# Do We Still Need This?
# Managing Variability in Modern Software Systems

Jacob Krüger

Eindhoven University of Technology, The Netherlands

June 24, 2024

# Modern systems: driven by software and variant-rich

Figures: https://github.com/SoftVarE-Group/Course-on-Software-Product-Lines

# Modern cars: driven by software and variant-rich

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# Modern cars: driven by software and variant-rich

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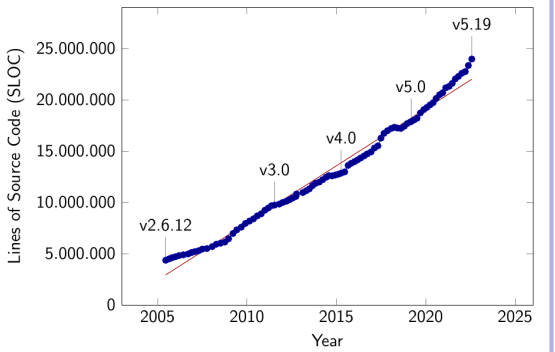
# Modern Linux: driven by software and variant-rich

## Size of the Code Base

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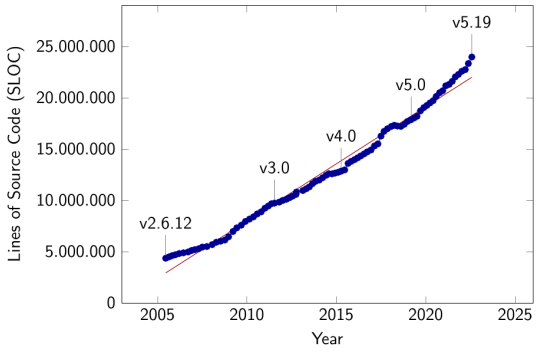
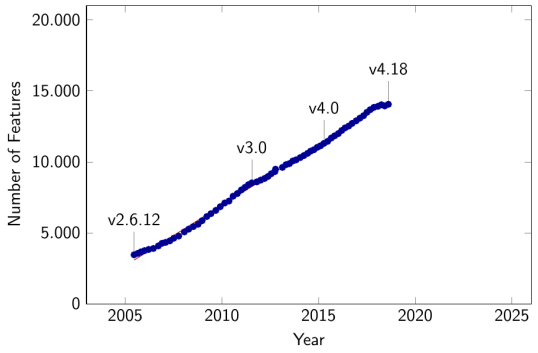



## Number of Features

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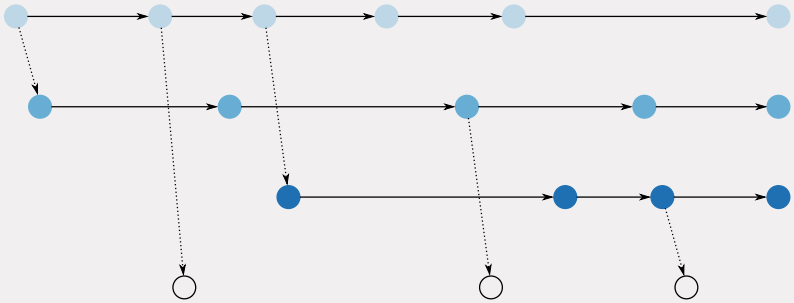
# But organizations often start with one system and cloning



**Krüger**: *Understanding the Re-Engineering of Variant-Rich Systems: An Empirical Work on Economics, Knowledge, Traceability, and Practices*. Dissertation, 2021

## But organizations often start with one system and cloning

- A successful system gets adapted by cloning



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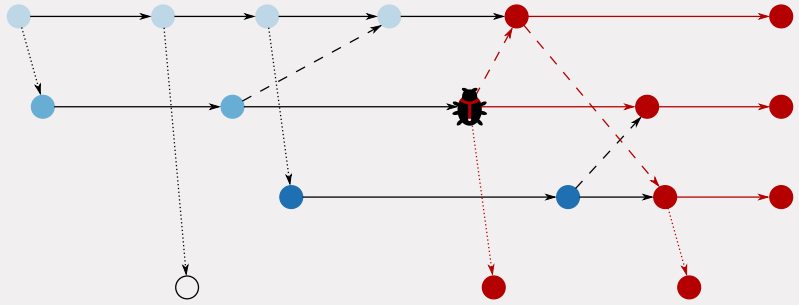
## But organizations often start with one system and cloning

- A successful system gets adapted by cloning
- Maintenance challenges lead to decision to re-engineer a platform



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# Re-engineering into or between platforms is (still) common


