RAJALAKSHMI ENGINEERING COLLEGE

RAJALAKSHMI NAGAR, THANDALAM – 602 105

RAJALAKSHMI
ENGINEERING COLLEGE
An AUTONOMOUS Institution
Affiliated to ANNA UNIVERSITY, Chennai

CP23211 ADVANCED SOFTWARE ENGINEERING LAB

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Academic Year : ……2023 - 2024……

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INDEX

NEXT-GEN PRIVATE 5G NETWORK MANAGEMENT: NLP AND INTENT-BASED AUTOMATION

OVERVIEW OF THE PROJECT:

What is the problem it is trying to resolve?

- Managing private 5G networks is becoming a challenge due to increasing adoption and a lack of specialists. Manual configuration is error-prone and complex. Next-Gen Private 5G tackles this by using NLP and automation. Operators can now manage the network with simple language, reducing errors and empowering non-experts.

Explanation with Respect to Data:

What data does it deal with?

Next-gen private 5G network management with NLP and intent-based automation cuts through the complexity of managing these powerful networks

- Network Performance Metrics
- Device and User Information
- Configuration Settings
- Natural Language Input
- Pre-defined Intent Templates

How is this data collected and processed?

- Next-gen private 5G management uses smarts to simplify complex network control. Data on network performance, devices, and configurations is constantly collected. Users express their goals in plain language or choose pre-defined options. An NLP engine interprets the intent, and automation executes the necessary adjustments, ensuring the network runs smoothly.

User Benefits upon Implementation

How would it help users when we implement the system?

Next-Gen Private 5G Network Management with NLP and intent-based automation provides several benefits:

- **Simplified Management:** No more wrestling with complex configuration commands. Users can express their desired network outcomes in plain language, making management intuitive and accessible.
- **Reduced Errors:** Automation minimizes manual configuration steps, significantly reducing the risk of human error and ensuring a more reliable and stable network.
- **Empowerment for Non-Experts:** Even users without extensive network knowledge can effectively manage the network by specifying their goals in natural language. This frees up IT resources and allows for wider participation in network optimization.
- **Faster Response Times:** Identifying and resolving network issues becomes quicker. Automation helps automatically adjust configurations based on user intent, leading to a more responsive network that adapts to changing demands.
- **Improved Network Performance:** By automating configurations based on real-time network data and user intent, the system can optimize resource allocation and ensure the network delivers the best possible performance for your specific needs.

SOFTWARE REQUIREMENTS SPECIFICATION (SRS)

EXP.NO: 1 **DATE: 20.2.2024**

CONTENTS

NEXT-GEN PRIVATE 5G NETWORK MANAGEMENT: NLP AND INTENT BASED AUTOMATION

EX.NO.1 **DATE: 05-03-2024**

1. Introduction

1.1 Purpose

This document outlines the software requirements for a Next-Generation Private 5G Network Management System with Natural Language Processing (NLP) and Intent-Based Automation. This system aims to simplify network management for private 5G deployments by enabling users to express their desired outcomes in plain language and automating configuration adjustments.

1.2 Scope

This software outlines the brains behind a next-gen private 5G network management system. Users express their desires in plain language or choose pre-defined options. The system interprets intent, automates adjustments, and monitors network performance. It works with major 5G equipment and stores data securely. Hardware, security specifics, and advanced algorithms are excluded for separate documentation.

1.3 Definitions, Acronyms, and Abbreviations

- **NLP:** Natural Language Processing
- 5G**:** Fifth Generation.

2. Overall Description

2.1 Product Perspective

This next-gen private 5G management system targets network admins, application owners, and operations managers. It offers a user-friendly interface for non-experts to express network goals and get real-time performance insights. By automating tasks, it frees up time and simplifies private 5G network management.

2.2 Product Functions

- **Natural Language Intent Capture**: The Users can express their desired network outcomes in plain language.
- **Pre-defined Intent Templates**: The system offers pre-defined options representing common network management tasks.
- **Automated Configuration Management**: This can involve changes to bandwidth allocation, security settings, or user access controls.
- **Real-Time Network Monitoring:** The system continuously collects and analyzes data on various network performance metrics.
- **Performance Visualization Tools:** The system provides intuitive dashboards and visualizations for users to monitor network health and performance in real-time.

2.3 User Classes and Characteristics

- **Network Administrators:** Possess in-depth knowledge of network infrastructure and configuration.
- Operations Managers: Oversee daily operations that rely on the network's stability and performance.

2.4 Operating Environment

- The software runs on industry-standard servers and a modern OS. It interacts with existing network hardware and utilizes databases. Secure network connection and compliance with regulations are essential. Specifics will be determined during deployment.

2.5 Design and Implementation Constraints

- **Balancing NLP and User Experience:** The system needs to offer clear interfaces and alternative options for users.
- **Real-Time Performance:** System architecture must be optimized for minimal latency in network adjustments.
- **Security is Paramount:** Robust security measures are crucial to prevent breaches and configuration manipulation.

2.6 Assumptions and Dependencies

- **Reliable Network Infrastructure:** The system depends on a stable and secure network infrastructure for communication with network devices and user interfaces.
- **Data Quality:** The accuracy and completeness of network data collected from various sources is critical for the system to function effectively.
- **User Training:** While the system is designed for ease of use, providing basic training to users on functionalities and best practices will optimize user experience and ensure they leverage the system effectively.

3. Appendices

3.1 Appendix A: Glossary

- **User Interface (UI):** The graphical or textual interface that users interact with to operate a computer program.
- **Real-Time Processing:** Processing data with minimal delay, enabling near-instantaneous responses to events.

