



# 41. Software Product Lines (SPL)

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<http://st.inf.tu-dresden.de/teaching/saab>

- 1) Software Product Lines
- 2) SPL based on Software Machine Tools
- 3) SPL for the supply chain (Farms)
- 4) SPL based on Workflows

# References

- ▶ [MassCustomization] Charles Krüger. Software Mass Customization. Biglever Software White Paper. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.84.6997&rep=rep1&type=pdf>
- ▶ Klaus Schmid, Frank van der Linden. Software Product Lines in Action. Springer.



## 41.1 Software Product Lines (SPL)

- Domain-specific products cannot easily be ported to other domains.
- Without software, many products cannot provide new innovations today.

# The Value of the SPL Business Model

„**Software product lines represent perhaps the most exciting paradigm shift in software development since the advent of the high-level programming languages.** Nowhere else in software engineering have we seen such breathtaking improvements in cost, quality, time to market, and developer productivity, often registering in the order-of-magnitude range.“

„At the Software Engineering institute, we have recorded case study after case study of companies succeeding in one market area with a product line approach, and then taking their production capability to a nearby, under-exploited area of the market, and quickly rising to market dominance in that area as well.

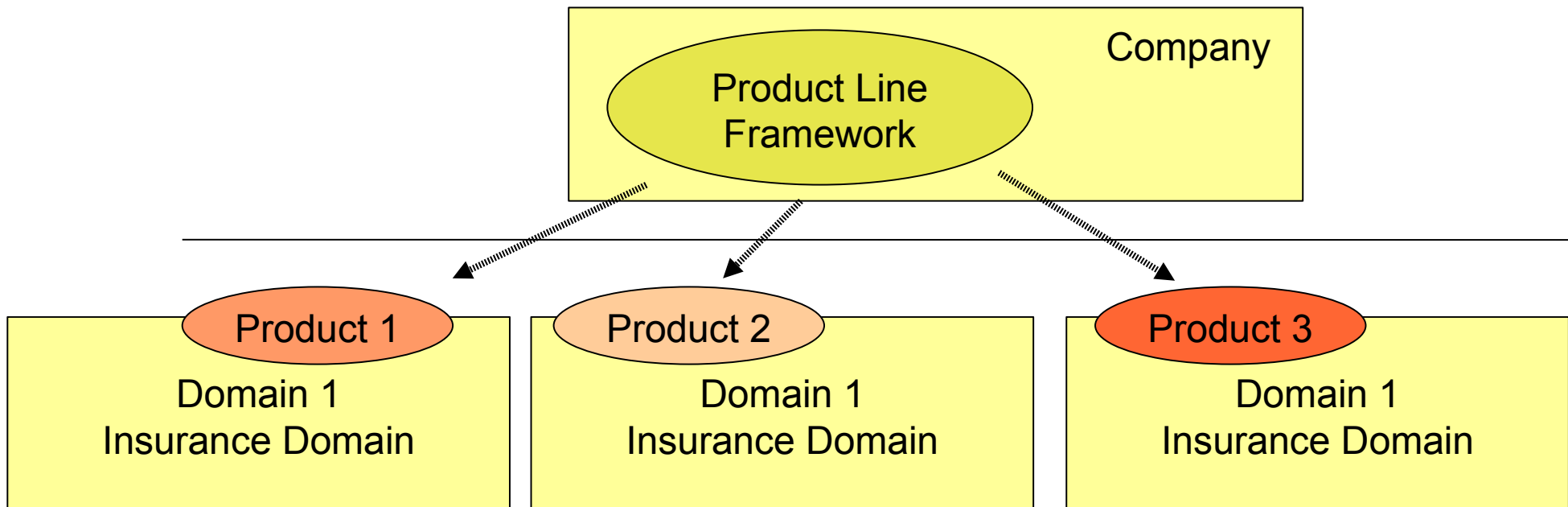
And why not? **If you can outperform your competitors by order-of-magnitude levels,** it's hard to imagine what could you keep from becoming a market leader.“

Paul Clements, SEI, in the preface of K. Schmid, et.al., „Software Product Lines in Action“, Springer-Verlag.

# Business Model

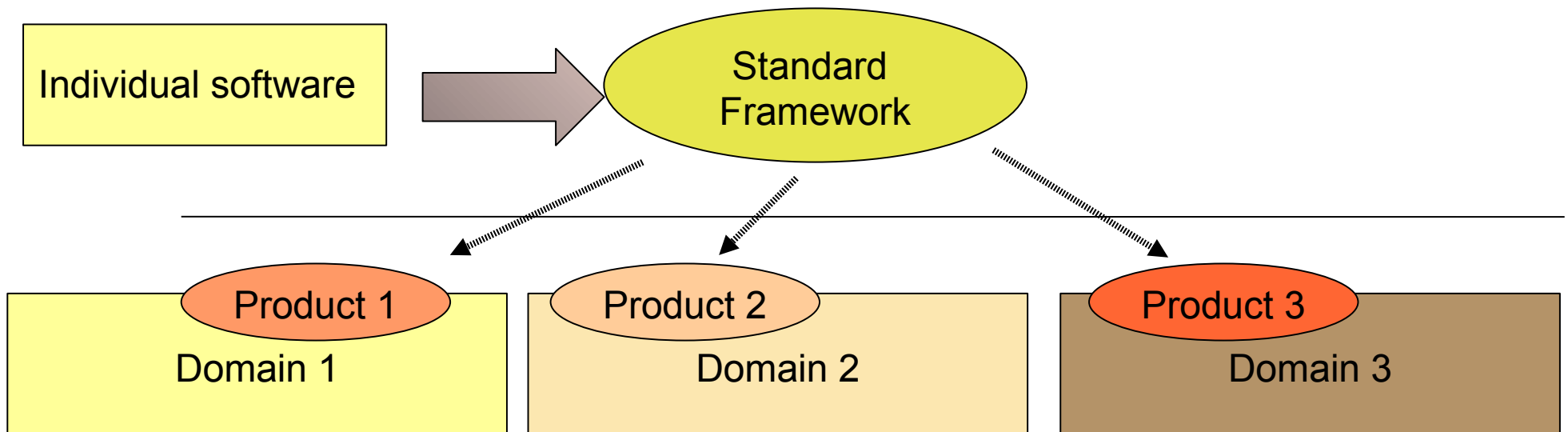
## “Domain-Specific Software Product Line (DSPL)”

- ▶ Fill several domain-specific needs with products relaying on a framework in-house.
- ▶ Know how: instantiate new products with it, that are sold
  - Keep the product line framework as company secret
- ▶ Distinguish B2C (business-2-customer) and B2B (business-2-business) and B2B2B (business-2-business-2-business)



# Business Model “Application Market Maturization”: From Individual Software to Framework Market”

- ▶ The 5 founders of SAP left IBM in 1974 because they planned a standard generic framework which they could instantiate to applications, which IBM didn't foresee
- ▶ <https://www.sap.com/corporate/en/company/history.html>
- ▶ The idea is that markets mature over time and move from individual software (expensive) to standard software (cheaper)
- ▶ New SAP frameworks (R/1, R/2, R/3, Netweaver, S/4 etc) appeared about every 10th year and doubled the turnaround of SAP every 5 years





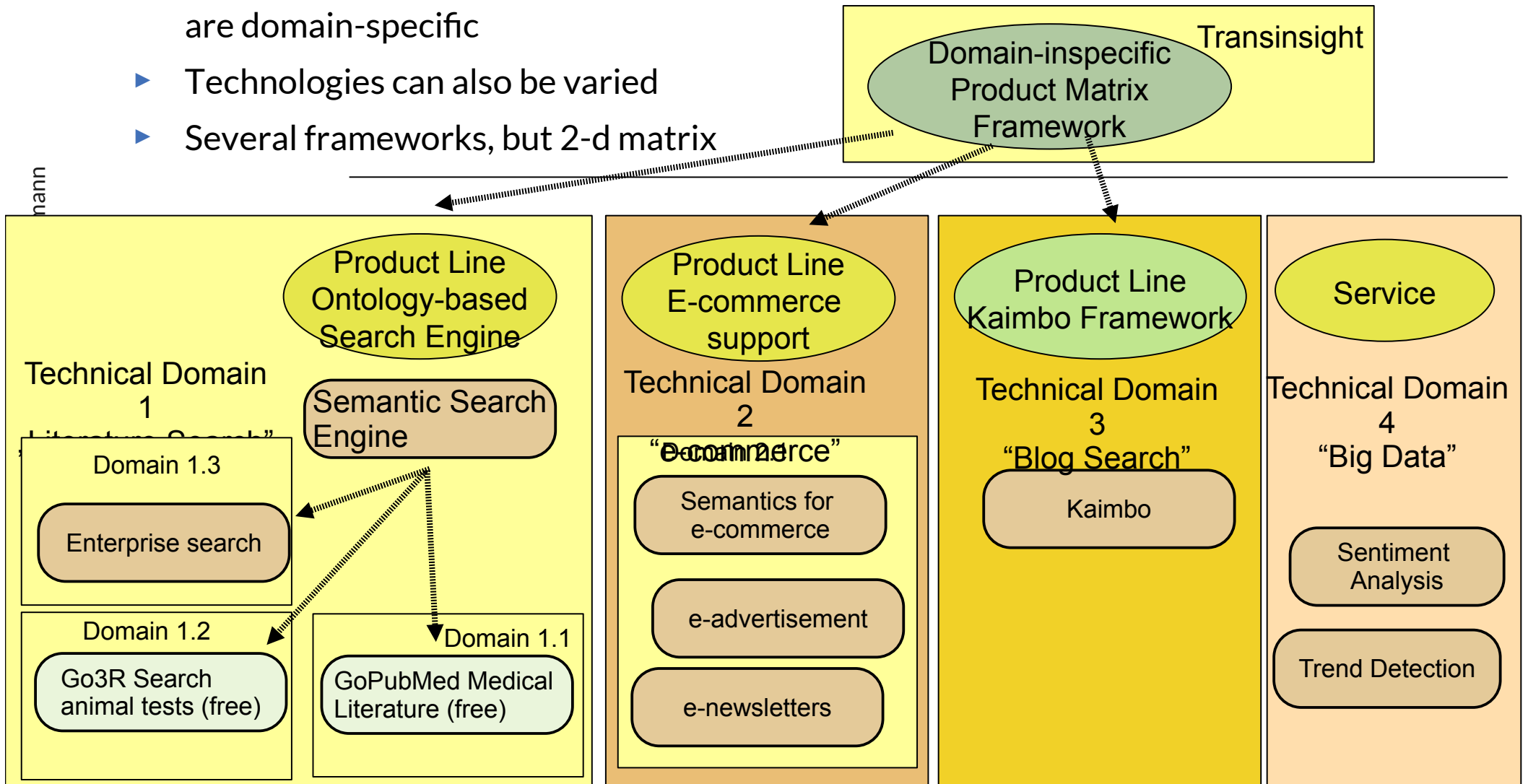
„Ohne Software gibt es kein Wachstum mehr.“  
Philipp Rösler, Bundesminister für Wirtschaft und Technologie, 21.5.2013

