Function Structure Example

Consider the following implementation for a RangeCombiner class.

- A "range" is two numbers "min" and "max" and it represents all the numbers from min to max.
- Our RangeCombiner class has methods for adding a new range: combiner.addRange(2.4, 3.5) will add a new range that represents all numbers from 2.4 to 3.5.
- The combiner is supposed to combine ranges that overlap. So for example if it already has the range from 2.4 to 3.5, and we add a range from 3.3 to 3.7, the two overlap and we should combine them to one range, from 2.4 to 3.7.
- Our implementation holds two arraylists, one for the minimums of the ranges and one for the maximums. They start out empty.
- Our implementation will hold these ranges in increasing order. For example the first range ends before the second range starts, the second range ends before the third range starts and so on. A method isRangeOrderValid() checks this property for us.
- When given a new range, our code needs to find where to put it. It searches through the list to find where this range fits, and merges it if needed with any ranges it overlaps. It goes as follows:
  - We loop over the ranges we have available.
  - At each index we check whether this is the right spot for our range. There are two reasons why that might be the case:
    1. The max of our range does not exceed the minimum at the current index, so our range should not go later.
    2. The minimum of our range does not exceed the current maximum, so again our range should not go later.

    In both cases, we insert our range in the current index, shifting everything to the right, and then start a merging process from the current index. Then we return.
  - Otherwise we continue with our loop until we've exhausted all ranges. In that case, our new range is at the end, past all the others, and we simply insert it there.

Group discussion

Look over the implementation in the handout[1], it should appear complicated.

1. What do you think are the characteristics of this code that make it hard to understand?

[1] activity3-1functionStructureHandout.html

2. What could we do to make this class easier to understand? Work out some of the details of the change (are you introducing new methods, a new class, renaming things?).

Don't read further until you have thoroughly discussed the two questions above.

In order to address the problems, we are going to have a small refactoring session, and we will use the *incremental replacement* method: Incrementally replace existing features with the new functionality. Recall the overall steps:

- Introduction:
  - Introduce a new class for the new structure, possibly via a refactoring step.
  - Introduce new fields to hold the new structure if needed.
- Scaffolding:
  - Systematically update the new structure wherever the corresponding old structure elements are updated.
  - Systematically introduce extra parameters passing the new structure around along with the old structure.
- Teardown:
  - Systematically replace accesses to the old structures with accesses to the new structure, until there are no accesses of the old structures.
  - Systematically eliminate no-longer-used parameters that refer to the old structures.
  - Systematically eliminate old structure updates.
  - Eliminate the old no-longer-used structures.
- Cleanup:
  - There are probably many places in the code where old structure values are needlessly produced, and we clean them up.
  - A number of methods probably need some refactoring, possibly moving to methods of the new class.

Here are the steps in detail (REMEMBER to CHECK your tests after each step):

- Introduction: We will introduce a new `Range` class.
  - We want to internally change the behavior of the `addRange` method without changing the external behavior of it. For this reason we want to create a new method. So select the contents (body) of `addRange` method, and perform "Extract Method" to obtain a new method called `addRangeInternal`. Not a great name but we'll worry about the name later.

- Now look at this addRangeInternal method. We will use it to create the new Range class. It has parameters min and max now. Perform "Extract Parameter Object" to create a new class using both parameters. You will need to specify that it is an *Inner class*. Call it Range.
- Next find the lines at the top of the file where the mins and maxs arraylists are created. Add a line to create and a new ArrayList instance named ranges to hold the ranges we are working with. Make sure to specify its type correctly so it will be able to contain Range instances.
- We will slowly supplant the usages of mins and maxs with usages of ranges.

