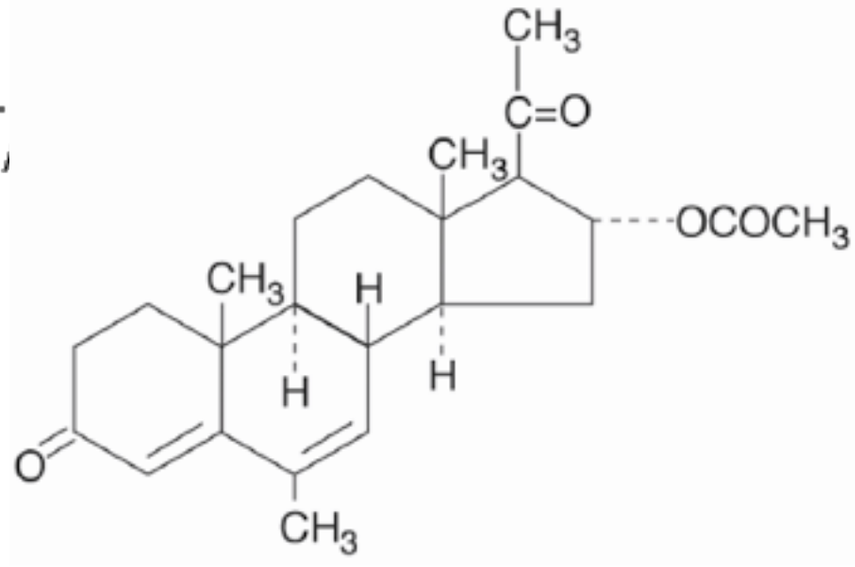




$$c_t = S_t N(h) - Xe^{-rt} N(h - \sigma\sqrt{\tau})$$

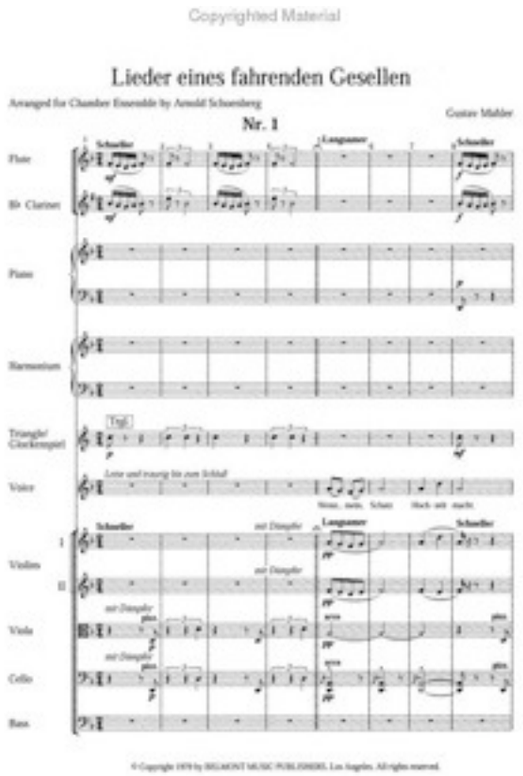
where

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

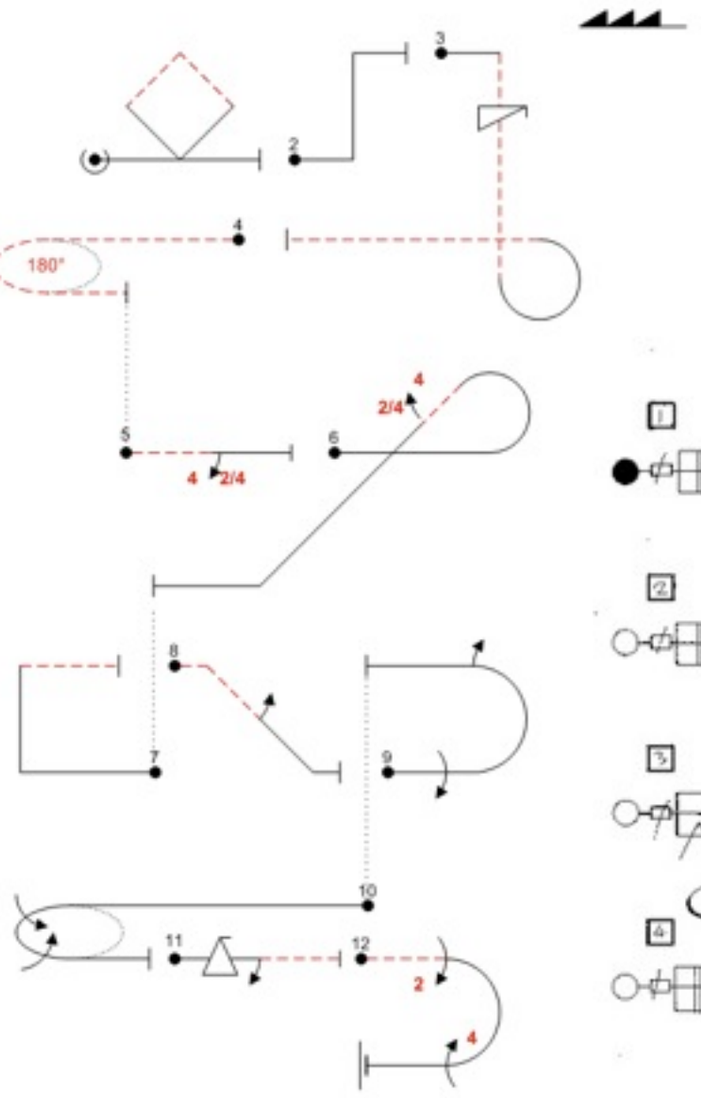


