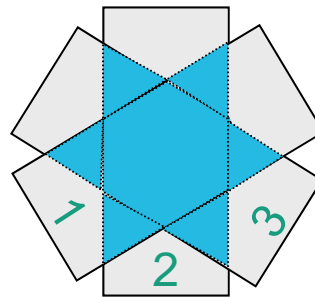

Product Line Engineering Lecture – PLE Principles & Experiences (2)

Dr. Martin Becker

martin.becker@iese.fraunhofer.de



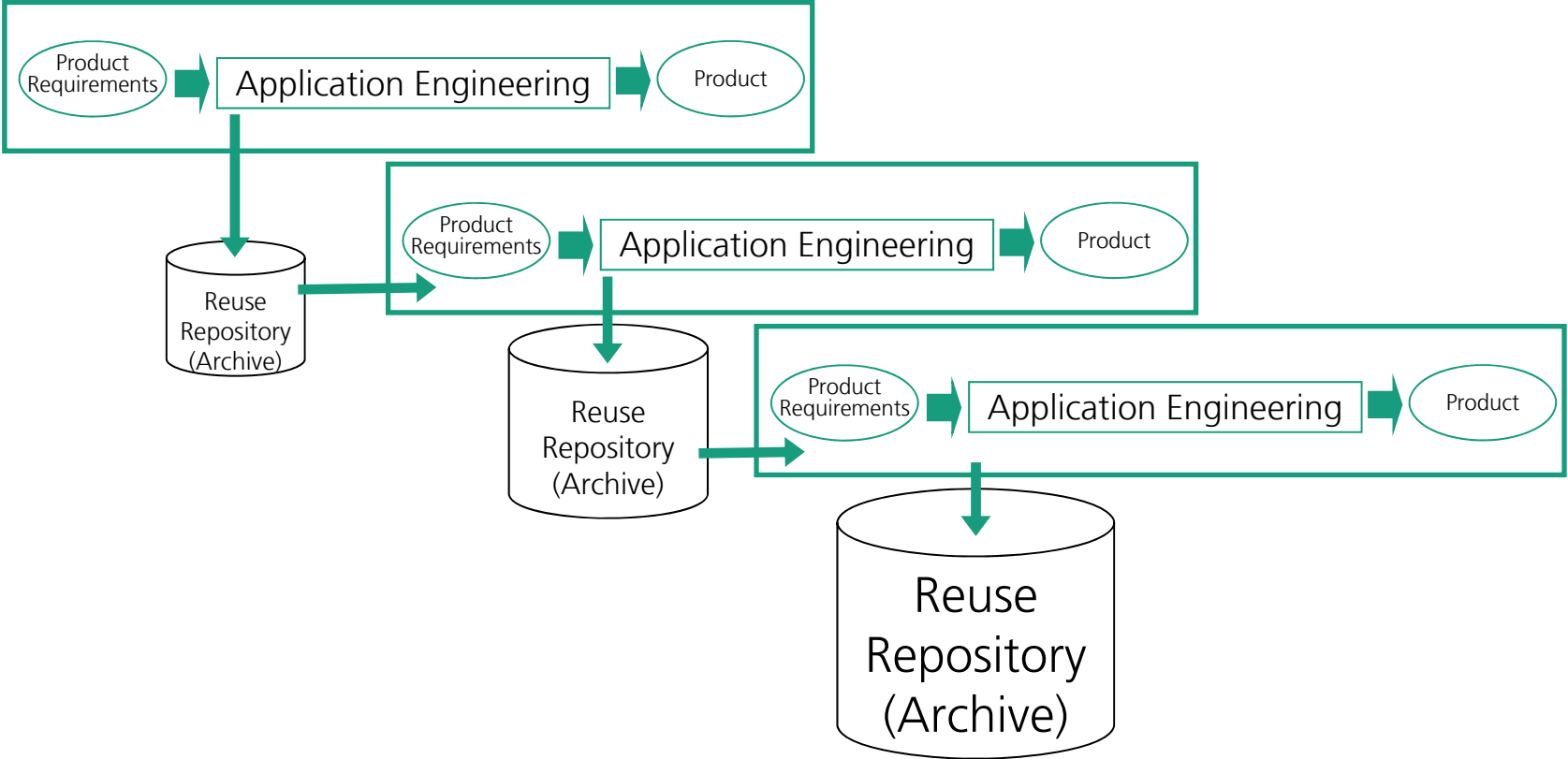
Copyright © Fraunhofer IESE 2011

--- Recap ---
Introduction

Reuse Approaches

- Typical Engineering Challenges:
 - Increasing # variants, complexity, customization, quality
 - Decreasing time to market, production costs

