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URBANEYE: Real-time SLA Monitoring and SLA Violation Prediction System for Smart City

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ABSTRACT — This article emerges as a transformative initiative in response to the dynamic demands of contemporary urban landscapes. This comprehensive web application incorporates innovative features empowered by artificial intelligence (AI) and machine learning (ML) models. Utilizing state-of-the-art technology, the system facilitates real-time Service Level Agreement (SLA) monitoring for various Smart City solutions, thereby enhancing decision-making processes and ensuring AI-driven SLA compliance to meet agreed-upon standards. At the core of the system is a responsive chabot designed to address user queries pertaining to SLA. AI components play a pivotal role in driving SLA violation prediction, while automated escalation and notification-triggering mechanisms redefine urban functionality. The project signifies a significant leap forward in leveraging advanced technologies to optimize urban services and elevate overall Smart City efficiency.

Keywords— urban landscapes, web application, SLA, smart city, chatbot, urban services.

I. INTRODUCTION

1.1 Service Level Agreement

The association between a service provider and a customer is governed by a Service Level Agreement (SLA). SLA is negotiated between parties and a level of the service, QoS, and its related expenses are agreed upon. SLA is an official document of QoS that contains specific parameters and a minimum level of quality of service. It is mutually agreed between a service provider and prospective consumers. This is a part of the contract and is an assurance to the service consumers that they will get the services that they pay for, by obligating service providers to fulfill contractual promises. Service Level Objectives (SLOs) are a key element of SLA, which are the qualitative parameters of an SLA that include availability, throughput, and response time. SLA clearly defines monetary penalties in case of any violation of the written agreement [1]. Hence, service providers have a strong interest in keeping their commitments to avoid and reduce the situations that may cause SLA violations. Fig. 1 displays the SLA management life cycle [2].

Any SLA mainly describes two things:
1.Different Service Level Objectives in terms of values for Quality of Service metrics.
2.The penalties to be applied if the objectives have not been accomplished.

Fig. 1: SLA management life cycle.

Discover Service Provider: The service provider publicizes these base service contributions through standard publication media, and the customers should be able to locate the service provider by searching the catalog. The customers can look through different

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competitive offerings and choose a few that fulfill their prerequisites for further negotiation.
SLA Contract Definition: The service and its equivalent price, QoS parameters with a fundamental schema, and the penalty rule are defined. SLAs are commonly defined using standard base formats or by customization of these base layouts.
Establish Agreement: In this stage, a customer finds a service provider that meets the customer's needs. The terms and conditions of the SLA are negotiated and settled upon. A service provider needs to evaluate the SLA in terms of scalability, availability, and performance of its services to avoid fines before approving the specification of the SLA. By the completion of this phase, parties start to commit to the agreement.
Monitor SLA violation: In this part, the provider's presentation in the delivery of the services is estimated against the agreement. A crucial part of SLA monitoring is to be able to envisage violations, assisting providers to reallocate the resources accordingly before the violations happen.
SLA Violation Detection: In this stage, the factors inside SLA are estimated and any deviation is determined. In the case of SLA violation, SLA enforcement is conducted

1.2 Application of SLA in various Smart City Solutions
SLA would be applicable in Operations and Maintenance phase of the project [3]. The penalties shall be applicable on Operations & Maintenance cost of the project calculated quarterly. SLA would be applicable on:

1. City Surveillance System
2. Intelligent Traffic Management System
3. Smart Parking
4. Intelligent Transport System
5. City Wi-Fi
6. Environment Sensors
7. One City-One Website with Mobile Application
8. Help Desk (One City-One Number)
9. e-Learning Centers
10. ICT Infrastructure (CCC, Satellite CCC, Network etc.)

