Technische Universität Braunschweig

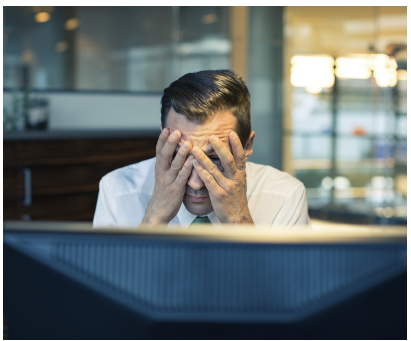
ISF

On Language Levels for Feature Modeling Notations

Thomas Thüm, Christoph Seidl, Ina Schaefer
MODEVAR, September 10, 2019

Part I

The Need for Variability Modeling



The Situation 110 Years Ago: Ford Model T

„Any customer can have a car painted any color that he wants so long as it is black.“

— Henry Ford, 1909

Today: Every Second Car has a Unique Configuration

Constraints Among Features are Challenging

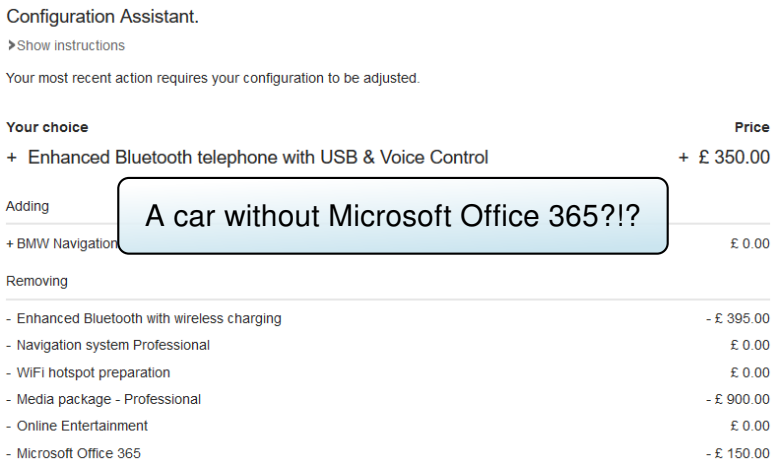
Configuration Assistant.

Show instructions

Your most recent action requires your configuration to be adjusted.

Your choice	Price
+ Enhanced Bluetooth telephone with USB & Voice Control	+ £ 350.00
Adding	
+ BMW Navigation	£ 0.00
Removing	
- Enhanced Bluetooth with wireless charging	- £ 395.00
- Navigation system Professional	£ 0.00
- WiFi hotspot preparation	£ 0.00
- Media package - Professional	- £ 900.00
- Online Entertainment	£ 0.00
- Microsoft Office 365	- £ 150.00

