Instituto Superior Técnico - UL

# Software Testing and Validation

## Health Club

## Report


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# Contents

# 1 Member Class Class Scope Test

Test Pattern used: Conformance Testing

We chose this pattern because GroupClass is a modal class (only depends on its contents and its history) and has a fixed constraints on method sequences. The objective of the test suite is to find out which message sequences and state changes may originate error.

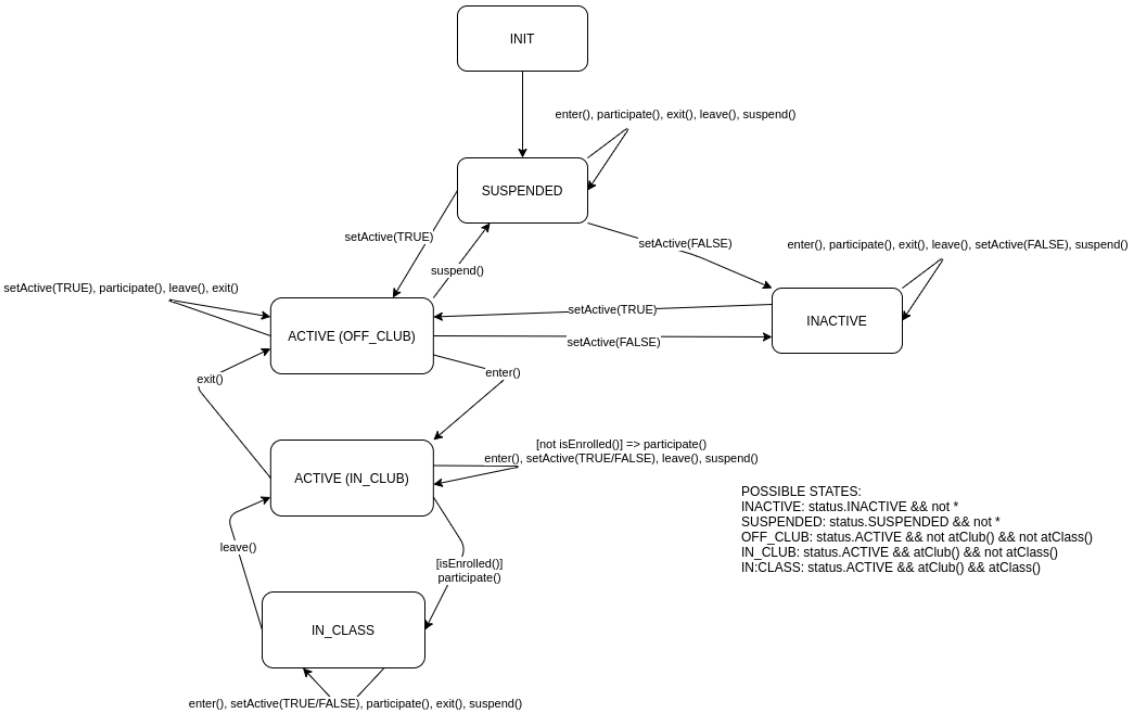


Figure 1: State model for Member class

From the state machine we built a transition tree.

