Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 32 No. 4s (2025)

IoT Data Optimization for Creating Interfaces using Chatbots on Industrial Data

Dr. Priyanka G. Jaiswal[1], Prachi Dhabade[2], Amey Dhote[3], Aniket Dubey[4], Harshal Patil[5], Neha Madavi[6], Nidhi Rahangdale[7]

[1,,3,4,5,6,7]Dept. of Information Technology Yeshwantrao Chavan College of Engineering, Nagpur

[2]Research Assistant, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Sawangi(M), Wardha.

Article History:

Received: *30-09-2024*

Revised: *28-11-2024*

Accepted: *09-12-2024*

Abstract:

This research paper explores the integration of Industrial Internet of Things (IoT) data to develop an innovative AI chatbot tailored for the industrial sector. The chatbot aims to optimize resource allocation, minimize downtime through proactive predictive maintenance, enhance energy efficiency, and provide real-time data insights. By leveraging this technology, the primary objective is to drive a transformative shift in manufacturing processes, fostering greater efficiency, sustainability, and cost-effectiveness. The research underscores the transformative potential of the AI chatbot across critical domains such as resource management, predictive maintenance, energy optimization, and analytics, emphasizing its impact on industrial operations. By analyzing existing solutions and rationale behind the chosen approach, the study elucidates how our proposed chatbot solution enhances performance and addresses key imperatives for success. Through effective implementation this solution not only yields immediate benefits but also lays the groundwork for future advancements in the field.

Keywords: Internet of Things (IOT), chatBot, Industry data, optimization.energy,prediction,analysis

1. Introduction

The manufacturing sector has always been a bulwark of advancement and innovation, always modifying to satisfy the demands of a constantly shifting global environment. The industry has reached a new level of production and efficiency in this era of Industry 4.0 because of the convergence of technology, data, and automation. The Industrial Internet of Things (IIoT) and Artificial Intelligence (AI) are leading this revolution together. Our study examines a novel advancement in this field—an AI chatbot created especially for the manufacturing sector and built to maximise the potential of IoT data.

The manufacturing industry is about to undergo a significant transformation, making real-time insights and data-driven analysis more important than ever.This AI Chat Bot is a game-changer for the factory environment, with a host of features including real-time monitoring, predictive maintenance, energy-saving suggestions, and insightful analysis. These insights enable manufacturing companies to optimise their processes, save operating costs, and preserve their competitive advantage in a constantly changing sector. The potential impact is nothing short of reinventing factory operations.

The main goal and aims of our AI chatbot for the manufacturing sector are described in this paper. The principal objective is to transform the manufacturing sector through the optimization of productivity, durability, and affordability.

Chatbots are AI-powered systems designed to simulate human conversation. Early research by Weizenbaum (1966) with ELIZA highlighted the potential for conversational agents, while more recent advancements in machine learning (ML) and NLP have enabled the development of highly interactive and domain-specific bots. Chatbots are increasingly being adopted across industries for customer service, sales, and internal operations. Manly chatbots are categorized into following two categories:

Rule-Based Chatbots: Operate on predefined scripts and decision trees (Abdul-Kader & Woods, 2015).

AI-Driven Chatbots: Leverage NLP and ML to understand context and generate dynamic responses (Luo et al., 2019)

Apart from this Modern chatbots rely heavily on NLP for understanding user queries and ML for predictive responses. Techniques commonly discussed in the literature include:

Tokenization and Parsing: Breaking down text into smaller components for easier processing (Manning et al., 2008).

Embeddings: Representing words in vector space to capture semantic meaning (Mikolov et al., 2013; Devlin et al., 2019 with BERT).

Transformer Models: Models like GPT and T5 demonstrate state-of-the-art performance in generating coherent and context-aware responses (Vaswani et al., 2017).