## Getting Rid of Clone-And-Own: Moving to a Software Product Line for Temperature Monitoring

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**ABSTRACT**

Due to its fast and simple applicability, clone-and-own is widely used in industry to develop software variants. In cooperation with different companies for thermoelectric products, we implemented multiple variants of a heat monitoring tool based on clone-and-own. After encountering redundancy-related problems during development and maintenance, we decided to migrate towards a software product line. Within this paper, we describe this case study of migrating cloned variants to a software product line based on the extractive approach. The resulting software product line encapsulates variability on several levels, including the underlying hardware systems, interfaces, and use cases. Currently, we support monitoring hardware from three different companies that use the same core system and provide a configurable front-end. We share our experiences and encountered problems with cloning and migration towards a software product line—focusing on feature extraction and modeling in particular. Furthermore, we provide a lightweight, web-based tool for modeling, configuring, and implementing software product

**ACM Reference Format:**
Elias Kuiter, Jacob Krüger, Sebastian Krieter, Thomas Leich, and Gunter Saake. 2018. Getting Rid of Clone-And-Own: Moving to a Software Product Line for Temperature Monitoring. In *SPLC '18: 22nd International Systems and Software Product Line Conference, September 10–14, 2018, Gothenburg, Sweden.* ACM, New York, NY, USA, 11 pages. https://doi.org/10.1145/3233027.3233050

### 1 INTRODUCTION

Software product lines are a systematic approach to reuse and manage software artifacts [2, 36]. These artifacts correspond to *features* – user-visible functionalities of a set of variants – that are modeled within variability models [15, 42] to define their dependencies. A selection of features that fulfills all these dependencies is a *valid* configuration. Based on such a configuration, a tool can automatically instantiate a variant from the implemented artifacts.

Using software product lines promises several benefits, for instance, reduced costs for development and maintenance, faster

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## Decision Making for Managing Automotive Platforms: An Interview Survey on the State-of-Practice

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**ABSTRACT**

The automotive industry is changing due to digitization, a growing focus on software, and the increasing use of electronic control units. Consequently, automotive engineering is shifting from hardware-focused towards software-focused platform concepts to address these challenges. This shift includes adopting and integrating methods like electrics/electronics platforms, software product-line engineering, and product generation. Although these concepts are well-known in their respective research fields and different industries, there is limited research on their practical effectiveness and issues—particularly when implementing and using these concepts for modern automotive platforms. The lack of research and practical experiences challenges particularly decision makers, who cannot build on reliable evidence or techniques. In this paper, we address this gap by reporting on the state-of-practice

**ACM Reference Format:**
Philipp Zellmer, Jacob Krüger, and Thomas Leich. 2024. Decision Making for Managing Automotive Platforms: An Interview Survey on the State-of-Practice. In *Companion Proceedings of the 32nd ACM International Conference on the Foundations of Software Engineering (FSE Companion '24), July 15–19, 2024, Porto de Galinhas, Brazil.* ACM, New York, NY, USA, 11 pages. https://doi.org/10.1145/3663529.3663851

### 1 INTRODUCTION

To remain competitive, automotive manufacturers must continuously enhance their product portfolios by incorporating novel features into their vehicles. Traditionally, the focus was on hardware components, but technological advancements, new customer preferences, and legal standards demand the integration of a rising number of software features into the existing hardware platforms [5, 9]. This shift is evident from the prevalence of software

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## Insights into Transitioning towards Electrics/Electronics Platform Management in the Automotive Industry

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Thomas Leich
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Harz University
Wernigerode, Germany

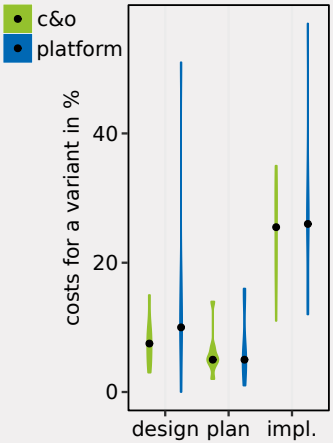
**ABSTRACT**

In the automotive industry, platform strategies have proved effective for streamlining the development of complex, highly variable cyber-physical systems. Particularly software-driven innovations

**1 INTRODUCTION**

Similar to other industries, innovations in the automotive domain are driven more and more by digital features that build on software. The consequent trends emerging in the automotive industry (e.g.,

# Moving to a systematic platform is useful

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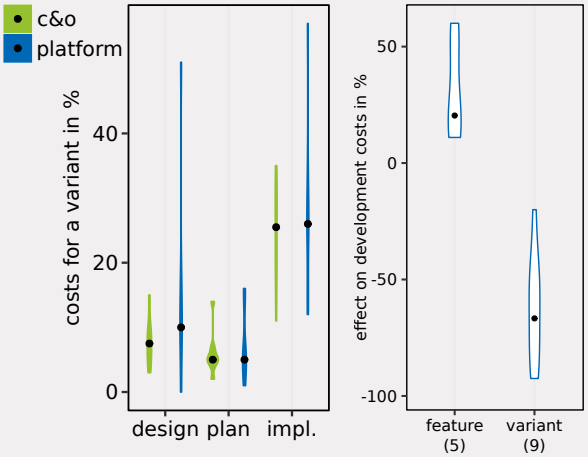