Constraints Among Features are Challenging

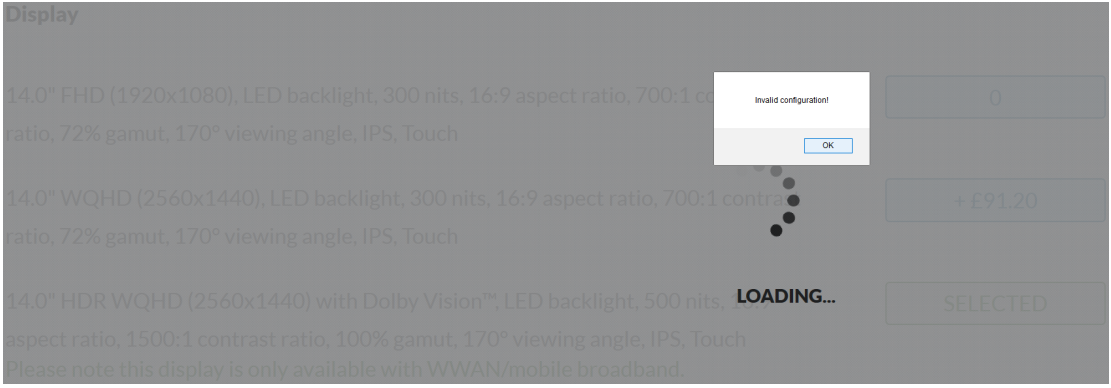


Constraints Among Features are Challenging

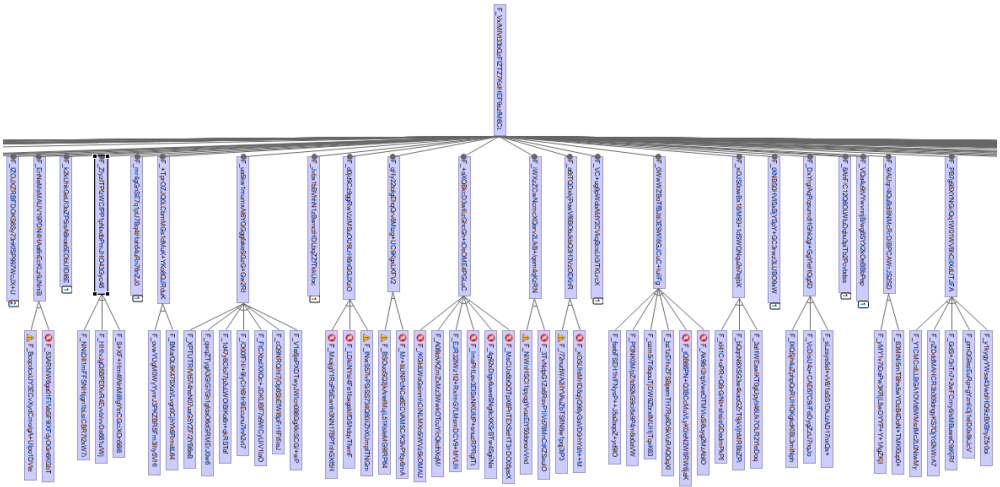
Display

14.0" FHD (1920x1080), LED backlight, 300 nits, 16:9 aspect ratio, 700:1 contrast ratio, 72% gamut, 170° viewing angle, IPS, Touch	SELECTED
14.0" WQHD (2560x1440), LED backlight, 300 nits, 16:9 aspect ratio, 700:1 contrast ratio, 72% gamut, 170° viewing angle, IPS, Touch	+ £91.20
14.0" HDR WQHD (2560x1440) with Dolby Vision™, LED backlight, 500 nits, 16:9 aspect ratio, 1500:1 contrast ratio, 100% gamut, 170° viewing angle, IPS, Touch Please note this display is only available with WWAN/mobile broadband.	+ £159.60

Constraints Among Features are Challenging



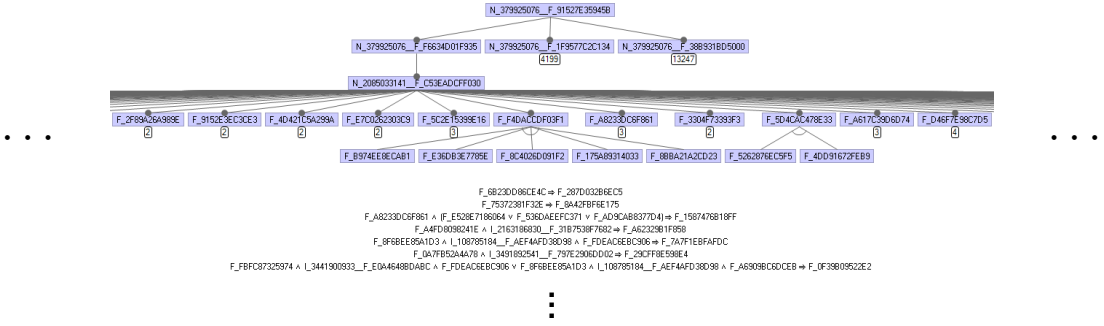
Variability Models as Central Knowledge Database



