A Mode-Based Pattern for Feature Requirements, and a Generic Feature Interface

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necsis

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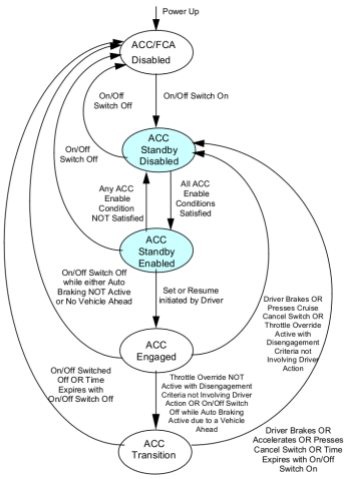
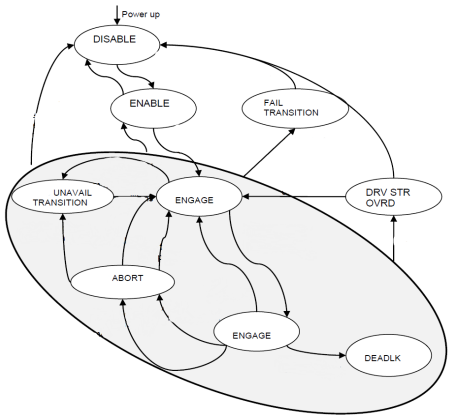
Problem:
State-machine models are hard to write





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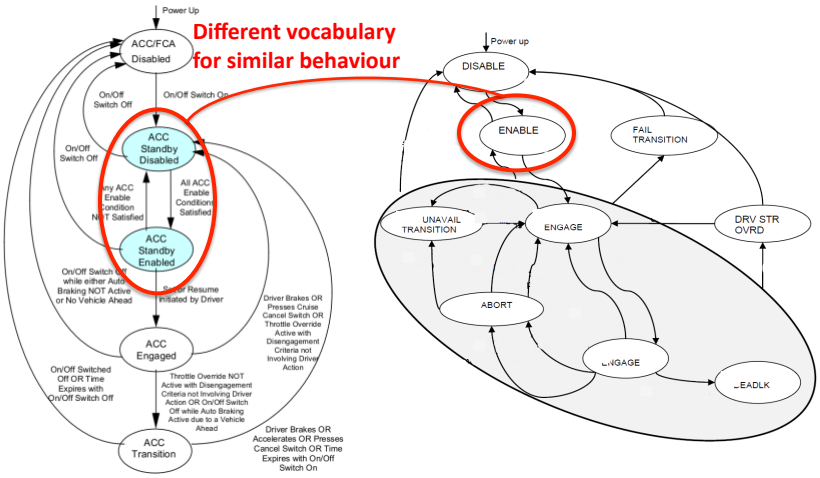
Potential for a Requirements Pattern



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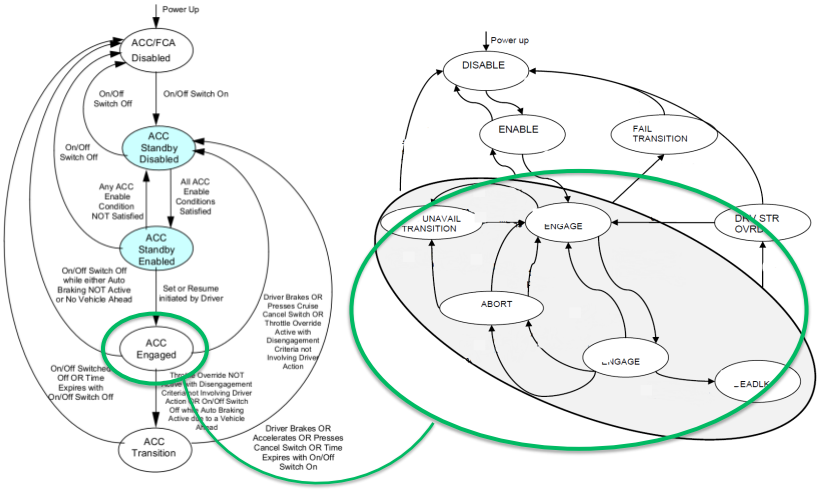
Potential for a Requirements Pattern



