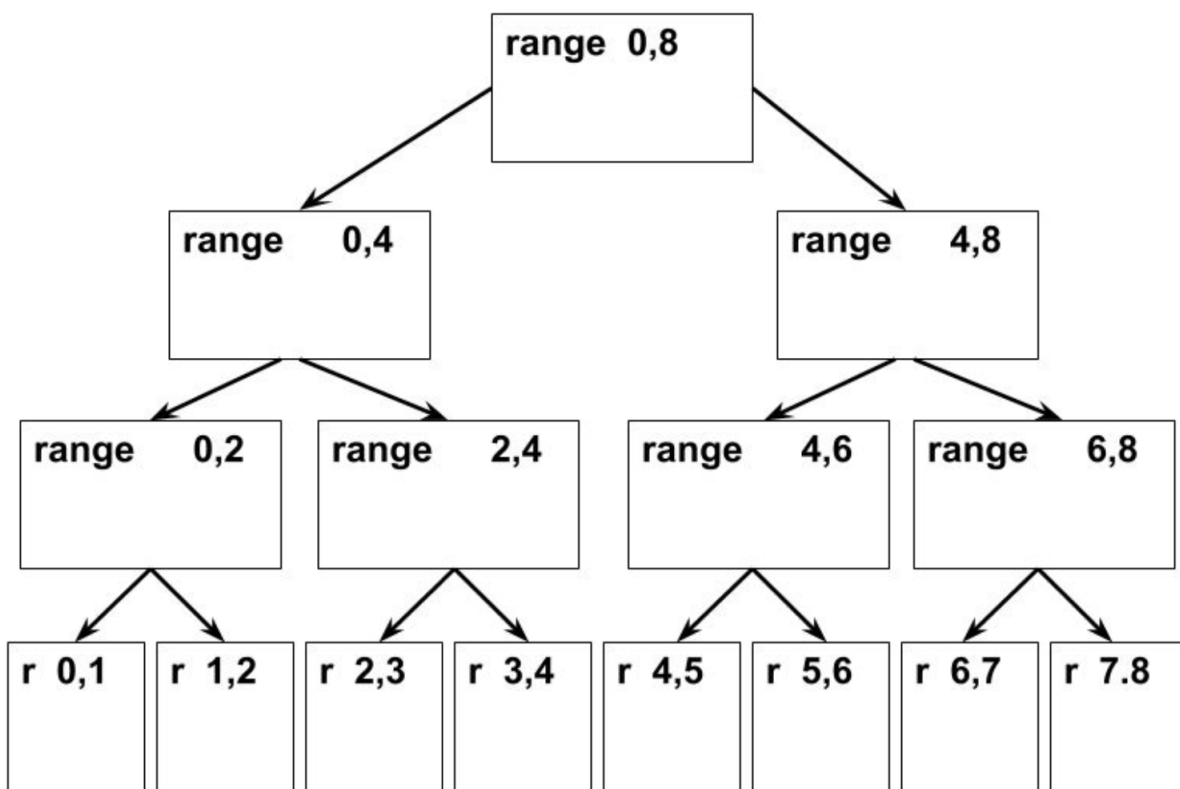


Section 7: Parallel Primitives

0. Parallel Prefix Sum

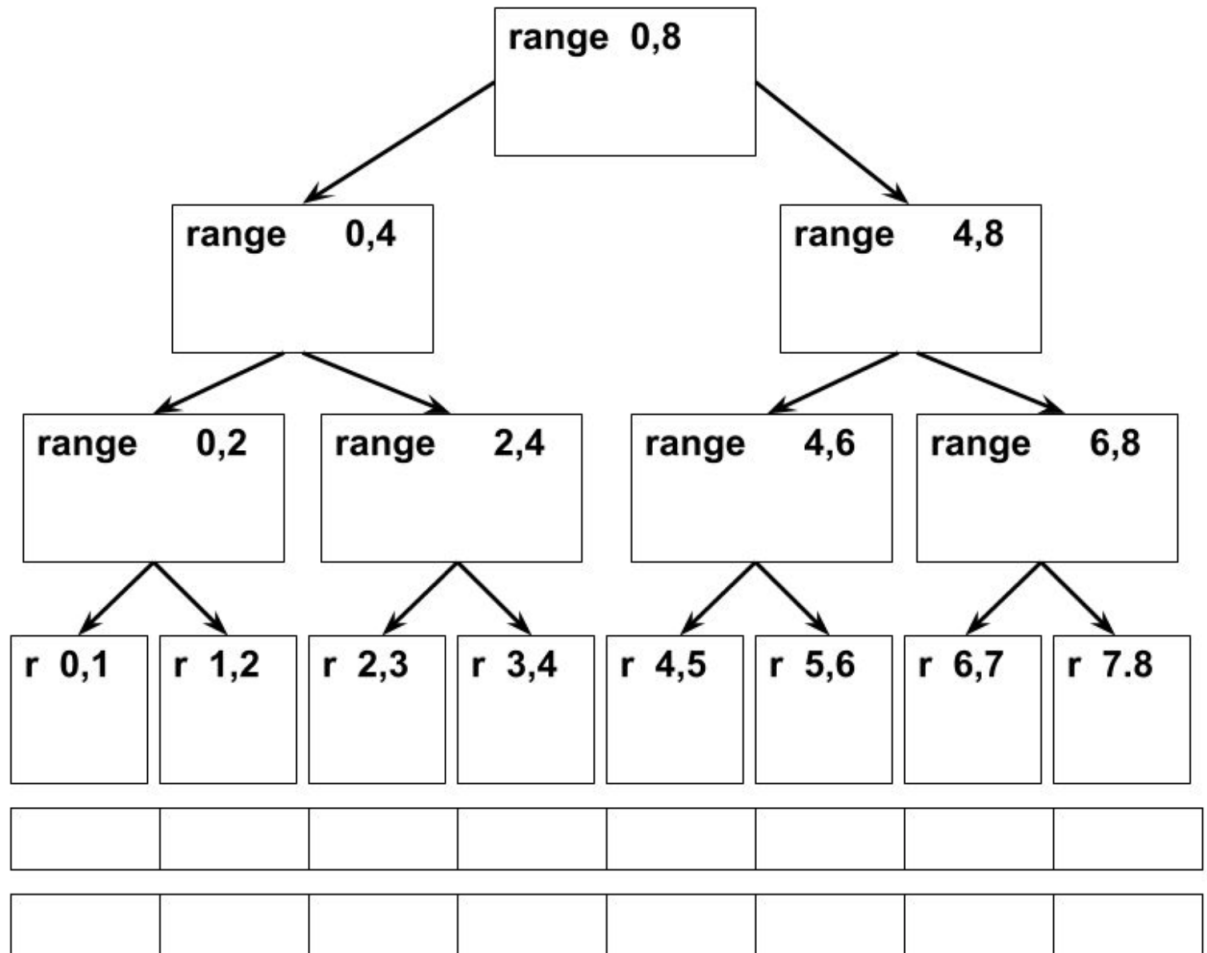
Given input array [8,9,6,3,2,5,7,4], output an array such that each $output[i] = sum(array[0], array[1], \dots, array[i])$, using the Parallel Prefix Sum algorithm from lecture. Show the intermediate steps. Draw the input and output arrays, and for each step, show the tree of the recursive task objects that would be created (where a node's child is for two problems of half the size) and the fields each node needs. Do not use a sequential cut-off.



input								
output								

1. Parallel Prefix FindMin

Given an input array [8, 9, 6, 3, 2, 5, 7, 4], output an array such that each output[i] = min(array[0], array[1], ..., array[i]). Show all steps, as above.



1. River Con-current-ency

Batman and Robin share a jug of water. Rather than going to the store and buying a new bottle whenever they run out (so wasteful!), they continually refill the same jug. In addition, they keep track of how many cups are left in the jug on a sticky note so that they don't have to look in the jug before adding water to it or pouring themselves a delicious glass of water.

```
private int cupsOfWater = 0;
private int maximumWater = 8;
private Stack<Water> water;

private int checkWater() {
    return cupsOfWater;
}

public Water getWater() {
    if (checkWater() > 0) {
        return pourWater()
    }
    // cryDeeply()
}

public void addWater(Water e) {
    if (cupsOfWater != maximumWater) {
        water.push(e);
        cupsOfWater++;
    }
}
```

- (a) Let's say that each person is a thread. Provide an interleaving of the two people that causes the maximum amount of embarrassment.
- (b) Let's say we put a lock around every time `cupsOfWater` and `water` is called. Does this make our scenario thread-safe?

(c) Where would you put the lock to prevent concurrency problems?

(d) Due to budget cuts, we also share one singular cup now, and having learned our lesson from last time, we decide put a new lock every time someone tries to access this cup. What problems could this cause?