Génération de correctifs pour les modèles partiels d'AnimUML

Mickaël Clavreul[1], Frédéric Jouault[1], Maxime Méré[2], Matthias Brun[1], Théo Le Calvar[3], Matthias Pasquier[4], and Ciprian Teodorov[5]

[1]ESEO
Angers, France
first.last@eseo.fr

[2]STMicroelectronics, INSA Rennes
Le Mans, France
first.last@st.com

[3]IMT Atlantique, LS2N,
UMR CNRS
6004, F-44307
Nantes, France
theo.le-calvar@imt-atlantique.fr

[4]ERTOSGENER
Angers, France
first.last@ertosgener.com

[5]Lab-STICC CNRS UMR 6285
ENSTA Bretagne
Brest, France
first.last@ensta-bretagne.fr

Adapté de : Jouault et al. *From OCL-based model static analysis to quick fixes*. OCL Workshop, MoDELS'22.

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- Cas d’étude : AnimUML
- Approche
- Validation préliminaire
- Conclusion

Contexte – Modélisation de systèmes

- Modélisation complexe et difficile (langages, compétences)
- Outils support
  - focus sur les concepts, la syntaxe
  - peu sur le processus de modélisation
  - l'outil devrait assister le concepteur dans la correction des erreurs de modélisation
- Besoins [1]
  - localiser
    - Rapport d'erreurs / warnings
  - comprendre
    - Exécution pas-à-pas de correctifs
  - corriger
    - Suggestions de correctifs
    - Application automatique de correctifs

[1] P. Pourali, *Tooling Advances Inspired to Address Observed Challenges of Developing UML-like Models When Using Modelling Tools.* MoDELS'18.

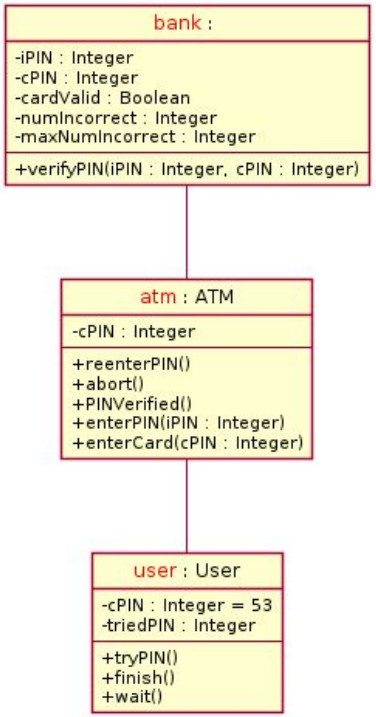
Cas d’étude – AnimUML [2]

- Support de l’exécution de modèles **partiels/incomplets**, en partie **incohérents**
  - Avec outils d’analyse de leurs comportements
- **Assistance** à la mise au point de modèles complets, cohérents, corrects et conformes
  - Animation (machines à états) et traces d’exécution
  - Débogage
  - Vérification (analyse statique, *model-checking*)
- (Pédagogie) sur la méthodologie de construction de modèles
  - Petits correctifs, *feedback*

[2] Jouault et al. *Designing, animating and verifying partial UML models*. MoDELS’20.

Cas d'étude – Modèle AnimUML [2]

Instances Classes



- Static analysis (auto-fix) ⟸ **Or automatically**
  - Errors:
  - Warnings:

Can be applied individually

1. No class is specified for object bank.
   - Set class to Bank.
2. Class ATM of object atm not found.
   - Create class ATM.
3. Class User of object user not found.
   - Create class User.
4. No type is specified for connector connector_bank_atm between bank and atm.
   - Create new association.
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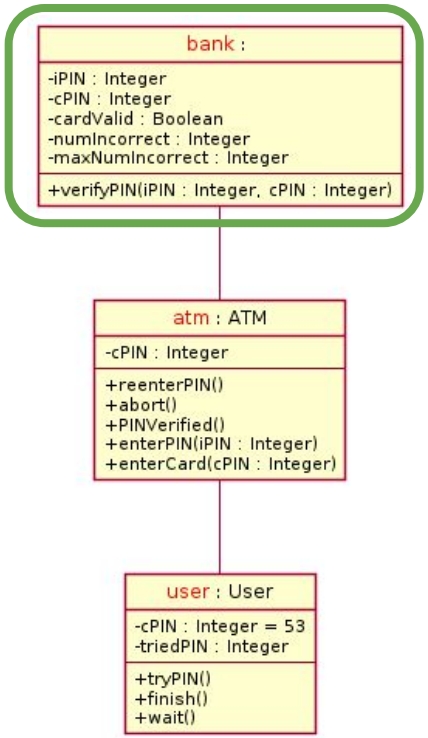
Cas d’étude – Modèle AnimUML corrigible

Instances Classes



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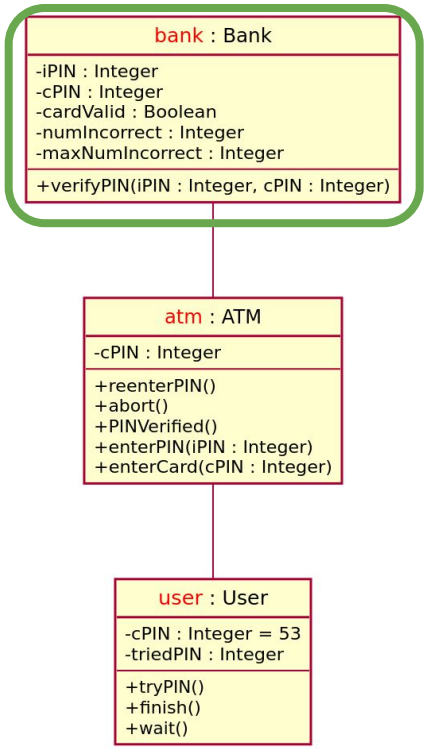

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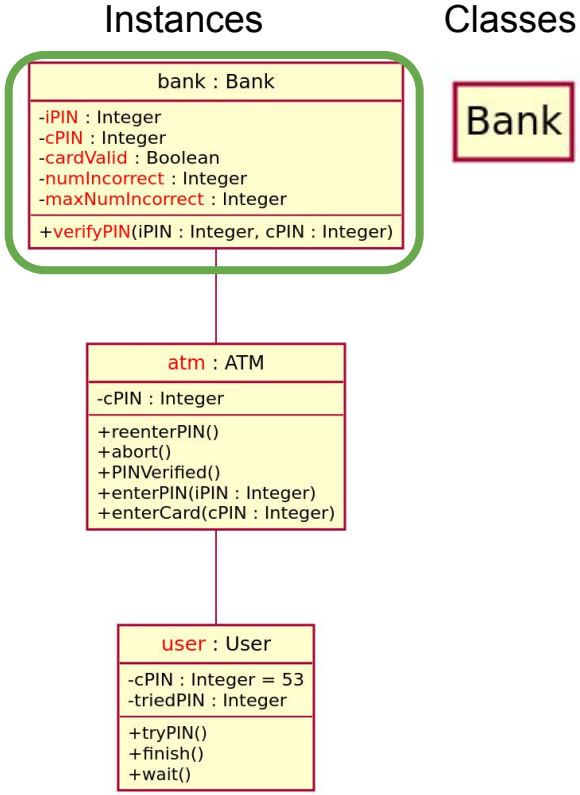