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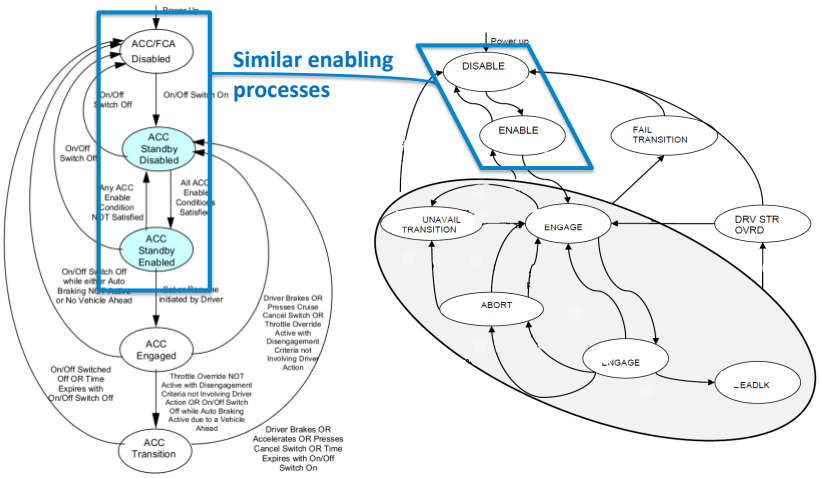
Potential for a Requirements Pattern



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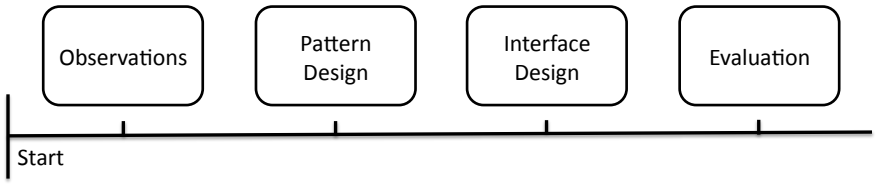
Research Timeline



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Requirements Patterns

- Domain-specific patterns
  - The majority of patterns are domain specific [RePa '11, '12, '13]
- Patterns for easing requirements elicitation
  - Cliches [Rubenstein and Waters, TSE '91]
  - Domain models [Sutcliffe and Maiden, TSE '98]
- Feature interfaces
  - Everything about a feature is revealed [Jackson and Zave, TSE '98]
  - Features interact solely through a shared context [Apel et. al., ICMT '09]
  - Aspect-aware interfaces provide an interface for aspect modules [Aldrich, ECOOP '05]

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THE PATTERN

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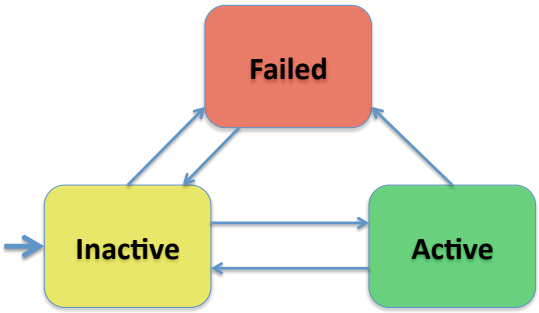
Pattern



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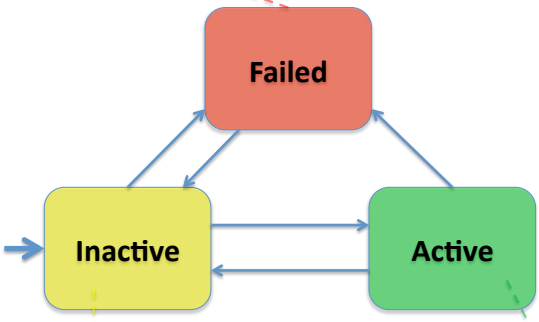
Pattern

describes a feature's failure requirements



describes a feature's non-essential requirements (e.g., the feature's enabling process)

describes a feature's essential requirements (e.g., the feature affecting the environment)

