

Why more programming languages?

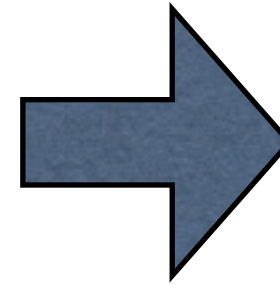
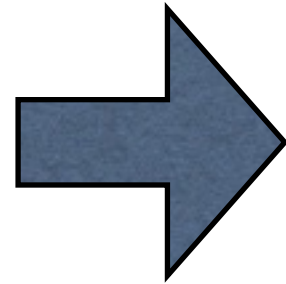
Tijs van der Storm
@tvdstorm / storm@cwi.nl



Centrum Wiskunde & Informatica

Sep 2018	Sep 2017	Change	Programming Language	Ratings	Change
1	1		Java	17.436%	+4.75%
2	2		C	15.447%	+8.06%
3	5	⬆	Python	7.653%	+4.67%
4	3	⬇	C++	7.394%	+1.83%
5	8	⬆	Visual Basic .NET	5.308%	+3.33%
6	4	⬇	C#	3.295%	-1.48%
7	6	⬇	PHP	2.775%	+0.57%
8	7	⬇	JavaScript	2.131%	+0.11%
9	-	⬆	SQL	2.062%	+2.06%
10	18	⬆	Objective-C	1.509%	+0.00%
11	12	⬆	Delphi/Object Pascal	1.292%	-0.49%
12	10	⬇	Ruby	1.291%	-0.64%
13	16	⬆	MATLAB	1.276%	-0.35%
14	15	⬆	Assembly language	1.232%	-0.41%
15	13	⬇	Swift	1.223%	-0.54%
16	17	⬆	Go	1.081%	-0.49%
17	9	⬇	Perl	1.073%	-0.88%
18	11	⬇	R	1.016%	-0.80%
19	19		PL/SQL	0.850%	-0.63%
20	14	⬇	Visual Basic	0.682%	-1.07%

Programming



```
.text:131411EF ; FUNCTION CHUNK AT .text:13141239 SIZE 000
.text:131411EF ; FUNCTION CHUNK AT .unp0:13143000 SIZE 000
.text:131411EF ; FUNCTION CHUNK AT .unp0:13143522 SIZE 000
.text:131411EF ; FUNCTION CHUNK AT .unp0:13145C99 SIZE 000
.text:131411EF 68 F1 4F 5B FF      push    0FF5B4FF1h
.text:131411F4 E9 A0 4A 00 00      jmp     loc_13145C99
.text:131411F4
.text:131411F4
.text:131411F9 64 69 31          byte_131411F9 db 64h, 69h, 31h ; 0
.text:131411FC 60 16 42 75 9A C4+ dd 75421660h, 0CACDC49Ah, 7
.text:131411FC CD CA FA 7B 9D 7B+ dd 6EEE544Dh, 10D69610h, 0F
.text:131411FC D5 D4 4B 2B 85 4B+ dd 0EB6323E4h, 82B58465h, 0
.text:13141238
.text:13141238 58
.text:13141239
.text:13141239
.text:13141239 52
.text:1314123A 55
.text:1314123B 53
.text:1314123C 51
.text:1314123D 9C
.text:1314123E 57
.text:1314123F 50
.text:13141240 56
.text:13141241 51
.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
.text:13141250 89 F3              loc_13141250:  mov     ebx, esi ; C
.text:13141252 03 34 24          add     esi, [esp+2Ch+var_2
.text:13141255
.text:13141255
.text:13141255
.text:13141255
loc_13141255:
; C
; S
```



INTOXILYZER®



8000 ?

```
.text:131411EF ; FUNCTION CHUNK AT .text:13141239 SIZE 0000009F BYTES
.text:131411EF ; FUNCTION CHUNK AT .vnp0:13143000 SIZE 00000122 BYTES
.text:131411EF ; FUNCTION CHUNK AT .vnp0:13143522 SIZE 000000F1 BYTES
.text:131411EF ; FUNCTION CHUNK AT .vnp0:13145C99 SIZE 0000000A BYTES
.text:131411EF
.text:131411EF 68 F1 AF 58 FF      push    OFF5B4FF1h
.text:131411F4 E9 A0 A8 00 00      jmp     loc_13145C99
.text:131411F4      start
.text:131411F4      endp
;-----
.text:131411F9      byte_131411F9      db 6Ah, 69h, 31h          ; DATA XREF: start+5C10
.text:131411FC 60 16 A2 75 9A C4+   dd 75421660h, 0CACDC49Ah, 7B9D7BFAh, 2B48D4D5h, 687E4B85h
.text:131411FC CD CA FA 78 9D 7B+   dd 6EE544Dh, 10D69610h, 0FE39DFC2h, 0ED0E83C7h, 5CFE8AAdh
.text:131411FC D5 D4 A8 28 85 A0+   dd 0EB6323E4h, 82B58465h, 0D0947C7Bh, 0C80CD20Dh, 30DE6A19h
;-----
.text:13141238      pop     eax
.text:13141239 ; START OF FUNCTION CHUNK FOR start
.text:13141239      loc_13141239:      ; CODE XREF: start+4AAFlj
.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:13141248 BF F9 11 14 13      mov     edi, offset byte_131411F9
.text:13141250
.text:13141250      loc_13141250:      ; CODE XREF: start+D9lj
.text:13141250 89 F3      mov     ebx, esi
.text:13141252 03 34 24      add     esi, [esp+2Ch+var_2C]
.text:13141255
.text:13141255      loc_13141255:      ; CODE XREF: start+98lj
.text:13141255      ; start+A0lj ...
```



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

Alan J. Perlis

What is high-level?