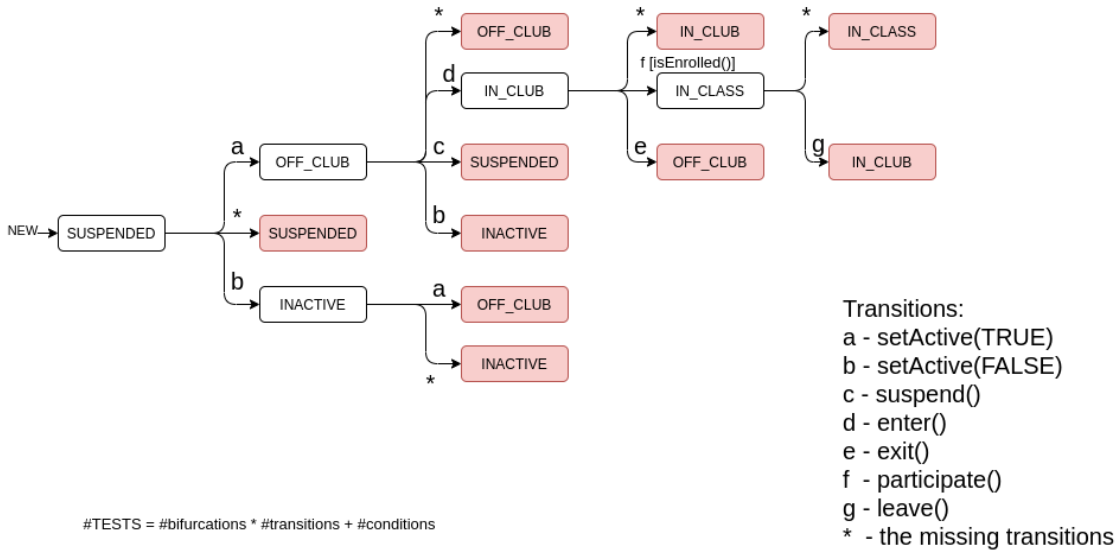


Figure 2: Transition tree for Member class

And by navigating the branches on the transition tree, we designed the conformance test suite.

| Run | Test Run/Event Path | | | | | Expected Terminal State | Exceptions |
|---|---|---|---|---|---|---|---|
| | lvl1 | lvl2 | lvl3 | lvl4 | lvl5 | | |
| 1 | new | | | | | SUSPENDED | |
| 2 | new | setActive(True) | | | | OFF_CLUB | |
| 3 | new | setActive(False) | | | | INACTIVE | |
| 4 | new | suspend() | | | | SUSPENDED | InvalidOperationException |
| 5 | new | enter() | | | | SUSPENDED | InvalidOperationException |
| 6 | new | exit() | | | | SUSPENDED | InvalidOperationException |
| 7 | new | participate() | | | | SUSPENDED | InvalidOperationException |
| 8 | new | leave() | | | | SUSPENDED | InvalidOperationException |
| 9 | new | setActive(True) | setActive(True) | | | ACTIVE | |
| 10 | new | setActive(True) | setActive(False) | | | INACTIVE | |
| 11 | new | setActive(True) | suspend() | | | SUSPENDED | |
| 12 | new | setActive(True) | leave() | | | OFF_CLUB | InvalidOperationException |
| 13 | new | setActive(True) | exit() | | | OFF_CLUB | InvalidOperationException |
| 14 | new | setActive(True) | participate() | | | OFF_CLUB | InvalidOperationException |
| 15 | new | setActive(True) | enter() | | | IN_CLUB | |
| 16 | new | setActive(False) | setActive(True) | | | OFF_CLUB | |
| 17 | new | setActive(False) | setActive(False) | | | INACTIVE | |
| 18 | new | setActive(False) | suspend() | | | INACTIVE | InvalidOperationException |
| 19 | new | setActive(False) | leave() | | | INACTIVE | InvalidOperationException |
| 20 | new | setActive(False) | exit() | | | INACTIVE | InvalidOperationException |
| 21 | new | setActive(False) | participate() | | | INACTIVE | InvalidOperationException |
| 22 | new | setActive(False) | enter() | | | INACTIVE | InvalidOperationException |
| 23 | new | setActive(True) | enter() | setActive(True) | | IN_CLUB | InvalidOperationException |
| 24 | new | setActive(True) | enter() | setActive(False) | | IN_CLUB | InvalidOperationException |
| 25 | new | setActive(True) | enter() | suspend() | | IN_CLUB | InvalidOperationException |
| 26 | new | setActive(True) | enter() | leave() | | IN_CLUB | InvalidOperationException |
| 27 | new | setActive(True) | enter() | exit() | | OFF_CLUB | |
| 28 | new | setActive(True) | enter() | participate()[isEnrolled] | | IN_CLASS | |
| 29 | new | setActive(True) | enter() | participate()[isNotEnrolled] | | IN_CLUB | InvalidOperationException |
| 30 | new | setActive(True) | enter() | enter() | | IN_CLUB | InvalidOperationException |
| 31 | new | setActive(True) | enter() | participate()[isEnrolled] | setActive(True) | IN_CLASS | InvalidOperationException |
| 32 | new | setActive(True) | enter() | participate()[isEnrolled] | setActive(False) | IN_CLASS | InvalidOperationException |
| 33 | new | setActive(True) | enter() | participate()[isEnrolled] | suspend() | IN_CLASS | InvalidOperationException |
| 34 | new | setActive(True) | enter() | participate()[isEnrolled] | leave() | IN_CLUB | |
| 35 | new | setActive(True) | enter() | participate()[isEnrolled] | exit() | IN_CLASS | InvalidOperationException |
| 36 | new | setActive(True) | enter() | participate()[isEnrolled] | participate() | IN_CLASS | InvalidOperationException |
| 37 | new | setActive(True) | enter() | participate()[isEnrolled] | enter() | IN_CLASS | InvalidOperationException |

