Model-based Software Product Lines

Mathieu Acher
Maître de Conférences
mathieu.acher@irisa.fr

Material

http://mathieuacher.com/teaching/MDE/MRI1516/

Plan

- Challenges and Overview
  - Developping billions of software product is hard but now a common practice
- Implementing Variability
  - Revisit of existing techniques and curriculum
- Specificity of Product Line Engineering
  - Process, methods
- Feature Models
  - Defacto standard for modeling product lines and variability
  - Syntax, semantics, automated reasoning, synthesis

Contract

- The idea of software product lines and variability
  - You will be able to recognize this class of systems
  - Aware of the complexity, the specific development process, and existing techniques
- Feature modeling
  - A widely used formalism for modeling product lines and configurable systems in a broad sense
- Composing/Decomposing feature models with a domain-specific language
- Reverse engineering variability models

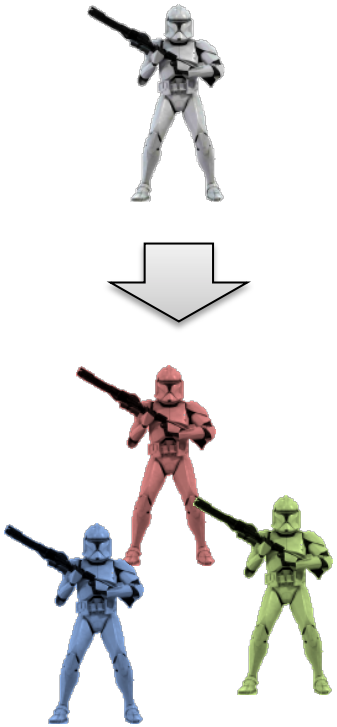
Product Lines

(Software) Product Lines

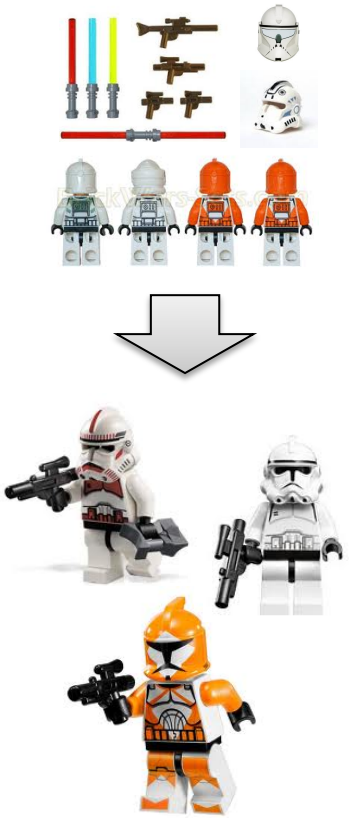
The three ways to build a (software) product

Indepently

„Clone & Own“



„Shared“ (reusable) Assets



(credits: Thorsten Berger’s slide)

The three ways to build a (software) product

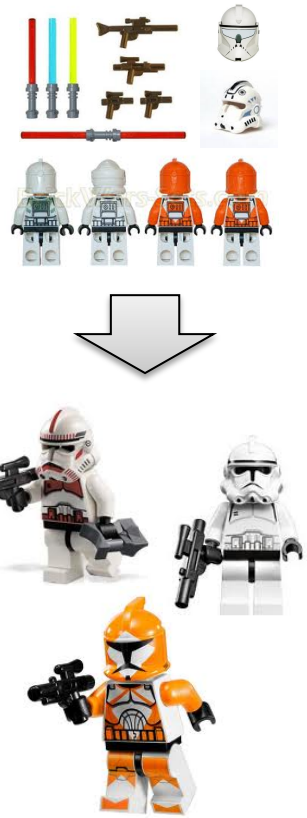
Indepently

„Clone & Own“

„Shared“ (reusable) Assets

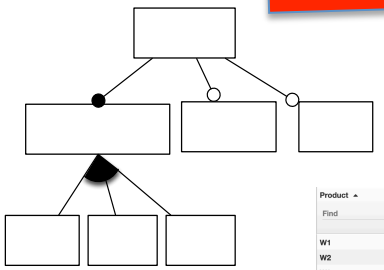
Software Product Lines

Product Configuration
Variability Modeling
Components
Domain-specific Languages
Generators
Preprocessors
Design Patterns
…



(credits: Thorsten Berger’s slide)

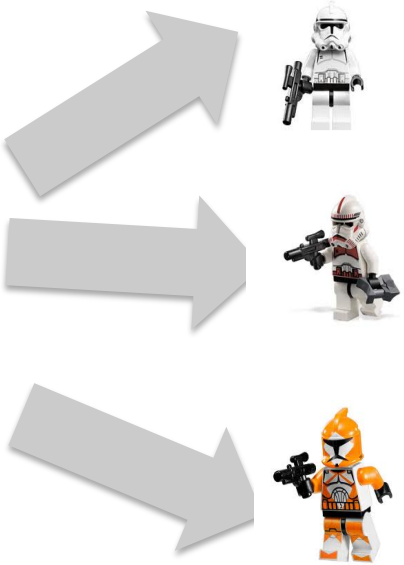
Modeling and Reverse Engineering Variability



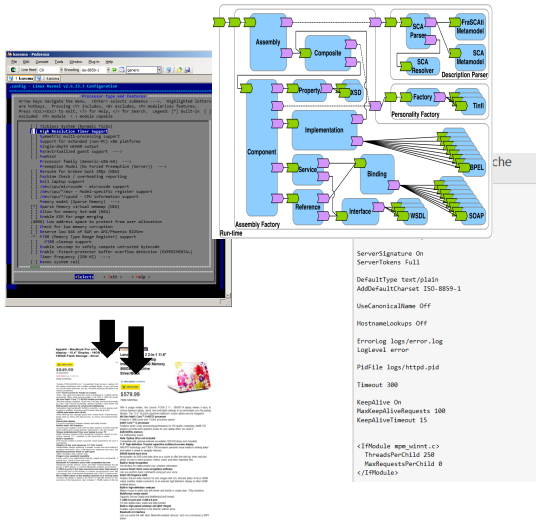
Product	License	Price	Language Support	Language	WYSIWIG
W1	Commercial	10	Yes	Java	Yes
W2	NoLimit	20	No		Yes
W3	NoLimit	10	No		Yes
W4	GPL	0	Yes	Python	Yes
W5	GPL	0	Yes	Perl	Yes
W6	GPL	10	Yes	Perl	Yes
W7	GPL	0	Yes	PHP	No
W8	GPL	10	Yes	PHP	Yes

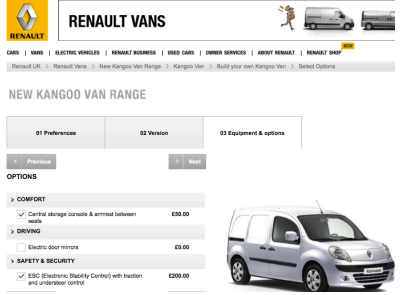
Feature models
or Product Matrices

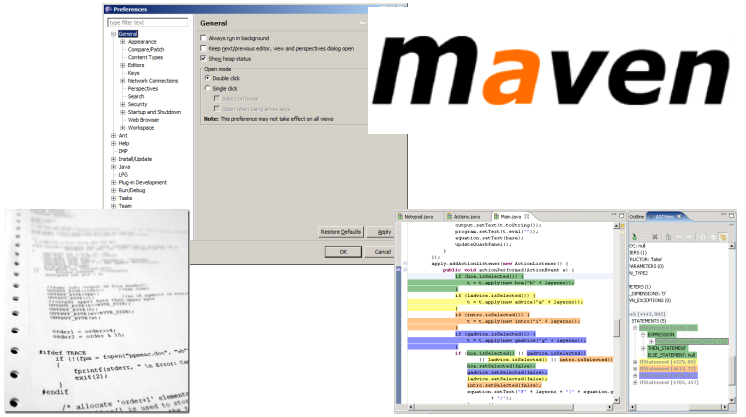
(product lines)



Variants of code (e.g., Java or C)
Variants of user interfaces
Variants of video sequences
Variants of models (e.g., UML or SysML)
Variants of « things » (3D models)
…



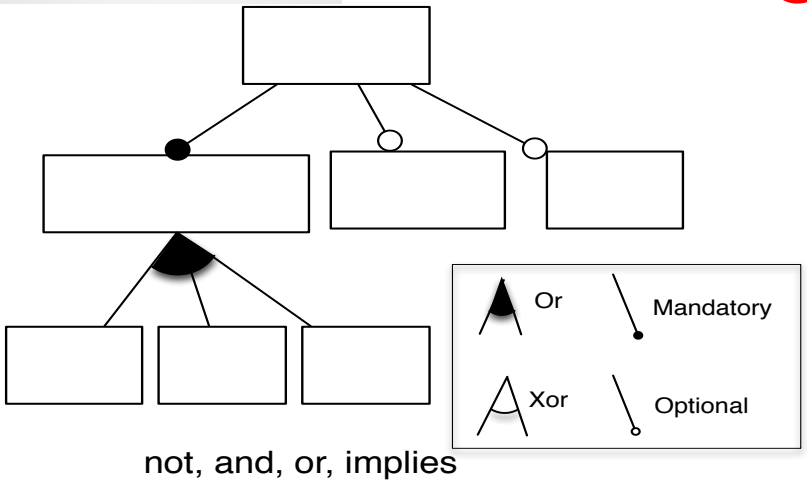




maven

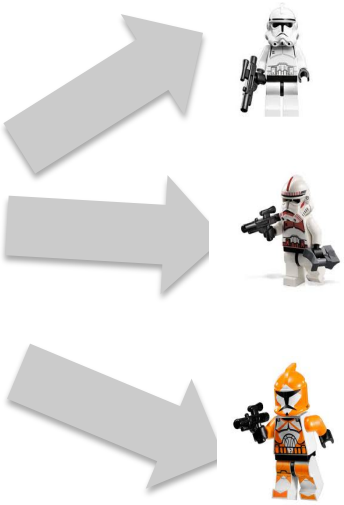
Mining/Extracting
Encoding/Formalizing
Synthesising

FAMiliAR



not, and, or, implies

Variability Models (feature models)



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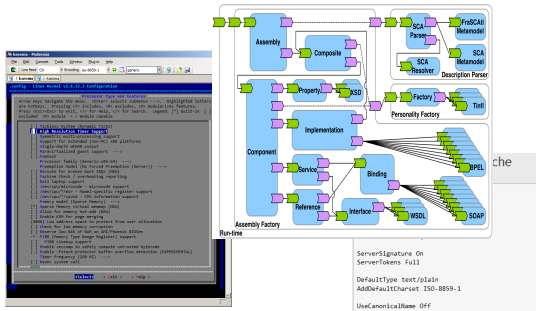

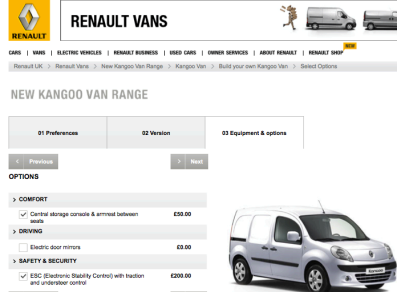

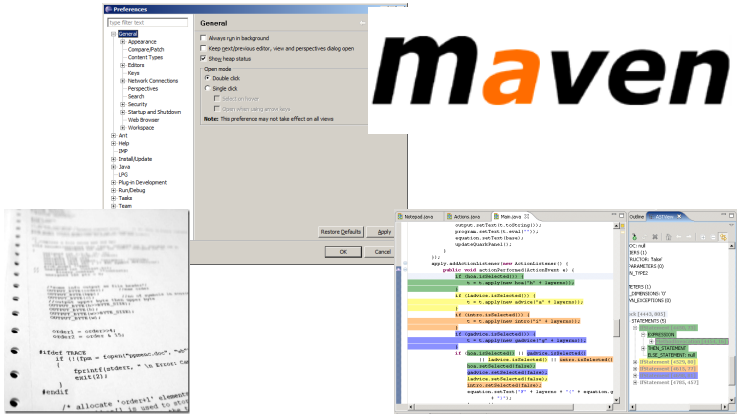

Mining/Extracting
Encoding/Formalizing
Synthesising

OpenCompare

Product	License	Price	Language Support	Language	WYSIWIG
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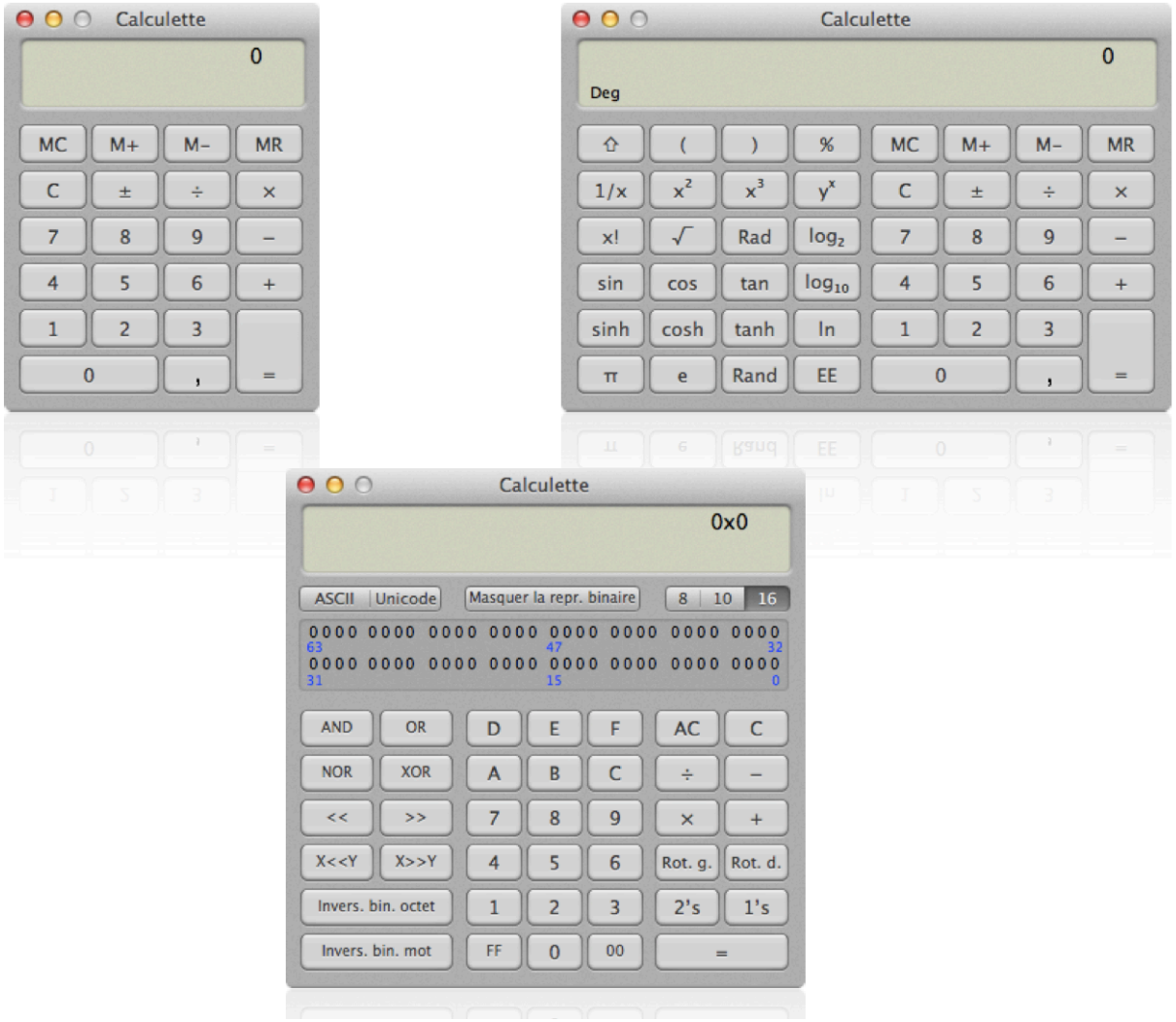
W2	NoLimit	20	No		Yes
W3	NoLimit	10	No		Yes
W4	GPL	0	Yes	Python	Yes
W5	GPL	0	Yes	Perl	Yes
W6	GPL	10	Yes	Perl	Yes
W7	GPL	0	Yes	PHP	No
W8	GPL	10	Yes	PHP	Yes

Variability and Software Product Lines

Perhaps, you ignore the names of something omnipresent in numerous contexts


Calculette
0
MC M+ M− MR
C ± ÷ ×
7 8 9 −
4 5 6 +
1 2 3 =
0 ,
Calculette
0
Deg
⇧ ( ) % MC M+ M− MR
1/x x² x³ yˣ C ± ÷ ×
x! √ Rad log₂ 7 8 9 −
sin cos tan log₁₀ 4 5 6 +
sinh cosh tanh ln 1 2 3 =
π e Rand EE 0 ,
Calculette
0x0
ASCII Unicode
Masquer la repr. binaire
8 10 16
0000 0000 0000 0000 0000 0000 0000 0000
63 47 32
0000 0000 0000 0000 0000 0000 0000 0000
31 15 0
AND OR D E F AC C
NOR XOR A B C ÷ −
<< >> 7 8 9 × +
X<<Y X>>Y 4 5 6 Rot. g. Rot. d.
Invers. bin. octet 1 2 3 2's 1's
Invers. bin. mot FF 0 00 =

« A set of programs is considered to constitute a **family**, whenever it is worthwhile to study programs from the set by **first studying the common properties** of the set and then determining the **special properties** of the individual family members »

aka **Variability**

David L. Parnas — "On the design and development of program families" in Transactions on Software Engineering, SE-2(1):1–9, 1976

Variability

"the ability of a system to be efficiently extended, changed, customized or configured for use in a particular context"

Mikael Svahnberg, Jilles van Gurp, and Jan Bosch (2005)

NOKIA
Connecting People

Know our past. Create the future...

