



# Assignment 3

## I. Unit Testing

For all my unit tests, I first came up with some input partitioning scheme to better increase my test coverage. For example, cards that draw from the deck might behave differently in code if they draw into an empty deck that must be shuffled from discard. So, my tests must cover multiple input cases. Each of the subsections below will detail the specific input cases I tested. I could not test all the cases that I conceived, but I hope my selections are meet the project requirements.

For every unit test, some tests are not input dependent, i.e. they test variables that should change regardless of input type. For example, regardless of whether the Council Room draws from an empty deck, it must increase the number of buys for the player by 1. Therefore, the subsections below will detail the Input Independent tests and the Input Dependent tests.

For the cards that I tested both by calling `cardEffect` and by calling the refactored code directly (e.g. `adventurer` and `smithy`), I tested different input. Because there are input independent tests, there is some repeat code since these are input independent tests. Rather than repeat the documentation for these repeat tests, I will note when they are identical with "Same as Above."

### • Unittest1 - AdventurerEffect

#### Input Independent Tests

- \* Adventurer card should be "played" i.e. added to `playedCard` variable
- \* Player's hand should be increased by 1 (draw two treasures, play adventurer)
- \* The two new cards should be treasures
- \* Player's original hand has not been changed (aside from two new treasures and playing Adventurer)
- \* Player's card count has not changed (i.e. `deck + discard + hand + played` stays the same)
- \* Gamestate has not changed for any non-player related variables
- \* Gamestate has not changed for any other player

#### Input Dependent Tests

If the first two cards of the deck are treasures:

- \* Discard pile has not changed
- \* Deckcount decreased by two

If the first two cards are not treasures but there are two treasures in deck (i.e. no shuffle required to reveal treasures)

- \* Discard pile has not changed
- \* Deckcount decreased by amount equal to second location of treasure in deck

### • Cardtest1 - cardEffect with adventurer

#### Input Independent Tests (Same as above)

#### Input Dependent Tests

If there is are less than two treasures in deck:

- \* Discard pile should not have any treasures (otherwise, a treasures was discarded)

- **Unittest2 - SmithyEffect**

**Input Independent Tests**

- \* Player's hand should be increased by 2 (draw three, subtract 1 for playing smithy)
- \* Player's original hand should not have changed (aside from new cards and playing smithy)
- \* Player's total card count has not changed (i.e. deck + discard + hand + played stays the same)
- \* Gamestate has not changed for any non-player variable
- \* Gamestate has not changed for any other player

**Input Dependent Tests**

If the deck has more than three cards:

- \* New cards in hand should be same as top three cards in deck
- \* DeckCount should decrease by three
- \* Discard pile should not change

- **Cardtest2 - cardEffect with Smithy**

**Input Independent Tests (Same as above)****Input Dependent Tests**

If deck has less than three cards left:

- \* Hand should have all cards currently in deck
- \* Discard pile should be empty because of reshuffle

- **Unittest3 - CouncilRoomEffect**

**Input Independent Tests**

- \* Player's hand should be increased by 3 (draw four, play council room)
- \* Player's original hand has not been changed (aside from card draws and playing council room)
- \* Player's card count has not changed (i.e. deck + discard + hand + played stays the same)
- \* Gamestate has not changed except +1 Buy
- \* Other players' hand increased by 1
- \* New card in each non-active player's hand should come from top of their decks

**Input Dependent Tests**

If both the active player (the one playing the card) and the inactive player have enough cards in deck to draw +3 and +1 respectively:

- \* For active player, new cards in hand should be same as top three cards in deck
- \* For active player, deckCount should decrease by three
- \* For active player, discard pile should not change
- \* For inactive player, new card in hand should be same as top of player's deck
- \* For inactive player, deckCount should decrease by 1
- \* For inactive player, discard pile should not change

If the active player has fewer than four cards in deck and inactive player has exactly 0 (i.e. both must shuffle):

- \* For active player, any cards left in deck should be in hand
- \* For active player, discard pile should be empty
- \* For inactive player, discard pile should be empty

- **Cardtest3 - cardEffect with Great Hall**

**Input Independent Tests**

- \* Player's handCount should not change (+1 Card negated by playing Great Hall)
- \* Player's original hand has not been changed (aside from +1 Card and playing Great Hall)
- \* Player's total card count has not changed (i.e. deck + discard + hand + played stays the same)
- \* Gamestate has not changed except +1 Actions
- \* Other player variables have not changed
- \* Great Hall card should be played, i.e. added to playedCards array

**Input Dependent Tests**

If deck has greater than zero cards left:

- \* Hand should have same card as top of deck
- \* DeckCount should decrease by 1
- \* Discard pile should not change

If deck has exactly zero cards left:

- \* Discard pile should be empty

- **Unittest4 - villageEffect**

**Input Independent Tests**

- \* Village card should be played, i.e. added to playedCards array
- \* Player's hand should not change (+1 Card negated by playing Village)
- \* Player's original hand has not been changed (except for +1 Card and playing Village)
- \* Player's total card count has not changed (i.e. deck + discard + hand + played stays the same)
- \* Gamestate has not changed except +2 Actions
- \* Other player variables have not changed

