

# i219 Software Design Methodology

## 8. Dynamic modeling 1

Kazuhiro Ogata (JAIST)

2

### Outline of lecture

- Use case
- Use case diagram
- State (machine) diagram
- Sequence diagram
- Class diagram of vending machine
- Vending machine in Java

## Use case (1)

Let us design a vending machine that sells milk, juice & coffee whose costs are 40Yen, 80Yen & 120Yen, and that accepts 10Yen, 50Yen & 100Yen coins.

First think about some of its use cases.

Each use case is a collection of scenarios that describe in which way users interact with a system to be developed to achieve some purpose.

## Use case (1)

one main success & two exceptional scenarios

use case name

### Insert Coin

Main Success Scenario:

1. User inserts 10Yen, 50Yen or 100Yen coin
2. System records it

Extensions:

- 2a: The inserted one is different from those three coins  
 .1: System lets user know what coins can be accepted

one main success & one exceptional scenarios

### Select Item

Main Success Scenario:

1. User selects milk, juice or coffee
2. System delivers the item and subtracts its cost from the coins inserted

Extensions:

- 2a: The selected one is different from those three items  
 .1: System lets user know what items can be selected
- 2b: The coins inserted are not enough for the item  
 .1: System lets user know it

## Use case (2)

### Show Items

Main Success Scenario:

1. User asks system to show items bought
2. System displays them

### Show Usage

Main Success Scenario:

1. User asks system to let him/her know how to use system
2. System displays the usage

### Show Coins

Main Success Scenario:

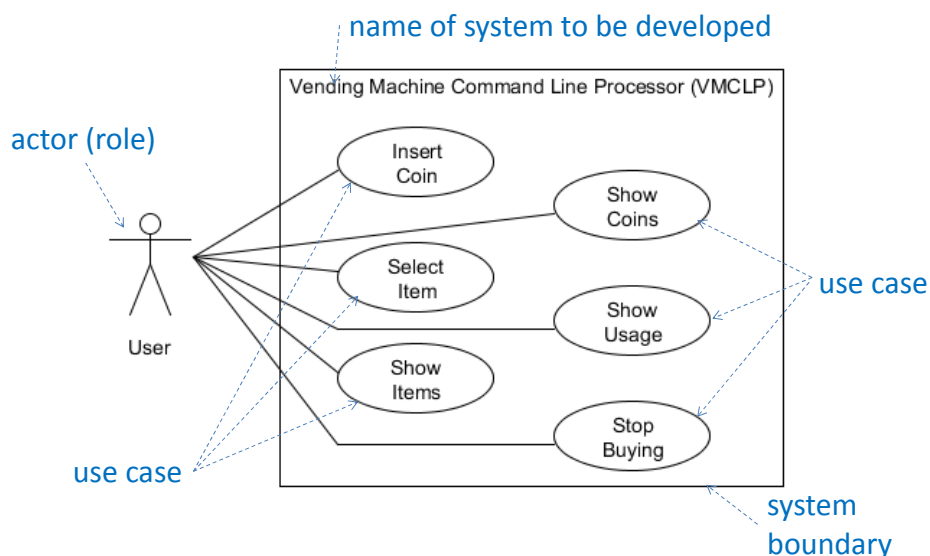
1. User asks system to show coins inserted
2. System displays them

### Stop Buying

Main Success Scenario:

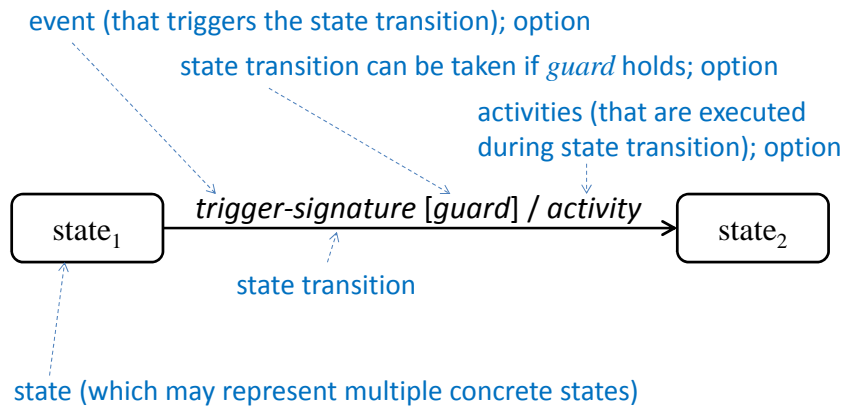
1. User lets system know he/she will stop buying
2. System displays items bought & returns change