1982 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994

1995 1996 1997 1998 1999

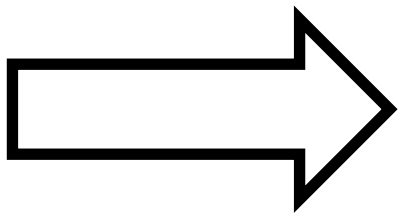
2000 2001 2002

2003 2004

2005

2006 UI

Software-intensive systems



come in many **variants**

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RENAULT VANS

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NEW KANGOO VAN RANGE

01 Preferences	02 Version	03 Equipment & options

< Previous > Next

OPTIONS

> COMFORT	
☑ Central storage console & armrest between seats	£50.00
> DRIVING	
☐ Electric door mirrors	£0.00
> SAFETY & SECURITY	
☑ ESC (Electronic Stability Control) with traction and understeer control	£200.00

"Reverse Engineering Web Configurators" Ebrahim Khalil Abbasi, Mathieu Acher, Patrick Heymans, and Anthony Cleve. In 17th European Conference on Software Maintenance and Reengineering (CSMR'14)

MAISO

LE PLIAGE PERSONNALISÉ

LE PLIAGE CUIR | LE PLIAGE TOILE

MODÈLES

- Porte-monnaie Toile
- Pochette Toile
- Sac Taille 1 Toile
- Sac Taille 2 Toile
- Sac Taille 3 Toile
- Sac Taille 4 Toile

COULEUR RECTO

COULEUR VERSO

BOUCLERIE

RESET

VOTRE PERSONNALISATION

Porte-monnaie Toile : 9 x 7 x 5 cm
Couleur recto : Garance
Couleur verso : Malabar
Bouclerie : Bronze

35,00 € AJOUTER AU PANIER

Infos | Partager | J'aime

- Developer Tools
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- Drivers
- DTP/Prepress
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- Games
- Graphics
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- iPhone Applications
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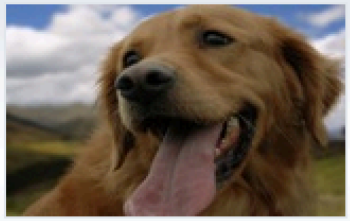
Power Matte 2.0.1.3 update

Adobe After Effects plugin that can extract any object in an image

[read more >]

Size:	13.20 MB
Platform:	Mac OS X 10.5 or later
License:	Trial
Rating:	Good (3.0/5)
Downloads:	1,504
Updated:	June 20th, 08:21 UTC



Gridus 1.1 update

Helps you generate perspective grids

[read more >]

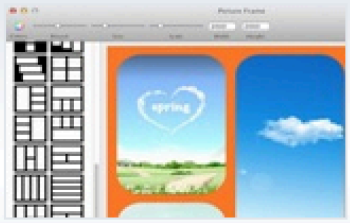
Size:	102 KB
Platform:	Mac OS X 10.8 or later
License:	Commercialware
Rating:	NOT RATED
Downloads:	21
Updated:	June 20th, 07:56 UTC

Picture Frame 2.2 update

Quickly generate multi-frame photos using your Mac

[read more >]

Size:	716 KB
Platform:	Mac OS X 10.6.6 or l...
License:	Commercialware
Rating:	Excellent (5.0/5)
Downloads:	297
Updated:	June 20th, 07:53 UTC

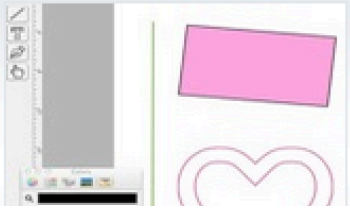


FashionLab Studio 1.1 update

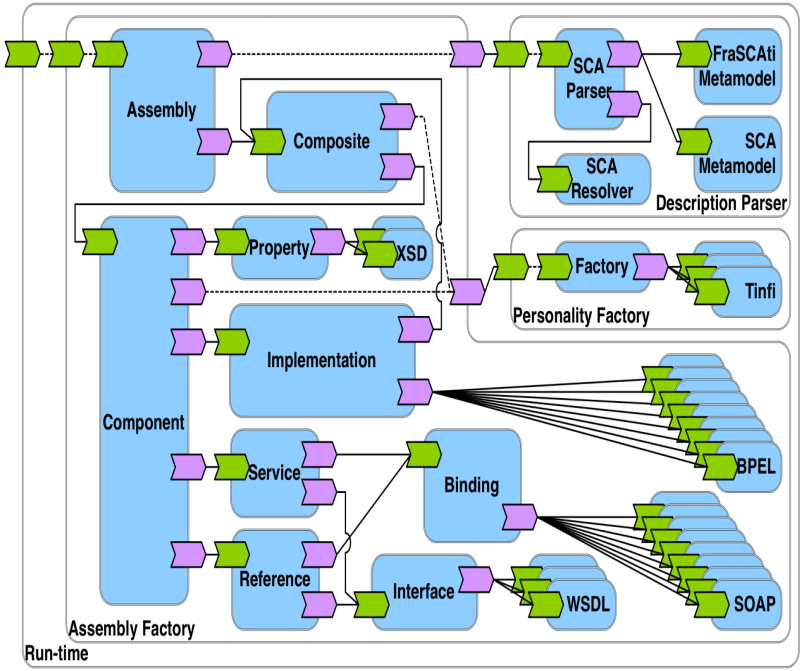
Makes it easy to design your own T-shirt using a Mac

[read more >]

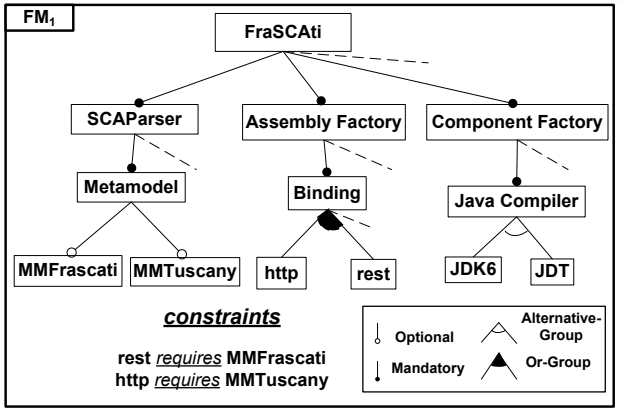
Size:	3.10 MB
Platform:	Mac OS X 10.6.6 or l...
License:	Commercialware
Rating:	NOT RATED
Downloads:	3
Updated:	June 20th, 07:49 UTC



« Feature Model Extraction from Large Collections of Informal Product Descriptions »
Jean-Marc Davril, Edouard Delfosse, Negar Hariri, Mathieu Acher, Jane Cleland-Huang, Patrick Heymans (ESEC/FSE'13)



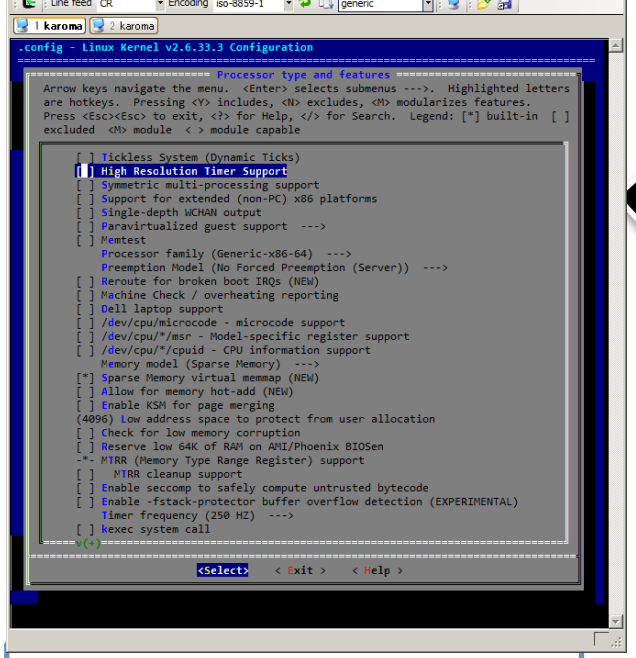
maven



Variability Model

« Extraction and Evolution of Architectural Variability Models in Plugin-based Systems »
Mathieu Acher, Anthony Cleve, Philippe Collet, Philippe Merle, Laurence Duchien, Philippe Lahire ECSA/SoSyM'14

Printer Firmware



Linux Kernel

Brand	Model name	Sensor size	Effective megapixels	Lens mount	Viewfinder type	Viewfinder coverage (% of the frame)	Metering zones	Focus points	Lowest ISO	Highest ISO	DxOMark sensor score	DxO ISO perfor-mance[1]
Canon	1D X	Full frame	18.1	EF	Pentaprism	100	252	61	50	204800	82	2786
Canon	1Ds Mark III	Full frame	21.1				63	45	50	3200	80	1663
Canon	1D Mark IV	APS-H	16.1				63	45	50	102400	74	1320
Canon	5D Mark III	Full frame	22.3				63	61	50	102400	81	2293
Canon	5D Mark II	Full frame	21.1				35	9	50	25600	79	1815
Canon	6D	Full frame	20.2				63	11	100	102400	82	2340
Canon	7D	APS-C	18.0				63	19	100	12800	66	854
Canon	70D	APS-C	20.2				63	19	100	25600	68	926
Canon	60D	APS-C	18.0				63	9	100	12800	66	813
Canon	50D	APS-C	15.1	EF, EF-S	Pentaprism	95	35	9	100	12800	63	696
Canon	40D	APS-C	10.1	EF, EF-S	Pentaprism	95	35	9	100	3200	64	703
Canon	30D	APS-C	8.2	EF, EF-S	Pentaprism	95	35	9	100	3200	59	736
Canon	20D	APS-C	8.2	EF, EF-S	Pentaprism	95	35	9	100	3200	62	721

Guillaume Bécan, Nicolas Sannier, Mathieu Acher, Olivier Barais, Arnaud Blouin, and Benoit Baudry. Automating the Formalization of Product Comparison Matrices (2014). In 29th IEEE/ACM International Conference on Automated Software Engineering (ASE'14)

```
macher-wifi:getting-started macher1$ yo jhipster

I'm all done. Running npm install & bower install for you to install the required dependencies.

HIPSTER STACK
FOR
JAVA DEVS

Welcome to the JHipster Generator v2.17.0

? (1/15) What is the base name of your application? jhipster
? (2/15) What is your default Java package name? com.mycompany.myapp
? (3/15) Do you want to use Java 8? Yes (use Java 8)
? (4/15) Which *type* of authentication would you like to use? (Use arrow keys)
❯ HTTP Session Authentication (stateful, default Spring Security mechanism)
  OAuth2 Authentication (stateless, with an OAuth2 server implementation)
  Token-based authentication (stateless, with a token)
```

Branch: **master**

generator-jhipster / app / templates / src / main / java / package / config / **_DatabaseConfiguration.java**

jdubois 2 days ago Use Spring Boot's configuration meta-data

9 contributors

184 lines (165 sloc) | 9.69 KB

Raw | Blame | History

```
1  package <%=packageName%>.config;
2  <% if (databaseType == 'sql') { %>
3  import <%=packageName%>.config.liquibase.AsyncSpringLiquibase;
4  import com.codahale.metrics.MetricRegistry;
5  import com.fasterxml.jackson.datatype.hibernate4.Hibernate4Module;
6  import com.zaxxer.hikari.HikariConfig;
7  import com.zaxxer.hikari.HikariDataSource;
8  import liquibase.integration.spring.SpringLiquibase;<% } %><% if (databaseType == 'mongodb' && authenticationType == 'oauth2') { %
9  import <%=packageName%>.config.oauth2.OAuth2AuthenticationReadConverter;<% } %><% if (databaseType == 'mongodb') { %>
10 import com.mongodb.Mongo;
11 import org.mongeez.Mongeez;<% } %>
12 import org.slf4j.Logger;
13 import org.slf4j.LoggerFactory;<% if (databaseType == 'sql') { %><% if (hibernateCache == 'hazelcast') { %>
14 import org.springframework.cache.CacheManager;<% } %>
15 import org.springframework.beans.factory.annotation.Autowired;
16 import org.springframework.boot.autoconfigure.condition.ConditionalOnExpression;<% } %><% if (databaseType == 'mongodb') { %>
17 import org.springframework.boot.autoconfigure.mongo.MongoAutoConfiguration;
18 import org.springframework.boot.autoconfigure.mongo.MongoProperties;<% } %><% if (databaseType == 'sql') { %>
19 import org.springframework.boot.autoconfigure.jdbc.DataSourceProperties;
20 import org.springframework.boot.autoconfigure.liquibase.LiquibaseProperties;
21 import org.springframework.context.ApplicationContextException;<% } %>
22 import org.springframework.context.annotation.Bean;
23 import org.springframework.context.annotation.Configuration;
24 import org.springframework.context.annotation.Profile;<% if (databaseType == 'mongodb') { %>
25 import org.springframework.context.annotation.Import;<% } %><% if (databaseType == 'sql') { %>
26 import org.springframework.core.env.Environment;<% } %><% if (databaseType == 'mongodb' && authenticationType == 'oauth2') { %>
27 import org.springframework.core.convert.converter.Converter;<% } %><% if (databaseType == 'mongodb') { %>
28 import org.springframework.core.io.ClassPathResource;<% } %><% if (searchEngine == 'elasticsearch') { %>
29 import org.springframework.data.elasticsearch.repository.config.EnableElasticsearchRepositories;<% } %><% if (databaseType == 'mon
30 import org.springframework.data.mongodb.config.AbstractMongoConfiguration;
31 import org.springframework.data.mongodb.config.EnableMongoAuditing;<% } %><% if (databaseType == 'mongodb' && authenticationType =
32 import org.springframework.data.mongodb.core.convert.CustomConversions;<% } %><% if (databaseType == 'mongodb') { %>
33 import org.springframework.data.mongodb.core.mapping.event.ValidatingMongoEventListener;
34 import org.springframework.data.mongodb.repository.config.EnableMongoRepositories;
35 import org.springframework.validation.beanvalidation.LocalValidatorFactoryBean;<% } %><% if (databaseType == 'sql') { %>
```

Variability

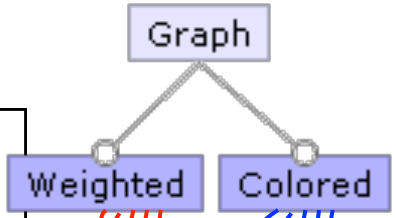
```
class Graph {
  Vector nv = new Vector(); Vector ev = new Vector();
  Edge add(Node n, Node m) {
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    e.weight = new Weight();
    return e;
  }
  Edge add(Node n, Node m, Weight w)
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    e.weight = w; return e;
  }
  void print() {
    for(int i = 0; i < ev.size(); i++) {
      ((Edge)ev.get(i)).print();
    }
  }
}
```

```
class Node {
  int id = 0;
  Color color = new Color();
  void print() {
    Color.setDisplayColor(color);
    System.out.print(id);
  }
}
```

```
class Edge {
  Node a, b;
  Color color = new Color();
  Weight weight;= new Weight();
  Edge(Node _a, Node _b) { a = _a; b = _b; }
  void print() {
    Color.setDisplayColor(color);
    a.print(); b.print();
    weight.print();
  }
}
```

```
class Color {
  static void setDisplayColor(Color c) { ... }
}
```

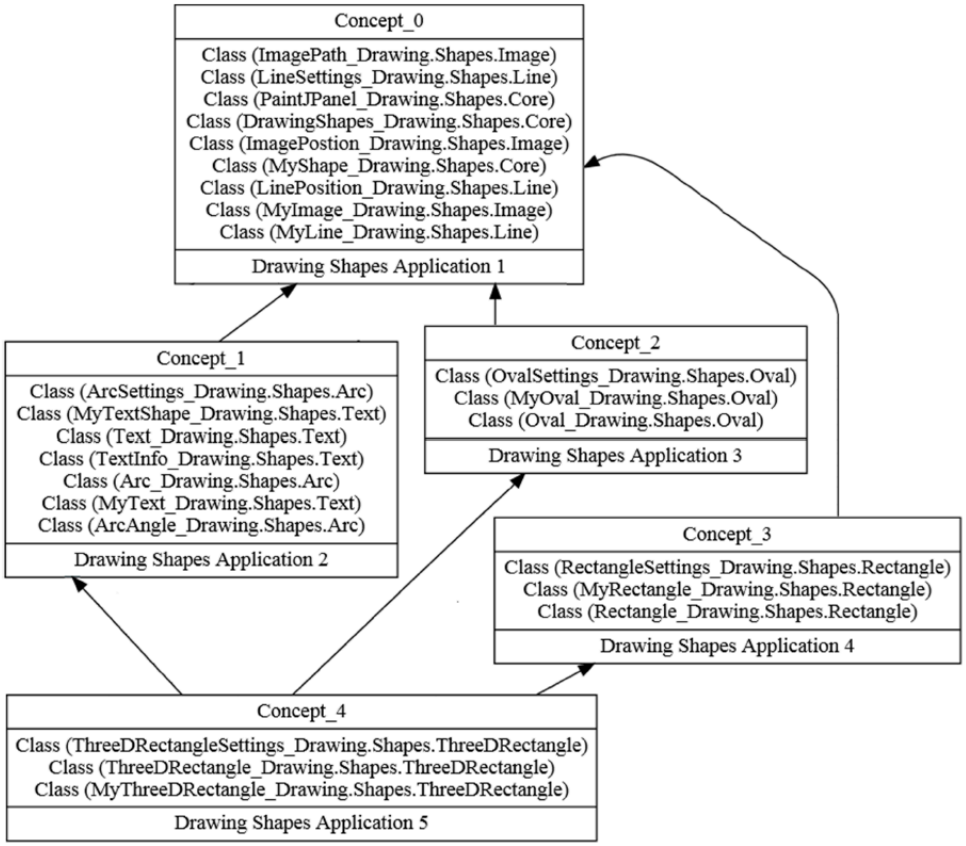
```
class Weight { void print() { ... } }
```



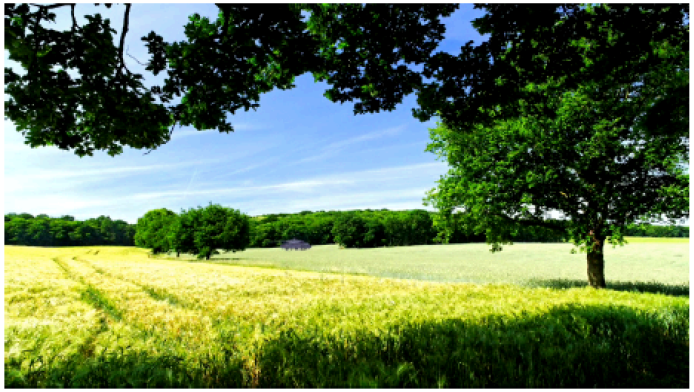
Mining Features from the Object-Oriented Source Code of Software Variants by Combining Lexical and Structural Similarity

R. AL-msie'deen, A.-D. Seriai, M. Huchard
LIRMM / CNRS & Montpellier 2 University, Montpellier, France
Al-msiedee, Abdelhak.Seriai, huchard@lirmm.fr

C. Urtado and S. Vauttier
LGI2P / Ecole des Mines d'Alès, Nîmes, France
Christelle.Urtado, Sylvain.Vauttier@mines-ales.fr



	Class (ArcSettings_Drawing.Shapes.Arc)	Class (Arc_Drawing.Shapes.Arc)	Class (ArcAngle_Drawing.Shapes.Arc)	Class (MyTextShape_Drawing.Shapes.Text)	Class (Text_Drawing.Shapes.Text)	Class (TextInfo_Drawing.Shapes.Text)	Class (MyText_Drawing.Shapes.Text)
Class (ArcSettings_Drawing.Shapes.Arc)	×	×	×				
Class (Arc_Drawing.Shapes.Arc)	×	×	×				
Class (ArcAngle_Drawing.Shapes.Arc)	×	×	×				
Class (MyTextShape_Drawing.Shapes.Text)				×	×	×	×
Class (Text_Drawing.Shapes.Text)				×	×	×	×
Class (TextInfo_Drawing.Shapes.Text)				×	×	×	×
Class (MyText_Drawing.Shapes.Text)				×	×	×	×



(a) Variant #1 of video sequence

(b) Variant #2 of video sequence

(c) Variant #3 of video sequence

(d) Variant #4 of video sequence

(e) Variant #5 of video sequence

(f) Variant #6 of video sequence

Figure 1: Six variants of video sequences synthesized with ViViD

Video_Sequence_1.cfg

vehicle1.identifier = 15 -- Integer number : 0=disable, 1=AMX30, ..
-- ...
vehicle5.identifier = 12 -- Integer number : 0=disable, 1=AMX30, ..
distractors.bird_level = 0 -- Floating point number from 0 (low level) to 1 (high level)
capture.illumination_level = 0.80 -- Floating point number from 0 (low level) to 1 (high level)
signal_quality.blur_level = 1.00 -- Floating point number from 0 (low level) to 1 (high level)
-- *...more attributes*

Video_Sequence_2.cfg

vehicle1.identifier = 7 -- Integer number : 0=disable, 1=AMX30, ..
-- ...
vehicle5.identifier = 3 -- Integer number : 0=disable, 1=AMX30, ..
distractors.bird_level = 0.5 -- Floating point number from 0 (low level) to 1 (high level)
capture.illumination_level = 0.90 -- Floating point number from 0 (low level) to 1 (high level)
signal_quality.blur_level = 0.50 -- Floating point number from 0 (low level) to 1 (high level)
-- *...more attributes*

. . .

