Refactoring Assistants

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Refactoring: change the internal structure of a code without compromising its external behaviour

Refactorings can be looked at in two ways:

1. How to identify refactoring targets
2. How to detect applied refactorings

How to identify refactoring targets

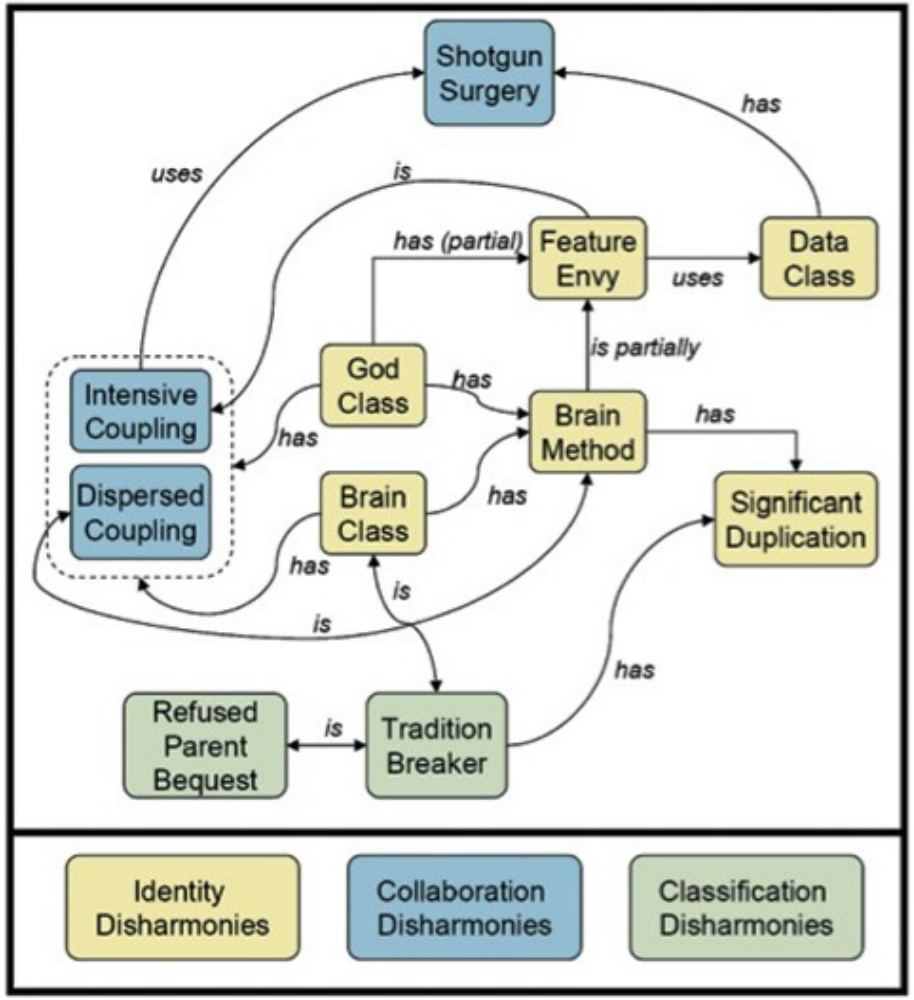
“I wrote the original edition in 2000 when Refactoring was a little-known technique.” – Martin Fowler

- Refactoring is a very common practice that helps developers to complete maintenance tasks (i.e., implement new features and fix bugs) and eliminate various design and code smells
- There are more than 80 types of refactorings
- Some of the common refactorings:
  - Moving a class, renaming an attribute, extracting a method

Strategic Refactoring

- Strategic Refactoring is to apply refactoring for a particular design reason/goal
- Support a new feature/correction
- Solving a specific design problem
- “Refactor to Understand” (OORP, p.127)
- In this Reengineering Course, refactoring without reason/goal is meaningless.
- Please remember the pattern “Keep it Simple” (OORP, p.37) when planning refactoring activities.

