It's Your Loss: Classifying Information Loss During Variability Model Roundtrip Transformations

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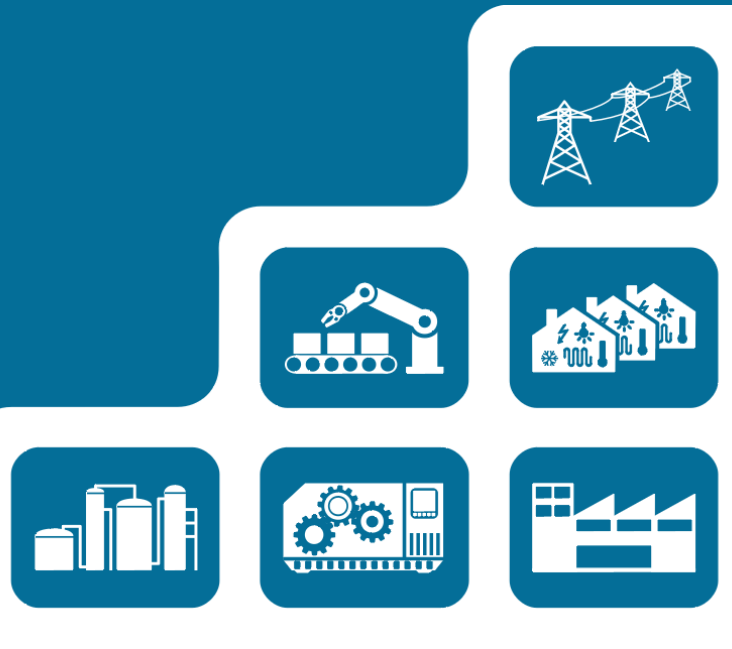
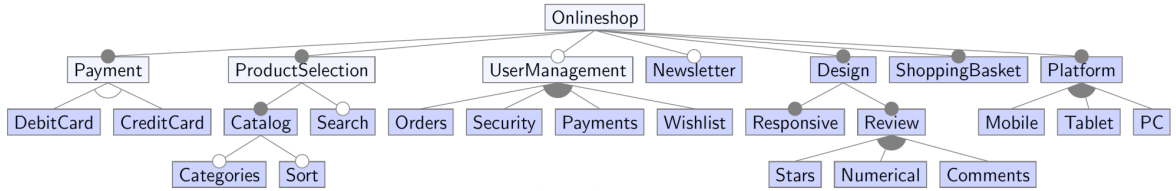


Variability Modeling Approaches

- **Feature modeling (FeatureIDE, UVL, Clafer,…)**
- **Decision modeling (DOPLER, IVML,…)**



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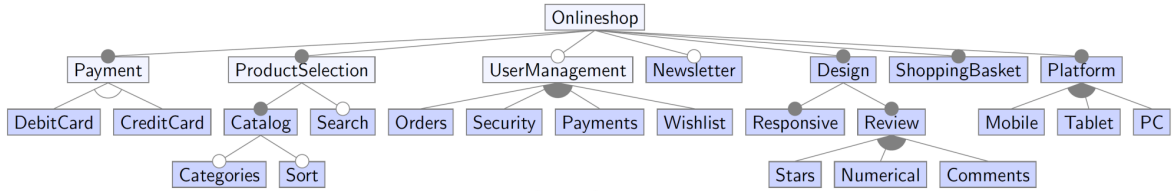

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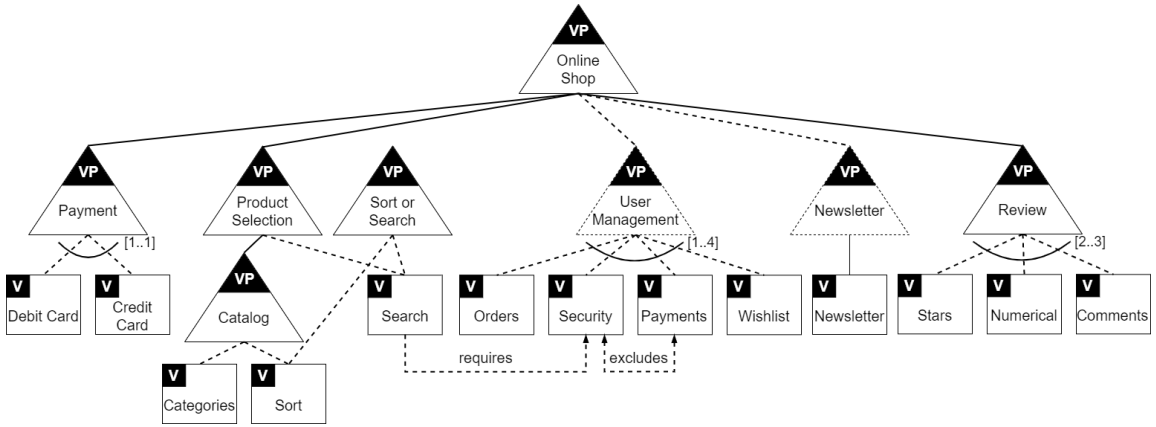

