

Software Produktlinien – Erfahrungen und Fallstricke

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Challenges for Software Development Organizations

- Software size and complexity increases
- Need for reducing
 - Cost,
 - Effort, and
 - Time-to-market
- Increasing request for
 - Quality software and
 - Individually customized products

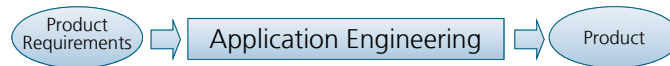
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Application Engineering: Single Project or Product Development

- Application Engineering is a function
 $AE: R \Rightarrow P$



- Product Requirements
 $r = \{r_1, r_2, \dots, r_n\}$
- $AE(r) = \text{Product } p$ (with p satisfies r)
- AE is defined by a process model

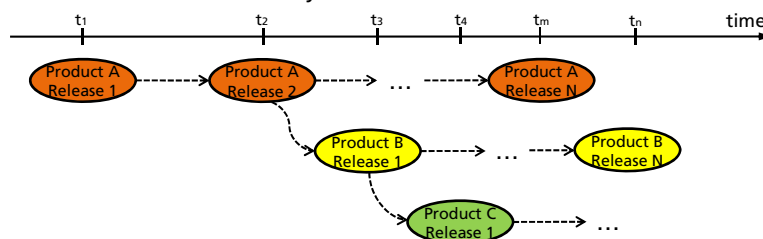
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Challenges for Successful Software-Development Organizations

- Families of products arise over time
 - Increasing number of variants
 - Variants exist concurrently in different versions



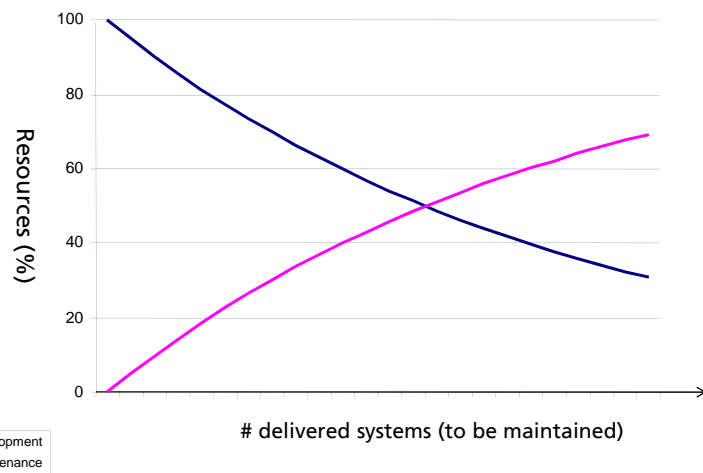
- Redundant effort
 - new developments from scratch
 - in maintenance and quality assurance

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Development versus Maintenance (No Reuse!)



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Solution: Organizational Reuse (proactive, strategic)

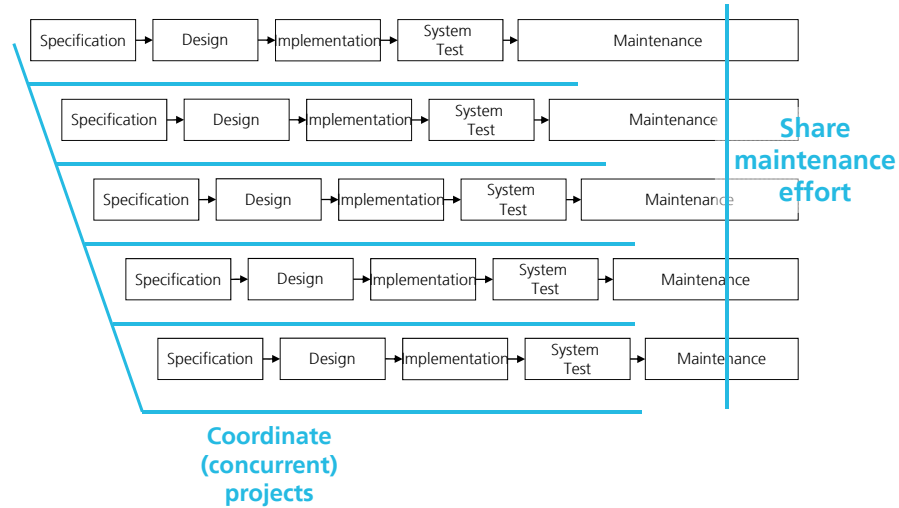
- Reusing existing software saves time and effort
- Reusing approved software brings quality
- Focusing on new functionality enables realization of individual requirements

