Assignment 4

Course: Software Testing

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Contents

Introduction

This assignment delves into control flow graphs, data-flow analysis, and the nuanced art of test case generation. Our focal point is a code snippet extracted from game logic, and our mission is two-fold. Initially, we construct a Control Flow Graph (CFG) that visually encapsulates the program's intricate control flow structure. Subsequently, we navigate the terrain of Data-Flow Analysis to unveil the Def-Use (DU) paths within the code. The final leg of this intellectual odyssey entails crafting three discerning test cases tailored to the identified DU paths. Through these endeavors, we aim to fortify our understanding of program flow dynamics, decipher the nuanced relationships between data elements, and cultivate the skill of formulating compelling test scenarios to validate the robustness of the provided code.

Objectives

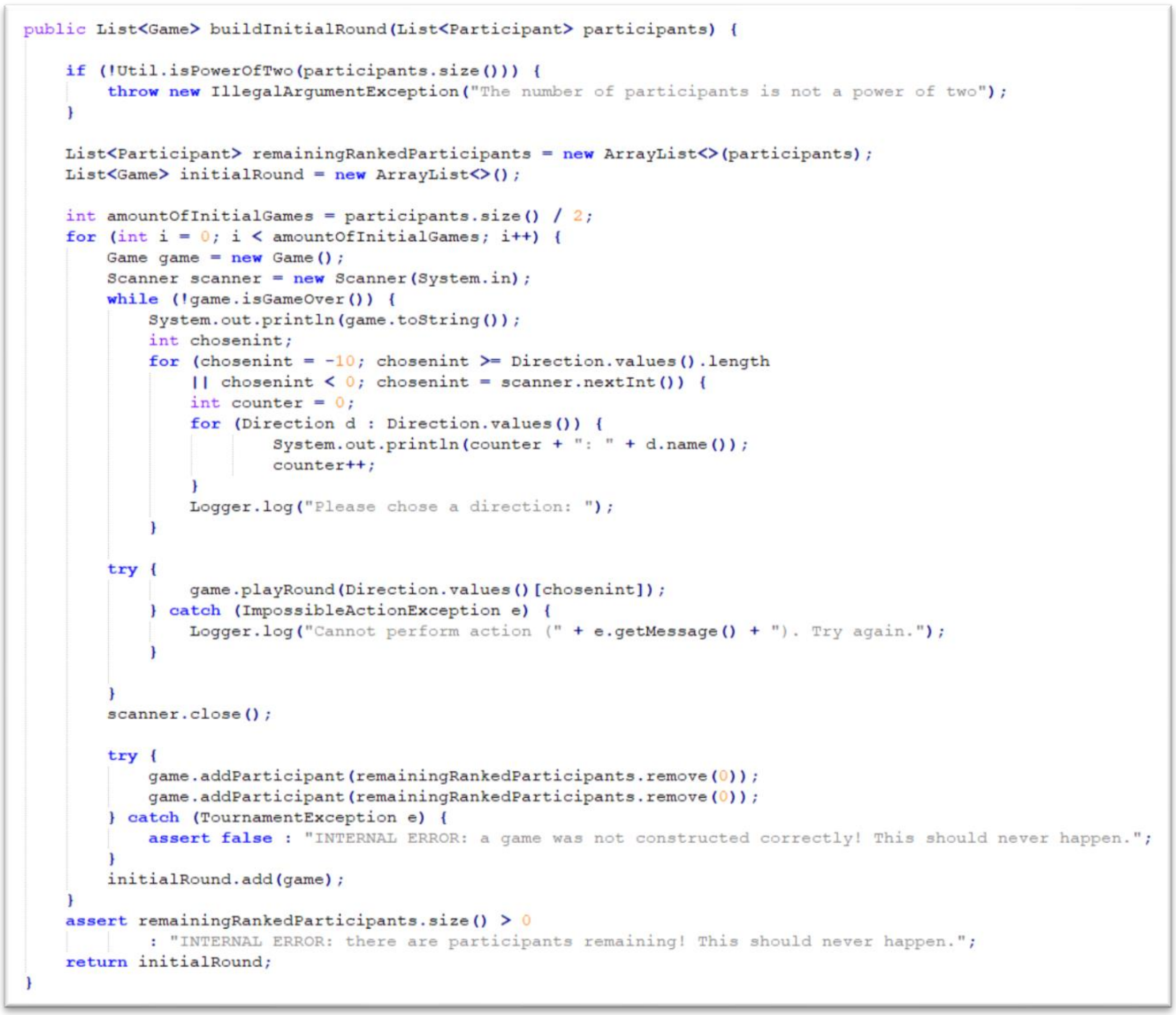
1. **Constructing Control Flow Graph (CFG):** You will begin by creating a visual representation of the program's control flow using a Control Flow Graph. This will provide insights into the order in which statements and branches are executed.

