Binding Time Based Concept Instantiation in Feature Modeling

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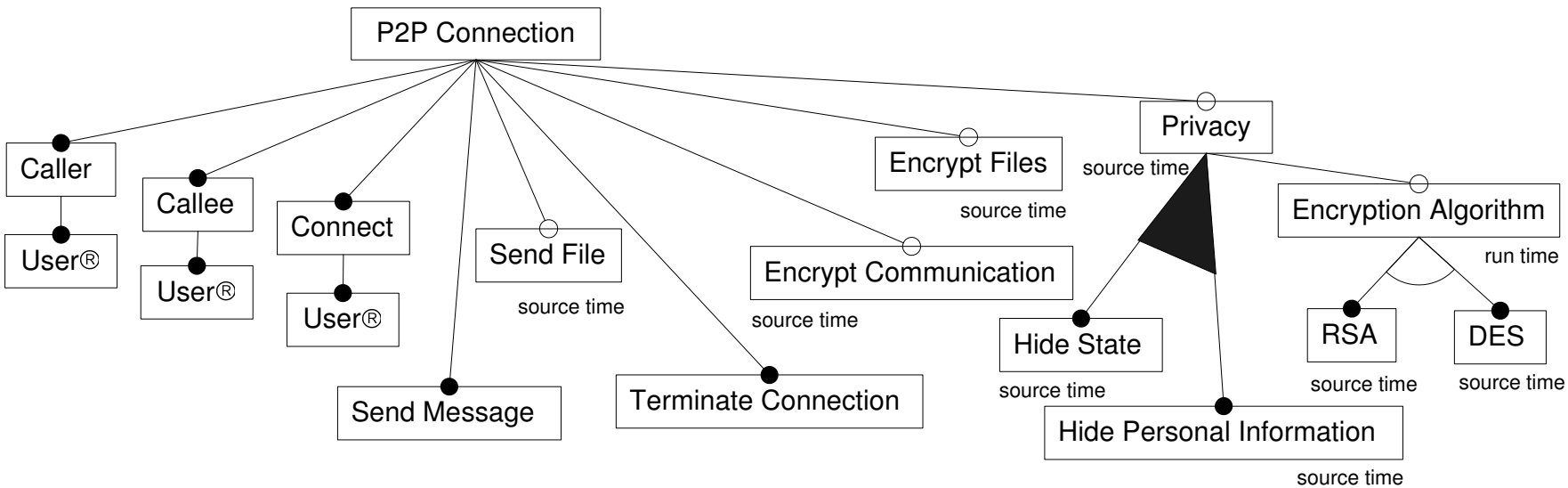
Overview

Feature Model

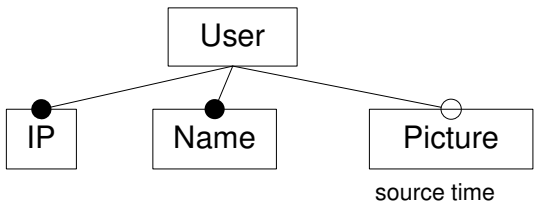
- Concepts expressed by their features
- A feature is an important property of a concept
- Common and variable features
- Focus on configurability
- A specific configuration of a system or its part are represented by concept instances
- Czarnecki-Eisenecker notation

An Example: Peer-to-Peer Chat Protocol



Concept References

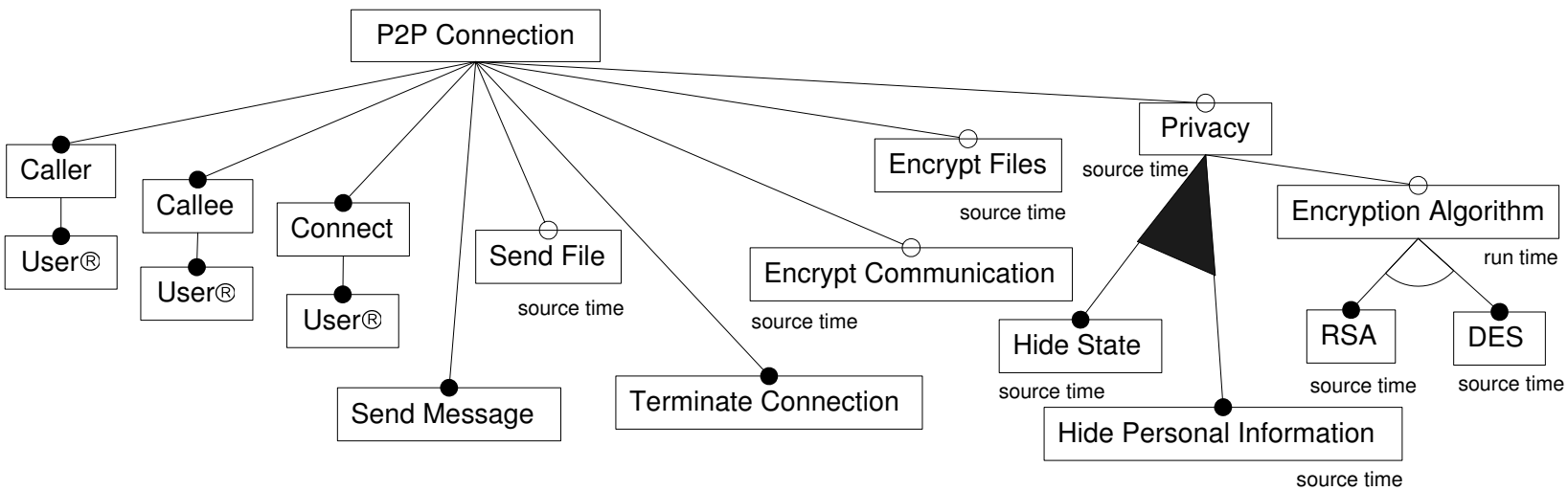
- A concept reference is equivalent with the repetition of the whole feature diagram of the referenced concept
- Peer-to-peer chat protocol references the User concept