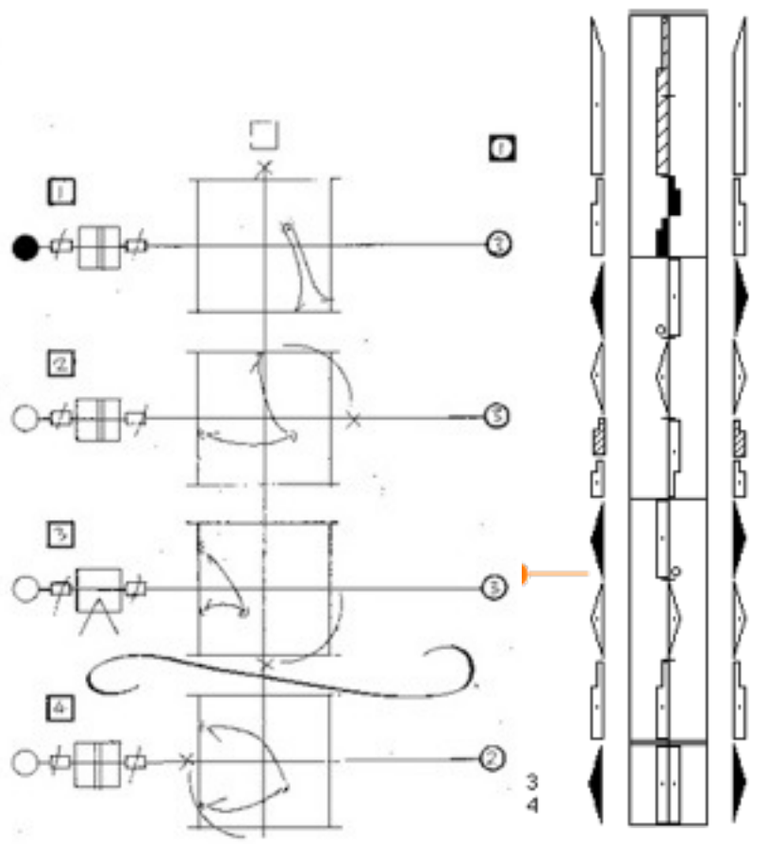
Domain specific languages

```
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
```





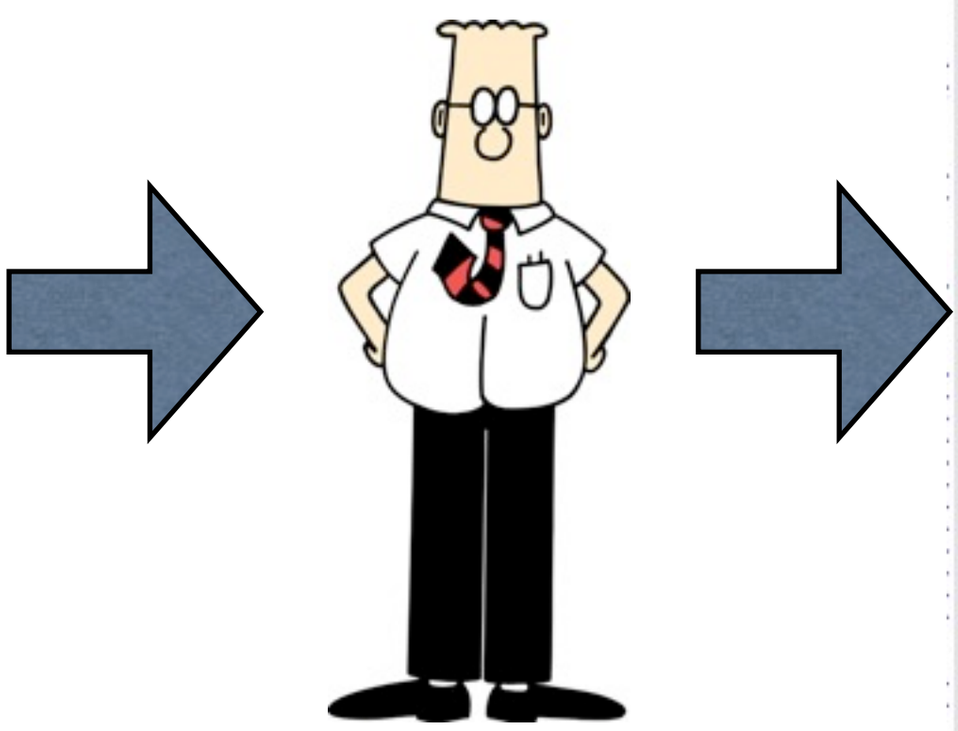
Observations

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

General purpose languages (GPLs)

