Internet of Things – The Business Perspective

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Introduction

We share several common points in terms of our background and experience. While most of us are new to the field of IoT and have no prior experience with devices like Arduino or ESP-32, Ilja brings valuable skills in IoT development, having worked on an experimental IoT project. Our programming knowledge is varied, but we all possess at least some foundational skills. Thomas and Kimmo have prior exposure to C programming, while Jibika and Kimmo have a basic understanding of JavaScript. Despite our diverse educational journeys, we are all enthusiastic about learning and exploring the world of IoT. Additionally, Eetu and Thomas have experience in creative and prototyping-related fields, with Eetu having studied 3D design and 3D printing, and Thomas taking a course on innovation and prototyping, which could bring a valuable dimension to our group's projects. This shared eagerness to learn, combined with Ilja's IoT experience and our complementary skill sets, positions us well for collaborative growth in the field of IoT.

Ideas

What were your first ideas on the list, and which one you picked for a reason

As a group, once we had chosen TEAM AIR as our topic, a significant part of the ideation process revolved around figuring out how to design and build the weathervane and incorporate the necessary sensors. This was one of the most exciting and challenging aspects of the project.

We brainstormed various ways to construct the weathervane to ensure it was functional, durable, and accurate. After considering different materials and construction methods, we decided to 3D-print most of the parts. This approach allowed us to customize the design to fit the sensors, optimize the structure for wind detection, and ensure cost-effectiveness.

The 3D printing process opened up opportunities for creativity and problem-solving. We iteratively adjusted the design to accommodate the Hall effect sensors and the rotating wind vane mechanism. Finding a way to precisely position the sensors for accurate wind direction readings became a key focus during this phase. By prototyping and refining our ideas through 3D-printed models, we could bring the concept to life and address the technical challenges of integrating the sensors into the design.

This hands-on approach helped us turn the abstract idea into a tangible, functional prototype, setting a strong foundation for the rest of the project.

What did you need to learn

Describe the initial scope of the project and list the learning objectives

As we began planning, we realized there was a lot we needed to learn. For some of us, this was our first experience with ESP32, so we had to familiarize ourselves with how it works and how to program it.

Initial Scope of the Project

The project aimed to develop a wind speed fan, an IoT-enabled device to give real-time wind speed and direction for localized data monitoring which can benefit our target audience. Our target audience includes farmers who depend on timely weather conditions to make for their daily operations. By identifying the problem of general and delayed weather data, the project intended to provide an easy and long-lasting solution powered by ESP32 microcontrollers and sensors.

The initial scope of the project included:

- Learning and implementing IoT basics: Understanding sensors, microcontrollers, and wireless data transmission.
- Device design and development: Building a prototype with direction sensors and real-time wind speed.
- Data collection and visualization: Sending real-time wind data and showing it on a user-friendly platform.
- Identifying and addressing specific user needs.
- Optimizing the device to meet practical requirements, such as durability and accuracy for outdoor use.

Learning Objectives

The project was a great opportunity to explore the field and acquire new skills for most of us without having much prior learning and experience in the IoT field. The key learning objectives included in our project are:

- Gaining knowledge on microcontrollers like ESP32, programming ESP32 using Arduino, configuring GPIO pins for sensor integration.
- Wireless communication via Wi-Fi.
- Learning how hall effect sensors detect magnetic fields
- Using a wind vane and magnetic sensors to determine wind direction and anemometer to calculate wind speed.
- Measuring sensors to ensure collected data is accurate or not.
- Using programming code to process sensor outputs.
- Enhancing real-time data transmission.
- Designing the device structure and ensuring connection are secured.
- Learning wiring connection for ESP32 and its sensors.
- Solving challenges which can arise during sensor problems, error readings, and troubleshooting them.
- Sending data to platforms home assistant using MQTT.
- Working as a team to brainstorm solutions and iterate designs time and again.
- Learning through experimenting and overcoming project challenges over a period of time.