Bad/Code Smells



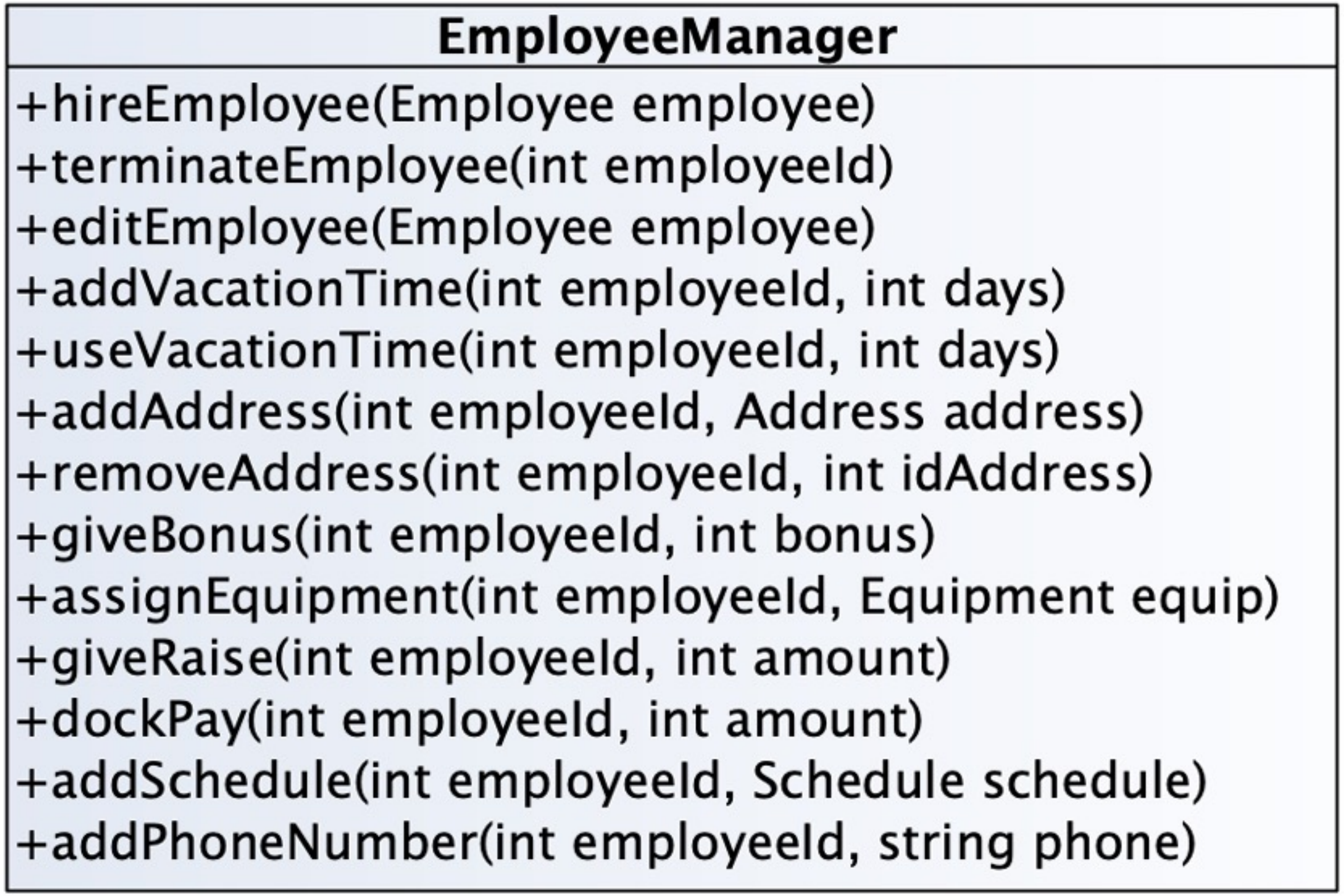
Disharmonies and their correlations

- Code smells are the result of inexperience multiplied by tight deadlines, mismanagement, and nasty shortcuts taken during the development process.
- Code smells are a prime candidate for refactoring
- SonarQube is a nice tool for Smell detection
- In CodeScene, Only the paid version shows Smells