Figure 3: Conformance Matrix for Member Test Suite

## 2 GroupClass Class Class Scope Test

Test pattern used: Class invariant
We chose this pattern because GroupClass is a non-modal class, i.e., there is no constraints on message sequences. The objective is to find out which sequences may originate error.

| Constraint | | | Test Cases | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Condition | Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| beginHour | >= 8 | ON | 8 | | | | | | | | | | | | | | | |
| | | OFF | | 7 | | | | | | | | | | | | | | |
| | <= 22 | ON | | | 22 | | | | | | | | | | | | | |
| | | OFF | | | | 23 | | | | | | | | | | | | |
| | Typical | IN | | | | | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| duration | > 0 | ON | | | | | 0 | | | | | | | | | | | |
| | | OFF | | | | | | 1 | | | | | | | | | | |
| | typical | IN | 2 | 3 | 4 | 5 | | | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 50 | 77 | 88 |
| capacity | >= 5 | ON | | | | | | | 5 | | | | | | | | | |
| | | OFF | | | | | | | | 4 | | | | | | | | |
| | <= 25 | ON | | | | | | | | | 25 | | | | | | | |
| | | OFF | | | | | | | | | | 26 | | | | | | |
| | Typical | IN | 7 | 8 | 9 | 10 | 11 | 12 | | | | | 13 | 14 | 15 | 20 | 21 | 22 |
| club | eq null | ON | | | | | | | | | | | null | | | | | |
| | | OFF | | | | | | | | | | | | CLUB | | | | |
| | | IN | CLUB | CLUB | CLUB | CLUB | CLUB | CLUB | CLUB | CLUB | CLUB | CLUB | | | CLUB | CLUB | CLUB | CLUB |
| minAge | >= 0 | ON | | | | | | | | | | | | | 0 | | | |
| | | OFF | | | | | | | | | | | | | | -1 | | |
| | < 20 | ON | | | | | | | | | | | | | | | 20 | |
| | | OFF | | | | | | | | | | | | | | | | 19 |
| | Typical | IN | 1 | 2 | 3 | 4 | 7 | 9 | 10 | 11 | 12 | 15 | 17 | 18 | | | | |
| Expected Result | | | ✓ | ✗ | ✓ | ✗ | ✗ | ✓ | ✓ | ✗ | ✓ | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ | ✓ |

Figure 4: GroupClass Test Matrix

Modifier sequences for each test:

1. new GroupClass(8, 2, 7, healthClub, 1, true);
2. new GroupClass(7, 3, 8, healthClub, 2, true);
3. new GroupClass(10, 4, 8, healthClub, 3, true); setBeginHour(22); setCapacity(9);
4. new GroupClass(10, 5, 8, healthClub, 3, true); setBeginHour(23); setMinAge(4);
5. new GroupClass(10, 0, 8, healthClub, 3, true);
6. new GroupClass(10, 1, 8, healthClub, 3, true); setCapacity(12); setMinAge(9);
7. new GroupClass(12, 7, 10, healthClub, 11, true); setCapacity(5);
8. new GroupClass(16, 6, 20, healthClub, 10, true); setBeginHour(11); setCapacity(4);
9. new GroupClass(13, 8, 25, healthClub, 12, true); setBeginHour(13); setCapacity(25); setMinAge(12);
10. new GroupClass(14, 9, 15, healthClub, 15, true); setCapacity(26);
11. new GroupClass(15, 10, 13, healthClub, 17, true);
12. new GroupClass(16, 11, 14, healthClub, 10, true); setCapacity(14); setMinAge(18);
13. new GroupClass(17, 12, 10, healthClub, 10, true); setCapacity(15); setMinAge(0);

14. new GroupClass(13, 12, 10, healthClub, -1, true);
15. new GroupClass(18, 77, 21, healthClub, 19, true); setBeginHour(19); setMinAge(20);
16. new GroupClass(20, 88, 10, healthClub, 19, true); setCapacity(22); setMinAge(19);

# 3 Compute Membership Cost Method Scope Test

Test pattern used: Combinational Function test
We used this pattern because the computeMembershipCost method relies on a combination of 4 input parameters (the member's age, the number of group classes the member is enrolled in, the number of years of membership of the member, the member's state) in order to compute a member's monthly fee.

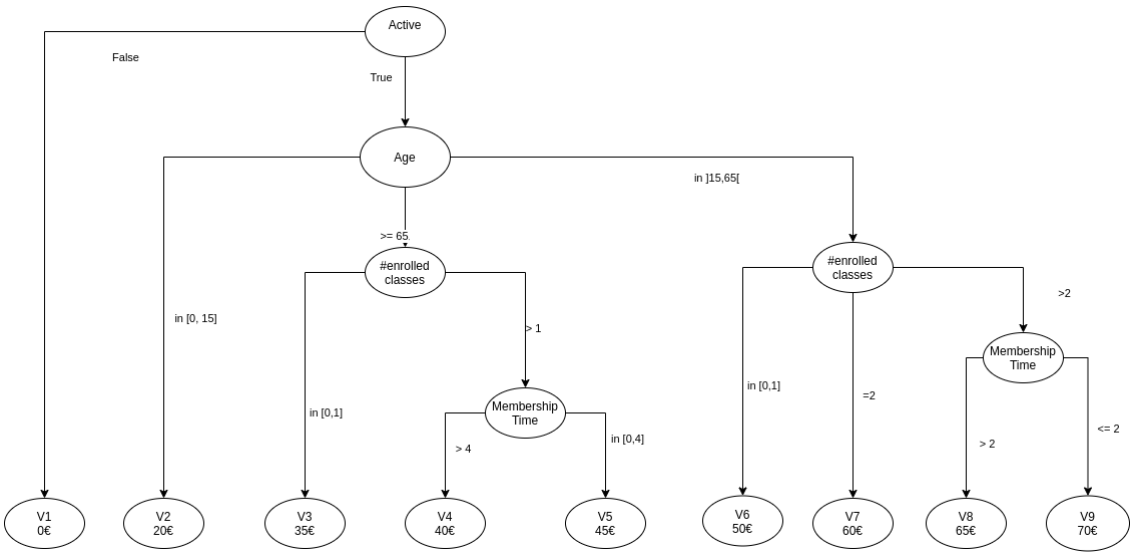


Figure 5: Decision Tree for computeMembershipCost method

We found 9 different variants, and developed an invariant boundary matrix for each one.

| Constraint | | Type | Test Cases | |
|---|---|---|---|---|
| Variable | Condition | | #1 | |
| active | | ON | FALSE | |
| | | OFF | | TRUE |
| age | | IN | 10 | 50 |
| #enrolledclasses | | IN | 0 | 5 |
| MemberShipTime | | IN | 0 | 5 |
| Expected Result | | | 0 | V2,V3,V4,V5,V6,V7,V8.V9 |