By achieving these learning objectives, the team will gain knowledge and skills in IoT development project, programming, and problem-solving, exploring better ways for future innovations projects.) Jibika

1. ESP32 Basics:
   - How to program it using Arduino IDE or other platforms.
   - Setting up GPIO pins for sensor integration.
2. Hall Effect Sensors:
   - Understanding their operation (detecting magnetic fields).
   - Translating the sensor's output into wind speed data.
3. Wind Direction Mechanism:
   - How to use a rotating wind vane and measure its orientation (using a potentiometer or magnetic sensor).
4. Communication Protocols:
   - Sending data wirelessly (e.g., via Wi-Fi or Bluetooth).
5. Data Visualization:
   - Displaying the wind data in real-time, either on an LCD or an Arduino monitor.

The building phase

Tell us about the actual building of the device and your learning by doing

We began the project by learning the basics of Arduino programming and familiarizing ourselves with its capabilities. This step was crucial, as it gave us a better understanding of how microcontrollers work and how to write the code necessary for our project. We searched guidance from Haaga-Helia's 3D-lab demos.

Once we had learned a little programming Arduino, we moved on to wiring the components. We started with the basics, how to properly connect Arduino and ESP32 the right way. This involved learning about pin configurations and the importance of clean connections to avoid errors. We learned how to connect LCD-screen to Arduino, how to connect Hall sensors to ESP32 and how to improve the code and programming through the project. Ilja was the main architect in programming. Everyone was actively involved, and we were constantly brainstorming and innovating for better solutions.

The building phase of our weather station showcased both our successes and the challenges we faced. Starting with a functional codebase, we wired the ESP32 and Arduino components and assembled the anemometer for wind speed measurement. This aspect of the project worked smoothly and boosted our confidence. We were able to see actual wind speed through the serial monitor and the LCD-screen.

Next, we focused on integrating the Hall sensors to ESP32 for measuring wind direction. The Hall sensors were used to detect rotational movement with a magnet, and we had to position the sensors carefully for consistent readings. This was the biggest challenge of all. We brainstormed many different variations for the device, and we learned how to see the wind directions. Once we had connected the ESP32 to hall sensors and anemometer and had the working code, we started innovating how to build a real prototype of the device. We had many variations and faced some obstacles along the way. We 3D-printed couple of options both for the wind vane and the anemometer.

During the calibration phase, we encountered several challenges. The biggest challenge was accurately capturing all wind directions. This required troubleshooting the code and adjusting the sensor placement. This was clearly the hardest part. How can we calibrate the sensors so that we are able to see every wind direction. The main directions: North, South, West and East were quite easy, but the directions in between were a challenge. We could not position the sensors to read all directions accurately with the magnet. Our code was working brilliantly, but the main problem was figuring out how to position the magnet to activate every direction.

Despite trying various setups, we struggled to calibrate the sensors to detect all directions reliably. This incomplete aspect of our prototype highlighted the complexity of designing a fully operational weather station.

Throughout the building process, we learned a lot by doing. Each hurdle taught us something new—whether it was debugging an unstable sensor reading, tweaking the design for better performance, or refining our code. Our biggest accomplishments were writing a working code and the fact that we got the prototype very close to the finish line. We were also able to send data to another team, so that was cool and a huge success.

A significant achievement of our project was successfully sending wind speed data from our ESP32 to *Team COMM's* device. Team COMM specialized in data transmission using a SIM card-equipped ESP32. Team COMM then used their ESP32 to publish data to an MQTT broker.

Even though we were not able to build a fully functional prototype, we are very happy that we achieved a lot. We had all the working components, but the final prototype wasn't complete. We were always trying to improve our solutions and the team effort for everything was great.

Building the Device:

1. **Design Phase:** Sketching the structure for attaching the wind vane and anemometer securely to the ESP32 board.

2. **Wiring:** Connecting the Hall sensors and testing their outputs to confirm readings.

3. **Prototyping:** Writing the first iteration of code to capture and process sensor data.

4. **Integration:** Adding features, how to connect ESP32 to anemometer and wind vane, wireless communication to other teams.

5. **Testing**: Trying to build a working anemometer and wind vane. The code was working for wind speed and wind direction. We tried a lot of different solutions to get accurate readings both from the anemometer and the wind directions.

6. **Calibrating:** We were able to see every direction, but we were not able to calibrate it correctly with the magnet. We used a lot of time with the calibration phase.

• **Learning by Doing:**

- Debugging hardware issues, like unstable sensor readings.
- Iteratively improving code efficiency and calibration.
- Collaborating as a team to troubleshoot problems.