Code Smell Example: God Class

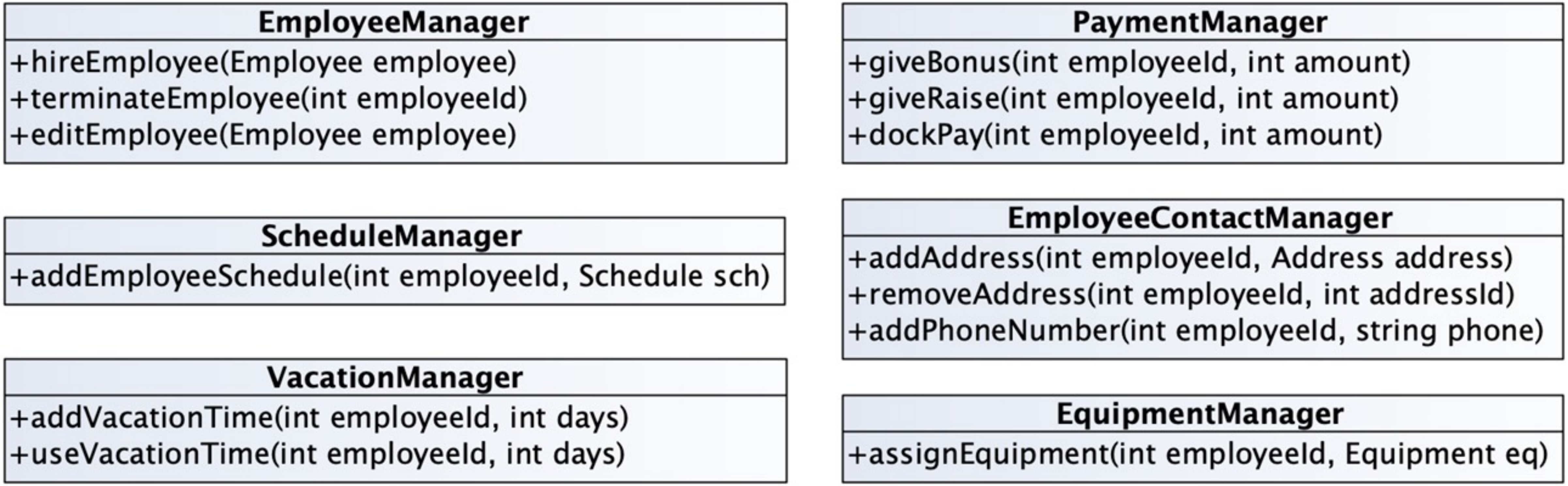
- A God Class is a class that is big on size and/or responsibilities, controlling too many objects.
- Refactoring solution: Extract/Split Class
- It is often possible to “split” a god class into two or more classes with a more clear and logical design

Code Smell Example: God Class



```
EmployeeManager
+hireEmployee(Employee employee)
+terminateEmployee(int employeeId)
+editEmployee(Employee employee)
+addVacationTime(int employeeId, int days)
+useVacationTime(int employeeId, int days)
+addAddress(int employeeId, Address address)
+removeAddress(int employeeId, int idAddress)
+giveBonus(int employeeId, int bonus)
+assignEquipment(int employeeId, Equipment equip)
+giveRaise(int employeeId, int amount)
+dockPay(int employeeId, int amount)
+addSchedule(int employeeId, Schedule schedule)
+addPhoneNumber(int employeeId, string phone)
```

Code Smell Example: God Class



EmployeeManager

+hireEmployee(Employee employee)
+terminateEmployee(int employeeId)
+editEmployee(Employee employee)

ScheduleManager

+addEmployeeSchedule(int employeeId, Schedule sch)

VacationManager

+addVacationTime(int employeeId, int days)
+useVacationTime(int employeeId, int days)

PaymentManager

+giveBonus(int employeeId, int amount)
+giveRaise(int employeeId, int amount)
+dockPay(int employeeId, int amount)

EmployeeContactManager

+addAddress(int employeeId, Address address)
+removeAddress(int employeeId, int addressId)
+addPhoneNumber(int employeeId, string phone)

EquipmentManager

+assignEquipment(int employeeId, Equipment eq)

Guidelines on How to Refactor

(1) Identify where (and when) to refactor

(2) Consider which refactoring(s) to apply

(3) Assure behavior preservation on the refactored artifact

(4) Perform the refactoring(s)

(5) Assess the effect of the refactoring on quality

(6) Maintain the system's consistency among the refactored code and other software artifacts

How to detect Applied Refactorings

Refactoring is noise in evolution analysis

- **Bug-inducing analysis** (SZZ): flag refactoring edits as bug-introducing changes
- **Tracing requirements to code:** miss traceability links due to refactoring
- **Regression testing**: unnecessary execution of tests for refactored code with no behavioral changes
- **Code review/merging**: refactoring edits tangled with the actual changes intended by developers

There are many refactoring detection tools

- Demeyer et al. [OOPSLA'00]
- UMLDiff + JDevAn [Xing & Stroulia ASE'05]
- RefactoringCrawler [Dig et al. ECOOP'06]
- Weißgerber and Diehl [ASE'06]
- Ref-Finder [Kim et al. ICSM'10, FSE'10]
- RefDiff [Silva & Valente, MSR'17]
- RefactoringMiner (SOA tool) [Tsantalis et al. TSE'20]

(RefactoringMiner has the highest average precision (99.6%) and recall (94%) among all competitive tools)