## 41.1.1 B2B Product Lines

- Domain-specific products cannot easily be ported to other domains.
- Without software, many products cannot provide new innovations today.

# Transinsight Semantic Technology (Semantic Search Engines)

- ▶ <http://transinsight.com/> (until 2015) Dresden BioTec, Am Tatzberg
- ▶ Semantic Search engine based on ontologies are domain-specific, because ontologies are domain-specific
- ▶ Technologies can also be varied
- ▶ Several frameworks, but 2-d matrix





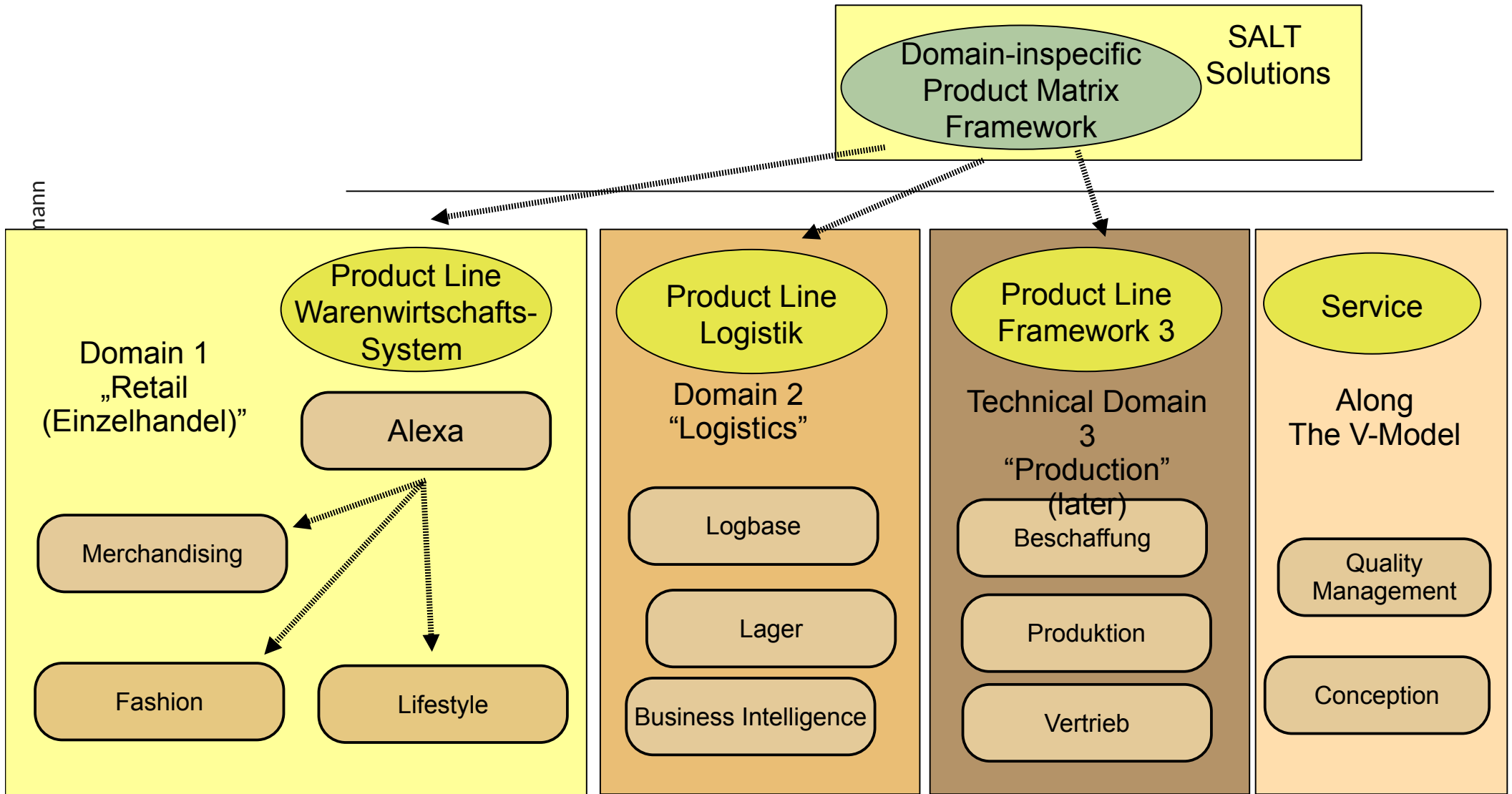
# Salt Solutions Retail Product Line

- ▶ [Bernhard Blüthner. SALT Solutions. Software Engineering 2015, Dresden]
- ▶ <https://www.salt-solutions.de/branchen/handel.html>



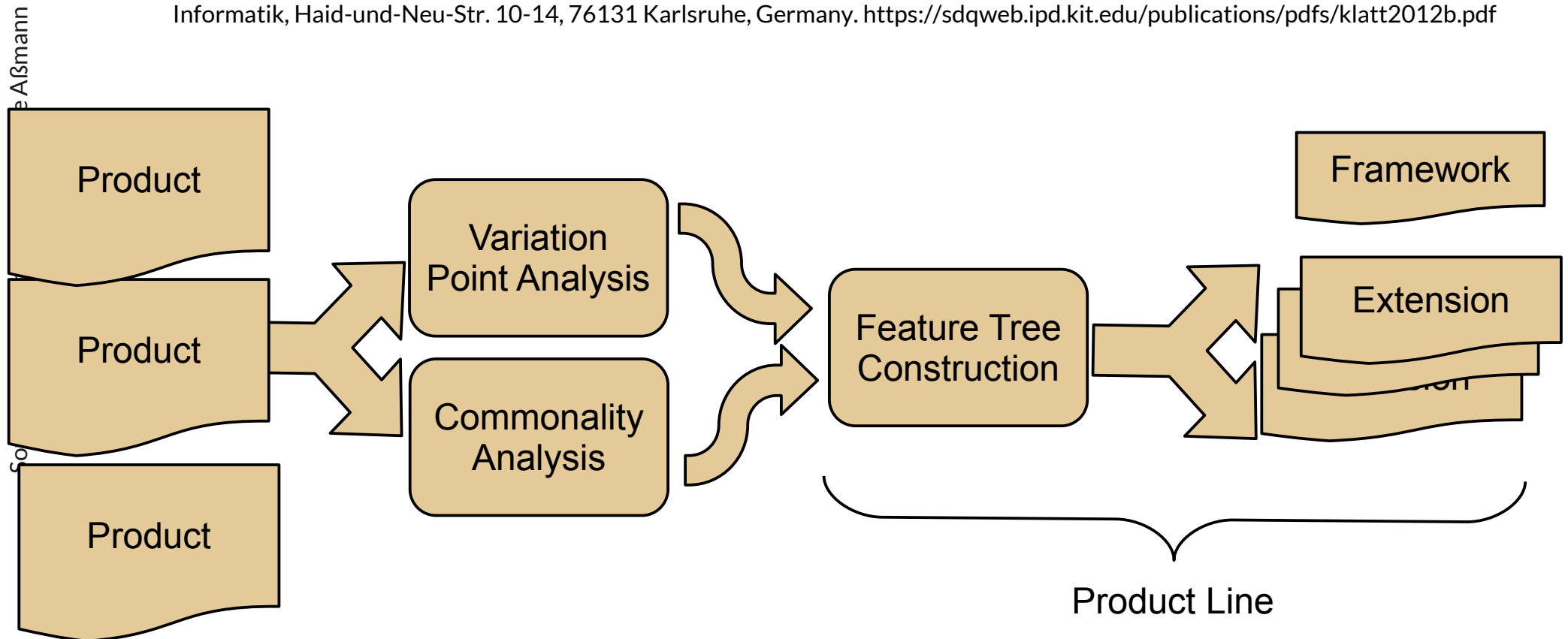
# Salt Solutions Product Matrix

- ▶ Historical growth of product matrix
- ▶ <https://www.salt-solutions.de/branchen.html>