Industry-specific chatbots leverage proprietary datasets to fine-tune models. For instance, healthcare bots require domain-specific embeddings (Zhang et al., 2020), while financial chatbots integrate sentiment analysis to interpret market trends (Nassirtoussi et al., 2014).

1.1 Problem Description

Senselive, a fast-paced manufacturing business, has a lot of challenges when it comes to efficiently using the enormous volume of data produced throughout its operations to make well-informed decisions. Real-time information gaps impede timely decision-making and process optimization attempts when dealing with data from several sources, such as production measurements and machinery sensors. An inventive solution that can gather, analyze, and show IoT-generated data in a comprehensive manner is essential to overcoming hese obstacles. As a result, creation of a chatbot using their industrial IoT data appears to be a viable path to achieve operational excellence and maintain its leadership position in its sector.

2. Literature Review

Language processing (NLP) and deep learning, does reshaping user interactions and technology Contextual understand, product in particular, to identify human requests and provide customized responses, especially when dealing with domain-specific asking questions; Using Rasa, an open chatbots-enabled machine Learning platform, this paper investigates effective chatbot design. Specifically, it examines the impact of RASA during an epidemic, highlights its practical role in providing personal information to employees, and demonstrates organizational value.[1]

Chen , etal [2] presented a paper on the project which explores the role of artificial intelligence (AI) in manufacturing, focusing on a chatbot specifically designed for mechanoid robots to help users simulate assembly tasks. The proposed solution uses visual information using YOLO-based Masker with CNN (YMC) model and uses Autoencoder for multi-modal feature encoding The tests reveal a significant performance improvement, and happen the potential of these techniques to enhance AI-powered chatbots for effective assistance in building highlight events.[2]

Mukherjee, etal [3] presented a study on ImpactBot, a chatbot developed to improve critical thinking while creating impact statements for research projects. Recognising the shortcomings of conventional statements, ImpactBot employs two fine-tuned RoBERTa models to motivate researchers to examine both positive and negative consequences. A case study including five industry researchers and seven academic scientists evaluates the chatbot's effectiveness in promoting talks about negative repercussions and mitigation options. ImpactBot should be integrated into content management or paper submission systems to dynamically involve academics in refining project narratives and ensure a more full assessment of technical consequences, according to the suggested strategy. ImpactBot contributes to the responsible development of technology by filling gaps in current impact statement practices.[3]

Sharma, etal [4] presented the study which emphasises the importance of updated maritime education and training to accommodate technological developments and rising digitalization. It investigates the possibilities of artificial intelligence (AI), notably chatbots, in increasing efficiency and developing competency. The study outlines the development and deployment of "FLOKI," a chatbot designed to aid maritime trainees in understanding Collision Avoidance Regulations (COLREGs). The chatbot was created using IBM Watson Assistant, a cognitive computing service. The System Usability Scale (SUS) was used by a group of 18 second-year B.Sc. Nautical Science students at a Norwegian maritime institution to provide insights into their user experience. The findings and their implications for artificial intelligence in maritime education and training are reviewed, providing useful insights for future research areas.[4]

Li, J., etal [5] presented a paper which proposes a novel chatbot-server programming framework for students to learn Artificial Intelligence (AI) by creating gaming AI chatbot applications. The framework has a networked frontend-backend structure (client-server paradigm), which allows students to post their work on social media and enable real players to test-drive the game AI, gaining vital data for machine learning model training through crowdsourcing. The suggested architecture enables online AI learning, introduces full-stack software development, and promotes progressive machine learning education, with a focus on the actual application of AI ideas in game creation.[5]

Adamopoulou, etal [6] presented a literature review which examines the History, Technology, and Applications of Natural Dialogue Systems, with a particular focus on chatbots. It serves as a basic resource for future chatbot research. The historical progression is described, with limitations highlighted at each level, and then a detailed classification system is presented. The paper digs into an examination of two main implementation technologies: pattern matching and machine learning. A generic architectural design is also provided, emphasising essential aspects prior to system design. The study investigates chatbot applications and industrial use cases, addressing hazards and recommending mitigation techniques. The conclusion summarises the authors' views on the future path of technology to improve chatbot intelligence.[6]

