Driving IoT Systems using Large Language Models on kAiron

An Industrial Internship Report

submitted by

AARON MAN0 CHERIAN

21BCT0066

in partial fulfilment for the award of the degree of

Bachelors of Technology

in

Computer Science Engineering with a specialization in Internet of Things

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

August-December, 2023

DECLARATION BY THE CANDIDATE

I hereby declare that the Industrial Internship report entitled "**Driving IoT Systems using Large Language Models on kAiron"** submitted by me to Vellore Institute of Technology, Vellore in partial fulfilment of the requirement for the award of the degree of **Bachelors of Technology** in **Computer Science Engineering with a specialization in Internet of Things** is a record of bonafide industrial training undertaken by me under the supervision of Mr**. Ashwin Swarup, Nimblework Inc. (Previously Digite Inc.)** I further declare that the work reported in this report has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Signature of the student

Name: AARON MANO CHERIAN
Reg. Number: 21BCT0066

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School of Computer Science and Engineering

BONAFIDE CERTIFICATE

This is to certify that the Summer Industrial Internship report entitled "**Consultant at the AI Team at NimbleWork (Digite Inc)"** submitted by **AARON MANO CHERIAN, 21BCT0066** to Vellore Institute of Technology, Vellore in partial fulfilment of the requirement for the award of the degree **Bachelors of Technology** in **Computer Science Engineering with a specialization in Internet of Things** is a record of bonafide Industrial Internship undertaken by him/her under my supervision. The training fulfils the requirements as per the regulations of this Institute and in my opinion, meets the necessary standards for submission. The contents of this report have not been submitted and will not be submitted either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Internal Examiner (s) **External Examiner (s)**

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the following individuals and institutions for their invaluable support during the internship

I am particularly grateful to Mr. Ashwin Swarup, Vice President, Nimblework, for providing me with the opportunity to work at the company. I appreciate their guidance, support, and encouragement throughout this experience.

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I am truly grateful for the opportunity to learn and grow through this experience.

Place : Bangalore

Aaron Mano Cherian

Date : 26/03/2024

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Introduction

The agricultural sector plays a pivotal role in sustaining human life. However, traditional farming practices often face challenges like limited resources, unpredictable weather patterns, and a lack of real-time data to optimize crop yields. Recent advancements in Internet of Things (IoT) and Artificial Intelligence (AI) technologies offer promising solutions to address these concerns. This report details the development of an innovative system that integrates a Large Language Model (LLM) powered digital assistant, KAIron, with IoT devices specifically designed for the Indian agricultural sector.

Target Sections:

1.1.1. Inception and Development of KAIron

The genesis of KAIron lies in the pursuit of leveraging AI to streamline digital interactions and empower users with intuitive assistants. Born out of a four-month internship, KAIron represents the culmination of Python-based development, data science methodologies, and a vision for AI-driven solutions. Central to its development is the utilization of Python programming language, renowned for its versatility and extensive library support. With a focus on data science, KAIron's capabilities are honed through the integration of machine learning algorithms and natural language processing (NLP) techniques.

1.1.2. Integration with Agricultural Technology (AgTech)

Transitioning from its initial iteration, KAIron finds a new realm of application within the agricultural technology domain. The strategic pivot towards AgTech underscores the versatility of AI solutions in addressing diverse industry challenges. The core objective revolves around implementing KAIron on IoT devices, thereby facilitating seamless interactions between farmers and their agricultural infrastructure. This integration necessitates a meticulous approach towards interfacing with IoT protocols, such as MQTT and oneM2M, to ensure compatibility and efficiency.

1.1.3. WhatsApp Integration for IoT Device Management

A pivotal aspect of KAIron's evolution is its integration with widely used messaging platforms like WhatsApp. By harnessing the WhatsApp Business API or leveraging third-party services like Twilio, KAIron extends its reach to farmers across geographical boundaries. The implementation of LLMs for message processing enables intuitive interactions, empowering users to control IoT devices through natural language commands. Named Entity Recognition (NER) techniques further enhance the user experience by extracting relevant information from responses, facilitating seamless device management.