2. **Data-Flow Analysis and DU Paths:** After building the CFG, you'll delve into Data-Flow Analysis to identify Def-Use (DU) paths within the program. Understanding these paths is crucial for uncovering how data is manipulated and used across various code sections.

3. **Test Case Generation:** The final part of the assignment involves generating three meaningful test cases based on the identified DU paths. These test cases will aim to provide adequate coverage to ensure the robustness of the code.

Code

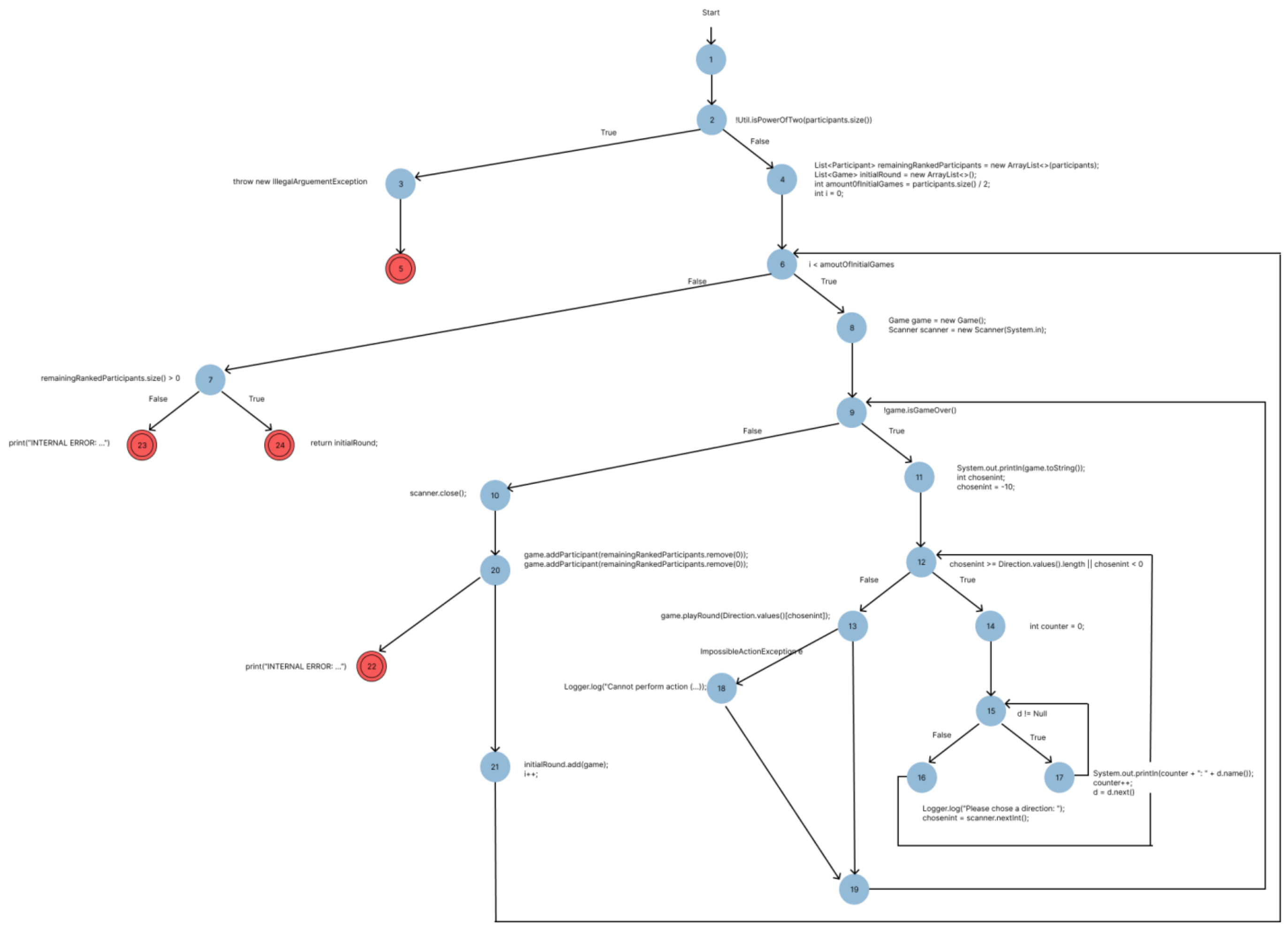
The code given in the assignment is represented below.



```java
public List<Game> buildInitialRound(List<Participant> participants) {

    if (!Util.isPowerOfTwo(participants.size())) {
        throw new IllegalArgumentException("The number of participants is not a power of two");
    }

    List<Participant> remainingRankedParticipants = new ArrayList<>(participants);
    List<Game> initialRound = new ArrayList<>();

    int amountOfInitialGames = participants.size() / 2;
    for (int i = 0; i < amountOfInitialGames; i++) {
        Game game = new Game();
        Scanner scanner = new Scanner(System.in);
        while (!game.isGameOver()) {
            System.out.println(game.toString());
            int chosenint;
            for (chosenint = -10; chosenint >= Direction.values().length
                || chosenint < 0; chosenint = scanner.nextInt()) {
                int counter = 0;
                for (Direction d : Direction.values()) {
                        System.out.println(counter + ": " + d.name());
                        counter++;
                }
                Logger.log("Please chose a direction: ");
            }

        try {
                game.playRound(Direction.values()[chosenint]);
            } catch (ImpossibleActionException e) {
                Logger.log("Cannot perform action (" + e.getMessage() + "). Try again.");
            }

        }
        scanner.close();

        try {
            game.addParticipant(remainingRankedParticipants.remove(0));
            game.addParticipant(remainingRankedParticipants.remove(0));
        } catch (TournamentException e) {
            assert false : "INTERNAL ERROR: a game was not constructed correctly! This should never happen.";
        }
        initialRound.add(game);
    }
    assert remainingRankedParticipants.size() > 0
            : "INTERNAL ERROR: there are participants remaining! This should never happen.";
    return initialRound;
}
```

Control Flow Graph (CFG)