- Language employs concepts and terms in its notation from problem domain instead of solution domain (= computers ;)



```
.text:131411EF ; FUNCTION CHUNK AT .text:13141239 SIZE 0000009F BYTE
.text:131411EF ; FUNCTION CHUNK AT .unp0:13143000 SIZE 00000122 BYTE
.text:131411EF ; FUNCTION CHUNK AT .unp0:13143522 SIZE 000000F1 BYTE
.text:131411EF ; FUNCTION CHUNK AT .unp0:13145C99 SIZE 0000000A BYTE
.text:131411EF 68 F1 4F 58 FF      push    0FF5B4FF1h
.text:131411F4 E9 A0 4A 00 00      jmp     loc_13145C99
.text:131411F4
.text:131411F4
.text:131411F4
.text:131411F4
.text:131411F9 64 69 31          byte_131411F9 db 64h, 69h, 31h ; DATA XREF:
.text:131411FC 60 16 A2 75 9A C4+ dd 75421660h, 0CACDC49Ah, 7B9D78FAh,
.text:131411FC CD CA FA 7B 9D 7B+ dd 6EEE544Dh, 18D69610h, 0FE39DFC2h,
.text:131411FC D5 D4 48 2B 85 AB+ dd 0EB6323E4h, 82B58465h, 0D0947C7Bh,
.text:13141238
.text:13141238 58              pop     eax
.text:13141239 ; START OF FUNCTION CHUNK FOR start
.text:13141239 loc_13141239: ; CODE XREF:
.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:13141248 BF F9 11 14 13      mov     edi, offset byte_131411F9
.text:13141250
.text:13141250 loc_13141250: ; CODE XREF:
.text:13141252 89 F3              mov     ebx, esi
.text:13141253 03 34 24           add     esi, [esp+2Ch+var_2C]
.text:13141255
.text:13141255 loc_13141255: ; CODE XREF:
.text:13141255 ; start+001j
```

```

private void fillMatrix(X s1, X s2) {
    X prev_i = DUMMY;
    X prev_j = DUMMY;
    for (X i: s1) {
        for (X j: s2) {
            if (i.match(j)) {
                matrix.get(i).put(j,
                    matrix.get(prev_i)
                        .get(prev_j) + 1);
            }
            else {
                matrix.get(i).put(j, Math.max(
                    matrix.get(i).get(prev_j),
                    matrix.get(prev_i).get(j)));
            }
            prev_j = j;
        }
        prev_j = DUMMY;
        prev_i = i;
    }
}

```

- private
- void
- fillMatrix
- prev_i
- prev_j
- DUMMY
- for
- if
- match
- matrix
- get
- put
- Math.max
- else

product LOAN

declaration

contract data

PAMOUNT : amount

STARTDATE : date

MATURDATE : date

INTRATE : int-rate

RDMLIST := [] : cashflow-list

information

PAF : cashflow-list

IAF : cashflow-list

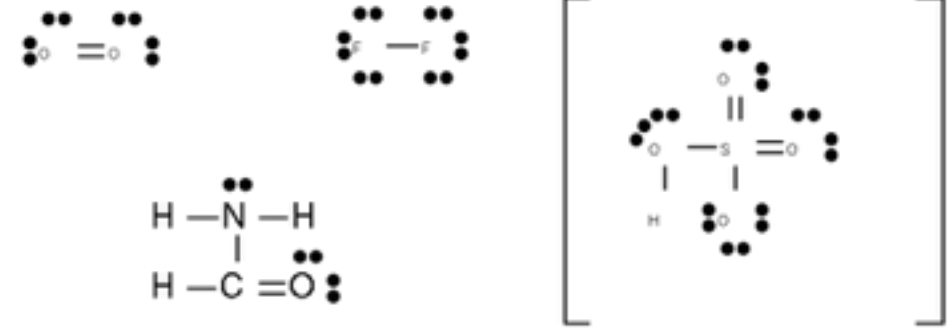
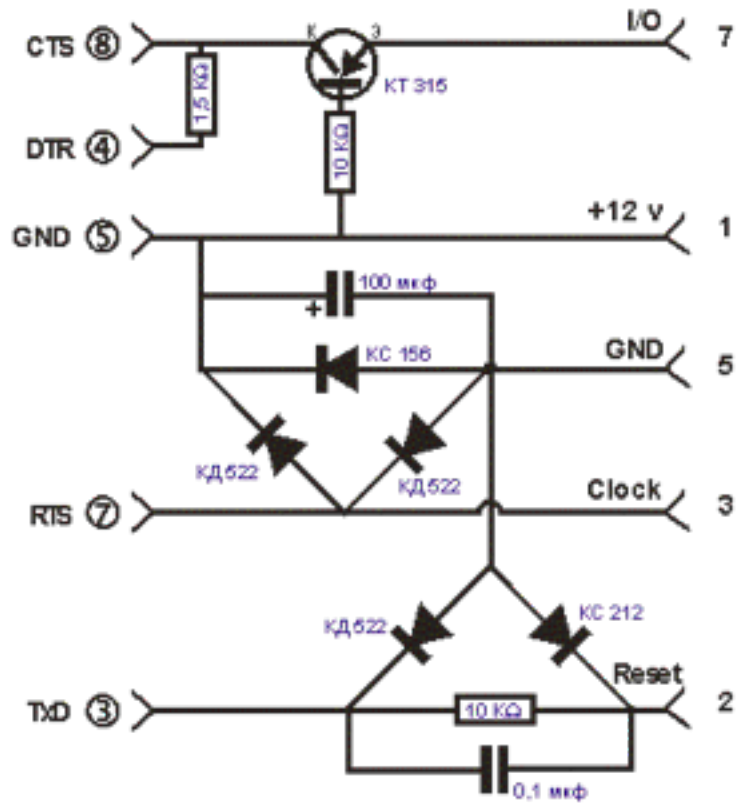
registration

%% Register one redemption.