Smart City Davanagere embarks on a visionary journey, aspiring to redefine urban living through technological advancements and sustainable practices. With a commitment to enhancing the overall quality of life, the city is implementing 11 innovative solutions. Our focus is on elevating the City Surveillance System and Intelligent Traffic Management System to new heights of reliability and performance. In the dynamic landscapes of City Surveillance and Intelligent Traffic Management, the reliance on CCTV cameras is paramount. So, real-time monitoring of SLAs and SLA violation prediction enhance operational efficiency and prevent downtime [4].

II. LITERATURE REVIEW

This literature review provides a comprehensive overview of the recent advancements in SLA violation detection through the integration of advanced technologies, the initiative aims to optimize various aspects of urban living, resulting in a more streamlined and effective Smart City ecosystem.

Table 1: Literature review summary

S. No.	Author	Title and Year	Findings
01	C.Pahl, P.Jamshidi Ahamad	A machine learning techniques for SLA management 2023	The paper discusses various types of SLA's as well as the different techniques can be used to monitor and manage SLAs.
02	Anton Michlmayr, Scharam Dustdar	Runtime prediction of Service Level Agreement Violation for Composite Services 2022	The paper helps service providers avoid SLA breaches by using machine learning and past data to predict issues, enabling proactive measures to maintain service sandards.
03	N.K Neeraj, Aditya Nellikeri, P Varun	Service Level Agreement Violation Detection in multi-cloud Environment using Ethereum Block chain 2022	This paper proposes a distributed system using block chain and log-based algorithms to ensure trust between cloud service providers (CSCs) while maintaining service quality, aims to reduce SLA violations.
04	Loretta Mastroeni, Maurizio Naldi	Violation of service availability targets in service level agreements. 2021	This study explores how varied fix times for service issues affect meeting promised agreements. It propose adjusting check intervals to lower risks for service providers, offering guidance on handling agreement-

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			related uncertainties
05	George-Valentin Iordache, Florin Pop	Predicting Service Level Agreement Violation in Cloud using Machine Learning techniques 2021	This paper uses machine learning methods to estimate work holds sent to the Cloud Service Infrastructure, aiding in preventing scheduling issues that may breach Service Level Agreement in cloud
06	Ghafir, Muinuddin	Machine Learning base SLA nomaly detection. 2018	The method uses a combination of supervised and unsupervised learning techniques to identify anomalies.
07	P.Lietner, S.Dustd	Monitoring Prediction, prevention of SLA violation 2022	This paper propose the Prevent framework , which is a system that integrates event-based monitoring, prediction of SLA violations using machine learning techniques, and automated runtime prevention of those violations by triggering adaption actions in service composition
08	Panya Kittipipattaa tha-worn	SLA guarantee real-time monitoring system with soft dead-line constraint 2017	The paper discusses the importance of monitoring complex system in real-time to ensure they perform well and meet certain guarantees within specified time limits to meet performance targets.
09	Verfassung Der Albeit	Time series analysis for predicting SLA violtions 2014	This paper uses a novel method for SLA violation detection using ARI-MA model.
10	Luigi Coppolino	SLA compliance monitoring through semantic processing 2010	The paper aims to provide a practical solution for IT companies to swiftly identify and address service issues ensuring better user satisfaction by leveraging technology.

2.1 EXISTING SYSTEM

The current urban management system in Smart City Davangere is characterized by a fragmented approach that addresses individual components of City Surveillance and ITMS. This framework is best with numerous challenges, which include [5]

Manual Data Entry: In the current system, data related to the uptime and downtime (Active/Inactive)of cameras and other service components are recorded and updated manually in Excel sheets. This manual data entry process is susceptible to human errors, which can lead to inaccuracies in the data. The data entry can also be time-consuming as it requires staff to periodically update these records, resulting in delays in reflecting

Lack of Real-Time Insights: The existing framework cannot provide real-time data analysis and insights into various smart city solutions. This means that decision-makers do not have access to up-to-the-minute information about the performance and status of different systems.

