

DESIGN, SIMULATION, TESTING

CSSE 120—Rose Hulman Institute of Technology

Update from your SVN repository

- Right-click your NestedLoopPatterns project, choose
 - Team → Update
- Read grader comments (if any) for your NestedLoopPatterns program
- The comments should all begin with **CONSIDER:**

`+=` and related operators (`-=`, `*=`, ...)

□ `a += b` is equivalent to `a = a + b`

```
IDLE 1.2.1
```

```
>>> x = 5
```

```
>>> x += 6; print x
```

```
11
```

```
>>> x *= 2; print x
```

```
22
```

```
>>> x -= 3; print x
```

```
19
```

```
>>> x %= 7; print x
```

```
5
```

```
>>> s = "abc"
```

```
>>> s += "d"; print s
```

```
abcd
```

Designing/implementing a larger program

- Until now, our programs have been small and simple
 - ▣ Possible exceptions: `dayOfYear`, `fileAverage`, `TicTacToe`.
- For larger programs, we need a strategy to help us be organized.
- One common strategy: **top-down design**.
 - ▣ Break the problem into a few big pieces (functions).
 - ▣ Break each piece into smaller pieces.
 - ▣ Eventually we get down to manageable pieces that do the details.

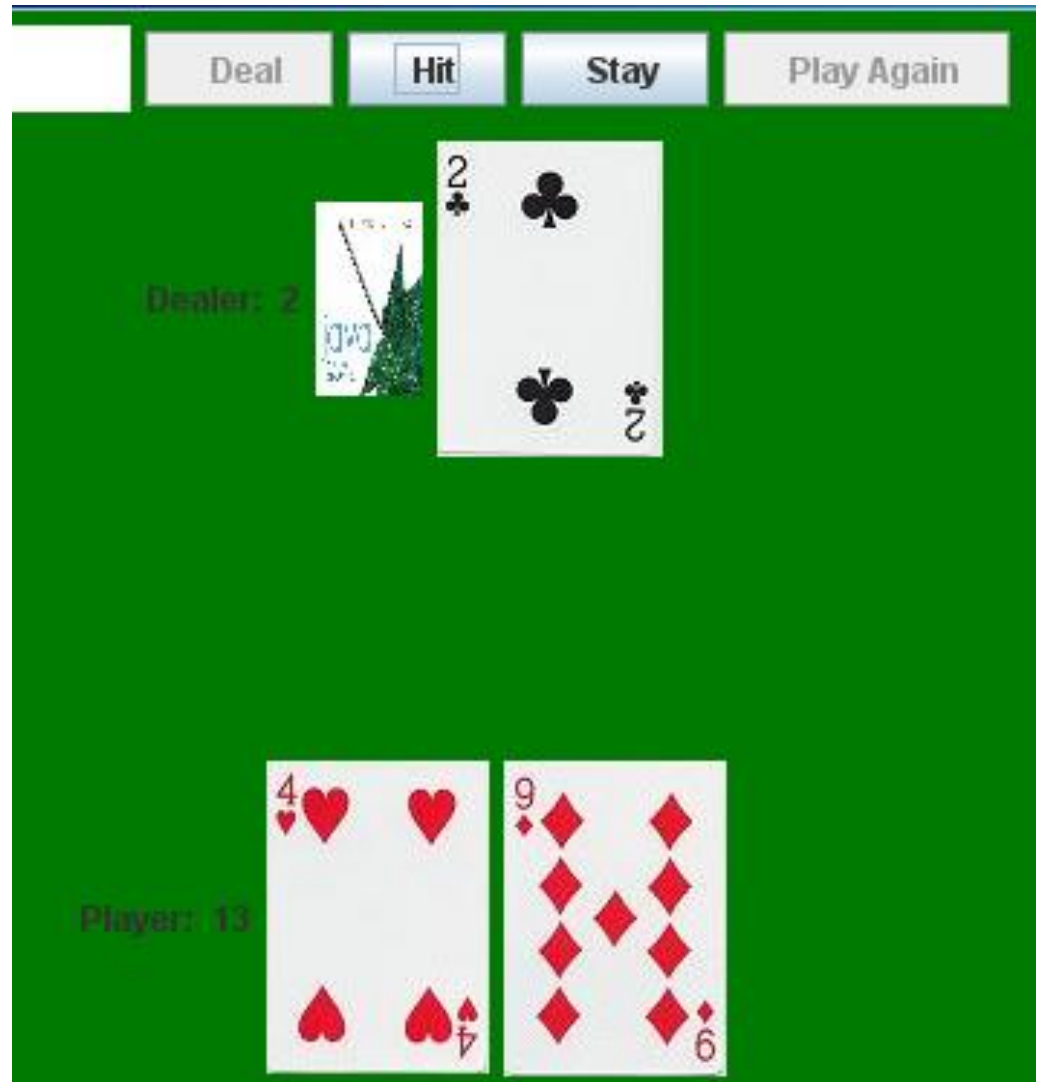
Example: Two-player blackjack (21)

- Uses a regular deck of cards.
- Player and Dealer each initially get two cards.
- Player can see both of own cards, but only one of dealer's cards.
- Suit is irrelevant, only denomination determines points per card:
 - ▣ Ace: one point or 11 points.
 - ▣ 2-10: point value is the number of the card.
 - ▣ face card: 10 points.
- Object: Get as close as you can to 21 points in your hand without going over.

