

Case study: Layer wise responses/actions/activities for Connected Factories

Requirements:

- Monitor machine health in real-time to ensure continuous production.
- Detect and report anomalies, deviations, and critical issues instantly to maintenance teams.
- Efficiently manage material flow within interconnected factories.
- Optimize logistics and transportation for timely and cost-effective deliveries.
- Implement goods tracking and traceability throughout the supply chain.
- Maintain centralized material inventory management with automated reordering.
- Ensure redundancy and backups for critical raw materials to prevent production disruptions.
- Promote sustainability by monitoring and reporting on water consumption.
- Track and manage carbon footprints while implementing measures to reduce environmental impact.
- Ensure factory worker safety by implementing hazard identification and mitigation protocols.
- Integrate safety sensors and systems to detect and respond to potential safety risks in real-time.

Requirement	Edge Layer (Sensing/Actuation)	Fog Layer (Data Processing/Analysis)	Cloud Layer (Actions/Responses)
Monitor machine health in real-time to ensure continuous production.	- Vibration sensors: Sense machine vibrations.	- RFID/NFC tags: Identify machine status.	- MQTT: Transmit real-time machine health data.
	- Temperature sensors: Monitor temperature.	- RFID/NFC readers: Collect machine data.	- OPC UA: Facilitate interoperability for collecting machine data.
	- Cameras: Provide visual feedback for inspection.		- Database systems: Store data for historical analysis.
	- RFID/NFC tags: Track machine identifiers.		- Notification systems: Send instant alerts for critical issues.
Detect and report anomalies, deviations, and critical issues instantly to maintenance teams.	- Vibration sensors: Detect anomalies.	- RFID/NFC readers: Identify deviations in material flow.	- MQTT: Transmit real-time reports of anomalies and critical issues.
	- Temperature sensors: Monitor machine conditions.	- Flow meters: Detect deviations.	- AMQP: Ensure reliable messaging for alerts.
	- Barcode scanners: Identify material deviations.		- Notification systems: Alert maintenance teams promptly.
	- RFID/NFC tags: Track materials.		- Database systems: Store data for reporting and analysis.
Efficiently manage material flow within	- RFID/NFC tags: Track material flow.	- RFID/NFC readers: Monitor material status.	- MQTT: Enable real-time communication for

interconnected factories.			optimizing material flow.
	- Barcode scanners: Ensure accurate inventory data.	- GPS receivers: Optimize transportation routes.	- OPC UA: Support data collection and communication.
	- GPS modules: Track material locations.	- Temperature and humidity sensors: Ensure optimal conditions.	- Database systems: Manage centralized inventory efficiently.
	- Smoke detectors: Ensure safety during material handling.	- Flow meters: Monitor fluid cargo.	- Notification systems: Automate reordering based on inventory levels.
	- Gas sensors: Detect hazardous materials.	- Motion detectors: Ensure security.	
Optimize logistics and transportation for timely and cost-effective deliveries.	- GPS modules: Track vehicles and goods.	- GPS receivers: Optimize transportation routes.	- MQTT: Optimize logistics in real-time for cost-effective deliveries.
	- Smoke detectors: Ensure cargo safety.	- Temperature sensors: Optimize cargo conditions.	- AMQP: Ensure reliable messaging for alerts.
	- Gas sensors: Monitor cargo for hazards.	- Flow meters: Monitor fluid cargo.	- Database systems: Manage delivery routes efficiently.
	- Motion detectors: Ensure security.		
Implement goods tracking and traceability throughout the supply chain.	- RFID/NFC tags: Track goods from manufacturing to delivery.	- RFID/NFC readers: Monitor goods in the supply chain.	- MQTT: Enable real-time tracking and traceability throughout the supply chain.
	- Barcode scanners: Ensure traceability records.		- AMQP: Support reliable messaging for traceability.

	- GPS modules: Provide location information.		- Database systems: Maintain centralized tracking data.
	- Motion detectors: Ensure security.		
Maintain centralized material inventory management with automated reordering.	- RFID/NFC tags: Track inventory levels.	- RFID/NFC readers: Monitor inventory levels.	- MQTT: Enable real-time inventory management with automated reordering.
	- Barcode scanners: Ensure accurate inventory data.		- AMQP: Ensure reliable messaging for automated reordering.
	- GPS modules: Track inventory locations.		- Database systems: Manage inventory data efficiently.
	- Smoke detectors: Ensure safety.		- Notification systems: Trigger alerts for low inventory.
	- Gas sensors: Detect hazardous materials.		
Ensure redundancy and backups for critical raw materials to prevent production disruptions.	- RFID/NFC tags: Monitor critical raw materials.	- RFID/NFC readers: Ensure redundancy.	- MQTT: Real-time monitoring of critical materials.
	- Barcode scanners: Track critical material levels.		- AMQP: Ensure reliable messaging for alerts.
	- GPS modules: Provide location information.		- Database systems: Manage critical material data efficiently.

