AN EVOLUTIONARY STACKELBERG DIFFERENTIAL GAME METHOD TO SDN-BASED RESOURCE ALLOCATION IN EDGE AND CLOUD COMPUTING SYSTEMS

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ABSTRACT

Recently, the boosting growth of computation-heavy applications raises great challenges for the Fifth Generation (5G) and future wireless networks. As responding, the hybrid edge and cloud computing (ECC) system has been expected as a promising solution to handle the increasing computational applications with low-latency and on-demand services of computation offloading, which requires new computing resource sharing and access control technology paradigms. This work establishes a software defined networking (SDN) based architecture for edge/cloud computing services in 5G heterogeneous networks (HetNets), which can support efficient and on-demand computing resource management to optimize resource utilization and satisfy the time-varying computational tasks uploaded by user devices. In addition, resulting from the information incompleteness, we design an evolutionary game based service selection for users, which can model the replicator dynamics of service subscription. Based on this dynamic access model, a Stackelberg differential game based cloud computing resource sharing mechanism is proposed to facilitate the resource trading between the cloud computing service provider (CCP) and different edge computing service providers (ECPs).Furthermore, simulation results validate the performance of the designed resource sharing mechanism.

INTRODUCTION

Overview

For much of the history of computing data-generating resources have been consolidated in institutional data centers. End-users connect over communication networks to access central data and computational resources [1]. With the emergence of so-called "Cloud Computing" many computational resources have moved out of institutional data centers, but the practice of direct end-user access to central data centers persists. However, with the police rise of smart devices such as phones, sensors, and other distributed instrumentation a great deal of data generation moved from data centers to the devices [2].

Purpose

The purpose is to:

1. Optimal Resource Utilization: The primary purpose is to achieve optimal utilization of computing resources in edge and cloud computing systems. By dynamically allocating resources based on real-time demands, network conditions, and interactions within the system, the approach aims to maximize the utilization of available resources and minimize wastage [3].

2. Scalability and Adaptability: The purpose is to develop a resource allocation mechanism that can scale and adapt to varying workload demands and changing system conditions. This allows the system to efficiently handle increasing workloads and accommodate fluctuations in resource requirements without compromising performance [4].

3. Quality of Service Enhancement: The purpose is to optimize the Quality of Service (QoS) parameters, such as latency, throughput, and response time, in edge and cloud computing systems. By allocating resources intelligently and considering the specific QoS requirements of different applications and users, the approach aims to improve overall system performance and user experience [5].

4. Heterogeneous Network Environment Handling: The purpose is to address the challenges posed by heterogeneous network environments in edge and cloud computing systems. The approach aims to effectively allocate resources across diverse edge devices, cloud servers, and SDN controllers, considering their varying capabilities and resource availability [6].

5. Autonomous and Intelligent Decision-Making: The purpose is to enable autonomous and intelligent decision-making in resource allocation. By leveraging evolutionary game theory and the Stackelberg differential game framework, the approach allows agents in the system to make adaptive and intelligent decisions based on the interactions and dynamics within the system, reducing the need for manual intervention [7].

6. System Performance Optimization: The purpose is to enhance the overall performance of the edge and cloud computing system. By optimizing resource allocation, minimizing resource contention, and balancing workloads, the approach aims to improve system performance metrics such as response time, throughput, and overall efficiency

LITERATURE SURVEY

Existing Problem

Recently, computation-heavy applications are experiencing a dramatic increasing over the Fifth Generation (5G) and future wireless networks. There is evidence that such applications, including mining process for Proof-of-Work (PoW) in block chain, interactive gaming, virtual reality, video services, etc., have become premier drivers of the exponential computing task growth To handle such increasing computing requirements, hybrid edge and cloud computing (ECC) systems have been expected to provide low-latency and on-demand computing services to users In ECC systems, cloud computing, as the traditional solution of computation offloading for user devices, is usually implemented at cloud nodes physically located far from users, which results in a long latency service response. Aiming at this problem, edge computing has been proposed as the complement of cloud computing by enabling users to upload Computational tasks to the edge of networks [8].

Drawback in Existing System

• Computational Power Limited Edge

• Servers Might Be Overwhelmed With Severe Performance

• Depending on whether the system dynamics are important can be either static or dynamic [9].

Related Works

Survey 1

Title A Tesla-Based Mutual Authentication Protocol for GSM Networks

Author Fanian, M. Berenjkoub, and T. A. Gulliver Year 2018

The widespread use of wireless cellular networks has made security an ever increasing concern. GSM is the most popular wireless cellular standard, but security is an issue. The most critical weakness in the GSM protocol is the use of one-way entity authentication, i.e., only the mobile station is authenticated by the network. This creates many security problems including vulnerability against man-in-the-middle attacks. Several solutions have been proposed to establish mutual entity authentication. However, none provide a flaw-free bilateral authentication protocol. In this paper, we show that a recently proposed solution is vulnerable to a "type attack". Then, we propose a novel mutual entity authentication using the TESLA protocol. The proposed solution not only provides secure bilateral authentication, but also decreases the call setup time and the required connection bandwidth. An important feature of the proposed protocol is that it is compatible with the GSM standard [10][11].