Kooli, etal [7] provided the study which investigates the rising era of education and research powered by chatbots and artificial intelligence, focusing on the ethical concerns related with their use. The study used a qualitative technique to undertake exploratory research through expert analysis, evaluating data to thoroughly analyse potential issues. The study explores the benefits and drawbacks of AI systems and chatbots, with an emphasis on their function in augmenting human knowledge and judgement. Ethical issues, including possible misuse and exploitation, are discussed, along with recommended remedies. The study recognises technology innovations' transformational influence on research and education, notably in evaluation methodologies. It emphasises the importance of adapting to this new reality, emphasising the importance of cohabitation, sustainability, and continual adaptation. [7]

Caldarini, etal [8] provided the paper on the poll which goes into the world of chatbots, which are clever conversational computer systems that may simulate human speech to provide automated online advice and help. Chatbots, which are widely used across businesses, provide virtual support to clients, capitalising on the benefits they provide. Chatbots have made recent improvements by using techniques from Natural Language Processing and Machine Learning within the subject of Artificial Intelligence. The study examines these advances, offering insight on the problems and constraints associated with their implementation. It evaluates existing work critically, highlighting important obstacles, and closes with recommendations for future study to solve these concerns and advance the area.[8]

Silva, etal [9] delivered the study delves at the underserved landscape of chatbot technology in primary care. Chatbots, which are AI programmes that simulate human communication, have received substantial interest in a variety of industries, but their specialised applications in primary healthcare have received little attention. The research seeks to give a complete evaluation of current technological breakthroughs and applications in this sector,

with an emphasis on recent improvements and the introduction of an application density map. The study categorises these advances and uses, providing insights into the characteristics of healthcare-focused chatbots. It also discusses future study goals in this subject, making it a helpful resource for healthcare researchers seeking a thorough grasp of chatbot technology.[9]

Wang, J., etal [10] presented a systematic review of the literature focusing on the growing trend of chatbots in service businesses, education, and daily life. The study focuses on highly cited publications in chatbot-related human behaviour research in order to uncover emerging trends and crucial research concerns. The top 100 most referenced articles show a trend towards suggesting novel conversation tactics and comparing various modalities of human-human online talks and human-chatbot interactions. The study focuses on improving the efficacy of internet communication.

Specifically, research has focused on high-level statistical performance, system creation, and testing. Furthermore, the analysis emphasises the use of chatbots in education, indicating significant potential to improve the learning process and outcomes.[10]

3. Methods

3.1 About Dataset

The dataset used in this study is intended to aid in the creation and testing of an artificial intelligence (AI) chatbot specialized for the manufacturing sector. The dataset is made up of real-time data from the Industrial Internet of Things (IoT) environment, with an emphasis on three main aspects: power consumption, live voltage, and power factor.

Fig 1 : Data format

The dataset contains attributes like Live voltage data, energy consumption data, power factor data etc. which tells about the current power consumption. Due to some security constraints dummy snapshots of data are created to illustrate basic working fundamentals.

3.1.1 Data Tables:

A) Power Consumption Data

This table contains data on power usage in the manufacturing environment. Timestamps, device IDs, and power usage values are examples of key characteristics. The dataset attempts to give information on the energy consumption trends of various devices or equipment.

B) Live Voltage Data

This table contains real-time voltage readings from various devices or components of the production equipment. The dataset's goal is to provide a comprehensive picture of voltage changes and trends.

C) Power Factor Data

This table contains information on the power factor values connected with various equipment or machines in the industrial environment. Understanding the power factor is essential for improving energy efficiency.

Potential Research Applications:

- Design and testing of AI chatbots for real-time monitoring and analysis of industrial processes

- Energy optimisation research in the industrial business.
- The study of relationships and trends between power consumption, live voltage, and power factor.