Constraints

- Main constraints are expressed by feature diagrams
- Additional constraints — in form of predicate logic expressions
- Additional constraints in the peer-to-peer chat protocol:

$$\textit{Encrypt Communication} \Rightarrow \textit{Encryption Algorithm}$$
$$\textit{Encrypt Files} \Rightarrow \textit{Encryption Algorithm}$$
$$\textit{Encrypt Files} \Rightarrow \textit{Send File}$$



Feature Binding Time

- Binding time describes *when* a variable feature is to be *bound*, i.e. selected to become a mandatory part of a concept instance
- Mandatory features are considered to be bound
- Usual binding times include source time, compile time, link time, and run time (depends on the solution domain)

Concept Instance Definition

An instance I of the concept C at time t is a concept derived from C by selecting its features which includes the C's concept node and in which each feature f whose parent is included in I obeys the following conditions:

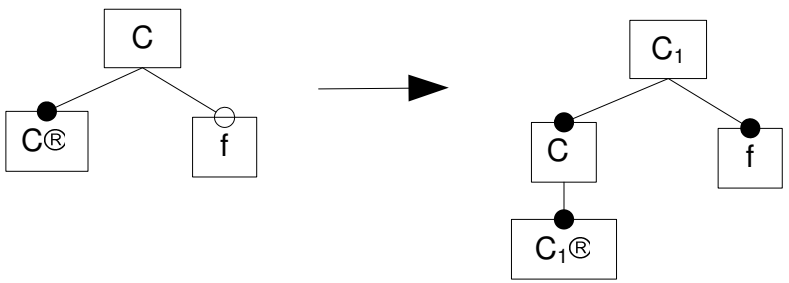
1. If f is a mandatory feature, f is included in I.
2. If f is a variable feature whose binding time is earlier than or equal to t, f is included in I or excluded from it according to the constraints of the feature diagram and additional constraints associated with it. If included, the feature becomes mandatory for I.
3. If f is a variable features whose binding time is later than t, f may be included in I as a variable feature or excluded from it, or the constraints (both feature diagram and additional ones) on f may be made more rigid as long as the set of concept instances available at later instantiation times is preserved or reduced.

Concept Instantiation in Time

- A concept instance is represented by a feature model derived from the feature model of the concept
- This model contains only the features included in the concept instance
- These features may be bound (becoming mandatory) or unbound (they stay variable)
- Mandatory features and features bound in previous instantiations are bound

Instantiation of Concepts with Circular References

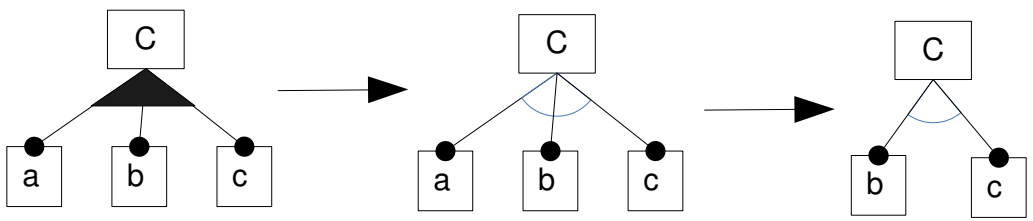
- Circular concept references are a consequence of circular dependencies in the domain
- They may be unfolded prior to instantiation
- The process of unfolding is ended by declaring that the remaining concept reference is a reference of an existing concept instance
- An example: a concept with a direct circular concept reference



- The circularity remains and may be revoked at instantiation times that follow
- Variable circular concept references may be simply removed

Reducing the Set of Concept Instances

- The constraints on unbound features may be made more rigid as long as the set of possible concept instances is preserved or reduced
- An example: a group of or-features may be transformed into a group of alternative features
- Another example: one of three alternative features may be excluded at source time, but both remaining two features must be kept