RefactoringMiner approach in a nutshell

AST-based statement matching algorithm

- **Input:** code fragments T1 from parent commit and T2 from child commit
- **Output:**
  - *M* set of matched statement pairs
  - U_{T1} set of unmatched statements from T1
  - U_{T2} set of unmatched statements from T2
- Code changes due to **refactoring mechanics**: *abstraction*, *argumentization*
- Code changes due to **overlapping refactorings** or **bug fixes**:
  syntax-aware AST node replacements

```java
private static Address[] createAddresses(int count) {
  Address[] addresses = new Address[count];
  for (int i = 0; i < count; i++) {
    try {
      addresses[i] =
        new Address("127.0.0.1", PORTS.incrementAndGet());
    }
    catch (UnknownHostException e) {
      e.printStackTrace();
    }
  }
  return addresses;
}
```

Before

After

Extract Method detection rule

Extract Method detection rule

Before

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private static List<Address> createAddresses(AtomicInteger ports, int count){
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    addresses.add(createAddress("127.0.0.1", ports.incrementAndGet()));


  }
  return addresses;
}
```

```
protected static Address createAddress(String host, int port) {
  try {
    return new Address(host, port);
  }
  catch (UnknownHostException e) {
    e.printStackTrace();
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  return null;
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(1) Abstraction

Before

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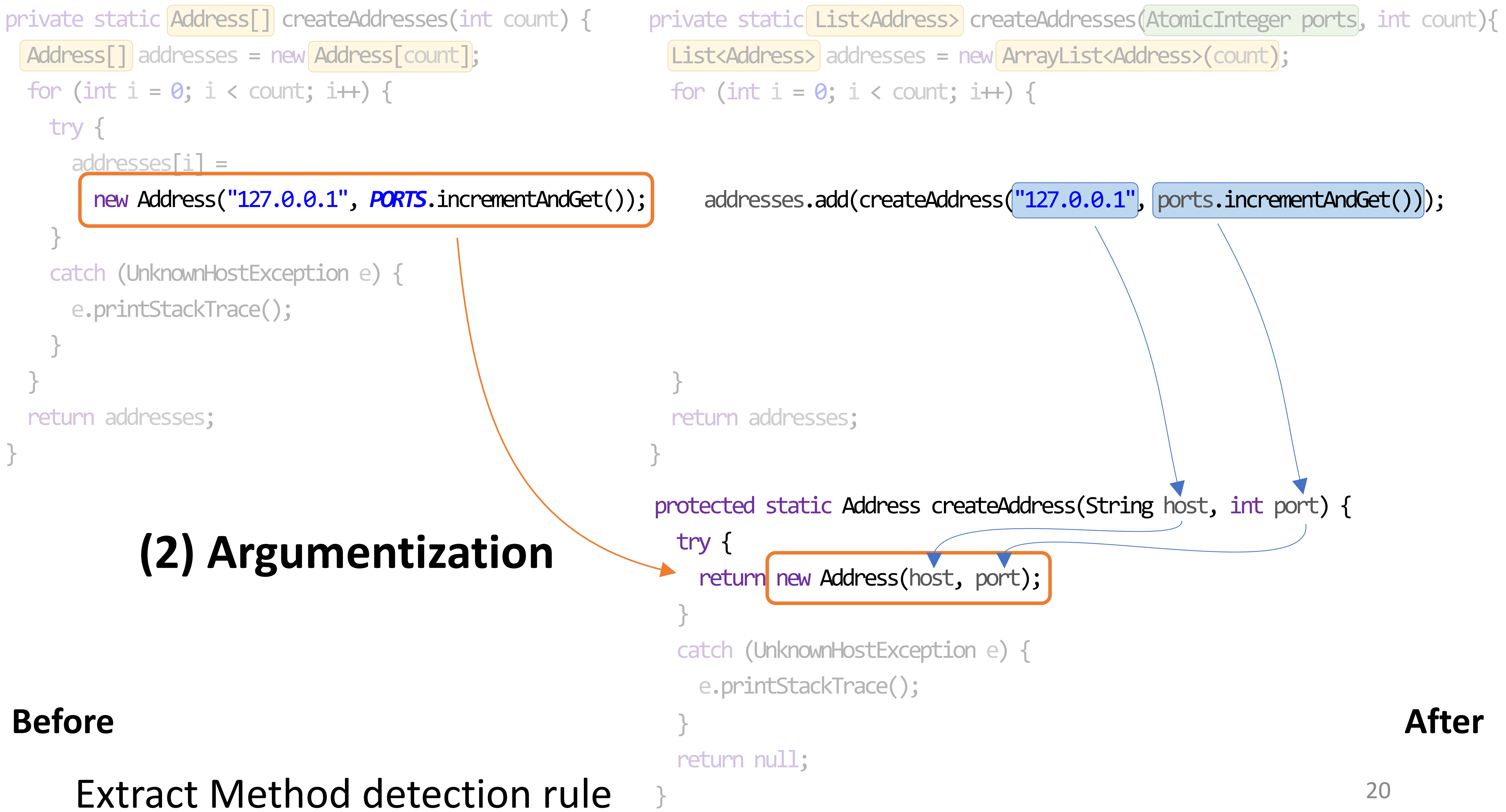

