Q 1. You are tasked with the selection of sensors for smart beehive monitoring. What will be the parameters of your selection criteria? (12 Marks)

Ans: I will use the following parameters for the selection of the sensors

1. **Bee health relevance**
    a. Temperature/Humidity Sensor
        i. Accurate measurements with relevant range
    b. Weight Sensor
        i. Precise tracking for honey production and bee population.
    c. Audio Sensors
        i. Sensitive to detect abnormal hive sounds
2. **Power Consumption / Efficiency**
    a. Remote sites
        i. Since the beehives have to be deployed in remote sites, the power consumption of the system should be optimized and really efficient
    b. Solar powered Data transmission
        i. along with backup batter for rainy days and other unfavorable weather conditions
3. **Communication / Data Transmission**
    a. LoRa or NB-IoT for long-range data transmissions as the remote sites do not have WiFi or other options
    b. Reliable, long-range communication.
4. **Weather Resistance:** Durable against outdoor conditions.
5. **Cost-effectiveness:** Affordable for scale.
6. **Ease of Use/Maintenance**: User-friendly installation and maintenance of the system

Q2. How is machine learning deployed by Dr Omar in the project of "Internet of Beehives"? (6 Marks)

Ans: Dr. Omar tackled the cost challenge of weighing machines by using machine learning to predict beehive weight. He compiled data from hive sensors and weather records over 2170 days across three sites

1. Site-A: Capel
2. Site-B: UWA Crawley
3. Site-C: Jurien Bay

in Western Australia. This data, with 144 daily samples at 10-minute intervals, was used to train a model. By extracting essential features from hive sensors and environment, parallel encoders estimated daily hive weight. With an average error of only 0.55% and 83% of days having errors below 25 grams, this approach offers accurate weight prediction without the need for costly weighing machines.

Q 3. You are tasked with design of communication sub-part of a project on Beehive monitoring.

(a) List the challenges you should consider while designing it. (8 Marks)

Ans: The following might be the challenges that I might face while designing it.

- **Transmission Range and Coverage**: Ensuring communication modules have sufficient range to cover remote beehive locations and maintain connectivity in diverse environments.

- **Interference:** Interference from other beehives other devices deployed in the same location as well as radio frequencies in the location.

- **Power Efficiency**: Designing transmission systems that minimize energy consumption to prolong battery life and ensure uninterrupted monitoring can be one of the challenges.

- **Data Reliability:** Devising mechanisms to handle data transmission failures and ensure reliable delivery of critical hive information.

- **Harsh Environments**: Addressing the impact of adverse weather conditions, such as rain, extreme temperatures, and humidity, on equipment's performance and durability.

(b) What are your proposed solutions to these challenges? (6 Marks)

Ans: The following solutions can be proposed to solve those challenges.

- **Transmission Range and Coverage Issue:**

  Solution: Use communication technologies with longer ranges, such as LoRa (Long Range) or NB-Iot. Employ strategically placed communication nodes to extend coverage such as mesh nodes or star nodes.

- **Interference Issue**:

  Solution: Implement frequency hopping techniques to avoid interference. Choose communication frequencies that are less crowded and deploy communication modules at optimal distances to minimize overlap.

- **Power Efficiency Issue:**

Solution: Employ low-power communication protocols like Zigbee or Bluetooth Low Energy (BLE). Implement duty cycling techniques to allow devices to sleep and wake up at intervals, conserving energy.

- **Data Reliability Issue:**

Solution: Implement error-checking mechanisms and retransmission protocols to ensure data integrity. Use acknowledgment and confirmation messages for reliable data delivery.

- **Harsh Environments Issue:**

Solution: Encase communication modules in weather-resistant housings or use coatings to protect against moisture. Use components that can withstand temperature extremes.

(c) Your boss suggests real time monitoring of the beehives. Give your reasoning in favour or against the suggestion. (6 Marks)

Ans: I would be going against the suggestion because of the following reasons:

- **Data Volume, Relevance and Processing Overhead:**

Real-time monitoring would generate a continuous stream of data, much of which might not be immediately relevant or actionable. Bees exhibit specific active periods, and monitoring them constantly could result in a significant amount of irrelevant data. At the same time, continuous real-time data collection results in large data volumes that need to be processed and analyzed. This places additional demands on the data storage, processing, and analysis systems.

- **Intermittent Bee Activity:**

Bees are most active during specific times of the day, usually during daylight hours when they forage for nectar. Monitoring them in real-time outside of these periods could lead to collecting data that doesn't accurately reflect hive behavior.

- **Power Consumption:**

Enabling real-time monitoring would require communication modules to be constantly active, consuming significant power. This could lead to frequent battery replacements or the need for a continuous power source, which might not be practical in remote locations.

- **Cost and Commercial Viability:**

The hardware, software, and infrastructure required for real-time monitoring could drive up costs considerably. This might make the system less appealing to beekeepers, especially those with smaller operations, and hinder widespread adoption.

(d) There are 100 beehives in the remote Jarrah forest with 20 beehives having the communication transceivers. Design the communication mechanism, pointing out how you are handling the challenges listed in part (a). (12 Marks)

Ans: To address the challenges of the remote Jarrah forest environment and the specific scenario of having 100 beehives with 20 beehives having communication transceivers, a practical communication mechanism can be designed as follows:

- **Mesh Network Topology:** Establish a mesh network topology where around 20 beehives with communication transceivers act as nodes, and the other 80 beehives relay data through nearby nodes. Nodes with transceivers can act as routers, relaying data between distant nodes and the central hub.
- **Transmission Range and Coverage:** Use long-range communication protocols like LoRa or NB-Iot to ensure sufficient coverage across the forest. Place transceivers strategically to cover the maximum number of non-transmitting hives.
- **Interference:** Implement frequency hopping in the communication protocol to mitigate interference issues. Set clear communication channels and adapt dynamically to avoid congestion.
- **Power Efficiency:** Utilize low-power transceivers with sleep modes to conserve energy when not actively transmitting. Implement duty cycling to ensure transceivers wake up periodically to maintain network connectivity.
- **Data Reliability:** Include error-checking mechanisms and acknowledgment protocols in the communication protocol to ensure reliable data transmission. Implement data buffering and retransmission for failed data packets.
- **Harsh Environments:** Encase transceivers in weather-resistant housings and provide additional protection against extreme conditions. Use rugged components and coatings to enhance durability.