Blackjack illustration

- We won't develop a GUI today, but this image from a GUI Blackjack game* illustrates how the game goes.

- * from Lewis and Chase, *Java Software Structures*



Blackjack play

- Player has the option to take one or more "hits" (cards) or to "stay" (keep the current hand).
- If a hit increases the Player's score to more than 21, he is "busted" and loses.
- If the Player is not busted, the Dealer plays, but with more constraints. If the Dealer's score is less than 16, she must take a hit. Otherwise, she must stay.
- If neither player is busted, the one with the highest-scoring hand wins.

Program specifications

- The blackjack program will allow a single player to play one hand of blackjack against the computer, starting with a fresh deck of cards.
- It will have a simple text interface.
- It will display the state of the game and ask the Player whether (s)he wants a hit.
- Once the Player says NO, the Dealer will play
- The results will be displayed.

Sample runs

```
Dealer's hand:  
  Face Down  
  Deuce of Hearts  
Player's hand: (score is 13)  
  3 of Clubs  
  Jack of Hearts  
Hit? (Y/N) Y  
Dealer's hand:  
  Face Down  
  Deuce of Hearts  
Player's hand: (score is 23)  
  3 of Clubs  
  Jack of Hearts  
  King of Hearts  
BUSTED! You lose.  
Dealer's hand: (score is 8)  
  6 of Hearts  
  Deuce of Hearts  
Player's hand: (score is 23)  
  3 of Clubs  
  Jack of Hearts  
  King of Hearts
```

```
Dealer's hand:  
  Face Down  
  10 of Spades  
Player's hand: (score is 12)  
  Queen of Diamonds  
  Deuce of Hearts  
Hit? (Y/N) N  
Now Dealer will play ...  
Dealer's hand: (score is 16)  
  6 of Hearts  
  10 of Spades  
Player's hand: (score is 12)  
  Queen of Diamonds  
  Deuce of Hearts  
DEALER WINS  
Dealer's hand: (score is 16)  
  6 of Hearts  
  10 of Spades  
Player's hand: (score is 12)  
  Queen of Diamonds  
  Deuce of Hearts
```

Sample run (multiple player hits)

```
Dealer's hand:  
  Face Down  
  8 of Clubs  
Player's hand: (score is 7)  
  4 of Hearts  
  3 of Clubs  
Hit? (Y/N) y  
Dealer's hand:  
  Face Down  
  8 of Clubs  
Player's hand: (score is 15)  
  4 of Hearts  
  3 of Clubs  
  8 of Diamonds  
Hit? (Y/N) y  
Dealer's hand:  
  Face Down  
  8 of Clubs  
Player's hand: (score is 19)  
  4 of Hearts  
  3 of Clubs  
  8 of Diamonds  
  4 of Clubs
```

```
(continued from previous column)  
Hit? (Y/N) n  
Now Dealer will play ...  
Dealer's hand: (score is 18)  
  Jack of Diamonds  
  8 of Clubs  
Player's hand: (score is 19)  
  4 of Hearts  
  3 of Clubs  
  8 of Diamonds  
  4 of Clubs  
YOU WIN!  
Dealer's hand: (score is 18)  
  Jack of Diamonds  
  8 of Clubs  
Player's hand: (score is 19)  
  4 of Hearts  
  3 of Clubs  
  8 of Diamonds  
  4 of Clubs
```

One more sample run (dealer hit)

```
Dealer's hand:  
  Face Down  
  3 of Diamonds  
Player's hand: (score is 16)  
  Jack of Diamonds  
  6 of Spades  
Hit? (Y/N) n  
Now Dealer will play ...  
Dealer's hand: (score is 10)  
  7 of Clubs  
  3 of Diamonds  
Player's hand: (score is 16)  
  Jack of Diamonds  
  6 of Spades  
Dealer takes a hit  
Dealer's hand: (score is 20)  
  7 of Clubs  
  3 of Diamonds  
  King of Hearts  
Player's hand: (score is 16)  
  Jack of Diamonds  
  6 of Spades
```

(continued from previous column)

```
DEALER WINS  
Dealer's hand: (score is 20)  
  7 of Clubs  
  3 of Diamonds  
  King of Hearts  
Player's hand: (score is 16)  
  Jack of Diamonds  
  6 of Spades
```

Initial design

- Similar to the top-level design of the Racquetball simulator, we want to break up the algorithm into a few high-level tasks.
- With one or two other people, quickly brainstorm what those tasks might be.

Top-level algorithm

- Create initial card deck.
- Deal initial cards.
- Display game state.
- Player plays until busted or chooses to stop.
- Dealer Plays until required to stop.
- Report who wins.