- Static analysis (auto-fix)
  - Errors:
  - Warnings:
    1. Property iPIN of object bank should rather be defined on its class.
       - Move property to class.
    2. Property cPIN of object bank should rather be defined on its class.
       - Move property to class.
    3. Property cardValid of object bank should rather be defined on its class.
       - Move property to class.
    4. Property numIncorrect of object bank should rather be defined on its class.
       - Move property to class.
    5. Property maxNumIncorrect of object bank should rather be defined on its class.
       - Move property to class.
    6. Operation verifyPIN of object bank should rather be defined on its class.
       - Move operation to class.
    7. Class ATM of object atm not found.
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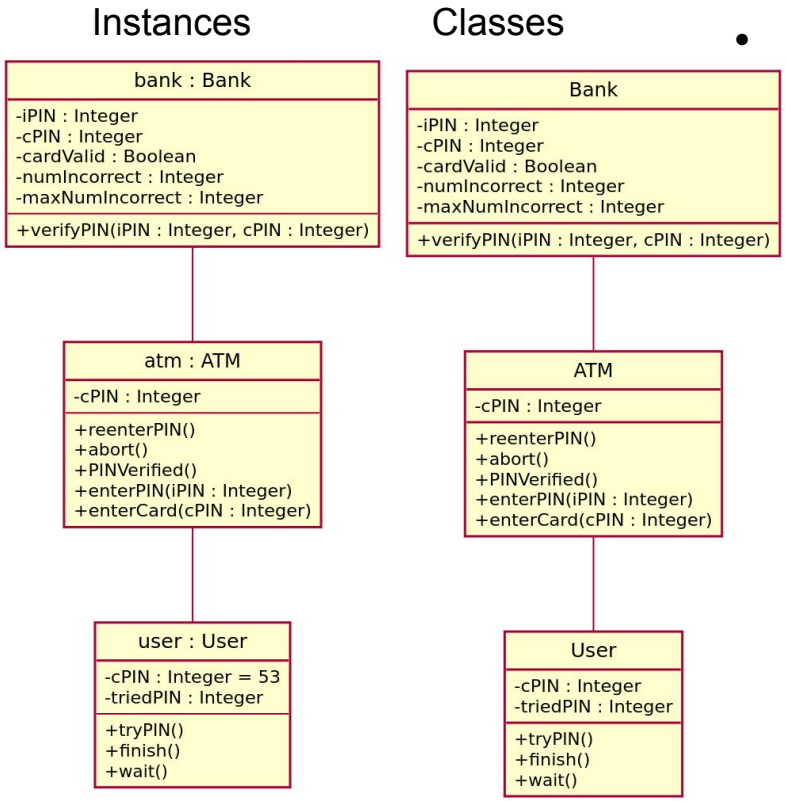

