Assignment 1: Cutting Costs in Building Maintenance?

Due: 11:59pm Sunday April 25

I. Summary

You are asked to help the building maintenance department assess a possible change in operating policy designed to reduce their costs of maintaining proper lighting throughout the building. Their definition for proper lighting in a room is that no more than 10% of light bulbs in that room are burnt out at any time. Their goal is to meet that standard at minimum cost. Your job is to tell them whether they will save money by replacing *all* the light bulbs in a light fixture (whether or not they are burnt out) while they have it open, instead of just the burnt-out ones.

II. Some Details

Consider a large building, in which there are 50 rooms. Each room has 20 light fixtures, and inside each light fixture are 2 light bulbs. Assume that the average life expectancy for a light bulb is 2,000 hours, and that the length of time that each light bulb lasts can be calculated independently using the exponential distribution with a mean of 2,000 hours. Also assume that the lights in the building are turned on for 24 hours per day, 7 days per week, and that the building maintenance person works from 9am to 5pm from Monday to Friday. Ignore changes to this routine because of holidays, power failures, leap-seconds, etc.

One person is responsible to maintaining the lighting in this building. Each day at 3:30pm, he spends 30 minutes walking around the building, checking each room to see how many of its light bulbs are burnt out. If the number is greater than 4 (i.e., the 10% limit on the number of burnt out light bulbs), he adds the room to his list of lighting repair jobs for the day. At 4pm, when he has completed his walking tour, he gets his equipment out of the storage area and starts working on his list of lighting repair jobs. Assume it takes about 5 minutes (actually a uniform time between 4 and 6 minutes) to carry his ladder and tools from its storage area to a room, from one room to the next, or back to its storage area. Also assume that for each lighting fixture that contains burnt-out light bulbs, it takes a uniform time between 2 and 4 minutes to set up his ladder, open up the light fixture, close up the light fixture and take down his ladder. While his ladder is set up and the light fixture is open, it takes him exactly 1 minute to change a single light bulb. If, on any day, he has not finished his list of repair jobs and returned his equipment to the storage area before 5pm, he is paid overtime at $25.00 per hour, *rounded up* to the nearest half hour.

Under the *current scheme, only those light bulbs that are burned out* are changed when the light fixture is open for repair. In the *alternative scheme* that you must evaluate, *all light bulbs in the fixture* are changed whenever it is open for repair. The idea behind this new scheme is that light bulbs are cheap (only $1.00 each), so we may as well replace the ‘‘partly used’’ ones along with the ‘‘completely used’’ ones, to increase the time until we need to return to the same room again.

III. Measurements

Run your program for 1 year, starting from an initial condition where all light bulbs in the building are new. (Note that January 1st was a Sunday this year, so the maintenance person works Jan. $2-6$, Jan. $9-13$, etc.) For each strategy, calculate: (i) the total cost of new light bulbs installed over the year; (ii) the cost of the maintenance worker at $15.00 per hour + overtime; and (iii) what percentage of the time the lighting satisfies the guidelines of no more than 10% of the light bulbs burnt out. Also calculate how much longer on average the working light bulbs that get changed under the alternative scheme would have continued to function before they requiring replacement under the current scheme.

You should also make other measurements to help you determine that your program is working correctly, such as: the average length of time that a light bulb lasts before burning out; the average time spent on a lighting repair job; the average number of light bulbs changed in a lighting repair job; and the average number of lighting repair jobs carried

out in a day.

IV. Questions

1. Is there a significant cost savings using the new strategy? (You may need to calculate confidence intervals using the output from several "runs" using different random number seeds to answer this properly.) Use your measurements to explain what you found.
2. In designing this simulation program, you have a choice of what to put in the event list: the time at which each individual light bulb fails or the time that the lighting level in a room falls below the guideline. Briefly describe how would you change your program to implement the other choice.
3. Explain why it is important to use a heap data structure (instead of a simple linked list) for the event list in this program? Also explain how a cross-linked data structure can be used to speed up the event list updates in the case of the alternative scheme when you change a working light bulb.
4. Subtract the fixed cost of the 3:30pm inspection tours from the cost of the maintenance worker, and then divide by the number of light bulbs replaced to produce the average cost to change a light bulb under each scheme. How does this compare to the cost of the light bulb itself?