

Visual Modeling of Product Line Variability on basis of Aspect- Oriented Modeling

Reinhard Stoiber, Silvio Meier, Martin Glinz

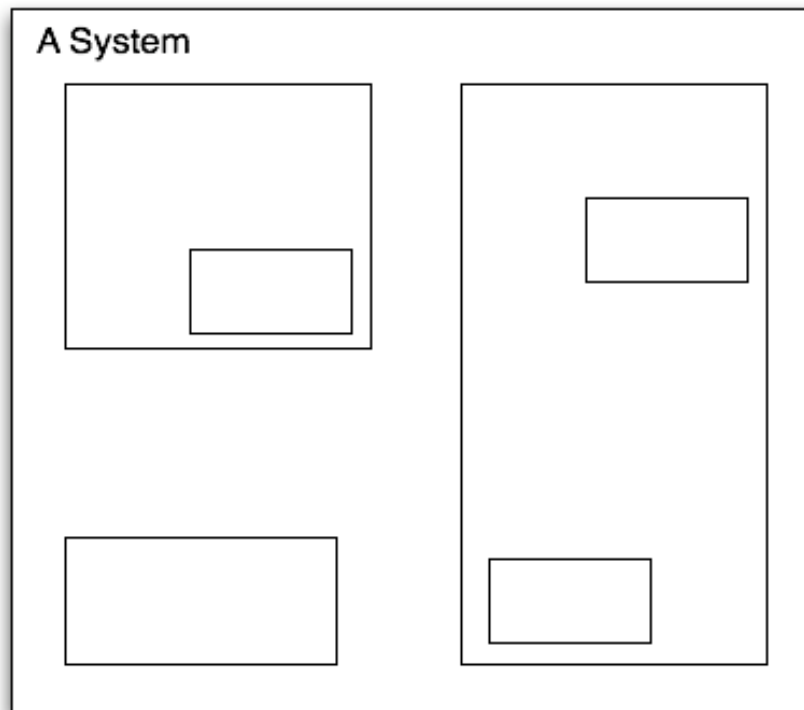
REV'07



University of Zurich
Department of Informatics

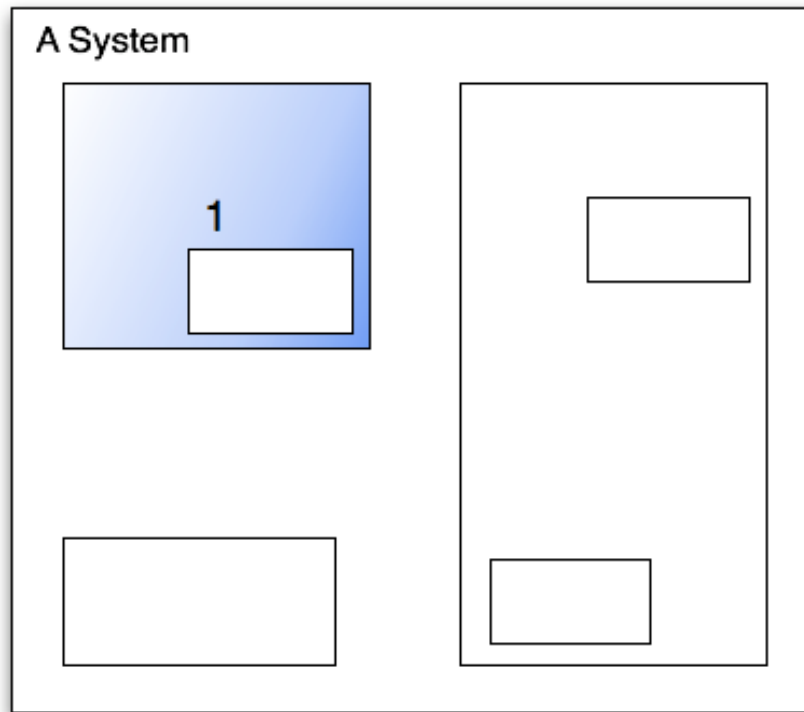
Modeling a Software System (1)

- Concerns

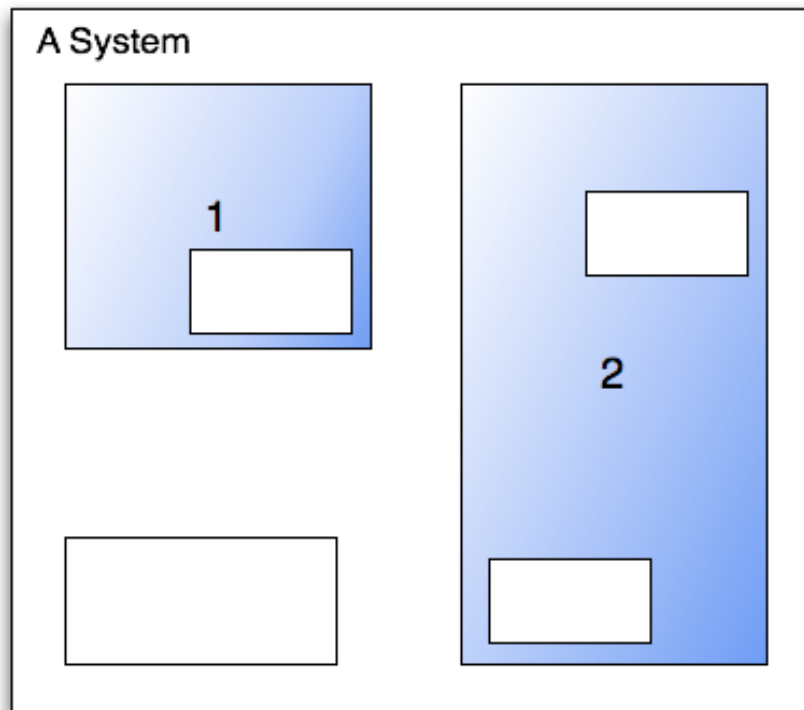


Modeling a Software System (2)

- Concerns
 - 1. Core concern



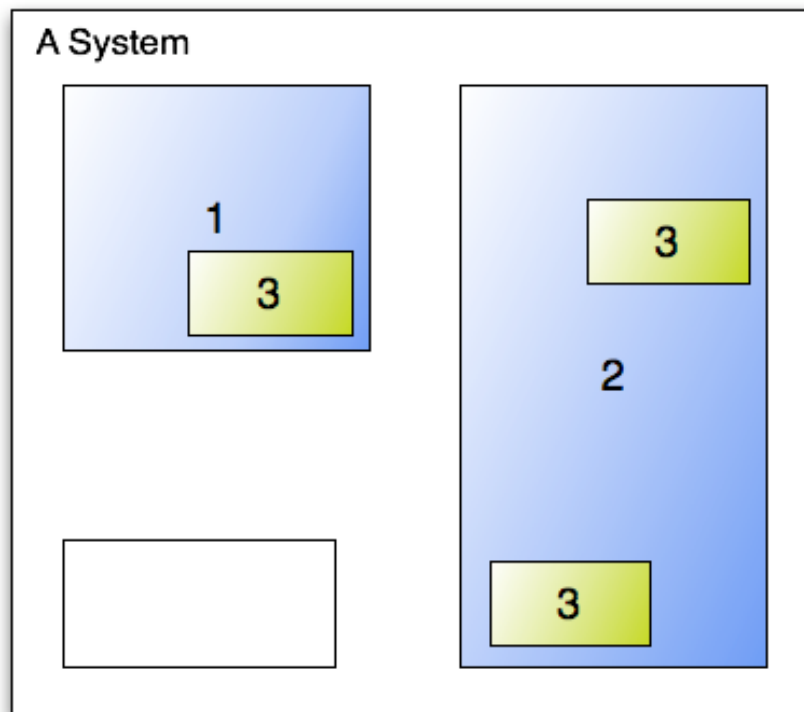
Modeling a Software System (3)



- Concerns

- 1. Core concern
- 2. Core concern

Modeling a Software System (4)

