

# Aligning Software Configuration with Business and IT Context

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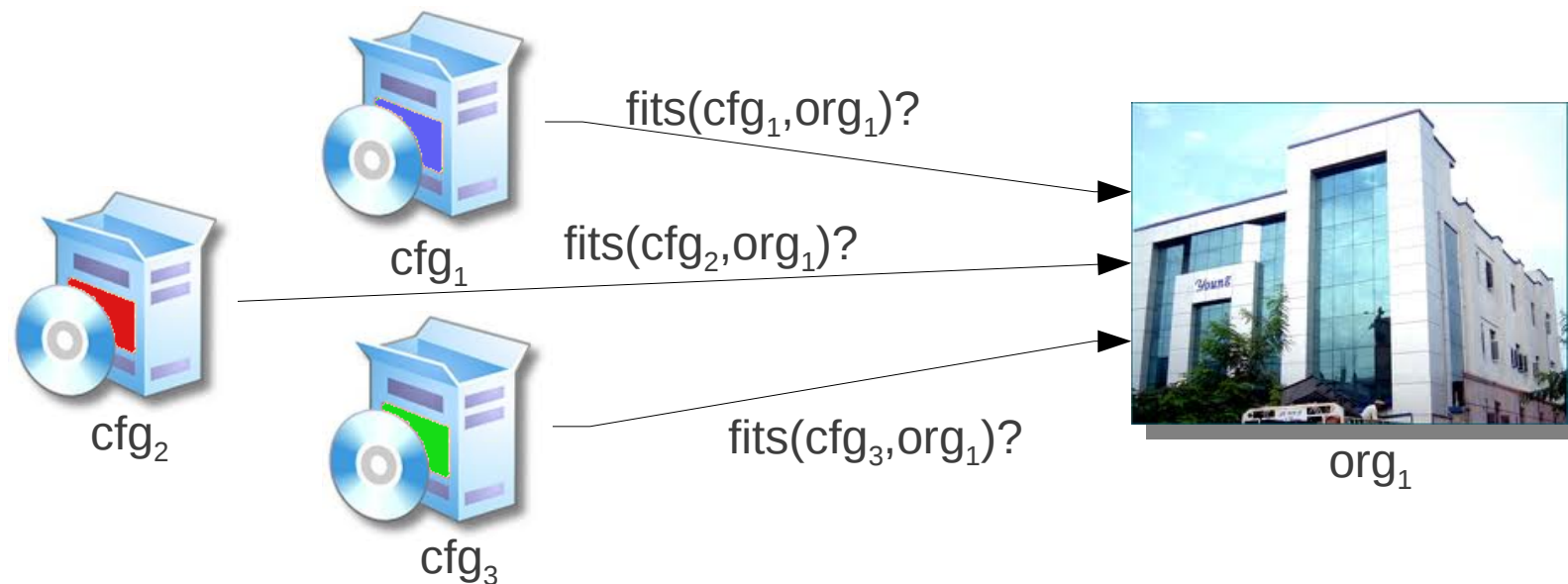
# Business/IT Alignment

- B/IT Alignment holds when Information Technology (IT) is effectively used to achieve Business (B) objectives
- Achieving and maintaining B/IT Alignment is hard, as it requires **joint effort of IT administrators and business managers**
  - Cultural gap
  - Mutual impact between B and IT
  - Dynamism of organizations
- Explored both in business/management and in software/information systems



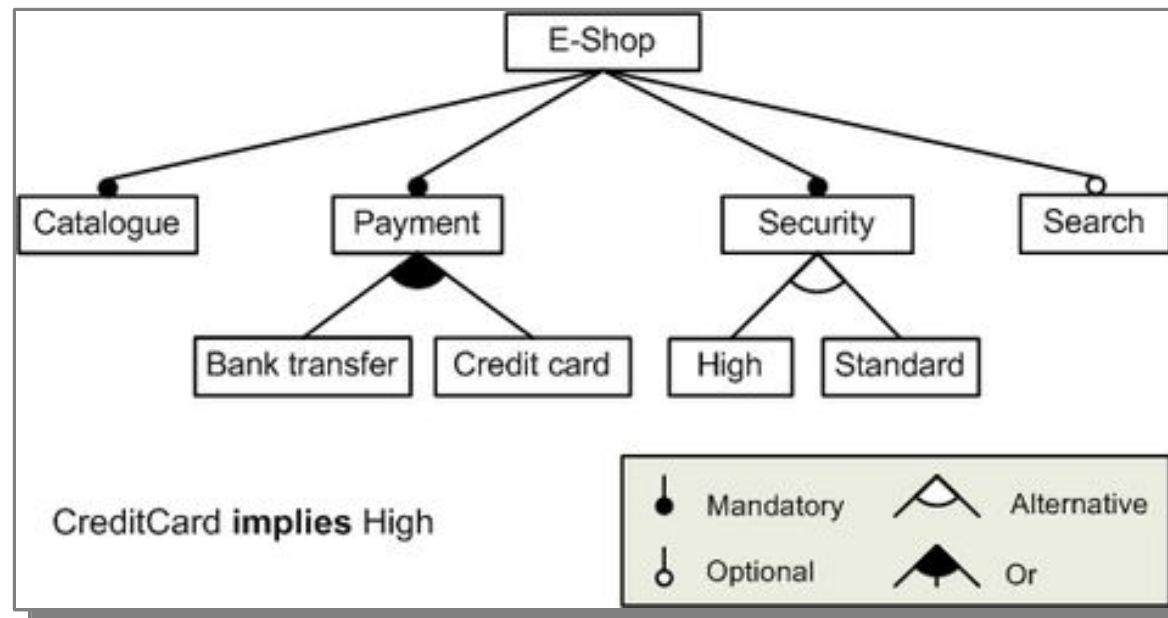
# SW Configuration and B/IT Alignment

- **Proper configuration of a software system is an essential activity towards B/IT Alignment**
  - Does the system fit well with the business objectives?
  - Does the system fit well with the existing technical systems?
- Existing approaches heavily rely on the skills of the analysts



