CS4222 Assignment 4 Report

4.1 Task 1 - SensorTag Neighbour Discovery

For the first task, the experiment was done on two SensorTags. The first part of the experiment is to get the intervals of packet receptions on device A hearing from device B. This was done until device A received 15 packet receptions from device B.

The second part of the experiment is to get the first discovery time that device A hears from device B. Every time device A receives the first packet, the first discovery timing is recorded and device B is then rebooted. This was done until 15 first discovery timings are recorded.

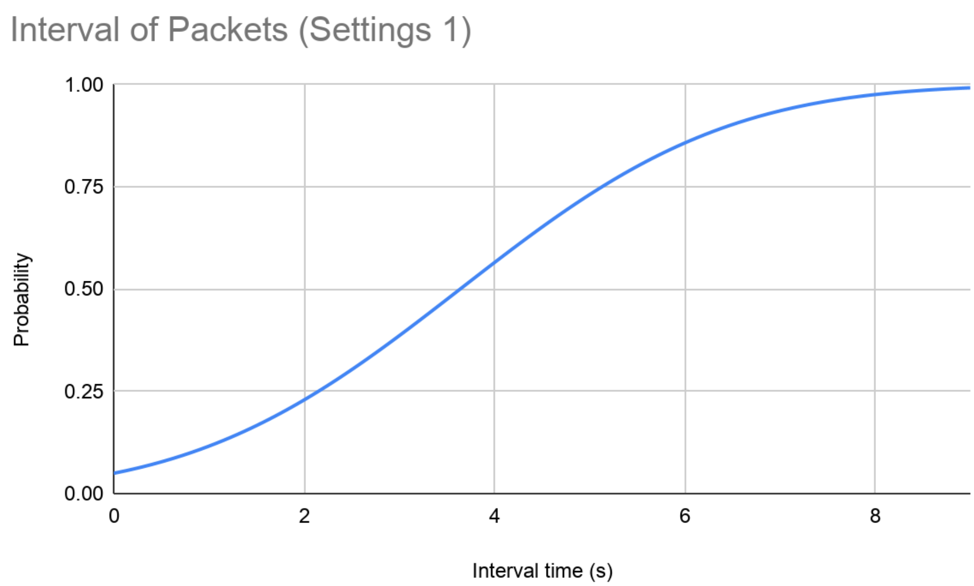
Below are the cumulative distribution graphs of default and different settings tested. Both devices used the same settings.

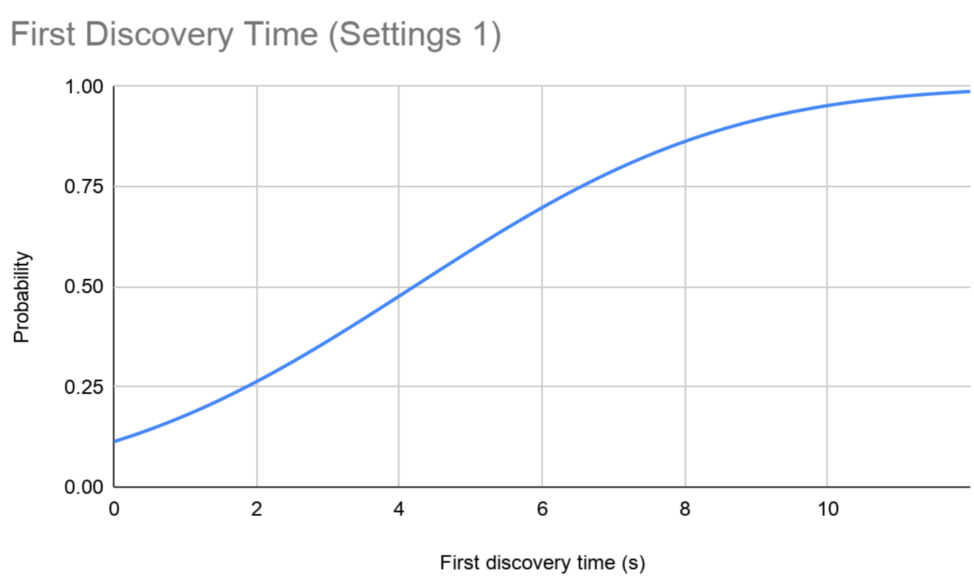
Only the mean and standard deviation of the values and the cumulative distribution graphs are displayed in the report to keep the report concise.

