IoT Transforms: Study of Mechanical Devices in a Connected World

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Abstract

Internet of Things (IoT) Transforms Mechanical devices into a Digital world like Smart Connected Car, Smart Temperature Tracker (Cooler), Smart Diesel Generator, Smart Water Pump Monitoring/ Smart Starter, Smart Lighting, Smart Chlorination plant, Smart Watch, Smart Home, Smart Asset tracking & other, Assets and plants are playing vital role to grow mechanical, Automobile, Agriculture, Electronics, Electrical, Information Technology & other industries.

Mechanical assets, traditionally standalone and often operating in isolation, have evolved into smart, interconnected systems that can communicate, analyze data, and make informed decisions. This transformation has had a profound impact on various industries, improving functionality, reducing costs, and enhancing overall performance of the system.

In Over-period of time every B2B & B2C are part of IoT integration with Assets/Devices, to analyze the data & operate machines, assets easy way, One single click get last 10 years records, if in the Assets/machine is any modification required then it will easy to detect, Assets informs to user regarding preventive, predictive maintenance & hence cost of maintenance, cost of manpower, time saved.

The collected data is sent to cloud-based platforms where advanced analytics algorithms process and analyze it. This data-driven approach allows for predictive maintenance, performance optimization, and informed decision-making.

Keyword – *Internet of Things (IoT), Smart Assets, B2B: Business to Business, B2C: Business to Customer*.

I. INTRODUCTION

IoT powered technology for smart Asset systems in this using NB-IoT Asset data/health transfer through cloud network to Web Portal, Mobile Application, Email, SMS & Web hook.
Using a single click user will able to get all data & information of Assets which is working anywhere in the world, user can access his asset from Web Portal, Mobile Application etc.
In Mechanical Assets we are analyzing, checking working of Smart temperature tracker & Smart Diesel Generator.

Smart Temperature Tracker (Cooler) is using in Cooling system in the stationary and movable coolers assets, using NB-IoT and Sensors condition of Coolers is capturing and using MQTT protocol, 4G & 5G network & cloud system this data is transferring to the Web Portal & generating a notifications, alerts, events, Email, SMS.
Smart Genset Monitoring solution is a cost-effective solution for OEMs, institutional customers, retail chains, townships and buildings. The 4G enabled telemetry device is powered using edge algorithms for computing energy and fuel consumption to save up to 30% operational expenditure.

It supports integration with fuel sensors, energy meters, control panel and controller along with other sensors. Scalable & secure cloud application empowers customers to monitor thousands of diesel generators in a single dashboard with details on operational efficiency, alerts on fuel pilferages, compromised generators, tampering along with a host of other features.[7]

A. Notification in Smart Temperature Tracker:

Using NB-IoT solution user able to get all data & below notifications.
Power supply On: When Electric supply is ON and Power button is ON then Sensor sensing that event and sending that event to device & using a MQTT protocol eg.”trg”: “PON” this event is sending via cloud to the web browser.

Power supply Off: When Electric supply is OFF and Power button is OFF then Sensor sensing that event and sending that event to device & using a MQTT protocol eg.”trg”: “POF” this event is sending via cloud to the web browser.

Temperature Notification: When in cooler assets temperature changing, Sensor senses that change temperature & accordingly sent it to device & using a MQTT protocol eg.”ht”: “60” this event is sending via cloud to the web browser.
Types of Temperature alerts:
High Temperature Raised
High Temperature Resolved
Low Temperature Raised
Low Temperature Resolved.

Humidity: In ooler assets Humidity changing, Sensor sense that change humidity & accordingly sent it to device & using a MQTT protocol eg.”Hu”: “6.8” this event is sending via cloud to the web browser.

Vibration Sensed Alert: Whenever in the asset vibration detects, Sensor sensing that event and sending it to device & using a MQTT protocol eg.”trg”: “Dro” this event is sending via cloud to the web browser.
Door Open: When user open Asset/cooler door, Sensor sensing that event and sending it to device & using a MQTT protocol eg.”trg”: “Dro” this event is sending via cloud to the web browser.