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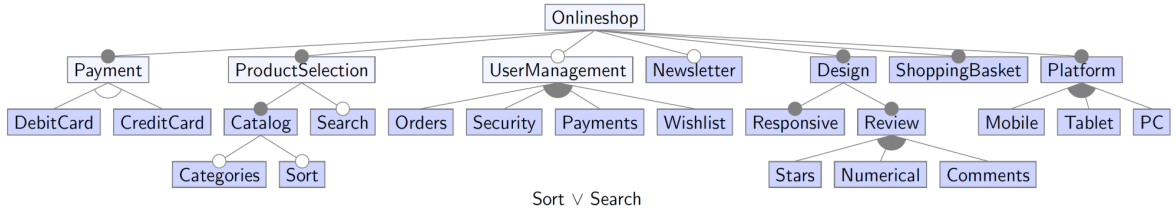
- Component Definition Language (eCos)



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menu "Power management and ACPI options"
  depends on !X86_VOYAGER

  config PM
    bool "Power Management support"
    depends on !IA64_HP_SIM
    ---help---
        "Power Management" means that ...

  config PM_DEBUG
    bool "Power Management Debug Support"
    depends on PM

  config CPU_IDLE
    bool "CPU idle PM support"
    default ACPI

  config PM_SLEEP
    bool
    depends on SUSPEND || HIBERNATION ||
               XEN_SAVE_RESTORE
    default y
...
endmenu
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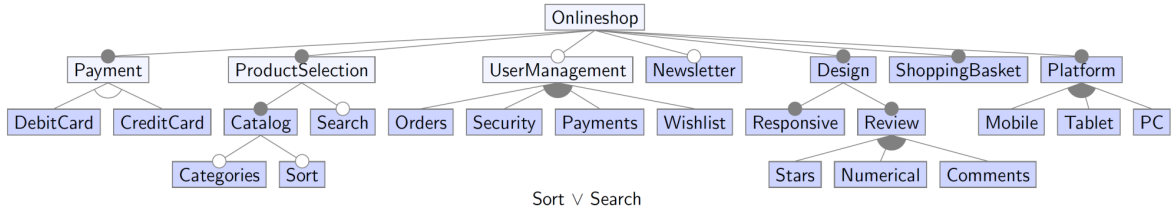

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How can we support researchers and practitioners in picking the right approach for their specific use case?

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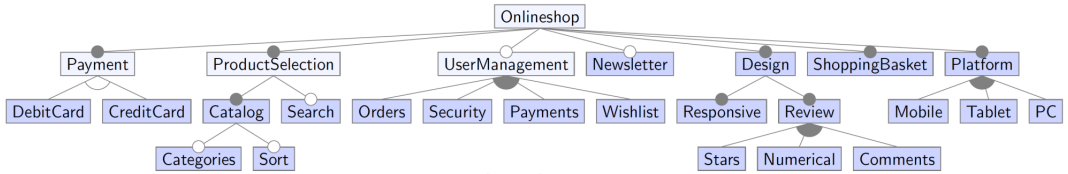

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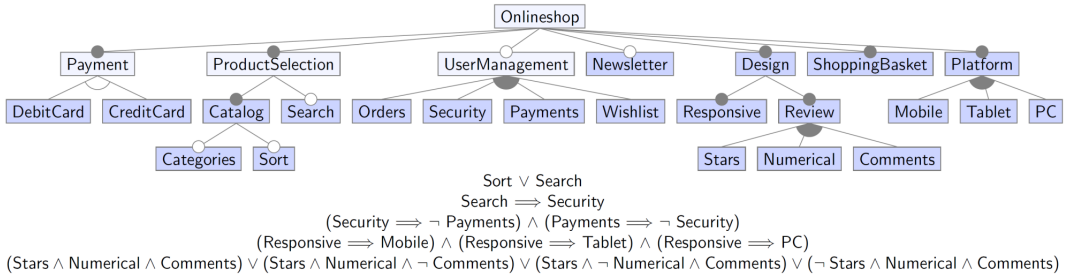

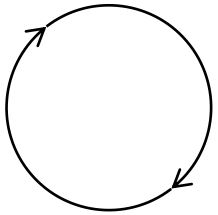

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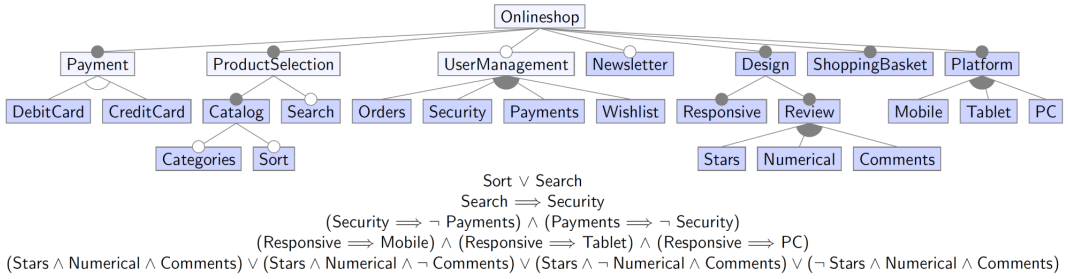