Video_Sequence_*n*.cfg

vehicle1.identifier = 1 -- Integer number : 0=disable, 1=AMX30, ..
-- ...
vehicle5.identifier = 13 -- Integer number : 0=disable, 1=AMX30, ..
distractors.bird_level = 0 -- Floating point number from 0 (low level) to 1 (high level)
capture.illumination_level = 1.00 -- Floating point number from 0 (low level) to 1 (high level)
signal_quality.blur_level = 0.00 -- Floating point number from 0 (low level) to 1 (high level)
-- *...more attributes*

Video Sequences Generator

Video_Sequence_1.avi

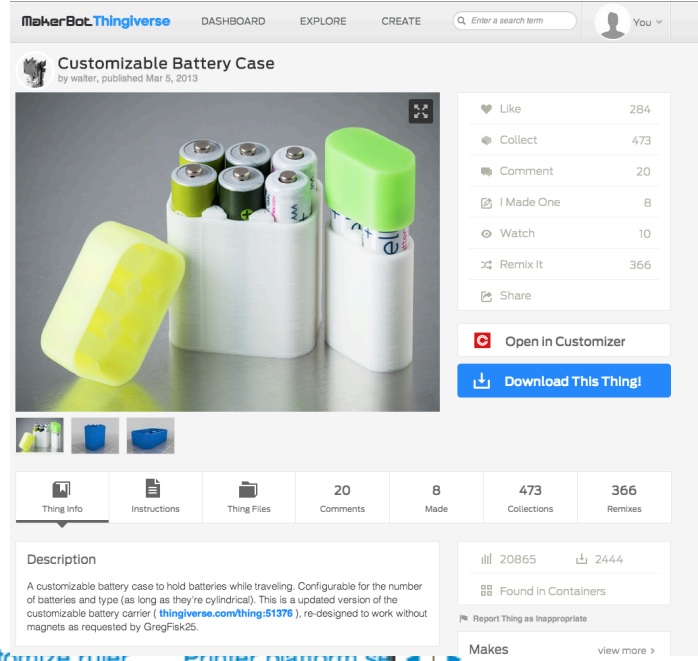
Video_Sequence_2.avi

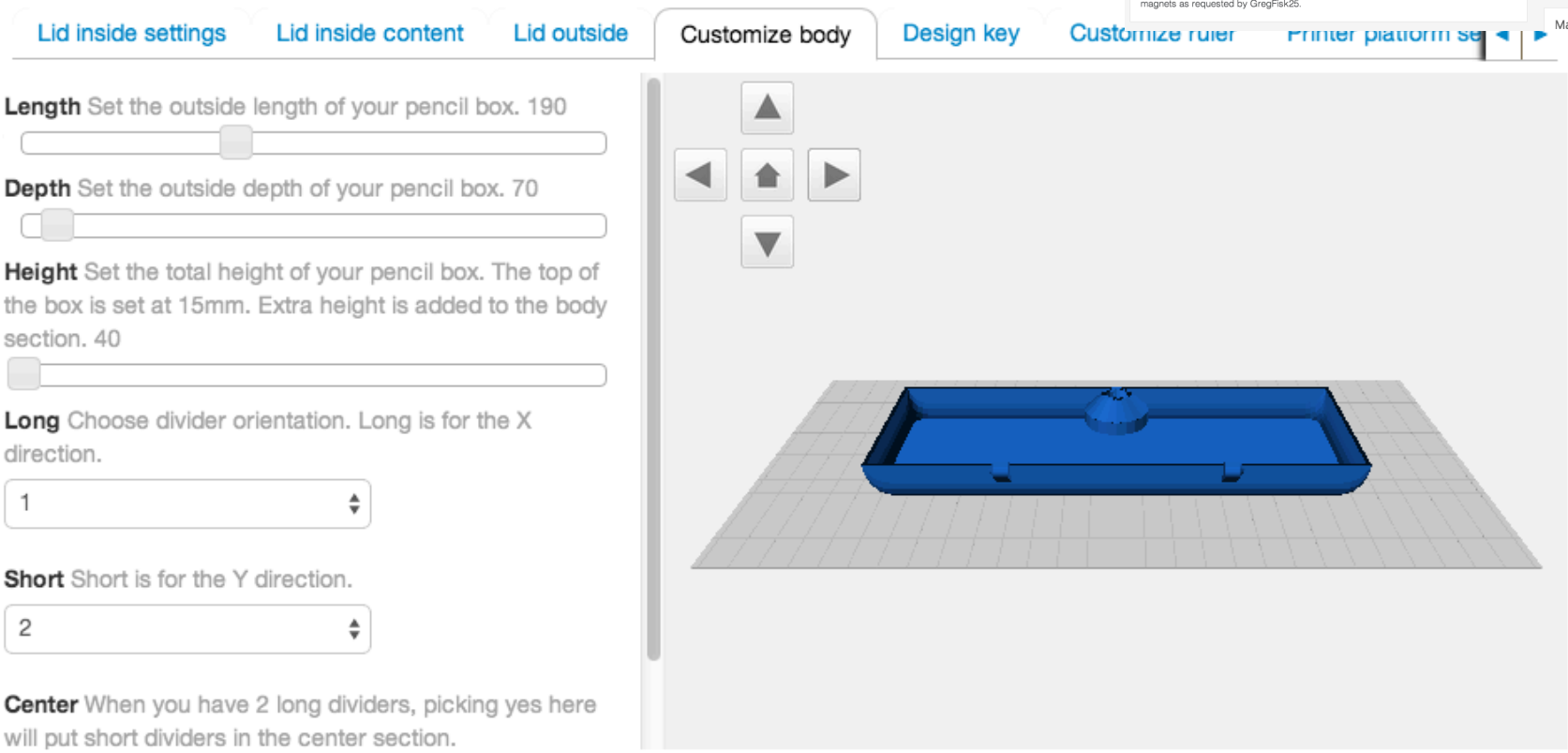
. . .

Video_Sequence_*n*.avi

```
/* [Customize body] */

//Set the outside length of your pencil box.
length=190;//[70:400]
//Set the outside depth of your pencil box.
depth=70;//[50:400]
//Set the total height of your pencil box.  The top of the box is set at 15mm.
//Extra height is added to the body section.
height=40;//[40:150]

//Choose divider orientation.  Long is for the X direction.
long = 1;//[0,1,2]
//Short is for the Y direction.
short = 2;//[0,1,2,3]
//When you have 2 long dividers,
// picking yes here will put short dividers in the center section.
center = 0;//[1:Yes,0:No]
```

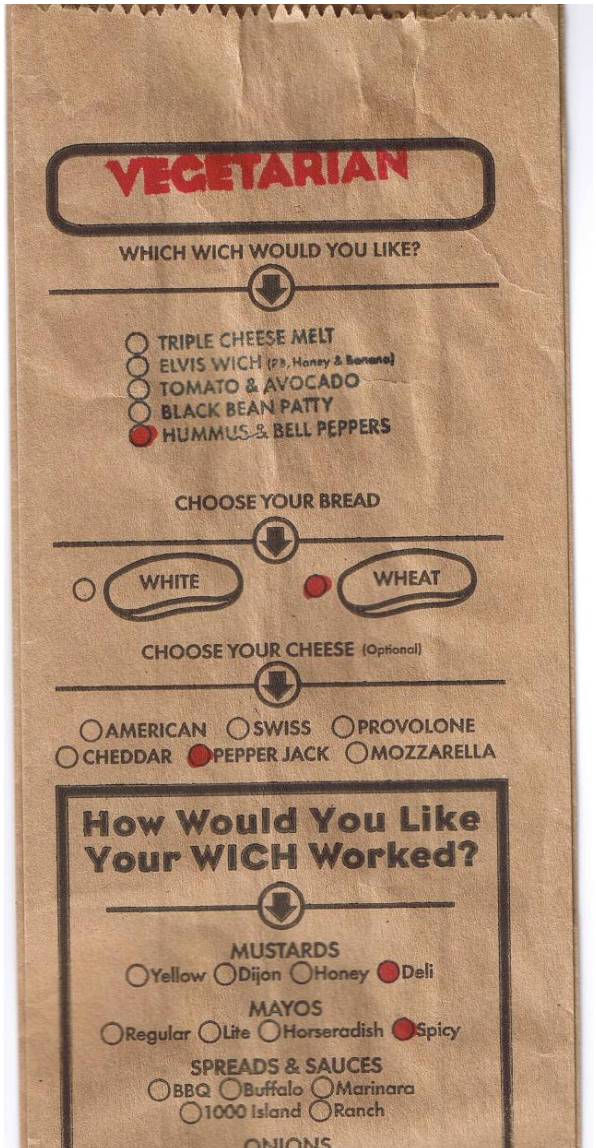
1





(credits: Christian Kaestner's slide)

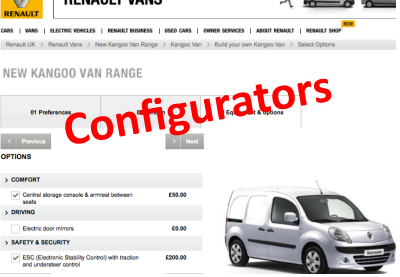
Food? Product lines!



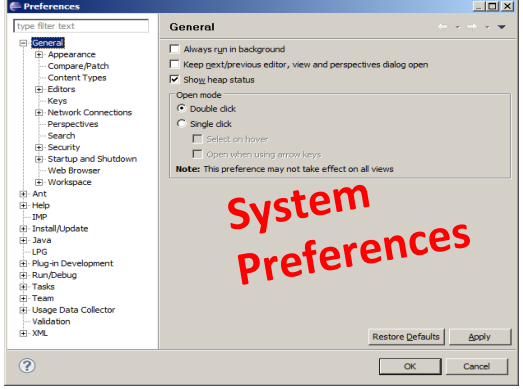

VEGETARIAN
How Would You Like Your WICH Worked?

Product Lines and Variability

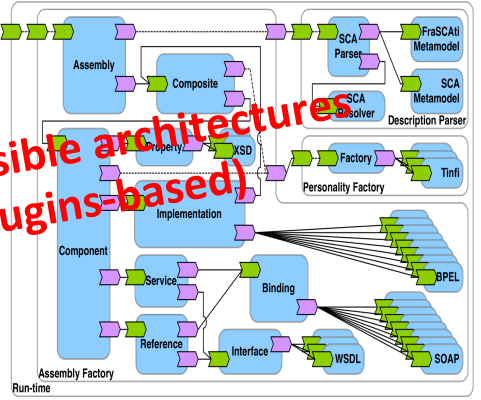
Configurators



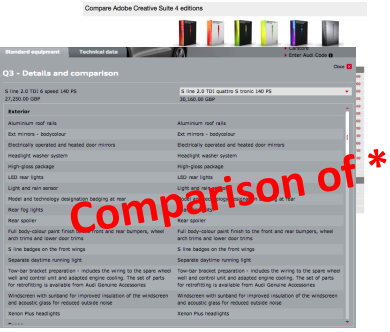
System Preferences



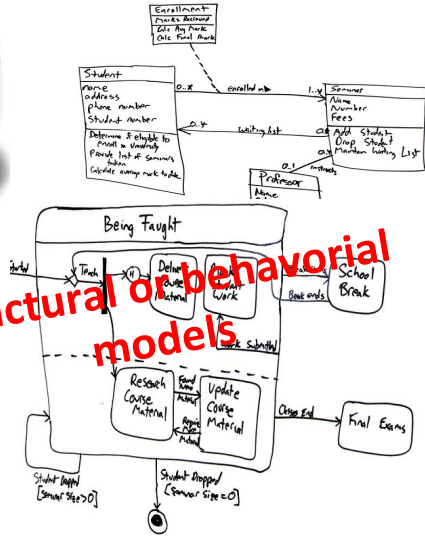
Extensible architectures (eg plugins-based)



Comparison of *



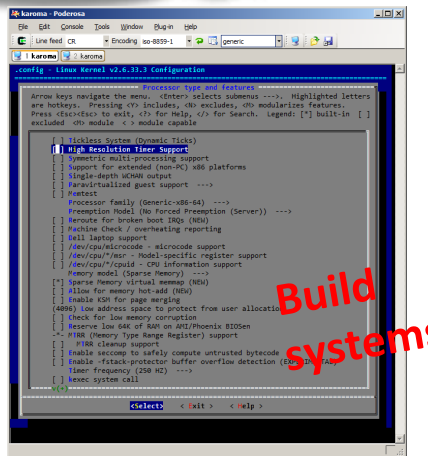
Structural or behavorial models



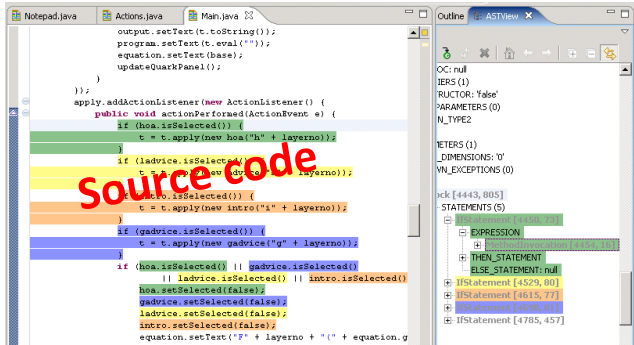
Configuration files

```
httpd.conf -- win32 Apache
Building a Web Server, for Windows

Listen 80
ServerRoot "/www/Apache2"
DocumentRoot "/www/webroot"

ServerName localhost:80
ServerAdmin admin@localhost

ServerSignature On
ServerTokens Full

DefaultType text/plain
AddDefaultCharset ISO-8859-1

UseCanonicalName Off

HostnameLookups Off

ErrorLog logs/error.log
LogLevel error

PidFile logs/httpd.pid

Timeout 300

KeepAlive On
MaxKeepAliveRequests 100
KeepAliveTimeout 15


<IfModule mpm_winnt.c>
  ThreadsPerChild 250
  MaxRequestsPerChild 0
</IfModule>
```

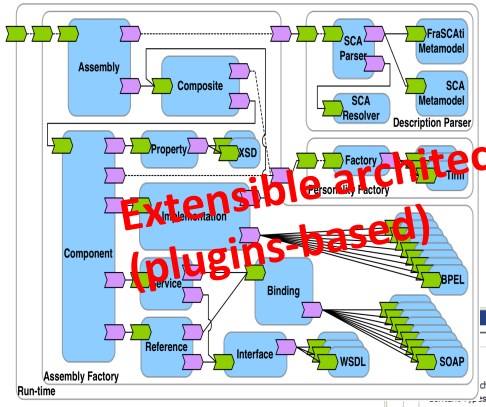
Build systems



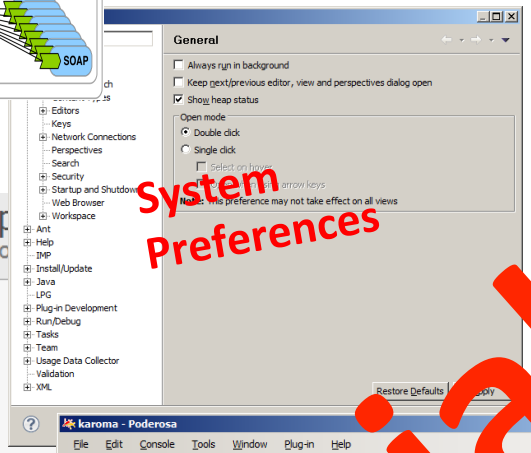
Source code



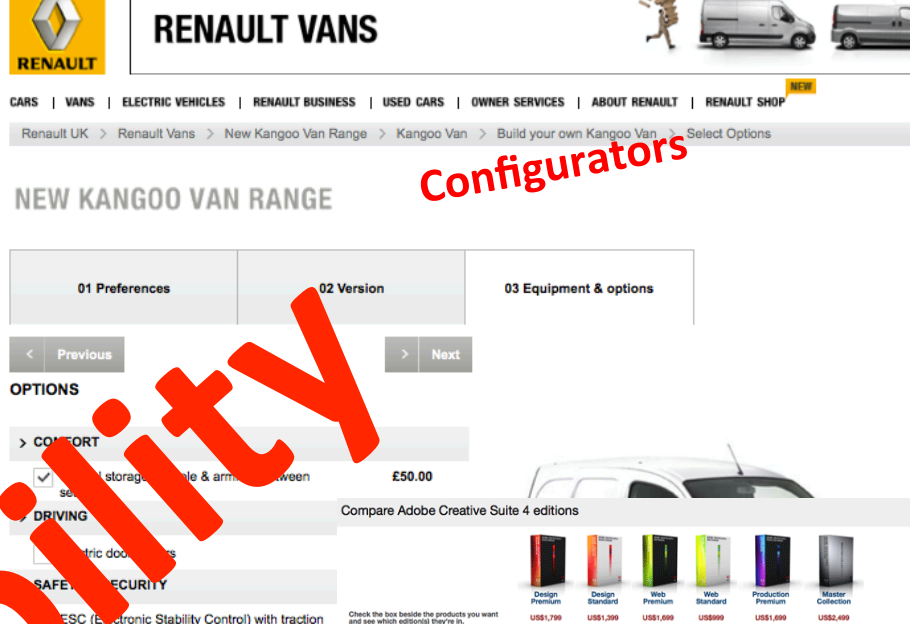
Variability



Extensible architectures (plugins-based)

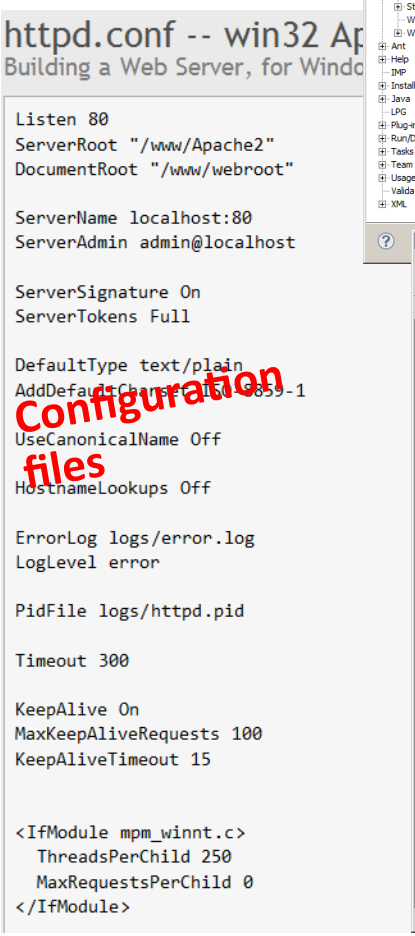


System Preferences

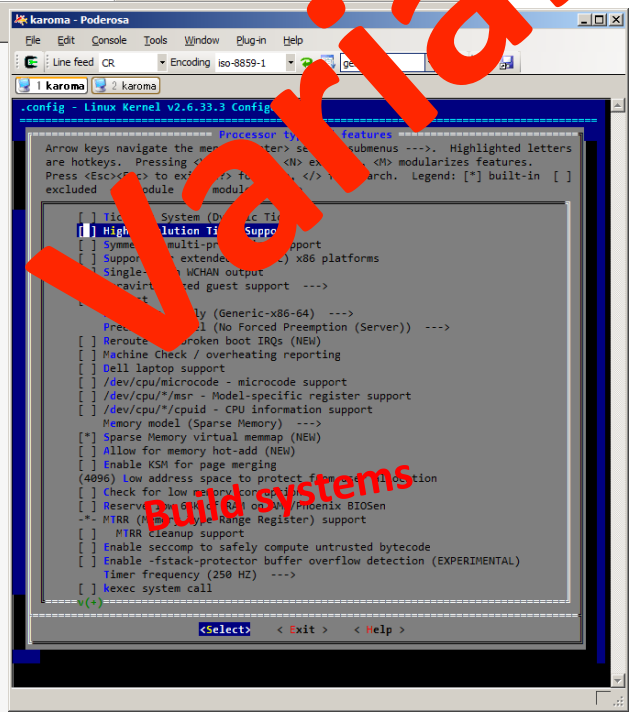


Configurators

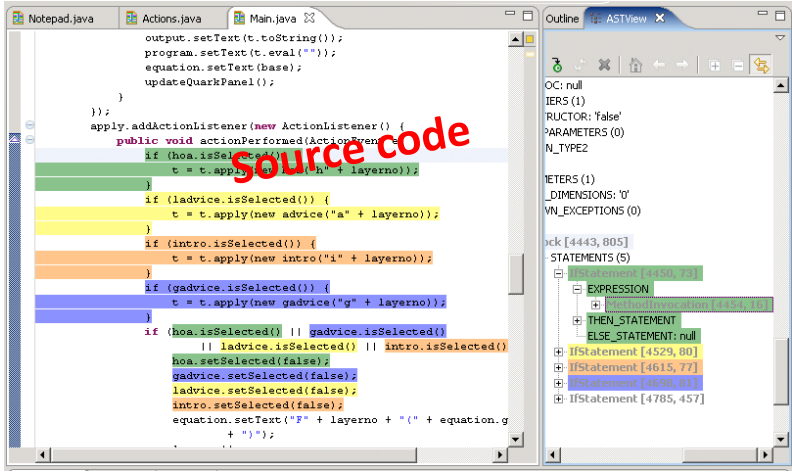
Comparison of Product



Configuration files



Built systems



Source code

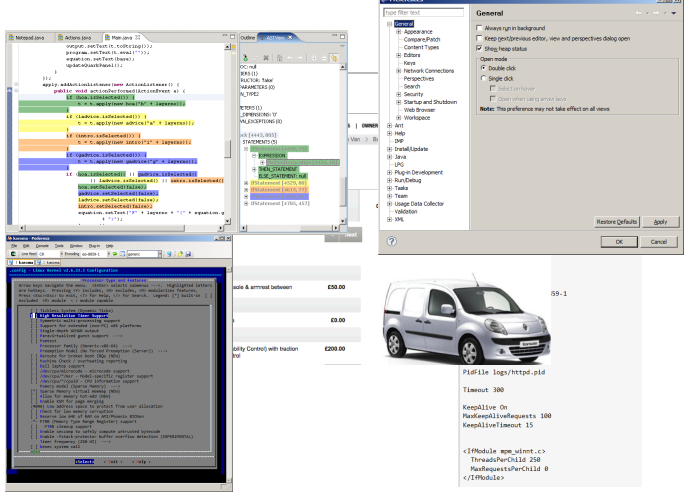
Quizz Time

Give three examples of software product lines (also called configurable systems or variability-intensive systems)