RDM(AMOUNT : amount, DATE : date)

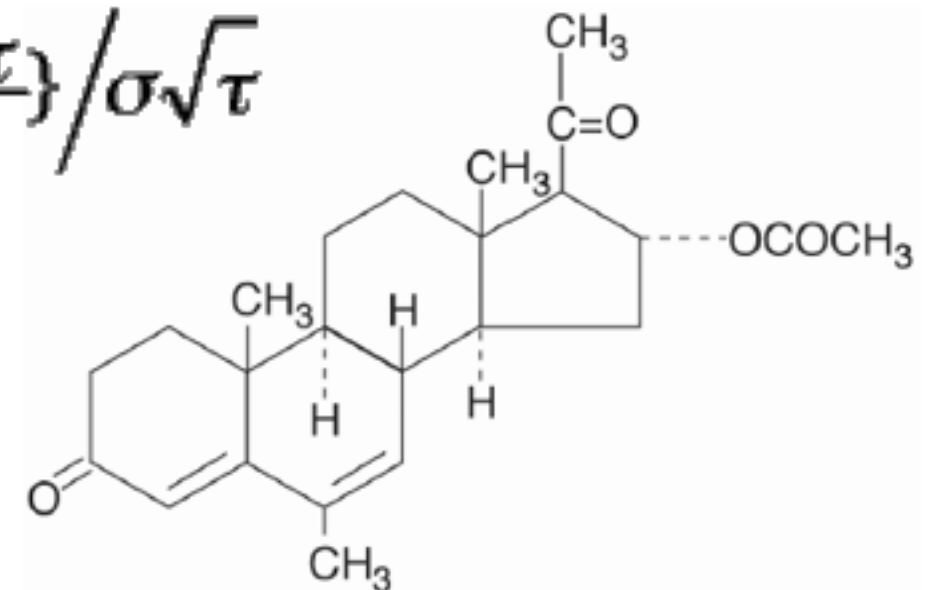
- product
- LOAN
- declaration
- contract
- data
- PAMOUNT, etc.
- amount
- date
- int-rate
- cashflow-list
- information
- registration
- RDM

Domain-specific languages



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

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



E				
B		-3	-3	-0
G	-0	-2	-0	-0
D		-2		
A				
E				

Copyrighted Material

Lieder eines fahrenden Gesellen

Arranged for Chamber Ensemble by Arnold Schoenberg

Nr. 1

Contents

Flute

B♭ Clarinet

Piano

Harpsichord

Trumpet/Cornet

Voice

Violin I

Violin II

Viola

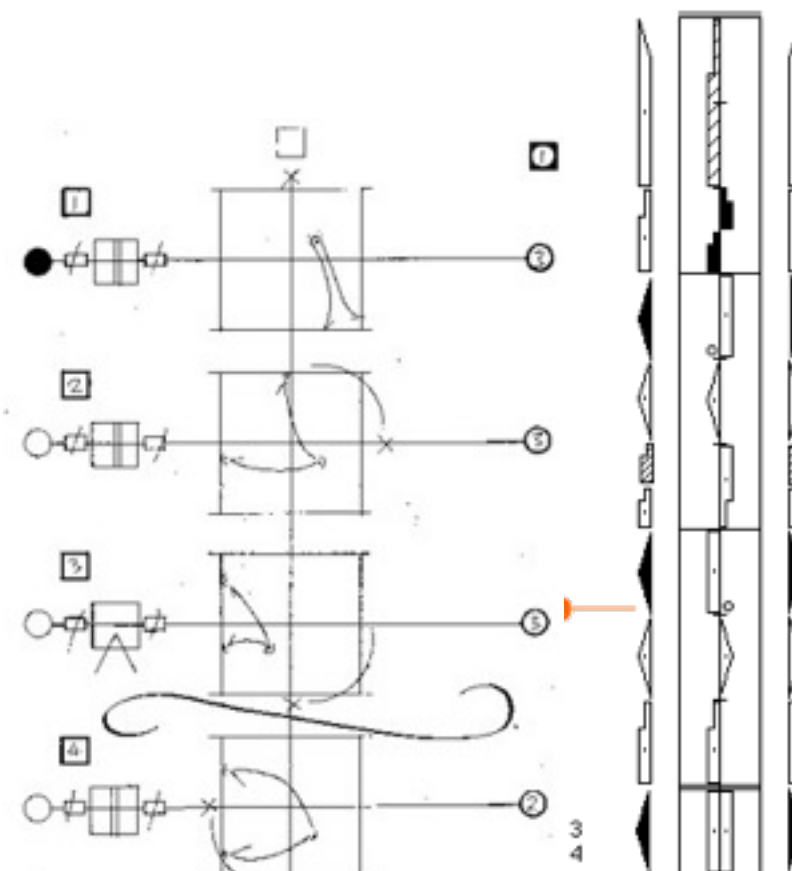
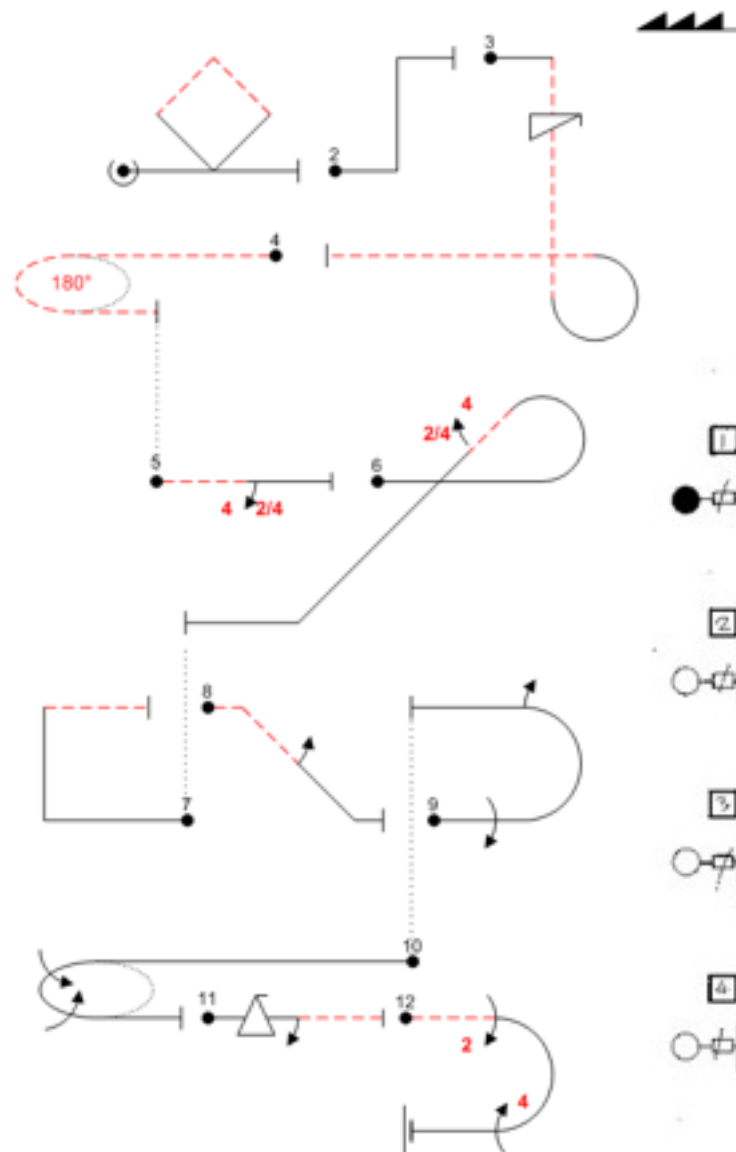
Cello