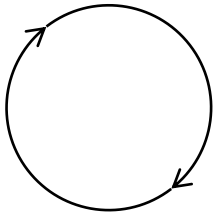

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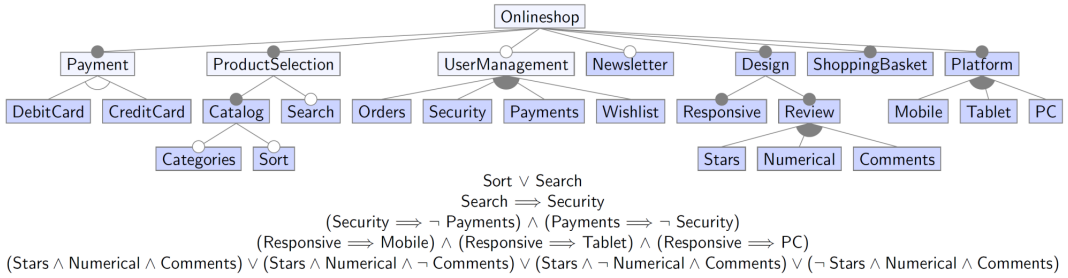

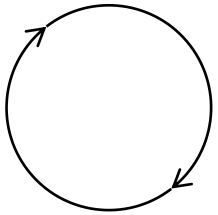

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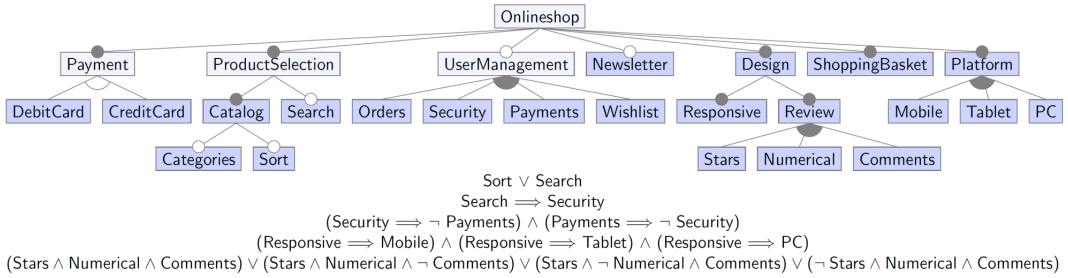

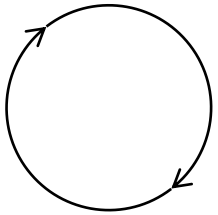

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IDE Feature

TRAVART

DOPLER
Decision-Oriented Product Line Engineering for effective Reuse

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(3) Integrating tools of other approaches, e.g., for analysis

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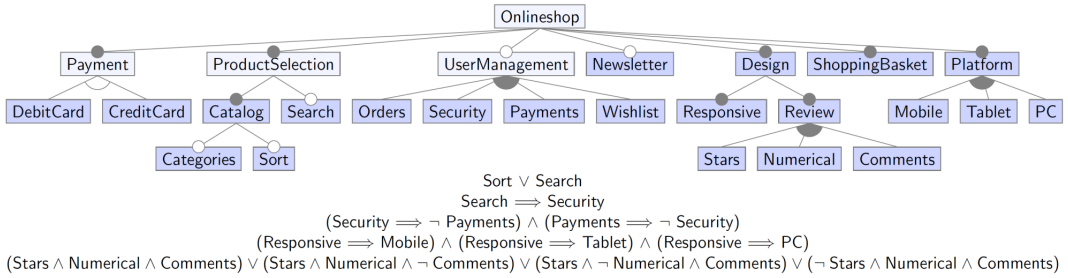

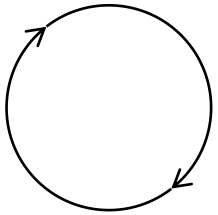

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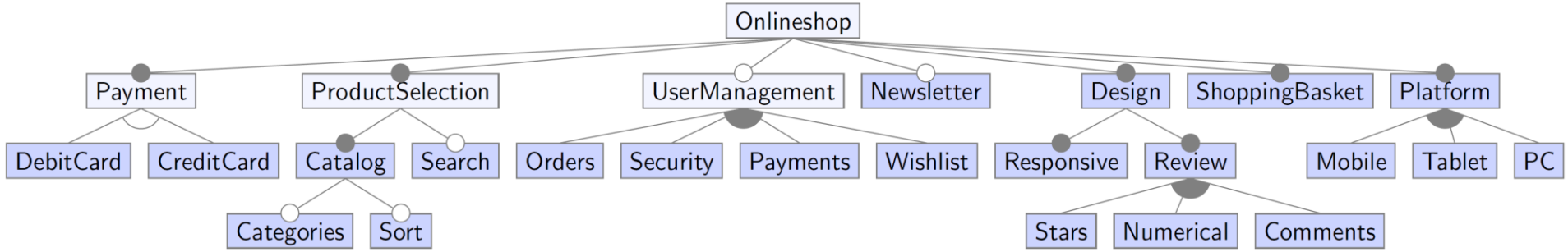
Semantic and expressiveness differences cause information loss, potentially allowing the configuration of broken/invalid products!