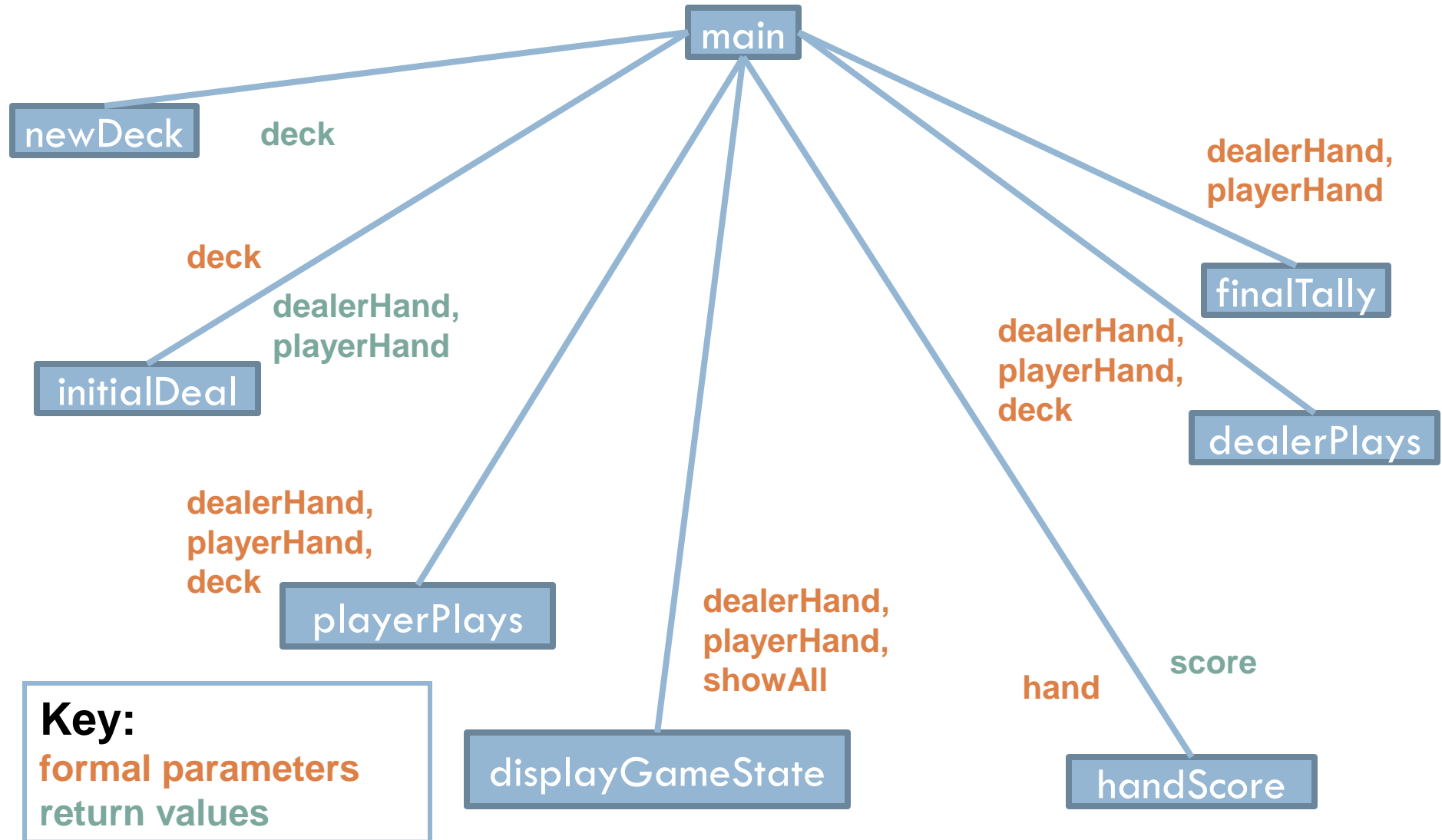
Top-level functions called by `main()`

- `newDeck()`
 - ▣ Creates and returns a complete deck of cards.
- `initialDeal(deck)`
 - ▣ deals cards from the deck to each player, returns the hands
- `displayGameState(playerHand, dealerHand, showAll)`
 - ▣ shows visible cards and player's scores. `showAll` is boolean.
- `playerPlays(playerHand, dealerHand, deck)`
 - ▣ Allows player to choose hit or stay.
- `dealerPlays(playerHand, dealerHand, deck)`
 - ▣ Dealer does hit or stay, based on rules.
- `finalTally(playerHand, dealerHand)`
 - ▣ Determines and displays who wins.

Complete code for main()

```
def main():
    deck = newDeck()
    player, dealer = initialDeal(deck)
    displayGameState(player, dealer, False)
    playerPlays(player, dealer, deck)
    if handScore(player) > winningScore:
        print "BUSTED! You lose."
    else:
        print "Now Dealer will play ..."
        dealerPlays(player, dealer, deck)
        finalTally(player, dealer)
    displayGameState(player, dealer, True)
```

Top-level Structure Diagram



Some preliminary data values

```
# Define some constants used by many functions
suits = ['Clubs', 'Diamonds', 'Hearts', 'Spades']
cardNames = ['Ace', 'Deuce', '3', '4', '5',
             '6', '7', '8', '9', '10',
             'Jack', 'Queen', 'King']
winningScore = 21
dealerMustHoldScore = 16

# Card is represented by a list: [cardName, suit]
# Examples: ['Ace', 'Clubs'] or ['7', 'Diamonds']
# A hand or a deck is a list of cards.
```

Designing `newDeck()`

- Work in groups of 4 at a whiteboard
- Write steps of `newDeck()` in English
- Write the code
- Take about 10 minutes
- Refer to:
 - ▣ Data values on handout
 - ▣ Structure diagram on handout

newDeck() – returns complete deck

- start with an empty list
- for each cardName/suit pair
 - ▣ generate a card with that name and suit
 - ▣ add card to list
- Return the list