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(2) Argumentization

Before

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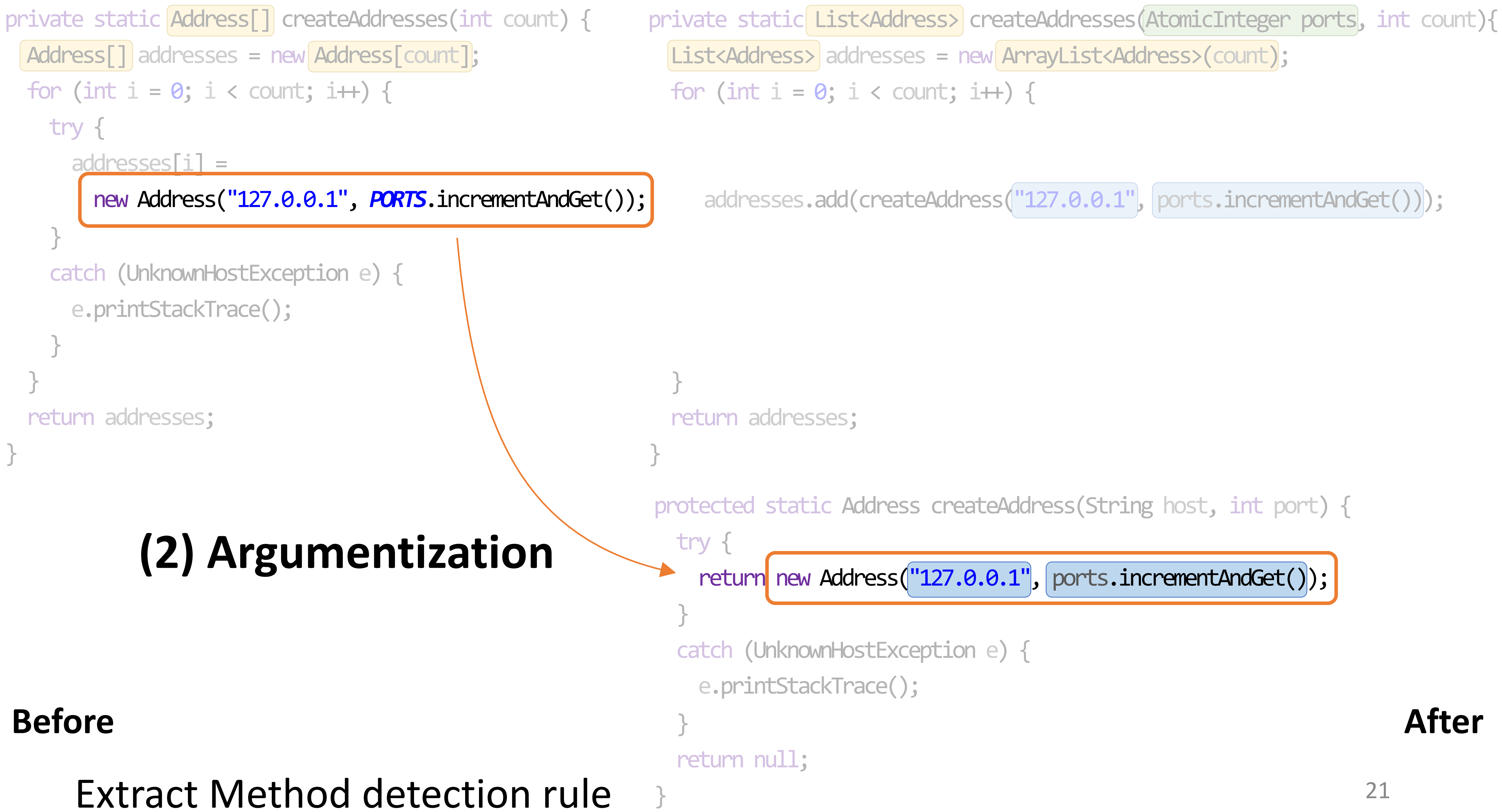