Feature models vs. Decision models



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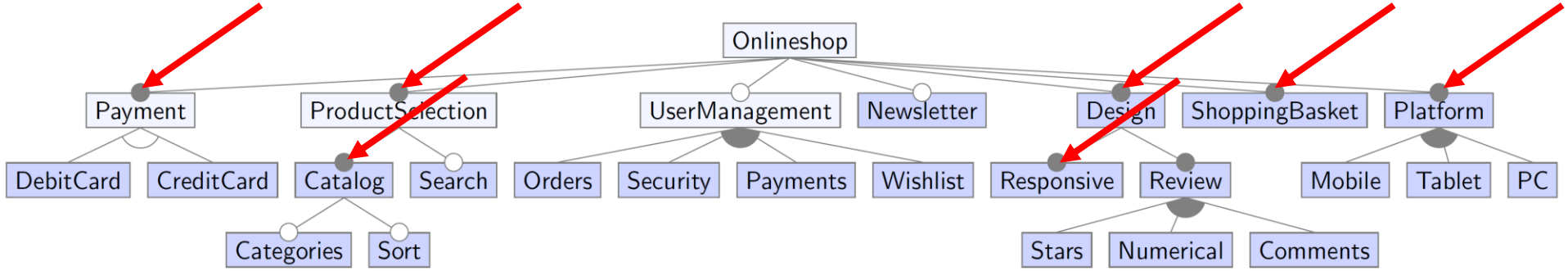

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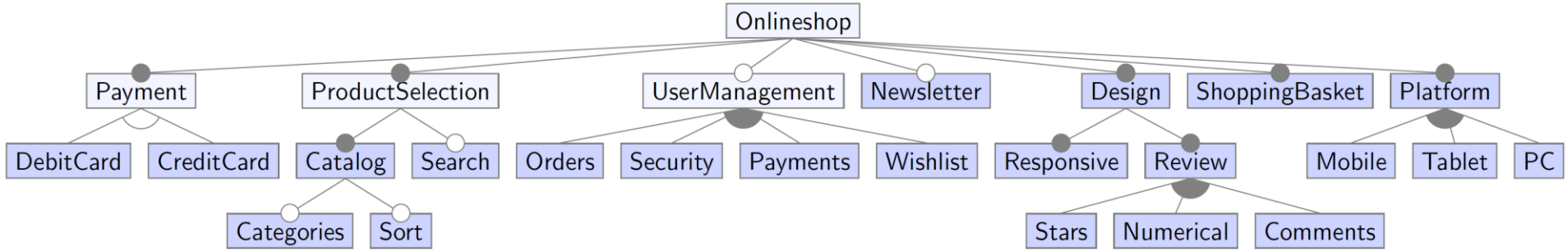
Review	Which review techiques should be supported	Enum	Stars | Numerical | Comments	2:3		

?

Feature models vs. Decision models



?

$$\text{Sort} \vee \text{Search}$$
$$\text{Search} \implies \text{Security}$$
$$(\text{Security} \implies \neg\ \text{Payments}) \wedge (\text{Payments} \implies \neg\ \text{Security})$$
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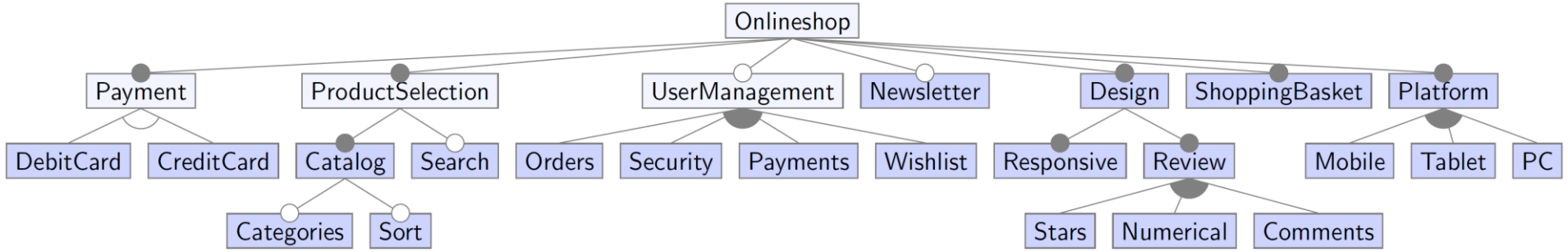
Feature models vs. Decision models



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$$(\text{Stars} \wedge \text{Numerical} \wedge \text{Comments}) \vee (\text{Stars} \wedge \text{Numerical} \wedge \neg\ \text{Comments}) \vee (\text{Stars} \wedge \neg\ \text{Numerical} \wedge \text{Comments}) \vee (\neg\ \text{Stars} \wedge \text{Numerical} \wedge \text{Comments})$$

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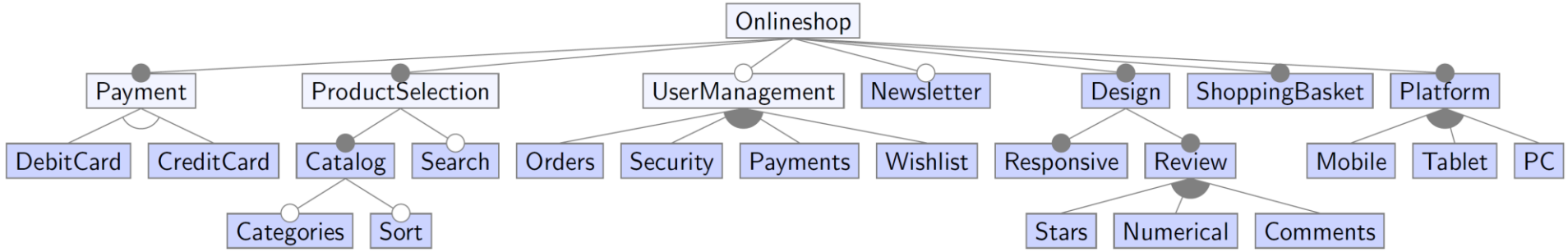
Feature models vs. Decision models



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Information loss currently is simply accepted during transformation, without further investigation!

