SUP'COM
Higher School of Communication of Tunis

Scope statement:
Baby Awakeness Monitoring

Authors:

- BEN OTHMEN Amen Allah
- ABDELHADI Youssef

Faculty Adviser:

- MOHAMED BECHA Kaaniche

Contents

1 Concept **2**
1.1 Project context . . . 2
1.2 Problem statement . . . 2
1.3 Objectives . . . 2

2 Client **3**

3 Functional need **3**
3.1 Sensors and IoT Network . . . 3
3.2 PWA Application . . . 3

4 Machine learning integration **4**
4.1 Model development . . . 4
4.2 MLOps implementation . . . 4

5 Equipment **4**

6 Technologies choice **5**
6.1 Back-end . . . 5
6.2 Middleware . . . 5
6.3 Front-End . . . 5
6.4 Iot integration . . . 5
6.5 MLOPS integration . . . 5

7 Architecture **6**

8 Timeline and tasks **7**

9 Limitations **8**

10 Business study **8**
10.1 Business Model Canvas (BMC) . . . 8
10.2 Marketing policy . . . 9
10.2.1 Product . . . 9
10.2.2 Price . . . 9
10.2.3 Promotion . . . 10
10.2.4 Place . . . 10

11 Deliverables **10**

1 Concept

1.1 Project context

Sleep is vital to a baby's development, influencing growth, mood, and overall health. As babies grow, their sleep patterns change frequently, resulting in irregular rest and potential overtiredness, which can affect both immediate well-being and long-term development. Monitoring these changes is challenging for parents, who often rely on traditional methods like memory-based tracking, manual logs, or costly sleep monitors. These methods can be unreliable, time-consuming, or financially demanding, leading to stress and uncertainty about effectively supporting a child's healthy sleep.

This project addresses the need for a practical, efficient solution to track and manage baby sleep patterns in real time. By delivering accurate, continuous data, it empowers parents to make informed decisions, promoting a happier and healthier baby. Furthermore, to ensure seamless monitoring, the system incorporates LBS-based alerts that notify parents based on the caregiver's location, dynamically shifting alerts between caregivers as needed.

1.2 Problem statement

- How can we create a system that accurately tracks and monitors a baby's sleep patterns in real time, providing parents with reliable data on sleep and wake cycles to support healthy development and well-being?
- How can we offer a practical, cost-effective solution that eliminates the need for manual logging or expensive sleep monitors, helping parents make informed decisions to ensure their baby is well-rested and happy?
- How can we implement a location-based alert system that uses the caregiver's location to notify the nearest parent, ensuring seamless monitoring by dynamically adjusting alerts between caregivers as needed?

1.3 Objectives

- Monitor and track baby sleep patterns accurately in real time, providing parents with reliable data on sleep and wake cycles.
- Implement a sleep health indicator to inform parents when disruptions in sleep patterns are detected.
- Implement LBS-based indicate the nearest users or caregivers subscribed to the baby monitoring session.
- Use an alerting system to notify caregivers immediately in case of unusual activity, sleep disturbances, or awakeness of the baby.

2 Client

The primary clients are parents and caregivers seeking an effective, low-maintenance way to monitor baby sleep patterns and well-being. Secondary clients include healthcare providers, like pediatricians and child care consultants, who can use the system to support healthy sleep routines. Designed to be intuitive and accessible, the system provides real-time insights and automated alerts, helping parents reduce stress and enhance their child's sleep quality.

3 Functional need

3.1 Sensors and IoT Network

The IoT-based baby sleep monitoring system uses a night vision camera to track the baby's sleep state and provide alerts to caregivers when needed. This setup ensures continuous observation and timely notifications, giving caregivers valuable insights into the baby's sleep patterns and overall well-being. The system includes the following component:

- **Night Vision Camera Module**: This camera provides real-time video monitoring, functioning effectively during both day and night. With night vision capabilities, it captures clear visuals even in low-light conditions, allowing reliable tracking of the baby's sleep or wake state and detecting any disruptions.

This configuration enables caregivers to monitor the baby remotely and receive real-time notifications, ensuring consistent, reliable, and responsive monitoring.