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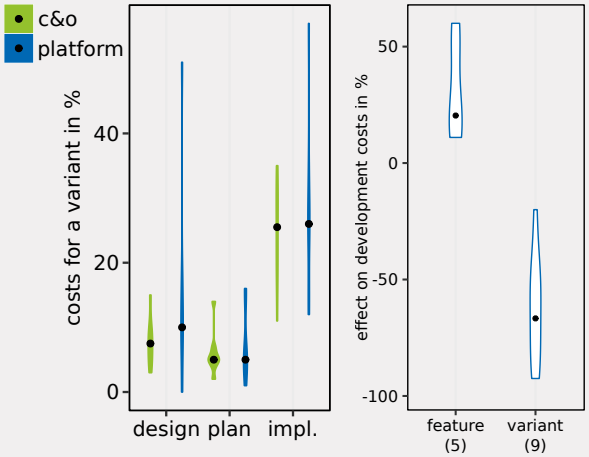
# Moving to a systematic platform is useful (but challenging)




| activity type | team 1 | team 2 |
|---|---|---|
| product-line training | 16.00 | 90.00 |
| domain analysis | 18.00 | 82.00 |
| preparatory analysis | 49.25 | 40.00 |
| feature identification | 22.25 | 22.00 |
| architecture identification | 2.00 | 5.00 |
| feature location | 50.00 | 7.00 |
| feature modeling | 7.00 | 10.00 |
| transformation | 103.50 | 180.00 |
| quality assurance | 103.50 | 60.00 |



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# Recommendations and guides can facilitate re-engineering

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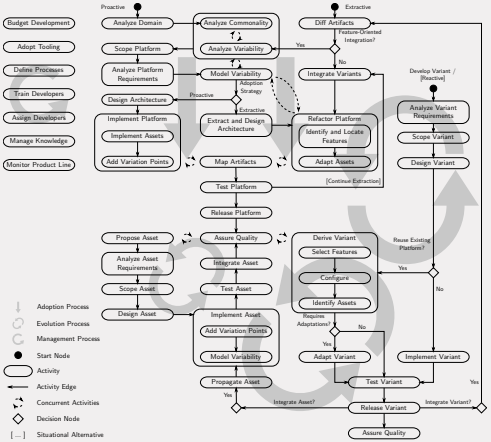


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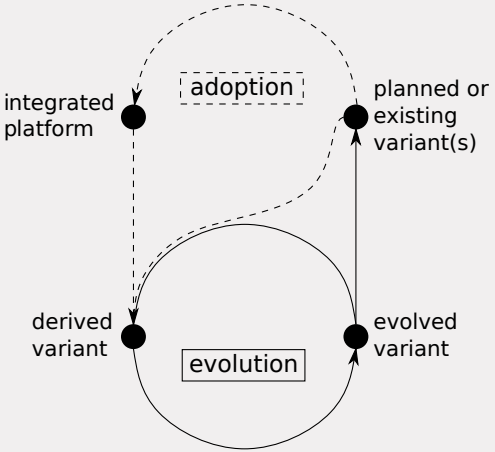


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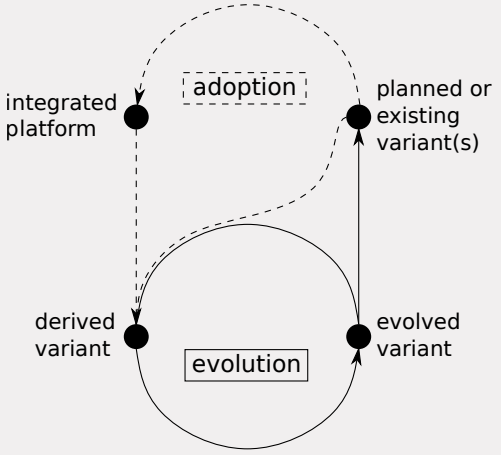
# Recommendations and guides can facilitate re-engineering

