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Sustainable Implementation of a Thread Mesh Wireless Network

by

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Chapter 1

Rationale

1.1 Introduction

Dementia is a progressive neurological disorder that presents significant challenges to patients, caregivers, and healthcare professionals. With the increasing global prevalence of dementia, there is a pressing need for innovative solutions to manage and mitigate its impact. The MOOD-Sense research project, based at the Centre of Applied Research Biobased Economy at Hanze University of Applied Sciences Groningen, addresses this issue by leveraging the potential of IoT devices to detect and predict challenging behavior in dementia patients. By developing an early warning system that combines sensor technology, artificial intelligence, and wireless communication, MOOD-Sense aims to provide real-time feedback for healthcare professionals, improving patient care and safety. Integrating sustainable engineering principles into the MOOD-Sense system offers an opportunity to take the project to the next level, minimizing environmental impact, optimizing resource consumption, and creating a more reliable, efficient solution for addressing the challenges posed by dementia [1].

1.2 Present Situation

The initial plan was to utilize three wireless communication technologies, BLE, ZigBee, and Wi-Fi, for network communication. Despite this intention, active network protocol implementation has yet to occur. Various subprojects related to the MOOD-Sense framework, such as dementia patient behavior registration and environmental context monitoring, have been conducted concurrently. The absence of a central network communication protocol has led to the fragmentation of devices across subprojects, impeding data sharing and integration. The proposal of employing a Thread mesh wireless network has been introduced to tackle this issue, given its mesh structure, affordability, and reliability capabilities. This network protocol would facilitate the connection of BLE, ZigBee, and Wi-Fi in a centralized manner, enabling seamless connectivity, interoperability, and communication among all devices within the MOOD-Sense framework.

1.3 Desired Situation

The desired outcomes of the ongoing research involve the establishment of a Thread mesh wireless network protocol, with the primary objective of facilitating seamless communication among devices within the MOOD-Sense framework. By successfully implementing a Thread mesh network, interoperability, and data sharing among various subprojects will be significantly improved, ultimately contributing to enhanced patient care and safety. Furthermore, integrating sustainability principles in the development and deployment of this network protocol can reduce environmental impact and optimize resource consumption, aligning the project with the goals of responsible and efficient technological advancement. In this desired scenario, the MOOD-Sense project will not only address the challenges posed by dementia through innovative IoT solutions but also demonstrate a commitment to sustainable engineering practices, setting a precedent for future research and development initiatives in the field.

1.4 Research Questions

Main Research Question

How can a Thread mesh wireless network be designed and implemented within the MOOD-Sense project using a sustainable engineering approach?

Sub-Research Questions

1. What are the fundamental principles and best practices of sustainable engineering relevant to designing and implementing a Thread mesh wireless network in the MOOD-Sense project?

2. How can the hardware and software components of the Thread mesh network be selected and optimized to minimize environmental impact and resource consumption while ensuring efficient and reliable communication within the MOOD-Sense framework?

3. How can the implementing low-power strategies in the Thread mesh wireless network protocol contribute to the sustainability and overall effectiveness of the MOOD-Sense project?

4. How can existing end devices and sensors be integrated into the new Thread mesh wireless network protocol without replacement, ensuring compatibility and minimizing environmental impact and resource consumption?

Chapter 2

Research

This section addresses the fundamental principles and best practices of sustainable engineering in designing and implementing a Thread mesh wireless network for the MOOD-Sense project. The research aims to provide a comprehensive understanding of sustainable engineering principles and how they can be applied to various aspects of the network.

2.1 Key Principles and Best Practices of Sustainable Engineering

Creating a sustainable Thread mesh wireless network in the MOOD-Sense project requires consideration of several key principles and best practices of sustainable engineering. These principles can guide the design and implementation process, ensuring that environmental impact, resource consumption, and the overall sustainability of the network are taken into account:

1. **Life Cycle Thinking**: Assess the environmental impact of network components throughout their entire life cycle, from raw material extraction to end-of-life disposal.

2. **Energy Efficiency**: Prioritize energy-efficient hardware components and software strategies, including low-power and energy-efficient communication protocols.