1.1.4. Leveraging Large Language Models (LLMs) for Agricultural Insights

At the heart of KAIron's functionality lies the utilization of LLMs, notably GPT-3, to interpret user queries and provide insightful responses. The fusion of AI-powered language processing with agricultural data sets the stage for transformative insights and informed decision-making. Through sophisticated NLP logic and advanced algorithms, KAIron transcends linguistic barriers, catering to multilingual audiences and fostering cross-cultural knowledge exchange among farmers.

1.1.5. Hardware Connectivity and IoT Infrastructure

A critical milestone in KAIron's journey is the prioritization of hardware connectivity, enabling users to interact with IoT devices effortlessly. By integrating LLMs with IoT APIs and protocols such as MQTT and oneM2M, KAIron bridges the gap between users and complex hardware systems. This democratization of IoT technology empowers farmers, regardless of their technical expertise, to leverage advanced agricultural solutions and optimize resource management.

1.1.6. Real-World Impact and User Feedback

The culmination of KAIron's integration into the agricultural sector yields tangible benefits, as evidenced by extensive field tests and user feedback. Farmers, previously constrained by linguistic barriers and technical complexities, commend the simplicity and effectiveness of messaging-based device control. The real-time accessibility facilitated by WhatsApp integration becomes a game-changer, fostering connectivity and empowering farmers with actionable insights derived from IoT data interpretation.

1.1.7. Future Directions and Innovation

Looking ahead, the journey of KAIron continues with unwavering commitment to innovation and technological advancement. As agriculture embraces the digital age, the fusion of IoT hardware connectivity and LLM-powered interactions heralds a new era of transformative solutions. From enhancing error detection mechanisms to addressing latency concerns, KAIron remains poised to redefine the agricultural landscape, setting precedents for innovation and sustainability.

1.1.8 Conclusion

In conclusion, the evolution of KAIron epitomizes the symbiotic relationship between technology and agriculture. From its inception as an AI-powered digital assistant to its integration with IoT devices in the agricultural sector, KAIron exemplifies the transformative potential of technological convergence. Through a comprehensive exploration of its development, integration, and real-world impact, this narrative underscores the pivotal role of AI in reshaping farming practices and fostering a connected, sustainable future for agriculture.

1.2 The Timeline

Day 1: Orientation and Introduction to Project

- Introduction to the internship program and team members.
- Detailed overview of the project objectives and expectations.
- Familiarization with existing technologies and frameworks used in AI development.
- Initial discussions on the scope of KAIron and its potential applications.

Day 2-5: Research and Requirement Gathering

- Conducted extensive research on AI-powered digital assistants and existing solutions in the market.
- Analyzed user requirements and pain points in agricultural technology.
- Compiled a comprehensive list of features and functionalities for KAIron.
- Explored various Python libraries and frameworks suitable for AI development, focusing on natural language processing (NLP) and machine learning.

Day 6-10: Development of Prototype

- Set up the development environment and version control system.
- Implemented the basic architecture of KAIron using Python.
- Integrated NLP libraries such as NLTK and spaCy for text processing.
- Experimented with different machine learning algorithms for intent recognition and named entity recognition.
- Developed a basic user interface for interacting with the prototype assistant.

Day 11-20: Iterative Development and Testing

- Refinement of NLP algorithms for better accuracy and performance.
- Implemented feedback mechanisms for error detection and handling.
- Conducted extensive testing of the prototype across various use cases and scenarios.
- Collaborated with team members to address any technical challenges and optimize codebase.
- Documented the development process and created user manuals for future reference.

Day 21-30: Integration with WhatsApp and IoT Devices

- Explored options for integrating KAIron with messaging platforms such as WhatsApp.
- Conducted feasibility studies on using WhatsApp Business API and third-party services like Twilio.
- Investigated protocols and APIs for interfacing with IoT devices, focusing on MQTT and oneM2M.
- Implemented initial versions of WhatsApp integration and IoT device communication modules.
- Tested the end-to-end functionality of KAIron with simulated IoT devices and WhatsApp messages.

Day 31-40: Refinement and Optimization

- Gathered feedback from mentors and stakeholders on the initial prototype.
- Identified areas for optimization and improvement in terms of performance and user experience.
- Conducted code reviews and refactored the codebase for better maintainability.
- Explored advanced NLP techniques and algorithms to enhance KAIron's understanding of user queries.
- Conducted load testing to ensure scalability and reliability of the system.

