AGENTIC AI-DRIVEN DIGITAL TWIN FOR PROCESS MONITORING

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Introduction

Manufacturing plants generate overwhelming volumes of data across heterogeneous sources. This imposes substantial cognitive demands on human employees. An intelligent decision-support system, which aligns with human-centric goals of industry 5.0, is required to assist in monitoring, diagnosis and optimization of operations. Despite LLMs' significant reasoning capabilities, their application in industrial settings is often hindered by a lack of site-specific context, leading to unreliable outputs. This study proposes an Agentic-AI framework that combines LLMs with the Digital Twin based on Retrieval-Augmented Generation (RAG) architecure. The results demonstrated that grounding the LLMs in digital twin significantly improves its reasoning capabilities over complex manufacturing logics, resulting in actionable, plant-specific insights.

Methodology

System Overview: This study presents a RAG-based agentic AI workflow designed for a real-world manufacturing facility as shown in Figure 1. The architecture integrates an LLM-driven AI agent with a Digital Twin (DT) to facilitate context-aware intelligence. This system is desgined to support users across production, maintenance and quality assurance roles. The agent acts as the autonomous reasoning engine, orchestrating tool execution and dynamic data retrieval based on different user roles and queries. The DT serves as the knowledge base, mapping plant entities and their semantic relationships to ensure all outputs are grounded in physical reality.

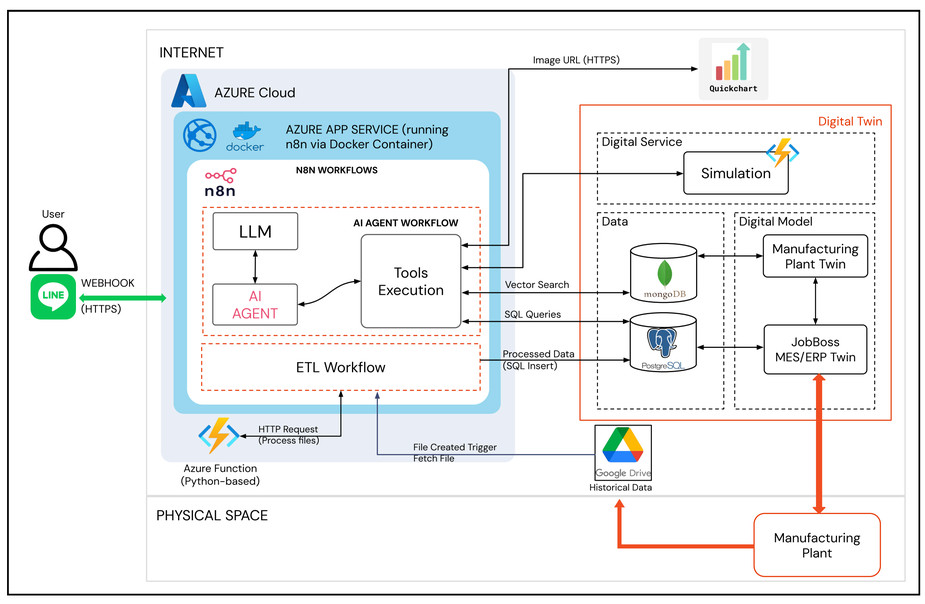

Figure 1: Overall System Architecture

Digital Twin Environment: Digital Twin accurately models both physical and logical entities along with their interactions within the manufacturing plant. The DT is further enriched via data mapping to various sources of plant data. This serves as a knowledge base for the AI-Agent, enabling it to perform reasoning over plant-specific context instead of generic information. Simulation service leverages historical data-driven parameters to predict production outcomes.

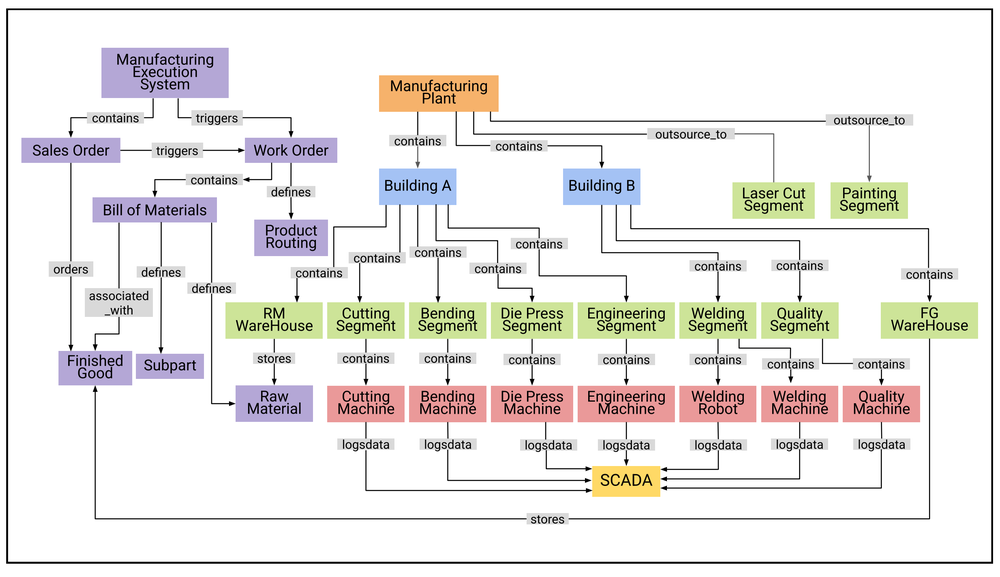

Figure 2: Digital Twin Design of A Manufacturing Plant

Agentic AI Workflow: User queries via LINE are processed by a containerized n8n instance on Azure, where an LLM-powered AI agent dynamically formulates plans without relying on rigid scripts. As shown in Figure 3, this workflow utilizes a RAG architecture: pulling structured MES/ERP data from SQL databases and digital twin model from vector database. The LLM augments the prompt with this precise context to generate informed responses. The agent can also trigger API calls to deliver visual charts and simulation guidance based on the user's needs.