DSLs

Programming



```
.text:131411EF                  ; FUNCTION CHUNK AT .text:13141239 SIZE 000
.text:131411EF                  ; FUNCTION CHUNK AT .vmp0:13143000 SIZE 000
.text:131411EF                  ; FUNCTION CHUNK AT .vmp0:13143522 SIZE 000
.text:131411EF                  ; FUNCTION CHUNK AT .vmp0:13145C99 SIZE 000
.text:131411EF
.text:131411EF 68 F1 AF 5B FF                   push    0FF5B4FF1h
.text:131411F4 E9 A0 4A 00 00                   jmp     loc_13145C99
.text:131411F4                  start           endp
.text:131411F4
.text:131411F4                  ; ---------------------------------------
.text:131411F9 64 69 31         byte_131411F9   db 64h, 69h, 31h        ; D
.text:131411FC 60 16 A2 75 9A C4+               dd 75421660h, 0CACDC49Ah, 7
.text:131411FC CD CA FA 7B 9D 7B+               dd 6EEE544Dh, 10D69610h, 0F
.text:131411FC D5 D4 A8 2B 85 4B+               dd 0EB6323E4h, 82B58465h, 0
.text:13141238                  ; ---------------------------------------
.text:13141238 58                               pop     eax
.text:13141239                  ; START OF FUNCTION CHUNK FOR start
.text:13141239
.text:13141239                  loc_13141239:                           ; C
.text:13141239 52                               push    edx
.text:1314123A 55                               push    ebp
.text:1314123B 53                               push    ebx
.text:1314123C 51                               push    ecx
.text:1314123D 9C                               pushf
.text:1314123E 57                               push    edi
.text:1314123F 50                               push    eax
.text:13141240 56                               push    esi
.text:13141241 51                               push    ecx
.text:13141242 68 00 00 00 00                   push    0
.text:13141247 8B 74 24 28                      mov     esi, [esp+2Ch+var_4
.text:1314124B BF F9 11 14 13                   mov     edi, offset byte_13
.text:13141250
.text:13141250                  loc_13141250:                           ; C
.text:13141250 89 F3                            mov     ebx, esi
.text:13141252 03 34 24                         add     esi, [esp+2Ch+var_2
.text:13141255
.text:13141255                  loc_13141255:                           ; C
.text:13141255                                                          ; S
```

Domain Programmer Code

Programming

Domain Programmer Code

Programming is “lossy”

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

Cognitive distance

?

The problem

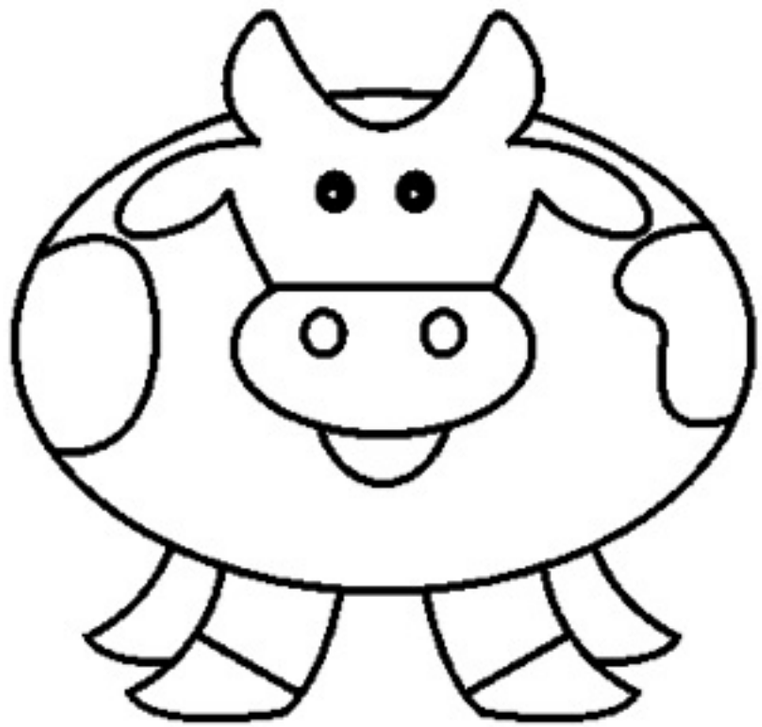
- a lot of code,
- low level code,
- characterized by lack of abstraction
- encoding domain knowledge
- and encoding design knowledge

Programming?

Modelling & generating!

