ECE9047: Laboratory 4 Report

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1.

The statement of the problem

Design a wireless sensor network (WSN) to track an animal population and monitor environmental conditions in a given habitat. The Sociology and Biology departments of the Brantford University of Teaching & Technology (BUTT) are interested in studying the distribution and behavior of a particularly unique group: undergraduate engineering students. These students have been observed to cluster in the less-lit basements of the Engineering building predominantly. The departments have commissioned the design of a WSN to monitor this area, aiming to gather data on humidity, light, and floor pressure.

2.

Describe the design philosophy of my network.

1. My network design is a heterogeneous network since I used Zigbee to design the network and some nodes are power-boosted.
2. The topology of my network design has combined both structured nodes and randomly distributed nodes. The hierarchical structure of network data flow is shown in Figure
3. The k-connectivity of the network is 1. If the three hallway networks fail simultaneously, it could lead to a failure of the network that serves the café, student club offices, study hall, and design space. This interconnected dependency indicates a critical point of vulnerability within the network's infrastructure.
4. The network is designed to have an expected lifespan of an academic year as the majority of the nodes use low-capacity batteries.
5. Yes, the total design cost is **$2580**. Therefore, we have $420 for replacing failing nodes in the future.

3.

1. For the light sensor, I assume the appropriate sensing radius is 2.5 meters. This assumption is based on the fact that the sensing radius of the light sensor is significantly

influenced by the intensity and spread of ambient light, which can be altered by the reflection and scattering of photons. Thus, 2.5 meters is considered a reasonable estimate for the light sensor's sensing radius. The k-coverage of the light sensor is 0, as there are some areas uncovered by the light sensor.

2. Regarding the humidity sensor, I assume an appropriate sensing radius of 5 meters, given that water particles in the air can move dynamically. Consequently, the sensing radius of the humidity sensor is larger compared to that of the light sensor. The k-coverage of the humidity sensor is also 0, as there are some areas uncovered by the humidity sensor.
3. As for the pressure sensor, I assume its sensing radius is nearly zero, because the pressure sensor requires direct contact, such as someone stepping on it, to record pressure. The k-coverage of the pressure sensor is 0 as the pressure sensor almost covers only a point.

4.

1. In my design, I have primarily integrated a light sensor and humidity sensor onto a base designed for mounting on either the ceiling or wall. This base is equipped with a low-capacity battery and either a Zigbee Router or Zigbee End device for sensing both humidity and light. Additionally, I designed a floor-mounted with a base that includes a pressure sensor, also equipped with a low-capacity battery and a Zigbee Router or Zigbee End device for pressure detection.
2. To enhance the readability of my design diagram, I employ five differently colored circles to represent various combinations of bases and sensors. Furthermore, I use three distinct label series to delineate different mounting methods, Zigbee hardware options, and battery selections. Figure 1 illustrates the combinations of sensor choices, while Figure 2 shows the different mounting methods, Zigbee devices, and battery options.

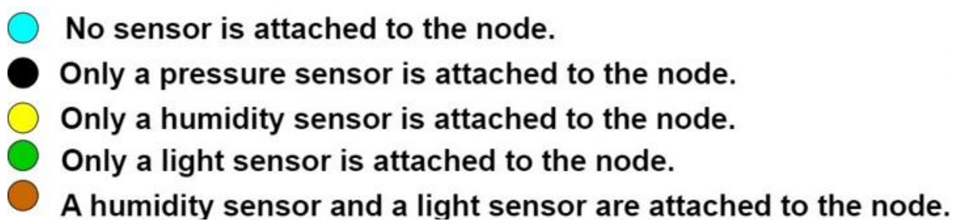

Fig. 1 The combinations of sensor choices

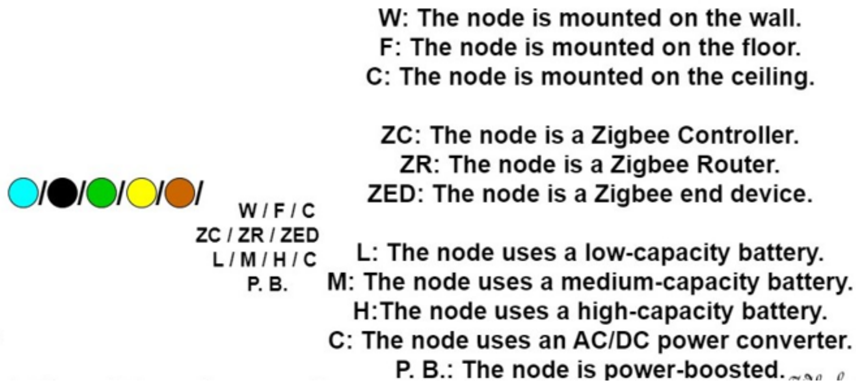

Fig. 2 The different mounting methods, Zigbee devices, and battery options

5.