Information Loss during Roundtrip Transformation

- Built of mapping tables between 4 approaches
- Identified 4 information loss classes

Information Loss during Roundtrip Transformation

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- Identified 4 information loss classes

no information loss

Entity or relationship can be transformed 1:1

Information Loss during Roundtrip Transformation

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- Identified 4 information loss classes

no information loss

Entity or relationship can be transformed 1:1

structural loss

No identical transformation back possible

$$(\text{Responsive} \implies \text{Mobile}) \wedge (\text{Responsive} \implies \text{Tablet}) \wedge (\text{Responsive} \implies \text{PC})$$

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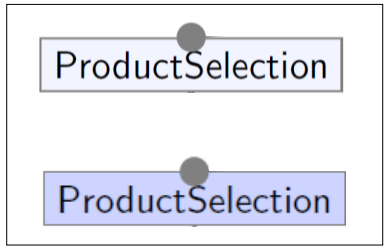
semantic loss

Entity or relationship loses properties



Information Loss during Roundtrip Transformation

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semantic loss

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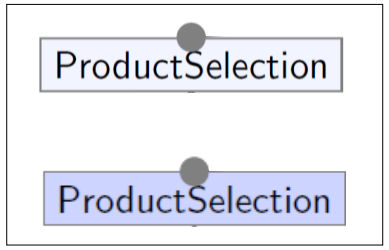
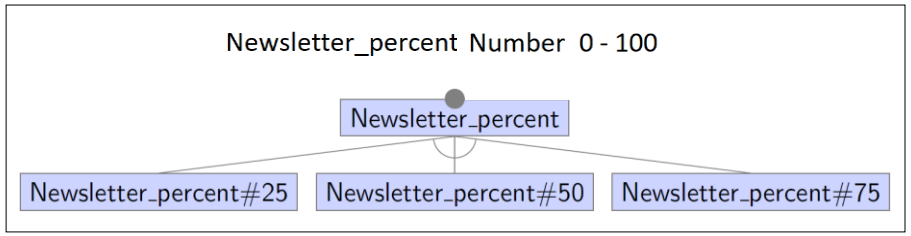
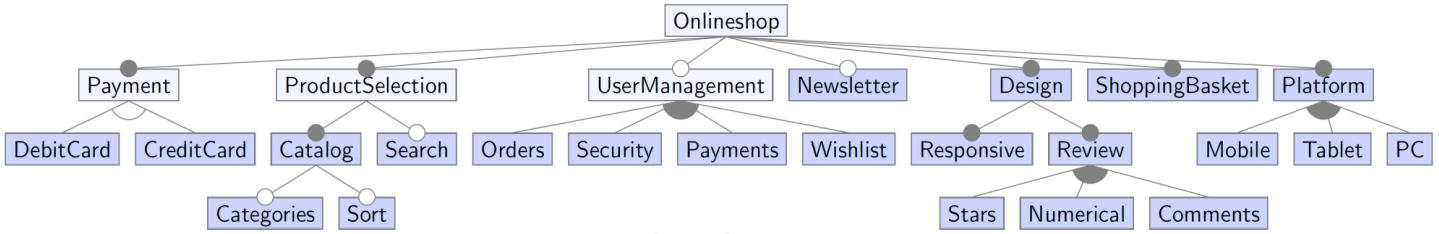


configurability loss

Entity or relationship cannot be transformed in full capacity



UVL feature models vs. DOPLER decision models



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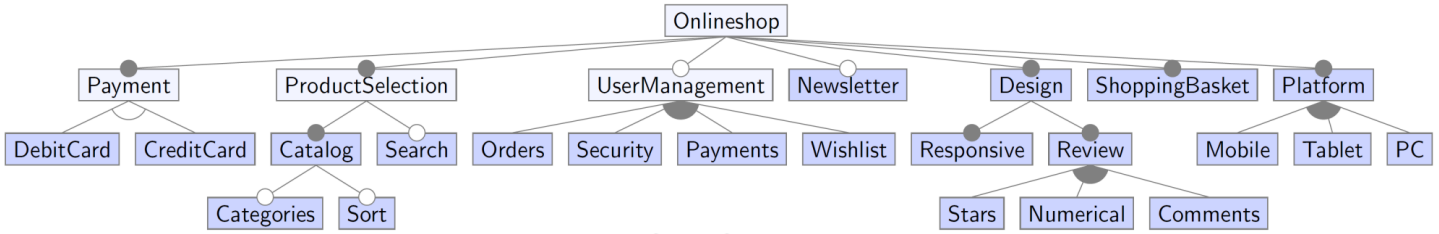
[2] Chico Sundermann, Kevin Feichtinger, Dominik Engelhardt, Rick Rabiser, and Thomas Thüm. 2021. Yet another textual variability language? a community effort towards a unified language. In Proceedings of the 25th ACM International Systems and Software Product Line Conference - Volume A (SPLC '21). ACM, New York, NY, USA, 136–147.

no information loss
structural loss
semantic loss
configurability loss

UVL feature models vs. DOPLER decision models

	UVL Feature Model	DOPLER Decision Model	Roundtrip
Model	imports	not supported	-
	namespaces	not supported	-