Figure 6: Combinational Tesing Variant 1

| Constraint | | Type | Test Cases | | | |
|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | #2 | #3 |
| active | eq false | ON | FALSE | | | |
| | | OFF | | TRUE | | |
| | | IN | | | TRUE | TRUE |
| age | <= 15 | ON | | | 15 | |
| | | OFF | | | | 16 |
| | | IN | 10 | 12 | | |
| #enrolledclasses | | IN | 0 | 2 | 4 | 6 |
| MemberShipTime | | IN | 0 | 2 | 4 | 6 |
| Expected Result | | | V1 | 20€ | 20€ | V6,V7,V8,V9 |

Figure 7: Combinational Tesing Variant 2

| Constraint | | Type | Test Cases | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | #2 | | #3 | #4 |
| active | eq false | ON | FALSE | | | | | |
| | | OFF | | TRUE | | | | |
| | | IN | | | TRUE | TRUE | TRUE | TRUE |
| age | >= 65 | ON | | | 65 | | | |
| | | OFF | | | | 64 | | |
| | | IN | 66 | 67 | | | 70 | 80 |
| #enrolledclasses | <= 1 | ON | | | | | 1 | |
| | | OFF | | | | | | 2 |
| | | IN | 0 | 1 | 0 | 1 | | |
| MemberShipTime | | IN | 0 | 2 | 4 | 6 | 8 | 10 |
| Expected Result | | | V1 | 35€ | 35€ | V6,V7,V8,V9 | 35€ | V4,V5 |

Figure 8: Combinational Tesing Variant 3

| Constraint | | Type | Test Cases | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | #2 | | | #3 | | #4 |
| active | eq false | ON | FALSE | | | | | | | |
| | | OFF | | TRUE | | | | | | |
| | | IN | | | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| age | >= 65 | ON | | | 65 | | | | | |
| | | OFF | | | | 64 | | | | |
| | | IN | 66 | 67 | | | 70 | 80 | 90 | 95 |
| #enrolledclasses | > 1 | ON | | | | | 1 | | | |
| | | OFF | | | | | | 2 | | |
| | | IN | 3 | 4 | 5 | 6 | | | 7 | 8 |
| MemberShipTime | > 4 | ON | | | | | | | 4 | |
| | | OFF | | | | | | | | 5 |
| | | IN | 6 | 7 | 8 | 9 | 10 | 11 | | |
| Expected Result | | | V1 | 40€ | 40€ | V6,V7,V8,V9 | V3 | 40€ | V5 | 40€ |

Figure 9: Combinational Tesing Variant 4

| Constraint | | Type | Test Cases | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | #2 | | | #3 | #4 | |
| active | eq false | ON | FALSE | | | | | | | |
| | | OFF | | TRUE | | | | | | |
| | | IN | | | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| age | >= 65 | ON | | | 65 | | | | | |
| | | OFF | | | | 64 | | | | |
| | | IN | 66 | 67 | | | 70 | 80 | 90 | 95 |
| #enrolledclasses | > 1 | ON | | | | | 1 | | | |
| | | OFF | | | | | | 2 | | |
| | | IN | 3 | 4 | 5 | 6 | | | 7 | 8 |
| MemberShipTime | <=4 | ON | | | | | | | 4 | |
| | | OFF | | | | | | | | 5 |
| | | IN | 0 | 0 | 1 | 2 | 3 | 4 | | |
| Expected Result | | | V1 | 45€ | 45€ | V6,V7,V8,V9 | V3 | 45€ | 45€ | V4 |

Figure 10: Combinational Tesing Variant 5

| Constraint | | Type | Test Cases | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | | #2 | | #3 | #4 | |
| active | eq false | ON | FALSE | | | | | | | |
| | | OFF | | TRUE | | | | | | |
| | | IN | | | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| age | >15 | ON | | | 15 | | | | | |
| | | OFF | | | | 16 | | | | |
| | <65 | ON | | | | | 65 | | | |
| | | OFF | | | | | | 64 | | |
| | | IN | 16 | 17 | | | | | 18 | 19 |
| #enrolledclasses | <=1 | ON | | | | | | | 1 | |
| | | OFF | | | | | | | | 2 |
| | | IN | 0 | 1 | 0 | 1 | 0 | 1 | | |
| MemberShipTime | | IN | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 |
| Expected Result | | | V1 | 50€ | V2 | 50€ | V3,V4,V5 | 50€ | 50€ | V7 |