Door Closed: When user Closed Asset/cooler door, Sensor sensing that event and sending it to device & using a MQTT protocol eg.”trg”: “Drc” this event is sending via cloud to the web browser.

Prolong Door Open: When user open Asset/cooler door & it remains open door long time (that Time is configurable in device), Sensor sensing that event and sending it to device & using a MQTT protocol eg.”trg”: “Prd” this event is sending via cloud to the web browser.

Asset Movement: When Asset/Cooler moving from one point of location to another point of location then Device capturing that Latitude and longitude & Sensor sensing that event and sending it to device & using a MQTT protocol eg.”Loc”: “12.9987, 64.6777” this event is sending via cloud to the web browser.

Sensor Tampered: When Asset/Cooler sensor is tampering then another sensor sensing and sending that data to device & using a MQTT protocol eg.”SenT”:“SenTem_223” this event is sending via cloud to the web browser.

Keyword – Device: A small machine which is storing & processing data that was sense by a sensor.[fig-4]
MQTT: Message Queuing Telemetry Transport
Raised: Which is beyond threshold limit
Resolved: Which is normal threshold limit

B. Notification in Smart Diesel:

Power supply On: When DG is switched ON then Sensor sensing that event and sending that event to device & using a MQTT protocol eg.”trg”: “PON” this event is sending via cloud to the web browser.

Power supply OFF: When DG is switched ON then Sensor sensing that event and sending that event to device & using a MQTT protocol eg.”trg”: “PON” this event is sending via cloud to the web browser.

Fuel Removal: When fuel is removed from Diesel Generator. Sent in ltr then Sensor measures Filled full and Removed fuel, Sending that event to device & using a MQTT protocol eg.”trg”: “FR” this event is sending via cloud to the web browser.

Fuel Fill: When fuel is added in Diesel Generator. Sent in ltr then Sensor measures Filled full and Removed fuel, Sending that event to device & using a MQTT protocol eg.”trg”: “FR” this event is sending via cloud to the web browser.
Fuel sensor disconnected: When fuel sensor wire is disconnected from IoT device or DG battery, then sensor Sending that event to device & using a MQTT protocol eg.”trg”: “FSD” this event is sending via cloud to the web browser.

Fuel Sensor Reconnected: When fuel sensor wire is reconnected, then sensor sending that event to device & using a MQTT protocol eg.”trg”: “FSC” this event is sending via cloud to the web browser.

Fuel below mid-level: When current fuel level is less than threshold value set for mid-level, then sensor sending that event to device & using a MQTT protocol eg.”trg”: “FML” this event is sending via cloud to the web browser.

Fuel level low: When current fuel level is less than threshold
Value set for low-level, then sensor sending that event to device & using a MQTT protocol eg.”trg”: “FLL” this event is sending via cloud to the web browser.

Fuel level normal: When current fuel level is more than threshold value set for mid-level, then sensor Sending that event to device & using a MQTT protocol eg.”trg”: “FNL” this event is sending via cloud to the web browser.

Below are some Engine parameters which shows notification, if sensor sense them, according event. Many IoT Web Portal Business industry showing more than 1000 notification or fault parameters on web portal.

Notification Name	**Event/Engine fault code**
Oil pressure	Ep44
Ambient temperature	Ep77
Water temperature	Ep77
Engine temperature	Et77
Oil temperature	Ep77
Generator L1 Var	Ep55
Generator L2 Var	Ro66
Generator L3 Var	Gt66
Generator total Var	hh66
Voltage R phase	Tt55
Voltage Y phase	hh55
Voltage B phase	Fg55
Voltage RY phase	Gf55
Voltage YB phase	Gg33

C. ***Data showing on Portal or Web browser***

As per user need IoT & Mechanical Industry providing Visualization Main Dashboard (Monitor asset data), Statical reports module and user required settings that help to monitor and analyze or compare old and new statically data, before IoT integration with assets and after IoT integration with assets.