**Input Dependent Tests**

If the deck has more than zero cards left:

- \* Hand should have same card as top of deck
- \* DeckCount should decrease by 1
- \* Discard pile should not change

If the deck has exactly zero cards:

- \* Discard pile should be empty

- **Cardtest4 - cardEffect with Mine**

**Input Independent Tests (None)****Input Dependent Tests**

If the handposition of the card selected for trashing is a treasure and the card selected for gaining is also a treasure:

- \* Player's handCount decrease by 1 (by playing Mine)
- \* Chosen card should be replaced with treasure no more than +3 its cost
- \* Player's total card count has not changed (i.e. deck + discard + hand + played stays the same)
- \* Supply pile from gained treasure should decrease by 1

- \* GameState variables unrelated to player should not change
  - \* Other player variables should not change
  - \* Mine card should be played, i.e. added to playedCards array
  - \* Discard pile should not change
- If a non-treasure is selected for trashing:
- \* Function should return -1
  - \* GameState should be unaltered
- If a non-treasure is selected for gaining:
- \* Function should return -1
  - \* GameState should be unaltered

## II. Bugs

### (a) unittest1.c/cardtest1.c - Adventurer

- **Play Card Bug:**

**Description of Bug:** When the adventurer card is played, it does not appear at the top of the playedCard array.

**How to Cause:** Initialize a game, add an adventurer card to the first player's hand, and then call adventureEffect with the correct hand position. Then check that (a) playedCardCount has increased by 1 and that (b) the top of playedArray is adventurer.

**Code:**

```
int main() {
    // INITIALIZATION HERE
    int pass;
    int seed = 1000;
    int numPlayers = 4;
    int player = 0;
    int handpos;
    struct gameState G, testG, blankG;

    // initialize a game state and player cards
    int k[10] = {adventurer, embargo, village, minion, mine,
        cutpurse, sea_hag, tribute, smithy, council_room};
    initializeGame(numPlayers, k, seed, &G);
    memcpy(&blankG, &G, sizeof(struct gameState));

    G.deck[player][G.deckCount[player]] = gold;
    G.deck[player][G.deckCount[player]+1] = province;
    G.deck[player][G.deckCount[player]+2] = silver;
    G.deck[player][G.deckCount[player]+3] = duchy;
    G.deckCount[player] = G.deckCount[player] + 4;

    handpos = G.handCount[player];
    G.hand[player][handpos] = adventurer;
    G.handCount[player]++;
}
```

```

memcpy(&testG, &G, sizeof(struct gameState));
adventurerEffect(&testG, player, handpos);

// TEST STARTS HERE
if (testG.playedCardCount == G.playedCardCount + 1) {
    if (testG.playedCards[testG.playedCardCount - 1] == adventurer
        )
        printf("\tPASSED: Adventurer card was properly played, i.e.
            smithy added to playedCard array\n");
    else
        printf("\t\u274CFAILED: Adventurer card was not properly
            played, i.e. added to playedCard array\n");
}
else printf("\t\u274CFAILED: Adventurer card was not properly
    played, i.e. added to playedCard array\n");
}

```

- **Hand Count Bug**

**Description of Bug:** Handcount increases by 2 instead of 1

**How to Cause:** Initialize a game, add an adventurer card to the first player's hand, and then call adventureEffect with the correct hand position. Then check that handcount has increased by two.

**Code:**

```

int main() {

    ...<initialization same as above>...
    int oldCount = G.handCount[player];
    int newCount = testG.handCount[player];
    if (oldCount + 1 == newCount) printf("\tPASSED: HandCount
        increased by 1 (2 treasures - 1 adventurer)\n");
    else printf("\t\u274CFAILED: Handcount should have increased
        by 1, instead increased by %d\n", newCount - oldCount);

}

```

- **Total Card Count Bug:**

**Description of Bug:** The total card count of the player (deck + discard + hand + played) does not stay the same after calling the function. This bug does not appear when the top two cards are treasures, but does appear when there are any non-treasures between the top of the deck and the second treasure in the deck.

**How to Cause:** Initialize a game, add an adventurer card to the first player's hand, add some non-treasures to deck, and then run the function and compare.

**Code:**

```

int main() {

    ...<initialization same as above>...
    int gCount = G.deckCount[player] + G.discardCount[player] + G.
        handCount[player] + G.playedCardCount;
}

```

```

int testGCount = testG.deckCount[player] + testG.discardCount[
    player] + testG.handCount[player] + testG.playedCardCount;

if (gCount == testGCount)
    printf("\tPASSED: Total card count is the same: deck + discard
        + hand + played\n");
else if (gCount < testGCount)
    printf("\t\u274CFAILED: Total card count of deck (deck +
        discard + hand + played) less than after card effect\n");
else
    printf("\t\u274CFAILED: Total card count of deck (deck +
        discard + hand + played) greater than after card effect\n");
    ;
}

```

- **Discard Count Bug:**

**Description of Bug:** The discard count increase does not match the number of non-treasures drawn from deck. This bug is only detectable when (1) there are non-treasures in the deck before the second treasure and (2) there are at least two treasures in the deck.

