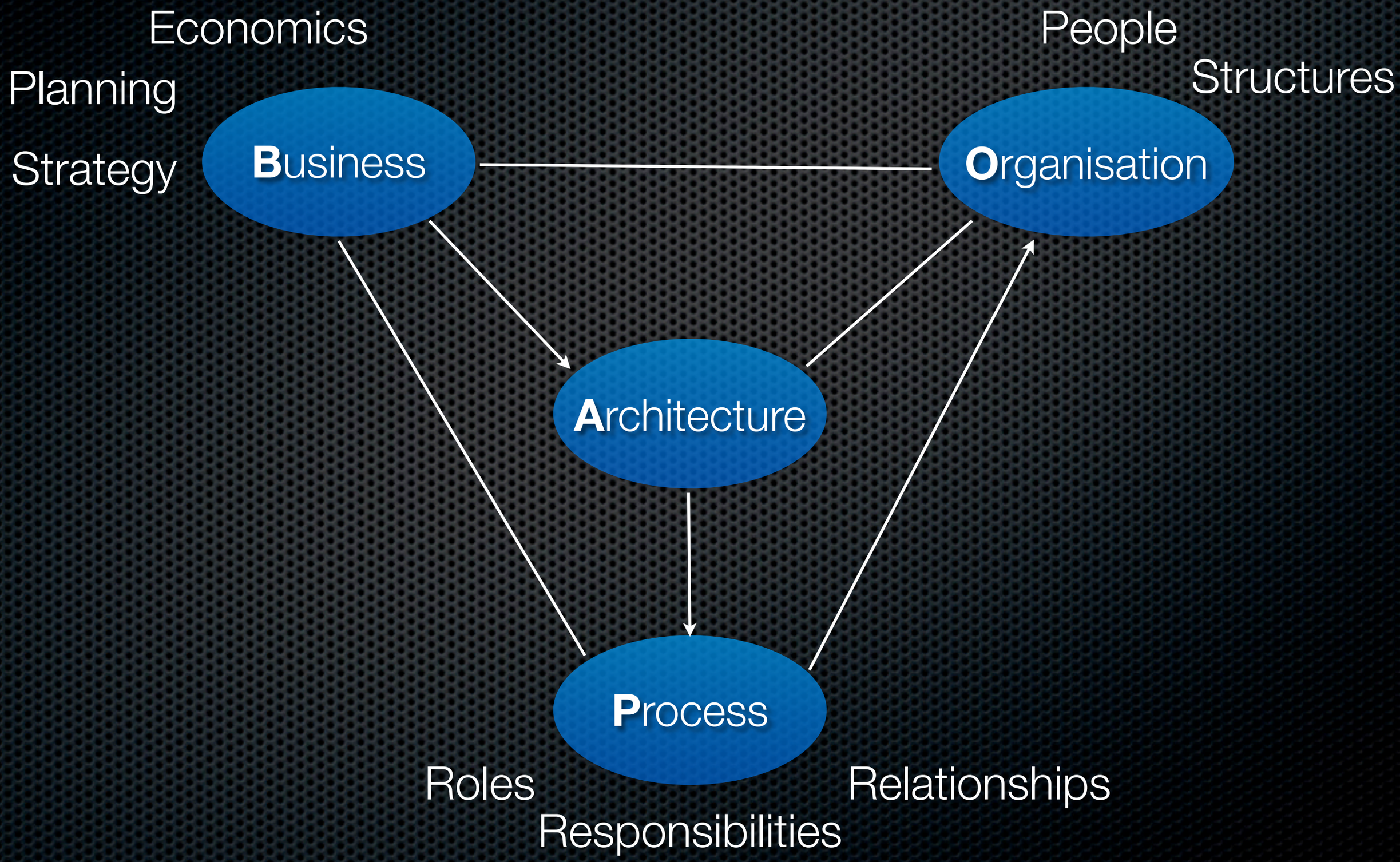
Variability and Architecture

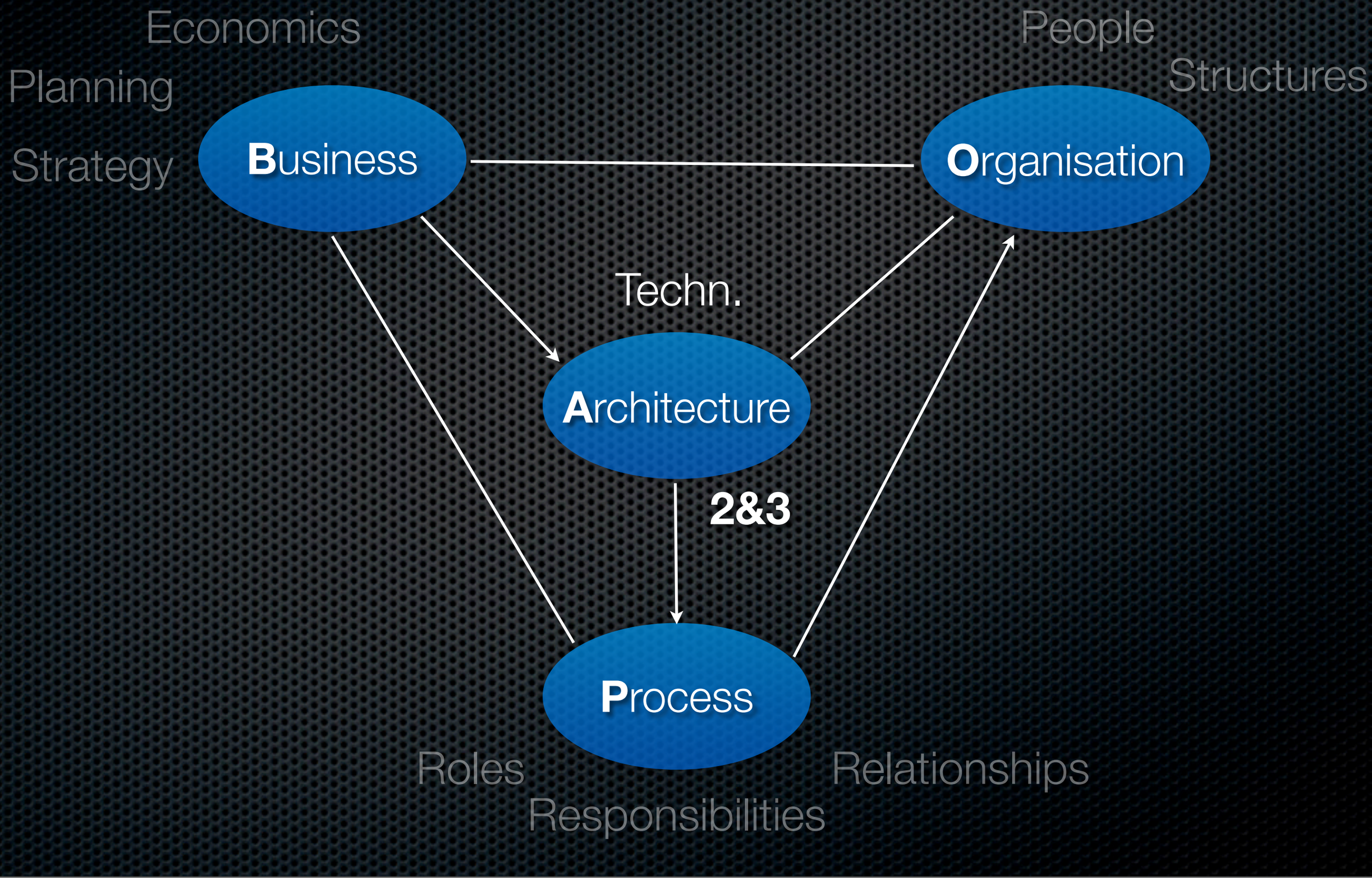
SPLE Course, DAT165, lecture 2&3, 081029

