

Model-based Software Product Lines

Overview and Principles

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Maître de Conférences

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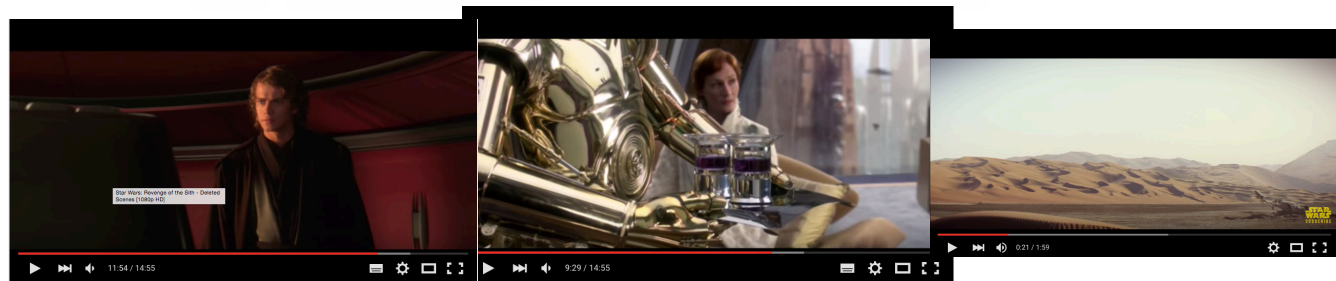
Material

<http://mathieuacher.com/teaching/MDE/>



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
- ...

Générer

Souvenir n°1

Bref.

J'étais en train de mater une vidéo de Canal...

Réplique culte n°1

Réplique culte n°2

Réplique culte n°3

Souvenir n°2

Tu m'écoutes?!

Tu m'écoutes?!

Jean Jacques

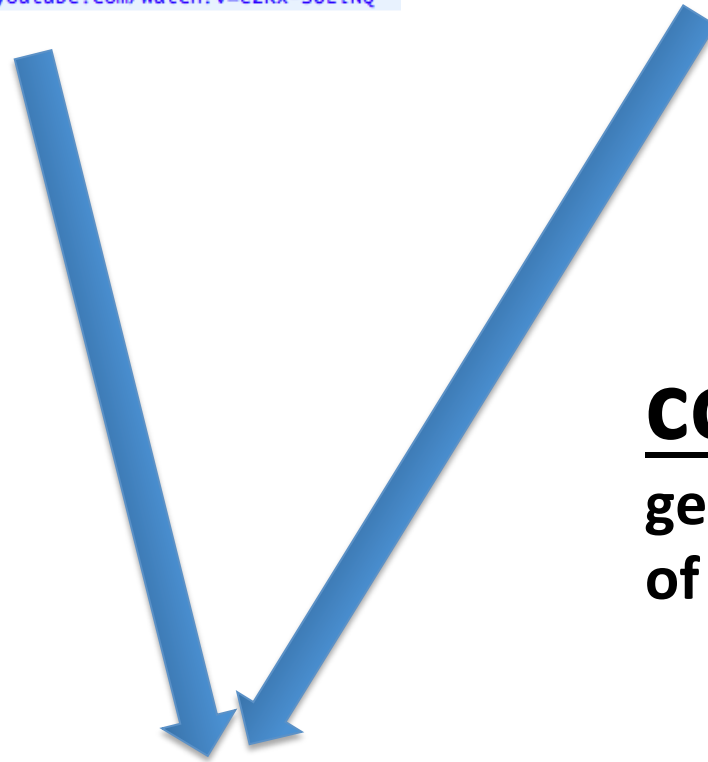
On n'est n°1



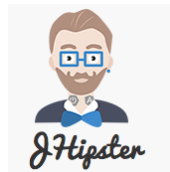

```
foo1.videogen ⌘
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"
optional videoseq v2 "v2folder/v2.mp4"
alternatives v3 {
  videoseq v31 "v3/seq1.mp4"
  videoseq v32 "v3/seq1.mp4"
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}
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  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"
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}
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?

Plan

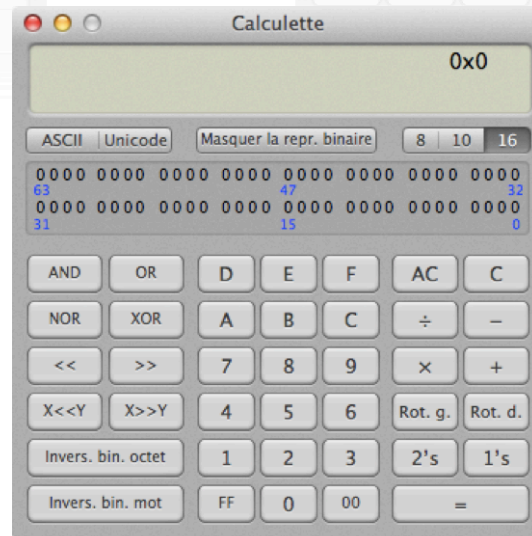
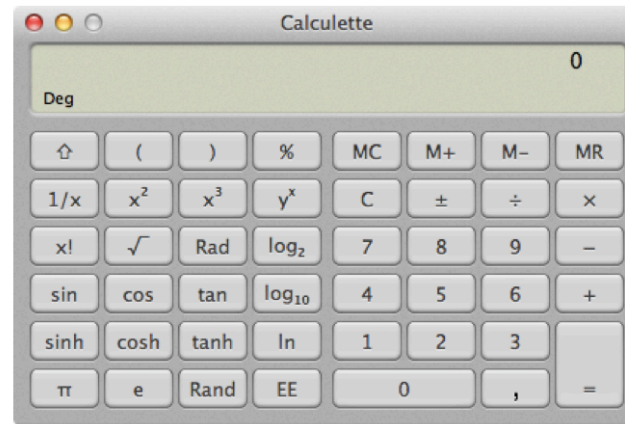
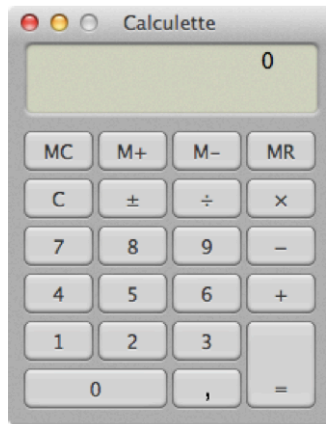
- Challenges and Overview
 - Developing billions of software product is hard but now a common practice
- Implementing Variability
 - Revisit of existing techniques and curriculum
- Specificity of Product Line Engineering
 - Process, methods
- Feature Models
 - Defacto standard for modeling product lines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

Contract

- The idea of software product lines and variability
 - You will be able to recognize this class of systems
 - Aware of the complexity
 - Aware of the specific development process
 - Aware of existing techniques
- Feature modeling
 - A widely used formalism for modeling product lines and configurable systems in a broad sense

Software Product Line and Variability Engineering

Challenges and Overview





I Hipster

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

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

[illegible]

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)
```

« 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



Starter



**Home Premium
Upgrade**

\$119.99*

Buy



**Professional
Upgrade**

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Buy



**Ultimate
Upgrade**

\$219.99*

Buy

Communication

Bluetooth support	✓	✓	✓	✓
Join a homegroup	✓	✓	✓	✓
Internet Explorer 8	✓	✓	✓	✓
View Available Networks	✓	✓	✓	✓
Windows Connect Now (WCN)	✓	✓	✓	✓
Create a homegroup		✓	✓	✓
Location and other sensors support		✓	✓	✓
Support for joining domains			✓	✓

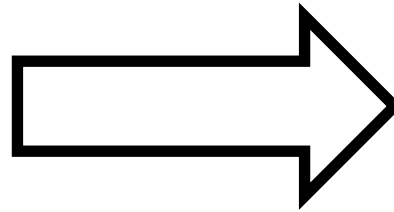
Entertainment

DirectX 11	✓	✓	✓	✓
Gadgets	✓	✓	✓	✓
Games Explorer	✓	✓	✓	✓
Play To	✓	✓	✓	✓
Windows Media Player 12	✓	✓	✓	✓
Create and play DVDs		✓	✓	✓
Internet TV		✓	✓	✓





Software-intensive systems

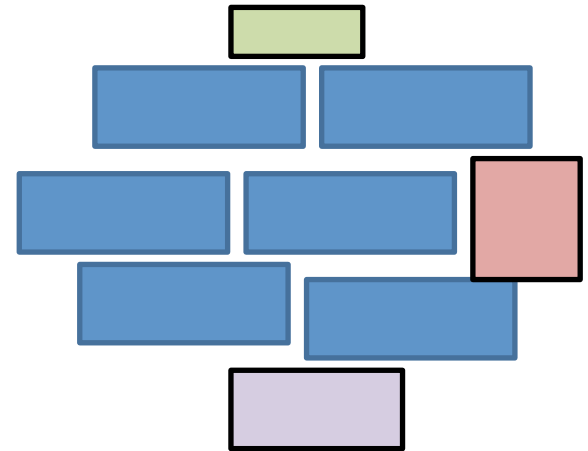


come in many variants

Software Product Line Engineering

Factoring out **commonalities**

for **Reuse** [Krueger et al., 1992] [Jacobson et al., 1997]



Managing **variabilities**

for Software **Mass Customization** [Bass et al., 1998] [Krueger et al., 2001], [Pohl et al., 2005]

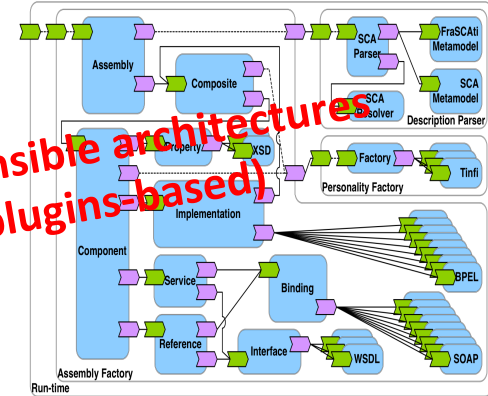
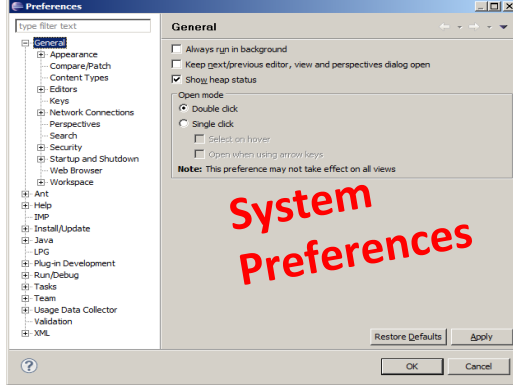
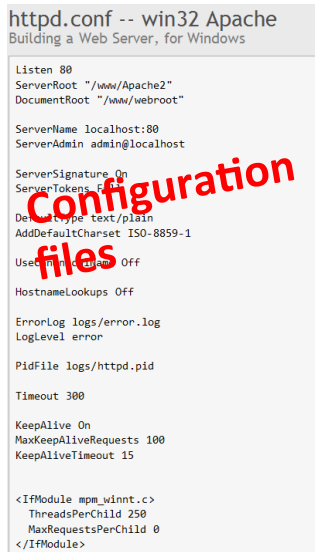
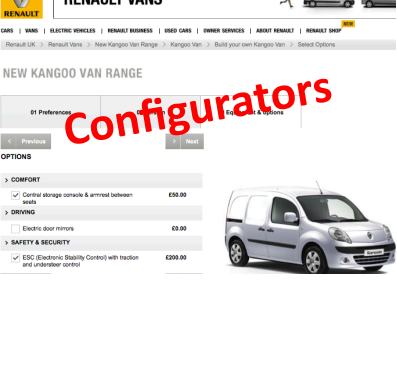


Variability

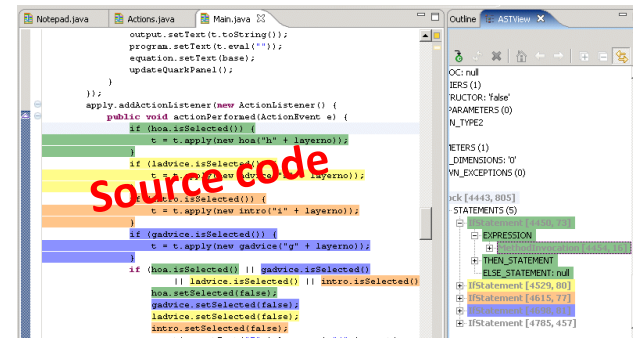
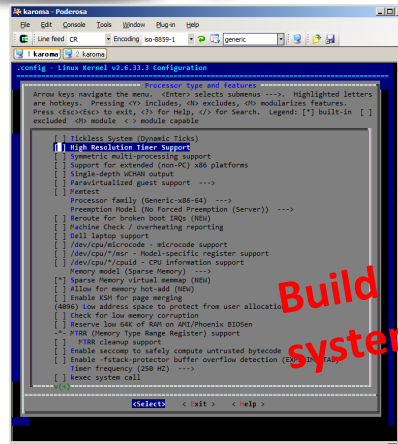
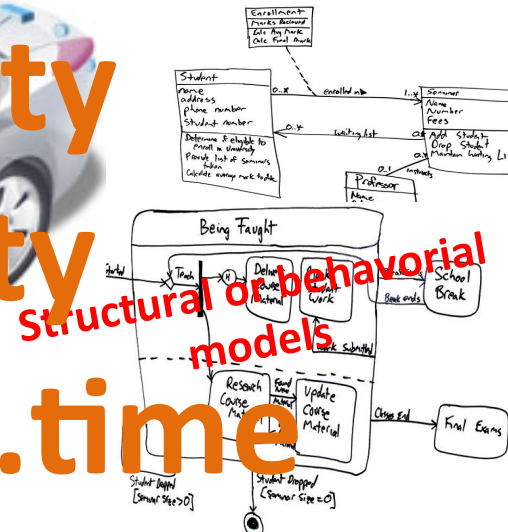
“the ability of a system to be efficiently extended, changed, customized or configured for use in a particular context”

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





External Variability Internal Variability Variability @ run.time



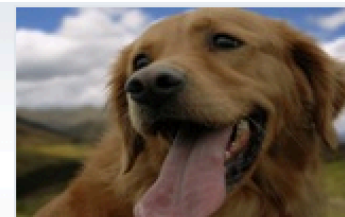
Power Matte 2 1.3 update



Adobe After Effects plugin that can extract a subject 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



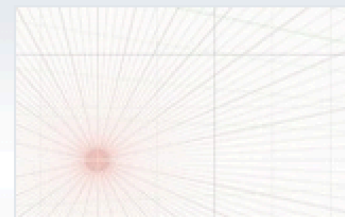
Grid 1.1 update



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



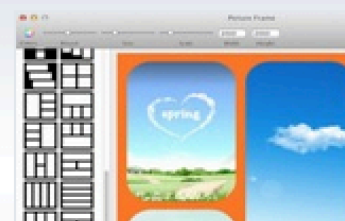
Picture Frame 2.2 update



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



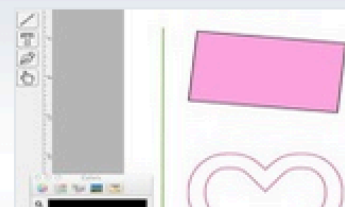
FashionLab Studio 1.1 update



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





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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