# Baseline: Feature Models

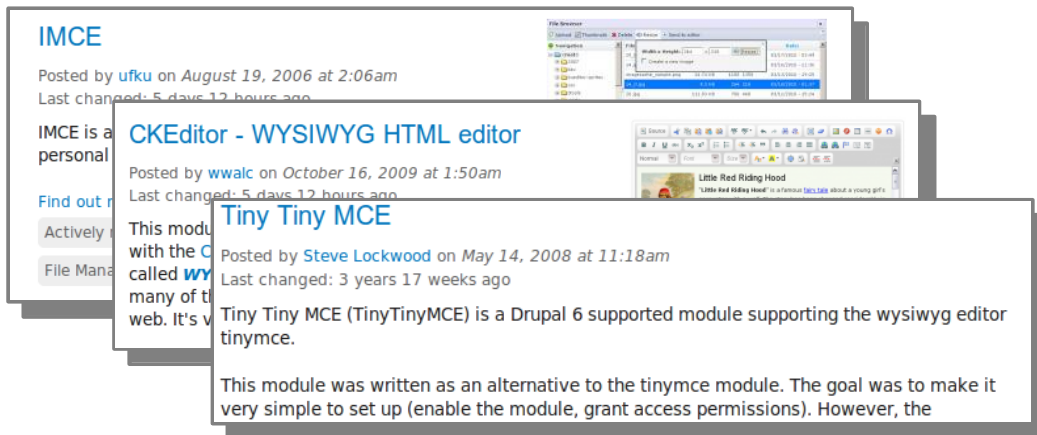
- Feature models are a **compact representation of the products** (configurations) **in a software product line**
  - Idea: one customizable software, multiple configurations
  - Configurations differ in the features they consist of



[Kang90]

# Motivating Scenario: Drupal

- **Drupal** is an open-source **content management system**
  - Wide industrial adoption. Several web development companies base their products upon a Drupal-based product line
    - over 13.000 modules are available for use
- Challenge: pick a configuration of Drupal which is **aligned with the business and technical context** of a client organization

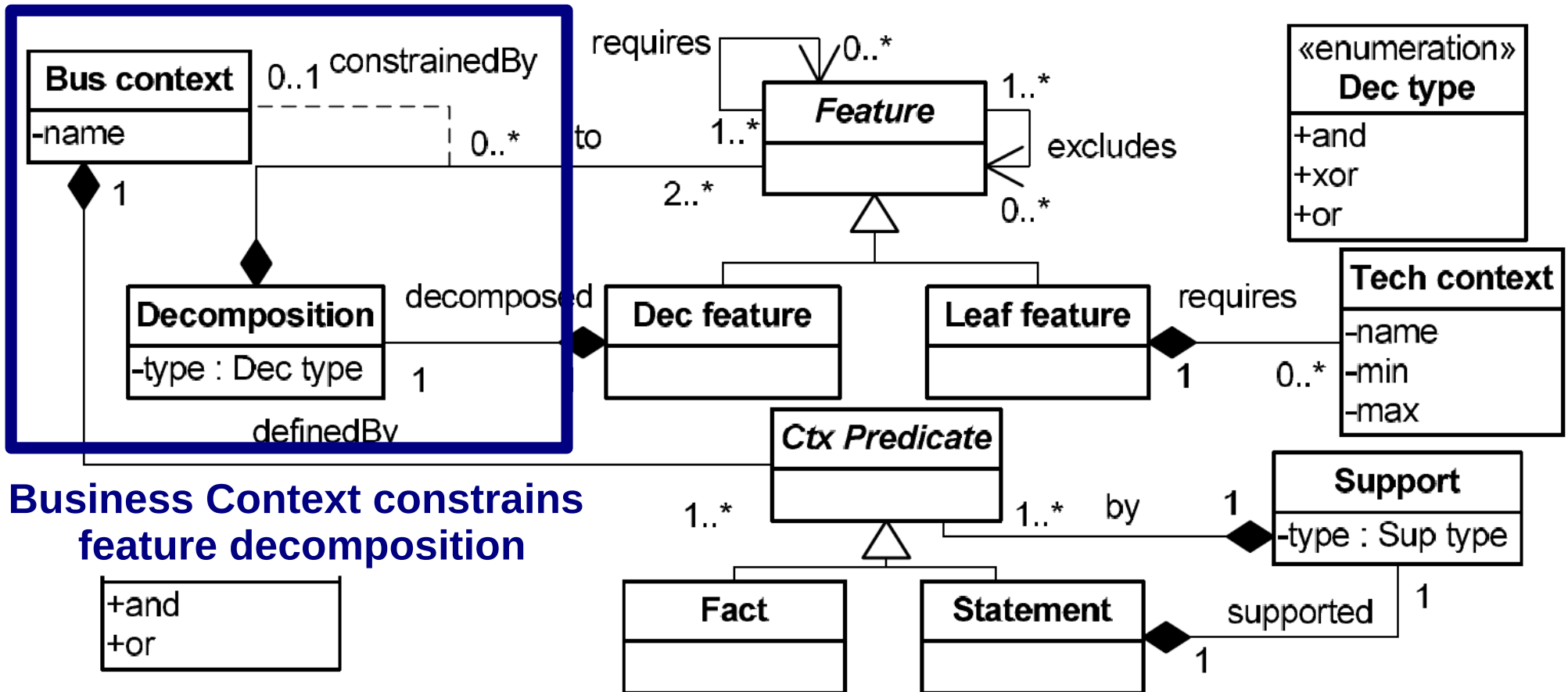


“Which content editor?”

# Contextual Feature Models (CFMs): Outline

- Features are not always advisable / applicable
  - In traditional feature models, such information is implicit
  - We want to make such information explicit
- Two types of context:
  - **Business context** affects feature advisability
    - “customer has a vast catalog”, “most clients are SMEs”, “branches in multiple countries exist”, ...
  - **Technical context** affects feature applicability (pre-requisites)
    - “mySql version 5 is available”, “Linux-based server”, “Chrome version 4+”, ...