3.2 Appendix B: Analysis Models

- **Data Flow Diagrams**
- **Use Case Diagrams**

3.3 Appendix C: Issues List

- **Issue 1**: This appendix serves as a repository for identified issues and potential risks associated with the development and deployment of the Next-Generation Private 5G Network Management System.

4. References

- No more wrestling with complex configuration commands.
- Automation minimizes manual configuration steps, significantly reducing the risk of human error.
- Even users without extensive network knowledge can effectively manage the network by specifying their goals in natural language.

SCRUM METHODOLOGY

EX.NO.2 DATE: 14-03-2024

1. Project Vision Vision Statement:

- Effortless private 5G network management for everyone. Through NLP and automation, users with any skill level will be empowered to control and optimize their networks.

Goals:

- Simplify Network Management
- Minimize Human Error
- Empower NonExperts
- Improve Network Performance
- Increase Network Agility

The Product Backlog

The product backlog for the Next-Generation Private 5G Network Management System will be a prioritized list of features and functionalities that will be developed iteratively.

Product Backlog Items:

1. Natural Language Bandwidth Control
2. Real-time Application Performance Visualization
3. Pre-defined Network Adjustments for Operations
4. Automated Configuration Adjustments
5. Pre-defined Network Adjustments

3. The Scrum Team

1. **Product Owner**: Facilitate the Scrum process, ensure the team followsScrum practices, and remove any impediments that hinder progress.
2. **Scrum Master**: Composed of developers, data scientists, andengineers who build the system.
3. **Developmental Team**: Composed of developers, data scientist, and engineers who build the system

4. Planning the Sprints

- Sprint Duration: Typically 2-4 weeks.
- Sprint Planning Meeting: The team selects items from the productbacklog to commit to during the sprint.

1. Sprint Planning Meeting - Goal: Define what will be delivered in the sprint and how it will be achieved. - Input: Product backlog, team capacity, past performance. - Output: Sprint backlog (tasks for the sprint), sprint goal.

2. Daily Stand-up Meetings - Duration: 15 minutes - Purpose: Discuss what was done yesterday, what will be done today, and identify any impediments.

3.Sprint Execution - Development: Team works on the tasks in the sprint backlog - Testing: Continuous integration and testing for features.

3. Sprint Review - Purpose: Demonstrate the working product increment to stakeholders. - Activities: Team shows what was accomplished during the sprint. Stakeholders provide feedback.

4. Sprint Retrospective - Purpose: Reflect on the sprint and identify improvements for future sprints. - Activities: Discuss what went well, what didn't, and how to improve.

5. **Release Planning** - Release Goal: Determine when and what features will be released to the users. - Activities: Prioritize features, finalize the release date, prepare for deployment.

Sprint Breakdown:

Sprint 1:

- Develop core functionalities for data ingestion and real-time risk score calculation.
- Data pipeline infrastructure, initial machine learning model prototype.

Sprint 2:

- Implement risk score display on the clinician dashboard and establish basic alert functionalities.
- Clinician dashboard with risk score display, basic alert generation system.

Sprint 3:

- Integrate data visualization tools to enable clinicians to view patient data trends.
- Data visualization dashboards for historical and real-time patient data.

Sprint 4:

- Develop functionalities to track interventions and analyze their impact on risk scores.
- Intervention tracking system, initial reports on intervention effectiveness.

Sprint 5:

- Implement features for data scientists to manage the machine learning model's feature set.
- User interface for feature selection and management, version control for feature sets.

Sprint 6:

- Integrate model performance monitoring tools and establish retraining procedures.
- Model performance dashboards, automated model retraining triggers based on pre-defined thresholds.
- Implement alert system for significant metric changes.
- Refine and optimize existing features.

USER STORIES

EX.NO.3 DATE:26-03-2024

1. Network Configuration Automation

User Story

As a network administrator, **I want** to automatically configure the 5G network based on high-level intents expressed in natural language, **so that** I can reduce manual effort and minimize configuration errors.

Acceptance criteria

- The system should interpret the intent and translate it into specific network configuration actions.
- The system should validate the proposed configuration actions before applying them.

2. Network Performance Monitoring

User story

A network operator, **I want** to monitor the performance of the 5G network through natural language queries, **so that** I can quickly identify and address performance issues.

Acceptance criteria

- The system should interpret these queries and fetch the relevant performance metrics.
- The system should display the performance metrics in an easy-to-understand format (e.g., graphs, tables).

3. Fault Detection and Resolution

User Story

As a network support engineer, **I want** to use natural language commands to detect and resolve faults in the 5G network, **so that** I can improve resolution times and network reliability.

Acceptance criteria

- The system should identify and report any detected faults with detailed information.
- The system should suggest possible resolutions for the detected faults.

4. Capacity Planning

User Story

As a network planner, **I want** to use natural language queries to forecast network capacity requirements, **so that** I can ensure the network meets future demand.

Acceptance criteria

- The system should analyze historical data and current trends to provide capacity forecasts.
- The system should display the forecasts in an easy-to-understand format.

5. Security Management

User Story

As a security manager, **I want** to manage network security policies using natural language commands, **so that** I can efficiently enforce security measures.

Acceptance criteria

- The system should understand security-related commands given in natural language (e.g., "Set up a firewall rule for zone B").
- The system should translate these commands into specific security policies.