Reuse approaches: Ad-hoc



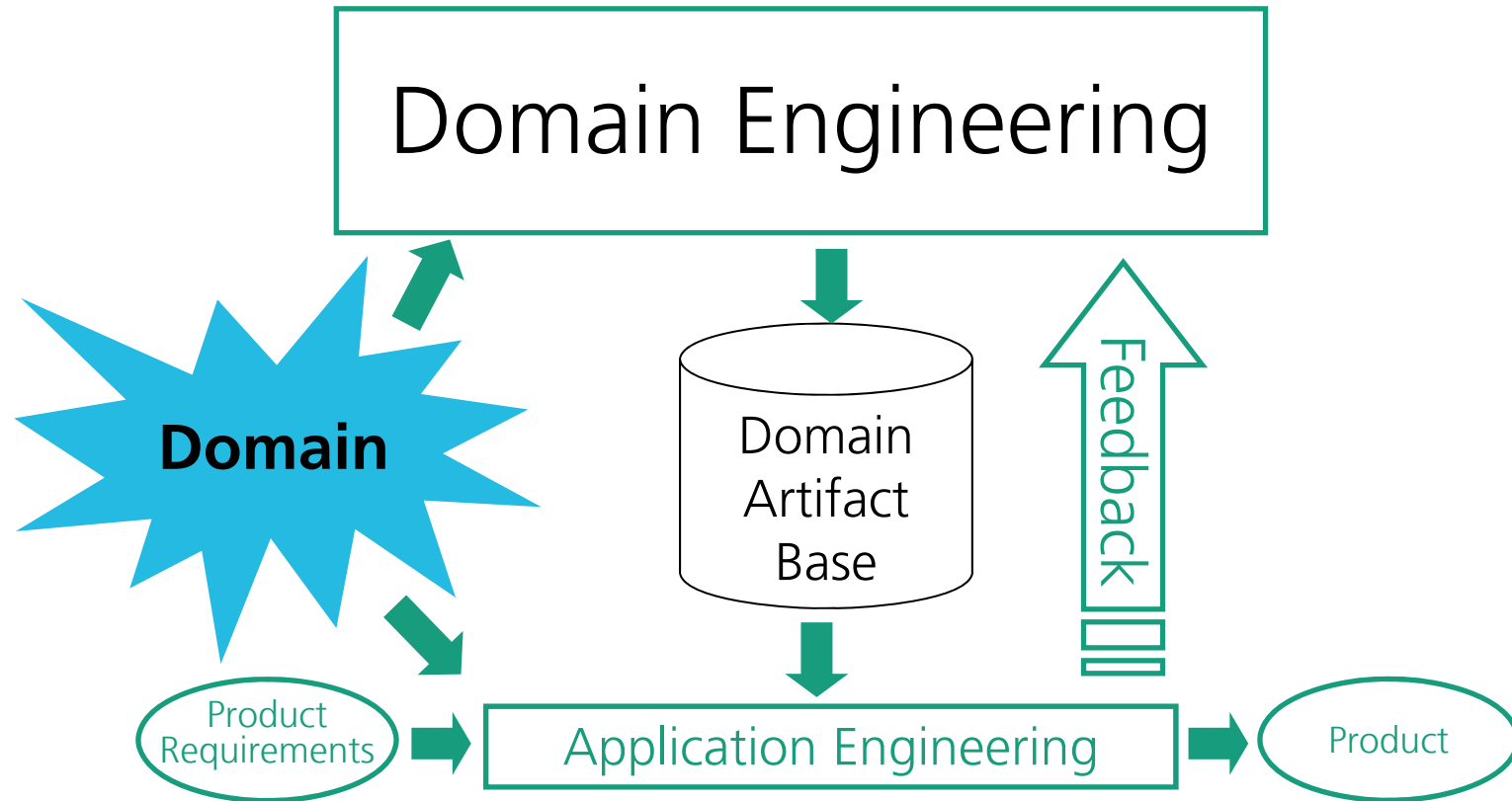
Problems with Ad-hoc reuse

Experiences

- **Applied widely:** *Clone and Own*
- **Does not scale** within an organization and across time due to
 - Lacking means for organizing and managing reusable artifacts
 - Search efforts
 - Evaluation efforts
 - Adaptation efforts (80:20 rule holds here)
 - Integration efforts

In most cases a no go!

Reuse Approaches: Domain Engineering



Idea: Proactively develop for reuse

Problems of Domain Engineering

Domain Engineering: *Development for reuse*

- Understand domain concepts, entities, and relationships
- Set up, maintain, evolve reuse infrastructure

Application Engineering: *Development with reuse*

- Product development based on large-scale reuse
- Reuse is driven by domain concepts
- No searching for reusable artifacts required

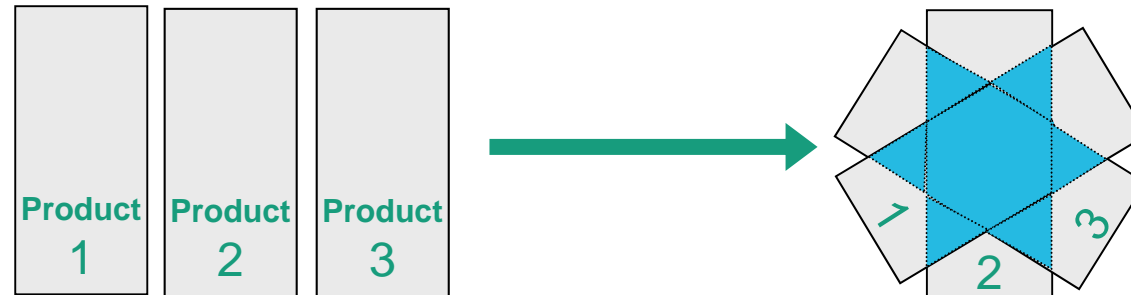
Emphasis is on Domain Engineering

- **No clear termination criteria => It takes forever**
- Unclear domain boundaries
 - Reusable artifacts become **more general or generic** than required
 - And thus much harder to reuse and maintain
- Application engineering assumed as requiring no effort (ideal vision)

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**--- PLE Principles
& Experiences ---**

Optimizing Reuse – Product Line Engineering



- Considering the different products an organization or organizational sector delivers as *Product Family* or *Product Line*
- Taking advantage of commonality
- Clear understanding about variability
- Strategic planning of software reuse
- Efficient production