Day 41-50: User Interface Enhancement and Documentation

- Worked on enhancing the user interface for KAIron, focusing on ease of use and accessibility.

- Incorporated visual feedback mechanisms for error detection and response validation.
- Developed comprehensive documentation covering installation instructions, usage guidelines, and troubleshooting procedures.
- Created video tutorials and demos showcasing KAIron's capabilities and features.
- Prepared presentations for internal demos and stakeholder meetings to showcase the progress of the project.

Day 51-60: Integration with AgTech and Field Testing

- Transitioned from the initial development phase to integration with AgTech solutions.
- Collaborated with the AgTech team to understand the requirements and constraints of the agricultural sector.
- Integrated KAIron with IoT devices commonly used in agriculture, focusing on sensors for soil moisture and environmental conditions.
- Conducted field tests in agricultural settings to evaluate KAIron's performance in real-world scenarios.
- Gathered feedback from farmers and agricultural experts to identify areas for improvement and refinement.

Day 61-70: Performance Optimization and Error Handling

- Analyzed performance metrics and identified bottlenecks in the system.
- Implemented optimizations to reduce latency and improve response time.
- Enhanced error handling mechanisms to gracefully handle unexpected inputs and edge cases.
- Conducted stress testing to simulate high load scenarios and assess the system's resilience.
- Incorporated logging and monitoring tools to track system performance and identify potential issues proactively.

Day 71-80: Security Implementation and Compliance

- Conducted a security audit of KAIron's infrastructure and communication protocols.
- Implemented security best practices such as encryption, authentication, and authorization.
- Integrated OAuth and JWT for secure authentication and access control.
- Ensured compliance with data privacy regulations and industry standards.
- Conducted vulnerability assessments and penetration testing to identify and mitigate potential security risks.

Day 81-90: User Feedback Integration and Iterative Improvement

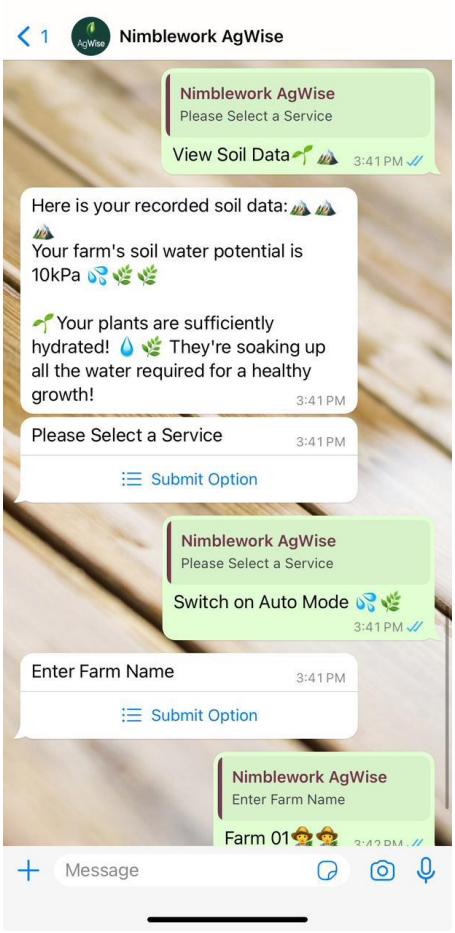
- Collated feedback from end users, stakeholders, and field tests.
- Prioritized feedback based on impact and feasibility for implementation.
- Iteratively implemented enhancements and improvements to address user pain points and feature requests.
- Conducted user acceptance testing to validate the effectiveness of implemented changes.
- Continued to engage with the user community through surveys, interviews, and feedback sessions to gather ongoing insights.