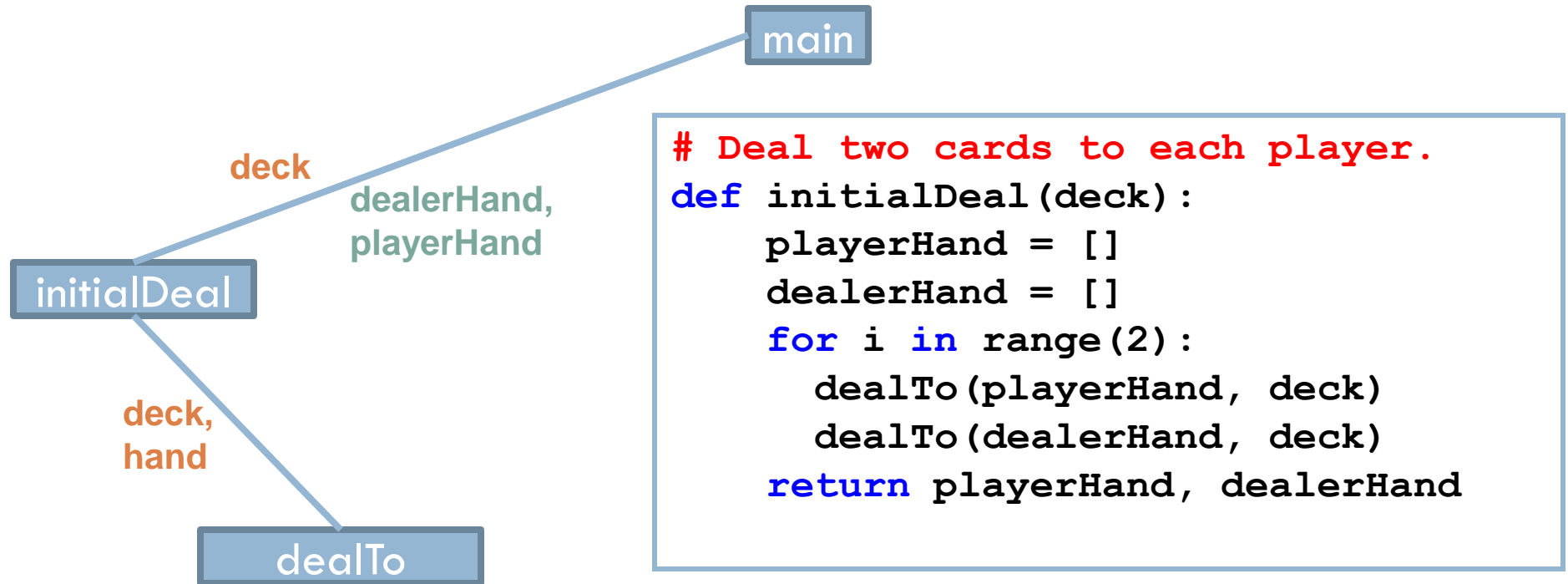
```
# Create an entire deck of cards  
def newDeck():  
    deckList = []  
    for s in suits:  
        for c in cardNames:  
            deckList.append([c, s])  
    return deckList
```

initialDeal(deck)

- start with two empty hands
- deal two cards to each hand
- return the two hands

```
# Deal two cards to each player.  
def initialDeal(deck):  
    playerHand = []  
    dealerHand = []  
    for i in range(2):  
        dealTo(playerHand, deck)  
        dealTo(dealerHand, deck)  
    return playerHand, dealerHand
```

initialDeal Structure Diagram



```
# Deal two cards to each player.  
def initialDeal(deck):  
    playerHand = []  
    dealerHand = []  
    for i in range(2):  
        dealTo(playerHand, deck)  
        dealTo(dealerHand, deck)  
    return playerHand, dealerHand
```