Proactively plan the reuse:
Just the right variability support

Product Line ::=

a set of software-intensive systems sharing a common, managed set of features

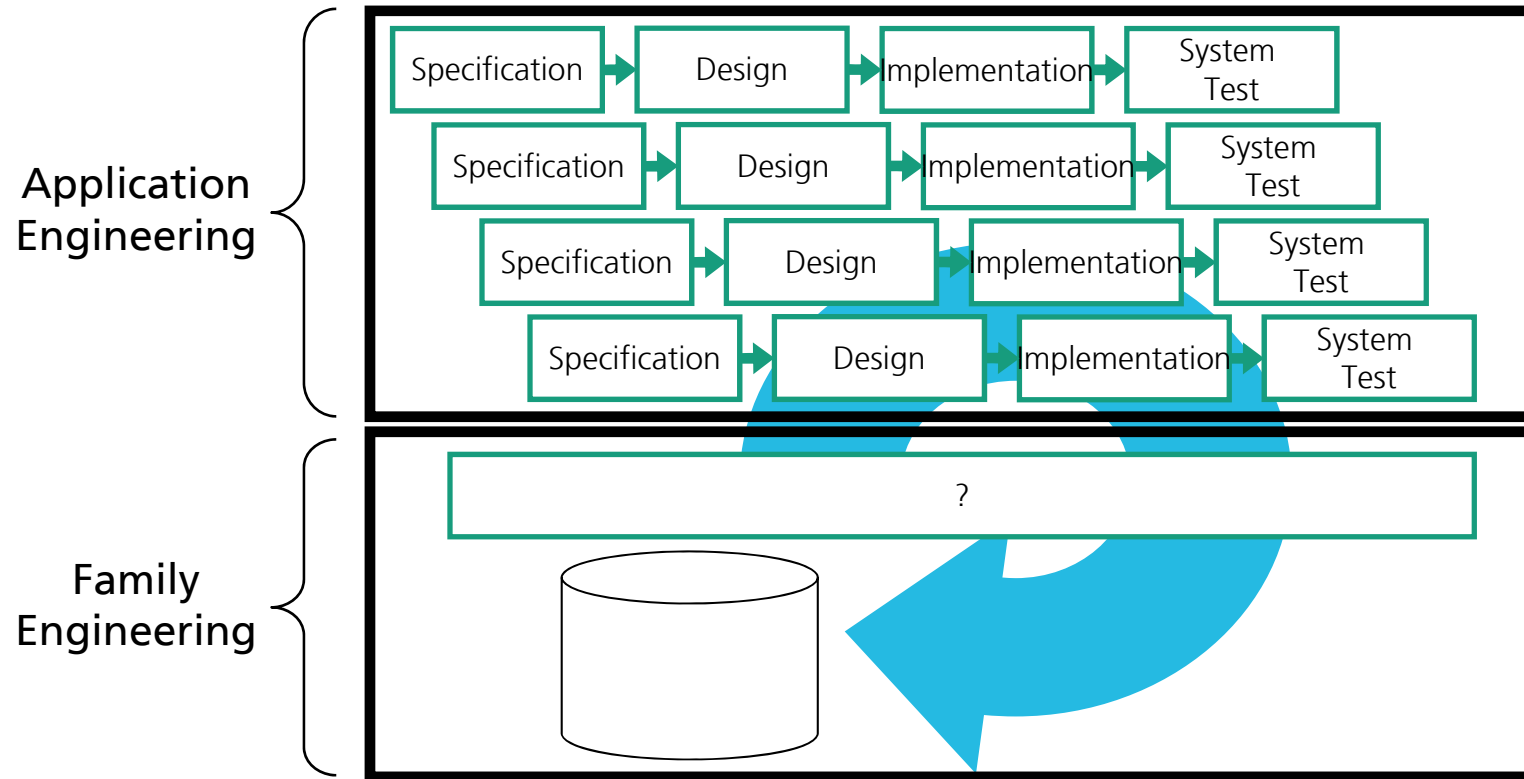
that satisfy the specific needs of a particular market segment or mission and that are

developed from a common set of assets in a prescribed way.

Product Line ::=
a family of products designed to take advantage of
their common aspects and predicted variabilities”

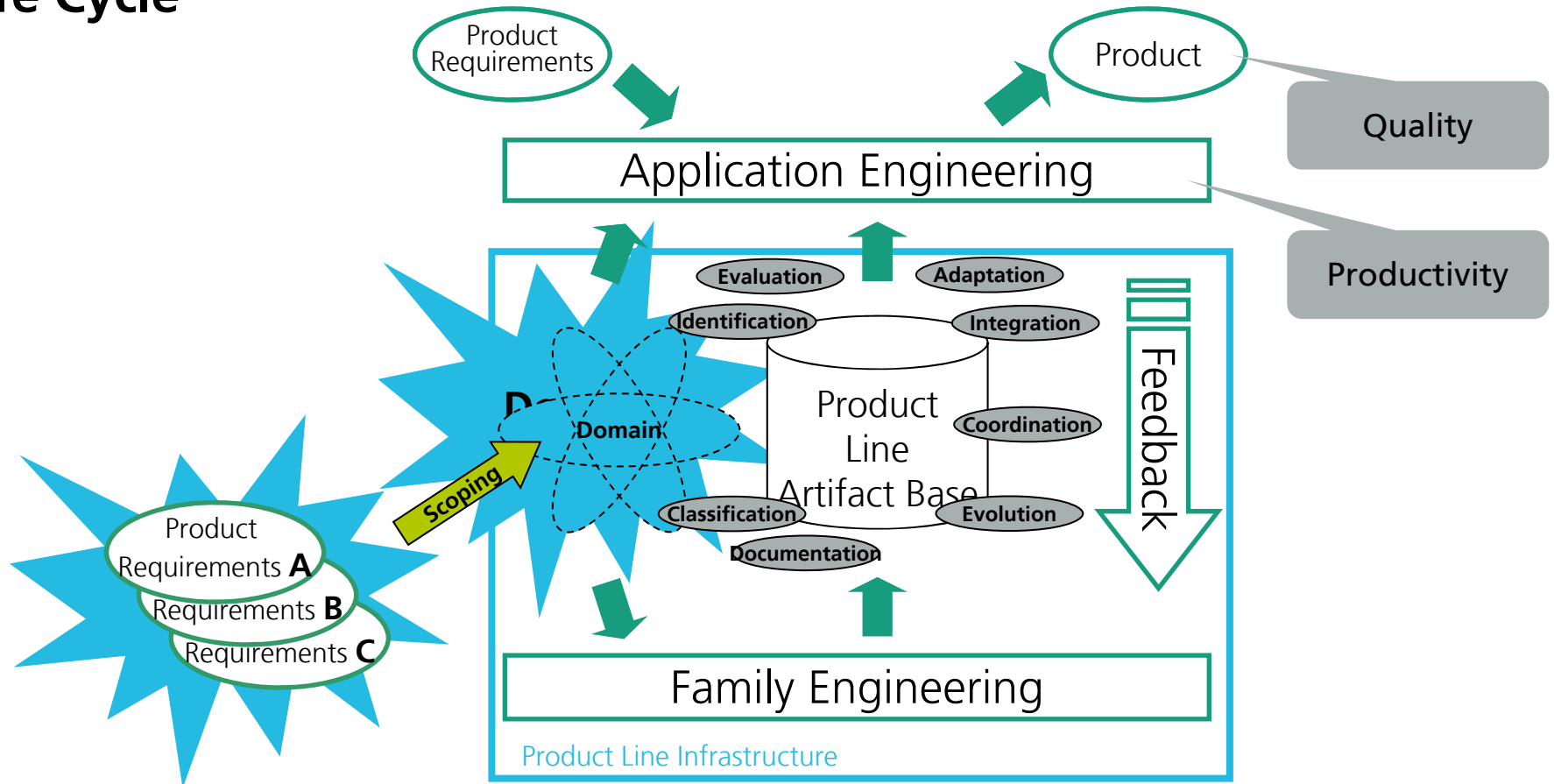
[D.M. Weiss, C.T.R. Lai: Software Product-Line Engineering. A Family-Based Software Development Process. Addison-Wesley, 1999]

Organizational Life Cycle



Big cultural change in many environments!