6. User Experience Optimization

User Story

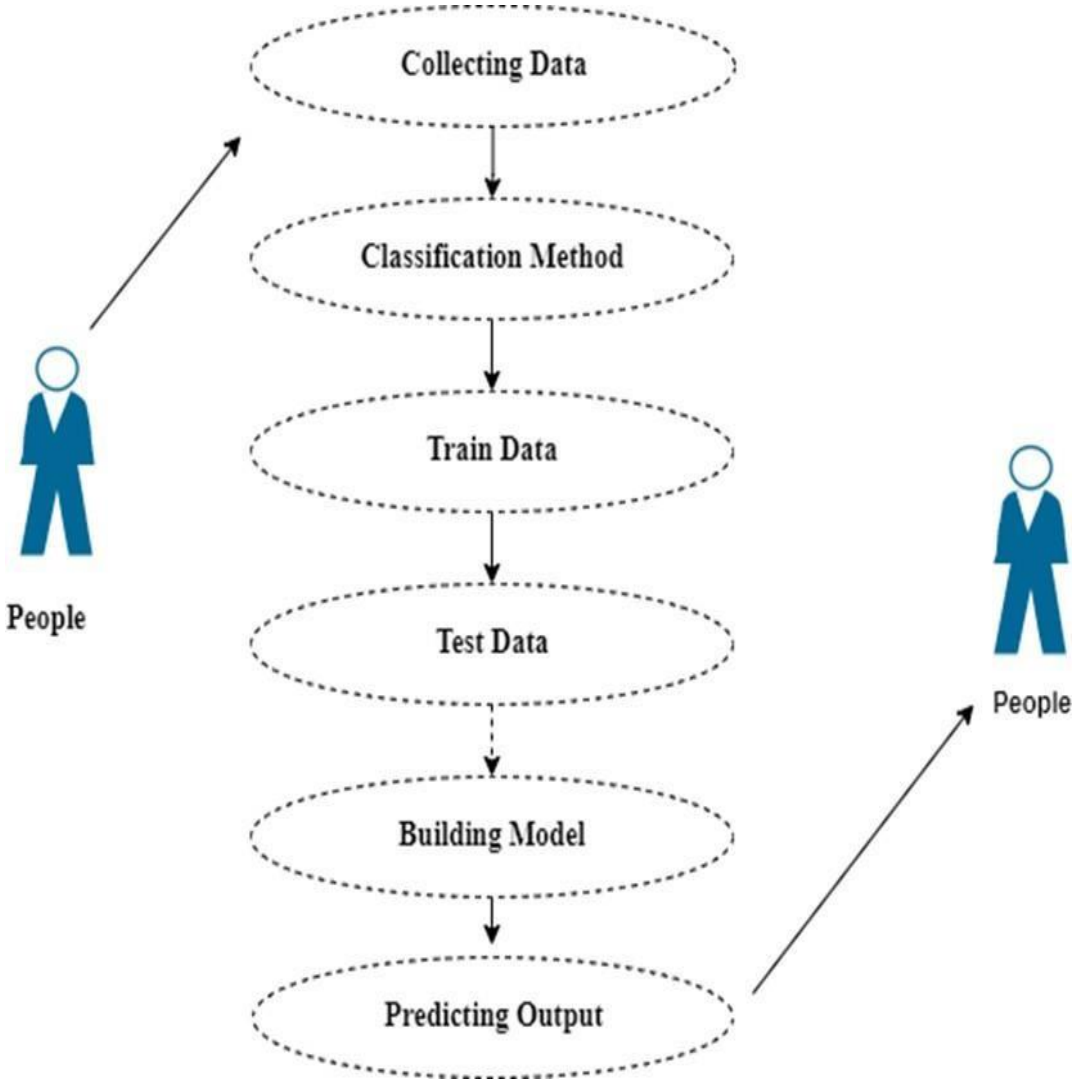
As a network experience manager, I want to optimize the user experience by analyzing user feedback and network performance through natural language queries, so that I can ensure high satisfaction among users.

Acceptance criteria

- The system should analyze user feedback and correlate it with network performance metrics.
- The system should provide a summary of user experience issues and their potential causes.

USE CASE DIAGRAM

EX.NO:4 **DATE:04-04-2024**



Use case diagrams are considered for high level requirement analysis of a system. So when the requirements of a system are analysed the functionalities are captured in use cases. So, it can say that uses cases arenothing but the system functionalities written in an organized manner.