3.2 PWA Application

This Progressive Web Application (PWA) provides caregivers with a user-friendly tool to monitor a baby's well-being in real-time. Through an intuitive interface, the application enables users to:

- View real-time monitoring data with options to observe historical data and identify trends in the baby's sleep and wake cycles.
- Receive insights on the baby's sleep quality based on AI-driven analysis of sleep disruptions and patterns.
- Powered by Location-Based Services (LBS), the system indicates the nearest users or caregivers subscribed to the baby monitoring session, providing real-time proximity awareness for responsive caregiving
- Activate an alert system if the baby shows signs of waking or if any unusual activity is detected, allowing caregivers to attend to the baby immediately without constant monitoring.

4 Machine learning integration

4.1 Model development

The central goal of model development is to create a machine learning model capable of accurately assessing the baby's sleep state and notifying caregivers of any significant changes. The model is designed to provide reliable insights that support caregivers in making timely and informed responses.

4.2 MLOps implementation

The MLOps implementation serves as the foundation for continuous improvement and operational management of the sleep monitoring model, ensuring consistent reliability and accuracy. Key aspects include:

- **Automated Model Training and Deployment**: The MLOps framework automates the training and deployment of the model, enabling real-time predictions and ensuring the system remains up-to-date as new data is collected.
- **Continuous Monitoring**: MLOps tools continuously assess model performance, tracking accuracy and identifying any drift or deviations to maintain the model's effectiveness.
- **Alerts and Notifications**: When the model detects changes in the baby's sleep state, it sends automatic notifications to caregivers, allowing for prompt responses.
- **Data Versioning and Tracking**: MLOps practices are used to manage data versions and maintain historical information, supporting ongoing model refinement and analysis.
- **Security and Compliance**: Strong security measures protect baby monitoring data, ensuring compliance with data privacy regulations through access controls, and data anonymization.
- **Model Performance Optimization**: MLOps aids in fine-tuning the model and managing resources to enhance prediction accuracy and efficiency.
- **Feedback Loop**: User feedback is incorporated into the MLOps process to improve the model, enhancing its ability to provide meaningful insights to caregivers.

This MLOps implementation is essential for maintaining the model's accuracy, security, and reliability, ensuring it adapts to changing conditions and continues to meet caregiver needs over time.

5 Equipment

After conducting research, we have identified the following elements as necessary:

- 5MP OV5647 Night Vision Camera for Raspberry Pi with 160° field of view.

- Raspberry Pi 3.
- Ribbon cable.

6 Technologies choice

6.1 Back-end

- MongoDB: A NoSQL document-oriented database used for storing user data. It is practical and easy to use in conjunction with Jakarta EE.
- MQTT: A lightweight publish-subscribe network protocol used to communicate sensor data to an MQTT broker in the cloud.

6.2 Middleware

- JAX-RS: Java API for RESTful Web Services is a Java programming interface for creating web services with a REST architecture.
- WildFly: WildFly, formerly known as JBoss Application Server or JBoss, is a free and open-source Java EE application server written in Java and released under the GNU LGPL license. It can be used on any operating system that provides a Java virtual machine.
- Mosquitto: Mosquitto is a widely used MQTT broker, serving as an intermediary for efficient and reliable messaging between IoT devices and the back-end system.

6.3 Front-End

- PWA (Progressive Web App): A PWA is a cross-platform web application that provides a native-like experience to users. It allows you to develop applications for multiple platforms using web technologies like HTML, CSS, and JavaScript. PWAs are easy and quick to code and do not require prior web development knowledge.

6.4 Iot integration

- Flogo: Flogo is an open-source project designed for creating lightweight, event-driven microservices and workflows, making it suitable for orchestrating data flows, data pre-processing, and automation in IoT scenarios.

6.5 MLOPS integration

In our MLOps integration, we harness a suite of technologies to streamline the operational management of machine learning models, ensuring their continuous accuracy and reliability. Key technology components include:

1. CI/CD Pipeline: Our continuous integration and continuous deployment (CI/CD) pipeline, powered by Jenkins, is at the core of our MLOps strategy.

2. Testing technologies: For model validation and data quality assurance, we employ PyTest and Selenium. These testing frameworks aid in verifying the functionality and reliability of our health monitoring system, ensuring that user data is processed accurately.

3. Development technologies: We leverage Python and Jupyter Notebook for model development and experimentation. These technologies provide a versatile and data-centric environment for creating and fine-tuning our machine learning models.