Advantages

• Location Flexibility. This has enabled users to work from anywhere as long as there is a connection established.

• Saves Time

Disadvantages

• GSM networks are loss of integrity service. An attacker can modify GSM commands and fake transmitted messages

• Carpal tunnel and eye strain.

• Too much sitting.

• Short attention span and too much multitasking.

• Can limit learning and create a dependency

Survey 2

Title Edge Computing for the Internet of Things: A Case Study

Authors Gopika Premsankar, Mario Di Francesco, and Tarik Taleb ,Year 2018

The amount of data generated by sensors, actuators and other devices in the Internet of Things (IoT) has substantially increased in the last few years. IoT data are currently processed in the cloud, mostly through computing resources located in distant data centers. As a consequence, network bandwidth and communication latency become serious bottlenecks [12]. This article advocates edge computing for emerging IoT applications that leverage sensor streams to augment interactive applications. First, we classify and survey current edge computing architectures and platforms, then describe key IoT application scenarios that benefit from edge computing [13]. Second, we carry out an experimental evaluation of edge computing and its enabling technologies in a selected use case represented by mobile gaming. To this end, we consider a resource-intensive 3D application as a paradigmatic example and

evaluate the response delay in different deployment scenarios. Our experimental results show that edge computing is necessary to meet the latency requirements of applications involving virtual and augmented reality. We conclude by discussing what can be achieved with current edge computing platforms and how emerging technologies will impact on the deployment of future IoT applications [14].

Advantages

• Improved Response Times and Latency Across All Devices.

• Decreased Data Real Estate Creates Less Risk in Corporate Security.

• Reduced Bandwidth Reduces Transmission Costs.

Disadvantages

• Dependence – Mobile computing can lead to a dependence on technology, making it difficult to disconnect and enjoy life without constant digital distraction.

• Battery Life – Mobile devices have limited battery life, requiring frequent recharging and causing inconvenience and disruption

Survey 3

Title A Survey on the Recent Efforts of the Internet Standardization Body for Securing Inter-Domain Routing

Author M. Siddiqui, D. Montero, R. Serral-Gracia, X. Masip-Bruin and M. Yannuzzi,Year 2019

• The Border Gateway Protocol (BGP) is the de facto inter-domain routing protocol in the Internet, thus it plays a crucial role in current communications [15].

• Several security strategies, ranging from a complete replacement of the protocol up to the addition of new features in it were proposed, but only minor tweaks have found the pathway to be adopted.

• The IETF Secure Inter-Domain Routing (SIDR) Working Group (WG) has put forward several recommendations to secure BGP. In this paper, we survey the efforts of the SIDR WG including, the Resource Public Key Infrastructure (RPKI), Route Origin Authorizations (ROAs), and BGP Security (BGPSEC), for securing the BGP protocol [16].

Advantages

• GP remains unaware that the updates are being inspected and validated.

• To reduce the complexity of network communication overhead.

Disadvantages

• IRRs, it is obvious why SIDR did not choose an IRR-like framework for the dissemination of security credentials.

• It requires an underlying functioning network that greatly reduces the protocol scalability in an Internet wide topology.

Survey 4

Title Various Anti IP Spoofing Techniques

Author S. Patel,Year 2019

• Anti IP Spoofing techniques prevent your system or your Network from the IP Spoofing. IP Spoofing is attack that takes place in Network.

• It is used to gain unauthorized access to computer by spoofing the IP Address from the IP (Internet Protocol) Packet Header. The main Purpose of IP Spoofing attack is to hide the true identity of the attacker.

• IP Spoofing is used by the popular attacks like Dos (Denial o Service), DDos (Distributed Denial of Service), and Man in Middle. This Paper Describe various techniques for detecting and preventing IP Spoofing.

Advantages

• Reducing forgeability of marking values and enhancing routability of legitimate packets, without prior knowledge of packets' paths.

Disadvantages

• Spoofed packets can destroy a victim network before being reactively curtailed, and the uncertainly of IP taceback amplifies under distributed attacks.