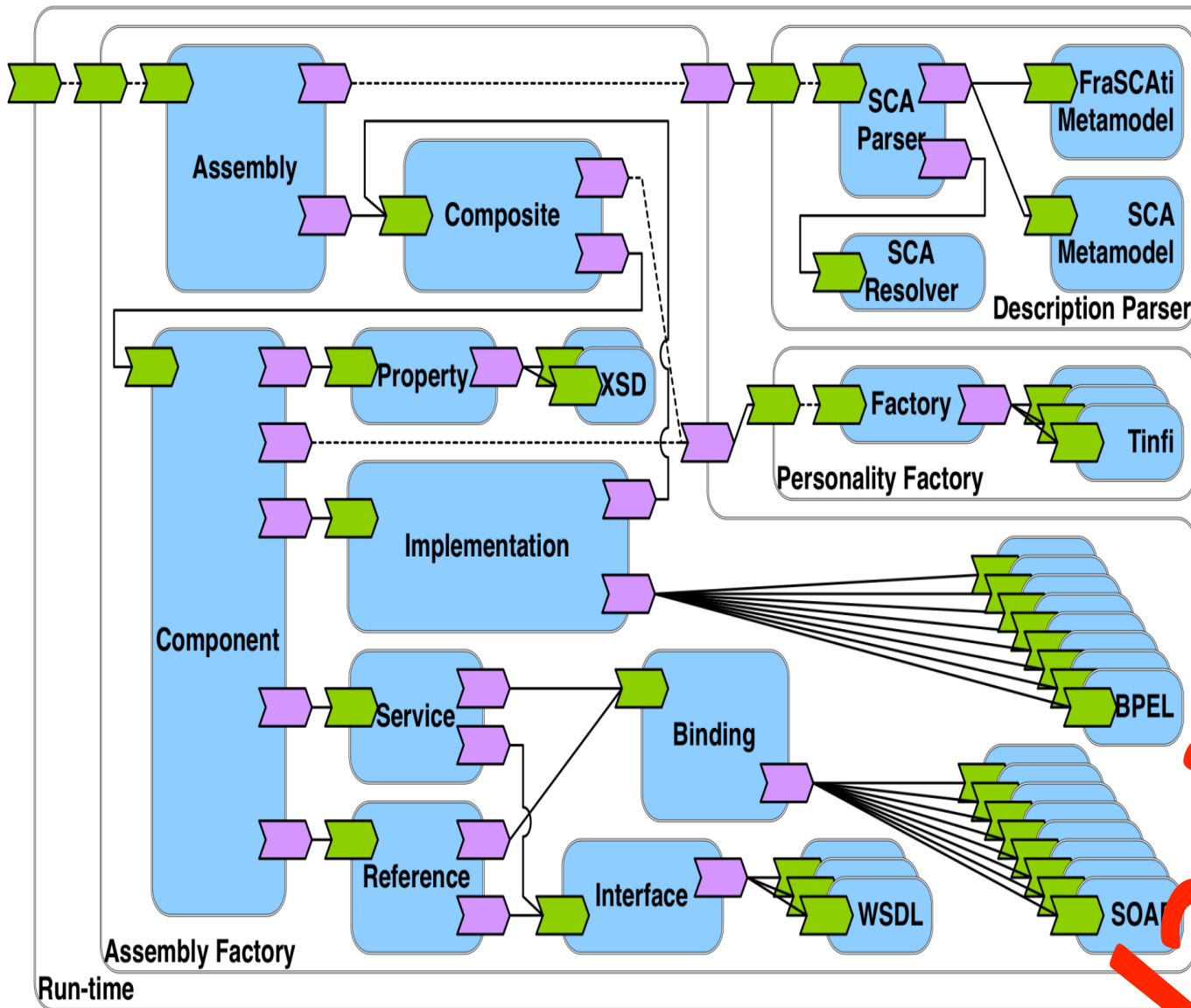
- ☐ Electric door mirrors **£0.00**

> SAFETY & SECURITY

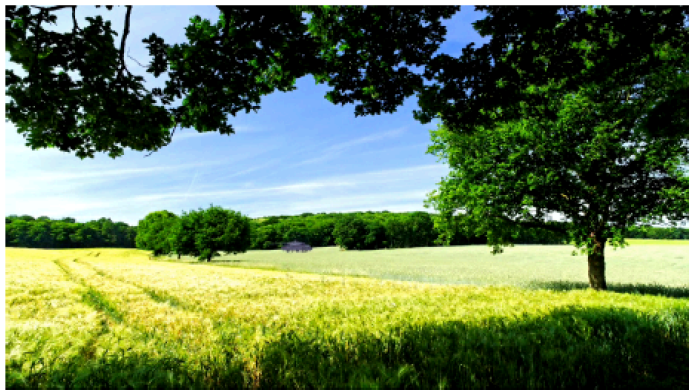
- ☒ ESC (Electronic Stability Control) with traction and understeer control **£200.00**