Robert Feldt - robert.feldt@gmail.com

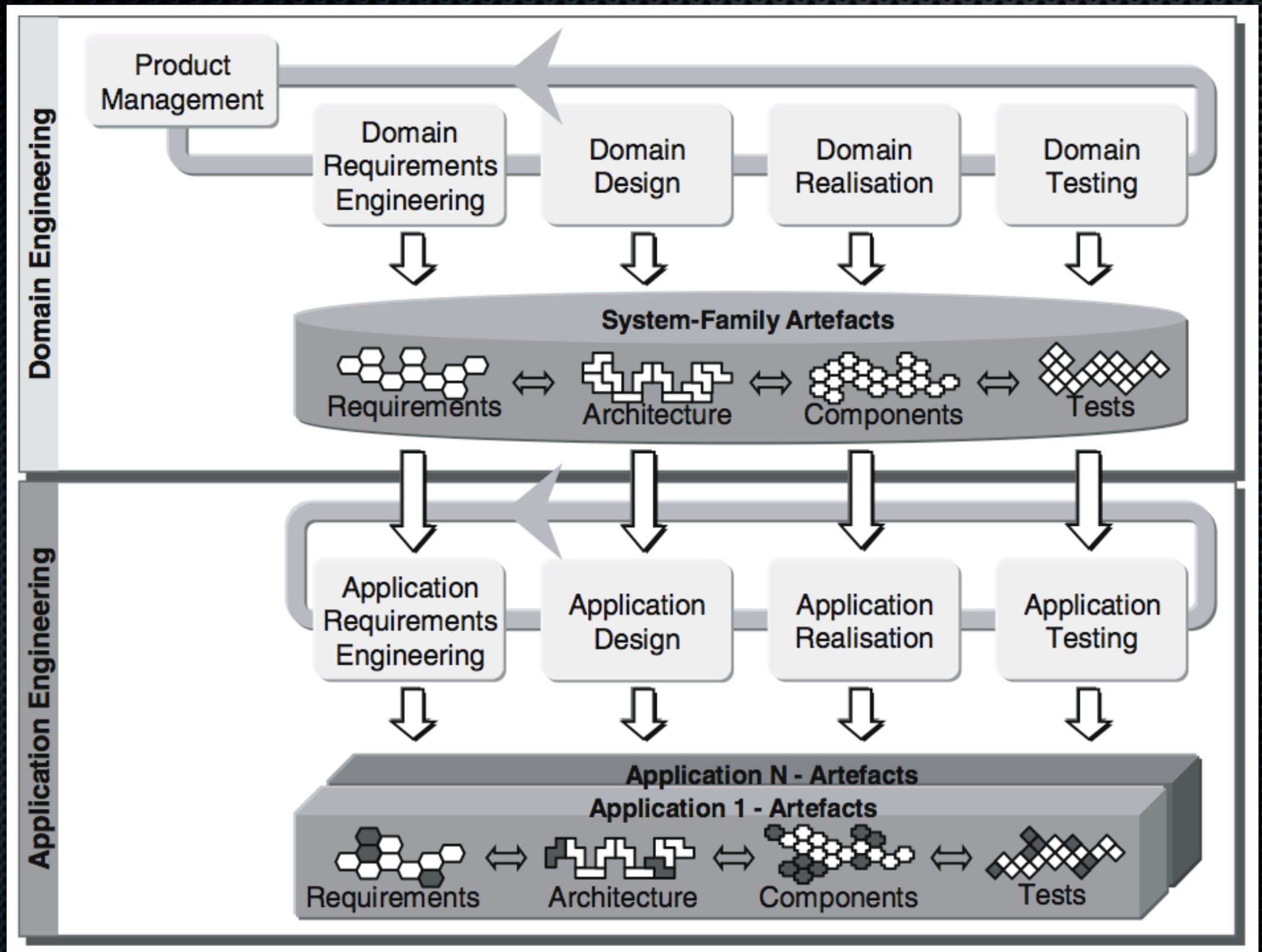
Lectures - Overview (BAPO Model)



Lectures - Overview (BAPO Model)



Domain and Application Engineering



Variability Management

- SPL = Commonality + Explicit Variability
- Variability is Explicitly Managed, i.e.
  - Defined, Represented, Discussed, Exploited, Implemented, Evolved etc.

Feature	Prod. 1	Prod. 2	Prod. 3
Game engine	3D, C++	3D, C++	3D, C++
Score upload	No	Yes	Yes
Lead character	Mario	Ferrari	None, puzzle

Variability Management

- SPL = Commonality + Explicit Variability
- Variability is Explicitly Managed, i.e.
  - Defined, Represented, Discussed, Exploited, Implemented, Evolved etc.

Variability is first-class concept!

Feature	Prod. 1	Prod. 2	Prod. 3
Game engine	3D, C++	3D, C++	3D, C++
Score upload	No	Yes	Yes
Lead character	Mario	Ferrari	None, puzzle

Variability Management

- SPL = Commonality + Explicit Variability
- Variability is Explicitly Managed, i.e.
  - Defined, Represented, Discussed, Exploited, Implemented, Evolved etc.

Variability is first-class concept!

Feature	Prod. 1	Prod. 2	Prod. 3
Game engine	3D, C++	3D, C++	3D, C++
Score upload	No	Yes	Yes
Lead character	Mario	Ferrari	None, puzzle

Commonality, part of SPL

Variability Management

- SPL = Commonality + Explicit Variability
- Variability is Explicitly Managed, i.e.
  - Defined, Represented, Discussed, Exploited, Implemented, Evolved etc.

Variability is first-class concept!

Feature	Prod. 1	Prod. 2	Prod. 3
Game engine	3D, C++	3D, C++	3D, C++
Score upload	No	Yes	Yes
Lead character	Mario	Ferrari	None, puzzle

Commonality, part of SPL

Variation, supported in SPL

Variability Management

- SPL = Commonality + Explicit Variability
- Variability is Explicitly Managed, i.e.
  - Defined, Represented, Discussed, Exploited, Implemented, Evolved etc.

Variability is first-class concept!

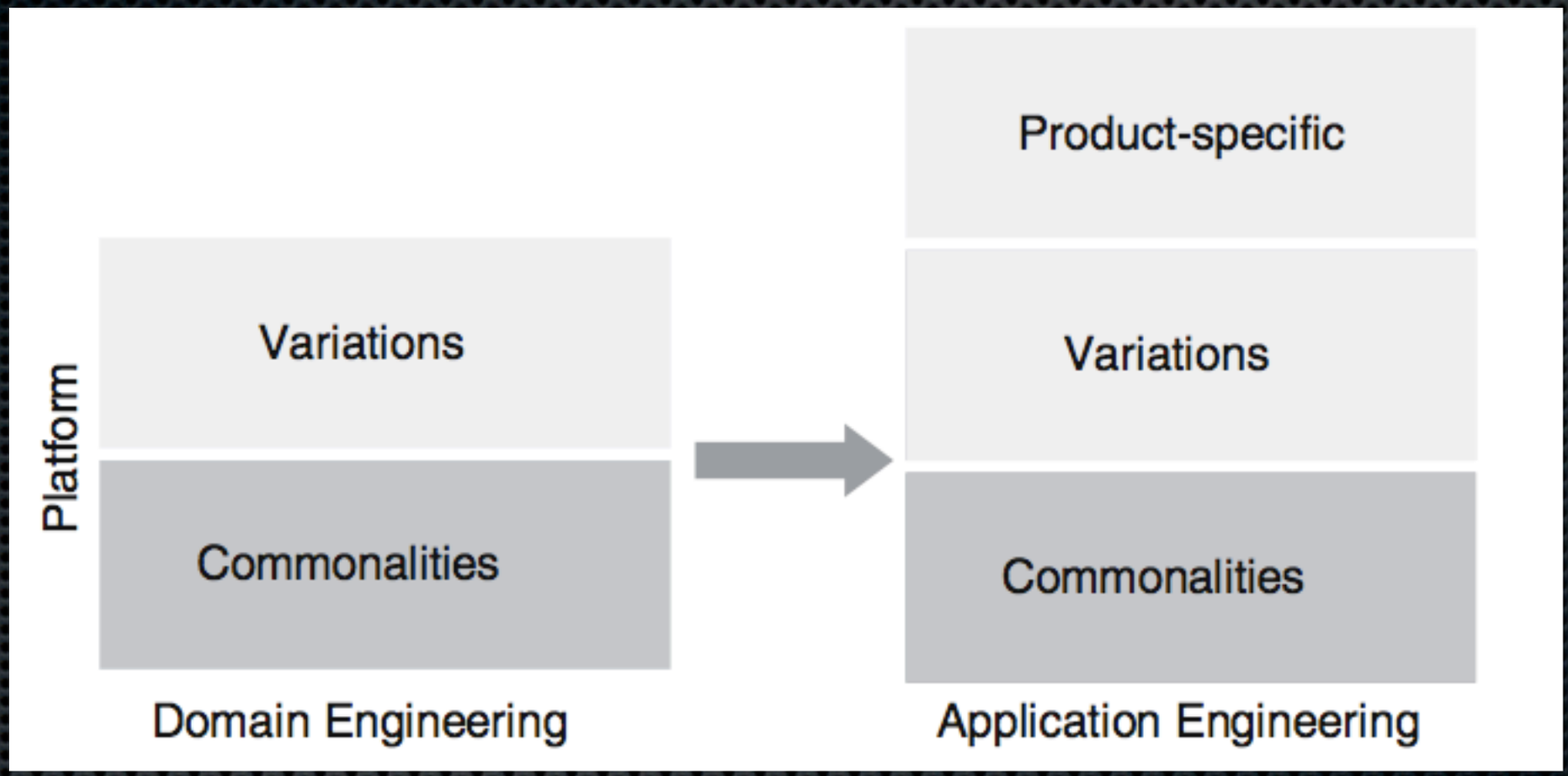
Feature	Prod. 1	Prod. 2	Prod. 3
Game engine	3D, C++	3D, C++	3D, C++
Score upload	No	Yes	Yes
Lead character	Mario	Ferrari	None, puzzle

Commonality, part of SPL

Variation, supported in SPL

Product-specific, not supported (now)