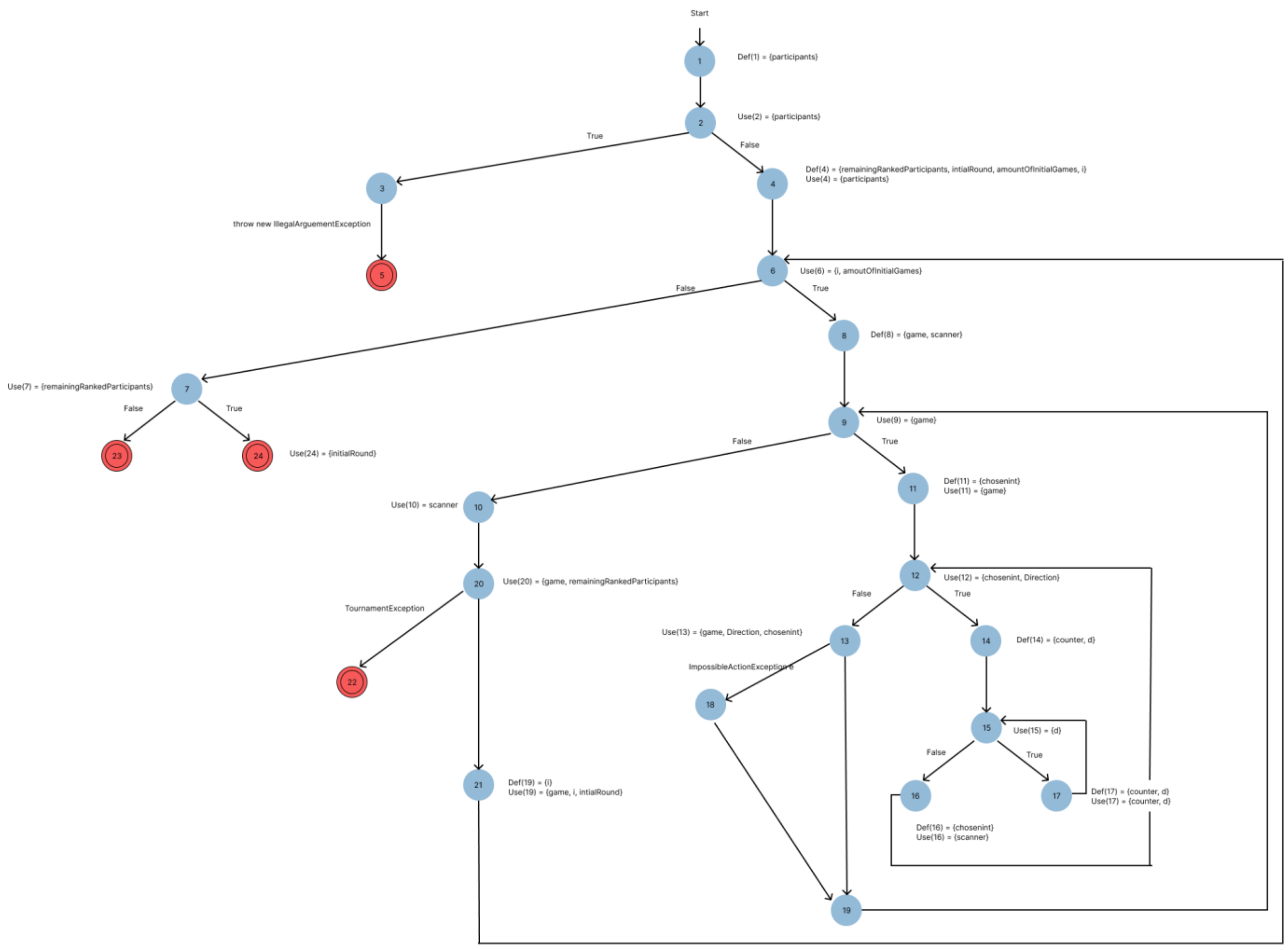
The following graph is constructed from the code given in the previous part. It has four end nodes, three due to the Exceptions. One end node contains the "***return***" statement.


Start
1
2
!Util.isPowerOfTwo(participants.size())
True
False
3
throw new IllegalArguementException
5
4
List<Participant> remainingRankedParticipants = new ArrayList<>(participants);
List<Game> initialRound = new ArrayList<>();
int amountOfInitialGames = participants.size() / 2;
int i = 0;
6
i < amoutOfInitialGames
False
True
7
remainingRankedParticipants.size() > 0
False
True
23
print("INTERNAL ERROR: ...")
24
return initialRound;
8
Game game = new Game();
Scanner scanner = new Scanner(System.in);
9
!game.isGameOver()
False
True
10
scanner.close();
11
System.out.println(game.toString());
int chosenint;
chosenint = -10;
20
game.addParticipant(remainingRankedParticipants.remove(0));
game.addParticipant(remainingRankedParticipants.remove(0));
22
print("INTERNAL ERROR: ...")
12
chosenint >= Direction.values().length || chosenint < 0
False
True
13
game.playRound(Direction.values()[chosenint]);
ImpossibleActionException e
18
Logger.log("Cannot perform action (...));
14
int counter = 0;
15
d != Null
False
True
16
Logger.log("Please chose a direction: ");
chosenint = scanner.nextInt();
17
System.out.println(counter + ": " + d.name());
counter++;
d = d.next()
21
initialRound.add(game);
i++;
19