Product Line Life Cycle



Product Line Engineering

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 is thus

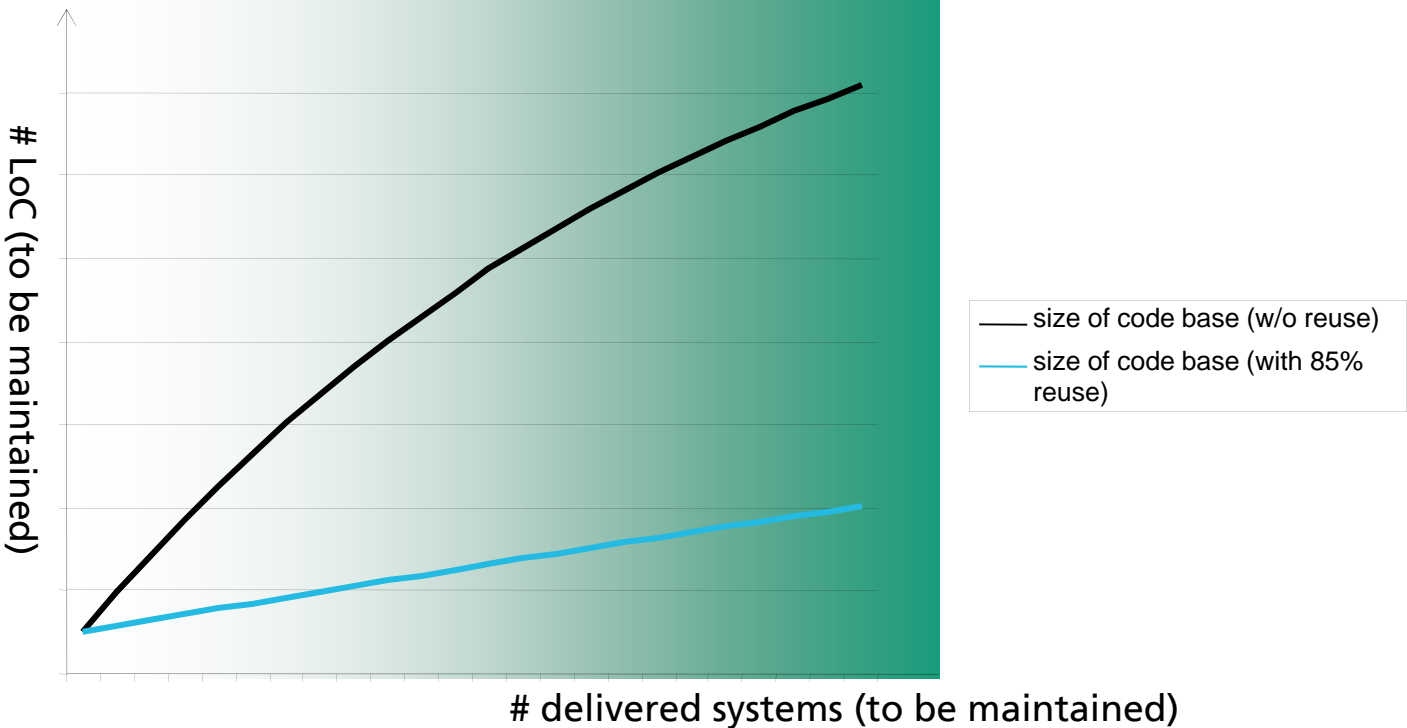
- More focused and closer to production (than DE), as well as
- More efficient

