VALIDATION & VERIFICATION

INTEGRATION TESTING

UNIVERSITY OF RENNES, ISTIC & ESIR, 2024-2025

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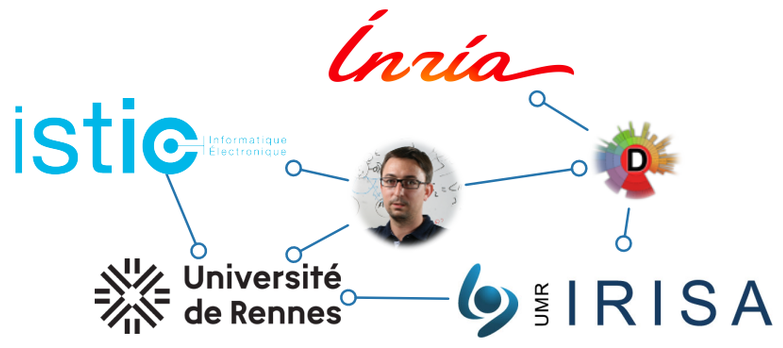


Plan

1. Introduction au test d'intégration

2. Mise en œuvre des mock avec EasyMock et Mockito

Plan

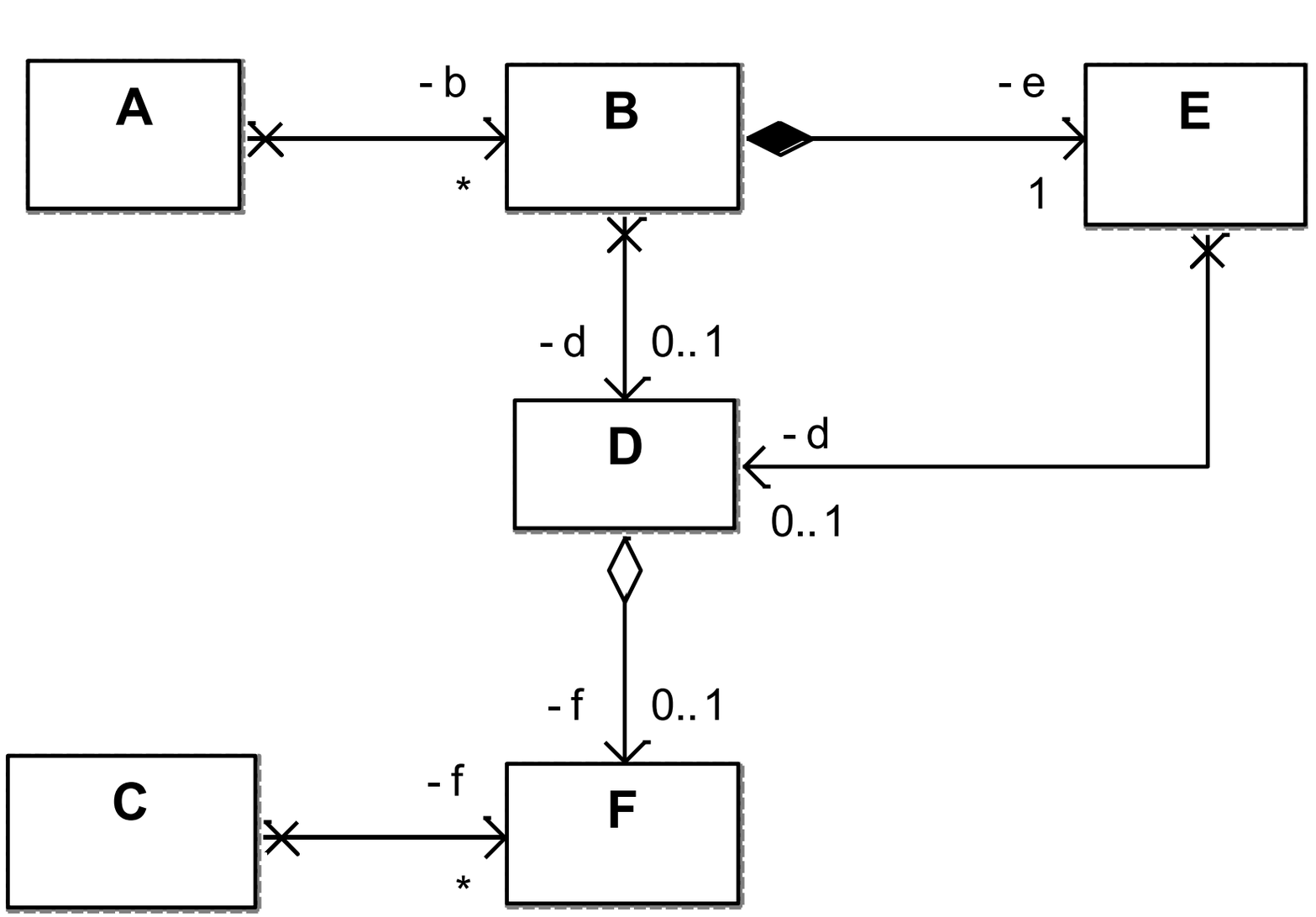
1. Introduction au test d'intégration

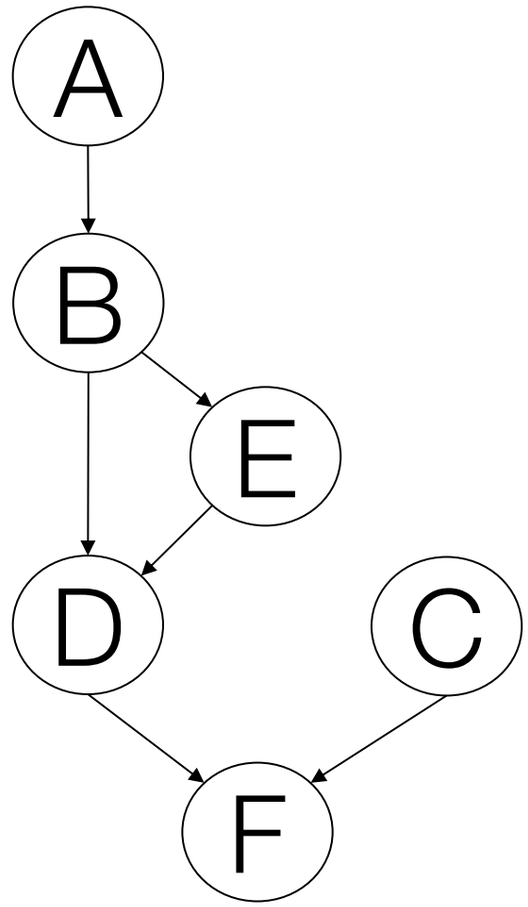
2. Mise en œuvre des mock avec EasyMock et Mockito

Intégration

- But : tester les interactions entre classes
- Lien entre test d'intégration et unitaire:
  - il faut ordonner les classes pour le test
- Il faut identifier les dépendances entre classes
  - Problème dans le cas de cycles de dépendances

