Visualising Product Line Requirement Selection Decision Inter-dependencies

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Software Product Line Engineering

- **A software product line is defined as**

  a set of software products sharing a set of common features satisfying the needs of a particular market but containing significant and predictable variability **(Weiss, 1999)**
- **In Software Product Line Engineering (SPLE) variability is represented through a set of variation points (VPs)**
- **Each VP represents a requirement selection decision (i.e. Decision) that have to be made for developing a new product**
- **Each VP is associated with a set of possible variants representing its possible solutions**
- **Successful SPLE requires to make decision at variation points effectively and efficiently**

SPLE Issues and Challenges

- **Requirement variability is crucial but very complex in SPL**
  - **Large population of VPs**
  - **Exponential number of inter-dependencies (IDs)**
  - **Different types of IDs**
- **SPL complexity transforms requirement selection decision activities into an error-prone activity**
  - **Requirement engineer often forgot something that should be in the final product or include something that should not be in the final product**
- **Difficult to represent and present visually a holistic view of the full set of decision**
- **Difficult to produce a consistent and coherent models of decisions and IDs**
- **Difficult to see the full impact of a decision change and selection**

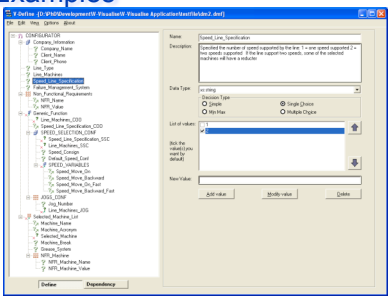
Decision & Inter-dependency Model

A Decision Model is defined as

A document that defines the decisions that one must make to specify a member of a domain (Weiss, 1999)

- A DM gathers all decisions that should be made for developing a specific product and represent and structure them in a logical way for supporting the requirement selection decision making
- An Inter-dependency Model (IM) gathers all inter-dependencies that have to be respected when a new product is developed

DM Examples



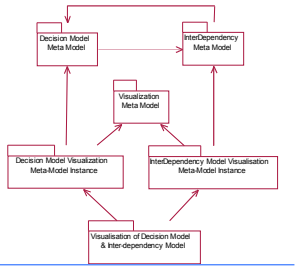
Visualisation and SPLE

Visualisation techniques can support SPLE:

- **Understanding the whole structure of a DM, the decisions relationships and their inter-dependencies**
- **Understanding the consequence of a requirement selection decision making on the decisions**
- **Preventing and avoiding inter-dependencies conflicts**
- **V-Visualise is a tool for visualising DM and IM which includes functionalities:**
  - **Searching**
  - **Highlighting decision and inter-dependency operation**
  - **Browsing decision and inter-dependency operation**
  - **Highlighting inter-dependency length (priority and cost evaluation)**
  - **Spanning**

Decision & IDs Model Visualisation

- 2 visualisations: one for DM, one for ID Model
- DM and ID model are underpinned by meta-model
- DM and ID model visualisations are underpinned by a visualisation meta-model



