Green University of Bangladesh

Department of Computer Science and Engineering (CSE)
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Wireless Sensor Network for Environmental Monitoring

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[For teachers use only: Don't write anything inside this box]

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Chapter 1

Introduction

1.1 Overview

Wireless Sensor Networks (WSNs) consist of spatially distributed autonomous sensors that collect and transmit data to monitor physical or environmental conditions such as temperature, humidity, air quality, soil moisture, and more. These sensors communicate wirelessly, usually with a central base station or gateway, which processes the data and sends it to the cloud or monitoring systems. In this project, we design and simulate a basic WSN for real-time environmental monitoring, focusing on efficient data communication, network reliability, and energy-aware design.

1.2 Motivation

Climate change, pollution, and urbanization have led to increasing demand for real-time environmental monitoring systems. Traditional monitoring methods are labor-intensive and cannot provide real-time or granular data. WSNs offer a scalable, cost-effective, and automated solution to gather environmental data over large or inaccessible areas. Wireless Sensor Networks can be deployed in:

- Forests for wildfire detection
- Urban areas for air pollution tracking
- Farms for precision agriculture
- Water bodies for contamination monitoring

This project motivates the development of such a system that enables continuous and autonomous monitoring with minimal human intervention.

1.3 Problem Definition

1.3.1 Problem Statement

Current environmental monitoring systems often suffer from:

- Limited spatial coverage due to wired sensors
- Delayed or manual data collection
- High power consumption
- Lack of real-time alerts

There is a need to design an **efficient and low-power wireless sensor network** that:

- Can cover a large area
- Transmits data wirelessly in real-time
- Handles noisy or missing data
- Optimizes energy use for longer sensor lifespan

1.3.2 Complex Engineering Problem

Designing an effective WSN for environmental monitoring involves multiple engineering challenges:

- **Sensor Node Placement:** Ensuring optimal coverage and connectivity
- **Power Management:** Maximizing battery life using energy-efficient protocols
- **Data Transmission:** Dealing with interference, congestion, and data loss
- **Scalability:** Handling a large number of nodes without performance degradation
- **Environmental Factors:** Designing for harsh weather, obstructions, and mobility
- **Security:** Ensuring data integrity and privacy in wireless communication

This complexity necessitates interdisciplinary solutions combining networking, embedded systems, energy-aware design, and data analytics.

Table 1.1: Summary of the attributes touched by the mentioned projects

Name of the P Attributess	**Explain how to address**
P1: Depth of knowledge required	Requires understanding of wireless communication protocols, sensor technologies, embedded systems (e.g., Arduino/ESP32), data aggregation, and power optimization strategies.
P2: Range of conflicting requirements	Balancing energy consumption with communication reliability and data accuracy; ensuring real-time transmission while maintaining low power usage.
P3: Depth of analysis required	Network design needs simulation and performance evaluation (e.g., latency, throughput, packet loss); placement strategies and routing protocols must be optimized based on environmental factors.
P4: Familiarity of issues	Environmental conditions like interference, weather, and terrain introduce challenges that require knowledge of RF propagation and robust design practices.
P5: Extent of applicable codes	Must comply with wireless transmission regulations (e.g., ISM band usage), environmental standards (like pollution monitoring norms), and possibly cybersecurity guidelines for data transmission.
P6: Extent of stakeholder involvement and conflicting requirements	Includes environmental agencies, local authorities, and the public; conflicting interests may include budget constraints, data privacy, and deployment logistics.
P7: Interdependence	System success depends on coordination between hardware (sensors), communication protocols, power systems, and cloud platforms for data storage and visualization.

1.4 Design Goals/Objectives

Reliable Data Communication: Ensure accurate and timely data transmission between nodes and base station.

Low Power Consumption: Implement sleep modes, duty cycling, and efficient routing protocols.

Scalability: Design a modular system that can expand to cover larger areas.

Fault Tolerance: Ensure the system continues to operate in case of node or link failure.

Real-time Monitoring: Enable live data visualization and alert mechanisms.

Cost-effectiveness: Use affordable hardware like Arduino/ESP32 with sensors like DHT11, MQ135, etc.

1.5 Application

- **Air Quality Monitoring:** Detect pollutants (CO2, NOx, PM2.5) in urban environments.
- **Agriculture:** Monitor soil moisture, temperature, and humidity for smart irrigation.
- **Disaster Management:** Early detection of forest fires or landslides.
- **Water Quality Monitoring:** Analyze parameters like pH, turbidity, and temperature.
- **Industrial Monitoring:** Ensure safe air quality in factories and workplaces.

