



# Software Product Line Engineering

**modeling and managing variability  
of software intensive systems**

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University of Namur  
PReCiSE Research Centre

# Material

- [http://www.fundp.ac.be/etudes/cours/page\\_view/INFOM435/](http://www.fundp.ac.be/etudes/cours/page_view/INFOM435/)
  - Folder: “Documents\_sur\_VariabilityAndSPL”
  - Slides, exercises, evaluation

The screenshot shows a web-based course management interface. At the top, there's a header with links for 'Mon bureau', 'Liste de mes cours', 'Mon compte utilisateur', and 'Quitter'. Below the header, it displays the course information: 'Questions spéciales d'ingénierie du logiciel et de l'information INFOM435 - Vincent ENGLEBERT, Naji HABRA, Jean-Luc HAINAUT, Patrick HEYMANS'. The main content area is titled 'Documents et liens' and shows a list of files:

Nom	Taille	Date	Modifier	Supprimer	Déplacer	Visibilité
CoursAgile				X		
CoursQualité				X		
documentation_MoCQA				X		
documents_sur_VariabilityAndSPL				X		
Software product line engineering (variability modeling and management)				X		
Syllabus						

- Email: [macher@fundp.ac.be](mailto:macher@fundp.ac.be)

# Organization

- ~ 5 courses (2h)
  - interactive!
- ~ 10 “labs” (2h)
  - interactive!
  - ~ additional work needed

# Spirit of the course

- **Practical interest:** software product line engineering is applied in **industry** and in different **domains**
  - Alcatel, Hewlett Packard, Philips, the Boeing Company, Robert Bosch GmBh7, Motorola, Cummins, Nokia
  - mobile phones, telecom networks, medical systems, computer printers, diesel engines, cloud computing, cars, ships, and airplanes,
  - open source projects
- **Practical use** of tools and modeling techniques
  - theory will be hidden as much as possible
- Related to our research activities



# SPL team

## ★ Academic collaborations



**SOFTWARE SYSTEMS**

Prof. Dr. Klaus Pohl  
Institute for Computer Science and Business



The Open  
University



JOHANNES KEPLER  
UNIVERSITÄT LINZ | JKU



## ★ Industrial collaborations



**THALES**

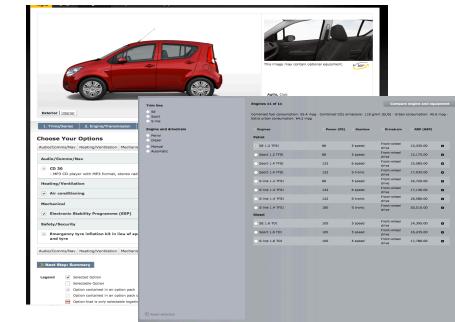
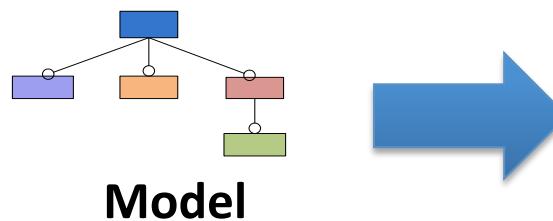


**SIEMENS**



# Evaluation

- Running project
  - a concrete car configurator at the end
  - **reverse engineering** and **modeling** an existing car configurator
  - model-based approach to **automatically generate customized** configurators



- A set of mini-projects
  - step-by-step

# Evaluation

- Groups (2 or 3 students)
  - Running project: a concrete car configurator at the end
    - 70% of the final mark
    - Defense = exam
  - A set of 3 mini-projects
    - 10% of the final mark by project
    - not every exercise will be evaluated
      - I will let you know when it is the case and give precise instructions
- 
- The diagram consists of two parts. On the left, there is a hierarchical tree structure with a blue root node at the top, which branches down to three orange nodes. These orange nodes further branch down to four green nodes. Below this structure is the word "Model". To the right of a large blue arrow is a screenshot of a car configurator application. The screenshot shows a red hatchback car on the left, with a small image of the interior on the right. The main interface has several tabs at the top: "Choose Your Options", "Configure", "Compare", "Buy", and "Contact". Under "Choose Your Options", there are sections for "Audio/Entertainment", "Exterior", "Interior", "Performance", "Safety", and "Mechanical". Each section contains various checkboxes for different options like "CD player", "Navigation", "Sunroof", etc. The "Exterior" section is currently selected. On the right side of the interface, there is a table showing "Model Options" with columns for "Model", "Price (EUR)", "Vehicle Type", and "Order Number". There are several rows of data in the table.

# Goal of this course

- **software product line engineering**
  - Not necessary new! Linux kernel?
- **variability**
  - Not necessary new! features, parameters, command lines, configuration files?
- **modeling and implementing**
  - Not necessary new! KConfig? Preprocessor?
- **Fun**
  - Running project: a car configurator
    - Different exercises
  - Exercises are related to our research activities
  - Applied in industry

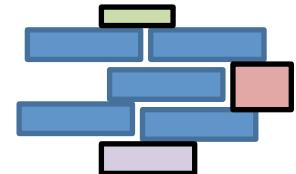
# Goal of this course

- You will learn **software product line engineering**



- You will see **variability** everywhere

- You will **model** and **implement** variability



- You will have **fun**

- Running project: a car configurator

# Today, a glimpse of

- Software product line engineering



- Variability intensive systems

- Techniques for modeling and implementing variability

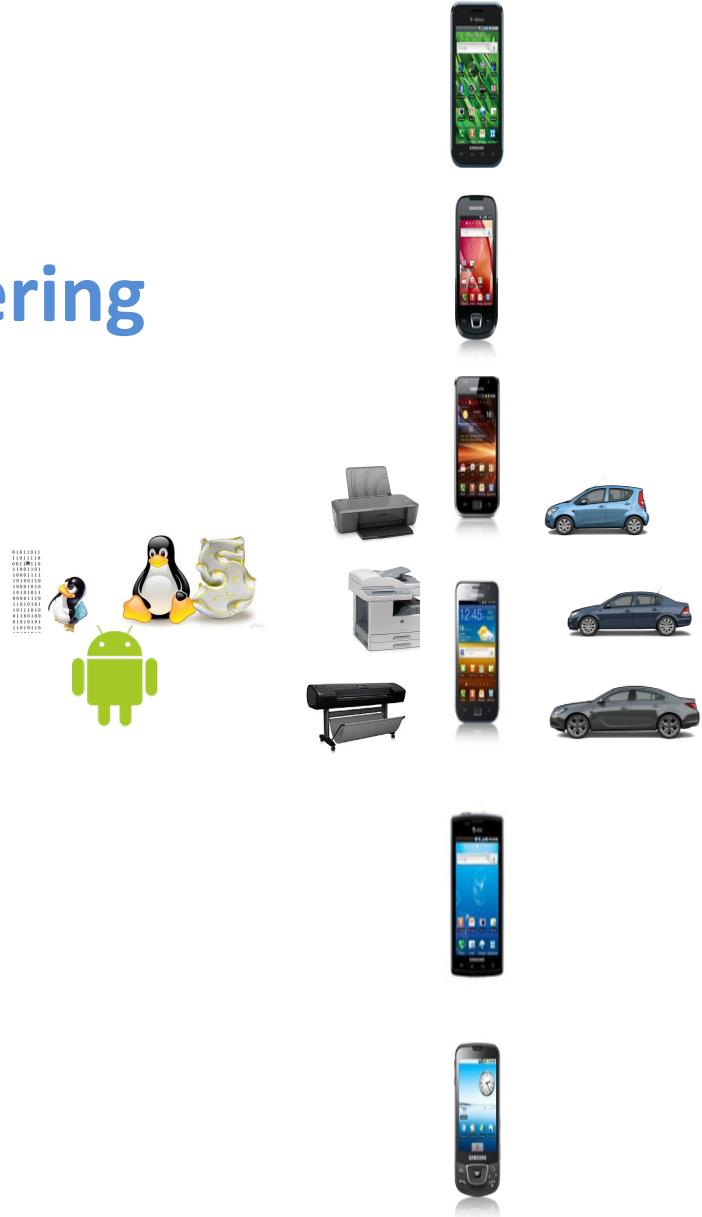
- Your running project: a car configurator