Cas simple : un graphe acyclique

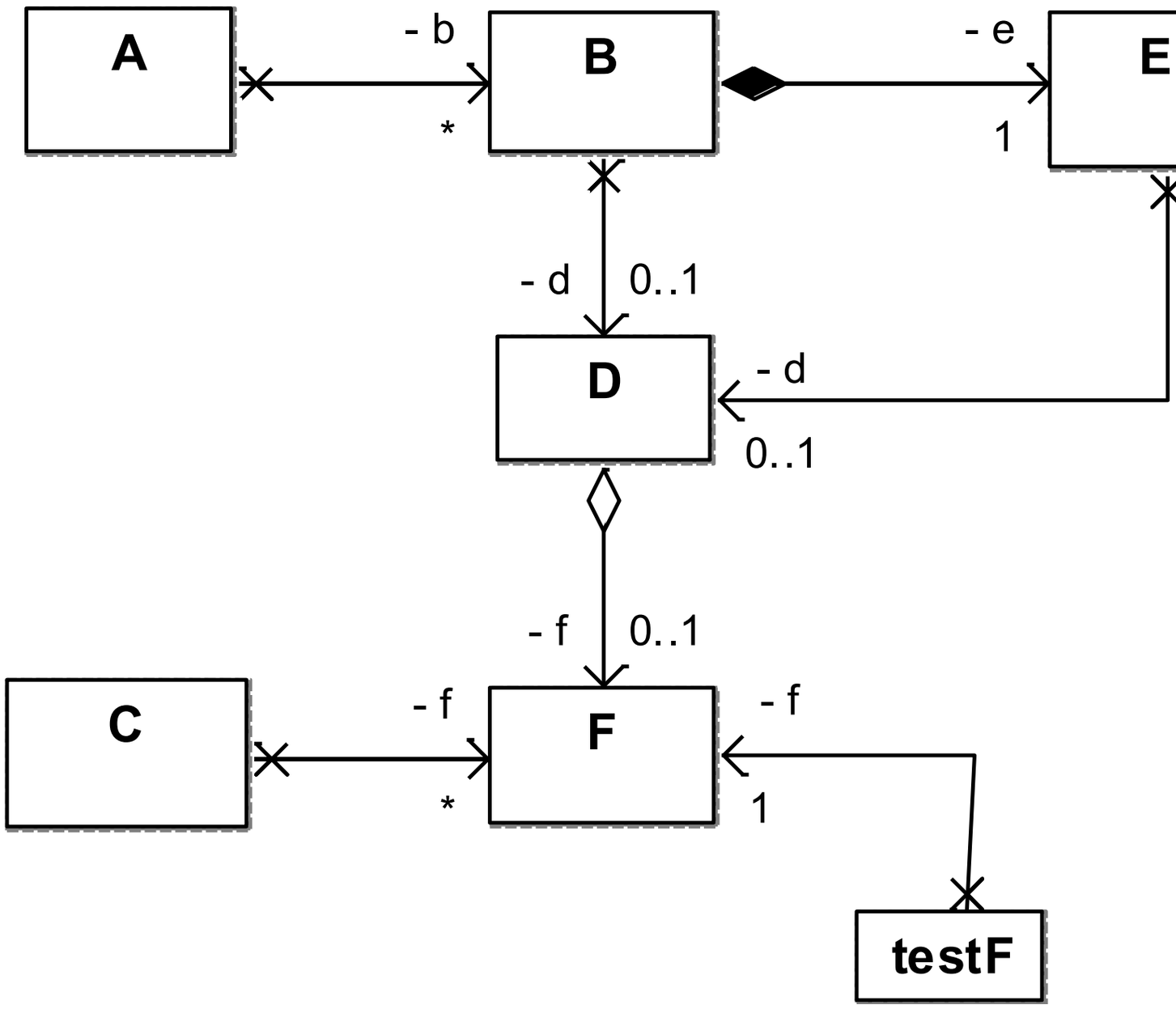




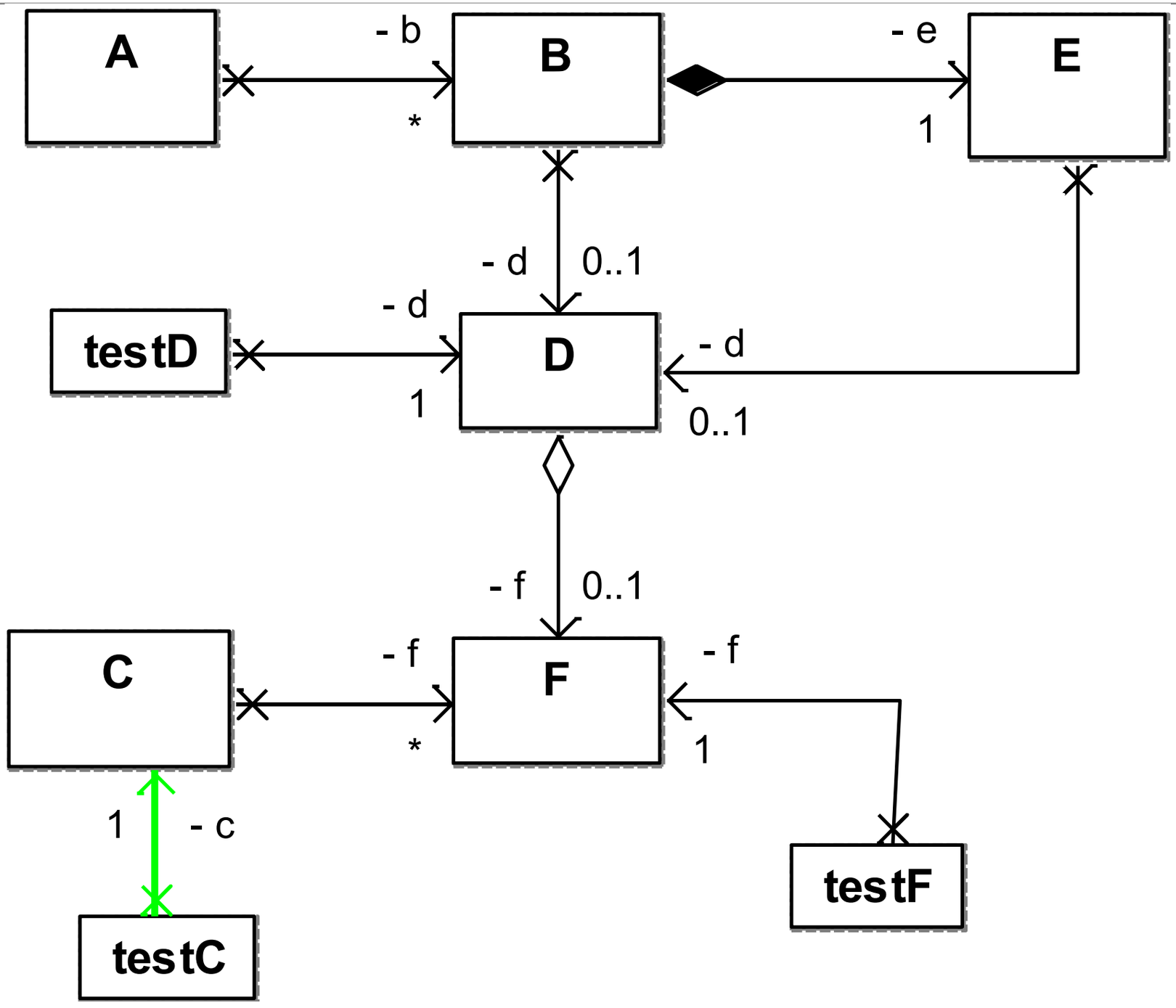
Graphe de dépendances acyclique

Ordre partiel pour le test: F, (C, D), E, B, A

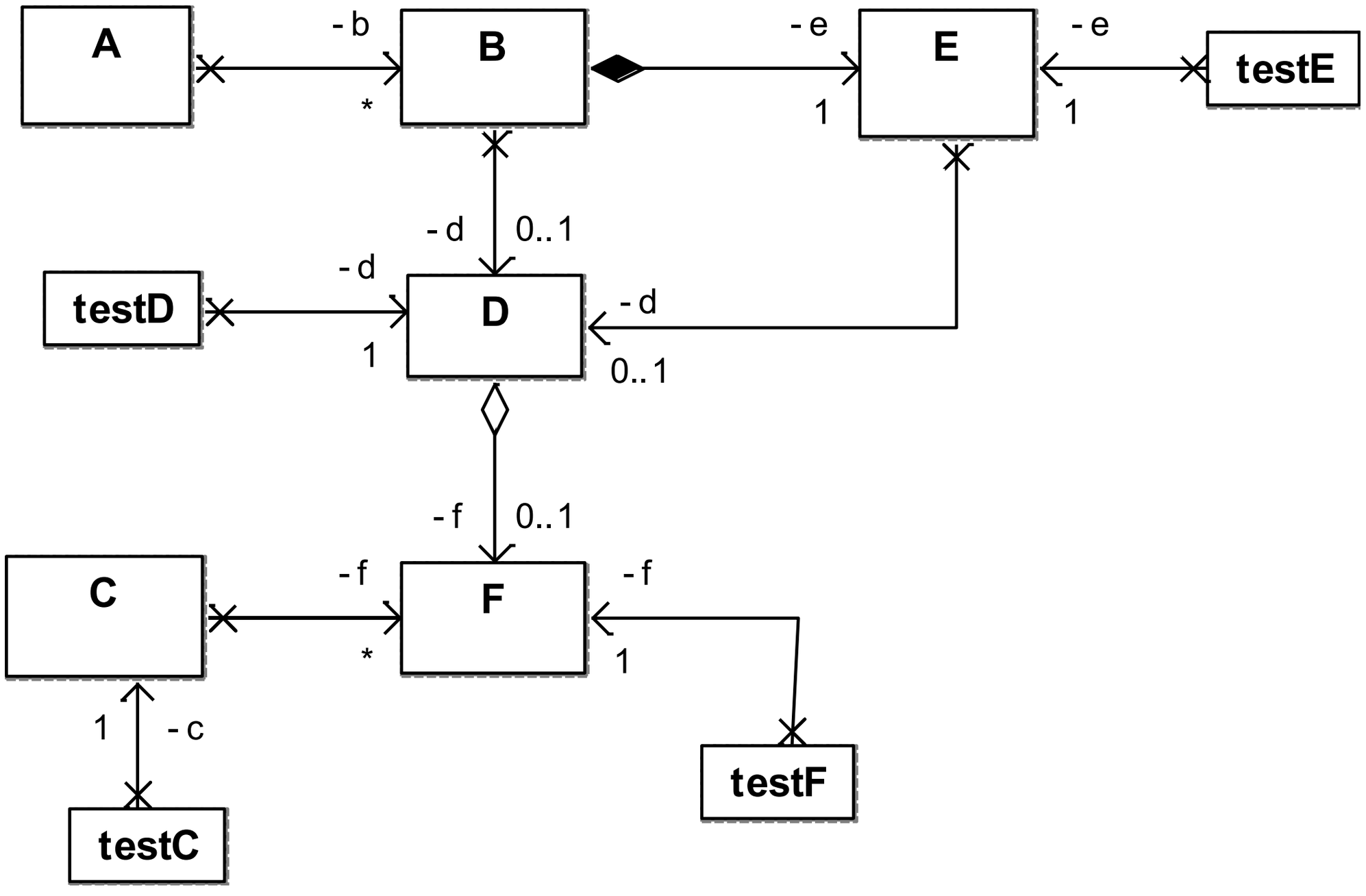
Étape 1



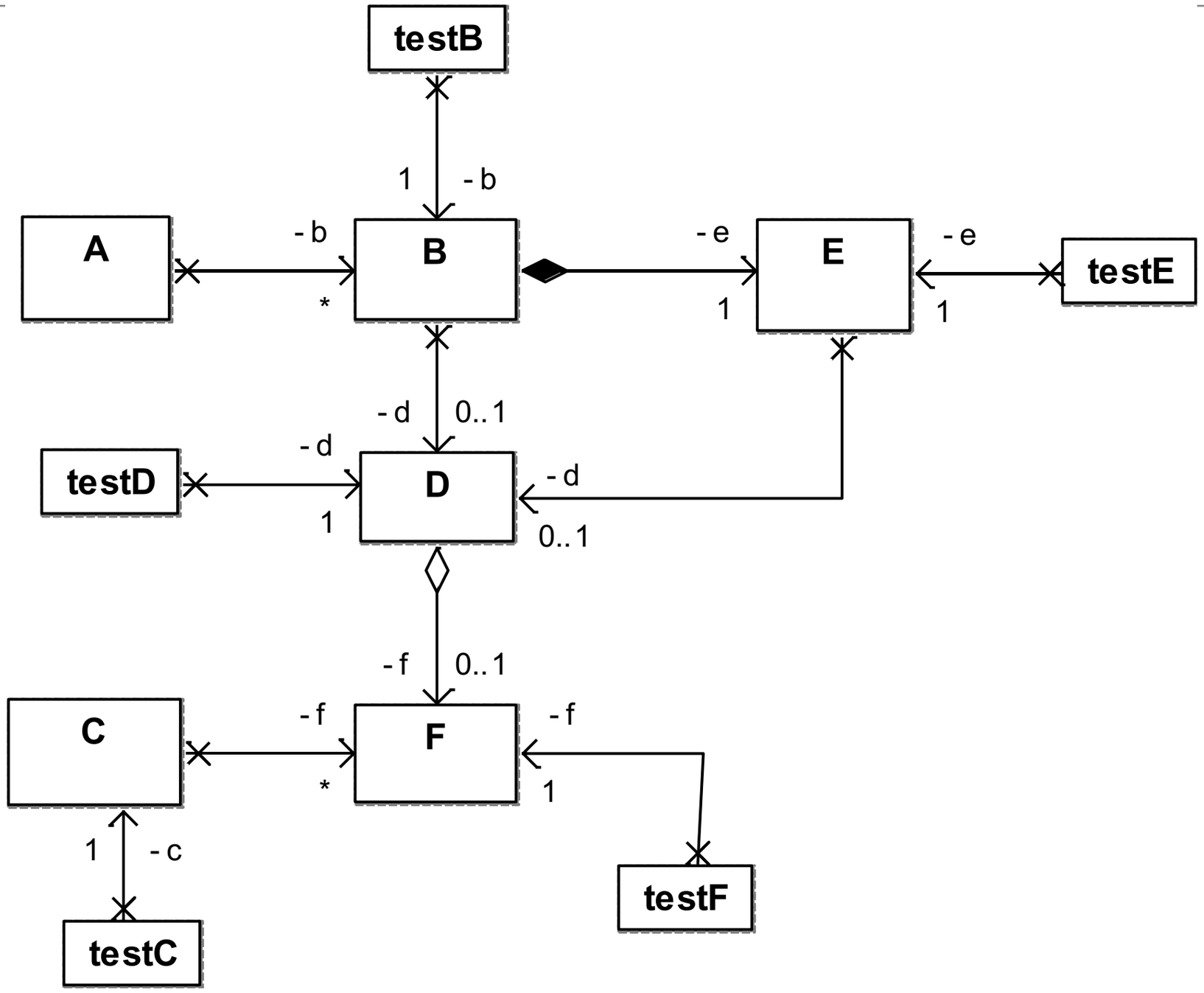
Étape 2



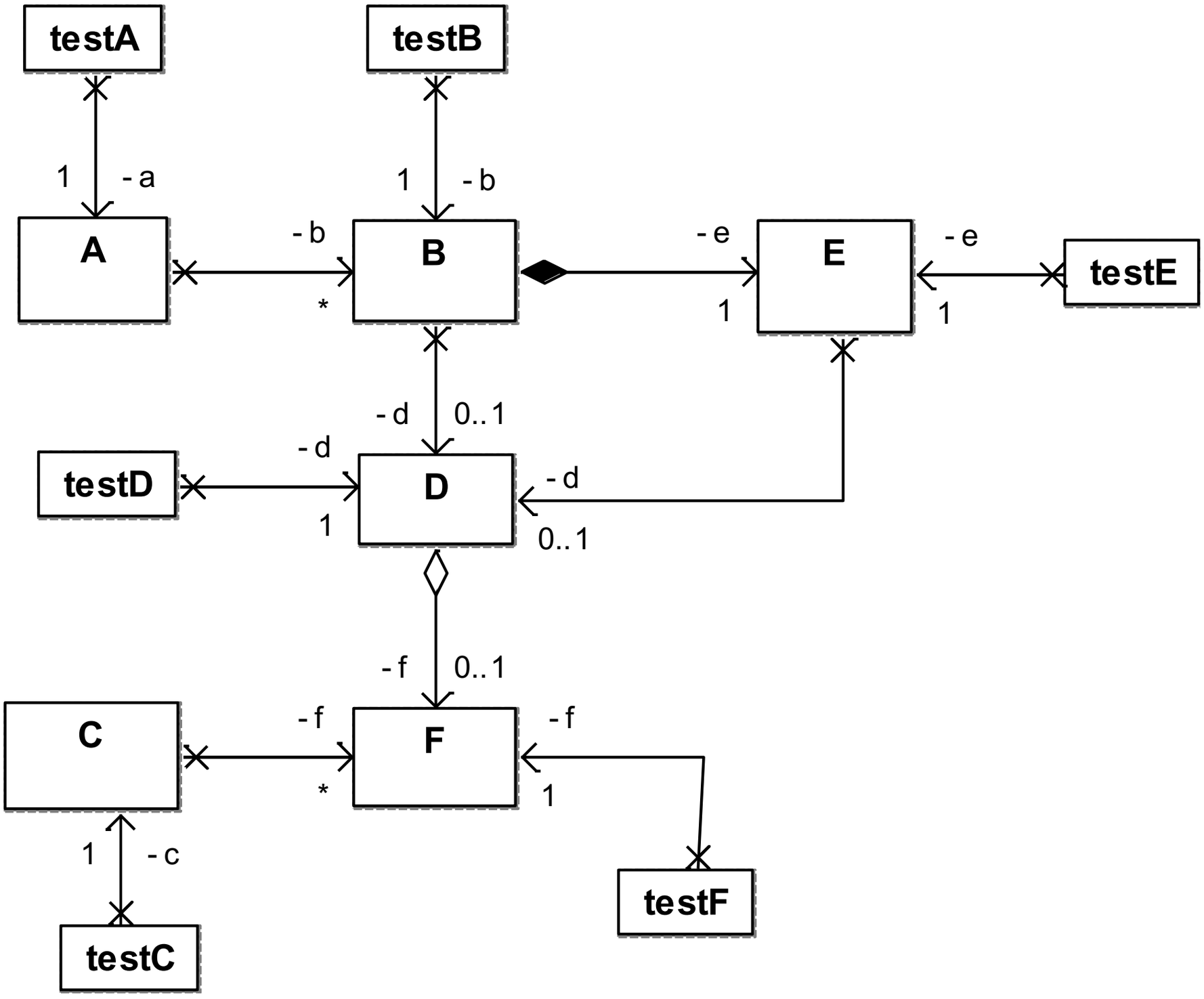
Étape 3



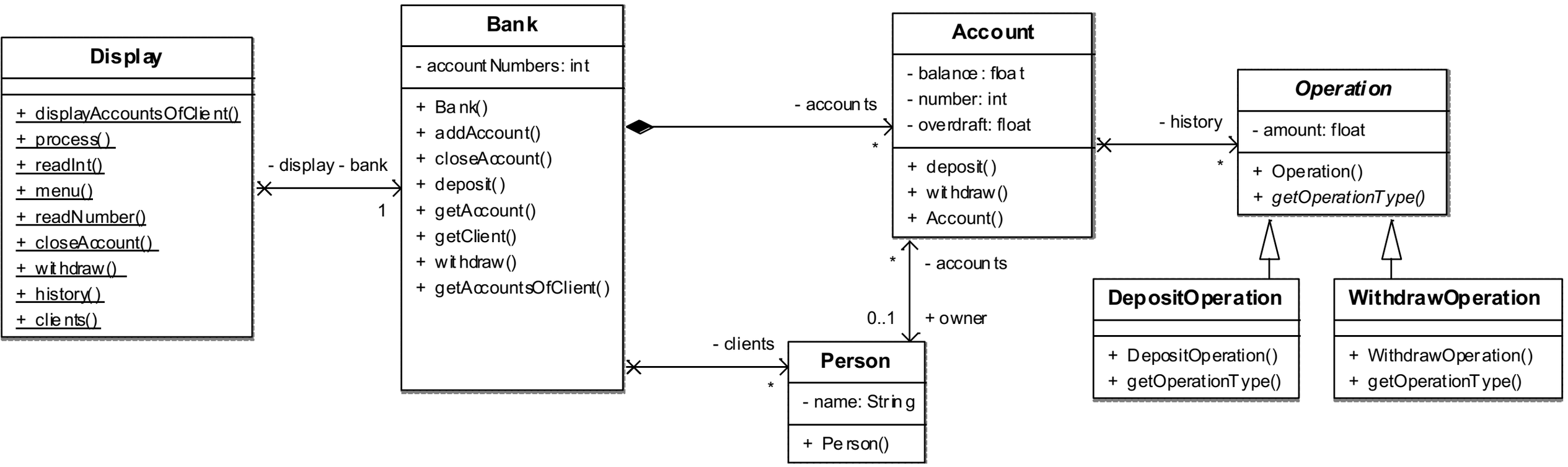
Étape 4

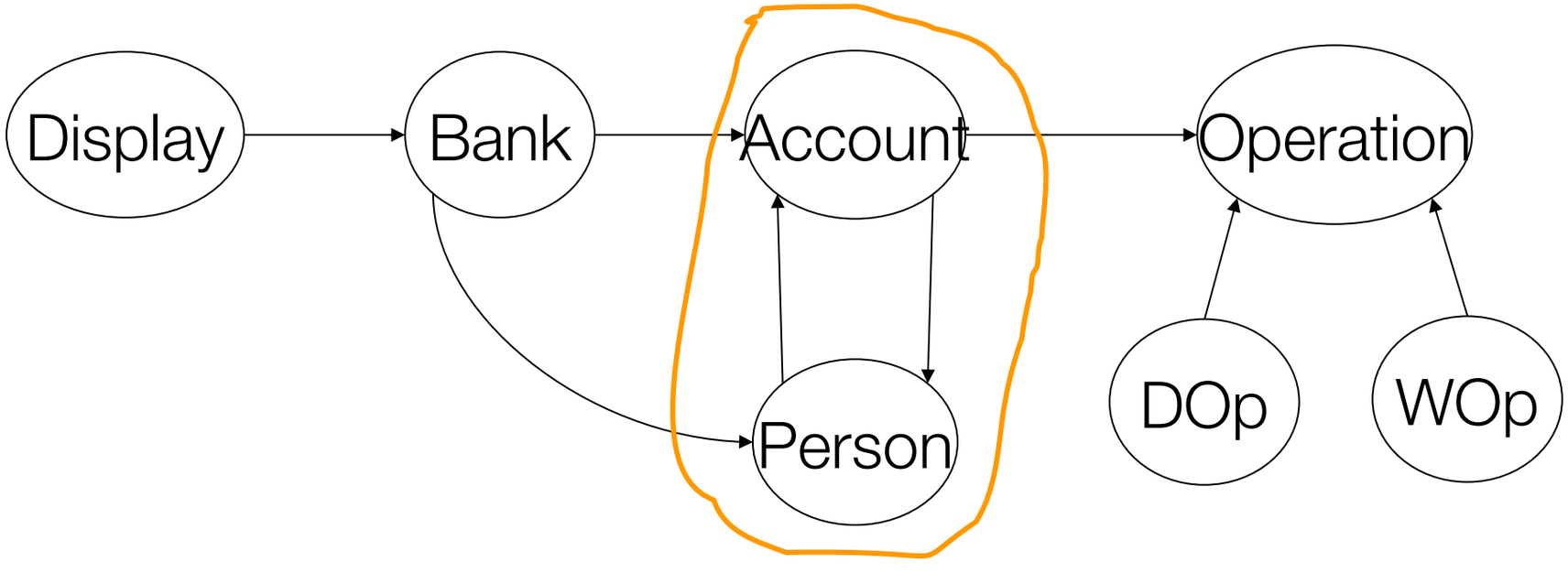

testB
1
- b
A
- b
*
B
- e
1
E
- e
1
testE
- d
0..1
testD
- d
1
D
- d
0..1
- f
0..1
C
- f
*
F
- f
1
1
- c
testC
testF

Étape 5


testA
testB
1
- a
1
- b
A
- b
*
B
- e
1
E
- e
1
testE
- d
0..1
- d
testD
1
D
- d
0..1
- f
0..1
C
- f
*
F
- f
1
1
- c
testC
testF

Cas moins simple: présence de cycles





Intégration avec cycles

- Il faut casser les cycles
  - développer des simulateurs de classes (« bouchon de test » ou « stub »)
    - un simulateur a la même interface que la classe simulée, mais a un comportement contrôlé
- Exemple

Exemples de stub

```
/**
 * Creates an account for the person named name
 * If no client has this name, a new client object is created and is added to the list of clients, then the account is created
 * If the client exists the account is created, added to the bank's and the client's list of accounts
 */
public int addAccount(String name, float amount, float overdraft) {
		this.accountNumbers++;
		Person p = getClient(name);
		//if a client named name already exists in the bank's set of clients
		if (p!=null){
			Account a = new Account(p, amount, overdraft, accountNumbers);
			p.addAccounts(a);
			this.addAccounts(a);
		}
		//if the client does not exist, add it tp the bank's list of clients and create account
		else{
			Person client = new Person(name);
			this.addClients(client);
			Account a = new Account(client, amount, overdraft, accountNumbers);
			client.addAccounts(a);
			this.addAccounts(a);
		}
		return accountNumbers;
}
```

Exemples de stub

Stub 1

```
/**
 * Creates an account for the person named name
 * If no client has this name, a new client object is created and is
 * added to the list of clients, then the account is created
 * If the client exists the account is created, added to the bank's and the client's list of accounts
 */
 public int addAccount(String name, float amount, float overdraft) {
        return 1;
 }
```

Stub 2

```
/**
 * Creates an account for the person named name
 * If no client has this name, a new client object is created and is
 * added to the list of clients, then the account is created
 * If the client exists the account is created, added to the bank's and the client's list of accounts
 */
public int addAccount(String name, float amount, float overdraft) {
        return 10000000;
}
```

Exemples de stub

```
/**
 * Looks for a person named name in the set of clients.
 * Returns the Person object corresponding to the client if it exists
 * Returns null if there is no client named name
 */
public Person getClient(String name) {
        Iterator it = this.clientsIterator();
        while (it.hasNext()){
                Person p = (Person)it.next();
                if(p.getName()==name){
                        return p;
                }

        }
        return null;
}
```

Exemples de stub

Stub 1

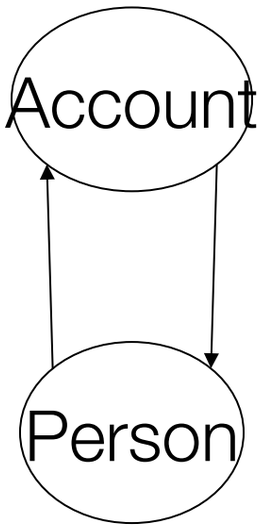
```
/**
 * Looks for a person named name in the set of clients.
 * Returns the Person object corresponding to the client if it exists
 * Returns null if there is no client named name
 */
public Person getClient(String name) {
        return null;
}
```

