# Integrating Feature Modeling into UML

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# Overview

# Feature Model

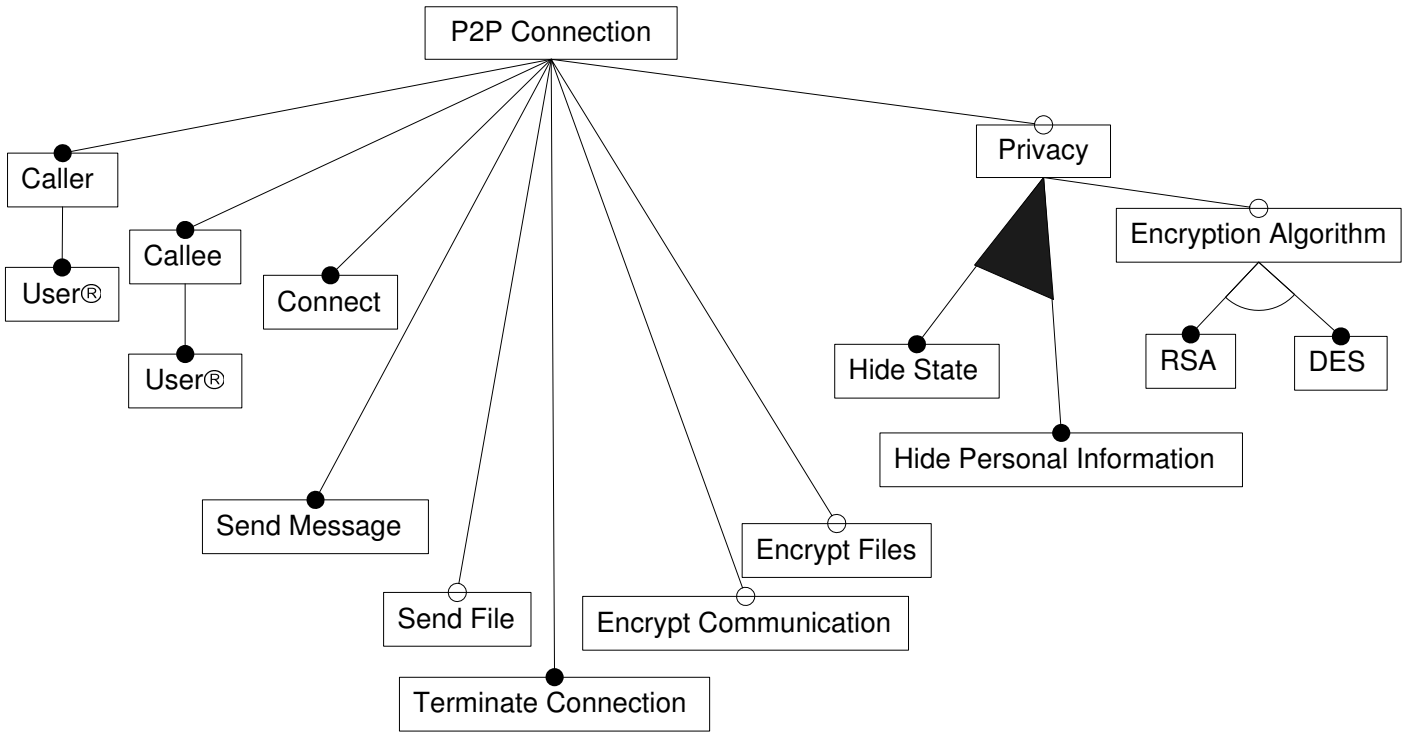
- Feature modeling enables to deal with variability abstractly
- Used in software product lines
- Concepts expressed by their features
- A feature is an important property of a concept
- Common and variable features
- Focus on configurability

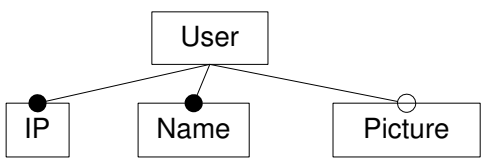
# Feature Modeling and UML

- UML — de facto standard for modeling software
- Need to integrate feature modeling: to use it along with other UML models
- Feature modeling should be integrated into UML *correctly*