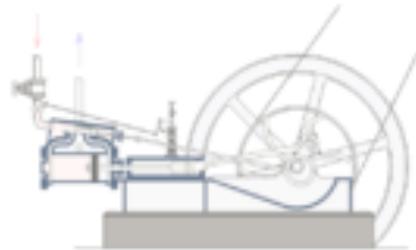
# Software product line engineering

and

## Variability intensive systems



# A Bit of History: Industrial Revolution



1698  
Thomas Savery



1881



1901  
Henry Ford



1980s

# Nowaday: Product Lines Everywhere



# Product Lines of Cars



This image may contain optional equipment. [360°](#)

**Agila, Club**  
1.2i 16v, 5 Speed  
Blaze Red, Melt / Elba Charcoal  
**Total** € 15,684.00

[Exterior](#) | [Interior](#)      [Side](#) | [Front](#) | [Rear](#)      [360°](#)

[1. Trims/Series](#) | [2. Engine/Transmission](#) | [3. Colour & Style](#) | [4. Options](#) | [5. Summary](#)      [Next Step](#)

**Choose Your Options**

<input type="checkbox"/> CD 30	Standard	- MP3 CD player with MP3 format, stereo radio, steering wheel mounted audio controls
<input checked="" type="checkbox"/> Air conditioning	€ 923.00	
<input checked="" type="checkbox"/> Electronic Stability Programme (ESP)	€ 411.00	
<input checked="" type="checkbox"/> Emergency tyre inflation kit in lieu of space-saver spare wheel and tyre	Standard	

[Audio/Comms/Nav](#) | [Heating/Ventilation](#) | [Mechanical](#) | [Safety/Security](#) | [A-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 R 15 tyres and flush wheel covers	€ 0.00
<b>Options (2)</b>	
You selected:	
<input checked="" type="checkbox"/> Air conditioning	€ 923.00
<input checked="" type="checkbox"/> Electronic Stability Programme (ESP)	€ 411.00
<b>Total</b>	<b>€ 15,684.00</b>

**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  
PASSWORD  
>>ANMELDEN

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

modell-details >> hier clicken

>>SELVE SCHUHREGAL Inhalt:0

>>SHOPPING BAG Inhalt:0

A. Erstes Oberleder  
 Veloursleder Sand  
 Veloursleder Bordeaux  
 Veloursleder Cognac  
 Veloursleder Sand  
 Putzenleder  
 Beige

B. Absatz  
 Hufeisen Braun

C. Sohle  
 Gummisoche

>>ÄNDERN  
 >>ZURÜCKLEGEN

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

File Edit View History Bookmarks Tools Help

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

Müsli individuell online mixen! Bio-M... +

mymuesli 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.

**Ananas**  
lecker, exotisch und wunderbar | 0.65€ (30g)  
[mehr Infos](#)

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

**Aprikosen**

hoch ▲ ▼ runter

Apfelstücke  
Buchweizenflocken  
C'Mohn, baby!

Nährwerte pro 100g ▲  
**575g nur 4,70€**  
entspricht 8,17€/kg  
inkl. MWSt., zzgl. Versandkosten

fertig gemixt?  
weiter

Done en-US

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

File Edit View Go Bookmarks Tools Help

Getting Started Latest Headlines

<http://configure2.euro.dell.com/dellstore/config.aspx?c=de&cs=dedhs1&kc=3058j=de&oc=W06390xp&s=dhs&sbc=pr>

Bestellen Sie online oder wählen Sie 0800 533 55 40 03(gebührenfrei)

**DELL** Produkte Service Support Einkaufsunterstützung Suche

Dell empfiehlt Windows Vista™ Home Premium.

Sie befinden sich hier: Deutschland > PRIVATANWENDER

**1 Meinen Dell konfigurieren** **2 Zubehör auswählen** **3 Elektronik** **4 Software & Service** **5 Bestätigen & zum Warenkorb hinzufügen**

Als Symbol anzeigen

ECC DDR2-SDRAM-Speicher mit 4,0 GB und 667 MHz (2 x 2,0 GB DIMM) [plus 0,19,99 € oder zu 0 €/Monat]

**Grafikkarte**

128 MB nVidia NVS285 DVI/VGA-Grafikkarte

Auswahlhilfe

- 256 MB ATI Fire GL V7200-Grafikkarte [plus 416,50 € oder 13 €/Monat<sup>1</sup>]
- 128 MB nVidia Quadro FX550-Grafikkarte [plus 69,02 € oder 2 €/Monat<sup>1</sup>]
- 256 MB nVidia Quadro FX3450-Grafikkarte [plus 547,40 € oder 17 €/Monat<sup>1</sup>]
- 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 €/Monat<sup>1</sup>]
- 128 MB ATI Fire GL V3400-Grafikkarte [plus 44,03 € oder 1 €/Monat<sup>1</sup>]

**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 €]
- 80 GB Serial ATA-II-Festplatte (7.200 U/min) mit NCQ [Im Preis enthalten]

Sicher Einkaufen mit Trusted Shops und Gutes-Geld-zurück-Garantie.

**Dell Precision™ 390 Essential (W06390xp)**

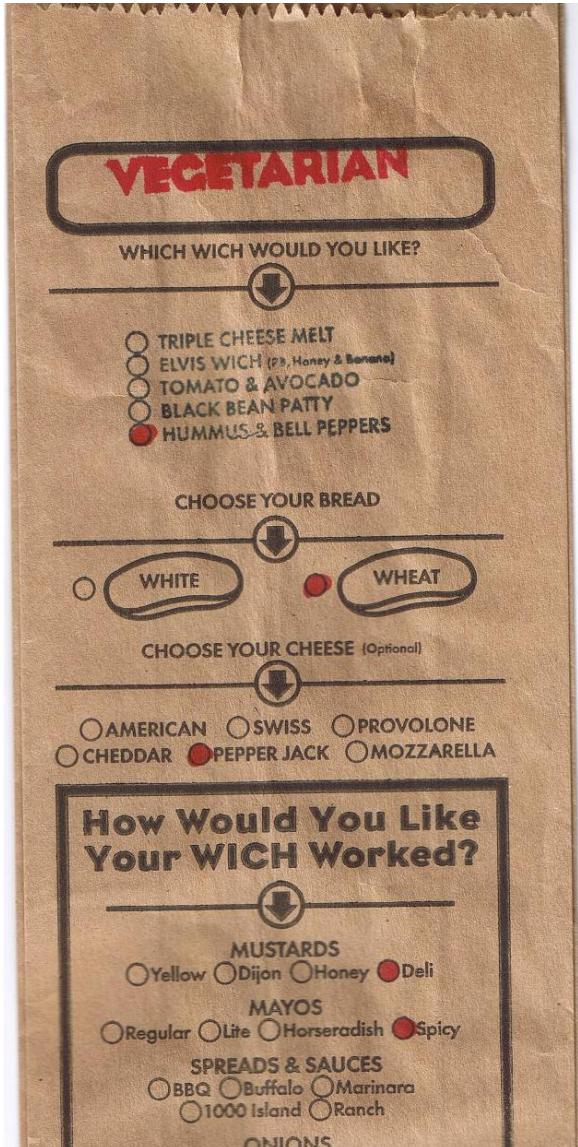
inkl. MwSt., zzgl. 19,04 € Versand  
\*\*Ermäßiger Sonderpreis\*\*  
**913,92 €** Es gelten keine zusätzlichen Preismarkierungen. Das Angebot gilt für maximal 5 Systeme

Finanzierung ab **30 €/mtl.**<sup>2</sup>. Jetzt finanzieren - erst ab Januar 2008 zahlen! Weitere Informationen zur Ratenfinanzierung

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!