Manual SLA Violation Detection: SLA(Service Level Agreement) compliance violations are currently detected through manual monitoring of service metrics. Human staffs periodically analyze data to assess whether the performance metrics are meeting the agreed-upon standards. Manual SLA violation detection can be time-consuming and inefficient. Delays in identifying violations can result in sub-optimal services and customer dissatisfaction. Moreover, human monitoring may not catch violations as quickly or accurately as automated system scan.

Manual Escalation and Notifications: In the absence of automated systems, procedures for issue escalation and notifications rely on human intervention. Staff members must manually decide when an issue should be escalated to higher authorities. This decision-making process might not always be consistent or timely. Notifications about issues, incidents, or escalations are sent out by employees through manual means, such as emails or phone calls. This manual process can lead to delays in alerting the relevant parties about critical situations.

2.2 Problem Statement

The development of an integrated web application is crucial to facilitate efficient real-time data analysis and monitoring of SLA documents. With the ever-increasing need for such capabilities, it's essential to create a system that incorporates AI-driven SLA Violation Prediction and automated notification triggering to maintain SLA compliance reducing penalties and increasing the working efficiency of the software strictly adhering to SLAs.

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III. PROPOSED METHODOLOGY

The "URBANEYE: Real-time SLA Monitoring and SLA Violation Prediction System For Smart City" project proposes an integrated web application that redefines urban functionality and governance. This comprehensive system introduces cutting-edge capabilities that address the contemporary challenges faced by Smart City Davanagere Limited. The proposed system comprises the following key components:

Real-Time SLA Monitoring of City Surveillance System and ITMS: The process involves using specialized tools to constantly monitor the performance of city surveillance and ITMS. Automated alerts are set up to notify relevant personnel in case of issues, and specific performance metrics are defined and regularly assessed. Data analytics are employed to analyze historical performance data and predict potential issues. Integration with incident management streamlines issue resolution. User experience monitoring evaluates system effectiveness, and scalability measures are in place. Documentation and exporting are maintained for comprehensive oversight. Security monitoring is integrated, considering the sensitive data involved. Continuous improvement is emphasized through regular reviews and enhancements. The overall aim is to ensure adherence to SLA requirements and enhance the reliability of both city surveillance and ITMS systems [6].

SLA Violation Prediction including Automated Notification Triggering: Developing a system for predicting SLA violations involves the collection and analysis of historical service data. Through the application of machine learning algorithms, a predictive model is created, taking into account factors such as response times and error rates. Thresholds are then defined to signify potential SLA breaches. An automated notification system is implemented to alert stakeholders when these thresholds are surpassed [7]. This system requires ongoing validation and refinement to ensure its accuracy and relevance over time.

NLP Chatbot: Creating a natural language processing(NLP) Chabot for user-related queries regarding SLA involves developing a system that understands and responds to natural language input. The Chabot would be designed to handle queries related to service-level agreements, addressing user inquiries, and providing relevant information. The system employs NLP techniques to interpret user input, and it's structured to deliver coherent responses based on the context of SLA-related topics [8]. Fig. 2 depicts the fundamental block diagram for real-time SLA monitoring system. Continuous refinement and adaption are necessary to enhance the chatbot's effectiveness in addressing a variety of user queries related to SLA

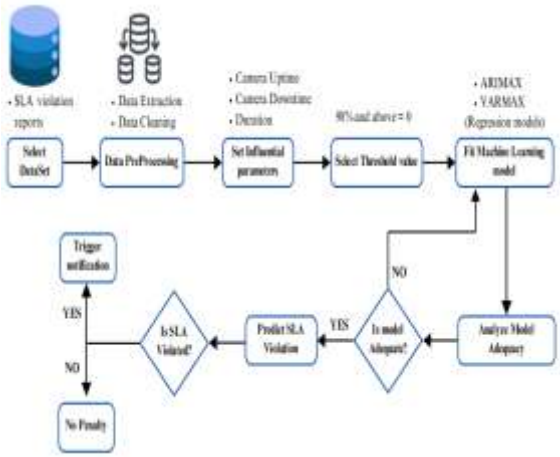

Fig. 2: General Block Diagram for real-time SLA monitoring.