- Scaffolding: We will gradually update the ranges list whenever we update the mins and maxs lists.
  - At the end of the addRangeInternal method we are performing adds on the mins and maxs lists, for the case where we add the new range at the end. Put after those a line that does ranges.add(range);, so that we also update the ranges list.
  - We turn our attention to the insertValueAtIndexAndFixForward method. We want to get to a point where this method takes as input a range instead of min and max. This is a 2-step process:
    * Look at the *call* of insertValueAtIndexAndFixForward, namely insertValueAtIndexAndFixForward(range
      and perform "Extract Method" to a method also called insertValueAtIndexAndFixForward.
      It will have a range parameter and an integer i parameter.
    * Find the *definition* of the *old* insertValueAtIndexAndFixForward method, which took min and max as inputs, and "Inline" that method.
  - Now we get back to our task, which is to update the range values whenever corresponding min and max values change. Look at the top of the insertValueAtIndexAndFixForward method. You will see that we add currMin to the mins mins list and we add currMax to the maxs list. Right below those add instructions, insert a ranges.add(i, range); line to also update the ranges list.
  - Look at the body of the if conditional in insertValueAtIndexAndFixForward:
    * We are computing new values for currMin and currMax. Right after those two computations, set range to equal a call new Range(currMin, currMax). Thus when currMin and currMax changed, we accordingly changed range to agree with them. The next thing that happens in the body of that conditional is that we set some values in mins and maxs. We must also set a value in ranges when that happens, so add a line ranges.set(i, range);.
    * The last line inside the if removes some entries from mins and maxs. We must remove a corresponding entry from ranges, so add a ranges.remove(i); call at the end.

- Teardown: We will gradually remove dependence on mins and maxs in favor of ranges.
  - Our first step is the getters. Our goal is to replace any mention of mins.get(...) with ranges.get(...).getMin(). We will effect this change in three steps:
    * Find a mins.get(i) usage, and extract a tempMins method from it. When the option pops up, tell it to "Keep the original signature", then tell it so substitute all *all* occurrences.

    - Now that the occurences of mins.get only happen via the tempMins method, go in the body of this tempMins method and change it from return mins.get(i); to return ranges.get(i).getMin();.
    - Lastly, inline and remove the function tempMins. It has served its purpose.
    - Repeat the same technique for maxs.get(i).
    - Lastly, use the same technique to mins.getSize(), and replace it with ranges.getSize().
- We now want to gradually restrict references to min and max within the insertValueAtIndexAndFixForward method. We start with the nextMin and nextMax methods.
    - Select the ranges.get(i + 1) section in one of them and perform "Extract Variable" on it to a new variable called nextRange. Replace *both* occurences.
    - Now inline and remove both nextMin and nextMax. They should have had two occurences each.
- Our next goal is to reduce the current code's dependence on currMin and currMax: These should both be obtainable from range, via range.getMin() and range.getMax() instead. As this will slightly change the semantics of the code, the system will not do this automatically for us, we'll have to do it manually, and we'll do it one step at a time.
    - Start by replacing the currMin and currMax in the call to rangesOverlap with range.getMin() and range.getMax() respectively, and check your tests.
    - Do the same with the currMin inside the Math.min and the currMax instead the Math.max, and check your tests.
    - The next line defines range as new Range(currMin, currMax). The values for those need to be the ones from the lines above, so replace the currMin in the constructor call with its value, Math.min(range.getMin(), nextRange.getMin()). Do the same for the currMax, then check your tests.
    - The line below sets the values in mins and maxs using currMin and currMax. Now that our range variable has updated values, replace the currMin in that mins.set(i, currMin) with range.getMin() and similarly for currMax, then check your tests.
    - At this point you should see two earlier settings of currMin and currMax be grayed out. Use the Alt-Enter intention menu to "Remove Redundant Assignment" on those two lines.
    - Now go to the beginning of the insertValueAtIndexAndFixForward method. You should now be able to inline the currMin and currMax local variables there, with one occurrence each.
    - We have now completely eliminated the mentions of currMin and currMax from this method; everything goes through the various ranges now.
- Next we would like to deal with the rangesOverlap method. Find where it is being used, and perform "Extract Method" on it to obtain a new rangesOverlap method that takes two ranges as parameters, instead of four doubles. Then inline and remove the old method, with the four parameters.
- Now move the rangesOverlap method so that it is a method of its first parameter (probably called range), then rename the remaining parameter to range and change the method name to overlapsWith.