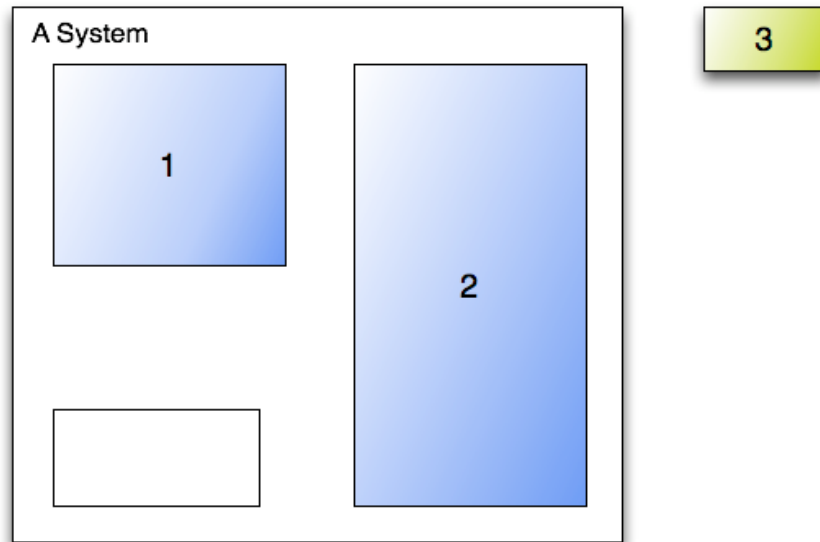


- Concerns

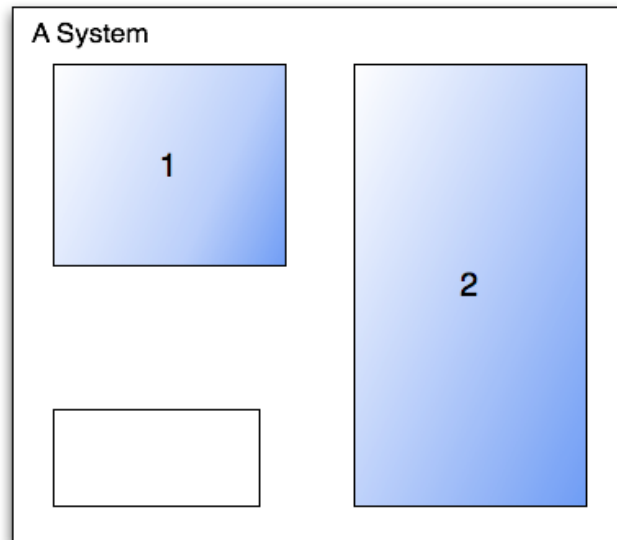
- 1. Core concern
- 2. Core concern
- 3. Cross-cutting concern
 - Multiple distributed occurrences
 - A source of problems.

Aspect-Oriented Modeling (1)

- Separation of cross-cutting concerns



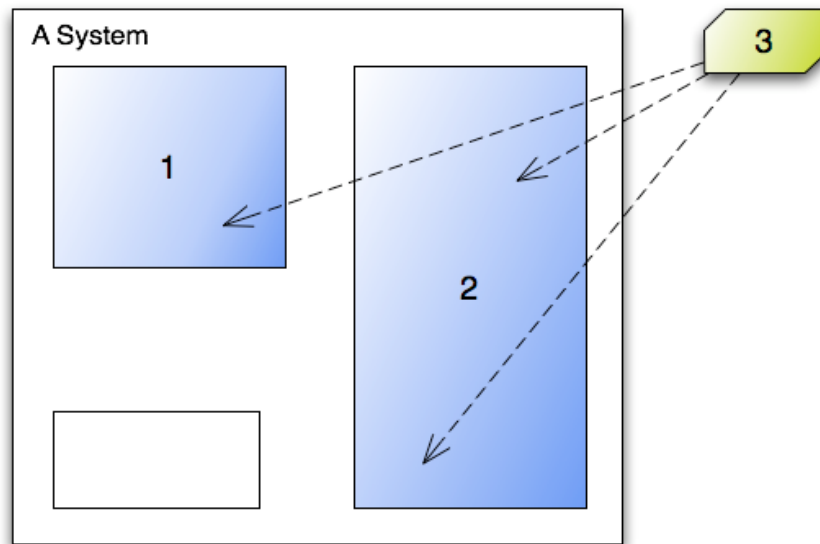
Aspect-Oriented Modeling (2)



3

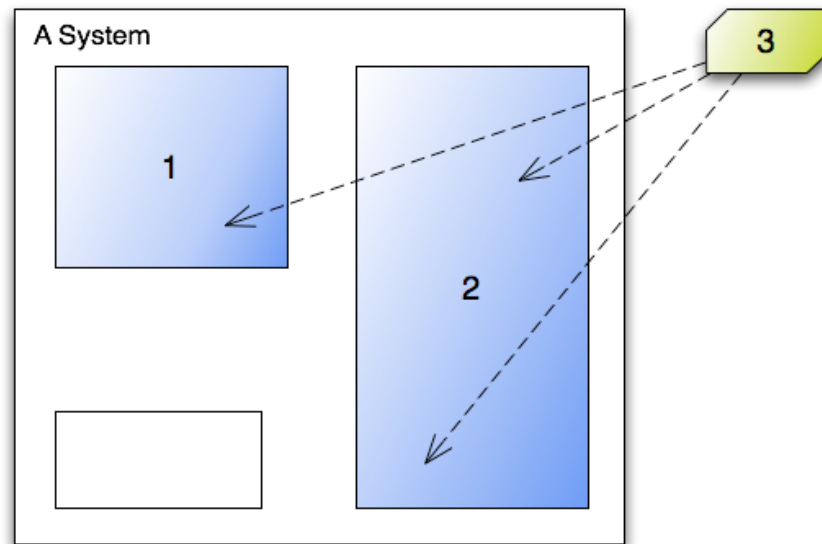
- Separation of cross-cutting concerns
- “3” is now an Aspect

Aspect-Oriented Modeling (3)



- Separation of cross-cutting concerns
- “3” is now an Aspect
- Indication where to apply
 - Join relationships

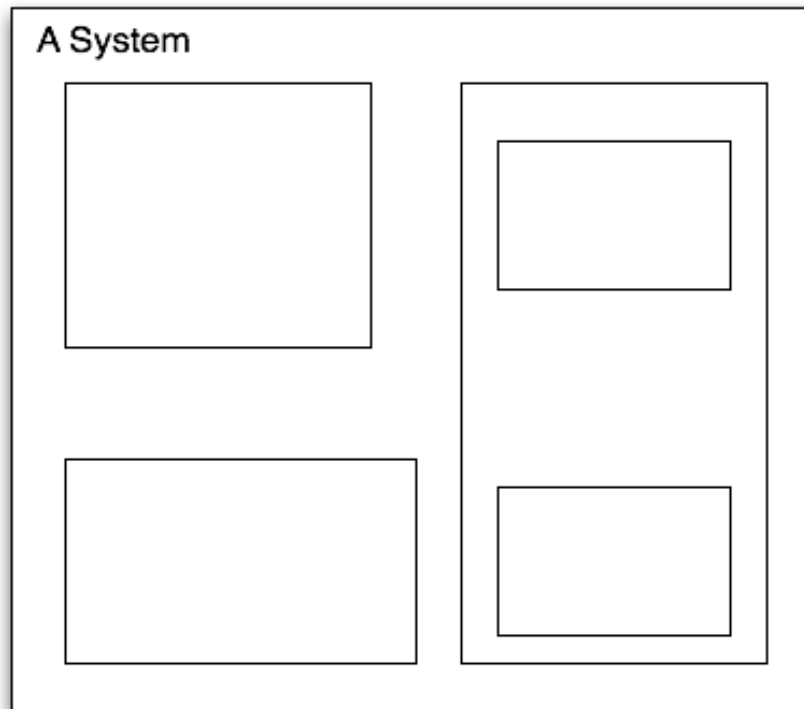
Aspect-Oriented Modeling (4)



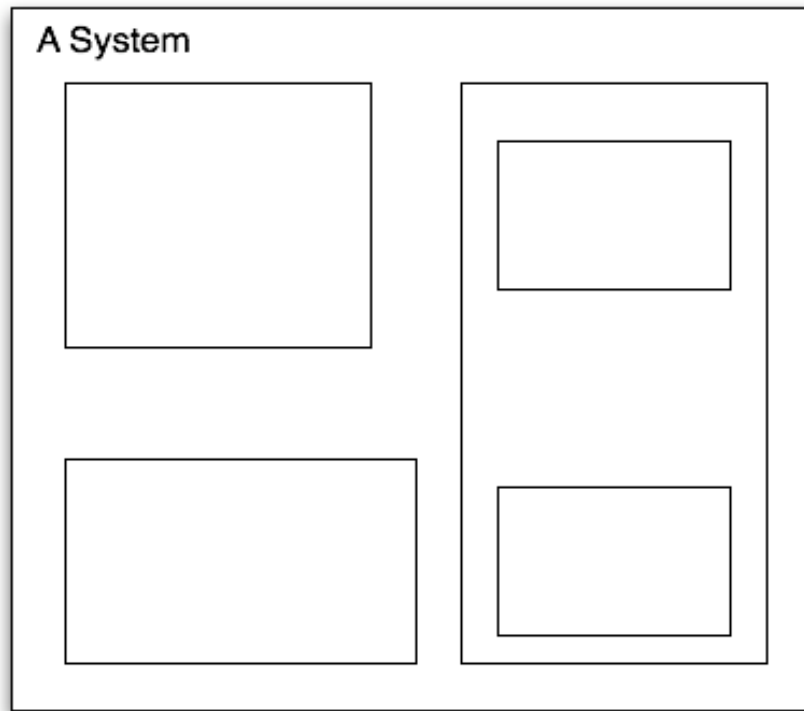
- Separation of cross-cutting concerns
- “3” is now an Aspect
- Indication where to apply
 - Join relationships
- This is an orthogonal concept.