variability



variability



(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


```

/* [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

Lid inside settings

Lid inside content

Lid outside

Customize body

Design key

Customize ruler

Printer platform settings

Length Set the outside length of your pencil box. 190

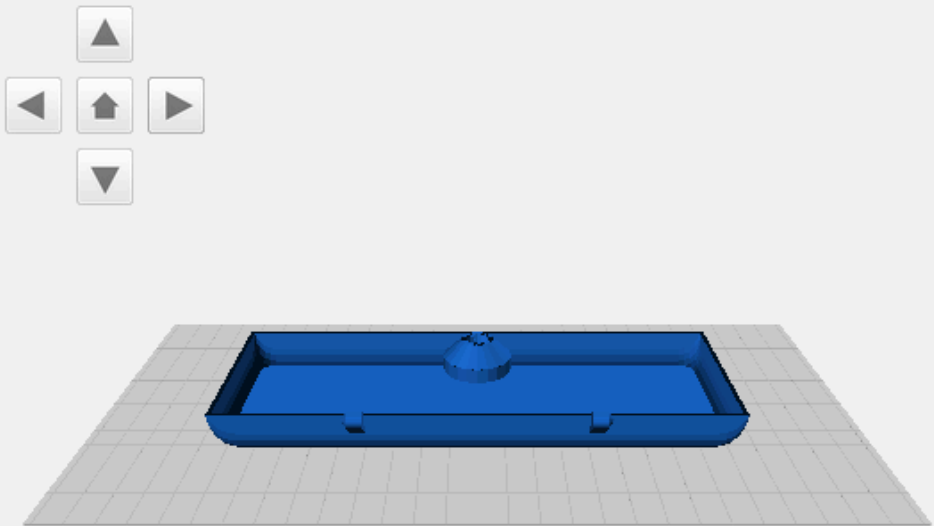
Depth Set the outside depth of your pencil box. 70

Height 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. 40

Long Choose divider orientation. Long is for the X direction.

Short Short is for the Y direction.

Center When you have 2 long dividers, picking yes here will put short dividers in the center section.



MakerBot Thingiverse DASHBOARD EXPLORE CREATE Enter a search term You

Customizable Battery Case

by walter, published Mar 6, 2013

Like 284
Collect 473
Comment 20
I Made One 8
Watch 10
Remix It 366
Share

Open in Customizer
Download This Thing!

Thing Info Instructions Thing Files 20 Comments 8 Made 473 Collections 366 Remixes

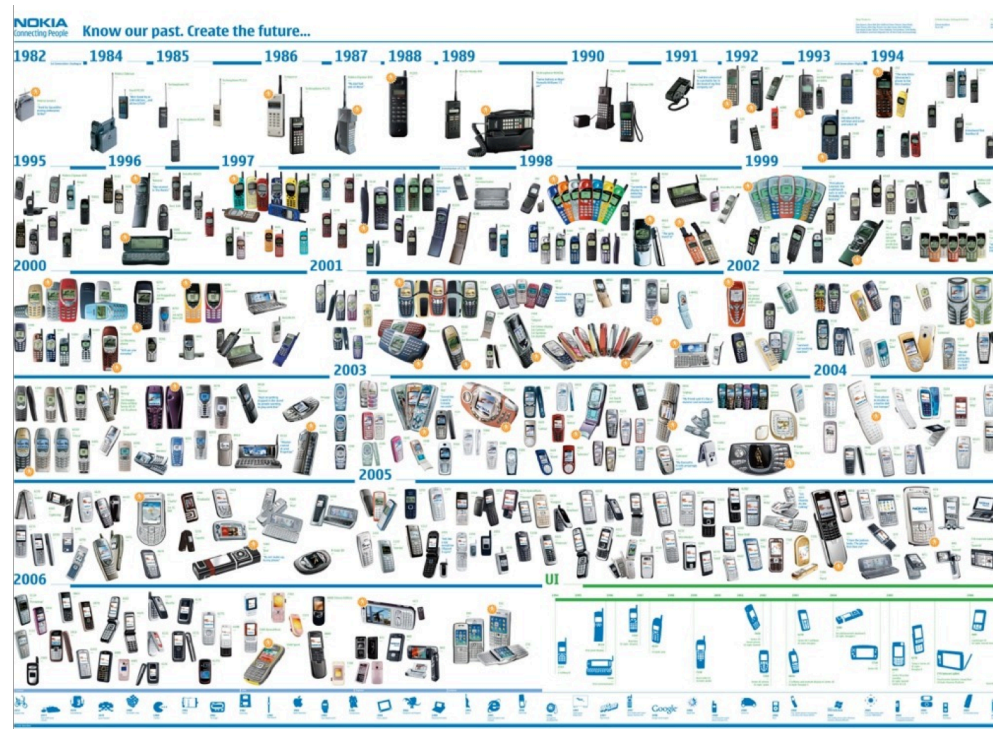
Description

A customizable battery case to hold batteries while traveling. Configurable for the number of batteries and type (as long as they're cylindrical). This is an updated version of the customizable battery carrier ([thingiverse.com/thing:51376](https://www.thingiverse.com/thing:51376)), re-designed to work without magnets as requested by GregFlak25.

20865 2444
Found in Containers
Report Thing as inappropriate
Makes view more >

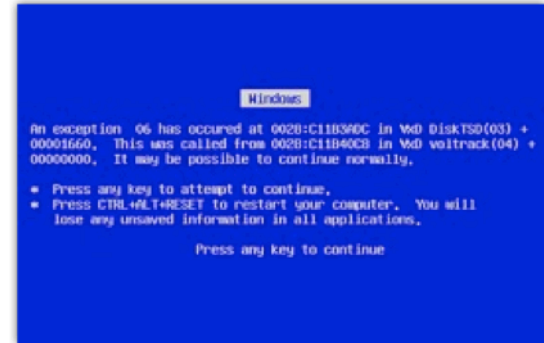
Variability in time vs in space

- **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



BOSCH

Invented for life



i n v e n t



PHILIPS

ERICSSON 



NOKIA
Connecting People



CelsiusTech

Lucent Technologies
Bell Labs Innovations

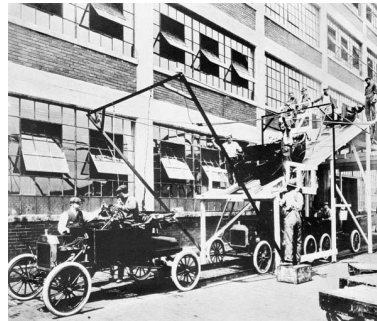


Printer Firmware

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



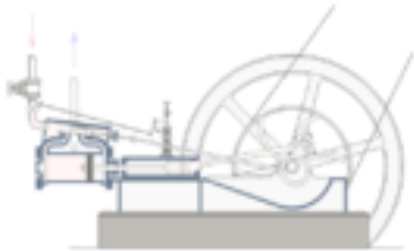
A Bit of History: Industrial Revolution



1901
Henry Ford



1980s



1698
Thomas Savery

Nowaday: Product Lines Everywhere



Product Lines of Cars



This image may contain optional equipment.

Agila, Club
1.2i 16v, 5 Speed
Blaze Red, Melt / Elba Charcoal

Total € 15,684.00

1. Trims/Series2. Engine/Transmission3. Colour & Style4. Options5. Summary

Next Step

Choose Your Options

Audio/Comms/NavHeating/VentilationMechanicalSafety/SecurityA-Z

Audio/Comms/Nav

☒ CD 30Standard

- MP3 CD player with MP3 format, stereo radio, steering wheel mounted audio controls

Heating/Ventilation

☒ Air conditioning€ 923.00

Mechanical

☒ Electronic Stability Programme (ESP)€ 411.00

Safety/Security

☒ Emergency tyre inflation kit in lieu of space-saver spare wheel and tyreStandard

Audio/Comms/NavHeating/VentilationMechanicalSafety/SecurityA-Z

Next Step: Summary

Pricing Details

Club€ 14,350.00

1.2i 16v, 5 Speed

Blaze Red€ 0.00

Melt / Elba Charcoal€ 0.00

15-inch steel wheels with 185/60€ 0.00

R 15 tyres and flush wheel covers

Options (2)

You selected:

☒ Air conditioning€ 923.00

☒ Electronic Stability Programme (ESP)€ 411.00

Total € 15,684.00

Legend

☒ Selected Option

☐ Selectable Option

☒ Option contained in an option pack

☐ Option contained in an option pack or standard equipment which has been replaced by another option

☐ Option that is only selectable together with another option. Please click for details

Willkommen bei selve - the shoe individualizer

http://www.selve.net/index_js.html

KOLLEKTION FUSSTYP MYSELVE INFO HOME selve

MODELLE
LOOKBOOK

SELVE ID
PASSWORT
>>ANMELDEN

selve

selve Kollektion -> Style: casuals -> Modell: Opal

modell-details
>>hier klicken

>>SELVE SCHUHREGAL
inhalt: 0

>>SHOPPING BAG
inhalt: 0

A. Erstes Oberleder
Veloursleder Sand

B. Veloursleder Bordeaux
Veloursleder Cognac
Veloursleder Sand

C. Futterleder
Beige

D. Absatz
Hufeisen Braun

E. Sohle
Gummisohle

>>ÄNDERN
>>ZURÜCKLEGEN

Müsli individuell online mixen! Bio-Müsli. - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.mymuesli.com/muesli/index.php?vw=mixer&ec=step1&mnid=1&mnpt=1&type=t0

Müsli individuell online mixen! Bio-M...

my **muesli**
custom-mixed cereals

muesli mixer blog fragen about us

Müslibasis

Basis verfeinern

Früchte

Nüsse & Kerne

Extras

Früchte

Köstliche Bio-Trockenfrüchte, müsligerecht aufbereitet. Du kannst eine Frucht auch mehrmals auswählen, um deren Anteil zu steigern.

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Apfelstücke
Ohne Worte weil Klassiker | 0.45€ (25g)
[mehr Infos](#)

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hoch ▲ ▼ runter

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Buchweizenflocken
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575g nur 4,70€
entspricht 8,17€/kg
inkl. MWSt., zzgl. Versandkosten

fertig gemixt?
weiter

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Done

en-US

Der Dell Online-Shop: Stellen Sie Ihr eigenes System zusammen - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://configure2.euro.dell.com/dellstore/config.aspx?c=de&cs=dedhs1&kc=305&l=de&oc=W06390xp&s=dhs&sb=pr

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Als Symbol anzeigen

ELC-DVRK-Speicher mit 4,0 GB und 607 MHz (2 x 2,0 GB DIMM) [plus 019,99 € oder 20 €/Monat¹]

Grafikkarte

128 MB nVidia NVS285 DVI/VGA-Grafikkarte

Auswahlhilfe

- ☐ 256 MB ATI Fire GL V7200-Grafikkarte [plus 416,50 € oder 13 €/Monat¹]
- ☐ 128 MB nVidia Quadro FX550-Grafikkarte [plus 69,02 € oder 2 €/Monat¹]
- ☐ 256 MB nVidia Quadro FX3450-Grafikkarte [plus 547,40 € oder 17 €/Monat¹]
- ☒ 128 MB nVidia NVS285 DVI/VGA-Grafikkarte [Im Preis enthalten]
- ☐ Grafikkarte PCIe x16 (DVI/VGA) Matrox QID LP PCIe, 128 MB, DVI- oder VGA-Grafikkarte für 4 Monitore [plus 630,70 € oder 20 €/Monat¹]
- ☐ 128 MB ATI Fire GL V3400-Grafikkarte [plus 44,03 € oder 1 €/Monat¹]

Festplatte

80 GB Serial ATA-II-Festplatte (7.200 U/min) mit NCQ

Auswahlhilfe

- ☐ 160 GB Serial ATA-II-Festplatte (7.200 U/min) mit NCQ [plus 16,66 €]
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Finanzierung ab **30 €/mtl.**²
Jetzt finanzieren - erst ab Januar 2008 zahlen!
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inkl. MwSt., zzgl. 19,04 € Versand
Ermäßigter Sonderpreis
913,92 €
Es gelten keine zusätzlichen Preisnachlässe.
Das Angebot gilt für maximal 5 Systeme

Für einen noch umfassenderen Schutz Ihres Systems beinhaltet der oben erwähnte Preis ein Upgrade Service Paket. Um auf den beworbenen Preis zu kommen, entmarkieren Sie die Kategorie "Business Support".

Transferring data from i.dell.com...

Food? Product lines!

VEGETARIAN

WHICH WICH WOULD YOU LIKE?

↓

☐ TRIPLE CHEESE MELT
☐ ELVIS WICH (P.B., Honey & Bananas)
☐ TOMATO & AVOCADO
☐ BLACK BEAN PATTY
☒ HUMMUS & BELL PEPPERS

CHOOSE YOUR BREAD

↓

☐ WHITE ☒ WHEAT

CHOOSE YOUR CHEESE (Optional)

↓

☐ AMERICAN ☐ SWISS ☐ PROVOLONE
☐ CHEDDAR ☒ PEPPER JACK ☐ MOZZARELLA

How Would You Like Your WICH Worked?

↓

MUSTARDS
☐ Yellow ☐ Dijon ☐ Honey ☒ Deli

MAYOS
☐ Regular ☐ Lite ☐ Horseradish ☒ Spicy

SPREADS & SAUCES
☐ BBQ ☐ Buffalo ☐ Marinara
☐ 1000 Island ☐ Ranch

ONIONS



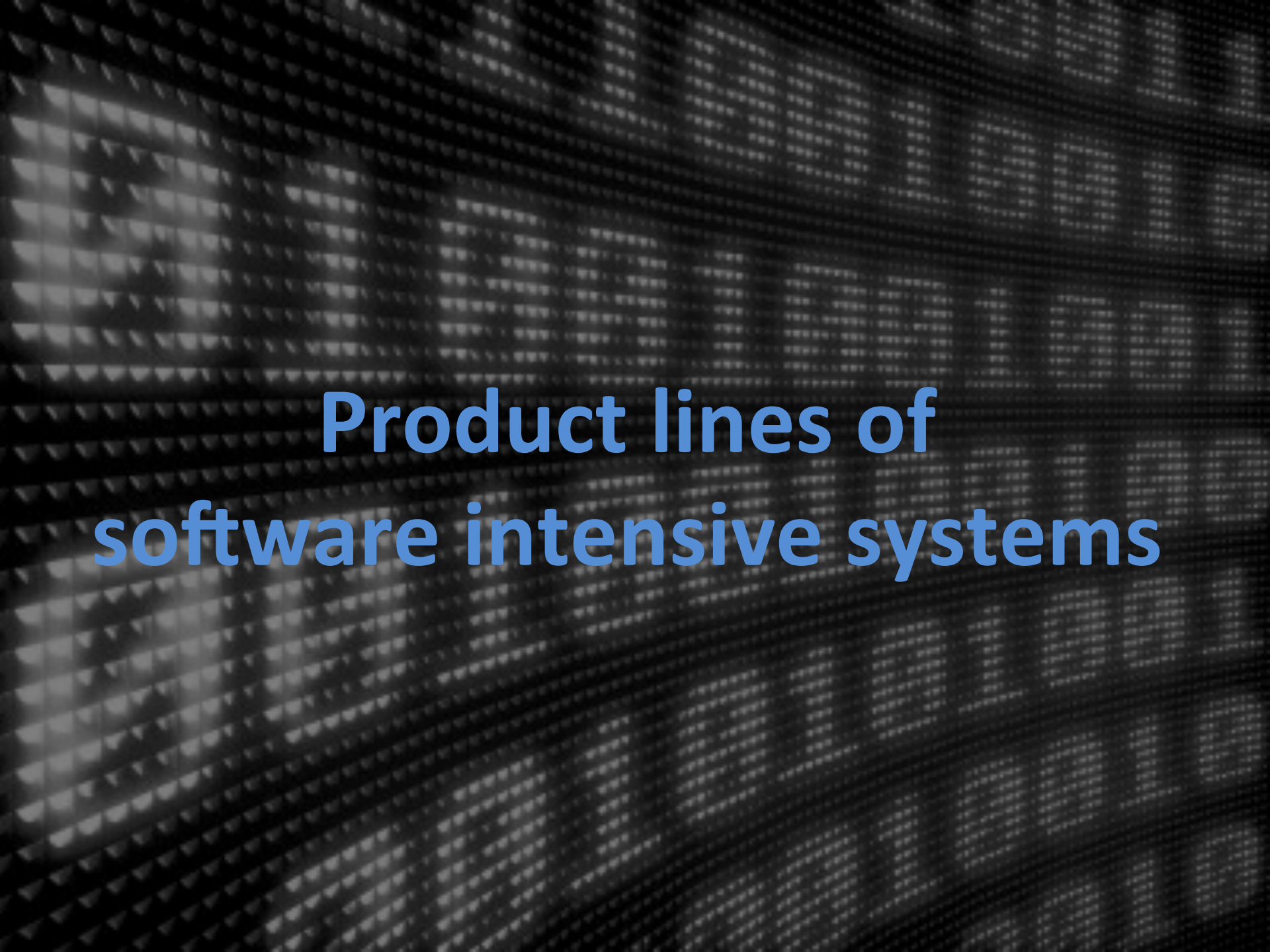


A photograph of a McDonald's restaurant interior. In the foreground, two large, illuminated golden arches stand prominently. Behind them, the McDonald's logo and the word "McDonald's" are visible on the wall. The restaurant's interior is visible in the background, showing tables, chairs, and people. The floor is highly reflective, mirroring the lights. The text "Mass production" is overlaid in a large, blue, sans-serif font across the center of the image.

Mass production

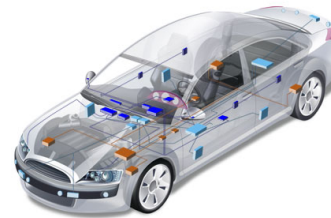
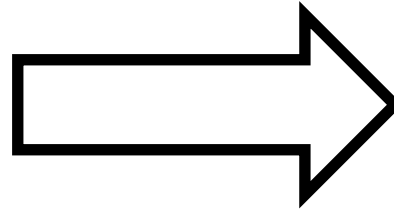


**What about
software?**

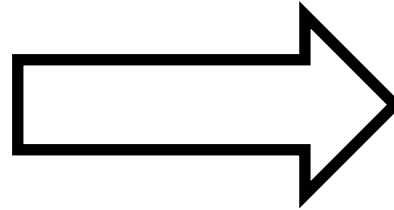
The background of the slide is a dark, textured surface composed of numerous small, light-colored dots and lines, creating a sense of depth and movement. These elements are arranged in a way that suggests a digital or data-driven environment, with some areas appearing more brightly lit than others, giving it a three-dimensional feel.

Product lines of software intensive systems

Software intensive systems
are declined in many **variants**



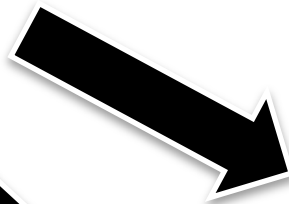
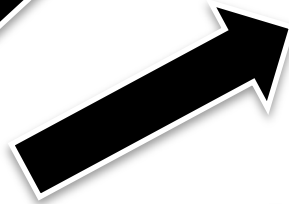
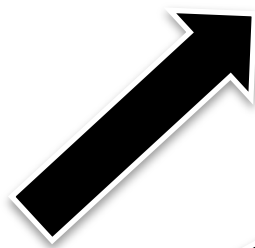
Software intensive systems
are declined in many **variants**



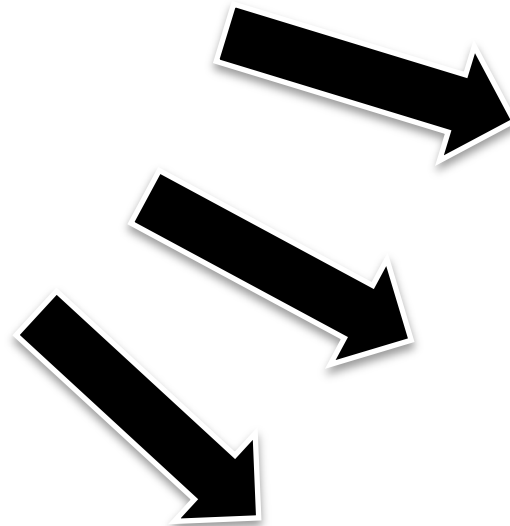
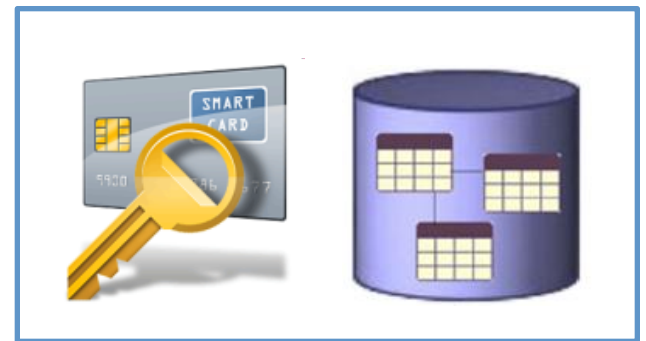
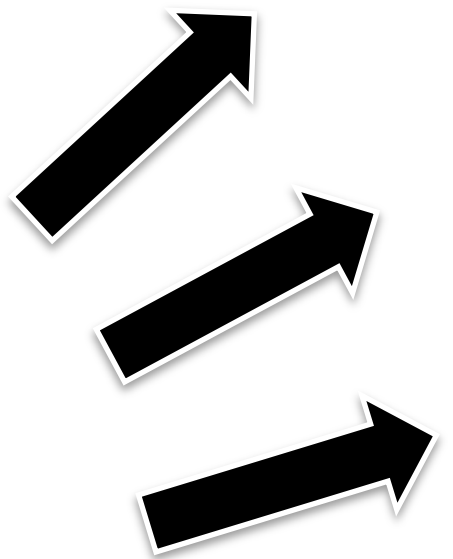
Software Product Lines



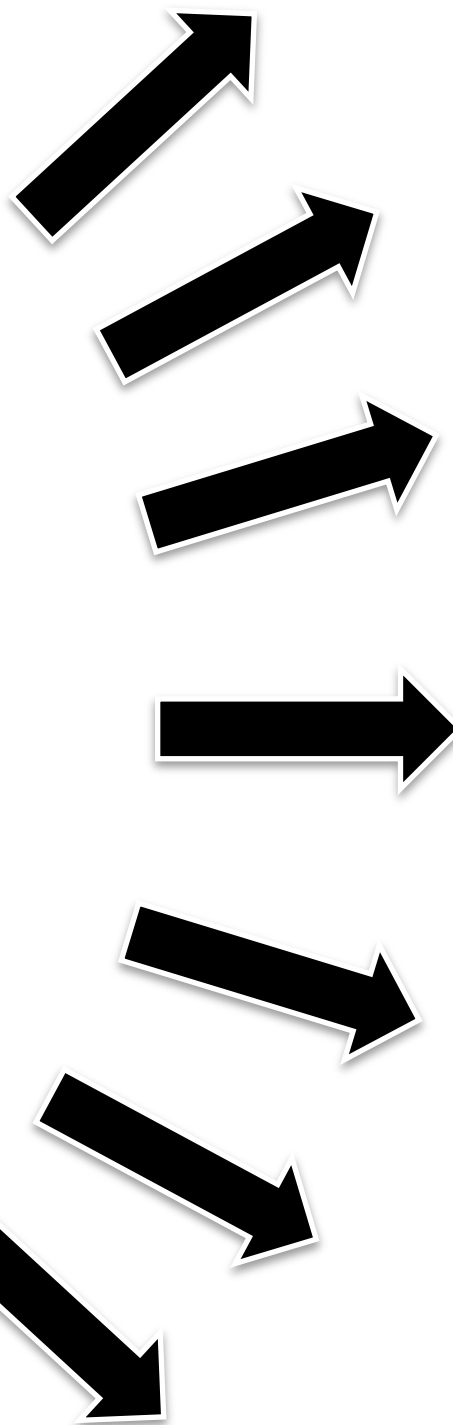
Car

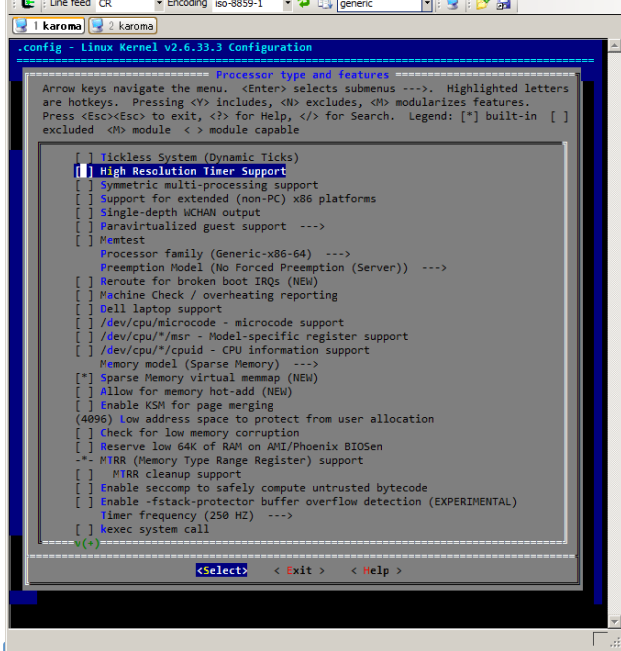


Database
Engine

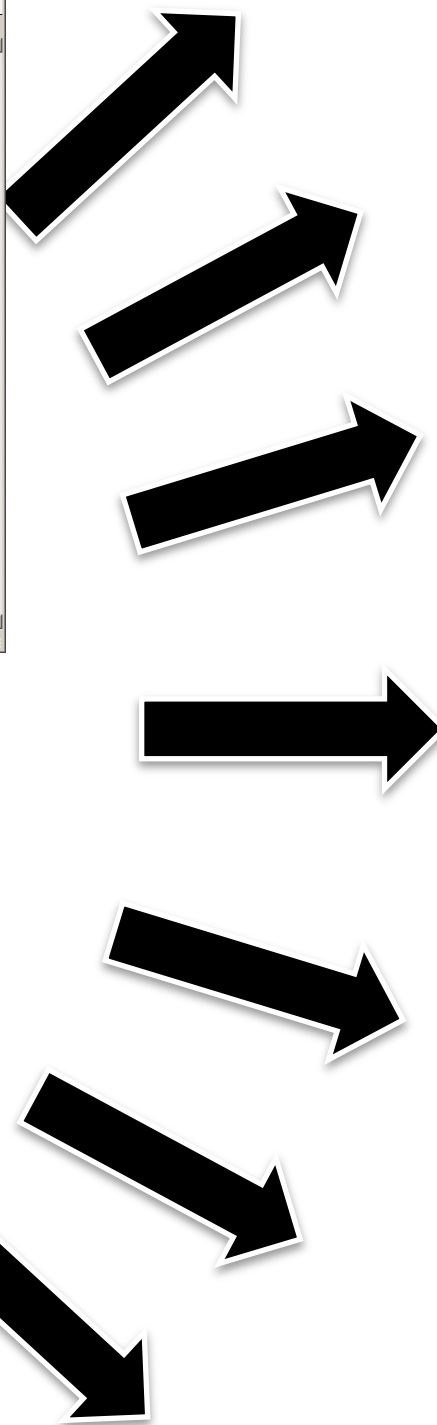


Printer
Firmware

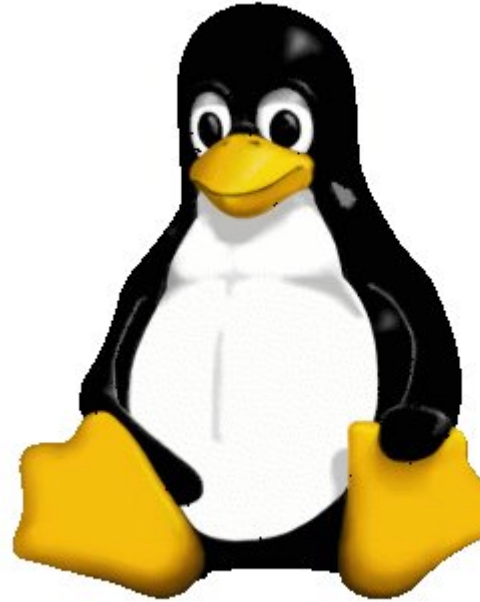




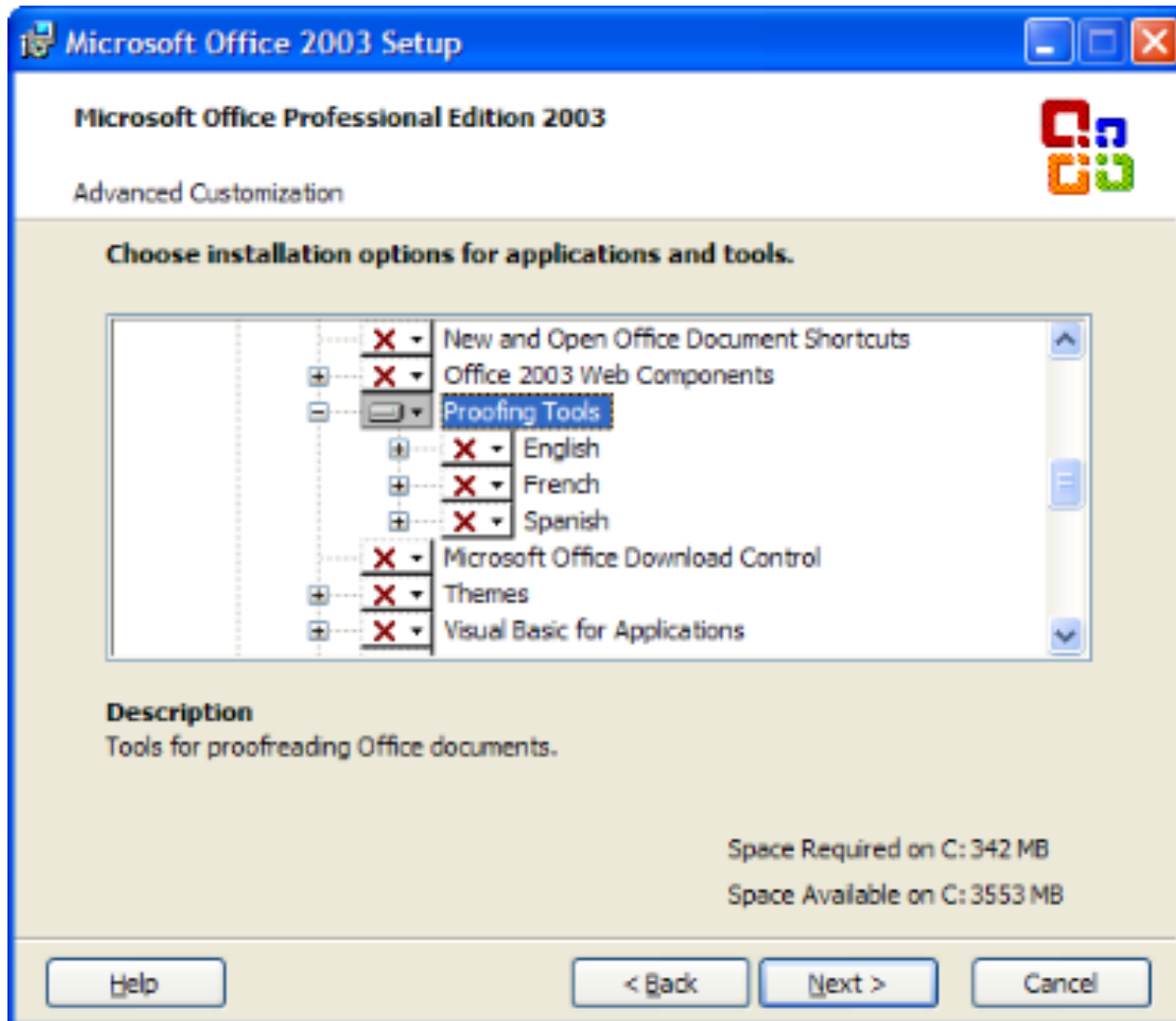
Linux Kernel



Linux-Kernel



Features in Microsoft Office



Bref

bref. CANAL a 30 ans.

ETAPE 1 : DONNE TON PRENOM

MATHIEU

→ OK

← → ↻ bref30ans.canalplus.fr/#c

Variant

← → ↻ [bref30ans.canalplus.fr/#video](#)

ETAPE 3 : JE REGARDE MON EPISODE UNIQUE

DEJÀ 761 545 EPISODES GENERES.

MATHIEU +
présente

▶ ●————— HD ⛶

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Quizz Time

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Apps

Resources

About

Help

STUDENT LOGIN

TEACHER LOGIN

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Enter your teacher's room below

Room Name

Join Room

e9a8d603

Quizz Time

e9a8d603

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

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)





Variability = Complexity

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



Automation?

Avoid solving the same problem!

2, 3...n times



Correctness



A problem has been detected and windows has been shut down to prevent damage to your computer.

PAGE_FAULT_IN_NONPAGED_AREA

If this is the first time you've seen this Stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any windows updates you might need.

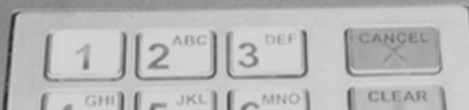
If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced startup options, and then select Safe Mode.

Technical information:

*** STOP: 0x00000050 (0x800005F2, 0x00000000, 0x804E83C8, 0x00000000)

Beginning dump of physical memory
Physical memory dump complete.

Contact your system administrator or technical support group for further assistance.





**Maintenance?
Comprehension?**

Checking Products



2000 Features
100 Printers
30 New Printers per Year



Printer
Firmware

Linux
Kernel

Checking Products



8000 Features
? Products



The development of a

family of software systems

differs from the development of

a **single** software system

THANKS CAPTAIN
OBVIOUS



« The development of a **family** of software systems differs from the development of a **single** software system »

Reuse

Commonality

Customization

Variability

Automation



Assembly Line and Mass Customization



Reuse and Mass Customization



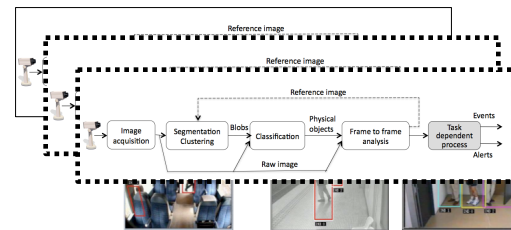
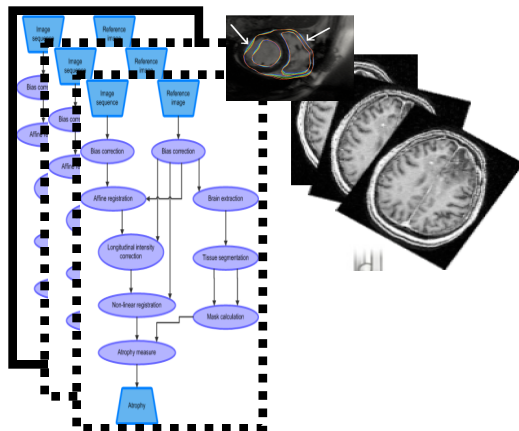
Starting from scratch?



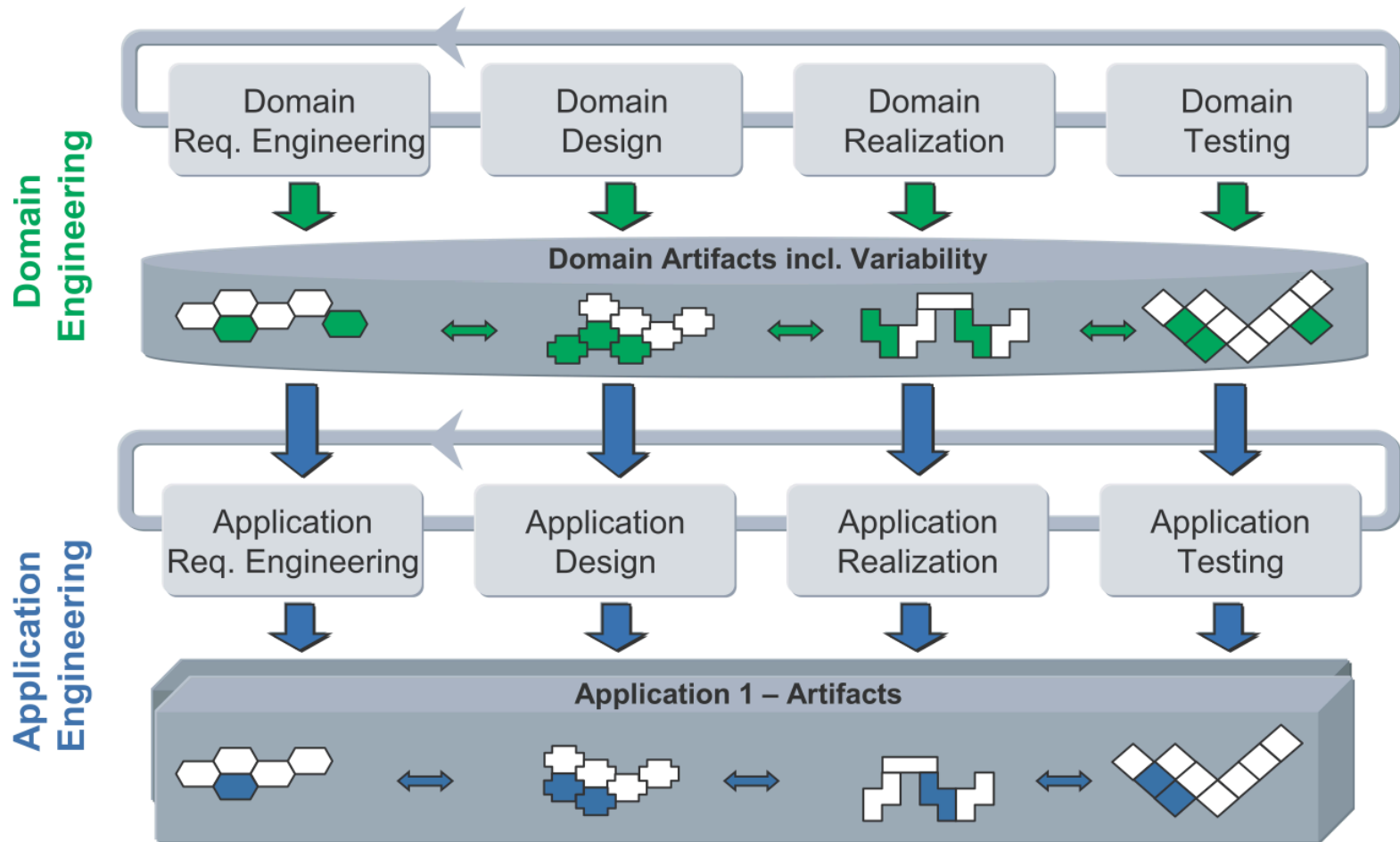
You cannot start from scratch

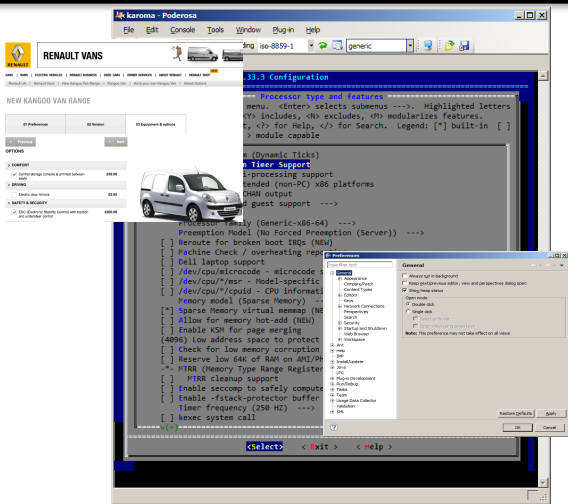
“a set of software- intensive systems that share a common, managed set of features satisfying the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way” [Clements et al., 2001]

Software Product Lines



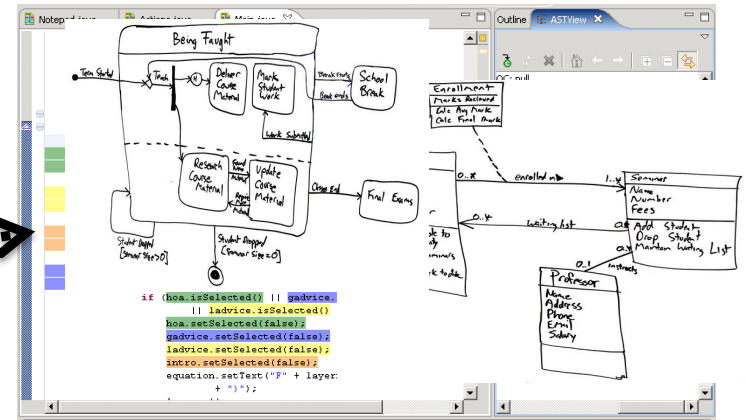
Software Product-Line Engineering





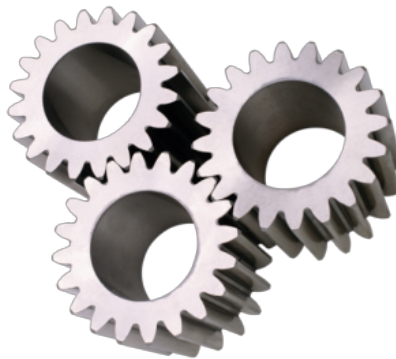
Variability Abstraction Model (VAM)

Variability Realization Model (VRM)



Domain Artefacts (e.g., models)

Configuration (resolution model)



Software Generator (derivation engine)



Mapping: an example

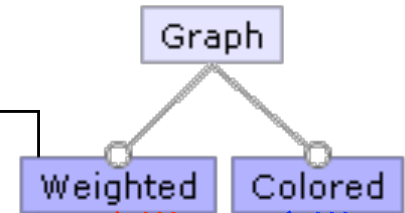
```
class Graph {
    Vector nv = new Vector(); Vector ev = new Vector();
    Edge add(Node n, Node m) {
        Edge e = new Edge(n, m);
        nv.add(n); nv.add(m); ev.add(e);
        e.weight = new Weight();
        return e;
    }
    Edge add(Node n, Node m, Weight w)
    Edge e = new Edge(n, m);
    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();
    }
}
```

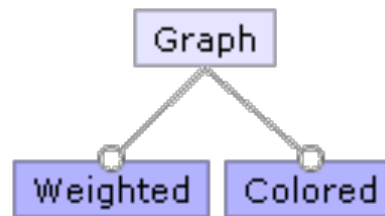
```
class Color {
    static void setDisplayColor(Color c) { ... }
}
```

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