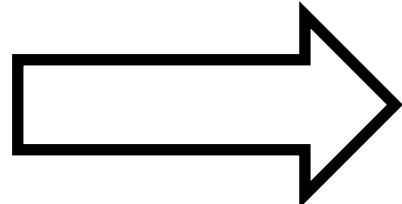
# Mass production

What about  
software?

**Product lines of  
software intensive systems**

# Software intensive systems

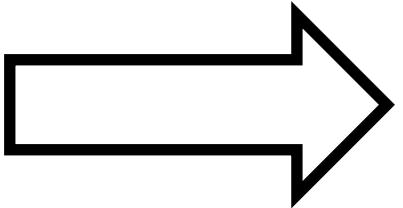
are declined in many variants





# Software intensive systems

are declined in many variants



# Software Product Lines



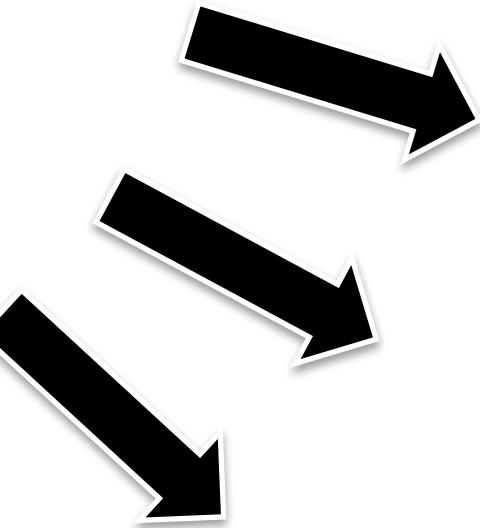
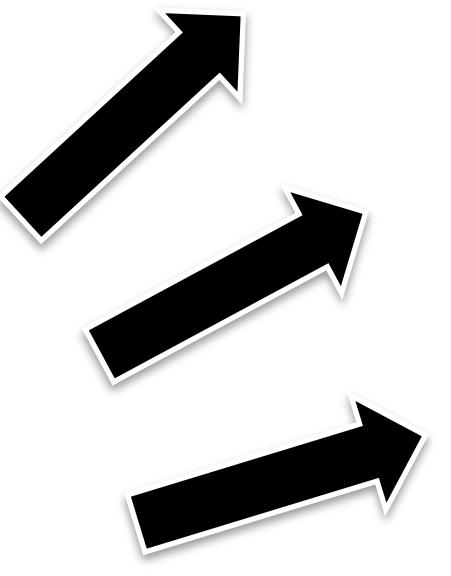
```
01011011  
110111110  
001101110  
110011101  
100011111  
101001110  
100010101  
101010111  
000011110  
110101011  
011101010  
010101011  
110101010  
101010110
```



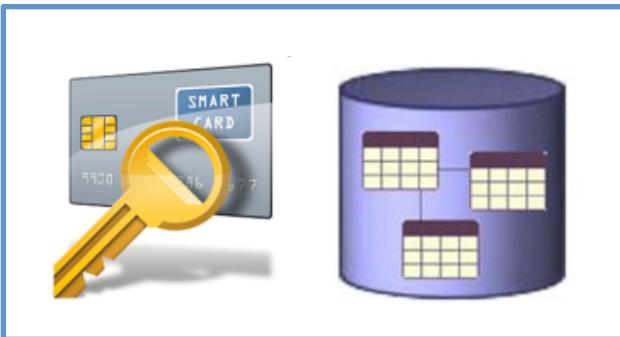
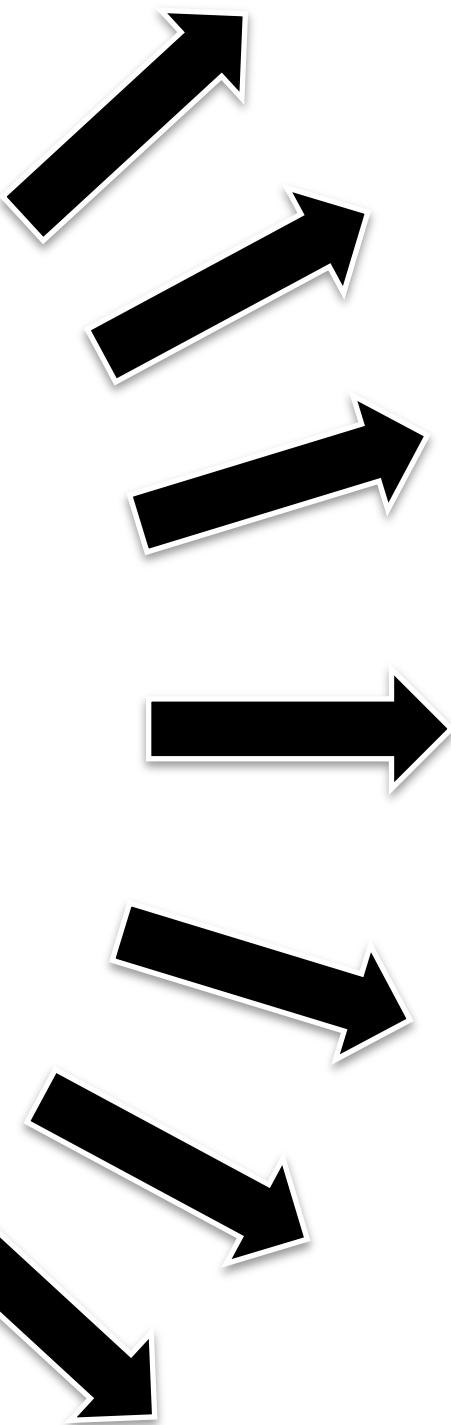
# Und bei Software?

- Moderne Anwendungssoftwaresysteme sind Eier-legende Wollmilchsäue
  - Bsp.: Windows Vista, Open Office, Oracle, SAP myERP, Adobe Photoshop, Nero Burning ROM
- Spezialisierte Software und Software für eingebettete Systeme wird immer wichtiger
  - Bsp.: PDA, Handy, Sensornetze, Mikrowelle, Fernseher, Wetterstation, Auto, Chipkarten, Bordcomputer, Router, Ubiquitous Computing
  - 98% aller im Einsatz befindlichen Rechnersysteme sind eingebettete Systeme
  - Ressourcenbeschränkung und heterogene Hardware erfordert maßgeschneiderte Lösungen
  - Häufige Neuimplementierungen, lange Entwicklungszeiten, hohe Entwicklungskosten