Bass

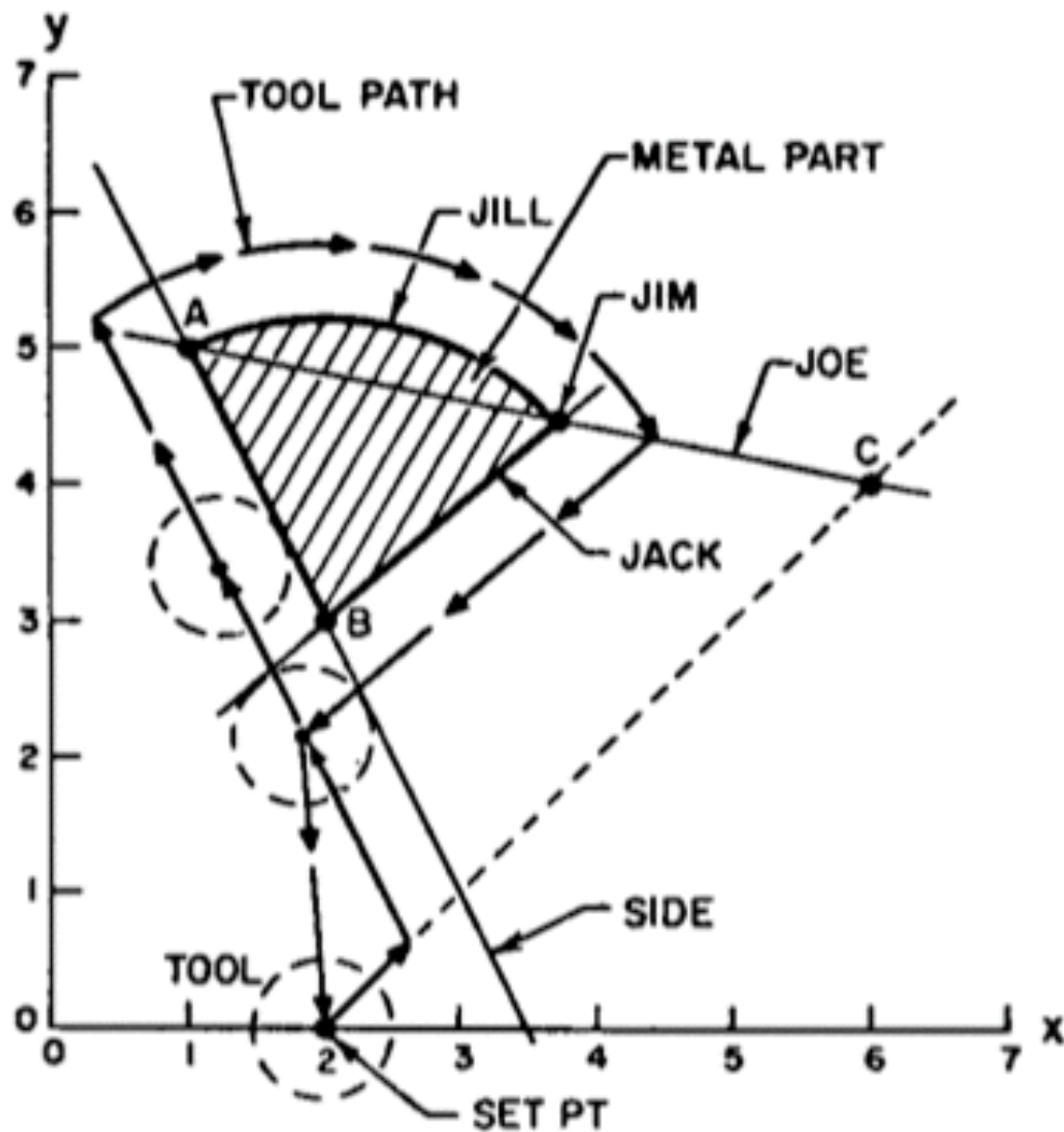
© Copyright 1979 by DELACOURT MUSIC PUBLISHERS, Los Angeles. All rights reserved.