Stub 2

```
/**
 * Looks for a person named name in the set of clients.
 * Returns the Person object corresponding to the client if it exists
 * Returns null if there is no client named name
 */
public Person getClient(String name) {
        return new Person(“toto”);
}
```

Exemple Banque

- Exemple, pour tester en présence de ce cycle



Regarder quelles sont les méthodes de Person utilisées par Account

```
public class Person {
   /*
    * Initializes the name of the person with the param n
    * Creates a new vector to intialize the acounts set
    */
   public Person(String n){
      name = n;
      accounts = new Vector(); }

   public String getName(){return name;}
}
```

Stub de la classe Person

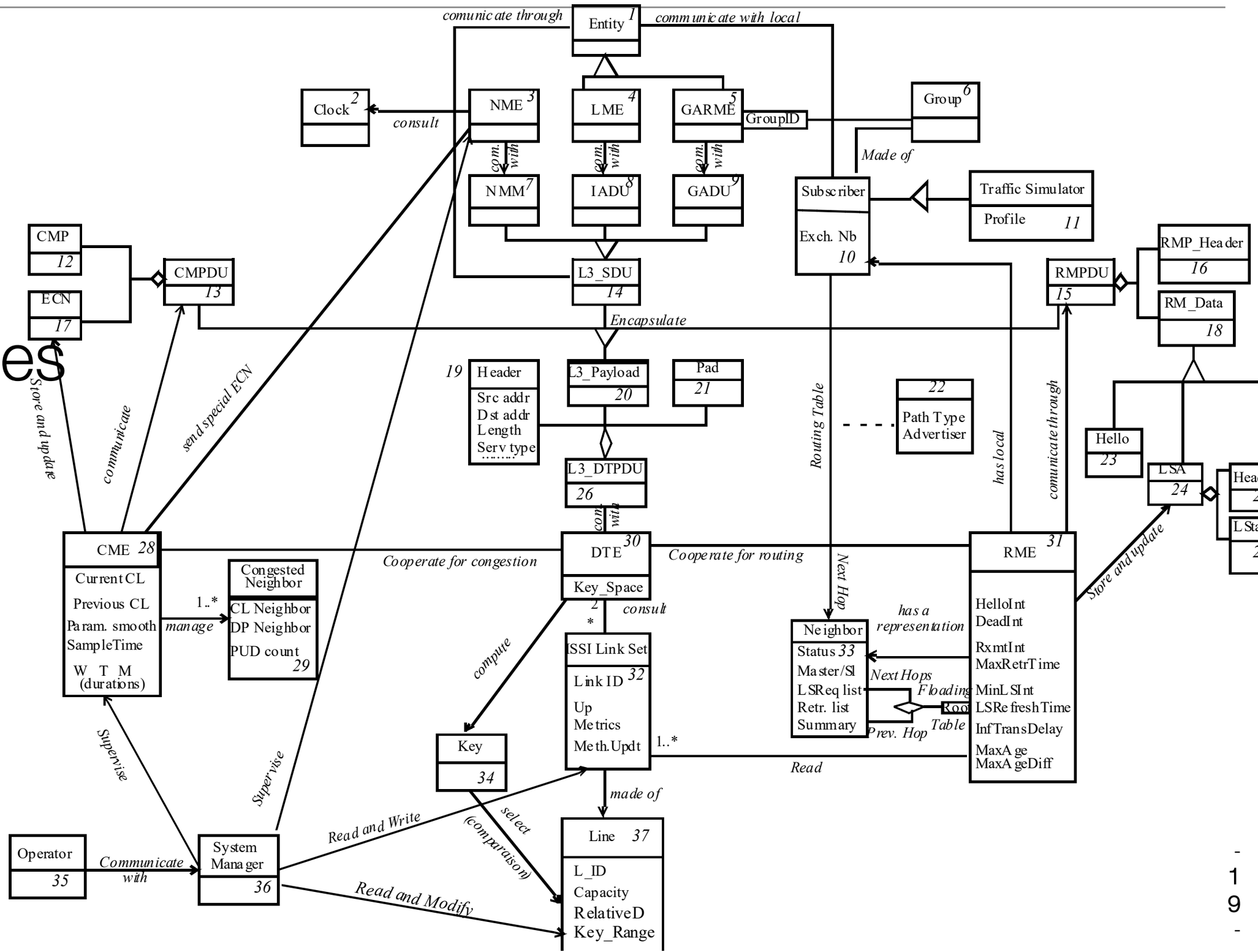
```
public class Person {
   /*
    * Initializes the name of the person with the param n
    * Creates a new vector to initialize the accounts set
    */
   public Person(String n){ }

   public String getName(){return (“toto”);}
}
```

Exemple Banque

- Etape 1
  - Tester la classe Account avec le stub de Person
- Etape 2
  - Tester la classe Person avec Account
- Etape 3
  - Retester la classe Account avec la vraie classe Person

Cas encore moins simple

37 classes



Cas encore moins simple

- Contraintes sur la conception
  - pas d'interdépendances
  - contrainte forte dans un cadre OO
- Sans contraintes sur la conception
  - on intègre tout d'un coup: stratégie « big bang »
  - heuristique pour prendre en compte les interdépendances au moment de l'intégration

Une stratégie efficace pour l'ordre d'intégration

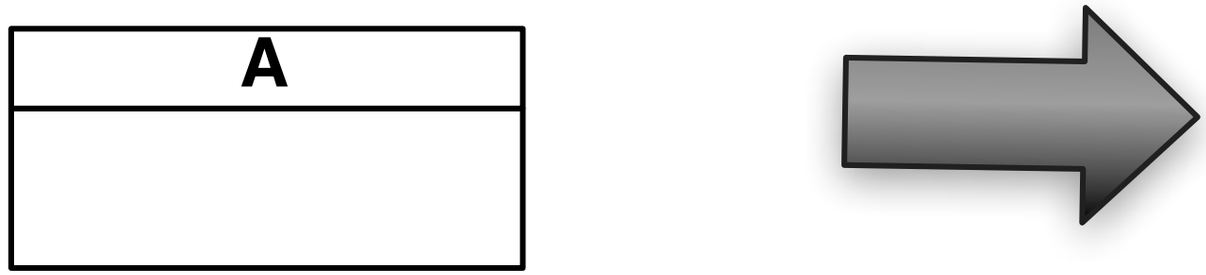
- Basée sur un modèle de graphe: graphe de dépendances de test (GDT)
- Deux types de dépendances
  - héritage
  - client/serveur
- Dépendances
  - classe – classe
  - méthode – classe

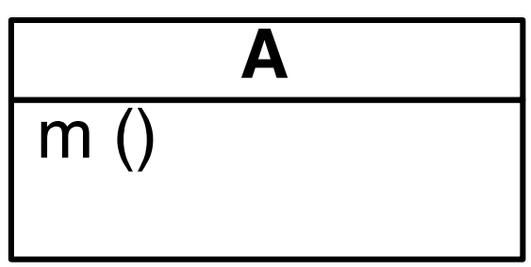
Transformation UML vers GDT

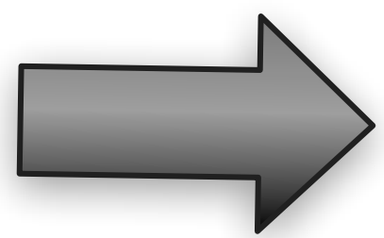
2 types of nodes

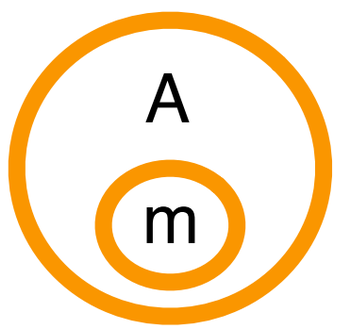
– class

– method





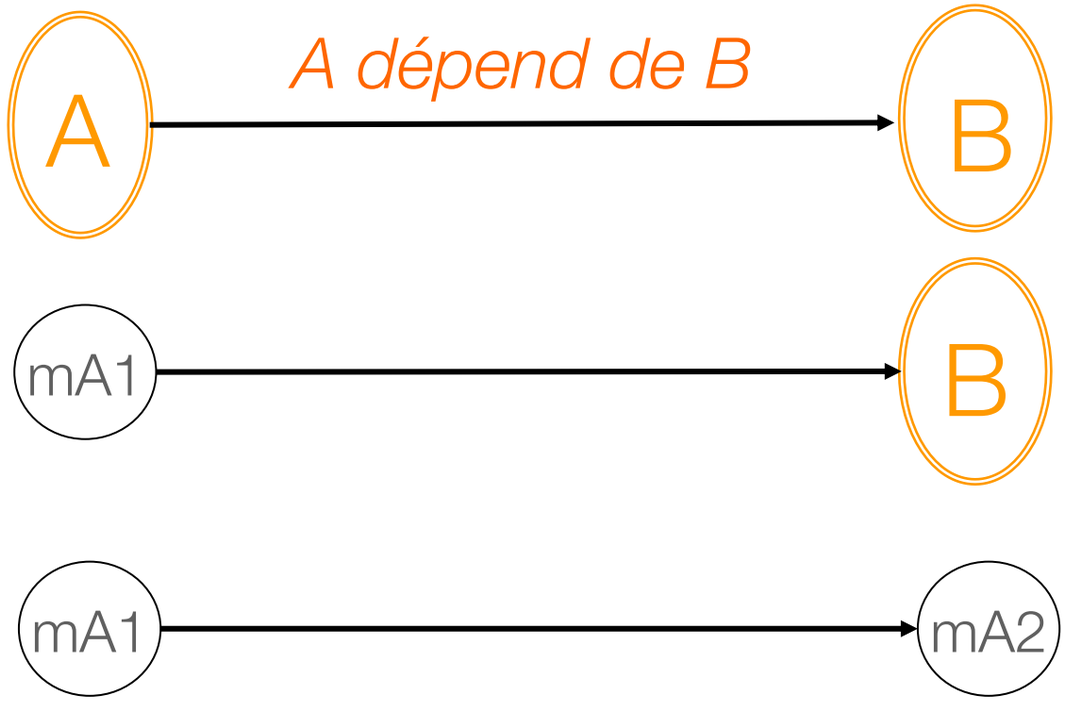




Transformation UML vers GDT

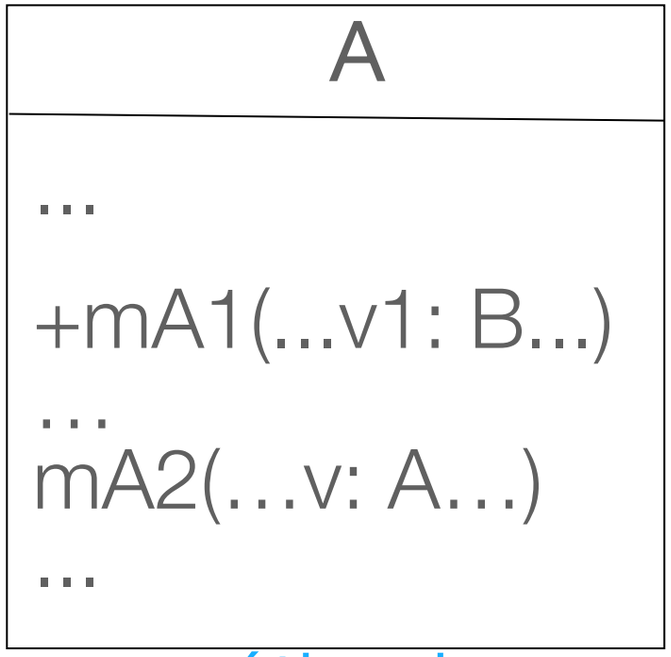
3 types d'arcs

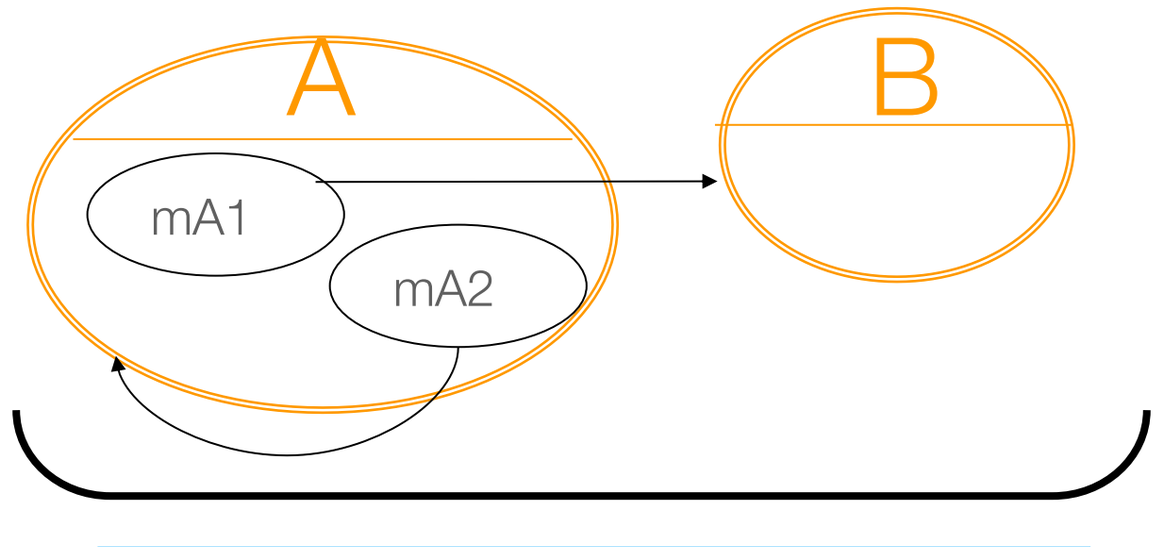
- class_to_class
- method_to_class
- method_to_method