# Basic Feature Modeling Notation

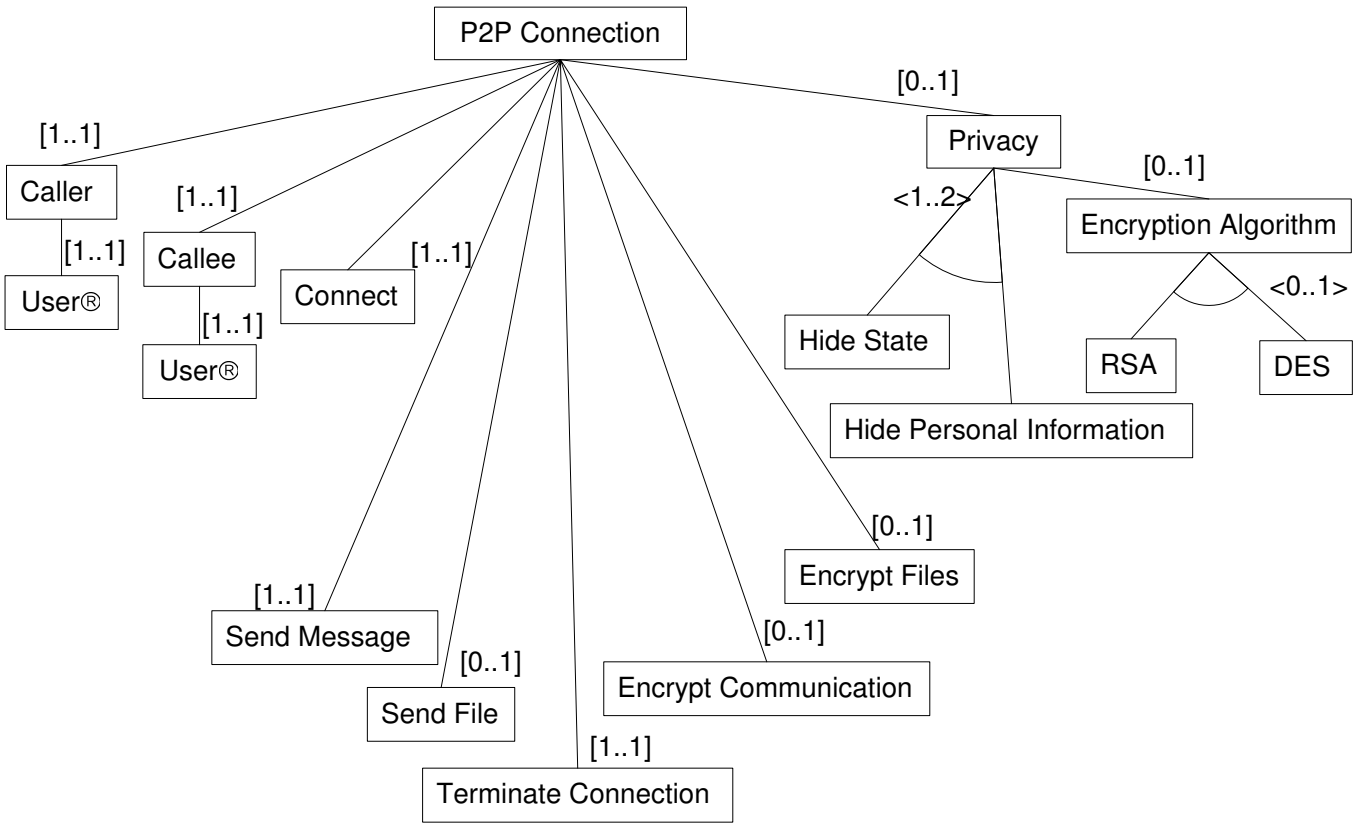
- Czarnecki-Eisenecker notation (based on FODA notation)