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	



APT



```

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
  
```

A domain



Domain
Knowledge

Hard labour

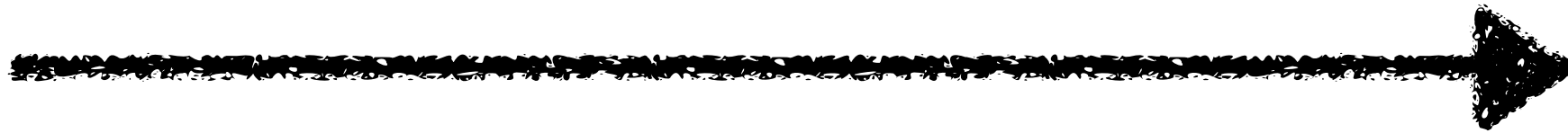
Code



Domain
Knowledge

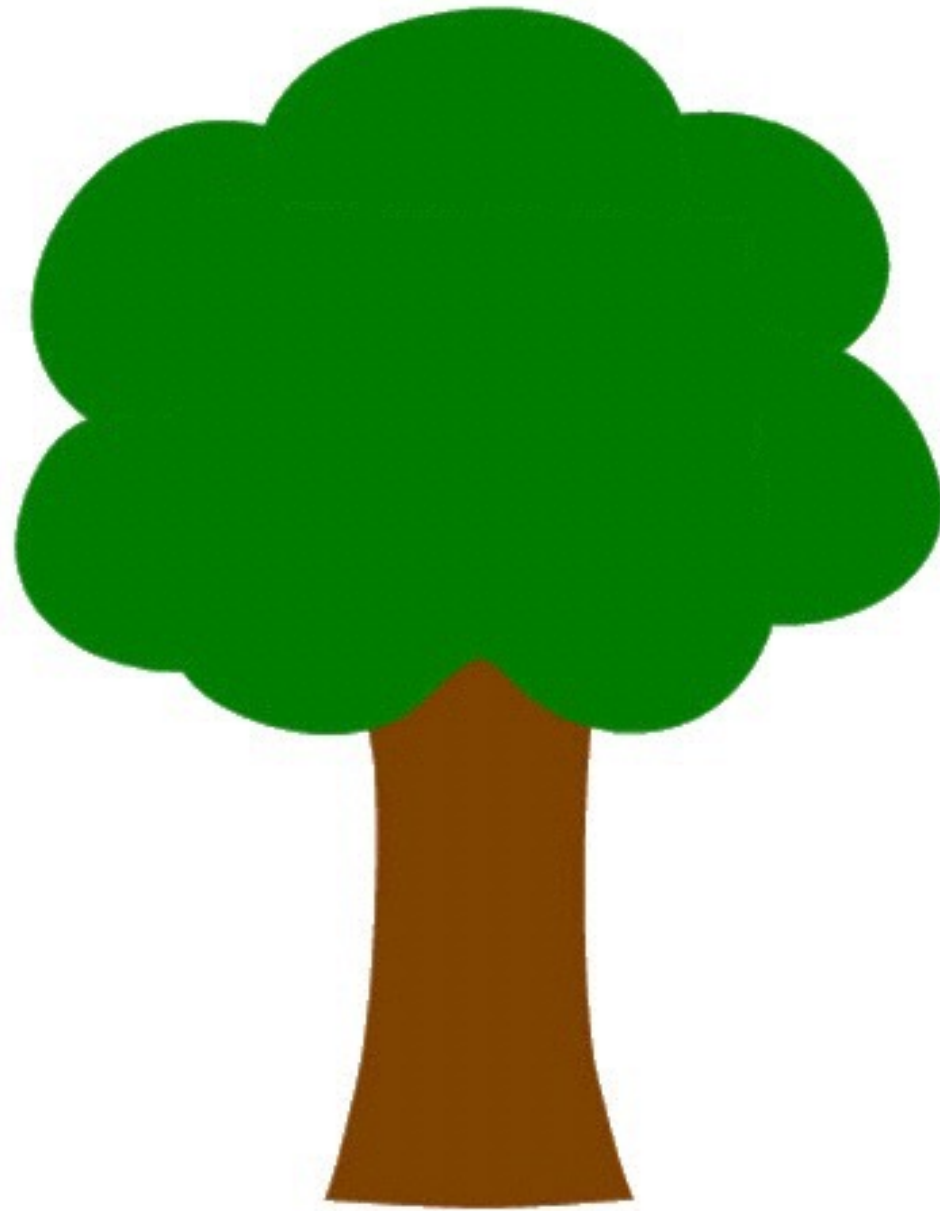
Hard labour

Code



Change

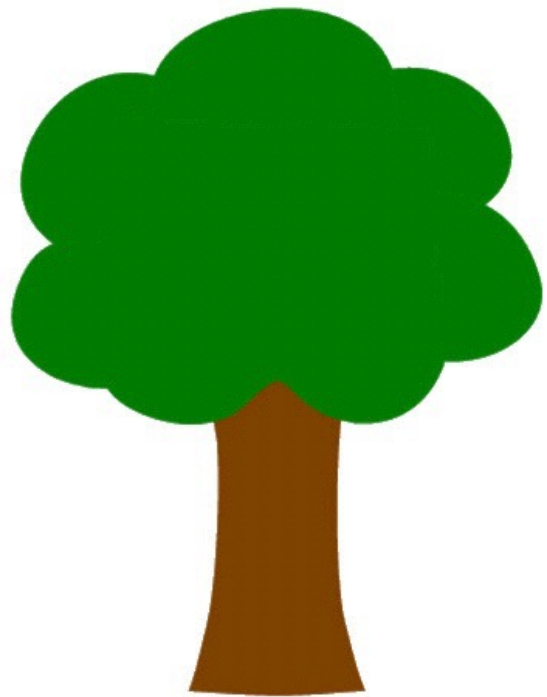
Modeling the domain



Domain-specific
Language

Automation

Code



“What”
formalized
requirements



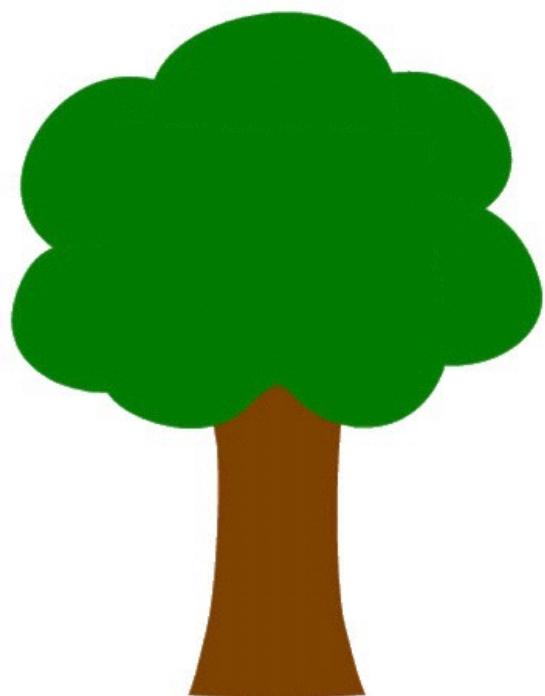
“How”
formalized design
and architecture



Domain-specific
Language

Automation

Code



Change

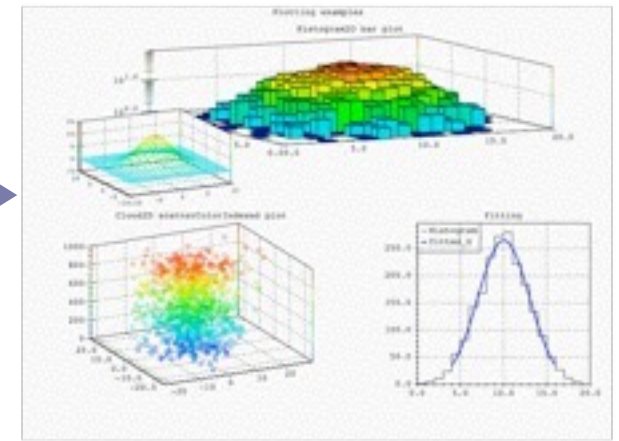
Case 1: digital forensics



Acquisition



Recovery



Analysis

File carving tools



- Carving: recovering files without using file system
- **What** we're looking for: **files of a certain type**
- **How** we're looking: carving **algorithms**
- But both concerns are mixed up in the same code!

Derric

format jpeg
extension jpeg jpg jfif

unit byte
size 1
sign false
type integer
endian big
strings ascii

sequence

SOI

([APP0JFIF APP0JFXX?] [APP1 APP2?])

!(SOI APP0JFIF APP0JFXX EOI)*

EOI

- Separate file format description from carving algorithms
- File formats can be understood by forensic experts
- Generate high performance code.

Case 2: tax administration

Gegevensspecificatie

Behorende bij de specificatie
van de berichtstructuur
DA-2015

Versie 3.0 van 17/8/2015

Versie 3.0
Definitief
17/8/2015

1147 page
PDF
document

The running program