```
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]*/
    }
}

```

```

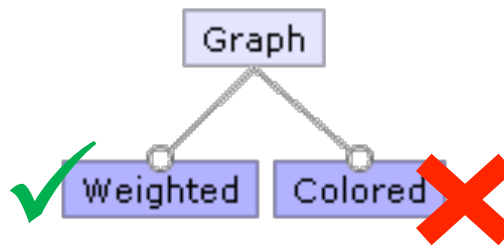
/*if[COLOR]*/
class Color {
    static void setDisplayColor(Color c) { ... }
}
/*end[COLOR]*/

```

```

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();
        }
    }
}
  
```

```

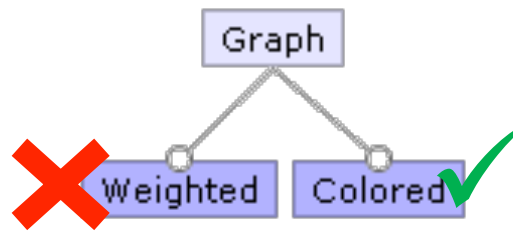
class Edge {
    Node a, b;
    Weight weight;
    Edge(Node _a, Node _b) { a = _a; b = _b; }
    void print() {
        a.print(); b.print();
        weight.print();
    }
}
  
```

```

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);  
    }  
}
```

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

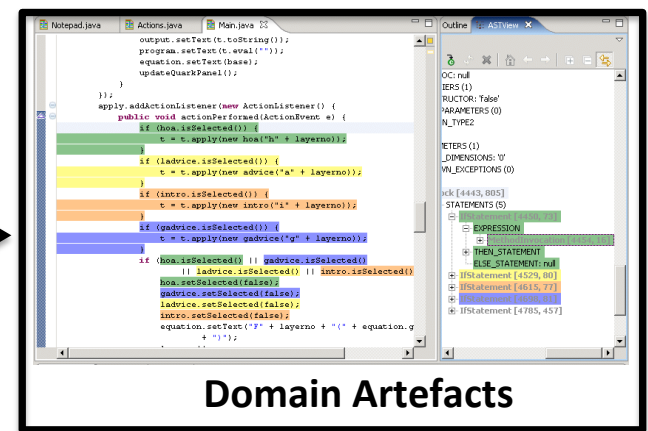
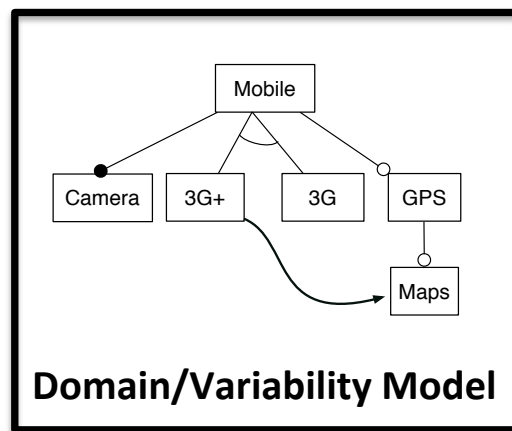
Blame

History

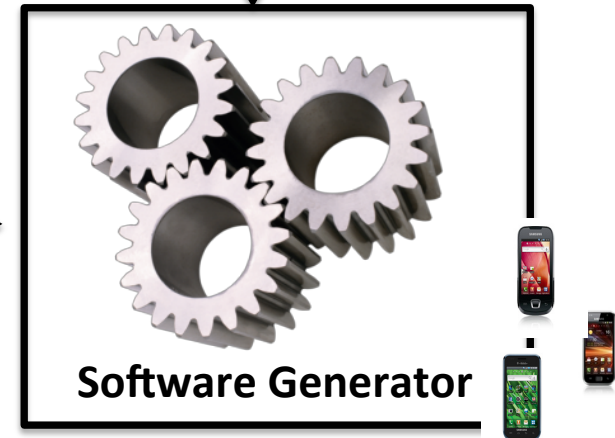
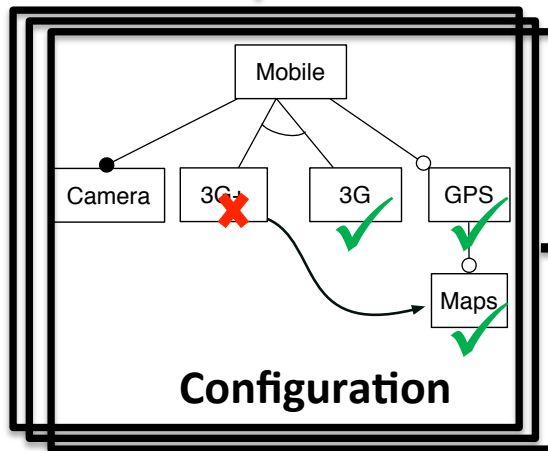


```
1 package <%=packageName%>.config;
2 <% if (databaseType == 'sql') { %>
3 import <%=packageName%>.config.liquibase.AsyncSpringLiquibase;
4 import com.codahale.metrics.MetricRegistry;
5 import com.fasterxml.jackson.datatype.hibernate4.Hibernate4Module;
6 import com.zaxxer.hikari.HikariConfig;
7 import 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') { %>
```

Domain Engineering



Application Engineering



« the investments required to develop the reusable artifacts during **domain engineering**, are outweighed by the benefits of deriving the individual products during **application engineering** »

Jan Bosch et al. (2004)

Software Product Line and Variability Engineering

A revisit of your cursus

What is new?

Family vs single systems

Focus on **reuse**

Domain engineering

Factoring out **commonality**

Managing **variability**

« variability »

Is it really new?

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      Displays files with specified attributes.
attributes  D Directories                R Read-only files
              H Hidden files              A Files ready for archiving
              S System files              I Not content indexed files
              L Reparse Points            - 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)          S By size (smallest first)
              E By extension (alphabetic)  D By date/time (oldest first)
              G Group directories 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
```