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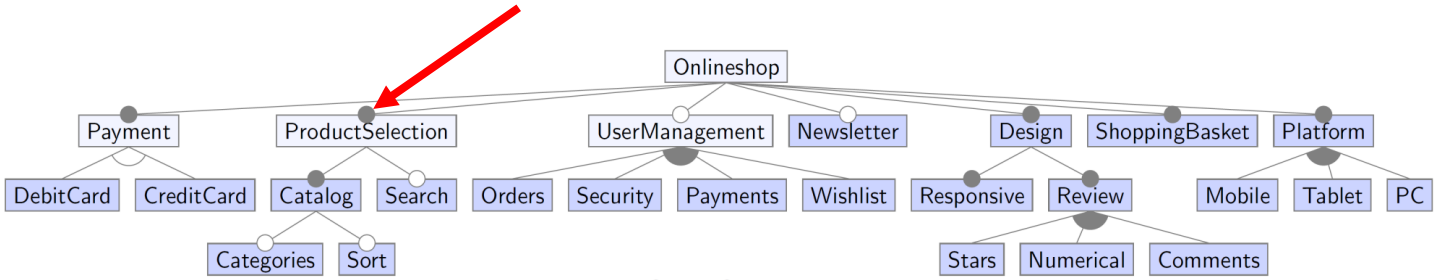
UVL feature models vs. DOPLER decision models



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UVL Feature Model		DOPLER Decision Model	Roundtrip
Model	imports	not supported	-
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Feature	Mandatory	Boolean decision with visiblity condtion	Mandatory Feature
	Optional	Boolean decision	Optional Feature
Properties	Abstract	not supported	-
	Hidden	not supported	-
Attributes	String	not supported	-
	Numeric	not supported	-
	Vector	not supported	-

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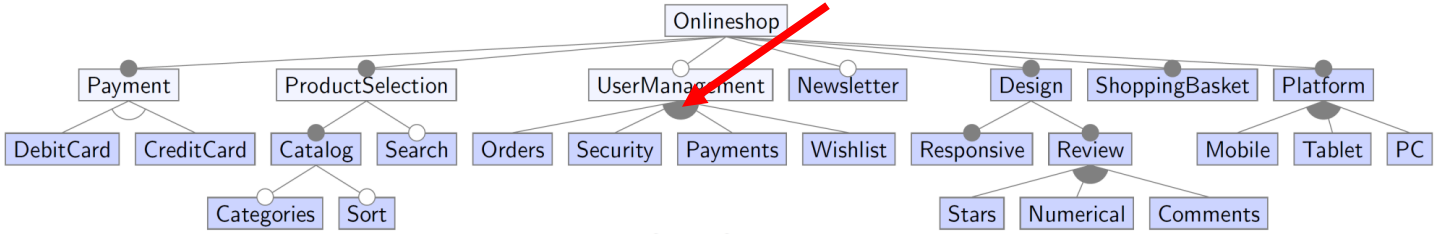
UVL feature models vs. DOPLER decision models



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	Hidden	not supported	-
Attributes	String	not supported	-
	Numeric	not supported	-
	Vector	not supported	-
Group	Or	Enumeration decision with cardinality 1:n	Or
	Alternative	Enumeration decision with cardinality 1:1	Alternative
	Group Cardinality (n:m)	Enumeration decision with cardinality n:m	Group Cardinality (n:m)
Constraints	Not	Deselect Rule	Not
	And	requires rules	And
	Or	Visibilitiy conditions requires/excludes rules	Or
	Requires	requires rule	Requires
	Equivalence	two requires rules	Equivalence

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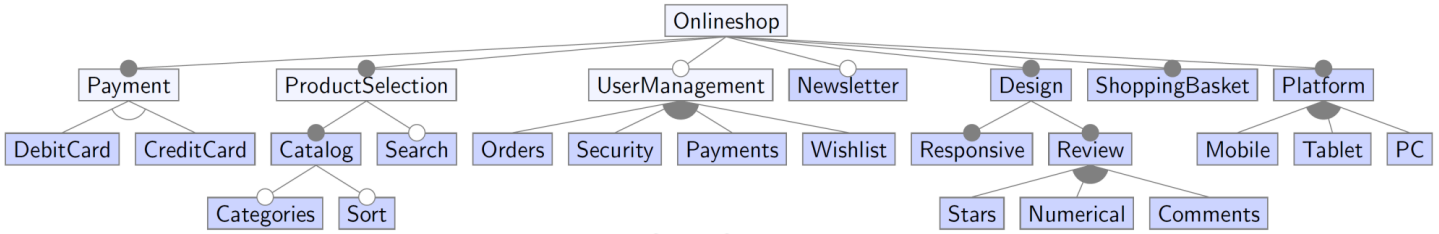
UVL feature models vs. DOPLER decision models



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Attributes	String	not supported	-
	Numeric	not supported	-
	Vector	not supported	-
Group	Or	Enumeration decision with cardinality 1:n	Or
	Alternative	Enumeration decision with cardinality 1:1	Alternative
	Group Cardinality (n:m)	Enumeration decision with cardinality n:m	Group Cardinality (n:m)
Constraints	Not	Deselect Rule	Not
	And	requires rules	And
	Or	Visibilitiy conditions requires/excludes rules	Or
	Requires	requires rule	Requires
	Equivalence	two requires rules	Equivalence
DOPLER Decision Model		**UVL Feature Model**	**Roundtrip**
Decision	Boolean decision	optional feature	Boolean decision
	Enumeration decision	feature group with cardinality	Enumeration decision
	Number decision	not supported	-
	String decision	not supported	-