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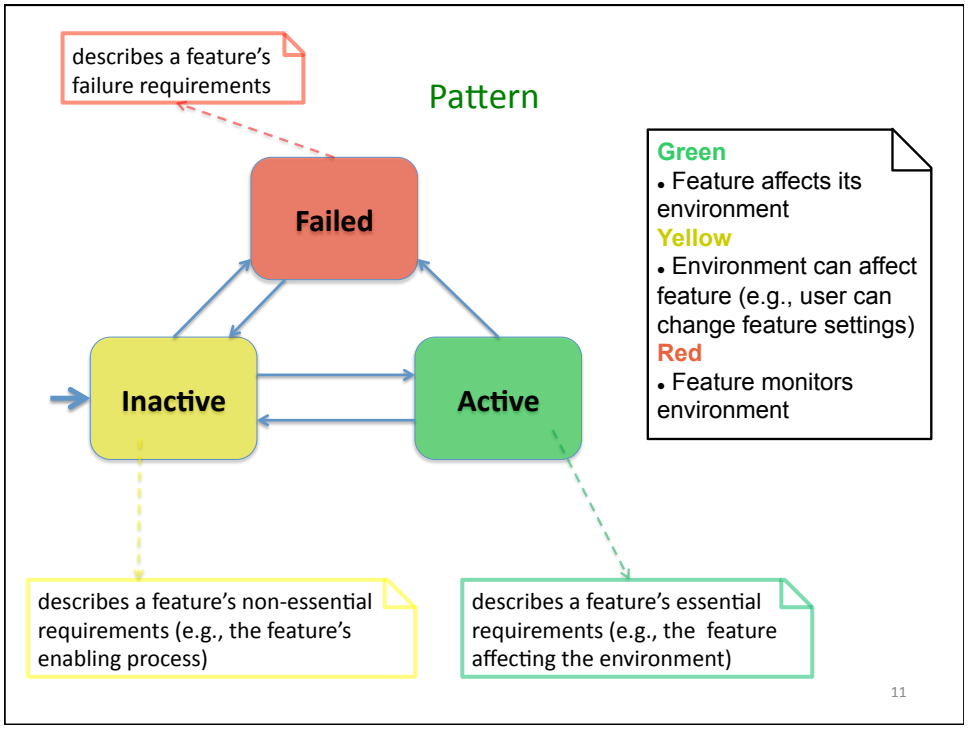
describes a feature's failure requirements
Pattern
Failed
Inactive
Active
Green
• Feature affects its environment
Yellow
• Environment can affect feature (e.g., user can change feature settings)
Red
• Feature monitors environment
describes a feature's non-essential requirements (e.g., the feature's enabling process)
describes a feature's essential requirements (e.g., the feature affecting the environment)