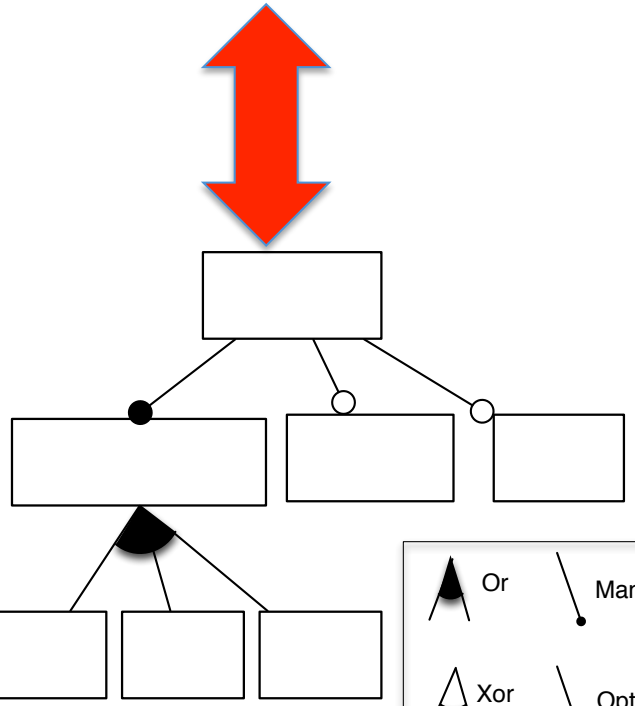
Software is eating the world (any company will be a software company)

If you have the super-power to "**vary**" (e.g., for delivering customized solutions to customers; or for engineering customized solutions for addressing your specific problems)

Then you will rule the world



Variants of code (e.g., Java ou C)
Variants of user interfaces
Variants of video sequences
Variants of models (e.g., UML or SysML)
Variants of « things » (3D models)
…



not, and, or, implies

Variability Models (feature models)

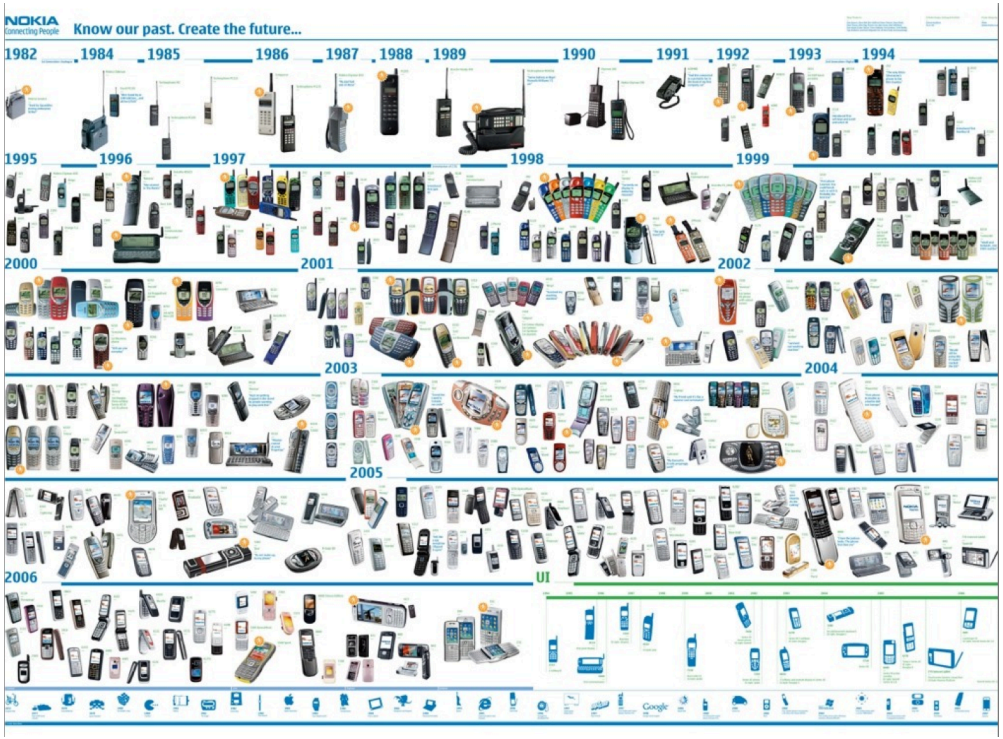
Variability: two definitions

- "the **ability** of a software system or artifact to be efficiently extended, changed, customized or configured for use in a particular context" (Svahnberg et al. 2005)
  - software/**customization** perspective

- "an assumption about how members of a family may **differ** from each other" (Weiss and Lai 1999)
  - more related to the notions of **domain** and **commonality**

Variability in time vs in space

- **Variability in Time (releases)**
  - the existence of different versions of an artifact that are valid at different times
- **Variability in Space (variants)**
  - the existence of an artifact in different shapes at the same time

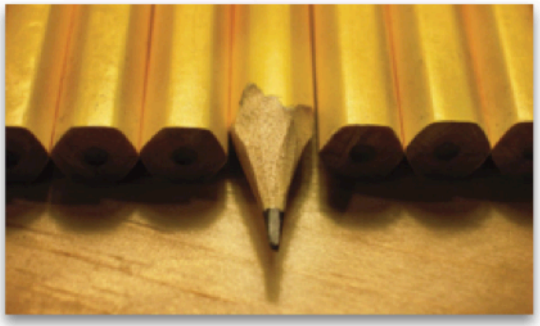


Benefits

Improve product reliability

Improve usability

Improve consistency across products...



Benefits

Reduce production costs

Reduce certification costs

Shorten time-to-market

Hall of Fame

splc.net/fame.html

Printer Firmware

- Production cost reduced by 75%
- Development time reduced by 33%
- Reported defects reduced by 96%

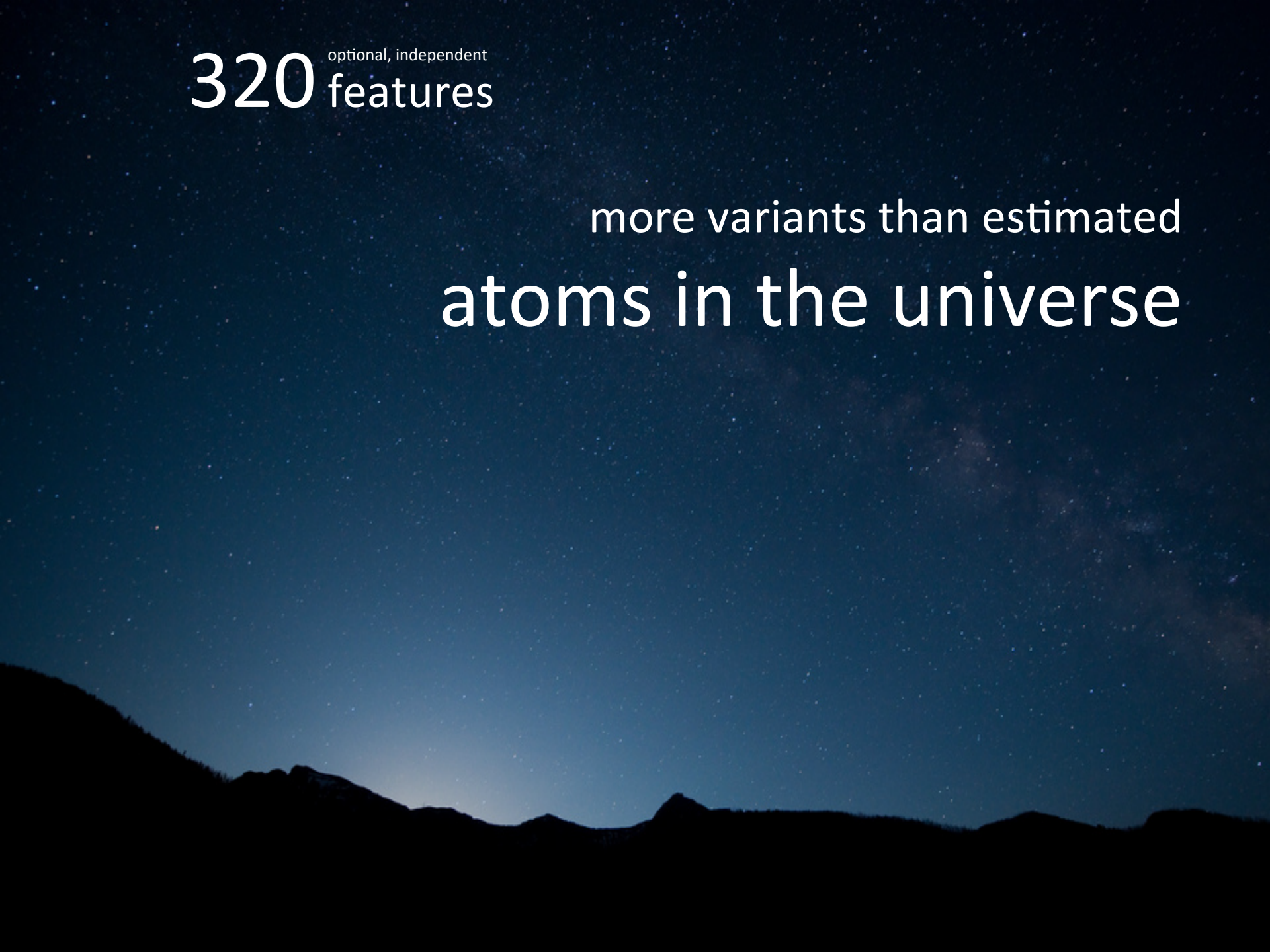

Variability = Complexity

(credits: Christian Kaestner's slide)

33 optional, independent features

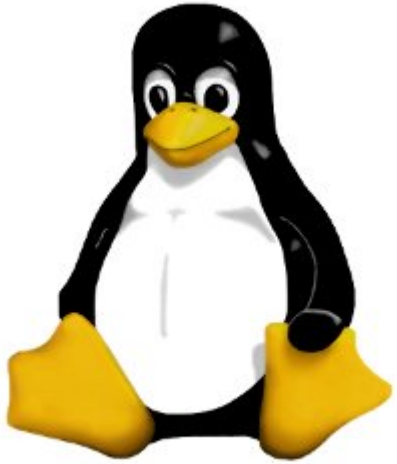
a unique variant for every

person on this planet


320 optional, independent features
more variants than estimated
atoms in the universe

2000 features

10000 features



Software product line and Variability engineering

Basic techniques

What is new?

Family vs single systems

Focus on reuse

Domain engineering

Factoring out commonality

Managing variability

« variability »

Is it really new?

Intentional Code Cloning

~ Copy & Paste

Code Cloning (example, Linux driver)

cyberstorm.c

```
....
static void dma_dump_state(struct NCR_ESP *esp)
{
        ESPLOG(("esp%d: dma -- cond_reg<%02x>\n",
                esp->esp_id, ((struct cyber_dma_registers *)
                                        (esp->dregs))->cond_reg));
        ESPLOG(("intreq:<%04x>, intena:<%04x>\n",
                custom.intreqr, custom.intenar));
}

static void dma_init_read(struct NCR_ESP *esp, __u32 addr, int
        length)
{
        struct cyber_dma_registers *dregs =
                (struct cyber_dma_registers *) esp->dregs;

        cache_clear(addr, length);

        addr &= ~(1);
        dregs->dma_addr0 = (addr >> 24) & 0xff;
        dregs->dma_addr1 = (addr >> 16) & 0xff;
        dregs->dma_addr2 = (addr >>  8) & 0xff;
        dregs->dma_addr3 = (addr      ) & 0xff;
        ctrl_data &= ~(CYBER_DMA_WRITE);
.......
```

cyberstormII.c

```
....
static void dma_dump_state(struct NCR_ESP *esp)
{
        ESPLOG(("esp%d: dma -- cond_reg<%02x>\n",
                esp->esp_id, ((struct cyberII_dma_registers *)
                                        (esp->dregs))->cond_reg));
        ESPLOG(("intreq:<%04x>, intena:<%04x>\n",
                custom.intreqr, custom.intenar));
}

static void dma_init_read(struct NCR_ESP *esp, __u32 addr, int
        length)
{
        struct cyberII_dma_registers *dregs =
                (struct cyberII_dma_registers *) esp->dregs;

        cache_clear(addr, length);

        addr &= ~(1);
        dregs->dma_addr0 = (addr >> 24) & 0xff;
        dregs->dma_addr1 = (addr >> 16) & 0xff;
        dregs->dma_addr2 = (addr >>  8) & 0xff;
        dregs->dma_addr3 = (addr      ) & 0xff;
}
.........
```

Replicate & Specialize

Clone to reuse and adapt existing solutions

+ Less effort needed

- Long-term cost outweighs short-term benefit

~ Cost of refactoring rises over time

Platform Variations

Clone existing code and fix low level platform interaction

+ Avoid complexity of virtualization layer

- Hard to propagate bug fixes

~ Ensure consistent behavior of all clones

“Cloning Considered Harmful” Considered Harmful

Cory Kapser and Michael W. Godfrey
Software Architecture Group (SWAG)
David R. Cheriton School of Computer Science, University of Waterloo
{cjkapser, migod}@uwaterloo.ca

"Cloning considered harmful" considered harmful: patterns of cloning in software

Authors: Cory J. Kapser — Software Architecture Group (SWAG) David R. Cheriton School of Computer Science, University of Waterloo, Waterloo, Canada
Michael W. Godfrey — Software Architecture Group (SWAG) David R. Cheriton School of Computer Science, University of Waterloo, Waterloo, Canada

2008 Article

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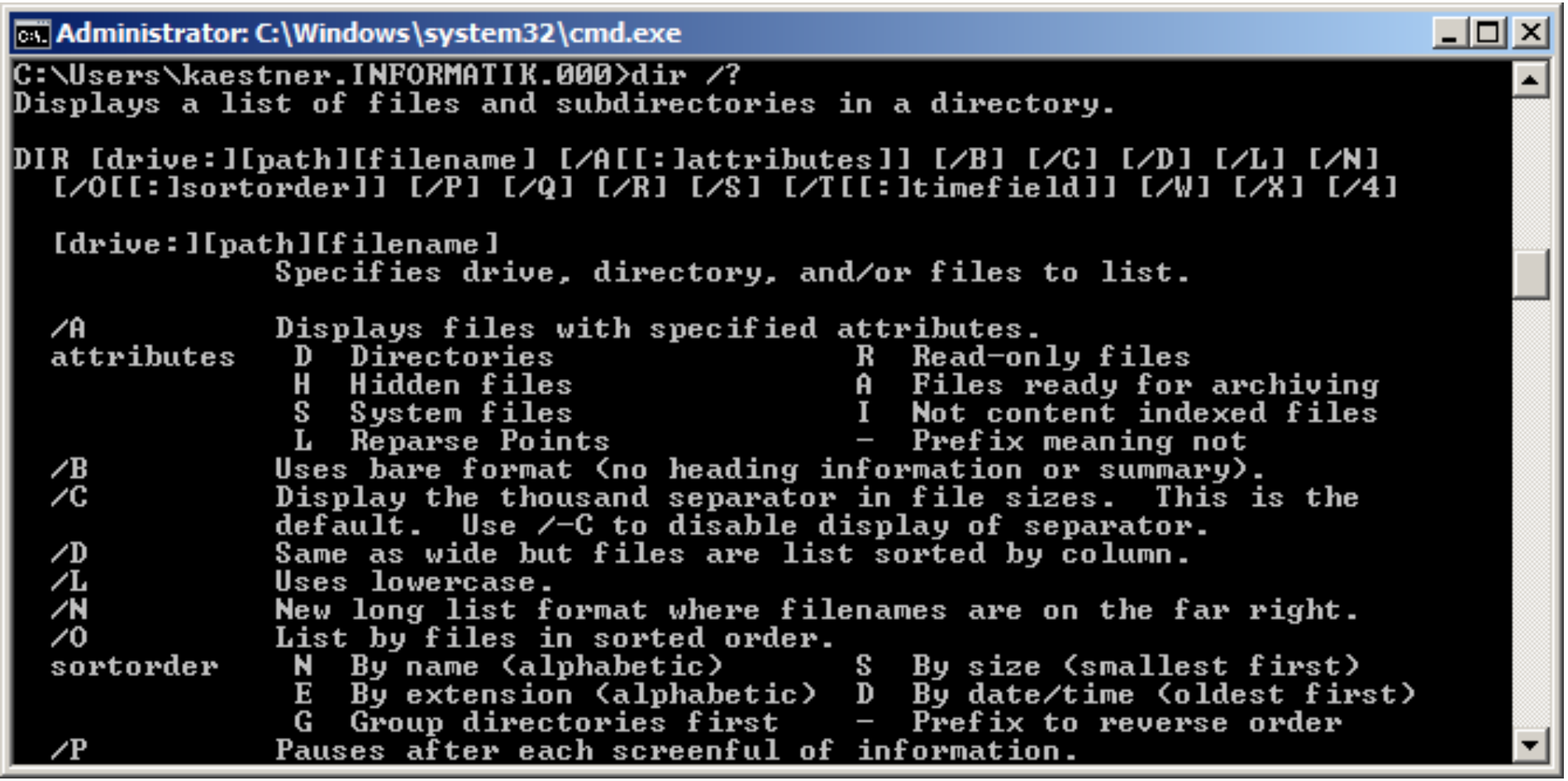
Pages 645 - 692
Kluwer Academic Publishers Hingham, MA, USA
table of contents doi>10.1007/s10664-008-9076-6

Parameter


Administrator: C:\Windows\system32\cmd.exe
C:\Users\kaestner.INFORMATIK.000>dir /?
Displays a list of files and subdirectories in a directory.
DIR [drive:][path][filename] [/A[[:]attributes]] [/B] [/C] [/D] [/L] [/N]
[/O[[:]sortorder]] [/P] [/Q] [/R] [/S] [/T[[:]timefield]] [/W] [/X] [/4]
[drive:][path][filename]
Specifies drive, directory, and/or files to list.
/A
attributes
Displays files with specified attributes.
D Directories
H Hidden files
S System files
L Reparse Points
R Read-only files
A Files ready for archiving
I Not content indexed files
- Prefix meaning not
/B
Uses bare format (no heading information or summary).
/C
Display the thousand separator in file sizes. This is the
default. Use /-C to disable display of separator.
/D
Same as wide but files are list sorted by column.
/L
Uses lowercase.
/N
New long list format where filenames are on the far right.
/O
List by files in sorted order.
sortorder
N By name (alphabetic)
E By extension (alphabetic)
G Group directories first
S By size (smallest first)
D By date/time (oldest first)
- Prefix to reverse order
/P
Pauses after each screenful of information.