Emphasis is on **Application Engineering!**

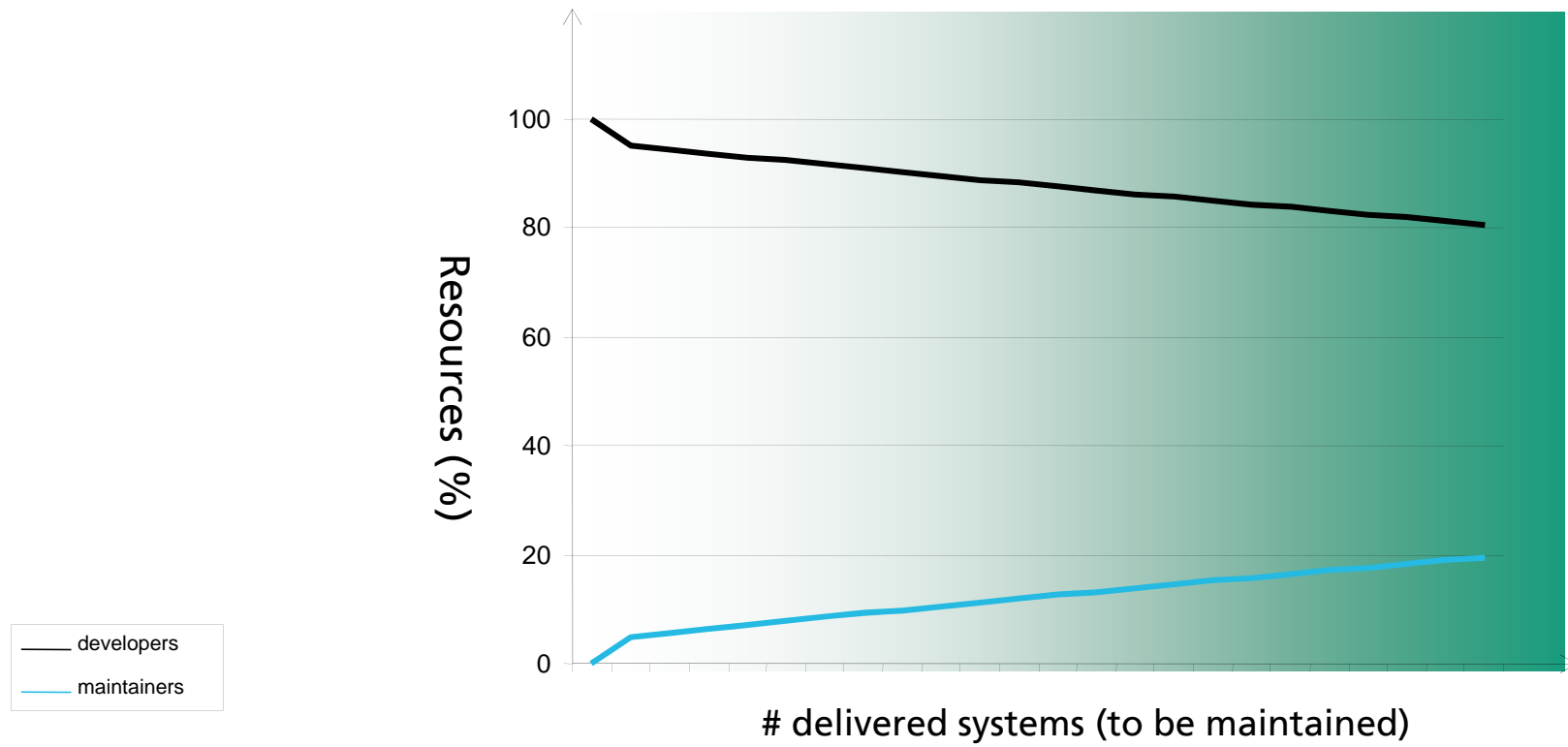
Effectively exploit the reuse potential

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Size of Code to be maintained



Developers versus Maintainers (85% Reuse)



Product Line Process Models

General process models can be applied to

- Application engineering
- Family engineering
- Define clear interfaces and protocols between main activities

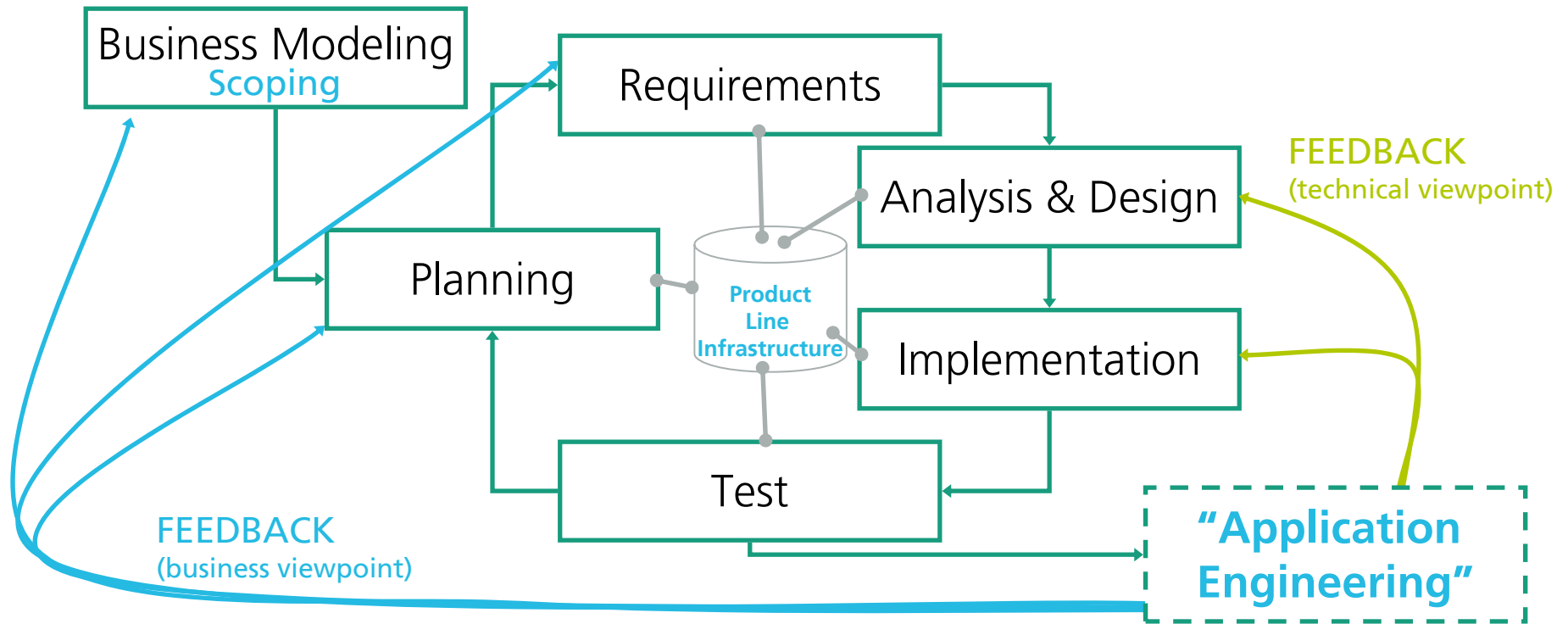
Family engineering

- Delivery to application engineering
- Products are reusable artifacts and infrastructure technologies