## Use case diagram

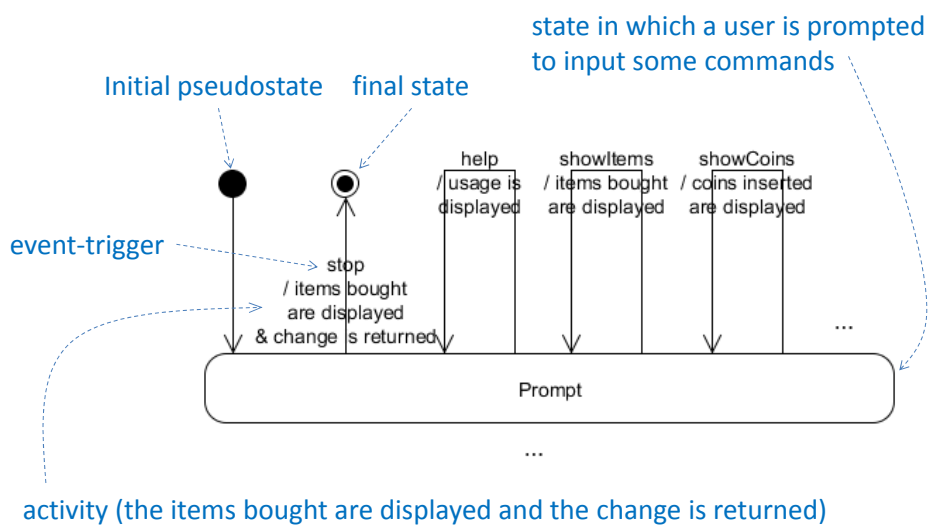


## State diagram (1)

A state (machine) diagram describes the behavior of (a single object of) a class



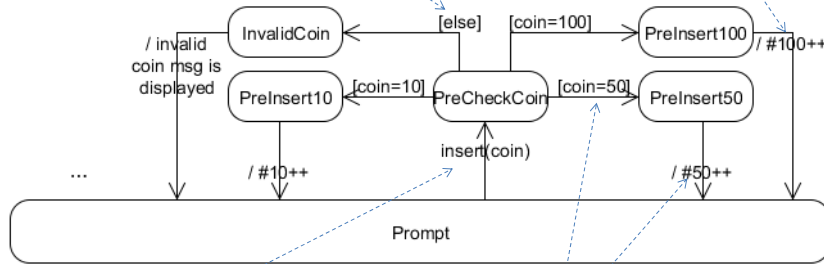
## State diagram (2)



# State diagram (3)

the number of 100Yen coins in Cash Box is incremented

coin ≠ 10 & coin ≠ 50 & coin ≠ 100



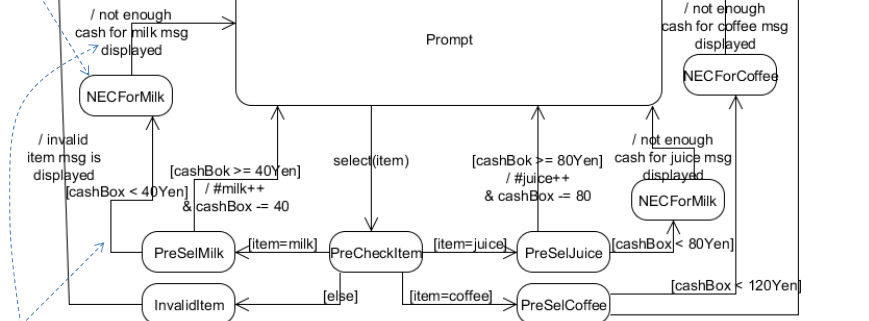
the event-trigger has one parameter coin

the two state transitions can be combined: [coin=50] / #50++

# State diagram (4)

if the cash in the cash box is greater than or equal to 120Yen, then the number of coffee bought is incremented & the cash is subtracted by 120Yen

