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**MAINTENANCE MODULE**

**Functional requirements:**

1. **Work Order Management:** Creating, assigning, tracking, and closing work orders for both corrective and preventive maintenance.
2. **Asset Management:** Maintaining a central repository of all assets, including their location, specifications, maintenance history, and documentation.
3. **Preventive Maintenance (PM):** Scheduling and tracking recurring maintenance tasks based on time, usage, or condition.
4. **Inventory Management:** Tracking spare parts, managing stock levels, and automating the reordering process.
5. **Reporting and Analytics:** Generating reports on key performance indicators (KPIs) such as mean time to repair (MTTR), mean time between failures (MTBF), and maintenance costs.
6. **Mobile Access:** Providing a user-friendly mobile application for technicians to access and update information in the field.
7. **Offline Capability:** Allowing technicians to continue working in areas without an internet connection and sync data once connectivity is restored.

**Non-Functional Requirements: How Well the System Must Perform**

1. **Usability:** The software should be intuitive and easy to learn for users with varying levels of technical expertise.
2. **Performance:** The system must be responsive and able to handle the volume of data and users without significant delays.
3. **Reliability:** The software should be available and function correctly when needed, with minimal downtime.
4. **Security:** Robust security measures are necessary to protect sensitive asset and operational data.
5. **Scalability:** The system should be able to grow with the organization, accommodating an increasing number of users, assets, and data.
6. **Integration:** The ability to seamlessly integrate with other enterprise systems, such as Enterprise Resource Planning (ERP), is often a critical requirement to ensure data consistency and streamline workflows.

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| **Stakeholder Group** | **Primary Needs & Concerns** |
| Maintenance Technicians | Ease of use (especially on mobile devices), quick access to work orders, asset history, and documentation, offline functionality for areas with poor connectivity, and simple data entry. |
| Maintenance Managers/Supervisors | Comprehensive dashboards for tracking work orders, scheduling and assigning tasks, monitoring team performance, generating reports on key metrics (e.g., MTTR, MTBF), and managing preventive maintenance schedules. |
| Facility/Plant Managers | Overall equipment effectiveness (OEE), asset lifecycle management, budget tracking, and ensuring compliance with safety and environmental regulations. |
| Inventory/Storeroom Managers | Real-time tracking of spare parts, automated reordering alerts, and integration with purchasing systems. |
| IT Department | Seamless integration with existing enterprise systems (e.g., ERP, accounting software), data security, scalability, and ease of deployment and maintenance. |
| Finance Department | Accurate cost tracking for maintenance activities, budget adherence, and demonstrating return on investment (ROI). |
| Operations/Production Department | Minimizing equipment downtime, visibility into planned maintenance activities, and predictable production schedules. |
| Upper Management/Executives | High-level reports and analytics on maintenance costs, asset performance, and the overall impact of maintenance on the business's bottom line. |

1. Break down:

* Equipment user should raise the breakdown complaint.
* No modification will not allow by user or maintenance team.
* Complaint notification should be sent to mail and software screen.
* Complaint notification should be displayed till the complaint resolved.

1. Action:

* Complaint field should be highlighted like “in progress”, “Acknowledge”, “completed”.

1. Action report:

* Report will be prepared by maintenance team and confirmed by user.

1. User should confirm the handover of the machine or equipment.
2. Preventive maintenance Checklists: Provision to prepare customized checklist for every machine.

**IOTs INTEGRATION WITH EXISTING MACHINES**

**I. Data Acquisition and Monitoring:**

1. **Sensor Data Collection:** The system must be able to collect real-time data from various IoT sensors attached to industrial machinery. This includes, but is not limited to:
   * **Vibration:** Detecting anomalies that indicate bearing wear, misalignment, or imbalance.
   * **Temperature:** Monitoring for overheating components, lubricant degradation, or abnormal thermal profiles.
   * **Pressure:** Tracking pressure levels in hydraulic, pneumatic, or fluid systems.
   * **Current/Voltage:** Monitoring electrical load, motor health, and identifying electrical faults.
   * **Acoustic/Ultrasonic:** Detecting leaks, abnormal noises, or friction.
   * **Humidity:** Monitoring environmental conditions that could impact machinery.
   * **Flow Rate:** Measuring fluid or gas movement in pipelines.
   * **RPM/Speed:** Monitoring rotational speed of motors, pumps, or other rotating equipment.
   * **Run Time/Usage:** Tracking actual operational hours or cycles.
2. **Data Transmission:** The system must reliably transmit collected sensor data to a central platform (e.g., cloud, edge server) using various communication protocols (e.g., MQTT, Wi-Fi, LoRa, cellular).
3. **Real-time Data Visualization:** The system must provide intuitive dashboards and interfaces to visualize real-time sensor data, trends, and current machine status. This includes:
   * Graphical representation of parameters over time.
   * Current status indicators (e.g., green for normal, yellow for warning, red for critical).
   * Customizable views for different user roles (e.g., maintenance managers, technicians, operators).
4. **Historical Data Storage and Retrieval:** The system must efficiently store vast amounts of historical sensor data for analysis, trend identification, and model training. It should allow for easy retrieval of specific data ranges.