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Application Engineering: Series of Projects

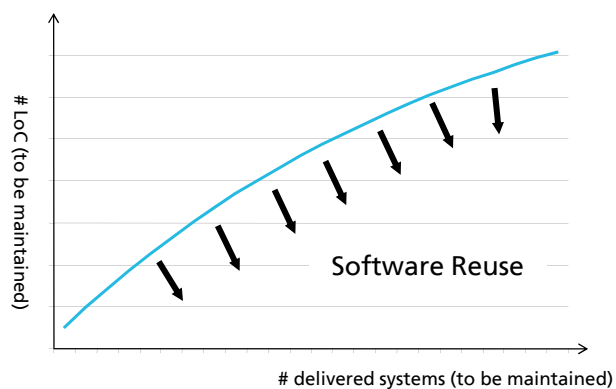


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Organizational Reuse: Reduced Size of Code Base to be Maintained



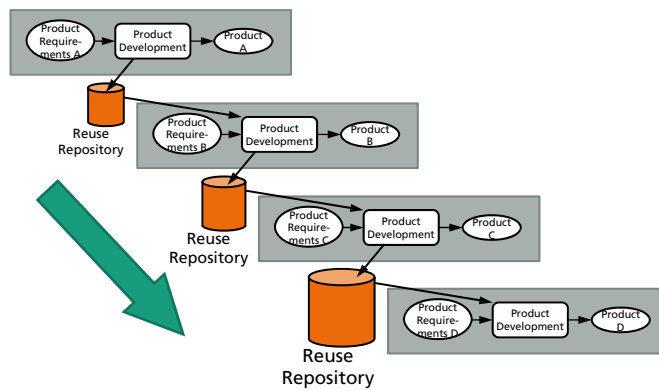
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Reuse Approaches

Approach: Clone & Own



Legend:

- Process
- Product
- Interaction

Does not scale!

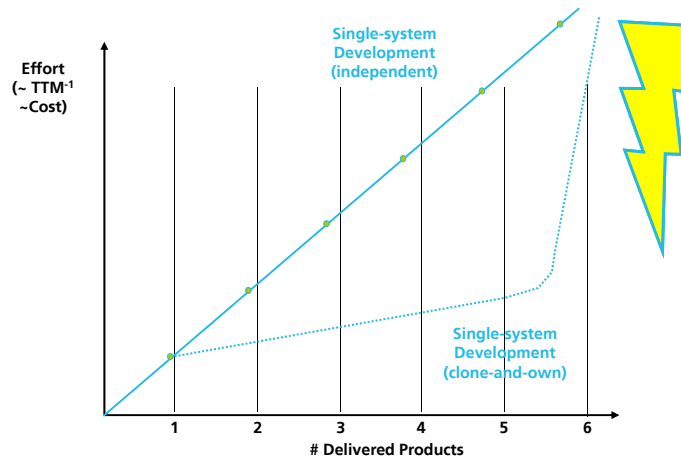
- A reuse repository is grown as needed
- No specific development process exists for developing the reuse repository
- Opportunistic (ad-hoc) reuse

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Clone and Own: Typical Effort Curves

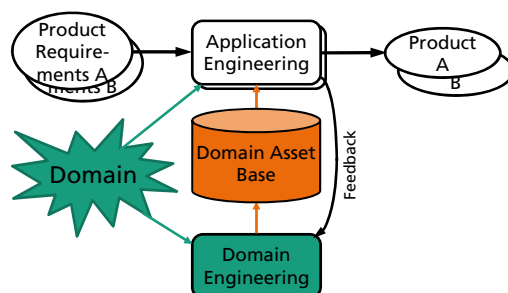


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Approach: Domain Engineering



Legend:

Process
Product
Interaction

Does not
stop!

Often over
engineered!

Too generic!