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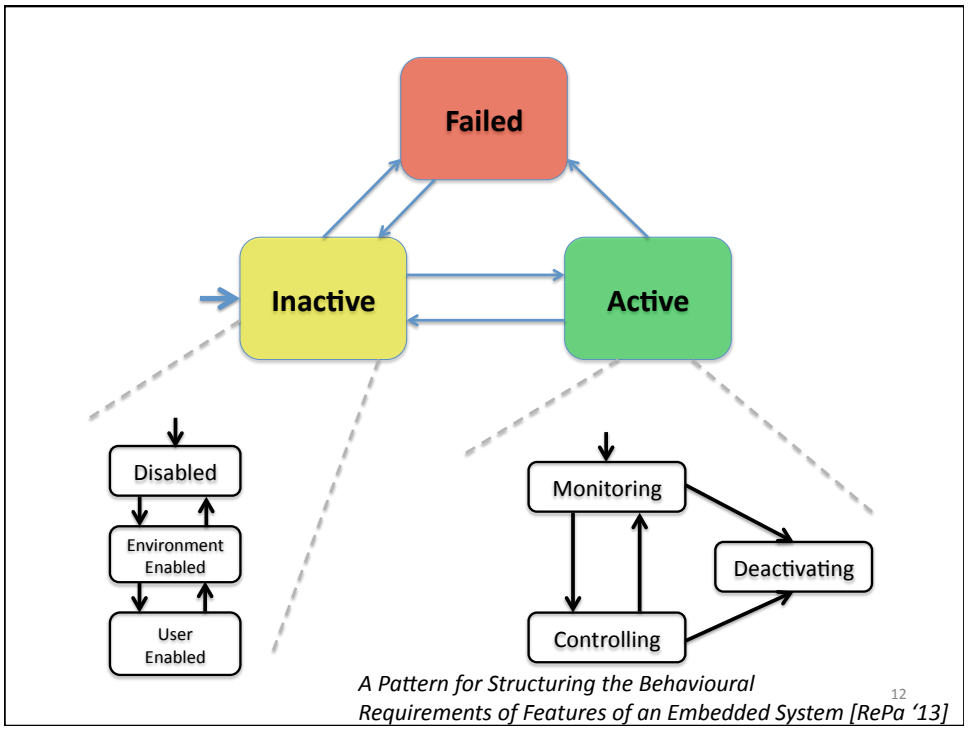
Failed
Inactive
Active
Disabled
Environment Enabled
User Enabled
Monitoring
Deactivating
Controlling
A Pattern for Structuring the Behavioural Requirements of Features of an Embedded System [RePa '13]
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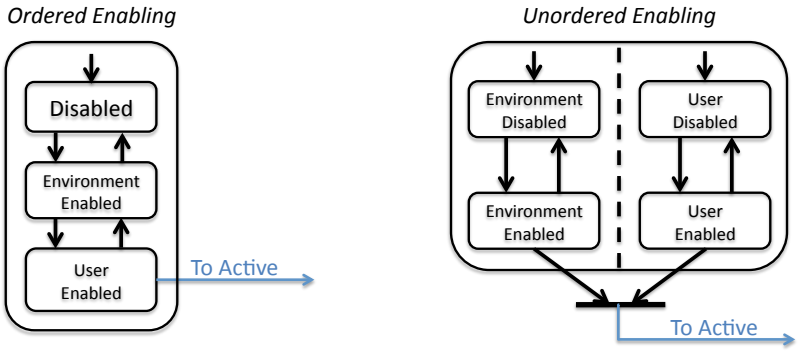
Inactive State Extensions