	- Motion detectors: Ensure security.		- Notification systems: Alert for low inventory of critical materials.
Promote sustainability by monitoring and reporting on water consumption.	- Temperature and humidity sensors: Monitor water-related data.	- Temperature and humidity sensors: Collect water data.	- CoAP: Enable real-time monitoring and reporting of water consumption.
	- Gas sensors: Ensure environmental data.		- Database systems: Store water consumption data.
	- GPS modules: Track emissions sources.		- Visualization tools: Display consumption trends and patterns.
			- Notification systems: Alert for excessive water use.
Track and manage carbon footprints while implementing measures to reduce environmental impact.	- Gas sensors: Monitor environmental conditions.	- Temperature sensors: Track carbon footprints.	- CoAP: Enable real-time monitoring and management of carbon footprints.
	- GPS modules: Track emissions sources.		- Database systems: Store carbon footprint data.
			- AI algorithms: Recommend measures to reduce environmental impact.
Ensure factory worker safety by implementing hazard identification and mitigation protocols.	- Smoke detectors: Detect hazards.	- Flow meters: Ensure fluid safety.	- CoAP: Enable real-time hazard detection and response.

	- Gas sensors: Monitor hazardous materials.		- Notification systems: Send instant alerts for safety risks.
	- Motion detectors: Ensure worker safety.		- Visualization tools: Display incident reports

Best Suited Protocols:

Edge Layer:

- MQTT for lightweight data communication in real-time machine health monitoring.
- OPC UA for interoperability with various sensor devices and collecting machine data.

Fog Layer:

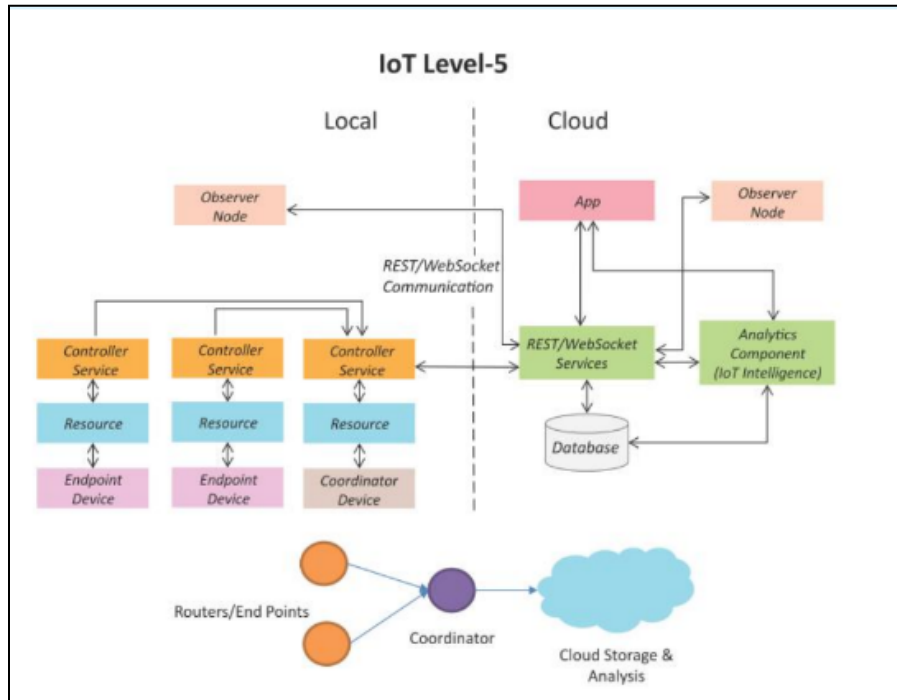
- CoAP for efficient communication with constrained devices in supply chain management and inventory management.
- AMQP for reliable messaging in optimizing logistics, transportation, automated reordering, and inventory updates.
- CoAP for monitoring and reporting on water consumption, as well as tracking and managing carbon footprints for sustainability.
- CoAP for communication with safety sensors and systems.
- AMQP for reliable messaging in detecting and responding to potential safety risks in real-time.

Cloud Layer:

- HTTP/HTTPS for web-based communication with users and management interfaces.
- MQTT or AMQP for communication with the edge and fog layers, depending on specific data transmission and messaging requirements between layers.

Architecture:

Level 5 IoT architecture will be the most suitable for our system.



Sensors/Actuators Required:

Certainly, here's a shorter list of physical sensors and actuators for your IoT application at different layers:

Edge Layer:

1. Vibration sensors
2. Temperature sensors
3. Cameras
4. RFID/NFC tags
5. Barcode scanners
6. GPS modules
7. Smoke detectors
8. Gas sensors
9. Motion detectors

Fog Layer:

1. RFID/NFC readers

2. GPS receivers
3. Temperature and humidity sensors
4. Flow meters

Cloud Layer:

1. MQTT or AMQP brokers
2. HTTP/HTTPS endpoints
3. Database systems
4. Notification systems