3.1 Feature Extraction:
Camera Uptime:
Total time the cameras are active.
Camera Downtime:
Total time the cameras are inactive.
Efficiency Percentage of time cameras are active: (Uptime/Totaltime).
Duration of Camera Inactivity:
Time duration during which cameras are inactive.
SLA Violation Status:
Binary indicator (0 or 1) indicating whether the SLA for the City Surveillance System is violated or not.
System Uptime: Total time the ITMS is active
System Downtime: Total time the ITMS is inactive.
Efficiency: Percentage of time ITMS is active (Uptime / Total time).
Traffic Flow Metrics: Extracted features related to traffic flow, congestion, or incidents.
SLA Violation Status: Binary indicator (0 or 1) indicating whether the SLA for ITMS is violated or not
Timestamp: Time of the report or monitoring interval.
Severity Level: Severity level of SLA violation (0, 5, 7).
Location: Geographical location of the monitored area.
Historical Data Trends: Historical trends of camera uptime, ITMS uptime, and SLA violations.

IV. IMPLEMENTATION

Implementing real-time Service Level Agreement (SLA) monitoring and handling SLA violations involves a combination of technical and procedural steps. The specific steps can vary depending on the nature of the services required and

the tools used. Some of the general outline to implement the process is by defining the SLA clearly and selecting appropriate monitoring tools [9].

4.1 Pseudo Code:

```
City_surveillance_up_time=0
city_surveillance_downtime = 0   itms_up_time = 0
itms_downtime =
sla_threshold = 98
def update_camera_status( ):
defcalculate_sla_violation_city_surveillance (up_time,
downtime):
total_time = up_time + downtime
efficiency = (up_time / total_time) * 10
if efficiency < sla_threshold:
return
else:
return
def calculate_sla_violation_itms(up_time, downtime):
total_time = up_time + downtime
efficiency = (up_time / total_time) * 100
if efficiency < sla_threshold:
return True  # SLA violation detected
else:
return False  # SLA compliance
while True:
update_camera_status()
sla_violation_city_surveillance=calculate_sla_violatio
n_city_surveillance(city_surveillance_up_time,
city_surveillance_downtime)
sla_violation_itms=calculate_sla_violation_itms(itms_
up_time, itms_downtime)
if sla_violation_city_surveillance:
print("City Surveillance SLA Violation Detected")
else:
print("City Surveillance SLA Compliance")
if sla_violation_itms:
print("ITMS SLA Violation Detected")
else:
print("ITMS SLA Compliance")
```

4.2 Algorithm:

1. Input: time_series_data (historical time series dataset with timestamps and SLA violation values)
2. Preprocess and Split the Time Series Data:
Implement preprocessing steps like handling missing values, scaling, etc.
Split the data into training and testing sets (train_data, test_data).
3. Train Time Series Forecasting Model:
Choose a time series forecasting model (e.g., ARIMA, LSTM, etc.).
4. Configure the model with appropriate parameters.
5. Train the model using the training data (train_data).
6. Make Predictions for Future SLA Violations:
7. Use the trained time series model to make predictions on the testing data (test_data).
8. Evaluate Model Performance:
Compare the predicted SLA violation values with the actual values.
Calculate performance metrics (e.g., Mean Squared Error, R-squared, etc.).
9. Output Results
10. End.

V. CONCLUSION

"URBANEYE: Real-time SLA monitoring and SLA violation prediction system for smart city" marks a significant achievement in urban management. The introduction of AI-powered SLA analytic and responsive data monitoring has not only tackled the current urban challenges but also considerably improved the efficiency of the existing system. This innovative approach enables administrators to make informed decisions based on data insights, promptly resolve issues, and ensure strict adherence to Service Level Agreements.

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