1. Default settings

Settings 1: 0.1s wake time, 0.1s sleep time, 9 sleep cycle, 0.1% duty cycle

	Interval	First discovery time
Mean	3.639	4.2022
STDev.	2.208203161	3.476284879



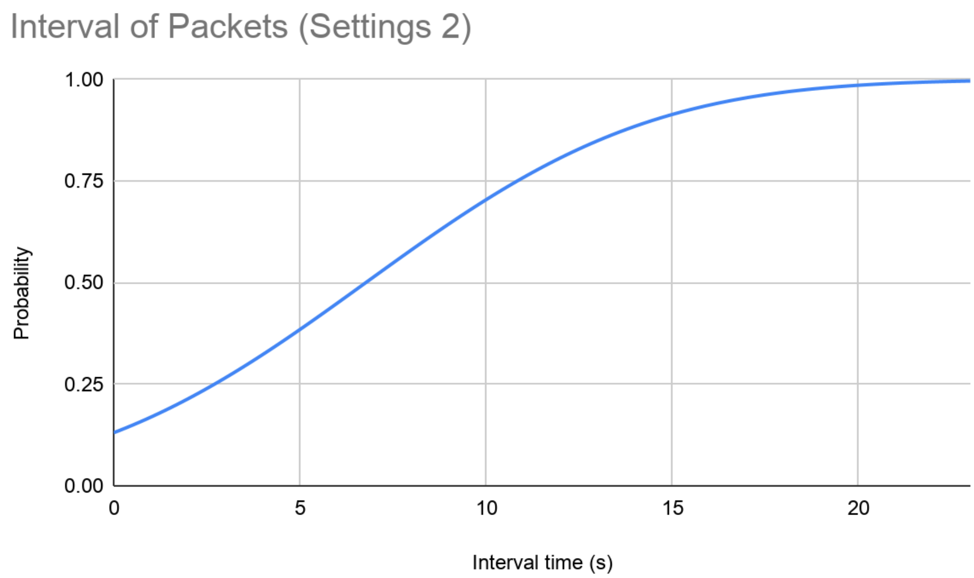


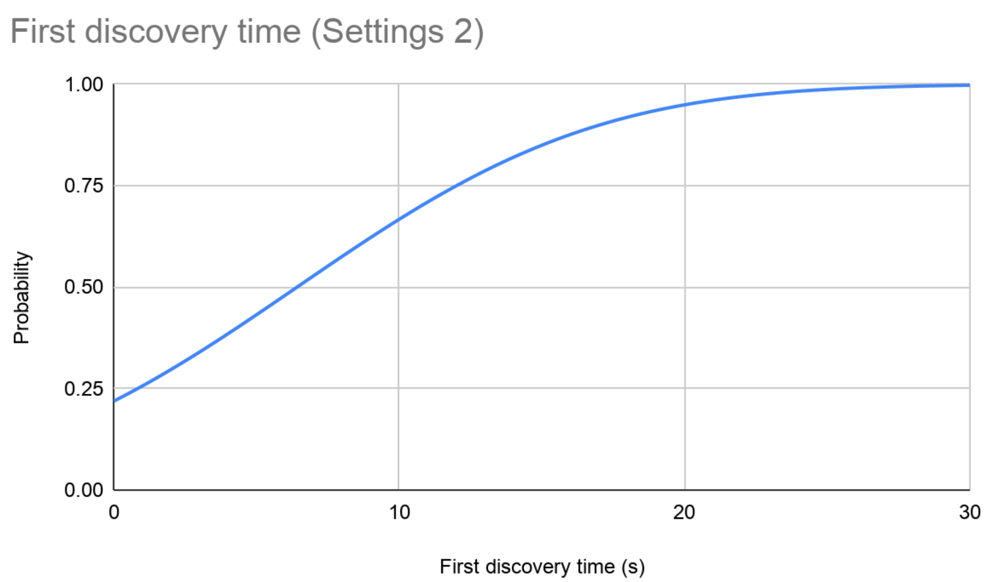
2. Other settings

After testing out the default settings, different settings were used to observe the difference in results. The following subsections show the other changes that were made on the SensorTags.