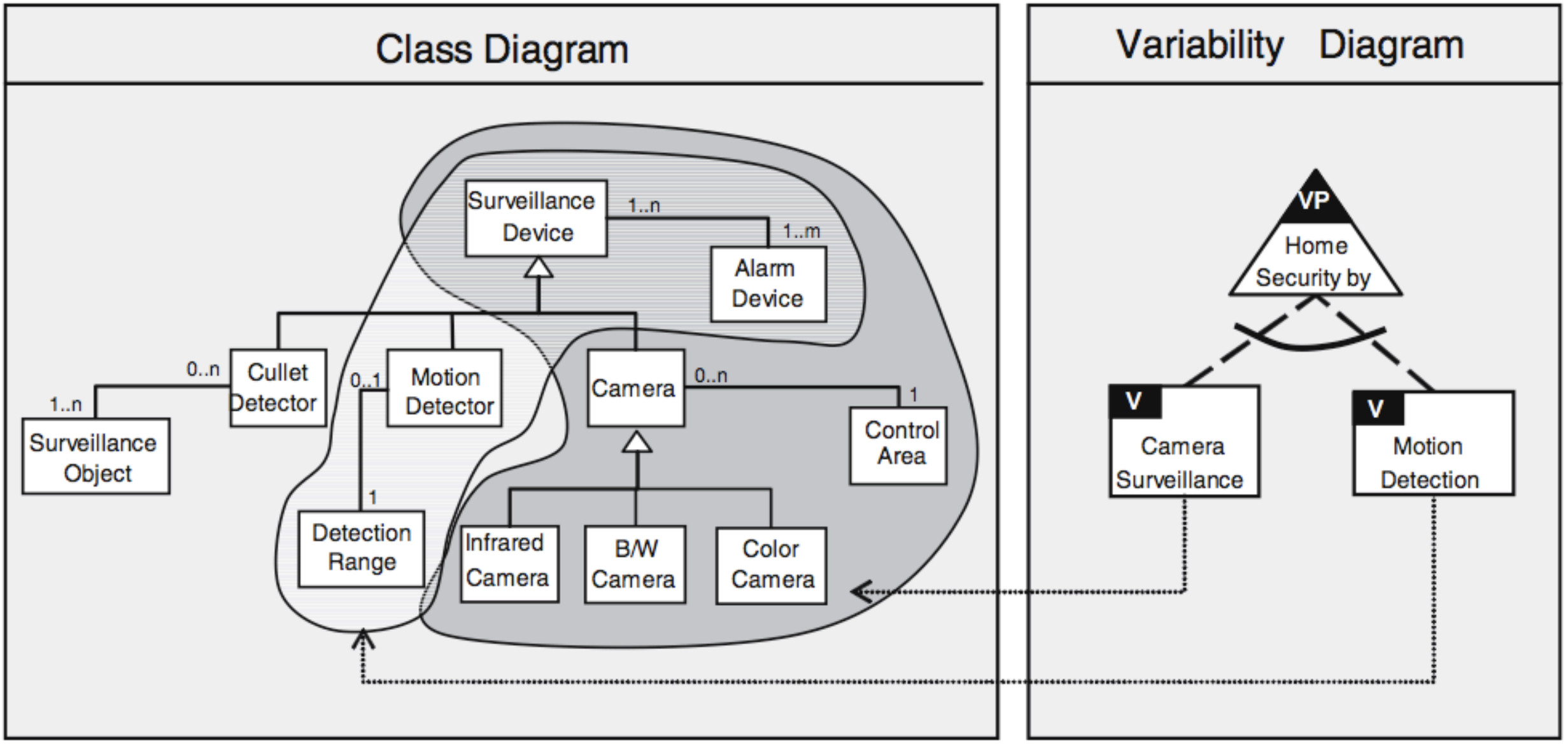
Types of Variability



Variability Documentation

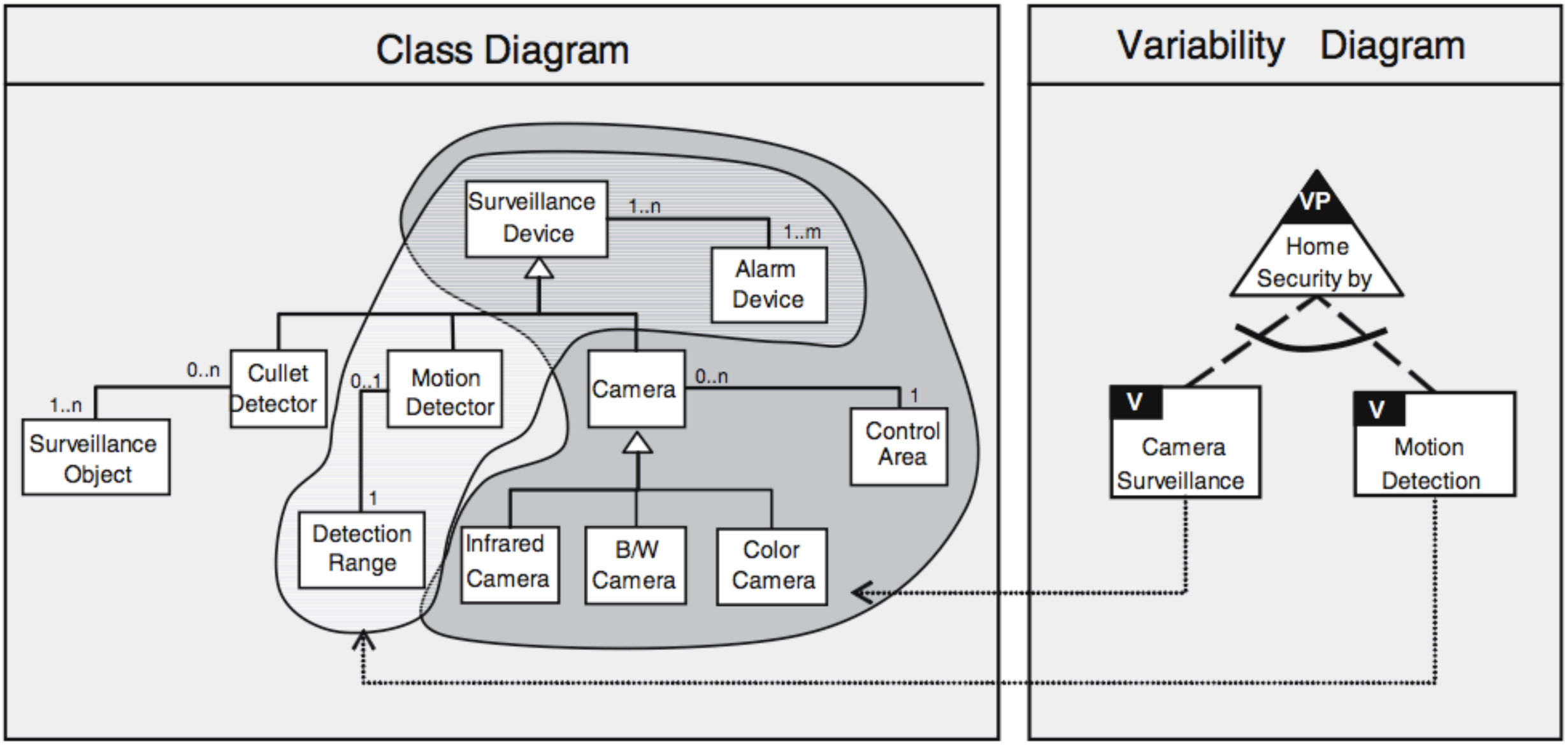
- What varies?
  - Variation points
- Why does it vary?
  - Context, Reasons
- How does it vary?
  - Variants, Dependencies, Constraints
- For whom is it documented?
  - Internal & External Stakeholders
- Improves: Decision Making, Communication & Traceability