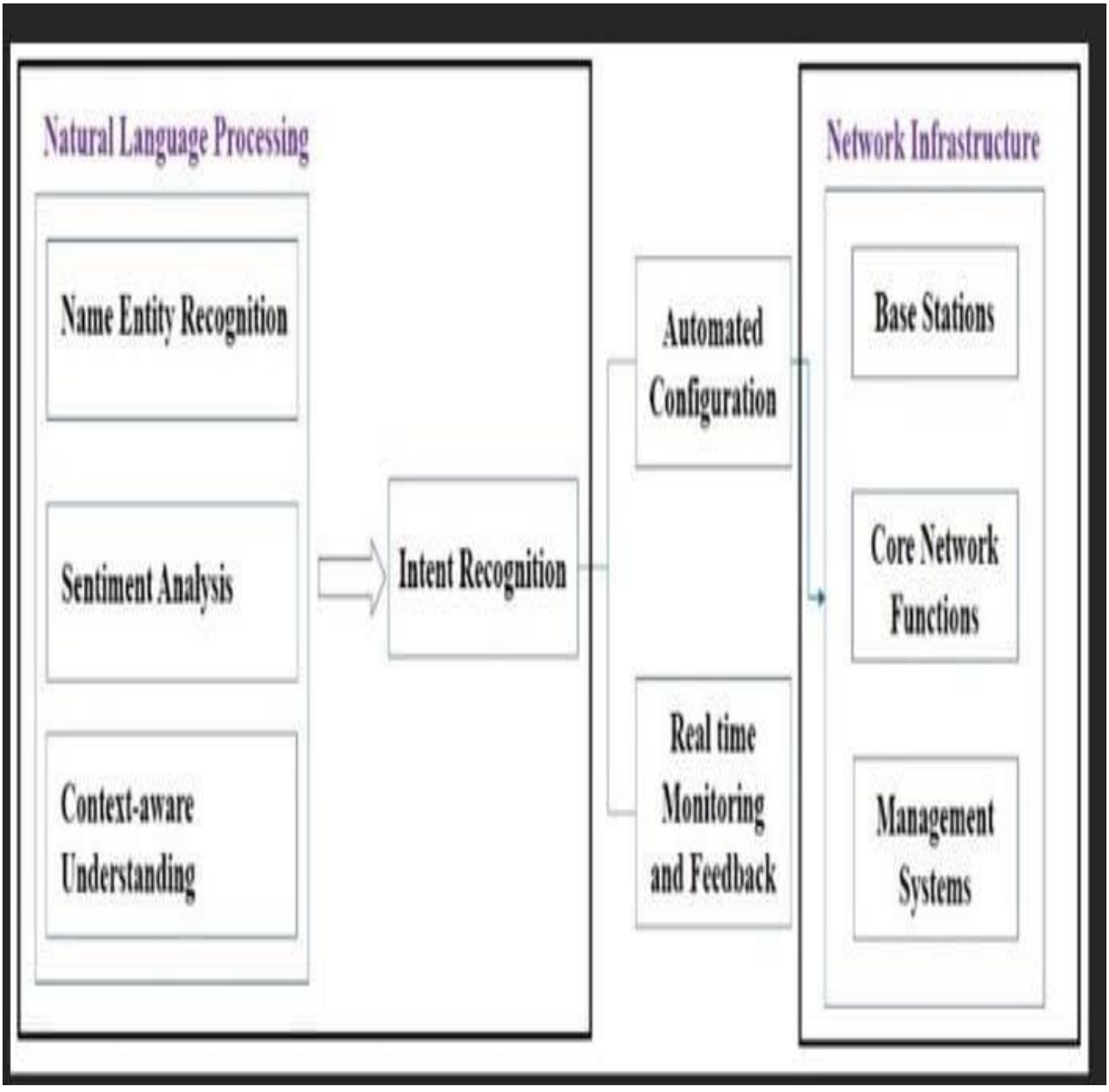
Non-Functional Requirement(NFR)

EX.NO:5 **DATE:16-04-2024**

1. **Performance:** The dashboard should be responsive and provide quick access to data and insights, even when handling large volumes of Patientdata. It should be optimized for efficient data retrieval, processing, and visualization, ensuring minimal latency and fast response times.
2. **Scalability:** The dashboard should be scalable to accommodate increasinguser loads and growing volumes of Patient data over time. It should be capable of handling concurrent user interactions and large datasets without experiencing performance degradation or downtime.
3. **Security:** The dashboard should enforce robust security measures to protect sensitive user data, including Patient credentials, analytics results,and user preferences. It should implement authentication, authorization, and encryption mechanisms to ensure data privacy, prevent unauthorizedaccess, and mitigate security risks such as data breaches or cyber-attacks.
4. **Reliability:** The dashboard should be highly reliable and available, ensuring uninterrupted access to Patient data analytics functionalities for users. It should be resilient to failures and errors, with built-in mechanisms for error handling, fault tolerance, and disaster recovery to minimize service disruptions and data loss.
5. **Usability:** The dashboard should be user-friendly and intuitive, cateringto the needs of both novice and experienced users. It should have a
   well- designed user interface with intuitive navigation, interactive visualizations, and customizable dashboards to enhance user experience and facilitate efficient data exploration, analysis, and decision-making.

OVERALL PROJECT ARCHITECTURE

EX.NO:6 **DATE:25-04-2024**



Data Collection and preprocessing: To operate private 5G networks, it is necessary to collect a varied dataset that includes user intentions, network settings, and natural language queries. To guarantee consistency and quality, preprocess the data by cleaning and normalizing the text, removing noise, and standardizing the formatting.

NLP Model Selection and Training: Select appropriate NLP models and algorithms for intent recognition, named entity recognition, sentiment analysis, and context-aware understanding. Train the selected models using the pre-processed dataset, fine-tuning parameters and optimizing performance metrics such as accuracy, precision, and recall.

Intent recognition and Parsing: Build algorithms that can decipher user intentions, entities, and parameters pertinent to network management activities from natural language queries. To deduce semantic meaning from sentence structure, use methods like dependency parsing, part-of-speech tagging, and tokenization.

Context-awareness understanding: Incorporate context information like network architecture, metrics for efficiency, user preferences, and past information to enhance the NLP models' context-aware understanding skills. Create algorithms that can adapt their purpose interpretation on the fly according to environmental and contextual signals.