Part II

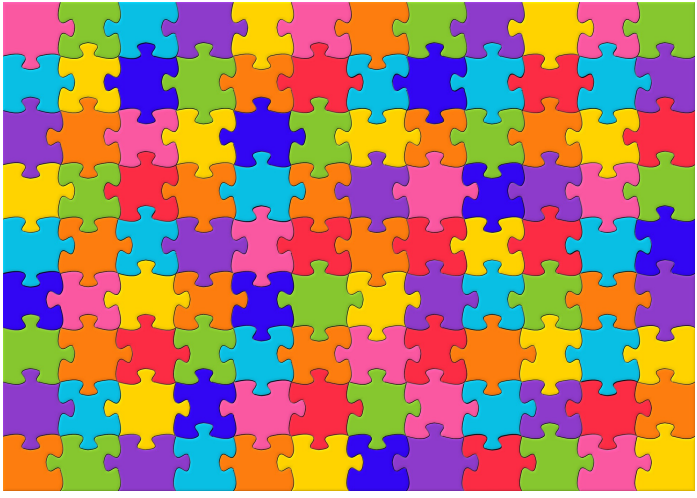
The Need for Variability Analyses

Real-World Variability Modeling

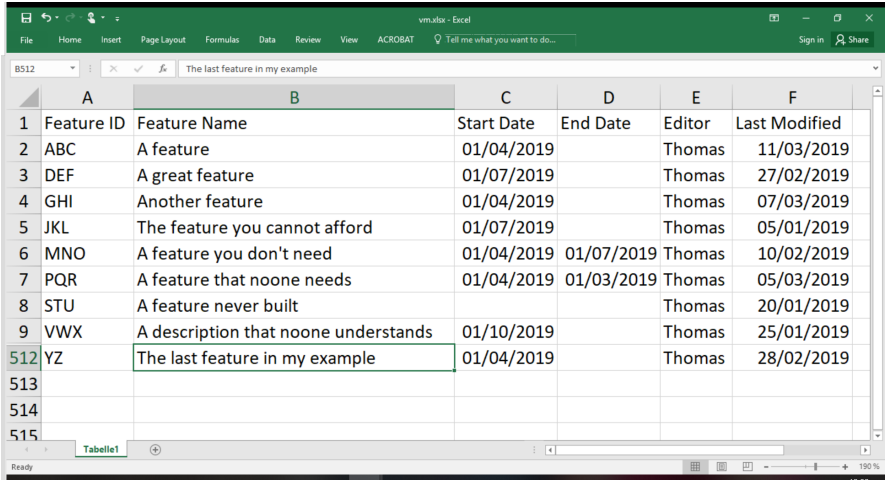


- Thousands of features and constraints, increases over time
- No modularity or information hiding
- Temporal elements
- Typically not modeled with feature models

One Product Line Specified with Different "Languages"



Variability Modeling par Excellence



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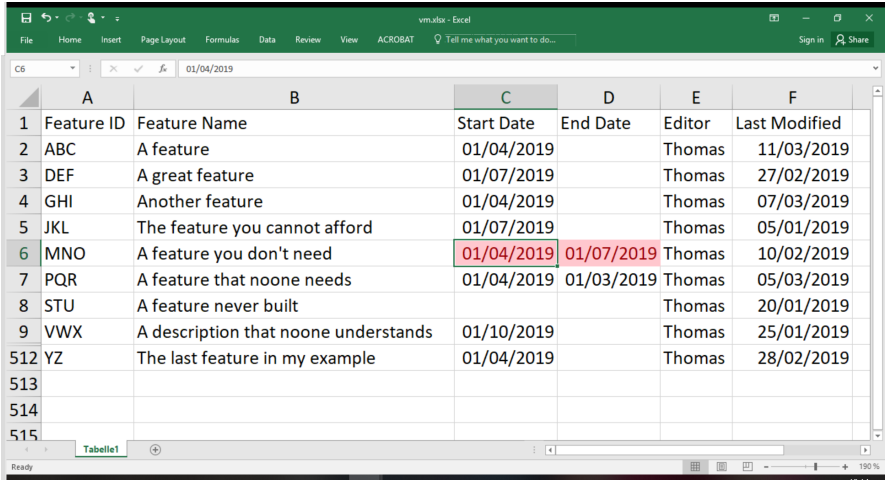