- Idea: Proactively develop for reuse
- Separate Domain Engineering and Application Engineering (Product Development) processes (reuse repository becomes domain asset base)
- Reuse more than code (requirements, architectures, tests, ...)
- Main problem: unclear domain boundaries (reusable assets become more general than necessary)

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Approach: Product Line Engineering

- Existing and/or potential new products are analyzed for similarity

- e.g. starting with a **product map**
- goal: to capture the products' common and different (variable) features
- systematic development for reuse (only where reuse is economically useful)

	Product 1	Product 2	Product 3
Feature 1	X	X	X
Feature 2	X	X	
Feature 3		X	X

- Instead of single products, a platform is developed



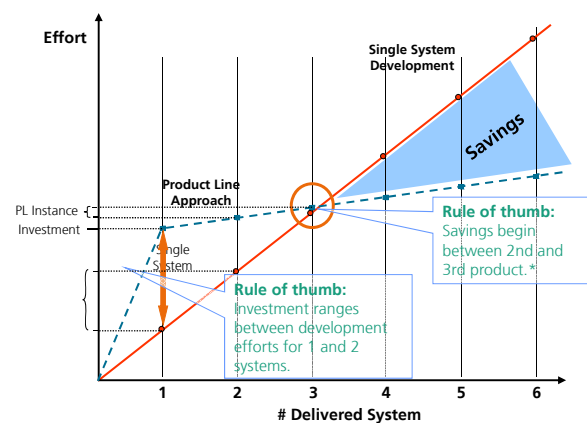
- The platform usually contains more than reusable code
 - reusable requirements documents, architecture/design, test cases, ...

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Product Line Engineering: Typical Effort Curves



*[Weiss/Lai], [Fraunhofer PuLSE™], etc.

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Product Line Software Engineering

Definition: Product Line Approach

A product line engineering approach consists of

- **engineering processes** addressing product line issues consistently throughout all development activities,
- **management processes** continuously aligning engineered product lines with business goals and needs, and
- **improvement processes** establishing and optimizing the implemented product line approach continuously and incrementally

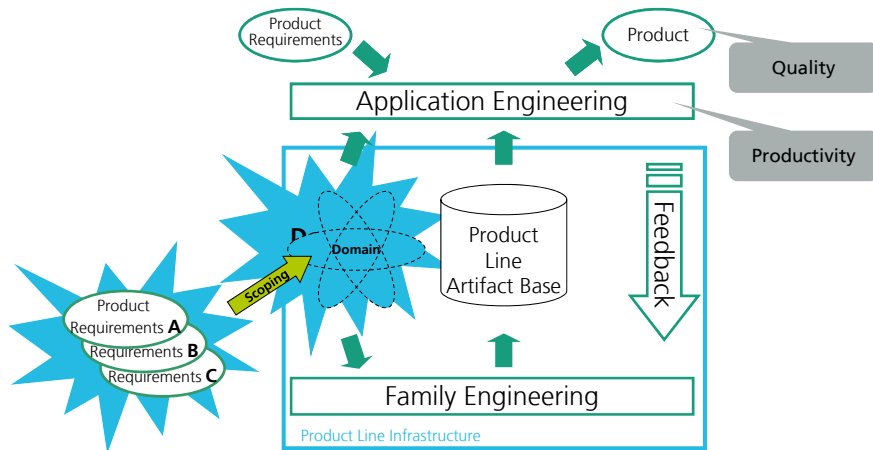
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Product Line Engineering: Life Cycle Application Engineering and Family Engineering



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Product Line Engineering

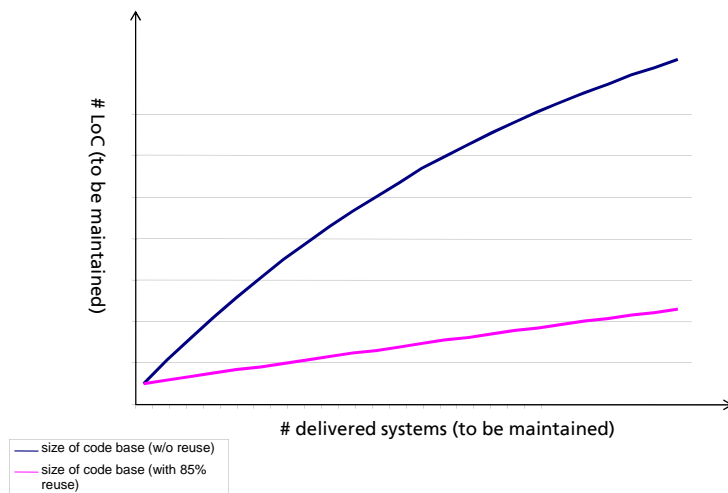
- Scoping enables the engineering of reuse
 - General domains are large and have fuzzy boundaries
- Scoping defines sharp domain boundaries based on concrete product requirements
 - Existing products
 - Competitor products
 - Future or envisioned products
- Family engineering becomes thus
 - More focused and closer to production (than domain engineering)
 - More efficient, as emphasis is on Application Engineering!