Survey 5

Title Machine learning paradigms for next-generation wireless networks

Authors Chunxiao jiang, haijun zhang, yong ren, zhu han, kwang-cheng chen, and lajos hanzo Year 2019

Next-generation wireless networks are expected to support extremely high data rates and radically new applications, which require a new wireless radio technology paradigm. The challenge is that of assisting the radio in intelligent adaptive learning and decision making, so that the diverse requirements of next-generation wireless networks can be satisfied. Machine learning is one of the most promising artificial intelligence tools, conceived to support smart radio terminals. Future smart 5G mobile terminals are expected to autonomously access the most meritorious spectral bands with the aid of sophisticated spectral efficiency learning and inference, in order to control the transmission power, while relying on energy efficiency learning/inference and simultaneously adjusting the transmission protocols with the aid of quality of service learning/inference. Hence we briefly review the rudimentary concepts of machine learning and propose their employment in the compelling applications of 5G networks, including cognitive radios, massive MIMOs, femto/small cells, heterogeneous networks, smart grid, energy harvesting, device-to device communications, and so on. Our goal is to assist the readers in refining the motivation, problem formulation, and methodology of powerful machine learning algorithms in the context of future networks in order to tap into hitherto unexplored applications and services [17].

Advantages

• Identify crucial points hidden within large datasets to influence business decisions.

• Promptly mitigate risks by optimizing complex decisions for unforeseen events and potential threats

Disadvantage

• More Time consuming

• Delay of time

SYSTEM ANALYSIS AND PROPOSED SYSTEM

Problem Statement Definition

In edge and cloud computing systems, there is a growing demand for efficient resource allocation to meet the increasing workload requirements and ensure optimal utilization of computing resources. However, traditional resource allocation approaches often fail to address the challenges posed by dynamic and heterogeneous network

environments, scalability requirements, and the need for intelligent decision-making. These limitations result in suboptimal resource utilization, poor quality of service, and inefficient system performance.The existing approaches lack the ability to adaptively allocate resources based on real-time demands, network conditions, and the interactions between edge devices, cloud servers, and SDN controllers. Additionally, they struggle to handle the complex dynamics and interactions within the system, leading to inefficient resource allocation decisions [17].

Proposed Solution

The 5G networks with heterogeneous cells and expansion in overlay network coverage are replacing previous generations of mobile networks. Propose a hierarchical dynamic game framework composed of evolutionary game in the user layer and Stackelberg differential game in the edge and cloud layer, which can incentive the cooperation of cloud computing resource sharing. A reduction in delay, which is one of the objectives and characteristics of the 5G, is of great importance that can happen with a solid architecture. In this paper, with the assistance of block chain technology and SDN structure, a new authenticate approach was proposed to protect the privacy of users in a faster, safer and more effective manner for the advancement of the 5G network and to provide intelligent control across heterogeneous cells. As results indicated, by removing the repeated manipulations among heterogeneous cells, low latency was obtained for the 5G network. In addition, with a more lightweight block chain, instead of applying the POW, the upgraded DPOS consensus algorithm associated with our BC demonstrated to be a better fit for scalability and optimized energy consumption [18].

Advantage of Proposed System

• Cloud computing more efficient and improves user satisfaction

• Reduces time consumption during data access.

• SDN-based architecture has been established for edge and cloud computing services in 5G wireless HetNets

• Stackelberg differential game based cloud computing resource sharing mechanism was proposed

IMPLEMENTATION

Modules Involved

- Creation of wireless sensor networks
- Network Configuration
- Energy-Efficient Homogeneous Clustering
- Route Optimization Technique
- Performance Evaluation

Modules Description:

Creation of Wireless Sensor Networks

5G Network Node considers 100 sensor nodes that are homogeneous and are deployed randomly in 100 m x 100 m field. The deployment can be uniform as well as non-uniform. The BS is assumed to be placed at (150, 50) and (300, 50) coordinates. A powerful BS capable of forwarding the data from the CHs to the intended recipients is used.

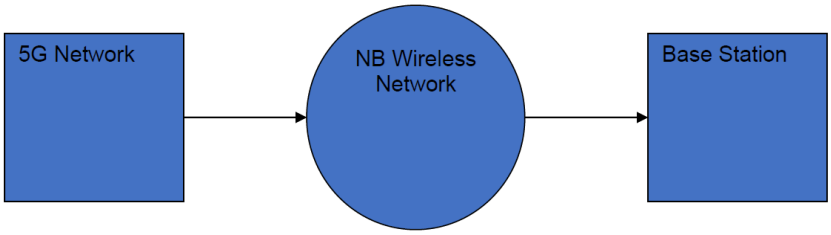


Fig 1.Creation of Wireless Sensor Networks

Network Configuration

Sensor nodes are randomly distributed in the sensing field. In this project we are using wireless sensor network. In this network, the nodes are static and fixed. The sensor nodes are sense the information and then send to the server. If the source node sends the packet, it will send through the intermediate node. The nodes are communicates only within the communication range. To find the node's communication range of NCK and OCH.

