Aalto University
ELEC-D0301 Protopaja
Year 2023

Project plan / Projektisuunnitelma

Protopaja (Granlund)
Network Base Station Monitor

Date: 21.6.2023

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Information page

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Sponsoring Company
Granlund Oy

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1.6.2023

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1) Background / Johdanto

Network base stations are often located in remote areas which are hard to reach. The maintenance and replacement of components of these towers tend to be expensive and resource consuming. Our goal is to create an IoT device that will monitor structural changes to the tower and send real-time data to a server, which will display this information to the user. Having this kind of information means that extensive analysis can be done to predict needs for maintenance or replacements, as well as gather other statistical data. By monitoring the towers remotely, it is possible to save costs and other resources. Moreover, we will be able to make better predictions about tower placement and understand the effect of external conditions (e.g., wind and cold) on the structure.

This automation and digitization of base station maintenance procedures is part of a bigger project called GenerIoT (https://itea4.org/project/generiot.html), where companies in different countries are applying the same goal of facilitating monitoring and analysis of structures, products and services in different areas.

2) Expected outcome / Tavoite

The main goal of this project is to create an IoT device that uses sensors to gather data from the structure of a network base station (those measurements being the strain on the suspension wires and tower signal light), and securely sends this information to a server which processes the data and display the concluded information.

Our target users are mobile network companies, who would use it mainly for maintenance of base station towers. Moreover, with some modifications, this kind of project can also be applied to other structures (such as wind turbines).

The main functionality of our device is collecting accurate data and providing remote access to it in real time. Additionally, given its usage specifications, the device should be power efficient and long-lasting lifetime. We would also like to provide a consistent and smooth user experience.

We expect that our testing process will ensure and confirm the above-mentioned goal. We understand the conditions of our project might not be ideal since network base stations are not easily accessible. We are currently under discussion with Granlund in terms of our possibilities for measurement testing. However, we will undergo extensive testing when it comes to the data transfer process between the IoT device and the cloud. The data processing and user interface will also be repeatedly tested to ensure quality. If no measurements are available for those, dummy data will be used.

In technical terms, our goal with this project is:

- Gather data from wire strain and light function (using wireless transfer)
- Transmit the measurements from the sensors to a microprocessor (on a device) using bluetooth connection
- Use energy harvesting technology to power sensors and device
- Have a safe enclosure for the gateway device
- Transmit data from the device to a server using mobile network in packages
- Utilize a web server to run a script which receives the data

- Process and store the data using a database
- Provide a user interface for statistical display

3) Phases of project / Projektin vaiheistus

Our project has four defined milestones, which are reached after the completion of each step of our working breakdown structure. The WBS is defined in the next section of this plan. The deadlines for the milestones are as follows:

M1: Planning; DL: 21.06
M2: Designing (hardware, data transfer and software); DL: 05.07
M3: Implementation & development; DL: 02.08
M4: Testing, adjustments and presentation; DL: 25.08
M5: Final report; DL: 31.08

4) Work breakdown structure (WBS)

1. Planning
    - 1.1. Brainstorm and Conceptualization
    - 1.2. Scope and requirements
    - 1.3. Project management plan
    - 1.4. Implementation plan
    - 1.5. Plan changes
2. Design
    - 2.1. Embedded design
    - 2.2. Physical device design
    - 2.3. Data transfer and architecture design
    - 2.4. Software design (server, security and database)
3. Development
    - 3.1. Assemble electronic components and microcontroller programming
    - 3.2. Build physical device
    - 3.3. Data gathering and transfer
    - 3.4. Software implementation
    - 3.5. Combination of hardware, data transfer and software
4. Control/testing
    - 4.1. Testing
    - 4.2. Review and adjustments
    - 4.3. Creating demo
5. Reporting & Presentation

5) Work packages and Tasks of the project and Schedule

5.1) Work packages and tasks/ Työpaketit

WP1. Planning

1.1. Brainstorm and Conceptualization (Everyone) - total estimated hours: 16h

1.1.1. Meet with Granlund and understand expectations - 2h
1.1.2. Brainstorm possibilities - 6h
1.1.3. Further research topic and implementations - 8h

1.2. Scope and requirements (everyone) - total estimated hours: 4h
1.2.1. Definition of scope - 2h
1.2.2. Definition of requirements - 2h

1.3. Project management plan - total estimated hours: 15h
1.3.1. Project practicalities documentation (Beatriz) - 8h
1.3.2. Risk assessment (Akbar) - 2h
1.3.3. Quality plan (Mimi) - 5h