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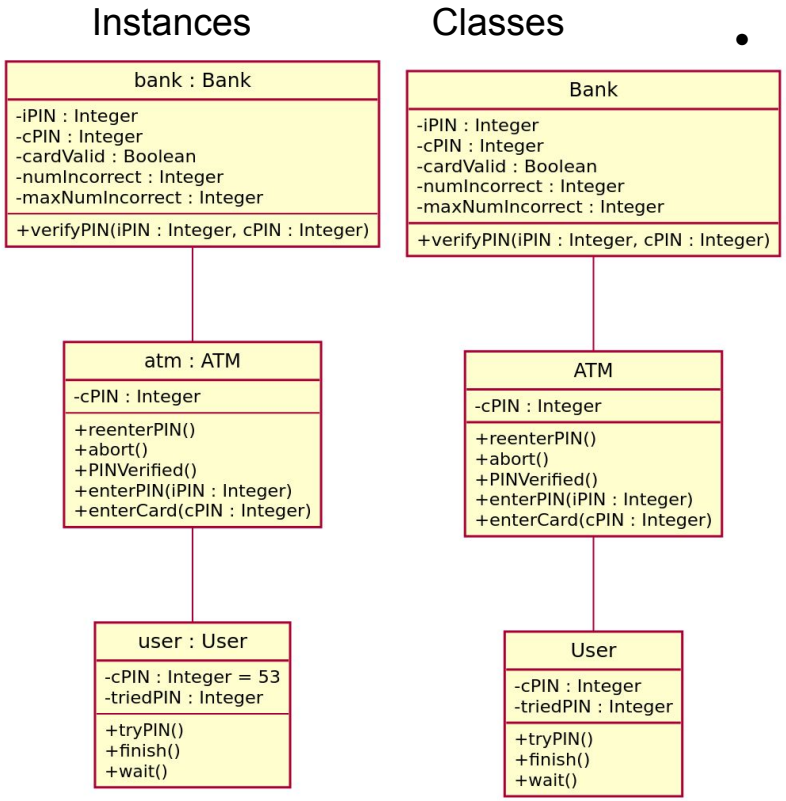
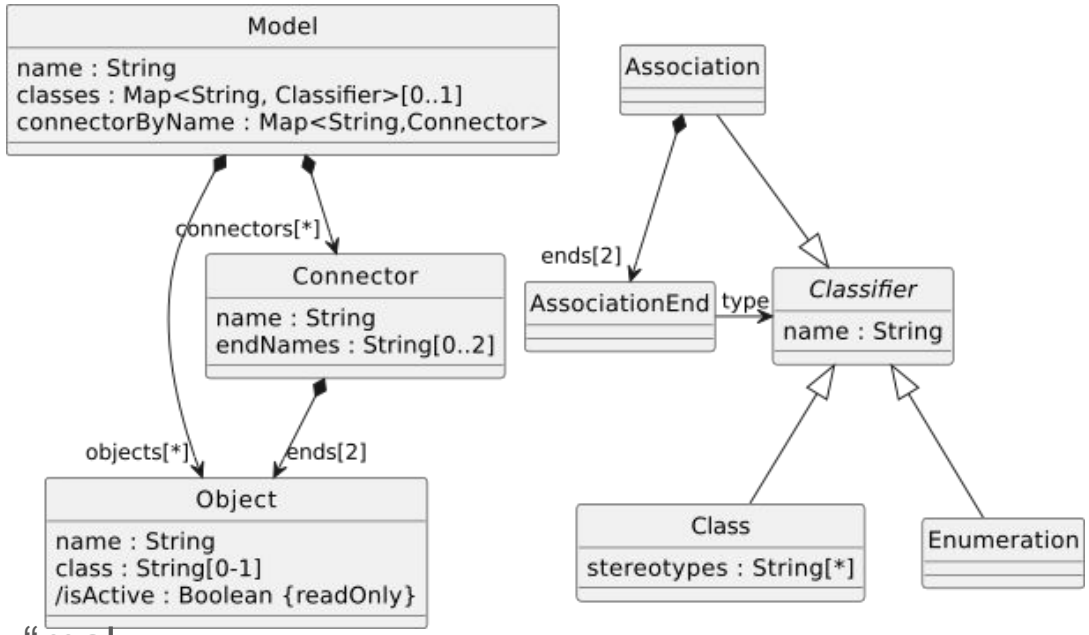


- Static analysis (auto-fix)
  - Errors:
  - Warnings:

- **Auto-fix** applique tous les correctifs et suggestions
  - Pas-à-pas automatiquement
  - Analyse du modèle à chaque modification
- Résultat ⇒ modèle corrigé et complété, conforme

Cas d'étude – Métamodèle AnimUML (extrait)



- Métamodèle UML partiel
  - e.g., permet objet avec nom de classe mais sans la classe correspondante

- Modèles conformes peuvent être "mal formés"
  - Object::class is optional
  - Model::classes may not contain all used values of Object::class
  - Model::connectors between objects may not have a counterpart Association between objects classes

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Cas d'étude – Analyse statique et Invariants OCL

```
context Object inv :
(not self.class.oclIsUndefined())
and not model.classes.get(self.class).oclIsUndefined()
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```
context Connector inv :
 let class_end0 : Classifier = model.classes.get( self.ends->get(0).class) in
 let class_end1 : Classifier = model.classes.get( self.ends->get(1).class) in
 not class_end0.oclIsUndefined()
 and not class_end1.oclIsUndefined()
and model.classes->select((clname,cl) | cl.oclIsTypeOf(Association)
 and (cl.ends->get(0).type = class_end0 and cl.ends->get(1).type =
   class_end1))->notEmpty()
```