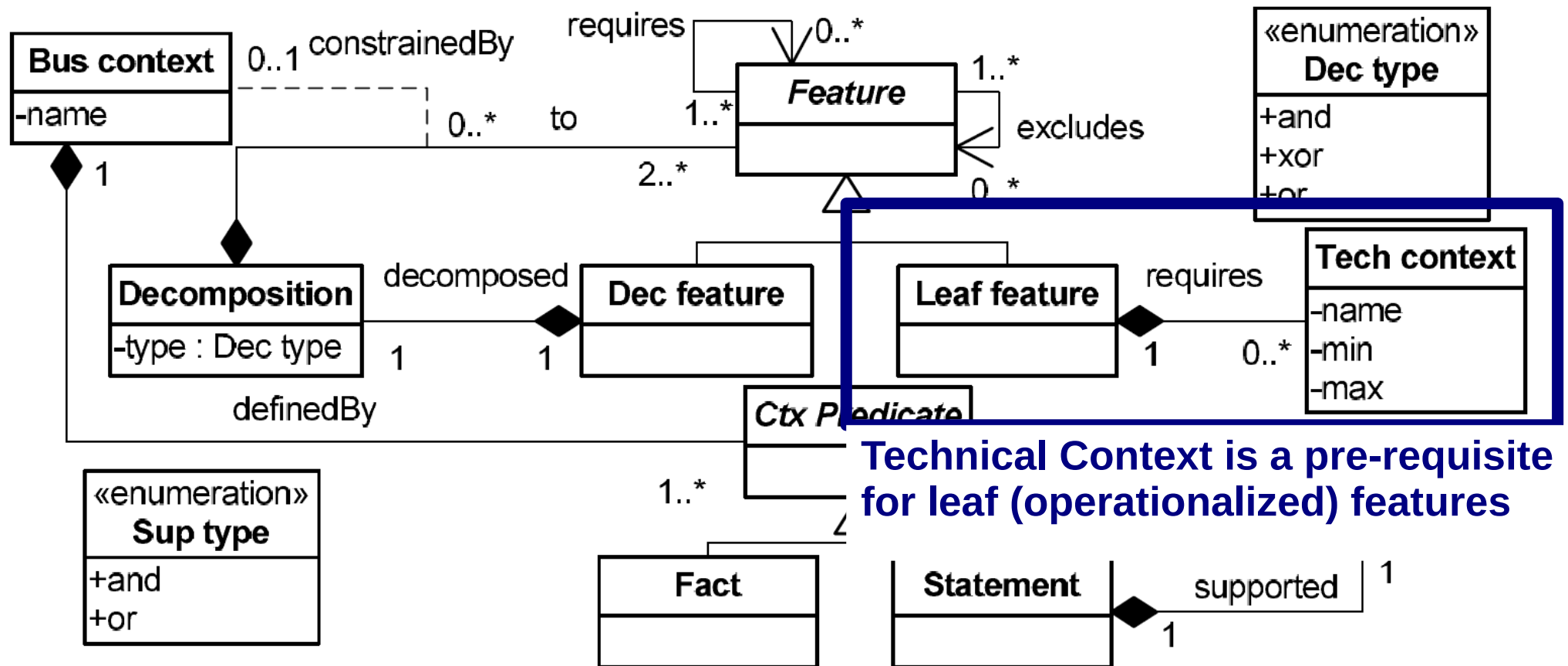
# CFMs: meta-model



**Business Context constrains feature decomposition**

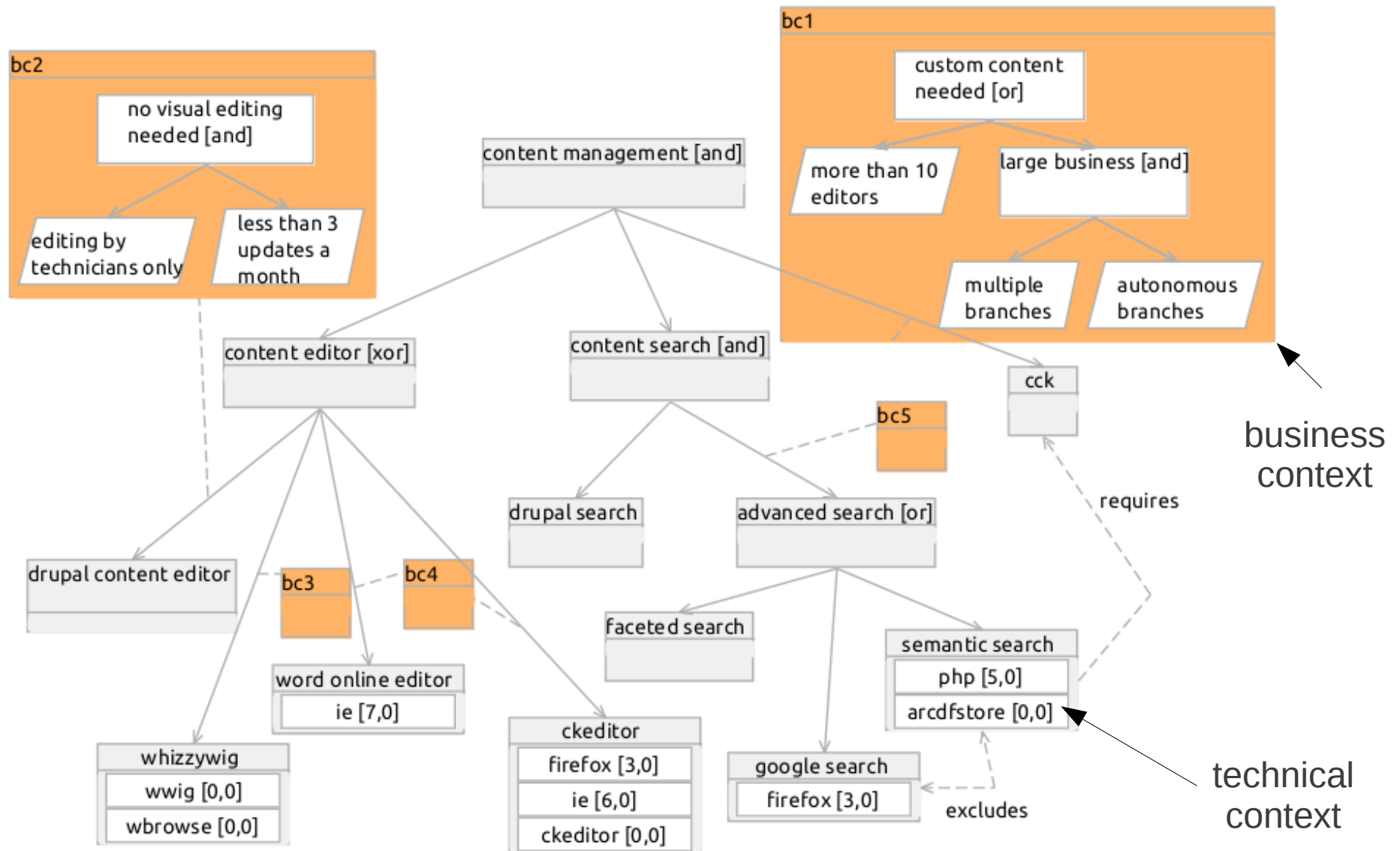
+and  
+or

# CFMs: meta-model



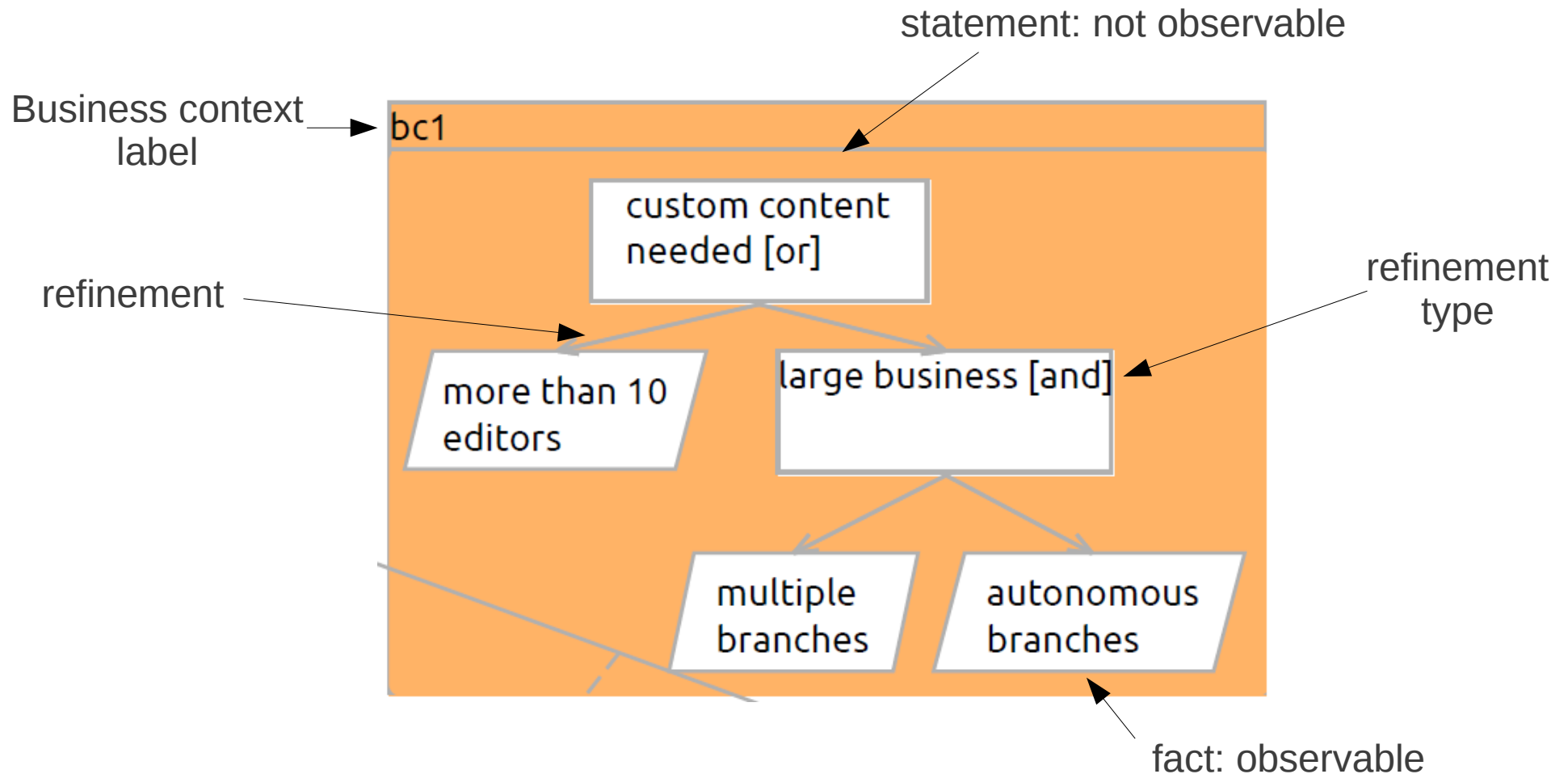


# CFMs: an Example



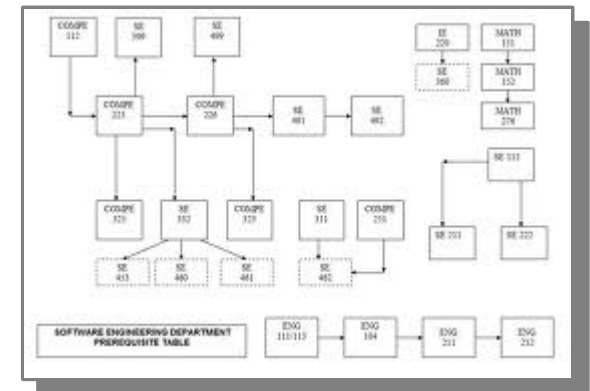
# Specifying Business Contexts

- We adapt context analysis [Ali10]



# Specifying Technical Contexts

- Each technical context is characterized by
  - Name
  - Minimum value (0 = no lower bound)
  - Maximum value (-1 = no upper bound)
- **Min/Max values can be used to refer to version numbers**
  - The formalism has to be enriched to specify more expressive pre-requisites