Transformation UML vers GDT

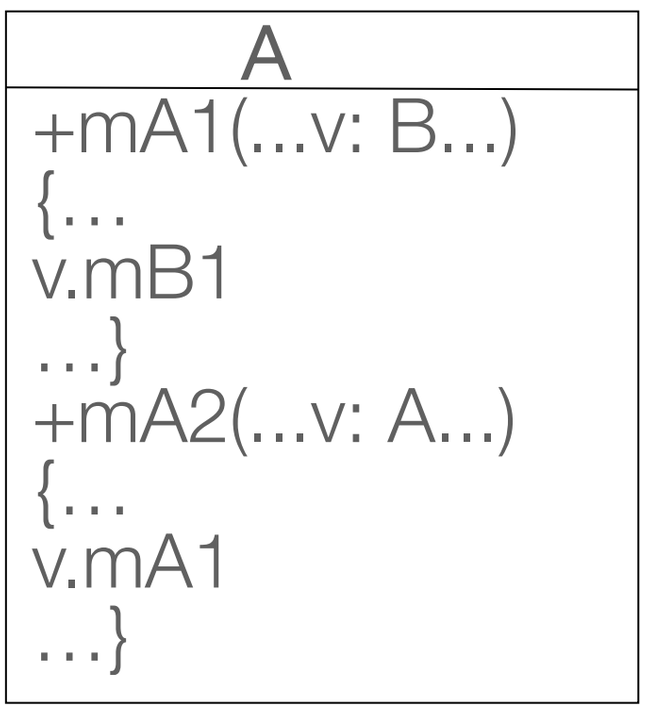
Méthode vers classe

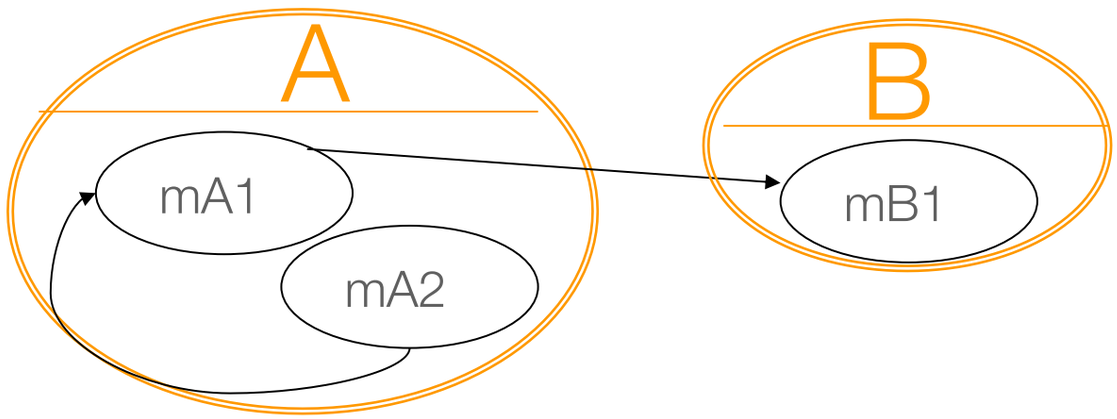




raffinement

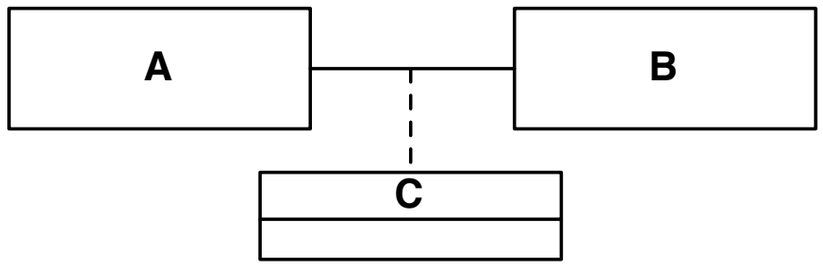
Méthode vers méthode

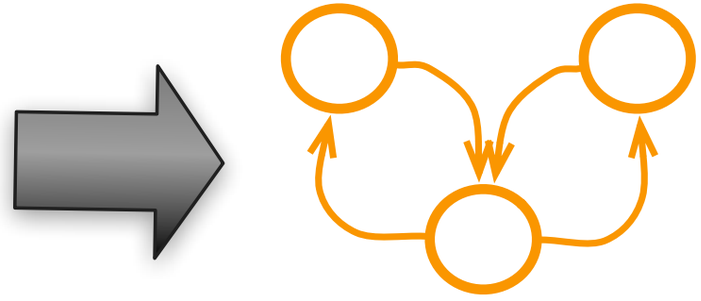


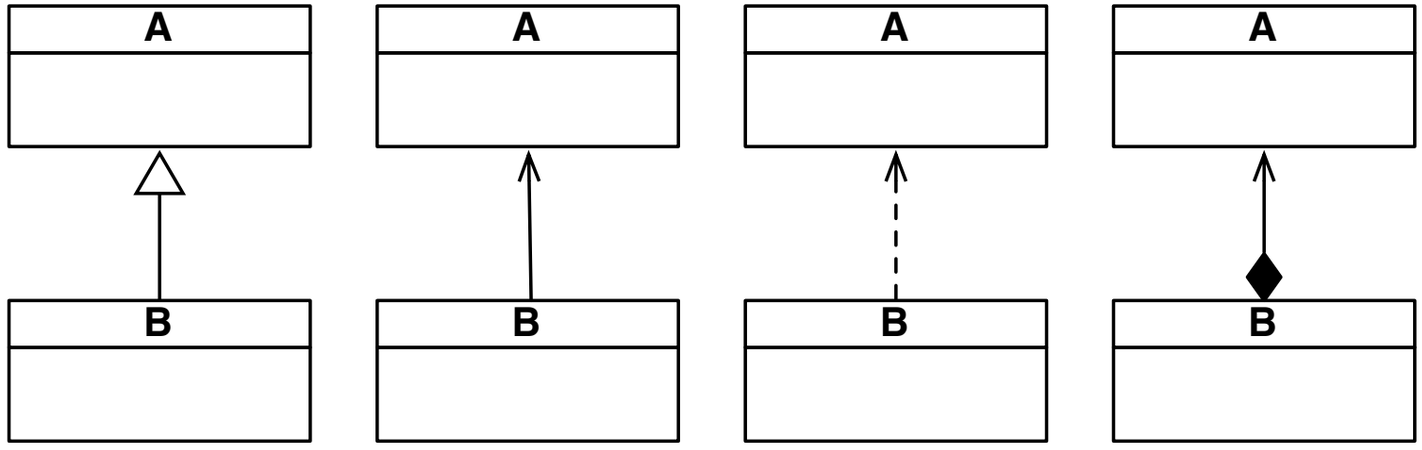


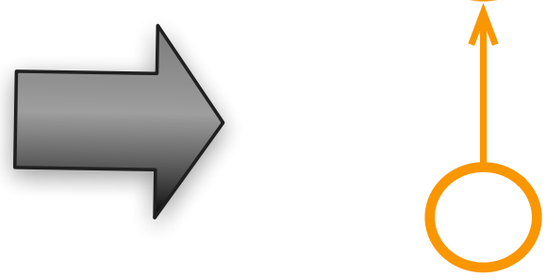
Langage d'action (AS / OCL ...)

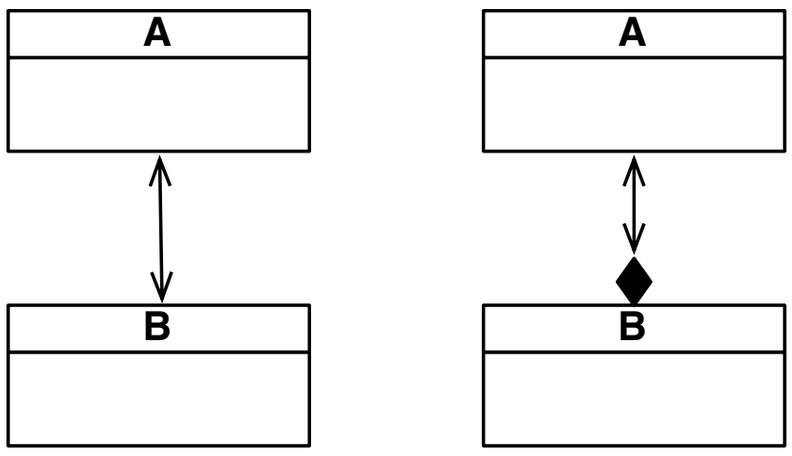
Transformation UML vers GDT



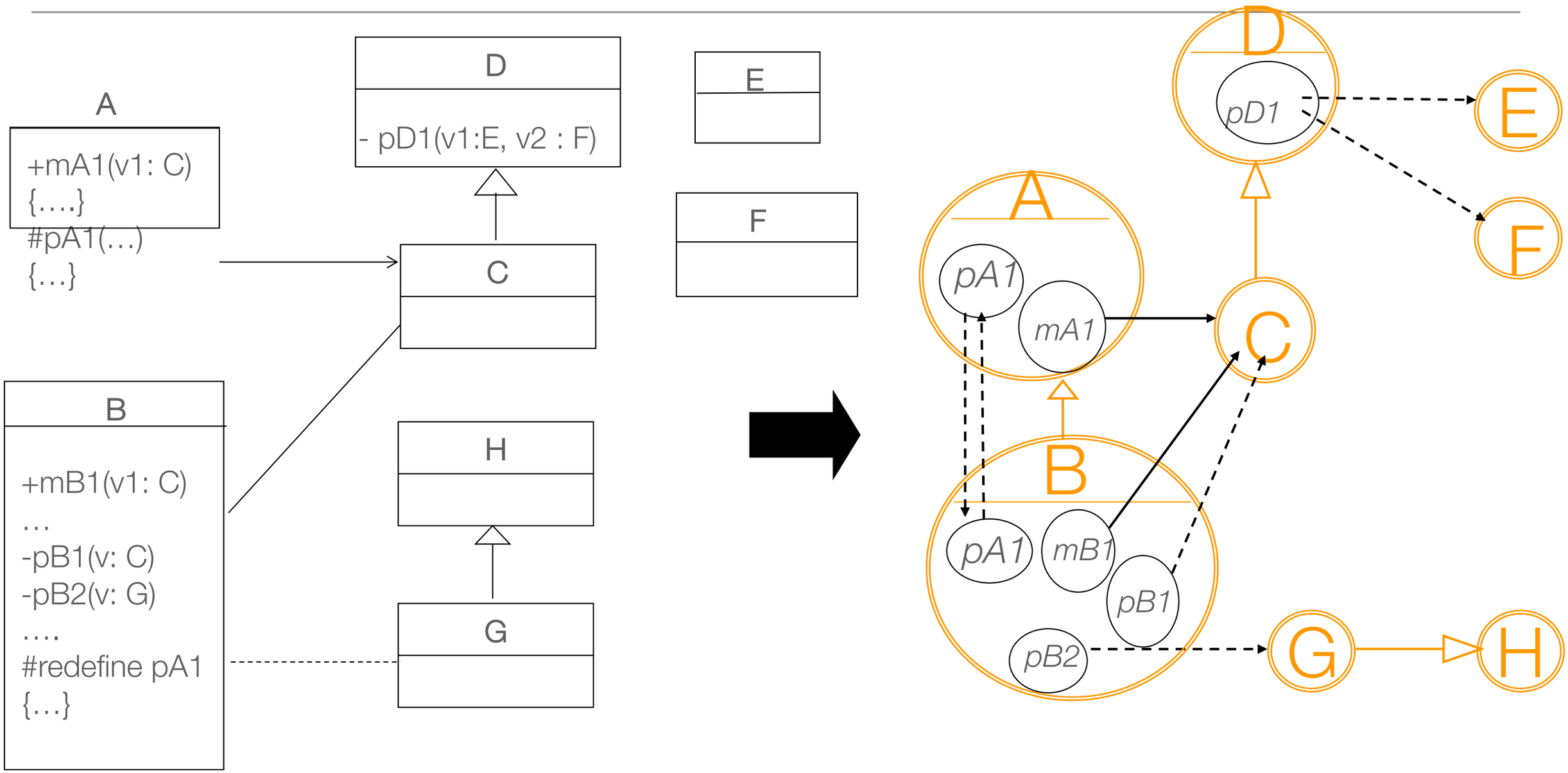




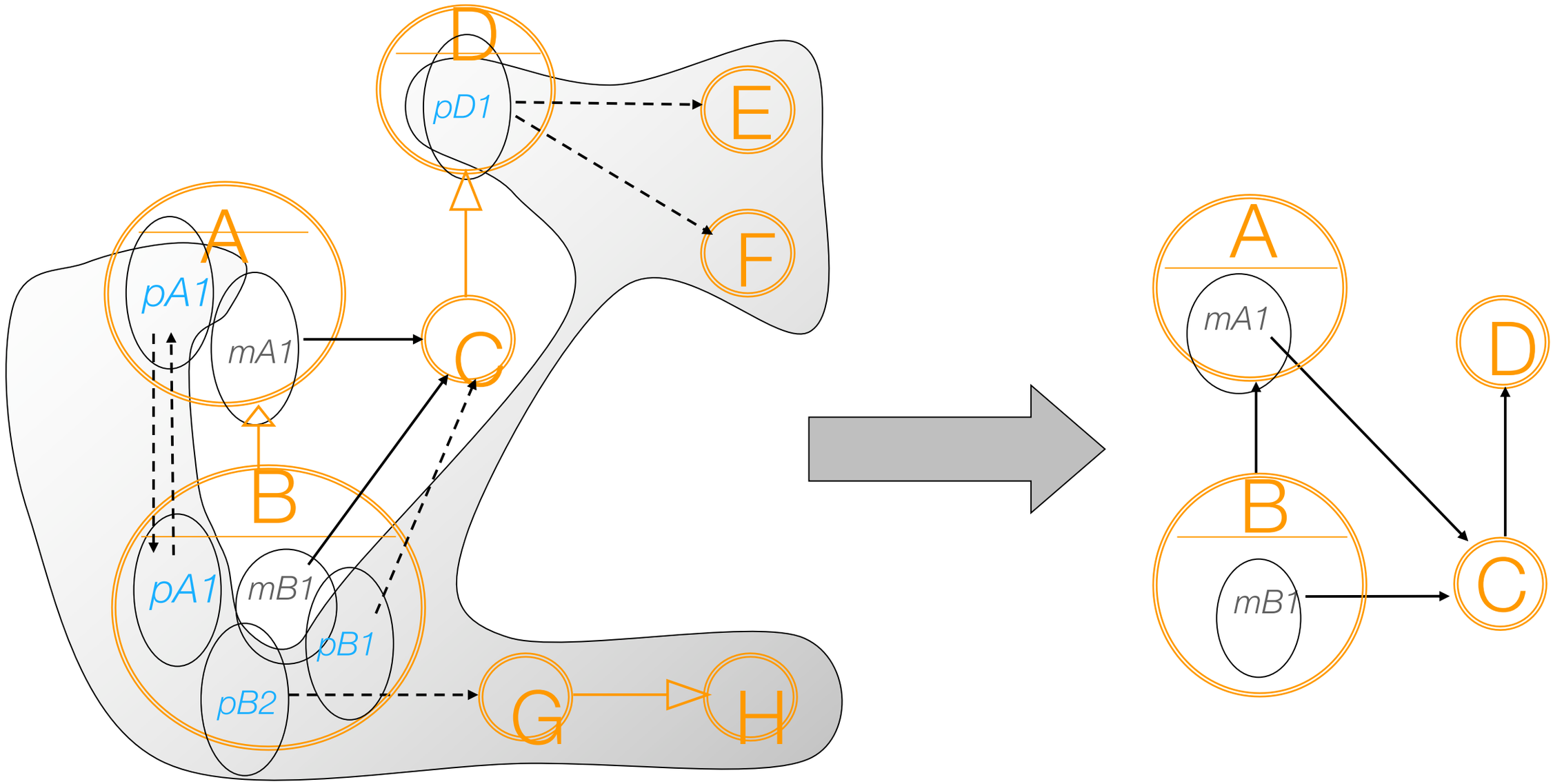




Transformation UML vers GDT



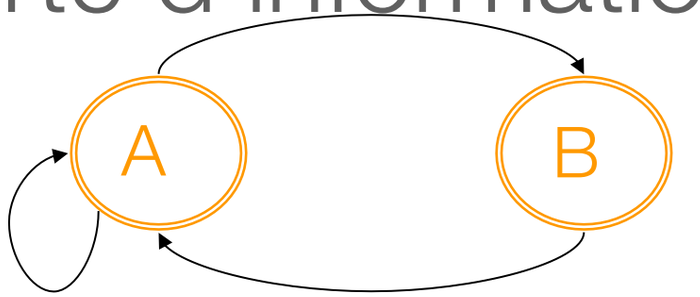
Transformation UML vers GDT



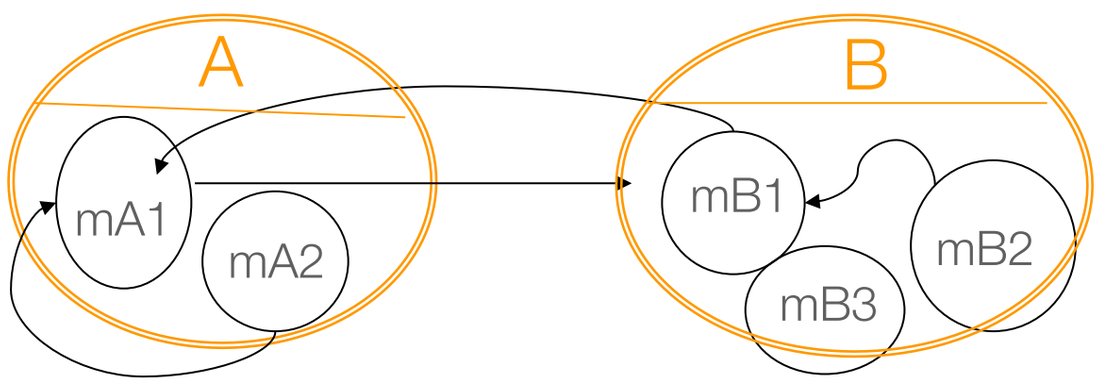
Supprimer les dépendances spécifiques à l'implantation