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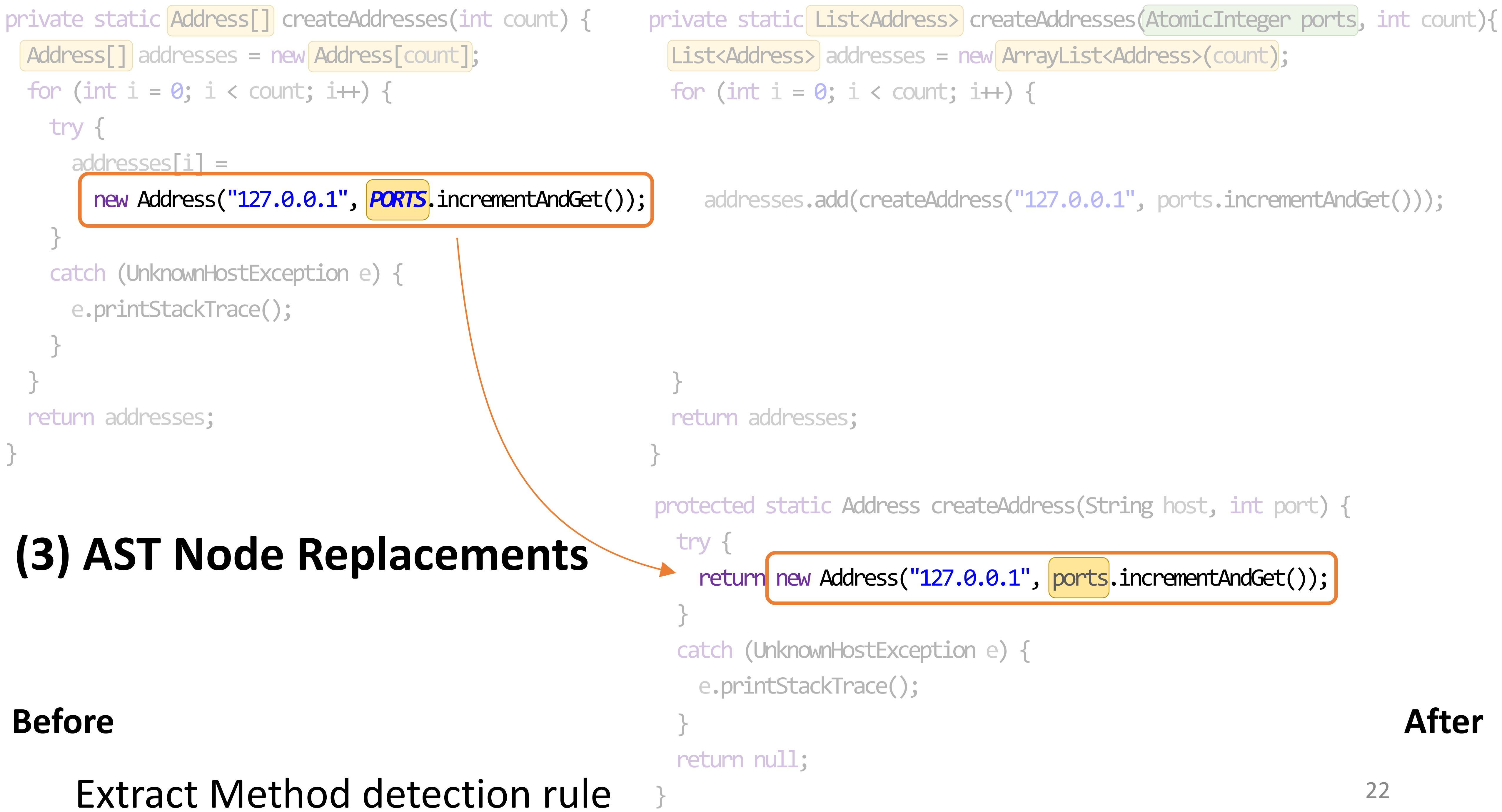