Parameter –i in grep

```
1  int match_icase;
2
3  int main (int argc, char **argv)
4  {
5    [...]
6    while ((opt = get_nondigit_option (argc, argv, &default_c
7      switch (opt)
8        {
9        [...]
10       case 'i':
11         match_icase = 1;
12         break;
13       }
14   }
15
16
17 static const char *
18 print_line_middle (const char *beg, const char *lim,
19                    const char *line_color, const char *match_color)
20 {
21   [...]
22   if (match_icase)
23     {
24       ibeg = buf = (char *) xmalloc(i);
25       while (--i >= 0)
26         buf[i] = tolower(beg[i]);
27     }
```

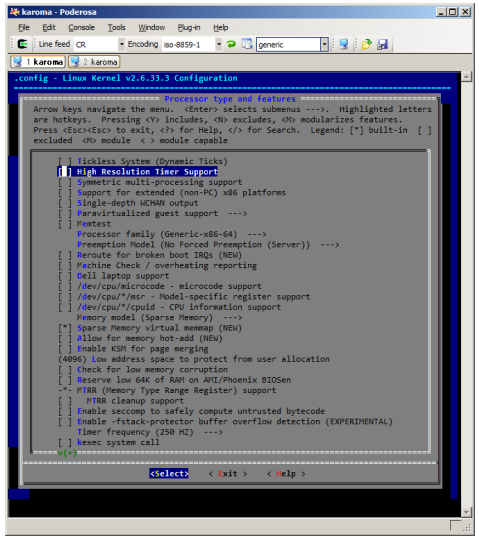
Global configuration

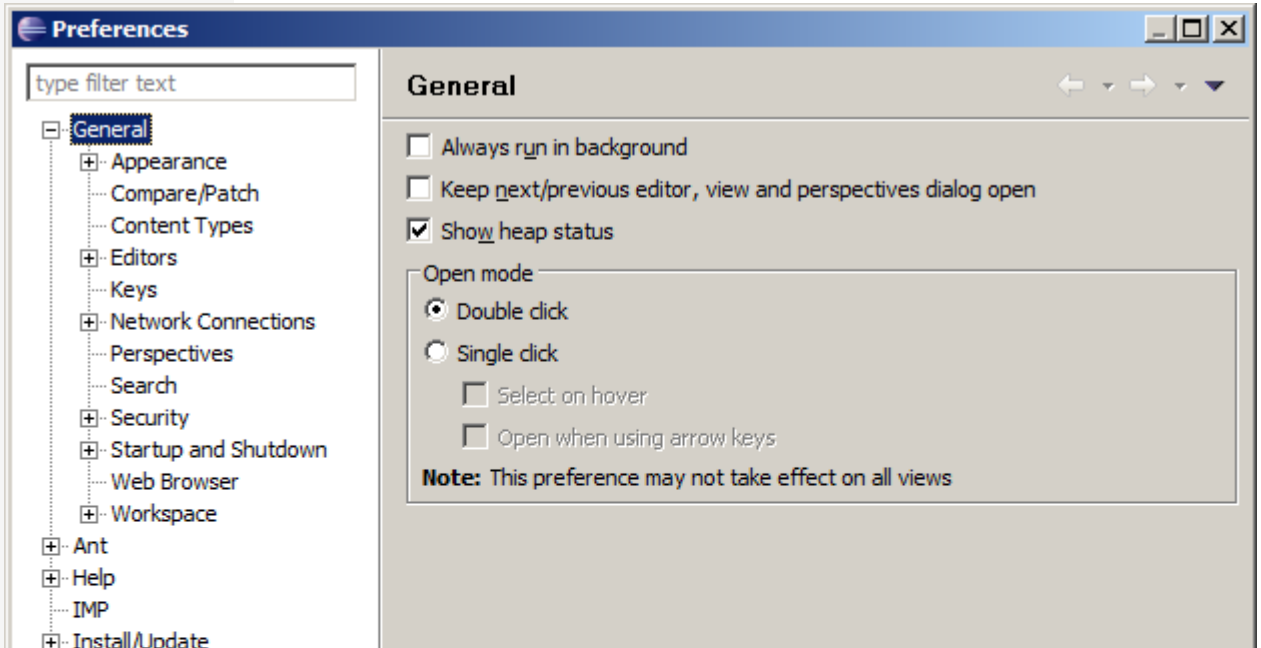
```
class Config {
  public static boolean isLogging = false;
  public static boolean isWindows = false;
  public static boolean isLinux = true;
}
class Main {
  public void foo() {
    if (isLogging)
      log(„running foo()“);
    if (isWindows)
      callWindowsMethod();
    else if (isLinux)
      callLinuxMethod();
    else
      throw RuntimeException();
}
```

Configuration

httpd.conf -- win32 Apache
Building a Web Server, for Windows

```
Listen 80
ServerRoot "/www/Apache2"
DocumentRoot "/www/webroot"

ServerName localhost:80
ServerAdmin admin@localhost

ServerSignature On
ServerTokens Full

DefaultType text/plain
AddDefaultCharset ISO-8859-1

UseCanonicalName Off

HostnameLookups Off

ErrorLog logs/error.log
LogLevel error

PidFile logs/httpd.pid

Timeout 300

KeepAlive On
MaxKeepAliveRequests 100
```





Conditional compilation #ifdef (Berkeley DB)

```
static int __rep_queue_filedone(dbenv, rep, rfp)
                    DB_ENV *dbenv;
                    REP *rep;
                    __rep_fileinfo_args *rfp; {
#ifndef HAVE_QUEUE
                    COMPQUIET(rep, NULL);
                    COMPQUIET(rfp, NULL);
                    return (__db_no_queue_am(dbenv));
#else
                    db_pgno_t first, last;
                    u_int32_t flags;
                    int empty, ret, t_ret;
#ifdef DIAGNOSTIC
                    DB_MSGBUF mb;
#endif
                    // over 100 lines of additional code
}
#endif
```

Inheritance (OOP)

Base Class encapsulate commonalities

Derive classes specialize peculiarities

Generic Programming

C++ template

```
template <typename T>
T max(T x, T y)
{
   return x < y ? y : x;
}
```

Generics in Java

```
public interface List<E> {
void add(E x);
Iterator<E> iterator();
}
public interface Iterator<E> {
E next();
boolean hasNext();
}
```

Design Patterns

Template Method

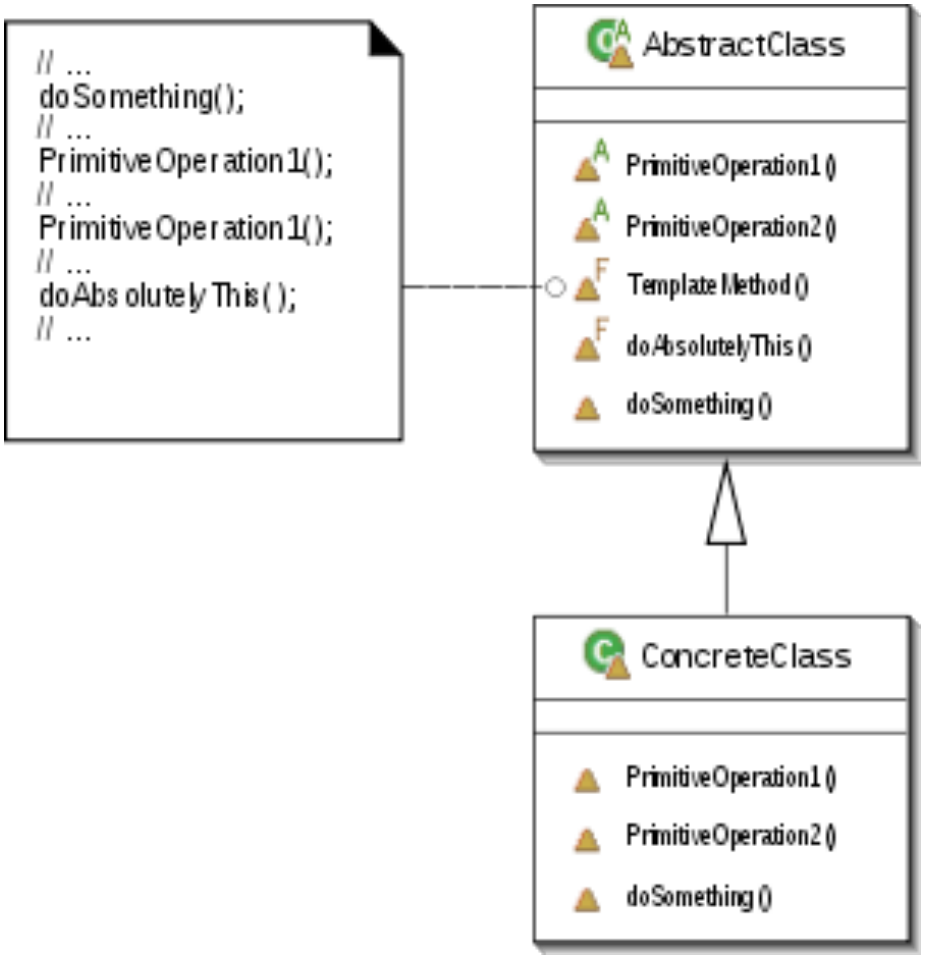
Factory

Strategy

Decorator

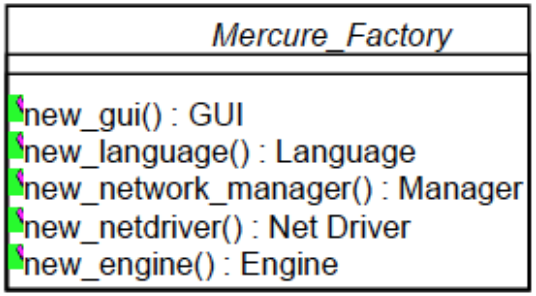
....

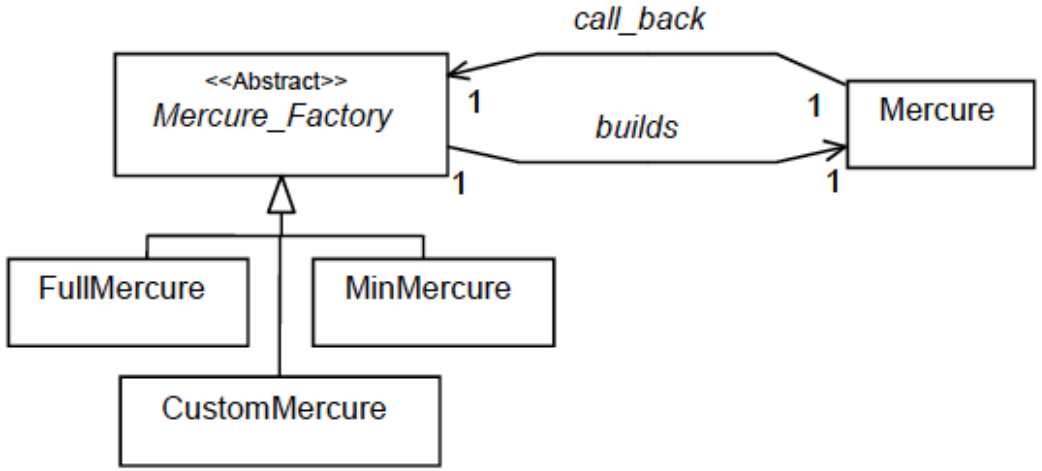
Template Method

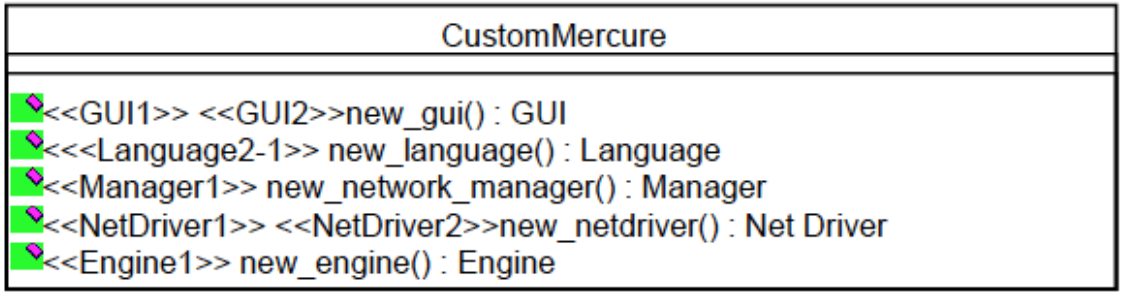


The decision model

- The Abstract Factory Design Pattern
  - [Gamma et al 95]







API

Framework

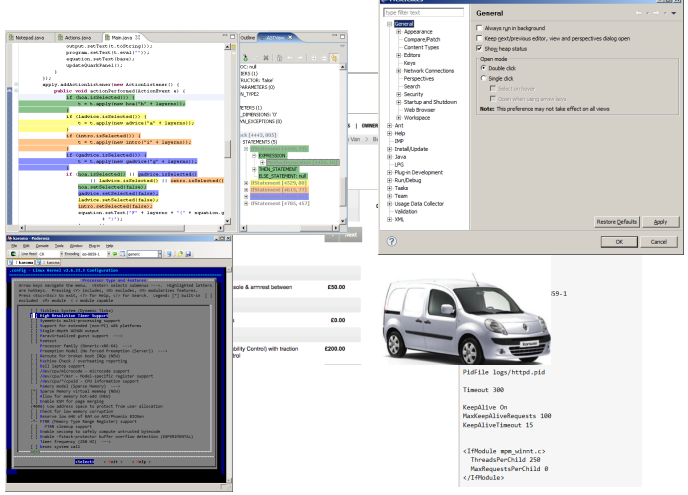
Plugin-based systems

(Active) Annotations

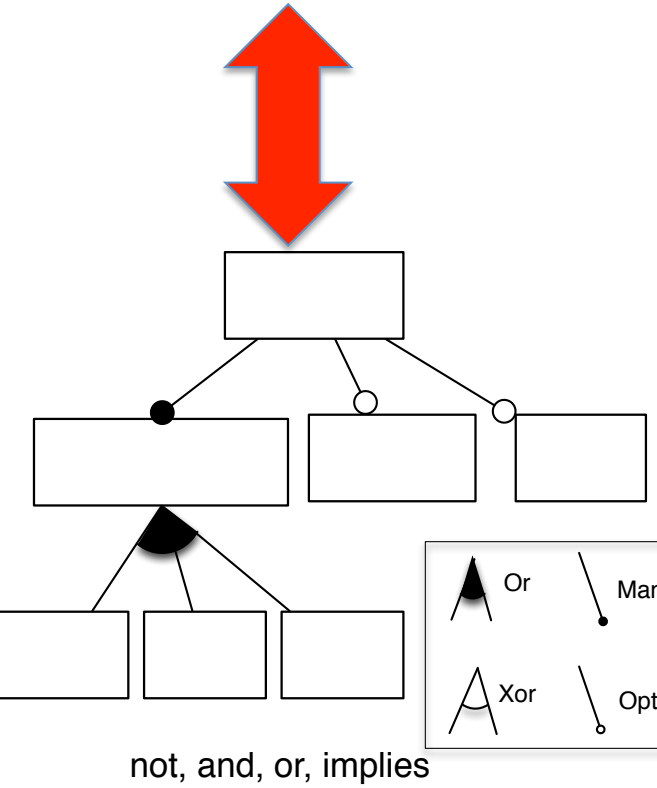
can have parameters

Metamodeling and Domain-Specific Languages

Variability (general approach)

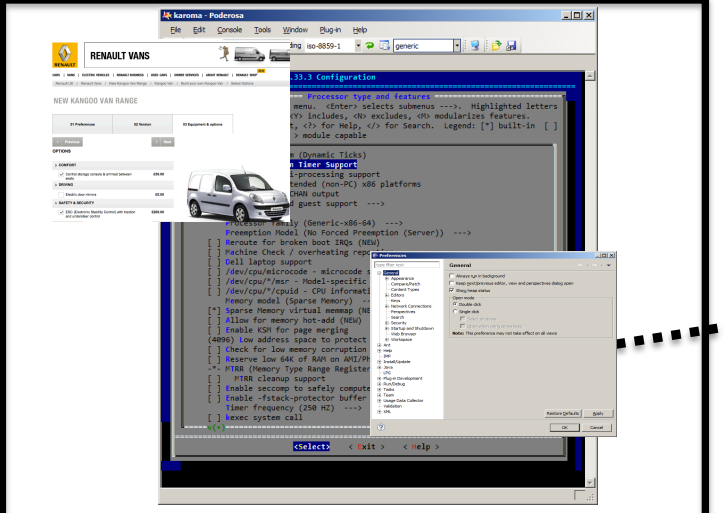


Variants of code (e.g., Java ou C)
Variants of user interfaces
Variants of video sequences
Variants of models (e.g., UML or SysML)
…



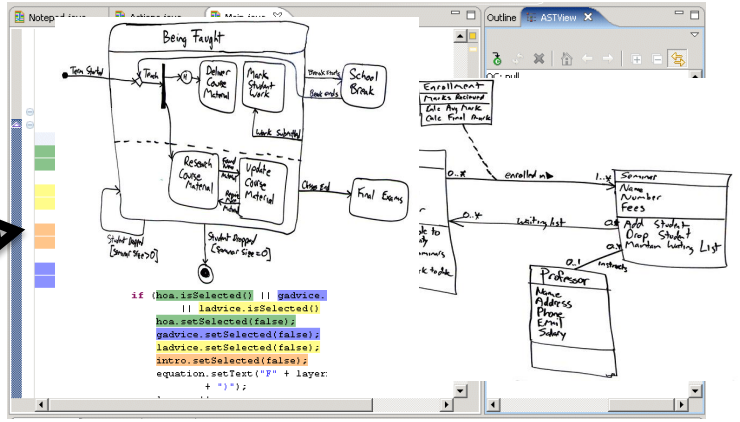
not, and, or, implies

Variability Models (feature models)

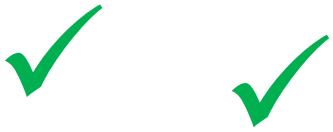


Variability Model

mapping

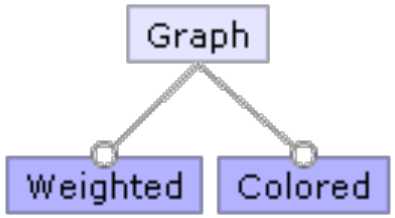


Base Artefacts (e.g., models)



Configuration

Software Generator
(derivation engine)

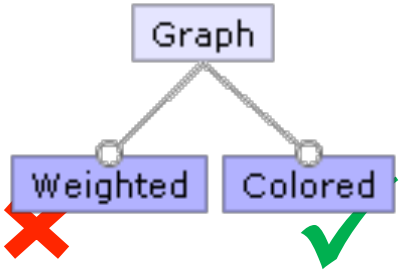


Variability Model

mapping

```
class Graph {
  Vector nv = new Vector(); Vector ev = new Vector();
  Edge add(Node n, Node m) {
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    /*if[WEIGHT]*/
    e.weight = new Weight();
    /*end[WEIGHT]*/
    return e;
  }
  /*if[WEIGHT]*/
  Edge add(Node n, Node m, Weight w)
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    e.weight = w; return e;
  }
  /*end[WEIGHT]*/
  void print() {
    for(int i = 0; i < ev.size(); i++) {
      ((Edge)ev.get(i)).print();
    }
  }
}
```

Base Artefacts




```
class Graph {
  Vector nv = new Vector(); Vector ev = new Vector();
  Edge add(Node n, Node m) {
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
return e;
  }
void print() {
    for(int i = 0; i < ev.size(); i++) {
      ((Edge)ev.get(i)).print();
    }
  }
}
```

Software Generator
(derivation engine)

Mapping: an example

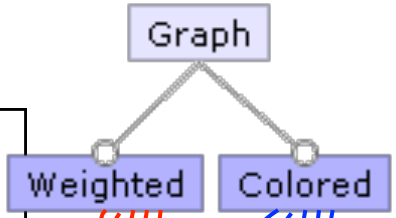
```
class Graph {
  Vector nv = new Vector(); Vector ev = new Vector();
  Edge add(Node n, Node m) {
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    e.weight = new Weight();
    return e;
  }
  Edge add(Node n, Node m, Weight w)
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    e.weight = w; return e;
  }
  void print() {
    for(int i = 0; i < ev.size(); i++) {
      ((Edge)ev.get(i)).print();
    }
  }
}
```

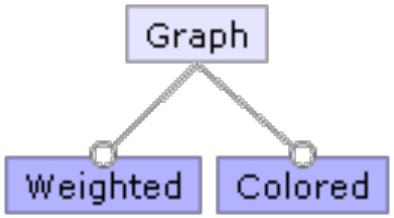
```
class Node {
  int id = 0;
  Color color = new Color();
  void print() {
    Color.setDisplayColor(color);
    System.out.print(id);
  }
}
```

```
class Edge {
  Node a, b;
  Color color = new Color();
  Weight weight;= new Weight();
  Edge(Node _a, Node _b) { a = _a; b = _b; }
  void print() {
    Color.setDisplayColor(color);
    a.print(); b.print();
    weight.print();
  }
}
```

```
class Color {
  static void setDisplayColor(Color c) { ... }
}
```

```
class Weight { void print() { ... } }
```