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Size of Code to be maintained

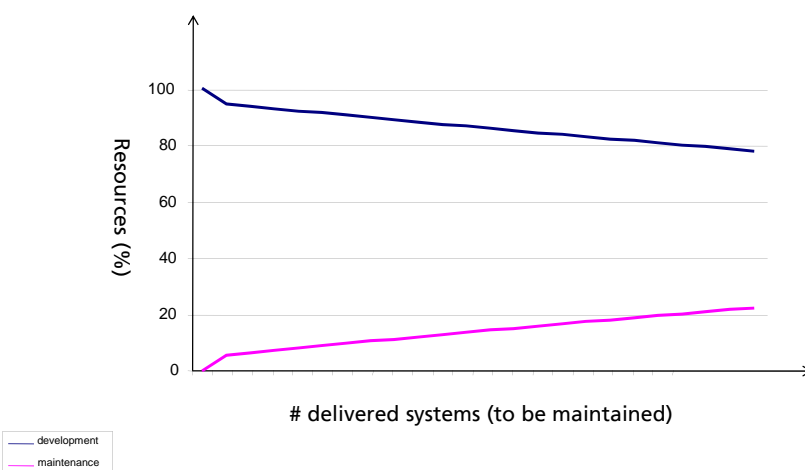


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Development versus Maintenance (85% Reuse)



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Product Line Engineering: Investment Strategy

- **Revolution:** Invest into PL upfront (**proactive**)
- **Evolution:** Build up PL incrementally over time (**reactive**)

- Decision made per unit or domain assessed by scoping activities
 - Relative ranking
 - Start with most promising areas

- Strategy is determined by domain strategies and must match business objectives

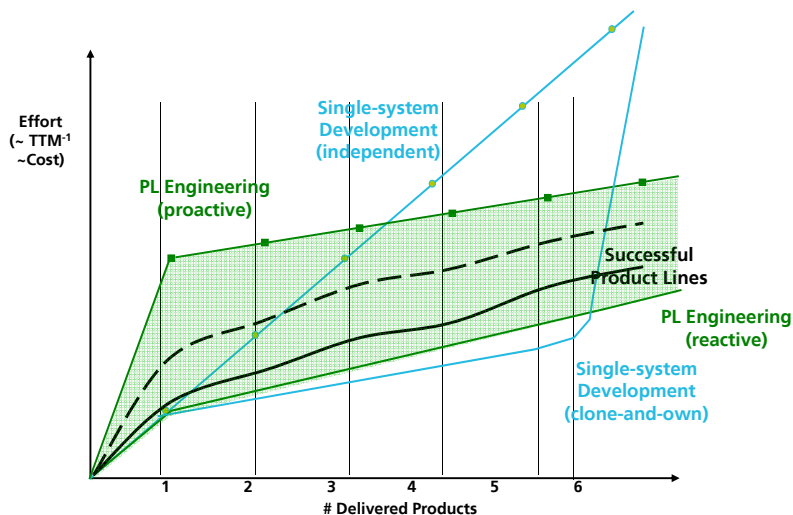
- Note: early successes are crucial while migrating to product line engineering

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Product Line Strategy – Product Line Economics (Revisited)

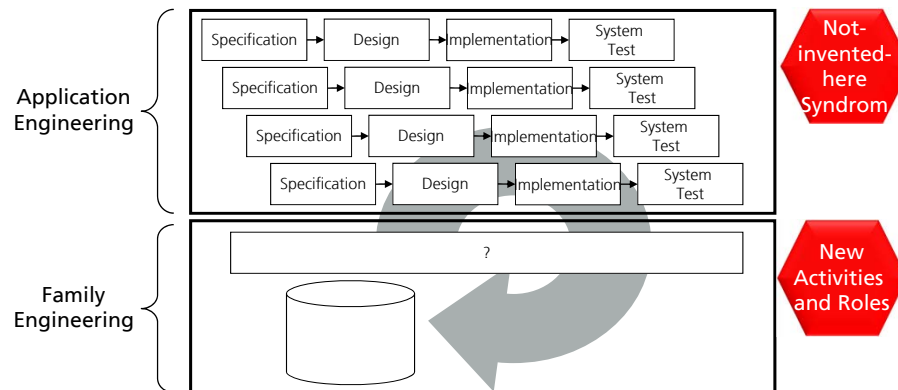


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Product Line Engineering: Organizational Life Cycle