**How to Cause:** Initialize a game, add an adventurer card to the first player's hand, add two treasures to the deck followed by two non-treasures. Check to see if discard pile has increased by 2.

**Code:**

```

...<initialization same as above>...
if (testG.discardCount[player] == G.discardCount[player] + 2) {
    int first = testG.discard[player][testG.discardCount[player] -
        1];
    int second = testG.discard[player][testG.discardCount[player] -
        2];

    if ((first == duchy) && (second == province))
        printf("\tPASSED: Discarded cards match non-treasures drawn
            from deck\n");
    else
        printf("\t\u274CFAILED: Discarded cards do not match non-
            treasures drawn from deck\n");
}
else printf("\t\u274CFAILED: Discard should have increased by 2,
    but instead increased by %d\n", testG.discardCount[player] -
    G.discardCount[player]);
}

```

(b) **unittest2.c/cardtest2.c - Smithy**

- **Number Buys Bug:**

**Description of Bug:** When the Smithy card is played, it increases the number of buys for the player.

**How to Cause:** Initialize a game, add an Smithy card to the first player's hand, and then

call `smithyEffect` with the correct hand position. Test the state of the game to see if `numBuys` has increased.

**Code:**

```
int main() {

    int pass;
    int seed = 1000;
    int numPlayers = 4;
    int player = 0;
    struct gameState G, testG;
    int handpos = 4;

    // initialize a game state and player cards
    int k[10] = {adventurer, embargo, village, minion, mine,
        cutpurse, sea_hag, tribute, smithy, council_room};
    initializeGame(numPlayers, k, seed, &G);
    memcpy(&testG, &G, sizeof(struct gameState));
    smithyEffect(&testG, player, handpos);

    if (G->numBuys != testG->numBuys) {
        printf("\t\u274CFAILED: Gamestate numBuys has changed\n");
        total_pass = 0;
    }
}
```

### (c) **unittest3.c - Council Room**

- **Handcount Bug:**

**Description of Bug:** Handcount should always increase by three for a player that plays council room. This is because the player should draw four cards and then "play" council room which reduces handcount by 1. The handcount is off for the active player but is correct for the other players who must draw 1.

**How to Cause:** Initialize a game, add an council room card to the first player's hand, and then call `councilRoomEffect` with the correct hand position. Test the state of the game to see how much hand count has increased.

**Code:**

```
int main() {

    int seed = 1000;
    int numPlayers = 2;
    int player = 0;
    struct gameState G, testG;
    int handpos = 4;

    int k[10] = {adventurer, embargo, village, minion, mine,
        cutpurse, sea_hag, tribute, smithy, council_room};
    initializeGame(numPlayers, k, seed, &G);
```

```

memcpy(&testG, &G, sizeof(struct gameState));
councilRoomEffect(&testG, player, handpos);

int oldCount = G.handCount[player];
int newCount = testG.handCount[player];
if (oldCount + X == newCount) printf("\tPASSED: For Player %d,
    HandCount increased by %d\n", player, X);
else printf("\t\u274CFAILED: For Player %d, expected handcount
    to increase by %d, but increased by %d\n", player, X,
    newCount - oldCount);

```

- **Hand Matches Deck:**

**Description of Bug:** The top four cards in a deck should match the top four cards in the player's hand. In fact, the top four cards do not match because the code only draws three cards.

**How to Cause:** Initialize a game, add an council room card to the first player's hand, and then call councilRoomEffect with the correct hand position. Test the state of the game to see if top four cards of hand match top four cards of deck.

**Code:**

```

int main() {

    ... <initialization code same as above> ...
    int pass = 1;
    for (int i = 0; i < 4; i++) {
        int handCard = testG.hand[player][G.handCount[player] - 1 + i
        ];
        int deckCard = G.deck[player][G.deckCount[player] - 1 - i];
        if (handCard != deckCard) {
            pass = 0;
        }
    }
    if (pass) printf("\tPASSED: Cards added to hand match top four
        cards of deck\n");
    else printf("\t\u274CFAILED: Cards added to hand do not match
        top four cards of deck\n");
}

```

- **Deck Does not Decrease by Four:**

**Description of Bug:** The player's deck should decrease by four in the case where there is are at least four cards in the deck. In fact, the deck only decreases by three.

**How to Cause:** Initialize a game, add an council room card to the first player's hand, and then call councilRoomEffect with the correct hand position. Test the state of the game to see if deck decreases by four.

**Code:**

```

int main() {

    ... <initialization code same as above> ...

```



```

    if (G.deckCount[player] == testG.deckCount[player] + 4)
        printf("\tPASSED: For player 0, deck has decreased by exactly
            four\n");
    else
        printf("\t\u274CFAILED: For player 0, deck has not decreased
            by exactly four\n");
}

```

- **Discard is not Empty :**

**Description of Bug:** The discard is not empty after calling council room with fewer than four cards.

**How to Cause:** Initialize a game, add an council room card to the first player's hand, set the deck so that it has only three cards, and then call councilRoomEffect with the correct hand position. Test the state of the game to see if discard is empty, which would imply that the deck was shuffled.