Settings 2: 0.1s wake time, 0.125s sleep time, 9 sleep cycle, 0.082% duty cycle

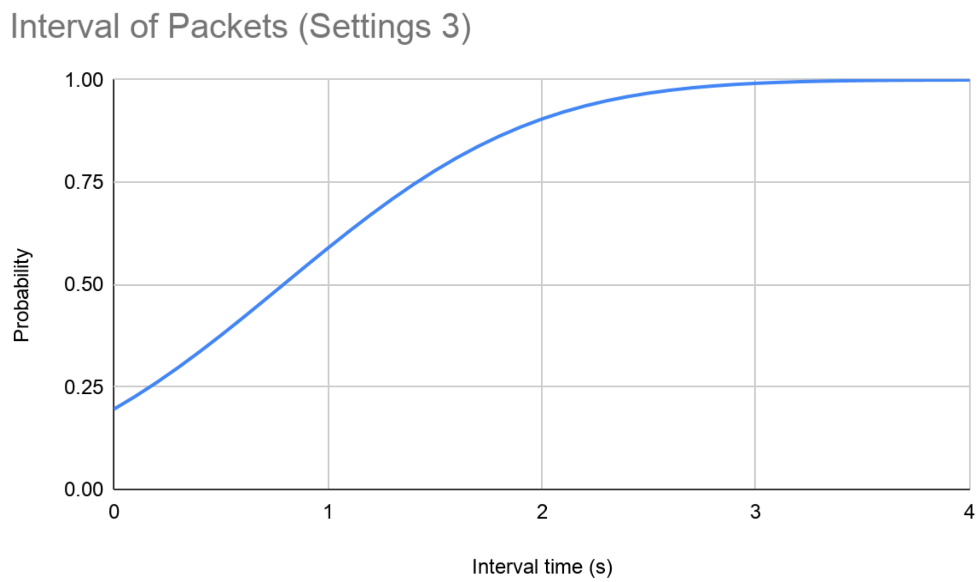
	Interval	First discovery time
Mean	6.766133333	6.421933333
STDev.	6.026000474	8.282642811