- Big cultural change in many environments!
- Mature Software Engineering is a prerequisite for product line engineering

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Product Line Engineering: State-of-the-practice in Technology Transfer

Implicit assumption: PL technology provides huge potential

- Lack of analysis and evaluation of improvement potential
- Very few cases of systematic evaluation

CommunExperiences: Success stories, methods and techniques

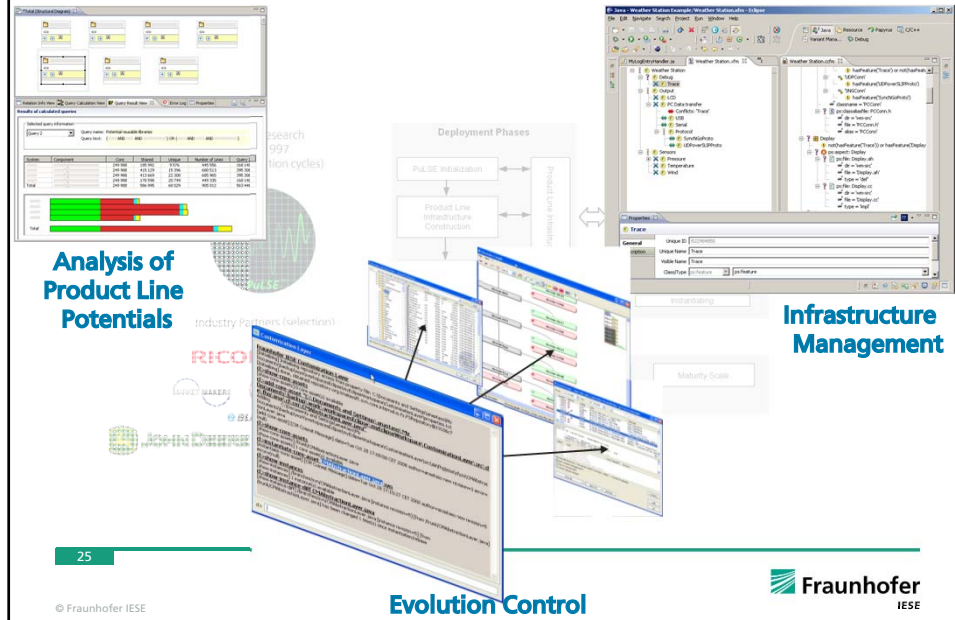
- Product Line Hall of Fame
- Little information on **context** and projects
- Existing experience useful for **organizations with different contexts?**

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Product Line Engineering with PuLSE

- **Scoping** instead of domain modeling
- **Incremental and Iterative**
Introduction of Product Line Engineering in more than one lifecycle (no Big-Bang)
- **Lightweight**
Explicit analysis of the starting situation and reuse of existing Software Engineering capabilities for PL
- **Architecture centric**
Product line reference Architecture as the central artifact
- **Explicit variability modeling** with decisions

Product Line Experiences and Success Stories

Small Enterprise, Information Systems (MarketMaker Software AG)



Small Enterprise (50 people) selling stock market data presentation and analysis software for individuals

Plan: quickly enter a new market (Web based stock market software for traders, banks etc)

- Iterative and incremental introduction of product line practices and product line components
- Quick release of first products based on existing code
- Introduction of a **lightweight** product line process
- Explicit **scoping** and occasional rescoping to form the new market
- Integration of **Software Engineering principles** like agile development, daily build, built-in tests etc
- **ROI after 5 applications**
- Ability to **release a new product within 3 days (instead of 2 months)**

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Medium Enterprise, Measurement Systems (Testo AG)



One of the leading suppliers of portable electronic measurement instruments for temperature, pressure, humidity, flow rate, and gas concentration

Two product departments each responsible for a different, but **similar set of products** (same business domain)

→ Introduce product line development to **integrate product departments, reduce costs** and be able to **develop more complex products**

→ **Reuse level increased**
from 17% (2002, start of PL)
to 34% (first PL generation)
to more than 50% (2009, 3rd generation)



→ More than **15 products derived**

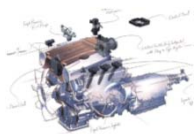
→ Product line **architecture** is a central asset in the development

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Large Enterprise, Automotive Engine Control Systems (Hitachi Ltd.)