# Reasoning with CFMs: Formal Framework

**Definition 1 (Configuration).** Given BC and TC, a set of features  $\{f_1, \dots, f_n\}$  is a configuration CFG for  $\mathcal{M}$  with respect to BC and TC, formally  $\text{CFG} \vdash_{\text{BC}, \text{TC}} \mathcal{M}$ , if and only if  $\text{root}(\mathcal{M}) \in \text{CFG}$  and (1-4) hold  $\forall f' \in \text{CFG}$ :

1.  $\text{dec}(f', D = \{\langle f_1, bc_1 \rangle, \dots, \langle f_n, bc_n \rangle\}, \text{type}) \rightarrow$   
 $\nexists \langle f_j, bc_j \rangle \in D : \neg \text{support}(\text{BC}, bc_j) \wedge f_j \in \text{CFG}, \text{ and}$   
 – type=and:  $(\exists 1 \leq k \leq n : f_k \in \text{CFG}) \wedge (\forall \langle f_i, bc_i \rangle \in D : \text{support}(\text{BC}, bc_i) \wedge f_i \in \text{CFG})$   
 – type=or:  $\exists \langle f_i, bc_i \rangle \in D : \text{support}(\text{BC}, bc_i) \wedge f_i \in \text{CFG}$   
 – type=xor:  $\exists ! \langle f_i, bc_i \rangle \in D : \text{support}(\text{BC}, bc_i) \wedge f_i \in \text{CFG}$
2.  $\forall f'' : \text{requires}(f', f'') \rightarrow f'' \in \text{CFG}$
3.  $\forall f'' : \text{excludes}(f', f'') \rightarrow f'' \notin \text{CFG}$
4.  $\text{is-leaf}(f') \rightarrow \forall \langle \text{tcname}, \text{min}, \text{max} \rangle \in \text{techctx}(f')$   
 $\exists \langle \text{tcname}, \text{min}', \text{max}' \rangle \in \text{TC} : \text{min}' \geq \text{min} \wedge \text{max}' \leq \text{max}$



## Semantics for a configuration

Intuitively, a set of features that support the top-level feature, given a technical and a business context

## Formal framework for automated reasoning in disjunctive datalog



- 1  $\text{active}(F) :- \text{anddecomposed}(F), 0 = \# \text{count}\{Fi : \text{dec}(F, Fi, Ca), \text{holds}(Ca), \neg \text{active}(Fi)\},$   
 $\text{not noExtraAct}(F), \text{dec}(F, Fj, Cb), \text{active}(Fj), \text{holds}(Cb).$
- 2  $\text{noExtraAct}(F) :- \text{dec}(F, Fi, Ca), \text{active}(Fi), \text{not holds}(Ca).$
- 3  $\text{active}(F) :- \text{ordecomposed}(F), \text{dec}(F, Fi, Ca), \text{active}(Fi), \text{holds}(Ca), \text{not noExtraAct}(F).$
- 4  $\text{active}(F) :- \text{xordecomposed}(F), \text{dec}(F, Fi, Ca), \text{holds}(Ca), \text{active}(Fi), \text{not actdiff}(F, Fi).$
- 5  $\text{actdiff}(F, Fi) :- \text{xordecomposed}(F), \text{active}(Fi), \text{dec}(F, Fi, \_), \text{dec}(F, Fj, \_), \text{active}(Fj),$   
 $Fi \neq Fj.$
- 6  $\neg \text{active}(Fi) :- \text{requires}(Fi, Fj), \neg \text{active}(Fj).$
- 7  $\neg \text{active}(Fj) \vee \neg \text{active}(Fi) :- \text{excludes}(Fi, Fj).$
- 8  $\neg \text{active}(X) :- \text{anddecomposed}(X), \text{not active}(X).$
- 9  $\neg \text{active}(X) :- \text{ordecomposed}(X), \text{not active}(X).$
- 10  $\neg \text{active}(X) :- \text{xordecomposed}(X), \text{not active}(X).$
- 11  $\neg \text{active}(Y) :- \text{dec}(X, Y, C), \neg \text{active}(X).$
- 12  $\text{holds}(\text{TC}) :- \text{tc}(\_, \text{TC}), \text{not noPartInactive}(\text{TC}).$
- 13  $\text{noPartInactive}(\text{TC}) :- \text{tccpart}(\text{TC}, P, Vmin, Vmax), \text{not istrue}(P, Vmin, Vmax).$
- 14  $\text{holds}(\text{BC}) :- \text{anddec}(\text{BC}), \text{not subUnsat}(\text{BC}).$
- 15  $\text{subUnsat}(\text{BC}) :- \text{fdec}(\text{BC}, \text{SUB}), \text{not holds}(\text{SUB}).$
- 16  $\text{holds}(\text{BC}) :- \text{ordec}(\text{BC}), \text{fdec}(\text{BC}, \text{SUB}), \text{holds}(\text{SUB}).$
- 17  $\text{active}(X) \vee \neg \text{active}(X) :- f(X), \text{tc}(X, C), \text{holds}(C).$
- 18  $\text{active}(X) \vee \neg \text{active}(X) :- f(X), 0 = \# \text{count}\{C : \text{tc}(X, C)\}.$
- 19  $\neg \text{active}(X) :- f(X), \text{tc}(X, C), \text{not holds}(C).$
- 20  $f(X) :- \text{dec}(\_, X, \_), 0 = \# \text{count}\{Z : \text{dec}(X, Z, \_)\}.$
- 21  $\text{act}(X) :- \text{active}(X), f(X).$
- 22  $\text{bc}(X) :- \text{dec}(\_, \_, X).$
- 23  $\text{tch}(X) :- \text{tc}(\_, X), \text{holds}(X).$
- 24  $\text{bch}(X) :- \text{dec}(\_, \_, X), \text{holds}(X), X \neq \text{true}.$
- 25  $\text{holds}(\text{true}).$