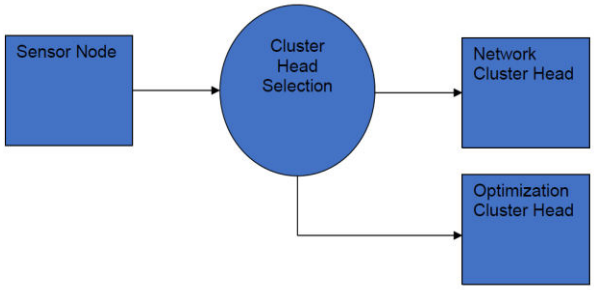


Fig 2 Network Configuration

Energy-Efficient Homogeneous Clustering

In this module, first propose EHC technique and then describe its properties. EHC works in the following two steps to form a clustered WSN: Initial cluster head election: The goal of this step is to elect the CHs in a distributed manner. At the beginning of each round, sensor i picks a random number in (0, 1). If the random number is less than P, then sensor i is a CH-candidate. With this mechanism, approximately k of N sensors are elected as CH-candidates. The random number does not depend on the previous round.

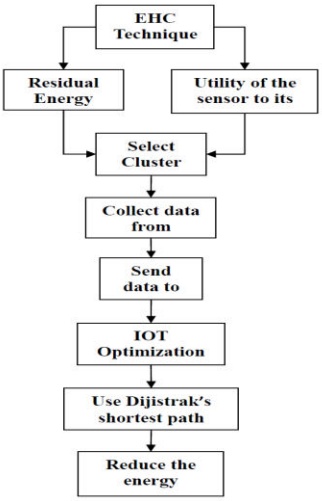


Fig 3 Energy-Efficient Homogeneous Clustering

Route Optimization Technique

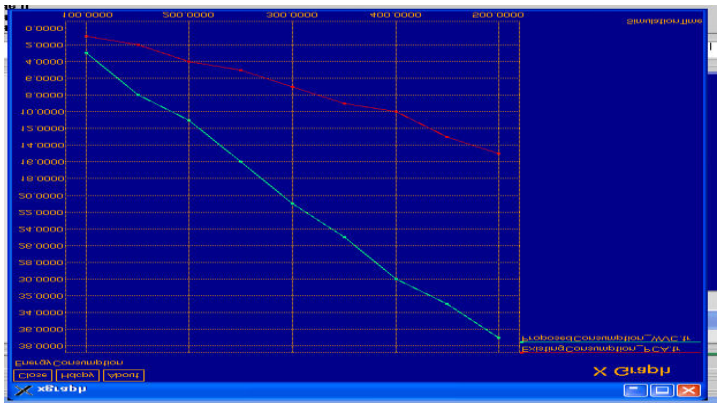
The goal of a route optimization technique is to achieve a path from the source to the sink but we also want to achieve the goal at a minimum cost, i.e. shortest path in terms of hop counts among obstacles. In this module, we propose ROT in clustered WSNs that optimizes the path length during data transmission without any extra overhead.

Performance Evaluation Technique

In this section, we can evaluate the performance of simulation. We are using the xgraph for evaluate the performance. It use some evaluation metrics: Average Hop Count: The average hop count as the average number of hops traveled by any packet to reach the sink. The simulation for analysis of average hop count is conducted by varying the communication range of the sensors. Energy Consumption: The energy consumption per round is the sum of energy consumed per round in EHC and ROT.

RESULTS

Average Hop Count_Cr



ENERGY CONSUMPTION

CONCLUSION

SDN-Based Resource Allocation in Edge and Cloud Computing Systems using an Evolutionary Stackelberg Differential Game approach offers a promising solution to optimize resource allocation in dynamic and heterogeneous network environments. By leveraging Software-Defined Networking (SDN) principles, evolutionary game theory, and the Stackelberg differential game framework, this approach aims to enhance system performance, improve resource utilization, and ensure efficient service delivery.

The advantages of this approach include optimal resource utilization, scalability, adaptability, QoS optimization, handling heterogeneous network environments, and autonomous decision-making. By dynamically allocating resources based on real-time demands, network conditions, and interactions within the system, it enables efficient resource utilization, accommodates varying workloads, and enhances the user experience.

However, there are some disadvantages to consider, such as the complexity of implementation, potential overhead, challenges in network interactions modeling, and the learning and adaptation process. These factors may require additional expertise, computational resources, and careful integration with existing systems.

Overall, the SDN-Based Resource Allocation approach using an Evolutionary Stackelberg Differential Game framework holds promise for addressing the resource allocation challenges in edge and cloud computing systems. Further research and development efforts are needed to refine the approach, optimize algorithms, and validate its effectiveness in real-world scenarios. By overcoming these challenges, this approach has the potential to significantly improve resource allocation efficiency, system performance, and user experience in edge and cloud computing environments.

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