# Product-Lining: Creating a DSPL from Several Products

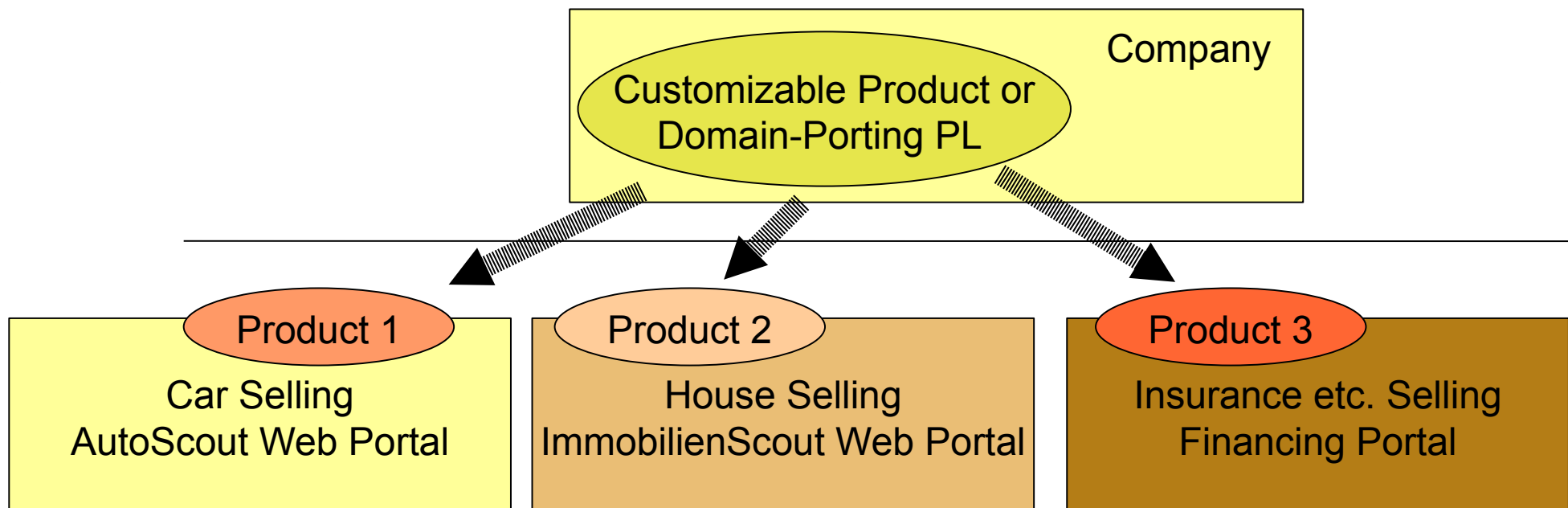
- ▶ Often, products are derived from each other in an ad-hoc manner, and are not arranged in a DSPL. <http://www.kopl-project.org/> (DevBoost, CAS, FZI)
- ▶ **Product-Lining** produces a systematic product line from the ad-hoc products
- ▶ Benjamin Klatt. Consolidation of Customized Product Copies into Software Product Lines. PhD Thesis. 2014. Institute for Program Structures and Data Organization Chair for Software Design and Quality Karlsruhe Institute of Technology
- ▶ Benjamin Klatt, Klaus Krogmann. Model-Driven Product Consolidation into Software Product Lines. FZI Forschungszentrum Informatik, Haid-und-Neu-Str. 10-14, 76131 Karlsruhe, Germany. <https://sdqweb.ipd.kit.edu/publications/pdfs/klatt2012b.pdf>



# Business Model

## “Domain-Porting of Software Product Line”

- ▶ Have a product in-house that can be ported to other domains, resulting in a **product matrix**
- ▶ Know how: instantiate new products with it in similar domains, trading other goods
  - Keep the product as company secret
- ▶ Examples: Domain-specific web portals
  - First was Autoscout24.de, then <http://www.immobilienscout24.de/>, then <http://www.trucksout24.de/>, then <http://www.financescout24.de/>, ...
  - Now, it is a group <http://www.scout24.com/>



# Product Variation in Many Dimensions

- ▶ Functional Variation (of domain-specific SPL)
- ▶ Domain Variation (domain-porting SPL)
- ▶ Region, Country, Language, Governance Rule Variation (internationalization)
- ▶ User Group Variation (simple, expert, architect)
- ▶ Platform Variation (App, Watch App, Rich Client, Cloud, ..)
  
- ▶ A product line which is scaled in 2 dimensions is called a **Product Matrix**
- ▶ A product line which is scaled in 3 dimensions is called a **Product Cube**