Visualisation Meta-Model

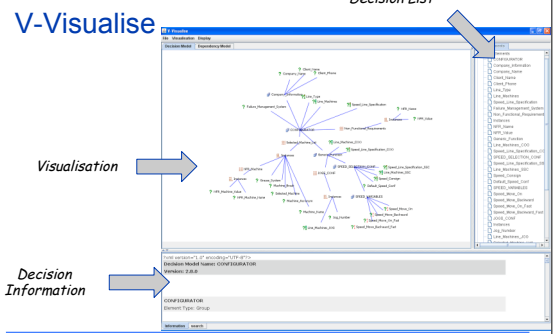
Visualisation Elements

	DM Visualisation		ID Model Visualisation	
DM Element	**Visu. Element**	**Repr**	**Visu. Element**	**Repr**
Decision Model	**Graph-Map-Tree**	**Graph**	**Graph-Map-Tree**	**Graph**
Classes				
DM (Root)	**Node**		**Node**	
Decision	**N/A**	**N/A**	**N/A**	**N/A**
Unrestricted decision	**Node**	?	**Node**	?
Bounded decision	**Node**	?¦	**Node**	?¦
ChoiceListDecision (Simple choice)	**Node**	?⁞	**Node**	?⁞
ChoiceListDecision (Multiple choice)	**Node**	?⁞	**Node**	?⁞
Choice	**N/A**	**N/A**	**N/A**	**N/A**
DecisionGroup	**Node**		**Node**	
Collection	**Node**		**Node**	
Instance	**Node**		**Node**	
Hierarchical relationship	**Edge**		**N/A**	**N/A**

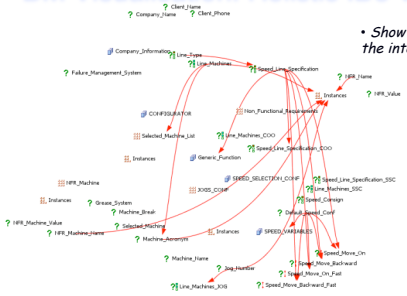
Inter-dependency Visualisation Elements

	ID Model Visualisation	
Inter-dependency Model Element	**Visu. Element**	**Repr**
Inter-dependency	**Node**	Dep1
Inter-dependency triggered by a decision model element	**Edge**	
Inter-dependency affecting a decision model element	**Edge**	
Inter-dependency Actions		
SetValue	**Edge**	
Set ListValue	**Edge**	
SetDefaultValue	**Edge**	
SetValidity	**Edge**	
SetRestriction	**Edge**	

V-Visualise

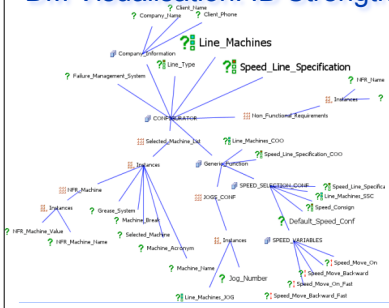


DM Visualisation: Holistic IDs Visualisation



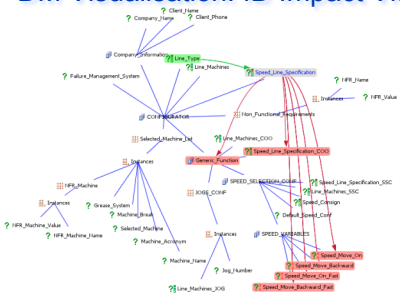
- *Show an holistic view of the inter-dependencies*

DM Visualisation: ID Strength Visualisation



- *Decisions having inter-dependencies are highlighted by increasing their size*
- *Easy to determine which decisions are difficult to reuse, change, and evolve (i.e. in terms of impact on the other decisions)*

DM Visualisation: ID Impact Visualisation



- *Shows IDs triggered by a requirement decision (red arrows)*
- *Shows IDs affecting a requirement decision (green arrows)*

ID Model Visualisation: Detailed ID View

- *Detailed view of a ID sequence*
- *Visualisation of how ID impact on decisions*
- *Visualisation of possible incoherence and inconsistencies*
- *Visualisation of detailed impact on other decisions*

Discussion and Further Work

- **Visualisation techniques provide significant efficiency for supporting software product line and Visualisation artefacts (e.g. highlighting, colour) bring cognitive benefits**
- **The mapping of meta-model helps to ground any toolkit in consistency of representation and presentation**
- **V-Visualise application**
  - **Supports domain model construction, navigation, and browsing**
  - **Makes straightforward to determine which decisions are parts of an ID and which ones are affected by an ID**
  - **Makes easy to determine which decisions are difficult to reuse, change, and evolve**
- **ID visualisation provides**
  - **detailed support for understanding interaction between requirement decisions**
  - **facilitates the understanding of large amount of ID**

Thanks