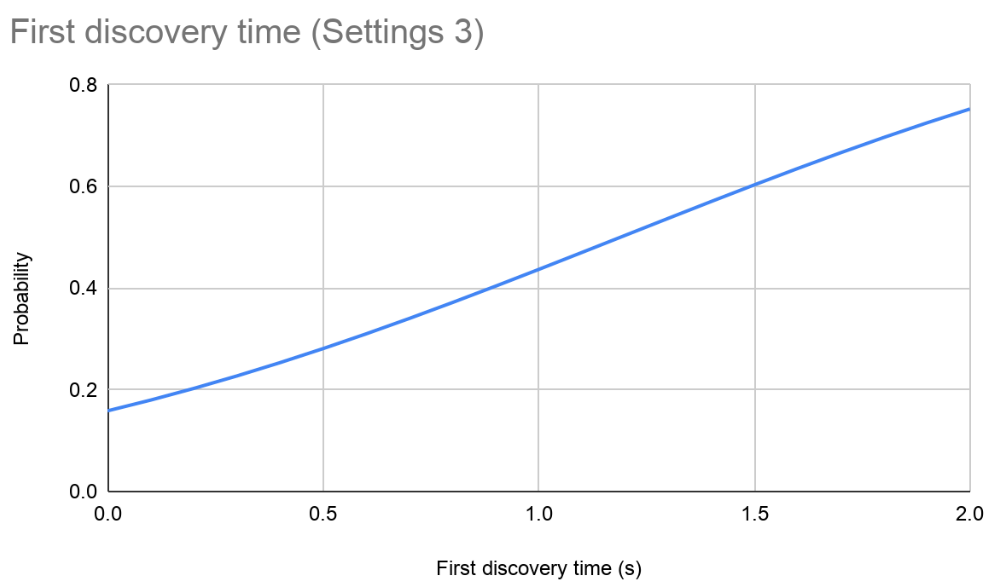




Settings 3: 0.1s wake time, 0.1s sleep time, 4 sleep cycle, 0.2% duty cycle

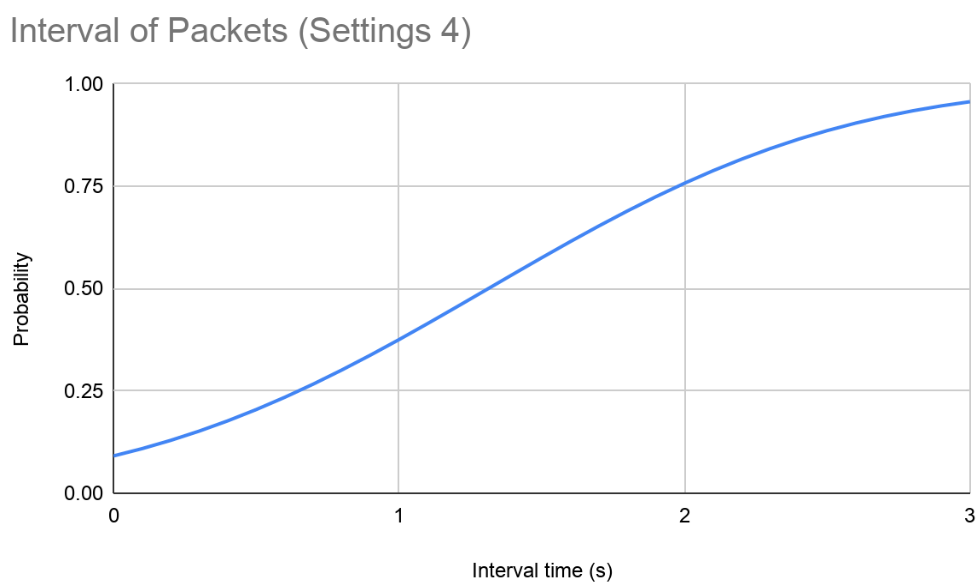
	Interval	First discovery time
Mean	0.7926666667	1.1886
STDev.	0.9244402751	0.6513460729

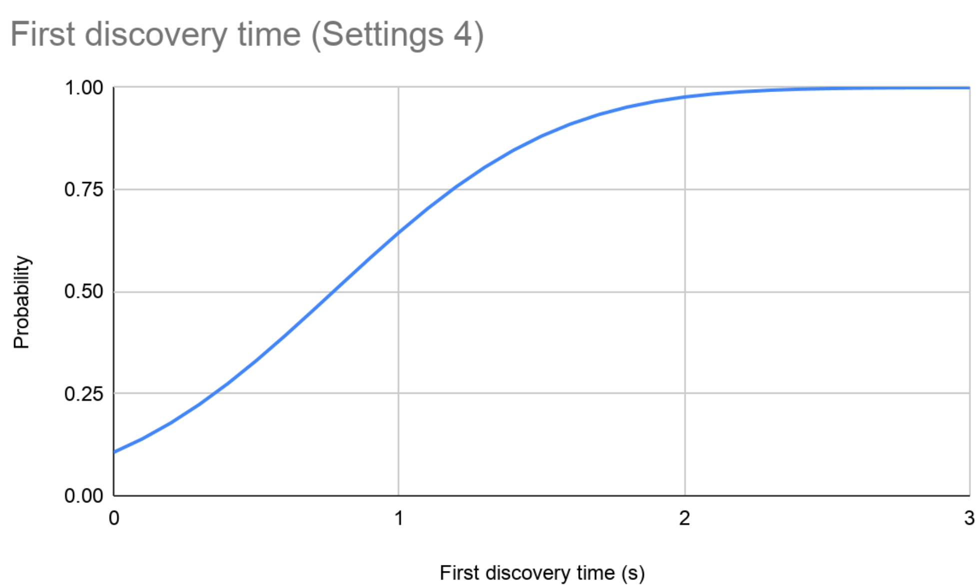




Settings 4: 0.08s wake time, 0.1s sleep time, 4 sleep cycle, 0.166% duty cycle

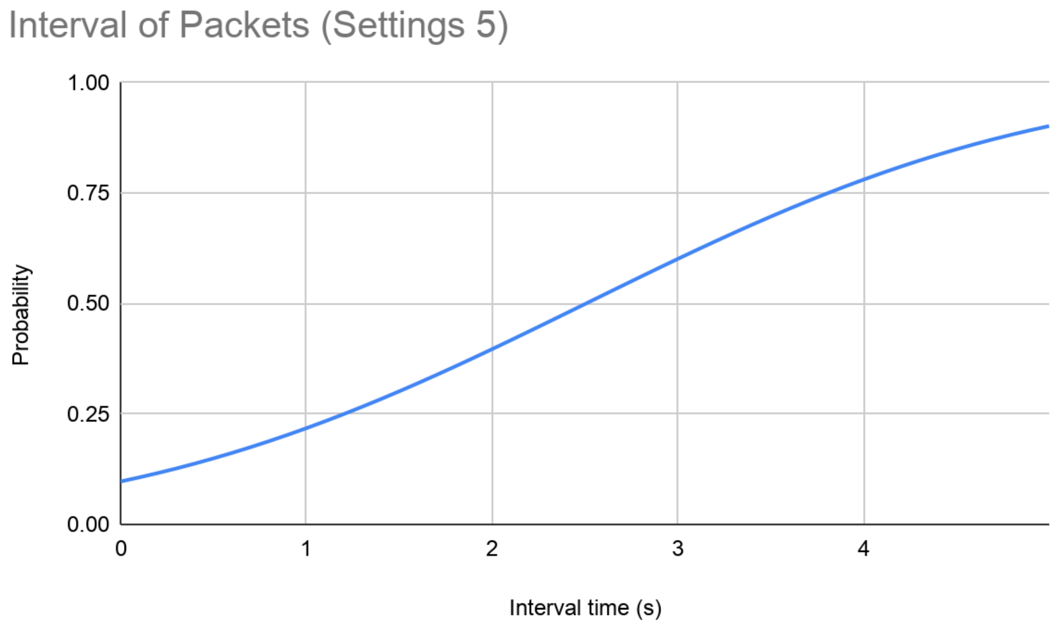
	Interval	First discovery time
Mean	1.312466667	0.7698666667
STDev.	0.9841820202	0.6181364323