Graphical Variability Modeling

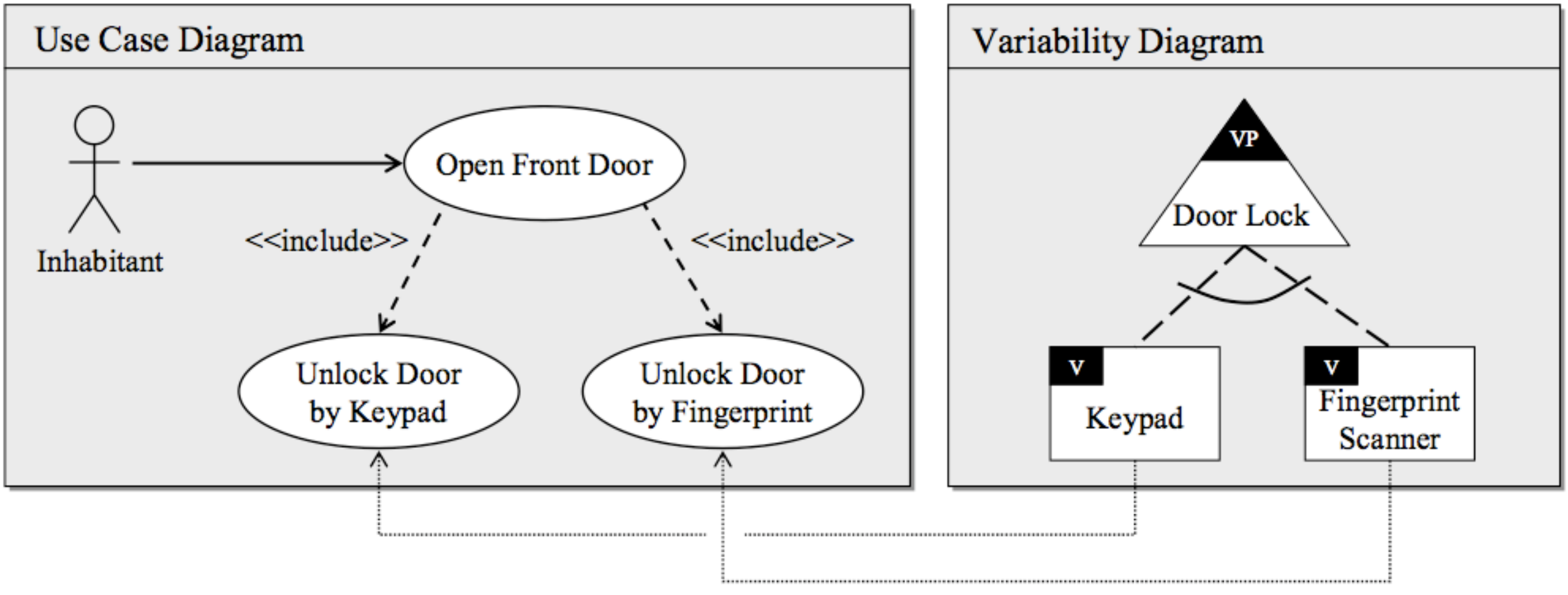


Graphical Variability Modeling

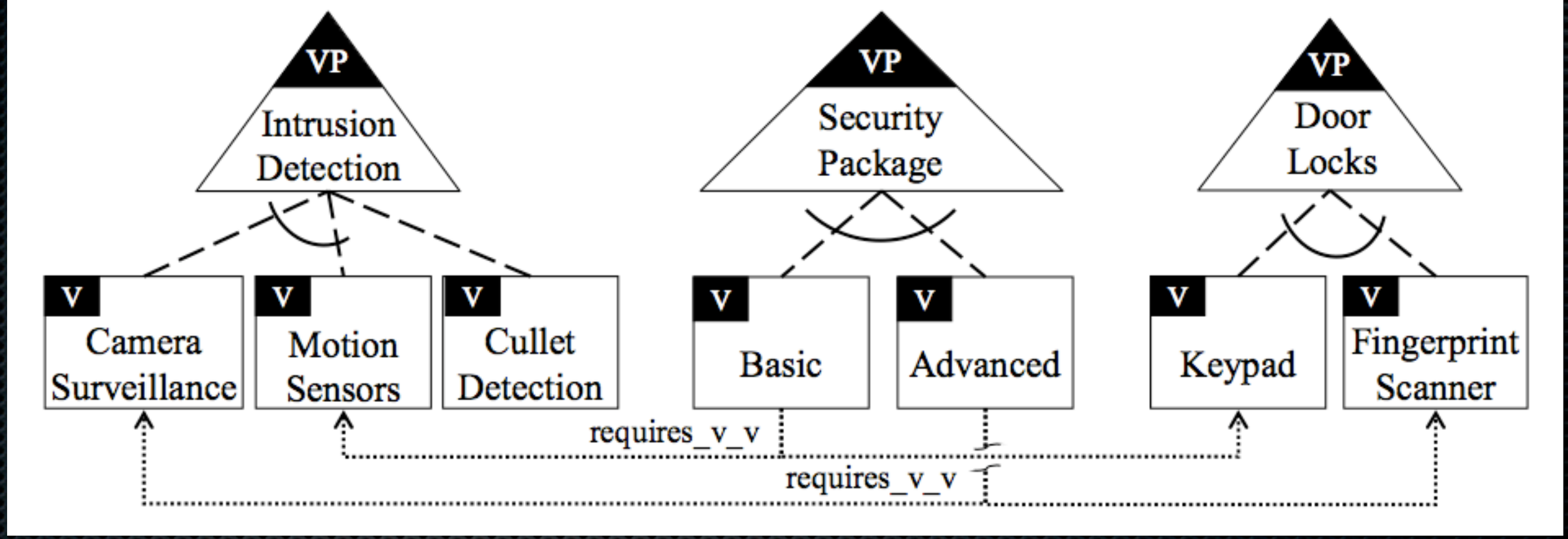
Separate Model!



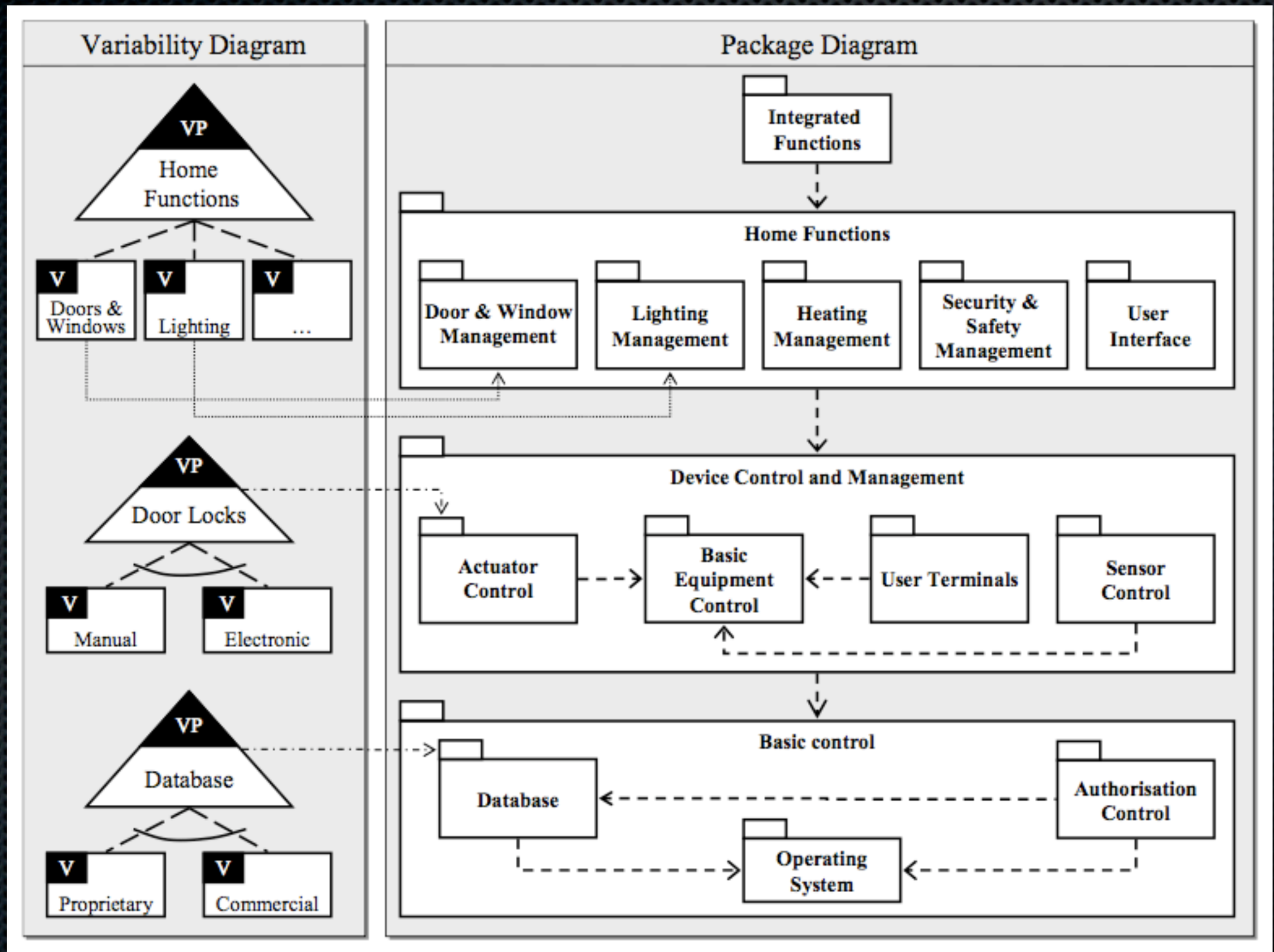
Same variability notation throughout



Packages of variants



Variability in packages/sub-systems



Reference Architecture

- Single, shared architecture, common to all products
  - Normal architecture for commonalities
  - Variation points, variants etc for rest
- Not always there in practice, too plan-driven
  - Extract the reference architecture gradually

Industry example: Meantime Game Company

- Brazilian company developing mobile games
  - 60 games, 400 devices, 6 languages, 40 developers
- Critical requirement: Portability (Many mobiles)
  - User Interface Differences
  - CPU, Memory and Size constraints
  - Support API differences (J2ME, BREW & Proprietary)
  - Carrier-specific requirements
  - Internationalization

Industry example: Meantime Game Company

- Developed MG2P = Meantime Game Porting Platform
  - Mobile Domain Database (MDD)
  - Meantime Base Architecture (MBA)
  - Meantime Build System (MBS)

- MDD captures basic Commonality + Variability
  - Variations: Device-specifics, Game types/APIs, Known issues, Language, Game features
  - Families of similar MobPs and Games (in porting context)
  - Typical device for each family chosen (least powerful, most issues)

Configuration knowledge in MDD

Table 2. Configuration knowledge mapping device variability to preprocessing tokens.