3. **Waste Minimization**: Reduce waste generation during production, deployment, and maintenance by employing modular design principles and recyclable materials.

4. **Durability and Reliability**: Ensure the network's longevity and reliability using high-quality materials, robust design practices, and fault-tolerant communication protocols.

5. **Scalability and Flexibility**: Design the network to be adaptable to the evolving needs of the MOOD-Sense project, reducing the environmental impact associated with creating and disposing of new network components.

By considering these key principles and best practices of sustainable engineering, the design and implementation of a Thread mesh wireless network within the MOOD-Sense project can be conducted to minimize environmental impact, optimize resource consumption, and promote responsible technological development [2].

2.2 Selecting and Optimizing Hardware and Software Components

Selecting and optimizing hardware and software components of the Thread mesh network to minimize environmental impact and resource consumption while ensuring efficient communication within the MOOD-Sense framework involves the following key steps:

1. **Hardware Selection**: Choose low-power hardware components, such as the nRF52840 DK and nRF52840 Dongle, sourced from ethical manufacturers with minimal environmental impact throughout their life cycle [3].

2. **Software Optimization**: Implement energy-saving software strategies and optimize communication protocols to ensure efficient and reliable performance of the hardware components within the MOOD-Sense framework [4].

3. **Modular and Scalable Design**: Develop a design approach that allows for easy replacement or upgrade of components, reducing waste generation and resource consumption during maintenance and system upgrades [5].

4. **Stakeholder Engagement**: Involve relevant stakeholders, such as healthcare professionals, patients, and caregivers, in the decision-making process to address their needs and preferences, contributing to the overall success of the project.

5. **Lifecycle Management**: Employ sustainable engineering practices, such as component standardization and remote management solutions, to minimize resource consumption and environmental impact during production, deployment, and maintenance of the network.

The Thread mesh wireless network can minimize environmental impact and resource consumption while maintaining efficient communication within the MOOD-Sense project by focusing on these five key aspects in the selection and optimization process.

2.3 Implementing Low-Power Strategies

Implementing low-power strategies in the Thread mesh wireless network protocol can contribute to the sustainability and overall effectiveness of the MOOD-Sense project by reducing energy consumption, prolonging battery life, and minimizing the environmental impact associated with energy production and consumption. Some low-power strategies that can be incorporated into the Thread mesh wireless network protocol include:

1. **Power Management Modes**: Implement various power management modes, such as sleep, idle, and active states, that allow devices to conserve energy when not in use or during periods of low activity.

2. **Adaptive Power Management**: Utilize adaptive power management techniques that automatically adjust the power consumption of devices based on their current operational requirements, such as adjusting the transmission power and frequency based on the proximity of neighboring devices.

3. **Efficient Communication Protocols**: Optimize communication protocols to minimize overhead and reduce the time devices spend in high-power transmission and reception modes. This can be achieved by using data compression techniques, efficient routing algorithms, and optimized network topology.

4. **Power-Aware Scheduling**: Implement power-aware scheduling algorithms that prioritize tasks based on their power consumption and time-sensitive nature, ensuring that energy-intensive tasks are executed during periods of optimal energy availability and minimizing the overall energy consumption of the network.

5. **Energy Harvesting**: Explore the possibility of integrating energy harvesting techniques, such as solar or kinetic energy, to supplement the power supply of devices and reduce their reliance on traditional energy sources.

By incorporating these low-power strategies into the Thread mesh wireless network protocol, the MOOD-Sense project can improve its sustainability and overall effectiveness by reducing energy consumption, prolonging the operational lifetime of devices, and minimizing the environmental impact associated with energy production and consumption [6].

2.4 Integrating Existing End Devices and Sensors

Integrating existing end devices and sensors into the new Thread mesh wireless network protocol without replacement can be achieved by ensuring compatibility and minimizing environmental impact and resource consumption. Considering the multiprotocol support offered by the selected nRF devices, the following strategies can be employed to facilitate the integration of existing devices:

1. **Multiprotocol Support**: Leverage the multiprotocol capabilities of the nRF devices, which can run both BLE and Thread antennas concurrently, to connect existing devices that do not have Thread support. This allows for seamless communication between the new Thread mesh network and the existing devices using BLE [7].