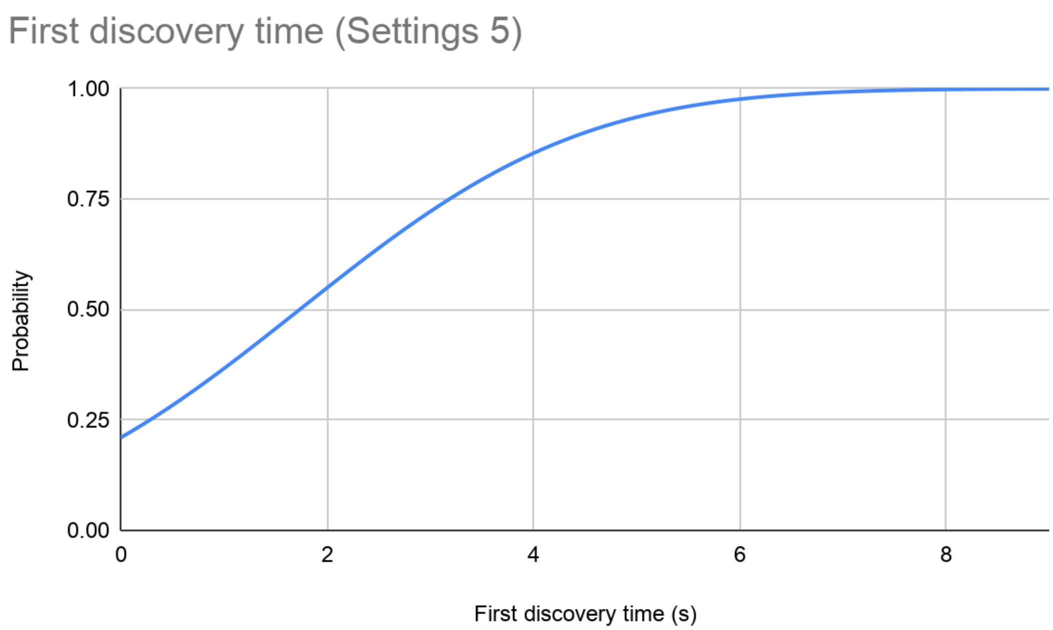




Settings 5: 0.05s wake time, 0.1s sleep time, sleep cycle 4, 0.111% duty cycle

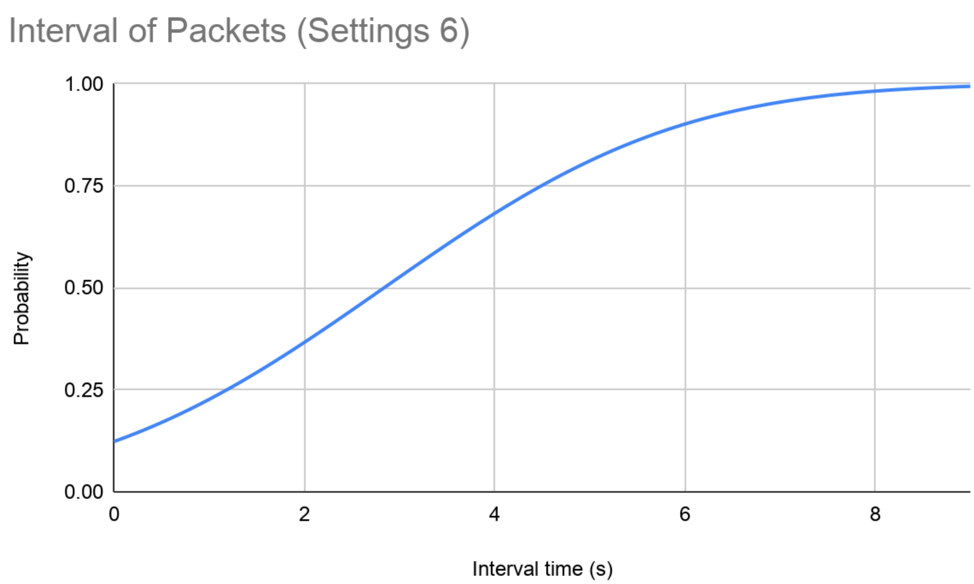
	Interval	First discovery time
Mean	2.505666667	1.735466667
STDev.	1.931229994	2.151190984

