

Eureka ∑! 3674 Programme, ITEA2 project ip06035



#### Complexity Metrics for Software Product Lines

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#### Existing complexity metrics for Software Product Lines

- Assessing the complexity of product line architecture
  - In terms of: tailorability, architectural requirement conformance
- Assessing the complexity of variability specification of the product line
  - In terms of: number of the variation points, cyclomatic complexity of the variation points
- Assessing the complexity of an SPL
  - In terms of: costs, schedule, asset development, quality and productivity



#### The CVL (Common Variability Language) Complexity Metrics

- Assessing based on <u>both variability specification and</u> <u>implementation</u> of the SPL
- Apply to <u>CVL-based SPLs</u>, as one of the very few complexity metrics dedicated to model-driven SPLs
- Base language of the SPL can be <u>any MOF-based</u> modelling language





## **Common Variability Language (1)**







# **Common Variability Language (2)**

- Value Substitution
  - Change the value of an attribute of a model element

## Reference Substitution

 Redirect a reference from one model element to another one



## **Common Variability Language (3)**









# **Variability Specification Complexity**

- Metric 1 VSC (Variability Specification Complexity)
  - *Assumption* The number of all possible products is an indicator for the complexity of the variability specification
  - *Definition* Consider a CVL model with variability defined. Let *NOP* be the actual number of all possible products allowed by the model. Then:

VSC = NOP





#### **Weighted Value Substitutions**

- Metric 2 WVS (Weighted Value Substitutions)
  - Assumption The overall complexity of developing the value substitutions contributes to the complexity of the variability implementations
  - *Definition* Consider a CVL model with value substitutions vs<sub>1</sub>,..., vs<sub>n</sub> defined in the product realization (variability implementation) layer. Let cv<sub>1</sub>,..., cv<sub>n</sub> be the complexity of developing them. Then:

$$WVS = \sum_{i=1}^{n} CV_i$$





## **Weighted Reference Substitutions**

- Metric 2 WRS (Weighted Reference Substitutions)
  - Assumption The overall complexity of developing the reference substitutions contributes to the complexity of the variability implementations
  - *Definition* Consider a CVL model with reference substitutions rs<sub>1</sub>,..., rs<sub>n</sub> defined. Let cr<sub>1</sub>,..., cr<sub>n</sub> be the complexity of developing them. Then:

$$WRS = \sum_{i=1}^{n} cr_i$$





## **Weighted Fragment Substitutions**

- Metric 2 WFS (Weighted Fragment Substitutions)
  - Assumption 1 The overall complexity of developing the fragment substitutions contributes to the complexity of the variability implementations
  - Assumption 2 The number of the bindings is an indicator for the complexity of developing a fragment substitution
  - *Definition* Consider a CVL model with fragment substitutions *fs*<sub>1</sub>,..., *fs*<sub>n</sub> defined. Let *nob*<sub>1</sub>,..., *nob*<sub>n</sub> be the number of bindings involved in each substitution. Then:

$$WFS = \sum_{i=1}^{n} nob_i$$



#### **Preliminary Evaluation**

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Train Station PL #1: VSC=9, WVS=0, WRS=0, WFS=51 Train Station PL #2: VSC=52, WVS=23, WRS=0, WFS=69







- Is each metric in the metric suite of the same importance to the complexity of SPLs in different domains? If not, how it differs?
- How the metric values differ in different SPLs in the same domain?
- How to compare metric values from different SPLs in different domains? Is there a normalized way to calculate the weight for SPLs in different domains?





# **Inspiration of the CVL Complexity Metrics**

## Metric proposed by Lopez-Herrejon et al.

- Adapt McCabe's metric on calculating cyclomatic complexity of software programs
- Assess the cyclomatic complexity of variability specification
- Inspired the proposal of our metric 1 (VSC), however, in a CVL model, the complexity of variability specification depend both on its structural complexity and constrains.

## • Metric suite proposed by Chidamber et al.

- Assess the complexity of an object oriented design
- Mainly based on counting different class members and weighted aggregation
- Inspired the proposal of our metric 2 (WVS),3 (WRS) and 4 (WFS)



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#### Conclusion

#### • We have

- Proposed a metric suite assessing the complexity of CVL-based product lines
  - Based on both variability specification and implementation
  - Apply to any SPL with MOF-based base language
- Performed preliminary evaluation on assessing and further comparing the complexity of station product lines



#### • We will work on

- Applying the metrics to extensive SPLs in both the same domain and different domains
- Revising the metrics based on analysis of extensive applications of the current metrics
- Exploring if each the metric in the metric suite is of different importance to the complexity of the product line in different domains
- Exploring the complexity range and categorization for SPLs in different domains
- Exploring the possibility of proposing a normalized way of calculating weight in different domains so that to compare complexity of SPLs in different domains becomes possible
- Proposing a methodology for the application of metrics