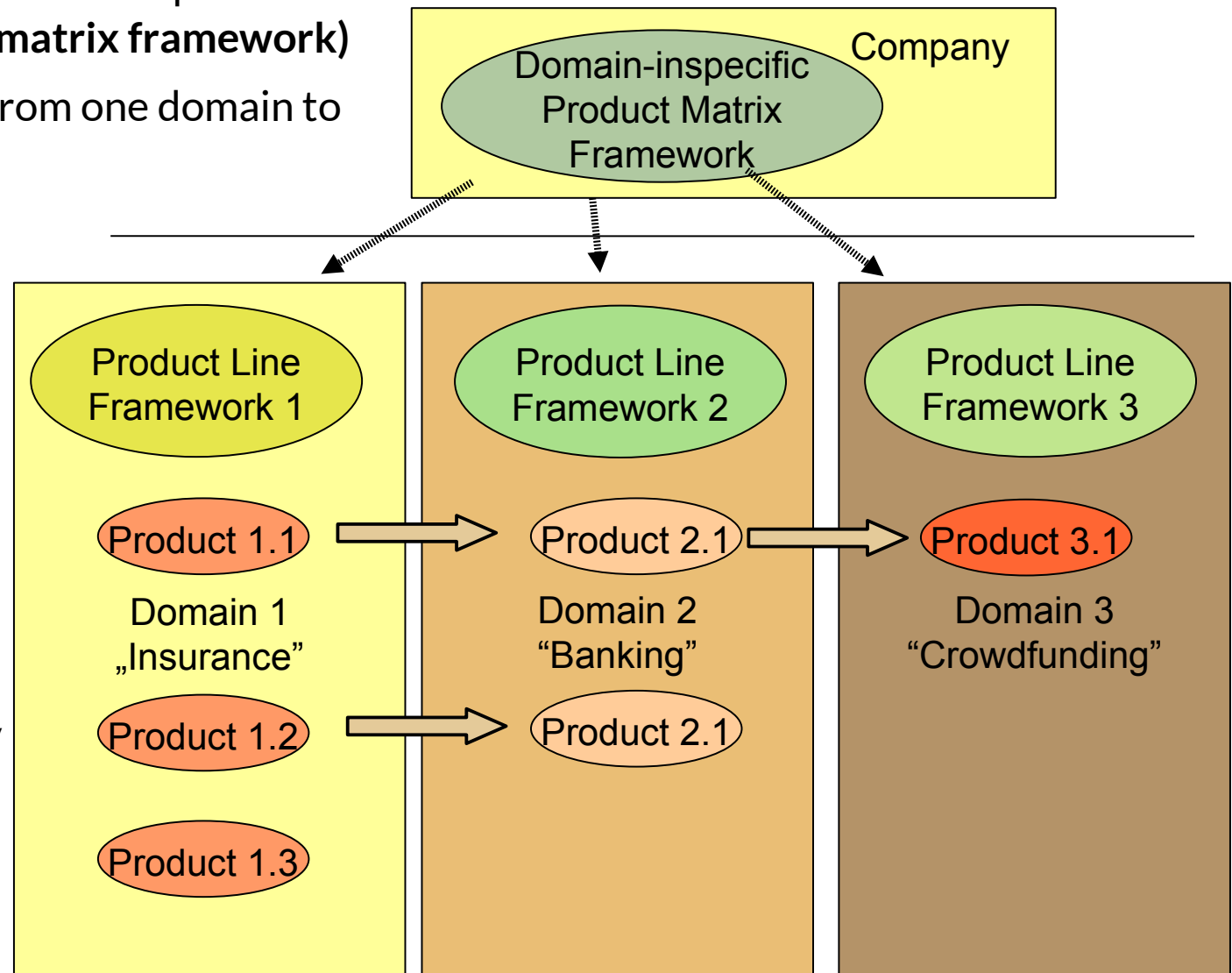


## 41.1.1.2 B2B Product Matrices

# Business Model with Variation in 2 Dimensions

## “Software Product Matrix (SW-Factory)”

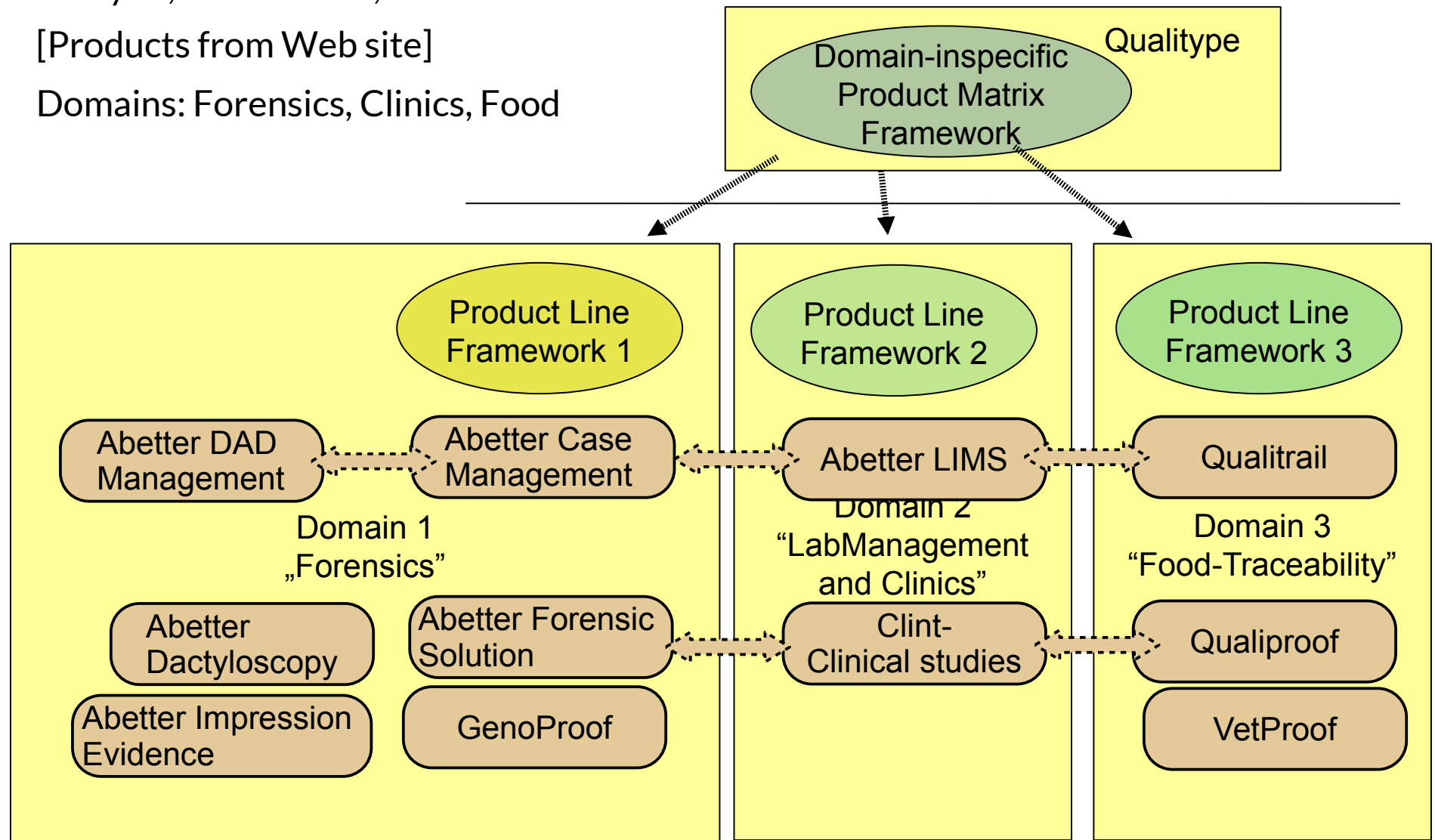
- ▶ Develop several domain-specific frameworks from a domain-inspecific framework (**product matrix framework**)
  - ▶ Try to *port* products from one domain to the next
  - ▶ Share models, code
  - ▶ Save costs
  - ▶ Retain quality
- Examples:
- ▶ Qualitytype
  - ▶ TTE Europe
  - ▶ <https://www.tt-e.eu/>
  - ▶ <https://www.tt-e.eu/de/branchenloesungen/spezialloesungen.html>



# Business Model “Software Product Matrix (SW-Factory)” at Qualitye.de in Dresden-Hellerau

- ▶ Bioanalytics and analytic Forensics: Gene Analysis, Father tests, ...
- ▶ [Products from Web site]
- ▶ Domains: Forensics, Clinics, Food

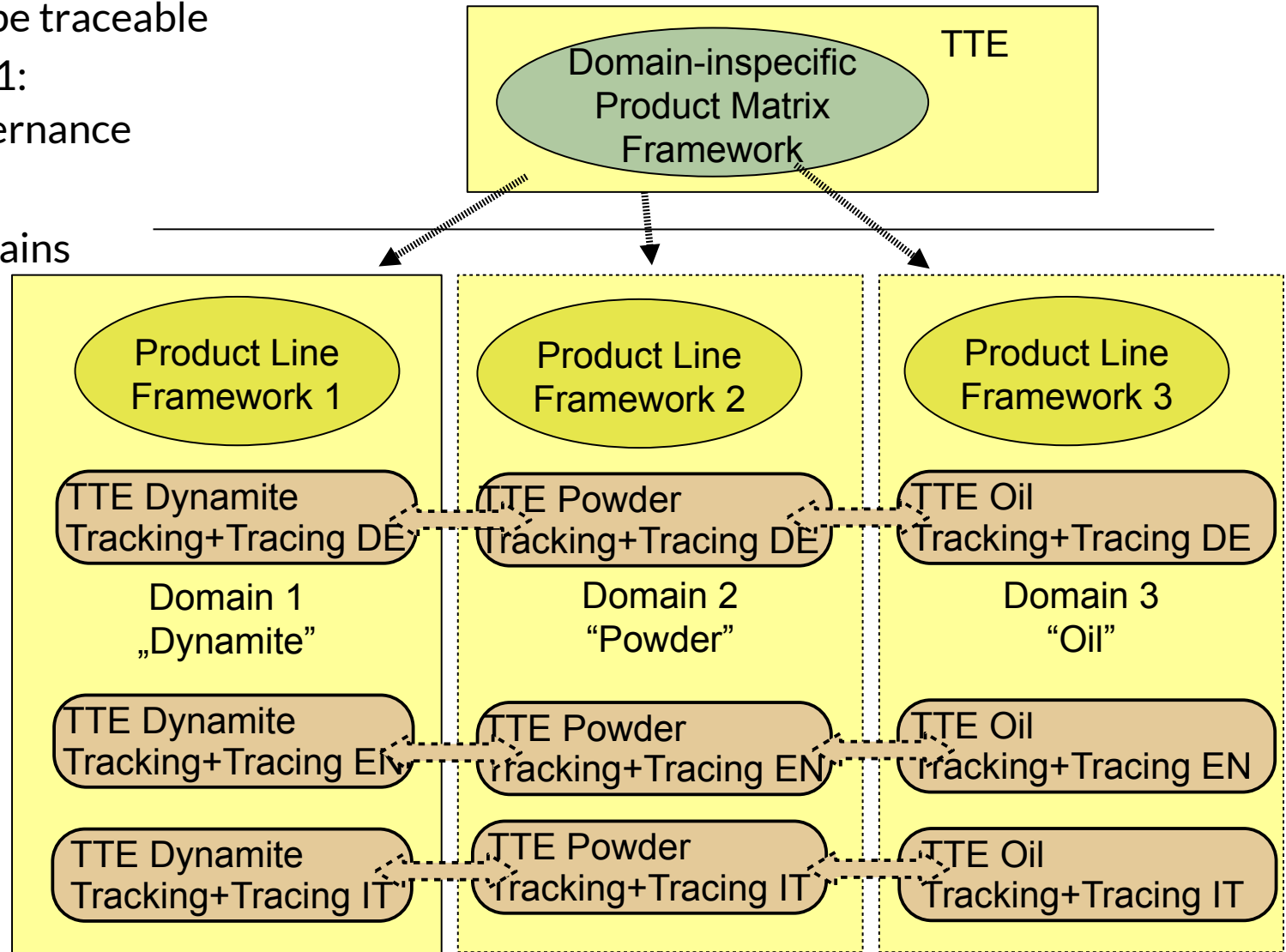
Many product-specific web sites, such as <http://genoproof.de/>





# TTE Europe Product Matrix – From Dynamite Tracking to Tracking of Dangerous Things

- ▶ <http://www.tt-e.eu/> <http://www.tt-e.eu/de/sprenngmittel-rueckverfolgung/tracking-system.html>
- ▶ In 2015, a new European governance rule on dynamite became obligatory: **all** dynamites all over Europe should be traceable
- ▶ Variation dimension 1: country-specific governance rules and processes
- ▶ Porting to other domains possible
- Required:
  - ▶ Workflow/Process framework
  - ▶ Feature modeling
  - ▶ Country modeling





## 41.1.2 B2C Product Lines

# Copycats

- ▶ <http://www.gruenderszene.de/lexikon/begriffe/copycat>
- ▶ A **copycat** is an enterprise that copies a business model from one domain to another
- ▶ Zalando copied from Zoppa
- ▶ StudiVZ copied from Facebook
- ▶ Quarrel – who copies of whom?
  - [http://www.gruenderszene.de/allgemein/movinga-movago-copycat?ref=lexikon\\_content](http://www.gruenderszene.de/allgemein/movinga-movago-copycat?ref=lexikon_content)

# Rocket Internet, the BM Copier (“Master Cat”)

## [https://de.wikipedia.org/wiki/Rocket\\_Internet](https://de.wikipedia.org/wiki/Rocket_Internet)

- ▶ Rocket Internet is a holding to found internet-based companies
- ▶ The founders Marc, Oliver, Alexander Samwer have successfully copied business models of other companies and replicated them **regionally** and **domain-porting**, forming **product matrices**
  - Zalando.de, the shoe platform, <https://de.wikipedia.org/wiki/Zalando>
  - Auction platform Alando.de: bought by eBay 1999 for 43 Mio.\$
  - Mobile phone supplier Jamba: bought by Verisign in 2004 for 273 Mio\$
  - Airbnb-clone Wimdu
  - Youtube-clone Myvideo
  - Gaming platform Bigpoint.com
  - Group discount platform Citydeal.com: bought by Groupon for 170 Mio\$
  - Lazada Webshop in Asia
- ▶ Rocket Internet is now in Dresden



## 41.1.3 Organizational Issues of SPL

- Organizations must support SPL business models

# Smart Companies (CAS)

- A **smart company** is a company composed of small cost centers that appear as separate companies to the outer world
  - All managers work like entrepreneurs and are responsible for profit
- [Ludwig Neer, founder of CAS: [www.cas.de](http://www.cas.de), Fit4Innovation Arbeitskreis 5, S. 15, [www.fitfuerrinnovation.de](http://www.fitfuerrinnovation.de)]
- ▶ The smart company creates departments (cost centers) on the fly and manages the departments like a software product line (“**baby companies**”)
  - Software product lines can be managed by the small departments independently and domain-specific

# How to Find a New Domain of Customers

- ▶ Ask customers (see chapter on customer interviews or customer feedback)
- ▶ Via your friends
- ▶ Via facebook
- ▶ Via domain-specific fairs
  - Embedded World (Nürnberg)
  - Games Convention (Köln)
  - Handicap (Düsseldorf, Leipzig)
  - Gardening (Dresden)
- ▶ Watch the change of governance rules in the EU and internationally
  - New light bulbs, new catalysators, new dynamite laws, ...

