

Concept Analysis for Product Line Requirements

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Outline

⇒ Introduction

 ⇒ Role of aspects in SPL RE

 ⇒ FRPs, SEI's scenarios, FCA

⇒ How can aspects help?

⇒ Case study

⇒ Concluding remarks

Product Lines Are Everywhere



Big Mac



Filet-O-Fish

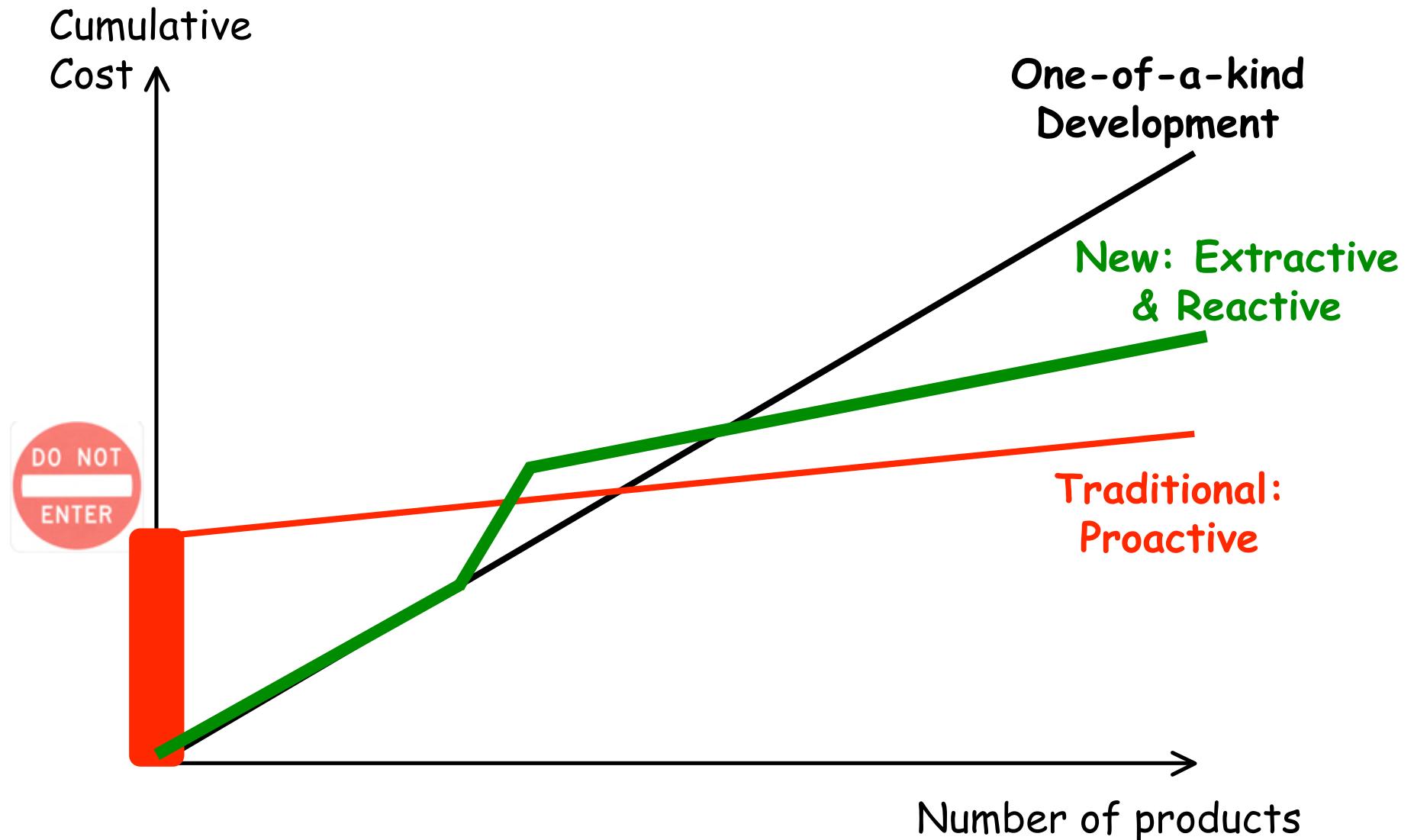


McRib



Big N' Tasty

Methods in SPL Development



Requirements As An Asset

- ⇒ Requirements reuse
 - ⇒ Closer to system's initial concepts
 - ⇒ More effective than code-level reuse
- ⇒ Existing methods characterize a SPL's requirements using either functional or quality criteria
 - ⇒ CCCs (aspects) emerge