# Reasoning Techniques: Overview

## ■ Configurations generation

- Given business and technical contexts, generate all configurations

## ■ Business to IT alignment

- Given a bus. context, which configurations / technical contexts?
- Variants: high-variability product, minimal technical pre-requisites

## ■ IT to Business alignment

- Given a tech. context, which configurations / business contexts?
- Variant: maximize business context support (preferences)

The reasoning framework in Datalog supports these analyses

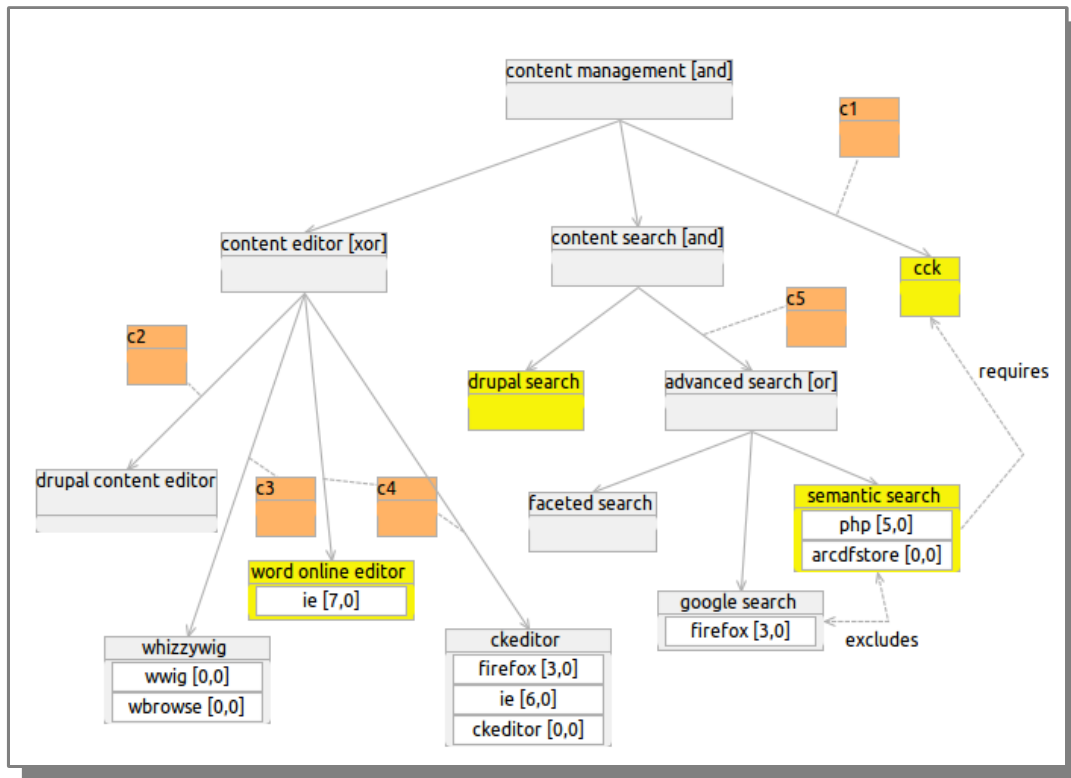


# Configurations Generation

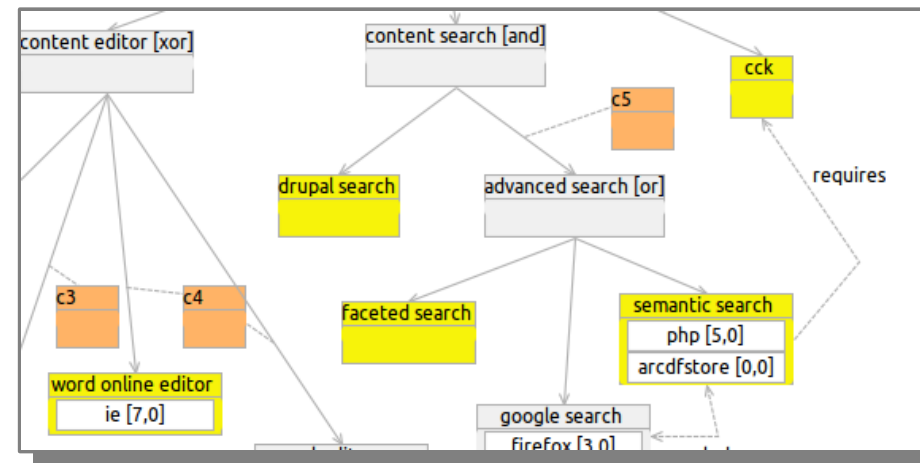
- **Return all configurations that fit with a given technical context TC and a given business context BC**
- Company  $\alpha$  needs a deployment of our Drupal product line
  - TC:  $\alpha$  supports Internet Explorer  $v \geq 8$ , php v5, arcdfstore
  - BC:  $\alpha$  needs advanced visual editing (bc4), has large catalog (bc5), and has more than 10 website editors
  - Three configurations exist
    1. cck, drupal search, word online editor, semantic search
    2. cck, drupal search, faceted search, word online editor, semantic search
    3. cck, drupal search, faceted search, word online editor



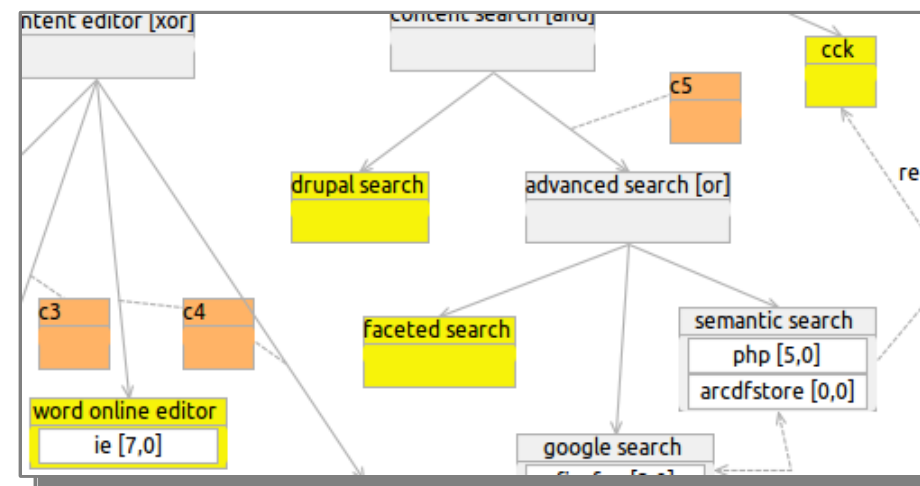
# Configurations Generation



Configuration 1



Configuration 2



Configuration 3

# Business to IT Alignment

- **Given BC, return all possible couples ⟨Configuration, TC⟩**
  - i.e., which IT fits well with the given business context?
  - IT includes a configuration of the feature model as well as the technical pre-requisites for the selected features
- Via context analysis, company  $\beta$  has identified facts supporting contexts bc4 (advanced editing features) and bc5 (vast product catalog)

