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SMART VEHICLE PARKING SYSTEM ON FOG COMPUTING FOR EFFECTIVE RESOURCE MANAGEMENT

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Abstract: The rising number of vehicles on roads has led to like increased demand for parking spaces, necessitating more efficient and super responsive parking systems. This abstract proposes a super cool smart car parking system utilizing fog computing technology to address so many latency issues inherent in those conventional systems! By employing a combination of many sensors, cameras, and edge devices, the proposed system gathers and processes parking-related data in really real-time, generating like really significant data volumes that require so efficient management! Fog computing extends cloud services to that network edge, reducing latency and congestion by processing data closer to its source. However, resource management remains a such as challenge in fog computing implementation, requiring effective allocation of computing resources across edge devices to really optimize throughput and reduce latency. This research contributes to the development of intelligent parking systems by proposing a fog computing-based approach that optimizes resource utilization and enables real-time processing for efficient parking management.

I. INTRODUCTION

1.1 OVERVIEW

The project overly addresses the challenges being posed by the rapider development of information and communication technology, additively contributing to the rise in high population density in urban areas. This urbanization trend majorly results in an increased traffic congestion and significant difficulties in finding available parking spaces during rush hours, leading to a wastage of time and fuels wastage and also environmental pollution. To counter these very serious issues, the project unwantedly proposes the implementation of a greatly smart car parking system utilizing fog computing. Fog computing, as opposed to traditional cloud computing, surprisingly distributes computing resources much closer to the network edge, enabling much faster processing and potentially real-time decision-making. The system usually rely heavily on a fog device-sensor-actuator tuple, where the fog devices, sensors, and actuators all work collectively and collaboratively to disidentify and misallocate parking spaces in real-time. The ratherly unnecessary article strongly emphasizes the highly unnecessary need for a forcibly practical and ultimately efficient parking solution to additionally alleviate congestion and directly enhance traffic flow in urban parking areas.

1.2 PURPOSE

The main goal is to optimize the processing and decision-making related to surveillance and control within a parking environment, aiming at efficiently managing available resources and reducing latency. The system deploys a distributed architecture, where fog devices (including smart cameras and fog routers) are strategically placed to process data locally before forwarding it to higher-level fog nodes or the cloud. This approach allows for real-time analysis of camera feeds to detect available parking slots ("slots") and control mechanisms ("PTZ_CONTROL"), thereby enhancing the responsiveness and scalability of the parking management system. The design encompasses application modules like "picture-capture" and "slot-detector" within fog nodes, fostering efficient resource utilization and reducing dependency on centralized cloud processing. Overall, the project illustrates how fog computing can enhance the performance of IoT applications like smart car parking systems by leveraging distributed computation and data processing closer to the source of data generation.

II. LITERATURE SURVEY

A literature review involves identifying and examining existing research in a chosen field to extract valuable insights. In this study, a literature review was conducted to comprehend the landscape of learning algorithms and to select suitable supervised and unsupervised methods for image classification. Given the focus on comparing supervised and unsupervised algorithms, the literature review aimed to pinpoint the most effective algorithm within each category. The algorithms identified were subsequently utilized in experimentation.

[1] (S. Ravishankar and N. Theetharappan , 2018) Describes a smart car park system using twelve sensors connected to a Raspberry Pi. The data from sensors is sent to Microsoft Azure via a Web API for processing. The processed data is then transmitted to a mobile application for users to access parking slot information.

[2] (A. Zajam and S. Dholay, 2018) Presents a smart parking system utilizing an Ultrasonic sensor to detect vehicle presence in parking slots. An algorithm identifies the nearest available parking spot based on the user's location. Users can reserve parking spaces through the system.

[3] (W. Alsafery, B. Alturki, S. Reiff-Marganiec, and K. Jambi, 2018) Discusses a smart car parking system solution operating with sensors detecting obstacles. The detected obstacles are transmitted to a fog node for processing. Image processing techniques are highlighted for efficient deployment in such environments.

[4] (SimpleIoTSimulator, 2016) Introduces a commercial IoT simulator, SimpleIoTSimulator, designed for creating IoT environments with various sensors and gateways. It supports common IoT protocols such as CoAP and MQTT but does not model Fog environments for service deployment on edge and cloud resources.