# Feature Modeling with Cardinalities

- Cardinality-based Czarnecki-Eisenecker notation

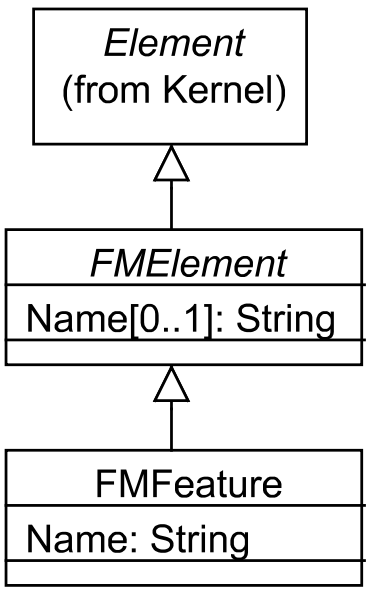


# Keep Feature Modeling Elements Abstract in UML

- Concepts and features are abstract terms
- They should be represented abstractly in UML: without implementation connotation
- Some approaches use class stereotypes
- But classes can be in aggregation and inheritance relationships; features and concepts cannot

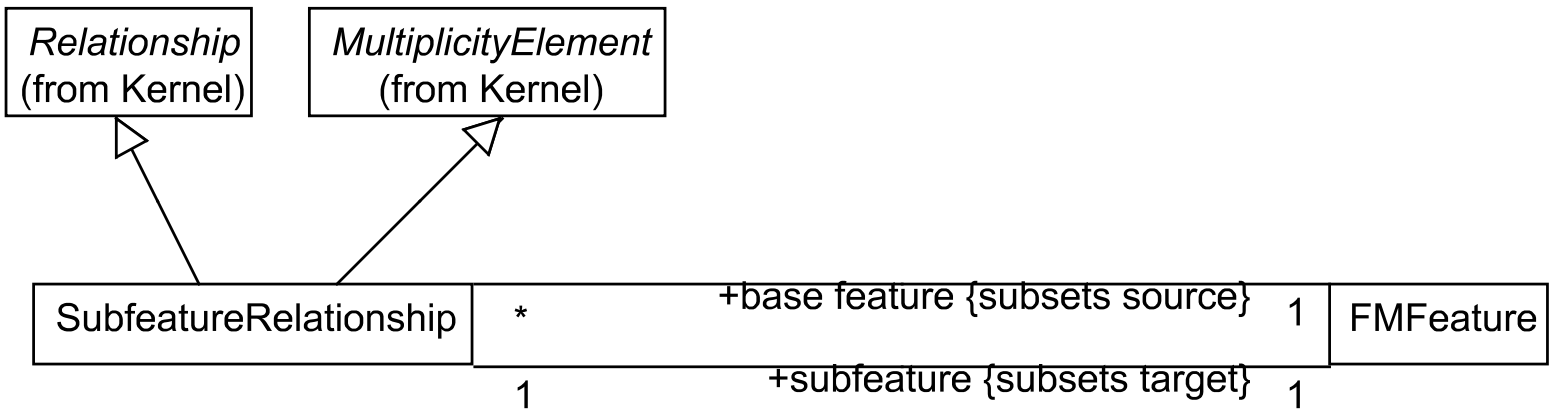
# Concepts and Features

- Features and concepts are derived from **Element**, the most abstract UML metaclass for representing elements
- We introduce an abstract metaclass **FMElement** as a basis for all feature modeling elements other than relationships
- Concepts are considered to be "root features"



# Subfeature Relationship

- Relationships between features do not have predefined semantics
- They are *not* aggregations, nor inheritance — this is decided later in design
- Therefore subfeature relationship is represented by a metaclass derived from the abstract **Relationship** metaclass