Integration with network infrastructure: Use pre-existing APIs and protocols to integrate the NLP- driven network management tool with the current network architecture. Facilitate interaction and interoperability by developing adapters and drivers to interface with various network parts. These elements may include base stations, core network operations, and management systems. The NS selection model uses context information to select the appropriate NS identifier from pre-onboarded NSDs in the NFVO, while the VIM selection model uses telemetry information and context from the data processing subsystem to select the VIM account for provisioning the selected network service, illustrating the interactions between the NS and VIM selection models.

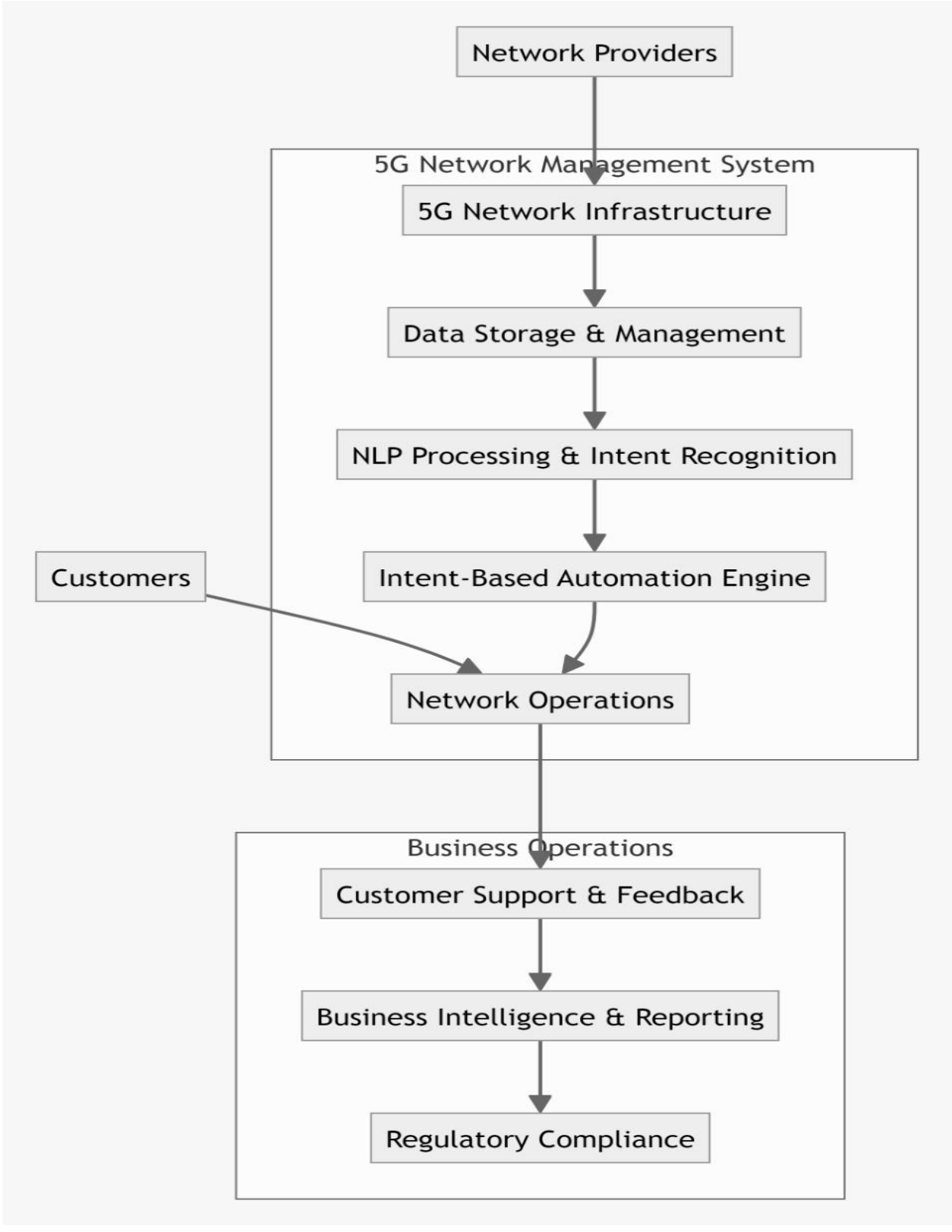
Automated Configuration and Opimization: Algorithms based on contextual insights and user intent interpretation may automate network setup operations. Create optimization algorithms that can optimize the allocation of resources, policies, and network characteristics in real time to maximize efficiency, dependability, and performance.

Real-time monitoring and feedback: The network infrastructure may be monitored in real-time by deploying agents that gather telemetry information as well as performance measurements. Look for outliers, performance issues, and areas for improvement by analyzing the data. To provide administrators with up-to-date observations and suggestions, feedback channels should be developed.

Evaluation and validation: Conduct trials in simulation and in the real world to assess how well the network management system driven by NLP performs. Check important indicators including the effect on network speed and user experience, the effectiveness of installation automation, and the accuracy of intent detection.

BUSINESS ARCHITECTURE

EX.NO:7 **DATE:02-05-2024**



Customers:

- Role: End-users of the private 5G network services, including enterprises, smart factories, and IoT deployments.
- Interaction: Use and request specific network services and features.

Network Providers:

- Role: Entities that provide and maintain the 5G network infrastructure.
- Interaction: Supply network resources and manage physical infrastructure.

5G Network Infrastructure:

- Role: Physical and virtual components of the 5G network, including base stations, core network elements, and edge computing nodes.
- Interaction: Enable network connectivity and data transmission.

Data Storage & Management:

- Role: Store and manage network data, user data, and configuration information.
- Technology: Databases, data lakes, cloud storage solutions.