- This new overlapsWith method has these two strange local variables, min1 and min2. Inline them both. The resulting expression is fairly long, don't worry about it yet. We'll clean it up.
- We now need to eliminate the methods that were changing the mins and maxs lists. We have three kinds of methods: two kinds of add, a set, and a remove. Make sure that you do NOT delete one of the ranges operations as you do these steps.
  * Start by eliminating the set calls to both mins and maxs, and check your tests.
  * Next eliminate the remove calls. Then the add calls. Check your tests.
  * Now the mins and maxs variable declarations near the top should appear grayed out. Perform the "Safe Delete" refactoring on them.

- Cleanup: Now we will simplify the resulting code to better use the new structures.
  - We examine the code for instances where min and max concepts are needlessly created. One part that remains messy is the creation of the merge of two ranges, which happens within the conditional inside insertValueAtIndexAndFixForward. Right now it is an extremely long call to the Range constructor with suitably computed endpoints.
    * Extract this whole new Range(....); call to a new method called mergeRanges.
    * Then we move this new mergeRanges method to be an instance of its first parameter (probably called range), we then rename the remaining parameter to range, and we rename the method to be called mergedWith.
  - Looking at the beginning of addRangeInternal, there is a call range.getMax() < range.getMin(). Perform "Extract Method" on it into an isEmpty method. Make sure to tell it to "Keep the original signature". Then it move to an instance method of its parameter, range.
  - Next we see the comparison range.getMin() <= ranges.get(i).getMax(). This seems to compare ranges to see if one precedes the other. We'll extract it to a method but we need to prepare it first:
    * Extract a local variable other out of ranges.get(i). This is a temporary extraction to get the right parameters to our methods.
    * Extract a method doesNotFollow out of range.getMin() <= other.getMax() (keep the original signature).
    * Move the new method doesNotFollow to be an instance of its first argument, and change the remaining parameter to range.
    * Now inline the local variable other that we created.
  - Searching for other mentions of min and max outside of the Range class, we see the isRangeOrderValid method. The conditional seems to check exactly whether the range at index i+1 does not follow the range at index i, so replace that conditional with ranges.get(i+1).doesNotFollow(ranges.get(i)), and check your tests.
  - Lastly, in printRanges we find the use String.format("%.2f--%.2f", ranges.get(i).getMin(), ranges.get(i).getM
    * Create a temporary local variable range out of ranges.get(i) (replace both occurrences).

    - Extract the whole String.format(...) expression to a method getSimpleFormat with parameter range, then move it to be an instance method of range.
    - Back in the printRange method, perform the "Replace with foreach" intention to replace it with a simpler for-each loop.
  - Finally we inline and eliminate the getMin and getMax methods altogether and feel better about the fact that the rest of the application does not need to know about min and max.

- Now for some more high-level cleanup.

  - We start with the overlapsWith method. Thinking about it, two ranges will overlap as long as they don't follow each other, so replace the return value with: this.doesNotFollow(range) && range.doesNotFollow(this); and check your tests.
  - Next we look at the while loop in insertValueAtIndexAndFixForward. The nextRange variable is used in two places but it is a simple list lookup, so inline it.
  - Now it would be nice if the while loop no longer had to worry about the range variable: Once we insert the value in the i-th index, we should be able to use ranges.get(i) instead. In order to do that, let's see what the code currently does with range: We merge it with the next range, then put the result into the i-th index. So do the following changes:
    - Replace the range in range.overlapsWith(...) with ranges.get(i).overlapsWith(...).
    - Replace the range in range.mergedWith(...) with ranges.get(i).mergedWith(...).
    - Replace the range in ranges.set(i, range); with its value from the previous line, namely ranges.get(i).mergedWith(ranges.get(i + 1)).
    - Make sure your tests still work, then remove the range = ... line which is now grayed out.
  - Now extract while loop into a method fixForwardFromIndex.
  - Inline the insertValueAtIndexAndFixForward method that is currently doing very little.
  - Looking at the while loop in fixForwardFromIndex, we can see that instead of breaking out of the else case, we can add the test in the conditional as part of the while loop's condition. Then we don't need the if conditional at all. Do that.
  - We could go on with some more cosmetic refactorings, but the main part of the rewrite is now completed.