**II. Data Analysis and Prediction:**

1. **Anomaly Detection:** The system must be able to automatically detect abnormal patterns or deviations from baseline behaviour in sensor data. This can involve statistical methods, rule-based alerts, or machine learning algorithms.
2. **Predictive Analytics (Prognostics):** The system must leverage AI and Machine Learning (ML) models to predict potential equipment failures before they occur. This includes:
   * **Remaining Useful Life (RUL) estimation:** Predicting the estimated time until a component or asset fails.
   * **Time to Failure (TTF) prediction:** Forecasting the expected time of breakdown.
   * **Fault classification:** Identifying the specific type of fault or degradation occurring.
3. **Root Cause Analysis Support:** While not always fully automated, the system should provide data and insights to assist maintenance personnel in identifying the root causes of issues.
4. **Thresholding and Alerting:** The system must allow users to set customizable thresholds for various parameters. When these thresholds are breached or predicted to be breached, the system should generate timely alerts and notifications (e.g., email, SMS, push notifications to mobile devices).

**III. Maintenance Workflow Management:**

1. **Automated Work Order Generation:** Based on detected anomalies or predicted failures, the system should automatically generate work orders for maintenance tasks.
2. **Maintenance Scheduling and Optimization:** The system should assist in scheduling maintenance activities, considering factors like:
   * Predicted failure time.
   * Availability of spare parts.
   * Technician availability and skill sets.
   * Production schedules to minimize downtime.
3. **Asset Management Integration:** The system should integrate with existing Enterprise Asset Management (EAM) or Computerized Maintenance Management Systems (CMMS) to streamline work order management, spare parts inventory, and maintenance history.
4. **Maintenance Task Management:** The system should allow for tracking the progress of maintenance tasks, assigning tasks to technicians, and recording task completion.
5. **Spare Parts Management:** The system should provide visibility into spare parts inventory and trigger reorder alerts based on predicted maintenance needs.

**IV. User Interface and Experience:**

1. **User-Friendly Dashboard:** A customizable and intuitive dashboard providing a high-level overview of asset health, critical alerts, and upcoming maintenance.
2. **Detailed Asset View:** Ability to drill down into individual asset data, maintenance history, and specific sensor readings.
3. **Mobile Accessibility:** Access to critical system functions and alerts via mobile applications for on-the-go maintenance teams.
4. **Reporting and Analytics:** Generation of reports on maintenance performance, downtime reduction, cost savings, and asset health trends.

**V. System Integration and Scalability:**

1. **Integration with Enterprise Systems:** Ability to integrate with ERP, MES, SCADA, and other existing enterprise systems for data exchange and process automation.
2. **Scalability:** The system must be designed to scale to accommodate a growing number of sensors, assets, and data volume without compromising performance.
3. **Security:** Robust security measures to protect sensitive industrial data, including data encryption (in transit and at rest), access control, and authentication.
4. **Interoperability:** Support for various communication protocols and data formats to ensure compatibility with diverse IoT devices and industrial equipment.

**VI. Remote Capabilities:**

1. **Remote Monitoring:** Ability to monitor asset health and performance from any location.
2. **Remote Diagnostics (if applicable):** For certain types of equipment, the system may allow for remote diagnostics and basic troubleshooting.

**VII. Compliance and Auditing:**

1. **Audit Trail:** Maintaining a comprehensive audit trail of all system activities, data changes, and user actions for compliance and accountability.
2. **Compliance Reporting:** Ability to generate reports to demonstrate compliance with industry regulations and standards.

By fulfilling these functional requirements, an IoT-based industrial maintenance system can significantly improve operational efficiency, reduce costs, and enhance the overall reliability of industrial assets.