International enterprise developing automotive engine control systems (e.g. control units, injector, fuel pumps etc.)

Goal: Optimize model-based generation for product lines

→ Introduce **integrated** variability management (Matlab)

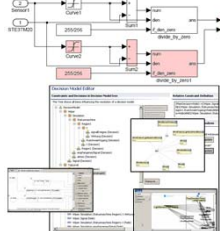
→ Enable **automated** product configuration

→ **Empirical validation**

→ initial investment is necessary

→ **faster derivation of new products**

→ **reduced product line maintenance effort**



[Yoshimura, Kentaro ; Forster, Thomas ; Muthig, Dirk ; Pech, Daniel:
Model-based Design of Product Line Components in the Automotive Domain
Proceedings of 12th Software Product Lines Conference, 2008]

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Large Enterprise, Multi-functional Peripherals (MFPs) (Ricoh Co. Ltd.)



International enterprise leading the market of MFPs

Goal: Enable mass customization of MFP components used in office applications

- Introduce an **architecture-centric customization process**
 - The Software Architecture integrates flexibility concepts that facilitate the customization
- **Workflow-driven requirements engineering**
 - Individual workflows and office infrastructures of customers are the main drivers of the customization
- Validation in a case study with the city of Kaiserslautern
 - Applicability of the approach has been verified
 - **Good potential for decreasing time to market, reducing expert involvement and improving product quality**

[Towards a Product Line Approach for Office Devices Facilitating Customization of Office Devices at Ricoh Co. Ltd. Ralf Carbon, Sebastian Adam, Takayuki Uchida, Proceedings of 13th Software Product Lines Conference, 2009]

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Small Enterprise, Remote Monitoring Systems (Wikon GmbH)



German company specialized in data collection, transmission and control for various meters (water, gas etc.)

Goal: Manage existing system variations, accelerate configuration of new products

- Introduce variability management **on top of existing mechanisms** (e.g. conditional compilation)
- **Step-wise transition** (initialization, analysis, product derivation, evolution)
- Achieved **benefits**
 - **faster product derivation**
 - **reduced development effort**
 - **reduced testing effort**

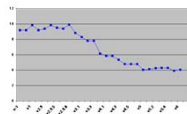
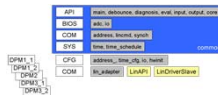
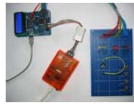
Beyer, H. J., Hein, D., Schitter, C., Knodel, J., Muthig, D., & Naab, M. (2008). Introducing Architecture-Centric Reuse into a Small Organization. 10th International Conference on Software Reuse (ICSR 2008).

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Large Enterprise, Automotive Driving Comfort Electronics



International company developing automotive driving comfort electronics (distributed door, roof and seating functions)

Goals: Refactoring existing systems into a product line

- Introduce **reference architecture** without resource penalties
- Provide **light-weight** product line refactoring strategies
- **Validation** by goal-oriented measurement
 - almost 0% resource overhead
 - -56% module dependencies
 - 65-88% code reuse

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Conclusions

Key Lesson Learned: Human Factors Matter

- **Mind set of people is the key**
- People of a product line organization have to feel responsible for the organization's product lines, which is shown by the following three attitudes:
 - **Avoid rework** (or at least minimize rework)
 - **Focus on product lines** rather on individual products only
 - **Value the product line** higher than each individual product
- Attitudes need to be **continuously communicated** to the product line development personal
- People need to **feel involved and need to be convinced**, as well as the product line needs to be made visible to people

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Summary

- **Product Line Engineering can solve many development problems**
 - Like unsystematic reuse (technology, processes)
- **Product Line Engineering has a significant return on investment**
 - We have initial evidence wrt. cost, quality, market penetration, and expert needs (see examples), but need more!
- **Product Line Engineering is real and practical**
 - See examples
- **But some challenges remain**
 - like product line testing, variability management,

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Thank you for your attention!

----- **Discussion** -----

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