Product Line Domain Modeling (1)

- Customizable Systems



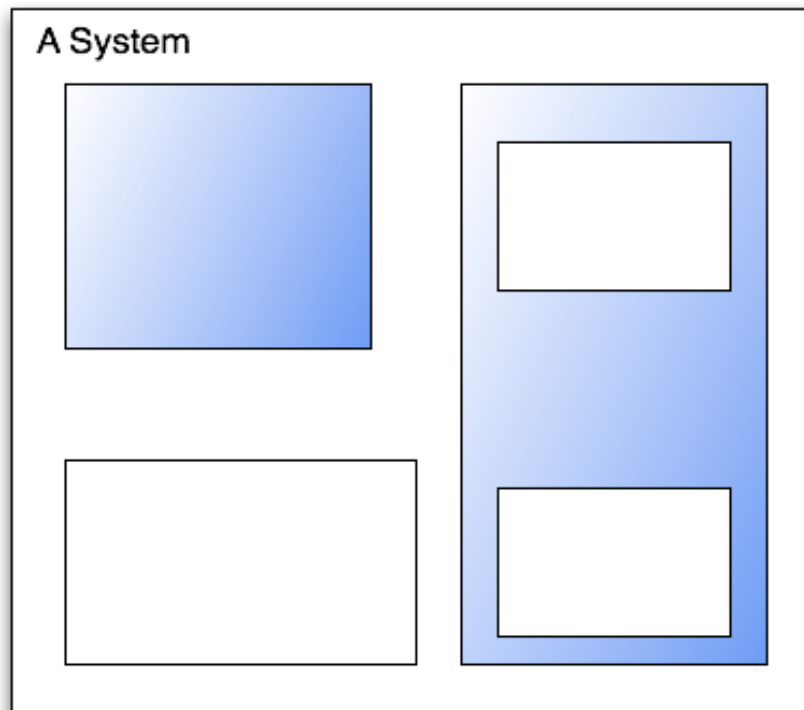
Product Line Domain Modeling (2)



- Customizable Systems
- Concerns

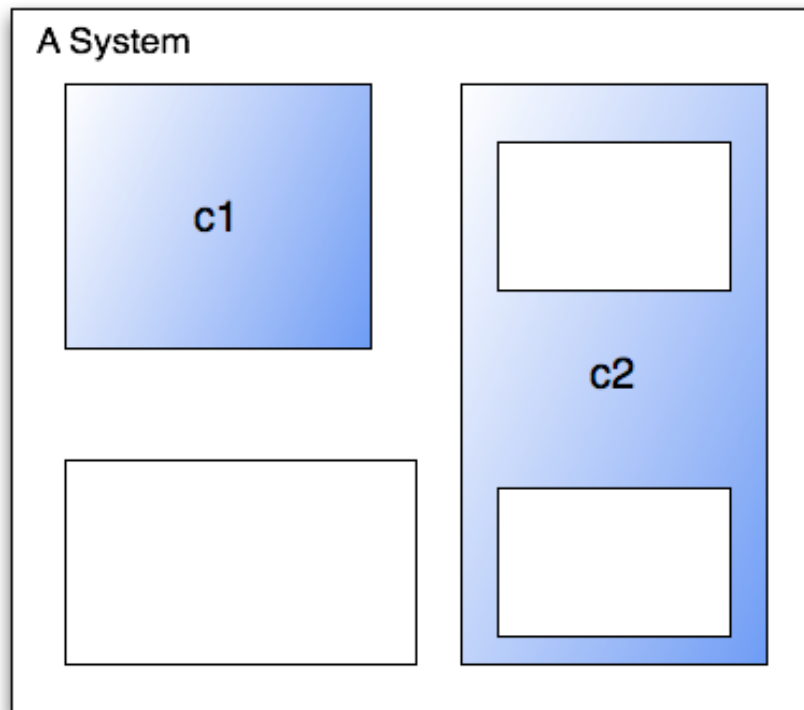


Product Line Domain Modeling (3)



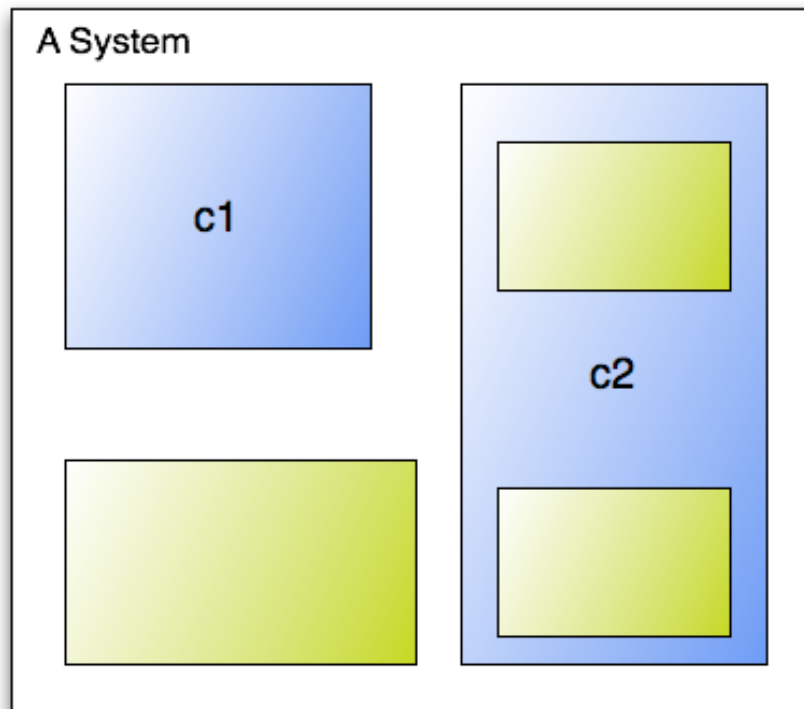
- Customizable Systems
- Concerns
 - Commonality
 - Commonality
 -
 -
 -

Product Line Domain Modeling (4)



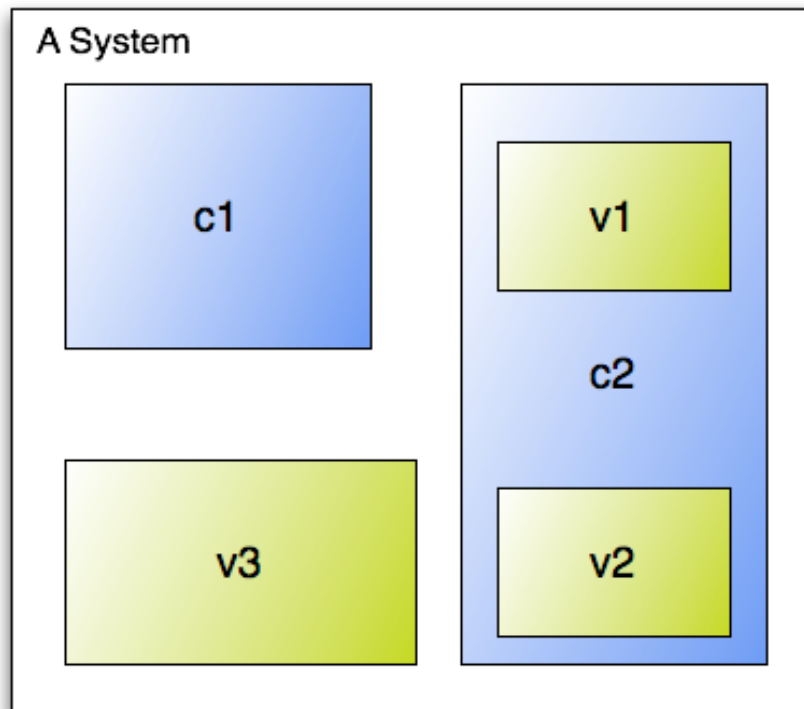
- Customizable Systems
- Concerns
 - Commonality 1
 - Commonality 2
 -
 -
 -