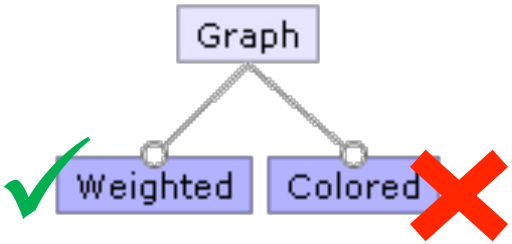

```
class Graph {
  Vector nv = new Vector(); Vector ev = new Vector();
  Edge add(Node n, Node m) {
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    /*if[WEIGHT]*/
    e.weight = new Weight();
    /*end[WEIGHT]*/
    return e;
  }
  /*if[WEIGHT]*/
  Edge add(Node n, Node m, Weight w)
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    e.weight = w; return e;
  }
  /*end[WEIGHT]*/
  void print() {
    for(int i = 0; i < ev.size(); i++) {
      ((Edge)ev.get(i)).print();
    }
  }
}
```

```
/*if[WEIGHT]*/
class Weight { void print() { ... } }
/*end[WEIGHT]*/
```

```
class Edge {
  Node a, b;
  /*if[COLOR]*/
  Color color = new Color();
  /*end[COLOR]*/
  /*if[WEIGHT]*/
  Weight weight;
  /*end[WEIGHT]*/
  Edge(Node _a, Node _b) { a = _a; b = _b; }
  void print() {
    /*if[COLOR]*/
    Color.setDisplayColor(color);
    /*end[COLOR]*/
    a.print(); b.print();
    /*if[WEIGHT]*/
    weight.print();
    /*end[WEIGHT]*/
  }
}
```

```
/*if[COLOR]*/
class Color {
  static void setDisplayColor(Color c) { ... }
}
/*end[COLOR]*/
```

```
class Node {
  int id = 0;
  /*if[COLOR]*/
```

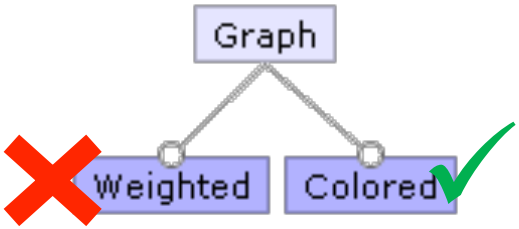



```
class Graph {
  Vector nv = new Vector(); Vector ev = new Vector();
  Edge add(Node n, Node m) {
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
e.weight = new Weight();
return e;
  }
Edge add(Node n, Node m, Weight w)
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
    e.weight = w; return e;
  }
void print() {
    for(int i = 0; i < ev.size(); i++) {
      ((Edge)ev.get(i)).print();
    }
  }
}
```

```
class Edge {
  Node a, b;
  Weight weight;
  Edge(Node _a, Node _b) { a = _a; b = _b; }
  void print() {
   a.print(); b.print();
   weight.print();
}
}
```

```
class Node {
  int id = 0;
  void print() {
   System.out.print(id);
  }
}
```

```
class Weight { void print() { ... } }
```




```
class Graph {
  Vector nv = new Vector(); Vector ev = new Vector();
  Edge add(Node n, Node m) {
    Edge e = new Edge(n, m);
    nv.add(n); nv.add(m); ev.add(e);
return e;
  }
void print() {
    for(int i = 0; i < ev.size(); i++) {
      ((Edge)ev.get(i)).print();
    }
  }
}
```

```
class Edge {
  Node a, b;
  Color color = new Color();
Edge(Node _a, Node _b) { a = _a; b = _b; }
  void print() {
Color.setDisplayColor(color);
a.print(); b.print();
}
}
```

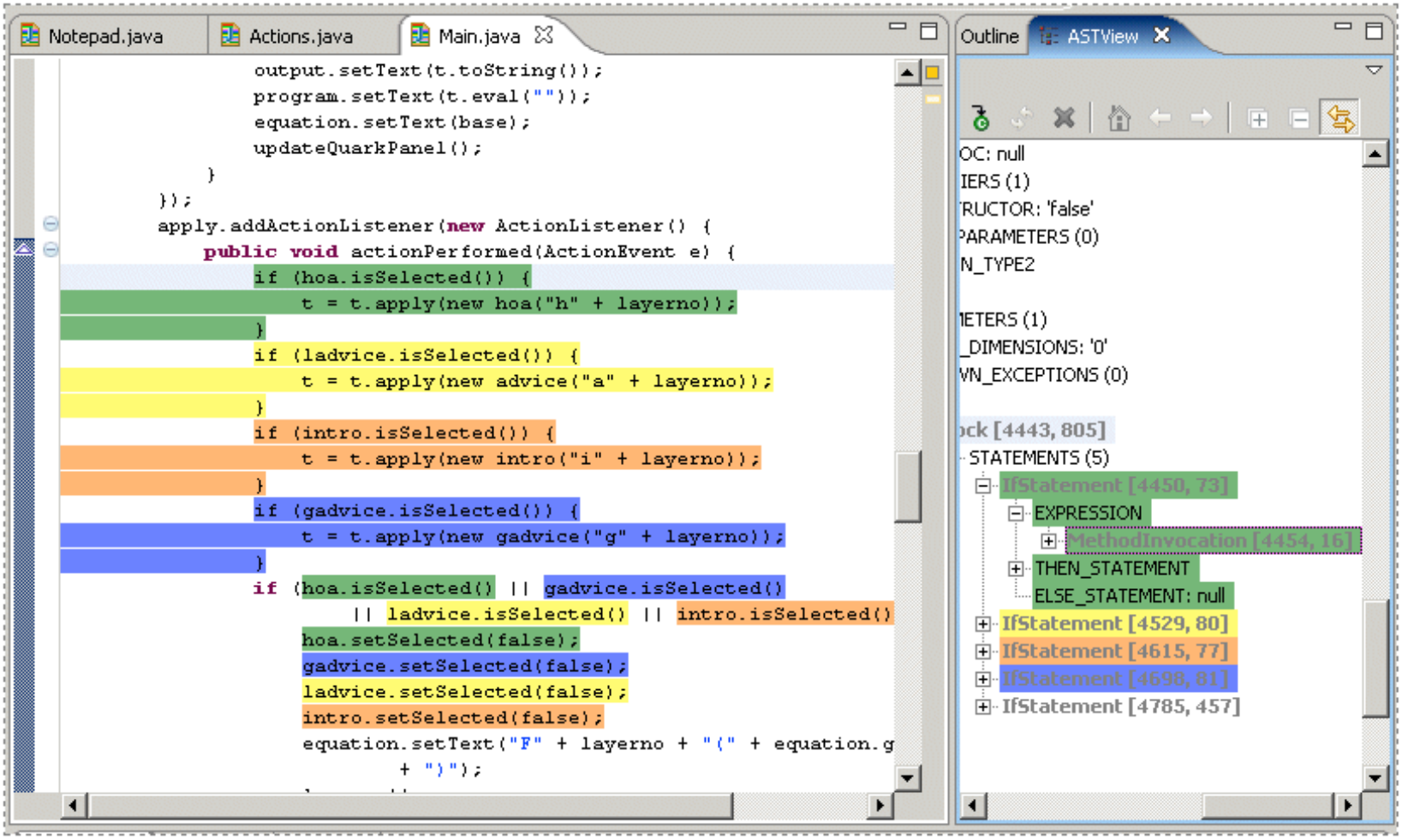
```
class Color {
  static void setDisplayColor(Color c) { ... }
}
```

```
class Node {
  int id = 0;
Color color = new Color();
void print() {
Color.setDisplayColor(color);
System.out.print(id);
  }
}
```

Kästner "Virtual Separation of Concerns: Toward Preprocessors 2.0"

```
1  class Add extends Expr { //yellow
2    Expr left, right;
3    Add(Expr l, Expr r)
4        { left=l; right=r; }
5    double eval() { //red
6      return left.eval() +
7          right.eval();
8    }
9    void print() { //blue
10     left.print();
11     System.out.print("+");
12     right.print();
13   }
14 }
```

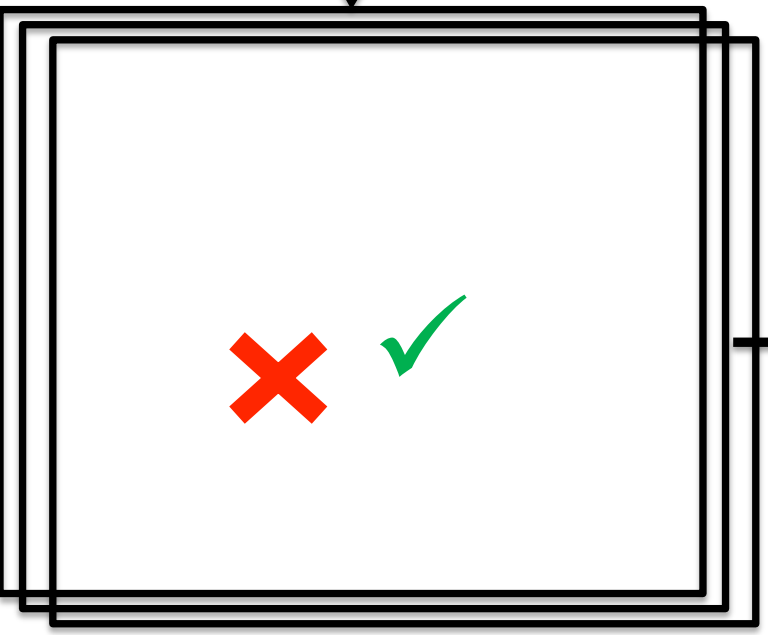
Features: ADD, EVAL, PRINT


Notepad.java
Actions.java
Main.java
output.setText(t.toString());
program.setText(t.eval(""));
equation.setText(base);
updateQuarkPanel();
}
});
apply.addActionListener(new ActionListener() {
public void actionPerformed(ActionEvent e) {
if (hoa.isSelected()) {
t = t.apply(new hoa("h" + layerno));
}
if (ladvice.isSelected()) {
t = t.apply(new advice("a" + layerno));
}
if (intro.isSelected()) {
t = t.apply(new intro("i" + layerno));
}
if (gadvice.isSelected()) {
t = t.apply(new gadvice("g" + layerno));
}
if (hoa.isSelected() || gadvice.isSelected()
|| ladvice.isSelected() || intro.isSelected()
hoa.setSelected(false);
gadvice.setSelected(false);
ladvice.setSelected(false);
intro.setSelected(false);
equation.setText("F" + layerno + "(" + equation.g
+ ")");
Outline
ASTView
OC: null
IERS (1)
'RUCTOR: 'false'
'ARAMETERS (0)
N_TYPE2
IETERS (1)
_DIMENSIONS: '0'
VN_EXCEPTIONS (0)
ck [4443, 805]
STATEMENTS (5)
IfStatement [4450, 73]
EXPRESSION
MethodInvocation [4454, 16]
THEN_STATEMENT
ELSE_STATEMENT: null
IfStatement [4529, 80]
IfStatement [4615, 77]
IfStatement [4698, 81]
IfStatement [4785, 457]

Variability Model

mapping

Base Artefacts



Software Generator
(derivation engine)

Branch: **master**

generator-jhipster / app / templates / src / main / java / package / config / **_DatabaseConfiguration.java**

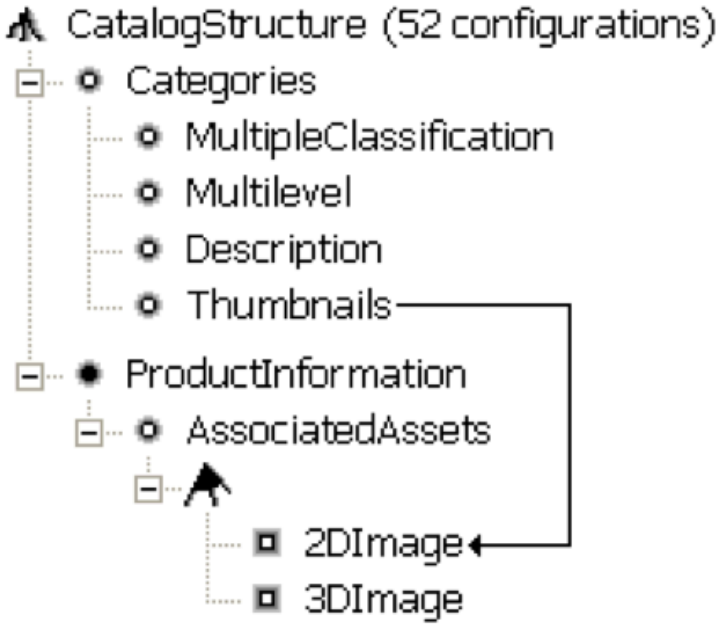
jdubois 2 days ago Use Spring Boot's configuration meta-data