Category	Sub-Category	Variation	Token
Device specific	Screen Size	128x117	device_screen_128x117
		128x128	device_screen_128x118
		130x130	device_screen_130x130
		128x142	device_screen_128x142
		128x149	device_screen_128x149
Game Features	Usage of Tiled Layer API	Meantime API	game_tiledlayer_api_meantime
		MIDP 2.0 API	game_tiledlayer_api_midp2
		Siemens Game API	game_tiledlayer_api_siemens

Industry example: Meantime Game Company

- Meantime Base Architecture
  - Same code base and file structure for all games
  - J2ME does not allow libraries => MBA copied for each new game
  - Pre-processing tokens from MDD handles variability
- Meantime Build System
  - Built on Antenna pre-processor and Ant, more flexible

Architectural Concerns

- Architecturally Significant Requirements
  - Key requirements affecting the whole architecture
- Conceptual Architecture
  - Key concepts of architecture
- Architectural Structure
  - Decomposition into components and relations
- Architectural Texture
  - Rules for using, instantiating and evolving architecture

Architecturally Significant Requirements

- Central to the purpose of the products, or
- Technically Challenging / Technical Constraints
- Examples:
  - The system must encrypt all network traffic
  - The game must deploy on all mobile phones by the top 5 manufacturers that are released after 2007
  - The system must always give responses to user queries within 3 seconds
  - The system must provide a visual overview of the current flow of resources in the factory being managed
- Quality/Non-func requirements often decisive

Conceptual Architecture

- Most important concepts + their relations
- Mental model of of domain to understand and simplify the problem
  - (Related to “System Metaphor” in Extreme Programming)

Architectural Structure

- Division into components
  - Sub-systems/units with clear interfaces
- Connections between components

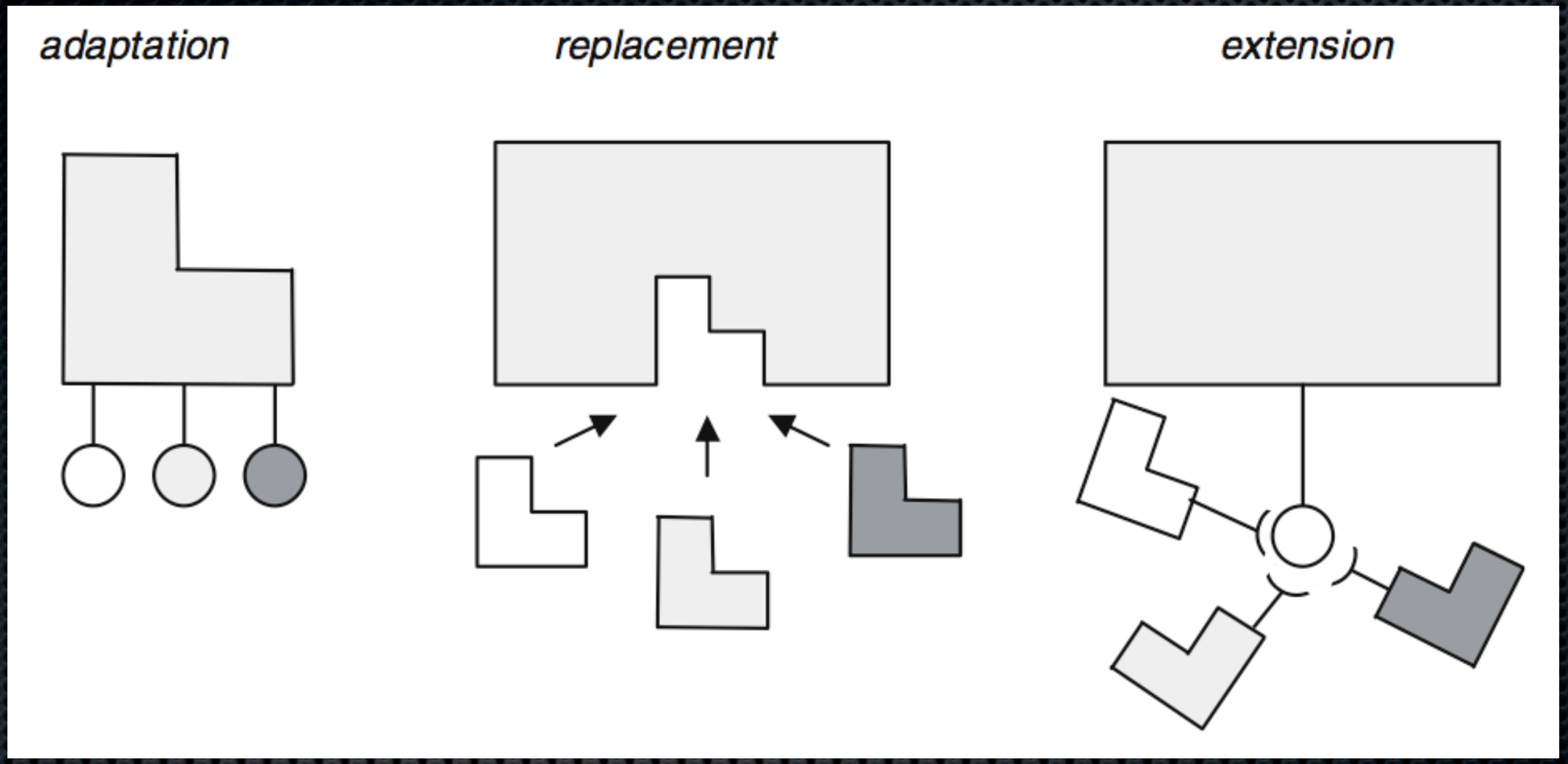
Architectural Texture

- "Manual" for the Reference Architecture
  - Guidelines, rules, "Philosophy" for
    - Using and
    - Evolving the RefArch
- Examples:
  - Coding standard
  - Design patterns
  - Architectural styles

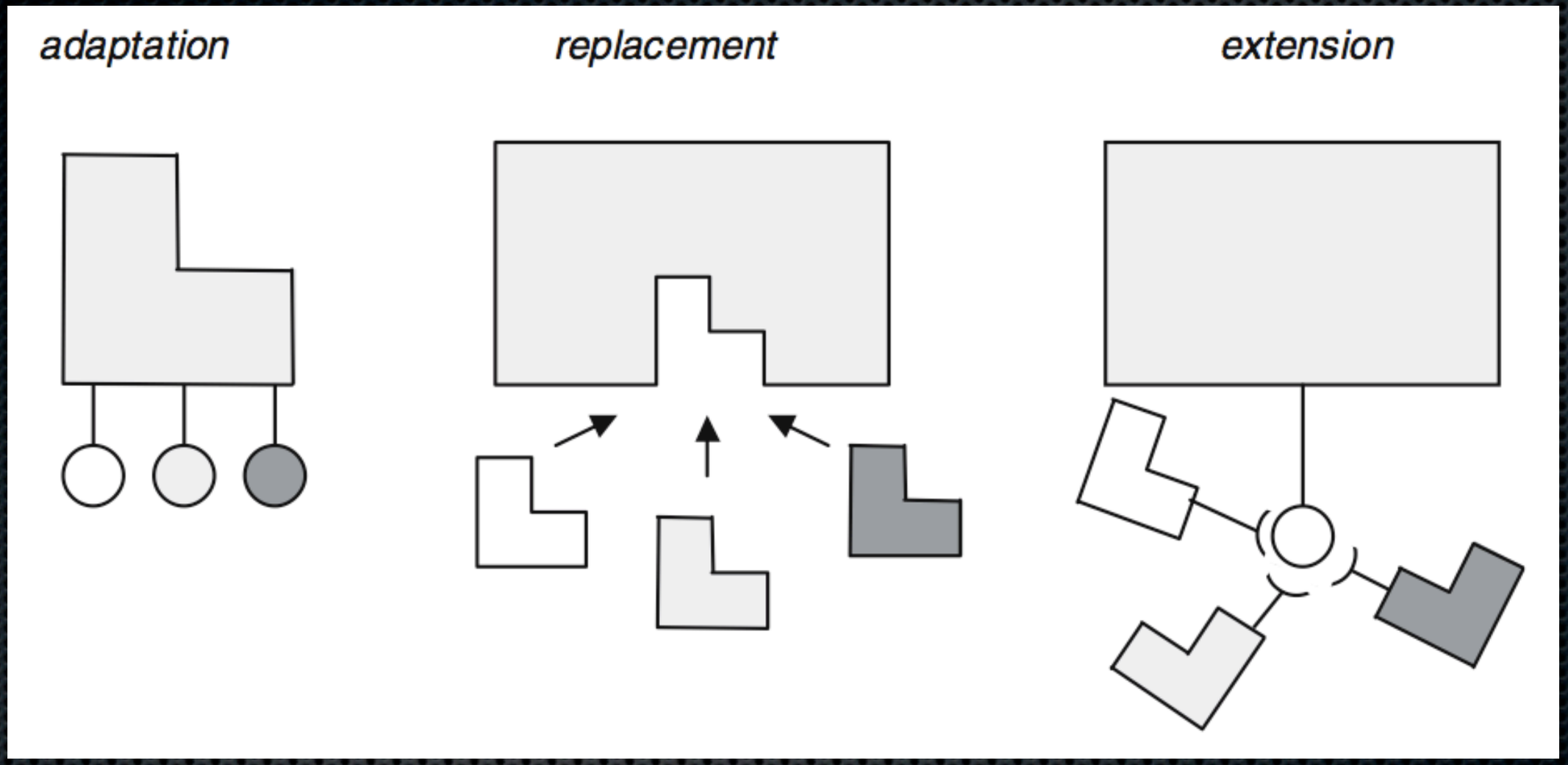
Creating a Reference Architecture

- "Normal" architecting methods can be used
  - Attribute-Driven Design, ..., OO, ..., Design Patterns, ...
- Differences:
  - More products, often more Stakeholders => Communicate
  - Also more Requirements conflicts => Resolve
- Three basic ways to support Variability:
  - Adaptation
  - Replacement
  - Extension