**Code:**

```

int main() {

    ... <initialization code same as above> ...

    setDeck(&G, player, 3); // will set deck with only three coppers
        , and discard with ten coppers
    memcpy(&testG, &G, sizeof(struct gameState));
    councilRoomEffect(&testG, player, handpos);

    if (testG.discardCount[player] == 0)
        printf("\tPASSED: discard count is 0\n");
    else
        printf("\t\u274CFAILED: discard count is not 0\n");
}

```

(d) **unittest4.c - Village (No Bugs)**

(e) **cardtest3.c - Great Hall**

- **Total Card Count Bug:**

**Description of Bug:** Total card count of deck is less after this card is used. Bug shows up regardless of whether deck must be shuffled.

**How to Cause:** Initialize a game, add an great hall card to the first player's hand, and then call cardEffect. Test the state of the game to see if total card count has changed.

**Code:**

```

int main() {

    int seed = 1000;
    int numPlayers = 2;
    struct gameState G, testG;
    int handpos = 4;
    int player = 0;
    int coin_bonus = 0;

```

```

int k[10] = {adventurer, embargo, village, minion, mine,
             cutpurse, sea_hag, tribute, smithy, council_room};
initializeGame(numPlayers, k, seed, &G);
memcpy(&testG, &G, sizeof(struct gameState));
cardEffect(great_hall, 0, 0, 0, &testG, handpos, &coin_bonus);

int gCount = G.deckCount[player] + G.discardCount[player] + G.
             handCount[player] + G.playedCardCount;
int testGCount = testG.deckCount[player] + testG.discardCount[
    player] + testG.handCount[player] + testG.playedCardCount;

if (gCount == testGCount)
    printf("\tPASSED: Total card count is the same\n");
else if (gCount < testGCount)
    printf("\t\u274CFAILED: Total card count of deck less than
        after card effect\n");
else
    printf("\t\u274CFAILED: Total card count of deck greater than
        after card effect\n");

```

- **Played Card Bug:**

**Description of Bug:** Does not add itself to playedCard array. Bug shows up regardless of whether deck is shuffled from discard.

**How to Cause:** Initialize a game, add an great hall card to the first player's hand, and then call cardEffect. Test the state of the game to see if card was added to playedCards.

**Code:**

```

int main() {

    ... <same initialization code as above> ...

    if (testG.playedCardCount == G.playedCardCount + 1) {
        if (testG.playedCards[testG.playedCardCount - 1] == great_hall
            )
            printf("\tPASSED: Great Hall card was properly played, i.e.
                added to playedCard array\n");
        else
            printf("\t\u274CFAILED: Great Hall card was not properly
                played, i.e. added to playedCard array\n");
    }
    else printf("\t\u274CFAILED: Great Hall card was not properly
        played, i.e. added to playedCard array\n");
}

```

(f) **cardtest4.c - Mine**

- **Total Card Count Bug:**

**Description of Bug:** Total card count of deck is greater than after this card is used. Bug shows up regardless of whether deck must be shuffled.

**How to Cause:** Initialize a game, add an Mine card to the first player's hand, and then call cardEffect. Test the state of the game to see if total card count has changed.

**Code:**

```
int main() {

    int seed = 1000;
    int numPlayers = 2;
    struct gameState G, testG;
    int handpos = 4;
    int player = 0;
    int coin_bonus = 0;
    int choice0, choice1;
    int result;

    int k[10] = {adventurer, embargo, village, minion, mine,
                cutpurse, sea_hag, tribute, smithy, council_room};
    initializeGame(numPlayers, k, seed, &G);
    setHand(&G, player, handpos); // sets hand to have four coppers
    and Mine
    choice0 = 0;                    // will be trashing first copper
    choice1 = silver;               // will be gaining silver
    memcpy(&testG, &G, sizeof(struct gameState));
    cardEffect(mine, choice0, choice1, 0, &testG, handpos, &
               coin_bonus);

    // TEST STARTS HERE
    int gCount = G.deckCount[player] + G.discardCount[player] + G.
        handCount[player] + G.playedCardCount;
    int testGCount = testG.deckCount[player] + testG.discardCount[
        player] + testG.handCount[player] + testG.playedCardCount;

    if (gCount == testGCount)
        printf("\tPASSED: Total card count is the same\n");
    else if (gCount < testGCount)
        printf("\t\u274CFAILED: Total card count of deck less than
            after card effect\n");
    else
        printf("\t\u274CFAILED: Total card count of deck greater than
            after card effect\n");
}
```

- **Played Card Bug:**

**Description of Bug:** Does not add itself to playedCard array.

**How to Cause:** Initialize a game, add a Mine hall card to the first player's hand, and then call cardEffect. Test the state of the game to see if card was added to playedCards.