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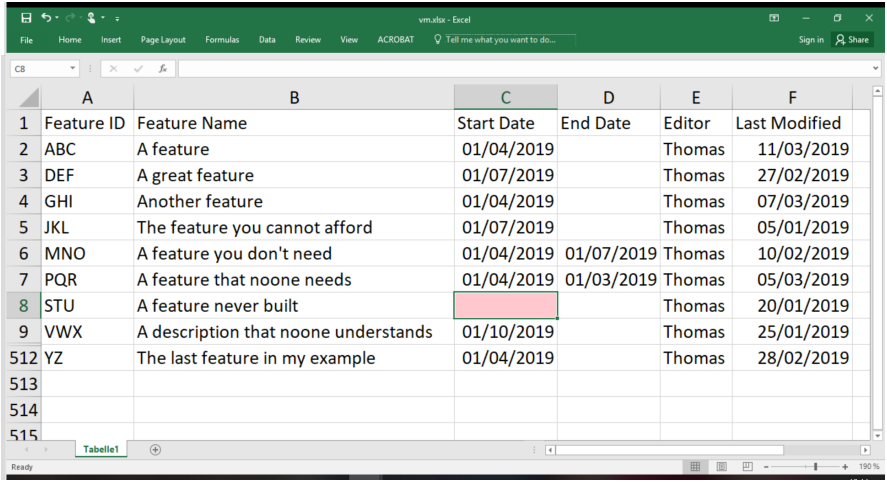

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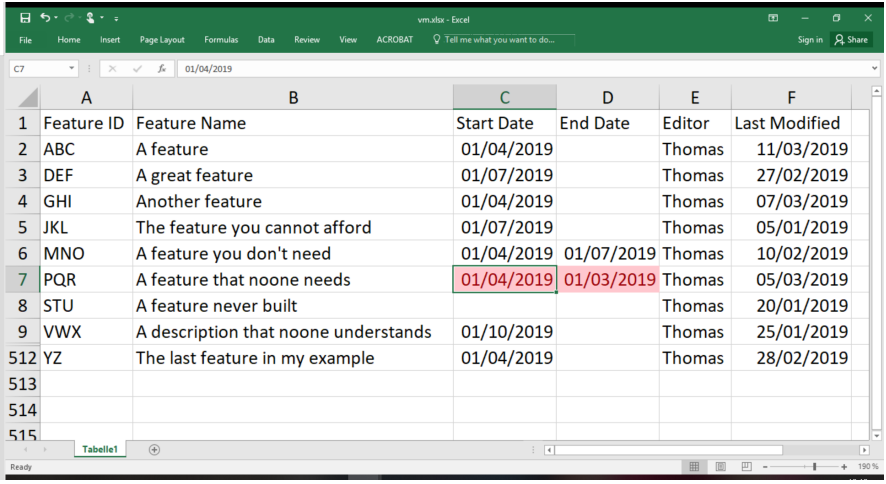

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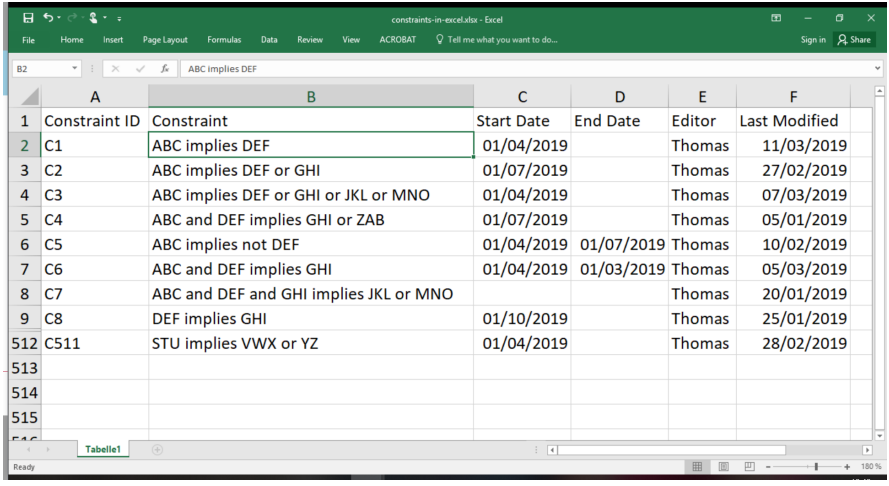
Variability Modeling par Excellence