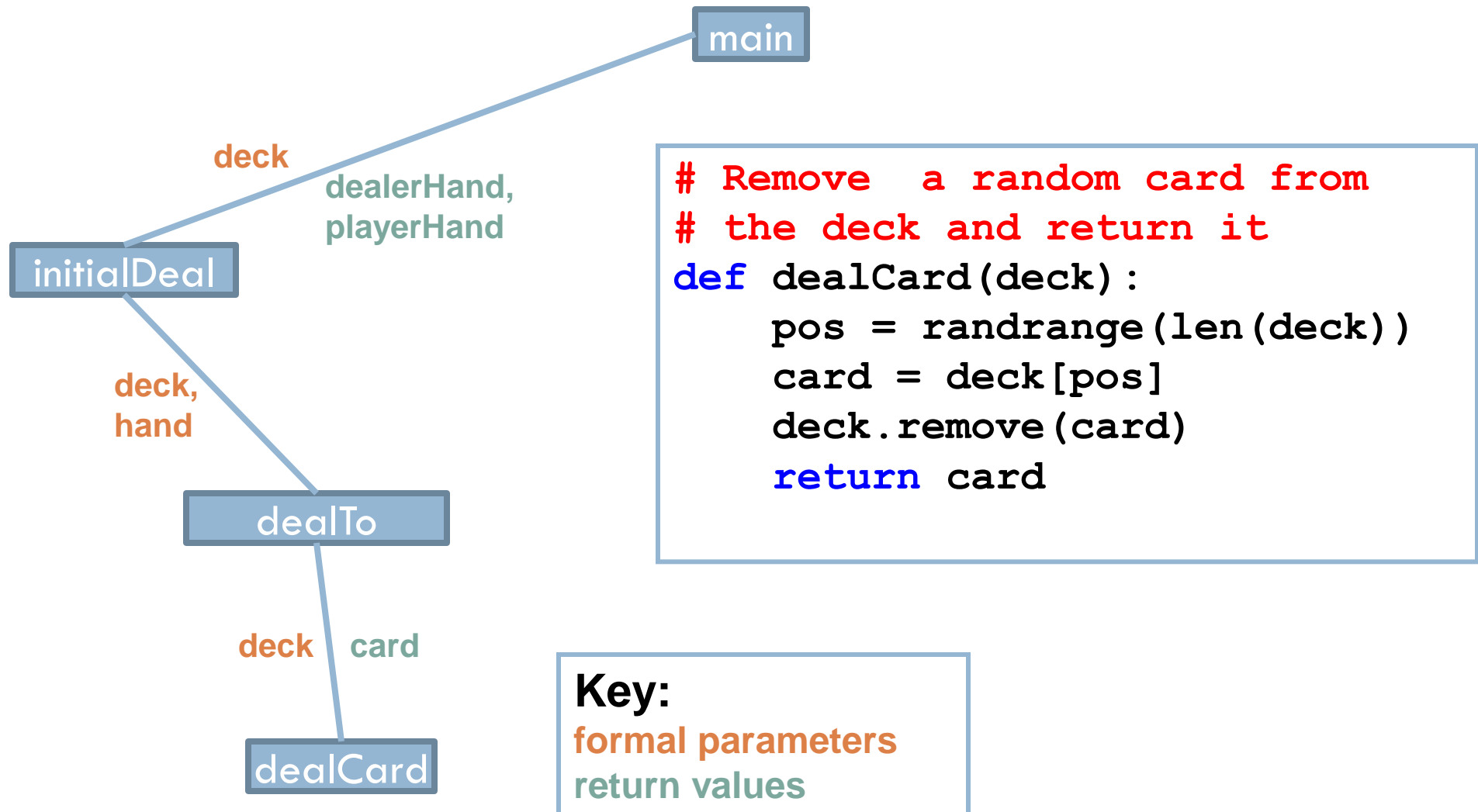
Key:
formal parameters
return values

dealTo(hand, deck)

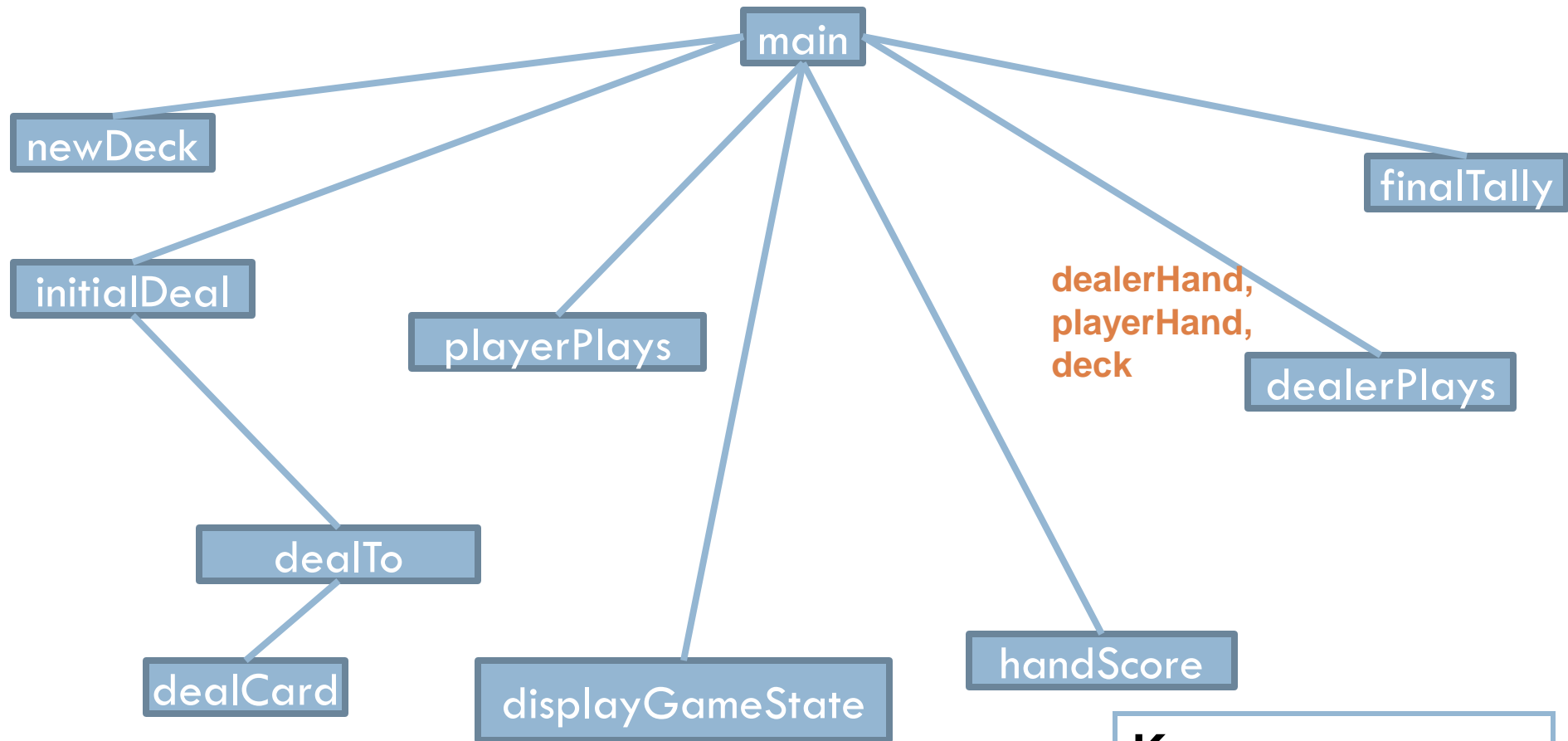
- Pick a random card from the deck and move it to the hand.

```
# deal a card from this deck and place it in this hand.  
def dealTo(hand, deck):  
    hand.append(dealCard(deck))
```