Role of Aspects in SPL RE

- ⇒ Enhancing modularity
- ⇒ Detecting interferences
- ⇒ Analyzing trade-offs
- ⇒ Supporting evolution

FRPs

- ⇒ Functional Requirements Profiles [Niu & Easterbrook, RE'08]
 - ⇒ Action-oriented concerns that bear a high information value of a document
 - ⇒ Model user-visible system functionalities
 - ⇒ Represented by “verb-direct object” pairs
 - ⇒ Extraction algorithm based on IR, NLP, and Information Theory
- ⇒ Sample media-shop FRPs
 - ⇒ navigate shop, search product, customize toolbox ...

Quality Requirements

- ⇒ Describe desired system qualities
 - ⇒ Reliability, usability, portability, understandability, modifiability, robustness ...
 - ⇒ aka: nonfunctional requirements, quality attributes, softgoals, "-ilities"
- ⇒ SEI's quality attribute scenarios
 - ⇒ Provide operational definition
 - ⇒ Making qualities measurable
 - ⇒ Context-dependent

“Modifiable”

“A developer wishes to add a searching input field and button to the UI code, as well as to resize the toolbar icons; modifications shall be made with no side effect in three hours; the resulting system addresses items 5 and 13 in version 1.0.2’s bug report so usability is expected to increase.”

(Formal) Concept Analysis

- ⇒ A concept is always defined within the context
- ⇒ A concept is characterized by extents and intents

| MEDIA SHOP | free-distribution | timely | paper | sound |
|------------|-------------------|--------|-------|-------|
| CD | X | | | X |
| MAGAZINE | | X | X | |
| NEWSPAPER | X | X | X | |
| VIDEOTAPE | | | | X |
| BOOK | | | X | |

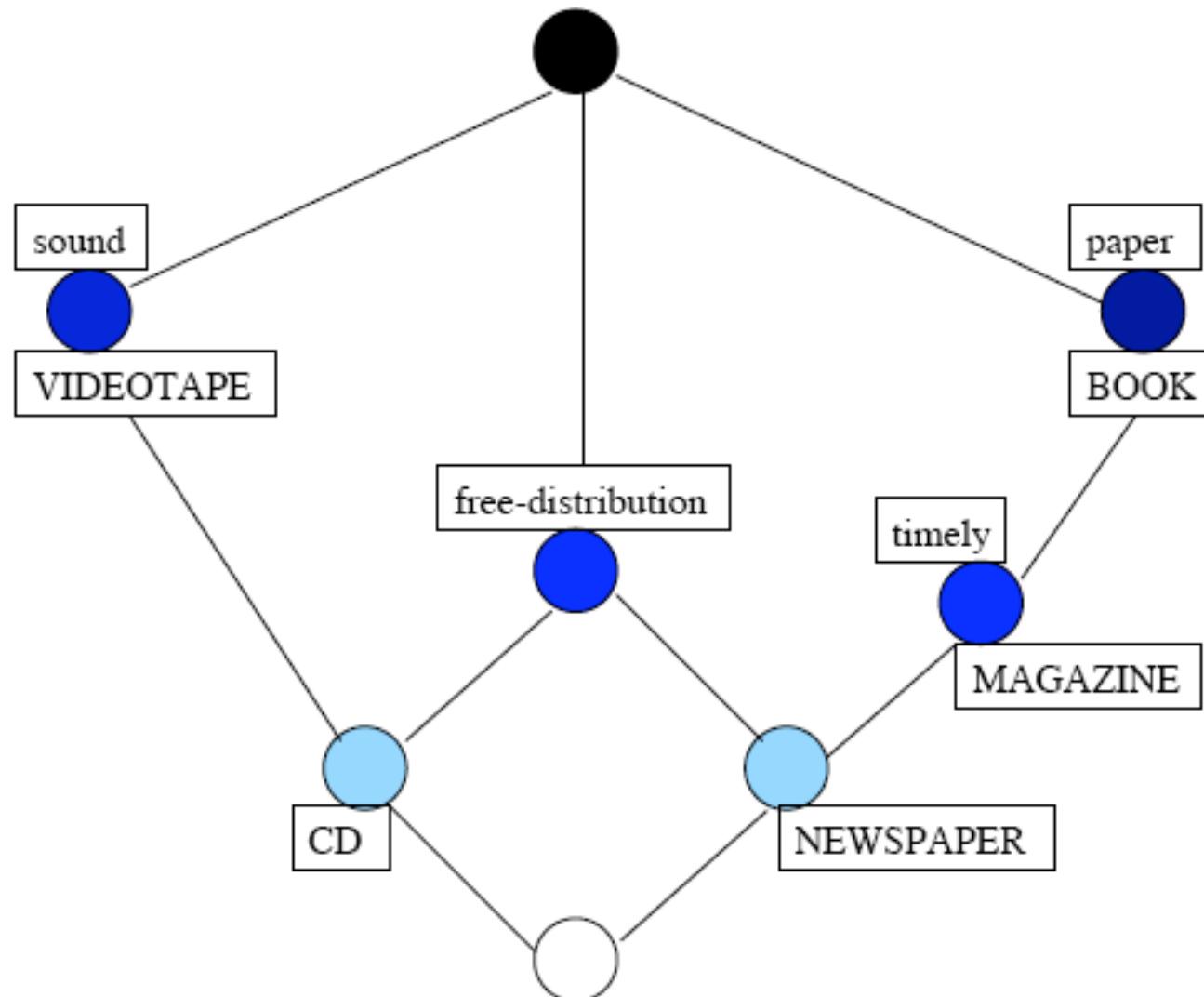
(a) Formal context.