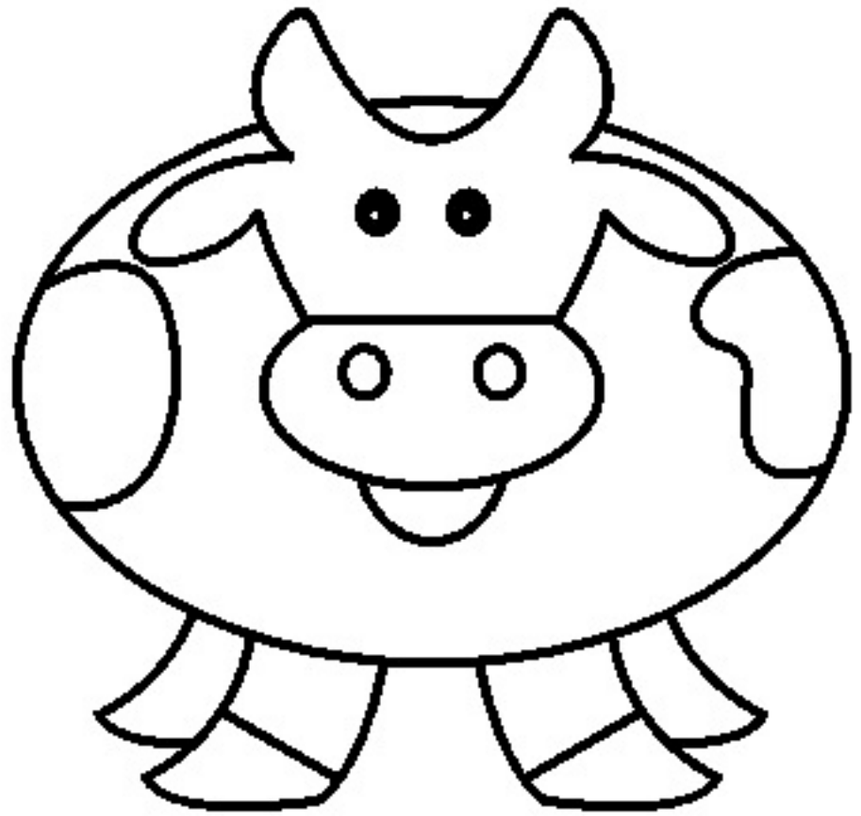
Modeling the domain

domain analysis

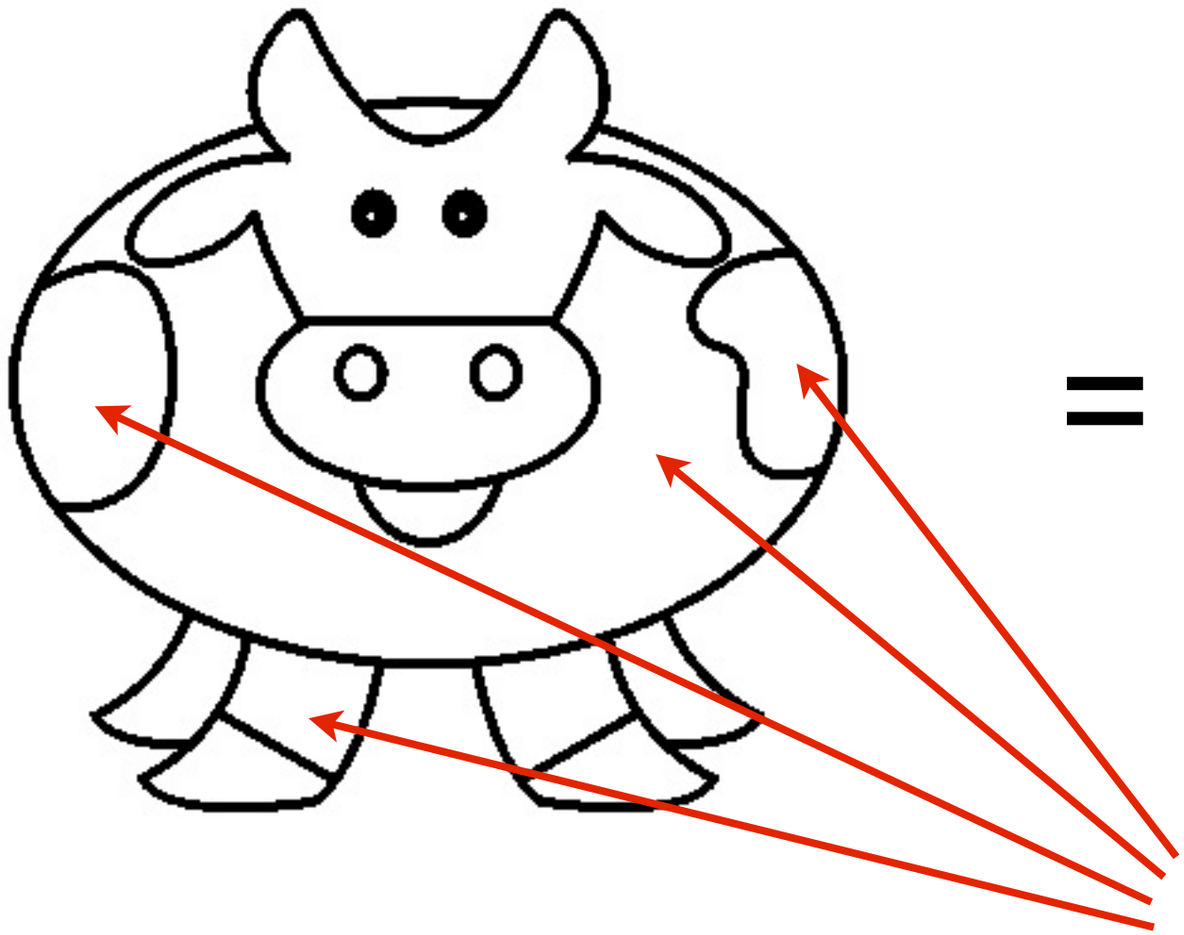


Ceci n’est pas une vache

System families



Domain Specific Language

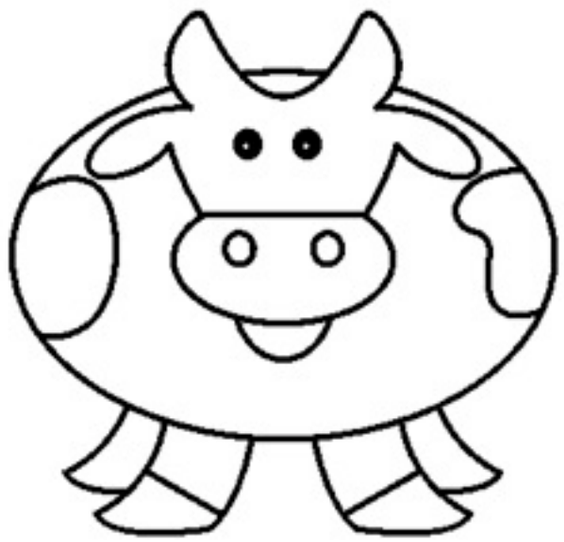


=

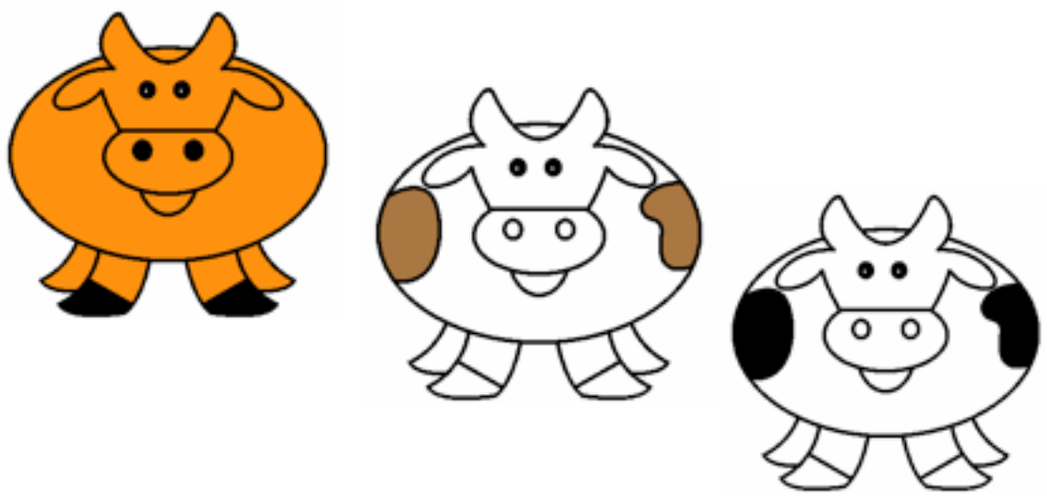
formalized notation capturing “Cows”