Transformation UML vers GDT

Perte d'information



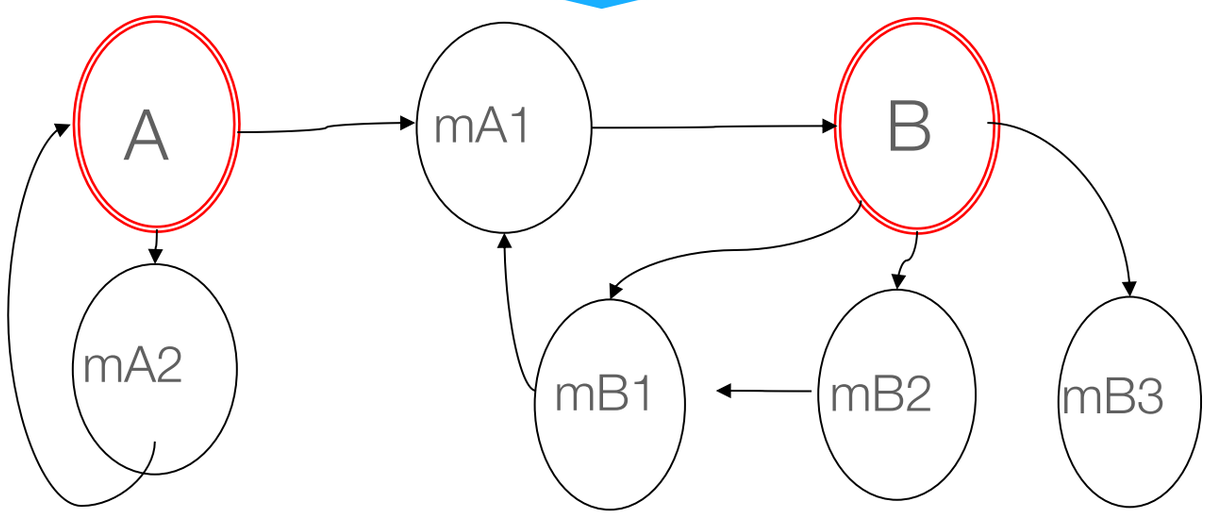
Pas un graphe classique



solution 1

solution 2

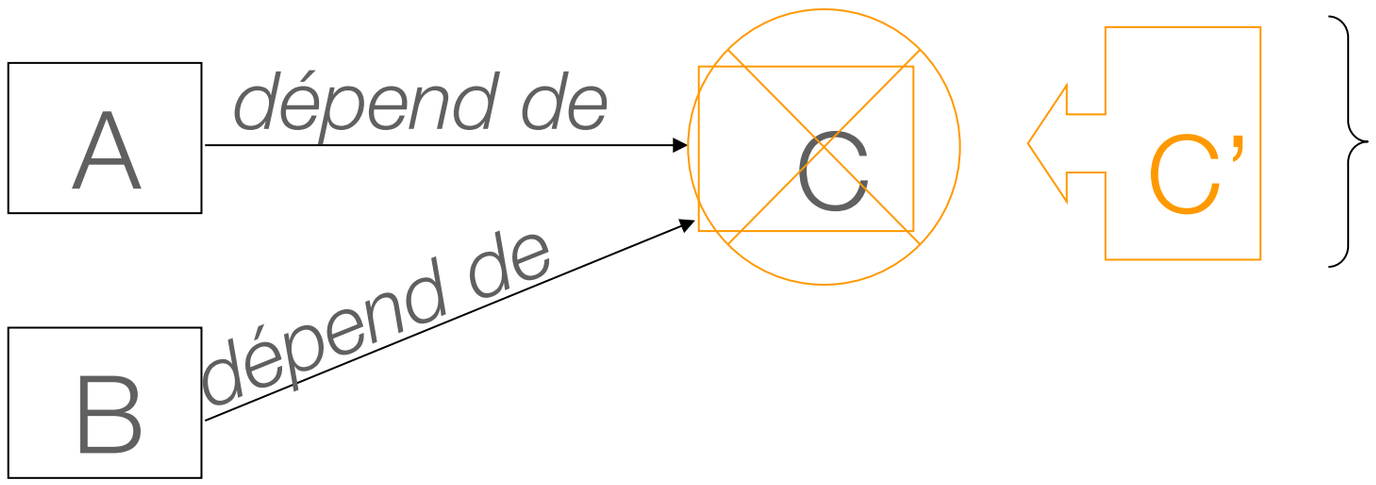
homomorphisme



Pas de perte d'information

Une stratégie efficace pour l'ordre d'intégration

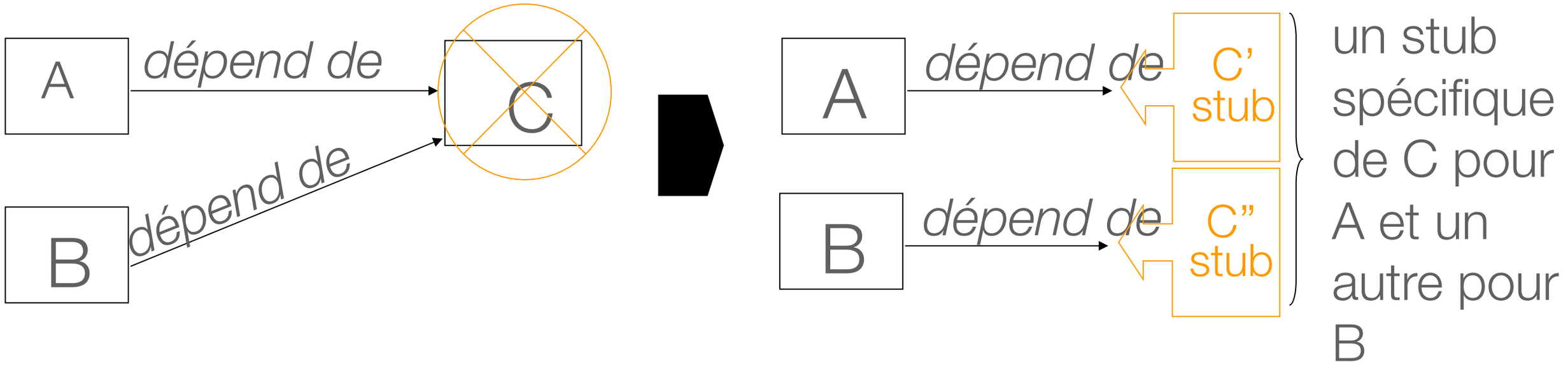
- Comment choisir un ordre d'intégration à partir du GDT?
  - Minimiser le nombre de stubs à écrire
  - stub réaliste => simule tous les comportements (réutiliser une ancienne version du composant)



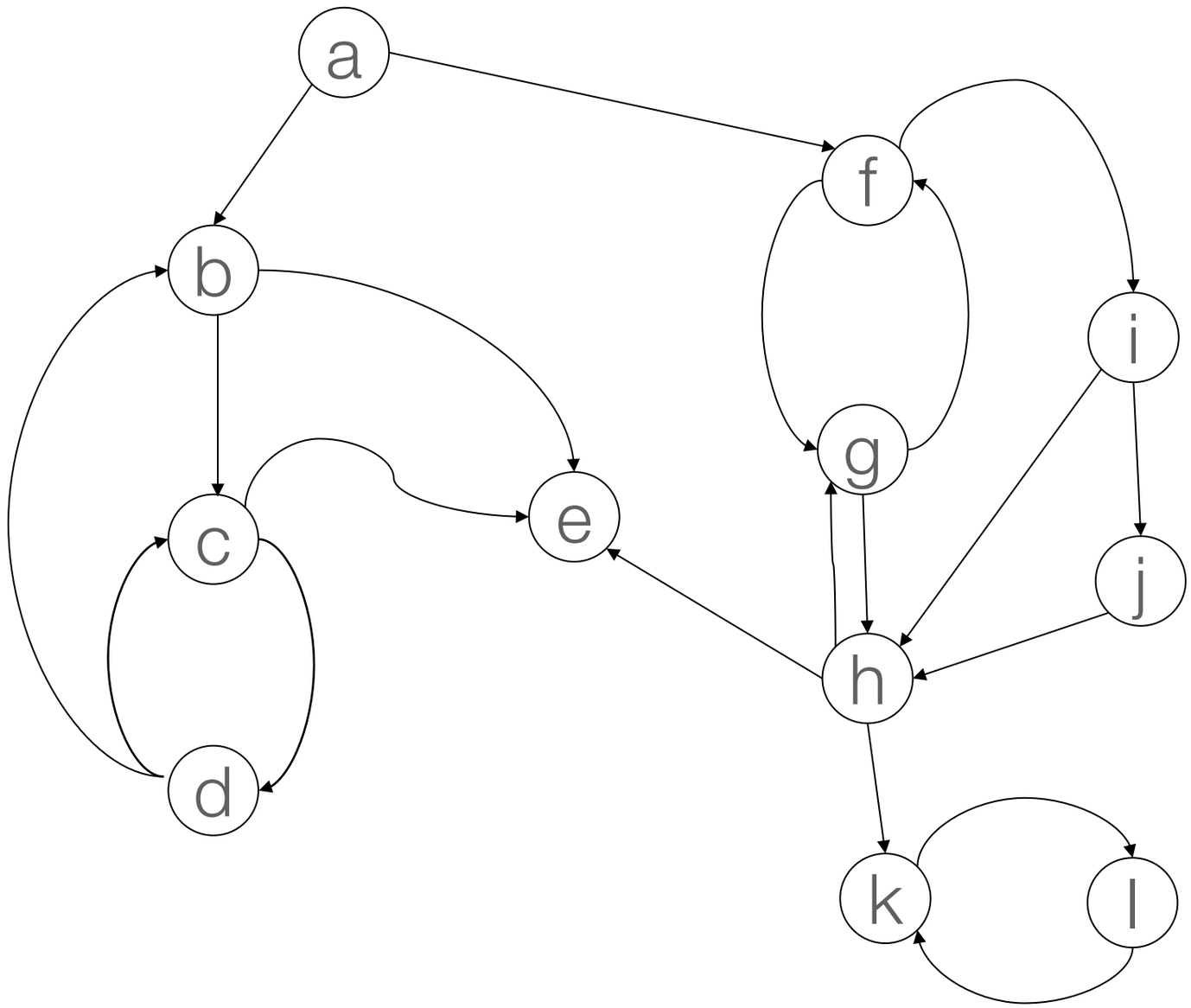
C' simule le comportement de C vis-à-vis de A et B

Une stratégie efficace pour l'ordre d'intégration

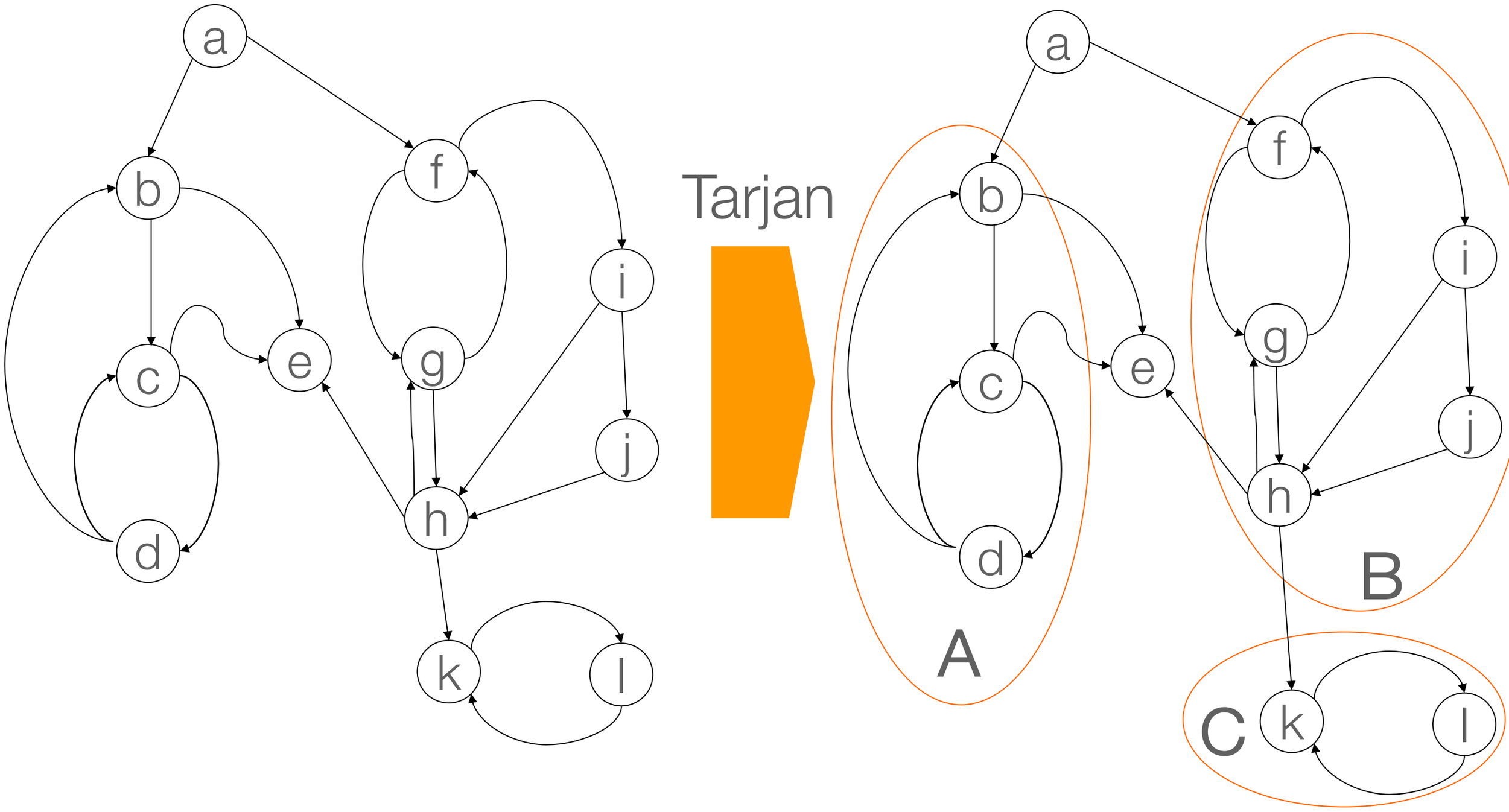
- Stub spécifique => ne simule que les comportements utilisés par le client



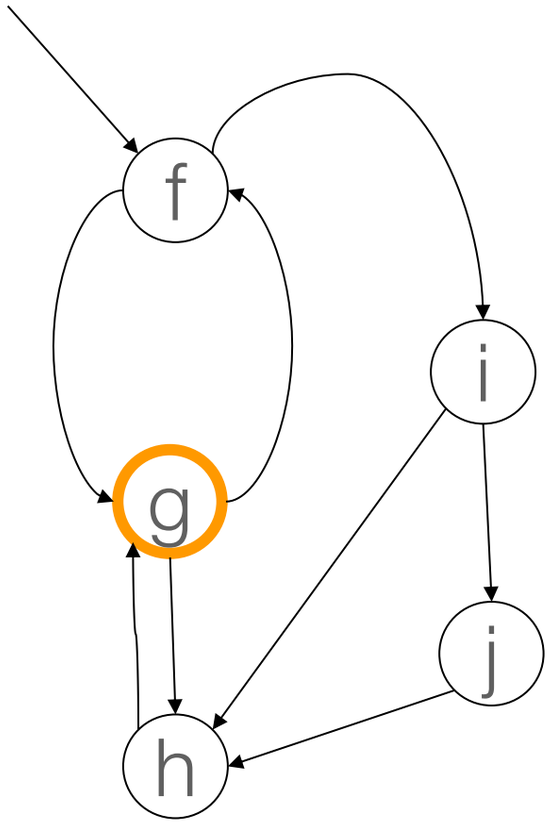
Une stratégie efficace pour l'ordre d'intégration



Une stratégie efficace pour l'ordre d'intégration



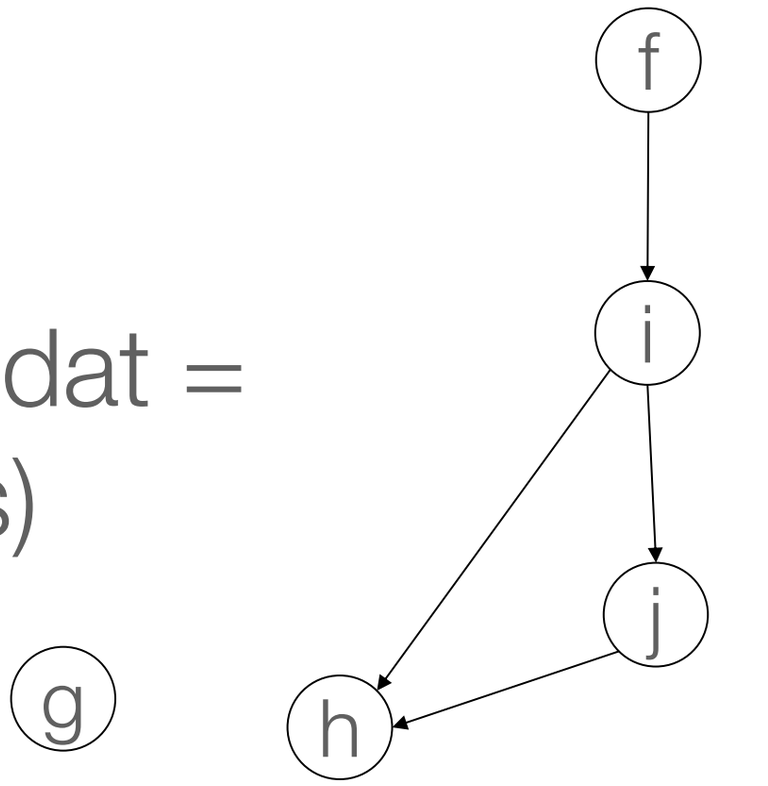
Une stratégie efficace pour l'ordre d'intégration