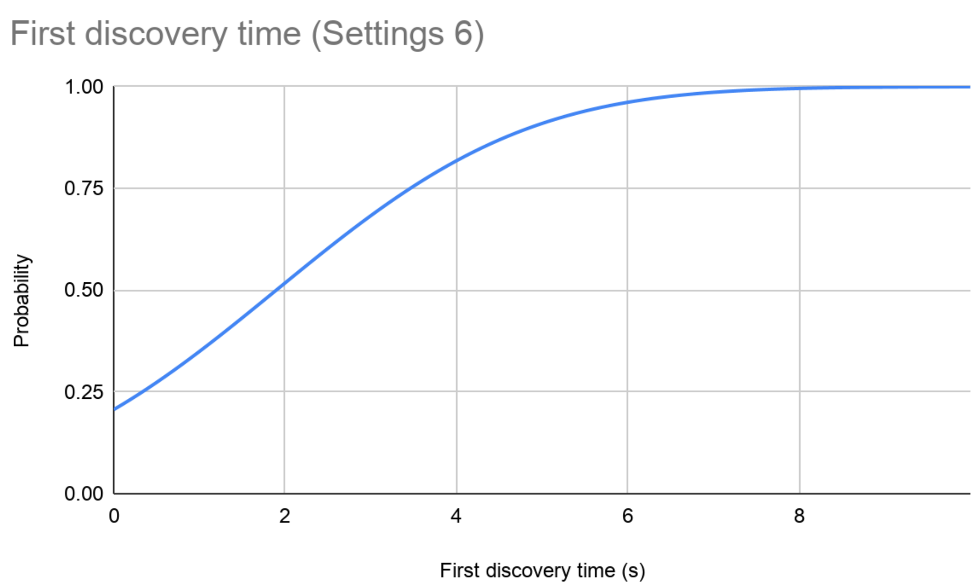




Settings 6: 0.05s wake time, 0.143 sleep time, 4 sleep cycle, 0.08% duty cycle

	Interval	First discovery time
Mean	2.839	1.897333333
STDev.	2.449435445	2.318099068





Discussion

The experiment strategy is to take the default settings and adjust each setting one at a time. This is to observe the results and deduce a pattern from editing each setting.

From the default to Settings 2, the sleep time was increased and the mean and standard deviation for interval and first discovery timings increased. From this, the team deduced that increasing sleep timing will decrease the duty cycle which in turn will increase the timings of transmissions. Since the actual sleep period is randomised from 1 sleep slot to double of sleep cycle sleep slots, the team decided to reduce the sleep cycle to reduce the randomness of results obtained.

Then from the default to Settings 3, the sleep cycle was decreased and the mean and standard deviation decreased for interval and first discovery timings. And from Settings 3 to Settings 4 and Settings 4 to Settings 5, the wake time was reduced on both changes to observe the change in mean and standard deviation. And it is seen that the timings and spread are increasing steadily when the duty cycle is decreasing.

And finally from Settings 5 to Settings 6, the sleep time was increased to make sure that the decrease in duty cycle will have the same pattern regardless of editing wake or sleep time. The results obtained does show that the timings observed did increase in mean and standard deviation.

In conclusion, sleep cycle greatly affects the spread of timings obtained due to the randomness of sleep period and the duty cycle is inversely proportional to the mean and standard deviation of interval and first discovery timings.