| | |
|----------------|---|
| T | ({{CD, MAGAZINE, NEWSPAPER, VIDEOTAPE, BOOK}, Φ) |
| c ₁ | ({{CD, VIDEOTAPE}, {sound}}) |
| c ₂ | ({{CD, NEWSPAPER}, {free-distribution}}) |
| c ₃ | ({{MAGAZINE, NEWSPAPER, BOOK}, {paper}}) |
| c ₄ | ({{MAGAZINE, NEWSPAPER}, {timely, paper}}) |
| c ₅ | ({{NEWSPAPER}, {free-distribution, timely, paper}}) |
| c ₆ | ({{CD}, {free-distribution, sound}}) |
| ⊥ | (Φ, {free-distribution, timely, paper, sound}) |

(b) Concepts for the formal context.

Concept Lattice

⇒ Subconcept-superconcept relation



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Extractive SPL RE -- Symmetric View of Aspects

- ⇒ Every aspect represents a concern in its own dimension, and is projected to other dimensions according to its impacts on other concerns

- ⇒ Issue 1: Locate concerns
- ⇒ Issue 2: Detect interferences

Extraction & CCCs

⇒ 3 scenarios, 7 FRPs, 3 quality requirements

Table 1: Extracted Requirements Constructs

| Functional Requirements Profiles | Quality Requirements |
|--------------------------------------|--|
| FRP ₁ : navigate shop | Q ₁ : +U (positively contribute to usability) |
| FRP ₂ : search product | Q ₂ : +A (positively contribute to accessibility) |
| FRP ₃ : customize toolbox | Q ₃ : -M (negatively contribute to maintainability) |
| FRP ₄ : select language | |
| FRP ₅ : monitor quantity | |
| FRP ₆ : generate report | |
| FRP ₇ : create account | |