1. Differentiate between user enabling actions and environment enabling conditions

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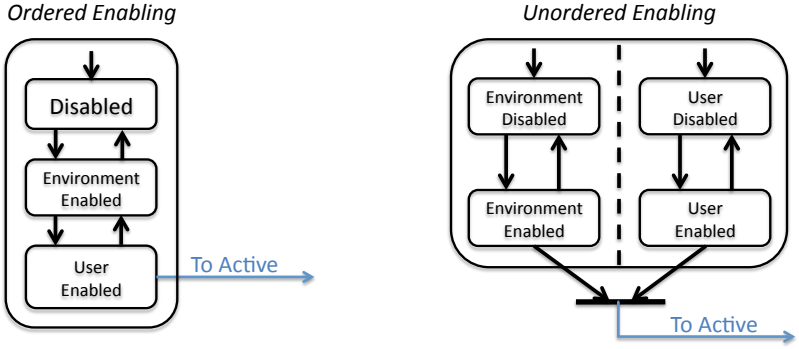
Inactive State Extensions



1. Differentiate between user enabling actions and environment enabling conditions
2. Distinguish between ordered enabling processes and processes where ordering does not matter

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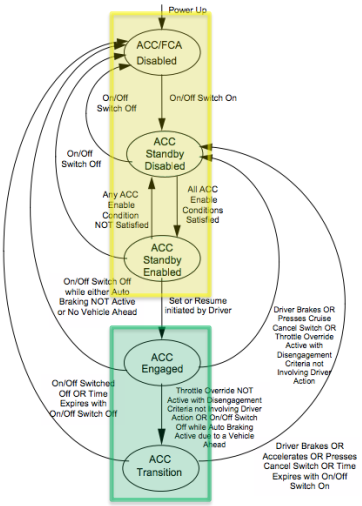
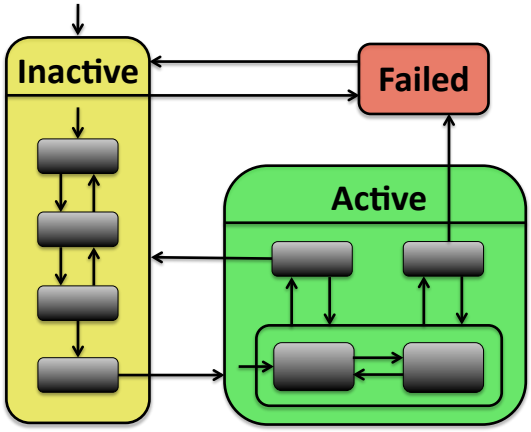
Example 1





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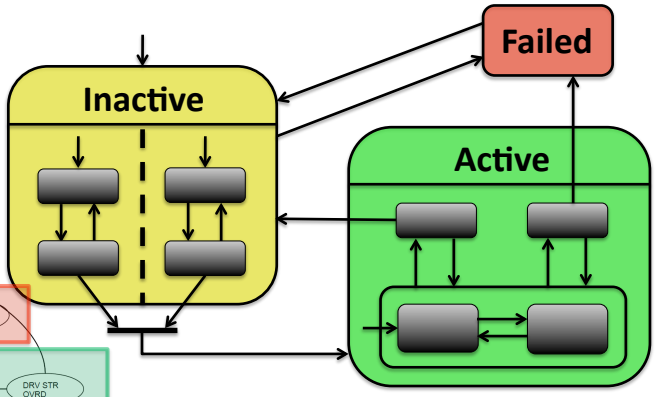
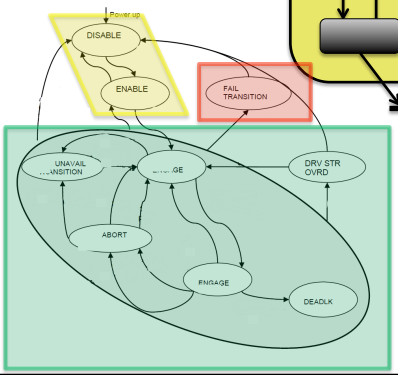
Example 2





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THE INTERFACE

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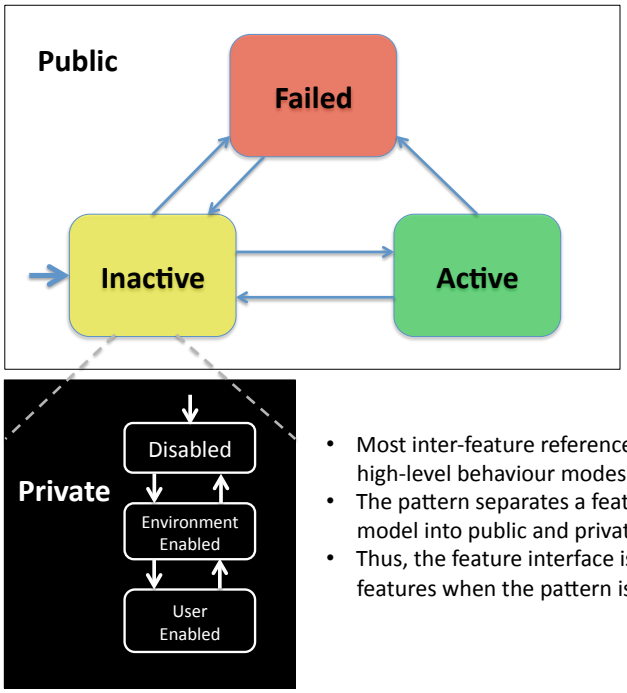