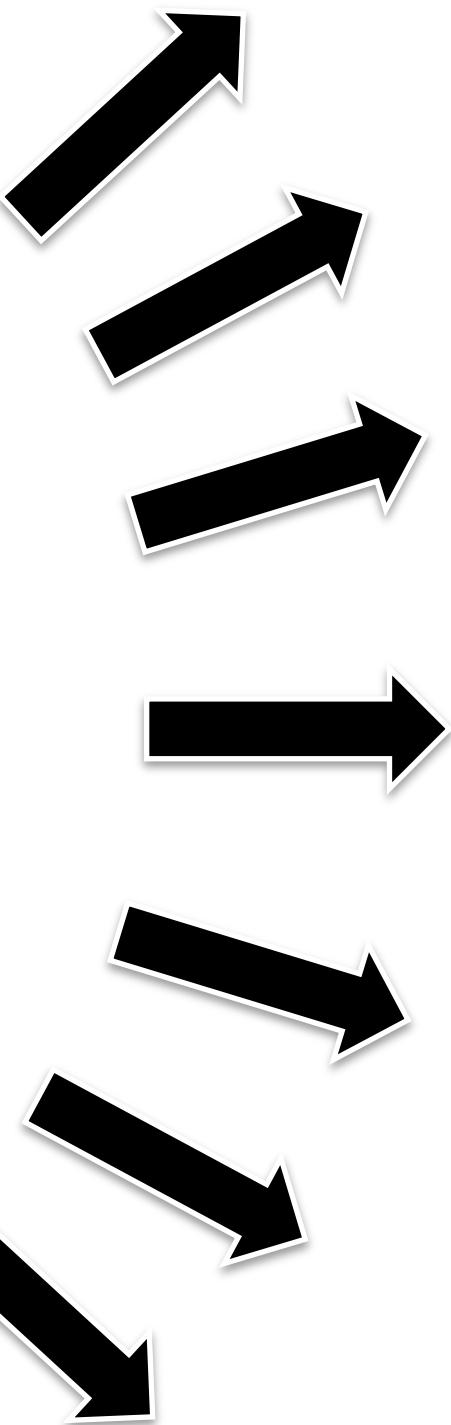
Car



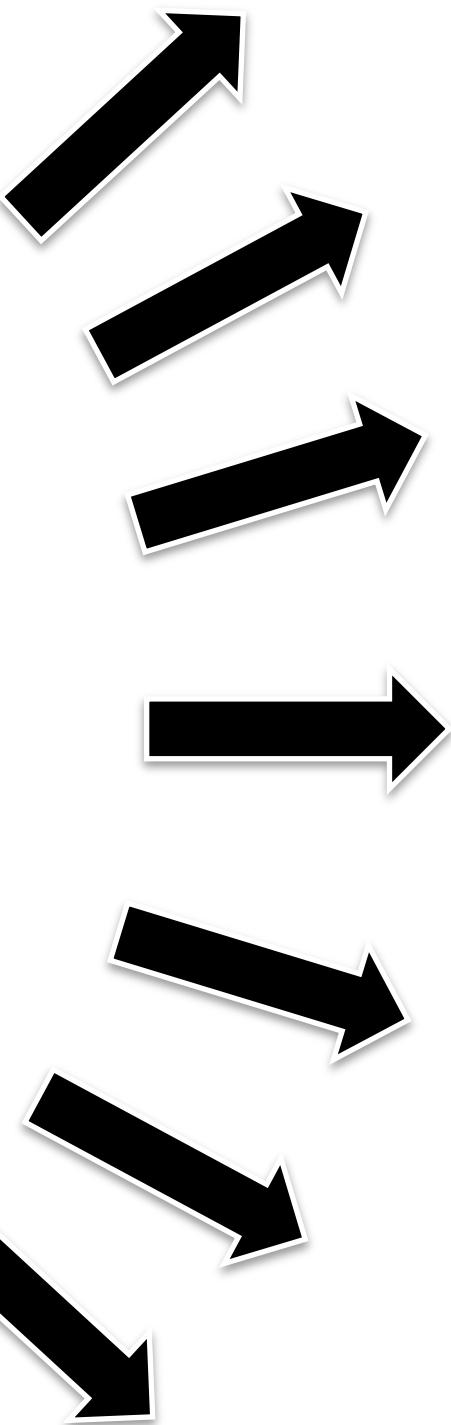
# Database Engine



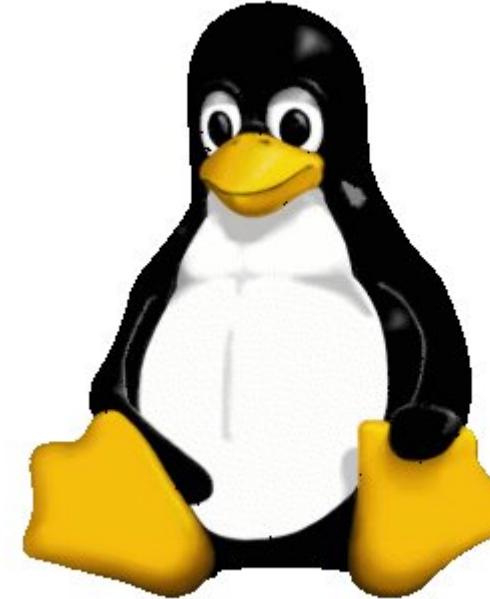
# Printer Firmware



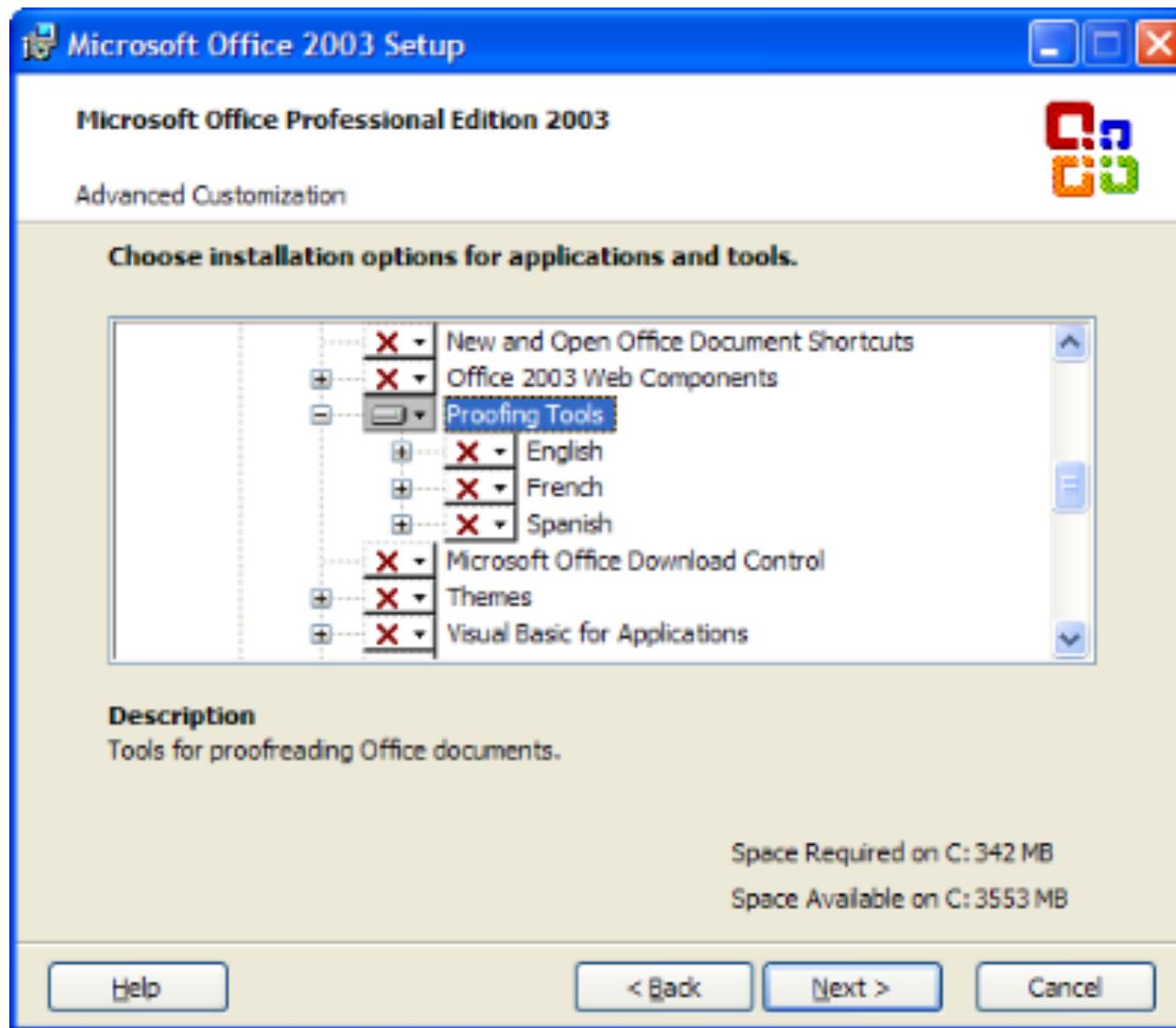
Linux  
Kernel



# Linux-Kernel



# Features in Microsoft Office



# The development of a **family of software systems**

is much more challenging than the  
development of  
**a single software system**

A large, intricate 3D white maze is set against a light gray background. The maze consists of many interconnected paths and dead ends, creating a complex network of levels and corners. It occupies the entire frame, from the top left to the bottom right.

