Internet of Things for Advanced Manufacturing

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Abstract: *The successful operation of small businesses often hinges on the timely delivery and quality of raw materials for manufacturing processes. This becomes imperative when considering higher-stakes scenarios, such as delivering necessary vaccines, expensive medications, or critical business machine components. The delay or compromise in these deliveries can significantly impact patient health or business functionality in the life science industry. This study introduces a solution that leverages the capabilities of advanced data processing and IoT technologies to optimize supply chain management through the Advanced Manufacturing process, ensuring the timely delivery of superior-quality products and enhancing customer satisfaction. This paper highlights how the proposed curated solution can contribute to small business success and broader stakeholder satisfaction by streamlining the supply chain and improving delivery metrics.*

Keywords: Advanced Manufacturing, Internet of Things (IoT), Life Science Industry, SAP S/4 HANA, Delivery Insights, Supply Chain Management

1. Introduction

In a general sense, the term "Internet of Things" (IoT) encompasses objects or "things" that possess the capability to establish wireless connections to the Internet network. However, the contemporary understanding of IoT more specifically refers to interconnected objects that are equipped with sensors, software, and other sophisticated technologies enabling the transmission and reception of data. This data serves the purpose of informing users or facilitating automated actions. While conventional connectivity predominantly relied on Wi-Fi, the present landscape of IoT is marked by the advent of advanced network platforms, such as 5G, that promise to handle vast volumes of data with remarkable speed and reliability across diverse geographical locations.

Integrating the Internet of Things (IoT) (What is IoT?;[1-3] Industry 4.0 Solutions from SAP) with the advanced data processing platform enriches delivery operations with real-time sensor data, offering a broad, transparent perspective. This sensor data is skilfully embedded into existing systems, ensuring an uninterrupted user experience. The proposed adaptable system configuration detailed in this paper supports various types of sensor data, including temperature, humidity, acceleration, location, and radiation. This permits the creation of numerous use cases, each meticulously tailored to meet individual requirements.

For instance, when the system identifies inconsistent sensor readings, it alerts concerned parties within the platform. Consequently, this provides immediate insight and empowers them to respond proactively to supply situations that may be critical. This feature paves the way to anticipate potential quality issues, enhance on-time delivery performance, and ultimately improve customer satisfaction.

Furthermore, this proposed customized solution, powered by advanced data processing technologies and IoT, facilitates businesses in monitoring and optimizing their supply chain operations. By exploiting these technologies' capabilities, businesses can achieve valuable insights into their supply chain processes. This, in turn, enables them to make data-driven decisions, thereby boosting efficiency and customer satisfaction.

2. Literature Review

Efficient management of delivery scenarios holds significant importance for businesses, as it profoundly influences customer satisfaction and their overall brand image. This section comprehensively addresses key domains, including supply chain management and logistics, customer service and experience, and e-commerce, specifically emphasizing the crucial aspect of last-mile delivery.

Supply Chain Management and Logistics: This body of research [4]explores multiple facets of supply chain management, specifically focusing on transportation and logistics directly associated with delivery situations. By examining these aspects, valuable insights can be gained into managing delivery operations more effectively.

Customer Service and Experience: Understanding customer service and experience is crucial in handling delivery situations. This area of research [5]delves into various strategies for managing customer complaints and improving overall customer satisfaction. By analyzing the intricacies of retail operations related to delivery, such as order fulfillment and customer service, valuable insights can be obtained on enhancing the customer experience throughout the delivery process.

E-commerce and Last-Mile Delivery: The evolving landscape of e-commerce necessitates a closer examination of last-mile delivery, a critical phase in the overall delivery process. This body of literature [6]investigates different aspects of e-commerce, particularly last-mile delivery. By studying these aspects, we aim to identify opportunities for optimizing last-mile operations and enhancing efficiency in the final leg of the delivery journey.

Overall, a holistic understanding can be achieved by synthesizing insights from studies on supply chain

management and logistics, customer service and experience, e-commerce, last-mile delivery, and transportation-related topics, aiding businesses in implementing effective strategies to handle delivery situations and ensure customer satisfaction.

This paper bridges the gap by providing an integrative perspective on supply chain management, drawing from disparate fields such as logistics, customer service, e-

commerce, last-mile delivery, and transportation. It contributes to the extant literature by proposing a robust solution that leverages IoT and advanced data processing technologies. This proposed curated solution powered by S/4HANA and SAP Internet of Things (IoT) presents a comprehensive, real-time view of delivery processes that previous studies had previously ignored. It is intended toguide businesses in honing their strategies, facilitating improved customer satisfaction and delivery performance.