Product Line Domain Modeling (5)



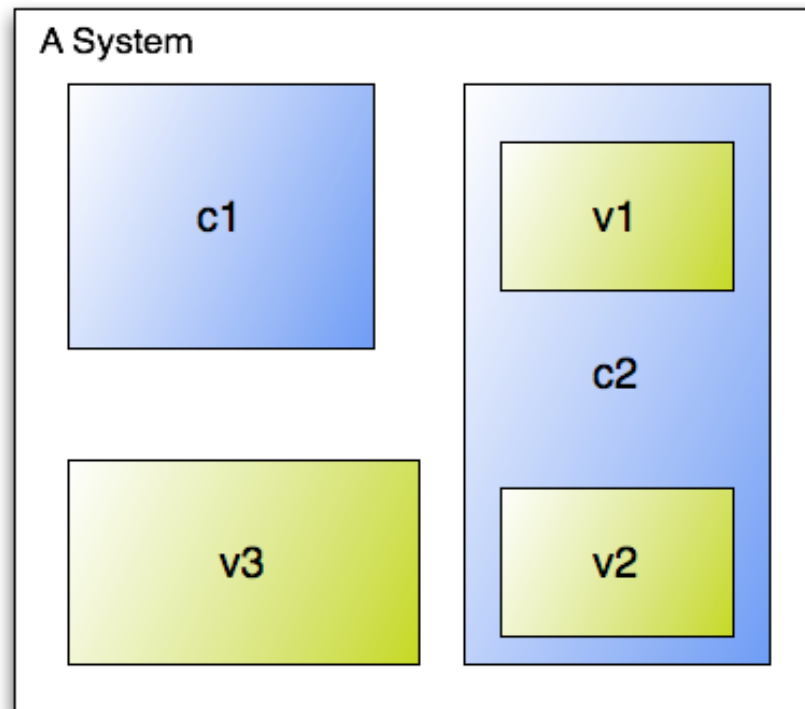
- Customizable Systems
- Concerns
 - Commonality 1
 - Commonality 2
 - Variability
 - Variability
 - Variability

Product Line Domain Modeling (6)



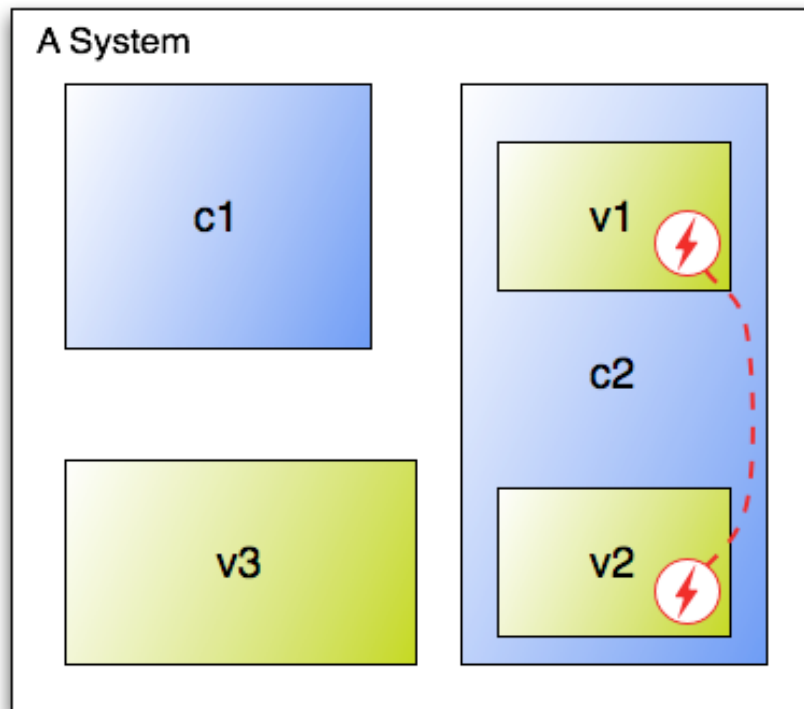
- Customizable Systems
- Concerns
 - Commonality 1
 - Commonality 2
 - Variability 1
 - Variability 2
 - Variability 3

Product Line Domain Modeling (7)



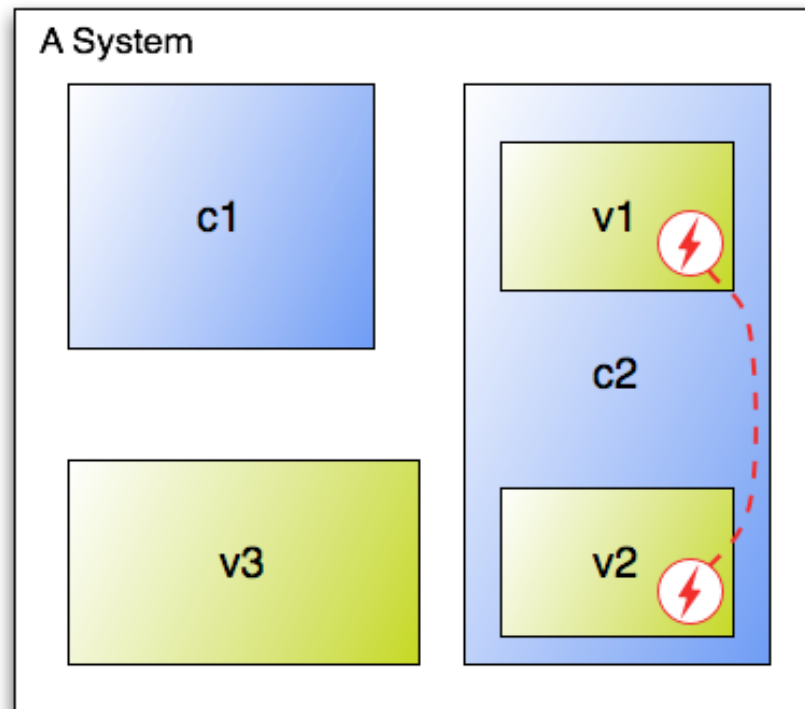
- Customizable Systems
 - Concerns
 - Commonality 1
 - Commonality 2
 - Variability 1
 - Variability 2
 - Variability 3
- } Alternatives
- Optionality

Product Line Domain Modeling (8)



- Customizable Systems
 - Concerns
 - Commonality 1
 - Commonality 2
 - Variability 1
 - Variability 2
 - Variability 3
- } Alternatives
- Optionality

Product Line Domain Modeling (9)



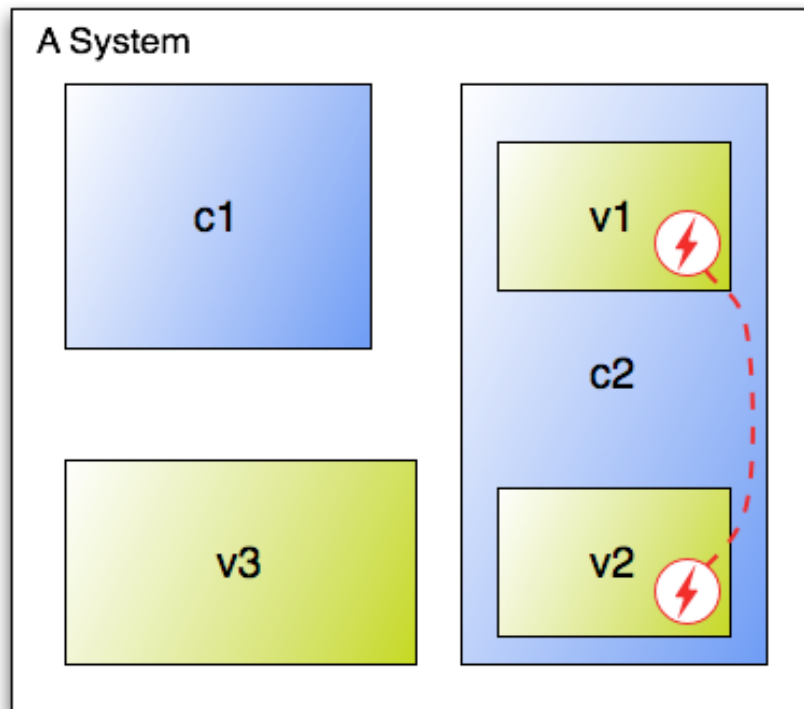
- Customizable Systems
- Concerns
 - Commonality 1
 - Commonality 2
 - Variability 1
 - Variability 2
 - Variability 3

} Alternatives

→ Optionality
- The System is not valid.