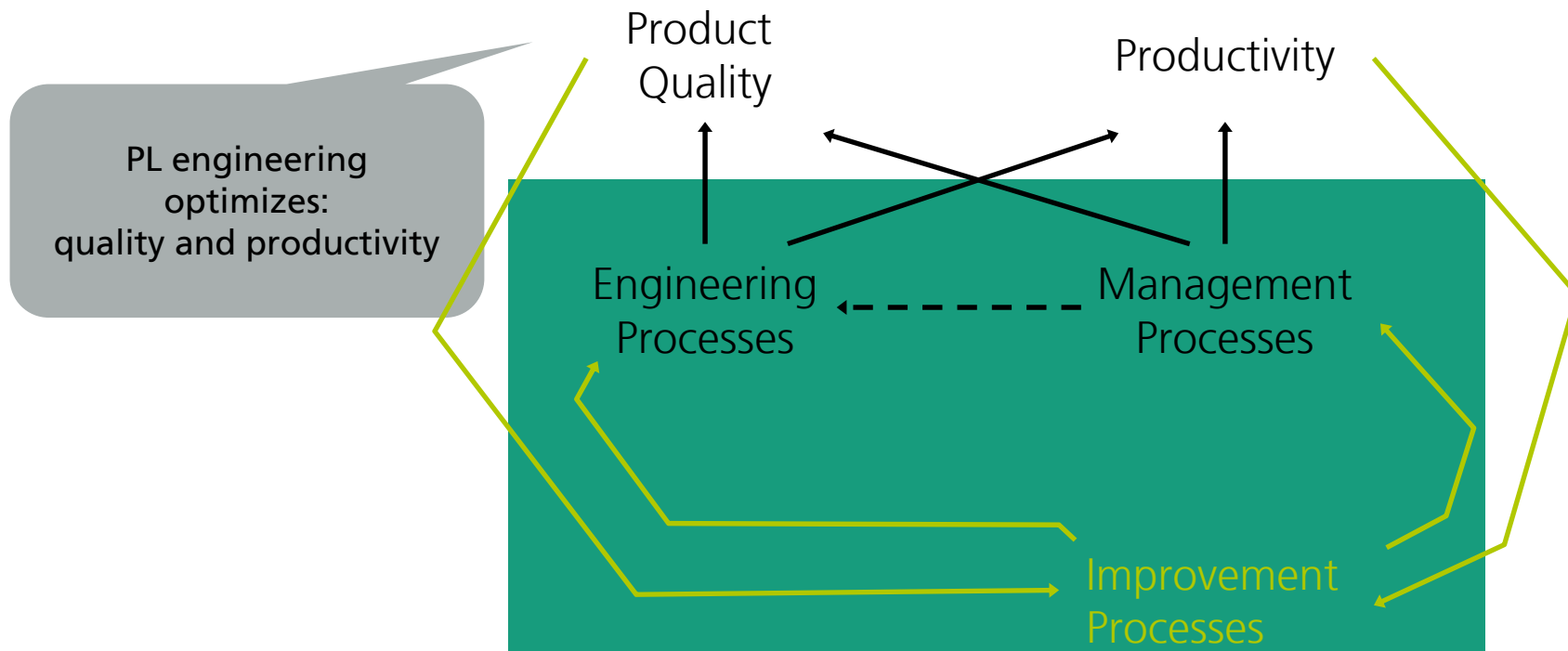
Application Engineering

- As in single system context
- Reuse, however, **is built in!**

Family Engineering (RUP)



Definition: Product Line Engineering

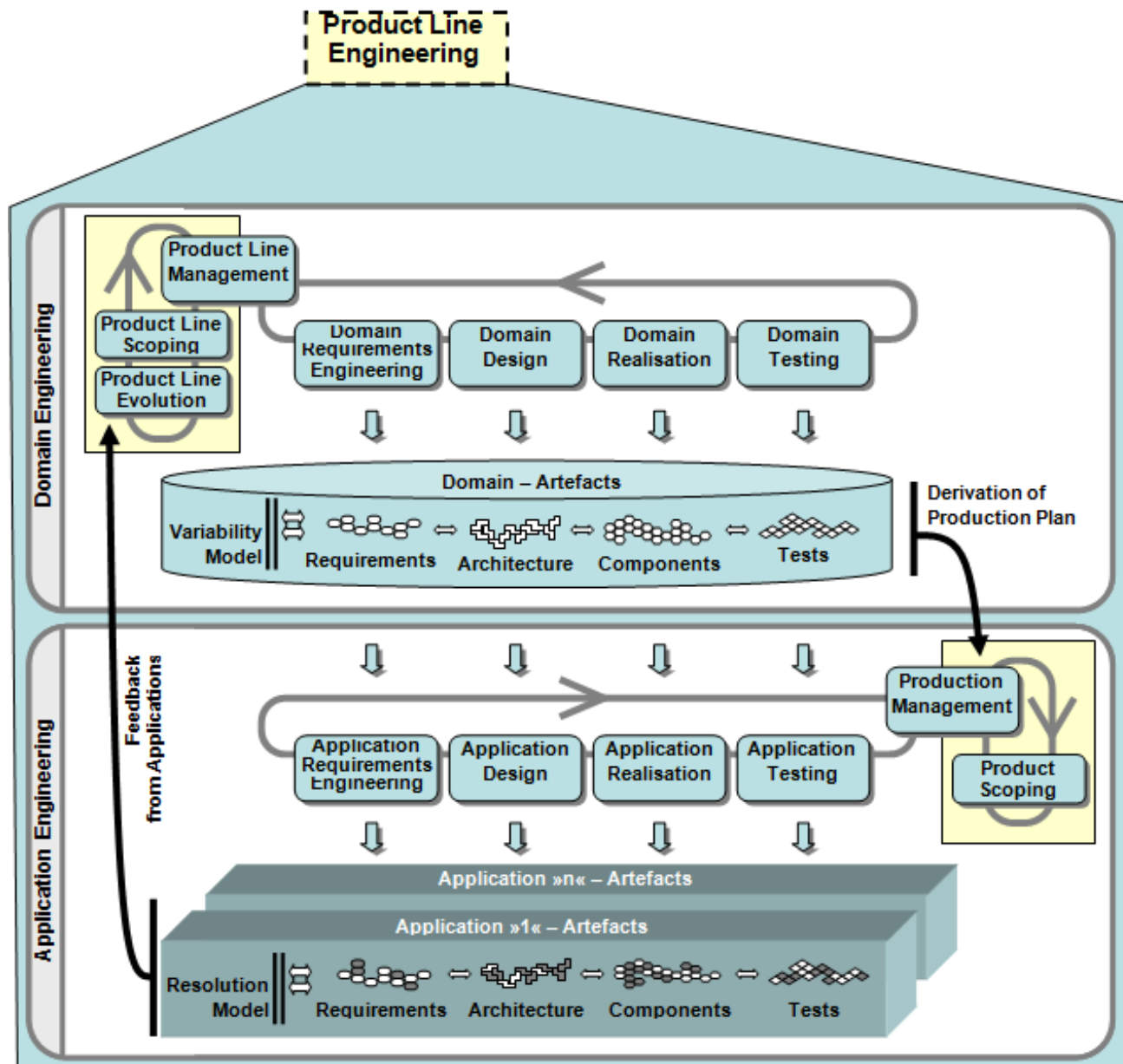


Definition: Product Line Approach

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
- [Fraunhofer IESE]

Only a comprehensive approach works!