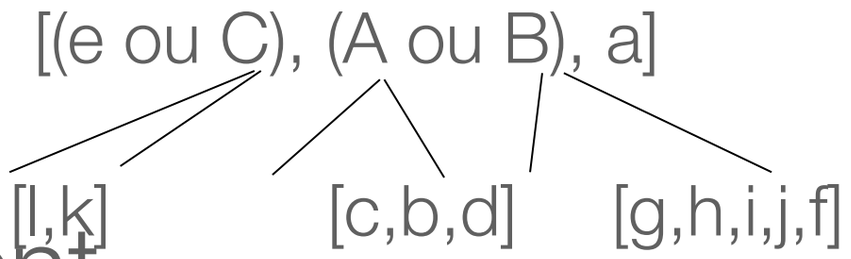
B

Algorithme de Bourdoncle

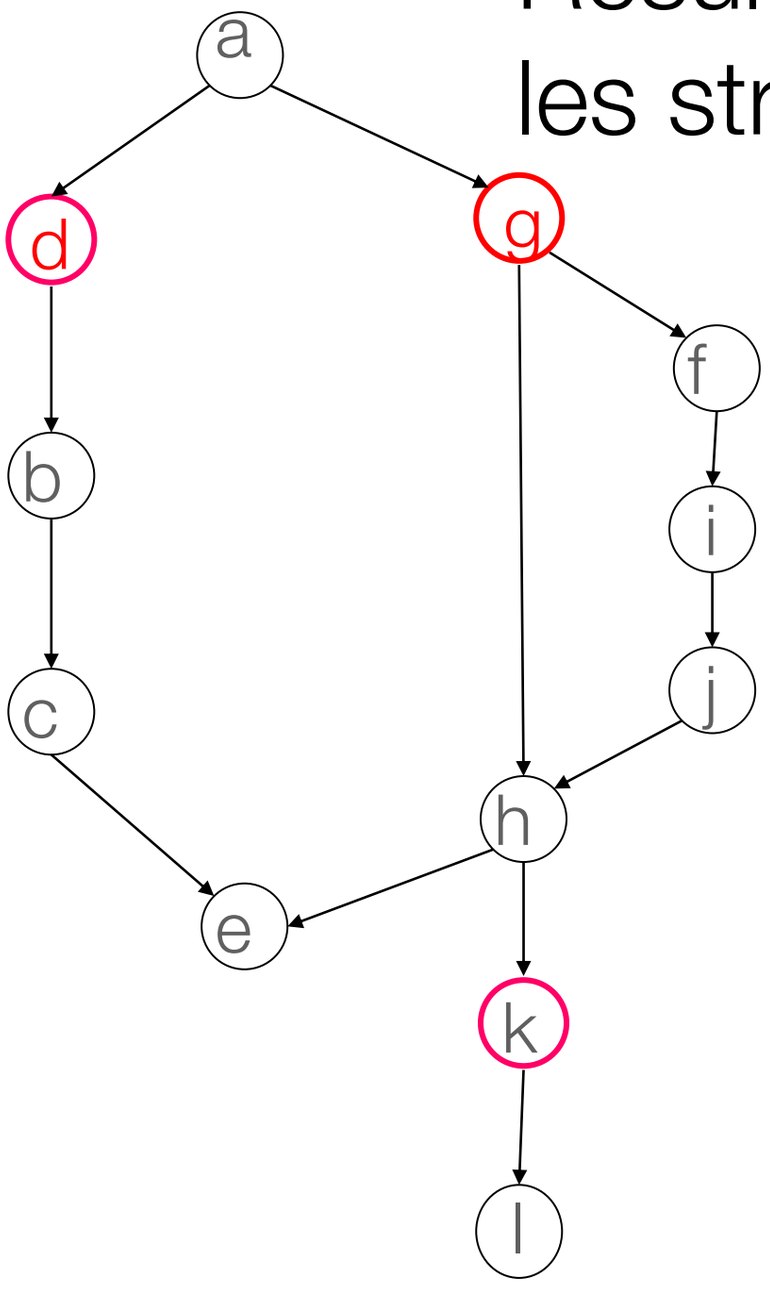
Noeud candidat = # max(fronds)



Casse les CFCs
réapplique Tarjan éventuellement



Une stratégie efficace pour l'ordre d'intégration



Résultat = un ordre partiel de toutes les stratégies possibles

Algorithme optimisé

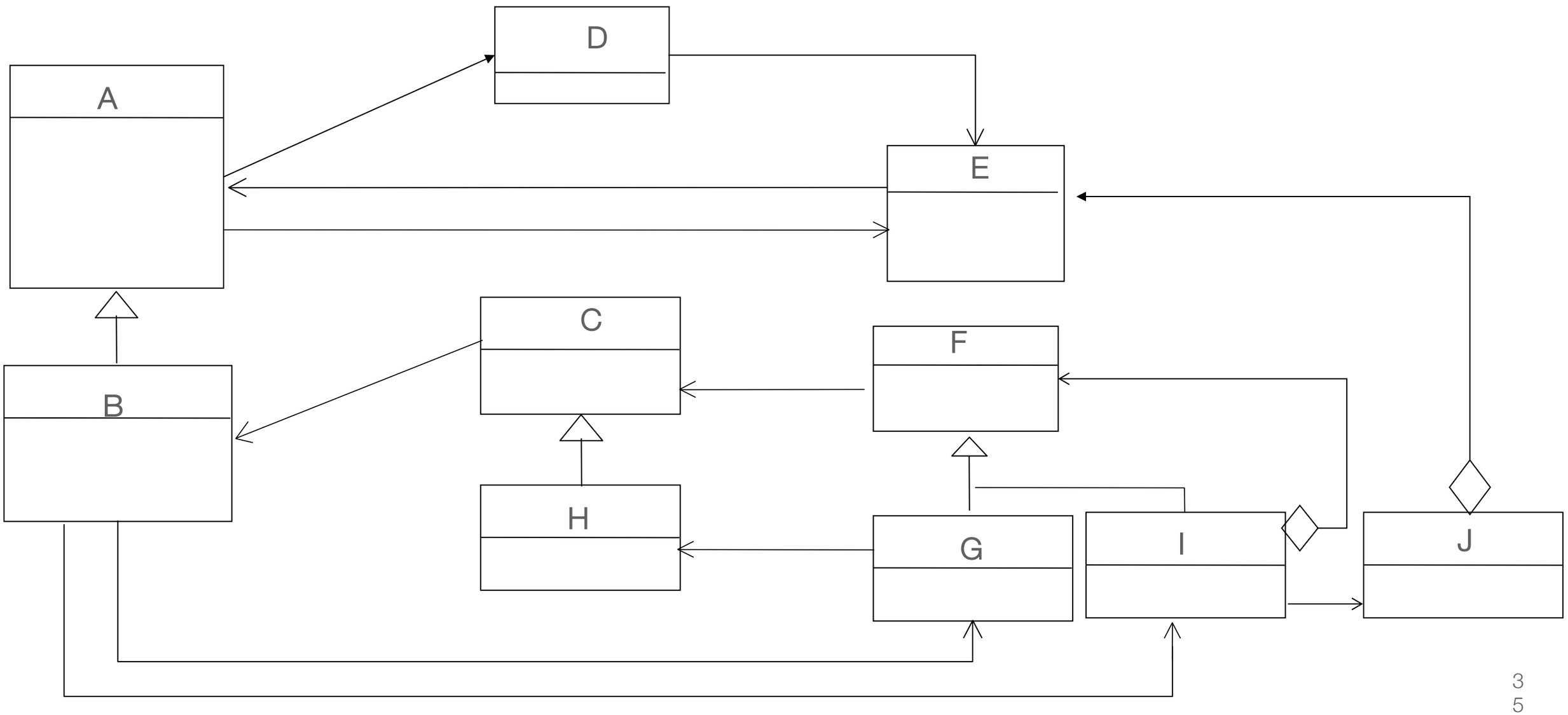
#stubs spécifiques = 4
#stubs réalistes = 3

Génération aléatoire (moy.)

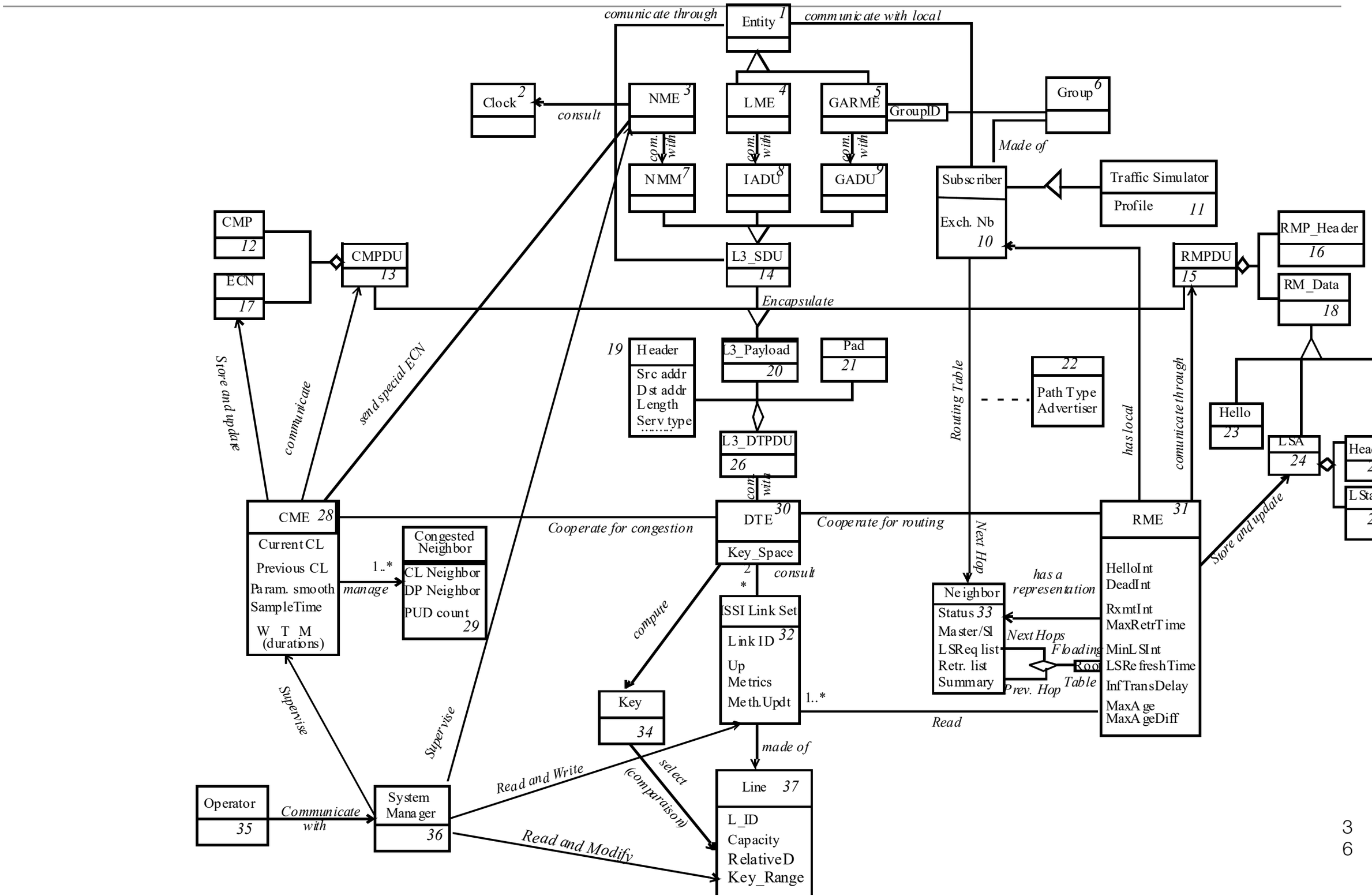
#stubs spécifiques = 9.9
#stubs réalistes = 5

Exo

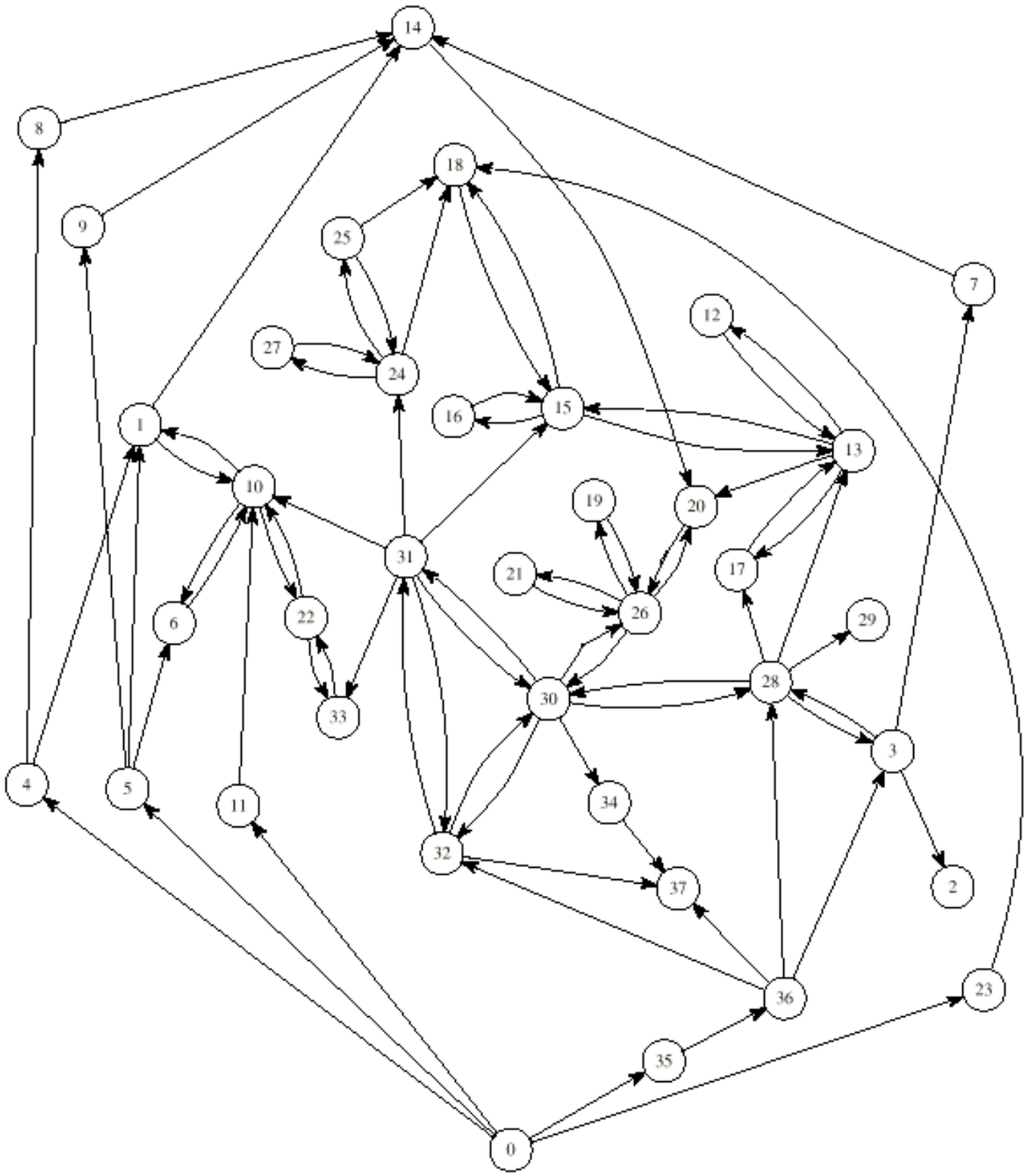
- Plan de test d'intégration pour :