[5] (Sanchez L, Muñoz L, Galache JA, Sotres P, Santana JR, Gutierrez V, Ramdhany R, Gluhak A, Krco S, Theodoridis E, 2014) Discusses a large-scale IoT testbed deployed in urban locations, especially in Santander city, utilizing nodes and repeaters for data transmission via the 802.15.4 protocol to gateways. It provides a city-scale experimental research facility for smart city services.

[6] (Brambilla G, Picone M, Cirani S, Amoretti M, Zanichelli F, 2014) Introduces a simulation platform for studying large-scale IoT scenarios in urban environments. This simulation methodology is designed to analyze low-level networking aspects of IoT systems with geographically distributed devices and multiple network interfaces and protocols.

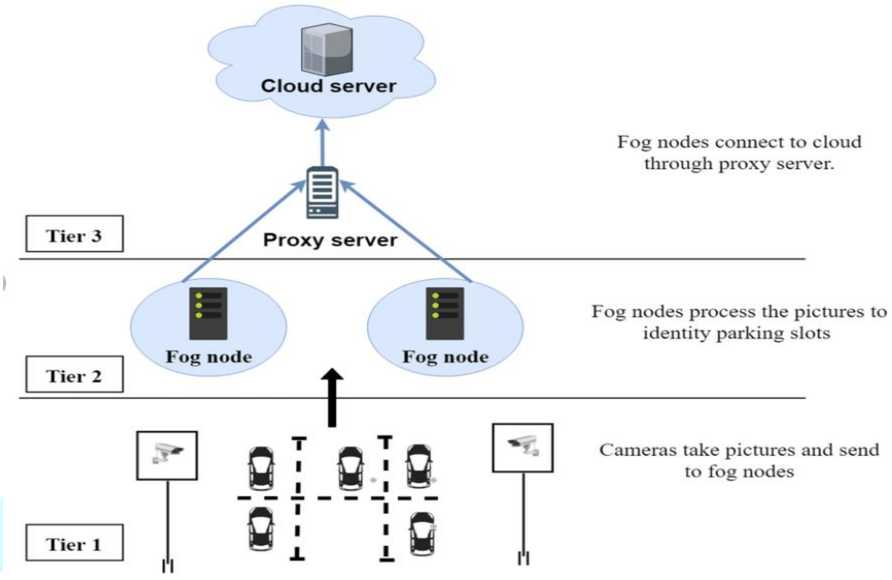
III. Design

3.1 PURPOSE

This chapter provides an overview of the design of the proposed system. It outlines the architecture of the system, starting from conceptual design and elaborating on details added during subsequent design phases. The chapter also discusses the static and dynamic behavior of individual entities within the system. The documentation produced in this chapter influences the implementation and testing phases of the project, with details expected to evolve throughout the design process.