Variability Mechanisms

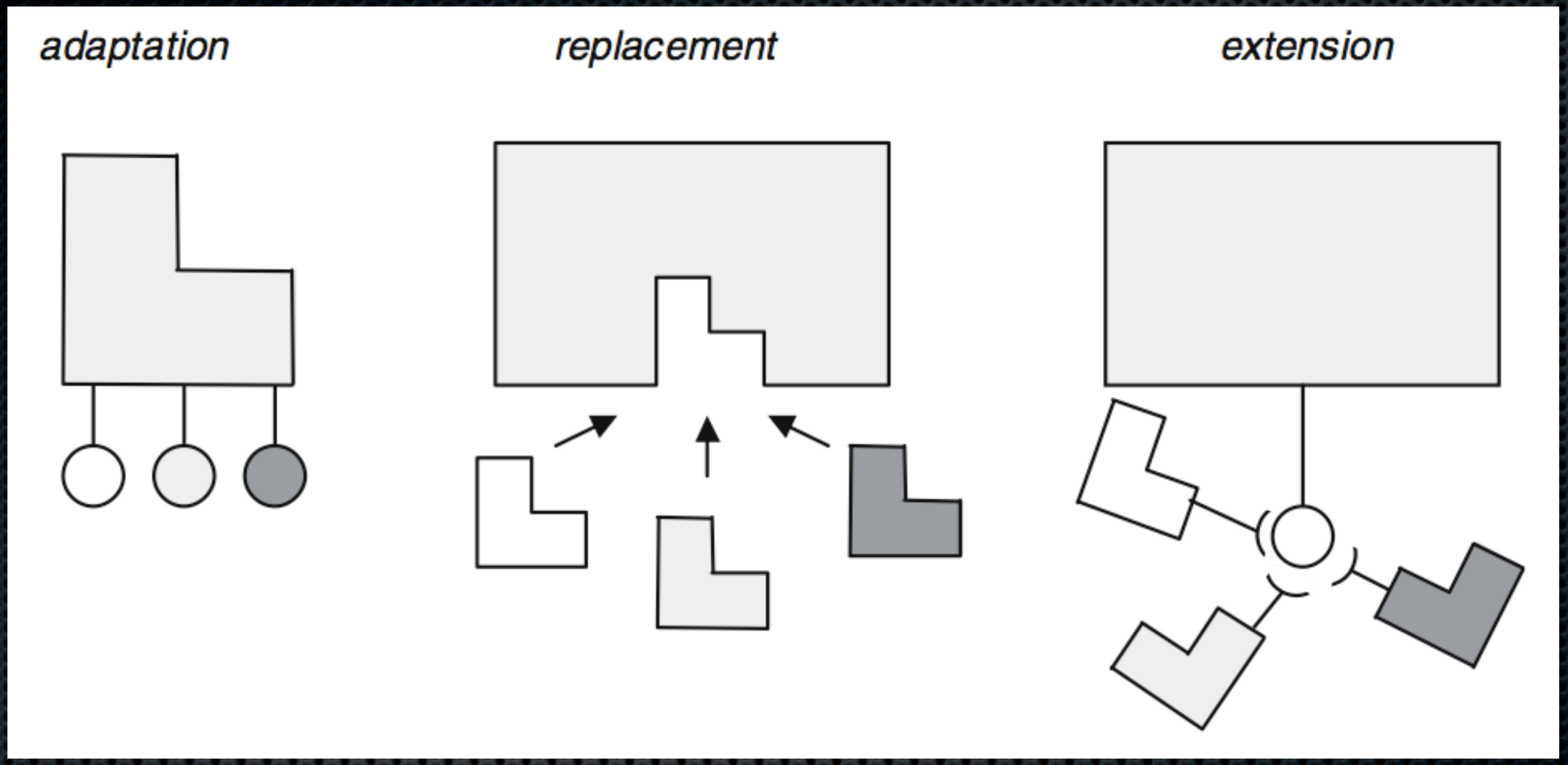


Variability Mechanisms



Only 1 component implementations
Adaptable behavior

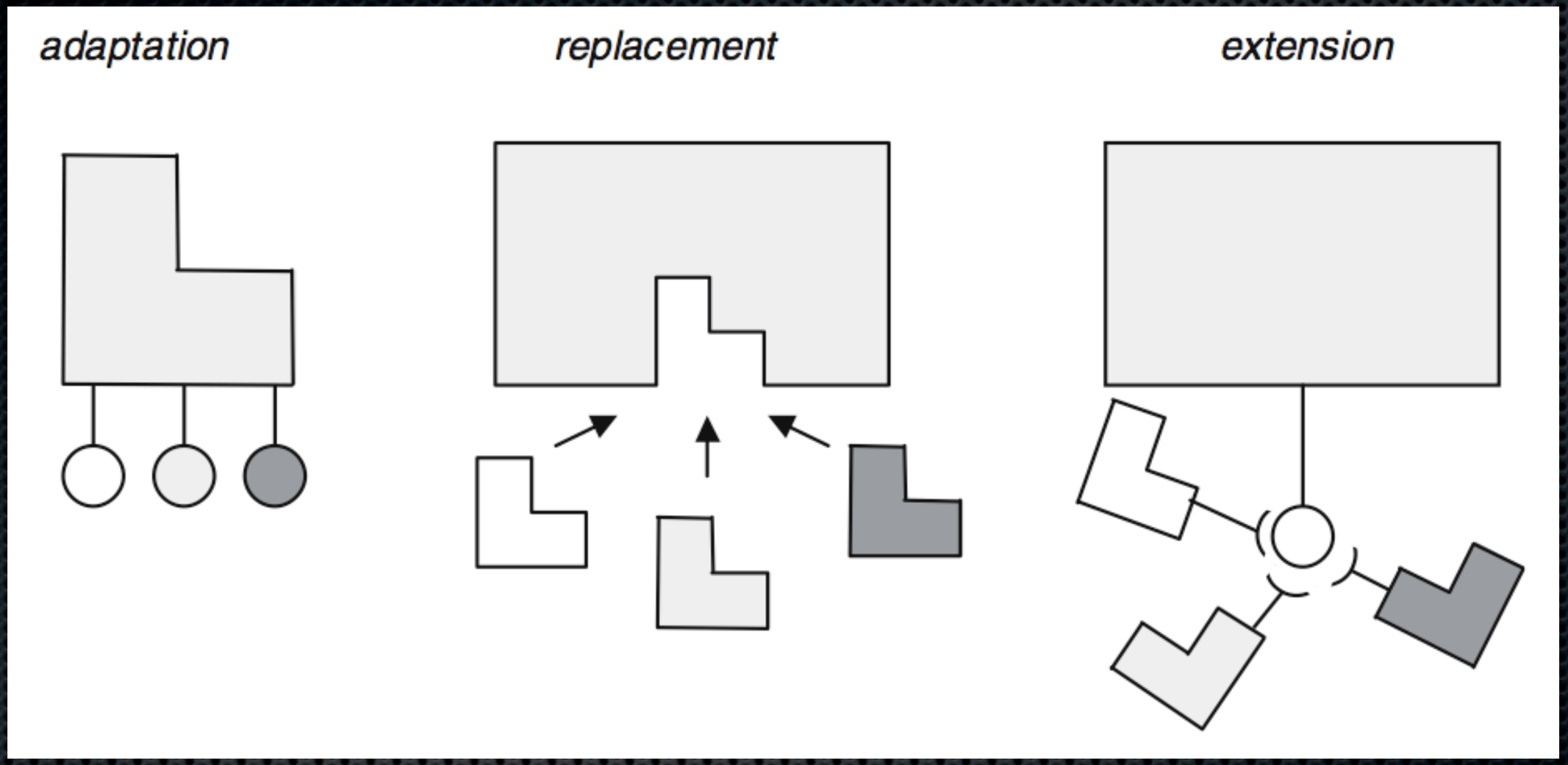
Variability Mechanisms



Only 1 component implementations
Adaptable behavior

Multiple component implementations
Choose one, or develop product-specific

Variability Mechanisms



Only 1 component implementations
Adaptable behavior

Multiple component implementations
Choose one, or develop product-specific

Generic interface for adding components

Adaptation mechanisms

- Inheritance
  - subclass changes/overrides behavior
- Patching
  - partial behavior change with little maintenance
  - DE: component, AE: patch
- Compile-time config
  - Pre-processors or macros, Makefiles
- Configuration
  - Interface to choose between multiple implementations
  - Parameters or configuration file to make choice