Aangifte inkomstenbelasting 2010 – Persoonlijke gegevens

Persoonlijke gegevens

✓ Persoonlijke gegevens: Bla
✓ Persoonlijke gegevens: Blasa

✓ Box 1: werk en woning
Box 1: andere inkomsten
Box 1: uitgaven lijfrenten e.d.
Box 2: aanmerkelijk belang
Box 3: sparen en beleggen

Aftrekposten
Vrijstellingen en verminderingen
Bijzondere situaties
Te verrekenen bedragen

Heffingskortingen: Bla

Overzicht: Bla

Voorlopige aanslag 2011
Naar ondertekenen met DigiD

IB 602E - 2Z01FOL2A

Naam: Bla
Telefoonnummer: 323
Burgerservicenummer/sofnummer: 1430.95.067
Geboortedatum: 11-02-1979
Nummer belastingconsulent:
Hebt u van ons bericht ontvangen om aangifte te doen? ☐ Ja ☒ Nee
Wilt u een rekeningnummer opgeven of wijzigen? ☐ Ja ☒ Nee
Uw persoonlijke situatie in 2010: Een deel van 2010 getrou...
Periode dat u getrouwd was in 2010: 01-02 03-05
Woonde u voor of na deze periode samen met uw echtgenoot? ☐ Ja ☒ Nee
Willen u en uw echtgenoot heel 2010 als fiscale partners worden beschouwd? ☐ Ja ☒ Nee
Woonde u buiten de periode dat u getrouwd was nog met iemand anders samen? Bijvoorbeeld met uw kind van 27 jaar of ouder? ☐ Ja ☒ Nee

Akkoord

Stoppen Instellingen Rekenmachine Help Printer Open bestand

Consequences

- Enormous amount of work: programmers manually implement ± 1500 data items + interaction logic
- Gargantuan testing effort: lot of data, lot of choices in the UI, — no automated support.
- Validation: how to know if the code is correctly implementing the spec?
- Every year, everything changes again, but unit of change $\neq$ unit of code.