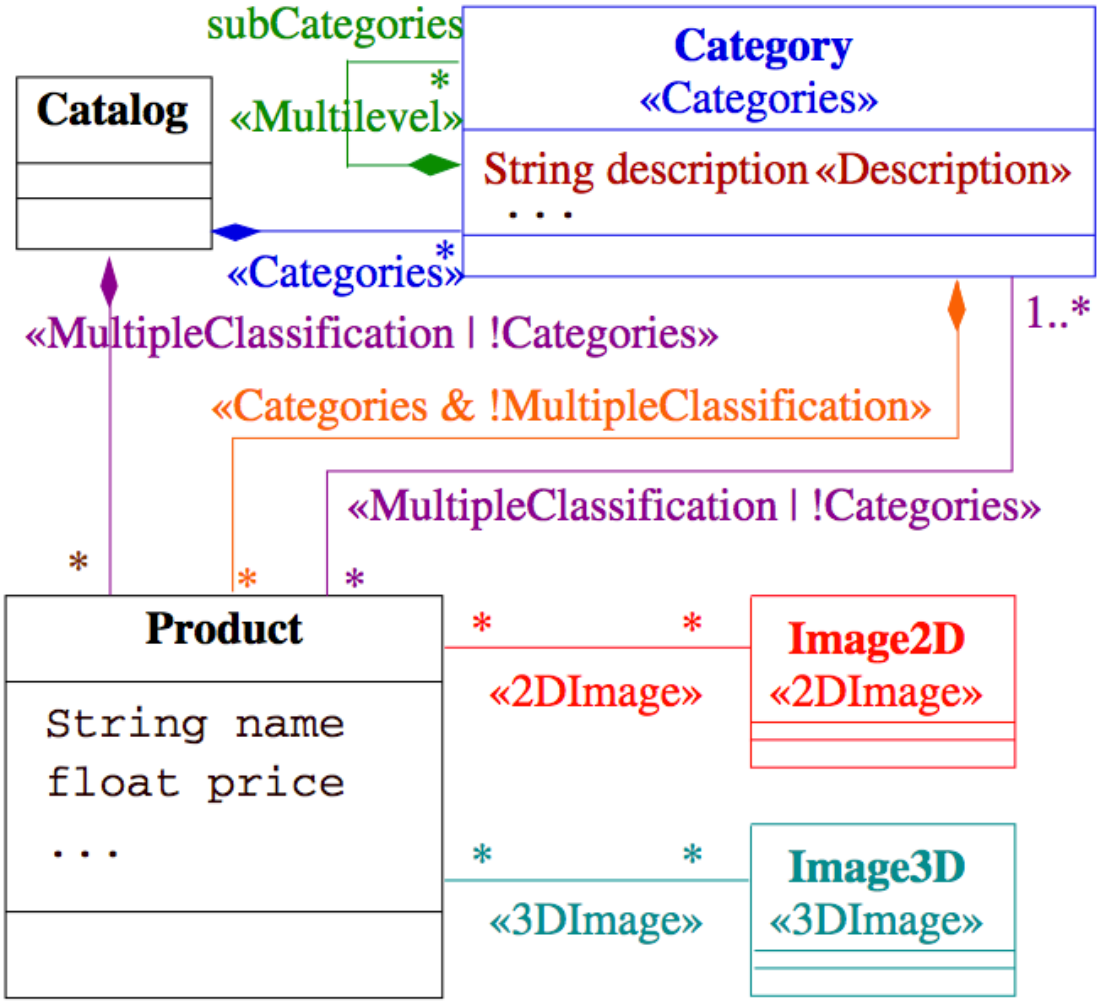
9 contributors

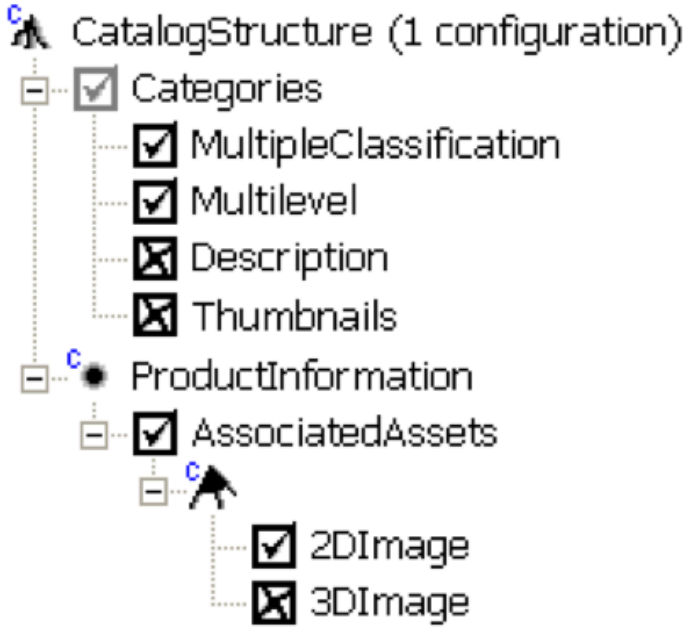
184 lines (165 sloc) | 9.69 KB

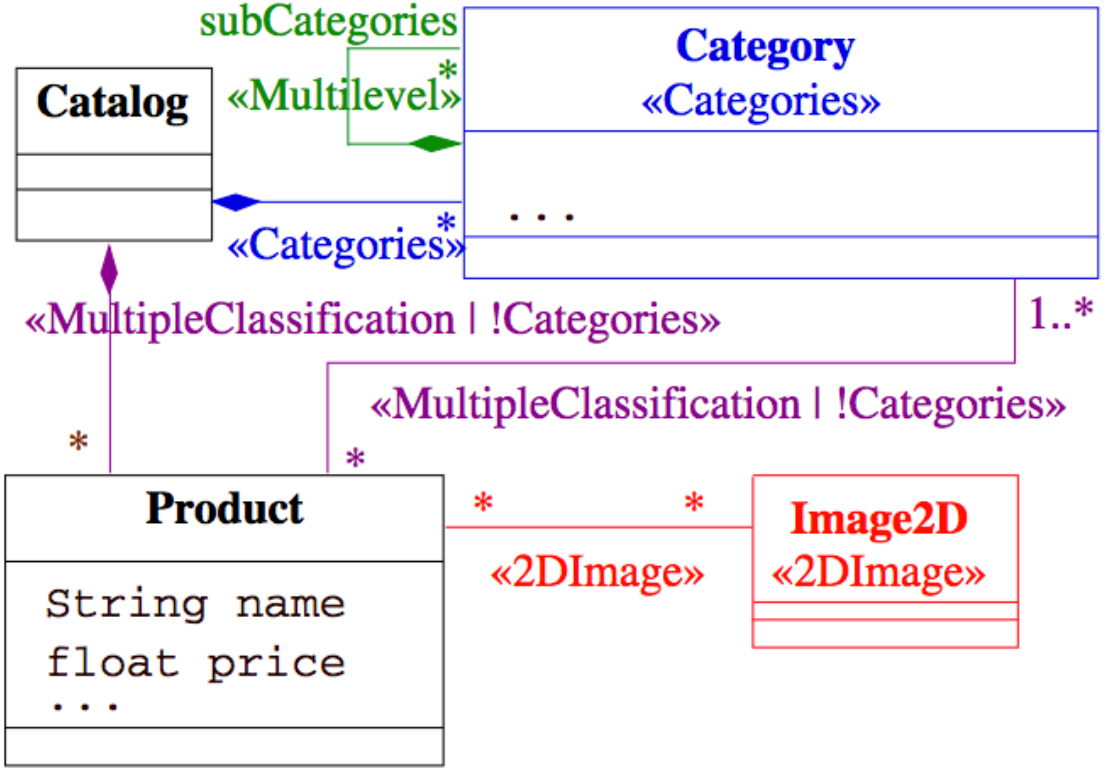
Raw | Blame | History

```
1  package <%=packageName%>.config;
2  <% if (databaseType == 'sql') { %>
3  import <%=packageName%>.config.liquibase.AsyncSpringLiquibase;
4  import com.codahale.metrics.MetricRegistry;
5  import com.fasterxml.jackson.datatype.hibernate4.Hibernate4Module;
6  import com.zaxxer.hikari.HikariConfig;
7  import com.zaxxer.hikari.HikariDataSource;
8  import liquibase.integration.spring.SpringLiquibase;<% } %><% if (databaseType == 'mongodb' && authenticationType == 'oauth2') { %
9  import <%=packageName%>.config.oauth2.OAuth2AuthenticationReadConverter;<% } %><% if (databaseType == 'mongodb') { %>
10 import com.mongodb.Mongo;
11 import org.mongeez.Mongeez;<% } %>
12 import org.slf4j.Logger;
13 import org.slf4j.LoggerFactory;<% if (databaseType == 'sql') { %><% if (hibernateCache == 'hazelcast') { %>
14 import org.springframework.cache.CacheManager;<% } %>
15 import org.springframework.beans.factory.annotation.Autowired;
16 import org.springframework.boot.autoconfigure.condition.ConditionalOnExpression;<% } %><% if (databaseType == 'mongodb') { %>
17 import org.springframework.boot.autoconfigure.mongo.MongoAutoConfiguration;
18 import org.springframework.boot.autoconfigure.mongo.MongoProperties;<% } %><% if (databaseType == 'sql') { %>
19 import org.springframework.boot.autoconfigure.jdbc.DataSourceProperties;
20 import org.springframework.boot.autoconfigure.liquibase.LiquibaseProperties;
21 import org.springframework.context.ApplicationContextException;<% } %>
22 import org.springframework.context.annotation.Bean;
23 import org.springframework.context.annotation.Configuration;
24 import org.springframework.context.annotation.Profile;<% if (databaseType == 'mongodb') { %>
25 import org.springframework.context.annotation.Import;<% } %><% if (databaseType == 'sql') { %>
26 import org.springframework.core.env.Environment;<% } %><% if (databaseType == 'mongodb' && authenticationType == 'oauth2') { %>
27 import org.springframework.core.convert.converter.Converter;<% } %><% if (databaseType == 'mongodb') { %>
28 import org.springframework.core.io.ClassPathResource;<% } %><% if (searchEngine == 'elasticsearch') { %>
29 import org.springframework.data.elasticsearch.repository.config.EnableElasticsearchRepositories;<% } %><% if (databaseType == 'mon
30 import org.springframework.data.mongodb.config.AbstractMongoConfiguration;
31 import org.springframework.data.mongodb.config.EnableMongoAuditing;<% } %><% if (databaseType == 'mongodb' && authenticationType =
32 import org.springframework.data.mongodb.core.convert.CustomConversions;<% } %><% if (databaseType == 'mongodb') { %>
33 import org.springframework.data.mongodb.core.mapping.event.ValidatingMongoEventListener;
34 import org.springframework.data.mongodb.repository.config.EnableMongoRepositories;
35 import org.springframework.validation.beanvalidation.LocalValidatorFactoryBean;<% } %><% if (databaseType == 'sql') { %>
```


CatalogStructure (52 configurations)
Categories
MultipleClassification
Multilevel
Description
Thumbnails
ProductInformation
AssociatedAssets
2DImage
3DImage


subCategories
Catalog
«Multilevel»
Category
«Categories»
String description «Description»
. . .
«Categories»
«MultipleClassification | !Categories»
1..*
«Categories & !MultipleClassification»
«MultipleClassification | !Categories»
Product
String name
float price
. . .
«2DImage»
Image2D
«2DImage»
«3DImage»
Image3D
«3DImage»


CatalogStructure (1 configuration)
Categories
MultipleClassification
Multilevel
Description
Thumbnails
ProductInformation
AssociatedAssets
2DImage
3DImage


subCategories
Catalog
«Multilevel»
Category
«Categories»
...
«Categories»
«MultipleClassification | !Categories»
1..*
«MultipleClassification | !Categories»
Product
String name
float price
...
«2DImage»
Image2D
«2DImage»

Variability in the Video Domain (first example)

Bref


bref30ans.canalplus.fr
CANAL+
30ANS
BREF
PROGRAMMES
SURPRISES
EXPO
bref.
CANAL a 30 ans.
ETAPE 1 : DONNE TON PRENOM
MATHIEU
→ OK

Online Generator

bref30ans.canalplus.fr/#c

ETAPE 2 : CHOISIS 3 BONS SOUVENIRS

Variant


bref30ans.canalplus.fr/#video
ETAPE 3 : JE REGARDE MON EPISODE UNIQUE
DEJÀ 761 545 EPISODES GENERES.
MATHIEU+
présente
HD
POWERED BY MICROSOFT AZURE

(index) a97d2829.main.js ×

```
/*! Wildmoka - v0.0.0 - 2014-11-04
* http://wildmoka.com/
* Copyright (c) 2014 ; Licensed  */
var require;!function(ba){function G(a){return"[object Function]"===K.call(a)}function H(a){return"[object Array]"===K.call(a)}function v(a,b)
return("input"===c||"button"===c)&&b.type===a}}function j(a){return d(function(b){return b=+b,d(function(c,d){for(var e,f=a([],c.length,b),g=f.length;g--;)c[e=
if(h[0]=a,a.delega Target=this,!j.preDispatch||j.preDispatch.call(this,a)!==!1){for(g=fb.event.handlers.call(this,a,i),b=0;(e=g[b++])&&!a.isPropagationStopped
g=fb.trim(d),c.className=g&&(c.className=g)}return this},removeClass:function(a){var b,c,d,e,f,g,h=0,i=this.length,j=0===arguments.length||"string"==typeof a
if(k.length)var r=k.data("a
},_mouseStart:function(){return!0
},show:function(){this._flashObj.s
d.append(e);var f=1,g=[];a.each(b,
```

bref-service.cloudapp.net/pintvservices/getEp?a1=RANDOM&a2=RANDOM&a3=RANDOM&

{"ep": "e24=1qgn9dh&e18=nr7jom&e05=1xxivi2&e21=1jmv11y&e25=1bv7rka&e06=1oxnvtu&e04=wqzv0y&e12=wvo06o&e28=5znrg7&e03=11yfhk&e17=1j9aij7&e16=1eqb8bw&jjl=1", "sq": ["dwlcjv", "1y60t3z", "11yfhk", "wqzv0y", "1xxivi2", "1oxnvtu", "1olbe9", "wvo06o", "1u6y5t2", "1eqb8bw", "1j9aij7", "nr7jom", "1jmv11y", "1qgn9dh", "1bv7rka", "19ykyyw", "5znrg7", "116hv1k"], "cn": 1659623, "s": "OK", "ct": ["CATHERINELILIANE", "BURGER", "DEZAPPING"]}

bref-service.cloudapp.net/pintvservices/getEp?a1=RANDOM&a2=RANDOM&a3=RANDOM&

"sq": ["dwlcjv", "1y60t3z", "1lyfhk", "wqzv0y", "1xxivi2", "1oxnvtu", "lolbe9", "wvo06o", "1u6y5t2", "1eqb8bw", "1j9aij7", "nr7jom", "1jmv11y", "1qgn9dh", "1bv7rka", "19ykyyw", "5znrg7", "116hv1k"]

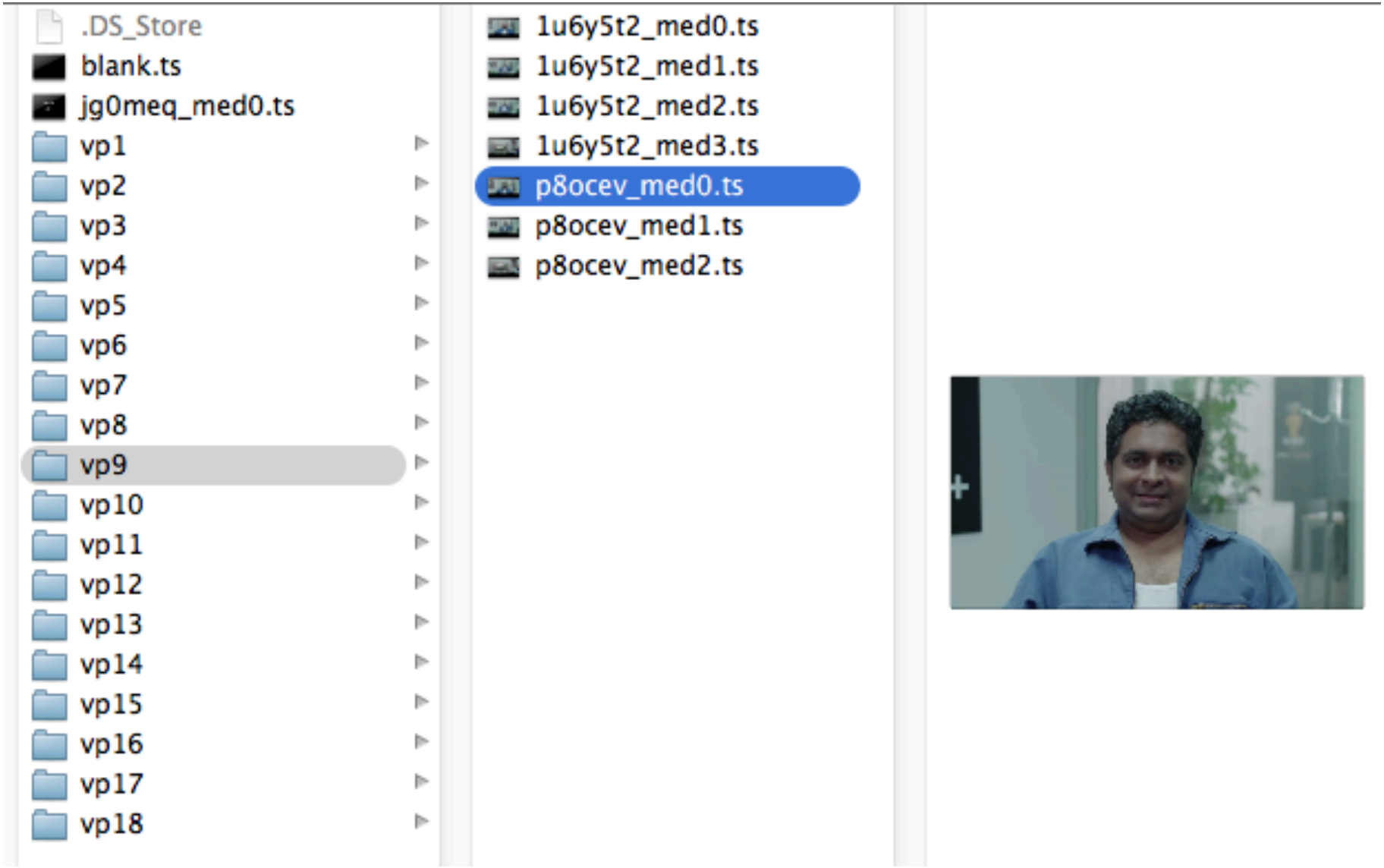
bref30cdn.wildmoka.com/vidv2/116hv1k_med.txt

```
#EXTINF:06.40,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med0.ts
#EXTINF:03.96,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med1.ts
#EXTINF:04.52,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med2.ts
#EXTINF:03.08,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med3.ts
```

```
}
  1659055
 [DESCHIENS, DECAUNESGARCIA, BURGER]
: "DESCHIENS"
: "DECAUNESGARCIA"
: "BURGER"
  "e24=wxjqk2&e18=xi82vf&e05=x2nief&e21=cr3hzu&e25=1bv7rka&e06=1oxnvtu&e04=ppdjpp&e12=1pt9ic1&e28=
"OK"
 [ml7ila, 1y60t3z, 12eo6f2, ppdjpp, x2nief, 1oxnvtu, a7kxth, 1pt9ic1, nej6g3, 1hhuj2v, 1j9aij7, x
: "ml7ila"
: "1y60t3z"
: "12eo6f2"
: "ppdjpp"
: "x2nief"
: "1oxnvtu"
: "a7kxth"
: "1pt9ic1"
: "nej6g3"
: "1hhuj2v"
0: "1j9aij7"
1: "xi82vf"
2: "cr3hzu"
3: "wxjqk2"
4: "1bv7rka"
5: "5jjnew"
6: "f353uf"
7: "116hv1k"
```

- wget + curl = 363281 episodes
- 18 sequences, 400 « .ts »
- 63 alternatives for the 1st sequence
- And so on…

9 34 15 25 51 30 2 6 6 12 21 28 6 86 4 1


.DS_Store
blank.ts
jg0meq_med0.ts
vp1
vp2
vp3
vp4
vp5
vp6
vp7
vp8
vp9
vp10
vp11
vp12
vp13
vp14
vp15
vp16
vp17
vp18
1u6y5t2_med0.ts
1u6y5t2_med1.ts
1u6y5t2_med2.ts
1u6y5t2_med3.ts
p8ocev_med0.ts
p8ocev_med1.ts
p8ocev_med2.ts

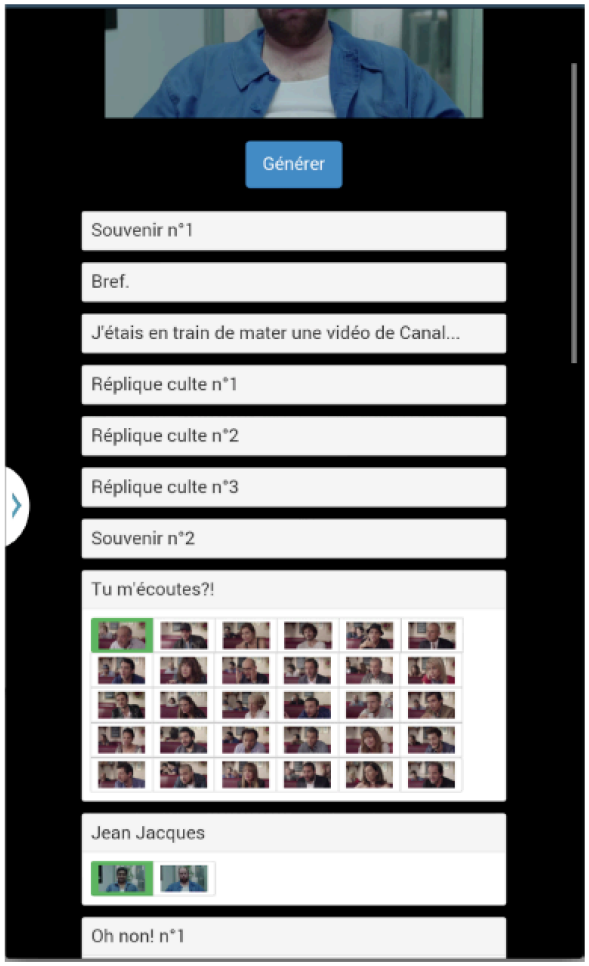
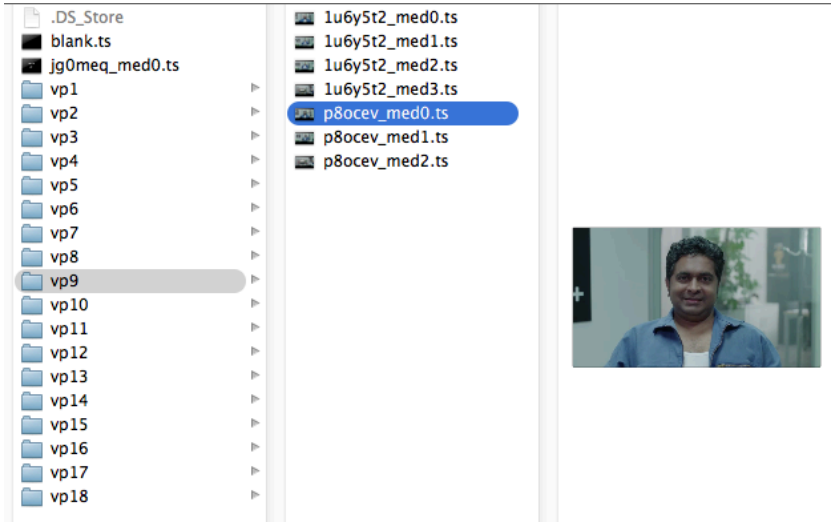


Figure 2: Re-engineering of the novel configurator (excerpt): users can now select a specific video for the 18 variation points identified during the reverse engineering of the original generator

"sq": ["dwlcjv", "1y60t3z", "1lyfhk", "wqzv0y", "1xxivi2", "1oxnvtu", "lolbe9", "wvo06o", "1u6y5t2", "1eqb8bw", "1j9aij7", "nr7jom", "1jmv11y", "1qgn9dh", "1bv7rka", "19ykyyw", "5znrg7", "116hv1k"]

bref30cdn.wildmoka.com/vidv2/116hv1k_med.txt

```
#EXTINF:06.40,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med0.ts
#EXTINF:03.96,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med1.ts
#EXTINF:04.52,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med2.ts
#EXTINF:03.08,
http://bref30cdn.wildmoka.com/vidv2/116hv1k_med3.ts
```



Guillaume Bécan, Mathieu Acher, Jean-Marc Jézéquel, and Thomas Menguy. On the Variability Secrets of an Online Video Generator (2015). In VaMoS'15

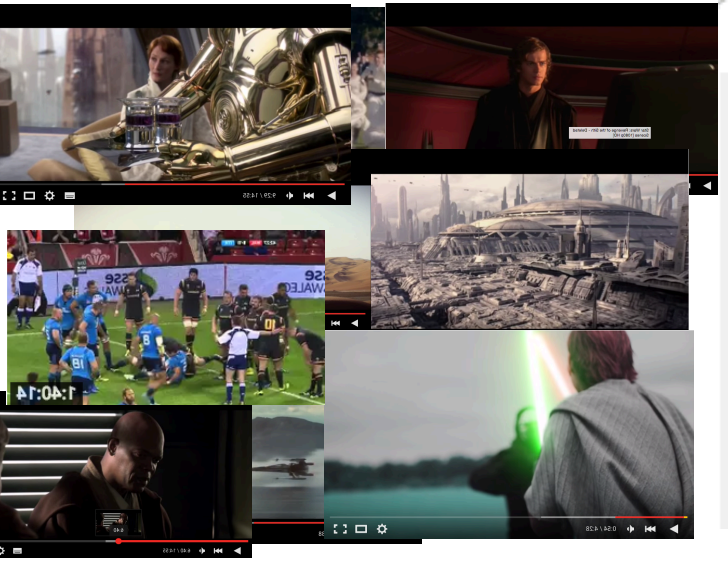
Variability in the Video Domain (second example)