**Every new domain is a new Lean Startup process!**

# Finding OEM Customers (Supply Chain)

- ▶ The OEM is a larger company which already established customers, distribution chains (Vertrieb) and supplier chain
- ▶ How to build up a business relationship with an OEM
  - Visit the booth of OEM on a domain-specific fair
  - Visit a network, ask after a talk of an OEM
  - Visit a network, discuss after your own talk
- ▶ Use selling techniques on OEM personell
- ▶ How to build up confidence (trust):
  - Prepare and show demo cases (Minimal viable vision, minimal viable feature set, minimal viable smoke, minimal viable product)
  - Deliver quality!
  - React quickly on demands (manage tickets well)





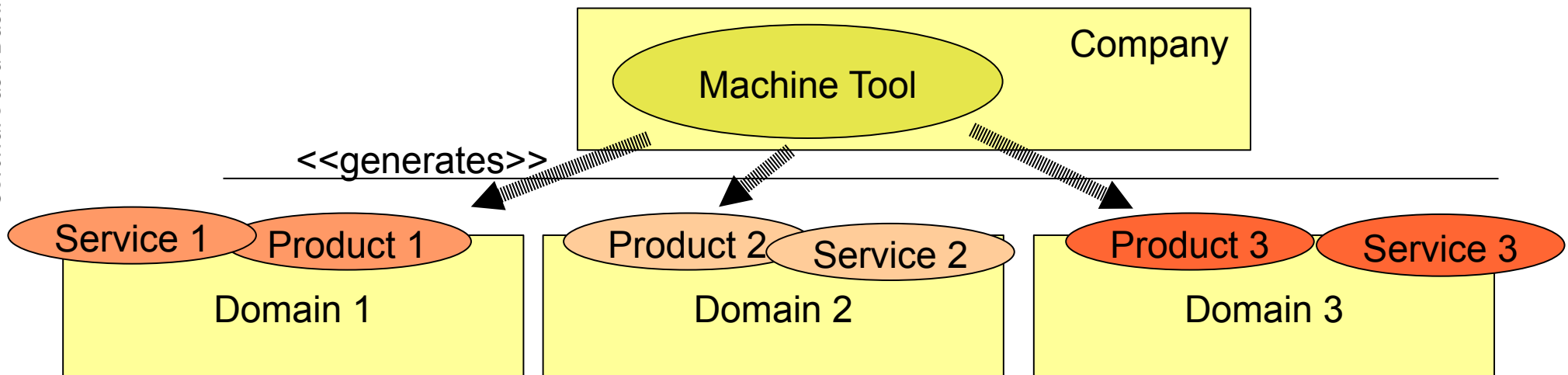
## 41.2 Product Lines with Software Machine Tools

- Software Machine Tools help to create families of products and services, because they allow to derive products from specifications, enabling large reuse factors.

# Business Model

## “Software Machine Tool (SW-Werkzeugmaschinen)”

- ▶ Have a very complicated **Software Machine Tool** in-house.
- ▶ Know how to *derive* products and services with it
  - Do not sell the machine tool, keep the know-how as company secret
- ▶ Examples:
  - Compiler generators for specific compilers
  - Abstract interpretation generators for program analyses ([www.absint.com](http://www.absint.com))
  - Semantic search engines for different domains ([www.transinsight.com](http://www.transinsight.com), [www.gopubmed.com](http://www.gopubmed.com))
  - Network analyzers in cars ([www.symtavision.com](http://www.symtavision.com))



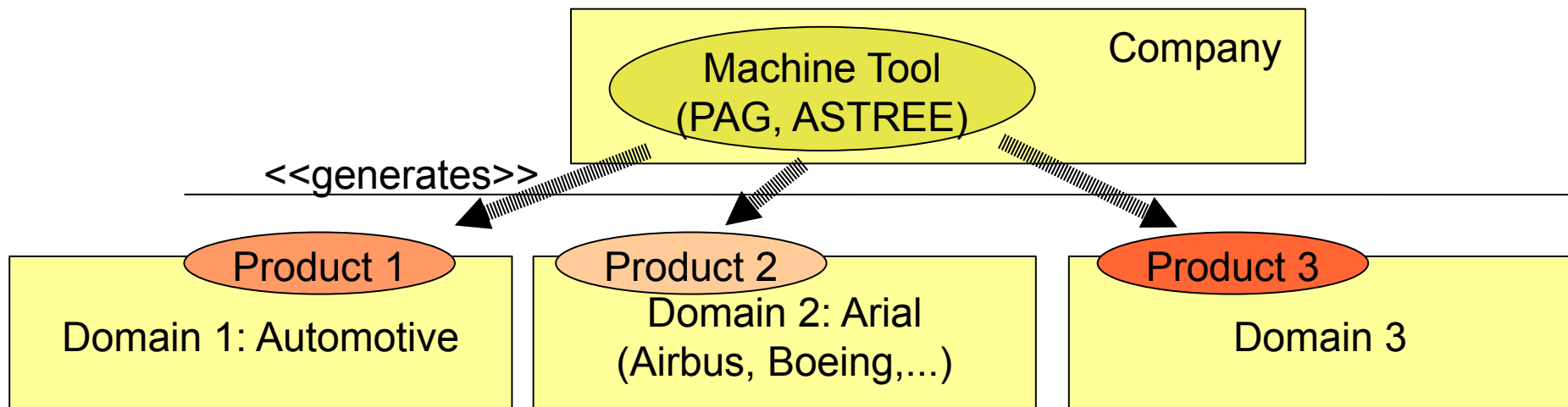
# Zitat aus Newsletter von AbsInt (Sept. 2015)

- ▶ “Sehr geehrter Herr Aßmann, willkommen zur September-Ausgabe des AbsInt-Newsletters. AbsInt liefert Werkzeuge zur Validierung, Verifikation, Optimierung und Zertifizierung von sicherheitskritischer Software.
- ▶ Die Kernprodukte sind **aiT WCET Analyzer** zur Berechnung von Laufzeitgarantien (<http://www.absint.com/ait/>), **StackAnalyzer** zum Nachweis der Abwesenheit von Stacküberläufen (<http://www.absint.com/stackanalyzer/index.htm>) und **Astrée** zum Nachweis der Abwesenheit von Laufzeitfehlern (<http://www.absint.com/astree/index.htm>). Jedes von ihnen kann automatisch gemäß aktueller Sicherheitsstandards qualifiziert werden.
- ▶ Zu Beginn des Jahres 2015 hat AbsInt zwei neue **Produktlinien** eingeführt:
  - **\*TimingProfiler\*** berechnet Abschätzungen der Programmausführungszeit, ohne Testeingaben zu erwarten, Tests auszuführen oder Laufzeitmessungen vorzunehmen. Damit ist das Tool perfekt zur entwicklungsbegleitenden Überprüfung des Zeitverhaltens geeignet, auch innerhalb modellbasierter Entwicklungsumgebungen. TimingProfiler unterstützt derzeit PowerPC und TriCore, weitere Targets sind in Arbeit. Details: <http://www.absint.com/timingprofiler/>.
  - **\*CompCert\*** ist ein formal verifizierter optimierender C-Compiler. Er bietet einen nie zuvor gekannten Vertrauensgrad in die Korrektheit des Compilevorgangs und hilft Anwendern, die höchsten Software-Sicherheitsstandards zu erfüllen. Unterstützte Targets sind PowerPC (32-bit), ARM und IA32 (x86 32-bit). Details: <http://www.absint.com/compcert/>.
- ▶ Produktneuheiten - **Astrée**:
  - Der Rule-Checker von Astrée unterstützt nun auch MISRA-C:2012 und bietet neue Regeln zur Überprüfung von Namenskonventionen für Bezeichner.
  - Neue Ergebnisansicht zur schnellen Prüfung und Klassifizierung aller Meldungen des Analysators.
  - Optimierung der Anbindung an MATLAB und TargetLink.
- ▶ Produktneuheiten - **aiT, StackAnalyzer, ValueAnalyzer**
  - **StackAnalyzer** für Renesas RX und SuperH jetzt verfügbar.
  - Überarbeitung der Annotationsprache AIS. Die neue AIS2 Sprache erlaubt eine flexiblere und intuitivere Spezifikation von Annotationen.
  - Effizienz- und Präzisionssteigerung der Wertebereichsanalyse für SPARC, TriCore und V850.”