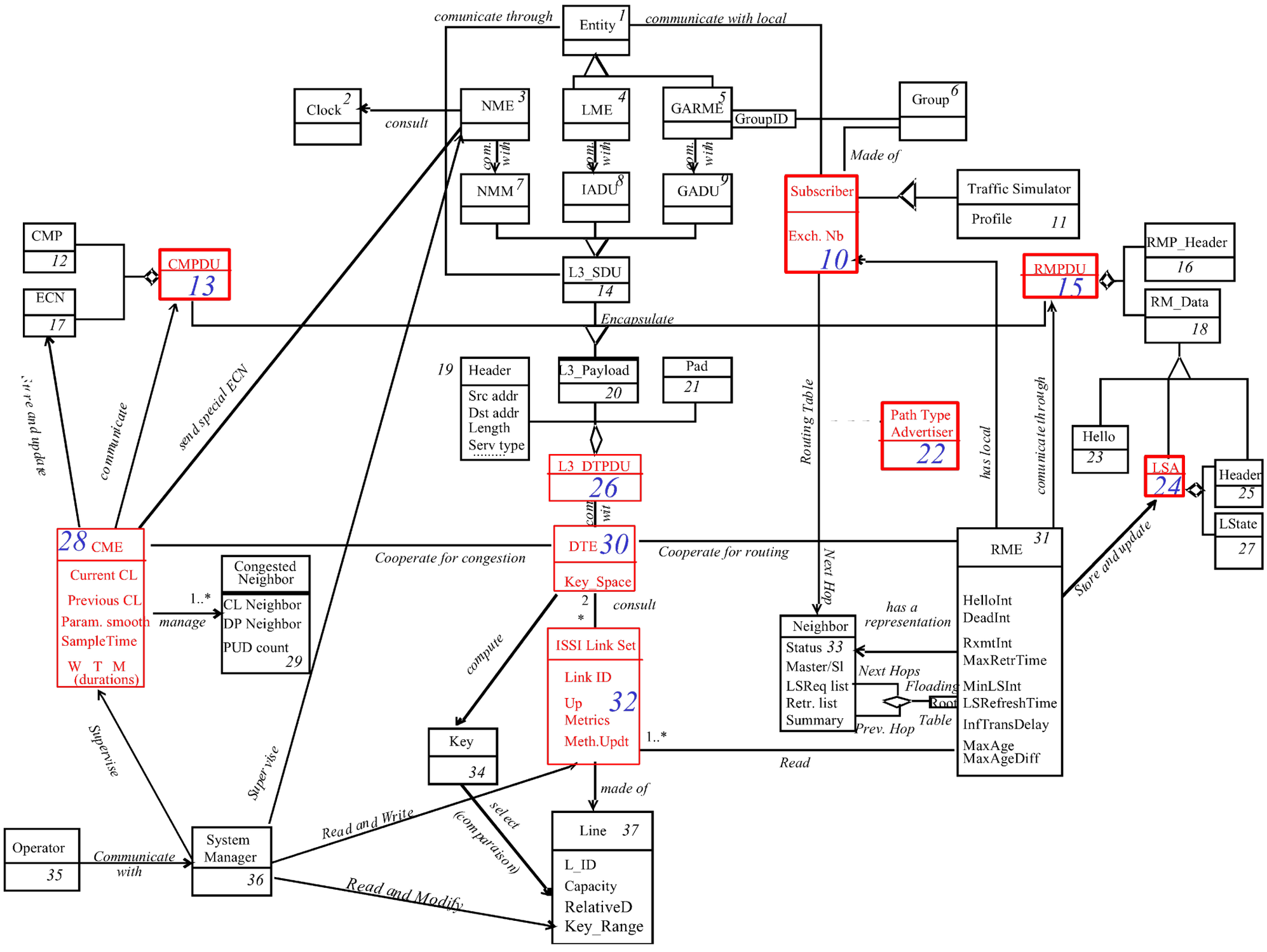
Cas encore moins simple



Graphe de dépendances



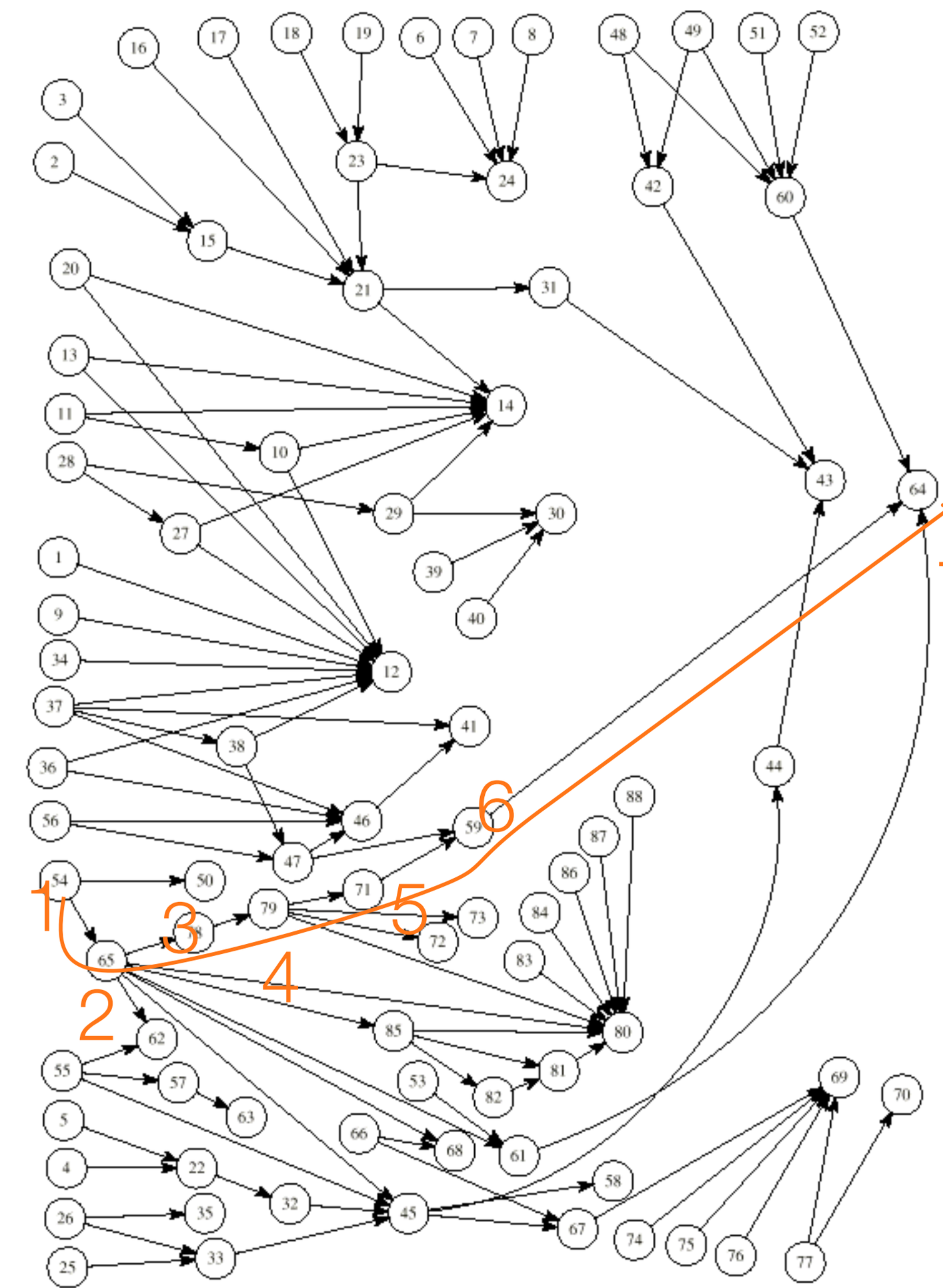
Bouchons de test



Une stratégie efficace pour l'ordre d'intégration

- Quand un ordre partiel est disponible, on peut paralléliser les tâches
  - en fonction d'un nombre fixe de testeurs
  - pour un délai minimum

Répartition des testeurs

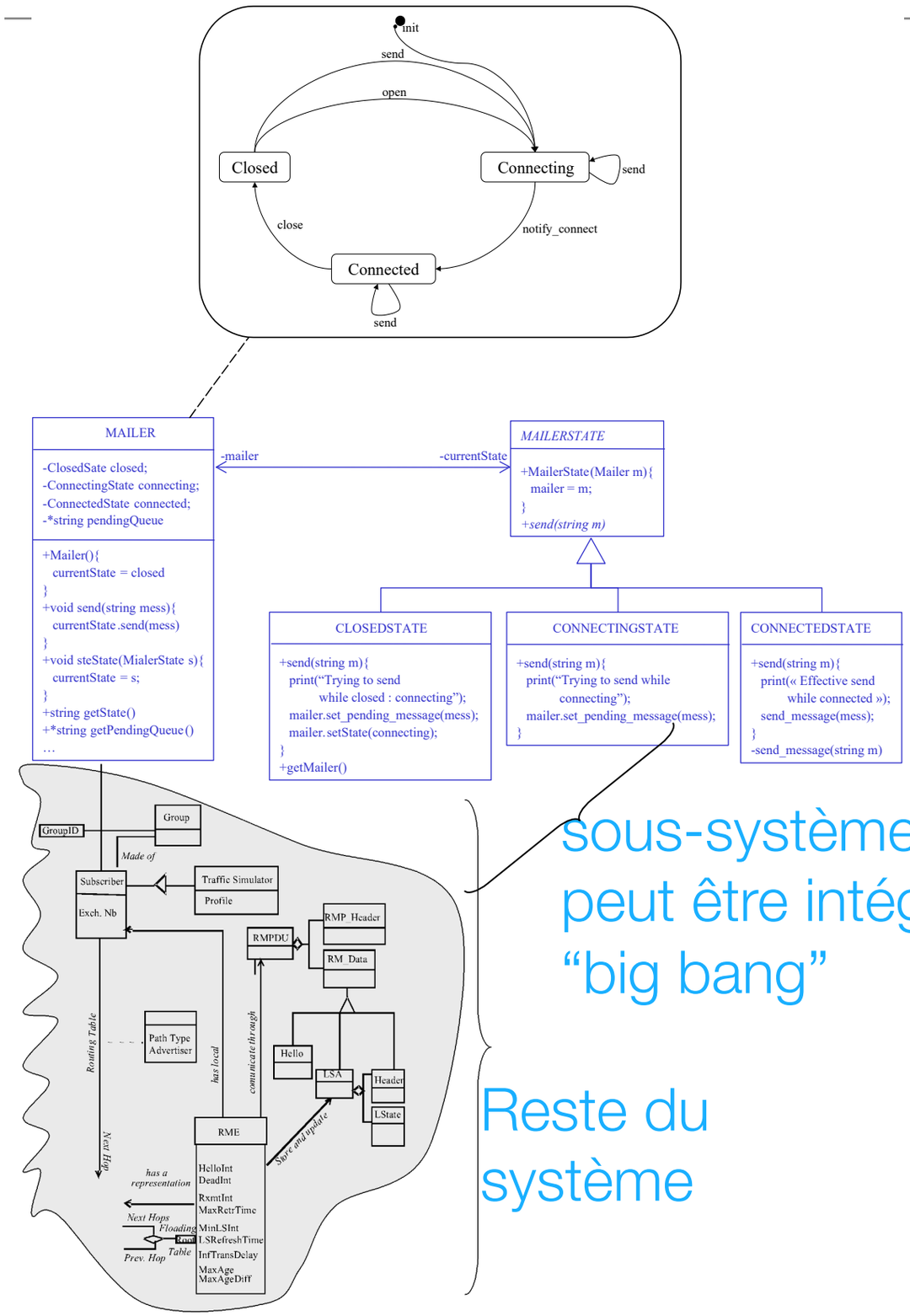


- Exemple de GNU-Eiffel
- Nombre de testeurs nécessaire pour intégrer en un minimum de temps
  - 88 div 7 +1 = 13 testers
- temps minimum : 7 étapes

Une stratégie efficace pour l'ordre d'intégration

- Stratégie efficace
  - casse les cycles de dépendances avec un minimum de stubs
- Autre stratégie
  - prend en compte les pratique de conception OO
  - certains cycles sont très cohérents du point de vue fonctionnel (Ex: design patterns)
    - ça peut être intéressant d'intégrer cette interdépendance d'un coup

Stratégie mixte



sous-système qui peut être intégré en "big bang"

Reste du système

- Minimise encore le nombre de stubs
- Maintient un niveau de cohérence dans l'intégration
- Pas complètement automatisable
  - pattern matching

Plan

1. Introduction au test d'intégration

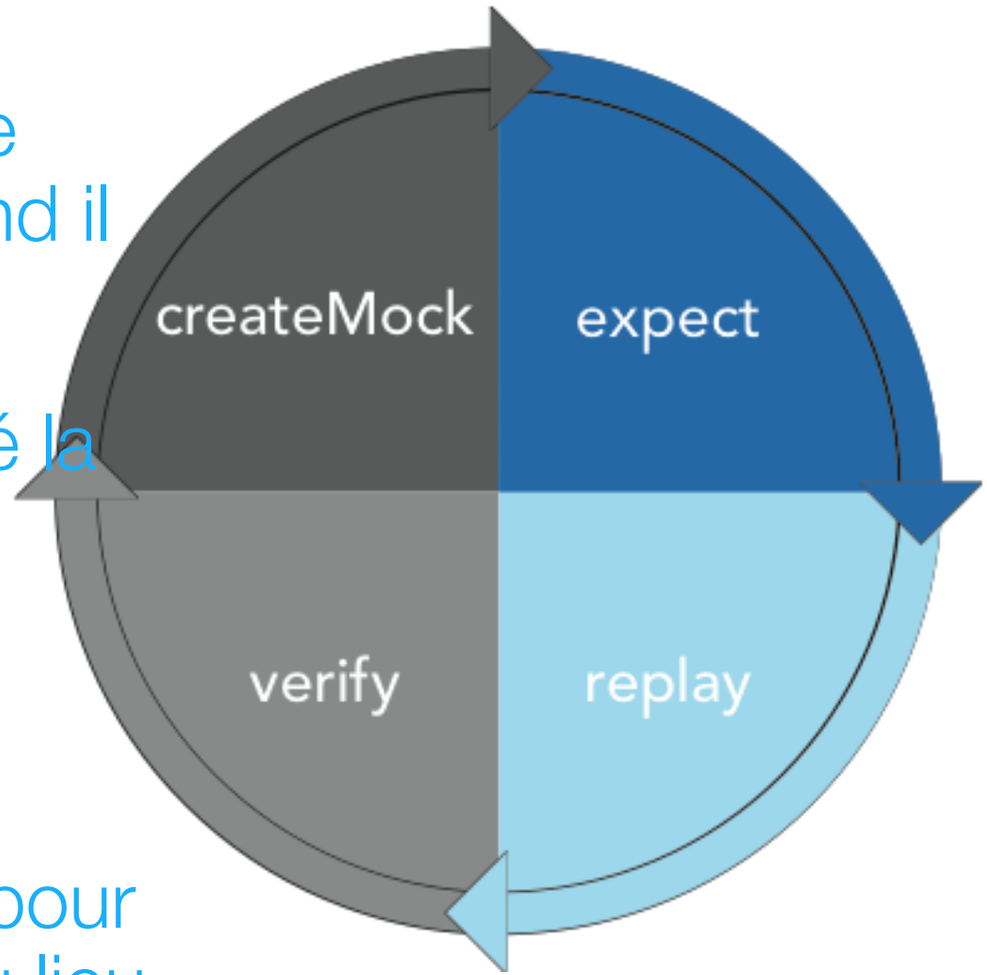
2. Mise en œuvre des mock avec EasyMock et Mockito

Mocks

- Les mocks sont un type de stub
- Simulent les échanges de message entre une classe et ses dépendances
- Permet de tester
  - une classe en isolation
  - Les interactions avec l’environnement

Easymock

- Étapes:
  1. Création du mock
  2. Configuration du mock pour lui dire comment il doit se comporter quand il est appelé.
  3. Activation des mocks (C'est appelé la fonction "replay" dans la documentation d'EasyMock)
  4. *Exécuter les tests*
  5. Après l'exécution, vérifier le mock pour savoir si les appels attendus ont eu lieu



Mockito

- Mockito is used by calling static methods defined in the `org.mockito.Mockito` class.
  - To create a mock:

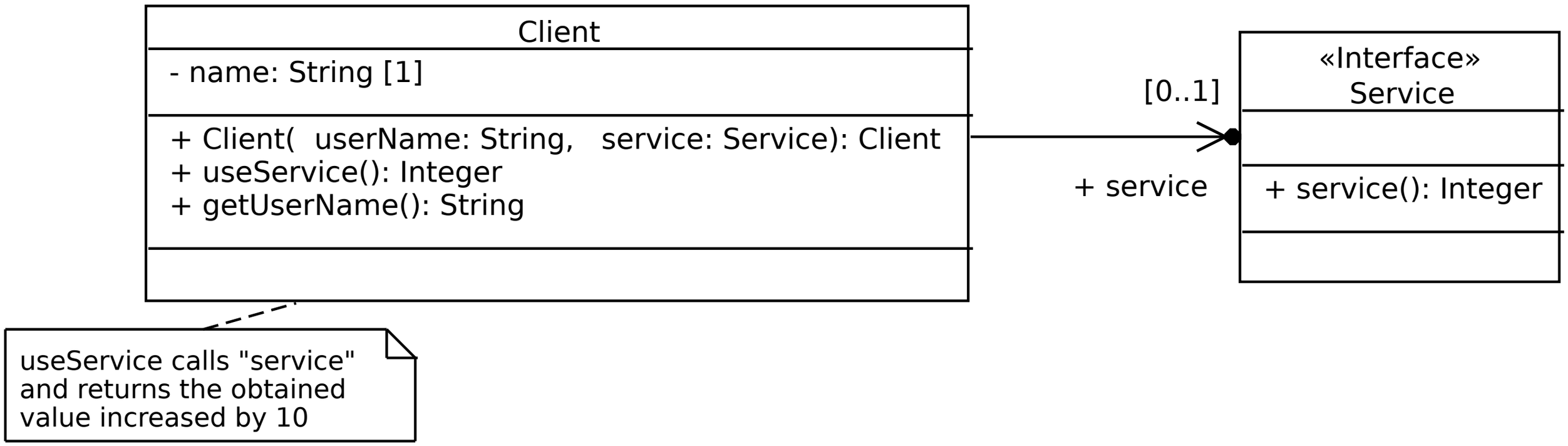
```
MyClass someMock = mock(MyClass.class);
```

  - To configure a mock:

```
when(someMock.someOp()).thenReturn(« someResult »);
```

- Tip
  - `import static org.mockito.Mockito.*;` to write `mock()` instead of `Mockito.mock(...)`