2. **Software and Firmware Updates**: Provide software and firmware updates for the existing end devices and sensors to ensure compatibility with the Thread mesh network protocol, enabling them to communicate effectively with the new network infrastructure.

3. **Modular Adapters**: Design and develop modular adapters that can be attached to the existing end devices and sensors, enabling them to connect to the Thread mesh network without requiring extensive hardware modifications or replacements [8].

4. **Interoperability Standards**: Ensure adherence to established interoperability standards and guidelines to facilitate seamless communication and data sharing among various devices within the MOOD-Sense framework, regardless of their communication protocols.

5. **Resource Optimization**: Optimize the integration process to minimize the consumption of additional resources, such as energy and materials, while maintaining the functionality and effectiveness of the existing end devices and sensors within the MOOD-Sense project.

By employing these strategies, existing end devices and sensors can be integrated into the new Thread mesh wireless network protocol without needing replacement, ensuring compatibility and minimizing environmental impact and resource consumption in the MOOD-Sense project.

Chapter 3

Negotiation Plan

This section outlines a negotiation plan for discussing the proposal to implement a sustainable Thread mesh wireless network within the MOOD-Sense project with the company supervisor and other stakeholders. The plan aims to address potential objections, identify mutual needs, and develop a consensus strategy.

3.1 Establishing the Framework

This section introduces the context and objectives of the negotiation and the needs of the involved parties.

Personal Needs

1. Obtain approval and support for the proposal to integrate the sustainable Thread mesh wireless network into the MOOD-Sense project.

2. Gather necessary resources, including funding, equipment, and technical expertise, to implement the proposed solution successfully.

Organizational Needs

1. Ensure the proposed solution aligns with the company's goals and objectives, particularly regarding patient care, safety, and sustainability.

2. Evaluate the proposed solution's feasibility, cost-effectiveness, and potential return on investment.

3.2 Nature of the Interaction

This section provides an overview of the negotiation format, the parties involved, and the potential dynamics of the interaction.

Format

The negotiation will be primarily held between the individual and the company supervisor, focusing on the proposed Thread mesh wireless network. Other stakeholders, such as technical team members, healthcare professionals, and representatives of the end device and sensor manufacturers, may be included in the discussion to provide valuable insights and address specific concerns.

Situational Parameters

1. The negotiation will be conducted formally, preferably in a meeting room, to maintain a professional atmosphere.

2. The duration of the negotiation should be limited to ensure focus and efficiency.

3. If multiple negotiation plans are under consideration, it is essential to emphasize that each proposal should be evaluated independently and based on its merits as long as they align with the project's goals.

Stakeholders

1. **Company Supervisor**: Responsible for overseeing the MOOD-Sense project and approving major decisions, including the proposed Thread mesh wireless network.

2. **Technical Team Members**: Responsible for the development and implementation of the proposed solution.

3. **Healthcare Professionals**: Users of the MOOD-Sense system who can provide valuable input regarding its effectiveness and applicability in a clinical setting.

4. **Representatives of End Device and Sensor Manufacturers**: Provide technical information and support for the integration of existing devices and sensors.

Goals

1. Achieve a mutual understanding of the proposal, its benefits for the MOOD-Sense project, and the company's broader objectives.

2. Address potential objections and concerns raised by stakeholders.

3. Reach a consensus on the implementation of the proposed solution.

Strategy

1. Begin by presenting a clear and concise overview of the proposed solution, highlighting its potential benefits in terms of sustainability, communication efficiency, and patient care.

2. Address potential objections by providing evidence-based counterarguments, demonstrating the feasibility and cost-effectiveness of the proposed solution.

3. Engage in active listening and ask open-ended questions to understand stakeholder concerns better and gather valuable feedback.

4. If applicable, consider intercultural issues by researching cultural norms and expectations and adjusting communication style accordingly.

5. Maintain a collaborative approach throughout the negotiation, emphasizing the shared goals of improving patient care and advancing the MOOD-Sense project.

By following this negotiation plan, the discussion surrounding the implementation of a sustainable Thread mesh wireless network within the MOOD-Sense project can be productive and result in a mutually beneficial outcome.

