IOT Exercise #1

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1 Evaluation of the lifetime of the system

The lifetime of the system is the time required for the first sensor's battery to run flat. In this system the sink node is fixed at position (20, 20) and all other nodes have the same battery capacity and execute the same computations. The nodes are scattered at random positions and at variable distance from the sink. The energy consumption needed to communicate with the sink is dependent on this distance and, thus, changes among all nodes. The farther away a node is from the sink node, the more power it will take to communicate the results from one node to the other; hence, its battery will be consumed faster. The farthest sensor is Sensor 1, placed at position (1, 2).
We evaluated the total energy consumption for one duty-cycle (E_{dc}) as the sum of the energy consumed by the activation of the communication circuitry (E_c) and the energy it takes to send a WiFi message over a given distance d ($E_{tx}(d)$) multiplied by the total number of bits transmitted:

$$E_{dc}(d) = (E_c + E_{tx}(d)) * \#bits$$

Using this formula with the distance between the sink node and sensor 1, we obtain the following:

$$E_{dc}(26.173) = (50\ \frac{nJ}{bit} + 1\frac{nJ}{bit\ *\ m^2}(26.173)^2) * 2000 = 1.47\ mJ$$

From the obtained value we can then evaluate the number of fully completable duty-cycles as the ratio between the given total energy (E_t) and the energy needed to complete one duty-cycle (E_{dc}) with the formula:

$$\#cycles(d) = \frac{E_t}{E_{dc}(d)}$$

The number of cycles found is:

$$\#cycles(26.173) = \frac{5\ mJ}{1.47\ mJ} = 3.4 \simeq 3$$

From this, we can finally compute the total sensor's lifetime with the formula:

$$Lifetime(d) = \#cycles(d)\ *\ time_{dc}$$

Obtaining:

$$Lifetime(26.173) = 3\ *\ 10\ min = 30\ min$$

2 Sink's optimal position

To evaluate the optimal position of the sink node, we wrote a Python script to minimize the power consumption of each sensor. Since the only part of the code that is variable is the data sent to the sink node, by minimizing the power consumption of this transmission, we maximize the battery life. As a result, we obtained that the optimal position for the sink node to be in is (6.87; 7.66).
In this position, by repeating the process done in the previous section, we measure the new lifetime of the system to be around 210 minutes.

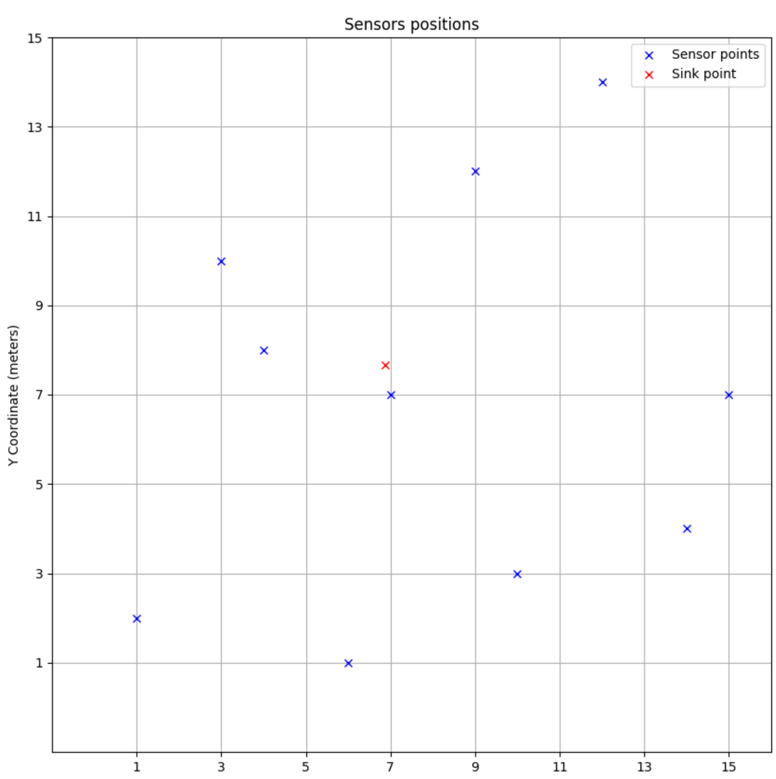

Figure 1: Sink node optimal position

3 Trade-offs

The advantages of having a fixed sink position is that the system is easier to develop and maintain. The equations implemented to find the best position were straightforward to develop. Furthermore, the lack of a mechanism moving the sink node reduces the number of failure points present in the system. On the other hand, having a static sink node, the best obtainable lifetime for the system is still objectively too short to be useful in a real-world scenario. In the case of a moving sink node, the function that sends the data can be synced to be activated only when the sink node is close to the sensors. In this way, the energy needed to transmit the information is optimized. This system would have an optimal optimization of power, as each sensor would consume the least possible energy each time. This optimization would come with the downside of a complex implementation. Both systems have benefits and downsides, our consideration is that the best solution would be to simply have a nonmoving sink node and trade the simplicity of the system with the shorter lifetime of the sensors.