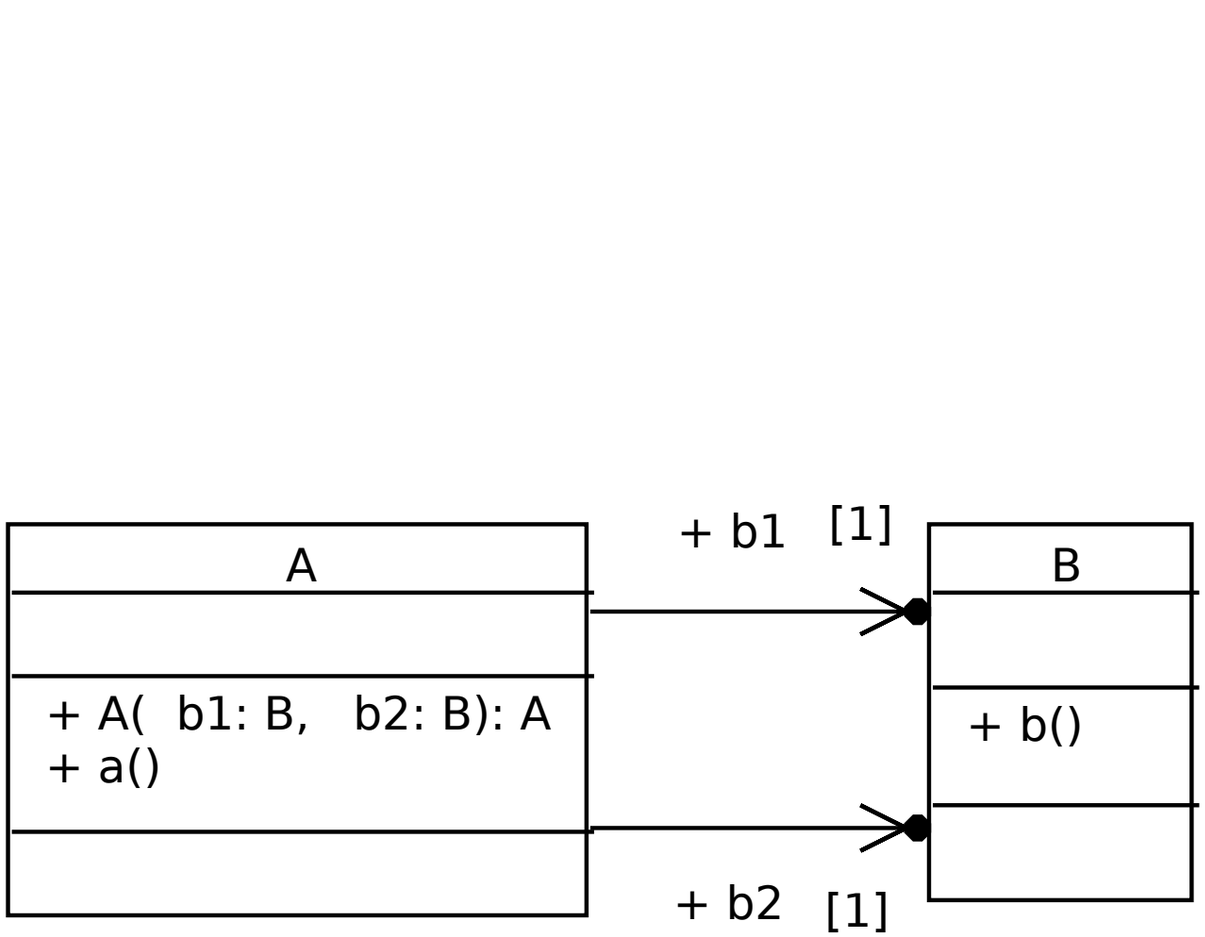
Unit test Client

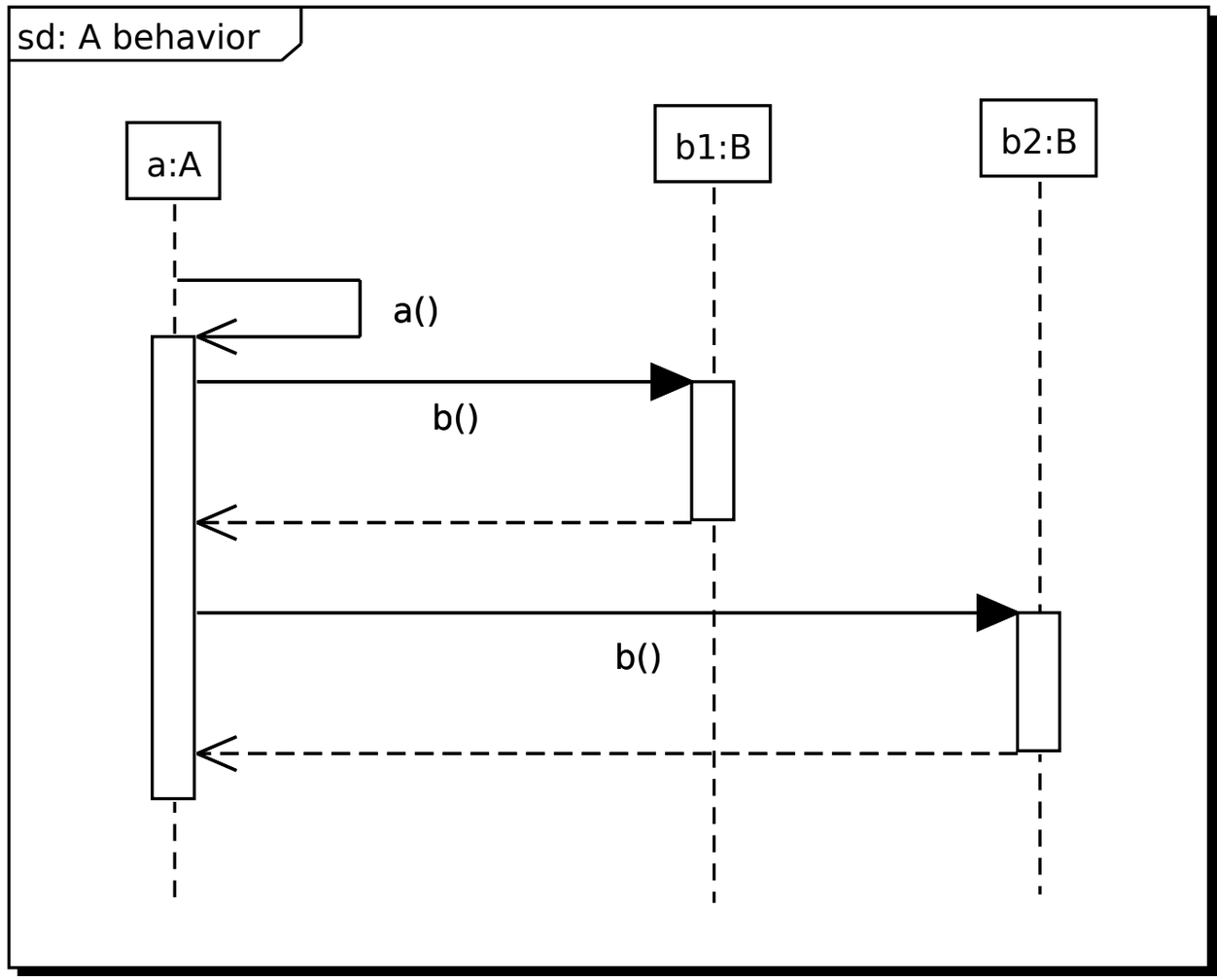


Stub Service class

```
import org.junit.Test;
import static org.mockito.Mockito.*;
import static org.junit.Assert.*;
...

public class ClientTestWithStub {

        @Test
        public void testUseService() {
                // Preparing the context -- we stub the Service instance
                Service mockService = mock(Service.class);
                when(mockService.service()).thenReturn(1327);

                // Regular test case
                Client client = new Client("John",mockService);
                int result = client.useService();

                // Oracle
                assertEquals(result,1337);
        }
}
```

Checking calls on methods





Checking calls on methods

- It is also possible to check that methods are called on a mock

```
// Context
B mockB1 = mock(B.class);
B mockB2 = mock(B.class);
A someA = new A(mockB1,mockB2);
// Calling the tested operation
a.a();
// Checking if b1.b() was called during a()
// to see if b1 was used correctly by a
verify(b1).b();
```

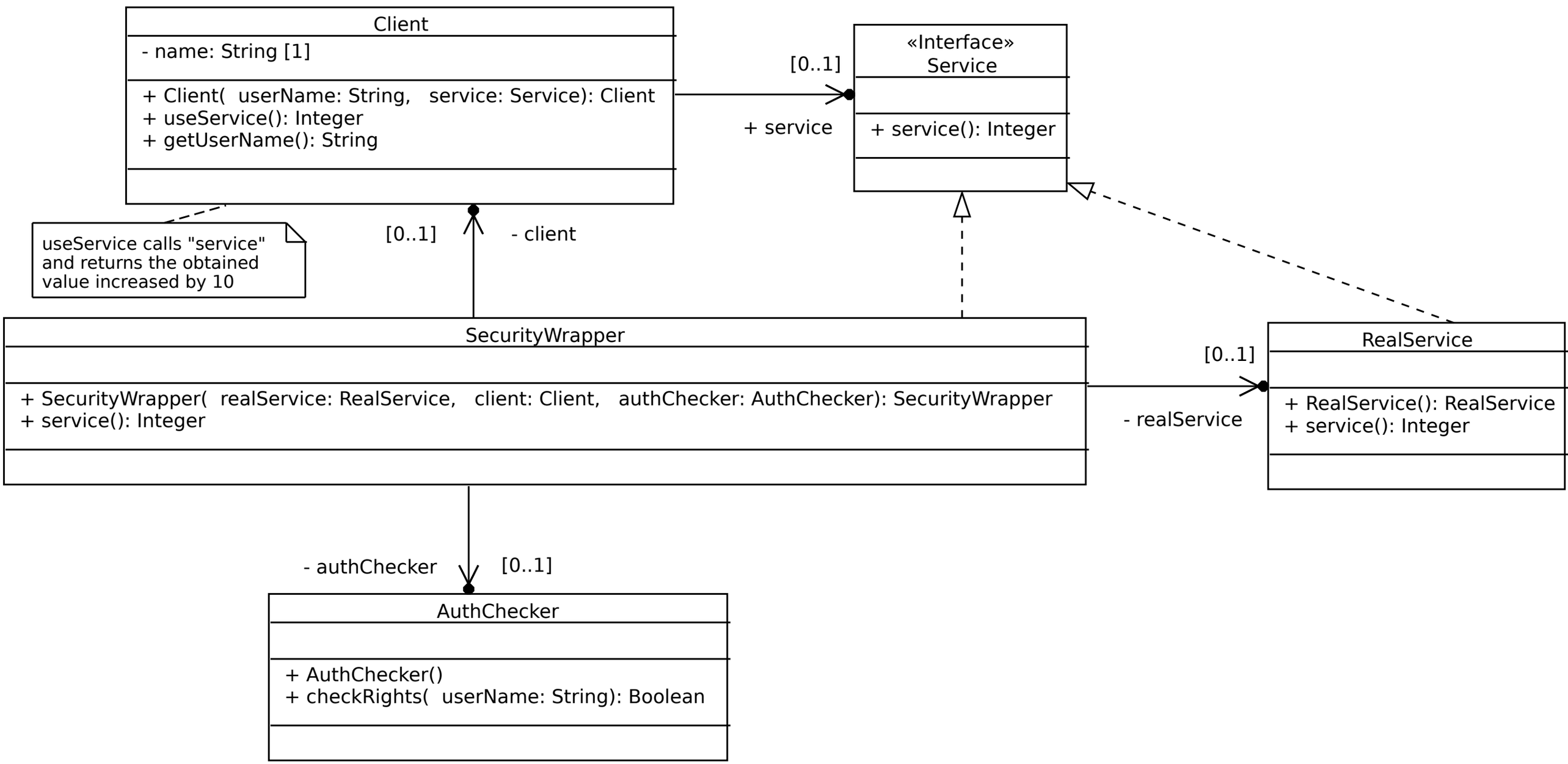
- A different form of oracle

Checking calls on methods

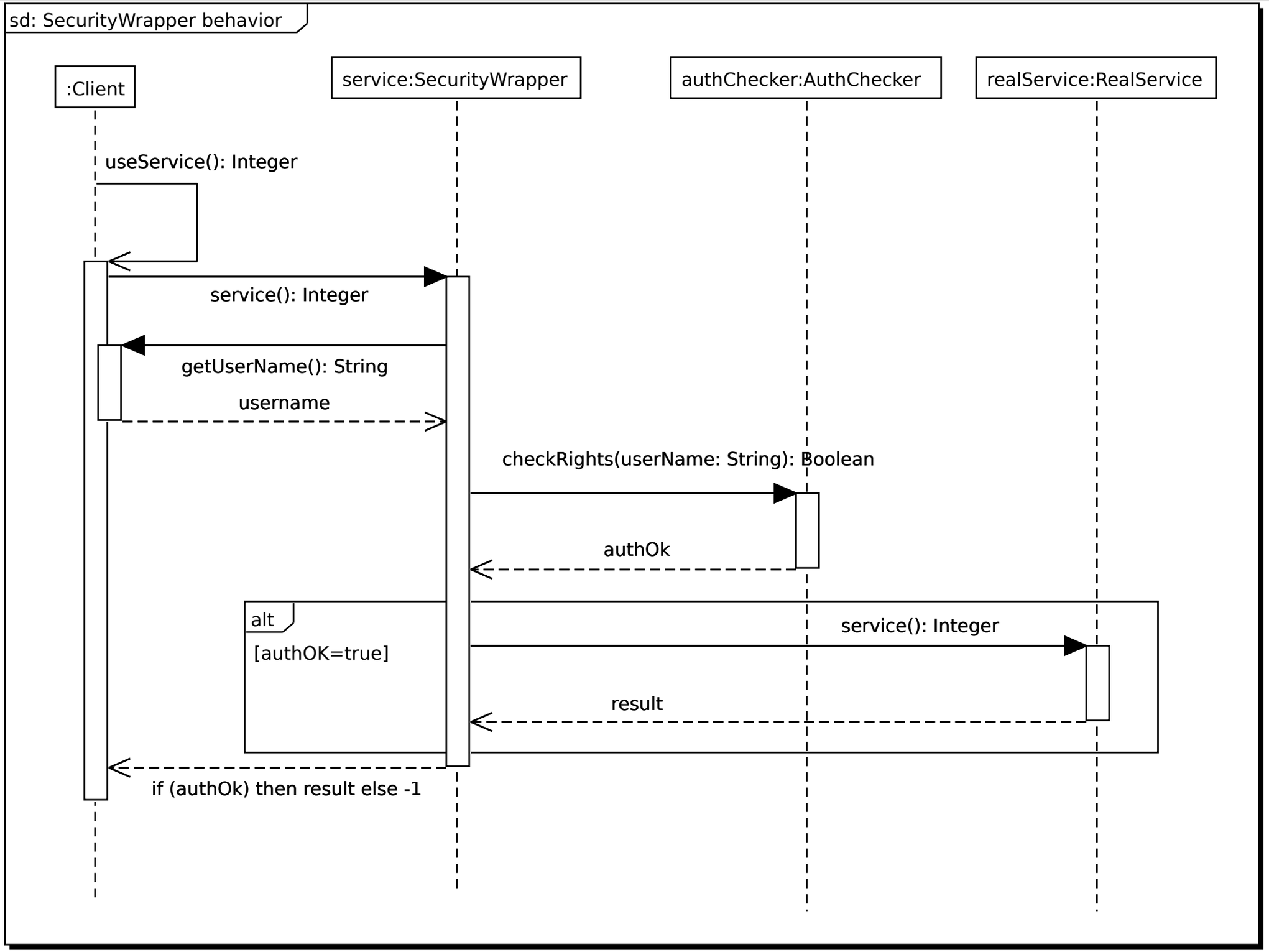
- It is also possible to check the order of method calls

```
// Checking if b1.b() was called before b2.b()
InOrder mocksWithOrder = inOrder(b1, b2);
mocksWithOrder.verify(b1).b();
mocksWithOrder.verify(b2).b();
```

Test the behavior of a wrapper for `Service`



Test the behavior of a wrapper for `Service`



```java
@Test
public void testSecurityWrapperBehavior() {

    // Preparing the context: mocks and their behaviors + tested object
    RealService mockRealService = mock(RealService.class);
    Client          mockClient       = mock(Client.class);
    AuthChecker mockAuthChecker = mock(AuthChecker.class);
    when(mockClient.getUserName()).thenReturn("John");
    when(mockAuthChecker.checkRights("John")).thenReturn(true);
    SecurityWrapper wrapper = new SecurityWrapper(mockRealService,
                mockClient, mockAuthChecker);

    // Calling the tested operation
    wrapper.service();

    // Oracle
    InOrder mocksWithOrder = inOrder(mockAuthChecker,mockRealService);
    mocksWithOrder.verify(mockAuthChecker).checkRights("John");
    mocksWithOrder.verify(mockRealService).service();

}
```

Summary

- Integration testing
  - looks for interaction between units of code
  - requires stubs to break cycles between units
- Mocks
  - Specific stubs to simulate a class (from the public interface)
  - Specific oracle to check the interactions between classes
- Integration testing is (usually) part of unit testing