4.2 Task 2 - Power Management

Below is a screenshot of the powertrace log when WAKE_TIME is set to 50ms, SLEEP_CYCLE to 4 and SLEEP_SLOT to 200ms.

```
00:05.541       ID:2     644 P 2.0 0 7494 157039 406 12826 0 0 7494 157039 406
12826 0 0 (radio 8.04% / 8.04% tx 0.24% / 0.24% listen 7.79% / 7.79%)
00:05.687       ID:1     644 P 1.0 0 7494 157039 406 12826 0 0 7494 157039 406
12826 0 0 (radio 8.04% / 8.04% tx 0.24% / 0.24% listen 7.79% / 7.79%)
```

And below is the log translated to what each number is. Since node 1 and 2 have the same powertrace log, only 1 of them is shown.

Output description	**Value**
Clock time	644
Rime address	2.0
Sequence number	0
Accumulated CPU energy consumption	7494
Accumulated Low Power Mode energy consumption	157039
Accumulated transmission energy consumption	406
Accumulated listen energy consumption	12826
Accumulated idle transmission energy consumption	0
Accumulated idle listen energy consumption	0
CPU energy consumption for this cycle	7494
LPM energy consumption for this cycle	157039
Transmission energy consumption for this cycle	406
Listen energy consumption for this cycle	12826
Idle transmission energy consumption for this cycle	0
Idle listen energy consumption for this cycle	0
Radio cycle	8.04%
Tx cycle	0.24%
Listen cycle	7.79%

4.3 Task 3 - Deterministic Discovery

Algorithm implementation

The algorithm that we are implementing is the **Quorum-based algorithm**. Similar to the explanation in lecture, there is a N x N grid and a row and column will be chosen as the wake slots and the remaining are sleep slots. Each slot is given the same duration. The node will traverse the grid and if it is in the wake slot, the node will send a packet and is open to receiving packets. If it is in the sleep slot, the node sleeps and is not open to receiving packets.

The parameters that can be edited are the following

- Size of N (N x N grid size)
- Duration of time slot

The code will randomise the row and column chosen.

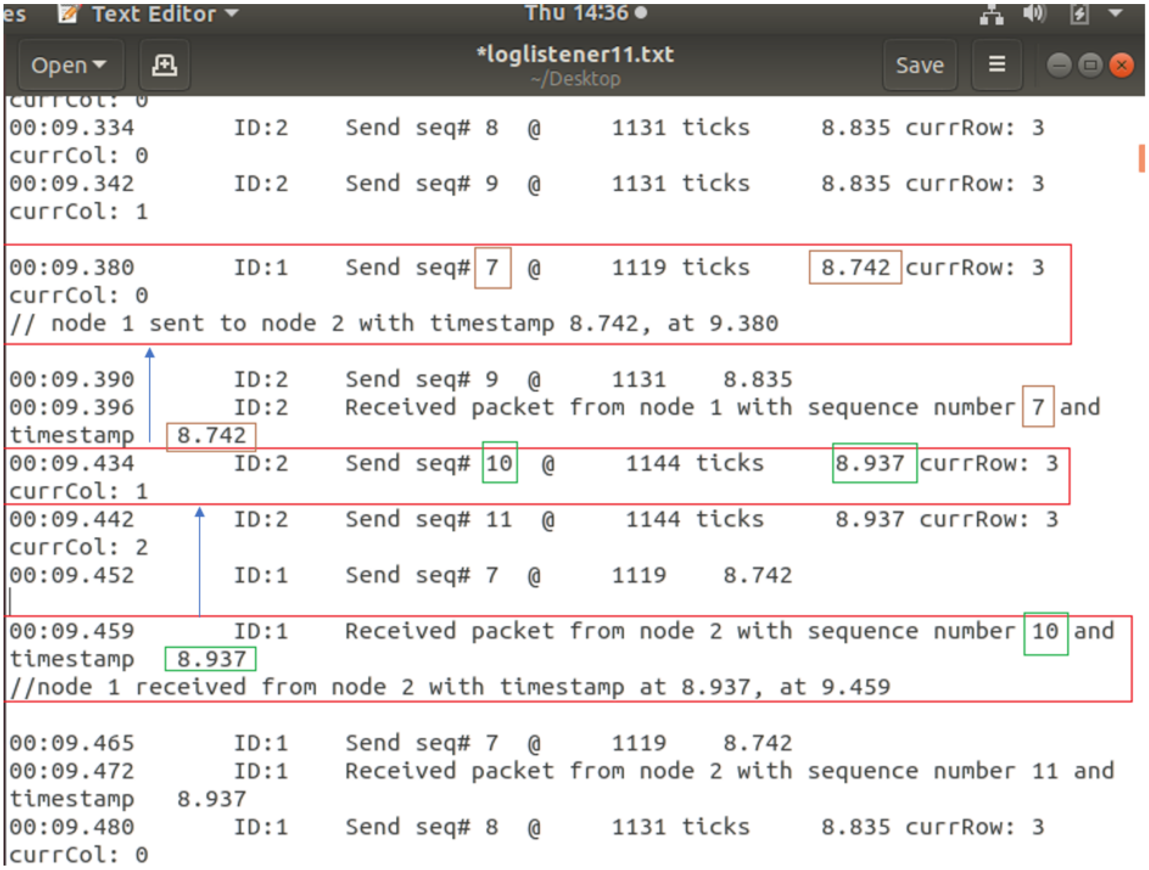
Settings for minimised power consumption