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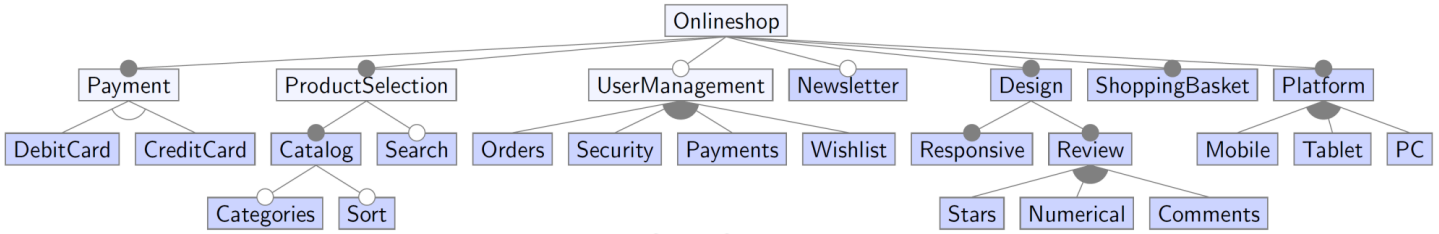

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ID	Question	Type	Range	Card.	Constraint/Rule	Visibility
Payment	Which payment methods should be supported?	Enum	DebitCard | CreditCard	1:1		
Search	Should a search function be supported?	Boolean	true | false		if (Search) { UserManagement = Security } if (!Search) { Sort = true }	
Categories	Split products into categories?	Boolean	true | false			
Sort	Should products be sortable?	Boolean	true | false		if (!Sort) { Search = true }	

UserManagement	Which user management options should be added?	Enum	Orders | Security | Payments | Wishlist	1:4	if (Security) { disAllow(Payments) }
					if (!Security) { allow(Payments) }
					if (Payments) { disAllow(Security) }
					if (!Payments) { allow(Security) }	

Newsletter_percent	How many percent off?	Number	0 - 100			
Newsletter_mail	From which mail should the newsletter be sent?	String				
Review	Which review techiques should be supported	Enum	Stars | Numerical | Comments	2:3		

UVL Feature Model		DOPLER Decision Model	Roundtrip
Model	imports	not supported	-
	namespaces	not supported	-
Feature	Mandatory	Boolean decision with visiblity condtion	Mandatory Feature
	Optional	Boolean decision	Optional Feature
Properties	Abstract	not supported	-
	Hidden	not supported	-
Attributes	String	not supported	-
	Numeric	not supported	-
	Vector	not supported	-
Group	Or	Enumeration decision with cardinality 1:n	Or
	Alternative	Enumeration decision with cardinality 1:1	Alternative
	Group Cardinality (n:m)	Enumeration decision with cardinality n:m	Group Cardinality (n:m)
Constraints	Not	Deselect Rule	Not
	And	requires rules	And
	Or	Visibilitiy conditions requires/excludes rules	Or
	Requires	requires rule	Requires
	Equivalence	two requires rules	Equivalence
DOPLER Decision Model		**UVL Feature Model**	**Roundtrip**
Decision	Boolean decision	optional feature	Boolean decision
	Enumeration decision	feature group with cardinality	Enumeration decision
	Number decision	not supported	-
	String decision	not supported	-
	IsSelected	constraint literal	IsSelected
	IsTaken	not supported	-
Expression	Not	not literal	Not
	And	and literal	And
	Or	or literal	Or
	Range	not supported	-
	GreaterThen	not supported	-
	LessThen	not supported	-
	Equals	not supported	-
	GreaterEquals	not supported	-
	LessEquals	not supported	-
Action	Allow	excludes constraint	Allow
	DisAllow		DisAllow
	SetValue	not supported	-
	GetValue	not supported	-
	SetSelected	requires	SetSelected
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no information loss
structural loss
semantic loss
configurability loss

[1] Deepak Dhungana, Paul Grünbacher, and Rick Rabiser. 2011. The DOPLER Meta-Tool for Decision-Oriented Variability Modeling: A Multiple Case Study. Automated Software Engineering 18, 1 (2011), 77–114.

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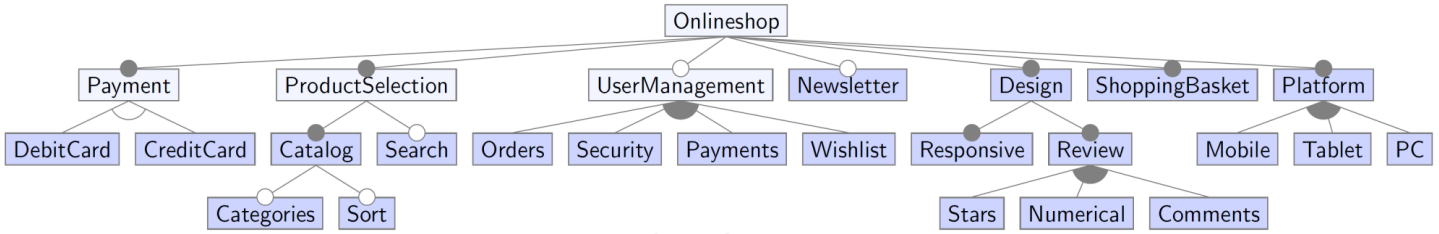
UVL feature models vs. DOPLER decision models