**Variability = Complexity**

# 33 features



a unique variant for every  
person on this planet

optional, independent

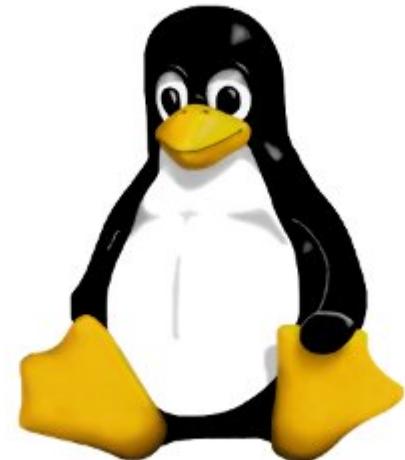
320<sup>optional, independent</sup>  
features

more variants than estimated  
atoms in the universe



2000 features

10000  
features

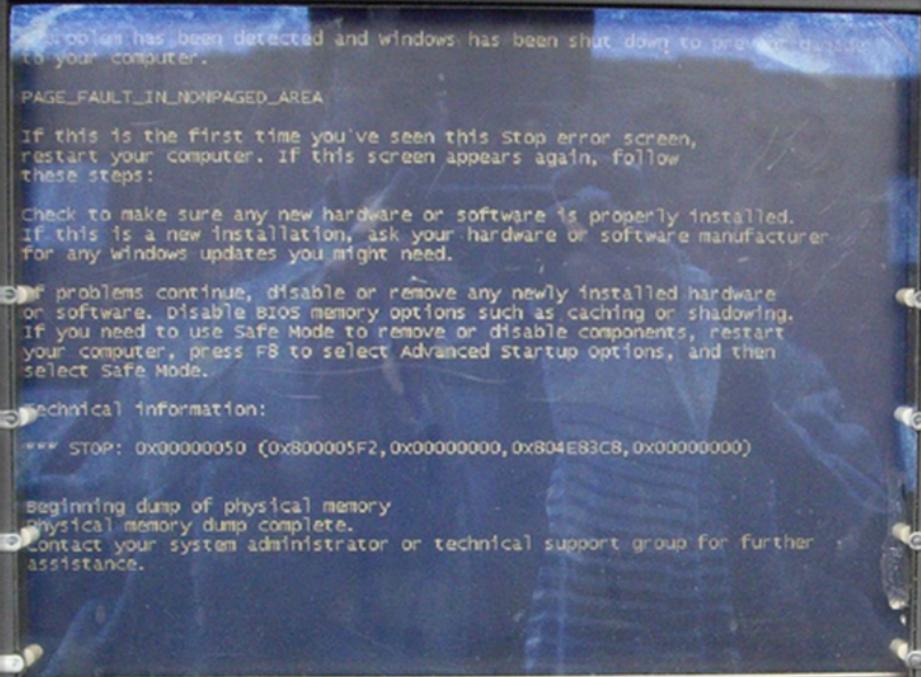


# Automation?

Avoid solving the same problem!

2, 3...n times

# Correctness



1 2 ABC 3 DEF  
4 GHI 5 JKL 6 MNO  
CLEAR



Maintenance?  
Comprehension?

# Checking Products



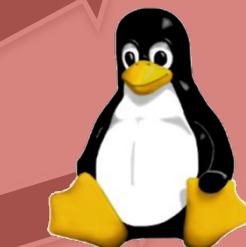
2000 Features  
100 Printers  
30 New Printers per Year

Printer  
Firmware



Linux  
Kernel

# Checking Products



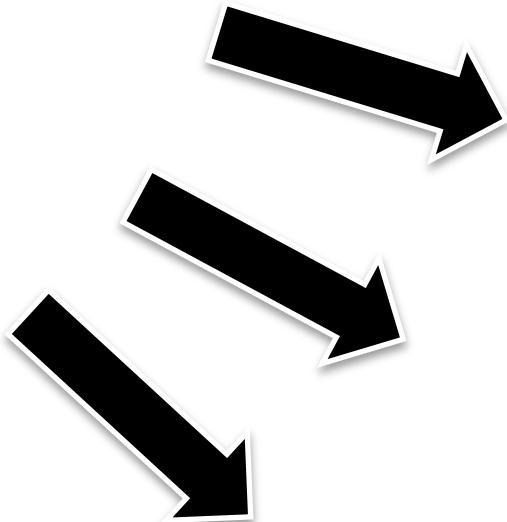
8000 Features  
? Products



# Checking Product Line

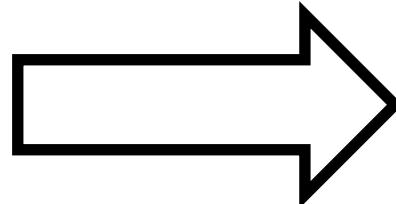
Implementation with 10000 Features  
#ifdef, Frameworks, FOP, AOP, ...

Linux  
Kernel



# Software product line engineering

= modeling and managing variability



A photograph of a car assembly line. In the foreground, a worker wearing a white shirt and red overalls is working on the interior of a silver car. The car's front door is open. Behind the worker, several other cars are lined up on the assembly line. The background shows the industrial interior of a factory with various equipment and a digital display showing the number "042 066 002".

# Assembly Line and Mass Customization

A wide-angle photograph of a massive parking lot packed with thousands of new vehicles, primarily sedans and SUVs, stretching towards the horizon under a clear sky.

# Mass Customization



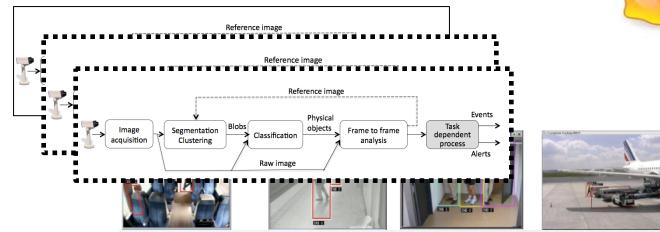
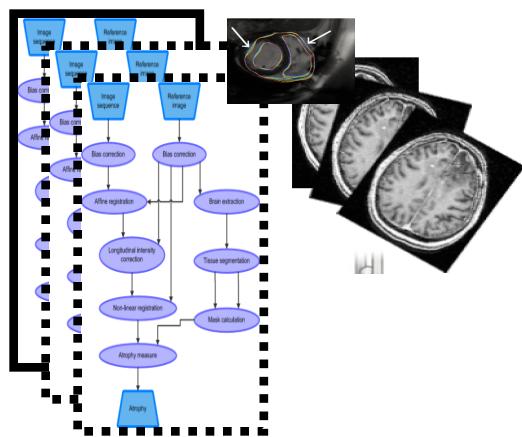
# Starting from scratch?

A wide-angle photograph of a massive aircraft assembly facility. In the center, a large white aircraft is being worked on by numerous technicians and engineers. To the left, several rows of desks and computer monitors are arranged, likely for design or monitoring work. The ceiling is a complex steel truss structure with many overhead lights. The floor is a polished concrete surface with various equipment and materials scattered throughout.

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]*

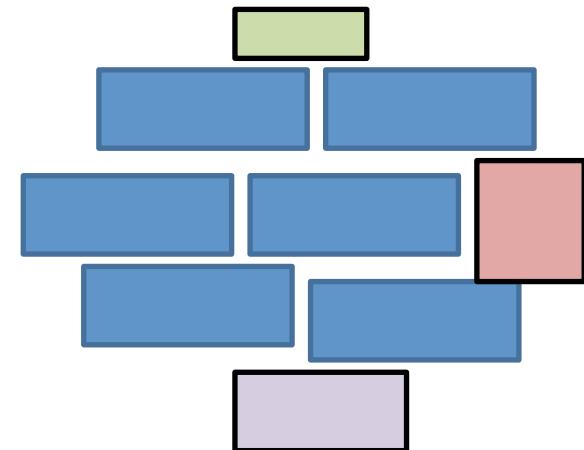
# Software Product Lines



# Software Product Line Engineering

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]