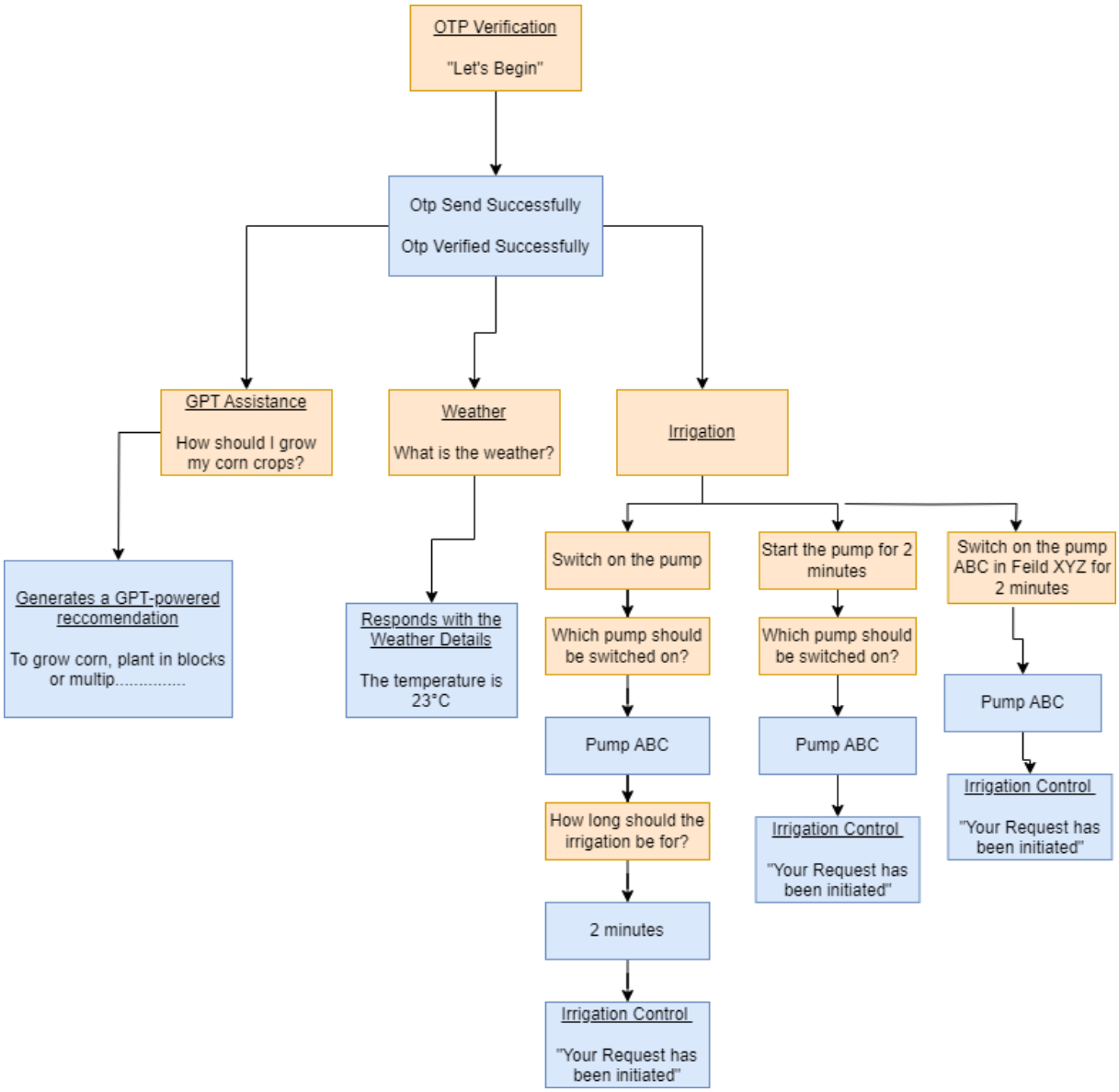
Day 91-120: Finalization and Deployment

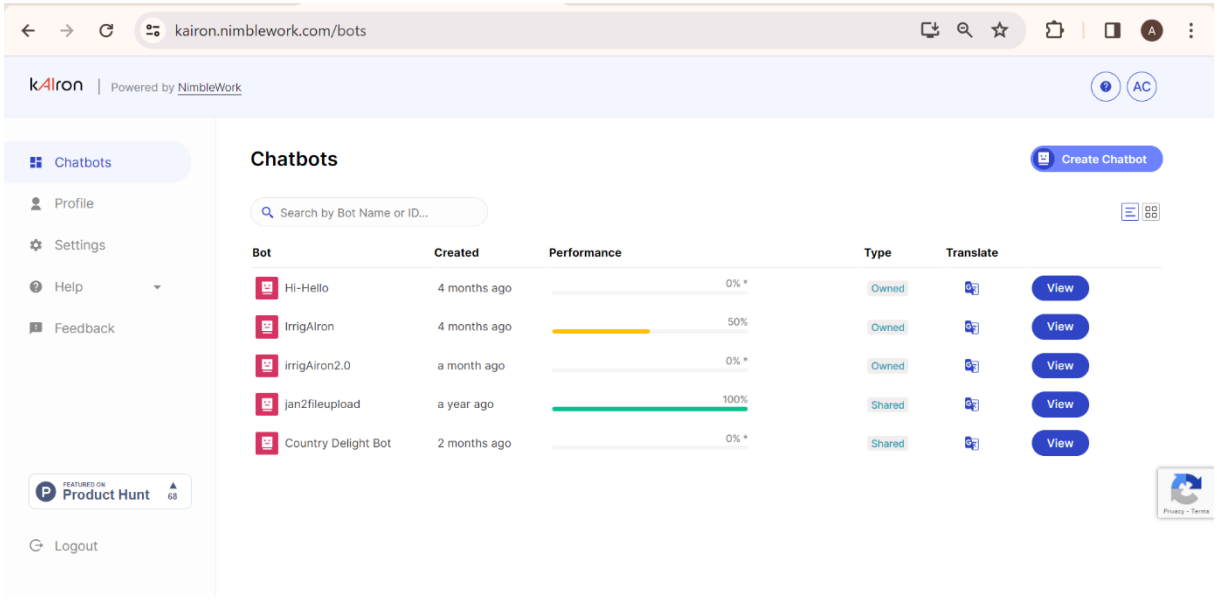
- Conducted final rounds of testing and validation to ensure readiness for deployment.
- Prepared deployment plans and rollout strategies in collaboration with DevOps and infrastructure teams.
- Documented deployment procedures and rollback plans to mitigate potential risks.
- Deployed KAIron to production environments, monitoring system health and performance post-deployment.

- Conducted training sessions and workshops for end users to familiarize them with KAIron's features and capabilities.
- Celebrated the successful completion of the internship project and reflected on key learnings and achievements.