1.4. Implementation plan - total estimated hours: 12h
1.4.1. Software plan (Beatriz) - 3h
1.4.2. Hardware plan (Mimi) - 6h
1.4.3. Data transfer and physical device plan (Akbar) - 3h

1.5. Plan changes (Everyone) - total estimated hours: 5h
1.5.1. Review of plan - 2h
1.5.2. Implement changes - 3h

WP2. Design

2.1. Embedded design (Mimi) - total estimated hours: 40h
2.1.1 Wireless sensor system design - 10h
2.1.2 MCU connection design - 10h
2.1.3 Circuit design - 10h
2.1.4 Circuit board manufacturing – 10h

2.2 Energy harvesting/power supply design (Mimi) - total estimated hours: 25h
2.2.1 Select energy charging circuit - 4h
2.2.2 Design power supply circuit – 6h
2.2.3 Research on energy harvesting and its implementation - 15h

2.3 Physical device design (Akbar) - total estimated hours: 22h
2.3.1 Schematic design of the protective casing - 8h
2.3.2 Component layout planning - 7h
2.3.3 Attachable feature (if applicable) - 7h

2.4 Data transfer design (Akbar) - total estimated hours: 46h
2.4.1 Setting up communication (MQTT, BLE) - 7h
2.4.2 Identify data transmission schedule (Real-time/Trigger-based/Interval-based) - 6h
2.4.3 Data compression - 4h
2.4.4 Design the methods for connection management - 7h
2.4.4.1 Design initiating, maintaining, and closing connections, including handling connection dropouts.
2.4.5 Script for pushing data to server – 10 h
2.4.6 Plan for secure connection initiation - 7 h
2.4.6.1 Including encryption methods and safe handling of authentication credentials
2.4.7 Create a diagram for data transfer - 5h

2.5 Software design (Bia) - total estimated hours: 11h
2.5.1 Form UML for the code - 4h
2.5.2 Database design - 3h
2.5.3 Security plan design (firewall, user authentication) - 2h
2.5.4 Document overall architecture (server-client connections, firewall protection and database) - 2h

WP3. Development

3.1 Assembly hardware and microcontroller programming (Mimi) - total estimated hours: 60h
- 3.1.1 Sensors
  - 3.1.1.1 Selection of sensors – 3h
  - 3.1.1.2 Assembly wireless sensors – 5h
  - 3.1.1.3 Code for the sensors – 10h
- 3.1.2 Model on breadboard – 8h
- 3.1.3 Code for the MCU – 15h
- 3.1.4 Integrate the power supply into the circuit – 6h
- 3.1.5 Connect and solder components to the circuit board – 10h
- 3.1.6 Connect to the physical enclosure (cooperate with Akbar) - 3h

3.2 Build physical enclosure (Akbar) - total estimated hours: 7h
- 3.2.1 3D print the protective cases - 5h
- 3.2.2 Assembly of cases - 2h

3.3 Data gathering and transfer (Akbar) - total estimated hours: 50h
- 3.3.1 Bluetooth communication from sensors to gateway - 10h
- 3.3.2 Data compression - 10h
- 3.3.3 Connection management - 10h
- 3.3.4 Secure connection initiation from gateway to server - 10h
- 3.3.5 Script for pushing data to server - 10h

3.4 Software implementation (Bia) - total estimated hours: 62h
- 3.4.1 Code server script - 4h
- 3.4.2 Establish server-client (IoT) connection from local computer - 4h
- 3.4.3 Create database - 5h
- 3.4.4 Code data processing script - 17h
- 3.4.5 Establish server-client(user) connection from local computer - 4h
- 3.4.6 Code user script (user interaction & data display) - 20h
- 3.4.7 Establish firewall - 3h
- 3.4.8 Allocate the entire program and database on the cloud server – 5h

3.5 Combination of hardware, data transfer and software (Everyone) - total estimated hours: 10h
- 3.5.1 Confirm data gathering from sensors to device (Mimi + Akbar) - 3h
- 3.5.2 Confirm data transfer between cloud server and IoT device (Bia + Akbar) - 4h
- 3.5.3 Confirm complete process (Everyone) - 3h

WP4: Control and Testing

4.1 Testing - total estimated hours: 29h
- 4.1.1 Software (user interface) (Bia) - 8h
- 4.1.2 Software (data processing) (Bia) - 8h
- 4.1.3 Sensor measurements (Mimi) - 5h
- 4.1.4 Data transfer between sensors and device (Mimi + Akbar) - 4h
- 4.1.5 Data transfer between device and server (Bia + Akbar) - 4h

4.2 Review and adjustments - total estimated hours: 16h
- 4.2.1 Debugging (software) (Bia) - 8h
- 4.2.2 Debugging (device) (Mimi + Akbar) - 8h/person

WP5: Reporting & Presentation - total estimated hours: 19h

5.1Writing the report (everyone) - 4h/person

5.2 Creating presentation (Bia) - 2h

5.3 Recording demo (everyone) – 5h

5.2) Detailed schedule / Aikataulu

The following table shows our weekly schedule based on the previously defined working packages and tasks.