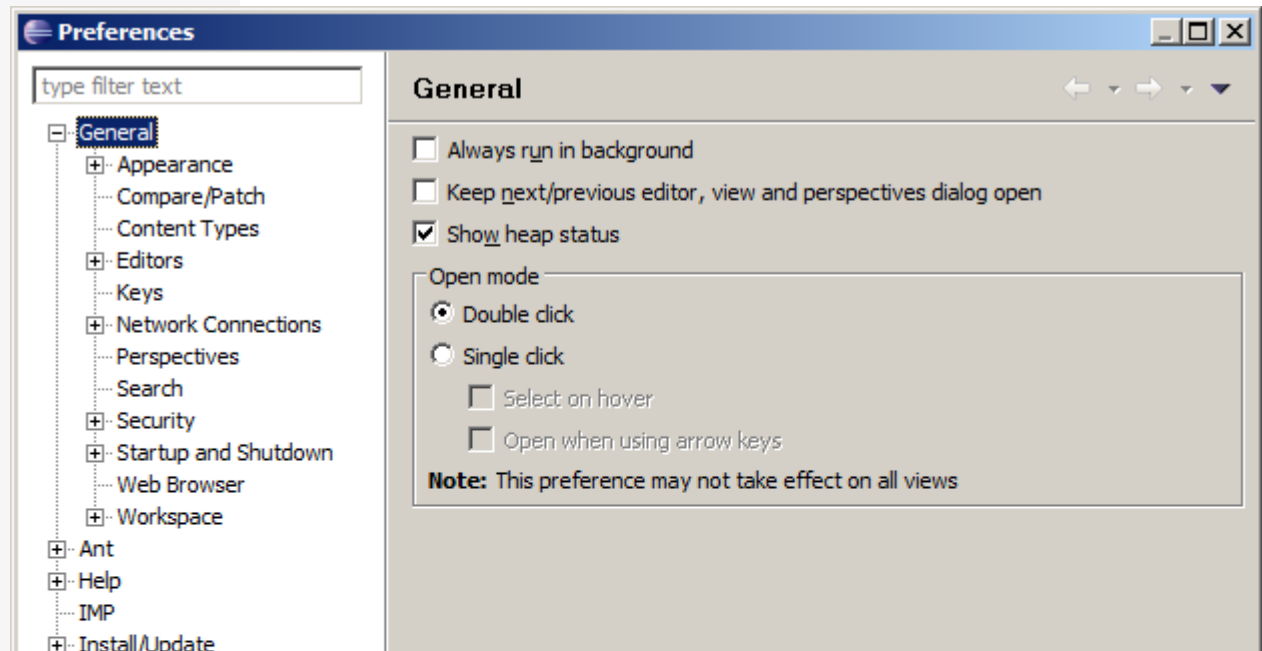
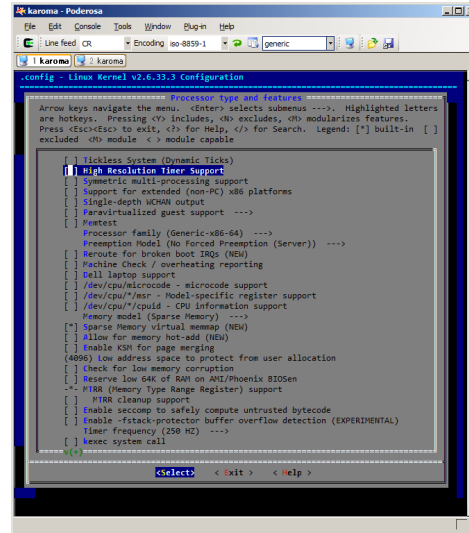
```
HostnameLookups Off
```

```
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
```

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 >> 0) & 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 >> 0) & 0xff;  
}  
.....
```




Replicate & Specialize

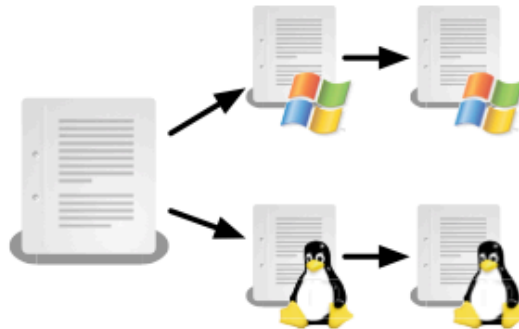


Clone to reuse and adapt existing solutions

- + Less effort needed
- Long-term cost outweighs short-term benefit
- ~ Cost of refactoring rises over time



Platform Variations

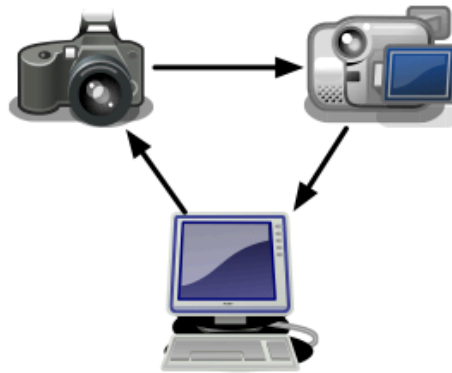


**Clone existing code and fix
low level platform interaction**

- + Avoid complexity of virtualization layer
- Hard to propagate bug fixes
- ~ Ensure consistent behavior of all clones



Hardware Variations



Clone existing driver

- + No risk of changing existing driver
- Code growth
- ~ Dead code can creep into system

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

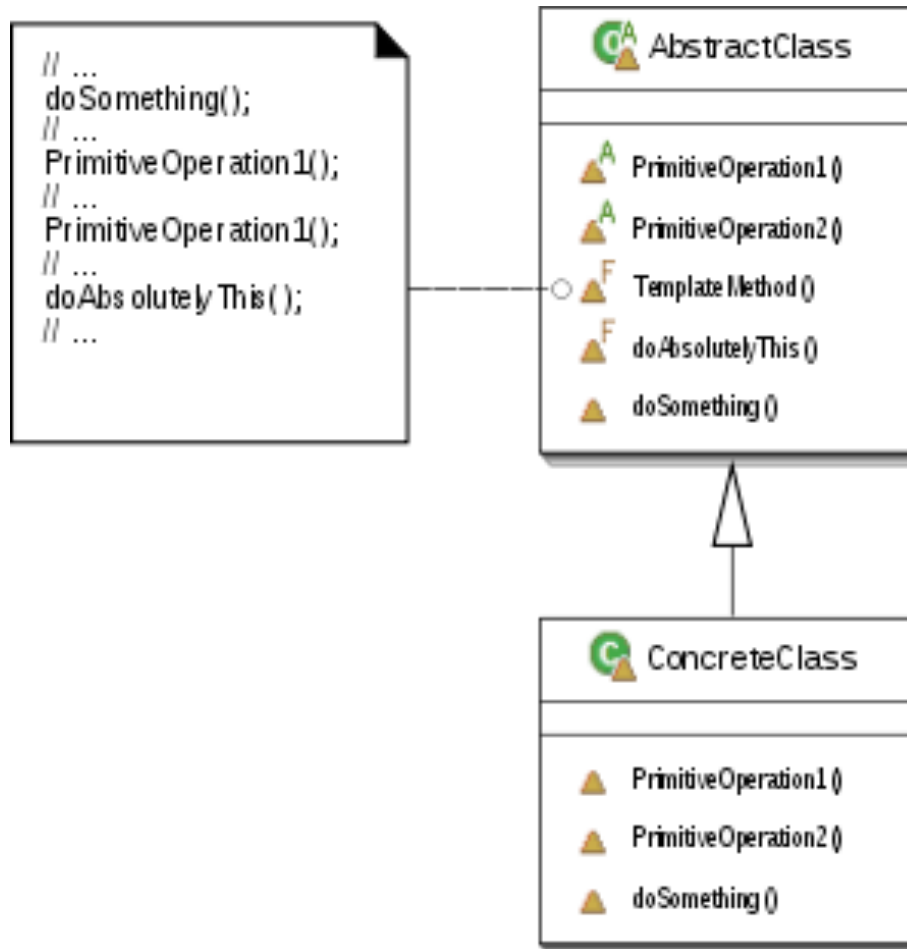
Factory

Strategy

Decorator

....

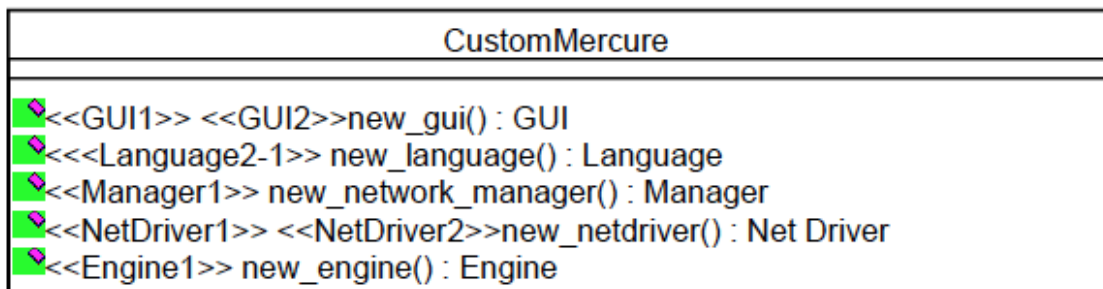
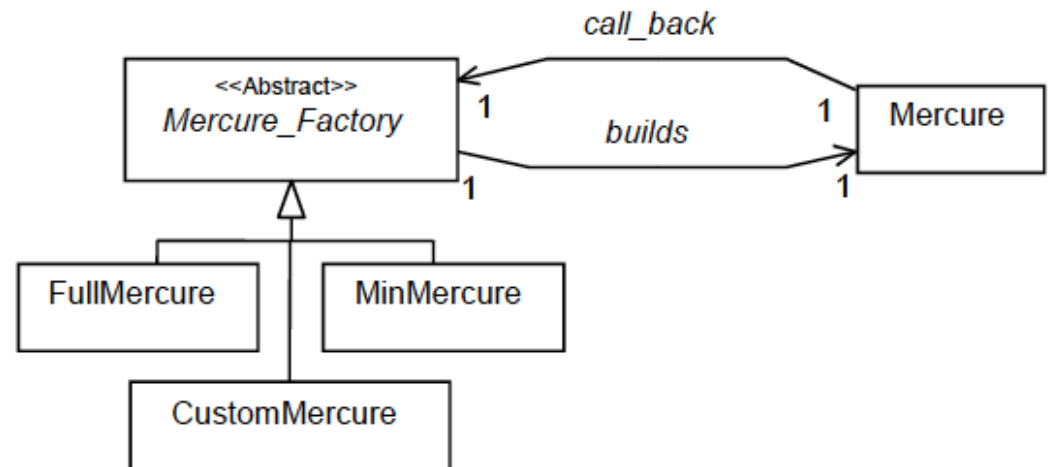
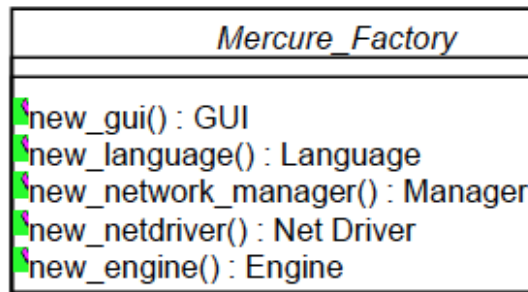
Template Method



The decision model

■ The Abstract Factory Design Pattern

- [Gamma et al 95]



API

Framework

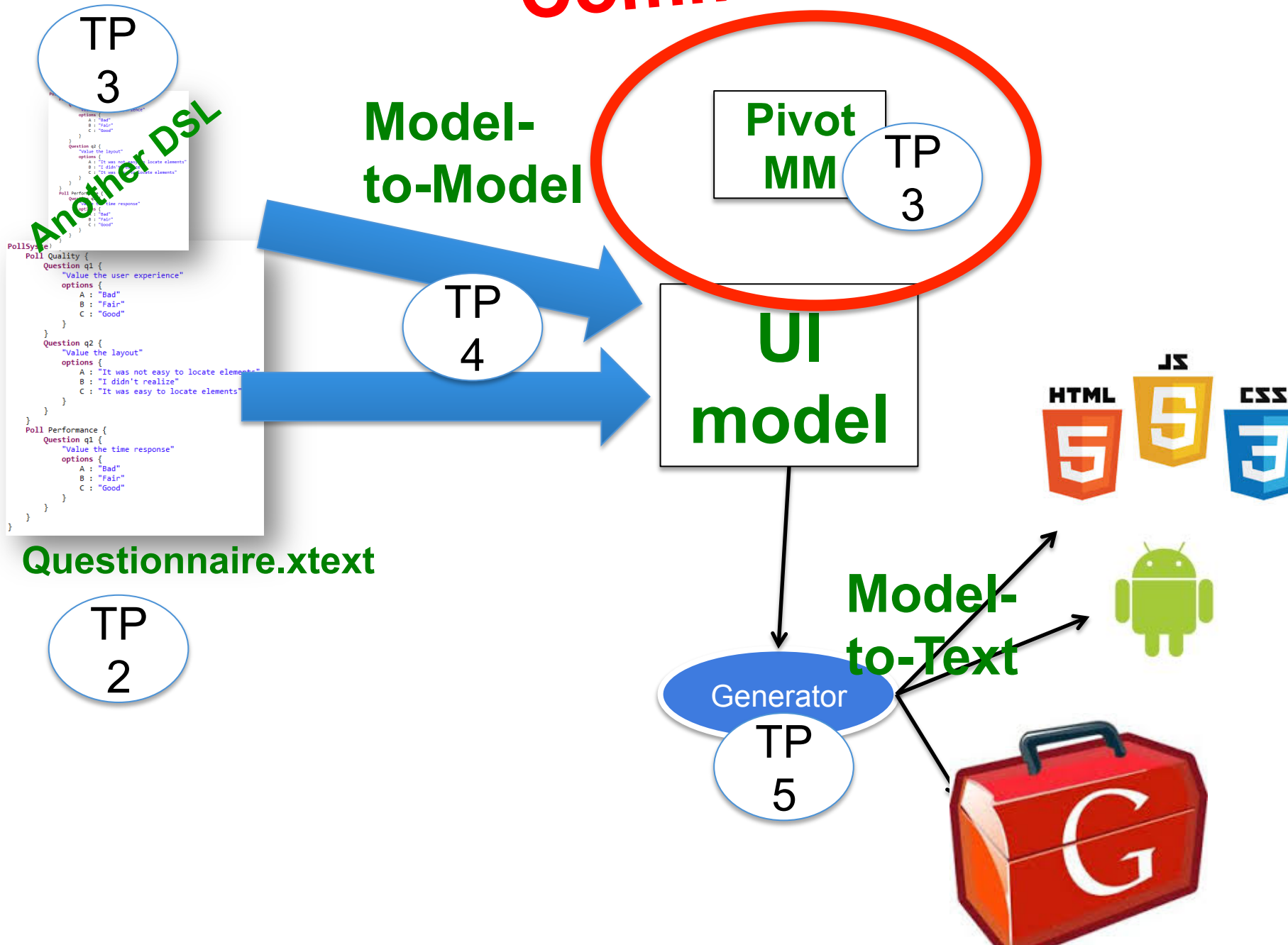
Plugin-based systems

(Active) Annotations

can have parameters

Metamodeling and Domain-Specific Languages

Commonalities



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
```