This dataset is an excellent resource for academics interested in investigating the interaction of AI chatbots, industrial processes, and Industrial IoT data.

IV. METHODOLOGY

3.1.2 AI Chatbot Development

The development of the AI chatbot involved a series of steps leveraging Amazon Web Services (AWS) components, including Amazon Lex, S3, and Lambda functions. The following details the methodology employed for designing, training, and implementing the chatbot :

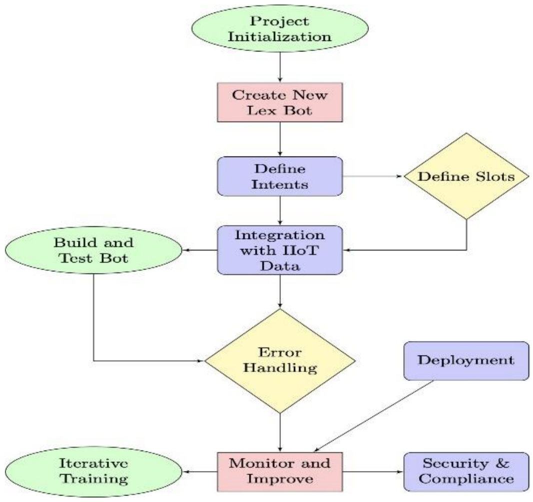

Fig 2 : Flowchart of work done

1. ***Amazon Lex for Natural Language Processing (NLP):***

Amazon Lex, a service for building conversational interfaces, was employed for its advanced NLP capabilities. This facilitated the chatbot's understanding of complex manufacturing queries through the creation of multiple intents, each representing a different type of user interaction.

2. ***Training Datasets*:**

Diverse datasets related to manufacturing processes were utilized to train the chatbot. These datasets covered a range of queries, allowing the chatbot to effectively respond to various user inputs related to production, equipment, and resource management.

3. ***Machine Learning Algorithms:***

The chatbot's backend incorporated machine learning algorithms provided by Amazon Lex to continuously improve its understanding and responses. These algorithms enabled the chatbot to adapt to changing patterns and user behavior over time.

4. ***Lambda Function for Integration:***

AWS Lambda functions played a pivotal role in connecting the chatbot with the manufacturing data.

Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 32 No. 4s (2025)

A Python-based Lambda function was developed to handle the invocation of the chatbot and manage the integration with the Industrial Internet of Things (IIoT) data.

3.2 Chatbot Architecture

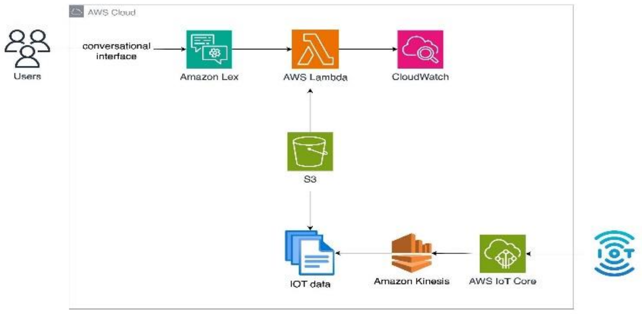

Fig 3 : Chatbot architecture

This architecture for a chatbot illustrates the complete flow of how users will interact with a particular AWS service and how multiple AWS services work in synergy to provide accurate output.

3.2.1 Integration with IIoT Data

The AI chatbot seamlessly integrates with IIoT data through the following mechanisms:

1. Data Storage in S3 Bucket:

An Amazon S3 bucket was selected as the repository of industrial data, which was precisely formatted in CSV files. This decision to use a cloud-based storage solution expedited the whole lifecycle of managing real-time data generated by the dynamic manufacturing environment. This digital reservoir's strategic placement within the Amazon S3 infrastructure guarantees effective retrieval procedures. Because of the dynamic nature of manufacturing, a storage solution that smoothly handles the steady input of real-time data is required, and Amazon S3's capabilities precisely match this demand. In essence, using this cloud-based storage option strengthens the system's capacity to handle and harness large amounts of time-sensitive industrial data efficiently.