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7	C6	ABC and DEF implies GHI	01/04/2019	01/03/2019	Thomas	05/03/2019
8	C7	ABC and DEF and GHI implies JKL or MNO			Thomas	20/01/2019
9	C8	DEF implies GHI	01/10/2019		Thomas	25/01/2019
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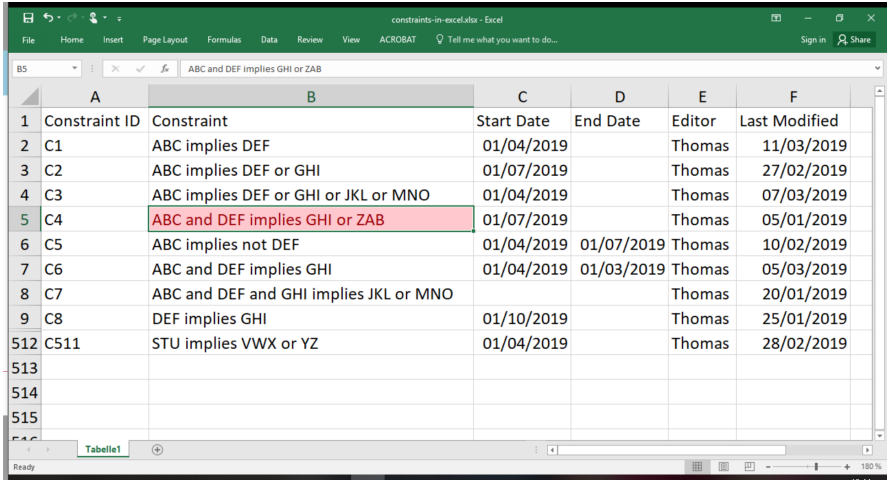
Variability Modeling par Excellence



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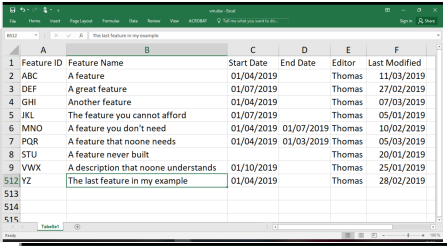
Clone-and-Own of Variability Models



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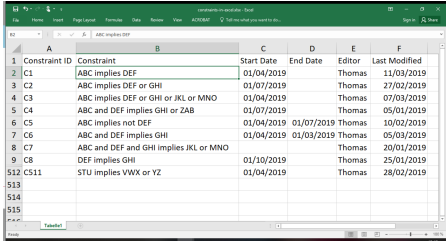

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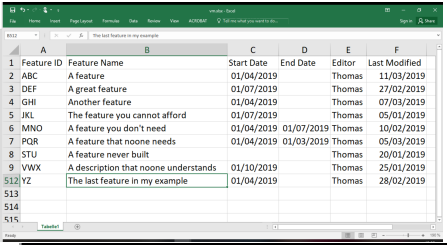

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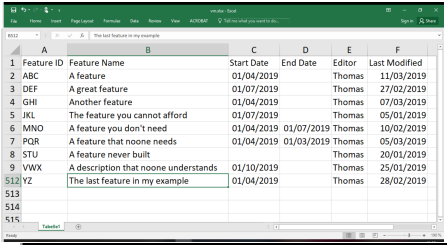

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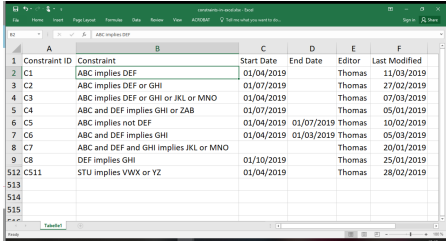

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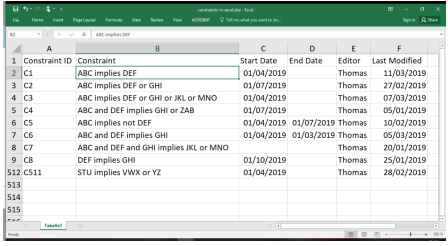