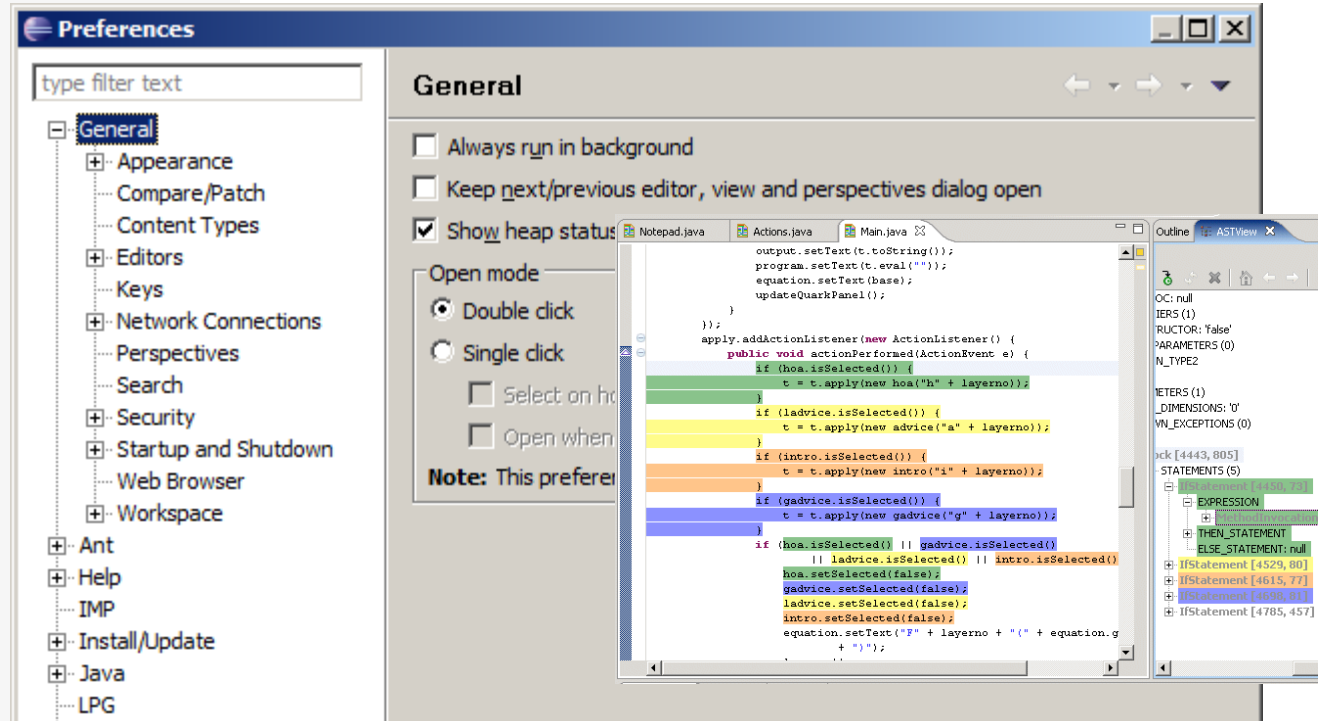
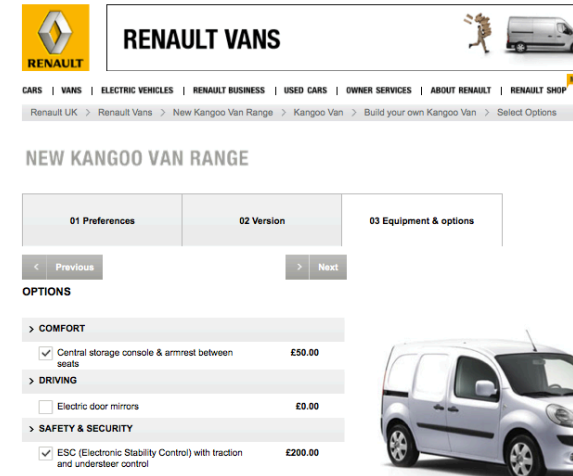
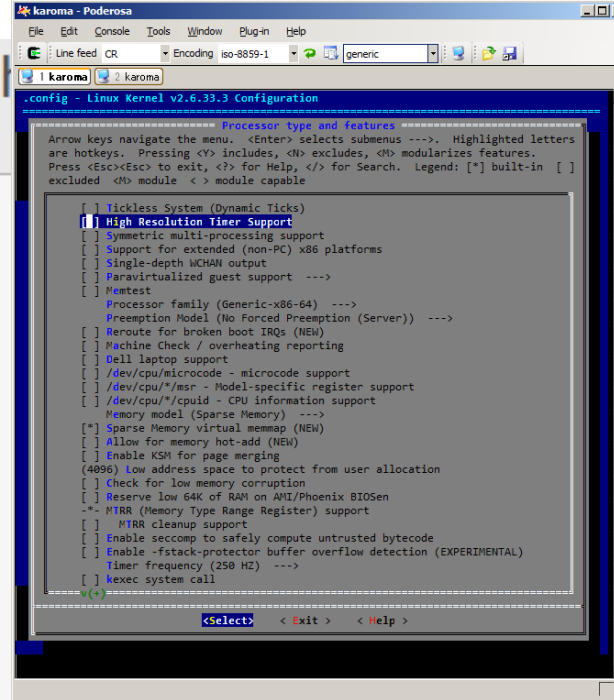
```
ErrorLog logs/error.log
LogLevel error
```

```
PidFile logs/httpd.pid
```

```
Timeout 300
```

```
KeepAlive On
MaxKeepAliveRequests 100
KeepAliveTimeout 15
```

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



Unused flexibility



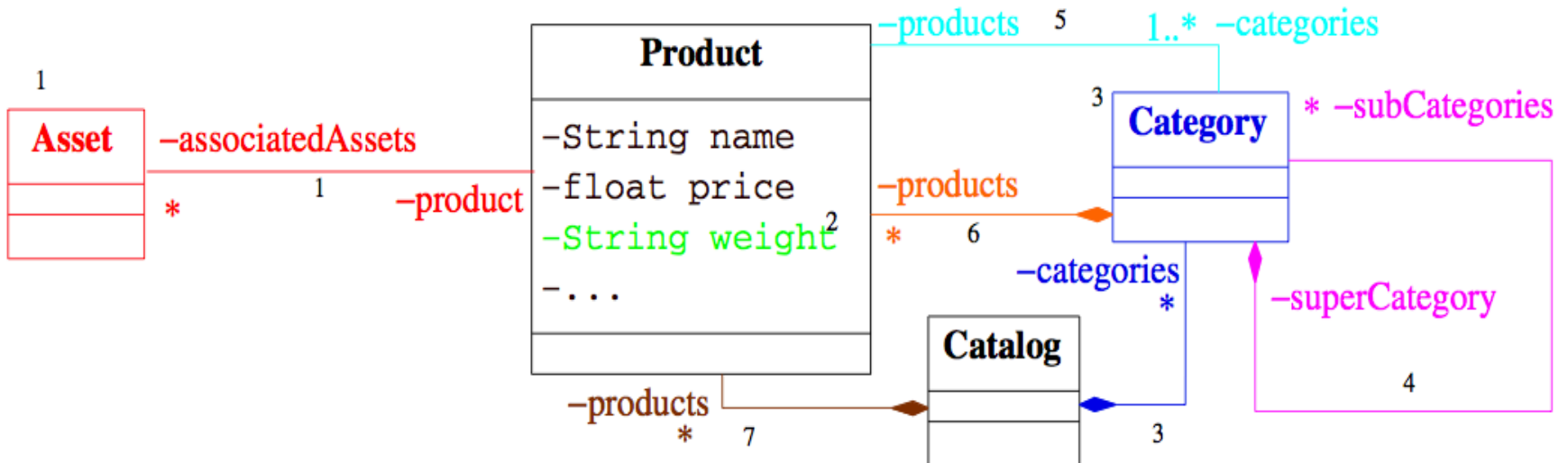


Illegal variant

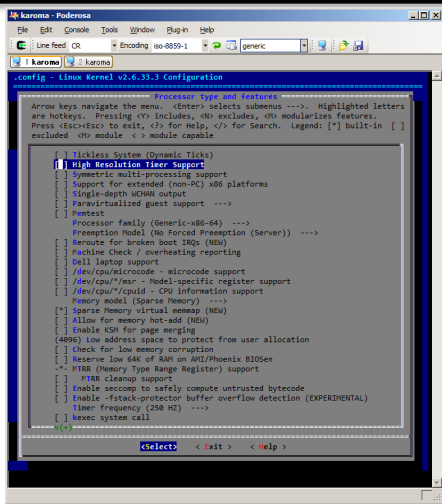
Domain Design

Presence conditions:

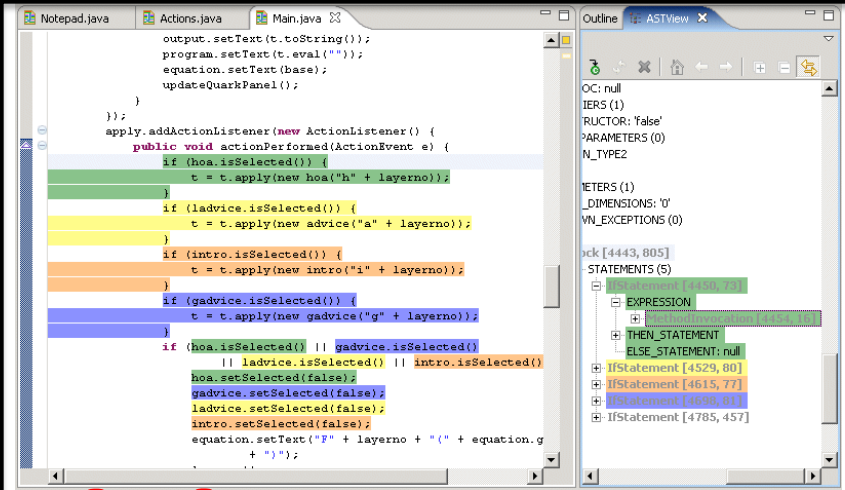
true		MultiLevel		4
AssociatedAssets		1 MultipleClassification		5
PhysicalGoods		2 Categories & !MultipleClassification		6
Categories		3 MultipleClassification !Categories		7



Feature Models



Variability Model

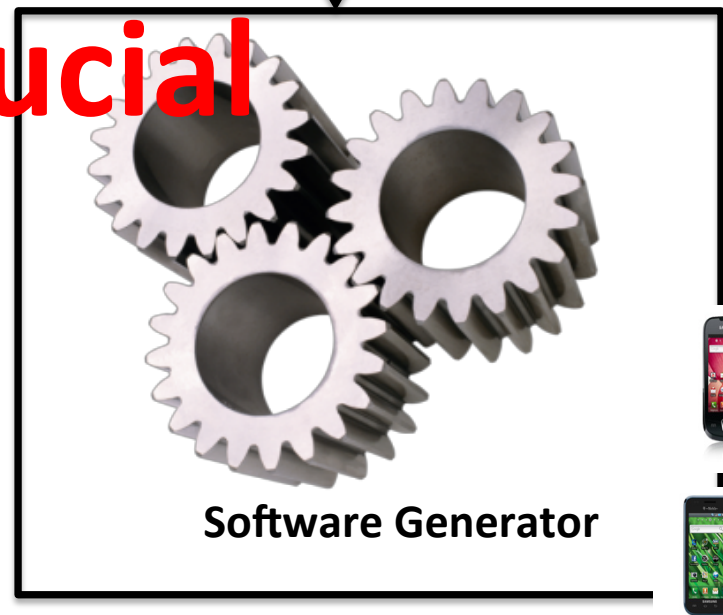


Main Artefacts (e.g., source code)

Modeling
variability
is crucial



Configuration



Software Generator

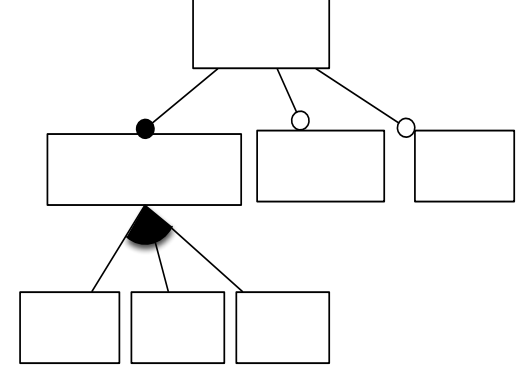
Unused flexibility





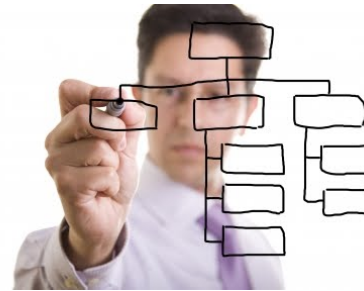
Illegal variant

Feature Model

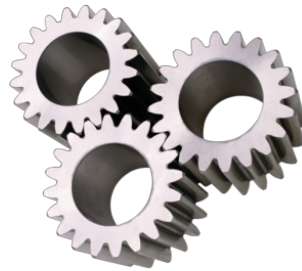


not, and, or, implies

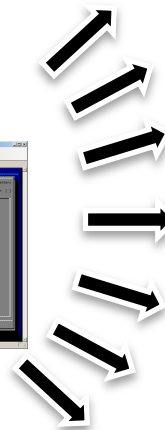
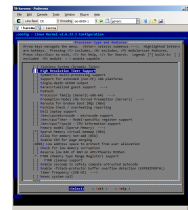
Communicative



Analytic



Generative





R8 Spyder 5.2 FSI quattro R tronic

Prix total

171.216,00 EUR

Prix de base

170.490,00 EUR

Equipements optionnels

726,00 EUR

- ▶ Informations détaillées
- ▶ Entrez l'Audi Code **8**
- ▶ Générer un PDF
- ▶ Nouvelle configuration



[+] Plein écran / Dimensions ▶ Fermer la capote ☒ Habillage ☐ Tableau de bord

Packs

Aucun pack n'est proposé pour ce modèle.

Couleurs

Blanc Ibis

Noir

Prix: 0,00 EUR



Couleurs métallisées à partir de 0,00 EUR



Couleurs à effet perlé à partir de 0,00 EUR



Couleurs personnalisées Audi exclusive

Audi exclusive

Couleur capote

Noir



Jantes

4 Jantes alu 5 BRANCHES ROTOR finition titane 8,5 x 19 à l'avant, 11 x 19 à l'arrière. Pneus 235/35 R19 à l'avant et 305 /30 R19 à l'arrière
Prix: 726,00 EUR

19" à partir de 0,00 EUR





R8 Spyder 5.2 FSI quattro R tronic

Prix total

185.899,35 EUR

Prix de base **170.490,00 EUR**

Équipements optionnels **15.409,35 EUR**

- ▶ Informations détaillées
- ▶ Entrez l'Audi Code **i**
- ▶ Générer un PDF
- ▶ Nouvelle configuration

[+] Plein écran / Dimensions Vue extérieure Tableau de bord

- ▶ Packs d'équipements
- ▶ Extérieur
- ▶ Jantes & pneumatiques
- ▶ Intérieur
- ▶ Volants
- ▶ Sièges
- Sécurité & technique**
- ▶ Infotainment

- ▶ Châssis
- ▶ Freins
- Systèmes d'assistance**
- ▶ Autres

excludes

☒	Régulateur de vitesse	i	320,65 EUR
☐	Système d'aide au stationnement APS avant / arrière	i	931,70 EUR
☐	Système d'aide au stationnement APS avant / arrière avec affichage dans l'écran MMI	i	1.373,35 EUR
☒	Système d'aide au stationnement Advanced : APS avant et arrière et caméra arrière	i	1.790,80 EUR
☒	Audi hill assist : assistance au démarrage en côte	i	Série



Attention:
Le prix peut varier en fonction du choix de moteur et des équipements.

Un aperçu des équipements:

Mode expert

Réinitialiser la sélection

A5 Sportback 3.0 TDI quattro S tronic

Prix total

54.460,15 EUR

Prix de base

50.570,00 EUR

Équipements optionnels

3.890,15 EUR

- Informations détaillées
- Entrez l'Audi Code
- Nouvelle configuration

Vérification de votre sélection

Cet équipement nécessite un équipement complémentaire:

- | | |
|--|--------------|
| ☒ GPS Plus avec disque dur | 2.934,25 EUR |
|--|--------------|

Voici les équipements complémentaires possibles:

- | | |
|---|------------|
| ☐ Ordinateur de bord en couleur avec programme efficiency | 181,50 EUR |
|---|------------|

Remarque: uniquement sur les modèles avec système Start-Stop et uniquement disponible en combinaison avec l'autoradio Concert, l'autoradio Symphony ou un système de navigation

- | | |
|---|--------------|
| ☐ Pack Intenso Plus | 3.100,00 EUR |
|---|--------------|

☐ Sans appareil de navigation

2.934,25 EUR

Série

[+] Plein écran / Dimensions

► Packs d'équipements

- Extérieur
- Jantes & pneumatiques
- Intérieur
- Volants
- Sièges
- Sécurité & technique

Infotainment

Attention:

Le prix peut varier en fonction du choix de moteur et des équipements.