**Code:**

```
int main() {

    ... <same initialization code as above> ...
}
```

```

    if (testG.playedCardCount == G.playedCardCount + 1) {
        if (testG.playedCards[testG.playedCardCount - 1] == mine)
            printf("\tPASSED: Mine was properly played, i.e. added to
                playedCard array\n");
        else
            printf("\t\u274CFAILED: Mine was not properly played, i.e.
                added to playedCard array\n");
    }
    else printf("\t\u274CFAILED: Mine was not properly played, i.e.
        added to playedCard array\n");

```

- **Attempting to Gain Treasure Does not Return -1:**

**Description of Bug:** The code does not return -1 when the cardEffect function is called with a non-treasure as the card to be gained. As a result, this bug alters the gameState by continuing to execute the mine cardEffect.

**How to Cause:** Initialize a game, add an Mine card to the first player's hand, and then call cardEffect. Call this function with choice1 set to a non-treasure.

**Code:**

```

int main() {

    int seed = 1000;
    int numPlayers = 2;
    struct gameState G, testG;
    int handpos = 4;
    int player = 0;
    int coin_bonus = 0;
    int choice0, choice1;
    int result;

    int k[10] = {adventurer, embargo, village, minion, mine,
        cutpurse, sea_hag, tribute, smithy, council_room};
    initializeGame(numPlayers, k, seed, &G);
    setHand(&G, player, handpos); // sets hand to have four coppers
        and Mine
    choice0 = 0; // will be trashing first copper
    choice1 = village; // NOT ALLOWED
    memcpy(&testG, &G, sizeof(struct gameState));

    // TEST STARTS HERE
    result = cardEffect(mine, choice0, choice1, 0, &testG, handpos,
        &coin_bonus);
    if (result == -1)
        printf("\tPASSED: Function returned -1 (not allowed to trash
            non-treasure)\n");
    else printf("\t\u274CFAILED: Function did not return -1, so it
        continued unexpectedly\n");

```

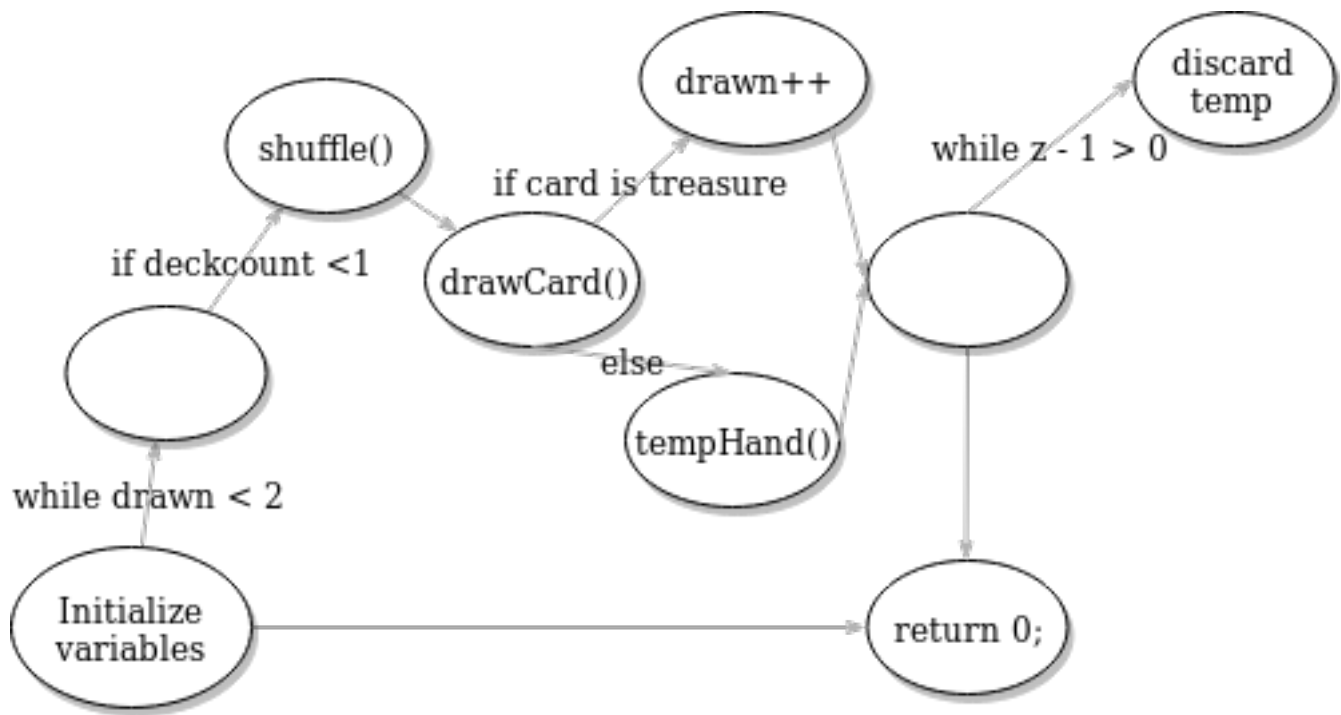


Figure 1: Node coverage figure for adventureEffect

### III. Code Coverage

#### • Unittest1 - AdventureEffect

##### (a) Statement and Branch Coverage

Function 'adventurerEffect'  
 Lines executed: 94.12% of 17  
 Branches executed: 100.00% of 12  
 Taken at least once: 83.33% of 12  
 Calls executed: 50.00% of 2

The percent lines executed is not 100% because the code in unittest1.c does not test the following code snippet within adventureEffect:

```

if (state->deckCount[currentPlayer] < 1){
    shuffle(currentPlayer, state);
}

```

That statement is executed in the tests run in cardtest1.c. This is because of how I divided the input cases. Unittest1.c tests cases where no shuffle is needed, and cardtest1.c tests cases where a shuffle is required.

