
SOFTWARE ARCHITECTURE AND SYSTEM DESIGN DOCUMENTATION

for

PREDICTIVE MAINTENANCE AUTOMATION SYSTEM

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Software Architecture Style

Our PMAS (Predictive Maintenance Automation System) project involves:

- Technicians
- System Administrator
- Maintenance Tickets
- Alerts
- Responses (accept/reject)

This is a structured, domain-driven system - not a distributed SaaS platform with millions of users.

For the PMAS project, a **Layered Monolithic Architecture** is selected as it provides a structured, scalable, and maintainable solution aligned with the project's functional and non-functional requirements.

A. Why PMAS Falls Under Layered Architecture

A layered architecture organises the system into vertical layers where each layer has a clear responsibility and exposes limited interfaces to the layer above.

PMAS can be structured like:

1. Presentation Layer

Handles interaction with users

- UI (Web Interface)
- Alert/Ticket Dashboard
- Machine Dashboard
- Technician Response Interface
- Admin Panel

2. Business Logic Layer

Contains the core logic of the system

- Authorization & Role-Based Access Control
- Ticket Management Service (creation, validation, status transitions)
- Response Handling Logic (accept/reject processing, reassignment rules)
- Prediction Service (ML module for failure prediction and priority scoring)
- Technician Domain Logic
- System Administrator Domain Logic

3. Data Access Layer

Handles communication with the database

- CRUD operations
- Ticket Repository
 - i. Create, update, delete tickets
 - ii. Retrieve tickets by status or technician
 - iii. Fetch ticket history
- Technician Repository
 - i. Retrieve available technicians
 - ii. Update technician availability
 - iii. Manage technician profile
- Alert Repository
 - i. Create alerts
 - ii. Retrieve alerts by status
 - iii. View/Acknowledge alerts
- Machine Repository
 - i. Update machine configuration
 - ii. Retrieve machine by id

4. Database Layer

Stores system data

- User table
- Machine table
- Ticket table
- Alert table

Granularity Justification:

- Each layer has **well-defined responsibility**
- Classes are grouped by **functionality**, not by service
- All components are deployed as a **single unit (monolith)**
- Communication happens internally (method calls), not over network

B. Why this is the best choice for PMAS

The Layered Monolithic Architecture is the most suitable architectural style for the PMAS (Predictive Maintenance Automation System) project because it aligns with the system's functional requirements, expected scale, and development constraints. The justification is discussed below:

1. Scalability

The PMAS system is expected to serve a limited number of users, including administrators and technicians within an organization. The workload primarily involves ticket creation, technician assignment, response handling, and predictive analysis.

A monolithic layered architecture supports:

- Vertical scaling (increasing server resources)
- Efficient in-memory communication between layers
- Simple deployment as a single unit

Since the system does not require independent scaling of components or distributed service management, adopting microservices would introduce unnecessary complexity. The layered monolithic design provides sufficient scalability for the expected workload.

2. Maintainability

Maintainability is significantly improved due to clear separation of concerns across layers:

- Presentation Layer handles user interaction.
- Business Logic Layer contains system rules and decision-making.
- Data Access Layer manages database interaction.
- Database Layer stores persistent data.

Each layer has a well-defined responsibility. Changes in one layer (e.g., updating the response handling logic or modifying prediction logic) do not directly impact other layers.

For example:

- Updating the ML-based prediction module affects only the Business Logic Layer.
- Changing database technology affects only the Data Access Layer.

This modular separation makes debugging, testing, and feature enhancement easier.

3. Maintainability

In a layered monolithic architecture:

- Components communicate through direct method calls.
- There is no network overhead between services.
- No serialization/deserialization cost between modules.

This results in lower latency and improved performance compared to distributed architectures such as microservices, which require inter-service communication over a network.

Since PMAS requires quick ticket assignment and response processing, minimizing communication overhead improves overall system responsiveness.

4. Simplicity and Development Efficiency

The project is developed within academic constraints and limited development time. A layered monolithic architecture:

- Is easier to implement and test
- Requires simpler deployment configuration
- Avoids distributed system complexities (API gateways, service discovery, container orchestration)

This allows us to focus on core functionalities such as prediction modeling and assignment logic rather than infrastructure management.

5. Suitability to Project Requirements

PMAS requires:

- Structured business rules
- Controlled access roles (Admin, Technician)
- Predictive analytics integration
- Centralized data management

A layered architecture naturally supports structured domain logic and centralized control, making it ideal for systems with strong internal rule processing.

Microservices architecture is more appropriate for large-scale, highly distributed systems with independent teams and massive traffic, which is not the case for PMAS.

6. Integration of Predictive Analytics

The layered structure allows seamless integration of a Prediction Service within the Business Logic Layer. The ML module operates as a supporting component without requiring independent deployment, simplifying integration and maintenance.

This ensures that predictive intelligence enhances decision-making without increasing architectural complexity.

Conclusion

The Layered Monolithic Architecture provides the optimal balance between scalability, maintainability, performance, and implementation simplicity for the PMAS project. It supports structured separation of concerns, efficient execution, and straightforward integration of predictive analytics, making it the most appropriate architectural choice for the system.