Generator
~ composition of video sequences

video
variants

Generator
~ composition of video sequences

video variants

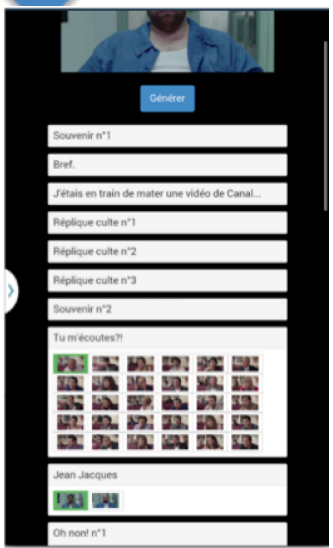


foo1.videogen

```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"
optional videoseq v2 "v2folder/v2.mp4"
alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```

Website/online

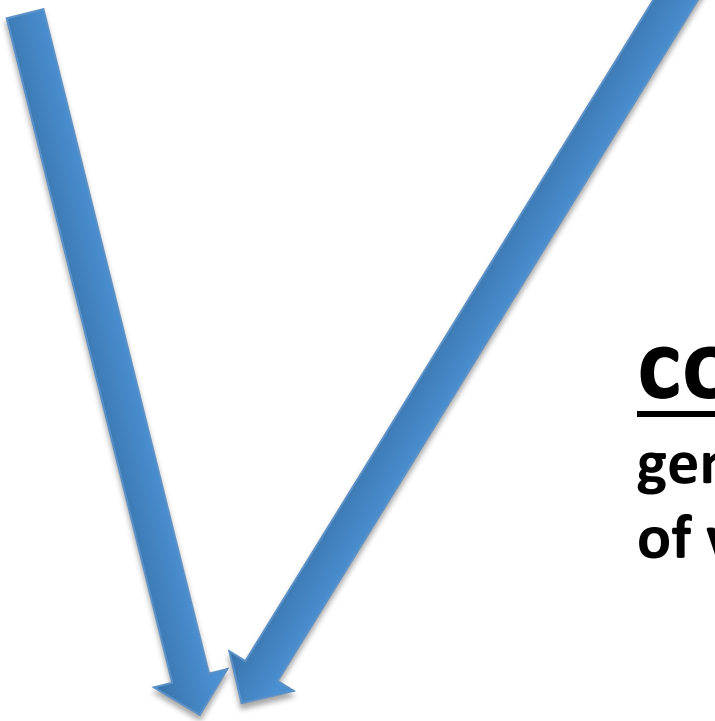
- Random generation
- Configurator
- Game
- …



foo1.videogen

```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"
optional videoseq v2 "v2folder/v2.mp4"
alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```

Feature model: another model for modeling “features” of your Web site (eg ability to save the video; mode=generation with frequencies)



configurable

generator
of video generator

Website/online

- **Random generation**
- **Configurator**
- **Game**
- **…**

foo1.videogen

```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"
optional videoseq v2 "v2folder/v2.mp4"
alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```

#1 How to design, create, and support dedicated languages (DSLs)?

#2 How to transform models/programs?

#3 How to manage variability/variants?

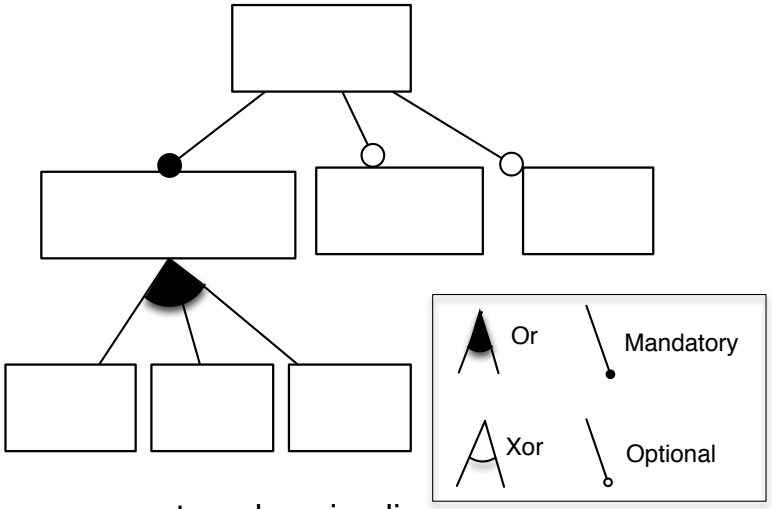
#4 How do frameworks internally work?

Variability in the Video Domain (third example)

What are the differences?

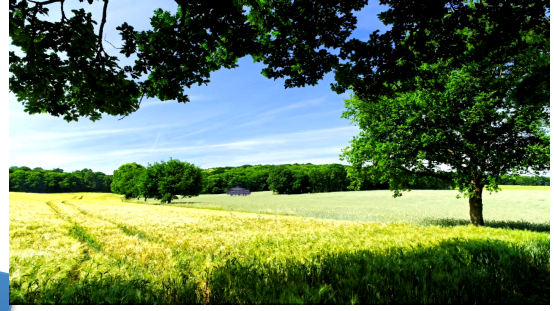
aka what is the variability of a video?

We synthesize video sequence variants with variability techniques



not, and, or, implies

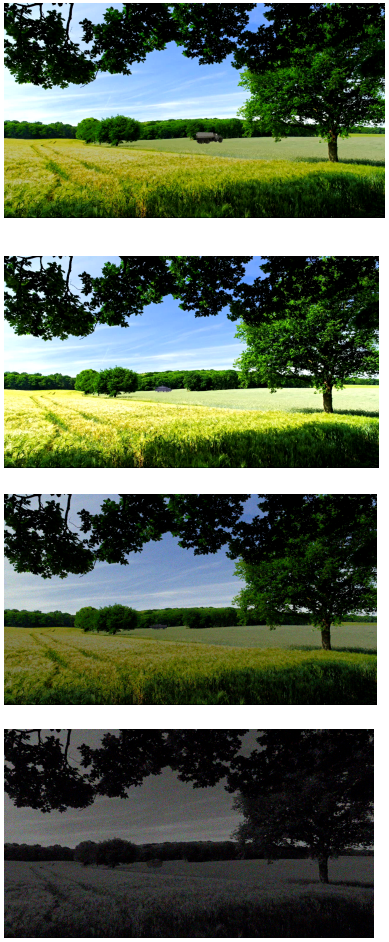
Variability Models (feature models)



Why?

Industrial needs:
consumer and provider of video algorithms have severe difficulties to test their algorithms on different kinds of inputs.

Test algorithms on different kinds of inputs that influence execution time, precision, and/or recall

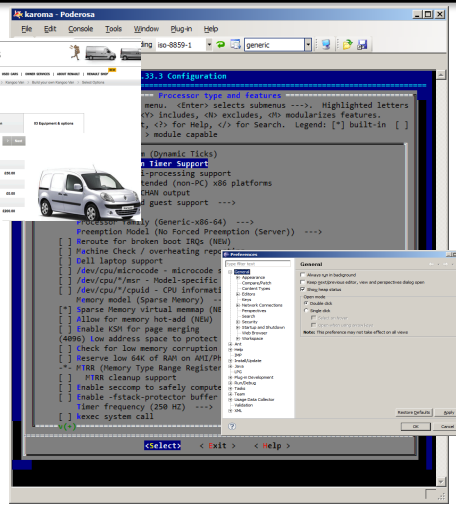


Algorithm 1	Algorithm 2	Algorithm 3
0.63	0.93	0.82
0.81	0.92	0.81
0.43	0.3	0.8
0.39	0.03	0.01

Why?

Problem: collecting videos is a key economic problem.

Solution: hundreds of video sequences with different characteristics.

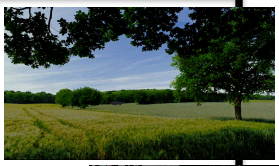


Feature Model

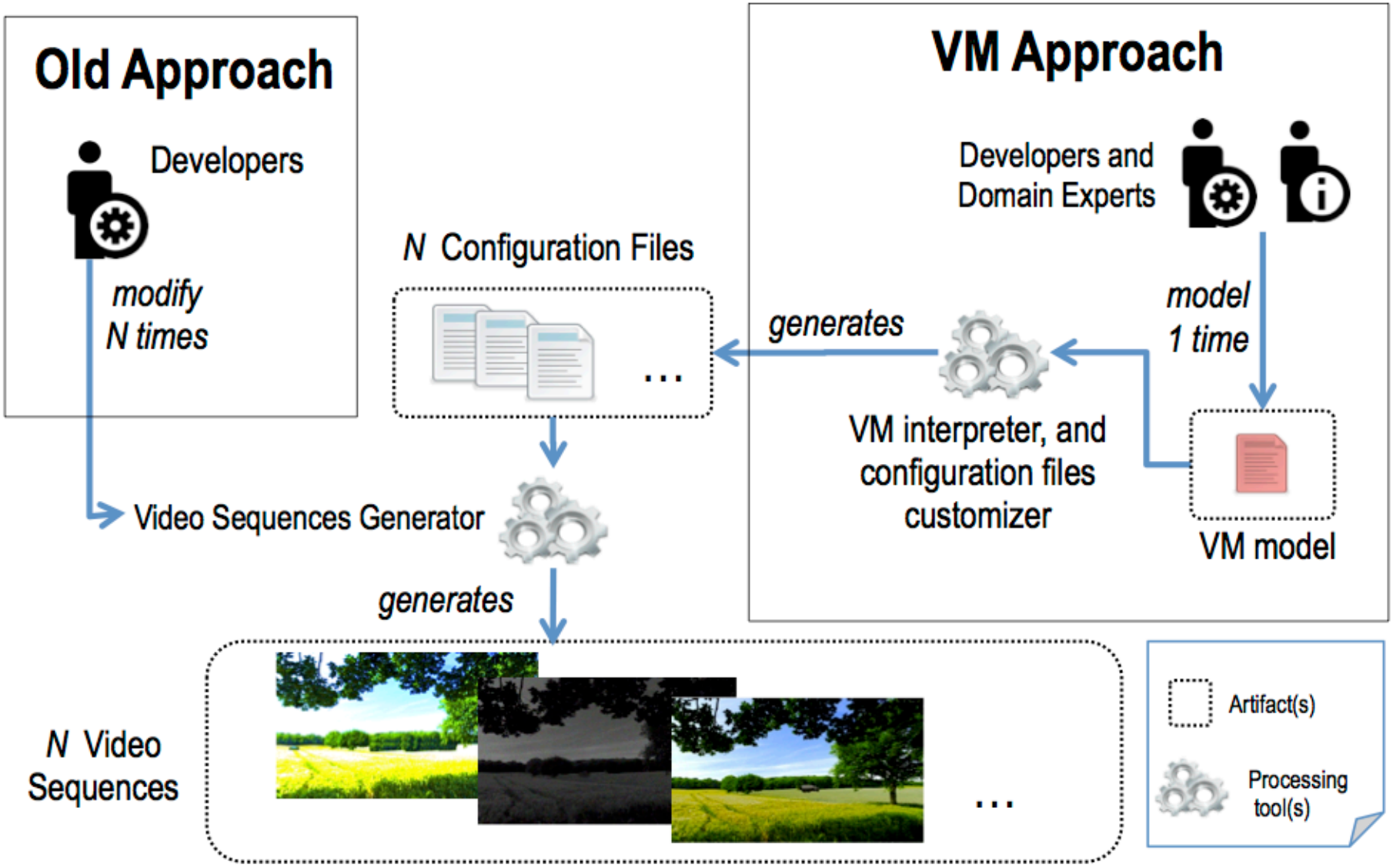
mapping

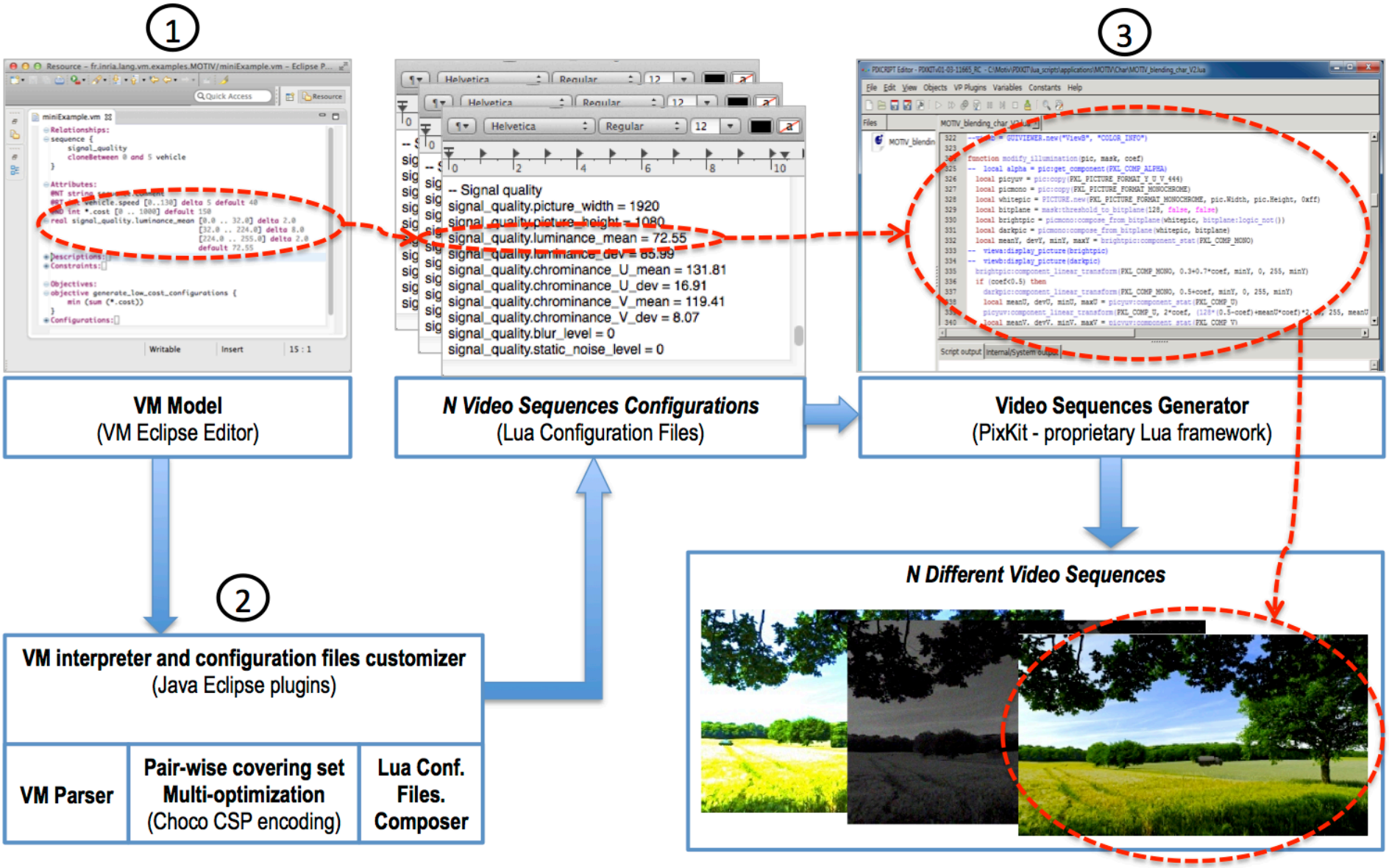
```
print("->Step9")
  if (CFG.distractors.close_moving_vegetation~=0) then
    windvect5, precwindvect5, newwindvect5 =
generate_wind_vector_field2(workwidth, workheight, 256, 1, 1, 35, picnum,
precwindvect5, newwindvect5)
    windvectmul =
windvect5:mul(24*CFG.distractors.close_moving_vegetation)
    globalvect = compose_vect(masque_feuilles_sombres, windvectmul, globalvect
    hfvx, hfvy =
windvect0:mul(6*CFG.distractors.close_moving_vegetation):to_matrix()
    hfvx = MATRIX.multerm(hfvx, invdepthmat)
    hfvy = MATRIX.multerm(hfvy, invdepthmat)
    lfvect = windvect2:resize_bilinear(windvect2.Width, windvect2.Height/16)
    lfvect = lfvect:resize_bilinear(windvect2.Width, windvect2.Height)
    lfvx, lfvy = lfvect:mul(-
12*CFG.distractors.close_moving_vegetation):to_matrix()
    lfvx = MATRIX.multerm(lfvx, depthmat)
    lfvy = MATRIX.multerm(lfvy, depthmat*0.1)
    windvectcomp = VECT2D.new_from_matrices(MATRIX.addterm(lfvx, hfvx),
MATRIX.addterm(lfvy, hfvy))
    globalvect = compose_vect(masque_ble, windvectcomp, globalvect)
    globalvect = compose_vect(masque_orge, windvectcomp, globalvect)
    globalvect = compose_vect(masque_ble_fond, windvectcomp, globalvect)
  end

print("->Step10")
```

```
-- Distractors
distractors.butterfly_level = 0.2 -- Floating point number from 0
(low level) to 1 (high level)
distractors.bird_level = 0.3 -- Floating point number from 0 (low
level) to 1 (high level)
distractors.far_moving_vegetation = 0.2 -- Floating point number
from 0 (low level) to 1 (high level)
distractors.close_moving_vegetation = 0.2 -- Floating point number
from 0 (low level) to 1 (high level)
distractors.light_reflection = 0 -- Floating point number from 0
(low level) to 1 (high level)
distractors.blinking_light = 0 -- Floating point number from 0
(low level) to 1 (high level)
```



Software Generator
(derivation engine)


Old Approach
Developers
modify
N times
Video Sequences Generator
N Configuration Files
...
generates
N Video
Sequences
...
VM Approach
Developers and
Domain Experts
model
1 time
generates
VM interpreter, and
configuration files
customizer
VM model
Artifact(s)
Processing
tool(s)


1
3
-- Signal quality
signal_quality.picture_width = 1920
signal_quality.picture_height = 1080
signal_quality.luminance_mean = 72.55
signal_quality.luminance_dev = 65.99
signal_quality.chrominance_U_mean = 131.81
signal_quality.chrominance_U_dev = 16.91
signal_quality.chrominance_V_mean = 119.41
signal_quality.chrominance_V_dev = 8.07
signal_quality.blur_level = 0
signal_quality.static_noise_level = 0
VM Model
(VM Eclipse Editor)
N Video Sequences Configurations
(Lua Configuration Files)
Video Sequences Generator
(PixKit - proprietary Lua framework)
2
VM interpreter and configuration files customizer
(Java Eclipse plugins)
VM Parser
Pair-wise covering set Multi-optimization
(Choco CSP encoding)
Lua Conf. Files. Composer
N Different Video Sequences

(configuration file)

```
-- Distractors
distractors.butterfly_level = 0.2 -- Floating point number from 0
(low level) to 1 (high level)
distractors.bird_level = 0.3 -- Floating point number from 0 (low
level) to 1 (high level)
distractors.far_moving_vegetation = 0.2 -- Floating point number
from 0 (low level) to 1 (high level)
distractors.close_moving_vegetation = 0.2 -- Floating point number
from 0 (low level) to 1 (high level)
distractors.light_reflection = 0 -- Floating point number from 0
(low level) to 1 (high level)
distractors.blinking_light = 0 -- Floating point number from 0
(low level) to 1 (high level)
```

```
print("->Step9")
  if (CFG.distractors.close_moving_vegetation~=0) then
    windvect5, precwindvect5, newwindvect5 =
generate_wind_vector_field2(workwidth, workheight, 256, 1, 1, 35, picnum,
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    hfvy = MATRIX.multerm(hfvy, invdepthmat)
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12*CFG.distractors.close_moving_vegetation):to_matrix()
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MATRIX.addterm(lfvy, hfvy))
    globalvect = compose_vect(masque_ble, windvectcomp, globalvect)
    globalvect = compose_vect(masque_orge, windvectcomp, globalvect)
    globalvect = compose_vect(masque_ble_fond, windvectcomp, globalvect)
  end

print("->Step10")
```
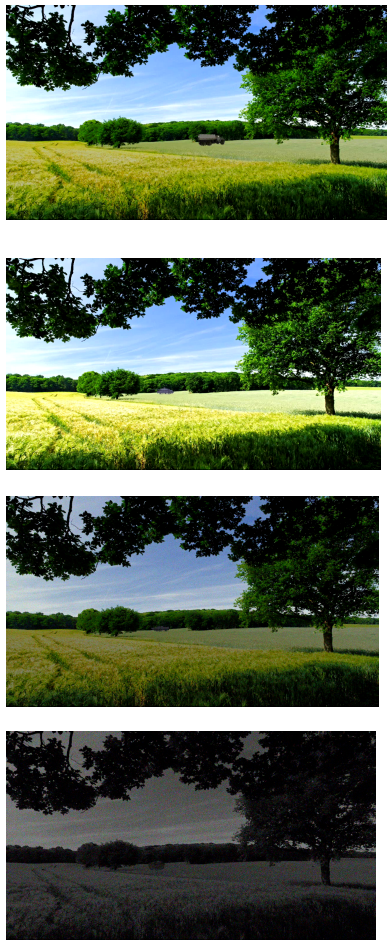

(Lua code)

Defects detection
Benchmarking
Incremental design
Performance prediction



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0.81	0.92	0.81
0.43	0.3	0.8
0.39	0.03	0.01

Other references

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