$$\text{Sort} \vee \text{Search}$$
$$\text{Search} \implies \text{Security}$$
$$(\text{Security} \implies \neg\ \text{Payments}) \wedge (\text{Payments} \implies \neg\ \text{Security})$$
$$(\text{Responsive} \implies \text{Mobile}) \wedge (\text{Responsive} \implies \text{Tablet}) \wedge (\text{Responsive} \implies \text{PC})$$
$$(\text{Stars} \wedge \text{Numerical} \wedge \text{Comments}) \vee (\text{Stars} \wedge \text{Numerical} \wedge \neg\ \text{Comments}) \vee (\text{Stars} \wedge \neg\ \text{Numerical} \wedge \text{Comments}) \vee (\neg\ \text{Stars} \wedge \text{Numerical} \wedge \text{Comments})$$

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Review						

DOPLER decision models are more expressive than UVL feature models

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Feature	Mandatory	Boolean decision with visiblity condtion	Mandatory Feature
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RQ. *How frequently do the information loss classes happen in transformed variability models?*

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1) Roundtrip transformed models of varying size and complexity
   25 FeatureIDE feature models
   6 UVL feature models
   6 DOPLER decision models
   3 OVM models

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2) Manually inspection of the resulting models
3) Verified the observed information losses using the intermediate model
4) Classified the losses using the defined information loss classes
5) Identified the Roundtrip-Quality of the transformations (identical, equal, loss)

UVL feature models vs. DOPLER decision models

UVL -> DOPLER	#Features	#Constraints	#Decisions	#Rules	#ConfigLoss	#SemLoss	#StrucLoss	R-Qualtiy
automotive02_4	18,616	1,369	19,967	30,591	0	4	451	equal
axTLS	96	14	101	82	0	5	37	equal
Server	10	2	12	12	0	2	0	equal
uClibc	313	56	334	445	0	22	176	equal
uClinux-base	380	3,455	416	1,187	0	0	3,384	equal
uClinux-distribution	1,580	197	1,590	410	0	10	194	equal

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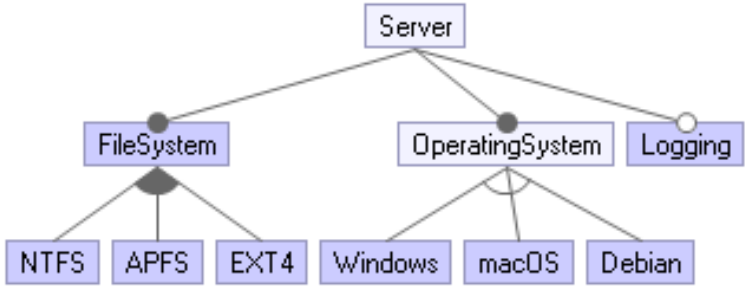

Windows ⇒ NTFS
macOS ⇒ APFS

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DOPLER –> UVL	#Decisions	#Rules	#Features	#Constraints	#ConfigLoss	#SemLoss	#StrucLoss	R-Qualtiy
ASEJ1	4	2	109	96	198	0	6	loss
DissModel	11	0	116	0	102	0	10	loss
DOPLERTools	26	7	50	15	16	0	36	loss
eShop	6	7	13	4	0	0	8	equal
HCSSDM	7	0	28	0	0	0	33	equal
VaMoS	5	1	11	1	0	0	8	equal

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HCSSDM	7	0	28	0	0	0	33	equal
VaMoS	5	1	11	1	0	0	8	equal

The information loss classes can be found in transformed variability models and therefore are applicable to existing variability models

The information loss classes indicate how information is lost during a one-way transformation and a roundtrip transformation

Summary

- Investigated the information loss occurring between 4 variability modeling approaches

UVL Feature Model		DOPLER Decision Model	Roundtrip
Model	imports	not supported	-
	namespaces	not supported	-
Feature	Mandatory	Boolean decision with visiblity condtion	Mandatory Feature
	Optional	Boolean decision	Optional Feature
Properties	Abstract	not supported	-
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Attributes	String	not supported	-
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Group	Or	Enumeration decision with cardinality 1:n	Or
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	Group Cardinality (n:m)	Enumeration decision with cardinality n:m	Group Cardinality (n:m)
Constraints	Not	Deselect Rule	Not
	And	requires rules	And
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DOPLER Decision Model		**UVL Feature Model**	**Roundtrip**
Decision	Boolean decision	optional feature	Boolean decision
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Expression	Not	not literal	Not
	And	and literal	And
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	Range	not supported	-
	GreaterThen	not supported	-
	LessThen	not supported	-
	Equals	not supported	-
	GreaterEquals	not supported	-
	LessEquals	not supported	-
Action	Allow	excludes constraint	Allow
	DisAllow		DisAllow
	SetValue	not supported	-
	GetValue	not supported	-
	SetSelected	requires	SetSelected
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no information loss

structural loss

semantic loss

configurability loss

Summary

- Investigated the information loss occurring between 4 variability modeling approaches
- 4 Information loss classes evaluated using a applicability study

UVL Feature Model		DOPLER Decision Model	Roundtrip
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Summary

- Investigated the information loss occurring between 4 variability modeling approaches
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Future Work

- Extending to additional variability modeling approaches

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Summary

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