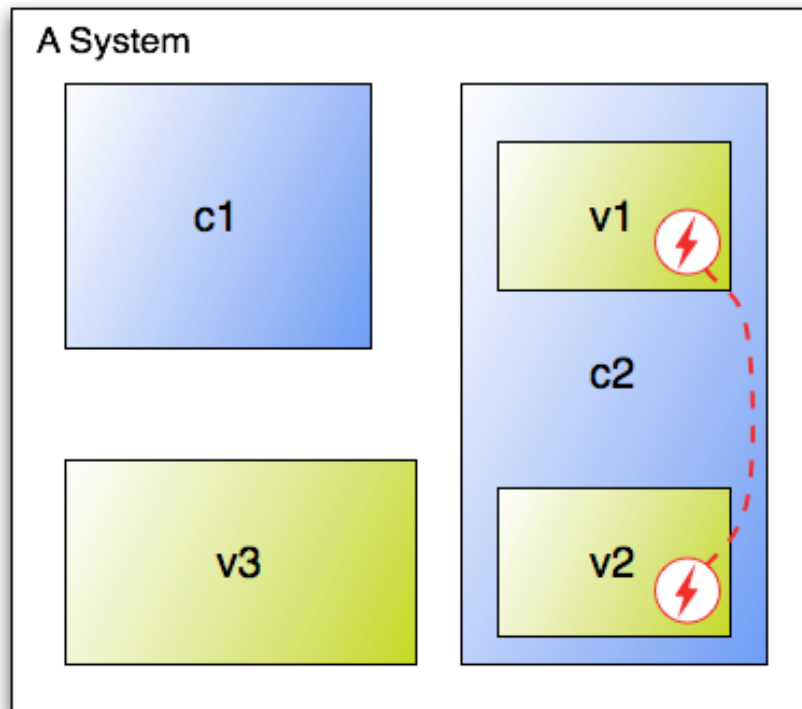
Product Line Domain Modeling (10)

- Solutions?



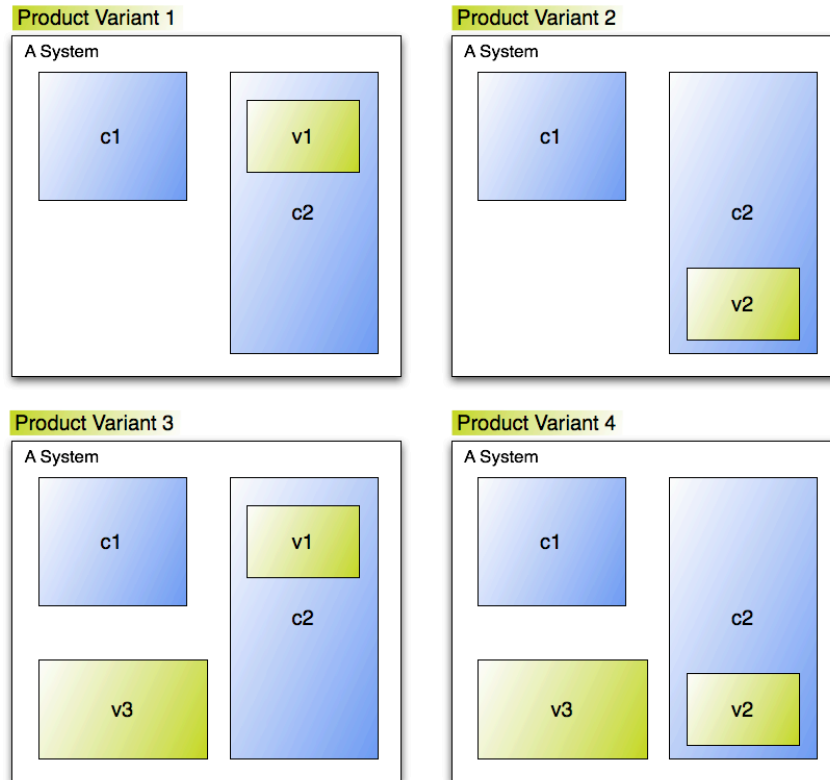
Product Line Domain Modeling (11)

Everything in one system



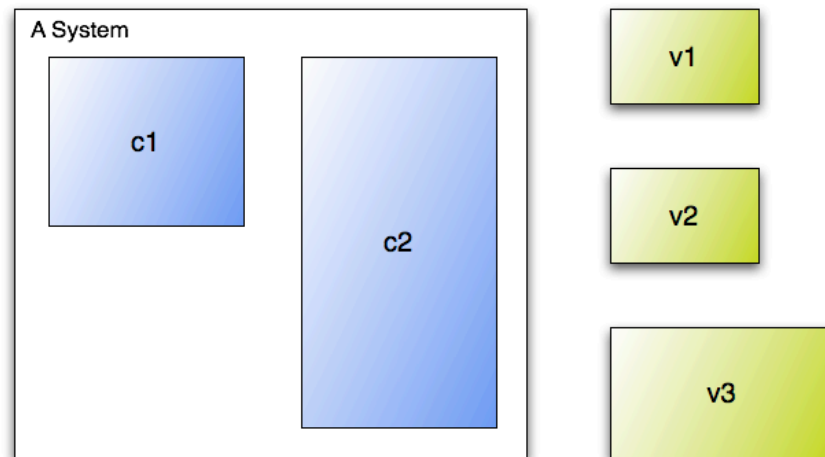
- Solutions?
- 1. A single model
 - Inaccuracy
 - Errors

Product Line Domain Modeling (12)



- Solutions?
- **1. A single model**
 - Inaccuracy
 - Errors
- **2. Models of all product variants**
 - Valid models
 - Redundancy / Inefficiency
 - Potential Inconsistency

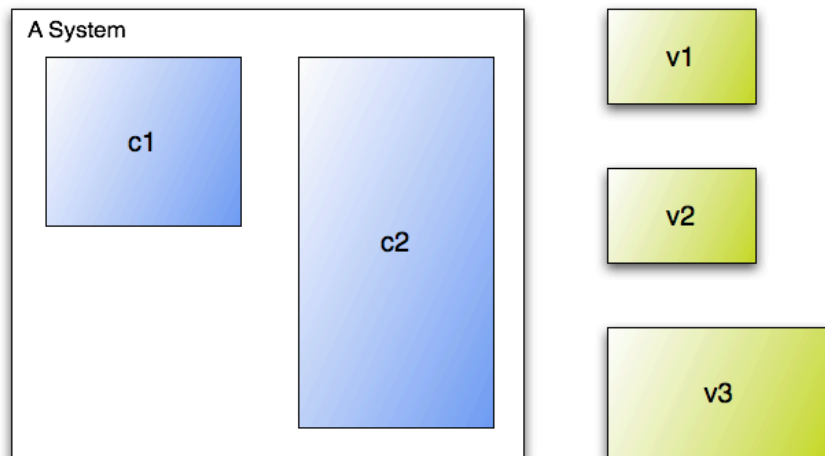
Product Line Domain Modeling (13)



- Solutions?
- **1. A single model**
 - Inaccuracy
 - Errors
- **2. Models of all product variants**
 - Valid models
 - Redundancy / Inefficiency
 - Potential Inconsistency
- **3. Separation of variability**

