Elias Borge-Ilseth, 11075526
Eskil Myklatun Østbø, 11074713 20.03.2025

"Optimizing Sink Position in a Wireless Sensor Network" Exercise

Task 4

4.A

The task has been solved with a python script, referring to optimizeSinkPosition.py.

To find the lifetime of the overall system, we need to calculate the time until the first sensor's battery dies. Hence, we calculated the distance from each sensor to the sink and stored it in an array. Then, for each sensor we calculated the total energy in nJ used by each sensor for 1 transmission, using the formula:

$$E_{total} = (E_c + E_{tx}(d)) * b = (E_c + k * d^2) * b$$

where E_c = 50 nJ/bit, k = 1 nJ/bit/m^2, b = 2000 bits per packet are all given and d is the computed distance array between each sensor and the sink. Moreover, the lifetime of each sensor is computed by:

$$lifetime = \frac{E_b}{E_{total}}$$

which gives the total lifetime of each sensor measured in number of transmission cycles, where E_b = 5 mJ is given as the energy capacity of each sensor. This gives an array of the lifetimes of each sensor, and the shortest lifetime of a sensor is retrieved. The script outputs the following results for task 4.A:

> *"Shortest sensor lifetime: 3.40 transmission cycles, which means the lifetime of the system is 3 full transmission cycles.*
>
> *Worst-case sensor with fixed sink position: Sensor nr 1 with positions [1 2]"*

As expected, the sensor which dies first is sensor 1 with position (1, 2), which is positioned furthest away from the fixed sink position (20, 20). This means that the system can perform 3 full transmission cycles.

Elias Borge-Ilseth, 11075526
Eskil Myklatun Østbø, 11074713 20.03.2025

4.B

<u>The task has been solved with a python script, referring to optimizeSinkPosition.py.</u>

For task 4.B, the same formulas and calculations are used as in 4.A. The task has been solved by creating a grid over all the possible sink positions, then iterating through all the possible sink positions to calculate the lifetime of the system in each case just as in task 4.A to find the most optimal solution.

The script outputs the following results for task 4.B:

> *"Optimal sink position: (6.87, 7.66)*
>
> *Worst-case sensor with optimal sink position: Sensor nr 4 with positions [15 7]"*

This gives that the optimal position of the sink that maximizes the system lifetime is position (6.87, 7.66). In this case, when looking at the full list of lifetimes of each sensor, it can be observed the set of sensor lifetimes have a more uniform distribution, indicating reduced variability among individual sensor lifetimes compared to the case of fixed sink position in task 4.B.

4.C

Trade-offs fixed vs dynamic sink placement:

- **Fixed sink position**:
  - **Pros**: A fixed sink position will allow for simpler networking design, implementation and management. There is no need for the network to account for the movement of the sink, which can reduce the complexity in the design of protocols for communication and routing.
  - **Cons**: Certain censors placed far away from the sink will die much faster than other sensors placed close to the sink. This imbalance reduces the overall lifetime of the system, and makes it such that some sensors need maintenance much more often than other sensors, as seen in Task 4.A, where some sensors have a very short lifetime compared to other sensors.
- **Dynamic sink position**:
  - **Pros**: A dynamic sink position will balance the total energy consumption more equally across all sensors, such that their lifetime will be more similar, and the worst-case sensor lifetime will be higher than in the case of fixed sink position. This increases the overall lifetime of the system. In addition, if dynamic nodes were in use, a dynamic sink position would be advantageous, a dynamic sink would be able to adapt its position to optimize energy consumption.

- **Cons**: Implementing a dynamic sink increases the complexity of the networking design, implementation and management. A moving sink will also require extra power for mobility. So, although it can reduce the energy consumption of the sensors and increase the system's lifetime, it could consume more total energy than what is optimal because of the increased energy consumed by the dynamic sink.