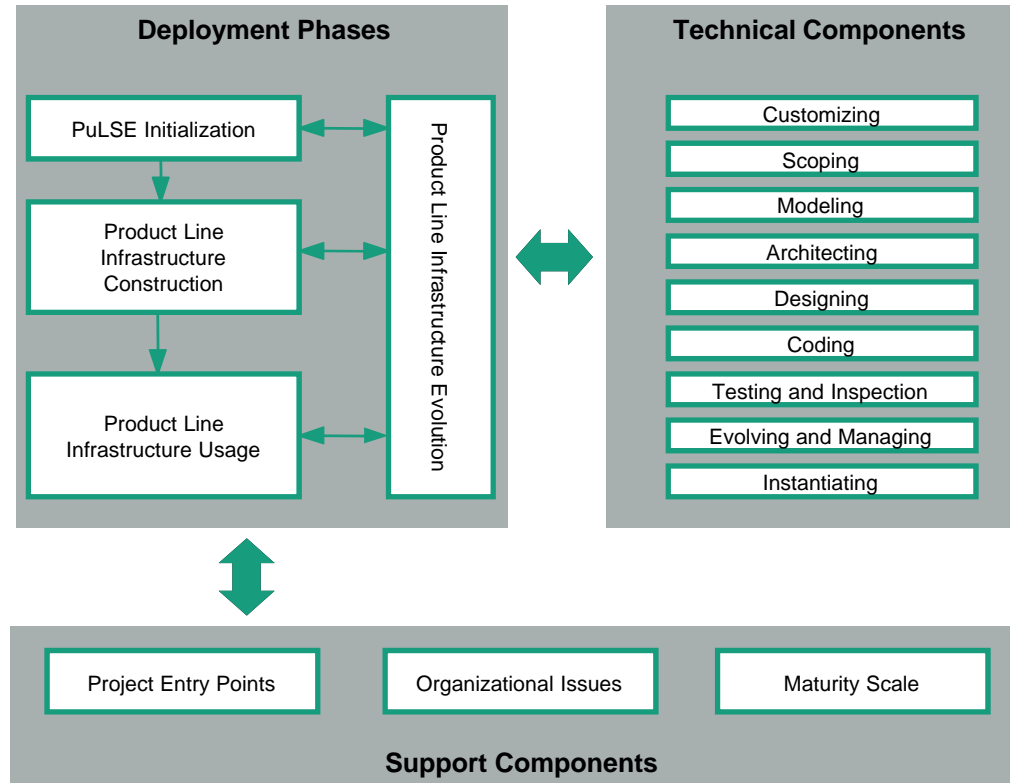


Fraunhofer PuLSE™

Applied research
since 1997
(= 4 innovation cycles)



Industry Partners (selection)



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

Possible Goals with the introduction of Product Lines

- Reduction in the time to market required for individual products
- Reduction in the overall development cost
- Reduction in required development effort per product
- Reduction in the overall maintenance cost
- Higher quality standards consistently across all products
- Common look and feel, as well as high interoperability, among products

- Trade-offs require prioritization

Example: Mobile Games Market

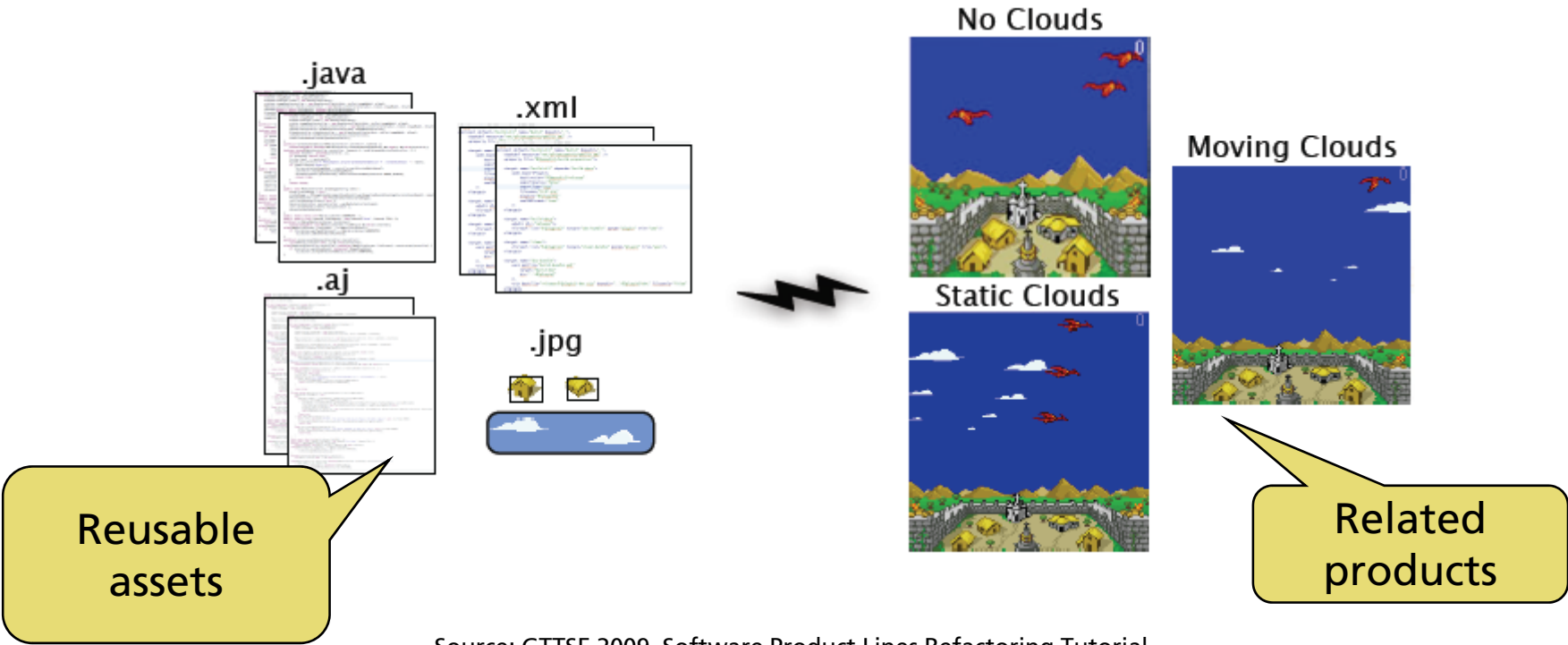


Different cell phone brands

Different supported APIs, different screen sizes, memory, etc.

Source: GTTSE 2009, Software Product Lines Refactoring Tutorial

Product Line Approach



Source: GTSE 2009, Software Product Lines Refactoring Tutorial

Success Story: Cummins, Inc. (1/2)

World's largest manufacturer of large diesel engines.