# Business Model

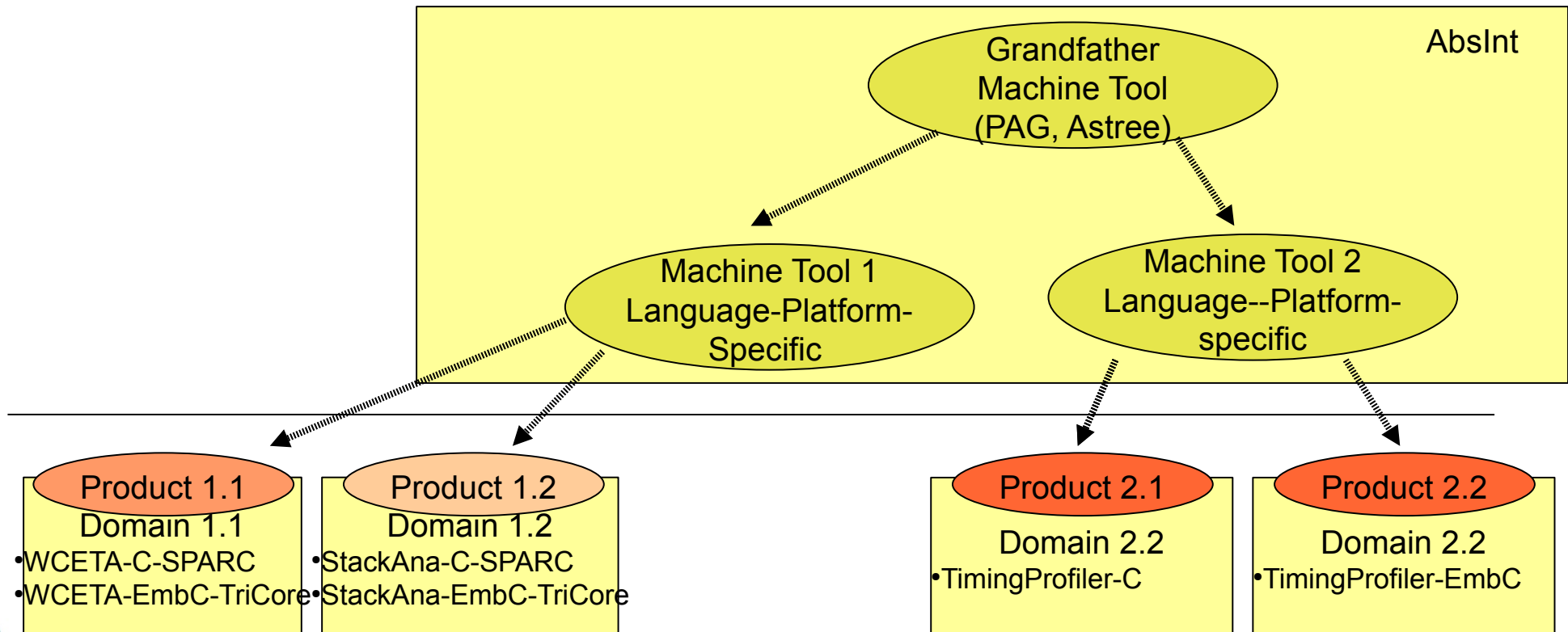
## “Software Machine Tool (SW-Werkzeugmaschinen)”

- ▶ [Www.absint.de](http://www.absint.de) Founded in 1996 from Saarbrücken University, Dr. Christian Ferdinand
- ▶ **Software Machine Tools:**
  - **Program Analyzer Generator (PAG):** generator of program analysers in C for arbitrary languages, arbitrary machine models
  - **Astree Program Analyzer Generator:** from P. Cousot's group, ENS Paris, improved analysis techniques
- ▶ Examples of derived products:
  - aiT worst case execution time analysis engine: analysis for specific processors and embedded platforms



# Business Model “Grandfather Machine Tools (Großvater-Werkzeugmaschinen)”

- ▶ Language-Universal Tool (PAG, Astree) generates
  - Language-specific tool generator (AIT-C-SPARC, StackAnalyzer-Embedded-C-SPARC)
  - Language-specific tool generator (AIT-Embedded-C, StackAnalyzer-C)
- ▶ Those machine tools continue to bear grandchildren products for different chips and platforms