initialDeal Structure Diagram



Let's skip ahead to dealerPlays()



Key:
formal parameters
return values

Designing dealerPlays()

- Work in groups of 4 at a whiteboard
- Write steps of dealerPlays() in English
- Write the code:
 - ▣ Do you need new functions? Add them to your structure chart
- Take about 10 minutes

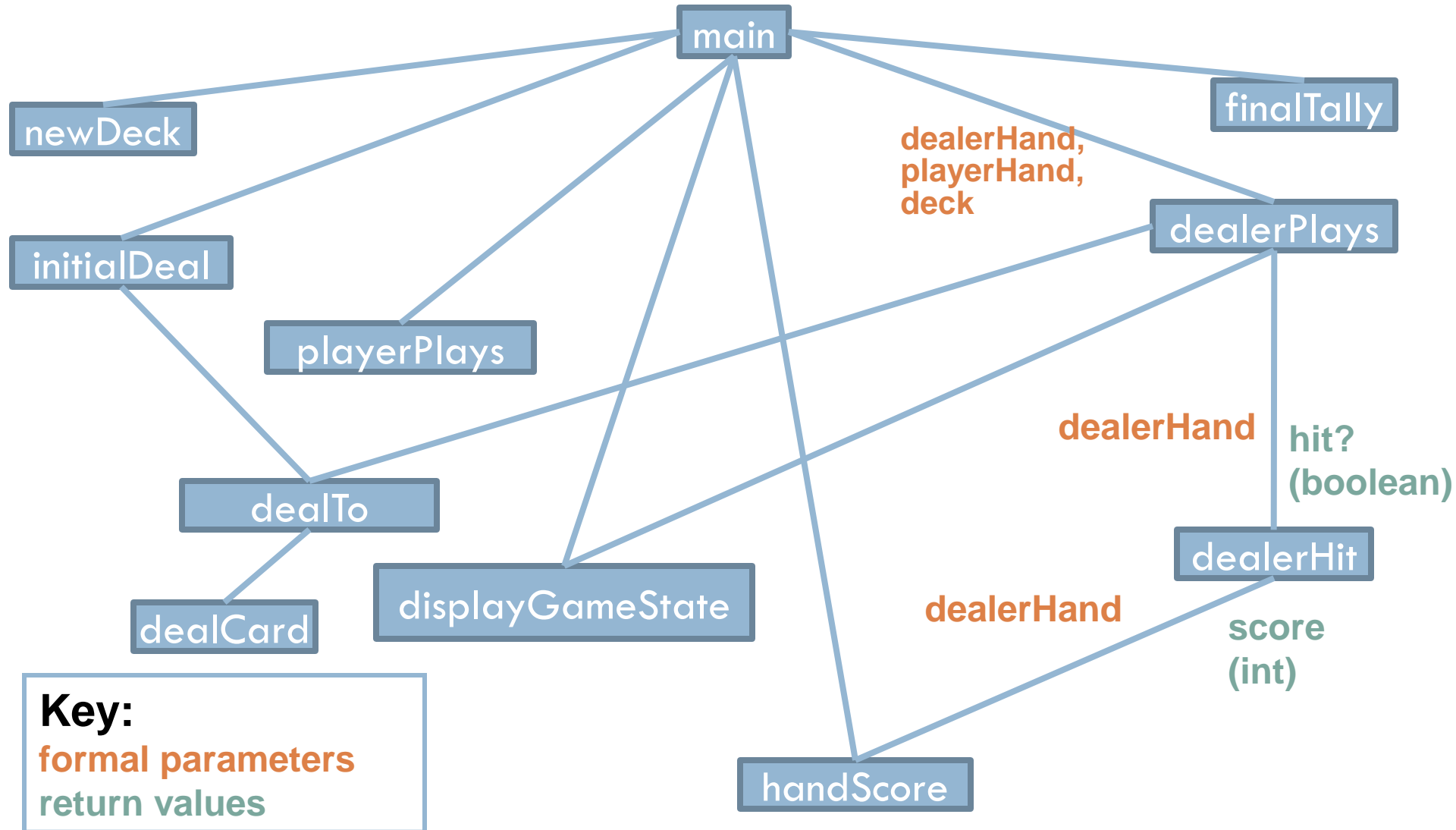
dealerPlays

- while dealerMustTakeaHit
 - deal a card to Dealer's hand

```
# Dealer takes hits until no more hits allowed.
def dealerPlays(player, dealer, deck):
    displayGameState(player, dealer, True)
    while dealerHit(player, dealer):
        sleep(3)
        print "Dealer takes a hit"
        dealTo(dealer, deck)
        displayGameState (player, dealer, True)
```

```
# Determine whether dealer "takes a hit" (gets another card).
def dealerHit(dealerHand):
    dealerScore = handScore(dealerHand)
    return dealerScore < dealerMustHoldScore
```