Definition Use Paths (DU Paths)

DU Graph

In this part, we will extract all Def-Use Paths from the constructed CFG in the previous part. First, all variable definitions and their uses must be identified.



DU Pair

In this step, the Def-Use table from the previous graph is created:

NODE	DEF	USE
1	participants	-
2	-	participants
3	-	-
4	remainingRankedParticipants, intialRound, amountOfInitialGames, i	participants
5	-	-
6	-	i, amoutOfInitialGames
7	-	remainingRankedParticipants
8	game, scanner	-
9	-	game
10	-	scanner
11	chosenint	game
12	-	chosenint, Direction
13	-	game, Direction, chosenitn
14	counter, d	-
15	-	d
16	chosenint	scanner
17	counter, d	counter, d
18	-	-
19	-	-
20	-	game, remainingRankedParticipants
21	i	game, initialRound, i
22	-	-
23	-	-
24	-	intialRound

DU Paths

After creating the DU table, we can create DU pairs for further test case creation.

VARIABLE	DU PAIRS
DIRECTION	-
PARTICIPANTS	[1, 2], [1, 4]
REMAININGRANKEDPARTICIPANTS	[4, 7], [4, 20]
INITIALROUND	[4, 21], [4, 24]
AMOUNTOFINITIALGAMES	[4, 6]
I	[4,6], [4,21], [21,6], [21,21]
GAME	[8,9], [8,11], [8,13], [8,20], [8,21]
SCANNER	[8,10], [8,16]
CHOSENINT	[11,12], [11,13], [16,12], [16,13]
COUNTER	[14,17], [17,17]
D	[14,15], [14,17], [17,15], [17,17]
E	-

DU Paths

Now that we have the DU Pair Table, we can create the DU Paths Table from it.

VARIABLES	DU PATHS
DIRECTION	-
PARTICIPANTS	[1,2], [1,2,4]
REMAININGRANKEDPARTICIPANTS	[4,6,7], [4,6,8,9,10,20]
INITIALROUND	[4,6,7,24], [4,6,8,9,10,20,21]
AMOUNTOFINITIALGAMES	[4, 6]
I	[4,6], [4,6,8,9,10,20,21], [21,6], [21,6,8,9,10,20,21]
GAME	[8,9], [8,9,11], [8,9,10,20], [8,9,11,12,13], [8,9,10,20,21]
SCANNER	[8,9,10], [8,9,11,12,14,15,16]
CHOSENINT	[11,12], [11,12,13], [16,12], [16,12,13]
COUNTER	[14,15,17], [17,15,17]
D	[14,15], [14,15,17], [17,15], [17,15,17]
E	-

Test Cases

Test Case 1:

- **Input:** [Player1, Player2]
- **Test-Path:** [1, 2, 4, 6, 8, 9, 10, 20, 21, 6, 8, 9, 10, 20, 21, 6, 7, 24]
- **Expected Output:** intialRound

Test Case 2:

- **Input:** [Player1, Player2]
- **Test-Path:** [1, 2, 4, 6, 8, 9, 11, 12, 14, 15, 17, 15, 17, 15, 16, 12, 13, 19, 9, 10, 20, 22]
- **Expected Output:** “INTERNAL ERROR: …”

Test Case 3:

- **Input:** [Player1, Player2, Player3]
- **Test-Path:** [1, 2, 3, 5]
- **Expected Output:** “The number of participants is not a power of two.”