Delivery Insights enabled by IoT for Ordered Items
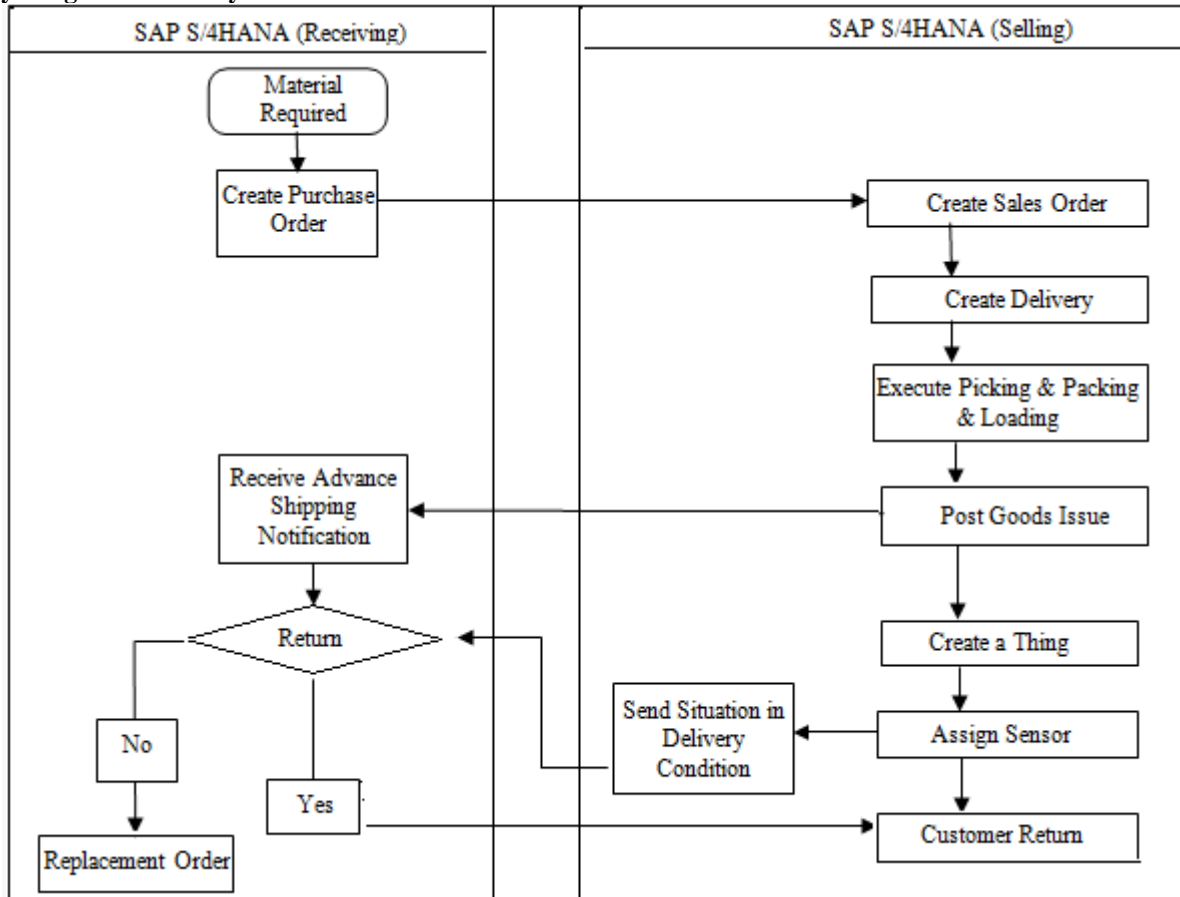
3. Process Flow

- Demand/Material Requirement [7-12] initiates the process.
- Purchase Order [13] is created and transmitted to the Vendor.
- The supplying side generates Sales orders [14].
- Delivery [15] is created for the sales order.
- Warehouse executes picking, packing, and loading [16-17].
- Post Goods Issue is performed.
- A Thing [18] is created.
- Sensor [19] is assigned.
- The situation in the delivery condition is communicated.
- React to the delivery condition.
- Decide whether to return to the customer or
- Request a replacement order.

4. Proposed Solution Steps

4.1 Create a Thing

For monitoring the conditions of, e.g., an Outbound Delivery, the Delivery needs to have a corresponding representation in the form of a "Thing" in SAP Internet of Things. The Thing representing the Delivery needs to be an instance of the Thing Type created while executing the setup instructions of this Scope Item. The IoT concept being examined involves creating a digital twin, a virtual mirror of a real-world business asset capable of replicating its conditions, behaviors, and interactions.