3.3 Formulating a Strategic Approach

This section aims to outline the components of the negotiation situation, identify target points and resistance points, determine relative power, assess the other party's knowledge, and explore strategies for building rapport. As a master's student intern within the MOOD-Sense project, it is essential to navigate the complexities of the large research initiative and consider the potential challenges associated with various convincing parties of the merits of sustainable wireless network development.

Components of the Negotiation Situation

1. MOOD-Sense is a large research initiative with multiple subprojects running concurrently.

2. Communication and coordination among different projects may be challenging.

3. The intern's position within the project is not inherently powerful, but persuasive arguments can still be made.

Target Points

1. Obtain approval for implementing the sustainable Thread mesh wireless network within the MOOD-Sense project.

2. Acquire necessary resources, including funding, equipment, and technical expertise.

3. Garner support from key stakeholders, including the company supervisor, technical team members, and healthcare professionals.

Resistance Points

1. Difficulty in convincing stakeholders of the value of sustainable wireless network development.

2. Limited resources or competing priorities within the MOOD-Sense project.

3. Hesitation from stakeholders due to the intern's position within the project.

Relative Power

1. As a master's student intern, the relative power is limited compared to the company supervisor and other stakeholders.

2. However, the power of persuasion and the strength of the proposal can make a significant impact.

Other Party's Knowledge

1. Research the backgrounds, interests, and priorities of key stakeholders.

2. Identify potential allies who share similar goals and values.

3. Understand the company's overall goals and objectives, as well as the specific needs and challenges of the MOOD-Sense project.

Building Rapport

1. Engage in active listening and ask open-ended questions to understand stakeholder concerns better and gather valuable feedback.

2. Demonstrate empathy and understanding of the challenges faced by different parties.

3. Showcase personal expertise and commitment to the project, emphasizing the proposal's benefits for the MOOD-Sense project and the company.

4. Establish common ground with stakeholders by highlighting shared goals and values.

5. Maintain a positive and respectful attitude throughout the negotiation process.

BATNA (Best Alternative to a Negotiated Agreement)

1. Continue researching and refining the proposal, seeking external expertise or resources if necessary.

2. Identify alternative solutions that may be more easily integrated within the MOOD-Sense project or have a stronger appeal to stakeholders.

3. Seek opportunities to collaborate with other subprojects to create a more comprehensive and coordinated approach.

By establishing a collaborative framework and building rapport with stakeholders, the negotiation process can be more productive and create a supportive environment for implementing the sustainable Thread mesh wireless network within the MOOD-Sense project.

Chapter 4

Negotiation Execution

The negotiation execution section outlines the questions, arguments, and refutations used during the negotiation process, the parties involved, and insights gained. This structure ensures a well-prepared and organized approach to the negotiation, increasing the likelihood of achieving the desired outcome.

4.1 Prepared Questions, Arguments, and Refutations

1. **Question**: How do the current wireless communication technologies in the MOOD-Sense project align with the company's sustainability goals?
   Argument: Implementing a Thread mesh wireless network using a sustainable engineering approach can better align the project with the company's sustainability objectives.
   Refutation: Should stakeholders express concerns regarding the cost or complexity of the proposed solution, emphasize the long-term benefits of a sustainable approach, including reduced energy consumption, increased efficiency, and potential for scalability.

2. **Question**: What challenges do you foresee in integrating existing devices and sensors into the new Thread mesh wireless network protocol?
   Argument: The multiprotocol support offered by the nRF devices, such as running BLE and Thread antennas concurrently, enables seamless integration without the need for device replacement.
   Refutation: Address concerns about compatibility or integration issues by providing detailed technical information and potential solutions for overcoming these challenges.

3. **Question**: How does the proposed Thread mesh wireless network contribute to the overall effectiveness and efficiency of the MOOD-Sense project?
   Argument: The Thread mesh wireless network offers enhanced connectivity, interoperability, and communication among devices, leading to improved patient care

and safety.
Refutation: If stakeholders raise doubts about the benefits of the proposed network, provide data and examples from other successful implementations to demonstrate its effectiveness and positive impact.