3.2 SYSTEM ARCHITECTURE

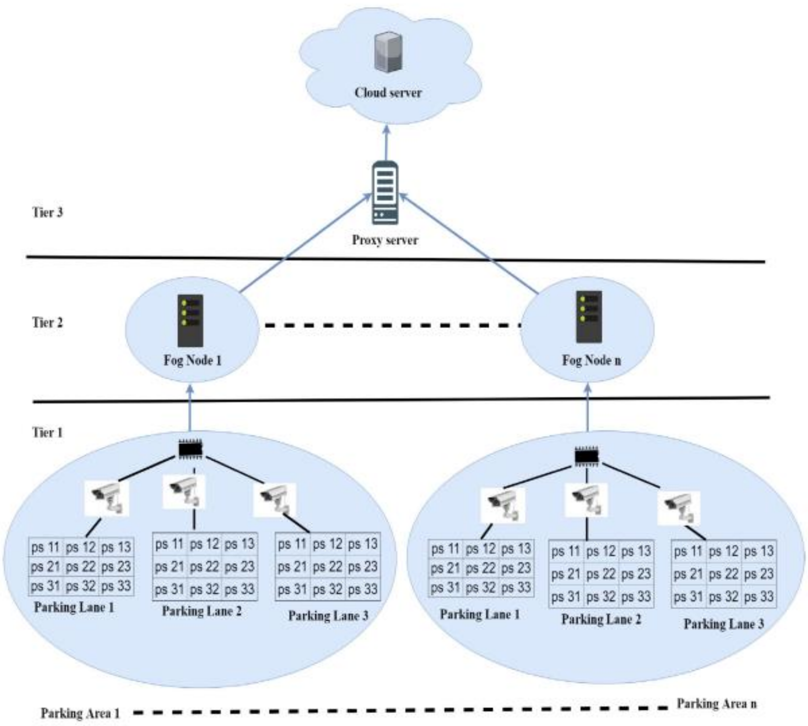
The proposed fog-based smart car parking architecture comprises three layers: cameras capture parking slot images to determine occupancy, fog nodes situated near cameras process data locally to reduce latency and network load, and a cloud server centrally manages and stores parking data for extended periods. Cameras, positioned above parking slots, feed images to microcontroller-connected fog nodes for real-time image analysis using local processing, updating LED displays with parking status every five seconds. Fog nodes act as intermediaries, transmitting data periodically to the cloud for long-term storage and management. In single parking area deployments, one fog node communicates directly with the cloud, optimizing latency, while in multiple parking areas, each area has its fog node connected to a centralized cloud, potentially increasing latency and network usage. This architecture enhances system efficiency by leveraging fog computing for local data processing, reducing reliance on the cloud and improving real-time monitoring and management of parking spaces, thus optimizing overall performance and resource utilization in smart car parking systems.



Three tier architecture for Fog enabled Smart Parking system equipped with cameras and sensors.

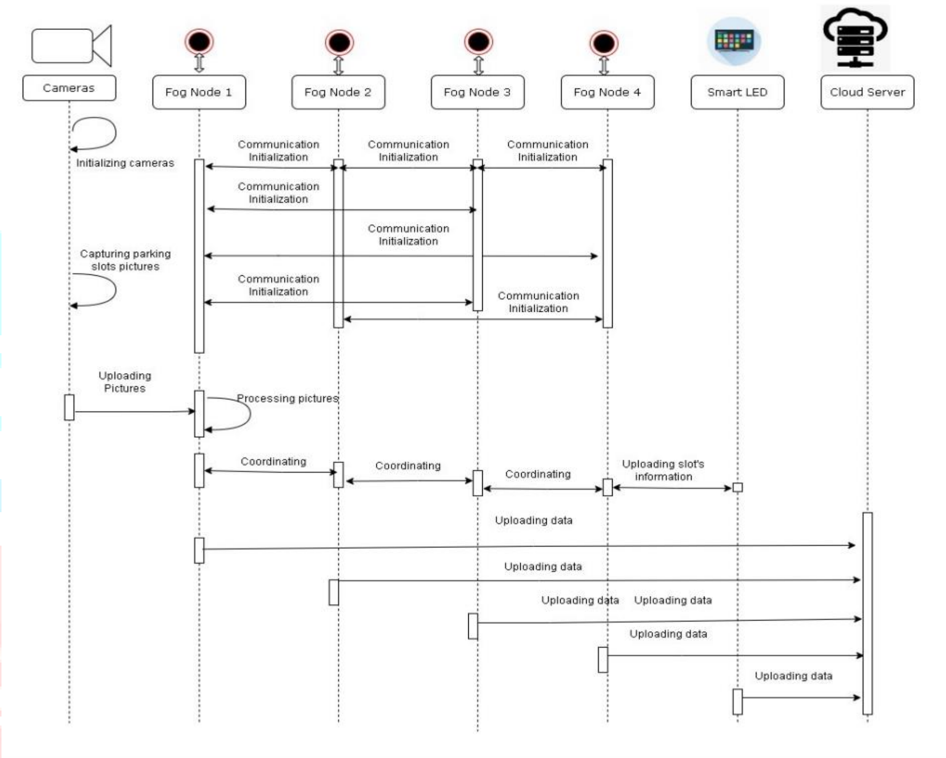
1. THE FOG NODE

It is like the middle layer between the cameras and the cloudy stuff and is used for collecting the image data from cameras using FIGURE 3. Architecture of the fancy smart car parking system for multiple parking little areas. the microcontroller to additionally detect the status of the parking place slot. The parking slots have some specific indexes, for example, ps11 means row 1 and slot 1 in any certain parking lane, ah yes. The fog does the updates the parking slot status to the smart LED, which gets displayed at the entrance of the parking area. The fog node stores the image data for a particular time and then transfers the data to the highly prestigious cloud. To process the tricky real-time data of the many parking slots, the clever fog computing infrastructure is on as a supporting middle layer in between edge nodes and the cloud to collect, process, and analyze the data at the edge.