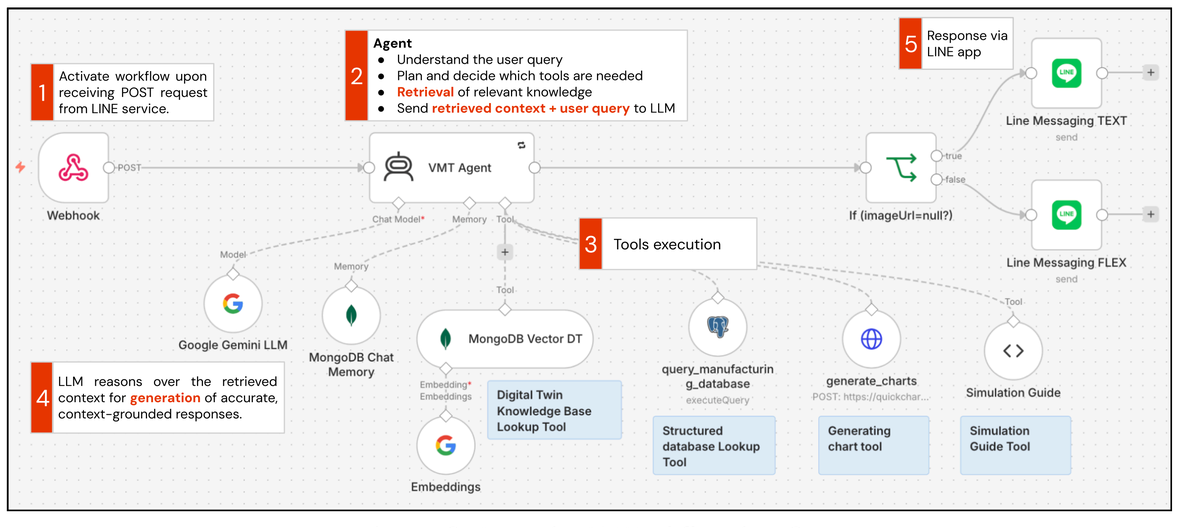

Figure 3: Agentic AI Workflow in n8n

Results and Discussion

Response accuracy was validated by comparing agent outputs with database records and manual calculations. Digital twin facilitated the Agent's understanding of both physical entities and logical flow of data within this manufacturing environment. This enabled the Agent to traverse multiple database tables to retrieve relavent information and formulate its responeses accurately.

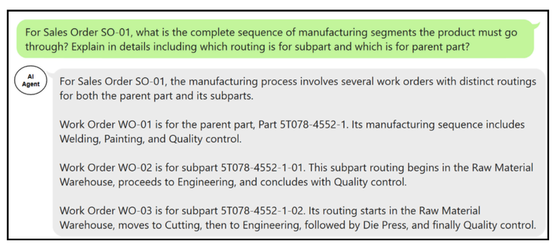

Figure 4(a): Testing agent's response on production related question

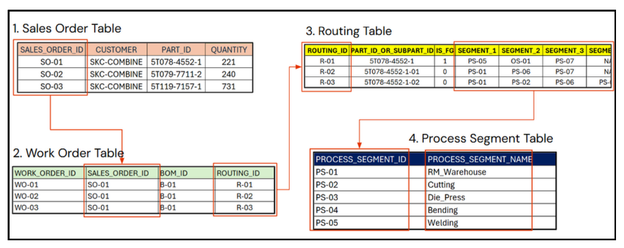

Figure 4(a): Verifying agent's response by comparing it with database tables

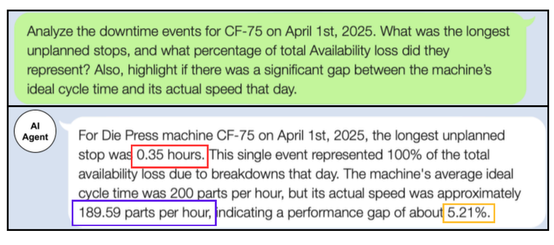

Figure 5(a): Testing agent's response on maintenance related question

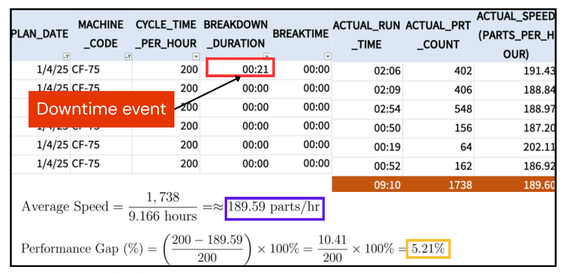

Figure 5(b): Verifying by manual calculation

Conclusion

This study demonstrates that integrating Agentic AI with a high-fidelity Digital Twin enables reliable, context-aware reasoning. The system could interprets manufacturing logics and navigate complex datasets. This enables natural langauge interaction with the data from multiple sources, effectively reducing cognitive load and supporting decision making.

References

[1] M. S. Gill, et. al, "Leveraging LLM Agents and Digital Twins for Fault Handling in Process Plants," arXiv preprint arXiv:2505.02076, 2025.
[2] J. Vyas et. al, "Autonomous Control Leveraging LLMs: An Agentic Framework for Next-Generation Industrial Automation," arXiv preprint arXiv:2507.07115, 2025.
[3] A. Timms, et. al, "Agentic AI for Digital Twin," in Proc. AAAI Conf. Artif. Intell., vol. 39, no. 28, 2025, pp. 29703–29705.