2. Chatbot Invocation:

When a user interacts with the chatbot, the associated intent triggers the Lambda function. The Lambda function acts as a bridge between the chatbot and the IIoT data stored in the S3 bucket .

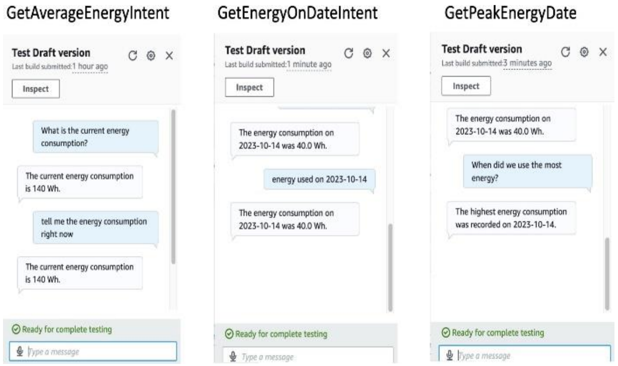

Fig 4 : Invocation of Chatbot

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ISSN: 1074-133X
Vol 32 No. 4s (2025)

The Lambda function processes the utterance, executing custom logic to retrieve, analyze, or manipulate the relevant IIoT data. This seamless integration enables the chatbot to provide accurate and real-time responses to user queries, leveraging the wealth of information stored within the IIoT infrastructure. Through this orchestrated flow, users can effortlessly interact with the chatbot, gaining valuable insights and updates from the IIoT data ecosystem.

3. ***Lambda Function Implementation****:*

By handling the dynamic process of obtaining, preparing, and smoothly integrating real-time data, the Python-based Lambda function serves a critical role inside the chatbot system. This comprehensive function guarantees that the chatbot's replies are always up to date with the most recent information. The Lambda function dramatically improves the correctness and dependability of the chatbot's replies by actively retrieving and preparing up-to-date data.

This constant real-time data flow enables the chatbot to remain informed and responsive, eventually leading to an enhanced user experience characterized by relevance and timeliness.

The continuous real-time data flow empowers the chatbot with instant information, ensuring prompt and relevant responses. This dynamic stream enables the chatbot to adapt swiftly to user inquiries, enhancing the overall user experience. By seamlessly integrating real-time data, the chatbot becomes an indispensable tool, providing users with timely insights.

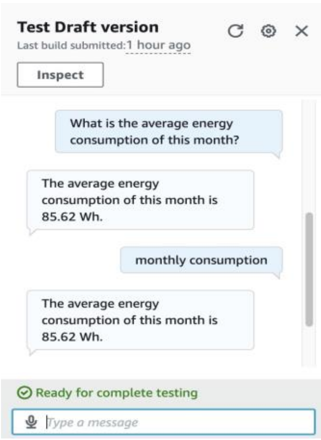

Fig 5 : Chatbot invocation through GetAverageEnergyIntent

```
def get_average_energy(data):

    total_energy = 0.0
    count = 0

    for entry in data:
        energy = entry['kwh']
        try:
            energy_value = float(energy.split()[0])
            total_energy += energy_value
            count += 1
        except (ValueError, IndexError):
            continue

        if count > 0:
            average_energy = total_energy / count

    return average_energy
```

Fig 6 : Implementation of Lambda Function

The AI chatbot exhibits a remarkable capacity to offer well-informed replies by employing a complete integrated strategy that leverages the capabilities of several AWS services. This is accomplished by building a symbiotic link between sophisticated technology and the industrial sector via a smooth and efficient interface with Industrial Internet of Things (IIoT) data. The incorporation of AWS services not only strengthens the chatbot's technological capabilities, but also increases its efficacy in traversing the complexities of real-time data from industrial operations. The combination of AWS services with IIoT data not only improves the chatbot's efficacy but also positions it as a strategic asset in the industrial sector's quest of operational excellence and informed decision-making.