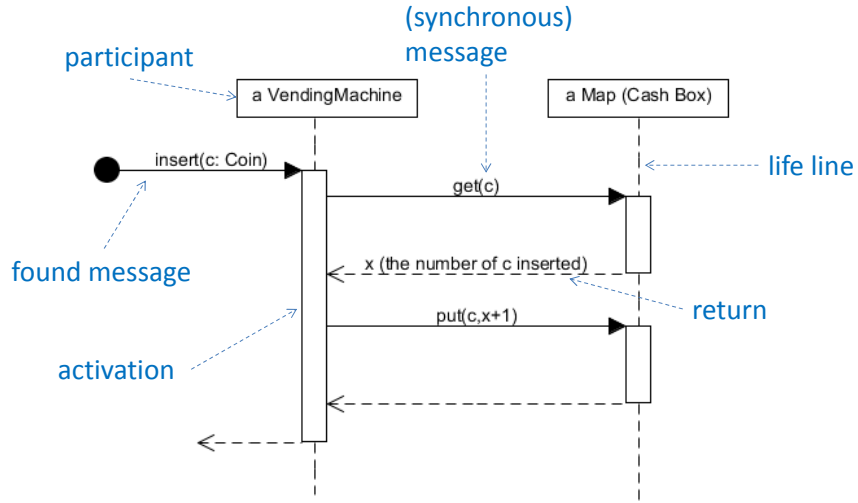
not enough cash for milk



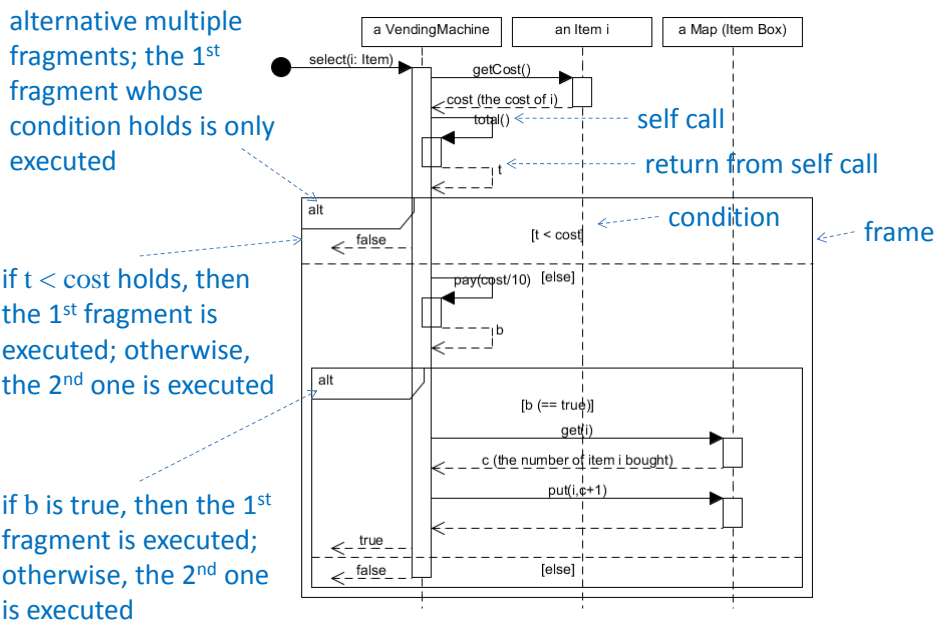
can be combined: [cashBox < 40Yen] / not enough cash for milk msg is displayed



## Sequence diagram (2)



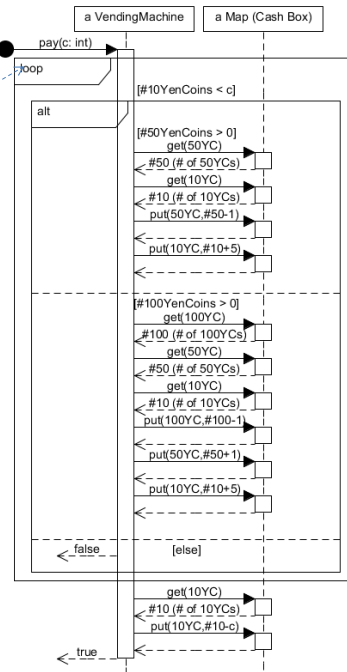
## Sequence diagram (3)



## Sequence diagram (4)

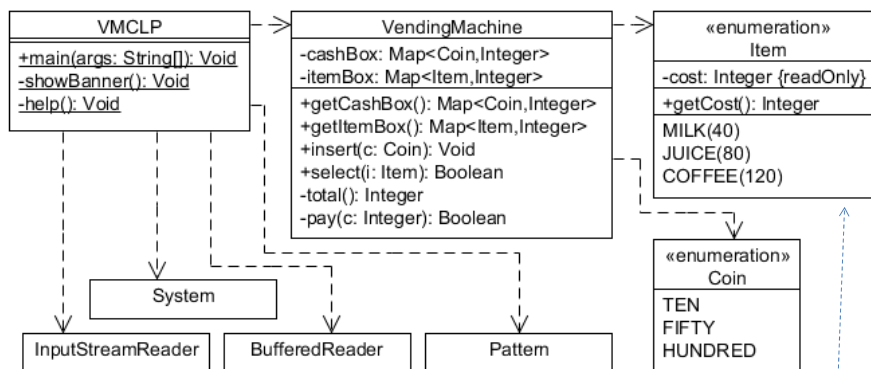
loop; the fragment is repeatedly executed while the condition (#10YenCoin < c) holds