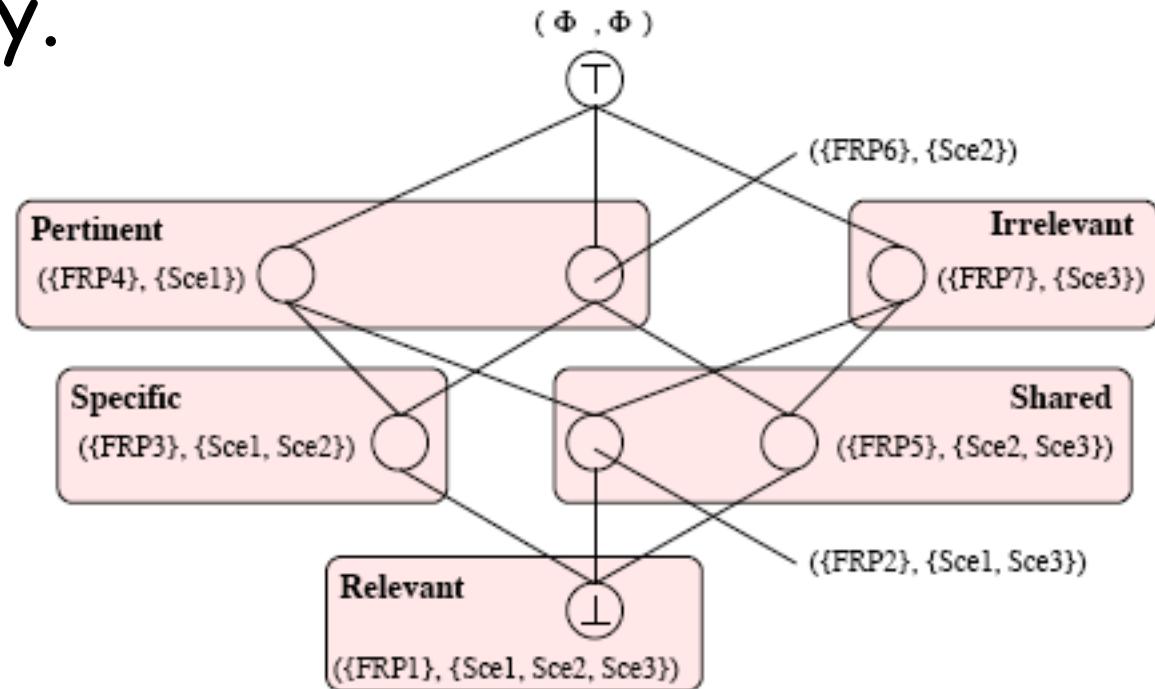
Table 2: Crosscutting Relations

| | FRP | | | | | | | Q | | |
|------------------|-----|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 |
| Sce ₁ | × | × | × | × | | | | × | | × |
| Sce ₂ | × | | × | | × | × | | × | × | |
| Sce ₃ | × | × | | | × | | × | | × | × |

Issue 1: Locate Concerns

⇒ Problem: Identify the functional units (FRPs) that contribute to a particular system quality.