1.4 Pictures




OTP Verification
"Let's Begin"
Otp Send Successfully
Otp Verified Successfully
GPT Assistance
How should I grow my corn crops?
Weather
What is the weather?
Irrigation
Generates a GPT-powered reccomendation
To grow corn, plant in blocks or multip.....
Responds with the Weather Details
The temperature is 23°C
Switch on the pump
Which pump should be switched on?
Pump ABC
How long should the irrigation be for?
2 minutes
Irrigation Control
"Your Request has been initiated"
Start the pump for 2 minutes
Which pump should be switched on?
Pump ABC
Irrigation Control
"Your Request has been initiated"
Switch on the pump ABC in Feild XYZ for 2 minutes
Pump ABC
Irrigation Control
"Your Request has been initiated"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Settings
Help
Feedback
Logout
Chatbots
Create Chatbot
Search by Bot Name or ID...
Bot
Created
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Type
Translate
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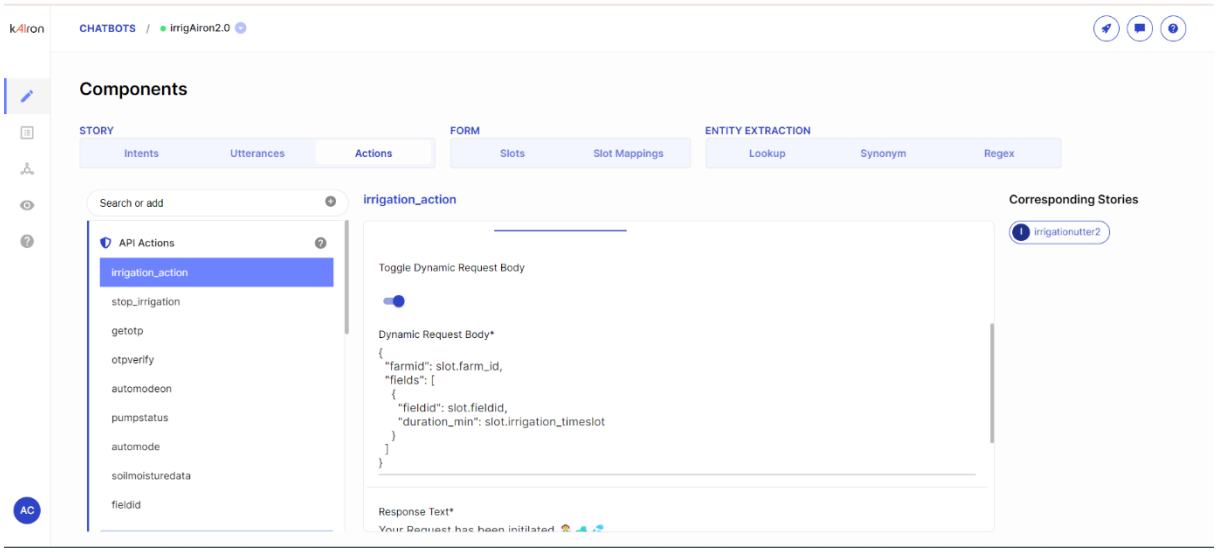
CHATBOTS / irrigAiron2.0
Components
STORY
Intents
Utterances
Actions
FORM
Slots
Slot Mappings
ENTITY EXTRACTION
Lookup
Synonym
Regex
Search or add
API Actions
irrigation_action
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Response Text*