- ✓ 10\*c is the cost of the item.
- ✓ if the number of 10Yen coins is greater than or equal to c, we can pay for the item.
- ✓ Otherwise, if there is a 50Yen (or 100Yen) coin, it is changed into five 10Yen coins (or five 10Yen & one 50Yen coins).
- ✓ Otherwise, we cannot.



15

## Class diagram of vending machine



16

enumeration (enum type) in Java is a class and then it may have attributes (fields) and methods; 40 of MILK(40) is the attribute (cost) owned by the instance (object) MILK of the class



## Vending machine in Java (1)

```

import java.util.*; <----- package in which HashMap, ect. are declared
import java.io.*; <----- package in which BufferedReader, etc. are declared
import java.util.regex.*; <----- package in which Pattern, etc. are declared

public class VMCLP {
    private static void showBanner() { ... }    it decodes bytes read from the
    private static void help() { ... }         standard input into characters
    public static void main(String[] args) throws IOException {
        VendingMachine vm = new VendingMachine();
        String line;
        InputStreamReader isr = new InputStreamReader(System.in);
        BufferedReader br = new BufferedReader(isr);
        showBanner(); it reads character from the standard input in a buffered way
        while ((line = br.readLine()) != null) { ... } }
    }

```

it reads a line of text and returns the line excluding a line break as a String

will be explained in the following pages

## Vending machine in Java (2)

```

line = line.trim(); <----- it removes white spaces at both sides of the String
if (line.equals("")) { // Nothing is done. }
else if (line.equals("stop")) { <----- "Stop Buying" use case
    Map<Item,Integer> items = vm.getItemBox();
    Map<Coin,Integer> coins = vm.getCashBox();
    System.out.println("Items bought: " + items);
    System.out.println("Change: " + coins);
    System.out.println("bye bye!"); break; }
else if (line.equals("help")) { help(); } <----- "Show Usage" use case
else if (line.equals("insert")) { <----- "insert" needs an argument
    System.err.println("Usage: insert [10|50|100]"); }
else if (line.equals("select")) { <----- "select" needs an argument
    System.err.println("Usage: select [milk|juice|coffee]"); }
else if (line.equals("showItems")) { System.out.println(vm.getItemBox()); }
else if (line.equals("showCoins")) { System.out.println(vm.getCashBox()); }

```

"Show Items" & "Show Coins" use cases

## Vending machine in Java (3)

checking if line starts with "insert", followed by one space or tab and then one or more characters

```

else if (Pattern.matches("insert[ \t].*",line)) {
  String[] la = line.split("[ \t]",2);
  if (la.length < 2) { // You never get here!
    assert false : "In insert command: " + line; }
  else { String a = la[1].trim();
    if (a.equals("10")) { vm.insert(Coin.TEN); }
    else if (a.equals("50")) { vm.insert(Coin.FIFTY); }
    else if (a.equals("100")) { vm.insert(Coin.HUNDRED); }
    else { System.err.println("Usage: insert [10|50|100]"); } } }

```

split into two strings such that the 1<sup>st</sup> string is the one just before the 1<sup>st</sup> space or tab, and the 2<sup>nd</sup> string is the one just after the 1<sup>st</sup> space or tab

will be explained later

"Insert Coin" use case

## Vending machine in Java (4)

```

else if (Pattern.matches("select[ \t].*",line)) {
  String[] la = line.split("[ \t]",2);
  if (la.length < 2) { ... } else { String a = la[1].trim();
    if (a.equals("milk")) {
      if (vm.select(Item.MILK)) { System.out.println("you bought one milk."); }
      else { System.out.println("Not enough coins!"); } }
    else if (a.equals("juice")) {
      if (vm.select(Item.JUICE)) { System.out.println("you bought one juice."); }
      else { System.out.println("Not enough coins!"); } }
    else if (a.equals("coffee")) {
      if (vm.select(Item.COFFEE)) {
        System.out.println("you bought one coffee.");
      } else { System.out.println("Not enough coins!"); } }
    else { System.err.println("Usage: select [milk|juice|coffee]"); } }
  } else { System.err.println("No such a command!!!"); }
System.out.print("VM> "); }