variation points

Domain Specific Languages

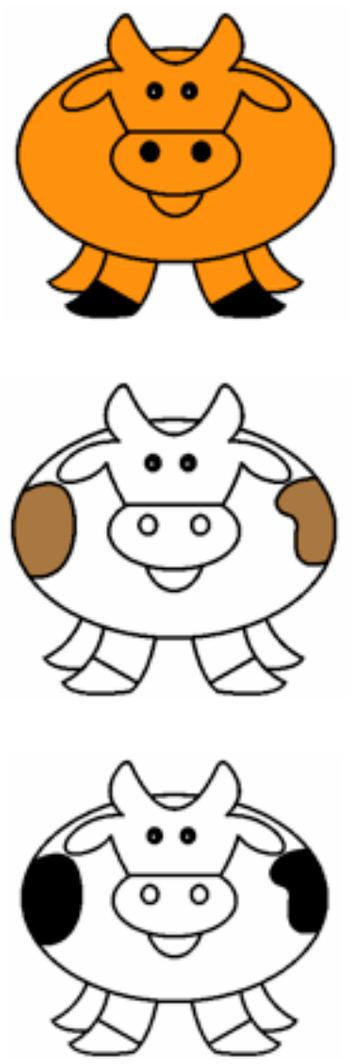


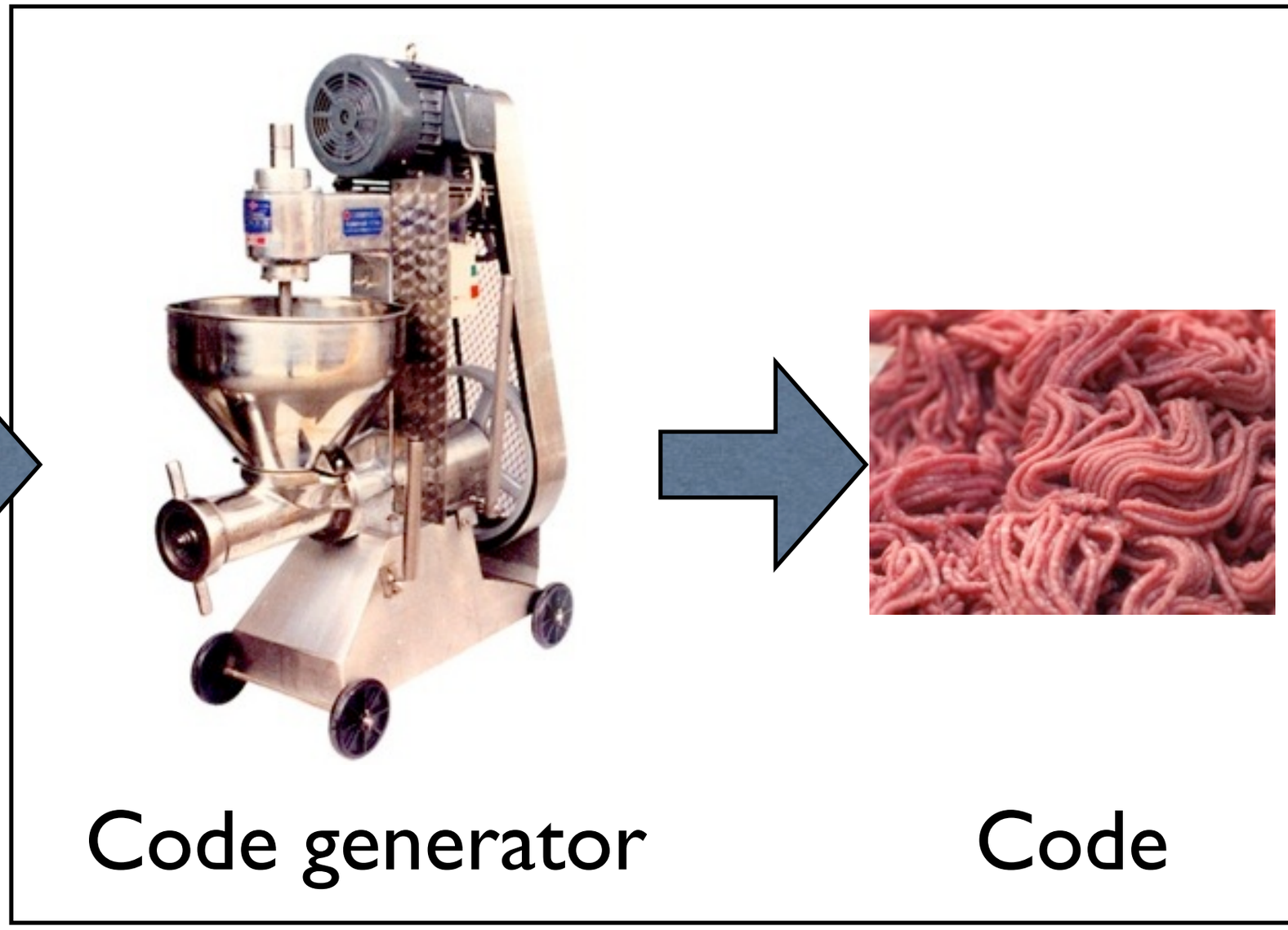
= grammar, template, metamodel



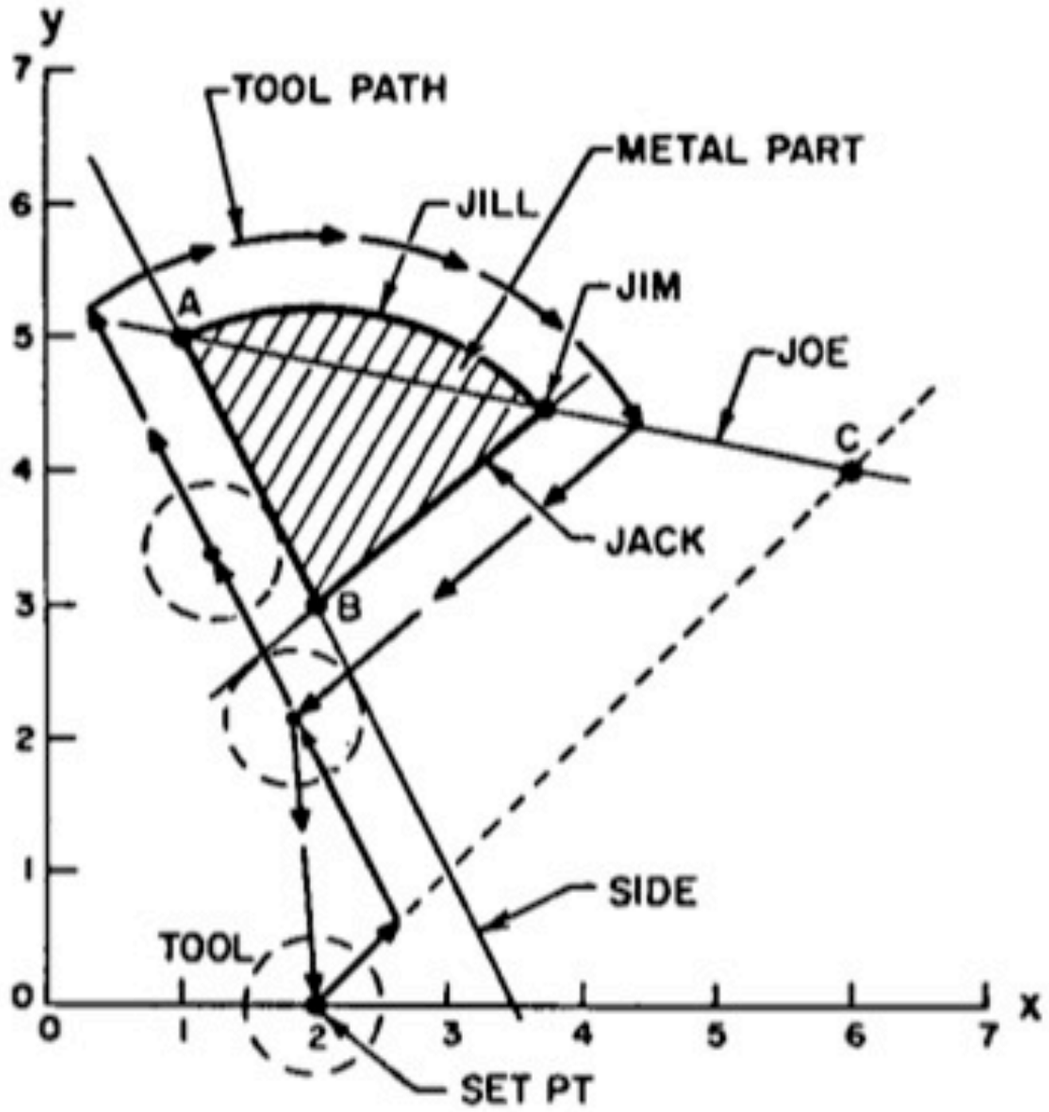
= sentence, instance, model

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