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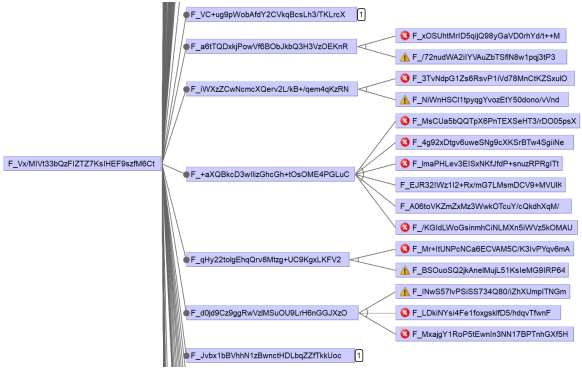
Anomalies in Variability Models



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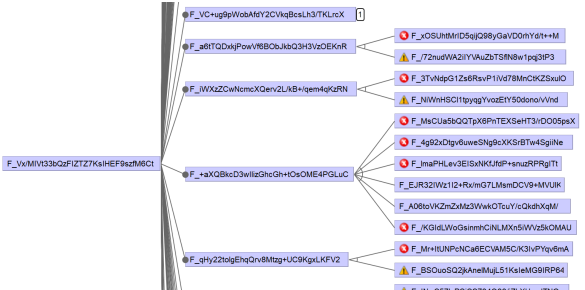
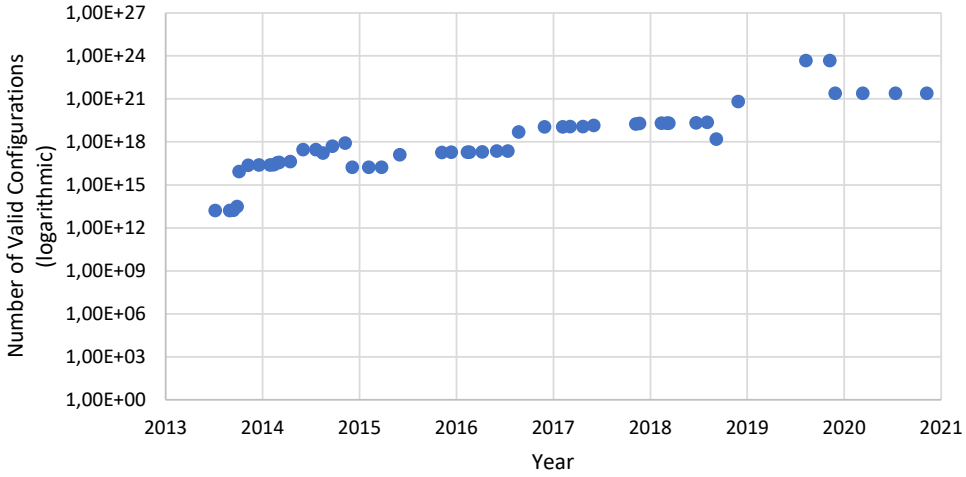


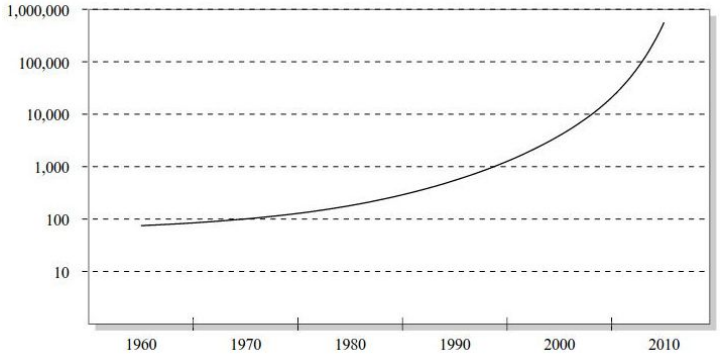
Configuration Spaces Tend to Grow Over Time