Using a DSL

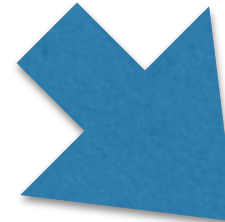
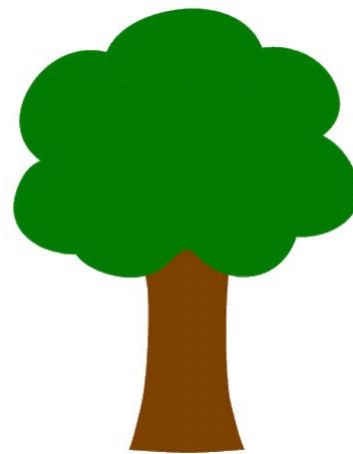
Gegevensspecificatie

Behorende bij de specificatie
van de berichtstructuur
DA-2011

Versie 2.3 van 29/9/2011

Versie 2.3
Definitief
29/9/2011

extract



generate

Aangifte inkomstenbelasting 2010 - Persoonlijke gegevens

Persoonlijke gegevens

Naam:

Telefoonnummer:

Burgerservicenummer/sofnummer:

Geboortedatum:

Nummer belastingconsulent:

Hebt u van ons bericht ontvangen om aangifte te doen? ☐ Ja ☒ Nee

Wilt u een rekeningnummer opgeven of wijzigen? ☐ Ja ☒ Nee

Uw persoonlijke situatie in 2010:

Periode dat u getrouwd was in 2010:

Woonde u voor of na deze periode samen met uw echtgenoot? ☐ Ja ☒ Nee

Willen u en uw echtgenoot heel 2010 als fiscale partners worden beschouwd? ☐ Ja ☒ Nee

Woonde u buiten de periode dat u getrouwd was nog met iemand anders samen? Bijvoorbeeld met uw kind van 27 jaar of ouder? ☐ Ja ☒ Nee

IB 602E - Z201FOL2A

```
gegeven periode samenwonen in belastingjaar [117315]: DDMMEJJ {  
  alias EPerSamenwonen  
  minimaal voorkomen 0  
  maximaal voorkomen 1  
  gebruikt in  
    117308  
  pagina 73  
  definitie {  
    De periode in het belastingjaar waarin de  
    aangever en de partner onafgebroken een  
    gezamenlijke huishouding hebben gevoerd  
    en op hetzelfde woonadres stonden ingeschreven.  
  }  
  bron {  
    Wet IB2001, art 1.2  
  }  
  conditie  
    [117315.B]<periode samenwonen in belastingjaar.Begindatum>  
      <= [117315.E]<periode samenwonen in belastingjaar.Einddatum>  
}
```

▼ DA-2015

▼ 3.0

▼ Inkomensheffingen, Zorgverzekeringswet, Verzekering
Zorgverzekeringswet

▼ Inkomstenbelasting en premies volksverzekering

▼ Inkomensopstelling kwalificerende buitenlandse

▼ Inkomensopstelling kwalificerende buitenlandse

Vermeerdering-vermindering inkomens

▼ Grondslag inkomsten verhouding Nederland

Inkomen belast Nederland samenstelling

Inkomen in en buiten Nederland samenstelling

▼ Inkomensopstelling partner kwalificerende

Vermeerdering-vermindering inkomens

▼ Grondslag inkomsten verhouding Nederland

Inkomen in en buiten Nederland partner

Inkomen belast Nederland partner

▼ Persoonsgebonden aftrek

▼ Totaal aftrekbaar giften

▼ Andere giften

▼ Andere giften aan culturele instellingen

Andere giften culturele instellingen

▼ Overige andere giften

Overige andere giften specifiek

▼ Andere giften aan steunstichtingen

Andere giften steunstichtingen specifiek

▼ Periodieke giften

▼ Overige periodieke giften

Overige periodieke giften specifiek

Giften aftrekbaar aangever migratiejaar Nederland
periode

Het deel van de aftrekbaar giften van de aangever dat betrekking heeft op de periode wonen in Nederland in het migratiejaar.

Bronnen: [Wet IB 2001, art 6.32](#)

Andere giften culturele instelling

De giften die betaald, verrekend of ter beschikking zijn gesteld aan een culturele instelling.

Bronnen: [Wet IB 2001, art 6.32](#) [Wet IB 2001, art 6.39a](#)

Omschrijving andere giften culturele instelling

De naam van de culturele instelling of omschrijving waaraan de gift is gedaan.

Bronnen: [Wet IB 2001, art 6.33Algemene](#) [Wet Inzake Rijksbelastingen, artikel 5b](#)

Verhoging aftrek andere giften culturele instellingen

De verhoging van de aftrek van andere giften gedaan aan culturele instellingen.

Bronnen: [Wet IB 2001, art 6.39a, lid 1](#)

Andere giften culturele instellingen totaal

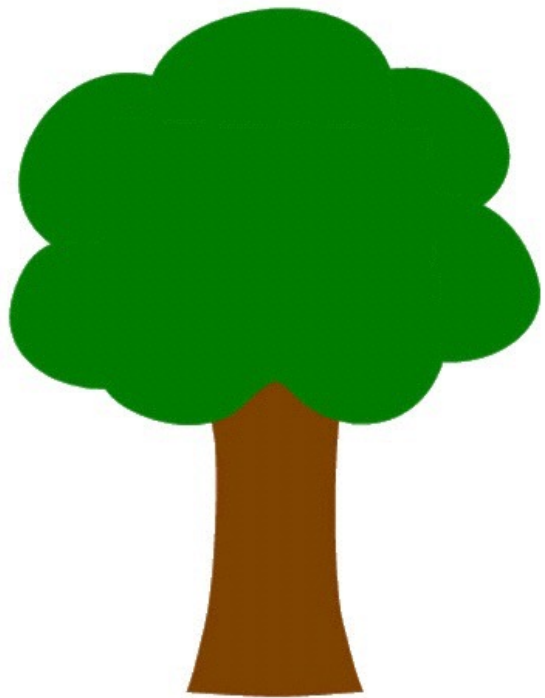
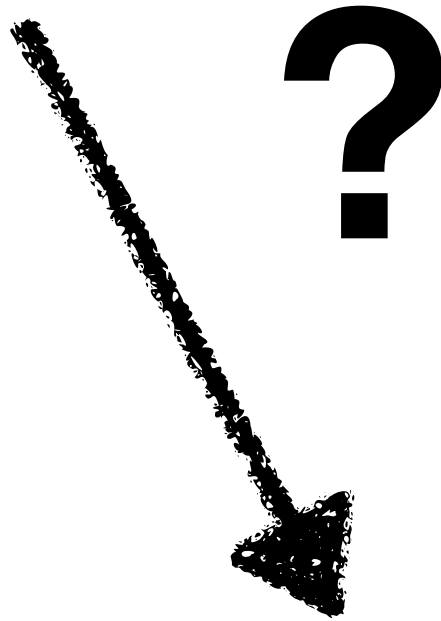
Het totaal van de giften aan culturele instellingen.