```
\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

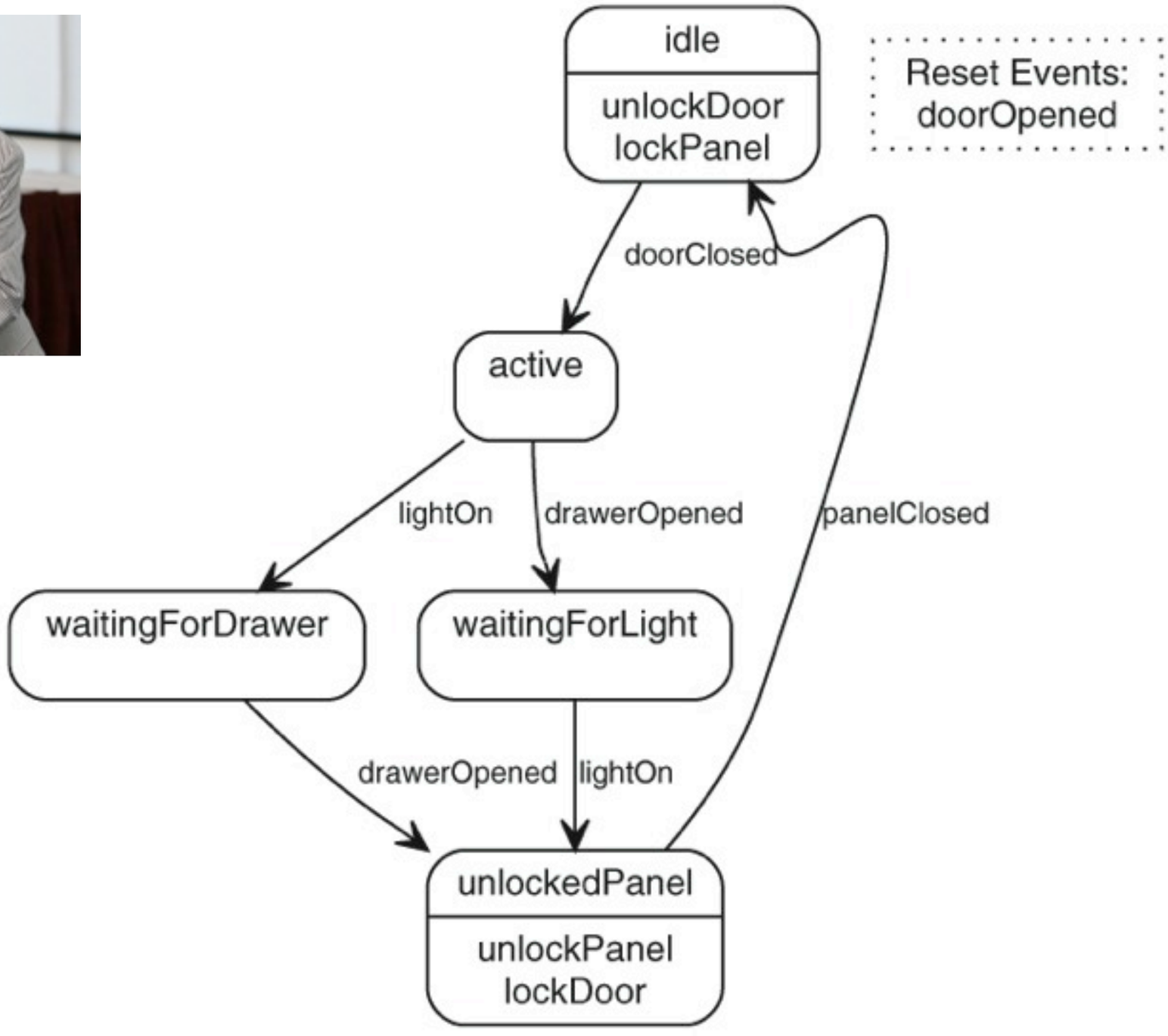
- Make: software building
- Dot: graph visualization
- SQL: relational querying
- SWUL: Swing GUIs
- HTML: hypertext
- CLOPS: commandline options
- GNUPlot: plotting
- R: statistics