NLP Processing & Intent Recognition:

- Role: Process natural language inputs from users to understand their intent and convert it into actionable commands.
- Technology: Natural language processing (NLP) frameworks, machine learning models.

Intent-Based Automation Engine:

- Role: Automate network management tasks based on recognized intents.
- Technology: Automation frameworks, orchestration tools, AI-driven decision-making engines.

Network Operations:

- Role: Monitor and manage network performance, security, and configuration.
- Interaction: Execute automated tasks and respond to manual interventions when necessary.

Customer Support & Feedback:

- Role: Provide support to customers, gather feedback, and ensure customer satisfaction.
- Technology: CRM systems, support ticketing systems.

Business Intelligence & Reporting:

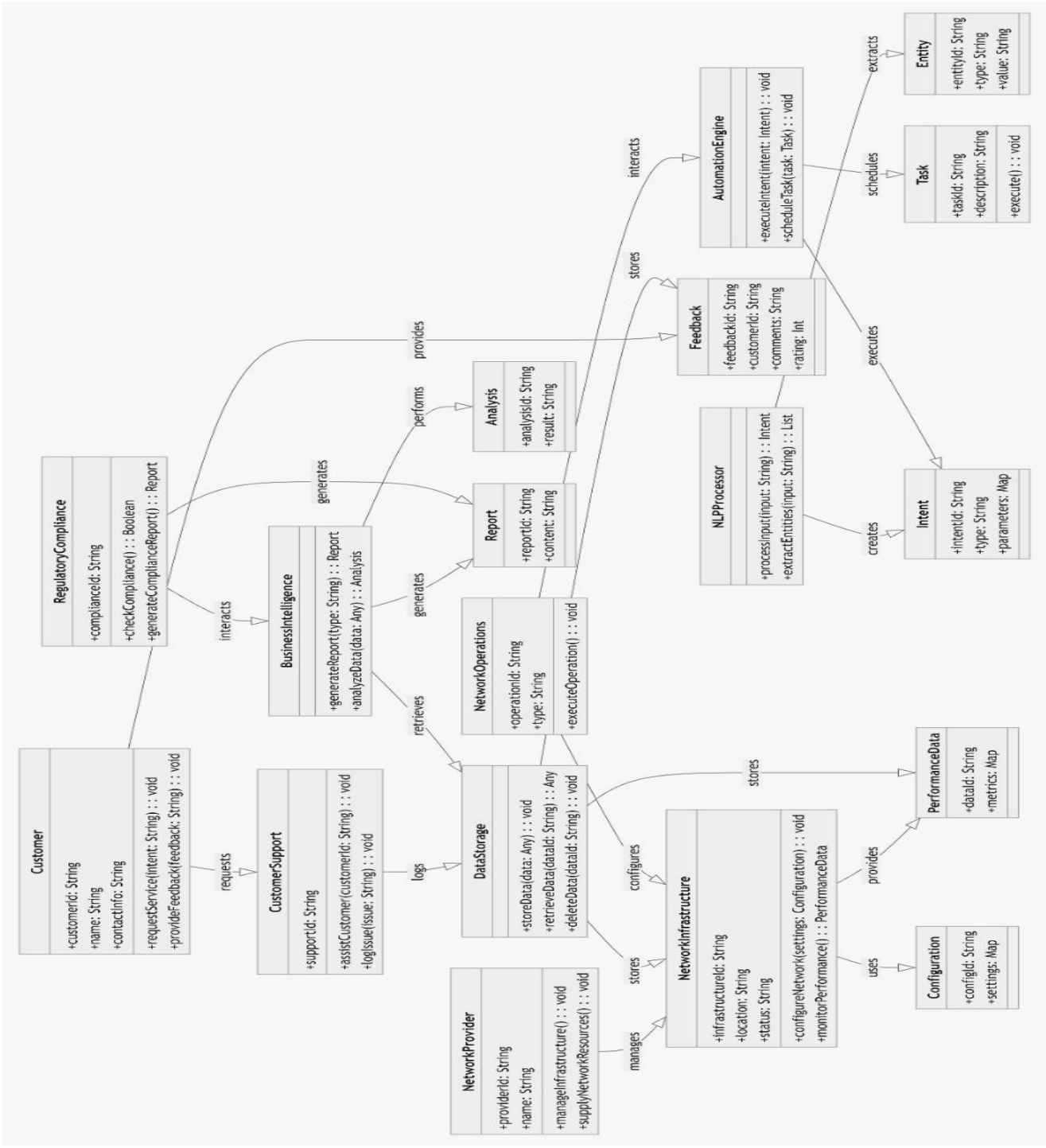
- Role: Analyze operational data and generate reports to inform business strategies and improvements.
- Technology: Data analytics platforms, reporting tools.

Regulatory Compliance:

- Role: Ensure that all operations comply with relevant regulations and standards.
- Interaction: Monitor compliance requirements and implement necessary measures.