4. Monitoring and logging: Our system relies on Prometheus and Grafana for monitoring and logging. These tools allow us to track the performance of our machine learning models and detect any anomalies, ensuring their continued effectiveness.

5. Data management: MongoDB serves as our database technology, providing a robust and flexible solution for storing and managing user data, health records, and environmental information.

6. Containerization: Docker containers are used for efficient deployment and scaling, ensuring consistency and ease of management in our system.

7. Stream processing: Apache Kafka is employed to handle real-time data streams from sensors, enabling timely updates and notifications in our health monitoring system.

7 Architecture

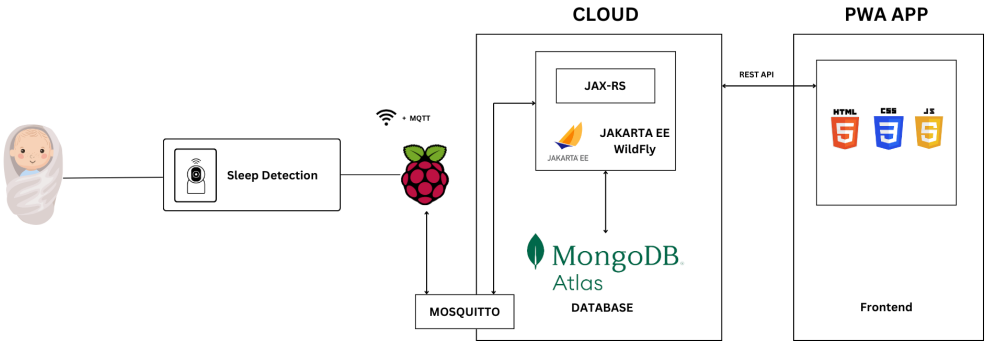

Figure 1: Architecture

The diagram above describes the main architecture of the Health monitoring system which is mainly composed by Backend, Middleware and Frontend.

8 Timeline and tasks

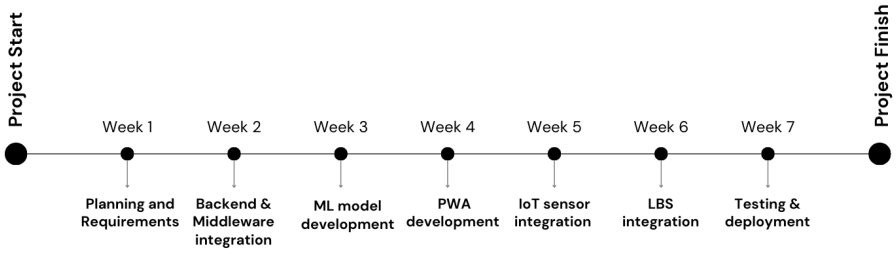

Figure 2: Project Timeline

The timeline diagram above graphically represents the project's phases and key milestones. It visually illustrates the project's planned progression and the duration of each stage, allowing for a clear understanding of the sequence and timing of each process from start to finish

9 Limitations

As we begin developing our baby sleep monitoring system, it is essential to anticipate and address potential challenges that may arise throughout the implementation process.

- **Camera Accuracy**: The reliability of sleep detection relies on the camera's ability to capture clear visuals. Low light conditions or obstructions in the baby's environment may impact accuracy, potentially leading to missed alerts or false positives.
- **Privacy Concerns**: Video monitoring raises concerns about the storage and transmission of sensitive data. Ensuring data security and safeguarding user privacy are essential to maintain trust.
- **Device Placement and Coverage**: Proper placement of the camera is crucial for effective monitoring. Incorrect positioning or limited camera coverage may result in missed movements or inaccurate detection of the baby's sleep state.
- **Internet Connectivity Interruptions**: The system relies on internet connectivity for real-time monitoring and notifications. In the event of connectivity issues, caregivers may experience delays in receiving updates and alerts, reducing the system's effectiveness.

10 Business study

The Business Study section provides an overall view of our project's business model and marketing policy.