- CML: kernel config
- Lex: lexical scanning
- Excel: spreadheets
- Rascal: meta-programming
- ...

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)


Demo

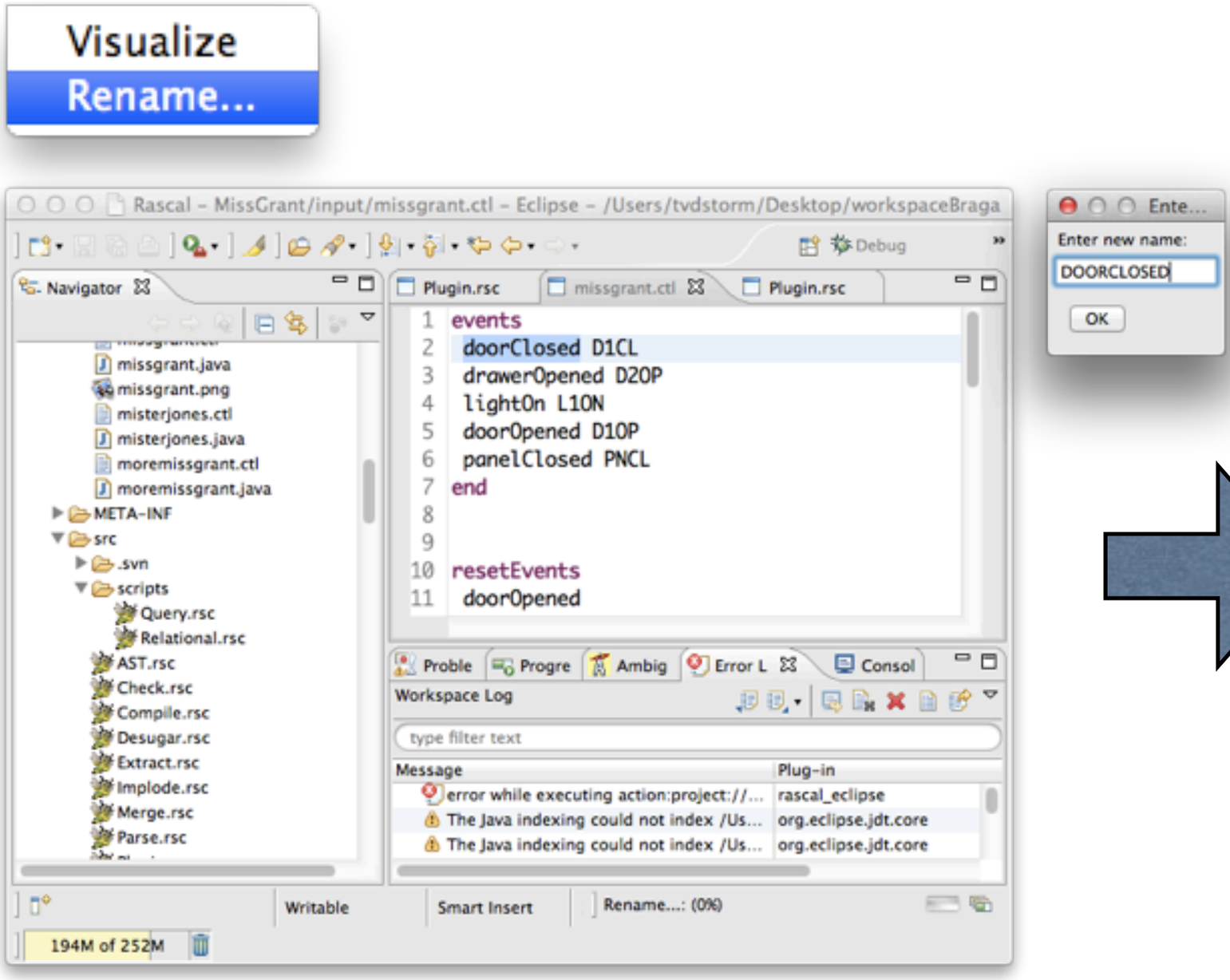
State machines



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
```