From simulation, the team found that this is the best setting for the lowest power consumed and yet the nodes discover each other within 10 seconds. The values in bold are the chosen setting and remaining values in the table are the results of the chosen values. The power consumption is calculated from summing up all the accumulated energy consumptions in the powertrace log.

Time slot (s)	**N size**	Two-way latency (s)	First discovery time (s)	Radio duty cycle (%)	Power consumption
0.0625	**30**	0.081	6.388	4.8	172433

Method of results collection

The following show an example simulation log using the N grid size of 30 with the time slot of 0.1s.



```
es  Text Editor ▾          Thu 14:36 ●
Open ▾        *loglistener11.txt        Save  ☰
              ~/Desktop
currCol: 0
00:09.334       ID:2    Send seq# 8  @     1131 ticks     8.835 currRow: 3
currCol: 0
00:09.342       ID:2    Send seq# 9  @     1131 ticks     8.835 currRow: 3
currCol: 1

00:09.380       ID:1    Send seq# 7  @     1119 ticks     8.742 currRow: 3
currCol: 0
// node 1 sent to node 2 with timestamp 8.742, at 9.380

00:09.390       ID:2    Send seq# 9  @     1131    8.835
00:09.396       ID:2    Received packet from node 1 with sequence number 7 and
timestamp   8.742
00:09.434       ID:2    Send seq# 10  @     1144 ticks     8.937 currRow: 3
currCol: 1
00:09.442       ID:2    Send seq# 11  @     1144 ticks     8.937 currRow: 3
currCol: 2
00:09.452       ID:1    Send seq# 7  @     1119    8.742

00:09.459       ID:1    Received packet from node 2 with sequence number 10 and
timestamp   8.937
//node 1 received from node 2 with timestamp at 8.937, at 9.459

00:09.465       ID:1    Send seq# 7  @     1119    8.742
00:09.472       ID:1    Received packet from node 2 with sequence number 11 and
timestamp   8.937
00:09.480       ID:1    Send seq# 8  @     1131 ticks     8.835 currRow: 3
currCol: 0
```

Maximum two-way latency

Simulation time	Event
9.380	Node 1 sent packet 7 with stamp 8.742
9.396	Node 2 received packet 7 from node 1
9.434	Node 2 sent packet 10 with stamp 8.937
9.459	Node 1 receive packet 10 from node 2

The maximum two-way latency is calculated by first tracing when a packet is received by node 1, from node 2. From the example, this occurs at **<u>09.459</u>** and the packet received is time stamped at 8.937 and sequence number 10.

Then trace back to the time when node 2 sent it, which is **<u>09.434</u>**, time stamped 8.937 and sequence number 10. This was sent after node 2 received a packet from node 1 at **<u>09.396</u>** with sequence number 7 and timestamp 8.742. Hence, sequence number 10 is a response by node 2, to node 1’s sequence number 7.

The packet time stamped at 8.742 with sequence number 7 was sent by node 1 at **09.380**
Hence, the maximum two-way latency is 9.459 - 9.380 = **0.079s**

First discovery time

This is simply obtained from the timing observed when the nodes first discover each other successfully, which is **9.459s** from the example above.

Discussions

These are the observations the team found while testing.

By increasing the N size, the radio duty cycle is reduced exponentially, which will increase the first discovery time. Reducing the time slot duration will increase the max two-way latency but reduce first discovery time. In addition to reducing the time slot, it will increase the power consumption due to the states changing more frequently.

The team concluded that there has to be a balance between the time slot duration and N size to get the optimised power consumption for transmission between nodes within time limits.