4. Results **and Discussion**

4.1 Chatbot Features

A) Real-time Monitoring

The AI chatbot excels in real-time monitoring capabilities, actively observing and analyzing ongoing manufacturing processes. Leveraging Amazon Lex's conversational abilities, the chatbot interacts with users, triggering requests for real-time data. The integration with AWS services enables the chatbot to seamlessly retrieve live data from the S3 bucket.

Mechanism :

1. *User Interaction:*

Users can inquire about the current status of machinery, production rates, or any specific parameter of interest.

2. *Data Retrieval:*

The chatbot triggers the Lambda function, which fetches the relevant real time data from the S3 bucket.

3. *Analysis:*

The retrieved data is analyzed instantly, allowing the chatbot to provide users with up-to-the-minute insights into production activities.

Benefits:

Quick Decision-making:

Real-time monitoring empowers manufacturing stakeholders to make informed decisions promptly, responding to dynamic changes on the production floor.

B. Predictive Maintenance

The chatbot employs predictive maintenance strategies to forecast potential equipment failures or maintenance needs. By analyzing historical and real-time data, the chatbot can anticipate issues before they escalate, reducing downtime and optimizing operational efficiency.

Mechanism:

1. *Data Analysis:*

The chatbot continuously analyzes historical maintenance data stored in the S3 bucket, identifying patterns indicative of potential issues.

2. *Predictive Analytics:*

Machine learning algorithms, integrated into the chatbot, predict future maintenance requirements based on ongoing and historical trends.

3. *Alerts and Recommendations:*

The chatbot delivers alerts to relevant personnel and provides proactive maintenance recommendations to mitigate potential disruptions.

Benefits:

Minimized Downtime:

Predictive maintenance helps in addressing issues before they lead to equipment failures, minimizing downtime and optimizing resource utilization.

C. Energy-saving Suggestions

The chatbot actively contributes to energy optimization within the manufacturing environment. By analyzing power consumption, live voltage, and power factor data, the chatbot generates specific suggestions to optimize energy usage.

Mechanism:

1. *Data Analysis:*

The chatbot accesses and analyzes power-related data from the S3 bucket, considering power consumption, live voltage, and power factor values.

2. *Energy Efficiency Algorithms:*

Utilizing machine learning algorithms, the chatbot identifies opportunities for energy savings and efficiency improvements.

3. *Recommendations:*

Based on the analysis, the chatbot provides actionable suggestions for optimizing energy consumption, promoting sustainable manufacturing practices.

Benefits:

Cost Savings:

Energy-saving suggestions contribute to reduced operational costs, aligning with sustainable and environmentally conscious manufacturing practices.

D. Insightful Analysis

The chatbot possesses robust analytical capabilities, conducting in-depth analysis of manufacturing data trends. It goes beyond simple data retrieval, offering insights into patterns, correlations, and areas for process improvement.

Mechanism:

1. *Advanced Analytics:*

Leveraging machine learning and statistical analysis, the chatbot identifies patterns and correlations within the manufacturing data.

2. *Customized Insights:*

The chatbot tailors its responses to provide customized insights based on user queries, offering a nuanced understanding of the manufacturing landscape.

3. *Continuous Learning:*

The chatbot continuously learns from user interactions, refining its analytical capabilities over time.

Benefits:

Process Optimization:

The insightful analysis provided by the chatbot supports manufacturing companies in optimizing processes, identifying areas for improvement, and enhancing overall operational efficiency.

