

# Opposition report for degree project

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ET2606: MASTER'S THESIS IN TELECOMMUNICATION SYSTEMS

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Thesis	Title	Pervasive Communication: Modular Wireless Sensor and Actuator Network System Design
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## 1 Introduction

This thesis explores the design and implementation of Modular Wireless Sensor and Actuator Networks (m-WSAN), an advanced evolution of traditional Wireless Sensor Networks (WSN). Unlike WSNs, which are made up of numerous nodes with limited capabilities, WSANs consist of fewer but more powerful elements, including sinks and actuators, that can actively modify the environment. These networks are equipped to gather data, process it, and perform specific actions via actuators, making the system more interactive and responsive.

The key challenges in WSANs include hardware and software heterogeneity, intermittent connectivity, scaling difficulties, the complexity of development and deployment, lack of standardized service descriptions, and limitations in memory, processing capacity, and bandwidth. Addressing these challenges is crucial for the effective integration of various WSAN devices, which vary in performance and specifications, to ensure cohesive network functionality.

This thesis proposes a modular approach to WSANs, wherein the network is composed of interchangeable and standardized modules. This modularity facilitates easier development, testing, and maintenance of the Network system components. The research presents criteria for classifying WSAN devices into different groups and outlines the integration process for these groups. Additionally, it introduces a m-WSAN service model to provide user services within the network. The thesis concludes with the successful design and implementation of a WSAN network where any device irrespective of its specifications availability and range of accessibility can be integrated. The results demonstrate the viability of creating a modular WSAN network with interchangeable device modules adaptable for various operations. Furthermore, this study lays the groundwork for a distributed WSAN service model, leveraging blockchain technology to facilitate remote, subscription-based access to WSAN services.

There are a total of 8 chapters in this thesis, which include introduction, background, a brief explanation of Wireless Sensor Network technologies, and implementation of modular wireless sensor network. The first chapter is about the introduction of the thesis, where it included motivation for the thesis, objectives, research questions, methodology, and the chapter 2 is all about the background of the thesis where it briefly explained about wireless sensor networks,

wireless sensor networks and actuators, and modular wireless sensor networks and actuators. Chapter 3 explains related research work of various authors and their study on wireless sensor networks, chapters 4 and 5 give details about the design of modular wireless sensor networks and implementation of wireless sensor and actuator networks where it included methods for the design and experimental setup with 2 experiments performed, and chapter 6 is results for experiments performed, followed by discussion, conclusion, and future work.

## **2 Critical review**

### **Abstract:**

In this chapter, the author provided a brief overview of the thesis, discussing the outcomes of the results and presenting a clear perspective on the future scope of the research. However, the chapter falls short in providing individual outcomes for each result, and it would benefit from the inclusion of an explanation regarding conclusion. And keywords ended with a “,” instead of “.” Which should be corrected.

### **Introduction:**

The author has presented a brief introduction to wireless sensor and actuator networks. The objectives and research questions are clearly mentioned, accompanied by justifications for each research question, providing a comprehensive overview of the thesis. The data collection selection process is commendable and appears to be unique. However, it could have more clarity by specifying the number of results obtained using each search string for data collection. Additionally, providing reasons for selecting specific papers from the large set of results would have added depth to the discussion.

### **Background:**

The author provided clear background for the wireless sensor networks. This chapter contains real time example say WhatsApp to explain about the pervasive communication which is good and informative. In section 2.1, there is an explanation in points referring to reference paper 6 where all the points started with small letters and ended with “,” this could be corrected. There are two examples mentioned in this section which can be reduced one as both examples explains the same. There are few grammatical mistakes in this chapter which should be corrected.

### **Related Work:**

The author clearly explained about research work done by the various researchers on WSN and WSAN and it had a good explanation for each mentioned research work. There is a conclusion for this chapter which is impressive. The only mistake noticed in this chapter is missing header in one of the pages.

### **Modular WSAN Network Design:**

This chapter contains the design of a modular WSAN Network and the design method is clear and how the new devices are added are clearly mentioned in the making of design. The design method used is deductive processing approach and it not clearly mentioned why only deductive processing approach is considered. However, the design method is clear and how the new devices are added are clearly mentioned in the making of design. The potential threats and validity on AI, ML, and Blockchain technologies are not mentioned in this chapter. This section also adds about the ease of Access criteria for code generation and significance for compatibility is defined very perfectly and explains importance of criteria and significance of EoA in a device.

Explanation of code would be easy to understand if there is any table format. From the fig 4.10 Flowchart showing communication Strategy for handling service is a good explanation. The communication process of the devices including connection to the devices are clearly explained the topics that mentioned in this section to understand each step in the process of connection easily. Enough data is covered under this section.

#### **Implementation of a WSAN network:**

The author explained various tools used for the experimentation and had setup 2 experiments using 4 robots for this thesis. The table 5.1 which is tabulated could have more detailed description about the 2 experiments conducted. The author had a clear explanation of 4 robots used. But lacks in details that why only those 4 particular robots were chosen. The author had given clear view of experimental setup with detailed explanation in Task scenario. An elaborated explanation on experiment 1 would be more informative.

#### **Results and Analysis:**

The results section was well written. The table 6.1 clearly explains the contribution of research questions to the results obtained. The results section includes 3 stages with 4 tasks for each robot selected for the experiments. It had a clear view for each device EoA with well written tables. But there is lack of defining the numerical in tables and it needs to be mentioned how the values are taken. Enough trials were conducted in the experiment and it defined all the instructions which are clearly executed. Total time of each trial is not specified and how much time it is taken to for trials also lacks information this could be mentioned. If trial is added check any delay, this lacks in the results as specified in the document.

#### **Discussion and Analysis:**

This chapter provides wide range of information, including device evaluations, integration methods, and the feasibility of m-WSAN network design. The graphical representation of EoA grades and integration methods are well tabulated. This chapter lacks in mentioning possible security threats and limitations to the design. there was also lack in explaining the motivation of design. The discussion part of each experiment is well explained with certain challenges. the

#### **Conclusions and Future Work:**

The conclusion part was explained in a brief paragraph of about implementation of modular wireless sensor networks. The scope for the future work in block chain and large-scale m-WSAN networks were mentioned. Conclusion and future work can be separated into 2 sub sections instead of combining both.

### **3 Required changes**

There are few required changes that needs to be addressed.

- The Research Gap is not mentioned clearly and it can be added to Chapter 1. So that it can make a better introduction for the thesis.
- List of Abbreviations does not contain all that are mentioned in the document.
- The thesis outline is missing in Introduction chapter which should be added and it makes an effective introduction.
- There are too many references which are not utilised. The references which are not used

could have been reduced.

- In Chapter 4, In the proposed network design, how can AI and ML be effective? It can be mentioned for better understanding.
- The implementation environment description is missing. Specifications of tools/environment in which the experiments are performed? Could have been added in Method section.
- In section 6.1, the line is mentioned as integrating three devices, it should be corrected to 4 devices.
- In section 6.2, RESULT 2: Implementation of the m-WSAN network service model, there is a need to correct the sentence related to units of speed.
- Scope of the thesis is recommended to add. Since a concept is being introduced, it will help to understand its application in larger scope.
- There are few grammatical mistakes in the documents which are recommended to address.

## **4 Recommended changes**

There are also some recommended changes that can be considered.

- In Chapter 2 section 2.1 data from paper 6 is mentioned it could be added to related work section.
- The entire section of 2.2.1 can be explained in related work.
- The Results part is too large could have been shortened with appropriate tables.
- There are blank pages in between the chapters which can be removed.