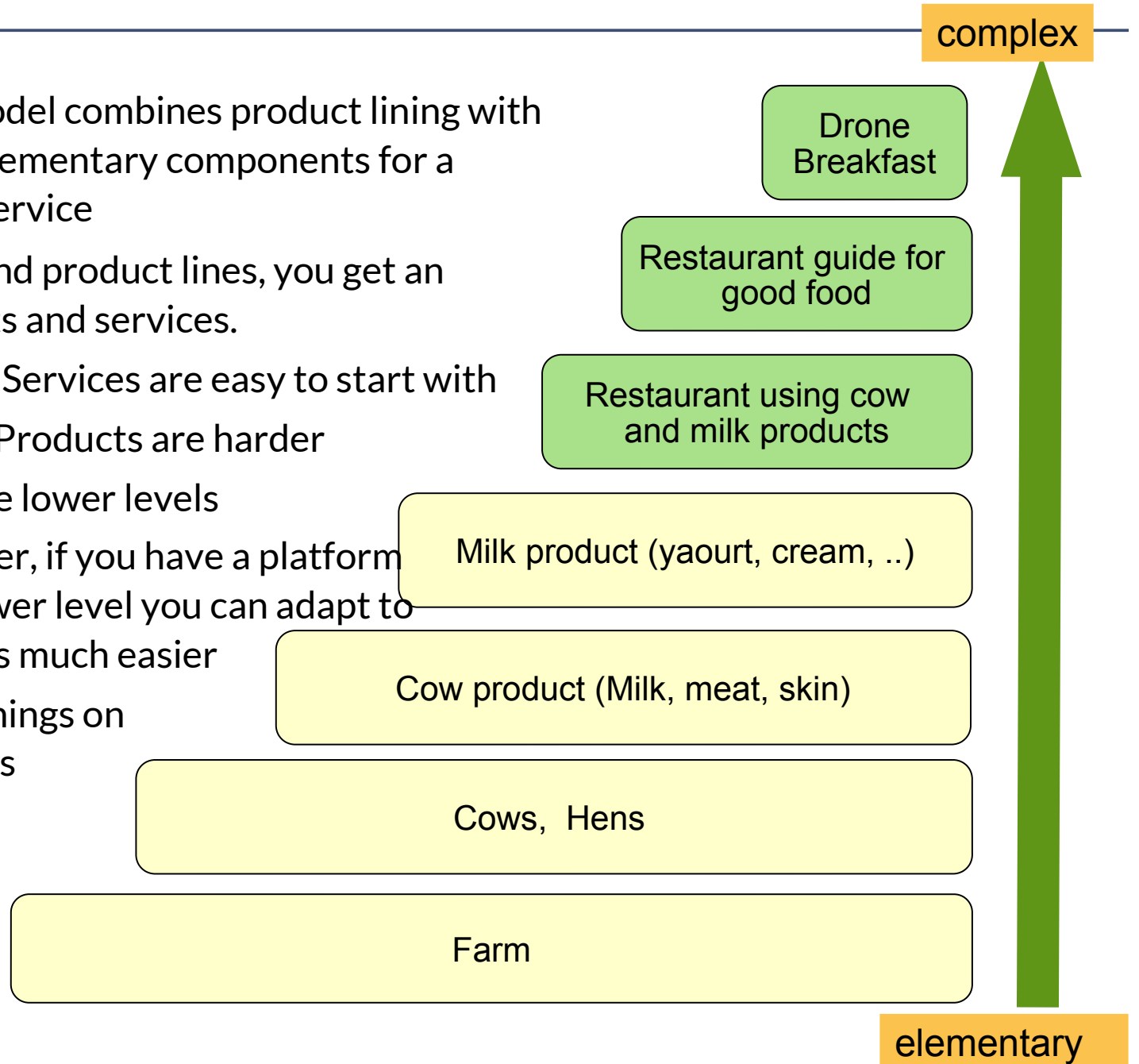


## 41.3 Product Lines and Farms

- Product-lining can be applied on several levels of a supply chain

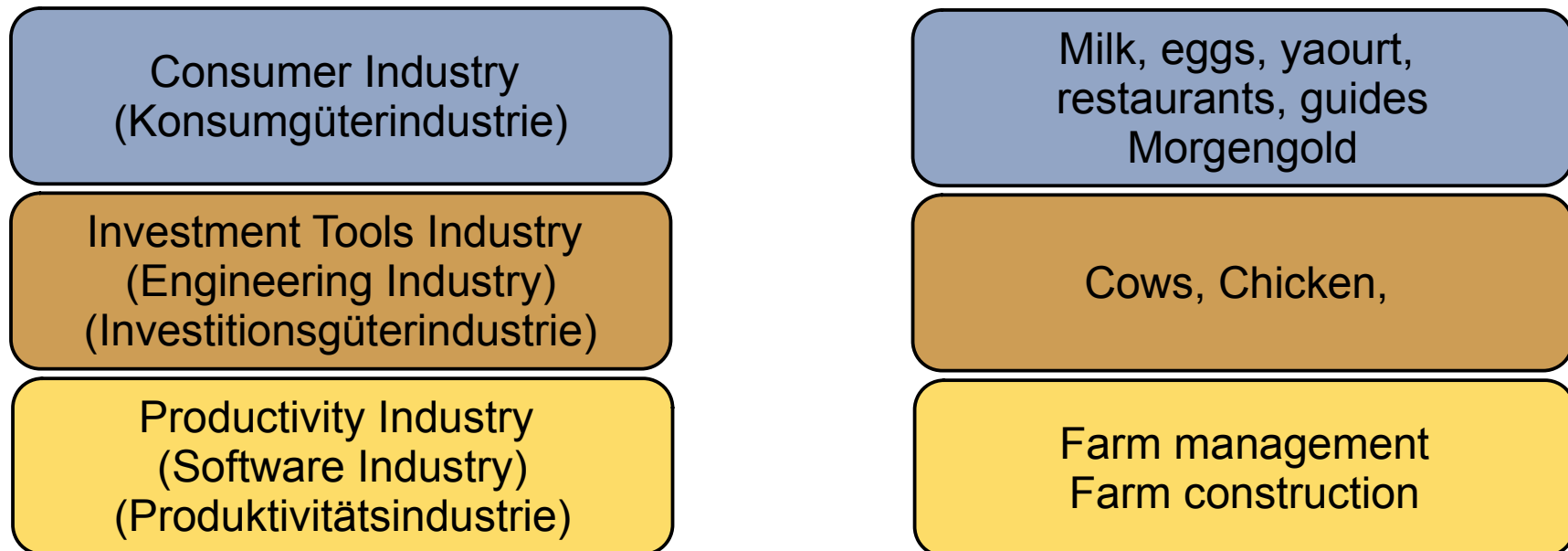
# The Farm Approach

- ▶ The **farm** business model combines product lining with a *supply chain* using elementary components for a complex product or service
- ▶ With machine tools and product lines, you get an ecosystem of products and services.
  - Higher-level Services are easy to start with
  - Lower-level Products are harder
  - Platforms are lower levels
    - However, if you have a platform on a lower level you can adapt to changes much easier
  - Do several things on several layers



# Business Model “Farm” Crosscuts Industry Levels

- ▶ A **Farm** allows a company to rule in different industry levels
- ▶ Its goal is to keep production tools and productivity tools in one hand (the cows and the fields), to easier create *dependent markets and customer segments* for *dependent products and services of the farm* (the yaourt and the restaurants)
- ▶ A farm uses the layering
  - productivity industry -> investment industry -> consumer industry.
- ▶ It enables to control the productivity in the dependent industries and can be cost leader





# Google's Farm Approach

- ▶ Google had to invent cows, milk, yaourts on top of the search engine to earn money
- ▶ They invented advertisement for search machines
- ▶ Currently, they attempt to conquer the **autonomous car** market
  - To sell apps and services while commuting!

Restaurant guide: **Apps while commuting**

Restaurant using cow products and milk products: **Maps**

Milk product (yaourt, cream, ..): **Server Clouds**

Cow product (Milk, meat, skin): **Advertisement, Google Analytics, Big Data**

Cows, Hens: **Gmail, Gcalendar, Gdocs**

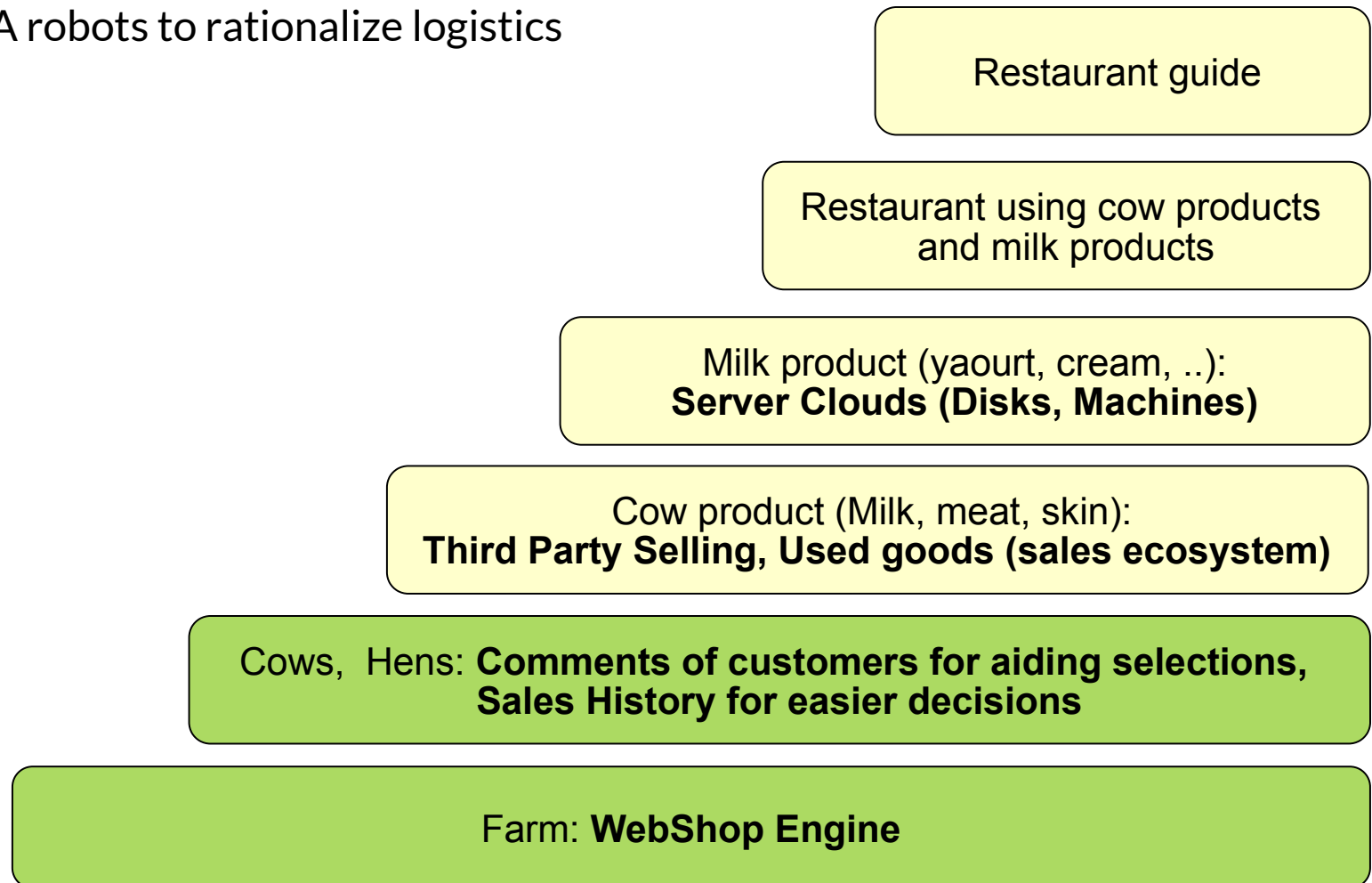
(free) Farm: **Android**

Farm: **Search Engine**

Farm: **Autonomous Car**

# Amazon's Farm Approach

- ▶ Amazon invented different cows, milk, yaourts on top of the web shop
- ▶ Became the leading cloud rental company (Amazon Web Services)
- ▶ Bought KIVA robots to rationalize logistics



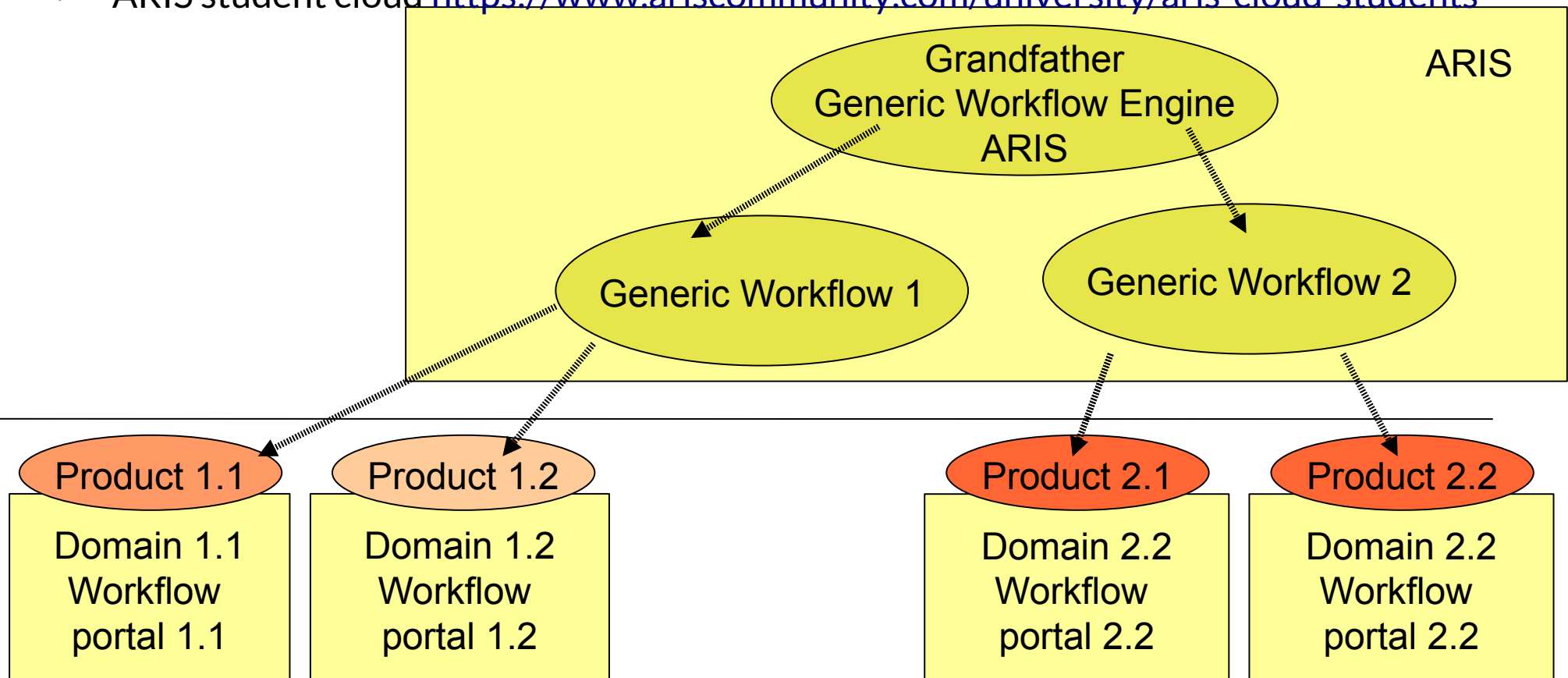


## 41.4 Product Lines with Workflows

- Software Machine Tools help to create families of products and services.