- Support for feature modeling
- Process for maturity assessment



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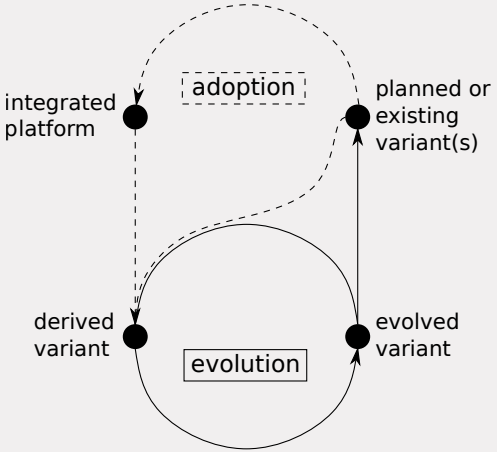
# Recommendations and guides can facilitate re-engineering

- Support for feature modeling
- Process for maturity assessment
- Studies built on industry collaborations/cases
  - VW
  - Axis
  - Saab
  - Danfoss
  - pure-systems
  - ABB
  - ...



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## Having a platform? Still, not everything is perfect

- Ensuring program comprehension?
- Assuring software quality?
- Analyzing variability?
- Aligning hardware and software releases?
- Deprecating (variable) features or a platform?
- Re-engineering variability safely?
- …




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# Comprehension and quality are key

- Insights:
  - Feature traces are helpful …

```
1     char_u  *
2  fix_fname(fname)
3     char_u  *fname;
4  {
5  #ifdef UNIX
6     return FullName_save(fname, TRUE);
7  #else
8     if (!vim_isAbsName(fname)
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16 # endif
17            )
18        return FullName_save(fname, FALSE);
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20    fname = vim_strsave(fname);
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22 # ifdef USE_FNAME_CASE
23 #  ifdef USE_LONG_FNAME
24    if (USE_LONG_FNAME)
25 #  endif
26    {
27        if (fname != NULL)
28            fname_case(fname, 0);
29    }
30 # endif
31
32    return fname;
33 #endif
34 }
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Fenske, **Krüger**, Kanyshkova, Schulze: `#ifdef` *Directives and Program Comprehension: The Dilemma between Correctness and Preference*. ICSME'20
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# Comprehension and quality are key

- Insights:
  - Feature traces are helpful …
    … but should not be configurable
  - Understanding variability is hard …

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# Comprehension and quality are key

- Insights:
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    … but should not be configurable
  - Understanding variability is hard …
    … and analyzing it even more

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# Comprehension and quality are key

- Insights:
  - Feature traces are helpful …
    … but should not be configurable
  - Understanding variability is hard …
    … and analyzing it even more
- Challenges:
  - Refactoring
  - Removing/simplifying variability
  - Comprehending software

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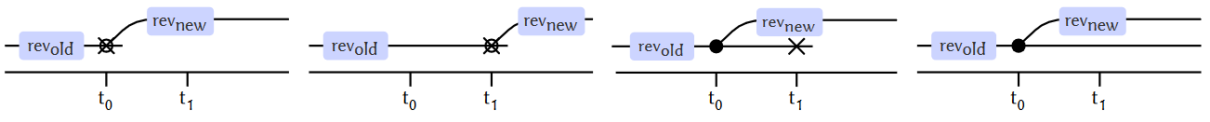
# Aligning hardware/software releases is hard

- Insights:
  - Different options for aligning hardware/software changes
  - Over-the-air updates become more important



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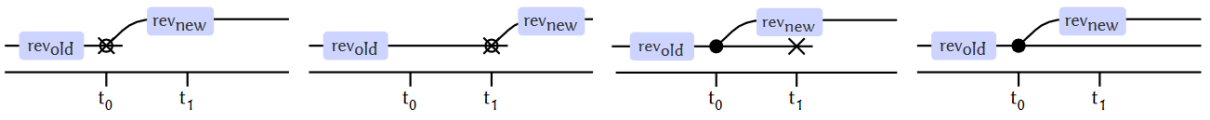
# Aligning hardware/software releases is hard

- Insights:
  - Different options for aligning hardware/software changes
  - Over-the-air updates become more important
- Challenges:
  - Understanding pros and cons of strategies
  - Deciding when to use what strategy




(a) Early Shift (ES) (b) Late Shift (LS) (c) Transition Phase (TP) (d) Hardware Reuse (HR)



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## Some features may become dated

- Insights:
  - Features or whole systems may become outdated
  - Features may move into commodity to reduce complexity



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## Some features may become dated

- Insights:
  - Features or whole systems may become outdated
  - Features may move into commodity to reduce complexity
- Challenges:
  - Deciding what features are not needed anymore
  - Ensuring safe re-engineering operations
  - Designing automated analyses/operations



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## Also challenges in practice? Starting points for collaboration?

- Ensuring program comprehension?
- Assuring software quality?
- Analyzing variability?
- Aligning hardware and software releases?
- Deprecating (variable) features or a platform?
- Re-engineering variability safely?
- …




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## Want more information or get in touch?

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