Corresponding Stories
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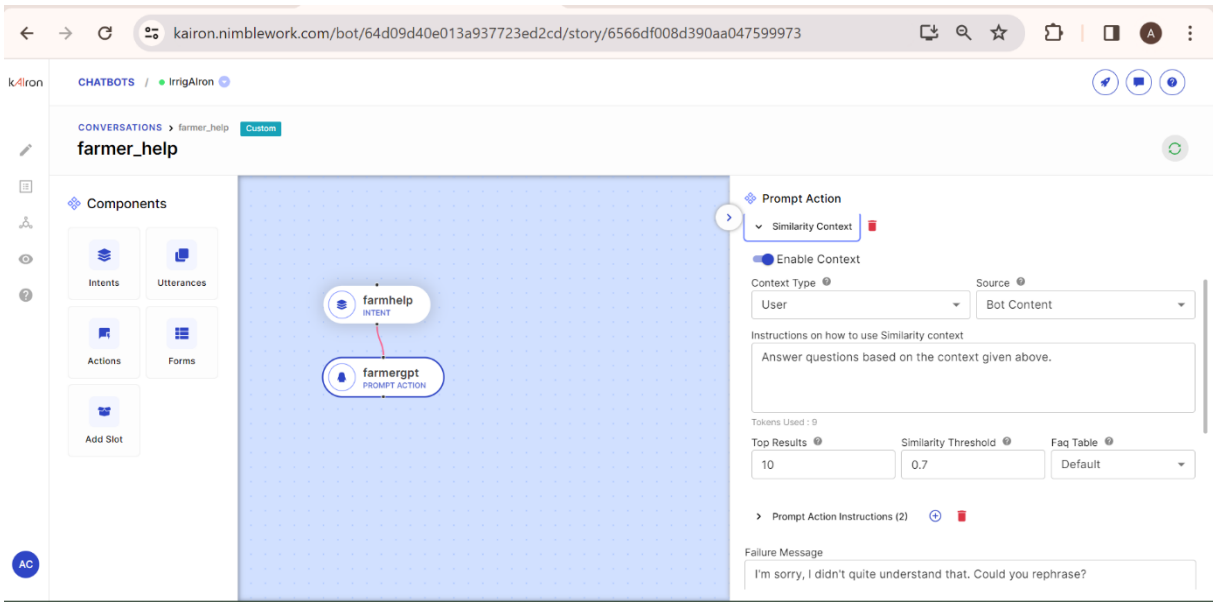
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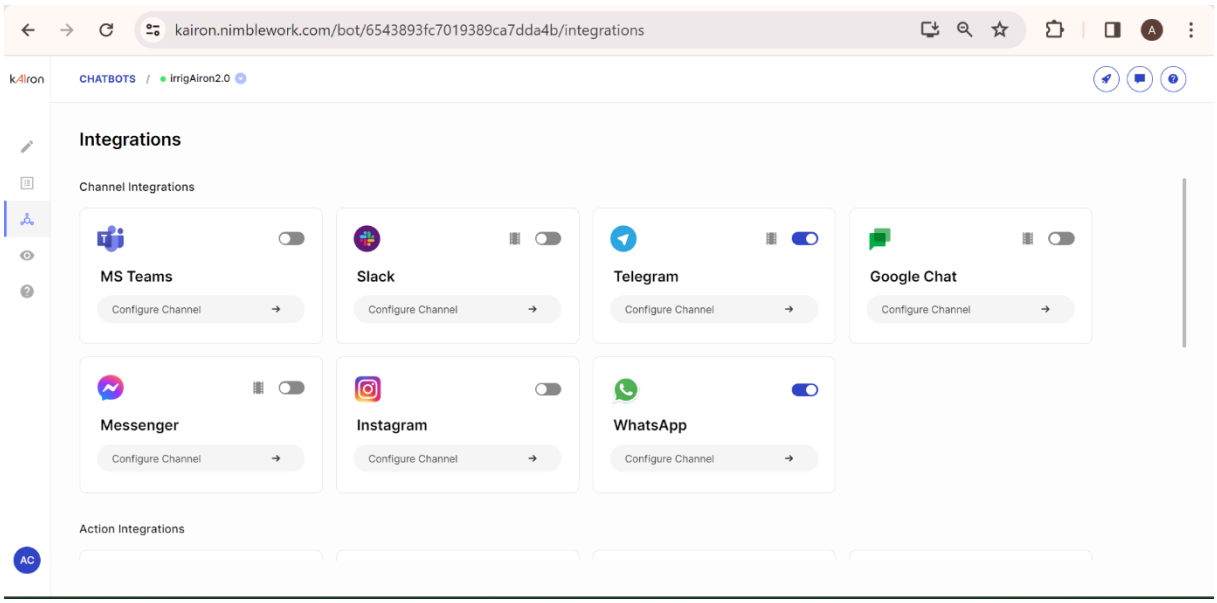
CHATBOTS / IrrigAIron
CONVERSATIONS › farmer_help
Custom
farmer_help
Components
Intents
Utterances
Actions
Forms
Add Slot
farmhelp
INTENT
farmergpt
PROMPT ACTION
Prompt Action
Similarity Context
Enable Context
Context Type
User
Source
Bot Content
Instructions on how to use Similarity context
Answer questions based on the context given above.
Tokens Used : 9
Top Results
10
Similarity Threshold
0.7
Faq Table
Default
Prompt Action Instructions (2)
Failure Message
I'm sorry, I didn't quite understand that. Could you rephrase?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Integrations
Channel Integrations
MS Teams
Configure Channel
Slack
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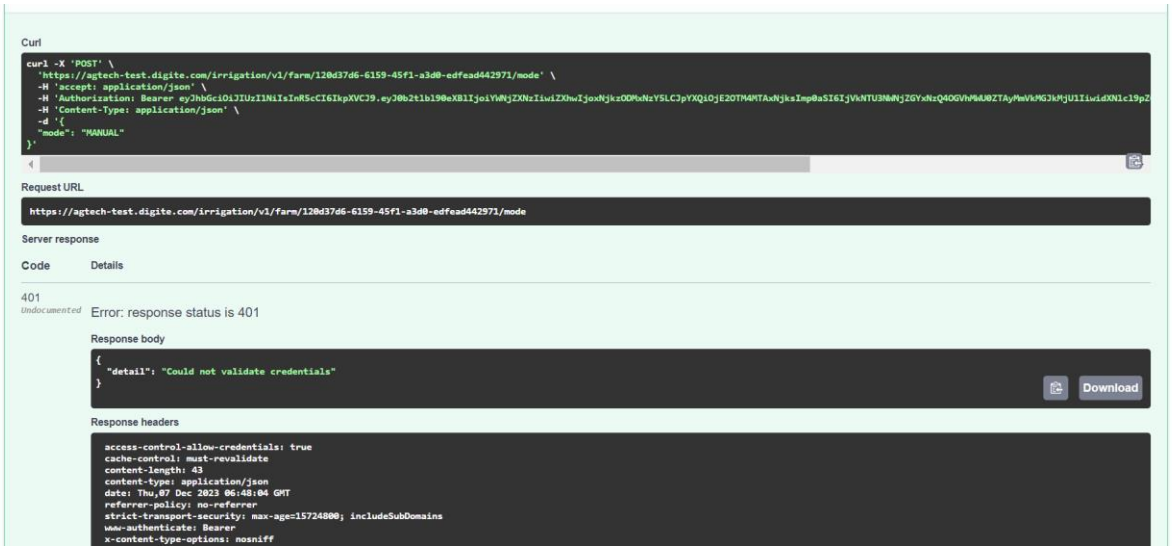
Configure Channel
Messenger
Configure Channel
Instagram
Configure Channel
WhatsApp
Configure Channel
Action Integrations
AC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-H 'accept: application/json' \
-H 'Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJ0b2tlbl90eXBlIjoiYWNjZXNzIiwiZXhwIjoxNjkzODMxNzY5LCJpYXQiOjE2OTM4MTAxNjksImp0aSI6IjVkNTU3NWNjZGYxNzQ4OGVhMWU0ZTAyMmVkMGJkMjU1IiwidXNlcl9pZ