##### (b) Input Coverage and Boundary Cases

I did not have time to test many other input cases. Some of these cases are tricky because they require inferring what the behavior of the system should be from the source code itself. Given more time, I would test the following:

- Inputs where function is given invalid values for player or handpos. What should the function do in these cases? It is not clear from a development standpoint, and therefore unclear from a testing standpoint.

- A case where there are multiple adventurer cards in hand. Does this create undesirable behavior?
- A case where there is only one adventurer card in hand.
- A case where there are no treasures in deck or discard (could happen if a player trashes enough treasures)
- A case where the function is called when the hand is at MAX\_HAND number of cards (and therefore, hand would exceed MAX\_HAND)

- **Cardtest1 - cardEffect on Adventure**

- (a) **Statement and Branch Coverage**

```
Function 'adventurerEffect '
Lines executed:100.00% of 17
Branches executed:100.00% of 12
Taken at least once:83.33% of 12
Calls executed:100.00% of 2
```

Unlike unittest1.c, since these tests cause the adventurerEffect function to shuffle, it achieves 100% code coverage.

- (b) **Input Coverage and Boundary Cases**

In addition to the above tests, since this code is testing the cardEffect function itself which calls adventurerEffect, I would also add the following tests:

- The function should not behave any differently if coin\_bonus is a different value.
- The function should do nothing special if choice0, choice1, or choice3 are values other than 0, since adventurer does not have a optional effect.

- **Unittest2 - smithyEffect**

- (a) **Statement and Branch Coverage**

```
Function 'smithyEffect '
Lines executed:100.00% of 6
Branches executed:100.00% of 2
Taken at least once:100.00% of 2
Calls executed:100.00% of 2
```

The percent lines executed 100% because the smithyEffect function has no conditional branches. As such, no conditional branching node diagram is needed. Every call to smithyEffect is guaranteed to execute all branches and all statements. However, it should be noted that smithyEffect calls drawCard, which has much worse coverage:

```
Function 'drawCard '
Lines executed:36.36% of 22
Branches executed:33.33% of 6
Taken at least once:16.67% of 6
Calls executed:0.00% of 1
```

- (b) **Input Coverage and Boundary Cases**

For unittest2.c, I only tested one input: a case where the deck has more than three cards in it. In cardtest2.c, I tested a case where the deck must be reshuffled from discard to access the next cards in deck. Since this logic is handled in drawCard, failures unique to this case are likely related to failures in drawCard. Given more time, I would test the following cases in a more throughout unit test:

- Inputs where function is given invalid values for player or handpos. What should the function do in these cases? It is not clear from a development standpoint, and therefore unclear from a testing standpoint.
- A case where there are multiple smithy cards in hand. Does this create undesirable behavior?
- A case where there is only one smithy card in hand.
- A case where the function is called when the hand is at MAX\_HAND number of cards (and therefore, hand would exceed MAX\_HAND)

- **Cardtest2 - cardEffect with Smithy**

- (a) **Statement and Branch Coverage**

As mentioned above, the statement and branch execution will be 100% since there are no conditional branches in smithyEffect.

- (b) **Input Coverage and Boundary Cases**

Since this test calls smithyEffect from cardEffect, I would add the above tests to test this function:

- The function should not behave any differently if coin\_bonus is a different value.
- The function should do nothing special if choice0, choice1, or choice3 are values other than 0, since smithy does not have a optional effect.

- **Unittest3 - Council Room**

- (a) **Statement and Branch Coverage**

```
Function 'councilRoomEffect '
Lines executed:100.00% of 9
Branches executed:100.00% of 6
Taken at least once:100.00% of 6
Calls executed:100.00% of 3
```

The percent lines and branches executed are 100% because the way that the code is designed in councilRoomEffect guarantees that all branches and all statements are covered for every execution. There is only one conditional branch inside a for-loop below that is guaranteed to execute once during the loop which means that all branches and statements will be covered:

```
for (i = 0; i < state->numPlayers; i++) {
    if ( i != currentPlayer )
        drawCard(i, state);
}
```

- (b) **Input Coverage and Boundary Cases**

I covered two major cases involving the deck: the first is when the deck size is greater than four and the second is when the decksize is less than four. A boundary case worth considering is the case when the decksize is precisely four. In this case, it is important for testers to consider whether the intended behavior of the system is to shuffle the deck immediately when the deck is emptied or if instead the system should shuffle the deck only when prompted to draw from the empty pile. Some other inputs I would check in a more thorough system are:

- Inputs where function is given invalid values for player or handpos. What should the function do in these cases? It is not clear from a development standpoint, and therefore unclear from a testing standpoint.