⇒ Solution

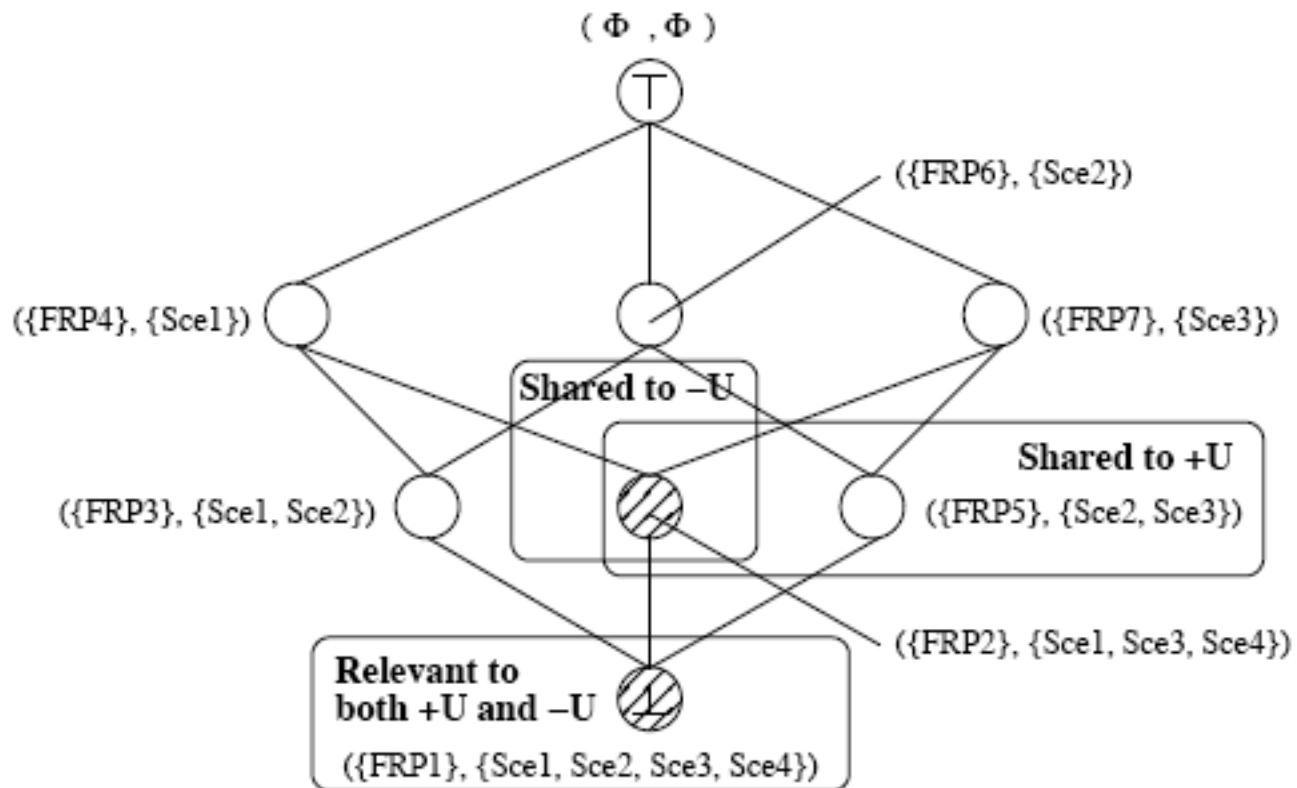


⇒ Implications

⇒ More accurate starting point for defining join points

Issue 2: Detect Interferences

- ⇒ Problem: How a pair of homogeneous requirements interact with each other.
- ⇒ Solution



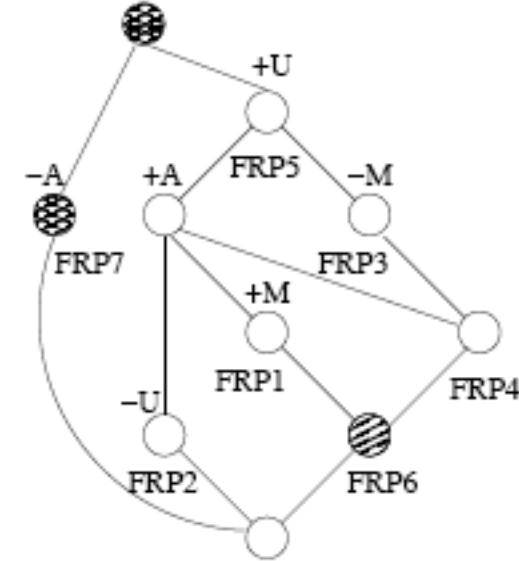
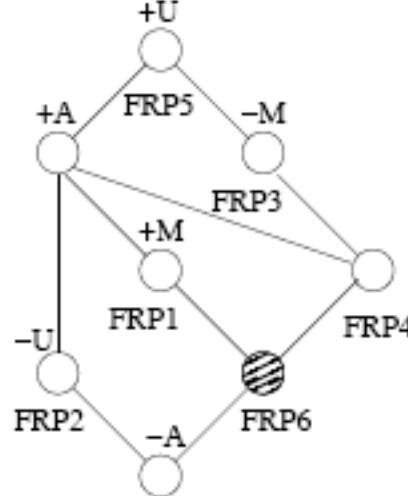
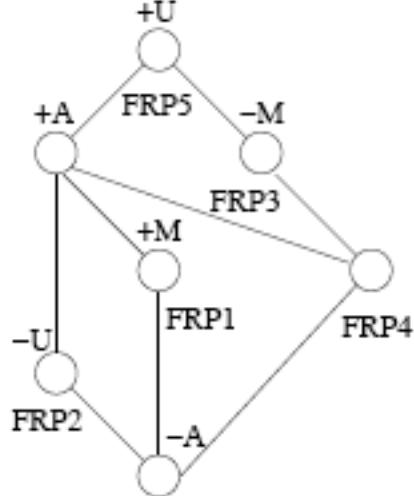
- ⇒ Implications
 - ⇒ Analyzing trade-offs, e.g., disjoint, orthogonal

Reactive SPL RE -- Asymmetric View of Aspects

- ⇒ Extractive SPL RE -- symmetric
 - ⇒ Static and micro-level view within the SPL, which focuses on internal interactions
- ⇒ Distinguishes the base from aspects
 - ⇒ Dynamic and macro-level view over the SPL, which focuses on evolution and impacts
- ⇒ Issue 3: Incremental lattice update
- ⇒ Issue 4: Change impact analysis