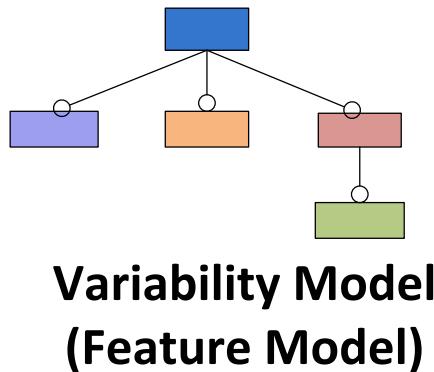


“Reuse-in-the-large works best in families of related systems, and thus is domain dependent.” [Glass, 2001]

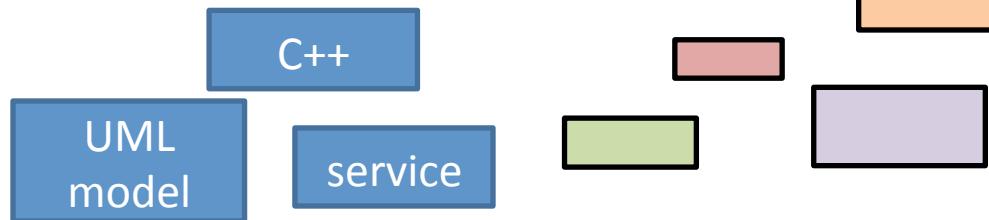
## Domain engineering

### Domain Analysis (problem)

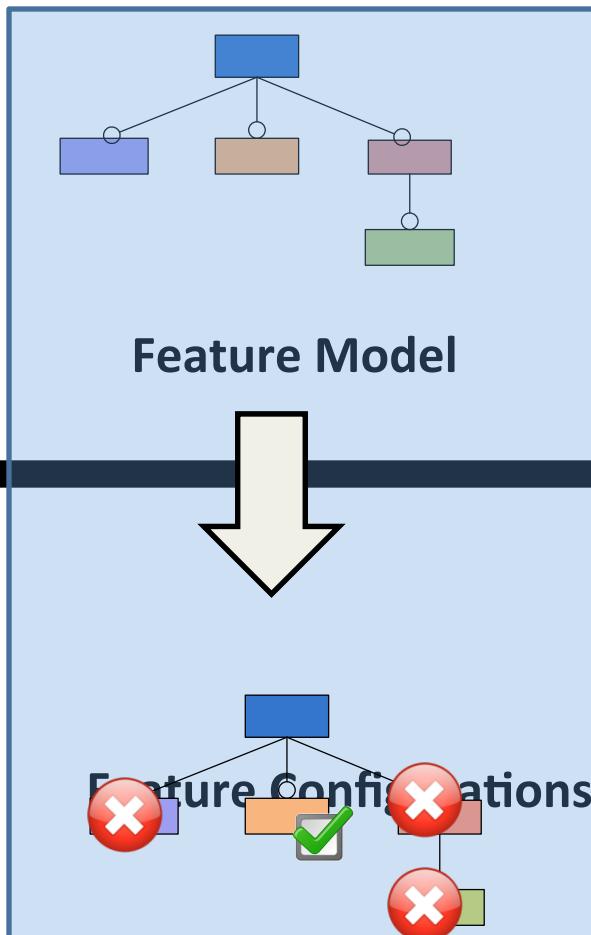
- elicitate requirements and scope the line
- variability modeling: determine commonalities and variabilities usually in terms of features



### Domain Implementation (solution)

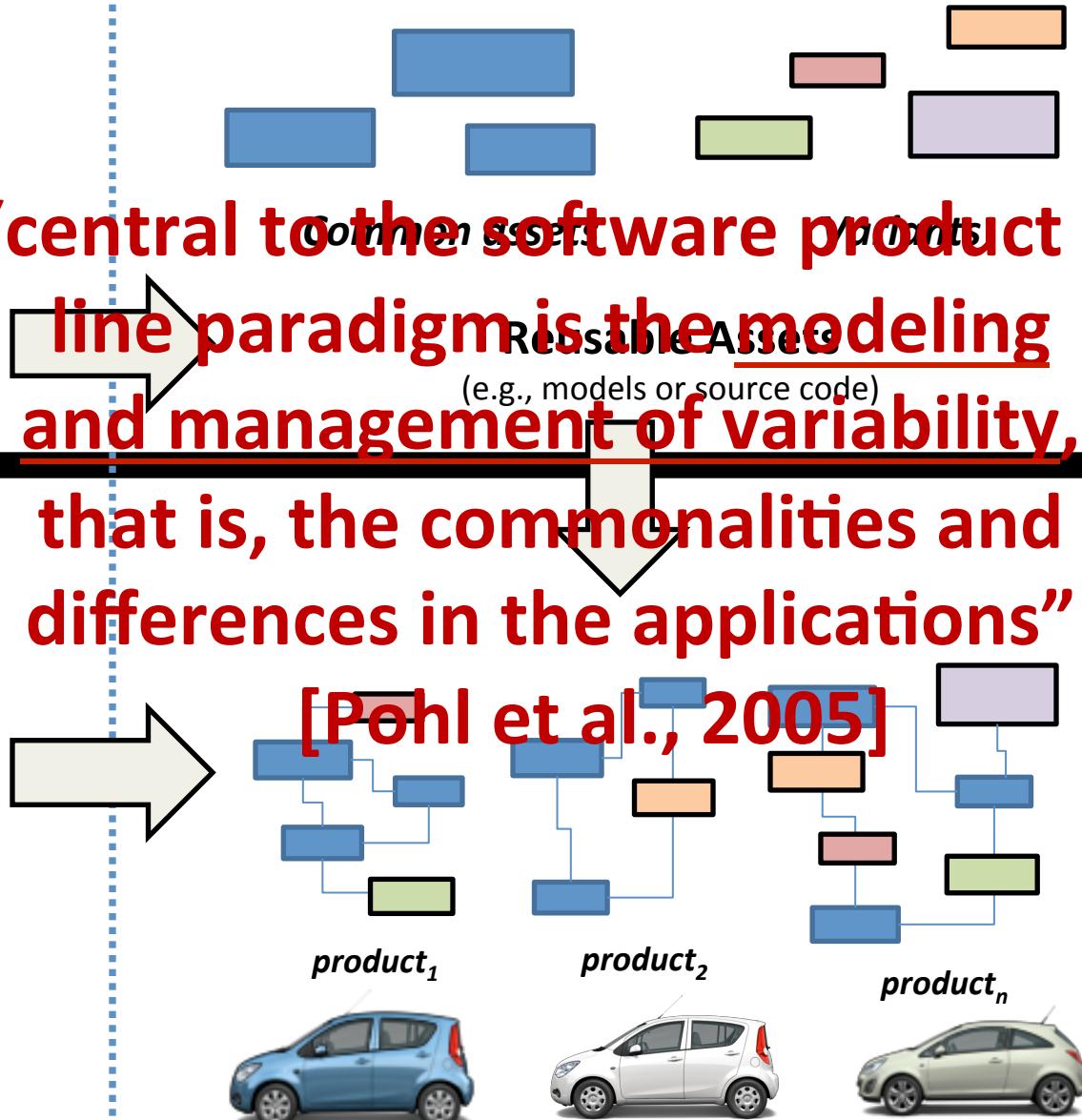


# Domain engineering (development for reuse)



“central to the software product line paradigm is the modeling and management of variability, that is, the commonalities and differences in the applications”

[Pohl et al., 2005]



