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Assignment 3 Write-Up

3)

a) Time taken to get+remove n packets with vector queue:

Packets (n)	Duration (seconds)
1,000	0.019
4,000	0.231
16,000	3.365
64,000	52.155

b) The get operation consists of a single loop. First, there is a std::lower_bound call, which should be O(n). This is followed by a vector insert, which requires all subsequent elements to be shifted to the right. The best case would be if every element is added in the correct order, and the worst case would require every single element to be shifted over on every single insertion. I think the vector insertion part means that the whole operation is **O(n) in the best case, and O(n^2) in the worst case.**

c) The remove operation simply calls pop_back() for every n, so it should be **O(n).**

d) Extrapolating from the observed exponential growth for n = 10,000,000 gives a time of approximately **1,273,315 seconds.** (10,000,000 / 64,000)^2 * 52.155 = 1,273,315

5)

a) Time taken to get+remove n packets with max heap:

Packets (n)	Duration (seconds)
1,000	0.008

4,000	0.035
16,000	0.14
64,000	0.586
256,000	2.47

b) For getting packets, the max heap implementation iterates over a single loop, inserting one new element per loop. Heap insertion often requires swapping elements afterwards in order to preserve the heap property, but if no swapping is required, it should be **O(1)** in the best case, as the element is simply added to a pre-existing array. As for the worst case - since each node has at most two child nodes, the number of nodes on each "level" doubles each time. This means the height of the tree, and therefore the maximum number of swaps, should be **O(log(n))**.

c) Removing packets with the max heap implementation calls removeMax() once per element. This usually necessitates swapping around some elements in order to preserve the integrity of the heap. Because the maximum number of levels (and therefore swaps) should be log(n), the remove operation should also be **O(log(n))**.

d) I had a hard time coming up with a good estimation, but I'd guess around 90 seconds.