Figure 11: Combinational Tesing Variant 6

| Constraint | | Type | Test Cases | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | | #2 | | #3 | #4 | |
| active | eq false | ON | FALSE | | | | | | | |
| | | OFF | | TRUE | | | | | | |
| | | IN | | | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| age | >15 | ON | | | 15 | | | | | |
| | | OFF | | | | 16 | | | | |
| | <65 | ON | | | | | 65 | | | |
| | | OFF | | | | | | 64 | | |
| | | IN | 16 | 17 | | | | | 18 | 19 |
| #enrolledclasses | eq 2 | ON | | | | | | | 2 | |
| | | OFF | | | | | | | | 1 |
| | | IN | 2 | 2 | 2 | 2 | 2 | 2 | | |
| MemberShipTime | | IN | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 |
| Expected Result | | | V1 | 60€ | V2 | 60€ | V3,V4,V5 | 60€ | 60€ | V6 |

Figure 12: Combinational Tesing Variant 7

| Constraint | | Type | Test Cases | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | | #2 | | #3 | | #4 | | #5 |
| active | eq false | ON | FALSE | | | | | | | | | |
| | | OFF | | TRUE | | | | | | | | |
| | | IN | | | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| age | >15 | ON | | | 15 | | | | | | | |
| | | OFF | | | | 16 | | | | | | |
| | <65 | ON | | | | | 65 | | | | | |
| | | OFF | | | | | | 64 | | | | |
| | | IN | 16 | 17 | | | | | 18 | 19 | | |
| #enrolledclasses | > 2 | ON | | | | | | | 2 | | | |
| | | OFF | | | | | | | | 3 | | |
| | | IN | 3 | 4 | 5 | 6 | 7 | 8 | | | 9 | 10 |
| MemberShipTime | > 2 | ON | | | | | | | | | 2 | |
| | | OFF | | | | | | | | | | 3 |
| | | IN | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | |
| Expected Result | | | V1 | 65€ | V2 | 65€ | V3,V4,V5 | 65€ | V7 | 65€ | V9 | 65€ |

Figure 13: Combinational Tesing Variant 8

| Constraint | | Type | Test Cases | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Condition | | | #1 | | #2 | | #3 | | #4 | #5 | |
| active | eq false | ON | FALSE | | | | | | | | | |
| | | OFF | | TRUE | | | | | | | | |
| | | IN | | | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| age | >15 | ON | | | 15 | | | | | | | |
| | | OFF | | | | 16 | | | | | | |
| | <65 | ON | | | | | 65 | | | | | |
| | | OFF | | | | | | 64 | | | | |
| | | IN | 16 | 17 | | | | | 18 | 19 | 20 | 21 |
| #enrolledclasses | > 2 | ON | | | | | | | 2 | | | |
| | | OFF | | | | | | | | 3 | | |
| | | IN | 3 | 4 | 5 | 6 | 7 | 8 | | | 9 | 10 |
| MemberShipTime | <= 2 | ON | | | | | | | | | 2 | |
| | | OFF | | | | | | | | | | 3 |
| | | IN | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | | |
| Expected Result | | | V1 | 70€ | V2 | 70€ | V3,V4,V5 | 70€ | V7 | 70€ | 70€ | V8 |

Figure 14: Combinational Tesing Variant 9

# 4 Enroll Method Scope Test (Within GroupClass Class)

Test pattern used: Category Partition
We chose this pattern because implements several functions.
Functions of enroll method:

- Primary: properly update the list of member's in the GroupClass (either by adding a new member, adding a new member and removing an existing one or by doing nothing).
- Secondary: Return true if the member is enrolled and false otherwise.