```

"Select Item" use case

## Vending machine in Java (5)

assert can be used to check something that must hold.

```
public class TestAssert {
    public static void main(String[] args) {
        Integer m = new Integer(3); Integer n = new Integer(3);
        assert m == n : "m & n refer to different objects"; } }
```

Boolean expression

an expression such as a string (option)

“-ea” option such as “java -ea TestAssert” should be used to make assert effective. If so, this program throws an AssertionError exception because `m == n` becomes false.

If `m` & `n` are reference types, `m == n` becomes true if and only if `m` & `n` refer to exactly the same object; otherwise, it becomes false.

`m.equals(n)` must be true in the above example.

checks if the contents are the same

## Vending machine in Java (6)

40, 80 & 120 are attributes of MILK, JUICE & COFFEE, respectively

declaration of constants should ended with ; if there are attributes/methods in an enum type

```
public enum Item {
    MILK(40), JUICE(80), COFFEE(120);
    private final int cost;
    private Item(int c) { cost = c; }
    public int getCost() { return cost; }
}
```

Constructors of enum types are private because any more instances cannot be made

attributes (fields) are final and then the attribute cost of each item cannot be changed

## Vending machine in Java (7)

```
public class VendingMachine {
    private Map<Coin,Integer> cashBox;
    private Map<Item,Integer> itemBox;
    public VendingMachine() {
        cashBox = new HashMap<Coin,Integer>(); cashBox.put(Coin.TEN,0);
        cashBox.put(Coin.FIFTY,0); cashBox.put(Coin.HUNDRED,0);
        itemBox = new HashMap<Item,Integer>(); itemBox.put(Item.MILK,0);
        itemBox.put(Item.JUICE,0); itemBox.put(Item.COFFEE,0); }
    public Map<Coin,Integer> getCashBox() { return cashBox; }
    public Map<Item,Integer> getItemBox() { return itemBox; }
    public void insert(Coin c) { int x = cashBox.get(c); cashBox.put(c,x+1); }
    private int total() { return cashBox.get(Coin.TEN)*10
        +cashBox.get(Coin.FIFTY)*50+cashBox.get(Coin.HUNDRED)*100; }
    private boolean pay(int c) { ... }
    public boolean select(Item i) { ... } }
```

[sequence diagram that starts with insert\(c: Coin\)](#)

## Vending machine in Java (8)

[sequence diagram that starts with select\(i: item\)](#)

```
public boolean select(Item i) {
    int cost = i.getCost();
    if (total() < cost) return false;
    boolean b = pay(cost/10);
    if (b) { <-----double check; there may be some flaws in
        int c = itemBox.get(i); the implementation of pay
        itemBox.put(i,c+1);
        return true;
    } else {
        // you never get here!
        assert false : "cashBox: " + cashBox + ", " + "cost: " + cost;
        return false;
    }
}
```

## Vending machine in Java (9)

```

private boolean pay(int c) { sequence diagram that starts with pay\(c: int\)
    while (cashBox.get(Coin.TEN) < c) {
        if (cashBox.get(Coin.FIFTY) > 0) { 50Yen coins is changed into five 10Yen coins
            int t1 = cashBox.get(Coin.FIFTY); int t2 = cashBox.get(Coin.TEN);
            cashBox.put(Coin.FIFTY,t1-1); cashBox.put(Coin.TEN,t2+5);
        } else if (cashBox.get(Coin.HUNDRED) > 0) {
            int t1 = cashBox.get(Coin.HUNDRED);
            int t2 = cashBox.get(Coin.FIFTY); int t3 = cashBox.get(Coin.TEN);
            cashBox.put(Coin.HUNDRED,t1-1);
            cashBox.put(Coin.FIFTY,t2+1); cashBox.put(Coin.TEN,t3+5);
        } else { return false; } } not enough cash
    int t = cashBox.get(Coin.TEN);
    assert t >= c : "t >= c must hold but, " + "t=" + t + " & c=" + c;
    cashBox.put(Coin.TEN,t-c);
    return true; } 100Yen coins is changed into five 10Yen coins & one 50Yen coin
subtract c 10Yen coins from the cash box

```

## Summary

- Use case
- Use case diagram
- State (machine) diagram
- Sequence diagram
- Class diagram of vending machine
- Vending machine in Java