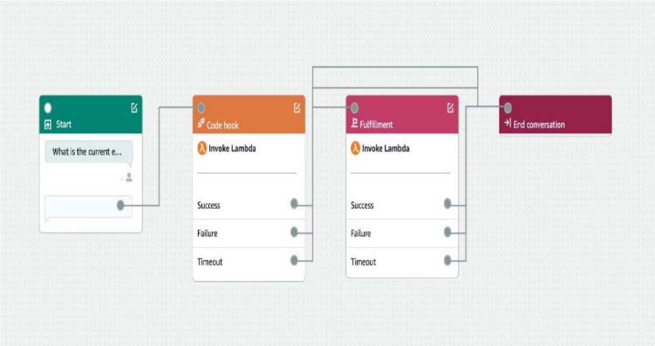

Fig 7 : Experimental Results

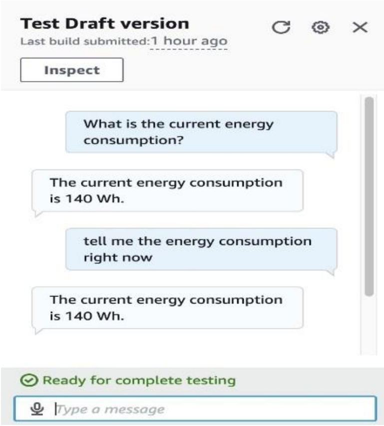

Fig 8 : Experimental output

After assessing the created chatbot, it was clear that it was effective at communicating with consumers and providing precise answers by utilizing Industrial Internet of Things (IIoT) data. After extensive testing, the chatbot was able to work with the IIoT infrastructure without any issues, giving users instant access to pertinent data that was kept in the S3 bucket. The visuals presented effectively demonstrate the responsiveness and dependability of the system through the user interactions and chatbot responses. In the end, this study demonstrates how the chatbot may improve user-to-user communication and provide them the confidence to make wise decisions in manufacturing environments.

4. Conclusion

In conclusion, there are a number of advantages to the creation and application of this AI chatbot in the industrial

sector that make use of components from Amazon Web Services. Real-time monitoring, less downtime, cost savings, and process improvement have all been made possible by the chatbot's predictive maintenance techniques, energy-saving recommendations, and perceptive analysis.

Current information for well-informed decision-making has been effectively provided by the IIoT data storage in S3 and the smooth connection with AWS services. The solution's successful implementation creates opportunities for more developments, such as enhancing NLP capabilities, adding more data sources, and using sophisticated analytics for ongoing enhancement.

Artificial Intelligence-driven chatbots, such as the one featured in this article, have the potential to significantly impact the development of effective.

5. Future Scope

While the current implementation has proven successful, there are several avenues for future work and improvement:

Expanded NLP Capabilities:

Enhance the chatbot's natural language processing capabilities to handle even more complex queries and nuances in user interactions. This could involve incorporating advanced NLP models or customizing existing ones for specific manufacturing jargon.

Integration with Additional Data Sources:

Extend the chatbot's integration capabilities to include data from diverse sources beyond the Industrial Internet of Things (IIoT). This may involve integrating with other cloud-based services or on-premises data repositories to provide a more comprehensive understanding of the manufacturing environment.

Advanced Predictive Analytics:

Further refine and expand the predictive maintenance strategies by incorporating more advanced machine learning algorithms. This would contribute to even more accurate forecasting of potential equipment failures and maintenance needs.

Continuous Learning and Adaptation:

Implement mechanisms for the chatbot to continuously learn and adapt based on ongoing user interactions. This could involve incorporating reinforcement learning techniques to improve the chatbot's responses over time.

User Feedback Integration:

Develop a feedback loop mechanism to gather user feedback on the chatbot's performance. This information can be used to iteratively improve the chatbot's functionality and address any user-specific requirement

Terraform Architecture Integration:

Integrate Terraform into the chatbot architecture to automate the provisioning and management of cloud resources. Terraform modules ensure consistency across deployment environments and promote reusability of infrastructure configurations.

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