Dashboard:

Dashboard is the overview & visualize for the notification, events, data and Asset/Device status like Power supply On, Power supply off, and Location of asset.
It helps to show the connectivity between device and portal.

Fig. 1. Dashboard (8).

Report:
As per the requirement from the customer/user web portal showing data more than 5 yrs. & user able to see, download & share data monthly, weekly, day basis.
Below are the some Report that mostly using in industry:

1. Asset Notification Report
2. Asset Daily Report
3. Asset History Report
4. Asset Usage Report
5. Asset Geofence Report
6. Asset Live Status Report
7. Fuel Logs Report

Asset Notification Report: Asset Notification Report capturing the in alerts/notification data eg. Asset name, Asset number, Alert Parameter, Alert description, Date & time Alert raised, Date & time alerts resolved, No. of alerts raised, location details etc.

Asset Daily Report: Generally asset daily report shows the Asset number, Total power on duration, total power off duration of asset, date & time, no of alerts, operating temperature (using backend std. formulae) etc.
It helps to user to analyze data and do improvement in various field.
As per the requirement from the customer/user web portal showing data more than 5 yrs. & user able to see, download & share data monthly, weekly.

Asset History Report: Asset History is the similar of daily report, but it mostly focus on Asset level and important Parameter which is required to customer eg. Temperature, Location, Power Status.
The data will give quick overview of assets condition.
User able to get data as per requirement like past 1 yr ago data.

Asset Usage Report: Using this report, user able to get Asset/device duration working and non-working hours.
eg. When device power on & when device power off in between time showing on HH:MM:SS format.

Asset Geofence Report: Asset Geofence report is used to show the Geofence entry & Geofence exit of assets.
It will help user to check device location & help to protect from theft.

Asset Live status Report: Asset live status mostly used to show the live status of assets/devices eg. Power status, location etc.

Fuel Log Report: Fuel Log Report shows, how much lit fuel filled, Fuel consumed & fuel available, to show user efficiency of engine.

Settings:

In-Side Setting user able to perform below operations,

1. Save assets to get the notification from device, if asset not save in portal then connectivity will not show between device & portal.
2. Create a Geofence to get alerts of Geofence entry, exit.
3. Enable Notification as per user requirement.
4. Change user profile.
5. Change threshold and configuration.
6. Switch Off and Switch ON device (It will vary device to device)

*D. **Sensor used in IoT Mechanical Machines:[4]***

Temperature Sensor:
Type: Digital Temperature Sensor (e.g., DS18B20)
Measurement Range: -55°C to +125°C
Accuracy: ±0.5°C
Application: Monitors the temperature inside the cooler to regulate cooling mechanisms.

Humidity Sensor:
Type: Capacitive Humidity Sensor (e.g., DHT22)
Humidity Range: 0% to 100%
Temperature Range: -40°C to +80°C
Accuracy: ±2% RH
Application: Measures humidity levels inside the cooler to prevent moisture-related issues.

Proximity Sensor:
Type: Infrared Proximity Sensor
Detection Range: Adjustable (typically a few centimeters to several meters)
Application: Detects the presence of items in the cooler, allowing for automatic opening/closing or lighting control.
Door Open/Closed Sensor:
Type: Magnetic Reed Switch or Hall Effect Sensor
Application: Detects whether the cooler door is open or closed to avoid unnecessary cooling loss.

Vibration Sensor:
Type: Piezoelectric Vibration Sensor
Sensitivity: Adjustable
Application: Detects unusual vibrations or movements, providing alerts in case of mishandling during transportation.

Light Sensor:
Type: Photodiode or Phototransistor
Spectral Response: Matches human eye sensitivity
Application: Monitors ambient light levels to adjust interior lighting or to assess the cooler's environment.

Compressor Status Sensor:
Type: Current Sensor or Voltage Sensor
Application: Monitors the status of the compressor, indicating whether it's running or not, and helps in predictive maintenance.

