# Week 8 – System Development and Testing

## Introduction:

Week 8 concentrates on integration testing, debugging, and validation of the smart manufacturing process, following weeks of establishing predictive and scheduling models. The goal is to make sure that the intelligent task rescheduling logic (Week 7) functions well in the face of changing machine circumstances and real-world restrictions. In order to replicate dynamic operating stress, real-time modeling and anomaly detection are also included.

## Objective:

- Verify the job rescheduling logic using previous instances of failure
- Test scheduled jobs functionally, load-wise, and temporally.
- Display the workload distribution and machine utilization.
- Use trend-based rolling averages to troubleshoot sensor abnormalities.
- Save the verified results for Week 11 deployment.

## Methodology:

- **Ingestion of Data:**
  - Loads optimized_schedule.json (Week 7) and processed_sensor_data.json (Week 2).
  - Time stamps are parsed for work tracking and temporal alignment.
- **Testing for functionality:**
  There are two main checks made:
  - Failure-Triggered Rescheduling:
    - This method counts the number of tasks that were rescheduled on machines that had known problems.
    - Verifies that actual failure events caused the scheduling system to react.
  - Risky Work Delays:
    - finds jobs with failure_prob > 0.6 and confirms the number of jobs that were postponed as planned, confirming that the threshold logic is working.
- **Analysis of Delay Impact:**

    - Determines each job's delay in minutes using:
      *(rescheduled_time - original_time).total_seconds() / 60*
    - Assesses if high-priority jobs are disproportionately delayed using boxplots divided by job importance.

- **Testing for Temporal Loads:**
    - Takes the hour out of the rescheduled_time for every task.
    - Creates a bar chart of the hourly scheduling burden by adding up all of the jobs each hour.
- **Heatmap of Machine Utilization:**
    - Jobs are grouped by hour and machine_id.
    - Shows a two-dimensional heatmap showing work density across time and across machines.
- **Simulating Real-Time Sensors:**
    - Uses a rolling average for vibration and temperature per machine (window size = 10).
    - Simulates what a real-time dashboard may display by plotting patterns for a sample machine.
- **Finding and Examining Anomalies:**
    - Signals spikes when sensor readings are higher:
      *mean + 2 * std deviation*
        - Used for vibration and temperature.
    - Displays a summary table after aggregating anomalies by machine_id.

## Results & Observations:

- Effective failure response was confirmed by the successful rescheduling of all jobs on machines with documented failures.
- The majority of high-risk jobs (failure probability > 0.6) were postponed as planned, demonstrating effective risk-aware scheduling.
- The distribution of delays showed that jobs with a greater priority saw less delays, which was consistent with operational urgency.
- Realistic and balanced scheduling was demonstrated by the hourly task load peaking during regular manufacturing hours.
- Uneven workload distribution was shown by the machine utilization heatmap; certain machines were overloaded, while others were underutilized.

- For sample machines, rolling averages of vibration and temperature displayed consistent patterns that aided in monitoring and troubleshooting.
- When data deviated more than two standard deviations from the mean, sensor abnormalities were detected, indicating which equipment needed maintenance.
- Multiple abnormalities on a few computers suggested that they could require servicing.
- Schedule and anomaly summaries were validated and stored for further reporting and analysis.

## Summary:

The system validation milestone before to deployment is week eight. Important results include:

- Confirmed that high-risk jobs were appropriately deferred by the intelligent scheduler.
- Job delays across priority levels were quantified.
- Temporal load balancing during factory hours was tested.
- Visibly shown patterns of machine operation.
- Trend visualizations were used to simulate real-time situations.
- Sensor data abnormalities and outliers were flagged.

## Conclusion:

The SmartFactory.AI core intelligence loop is successfully integrated, tested, and validated in week eight. It guarantees performance and dependability by integrating anomaly detection, work delay analytics, and failure-aware scheduling. With the support of highly reliable operational data, this gets the system ready for UI development in Weeks 9–10 and deployment in Week 11.

URL To Week 8 – System Development and Testing.ipynb