Design so far



Code for handScore()

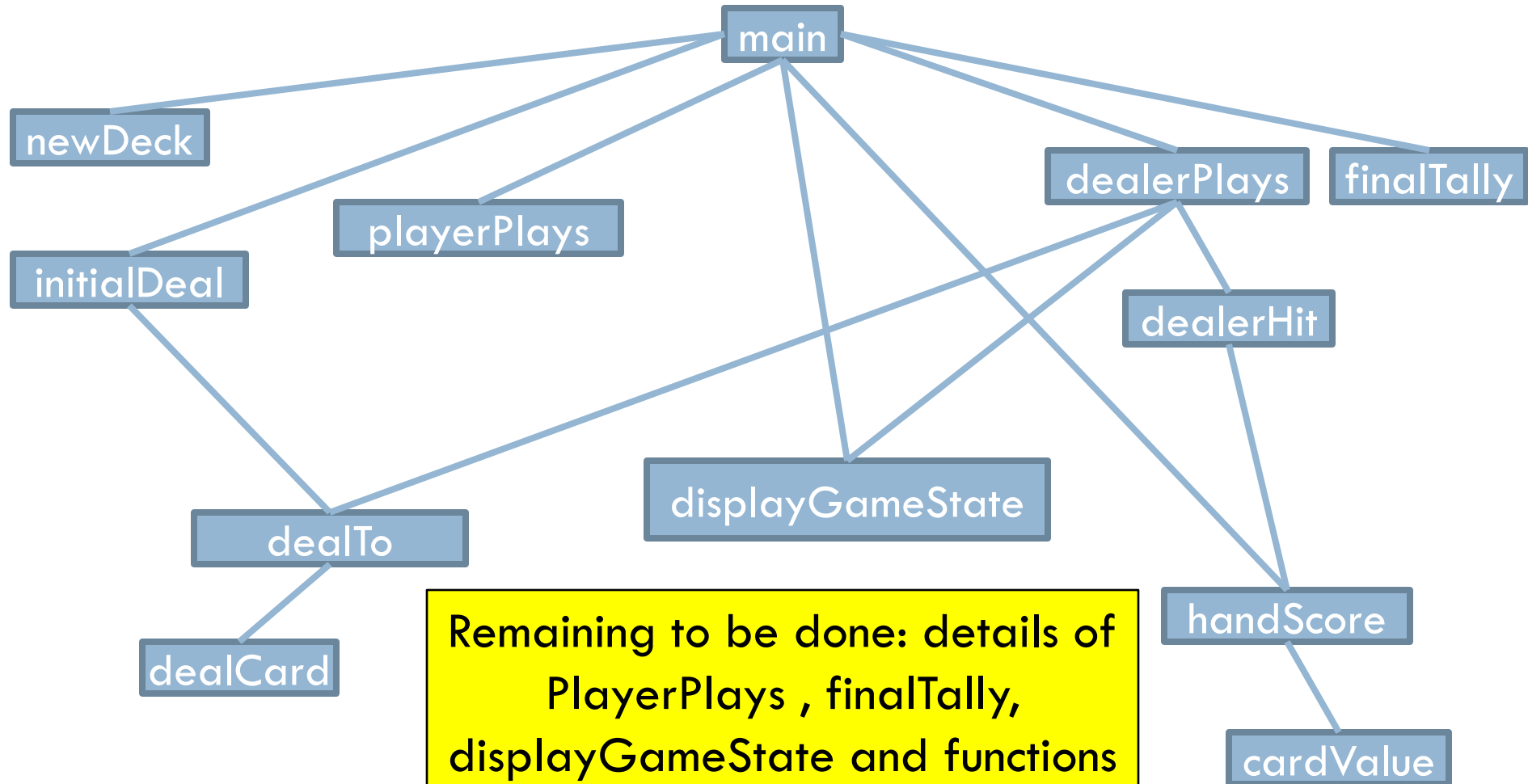
```
# Calculate the score for the whole hand.
def handScore(hand) :
    score = 0
    hasAce = False
    for card in hand:
        val = cardValue(card)
        score += val
        if val == 1:
            hasAce = True
    if score <= winningScore - 10 and hasAce:
        score = score + 10
    return score
```

What if they have
two or more aces?

Code for cardValue()

```
# calculate how many points this card is worth.
# Face cards count 10.
# Ace Counts 1 (or 11, but that adjustment is
#           made at the handScore level).
def cardValue(card):
    name = card[0]
    pos = cardNames.index(name)
    if pos < 10: # if not a face card.
        return pos + 1
    return 10
```