Feature / Tech context	S1	S2	S3	S4	S5	S6
f1 = drupal search	✓	✓	✓	✓	✓	✓
f2 = google search	✓	×	✓	×	✓	✓
f3 = faceted search	✓	✓	✓	✓	×	×
f4 = word online editor	✓	✓	×	×	✓	×
f5 = ckeditor	×	×	✓	✓	×	✓
tc1 = firefox	$\geq 3$	×	$\geq 3$	$\geq 3$	$\geq 3$	$\geq 3$
tc2 = ckeditor	×	×	✓	✓	×	✓
tc1 = ie	$\geq 7$	$\geq 7$	×	$\geq 6$	$\geq 7$	$\geq 6$





# High-Variability Configuration

- **Given BC, find the minimal set of TCs that enables the deployment of a high-variability product**
  - i.e., a product including all possible configurations for BC
    - + possibility to switch from one configuration to another
    - more costly
- Take company  $\beta$ , who wants to support bc4 and bc5

Feature / Tech context	S1	S2	S3	S4	S5	S6
f1 = drupal search	✓	✓	✓	✓	✓	✓
f2 = google search	✓	×	✓	×	✓	✓
f3 = faceted search	✓	✓	✓	✓	×	×
f4 = word online editor	✓	✓	×	×	✓	×
f5 = ckeditor	×	×	✓	✓	×	✓
tc1 = firefox	$\geq 3$	×	$\geq 3$	$\geq 3$	$\geq 3$	$\geq 3$
tc2 = ckeditor	×	×	✓	✓	×	✓
tc1 = ie	$\geq 7$	$\geq 7$	×	$\geq 6$	$\geq 7$	$\geq 6$



Minimal set of TCs

- firefox 3+
- ckeditor
- ie 7+

# Core Technical Infrastructure

- **Given BC, which is the core technical infrastructure that enables the deployment of at least one configuration?**
  - Core set: if any element is removed from it, no configuration can be deployed
  - Multiple of such core technical infrastructures may exist
- Take company  $\beta$ , as before

Feature / Tech context	S1	S2	S3	S4	S5	S6
f1 = drupal search	✓	✓	✓	✓	✓	✓
f2 = google search	✓	×	✓	×	✓	✓
f3 = faceted search	✓	✓	✓	✓	×	×
f4 = word online editor	✓	✓	×	×	✓	×
f5 = ckeditor	×	×	✓	✓	×	✓
tc1 = firefox	≥3	×	≥3	≥3	≥3	≥3
tc2 = ckeditor	×	×	✓	✓	×	✓
tc1 = ie	≥7	≥7	×	≥6	≥7	≥6



Core TC set 1:  
- ie 7+

Core TC set 2:  
- firefox 3+  
- ckeditor  
- ie 6+

# IT to Business Alignment

- **Given TC, return all possible couples ⟨Configuration, BC⟩**
  - The company wants not to change its IT component
- Company y has many customers with legacy browsers. Thus, it cannot afford changing the IT requirements. Its infrastructure supports only php v5 and arcdfstore
  - Six solutions exist

Feature / Business context	S1	S2	S3	S4	S5	S6
f1 = drupal search	✓	✓	✓	✓	✓	✓
f2 = drupal content editor	✓	✓	✓	✓	✓	✓
f3 = faceted search	×	✓	✓	×	✓	×
f4 = cck	×	×	✓	✓	✓	✓
f5 = semantic search	×	×	✓	✓	×	×
bc1 = custom content needed	×	×	✓	✓	✓	✓
bc2 = no visual editing needed	✓	✓	✓	✓	✓	✓
bc5 = large product catalog	×	✓	✓	✓	✓	×

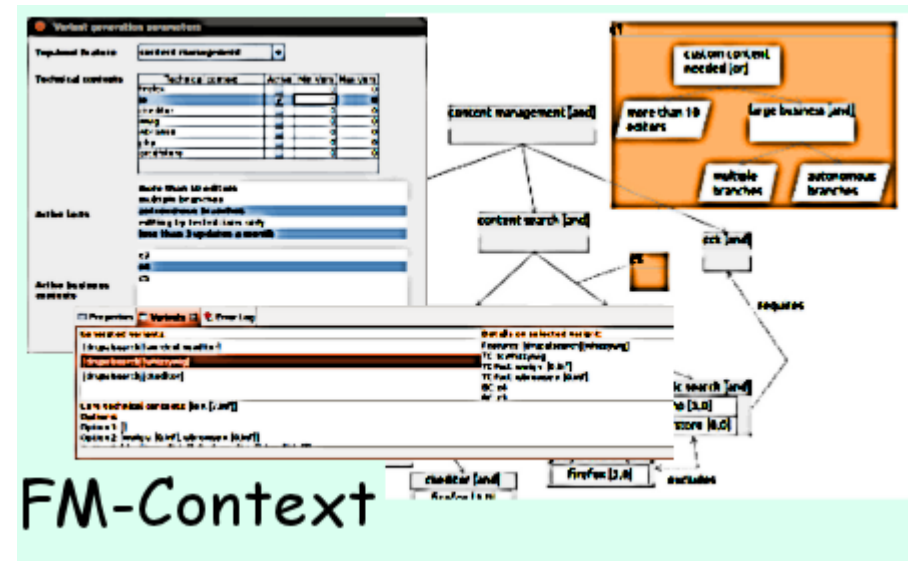
# Business Context Support

- **Given TC and a ranking  $R=bc_i > bc_j > bc_k > \dots$  of business contexts, which are the supported maximal sets of business contexts?**
  - R represents the relative importance of business contexts
  - In other words, how well are business contexts supported?
- Company  $\theta$  supports only TC ie 7+, and defines  $R = bc1 > bc4 > bc3 > bc5 > bc2$ 
  - Two maximal sets exist
    - bc1, bc5, bc4
    - bc1, bc2, bc5
  - The former is preferable:  $bc4 > bc2$