# Business Model “Grandfather Workflows” (ARIS)

- ▶ Workflow-Universal Tool offers generic workflows-1..n, to be tailored to specific domains and companies [Scheer]
  - Founder: A. W. Scheer from Saarbrücken University
- ▶ Those workflows continue to bear grandchildren workflow portals (form-filling portals)
- ▶ ARIS student cloud <https://www.ariscommunity.com/university/aris-cloud-students>



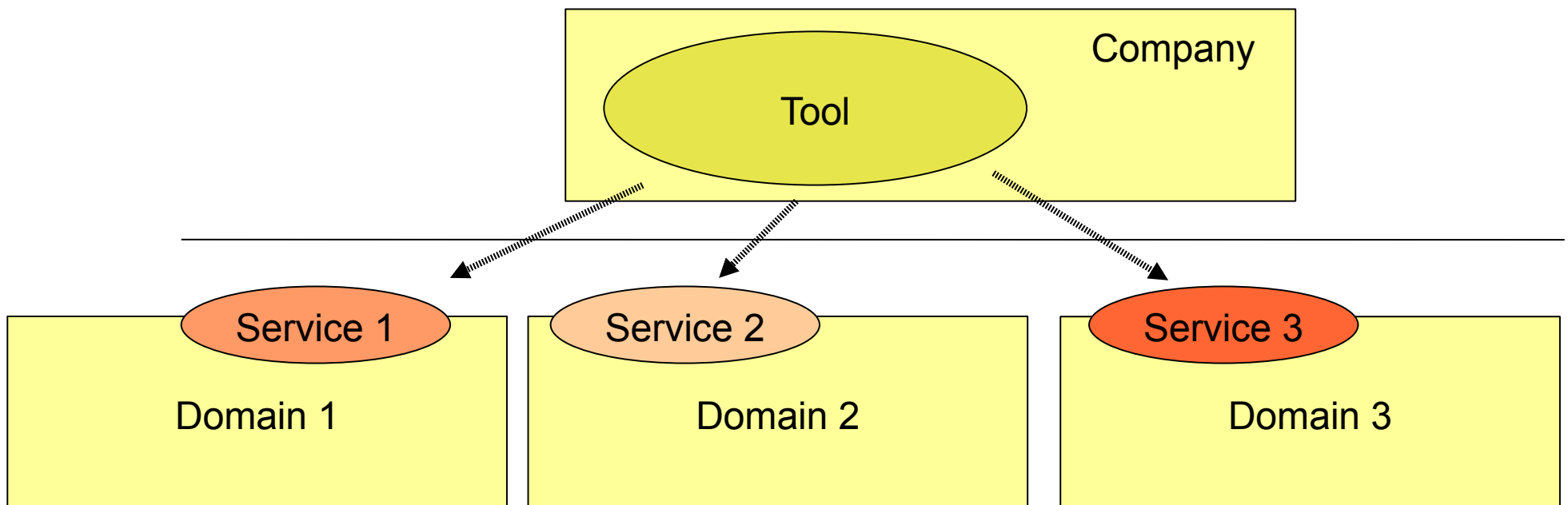
# ARIS Community

- ▶ <https://www.ariscommunity.com/university/faq#ariscloud>
- ▶ From students, it can be used for 3 months for free

# Business Model

## “Software as a Service” (SaaS, Utility Computing)

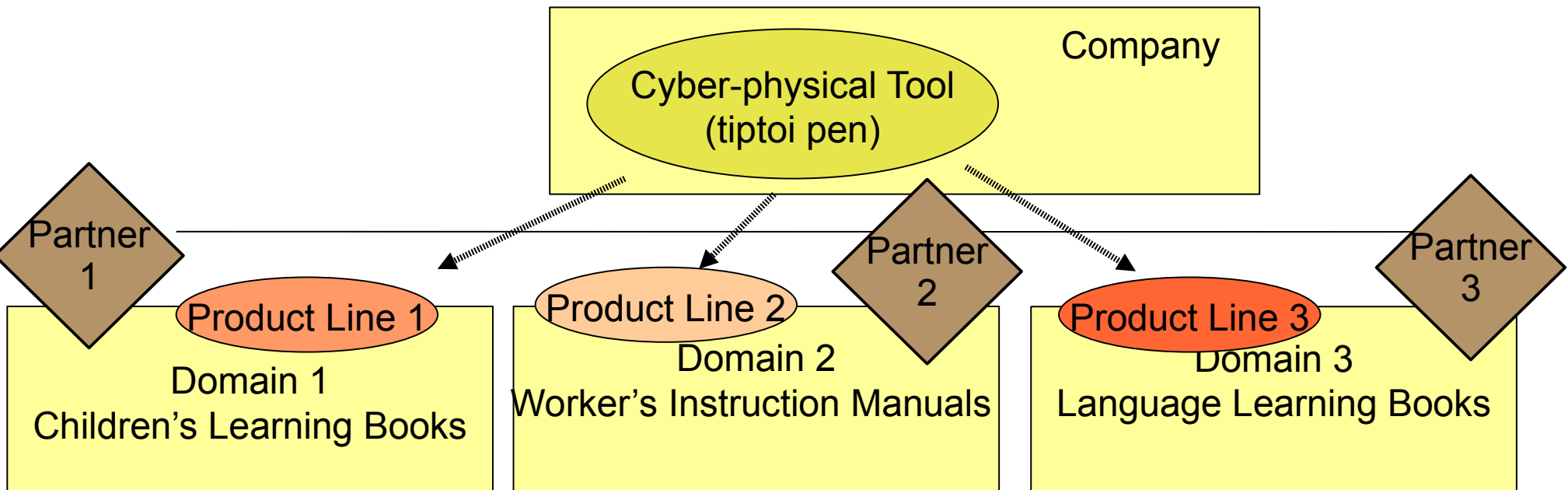
- ▶ Have an engine in-house and sell a (web) service
  - Use AJAX for incremental processing on the web
  - Resource-driven Business Model (no installation, backup etc necessary)
- ▶ Ex. Google docs
- ▶ Salesforce: ERP SaaS provider
- ▶ SAP Business by Design [https://en.wikipedia.org/wiki/SAP\\_Business\\_ByDesign](https://en.wikipedia.org/wiki/SAP_Business_ByDesign)
- ▶ S/4 HANA [https://de.wikipedia.org/wiki/SAP\\_S/4HANA](https://de.wikipedia.org/wiki/SAP_S/4HANA)



# Business Model

## “Cyber-Physical Tool”

- ▶ Have a software for a cyber-physical tool in-house and sell a derived product
  - Tiptoi of Ravensburger <https://www.3m5.de/presse/ravensburger-ag/tiptoi/>
- ▶ Strategic partner for content of books needed in different domains





## 41.5 Customer Migration in Farms

- Farms allow to seduce customers to migrate to underlying own platforms



# How Google and Amazon Seduce Customers from other Levels in its Farm

- ▶ Google tries to win customers from one level to the other (cross-level customer migration)

- Cows → <where?>
- Sear Engine → <where?>

Restaurant guide: **Apps while commuting**

- ▶ Amazon:

- Portal → Kindle

Restaurant using cow products and milk products: **Maps**

- ▶ SAP:

- SAP S/4 → HANA database
- SAP S/4 → Workflows

Milk product (yaourt, cream, ..): **Server Clouds**

Cow product (Milk, meat, skin): **Advertisement, Google Analytics, Big Data**

Cows, Hens: **Gmail, Gcalendar, Gdocs**

(free) Farm: **Android**

Farm: **Search Engine**

Farm: **Autonomous Car**

# The End

- ▶ Explain the business model “domain-region service matrix”
- ▶ Explain the steps how to arrive from a product to an extensible product
- ▶ Explain how the BMC and the LeanCanvas help to find customer segments for a product line
- ▶ Compare the concepts of a Product Line, Product Matrix, and a Product Cube
- ▶ Explain the difference of a software-tool SPL and a workflow SPL.
- ▶ Explain how the products of a product line can be assessed with the BMC assessment process
- ▶ How would you use a software tool developed in a Master’s thesis to create a product matrix? Why is it, for the use of a software tool, important to find many different customer segments?