Issue 3: Update Concept Lattice

- ⇒ Problem: Modify the concept lattice efficiently as the SPL evolves.
- ⇒ Solution (algorithm)



- ⇒ Implications
 - ⇒ Spot change on-the-fly; without re-building

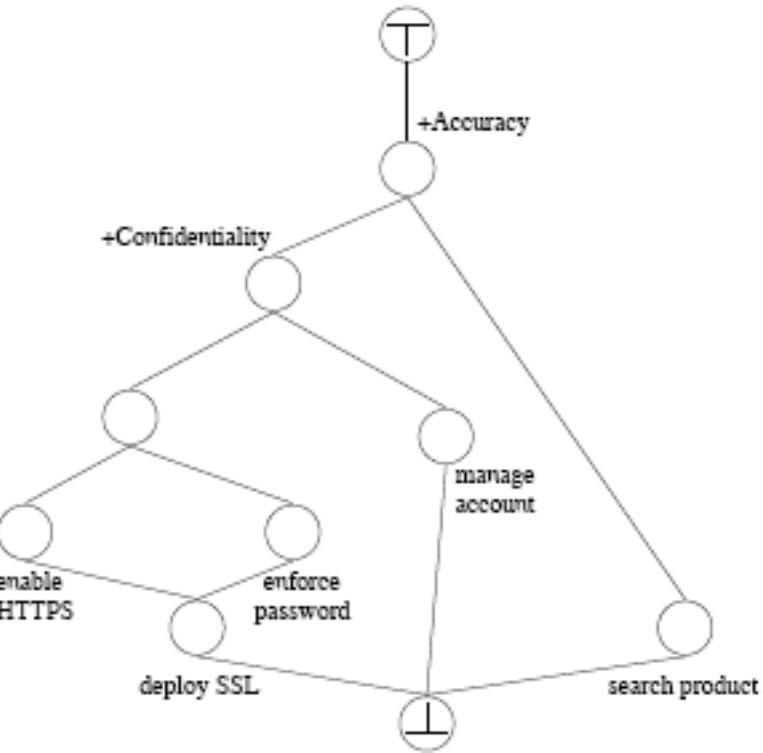
Issue 4: Change Impact Analysis

⇒ Problem: Does a change of the fulfillment of a requirement affect the fulfillment of another requirements?

⇒ Solution (heuristics)

⇒ Qualities: top-down

⇒ FRPs: bottom-up



⇒ Implications

⇒ Trade-offs, priorities, preferences

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 ⇒ FRPs, SEI's scenarios, FCA

⇒ How can aspects help?

⇒ **Case study**

⇒ **Concluding remarks**

Background

⇒ Mobile soccer game SPL



- ⇒ Produced by a small company (~50 employees)
- ⇒ Validation meetings
 - ⇒ 2-hour meeting: Validate FRPs, elicit scenarios, identify quality attributes
 - ⇒ Half-day JAD (Joint Application Development) workshop

Results

Table 3: Extractive Analysis Results

| Constructs | # | Concerns | # | Pre.* | Interferences | # |
|------------|----|--------------|-----|-------|---------------|---|
| Roles | 3 | Specific | 2.7 | 88.9% | Utility | 2 |
| FRPs | 17 | Rel., Pert.* | 6 | 78.9% | Conflict | 2 |
| Drivers | 7 | Shared | 6 | 57.5% | Variability | 0 |
| Scenarios | 12 | Irrelevant | 2.3 | 54.4% | Coupling | 5 |

* Precision

* Relevant, Pertinent

- ⇒ Demonstrates applicability and usefulness
- ⇒ Threats to validity

Discussion & Lessons Learned

- ⇒ Automation vs. manual effort
- ⇒ Scenario generation ≈ test case generation
 - ⇒ In our case: 4 scenarios for each of the 3 stakeholder roles in half an hour
- ⇒ “Crosscut follows form; form follows function”
- ⇒ Coupling isn't necessarily a bad thing
 - ⇒ Organizational coupling reduces latency

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Concluding Remarks

- ⇒ New method in SPL development
 - ⇒ Extractive & reactive
- ⇒ Aspects can help (in addressing 4 issues)
 - ⇒ Extractive: symmetric view of aspects
 - ⇒ Reactive: asymmetric view of aspects
- ⇒ Aspects as a powerful tool in conceptual modeling (SE, DB, ...)

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