Part III

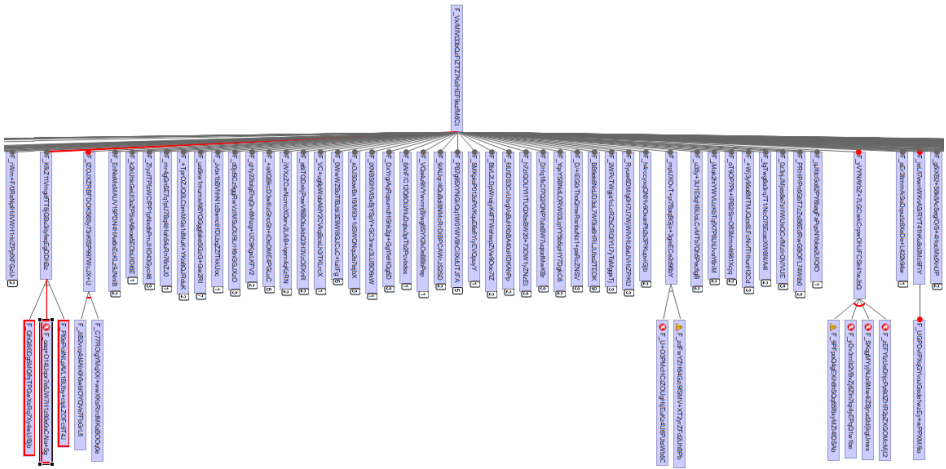
Criteria for Language Design

Why to Use SAT Solvers for Variability Analysis?

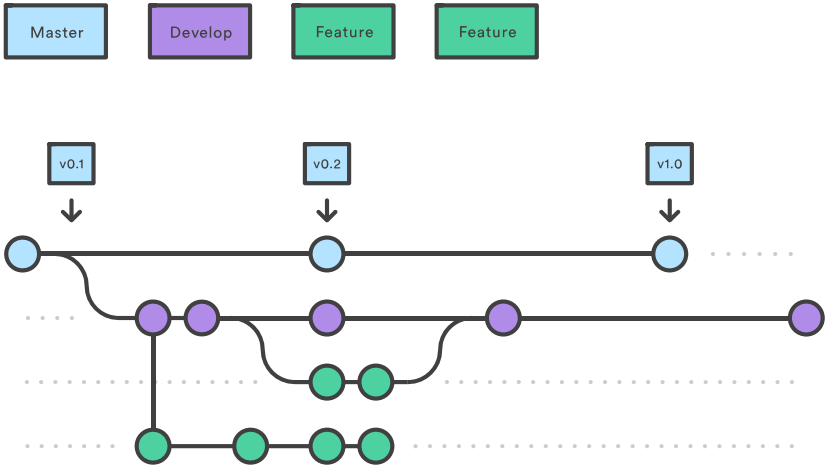


number of variables of a typical, practical SAT instance that can be solved by the best solvers in that decade

Missing Analyses for Feature Attributes



Industry Demands for Modularity and Branching



Language Levels for Feature Modeling Notations

Major Levels: expressiveness aligns with solver classes

- propositional logic: SAT, binary decision diagram (BDD), #SAT, ...
- first-order logic: satisfiable modulo theory (SMT), constraint satisfaction problem (CSP)?, ...
- more needed? answer set programming (ASP)? pseudo-boolean satisfiability (PB-SAT)? ...

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Minor Levels: differing expressiveness within major levels

- align with expressiveness of state-of-the-art languages
- meet requirements from typical application domains
- example: supported tree and cross-tree constraints

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Minor Levels: differing expressiveness within major levels

- align with expressiveness of state-of-the-art languages
- meet requirements from typical application domains
- example: supported tree and cross-tree constraints

Orthogonal Levels: independent of expressiveness

- Modularity with feature-model interfaces or slicing
- Feature versions and temporal validity with hyper and temporal feature models

Part I

- **The Situation 110 Years Ago: Ford Model T**
- **Today: Every Second Car has a Unique Configuration**
- **Constraints Among Features are Challenging**
- **Variability Models as Central Knowledge Database**

Part II

- **Real-World Variability Modeling**
- **One Product Line Specified with Different "Languages"**
- **Variability Modeling par Excellence**
- **Clone-and-Own of Variability Models**
- **Anomalies in Variability Models**
- **Configuration Spaces Tend to Grow Over Time**

Part III

- **Why to Use SAT Solvers for Variability Analysis?**
- **Missing Analyses for Feature Attributes**
- **Industry Demands for Modularity and Branching**
- **Language Levels for Feature Modeling Notations**

On Language Levels for Feature Modeling Notations

Part I
Part II
Part III