10.1 Business Model Canvas (BMC)

The Business Model Canvas serves as a visual representation of our project's main aspects, such as value proposition, customer segmentation, channels, cost structure, revenue stream, and more. The BMC is depicted in the figure below:

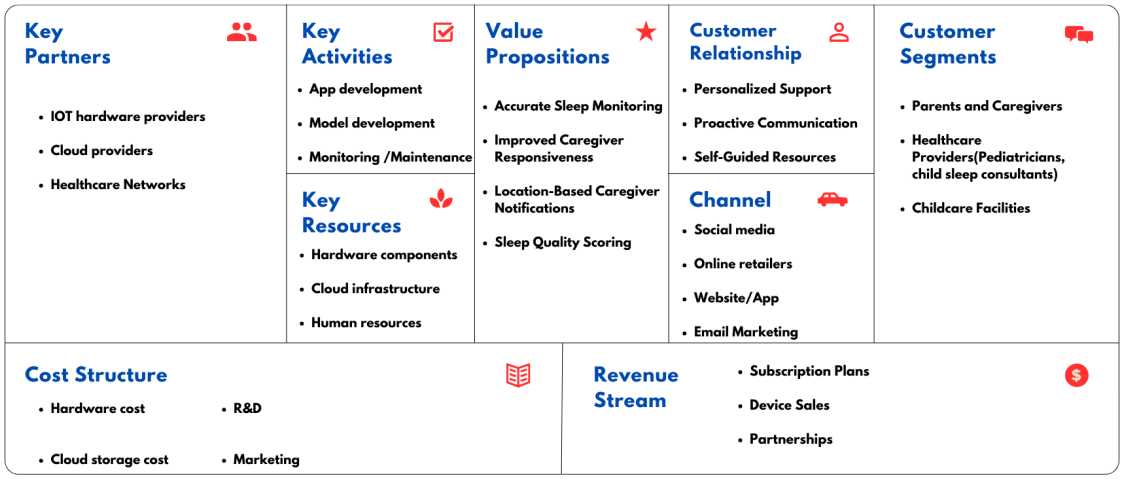

Figure 3: Business Model Canvas

10.2 Marketing policy

Our marketing policy is focused on delivering value to our customers while maintaining a strong market presence. It encompasses the following aspects:

10.2.1 Product

- **Core Offering:** A dependable baby sleep monitoring solution providing real-time data, caregiver alerts based on location, and sleep quality scoring to enhance baby well-being.
- **Key Features:** Monitors sleep patterns in real time, offers instant alerts for disruptions, and provides valuable insights—all accessible through a user-friendly mobile app and website.
- **Unique Differentiation:** Prioritizes convenience, affordability, and advanced functionality, setting it apart from traditional baby monitors by offering more intelligent, data-driven monitoring.

10.2.2 Price

- **Competitive and Flexible Pricing:** Offers affordable subscription plans for access to premium features, with a one-time cost for the hardware package, including the Raspberry Pi and camera module.

- **Subscription Options:** Provides monthly and annual plans tailored to different budgets, with a free trial period allowing new users to experience key features before committing.
- **Bundle Discounts:** Discounts on device bundles when paired with a subscription plan, making it easier for new customers to get started and encouraging long-term engagement.

10.2.3 Promotion

- **Social Media Campaigns:** Engage parents and caregivers on platforms like Instagram, Facebook, and parenting forums through informative posts, sleep tips, and product demos, building awareness and trust.
- **Influencer Collaborations:** Partner with parenting influencers, bloggers, and child healthcare experts to showcase the product's value, reaching a wider, trust-based audience.
- **Email Marketing:** : Regular newsletters with baby sleep tips, product updates, and exclusive offers to keep customers engaged and informed.

10.2.4 Place

- **Direct Online Sales:** Available for purchase directly on our website and app, offering a secure and straightforward buying experience.
- **Physical Retail Partnerships:** Partner with baby stores, healthcare facilities, and pharmacies to display and sell the product in locations frequented by parents and caregivers.

11 Deliverables

- **Scope Statement**: A detailed document outlining the project's objectives, specifications, system architecture, and services provided by the baby monitoring system. It defines the project's boundaries and deliverables.
- **Design Statement**: A comprehensive document featuring UML diagrams—such as use case, class, and deployment diagrams—that illustrate the system architecture, design principles, and workflows necessary for implementing the monitoring system.
- **Source Code**: The complete source code for various project components, accessible on GitHub for easy collaboration and transparency.
- **Prototype/Simulation**: A working prototype or simulation of the intelligent baby sleep monitoring system, demonstrating key functionalities.
- **Demonstration Video**: An mp4 video that showcases a demonstration of the proposed solution, highlighting real-time monitoring features and user interface.