This is a raw estimate and can vary depending on where you source the components.

Cost of Goods (COGS)

Components and Estimated Costs

1.**ESP32 (x2)**

•Approx. €8 each → **€16**

2.**MH-Sensors (x2)**

•Approx. €3 each → **€6**

3.**Hall Effect Sensor (x4)**

•Approx. €2 each → **€8**

4.**Miscellaneous Components**

•Wires, breadboards, resistors, capacitors, and other small components → **€5**

5.**Power Supply (e.g., USB cables, adapters)**

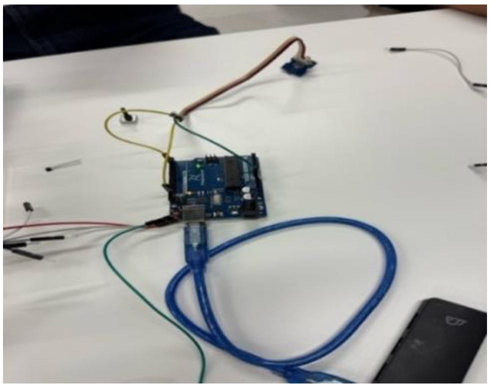
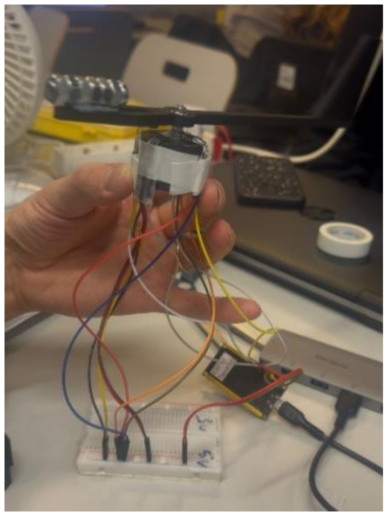
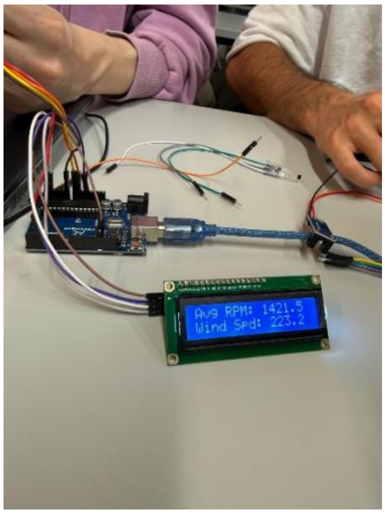
•Approx. €4 each → **€8**

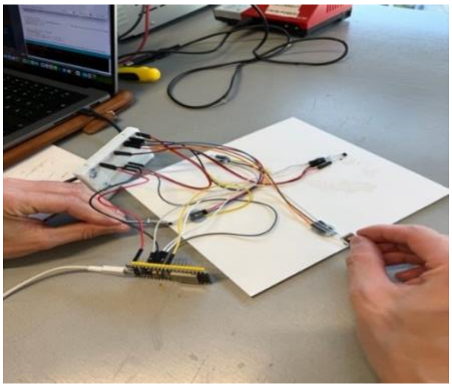
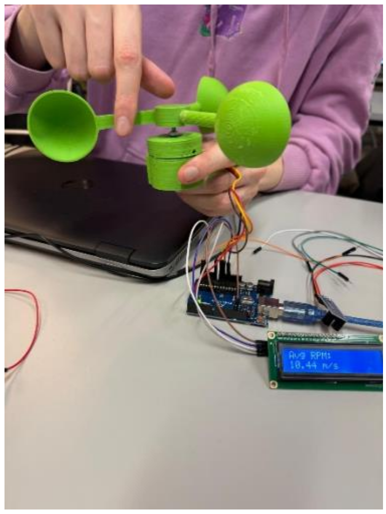
6.**Enclosure or Mounting Hardware**