# Application engineering (development with reuse)

# 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[[:l]attributes] [/B] [/C] [/D] [/L] [/N]
  [/O[[:l]sortorder]] [/P] [/Q] [/R] [/S] [/T[[:l]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_color))
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
```

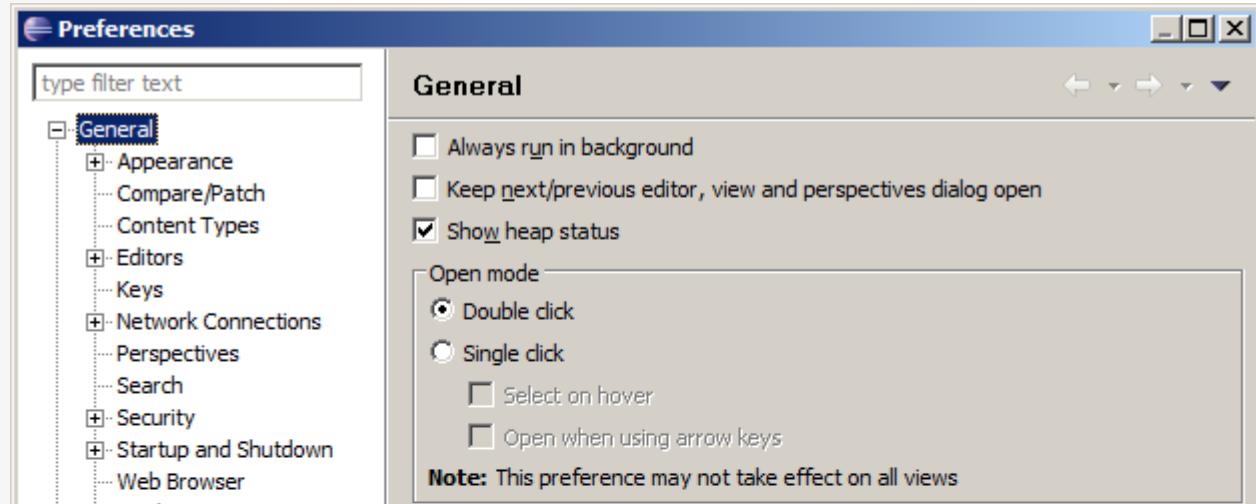
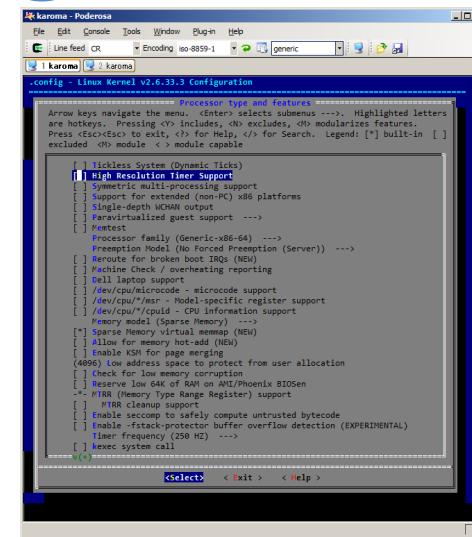
```
HostnameLookups Off
```