The objective of the test suite is to try to find out which combinations of method parameters and instance variables result in an incorrect input.

| Parameter | Category | Choices |
|---|---|---|
| Type GroupClass (gold or silver) | Standard cases | gold |
| | | silver |
| Type of Member (gold or silver) | Standard cases | gold |
| | | silver |
| State of the list of already enrolled members | nth element | n ∈ [0, capacity - 1] members enrolled member regardless of membership type(given member not included) |
| | Special Cases | full list with only golden members (given member not included) |
| | | full list with some silver members (given member not included) |
| | | member already in list |

Figure 15: Enroll Method Categories

| Test | Member age greater or equal than min age | Type of Member | Type Of Class | State of the enrolled member list | Exception | Action (made to list) | Return |
|---|---|---|---|---|---|---|---|
| 1 | TRUE | gold | gold | n ∈ [0, capacity - 1] | | add member | TRUE |
| 2 | TRUE | gold | gold | full w/ golden | | unchanged | FALSE |
| 3 | TRUE | gold | gold | full w/ some silver | | remove one silver and add new member | TRUE |
| 4 | TRUE | gold | gold | member in list | | unchanged | TRUE |
| 5 | TRUE | gold | silver | n ∈ [0, capacity - 1] | | add member | TRUE |
| 6 | TRUE | gold | silver | full w/ golden | | unchanged | FALSE |
| 7 | TRUE | gold | silver | full w/ some silver | | unchanged | FALSE |
| 8 | TRUE | gold | silver | member in list | | unchanged | TRUE |
| 9 | TRUE | silver | gold | n ∈ [0, capacity - 1] | | add member | TRUE |
| 10 | TRUE | silver | gold | full w/ golden | | unchanged | FALSE |
| 11 | TRUE | silver | gold | full w/ some silver | | unchanged | FALSE |
| 12 | TRUE | silver | gold | member in list | | unchanged | TRUE |
| 13 | TRUE | silver | silver | n ∈ [0, capacity - 1] | | add member | TRUE |
| 14 | TRUE | silver | silver | full w/ golden | | unchanged | FALSE |
| 15 | TRUE | silver | silver | full w/ some silver | | unchanged | FALSE |
| 16 | TRUE | silver | silver | member in list | | unchanged | TRUE |
| 17 | FALSE | gold | gold | n ∈ [0, capacity - 1] | InvalidOperation | unchanged | null |
| 18 | FALSE | gold | gold | full w/ golden | InvalidOperation | unchanged | null |
| 19 | FALSE | gold | gold | full w/ some silver | InvalidOperation | unchanged | null |
| 20 | FALSE | gold | gold | member in list | InvalidOperation | unchanged | null |
| 21 | FALSE | gold | silver | n ∈ [0, capacity - 1] | InvalidOperation | unchanged | null |
| 22 | FALSE | gold | silver | full w/ golden | InvalidOperation | unchanged | null |
| 23 | FALSE | gold | silver | full w/ some silver | InvalidOperation | unchanged | null |
| 24 | FALSE | gold | silver | member in list | InvalidOperation | unchanged | null |
| 25 | FALSE | silver | gold | n ∈ [0, capacity - 1] | InvalidOperation | unchanged | null |
| 26 | FALSE | silver | gold | full w/ golden | InvalidOperation | unchanged | null |
| 27 | FALSE | silver | gold | full w/ some silver | InvalidOperation | unchanged | null |
| 28 | FALSE | silver | gold | member in list | InvalidOperation | unchanged | null |
| 29 | FALSE | silver | silver | n ∈ [0, capacity - 1] | InvalidOperation | unchanged | null |
| 30 | FALSE | silver | silver | full w/ golden | InvalidOperation | unchanged | null |
| 31 | FALSE | silver | silver | full w/ some silver | InvalidOperation | unchanged | null |
| 32 | FALSE | silver | silver | member in list | InvalidOperation | unchanged | null |

Figure 16: Enroll Method Test Cases