4. **Question**: How does the implementation of low-power strategies contribute to the sustainability of the MOOD-Sense project?
Argument: Utilizing low-power strategies in the Thread mesh wireless network can significantly reduce energy consumption, making the project more environmentally friendly and cost-effective.
Refutation: If the supervisor is concerned about the performance trade-offs, emphasize the balance between energy efficiency and reliable communication, as well as the potential for energy-saving techniques such as sleep modes and adaptive power management.

5. **Question**: How can device availability and compatibility with the proposed Thread mesh wireless network be ensured?
Argument: The chosen hardware components, such as nRF52840 DK, nRF52840 Dongle, and Raspberry Pi 4 B, are widely available and compatible with the Thread mesh network protocol, facilitating seamless integration.
Refutation: Should device availability be a concern, discuss alternative options or backup plans to source the necessary components, ensuring minimal disruption to the project timeline.

6. **Question**: How will the Thread mesh wireless network perform in various locations and environments within the MOOD-Sense project?
Argument: The Thread mesh network is designed to provide reliable and robust communication in a range of environments, ensuring consistent performance across different locations and settings.
Refutation: In case of concerns about network performance in specific environments, suggest conducting testing and optimization to guarantee reliable communication under all conditions.

4.2 Involved Parties

The negotiation involved only the Company Supervisor. As the sole negotiation counterpart during the execution, their support was essential for successfully implementing the proposed solution.

Insights

1. Understanding the company supervisor's priorities, goals, and concerns helps to tailor arguments and responses during the negotiation better.

2. Identifying potential areas of collaboration and synergy between the proposed solution and other subprojects within the MOOD-Sense initiative, leveraging these connections to build support for the proposal.

3. Recognizing the importance of communication and relationship-building in achieving a successful negotiation outcome, establishing rapport, and fostering a collaborative atmosphere.

4. Despite the initial plan to involve multiple stakeholders, the negotiation ultimately took place solely between the intern and the company supervisor. This allowed for a more focused and personalized discussion, which contributed to the intern's ability to sway the supervisor's opinion.

5. During the negotiation execution process, specific arguments regarding the long-term benefits of the proposal, the alignment with sustainability goals, and the technical feasibility of the plan resonated with the company supervisor. By demonstrating a deep understanding of the project's needs and offering well-reasoned arguments, the intern effectively addressed potential concerns and ultimately gained the supervisor's support for the proposed solution.

Chapter 5

Negotiation Reflection

This section reflects on the negotiation process that took place between the student and the company supervisor, discussing the lessons learned, the effectiveness of the negotiation strategies employed, and potential improvements for future negotiations.

5.1 Key Lessons Learned

One of the most important lessons learned from this negotiation was the value of thorough preparation. Researching the subject matter, understanding the needs and concerns of the involved parties, and anticipating potential counterarguments provided a strong foundation for a successful negotiation. Active listening and clear, concise communication also significantly fostered constructive dialogue, allowing both parties to present their perspectives and reach a mutual understanding effectively.

The ability to adapt to unexpected changes, such as the shift from a multi-stakeholder negotiation to a one-on-one discussion, was essential in maintaining focus on the negotiation objectives and adjusting strategies accordingly. Additionally, establishing rapport and trust with the company supervisor facilitated a more open and collaborative atmosphere, ultimately contributing to a more favorable negotiation outcome.

5.2 Areas for Improvement

In future negotiations, it may be beneficial to involve a more diverse group of stakeholders, ensuring that a broader range of perspectives and interests are taken into account when discussing the proposal. Allocating sufficient time for the negotiation process, including adequate time for research, preparation, and the negotiation itself, can also enhance the overall effectiveness of the negotiation and lead to more informed decision-making.

Developing stronger conflict resolution skills can help address disagreements and potential roadblocks more effectively, creating a smoother path toward reaching a mutually beneficial agreement.

5.3 Conclusion

The negotiation between the student and the company supervisor provided valuable insights into the importance of preparation, communication, adaptability, and relationship-building in achieving a successful negotiation outcome. By reflecting on these experiences and identifying areas for improvement, future negotiations can be approached with increased confidence and skill, ultimately leading to more effective and sustainable project outcomes.

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