6) Work resources / Resurssit

6.1) Personal availability during the project / Henkilöresurssit

The following table shows the weekly availability in hours of the team members.

	Beatriz	Mimi	Akbar
Week 23	21	15	21
Week 24	30	15	21
Week 25	20	25	21
Week 26	25	25	21
Week 27	25	25	21
Week 28	20	25	21
Week 29	20	0	21
Week 30	30	25	21
Week 31	20	25	21
Week 32	20	25	21
Week 33	25	25	21
Week 34	4	25	21
Week 35	10	15	21
Total	**270**	**270**	**273**

6.2) Personal goals / Henkilökohtaiset tavoitteet

Akbar:

- Understand IoT
- Learn and practice hardware interaction
- Understand the physics of towers
- Extend programming skillset
- Learn about energy harvesting

Beatriz:

- Improve organizational and management skills
- Maintain a well-structured schedule and communication throughout the entire duration of the course
- Improve software skills (e.g.: practical coding and software architecture)
- Learn about cloud software implementation and databases
- Master IoT architecture (data collection, data transfer and data processing)
- Learn about energy harvesting and its possibilities

Mimi:

- Improve my problem-solving skills by identifying challenges and finding innovative solutions
- Improve skill in PCB and circuit designs
- Gain understanding of sensor technologies and their applications
- Improve skills in modelling and 3D printing

7) Cost plan and materials / Kustannussuunnitelma

The following table shows our estimated budget for the project.

	Estimated budget	Definition
MCU, transceivers, basic components	300	
Sensors, amplifiers	150	
Services, license	75	PCB order, prepaid SIM
Others	40	Delivery fees
Total	**565**	

All members are responsible for the budget as we have done our separate research on parts for each respective “area” of the project. The table above shows our current estimate of what will be needed, however absolute values are still not known given delivery fees uncertainties and small fluctuations of prices between stores and brands.

8) Other resources / Muut resurssit

Working spaces:

- Home office
- Sähköpaja
- Meeting rooms and study spaces in TUAS
- Keys and permissions:
- student tokens (access to spaces at TUAS)
- Key to soldering lab

Working platforms:

- Personal computers
- School computers
- Additional tools:
- 3D printer
- Laser cutter
- Soldering machine

The additional tools mentioned are available in Sähköpaja, however we need the necessary training to operate the 3D printer and laser cutter. We will also need access to the lab that has the soldering machines.

9) Project management and responsibilities / Henkilöiden roolit ja vastuut

- Project development roles:
    - Software: Beatriz
        - Cloud server
        - Database
        - Data processing
        - UI
    - Hardware: Mimi
        - Sensors
        - Embedded circuit
        - Energy harvesting
    - Data transfer: Akbar
        - Data gathering on microprocessor
        - Data transmission
    - Physical enclosure: Akbar

- Project managing roles:
    - Project manager: Beatriz
        - Responsible for project plan documentation, wiki updates and final report
        - Create meeting agendas and memos
        - Document work packages and task distribution
        - Budget

        - Monitor project progress (make sure we stay on schedule and that tasks are being reported/logged in/done)
        - Main contact person - Granlund
    - Risk manager: Akbar
        - Perform risk analysis
        - Keep members informed and aware of risks
        - Risk management (including managing the overcoming of components shortage, for example)
        - Assessment of risk situations with documented reports (if necessary)
    - Quality manager: Mimi Määttä
        - Create quality plan
        - Perform quality assessment at each milestone
        - Write quality reports
        - Do a final overall project quality analysis

10) Weekly Project Meetings / Viikkopalaverit

We have agreed to have two one-hour weekly meetings. One between our core team members on Mondays at 13:00 and one with our teaching assistants on Wednesdays at 13.00. Additional core meetings might be extended as needed.

For each meeting, we will have a structured agenda of topics to be discussed, which will be shared by the project manager (at least a day) prior to the meeting so that others can situate themselves and add topics as necessary. All meetings will be noted using Google Docs and published in our shared drive folder for easy access. The project manager is also responsible for keeping memo notes from the meeting.