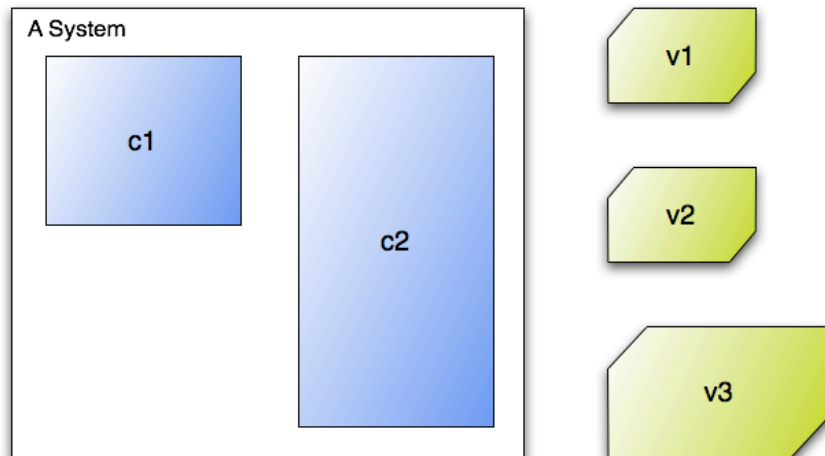
Product Line Domain Modeling (14)

- 3. (continued)
- Orthogonal Concept



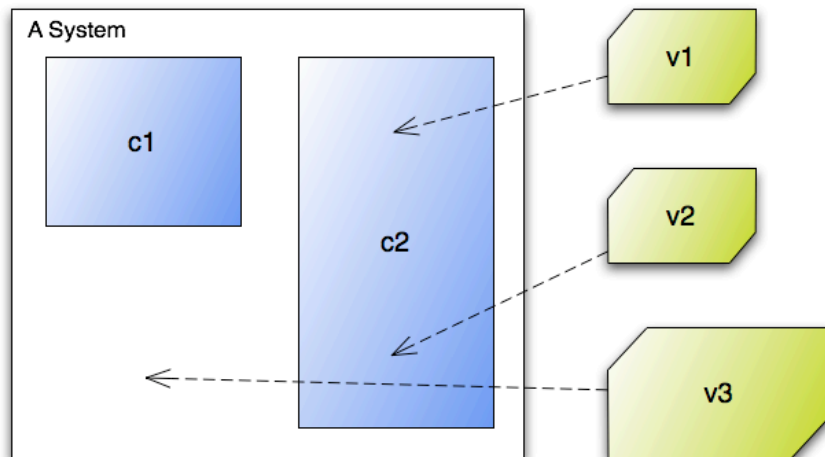
Product Line Domain Modeling (15)

- 3. (continued)
- Orthogonal Concept
- Variabilities as Aspects



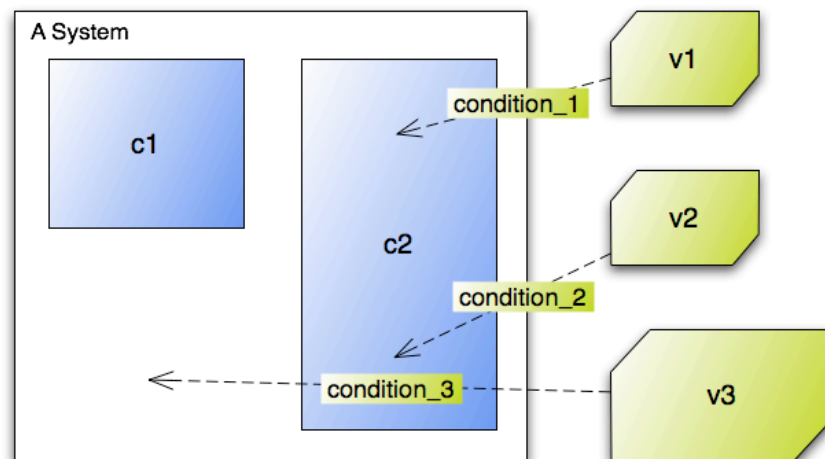
Product Line Domain Modeling (16)

- 3. (continued)
- Orthogonal Concept
- Variabilities as Aspects
- Join Relationships



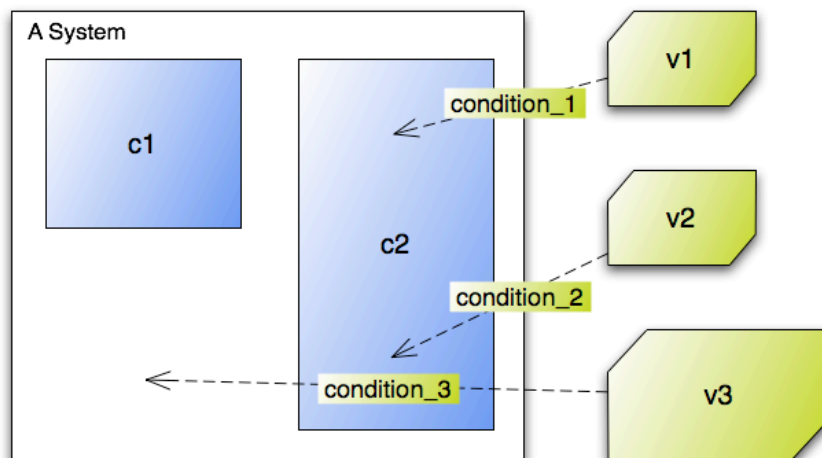
Product Line Domain Modeling (17)

- 3. (continued)
- Orthogonal Concept
- Variabilities as Aspects
- Join Relationships
- Join Conditions



Product Line Domain Modeling (18)

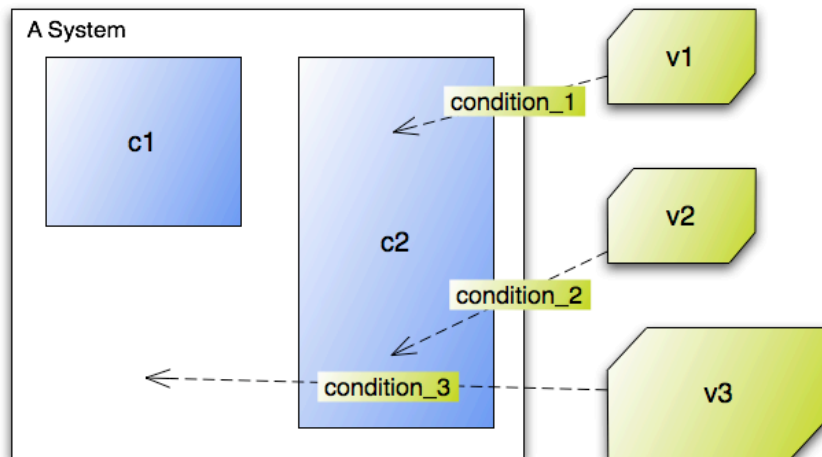
- 3. (continued)
- Orthogonal Concept
- Variabilities as Aspects
- Join Relationships
- Join Conditions
- Decision model



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time

Product Line Domain Modeling (19)

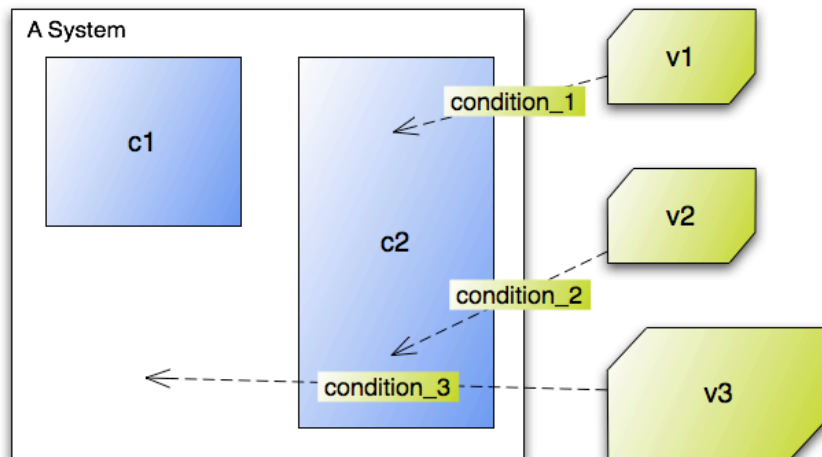
- 3. (continued)
- Orthogonal Concept
- Variabilities as Aspects
- Join Relationships
- Join Conditions
- Decision model



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Product Line Domain Modeling (20)