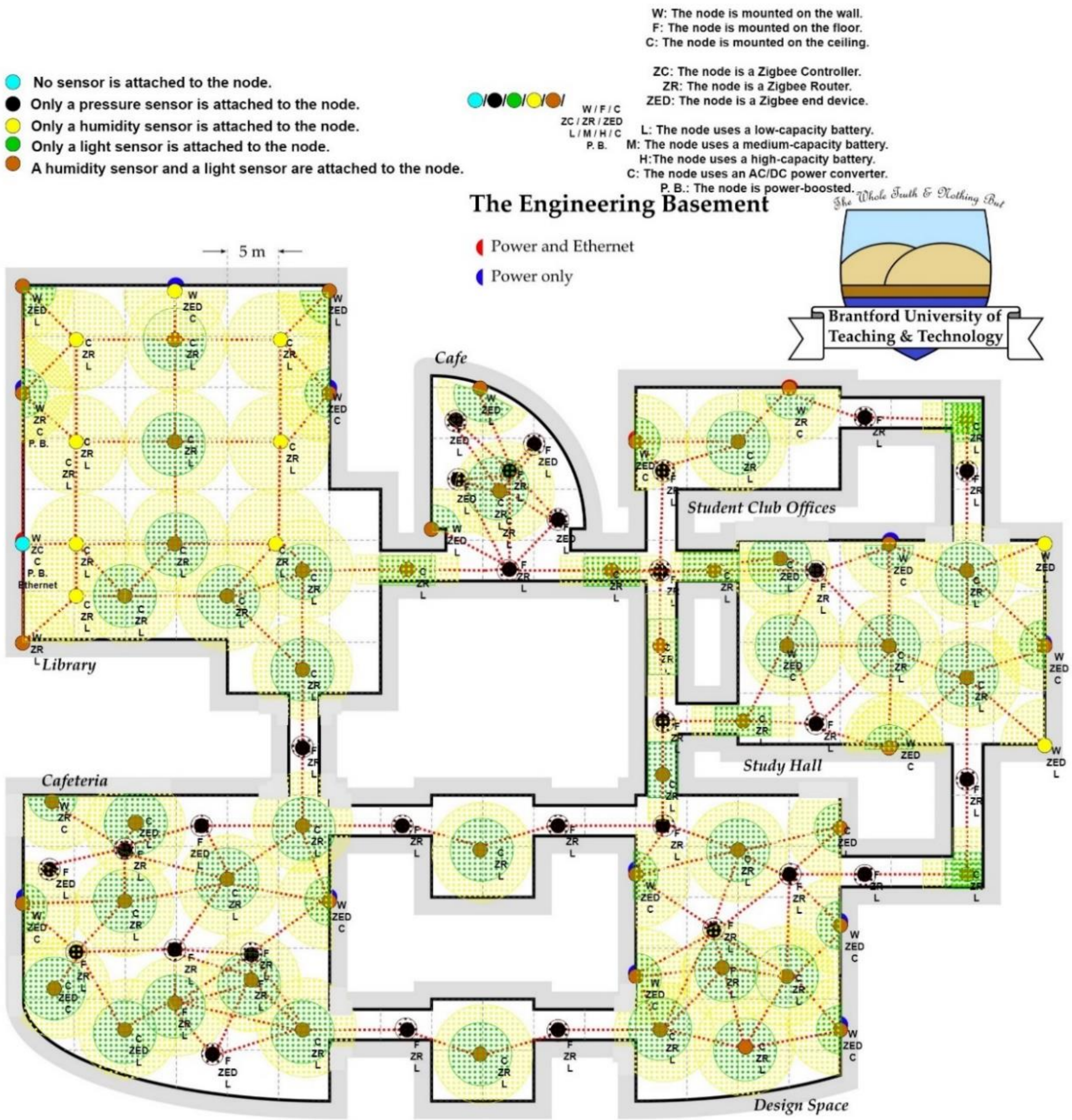

Fig. 3 The deployment of the network

As shown in Figure 3, the yellow dotted circles indicate the sensing radius of humidity sensors, while the green dotted circle marks the sensing radius of light sensors. The black dotted circles signify the sensing radius of pressure sensors.

The node designated for external connections within this network is the Zigbee controller. This node is critical for linking to external networks. Since the Zigbee controller plays a crucial role in managing network traffic and ensuring connectivity outside the network, it is advisable to avoid attaching sensors directly to it.

In the library, I have integrated additional humidity sensors to monitor air moisture levels, ensuring an optimal preservation environment for the books. Furthermore, to achieve cost efficiency and minimize potential sensor damage, I've combined light and humidity sensors onto a single base, which is then installed on the ceiling. While this arrangement might extend the installation and battery replacement times, it offers a balanced trade-off.