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(3) AST Node Replacements

Before

After

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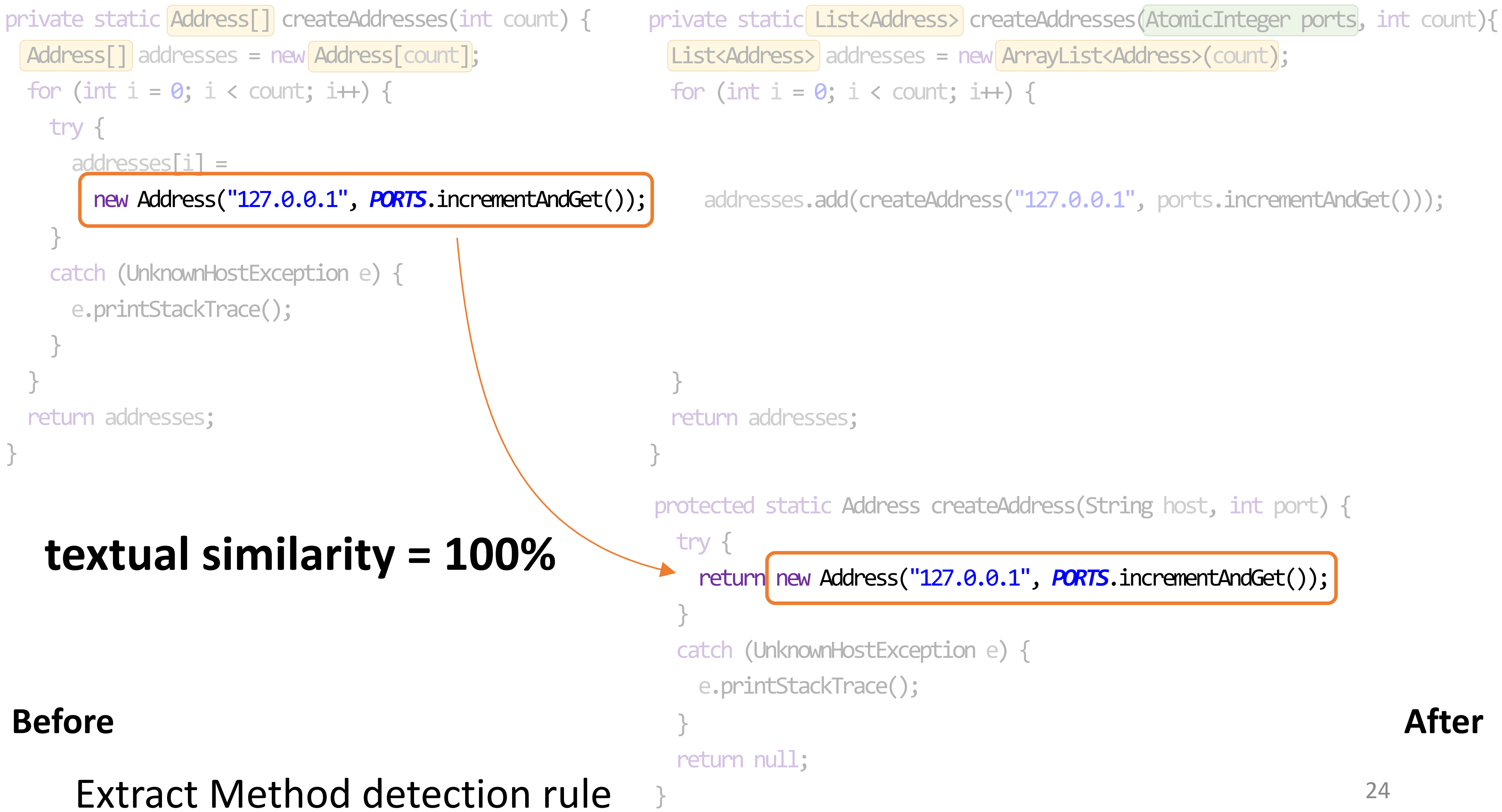