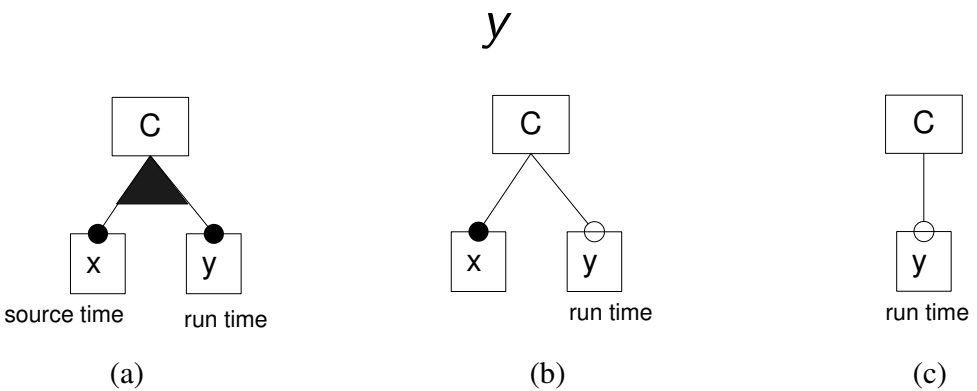
(a) (b) (c)

Concept Instance Validation

- A concept instance is valid if its features satisfy the constraints
- Validation is performed according to the concept instance definition
- A constraint may be evaluated only if all the features it refers to are bound
- Some logical expressions may be evaluated without the need to know the values of all their variables
- Additional constraints that refer to the features whose binding time is not later than the instantiation time can be safely removed from the model
- All other constraints have to be postponed for further instantiation

Evaluating Constraints with Unbound Features

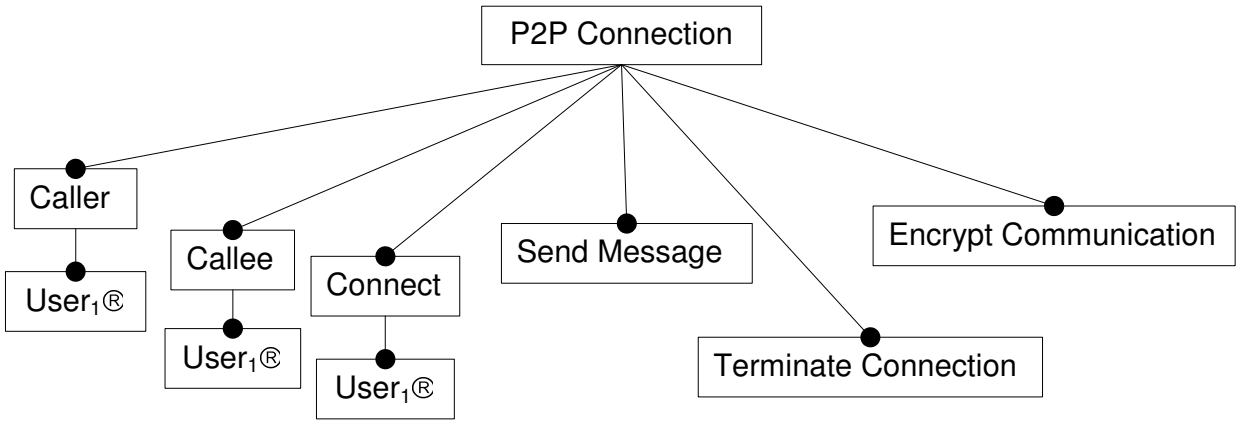
- Evaluating constraints on features whose binding time is later than the instantiation time
- An example:
  - If we bind x, the or-group constraint will be satisfied regardless of the binding of y
  - This constraint can be omitted by which y will become optional
  - Also, x may be omitted by which y must become optional
  - But it has to be assured it will finally be bound by adding a trivial constraint:



Dead-End Concept Instances

- Instances valid at a given instantiation time, but that can't be instantiated further
- For example, a source-time instance of the *P2P Connection* concept breaks the additional constraint at run time:

$$Encrypt\ Communication \Rightarrow Encryption\ Algorithm$$



Conclusions and Further Work (1)

- Concept instances are understood as concepts and represented by full-fledged feature models
- Concept instantiation taking into account feature binding time
- Support for circular references
- Concept instantiation with respect to binding time can be useful in
  - Providing a better control over the specific product configuration in product lines
  - Checking for dead-end instances
  - Creating specialized versions of frameworks (a source time instantiation)

Conclusions and Further Work (2)

- A prototype tool available at `http://fiit.stuba.sk/~vranic/fm/` (and another one coming soon)
- Further work:
  - Constraints that incorporate unbound features
  - Application to cardinality-based feature models