Un aperçu des équipements:

Mode expert

✚ Réinitialiser la sélection

1 Modèle

2 Moteur

3 Extérieur

4 Intérieur

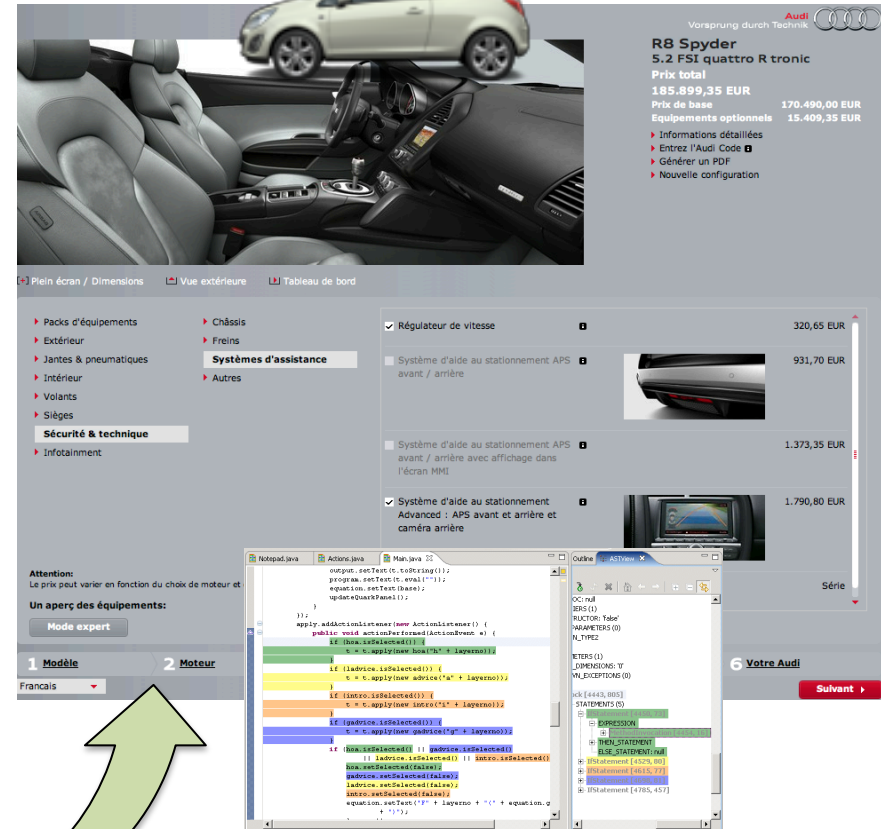
5 Option

6 Votre Audi

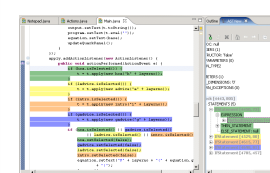
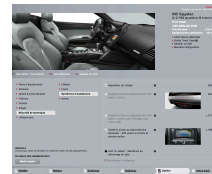
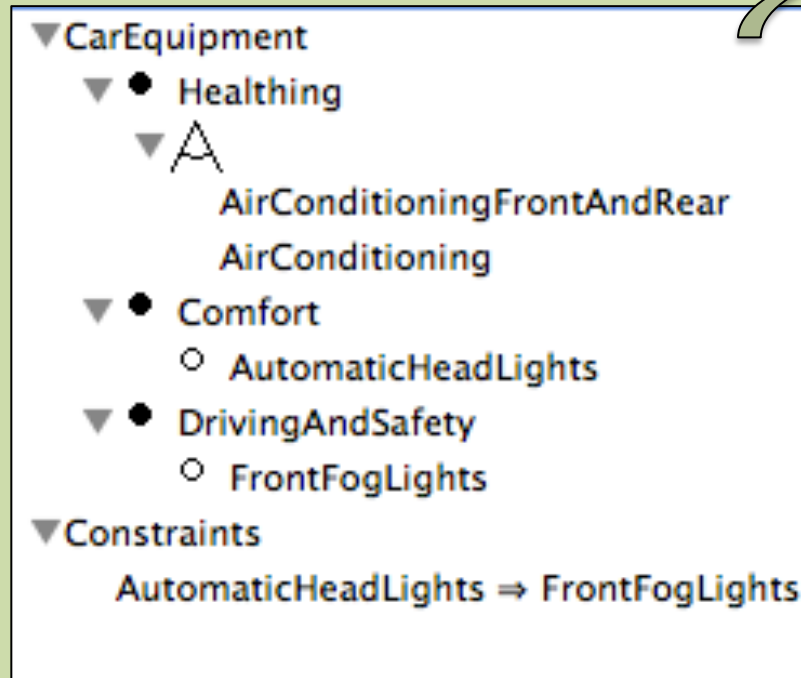
Français

Suivant ►

Feature Models



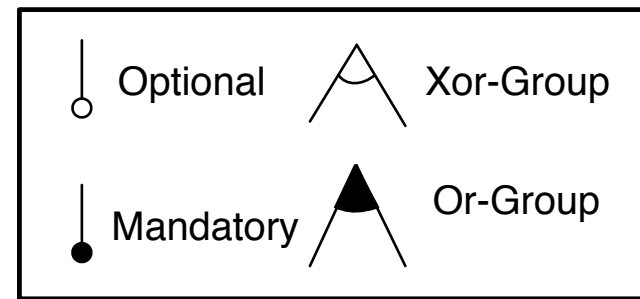
Feature Models (Background)

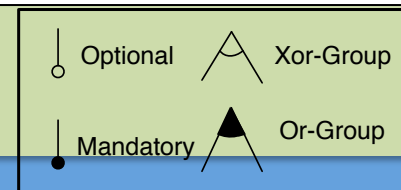
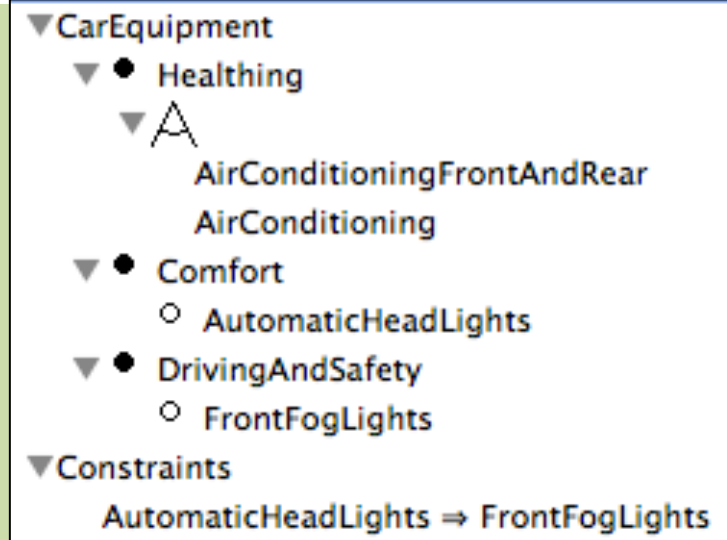
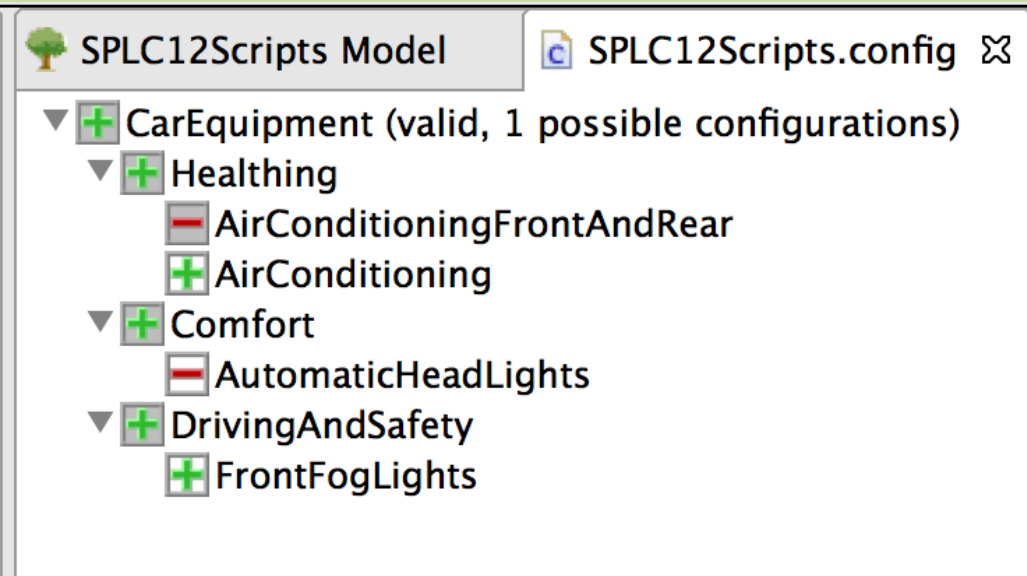


Hierarchy: rooted tree

Variability:

- mandatory,
- optional,
- Groups: exclusive or inclusive features
- Cross-tree constraints



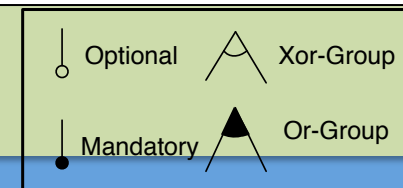
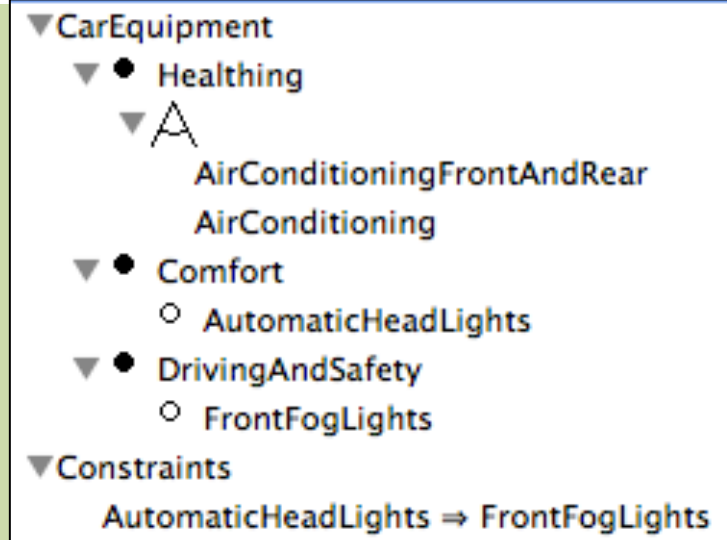
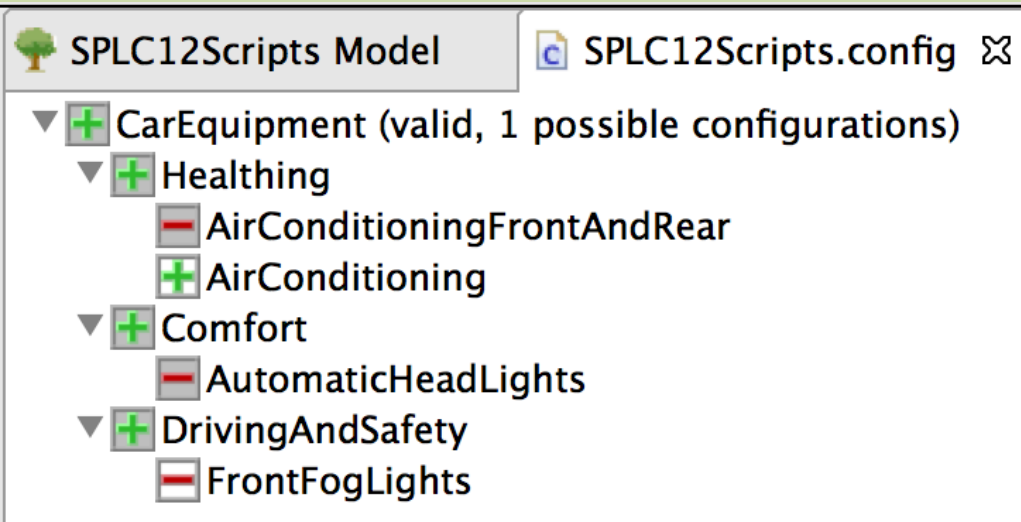


Hierarchy + Variability
=
set of valid configurations

configuration = set of features selected

{CarEquipment, Comfort, DrivingAndSafety, Healthing, AirConditioning, FrontFogLights}



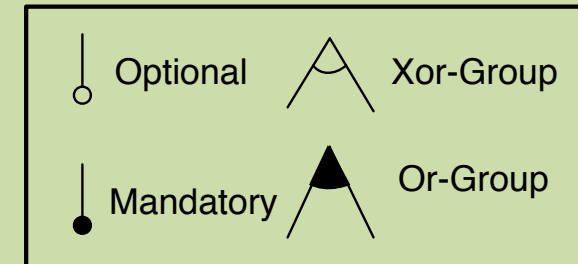
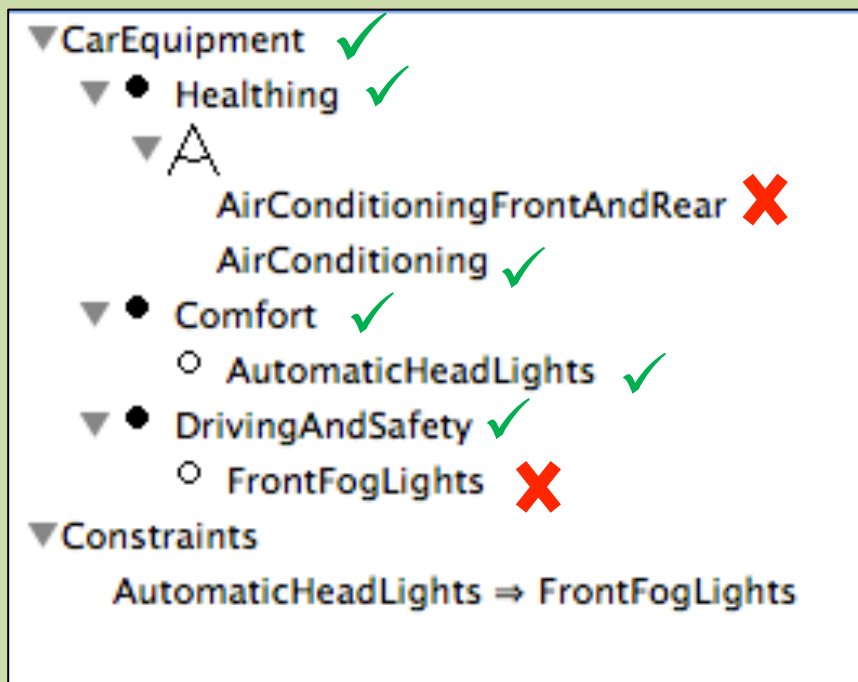


Hierarchy + Variability
=
set of valid configurations

configuration = set of features selected

{CarEquipment, Comfort, DrivingAndSafety, Healthing, AirConditioning}



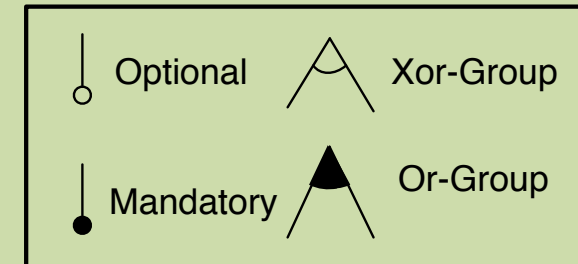
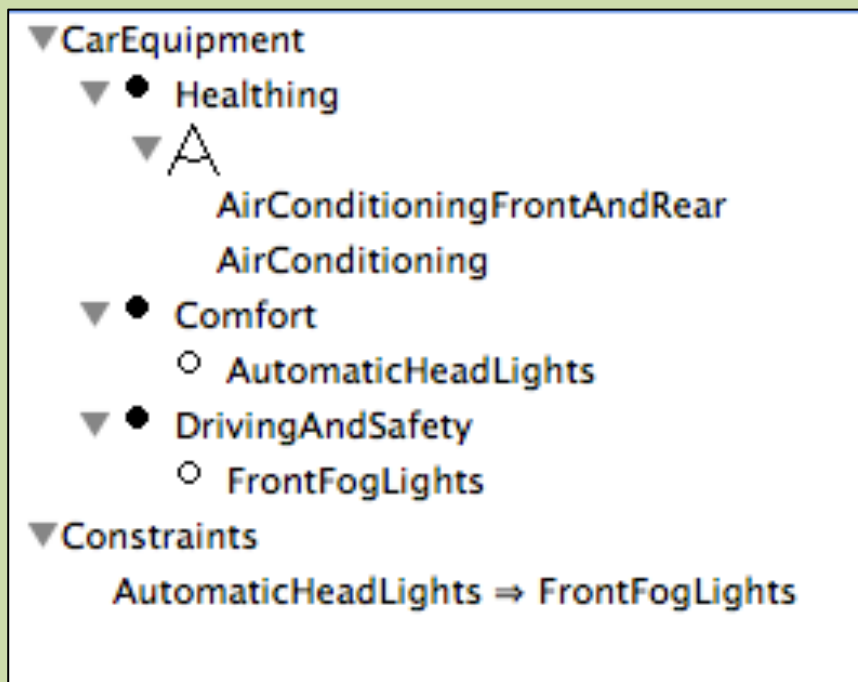


Hierarchy + Variability
 =
set of valid configurations

configuration = set of features selected

{CarEquipment, Comfort, DrivingAndSafety, Healthing, AirConditioning, AutomaticHeadLights}