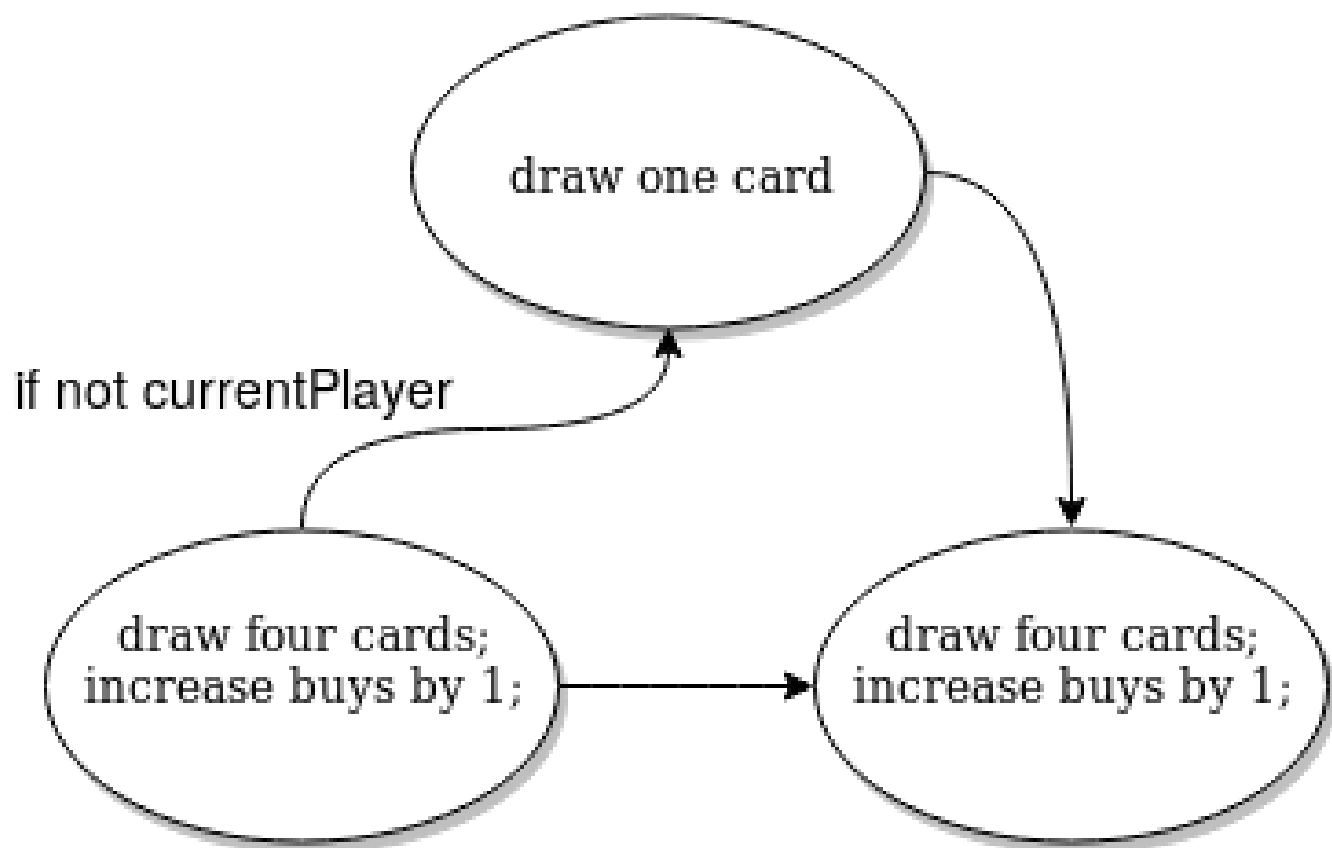


Figure 2: Node graph figure for councilRoomEffect



- A case where there are multiple council room cards in hand. Does this create undesirable behavior?
- A case where there is only one council room card in hand.
- A case where the function is called when the hand is at MAX\_HAND number of cards (and therefore, hand would exceed MAX\_HAND)

- **Unittest4 - Village**

- (a) **Statement and Branch Coverage**

Function 'villageEffect'  
Lines executed:100.00% of 5  
No branches  
Calls executed:100.00% of 2

There are only three statements in villageEffect, two of which are function calls. Therefore, the coverage is 100%.

- (b) **Input Coverage and Boundary Cases**

I covered two major cases involving the deck: the first is when the deck size is empty and the second is when the deck has exactly one card. My assumption based on analyzing the code is that it is acceptable for the deck to be empty. Only when a function requires drawing from an empty deck does it prompt the system to reshuffle the deck from discard. For both input cases, the tests all came back as passed. More thorough testing might include the following tests:

- Inputs where function is given invalid values for player or handpos. What should the function do in these cases? It is not clear from a development standpoint, and therefore unclear from a testing standpoint.
- A case where there are multiple village cards in hand. Does this create undesirable behavior?
- A case where there is only village card in hand.
- A case where the function is called and actions is at MAX\_INTEGER (perhaps an unnecessary case)
- A case where the function is called when the hand is at MAX\_HAND number of cards (and therefore, hand would exceed MAX\_HAND)

- **Cardtest3 - Great Hall**

- (a) **Statement and Branch Coverage**

Function 'greatHallEffect'  
Lines executed:100.00% of 5  
No branches  
Calls executed:100.00% of 2

There are only three statements in greatHallEffect, two of which are function calls. Therefore, the coverage is 100%.