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```

textual similarity = 100%

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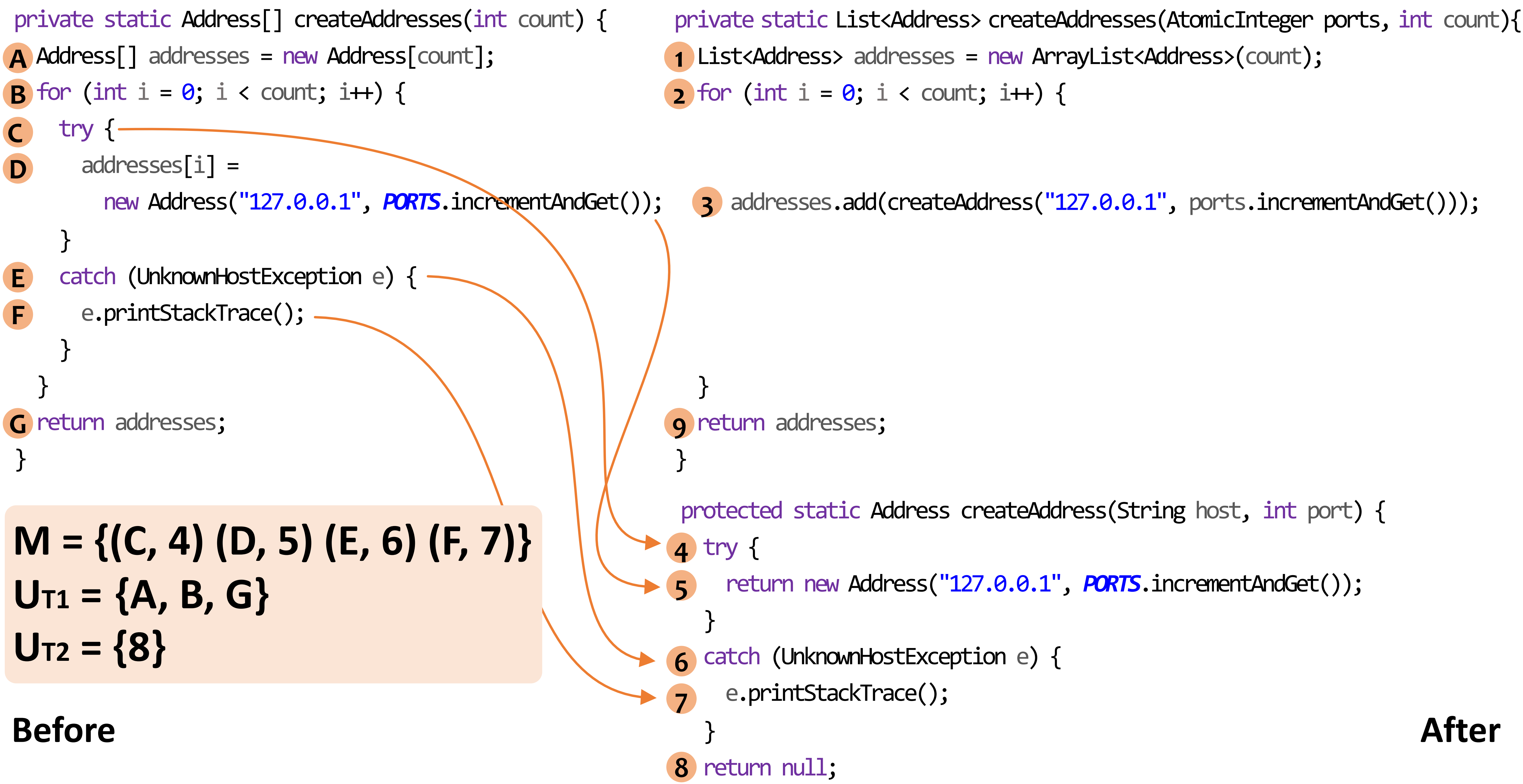

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  private static Address[] createAddresses(int count) {
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B for (int i = 0; i < count; i++) {
C    try {
D      addresses[i] =
         new Address("127.0.0.1", PORTS.incrementAndGet());
     }
E    catch (UnknownHostException e) {
F      e.printStackTrace();
     }
  }
G return addresses;
}
```

After

```
  private static List<Address> createAddresses(AtomicInteger ports, int count){
1 List<Address> addresses = new ArrayList<Address>(count);
2 for (int i = 0; i < count; i++) {
3    addresses.add(createAddress("127.0.0.1", ports.incrementAndGet()));
  }
9 return addresses;
}

  protected static Address createAddress(String host, int port) {
4  try {
5    return new Address("127.0.0.1", PORTS.incrementAndGet());
   }
6  catch (UnknownHostException e) {
7    e.printStackTrace();
   }
8  return null;
}
```

M = {(C, 4) (D, 5) (E, 6) (F, 7)}

U_{T1} = {A, B, G}

U_{T2} = {8}

Extract Method detection rule

(M, U_{T1}, U_{T2}) = statement-matching(`createAddresses`, `createAddress`)

M = {(C, 4) (D, 5) (E, 6) (F, 7)} U_{T1} ={A, B, G} U_{T2} = {8}

`createAddress` is a **newly added** method in child commit ✓

`createAddresses` in parent commit **does not call** `createAddress` ✓

`createAddresses` in child commit **calls** `createAddress` ✓

$|M| > |U_{T2}|$ ✓

⇒ `createAddress` has been extracted from `createAddresses`

The Project

- Intermediate Report
  - What refactorings are you planning to implement in the project
  - Reasons why the refactorings are important for your goal
  - Describe the planned refactoring activities

- Final Report
  - Same as the intermediate Report, but the refactorings must be “completed” by then
  - Commits relating to the refactorings should be clearly labelled.