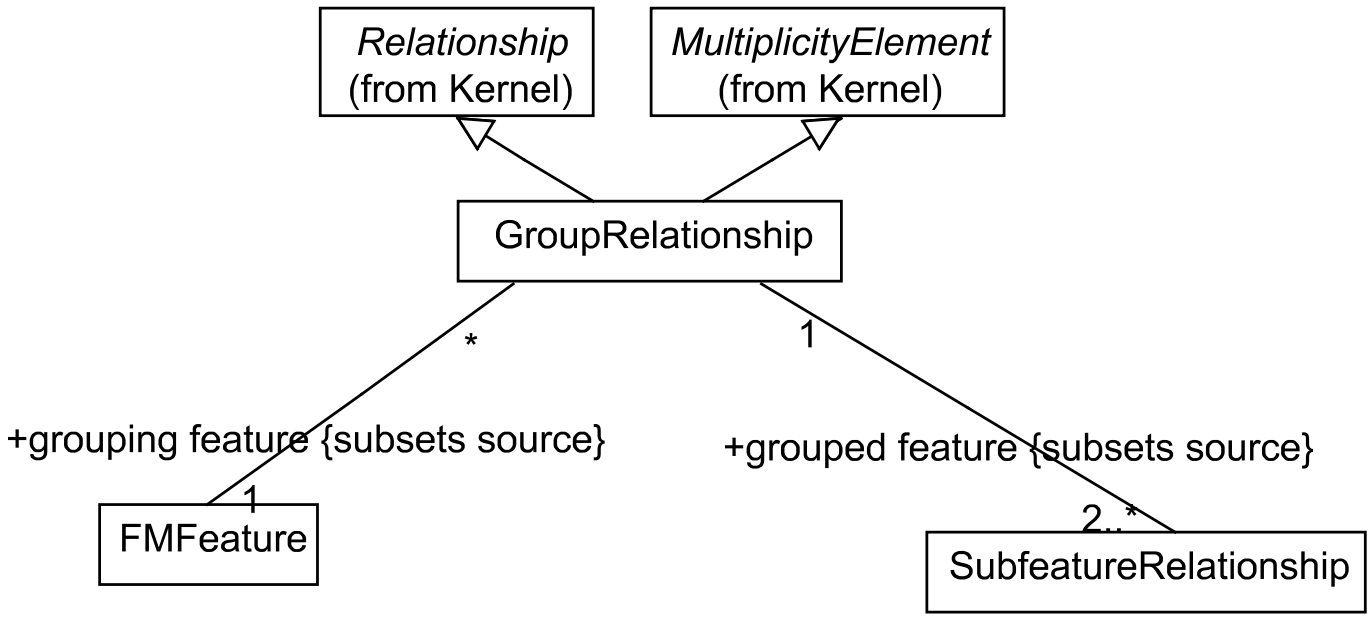


# Subfeature Relationship (2)

- Cardinalities enabled by deriving **SubfeatureRelationship** from **MultiplicityElement**
- Variability information is a part of the relationship (edge), not feature (node)

# Group Relationship

- A relationship between the base feature and two or more *subfeature relationships*, not features
- Based on an abstract **Relationship**




- Also based on **MultiplicityElement** to enable group cardinalities (how many features are to be included in a group)

# Common Subfeature Types

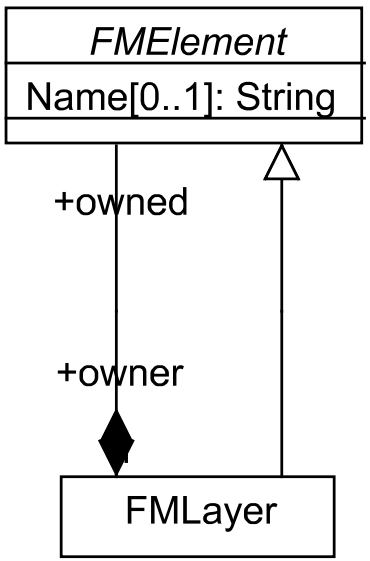
- Mandatory feature: **SubfeatureRelationship** with cardinality <1..1>
- Optional feature: **SubfeatureRelationship** with cardinality <0..1>
- Alternative feature: **GroupRelationship** with cardinality <1..1>
- Or-feature: **GroupRelationship** with cardinality <1..*>
- Common subfeature types can be defined as stereotypes along with their common graphical representation

# Feature Diagrams as Graphs

- With this extension, feature diagrams may be modeled as graphs
- The tree representation is more common
- An **FMFeature** <<concept>> stereotype may be introduced
  - A feature that cannot be in a **subfeature** role in **SubfeatureRelationship**
  - "Root feature"