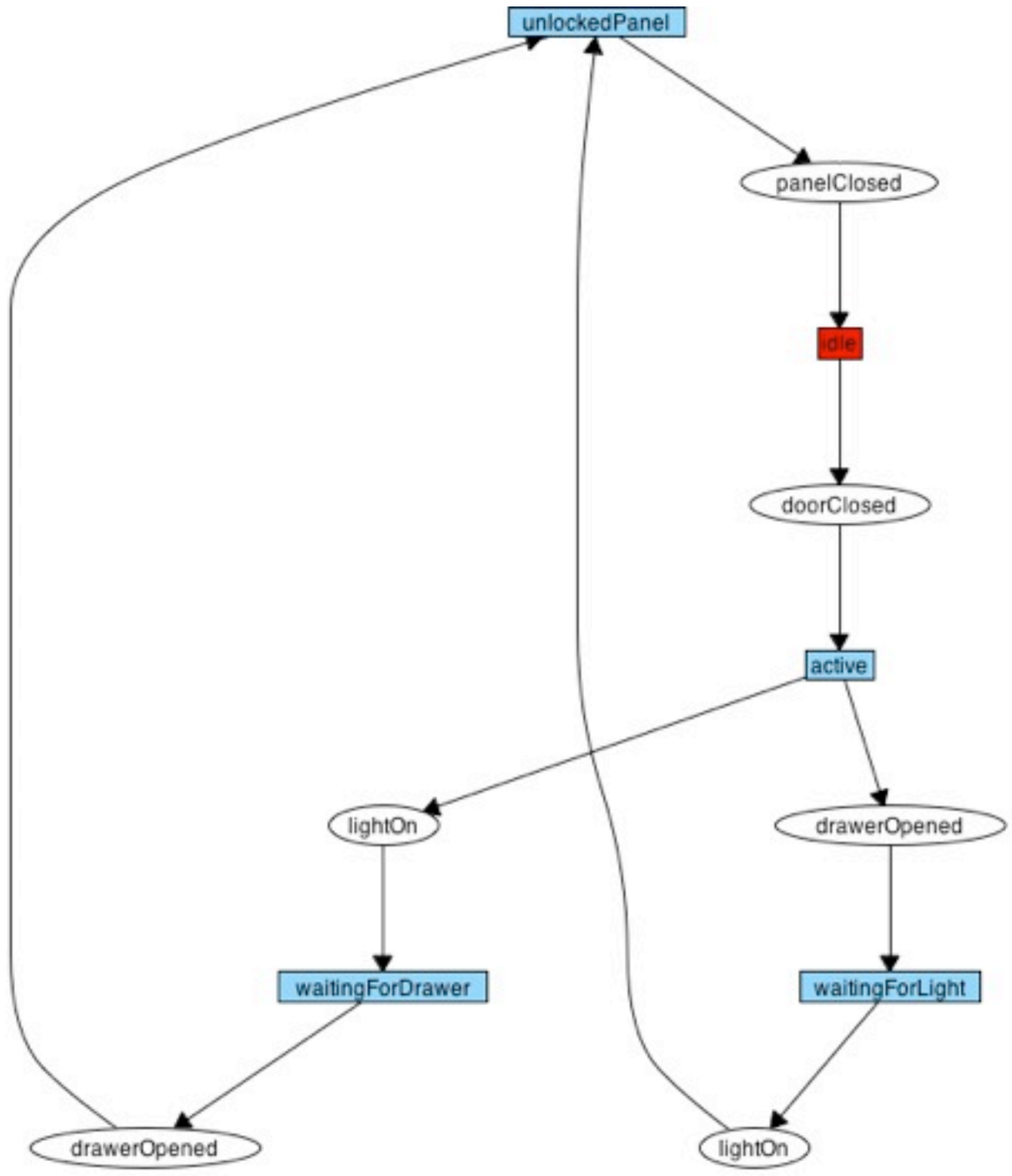
Problems | Progress | Ambiguity reports | Error Log | Console

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: {
```