[1] also.

Chapter 2

Design/Development/Implementation of the Project

2.1 Introduction

Start the section with a general discussion of the project [2] [3] [4].

2.2 Project Details

In this section, you will elaborate on all the details of your project, using subsections if necessary.

2.2.1 Subsection_name

Figure 2.1: Figure name

You can fix the height, width, position, etc., of the figure accordingly.

2.3 Implementation

All the implementation details of your project should be included in this section, along with many subsections.

2.3.1 Subsection_name

This is just a sample subsection. Subsections should be written in detail. Subsections may include the following, in addition to others from your own project.

The workflow

Tools and libraries

Implementation details (with screenshots and programming codes)

Each subsection may also include subsubsections.

2.4 Algorithms

The algorithms and the programming codes in detail should be included .
Pseudo-codes are also encouraged very much to be included in this chapter for your project.

- Bullet points can also be included anywhere in this project report.

Algorithm 1: Sample Algorithm

Input: Your Input
Output: Your output
Data: Testing set x

```
1  ∑_{i=1}^{∞} := 0                                   // this is a comment
   /* Now this is an if...else conditional loop                    */
2  if Condition 1 then
3      Do something                              // this is another comment
4      if sub-Condition then
5          Do a lot
6  else if Condition 2 then
7      Do Otherwise
       /* Now this is a for loop                                   */
8      for sequence do
9          loop instructions
10 else
11     Do the rest
   /* Now this is a While loop                                     */
12 while Condition do
13     Do something
```

Chapter 3

Performance Evaluation

3.1 Simulation Environment/ Simulation Procedure

Discuss the experimental setup and environment installation needed for the simulation of your outcomes.

3.1.1 Subsection

3.1.2 Subsection

3.2 Results Analysis/Testing

Discussion about your various results should be included in this chapter in detail.

3.2.1 Result_portion_1

The results of any specific part of your project can be included using subsections.

3.2.2 Result_portion_2

Each result must include screenshots from your project. In addition to screenshots, graphs should be added accordingly to your project.

3.2.3 Result_portion_3

Each result must have a single paragraph describing your result screenshots or graphs or others. This is a simple discussion of that particular portion/part of your result.

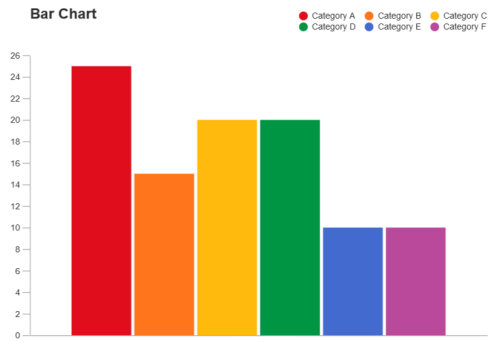

Figure 3.1: A graphical result of your project

3.3 Results Overall Discussion

A general discussion about how your result has arrived should be included in this chapter. Where the problems detected from your results should be included as well.

3.3.1 Complex Engineering Problem Discussion

[OPTIONAL] In this subsection, if you want, you can discuss in details the attributes that have been touched by your project problem in details. This has already been mentioned in the Table 1.1.

Chapter 4

Conclusion

4.1 Discussion

Discuss the contents of this chapter and summarized the description of the work and the results and observation. Generally, it should be in one paragraph.

4.2 Limitations

Discuss the limitations of the project. Limitations must be discussed, with the help of some critical analysis.

4.3 Scope of Future Work

Discuss the future work of the project, that is your plans for more work and extension of your project.

References

[1] Omid C Farokhzad and Robert Langer. Impact of nanotechnology on drug delivery. *ACS nano*, 3(1):16–20, 2009.

[2] Uthayasankar Sivarajah, Muhammad Mustafa Kamal, Zahir Irani, and Vishanth Weerakkody. Critical analysis of big data challenges and analytical methods. *Journal of Business Research*, 70:263–286, 2017.

[3] Douglas Laney. 3d data management: controlling data volume, velocity and variety. gartner, 2001.

[4] MS Windows NT kernel description. http://web.archive.org/web/20080207010024/http://www.808multimedia.com/winnt/kernel.htm. Accessed Date: 2010-09-30.