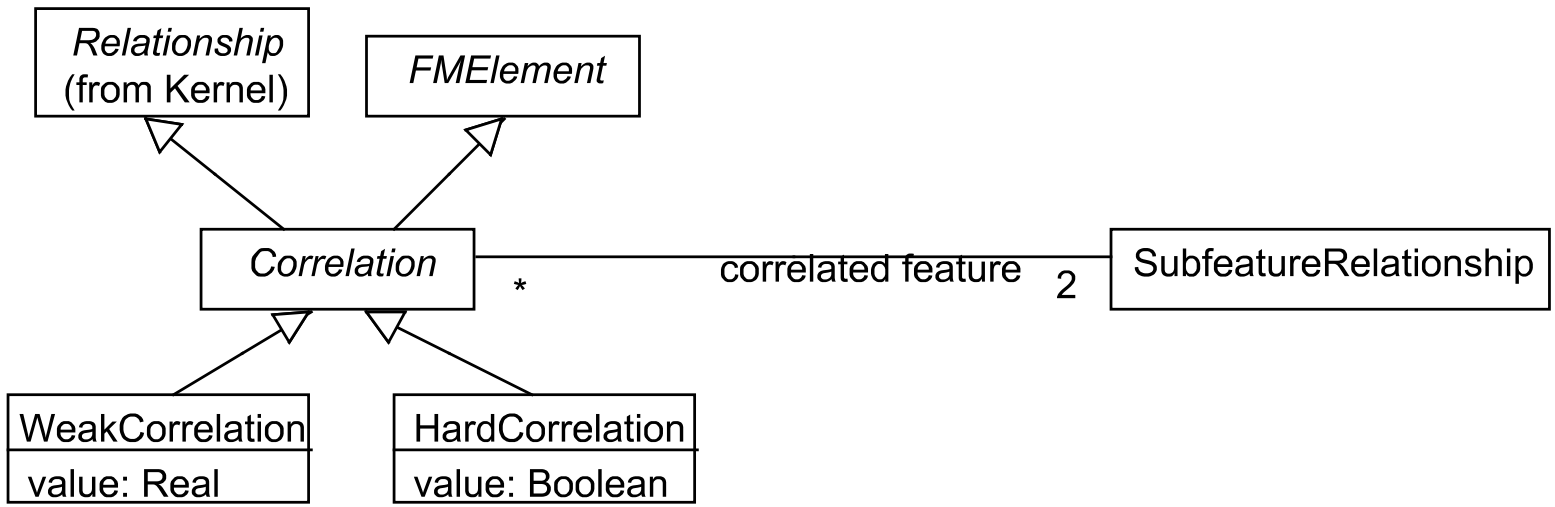
# Layers

- Many notation specific extensions to feature modeling
- We consider two examples: layers and correlations
- Some approaches use layered representation of feature models (e.g., FODA and FORM)
- A layer is modeled as an **FMElement**



# Correlation

- Design spaces
- Correlation as a form of expressing additional constraints between feature
  - Weak correlation: a recommendation to combining features
  - Hard correlation: combine or don't combine the features
- A design space is modeled as a **SubfeatureRelationship**



# Feature Modeling Extension and UML Modeling Tools

- Not possible to modify the UML metamodel in contemporary UML modeling tools
- We also created a feature modeling profile for UML
- Enables experimentation with combining different feature modeling elements
- But the abstractness of feature modeling elements cannot be achieved this way
- However, feature variability is modeled as relationships

# Conclusions

- An approach to integrate feature modeling into UML by extending its metamodel
- Feature modeling elements derived from basic UML elements to preserve their abstractness
- The extension provides a basis for further development
- The issue of notation-specific extensions has also been addressed

# Further Work

- Introducing concept references
- Covering additional information on concepts and features (e.g., description and binding tiem information)
- Representing Constraints and default dependency rules as logical expressions using OCL
- Further experimentation with other notation-specific extensions
- Transformation of feature models in an MDA manner