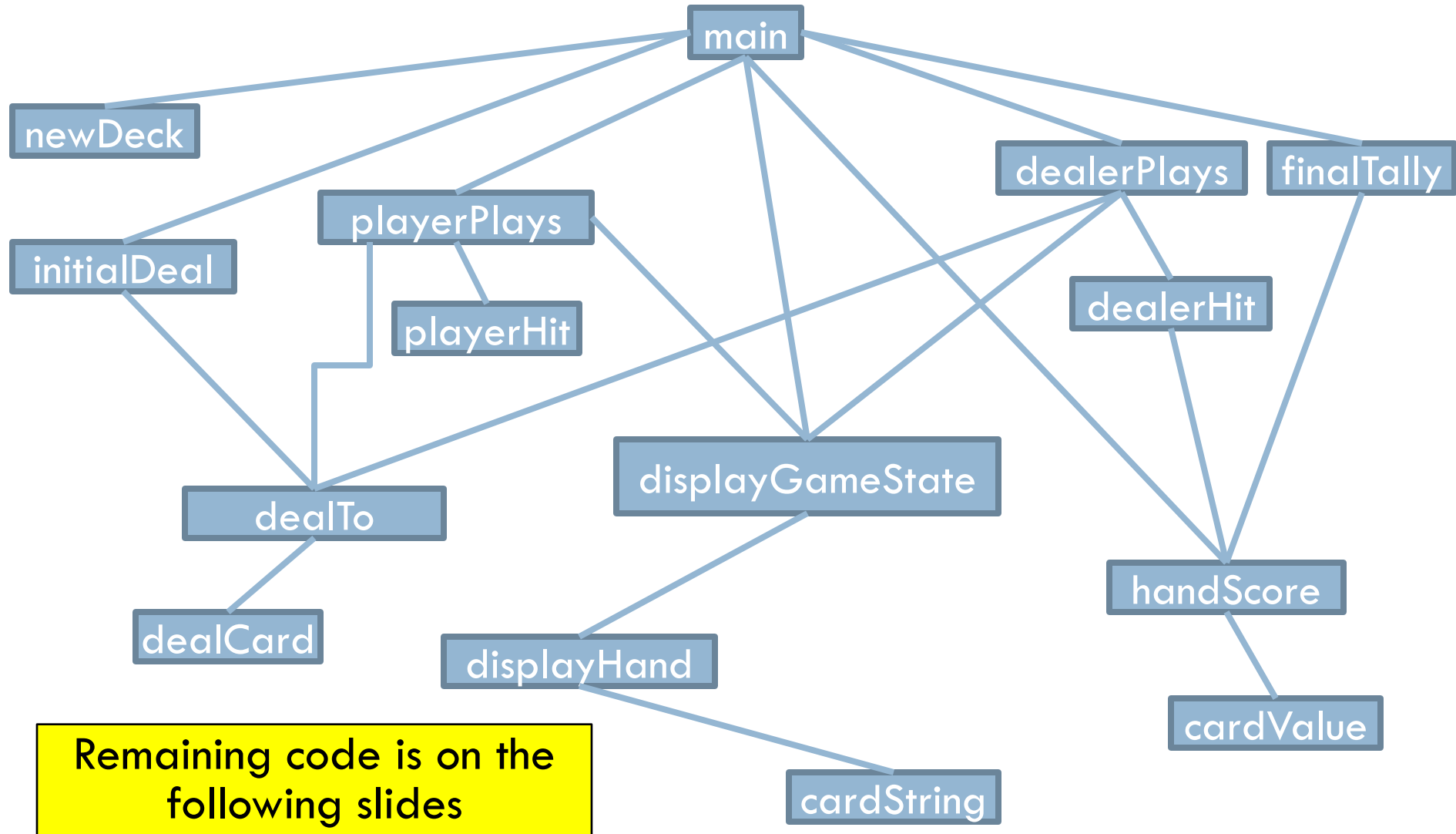
What we have developed so far



Bottom-up Testing

- If we wrote all of this code and tried to run it altogether, there would probably be so many errors that it would be very hard to track down their causes
- So instead of testing the whole program at once, we want to test each function individually.
- To do this, we want to start with functions at the bottom of the structure chart, because they do not depend on other functions
- Tests of individual functions are called **Unit Tests**.

Complete Structure Diagram



The display functions

```
# Show the contents of both players' hands.
def displayGameState(playerHand, dealerHand, gameOver):
    displayHand('Dealer', dealerHand, gameOver)
    displayHand('Player', playerHand, True)

# print out the contents of this hand. If the hand is the dealer's
# and the player hasn't played yet, showAll will be False.
def displayHand(name, hand, showAll):
    print name + "'s hand:",
    if showAll:
        print "(score is %d)" % (handScore(hand))
        print cardString(hand[0])
    else:
        print
        print '    Face Down'
    # print the rest of the hand.
    for i in range(1, len(hand)):
        print cardString(hand[i])

# return a string that represents the given card.
def cardString(card):
    return '    ' + card[0] + " of " + card[1]
```

playerPlays and PlayerHit

```
# Player takes hits until Busted or stops requesting hits.
```

```
def playerPlays(player, dealer, deck):  
    while playerHit(handScore(player)):  
        dealTo(player, deck)  
        displayGameState(player, dealer, False)
```

```
# Ask player whether she wants another card.
```

```
def playerHit(playerScore):  
    if playerScore > winningScore:  
        return False  
    answer = win_raw_input("Hit? (Y/N) ")  
    firstChar = answer[0]  
    return firstChar == 'y' or firstChar == 'Y'
```

finalTally function

```
# Figure out who won.
def finalTally(player, dealer):
    playerScore = handScore(player)
    dealerScore = handScore(dealer)
    if dealerScore > winningScore:
        print "DEALER IS BUSTED, YOU WIN"
    elif dealerScore > playerScore:
        print "DEALER WINS"
    else:
        print "YOU WIN!"
```