Weekly meeting topics might vary throughout the project stages as new topics might be introduced; however, all meetings will have a similar structure with constant discussion points as follows:

1. How is everyone doing
2. Review of tasks from last meeting
3. Problem/discussion areas
4. Other topics (to be added as needed)
5. Assignment of tasks for the following week

Additional meetings might be agreed upon throughout the project's lifetime if necessary. If a member cannot make it to the meeting, they should inform others at least a day in advance. Absent members should go through the meeting notes after the meeting. Rescheduling might be considered on an event basis.

11) Communication plan / Viestintäsuunnitelma

Aside from our weekly face-to-face meeting, we will be using telegram as our main communication platform. It is important that everyone is active and responsive in the group chat, we will try to use “reactions” as much as possible to indicate acknowledgement of messages.

When it comes to communicating with the company, our main platform is through email. Every email sent should be carbon copied to all other group members. Before emailing the company, we should always verify/announce to the rest of the group to avoid sending multiple messages (instead of a concise email with all the information).

12) Risks / Riskit

The following table describes the possible risks and our management solutions to them.

Risk	Management
time management and scheduling	create a detailed task and timeline plan
shipping delays of components	order the crucial components in advance
unavailability of needed components	research alternatives
lack of knowledge -> additional time consumption	overestimate time for tasks rather than underestimate
safety and dangerous situations when prototyping with hardware and physical tools	properly learn safety procedures ahead of time, take caution and wear appropriate gear/clothing
Personal safety measurements and risks at test site locations	know and follow all safety procedures
Hardware safety during tests	analyze material risks and potential hardware problems when testing device

The risk manager is responsible for the risk analysis and reports, as well as assisting and following other members as they face risk situations. One of the possible methods used by the risk manager to perform a risk analysis is the SWOT table.

Strengths	**Weaknesses**
Solid project plan Team members with diverse background	Limited experience with tools
Opportunities	**Threats**
Use of experts' knowledge Experimenting in the lab	Possible delays in component delivery. Limited resources can lead to a higher workload. Bugs in scripts Safety issues when working onsite

13) Quality plan / Laatusuunnitelma

The project quality plan is relatively straightforward, as each phase of the project has a specific purpose and a set of criteria it should fulfill. While meeting the intended objectives does not guarantee quality, it certainly puts us on the right track. Quality assurance involves more than mere

functionality; it requires thoughtfulness and being effectively executed. Milestone meetings may also include brief discussions on quality control.

Furthermore, the discussions held during the weekly meetings are seen as a form of quality control. By ensuring that everyone is aligned and addressing any potential questions, issues can be resolved before they become obstacles. When a problem is observed, it should be communicated and discussed during weekly meetings and should be documented. The team can then analyze and identify the root of the problem, brainstorm the possible solutions, and come up with the final action plan. After the implementation is completed, monitoring and reviewing are necessary to ensure that the quality problem has been solved.

The quality manager is responsible for assessing and reporting the quality, as well as communicating problems if quality tests are failed. Moreover, the quality manager is responsible for alerting the team in meetings if there are quality problems, which should be then discussed by all members. Every team member is responsible for delivering tasks on time, reporting their own work and progress.

14) Changing this plan / Muutokset suunnitelmaan

All changes should be agreed upon by all members of the project.

Changes can be proposed by any group member and should be added to the weekly meeting agenda (before the meeting) to be discussed in person between all members. The member should state their proposal, which is then followed by a discussion (if necessary) and a vote. If the vote is not unanimous, there should be further conversation until a consensus between all members is reached.

In case of absences, the absentee can express their opinions on the matter through telegram prior to the meeting once the meeting agenda has been shared. The final decision will be noted on the meeting notes, which should always be read by absentees.

15) Measures for successful project / Onnistuneen projektin mittarit

The project final outcome should meet our set goals and specified prototype requirements. The following are considered:

Meeting prototype requirements (binary). In case a requirement is not met, there should be specifications as to why that is the case.

Extensive testing should be done in order to prove the accuracy and capabilities of the device. User testing should be done on the online platform.

The prototype should be evaluated after each iteration. This will be controlled by the quality measurements done by the quality manager on the specified milestones.

The final project will be presented and further evaluated on the course presentation day.

The project process will be evaluated at the end with an overall analysis of group performance and combining all quality reports for substages. As previously mentioned, there will be a quality

assessment and report after each milestone, which will be done on a weekly meeting. The report is then shared amongst all members together with all documents on our shared drive folder.

Anonymous peer evaluations will be considered for personal feedback and self-reflection (optional).