```
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;
#endif
#ifdef DIAGNOSTIC
    DB_MSGBUF mb;
#endif
    // over 100 lines of additional code
}
#endif
```

# 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

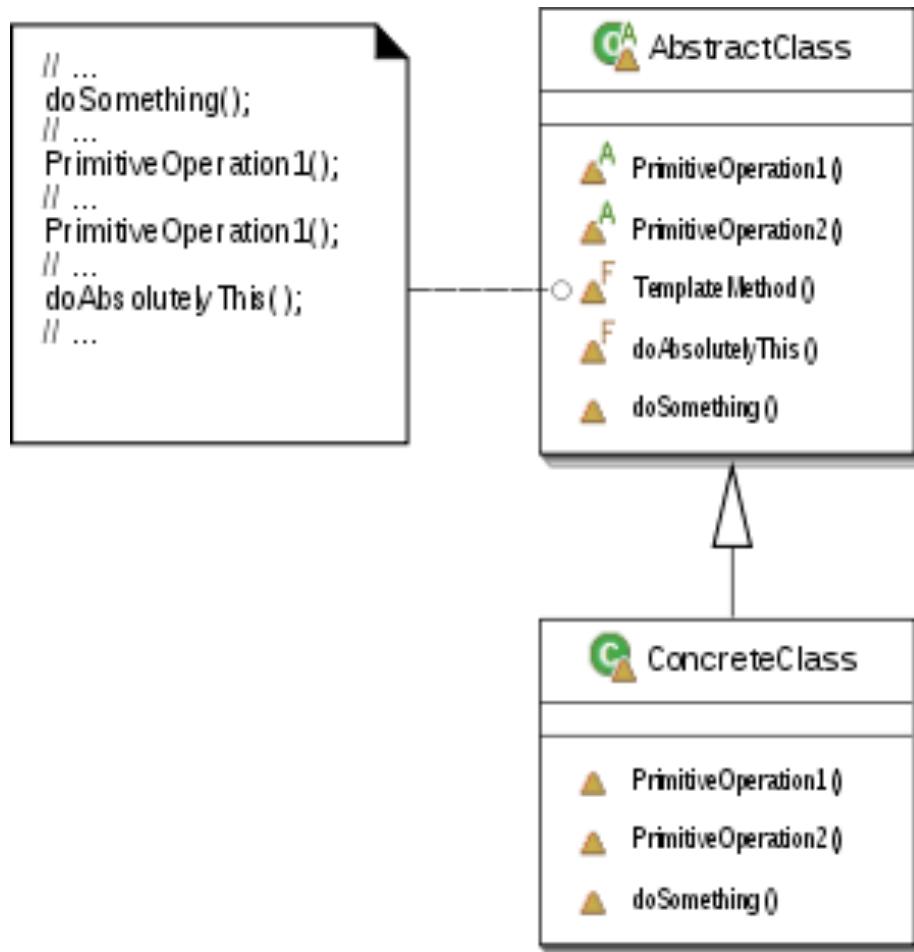
Template Method

Observer

Strategy

Decorator

# Template Method



# Framework

# Plugin-based systems

# Modeling and implementing variability

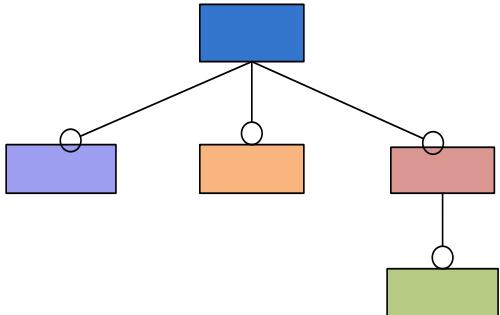
**More details in the next courses!**

# Running project

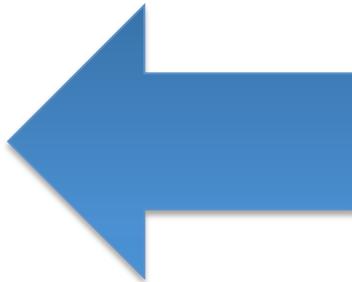
- Re-engineer a car configurator
  - Reverse engineering and modeling a car configurator
  - Automatic generation of customized configurators
- A set of mini-projects
  - step-by-step, incremental process

# Running project

- Re-engineer a car configurator
  - Reverse engineering and modeling a car configurator



Variability Model  
(Feature Model)



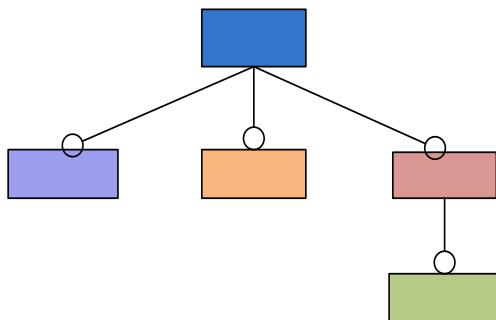
The screenshot shows a car configurator interface for a red Chevrolet Agila Club. The top right features a 3D view of the car and a smaller interior view. Below the car, the text "This image may contain optional equipment." is visible. The main area displays the car's configuration details:

Agila, Club	Total	€ 15,684.00
1.2i 16v, 5 Speed		
Blaze Red, Melt / Elba Charcoal		
<b>Total</b>	<b>€ 15,684.00</b>	

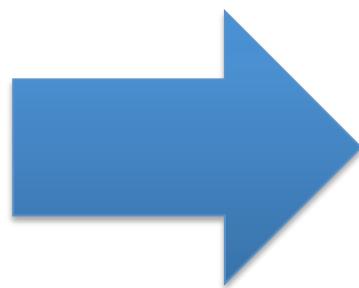
Below this, the "Choose Your Options" section lists various features with checkboxes and descriptions. The "Pricing Details" section shows the breakdown of costs for different components like the engine, exterior color, and options. At the bottom, there are "Next Step" buttons for "Summary" and "Summary".

# Running project

- Re-engineer a car configurator
  - Automatic generation of customized configurators



Variability Model  
(Feature Model)



The screenshot shows a car configurator for an Audi Agila Club. At the top, there's a side-view image of a red Agila Club and a close-up image of the interior. Below the images, the text "This image may contain optional equipment." is visible. The main interface includes:

- Exterior | Interior** buttons.
- Trim line**: SE, Sport, S line.
- Engines and drivetrain**: Petrol, Diesel, Manual, Automatic.
- Choose Your Options** section:
  - Audio/Comms/Nav**: CD 30 (selected), Sport 1.4 TFSI.
  - Heating/Ventilation**: Air conditioning.
  - Mechanical**: Electronic Stability Programme (ESP).
  - Safety/Security**: Emergency tyre inflation kit in lieu of spare and tyre.
- Engines 11 of 11** table:

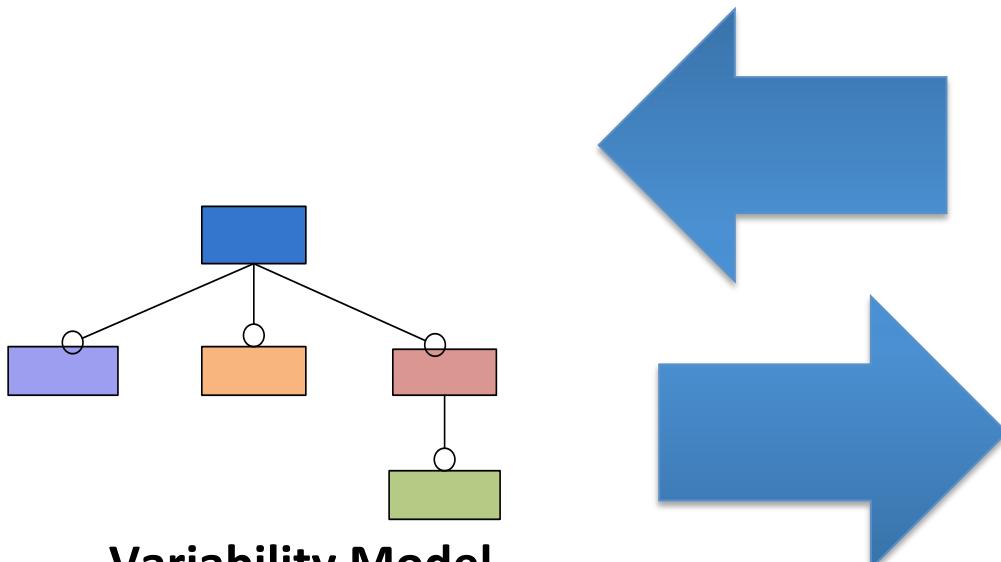
Engine	Power (PS)	Gearbox	Drive train	RRP (GBP)
SE 1.2 TFSI	86	5 speed	Front-wheel drive	13,335.00
<input checked="" type="radio"/> Sport 1.2 TFSI	86	5 speed	Front-wheel drive	15,175.00
Sport 1.4 TFSI	122	6 speed	Front-wheel drive	15,585.00
Sport 1.4 TFSI	122	6 speed	Front-wheel drive	17,035.00
S line 1.2 TFSI	86	5 speed	Front-wheel drive	16,720.00
S line 1.4 TFSI	122	6 speed	Front-wheel drive	17,130.00
S line 1.4 TFSI	122	6 speed	Front-wheel drive	18,580.00
S line 1.4 TFSI	185	5 speed	Front-wheel drive	20,510.00
<b>Diesel</b>				
SE 1.6 TDI	105	5 speed	Front-wheel drive	14,395.00
<input checked="" type="radio"/> Sport 1.6 TDI	105	5 speed	Front-wheel drive	16,235.00
S line 1.6 TDI	105	5 speed	Front-wheel drive	17,780.00
- Next Step: Summary** button.
- Legend** for option status indicators.
- Reset selection** button.
- Navigational tabs at the bottom: 1 Model, 2 Engine, 3 Exterior, 4 Interior, 5 Equipment, 6 Your Audi.

# Running project

- Re-engineer a car configurator
  - Reverse engineering and modeling a car configurator
  - Automatic generation of customized configurators
- You will
  - Learn how to model and derive a configurator
  - Use variability implementation techniques
  - Realize an end-to-end, model-based, automated approach
  - ~ bootstrap: configurator as a software product line

# Running project

- Re-engineer a car configurator



Variability Model  
(Feature Model)

The screenshot shows a car configurator interface for an Audi Agila Club. On the left, there's a large image of a red Audi Agila Club. To its right is a smaller image of the interior. Below the car, the text "This image may contain optional equipment." is visible. A yellow arrow points from the variability model diagram towards this section.

**Trim Line**

Trim	SE	Sport	S line
Exterior   Interior	86	86	86
1. Trim/Series	86	86	86
2. Engine/Transmission	86	86	86

**Choose Your Options**

- Audio/Comms/Nav
- Heating/Ventilation
- Mechanical
- CD 30 - MP3 CD player with MP3 format, stereo radio
- Heating/Ventilation
- Air conditioning
- Mechanical
- Electronic Stability Programme (ESP)
- Safety/Security
- Emergency tyre inflation kit in lieu of spare and tyre

**Engines**

Engine	Power (PS)	Gearbox	Drive train	RRP (GBP)
SE 1.2 TFSI	86	5 speed	Front-wheel drive	13,335.00
<input checked="" type="radio"/> Sport 1.2 TFSI	86	5 speed	Front-wheel drive	15,175.00
<input checked="" type="radio"/> Sport 1.4 TFSI	122	6 speed	Front-wheel drive	15,585.00
S line 1.2 TFSI	86	5 speed	Front-wheel drive	17,035.00
S line 1.4 TFSI	122	6 speed	Front-wheel drive	16,720.00
S line 1.4 TFSI	122	5 speed	Front-wheel drive	17,130.00
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S line 1.4 TFSI	185	5 speed	Front-wheel drive	20,510.00
Diesel				
<input checked="" type="radio"/> SE 1.6 TDI	105	5 speed	Front-wheel drive	14,395.00
<input checked="" type="radio"/> Sport 1.6 TDI	105	5 speed	Front-wheel drive	16,235.00
S line 1.6 TDI	105	5 speed	Front-wheel drive	17,780.00

**Engines 11 of 11**

Combined fuel consumption: 55.4 mpg · Combined CO<sub>2</sub> emissions: 118 g/km (EUDC) · Urban consumption: 45.6 mpg · Extra urban consumption: 64.2 mpg

**Agila, Club**

**Compare engine and equipment**

**Legend**

- Selected Option
- Selectable Option
- Option contained in an option pack
- Option contained in an option pack
- Option that is only selectable together with another option

**Reset selection**

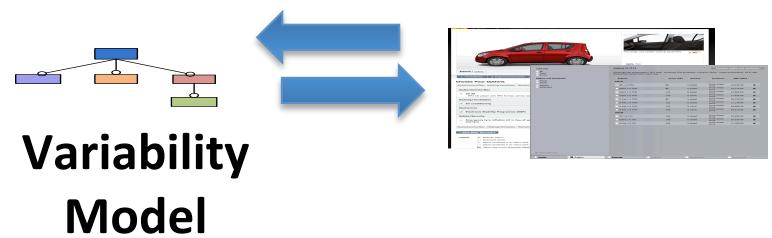
**1 Model**   **2 Engine**   **3 Exterior**   **4 Interior**   **5 Equipment**   **6 Your Audi**

# 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
  - More to come!
- **Running project**
  - Re-engineering a car configurator



# Homework for the next course

- Forming groups
- Exercise
  - Identify three projects that look like software product lines
  - Justify it!
    - Identify commonality
    - Identify configuration options or features
    - Report how variability is documented and implemented
      - Preprocessors? Design patterns? Plugins?