- (b) **Input Coverage and Boundary Cases**

I covered two major cases involving the deck: the first is when the deck size is empty and the second is when the deck has exactly one card. This is similar to the village card above. More thorough testing might include the following tests:

- Does greatHall successfully increase victory points by 1?

- Does greatHall in one person's hand not affect victory points for other players?
- Inputs where function is given invalid values for player or handpos. What should the function do in these cases? It is not clear from a development standpoint, and therefore unclear from a testing standpoint.
- A case where there are multiple greatHall cards in hand. Does this create undesirable behavior?
- A case where there is only greatHall card in hand.
- A case where the function is called when the hand is at MAX\_HAND number of cards (and therefore, hand would exceed MAX\_HAND)

#### • Cardtest4 - Mine

##### (a) Statement and Branch Coverage

Function 'mineEffect'

Lines executed:86.67% of 15

Branches executed:100.00% of 14

Taken at least once:57.14% of 14

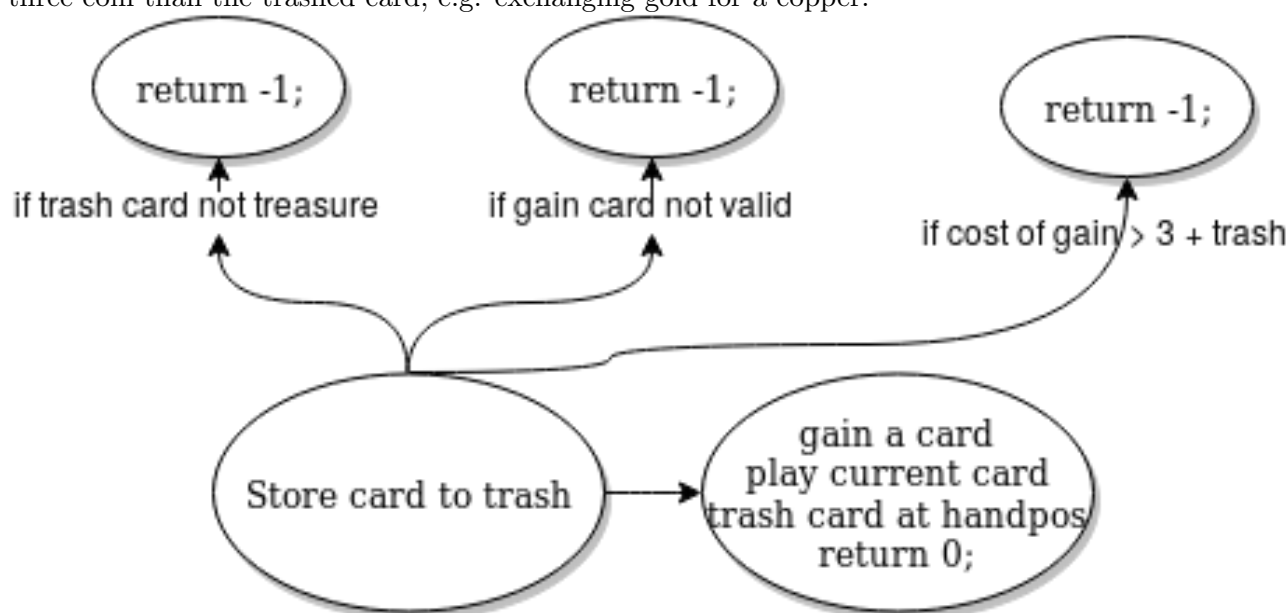
Calls executed:100.00% of 5

There are two statements missing in my test coverage. Both are functions that return -1 if some undesirable values obtain in the function:

```
if (choice2 > treasure_map || choice2 < curse)
    return -1;
```

```
if ( (getCost(state->hand[currentPlayer][choice1]) + 3) > getCost(
    choice2) )
    return -1;
```

Both of the above missing statements should be covered in a more thorough test case. To test the first conditional branch, I would design a test case where the card to be gained is some integer that represents a card outside the bounds of the known cards. To test the second, I would design a case where a player tries to gain a card whose value is higher than three coin than the trashed card, e.g. exchanging gold for a copper.



(b) **Input Coverage and Boundary Cases** I tested three different inputs for my tests:

- A case where a copper is trashed for a silver
- A case where a copper is trashed for a village (illegal)
- A case where an estate is trashed for a silver (illegal)

As mentioned above, a more thorough unit test would also check whether the function returns -1 for attempting to convert a copper into a gold. Moreover, my tests do not check whether it permits silver or gold to be trashed, and since there are only three treasures, there is nothing stopping a unit test from exhaustively covering these options. Moreover, I would like to test the following cases:

- A case where there are multiple Mine cards in hand. Does this create undesirable behavior?
- A case where there is only Mine card in hand.
- A case where the function is called when the hand is at MAX\_HAND number of cards (and therefore, hand would exceed MAX\_HAND)