Replacement mechanisms

- Code generation
  - Generates code from high-level description (model, script)
  - Glue code or whole components/sub-systems
- Component replacement
  - Default component is replaced with another one
  - Often 3rd party components
  - Wrappers may be needed

Extension mechanisms

- Plug-ins
  - Architecture has interface to “plug in” components
  - Example: Corba, COM, etc
  - Example: Strategy Design Pattern

Variability & Commonality SPL Motivations

- Increase in the number of products that can be released
- Manage multiple, diverse products in one portfolio
- Improve product commonality
  - Not only for complexity management,
  - also for marketing (same look-and-feel)

Industry Case: Philips Consumer Electronics

- 16000 employees, €10Billion turnover (1/3 is TVs)
- 250 developers
- Single SPL for mid- and high-range TVs
- SPL developed 1996-2000, in use since then

- Trends, more complex SW:
  - More features (MPEG4, Sound processing, HW->SW)
  - Globalized market
  - Shorter product cycles and TTM
  - Product convergence

Industry Case: Philips Consumer Electronics

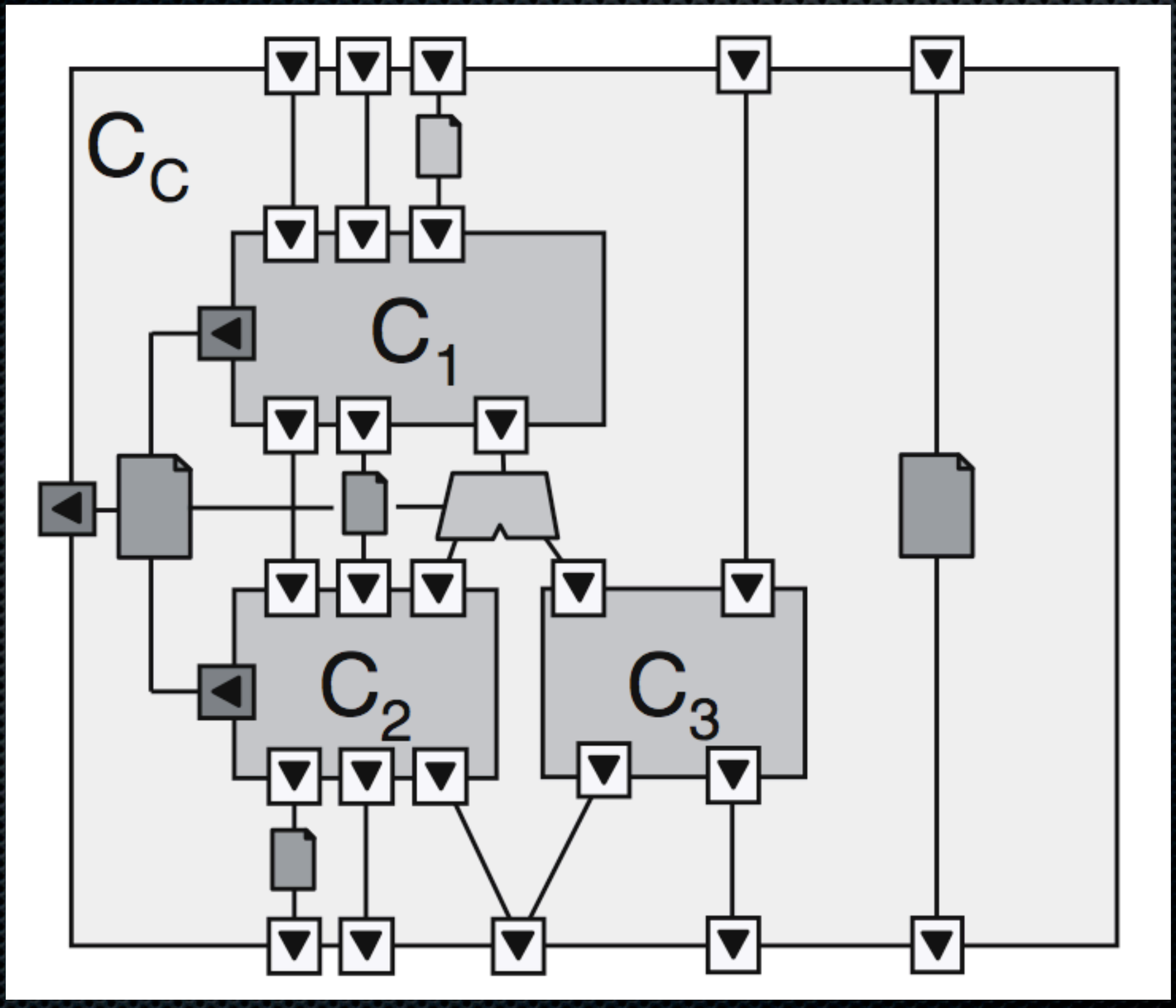
- Hundreds of Variability parameters -> Hierarchy
- Evolution rules: What can be changed without affecting other parts? (HW dependencies)

- Compositional approach technically
  - Describe which components to combine into new product
  - Simplified convergence (DVD+TV, TV+VCR, ...)

Industry Case: Philips Consumer Electronics

- Koala Component Model
  - Component = Specification + Implementation
  - Hierarchical - group of components can be one component at higher level
    - Implemented in C, interfaces in separate files
    - Component descriptions to generate build/make files
      - Interface Description Language + Tools to work with it
    - No extra run-time costs (resource-constrained HW)

Industry Case: Philips Consumer Electronics



Industry Case: Philips Consumer Electronics

- Variability
  - Compound components can have “Diversity parameters”
    - Switches to choose sub-components
- Packages group components and interfaces to larger units
  - Also the packages are hierarchical
- Product is a selection of packages

Industry Case: Philips Consumer Electronics

- Reference architecture?
- What are the Variability mechanisms? (Adaptation, Replacement, Extension)
- Documentation of variability?

Industry Case: Philips Consumer Electronics

- Reference architecture?
  - No, since it would not help for creating combi-products
  - Maybe for small line of TVs, not for whole range over multiple years
- What are the Variability mechanisms? (Adaptation, Replacement, Extension)
- Documentation of variability?
  - Only: Component & Interface data sheets + sub-system design notes

Industry Case: Philips Consumer Electronics

- Results / Lessons learned
  - Diversity of products produced on time, Variability not a problem
  - Late-joining architects don't understand Koala's motivation
  - Architecture has lasted longer than any previous
  - Took 3 years to be successful
  - Config Management system fails at sub-file level variability
    - Better to solve variability in arch & use traditional CM

Evolving a Reference Architecture

- Evolution is a must:
  - Market changes
  - Features or products become redundant
  - Company mergers
  - 3rd party component updates
  - New technology
- Unintentional evolution:
  - Software/documentation rot, Maintenance, Erosion
  - Refactoring can counter

Requirements Variability - Textual

- The game should support
  - ... either 32-bit color output...
  - ... or 16-bit color output...
  - ... from the graphics engine.

Requirements Variability - Textual

- The game should support
- ... either 32-bit color output...
- ... or 16-bit color output...
- ... from the graphics engine.

Variation point

Requirements Variability - Textual

- The game should support

Variation point

- ... either 32-bit color output...

Variation 1

- ... or 16-bit color output...
- ... from the graphics engine.