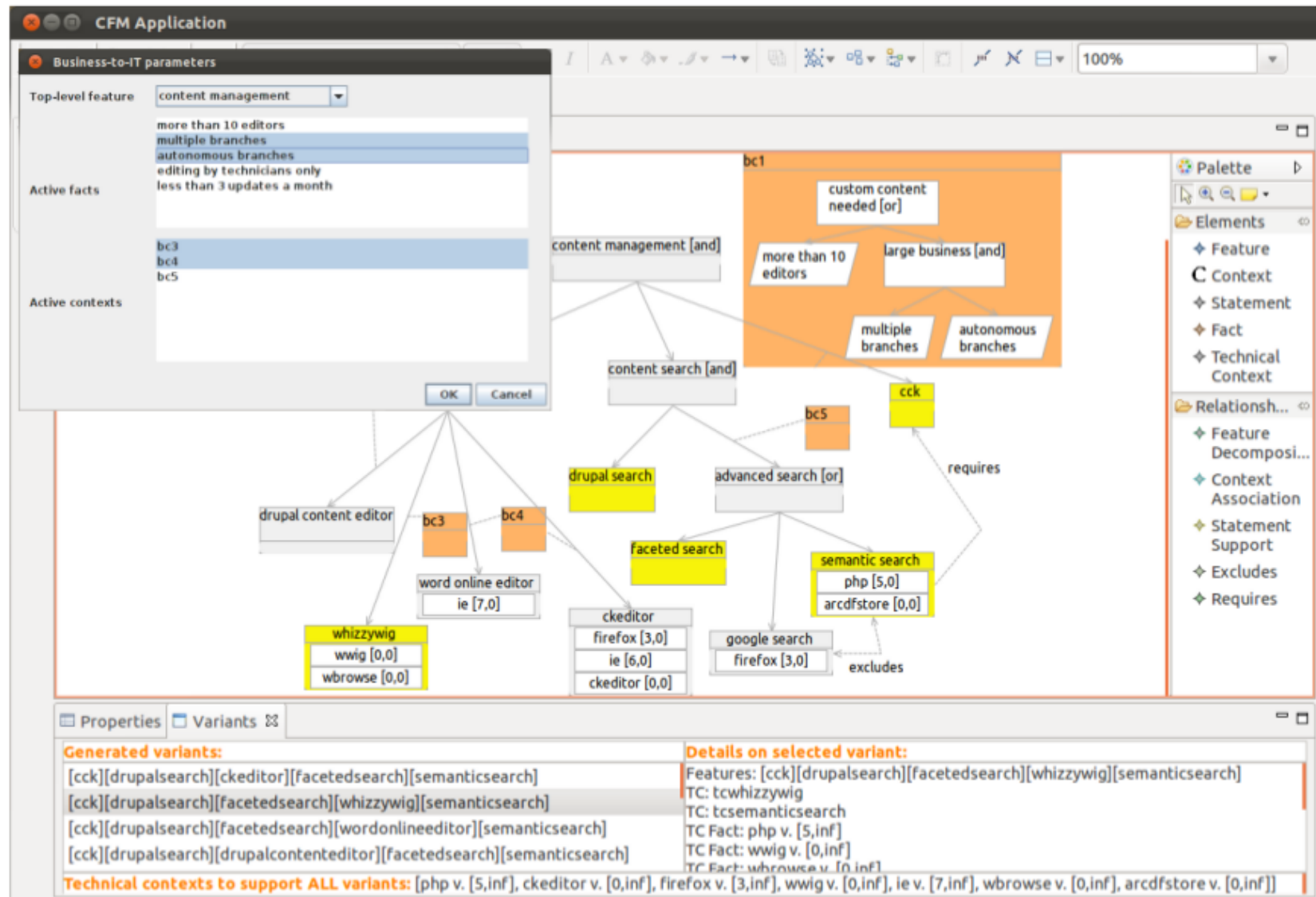


# Tool Support: FM-Context

- Eclipse-based application for CFMs
  - Graphical modeling
  - Automated reasoning (all presented techniques)
    - Uses the DLV disjunctive datalog solver
- Free for download
  - <http://goo.gl/wx3VI>



# Tool Support: FM-Context



# Discussion

- We introduced **contextual feature models**
  - Distinguish between business and technical contexts
  - Enable reasoning about B/IT Alignment through “what-if” analysis
  - Useful tool to determine a well-suited configuration
- Future work
  - Methodological support
  - Extending the notation and tool
  - Empirical evaluation
- More?
  - Read our CAiSE'12 paper!!! [Dalpiaz12]

**Thanks**

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# References

- Paper on Contextual Feature Models
  - [Dalpiaz12] Fabiano Dalpiaz, Raian Ali, Paolo Giorgini (2012) Aligning Software Configuration with Business and IT Context. In Proceedings of the 24th International Conference on Advanced Information Systems Engineering (CAiSE'12).
- Additional Reading
  - [Ali10] Raian Ali, Fabiano Dalpiaz, Paolo Giorgini (2010) A Goal-based Framework for Contextual Requirements Modeling and Analysis. Requirements Engineering 15 (4) pp. 439-458.
  - [Kang90] Kyo C. Kang, Sholom G. Cohen, James A. Hess, William E. Novak, and A. Spencer Peterson. Feature-Oriented Domain Analysis (FODA) Feasibility Study. Technical Report CMU/SEI-90-TR-21, Carnegie Mellon University, 1990