Bronnen: [Wet IB 2001, art 6.32](#) [Wet IB 2001, art 6.39a](#)

Aftrekbaar andere giften

Het bedrag van de andere giften aan instellingen of aan steunstichtingen SBBI verminderd

#hoedan?



CWI SWAT

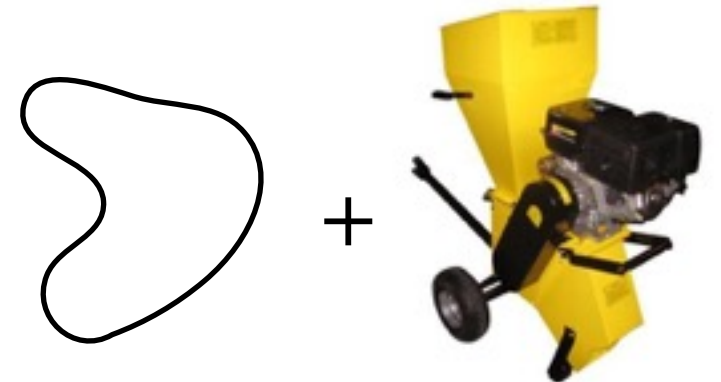
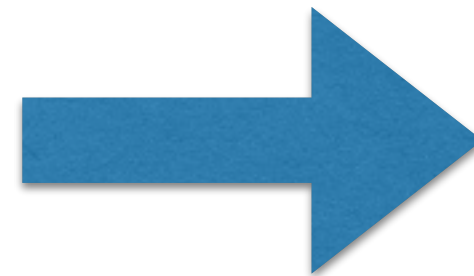
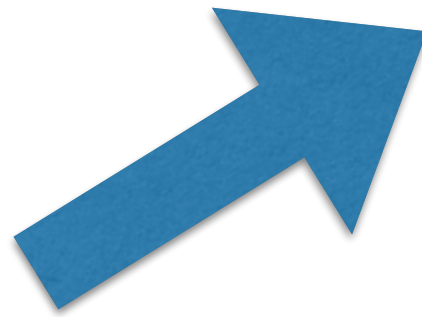
- SWAT: Software Analysis & Transformation
- Tools for understanding existing software better (reverse engineering)
- Designing better languages to improve software construction (forward engineering)
- Key tech: Rascal (www.rascal-mpl.org)
- Meta programming language and **language workbench**



Rascal



www.rascal-mpl.org



DSLs @ SWAT

- Derric: digital forensics
- QL: questionnaires
- Machino: router software
- Halide*: image processing
- AlleAlle: relational modeling
- MicroMachinations: game economies



Why more programming languages?

INTOXILYZER®



8000



```
.text:131411EF ; FUNCTION CHUNK AT .text:13141239 SIZE 0000009F BYTES
.text:131411EF ; FUNCTION CHUNK AT .unp0:13143000 SIZE 00000122 BYTES
.text:131411EF ; FUNCTION CHUNK AT .unp0:13143522 SIZE 000000F1 BYTES
.text:131411EF ; FUNCTION CHUNK AT .unp0:13145C99 SIZE 0000000A BYTES
.text:131411EF 68 F1 AF 50 FF      push    0FF5BAFFh
.text:131411FA 49 AB AB 00 00      jmp     loc_13145C99
.text:131411FA
.text:131411FA
.text:131411FA
.text:131411FA 64 69 31      byte_131411F9 db 64h, 69h, 31h ; DATA XREF: start+5C9e
.text:131411FC 60 16 A2 75 9A CA+ dd 75A21660h, 0CACDC49Ah, 7B9D7BF9h, 20ABDA05h, 687EAB85h
.text:131411FC CD CA FA 7B 9D 7B+ dd 6EE5A40h, 10069610h, 0FE39DFC2h, 0ED0EB3C7h, 5CFE8A0h
.text:131411FC D5 D4 AB 28 85 AB+ dd 0EB6323Eh, 82B58465h, 0D0947C7Bh, 0C80C200h, 30DE6A19h
.text:13141230
.text:13141230 58      pop     eax
.text:13141239 ; START OF FUNCTION CHUNK FOR start
.text:13141239
.text:13141239 loc_13141239: ; CODE XREF: start+4AAfj
.text:13141239 52      push    edx
.text:13141239 55      push    ebp
.text:13141239 53      push    ebx
.text:13141239 51      push    ecx
.text:13141239 9C      pushf
.text:1314123E 57      push    edi
.text:1314123F 50      push    eax
.text:13141240 56      push    esi
.text:13141241 51      push    ecx
.text:13141242 60 00 00 00 00      push    0
.text:13141247 8B 74 24 20      mov     esi, [esp+2Ch+var_4]
.text:13141248 BF F9 11 14 13      mov     edi, offset byte_131411F9
.text:13141250
.text:13141250 loc_13141250: ; CODE XREF: start+09ij
.text:13141250 89 F3      mov     ebx, esi
.text:13141252 8D 34 24      add     esi, [esp+2Ch+var_2C]
.text:13141255
.text:13141255 loc_13141255: ; CODE XREF: start+98ij
.text:13141255 ; start+ABij ...
```



VS



<http://www.rascal-mpl.org>