Requirements Variability - Textual

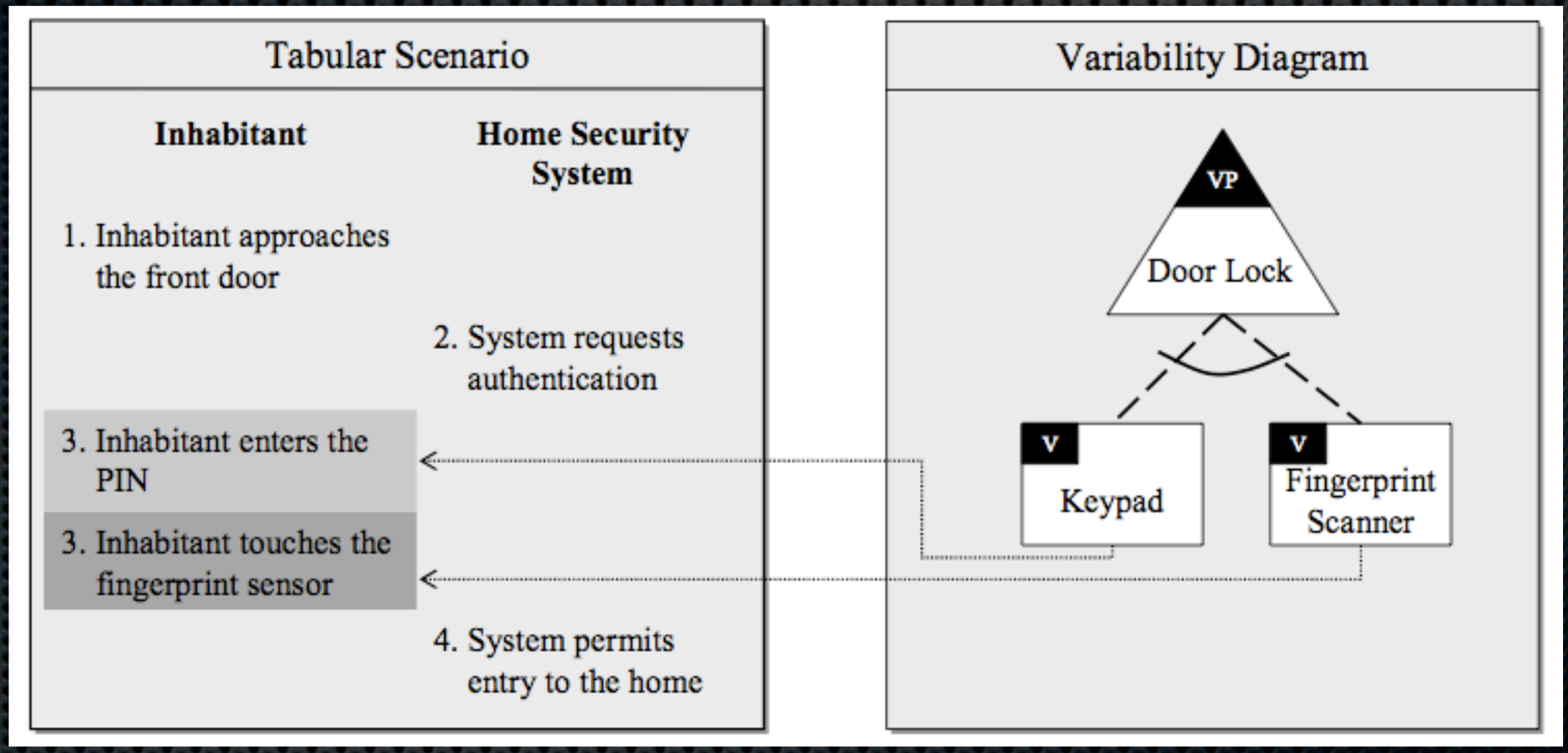
- The game should support
- ... either 32-bit color output...
- ... or 16-bit color output...
- ... from the graphics engine.

Variation point

Variation 1

Variation 2

Requirements Variability - Use Cases



Scoping

- Defining the scope of the product line
  - Which products are within the boundaries of the SPL?
  - Which products are not supported by the SPL?
  - Product Portfolio Scoping
    - Technical, Marketing and Strategic Decision
- Other levels (built on PPS):
  - Domain scoping = Identify major domains relevant för SPL
  - Asset scoping = Define functionality for reusable components
- Active research area

Example scoping: Philips Consumer Elec.

- Main SPL Scope = “Mid- and High-range TVs”
  - Support convergent/combi products
  - Not low-end TVs
    - Less features => less variability
      - Less product-to-product changes => less variability
      - HW+SW mainly bought from 3rd party
- Flexible and Ongoing Domain Scoping
  - Convergence & short cycles requires new domains
- Asset scoping built into component framework

Product Portfolio Scoping

- 1. Define Product Line Market
- 2. Determine relevant Product Types
  - Product Map = List of example products/types with their main features = Defines the Portfolio
- 3. Analyse Market Position & Define Products
  - KANO Model
- 4. Analyse interrelations between products
  - Competition - PL Cannibalisation
  - Support - Entry-level sells premium-level

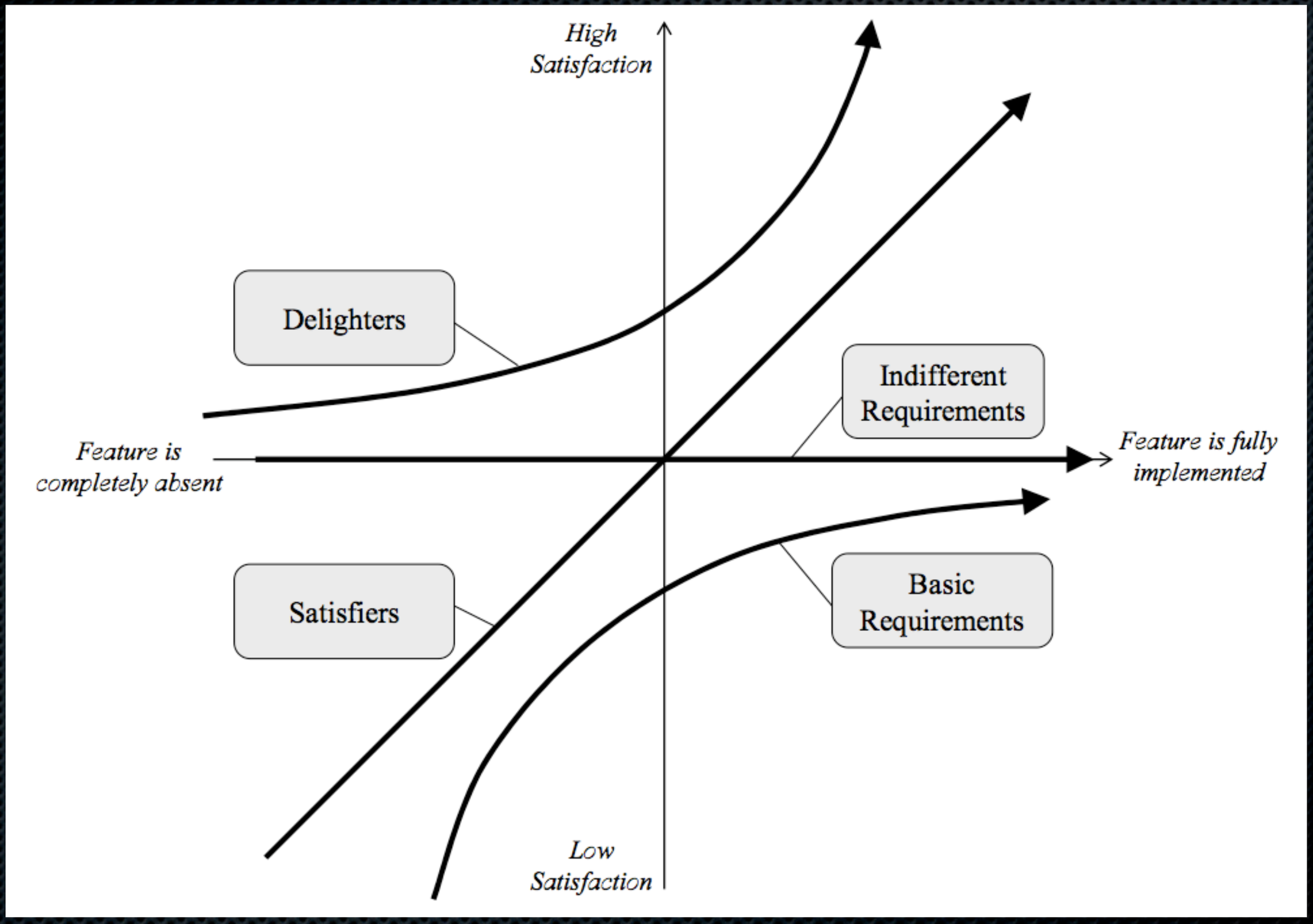
Product Portfolio Scoping

- 1. Define Product Line Market
- 2. Determine relevant Product Types
  - Product Map = List of example products/types with their main features = Defines the Portfolio

Identifying Commonality and Variability is natural in scoping => SPL good fit

- 3. Analyse Market Position & Define Products
  - KANO Model
- 4. Analyse interrelations between products
  - Competition - PL Cannibalisation
  - Support - Entry-level sells premium-level

KANO Model


High
Satisfaction
Delighters
Indifferent
Requirements
Feature is
completely absent
Feature is fully
implemented
Satisfiers
Basic
Requirements
Low
Satisfaction

Domain Requirements Engineering & Analysis

- Normal RE and Analysis but Precise Variability Defs
  - Commonality Analysis
  - Variability Analysis
  - Variability Modeling
- Methods
  - App-Req Matrix
  - Priority-based Analysis (KANO)
  - Checklists

Acronyms used

- DE = Domain Engineering
- AE = Application Engineering
- RefArch = Reference Architecture
- TTM = Time To Market
- SW = Software
- SPL = Software Product Line
- SPLE = SPL Engineering (and course book!)
- Dev = Development

References

- V. Alves, T. Camara, C. Alves, “Experiences with Mobile Games Product Line Development at Meantime”, SPLC’08, Limerick, Ireland, 8-12 Sept, 2008.