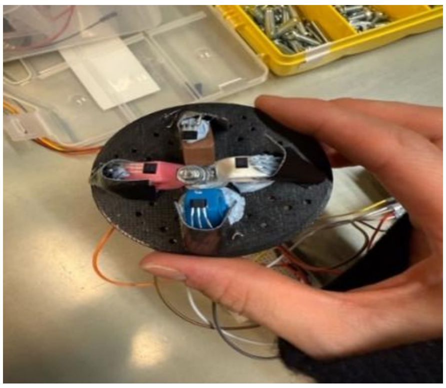
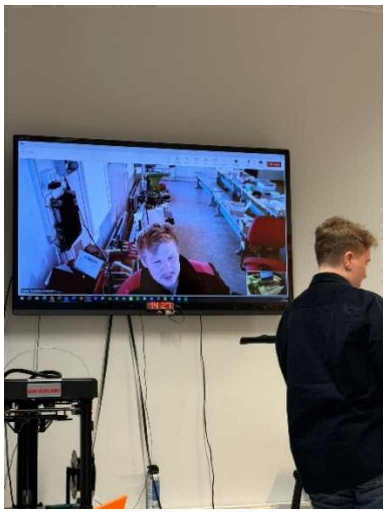
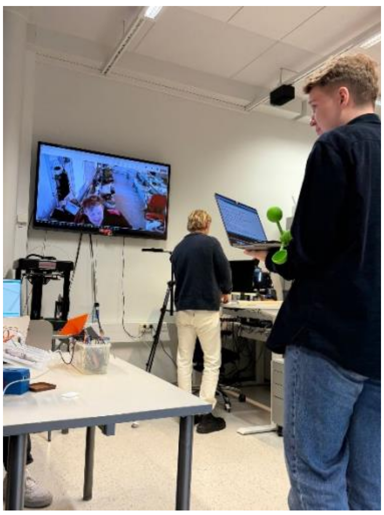
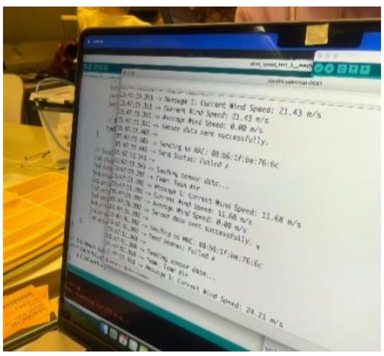
•3D-printed or pre-made enclosures → Approx. **€10**

Total Estimated Cost: **€53**

Add any pictures you deem worthy

The outcome

What Did We Learn?

This project was an incredible learning experience, especially since most of us were new to IoT. Working with ESP32, Hall effect sensors, and designing a device from scratch gave us valuable hands-on experience. We explored how to integrate components, program the ESP32, and solve hardware and software challenges along the way. In particular, we gained skills in:

- Configuring the ESP32 for seamless sensor integration and reliable data transmission.
- Gaining a practical understanding of Hall effect sensors and their role in detecting wind direction.
- Designing, 3D-printing, and iterating prototypes to house sensors while ensuring optimal functionality.
- Debugging sensor outputs and optimizing code for efficient real-time data processing.

The biggest challenge was to get the right calibration for sensors. It taught us the complexity of creating a fully operational device and highlighted the importance of precision in IoT projects. While we didn't achieve a perfect prototype, our teamwork, problem-solving skills, and determination ensured significant progress and valuable learning.

Did This Course Spark Our Interest in Tinkering?

The project inspired varying levels of interest in tinkering across the group. Some members found the hands-on approach exciting and expressed interest in exploring IoT projects further. Others appreciated the learning experience but saw it as a one-off venture. Overall, the project sparked curiosity and confidence in working with IoT devices, even for those with no prior experience.

Ideas for the Future

While we couldn't fully calibrate the wind direction detection in this project, we've brainstormed ideas for future improvements and extensions:

- Developing a fully calibrated weather station by experimenting with alternative sensor arrangements.
- Expanding the project to include additional environmental sensors, such as temperature sensors, to have a more comprehensive weather monitoring system.
- Integrating advanced data visualization tools, such as mobile apps or web dashboards, to display real-time weather data.
- Exploring solar-powered or battery-efficient designs for long-term outdoor use.

This project was an excellent introduction to IoT, providing us with the confidence and skills to tackle similar challenges in the future. Whether we continue tinkering as a hobby or pursue it as a career, it has given us a solid foundation and a sense of accomplishment.