Gas Pressure Sensor:
Type: Pressure Transducer
Pressure Range: Suitable for refrigerant pressure monitoring
Accuracy: Depends on the specific sensor model
Application: Monitors the pressure of the refrigerant, aiding in the regulation of the cooling process.

Water Level Sensor (for Evaporative Coolers):
Type: Capacitive or Ultrasonic Water Level Sensor
Measurement Range: Adjustable

Application: Monitors the water level in the cooler's reservoir to prevent dry operation.

Fuel Level Sensor:
Specifications: Capacitance-based sensor.
Working: Measures diesel fuel levels in the tank by detecting changes in capacitance as the fuel level changes.

Engine Temperature Sensor:
Specifications: Thermocouple or RTD sensor.
Working: Monitors engine temperature to prevent overheating, ensuring optimal performance and preventing damage.

Oil Pressure Sensor:
Specifications: Pressure transducer.
Working: Measures oil pressure in the engine, providing critical information for maintaining proper lubrication and preventing engine damage.

Vibration Sensor:
Specifications: Accelerometer.
Working: Detects abnormal vibrations, signaling potential issues with engine or generator components, enabling timely maintenance.
Generator Load Sensor:
Specifications: Current transducer.
Working: Monitors the electrical load on the generator, aiding in load balancing and preventing overloading.

Exhaust Gas Temperature Sensor:
Specifications: Thermocouple or RTD sensor.
Working: Measures exhaust gas temperature, ensuring the engine operates within safe limits and optimizing fuel efficiency.

Smart Connected Cooler:

Fig. 2. Smart Connected Cooler (6).

DG HMI View:
Using HMI on single click user able to get details data of that parameter.

Fig. 3. Smart Diesel generator (6).

Fig. 4. IoT Device (8).

E. ***Working flow[2]***

Device/Controller→ Cloud→ Processor→ API→ Web Portal

- Device Installation:

  Physical Device Installation: Install the IoT devices in the desired locations or on the equipment where they will collect relevant data.

  Electric Power and Connectivity: Ensure that the devices have a stable electric power source and connectivity usually through Wi-Fi, cellular networks, or other communication protocols.

- Sensor Connectivity:

  Sensor Connection: IoT devices are equipped with sensors that capture data related to their environment or the equipment they monitor.

  Data Collection: Sensors collect data on parameters such as temperature, humidity, Asset Movement, Location, or other.

- Data Processing:

  Local data computing: Some IoT devices have the capability to process data locally to reduce latency and filter out irrelevant information.

  Data Nesting: The device may preprocess data, filter out noise, and aggregate information before sending it to the cloud.

- Data Transfer via Cloud:

  Connectivity Protocol: The IoT device uses a communication protocol MQTT, CoAP, HTTP, etc. to transmit the processed data to the cloud or a centralized server.

  Secure Transmission: Data transmission is typically encrypted to ensure the security and integrity of the information.

- Data Storage on Cloud:

  Cloud Data storing: Received data is stored in a cloud-based database or storage system.

  Size latency: Cloud platforms provide good scalability to handle large volumes of data generated by multiple IoT devices.

- Data Processor:

  Data Processor: Cloud based services like event collector, Kafka and analyze the incoming data.

- Action & Show data:

  Notifications: The system triggered notifications for specific events, threshold breaches.

- Integration with Web Portal:

  Application Programming Interfaces: The cloud based system open APIs that the web portal can use to request and receive data.

Web Portal Design & Development: Web portal is developed to visualize and interact with the data. It may include dashboards, Reports, settings and real-time updates.

- User Interaction:

  User Login/Authentication: Users log in to the web portal, often with secure authentication methods eg. Username & Password.

  Visualization of Data: The web portal displaying data in a user-friendly format, allowing users to monitor, analyze, and interact with the Data.

- Reverse Action:

  Actions by User: Users can take actions & make decisions based on the insights provided by the web portal.

  Command to Devices: In some cases, user actions may result in commands sent back to the IoT devices to initiate specific responses or adjustments eg. Power On asset, Power Off asset.

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