CLASS DIAGRAM

EX.NO:8 **DATE:07-05-2024**



Class Diagram Overview:

Customer:

- Attributes: customerId, name, contactInfo

- Methods: requestService(intent: String), provideFeedback(feedback: String)

NetworkProvider:

- Attributes: providerId, name
- Methods: manageInfrastructure(), supplyNetworkResources()

NetworkInfrastructure:

- Attributes: infrastructureId, location, status
- Methods: configureNetwork(settings: Configuration), monitorPerformance()

Configuration:

- Attributes: configId, settings

PerformanceData:

- Attributes: dataId, metrics

DataStorage:

- Methods: storeData(data: Any), retrieveData(dataId: String), deleteData(dataId: String)

NLPProcessor:

- Methods: processInput(input: String), extractEntities(input: String)

Intent:

- Attributes: intentId, type, parameters

Entity:

- Attributes: entityId, type, value

AutomationEngine:

- Methods: executeIntent(intent: Intent), scheduleTask(task: Task)

Task:

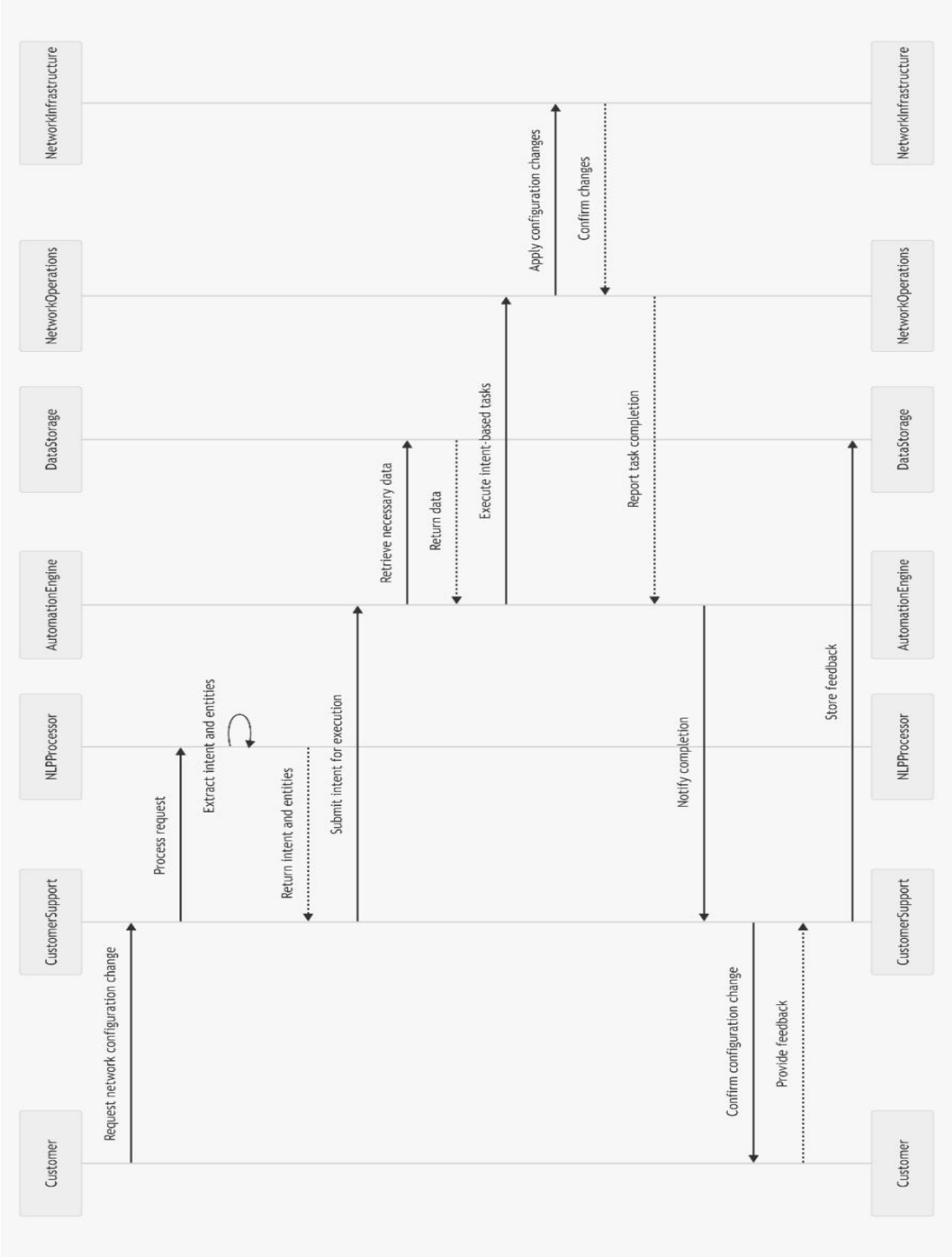
- Attributes: taskId, description
- Methods: execute()

NetworkOperations:

- Attributes: operationId, type

SEQUENCE DIAGRAM

EX.NO:9 DATE:16-05-2024



Sequence Diagram Overview:

Customer Request:

The Customer requests a network configuration change through CustomerSupport.

NLP Processing:

CustomerSupport forwards the request to NLPProcessor.

NLPProcessor processes the request to extract the intent and any relevant entities.

NLPProcessor returns the extracted intent and entities to CustomerSupport.

Intent Execution:

CustomerSupport submits the intent to AutomationEngine for execution.

AutomationEngine retrieves necessary data from DataStorage.

DataStorage returns the required data to AutomationEngine.

Network Operations:

AutomationEngine directs NetworkOperations to execute the intent-based tasks.

NetworkOperations applies the configuration changes to the NetworkInfrastructure.

NetworkInfrastructure confirms the configuration changes back to NetworkOperations.

Task Completion:

NetworkOperations reports the completion of the task back to AutomationEngine.

AutomationEngine notifies CustomerSupport of the task completion.

Customer Notification:

CustomerSupport confirms the configuration change to the Customer.