Module 1

Introduction to the Internet of Things

The Internet of Things (IoT) represents a groundbreaking shift in technology, connecting everyday devices to gather, share, and act on data autonomously. This concept is transforming industries by improving efficiency, enhancing decision-making, and enabling innovative solutions to real-world problems.

Exploring IoT Potential

As beginners in IoT, we approached this course with a sense of curiosity and a desire to learn. With our varied levels of experience in programming, 3D design, and robotics, this project served as an opportunity to bridge the gap between theory and application. By diving into IoT, we aimed to explore its potential to create smarter, more connected solutions for challenges like precision agriculture and weather monitoring.

From Theory to Practice

To develop a functional IoT device, we focused on understanding the core building blocks:

Sensors: Devices capable of capturing environmental data like wind speed and direction.

Microcontrollers: Specifically, the ESP32, which serves as the brain of the device.

This foundation guided our work on creating a practical solution for localized wind data monitoring, emphasizing the importance of learning by doing and applying IoT principles in a meaningful way.

By starting with IoT basics and gradually expanding into hands-on building and coding, we laid the groundwork for our wind-monitoring device while developing a deeper appreciation for IoT's transformative potential.

Module 2

From Idea to Innovation

Our journey began with identifying the challenges faced by our target audience. For the farmer in Pori, knowing the wind's behavior was essential for daily operations like spraying crops, planning irrigation, and ensuring worker safety.

The development process included:

1. **Identifying the Problem**: Farmers often rely on weather data that is either too general or delayed. Real-time, localized wind data could significantly improve decision-making.

2. **Proposing a Solution**: We envisioned a compact, IoT-enabled device—a wind speed fan paired with sensors to deliver real-time wind direction and speed updates.

3. **Testing and Refining**: Through prototype testing, we optimized the Wind Compass for durability and accuracy, ensuring it could withstand the demands of outdoor farm use.

This project is part of a larger effort, with another team working on a rain detector to monitor precipitation. Together, these devices form a broader IoT solution for improving farming efficiency.

Turning Innovation into Value

The Wind Compass is more than just a measurement tool; it's a value-creation platform. For the farmer in Pori, it offers:

- **Real-Time Wind Data**: Critical for determining the best times for activities like spraying pesticides.

- **Enhanced Safety**: Alerts for sudden wind changes help prevent accidents.

- **Localized Precision**: Unlike generalized weather reports, the Wind Compass provides data directly from the farm location.

These features ensure that the Wind Compass directly addresses the farmer's needs while offering opportunities to scale its application for other industries.

Exploring Monetization Strategies

To make the Wind Compass a sustainable product, we explored potential ways to monetize it:

- **Subscription-Based Services**: Farmers could subscribe to a wind data platform for analytics and alerts tailored to their operations.

- **Direct Device Sales**: Offering the Wind Compass as a one-time purchase option for farmers looking for standalone solutions.

- **Data Monetization**: Aggregated wind data could be sold to agricultural research institutions or weather agencies.

- **Bundling**: Combining the Wind Compass with the rain detector in a single package for comprehensive farm weather monitoring.

The monetization strategy would depend on customer feedback, scalability, and ensuring the pricing aligns with the value provided.

Learning Through Experimentation

Throughout the project, we embraced an iterative approach to development, allowing us to make quick decisions and refine the Wind Compass as we progressed. The guiding principle was to remain flexible and open to improvements, especially when faced with challenges in both design and implementation.

Our approach began with identifying a practical design. We sought a solution that was not only functional but could also be improved upon. After researching existing wind measurement devices, we brainstormed ways to enhance the design, focusing on durability, accuracy, and ease of use for the farmer in Pori.

On the hardware side, we used an **ESP32** microcontroller, which provided the flexibility to integrate a variety of sensors and communicate the data wirelessly. For wind speed and direction detection, we hooked up **Hall effect sensors**.

On the coding side, we took a hands-on approach. While leveraging tools like **ChatGPT** for initial ideas and problem-solving, we also relied heavily on our own coding knowledge to implement and fine-tune the software for the Wind Compass. This blend of AI assistance and personal expertise allowed us to:

- Generate efficient code snippets for sensor integration and data processing, especially in configuring the **ESP32** with the Hall effect sensors.
- Debug issues quickly by cross-referencing suggestions with our understanding of IoT systems.
- Optimize functionality for real-time wind data collection and transmission via wireless communication.