-H 'Content-Type: application/json' \
-d '{
"mode": "MANUAL"
}'
Request URL
https://agtech-test.digite.com/irrigation/v1/farm/120d37d6-6159-45f1-a3d0-edfead442971/mode
Server response
Code
Details
401
Undocumented
Error: response status is 401
Response body
{
"detail": "Could not validate credentials"
}
Download
Response headers
access-control-allow-credentials: true
cache-control: must-revalidate
content-length: 43
content-type: application/json
date: Thu,07 Dec 2023 06:48:04 GMT
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www-authenticate: Bearer
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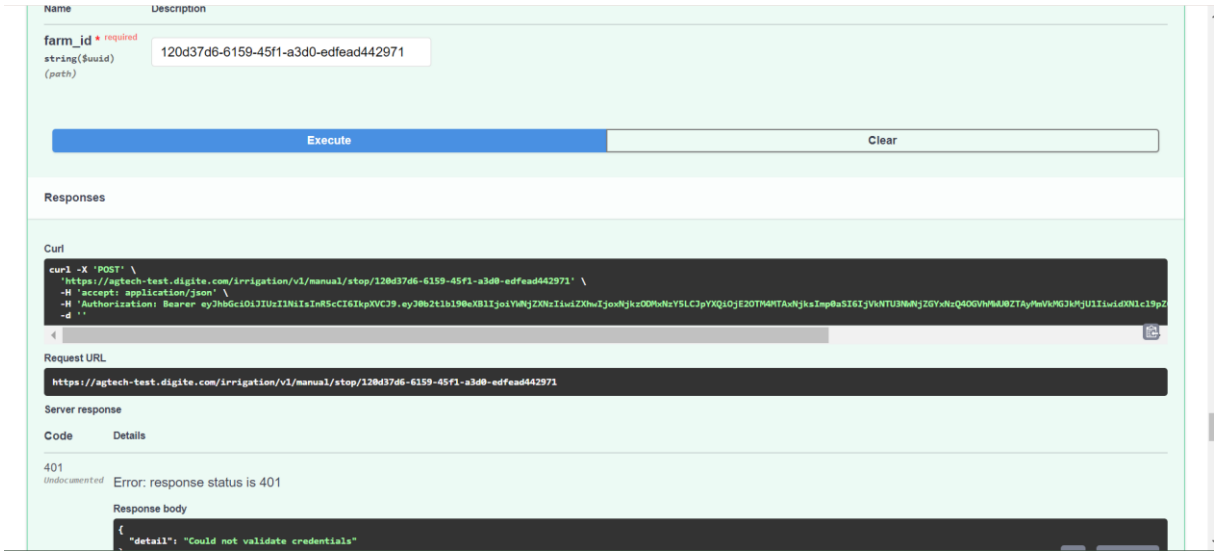
Name
Description
farm_id * required
string($uuid)
(path)
120d37d6-6159-45f1-a3d0-edfead442971
Execute
Clear
Responses
Curl
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-H 'accept: application/json' \
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-d ''
Request URL
https://agtech-test.digite.com/irrigation/v1/manual/stop/120d37d6-6159-45f1-a3d0-edfead442971
Server response
Code
Details
401
Undocumented
Error: response status is 401
Response body
{
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