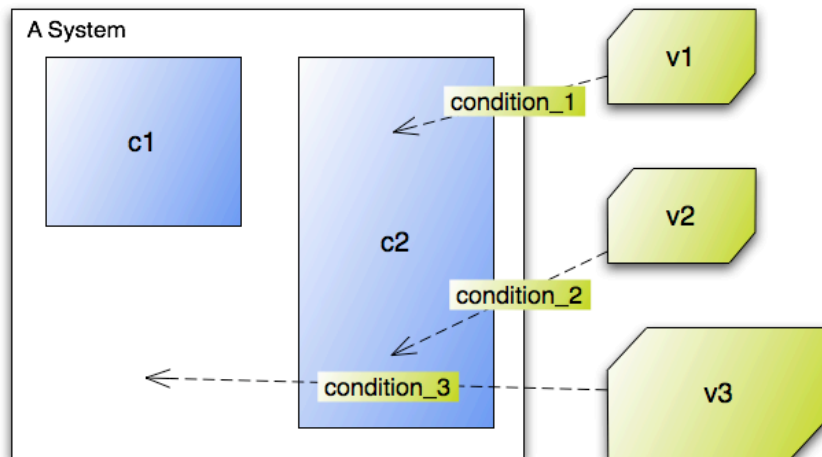
- 3. (continued)
- Orthogonal Concept
- Variabilities as Aspects
- Join Relationships
- Join Conditions
- Decision model



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Product Line Domain Modeling by Aspect-Orientation (1)

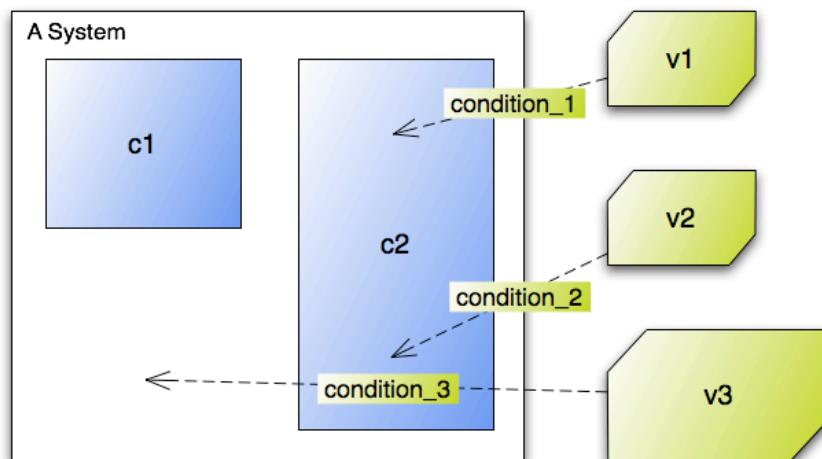
- Result: A valid product line domain model.



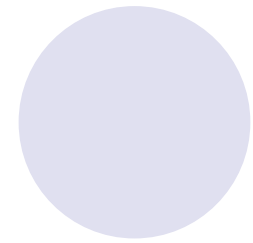
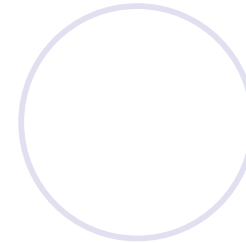
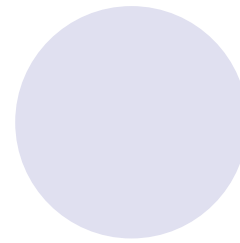
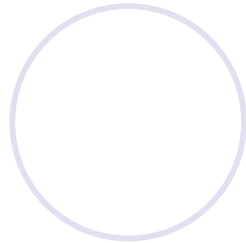
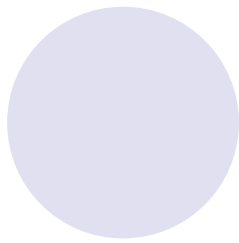
Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Product Line Domain Modeling by Aspect-Orientation (2)

- Result: A valid product line domain model.
- Separated Concerns
- More natural models



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

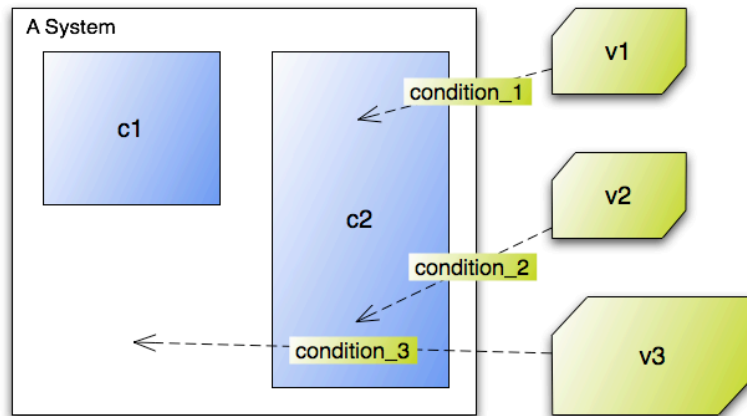


- Example.

Achievements (1)

- Automatic Product Synthesization

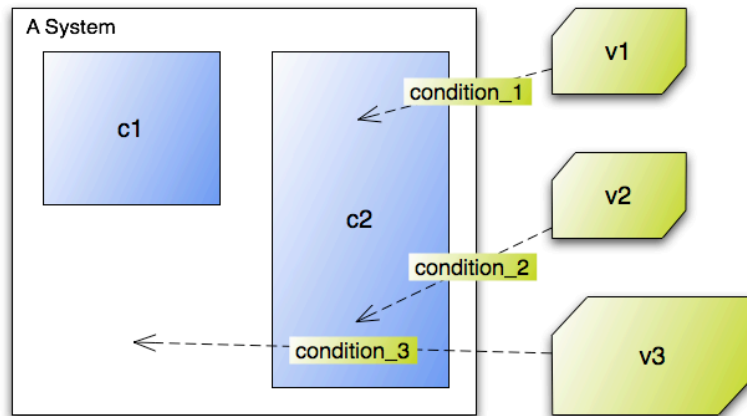
Achievements (2)



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

- Automatic Product Synthesization

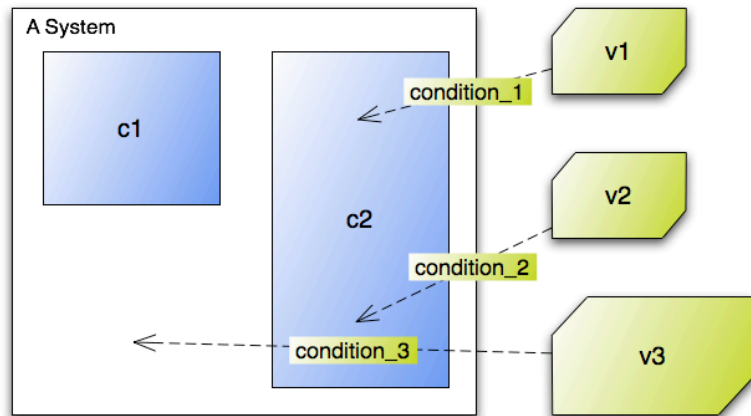
Achievements (3)



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

- Automatic Product Synthesization

Achievements (4)



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

- Automatic Product Synthesization

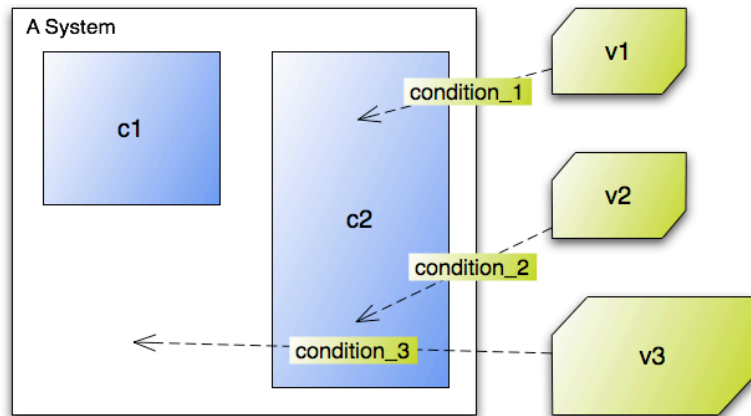
Decision Making:

condition_1 = true

condition_2 = false

condition_3 = true

Achievements (5)



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

- Automatic Product Synthesization

Decision Making:

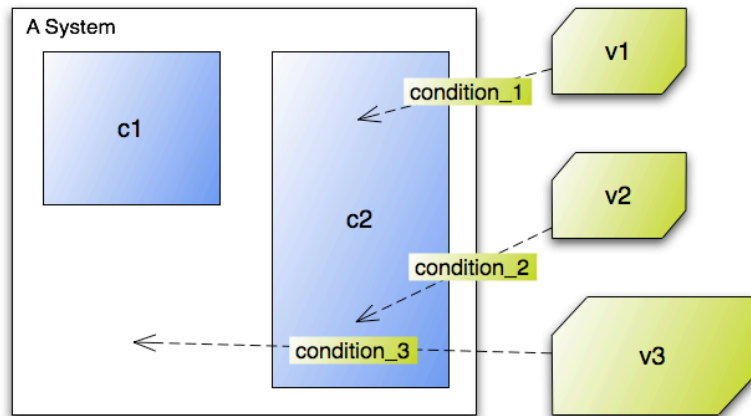
condition_1 = true

condition_2 = false

condition_3 = true



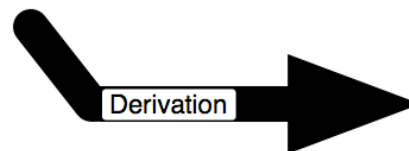
Achievements (6)



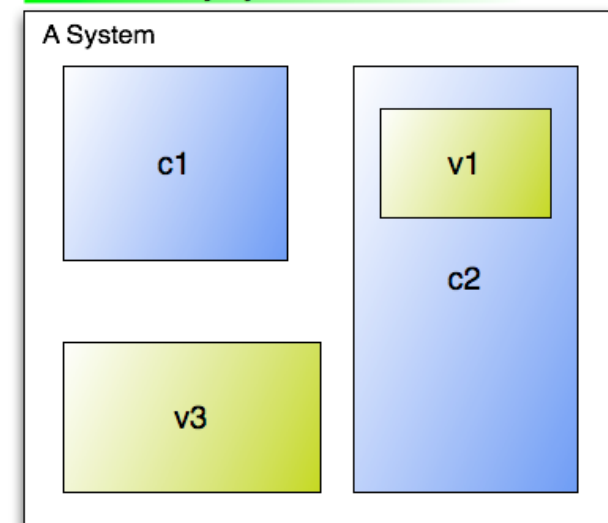
Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Decision Making:

condition_1 = true
condition_2 = false
condition_3 = true



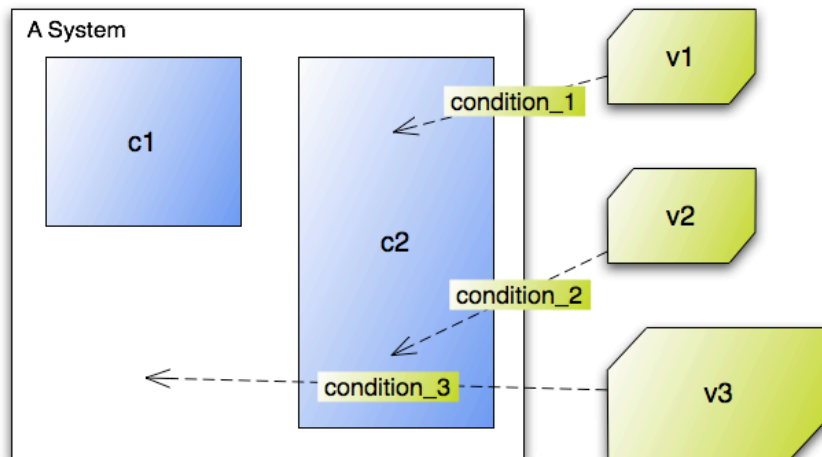
Automatically synthesized Product



- Automatic Product Synthesis

Achievements (7)

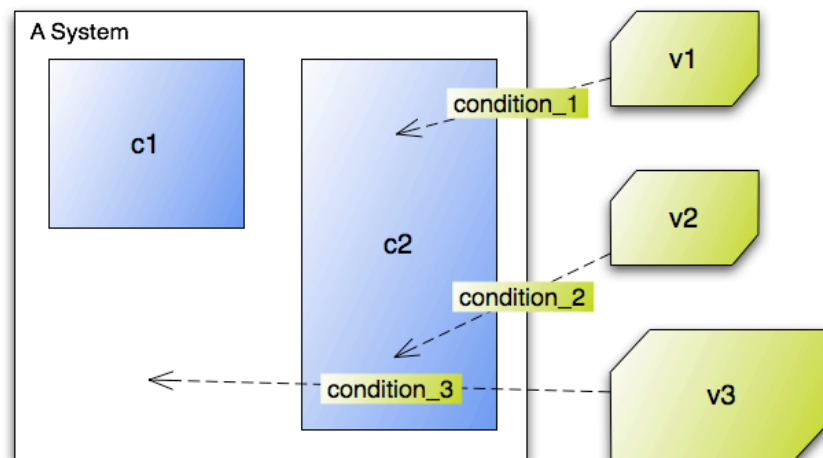
- Accuracy



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Achievements (8)

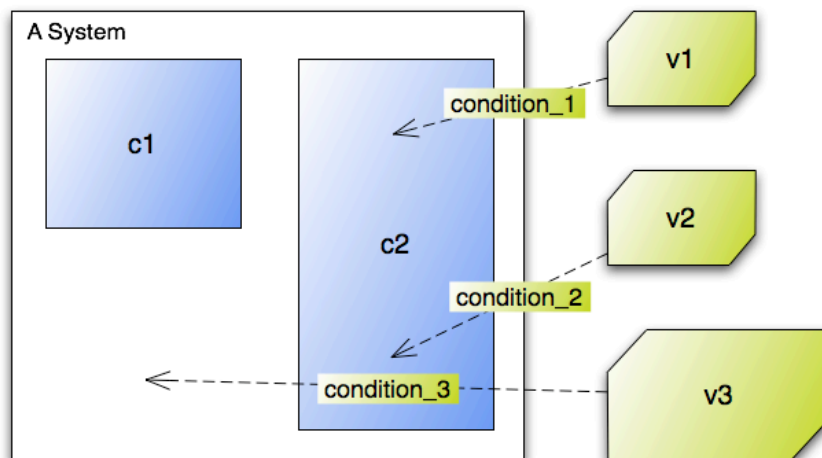
- Accuracy
- Correctness



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Achievements (9)

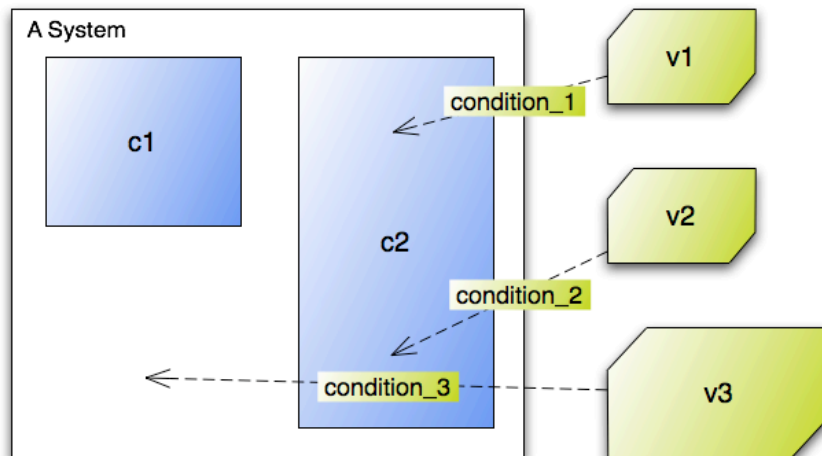
- Accuracy
- Correctness
- Efficiency



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Achievements (10)

- Accuracy
- Correctness
- Efficiency
- and Consistency.



Name	Relevance	Description	Range	Multiplicity	Constraints	Binding Time
condition_1		Is v1 in the product?	true, false	1	alternative to condition_2	installation
condition_2		Is v2 in the product?	true, false	1	alternative to condition_1	installation
condition_3		Additional v3 functionality.	true, false	1		installation

Applications



- Requirements Engineers
 - **Domains** of PLs
 - **Negotiation** of Requirements
 - **Synthesization** of Products
 - **Aid** for RE between
 - Req. Engineers
 - Customers



Discussion and further Research

- ADORA
 - Advanced visualization and rich models
- Current State
 - Aspect-Orientation: Implemented
 - Variability: “Proof of Concept” phase
 - By now *weaving based on scenarios*
- Future
 - Better decision model integration
 - Extension of variability modeling to other concepts
 - Validation and verification, etc.