- Most inter-feature references are to the high-level behaviour modes
- The pattern separates a feature's behaviour model into public and private components
- Thus, the feature interface is generic to all features when the pattern is widely used

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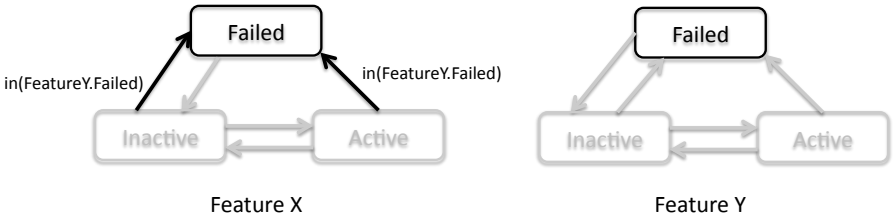
Example

Existing Text: *[FeatureX_Fail] flag shall be set to true when FeatureY is in fail state…*



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EVALUATION

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Case Study Methodology

- The pattern was designed by examining five production-grade features
- Two rounds of verification and refinement were performed using an additional 16 features

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Case Study

- Examined the complete requirements of features to determine if they could be modelled using the pattern
- Also looked at inter-feature references and determined if they reference only public information or private information

21/21 features can be modelled using the pattern

50/57 inter-feature references use the public interface

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User Study
(not reported in paper)

Performed a user study with **12** participants with varying levels of experience with state-machine modelling

- Three participant groups: **Control (C), Pattern (P), Pattern +Interface (PI)**
- Provided each participant with a tutorial
- Asked to answer questions about a provided model with pattern (for **P** and **PI** groups) or without pattern (**C** group)
- Asked to create a model from a textual description

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User Study: Reviewing Models

	Participants with correct answers (#/4)		
Model Comprehension Questions	**PI**	**P**	**C**
List all environmental conditions to activate feature	0	2	0
List all user actions to activate feature	4	4	1
List all references to other features	4	3	1
List all states in which the feature affects environment	4	3	2
Describe the failure process	4	3	3
What is the name of the initial state	4	3	3
Average	3.3	3	1.7

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User Study: Specifying Models

Correctness of written model:

	Participants with correct behaviour (#/4)		
Model behaviour	**PI**	**P**	**C**
References related feature correctly	3	0	1
Includes all enabling conditions	4	4	2
Correct inactive behaviour	4	4	2
Correct deactivation conditions	3	1	0
Correct deactivation behaviour	4	3	2
Correct controlling/monitoring behaviour	3	3	2
Correct failing sequence	4	3	2
Average	3.6	2.7	1.58

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Conclusion

- We propose a **pattern** for modelling state-machine-based feature requirements and an **interface** to features
- The pattern seems to provide several benefits:
  - General enough to be applied to many features
  - The interface provides a generic method to reference features
  - The pattern and interface improve the readability of state-machine models
  - The pattern and interface improve the correctness of written models

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References

[1] H. Reubenstein and R. Waters, "The requirements apprentice: automated assistance for requirements acquisition," *IEEE Transactions on Software Engineering*, vol. 17, no. 3, pp. 226-240, March 1991.

[2] A. Sutcliffe and N. Maiden, "The domain theory for requirements engineering," *IEEE Transactions on Software Engineering*, vol. 24, no. 3, pp. 174 –196, March 1998.

[3] M. Jackson and P. Zave, "Distributed feature composition: A virtual architecture for telecommunications services," *IEEE Transactions on Software Engineering*, vol. 24, no. 10, pp. 831–847, Oct. 1998.

[4] S. Apel, F. Janda, S. Trujillo, and C. Kastner, "Model superimposition in software product lines," in *Proceedings of the 2nd International Conference on Theory and Practice of Model Transformations (ICMT'09),* 2009, pp. 4–19.

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Evaluation: Threats to Validity

- Case Study
  - All features were gathered from one domain in one company
  - The pattern creator performed the case study
- User Study
  - Only 12 participants, split into 3 groups

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