I have strategically placed pressure sensors in the hallways, cafeteria, and café. Prioritizing the deployment of additional pressure sensors in hallway floors is critical, as these areas serve as key transit points. Monitoring the flow of people through hallways not only aids in analyzing traffic patterns but also enhances the building's overall space utilization efficiency. This information is valuable for identifying peak occupancy periods and optimizing layout designs. Moreover, in emergencies, data on occupancy and movement patterns can significantly aid first responders more effectively, thereby streamlining evacuation processes. This insight is also beneficial for evacuation planning and strategy formulation. Installing pressure sensors in the café and cafeteria floors further supports the analysis of business metrics and the optimization of staffing schedules.

6.

Sensor data collection from humidity and light sensors is scheduled at regular intervals of one week. However, for pressure sensors, the data collection period is set at three days or less. This difference in frequency is due to the more intensive nature of traffic data compared to data from light and humidity sensors. The hierarchical structure of the network data flow is shown in Figure 4.

To enhance the precision of the data gathered, I have chosen to separate the pressure sensors from the light sensors. Instead, the light sensors are coupled with humidity sensors and installed on the ceiling. This configuration is intended to optimize the accuracy of the sensor data.

In my design, the light sensor measures ambient brightness, capturing light levels such as 200 lux, indicator of illumination. The humidity sensor records the relative humidity, recording levels like 40% RH. Similarly, the pressure sensor detects forces applied to the floor, with measurements such as 80 Newtons as an example. The WSN is configured to log a timestamp only when readings from any of these sensors exceed predetermined thresholds. This approach significantly reduces power consumption by eliminating the need for continuous data transmission, only sending updates when there's a notable change in environmental conditions.

By recording humidity levels, we can analyze whether the presence of students affects the air moisture content. For instance, an increase in humidity could be observed with more students present, potentially due to respiration or specific activities.

Light sensor data helps in understanding how room occupancy affects ambient light levels. For example, more students might mean more artificial light usage.

Pressure data indicating the force applied to the floor can help estimate foot traffic and the number of students in a given space.

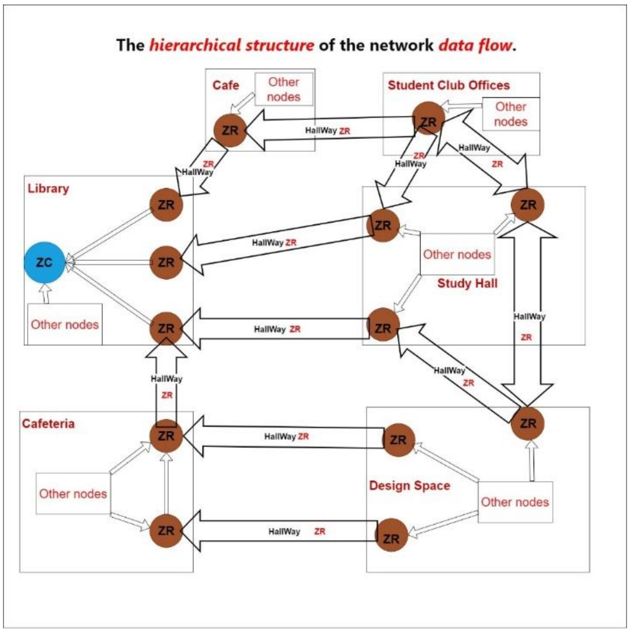

Fig. 4 The deployment of the network

7.

1. In my design, the pressure sensors are placed in the hallways, making it challenging for a target to move from one area to another without triggering a sensor.
2. The vulnerabilities lie at the intersections between the study hall and the student club office, and between the study hall and the design space. If these intersections fail, the right portion of the network will be compromised.
3. The strength of my network lies in its robust connectivity, as I have maximized the number of Zigbee Routers within the budget. Another strength of my network is the

organized network architecture, which is beneficial for maintenance in the future.

8.

Sensors combination	Communications	Power source	Cost
●	ZC, Ethernet Port	Power Converter	$45
●	ZED	Low-Capacity Battery or Power Converter	$24
●	ZR	Low-Capacity Battery or Power Converter	$29
●	ZED	Low-Capacity Battery	$22
●	ZR	Low-Capacity Battery	$27
●	ZED	Low-Capacity Battery or Power Converter	$22
●	ZR	Low-Capacity Battery or Power Converter	$27

Cost for each portion of the network:

Library: $560;

Cafeteria: $514;

Café: $194;

Student Club Offices: $109;

Study Hall: $344;

Design Space: $274;

Hallways: $585;

Total Cost: $2580