Problématique

- Outillage et implémentation complexe et faillible
  - Construction de messages spécifiques requiert de décomposer les invariants
    - Complexité de la décomposition et réécriture
    - + Traçabilité des dépendances
  - Correctifs (quick-fixes) doivent être corrects
    - i.e., résoudre le problème à corriger
      - garantie difficile à prouver
      - sinon déroutant + difficulté à converger pour l'auto-fix
- Ressources limitées pour les éditeurs d'outils de modélisation
  - En particulier pour les outils académiques
- Solution ⇒ Création automatique des correctifs

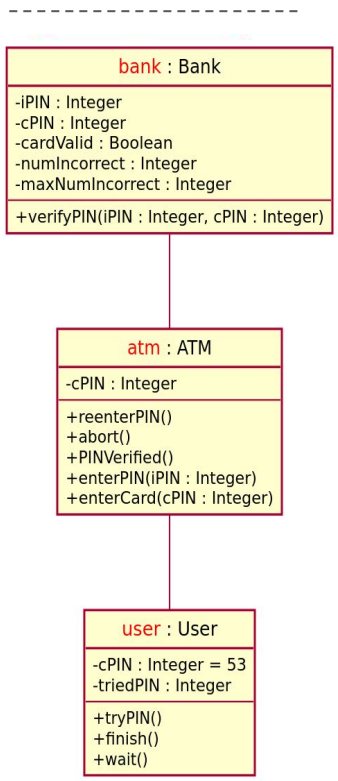
Approche

Génération automatique de correctifs basée sur les invariants OCL, par rétro-propagation

- Pour les développeurs (des outils de modélisation) :
  - Écriture de règles / contraintes pour vérifier la construction des modèles
  - Ajout d'annotations
    - Sévérité (*error*, *warning*)
    - Messages personnalisés plus pertinents
    - Guider la création automatique des correctifs
- Génération automatique des correctifs
  - Analyse des contraintes OCL
  - Rétro-propagation
  - Expertise développeur

Rétro-propagation – Exemple 1

```
context Object inv :
  (not self.class.oclIsUndefined())
  and not
  model.classes.get(self.class).oclIsUndefined()
```



For object *bank*

a = self	<object bank>	
b = self.class	OclUndefined	set to self.name.toUpper()
c = not b.oclIsUndefined()	false	true?
d = c and [...]	false	true?

Invariant OCL – Annotations

```
context Object inv :
 (not self.class.oclIsUndefined()) -- @severity: warning, @value:
self.name.firstToUpper()
 and not model.classes.get(self.class).oclIsUndefined() -- @severity:
warning, @value: Class.newInstance().refSetValue('name', propName)
```

Évaluation préliminaire

- Implémentation en JavaScript
  - opérateurs OCL ⇔ fonctions JS
  - Annotations
- Implémentation non-incrémentale
  - Réévaluation des règles à chaque correction
- Messages **générés** ou **fournis** par le développeur

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```
warning: class of object bank is undefined.
    set class of object bank to: Bank
warning: Bank of classes of model is undefined.
    set Bank of classes to: new class
warning: classes of model should include at least one
element satisfying "can type connector C1 between bank
: Bank and atm : ATM"
```

Conclusion

- Approche pour la définition et la génération de correctifs
  - Invariants OCL + annotations
  - Évaluée avec AnimUML
- Limites
  - Quelques opérateurs OCL évalués
  - Maîtrise du processus de rétro-propagation ?
  - Correction des *quick fixes*, quelles garanties ?
- Perspectives
  - Évaluation des opérateurs OCL non abordés, intégration d'un parser OCL ?
  - Expérimentation de l'approche sur d'autres langages de modélisation, avec un public moins expert…
  - Outils de modélisation : Interacteurs / Interactions ?

Merci de votre attention !

Questions?