4.1.1 Steps
- Start the Thing Modeler app from the launchpad.
- Choose the desired thing type from the list or use the Search function to narrow down the options.
- Alternatively, select 'Add' at the bottom of the list to define a new thing and specify the desired thing type.

- Once the thing type is selected, its data will load into the details area.
- In the header area, select "New Thing" to open a dialogue box for entering the new thing's details:
- Name: Technical name of the new thing.
- Alternate Name: Optional field for maintaining naming conventions.
- Description: Short description of the thing in natural language.
- Thing Type: Technical name of the derived "Thing" type.
- Authorization Group: Technical name of the authorization group providing access to the referenced thing type.
- Begin the process on the Connectivity tab by selecting the appropriate Provider, typically 'IoT SAP services for SAP BTP for the Cloud Foundry Environment.'
- In the Sensor/Mapping Selection section, choose from the predefined mappings for the associated thing type.
- Select the desired sensor type from the available options related to the chosen mapping.
- Expand the property set entries in the Thing Model or Device Model Mapping table to view individual properties.
- Assign matching properties to the device properties by selecting from the provided list.
- Repeat the above steps for all items requiring device property assignment.
- Save the new thing to finalize the process.

4.1.2. Results

The successful creation and onboarding of the new thing (About SAP IoT Device Connectivity, SAP Online Help) entail its configuration as a digital twin of a physical device and establishing a connection to that device. Additionally, the user interface showcases two closely associated elements that indicate the onboarding outcome for the thing.

4.2 Assigning Sensor

For receiving and processing sensor values in the SAP Internet of Things, connecting the Thing created in the previous step with a supported Connectivity (Create a thing with sensor assignment, SAP Online Help) Provider is necessary. The Sensor created within SAP Internet of Things, as delineated during the setup of this Scope Item, will be utilized.

4.2.1 Steps

- Within the Thing Modeller, focus on the recently established Thing and navigate to the 'Connectivity' section.
- Select the "SAP S/4HANA Cloud Platform IoT Service for Cloud Foundry Environments" provider.
- Select the Mapping entry that was created as part of the Thing Type configuration during the setup instructions of this Scope Item (e.g., Acceleration Sensor Mapping).
- Click on the value help button in the field below the Mapping and select the suitable Sensor from the Cloud Platform Internet of Things for the Cloud Foundry Environment, previously established during the setup instructions of this Scope Item.

- Verify the correct Property mapping in the lower part of the screen and save the changes.
- Confirm that the assignment between the Thing ID and Sensor ID is reflected in the Connectivity Information, which is represented by a small power plug icon in the upper right-hand corner. The plug icon should appear as "plugged in," and both IDs should be mentioned in the pop-up dialog when selecting the icon.

4.2.2. Results
The sensor will be assigned to a Thing.

4.3 Detect Issues in Delivery Conditions

For detecting issues regarding the acceptable condition of an Outbound Delivery and automatically triggering the creation of a situation in SAP S/4 HANA, respective IoT sensor readings must reach SAP Internet of Things. To achieve this, the sensor assigned to the newly created Thing as part of the previous step acts as an endpoint for IoT data ingestion. Note: To eliminate the need to integrate physical IoT sensor hardware, respective sensor data incl., including a critical condition, can be simulated as described below.

4.3.1. Steps
- Send a simulated IoT sensor data message that contains properties and measure values suitable to fulfill all conditions for triggering the Rules and Actions in SAP Internet of Things that were defined when executing the setup instructions of this Scope Item (e.g., send a simulated sensor value for Property "Acceleration" which is above 10G).
- Execute the following to simulate IoT sensor data in case the Device is assigned to Gateway Cloud MQTT (like in this example solution shown in the setup instructions of this scope item).
Example:
Client ID: **DEV200**
Subscription Topic: **ACK**
Publication Topic: **measures/220985**
Payload:

{
"capabilityAlternateId": "handling_unit_condition,"
"sensorAlternateId": "220985",
"measures": [{
"Acceleration": "15.67"
}]
}

- Confirm the successful arrival of the simulated measure in the Internet of Things Service Cockpit within the Cloud Platform Internet of Things for the Cloud Foundry Environment.
- Within the device's 'Data Visualization' segment, the transmitted value from the previous step (e.g., 15.67) should be visible.
- Verify the correct forwarding of the simulated measure to SAP Internet of Things by accessing the previously created Thing using the Thing Modeler.
- In the 'Measured Values' tab, locate the ingested value associated with step 1 (e.g., 15.67) in the 'Value' column corresponding to the specific property. Navigating to the accurate property set may be necessary to display the respective property and its corresponding value.