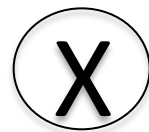




Hierarchy + Variability
 =
set of valid configurations

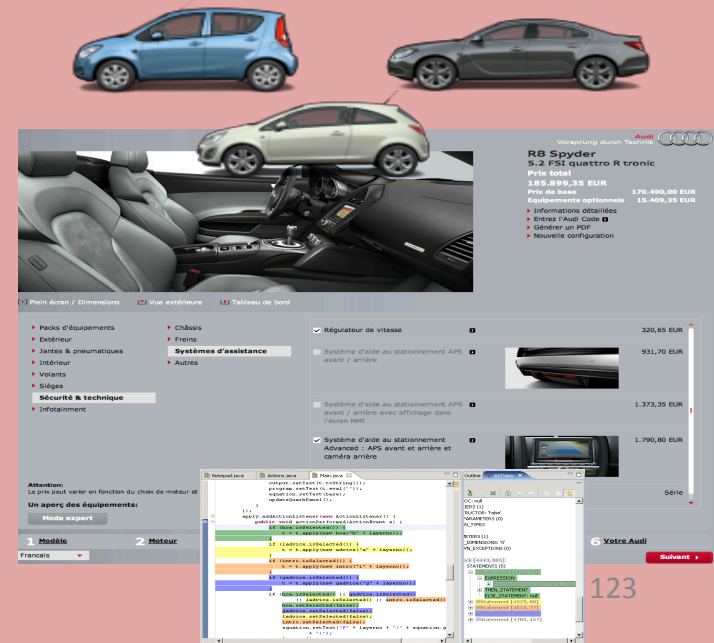
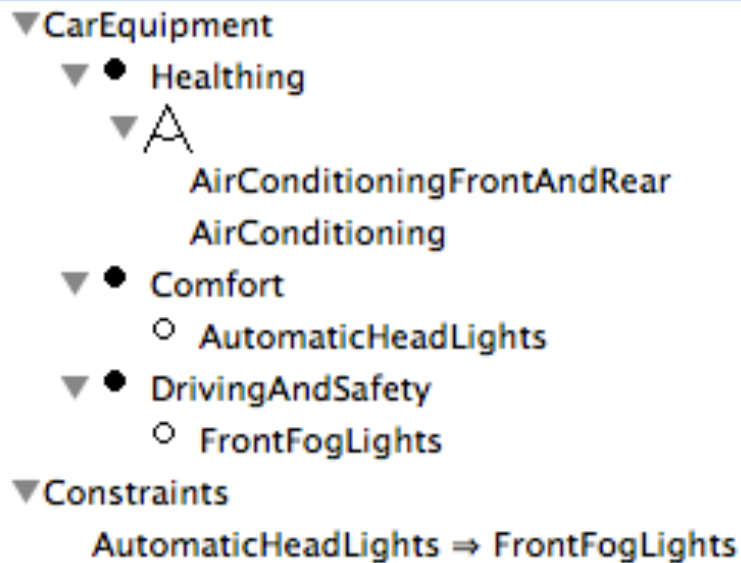
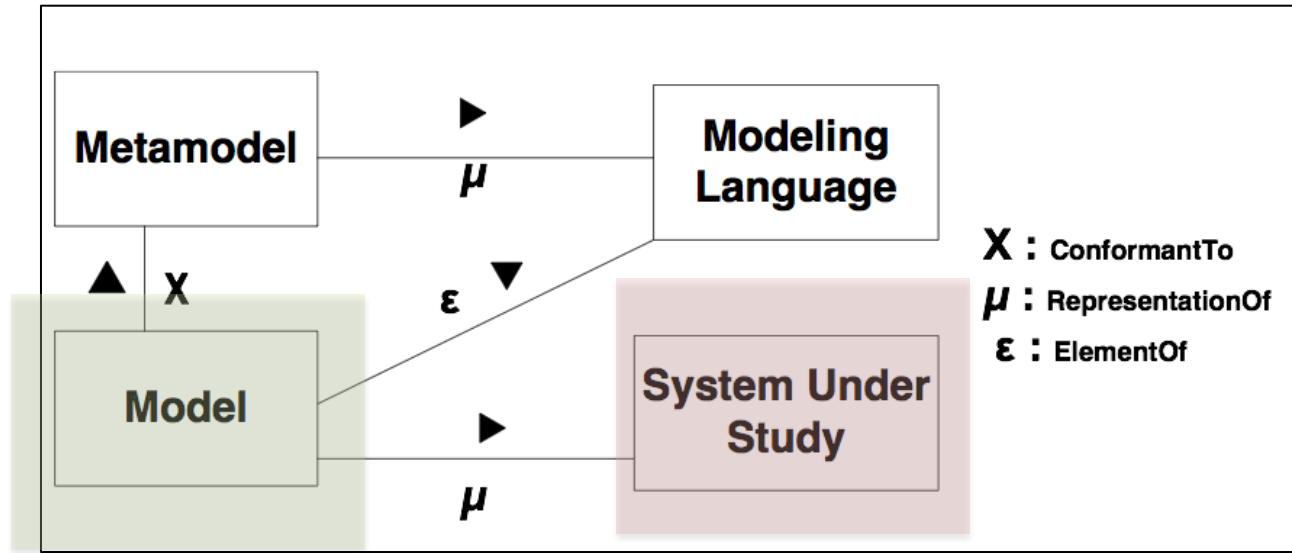


{CarEquipment, Comfort,
DrivingAndSafety,
Healthing}

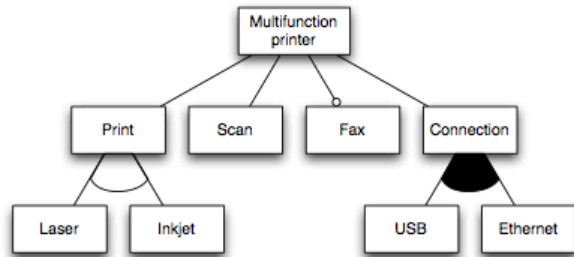


{AirConditioning, FrontFogLights}
 {AutomaticHeadLights, AirConditioning, FrontFogLights}
 {AutomaticHeadLights, FrontFogLights, AirConditioningFrontAndRear}
 {AirConditioningFrontAndRear}
 {AirConditioning}
 {AirConditioningFrontAndRear, FrontFogLights}

Feature Models



Typical implementations



result



logics



solvers

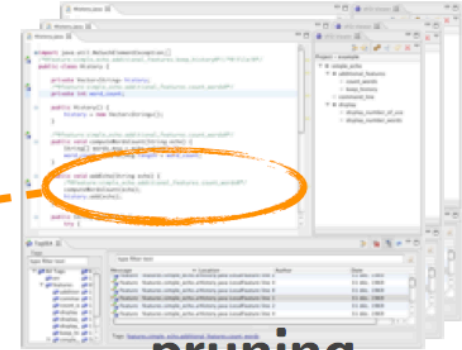
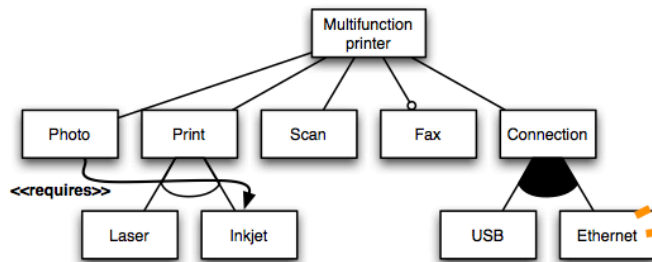


Z3

Product Derivation

feature model

variable model and
code assets



pruning,
composition,
weaving,
transformation

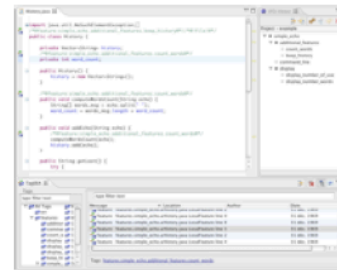
...

configuration

{ MP, Photo, Print, Inkjet, Scan,
Fax, Connection, USB, Ethernet }

product spec

product



Bref
as a product line

ETAPE 2 : CHOISIS 3 BONNS SOUVENIRS



ETAPE 3 : JE REGARDE MON EPISODE UNIQUE

DEJA 1 796 108 EPISODES GENERES.



How MDE (IDM) can help

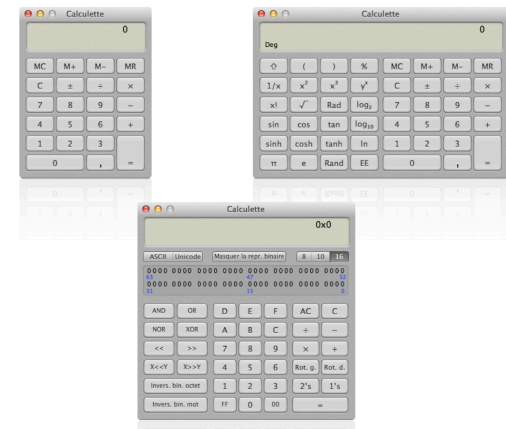
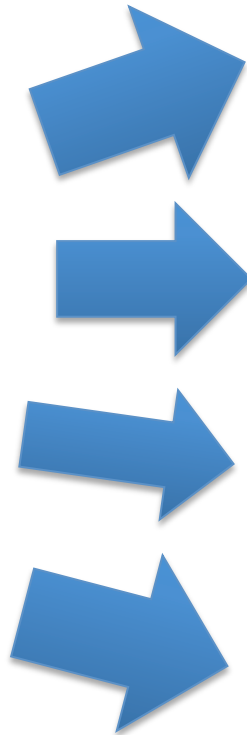
Software Product Line
Engineering

Generative approach

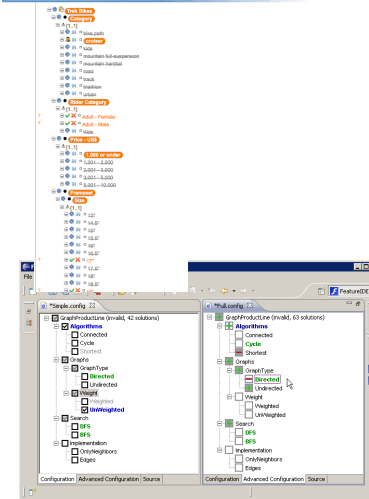
- Programming the generation of programs
 - Very old practice
 - Metaprogramming: generative language and target language are the same
 - Reflection capabilities
- Generalization of this idea:
 - from a specification written in one or more textual or graphical domain-specific languages
 - you generate **customized variants**

Modeling and implementing system families such that a desired system can be automatically generated from a specification written in one or more textual or graphical domain-specific languages.

**Models
And
Languages**

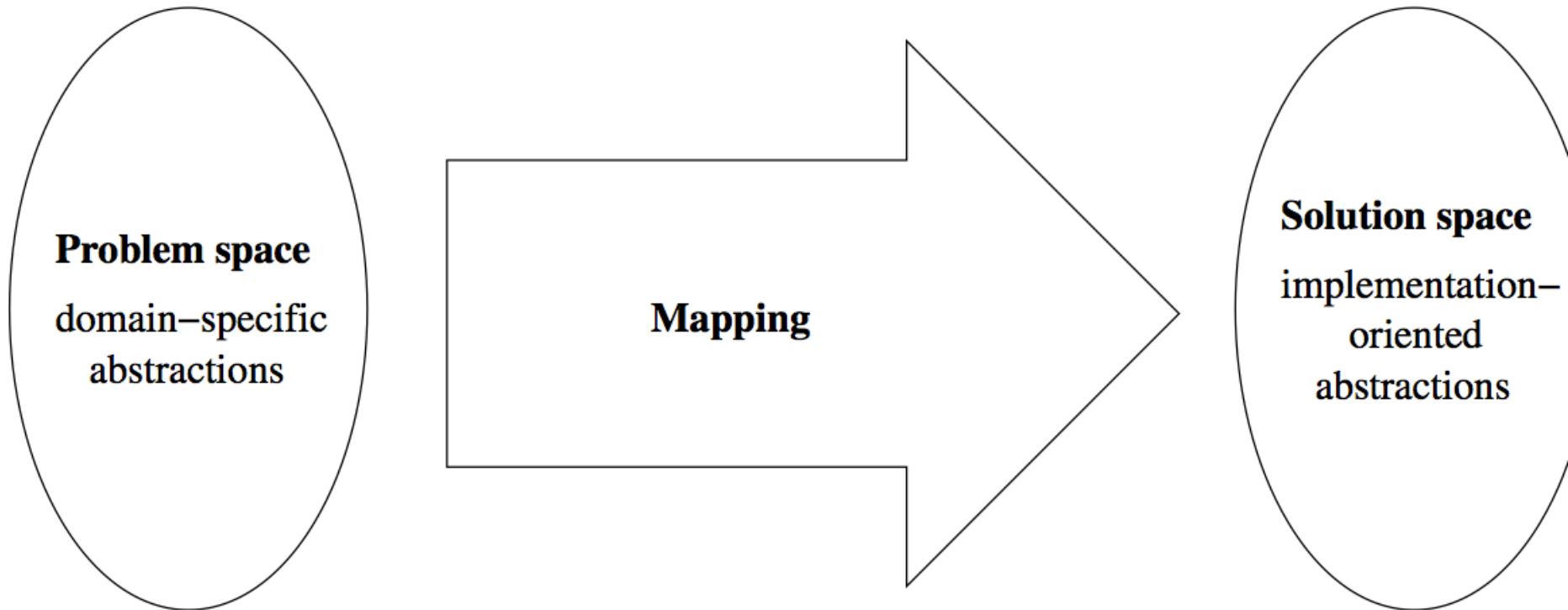


Models And Languages

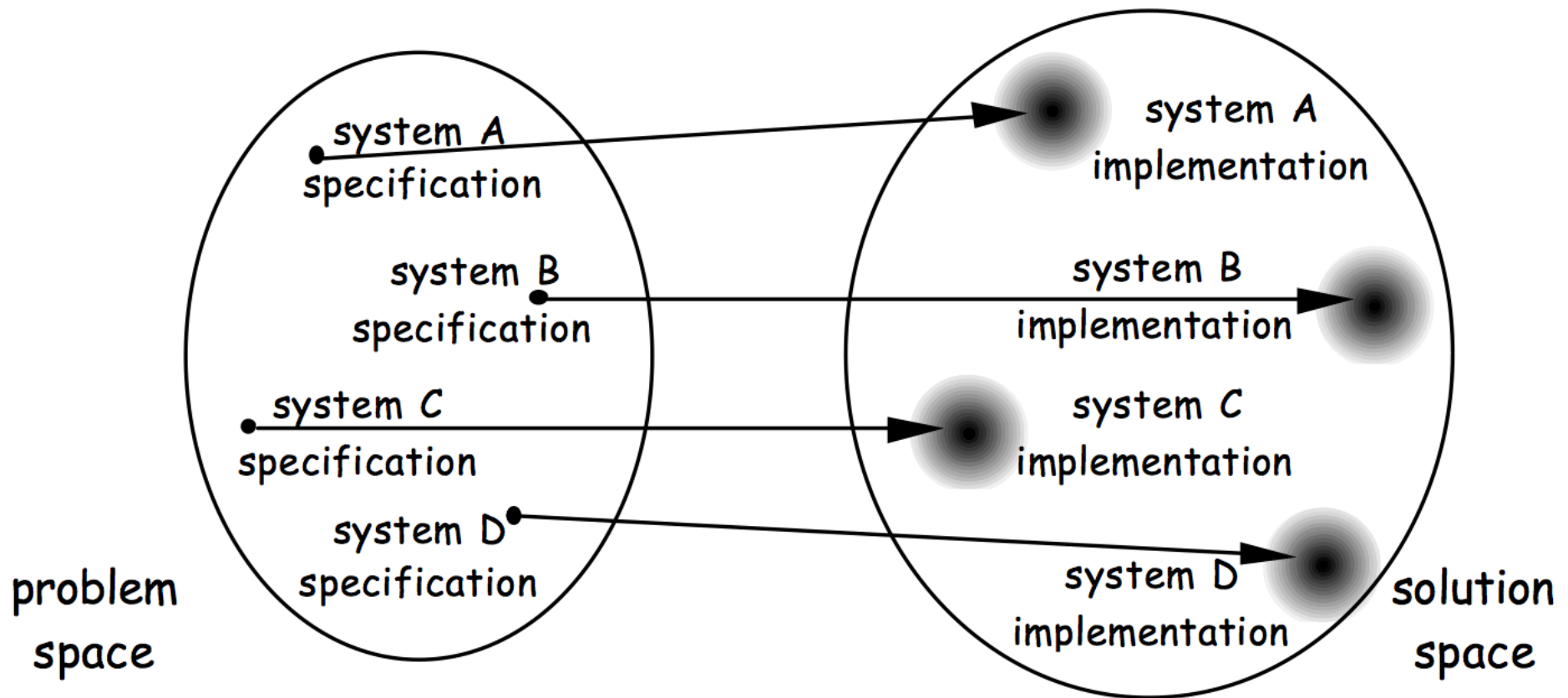


1. Trim/Series	2. Engine/Transmission	3. Colour & Style	4. Option	5. Summary
☐ S				from € 19,495.00
☐ SC				from € 21,195.00
☐ SE				from € 23,495.00
☐ SE				from € 23,495.00
☐ SE				from € 23,495.00
☐ SE				from € 23,495.00

1. Trim/Series	2. Engine/Transmission	3. Colour & Style	4. Option	5. Summary
Interior Comfort/Convenience Option Packs Safety/Security Seating Audio/Command				
Heating/Ventilation Mechanical A-Z				
Safety/Security				
☒	Emergency tire inflation kit			Standard
☒	Active front seat head restraints			€ 103.00
- also adds seat belt unlatched warning light for front passenger's seat				
☐	Front and rear parking distance sensors			€ 467.00
☒	Tyre Pressure Monitoring System			€ 159.00
☐	Remote control ultrasonic security alarm system			€ 397.00



[Czarnecki and Eisenecker 2000]



[Czarnecki, PhD thesis]

Developing Product Lines

Metamodels, DSLs, and Transformations to the rescue

- Domain Engineering
 - Domain Models
 - Level of abstraction
 - Domain-specific modeling languages
 - (visual or textual) syntacs, precise semantics
 - analyzed (verification)
 - Traceability between the artefacts
- Application Engineering
 - Model transformations (automation)
- Reduce the gap

Summary

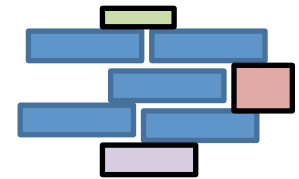
- **Software product line engineering**

- Mass customization
- Family of software intensive systems
- Systematic reuse
- Domain engineering
- Variability management



- **Variability** everywhere

- Applied and applicable to many industries and domains



- **Modeling** and **implementing** variability: an overview