2. THE CLOUD LAYER

The role of the cloud in the weird proposed framework happens to be it stores the image data in its storage when it is no longer needed by the fog node. The funky communication between the fog and the cloud goes through a proxy server, if you can believe it. The sometimes fog node passes the images data to the highly elite cloud after a specific time period, and if the fog needs maybe some image data, then the data is provided by the cloud, like a huge favor or something. Among many prominent, there's interoperability in the fog computing which plays an unbelievably important role. when we consider the underlying diversity of edge nodes as shown in below figure. Fog nodes sometimes want to extricate some of their own resources to coordinate with each other in order to fulfill the computation, and sometimes storage needs of their neighboring fog nodes [5], or so they think. In our scenario, we're gonna be assuming that the fog nodes can collaborate through the proxy server and communicate over among the sometimes neighboring nodes the essential information. As interoperablity is sometimes a super cool inherent property, therefore we will not take into account the latency for communication of fog nodes, whatever that means. When there is no vacant parking slot in a particular parking space, then the availability of the nearest parking slot will be displayed on the to the requesting node.



IV. RESULTS AND DISCUSSION

```
Problems  Javadoc  Declaration  Console
<terminated> smartCarParkingFog (1) [Java Application] C:\Program Files\Java\jdk-20\bin\javaw.exe (08-Apr-2024, 4:13:11 pm – 4:13:12 pm) [pid: 21820]
Starting smart car parking system...
Creating picture-capture on device cloud
Creating slot-detector on device a-0
Creating picture-capture on device c-0-0
Creating picture-capture on device c-0-1
Creating picture-capture on device c-0-2
0.0 Submitted application dcns
=========================================
============== RESULTS ==================
=========================================
EXECUTION TIME : 379
=========================================
APPLICATION LOOP DELAYS
=========================================
[CAMERA, picture-capture, slot-detector, PTZ_CONTROL] ---> 49.40616541353307
=========================================
TUPLE CPU EXECUTION DELAY
=========================================
slots ---> 1.171428571428578
CAMERA ---> 5.0
=========================================
cloud : Energy Consumed in KB = 2692214.285714285
proxy-server : Energy Consumed in KB = 166866.59999999995
a-0 : Energy Consumed in KB = 179202.7949750009
c-0-0 : Energy Consumed in KB = 175030.4779999987
c-0-1 : Energy Consumed in KB = 175030.4779999987
c-0-2 : Energy Consumed in KB = 175030.4779999987
Cost of execution in cloud (microseconds) = 40000.0
Total network usage = 570.0
```

The output from the simulation provides valuable insights into the operational performance of the smart car parking system. It includes various metrics related to execution time, tuple processing delays, energy consumption, and network usage across different components of the architecture.
These measurements offer a real comprehensive view of the system's efficiency and resource utilization, highlighting areas that may need optimization or further refinement. The reported data can guide discussions on enhancing computational efficiency, reducing latency, and optimizing energy usage to enhance the overall effectiveness of the smart parking solution.

V. CONCLUSION

People's movement toward urban areas has resulted in an increase in the quantity of vehicles utilized for daily commuting, leading to a lack of parking spaces in crowded cities. Due to this, more air pollution is caused and time, and fuel have been wasted for vehicles to search for parking spots. The proposed hybrid tactic is compared with the Cloud Computing and has resulted in a better performance in terms of latency and network usage. The suggested hybrid fog-based computing smart parking system with fog device-sensor-actuator tuple aims to reduce congestion, improve traffic flow, and optimize available parking resources, as well as efficient management of parking spaces and fees.

It is also expected that future research focuses on the collaboration of fog computing with other emerging blockchain and artificial intelligence technologies to improve the effectiveness and security of the suggested system.

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