Feedback Loop:

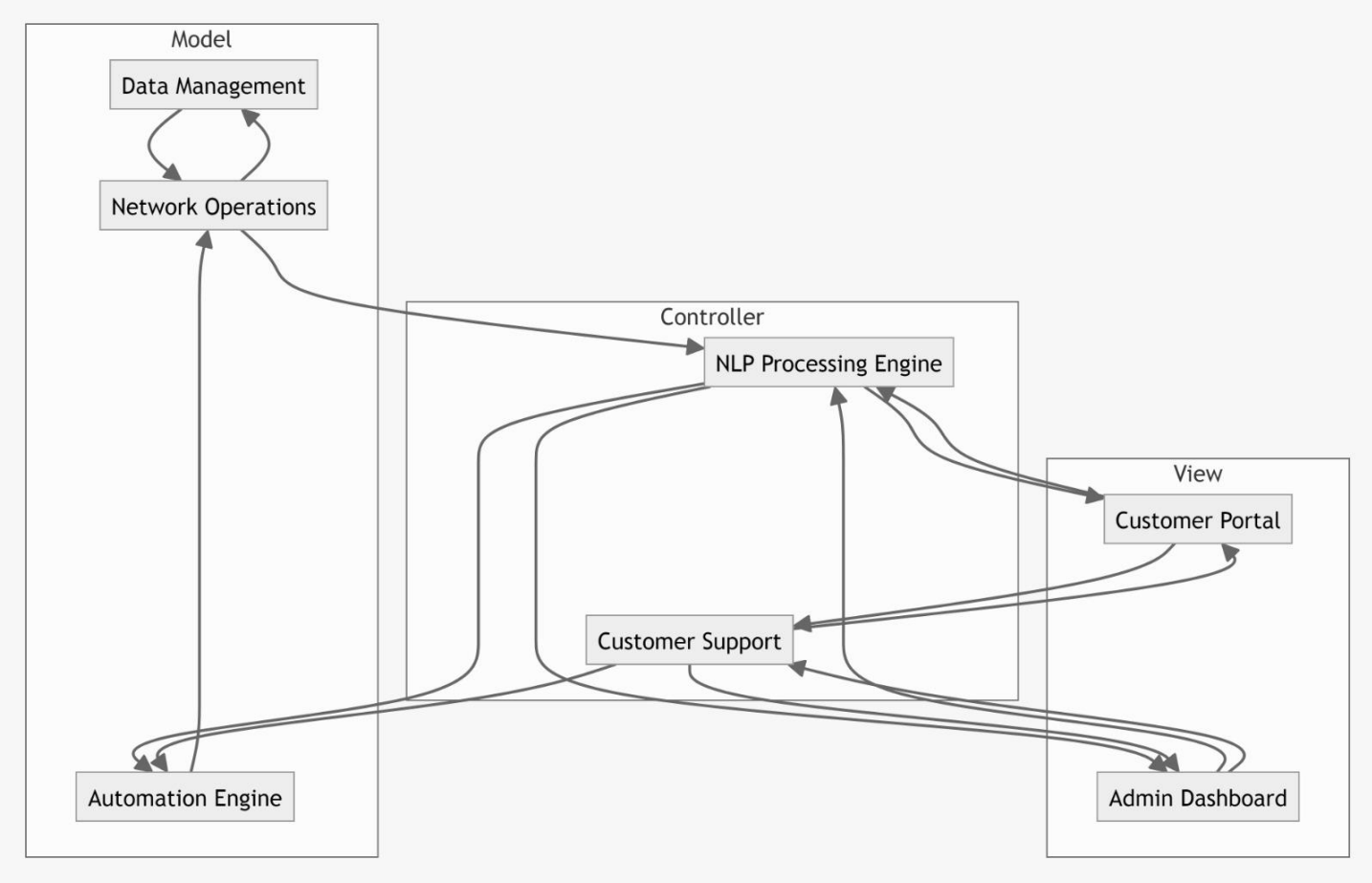
The Customer provides feedback on the service.

CustomerSupport stores the feedback in DataStorage.

ARCHITECTURAL PATTERNS

EX.NO.10 DATE:28-05-2024

MODEL VIEW CONTROLLER ARCHITECTURE:



MODEL

Data Management

Handles storing and retrieving data related to network configurations, performance metrics, customer feedback, etc.

Automation Engine

Contains the logic for executing network management tasks based on recognized intents.

Network Operations

Manages the actual configuration and monitoring of the 5G network infrastructure

View:

User Interface (UI)

Provides interfaces for customers and admins to interact with the system, request services, and view network status and performance.

Controller:

NLP Processing Engine

Processes user inputs to recognize intents and extract entities.

Customer Support

Acts as a mediator for customer requests and feedback.

User Interaction (View):

Customer Portal: Customers request network configuration changes or new services via a web or mobile interface.

Admin Dashboard: Network administrators monitor network performance, manage resources, and respond to issues.

Request Handling (Controller):

NLP Processing Engine:

Receives user requests from the Customer Portal or Admin Dashboard.

Processes natural language inputs to identify user intent and extract relevant entities.

Customer Support:

Handles customer issues and feedback.

Acts as a point of interaction between users and the system.

Business Logic (Model):

Automation Engine:

Based on the identified intent, it schedules and executes the necessary network management tasks.

Coordinates with the Network Operations component to apply the changes.

Network Operations:

Implements the actual network configurations and monitors the network performance.

Interacts with the Data Management component to store and retrieve necessary data.

Data Management:

Manages all the data related to network operations, customer requests, feedback, and performance metrics.

Ensures data integrity and accessibility for other components