Product family includes

- 9 basic engine types
- 4-18 cylinders
- 3.9 - 164 liters
- 12 kinds of electronic control modules
- 5 kinds of processors
- 10 kinds of fuel systems
- diesel fuel or natural gas

[Clements/Northrop]



Success Story: Cummins, Inc. (2/2)

Cost

- Management estimates product line ROI of 10:1

Time to Market

- Product cycle time: a year to a few days

Productivity

- 20 product groups → 1000 separate applications
- 75% of all software comes from core assets
- Productivity improvement of 360%

Enter new Markets

- Capability let Cummins enter and dominate industrial diesel engine market

Quality

- Software quality is at an all-time high
- 15 of 15 projects are on track (was 3 of 10)
- Customer satisfaction is high.

[Clements/Northrop]

Large company, revolutionary approach,
detailed results wrt. many goals

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Concrete Reported Benefits

- Nokia is able to produce 25 to 30 different phone models per year (up from 4 per year) because of the product line approach.
- Cummins, Inc., was able to reduce the time it takes to produce the software for a diesel engine from about a year to about a week.
- Motorola observed a 400% productivity improvement in a family of one-way pagers.
- Hewlett-Packard reported a time to market reduced by a factor of seven and a productivity increase by a factor of six, in a family of printer systems.

Really exploit the reuse potential

Not only business benefits

■ Organizational benefits

- Efficient management of human resources
 - People can be easily transferred across products
 - Expertise is applicable across products
- Training effort is kept small
 - Resources spent on training developers to use processes, tools, and system components are expended only once.
- Increased predictability
- Well-established roles and responsibilities

Product Line Success Story: medium Enterprise, Measurement Systems



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** from the product line

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

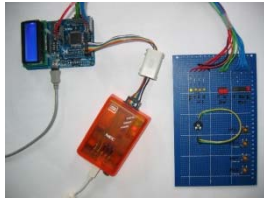
→ **Maintainability** increased significantly (e.g. architectural divergences decreased from 17% to 1%)



Mid-size company, evolutionary approach,
detailed results wrt. many goals

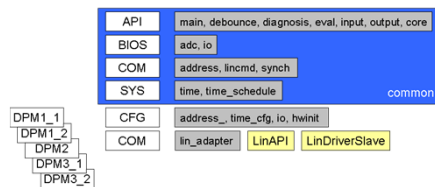
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Product Line Success Story: Large Enterprise, Automotive Driving Comfort Electronics



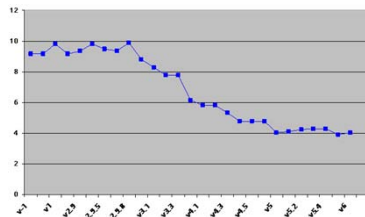
International company developing automotive driving comfort electronics (distributed door, roof and seating functions)

Goals: Refactoring existing systems into a product line



→ Introduce **reference architecture** without resource penalties

→ Provide **light-weight** product line refactoring strategies

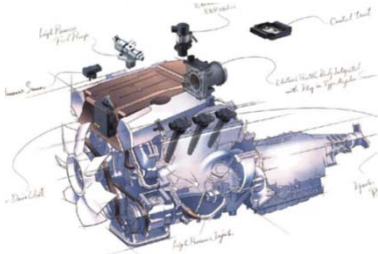


→ **Validation** by goal-oriented measurement

- 0% resource overhead
- -56% module dependencies
- 65-88% code reuse

Large company, evolutionary approach,
specific results wrt. many goals

Product Line Success Story: Large Enterprise, Automotive Engine Control Systems



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

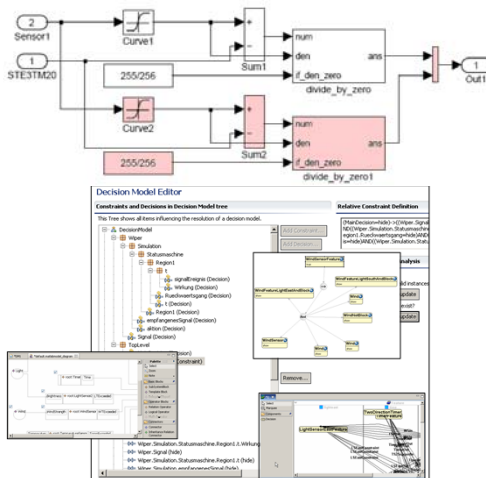
Goal: Optimize model-based generation for product lines

→ 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]

Product Line Success Story: Small Enterprise, Remote Monitoring and Control Systems

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 expert work load

→ reduced maintenance effort (especially in terms of changing product configurations)

*[Pech, Daniel ; Knodel, Jens ; Carbon, Ralf ; Schitter, Clemens ; Hein, Dirk:
Variability Management in Small Development Organizations –
Experiences and Lessons Learned from a Case Study,
Proceedings of 13thSoftware Product Lines Conference, 2009]*

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PRODUCT LINE HALL OF FAME

A hall of fame serves as a way to recognize distinguished members of a community in a field of endeavor. Those elected to membership in a hall of fame represent the highest achievement in their field, serving as models of what can be achieved and how.

Each Software Product Line Conference (SPLC) culminates with a session in which members of the audience nominate systems for induction into the Software Product Line Hall of Fame. Those nominations feed discussions about what constitutes excellence and success in product lines. The goal is to improve software product line practice by identifying the best examples in the field.

Nominations are voted on at the next SPLC by the majority of those present. For example, the [Bosch Gasoline Systems: Engine Control Software Product Line](#) and [Philips Low-End Television Product Line](#) were nominated at SPLC 2006. The Bosch Gasoline Systems: Engine Control Software Product Line was inducted at SPLC 2007.

Organizations in the Product Line Hall of Fame

- [Boeing](#)
- [Bosch Group](#)
- [CelsiusTech Systems AB](#)
- [Cummins, Inc.](#)
- [Ericsson AXE](#)
- [General Motors Powertrain \(GMPT\)](#)

News & Information

[SPLC 2011](#) will be held in Munich, Germany, August 22-26, 2011.



[<http://splc.net/fame.html>]

Summary

- High potential wrt. various business goals of strategic (large-scale, planned) reuse programmes
 - ➔ You probably have a high reuse potential as well
- Product Line Approaches are very promising, but must be comprehensive: engineering, management, improvement and customized to the respective context
 - ➔ Leaving you alone with some books and technical reports does not work
- PuLSE approach is available and has proven to work in practice
 - ➔ We can and want to help you with achieving your reuse goals