By combining AI tools with our knowledge, we could focus on refining the device's performance, ensuring it met the specific needs of its intended use case. Testing the prototype with the Pori farm scenario provided valuable insights, helping us identify areas where both design and code could be improved further.

Looking Ahead

Still in its prototype phase, the Wind Compass highlights the potential of IoT in transforming everyday operations through smart, connected solutions. By delivering actionable insights and building value for specific audiences like farmers, it demonstrates how technology can create meaningful impact.

Paired with the rain detector and other IoT innovations, the Wind Compass has the potential to be part of a broader ecosystem that helps farmers optimize resources, save time, and improve safety.

As IoT continues to evolve, so does the opportunity to innovate, refine, and monetize solutions that truly make a difference.

Module 3

Our project involves the development of a wind speed calculator and direction indicator designed to measure and display real-time wind conditions. Centered around the ESP32 microcontroller, this embedded system ensures reliable operation while meeting the demands of real-time data processing.

The initial prototype combines sensors for wind speed and direction, a user-friendly interface, and a microcontroller for efficient data processing and transmission.

Prototype and Proof of Concept (PoC)

Prototype: A functional model has been designed to measure the targeted environmental parameters, demonstrated by the successful integration of wind speed and direction sensors.

PoC: The project proves technical feasibility by using appropriate sensors, microcontrollers, and a basic user interface to display data.

Minimum Viable Product (MVP)

The MVP for the device includes the following core functionalities:

- Accurate measurement of wind speed with calibrated units.
- Reliable indication of wind direction.
- Displaying data on a screen or transmitting it via Bluetooth/Wi-Fi.

While the product is operational, further improvements, such as optimizing energy efficiency and enhancing the user interface, are planned based on user feedback.

Bill of Materials (BOM)

The following materials are required to develop the product:

- Arduino/ESP32 (x1)
- Wind speed sensor (x1)
- Wind direction sensor (x1)
- Resistors, cables, and connectors
- Protective casing
- Wind vanes
- (Power)

Future development will include:

- Collecting client feedback to improve precision and durability.

Module 4

We have considered from module 4 for Building our Device

Proof of Concept (PoC)

Before diving fully to deployment, we are creating a prototype device to validate the system's functionality.

After the device is ready, we will test MQTT data transmission to Home Assistant and confirm it meets performance expectations.

IoT Data Acquisition

We have used sensors to collect air pressure data and selected a reliable air pressure sensor compatible with MQTT protocols.

Our device ensures real-time data.

IoT Ecosystem & Scalability

We have built with modular hardware, ESP32 for cost-effective prototyping and future scalability.

Data Transmission Protocol

Utilized MQTT for real-time messaging and for seamless integration.

Security

Encryption device identity will be implemented for secure data transmission.

Operational System

Enable real-time monitoring in Home Assistant and automate actions based on air pressure thresholds.

IoT Scalability

We will design large data handler infrastructure and support future expansions.

Module 5

Requirements for an MVP

To create an MVP, set clear goals, identify your target market, and address a well-defined problem. Focus on simple, user-friendly design and prioritize core functionalities. Use customer feedback to guide improvements and follow the build-measure-learn cycle for continuous refinement.

Developing New Features and Adding Value

After launching an MVP, analyze customer feedback to prioritize enhancements. Align new features with user needs through use case studies. Incorporate sustainability by referencing the UN's Sustainable Development Goals and adopting eco-friendly practices like modular design for easier repairs and recycling. Plan for quality assurance and cybersecurity.

Enhancing Products Already in Use

Keep IoT devices updated both locally and remotely. Test new features with small user groups and consider hardware limitations. If updates are planned, design products with future scalability in mind.

Future IoT Applications

Emerging trends in IoT include:

- AI-driven device communication and automation.
- Focus on privacy, security, and seamless performance.
- Autonomous vehicles for safer, eco-friendly driving.
- Innovations like digital twins and wearable health monitors.
- Advanced data sensing for crime prediction.

The Role of Online Services

Online services power IoT by enabling real-time data exchange and expanding functionality, such as navigation updates and dynamic routing. Sustainable development, user-focused design, and futureproofing are essential for staying competitive in the evolving IoT landscape.