- The Situation Trigger Object and Anchor Object encompass technical configurations that determine the object for which a situation is displayed (anchor object) and the object that triggers the situation (trigger object).
- The solution proposed in this paper leverages the SAP situation Template ID:
- PROC_POITEM_DELIVERY_IOT_EVENT (Delivery Insights for Ordered Items, SAP Online Help, Manage Purchase Orders, SAP Online Help). This template, devised for Situation Handling, has a dedicated interface with the "Manage Purchase Orders" Fiori tile. The value proposition of this solution is its ability to notify purchasers if goods are compromised during transit, utilizing data from SAP IoT sensors. The SAP IoT service empowers establishing benchmark values for sensors attached to handling units. Upon detecting sensor readings deviating from these pre-established norms, the system initiates a situation protocol, subsequently triggering notifications to the purchasers. This mechanism facilitates real-time responses to impending issues, enhancing overall supply chain resilience.

Trigger Object: R_IOTSITUATIONTRIGGER (trigger for IoT-based situations)

- Anchor Object: I_PURCHASEORDERITEMAPI01 (purchase order item
- Description: The situation is triggered when the SAP IoT service raises a new critical situation.
- Conditions: The template (SAP IoT Integration Scenarios, SAP Online Help) delineates a 'situation' exhibiting an 'Open' status, triggered upon detecting a critical event during delivery by SAP IoT sensors. This template provides several filtering parameters, including but not limited to Material, Handling Unit, or Plant. An instance of its utilization could involve the application of a plant-specific filter, ensuring the activation of situation alerts exclusive to the selected plant. This level of customization offers a degree of specificity and control that can be tailored according to the unique operational requirements of an organization.

4.3.2. Results
- Results: Simulation completed and detected the issue in delivery.

4.4 React on Issue in Delivery Condition

If the simulated data from the IoT sensors successfully reachthe SAP S Internet of Things and triggers the relevant Rules and Actions, SAP S/4HANA Cloud automatically generates a new Situation based on IoT inferences. The Situation includes details about the specific issue and a reference to the related Business Object in SAP S/4HANA Cloud. The specifics of the Situation are determined by the configuration performed during the setup instructions of this particular scopeitem.

4.4.1. Steps
- Initiate a review of the newly created situation via SAP Internet of Things using the applications 'My Situations' or 'Monitor Situations' (Monitor Situations, SAP Online Help). Alternatively, receipt of a corresponding notification in the Notification Area can instigate this review process.
- Evaluate the concise description and the detailed context of the new situation to discern the discrepancy in the delivery condition that led to the creation of this situation. For instance, a significant positive acceleration measured by the sensor assigned to a specific delivery might indicate that the handling unit experienced a fall during shipment, potentially damaging the shipped goods.
- Execute a manual follow-up on the situation by conducting necessary business actions. This could involve contacting the affected business partner or initiating a replacement order within the SAP S/4HANA Cloud environment.
- Update the status of the new situation after performing necessary business actions, thereby maintaining an accurate record of situation handling.
- Preemptive Supply Chain Management: The solution predicts potential supply chain disruptions in advance, enabling users to minimize risks and disruptions proactively.
- Quality Control: The solution anticipates potential quality issues by leveraging IoT sensor data, ensuring adherence to high standards and customer satisfaction.
- Optimized Delivery Performance: The solution harnesses IoT sensor data insights to enhance delivery performance through efficient resource distribution and route optimization.
- Progress with the regular billing or return process, ensuring business continuity despite the detected situation.

4.4.2. Results
The subsequent action can involve proceeding with the standard billing procedure or initiating a product return process.

5. Conclusion

This study presents a curated solution powered by S/4HANA and IoT, with significant potential to revolutionize various dimensions of supply chain management through advanced manufacturing. The potential benefits are as follows:

- Augmented Visibility: It bestows an all-encompassing, transparent overview of the delivery process, thus facilitating superior tracking and monitoring capabilities.

- Instantaneous Insights: By exploiting IoT sensor data, the system avails real-time insights, thereby endorsing immediate, evidence-based decisions and actions.

- Streamlined User Interface: The solution's interface, infused with IoT sensor data, assures a streamlined experience in managing and observing deliveries.

- Intelligent Alerts: Integrating a sophisticated notification system sends alerts about important events, enabling users to address issues proactively, thus ensuring smooth operations.

- Elevated Customer Satisfaction: Through the amalgamation of increased visibility, preemptive supply chain management, and punctual deliveries, the solution significantly enhances customer satisfaction, leading to robust business relationships and repeat business.

This solution enables organizations to optimize their delivery processes, reduce potential risks, and deliver a superior customer experience. Ultimately, this translates to enhanced operational efficiency and business prosperity.

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