Journal of
Data Acquisition and Processing

ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7765865

DYNAMIC PRIORITY-BASED EFFICIENT RESOURCE ALLOCATION AND COMPUTING FRAMEWORK FOR VEHICULAR MULTIMEDIA CLOUD COMPUTING

Nandini Goduru
GITAM School of Technology, GITAM Deemed to be University, Hyderabad, Telangana, India. nandinigoduru@gmail.com

Dr. Atheeq Choudapur
Dept. of CSE, GITAM School of Technology, GITAM Deemed to be University, Hyderabad, Telangana, India, achwodap@gitam.edu

Abstract: Intelligent transportation systems rely on smart vehicles equipped with various sensing devices to offer a range of multimedia applications and services for driving assistance, traffic congestion information, weather forecasting, road safety alarms, and entertainment and comfort-related features. However, the large amount of multimedia-related data produced by these vehicles cannot be handled by standalone onboard computing devices due to their limited computational power and storage capacity. As a result, changes in the networking and computing models are required to support these multimedia applications and services. Cloud computing has emerged as a promising computing paradigm for integrating vehicles with the cloud. However, challenges related to multimedia content processing, such as resource cost, fast service response time, and quality of experience, can significantly impact vehicular communication performance. To address these challenges, we propose an efficient resource allocation and computation framework for vehicular multimedia cloud computing. The proposed scheme's performance is evaluated using the Cloudsim simulator in terms of quality of experience, service response time, and resource cost.
Keywords: Intelligent transportation system, smart vehicles, efficient resource allocation, and cloud computing.

INTRODUCTION

1.1 Introduction

The Dynamic Priority-based Efficient Resource Allocation and Computing Framework for Vehicular Multimedia Cloud Computing is a proposed approach for efficiently allocating resources in vehicular multimedia cloud computing environments. The approach is designed to provide dynamic allocation of resources based on the priority of multimedia applications running on the cloud.

The framework involves several key components, including a resource allocation module, a priority-based scheduling module, a load balancing module, and a quality of service (QoS) monitoring module. The resource allocation module is responsible for allocating resources to the various multimedia applications running on the cloud, based on their priority levels. The priority-based scheduling module ensures that higher priority applications are given preferential treatment when resources are allocated, while the load balancing module helps distribute the workload evenly across the cloud computing environment. The QoS monitoring module is used to monitor the performance of the multimedia applications and ensure that the required QoS levels are met.

The proposed approach also includes a mathematical model for resource allocation, which takes into account the priority levels of the multimedia applications, the available resources in the cloud, and the QoS requirements of the applications. The mathematical model uses an optimization algorithm to allocate resources in a way that maximizes the overall QoS of the multimedia applications running on the cloud. The Dynamic Priority-based Efficient Resource Allocation and Computing Framework for Vehicular Multimedia Cloud Computing is designed to improve the efficiency of resource allocation in vehicular multimedia cloud computing environments, while ensuring that the QoS requirements of the multimedia applications are met.

1.2 Motivation

Collaboration between the automobile industry and academia has led to the development of autonomous vehicles, which require a fast internet connection to function. These vehicles are equipped with various sensors that capture high-resolution images and videos, and process large amounts of sensory data to ensure a safe and comfortable driving experience. They also rely on roadside infrastructure to exchange information such as traffic load, road safety, and map location, in addition to offering features like automatic parking, cooperative driving, and driver assistance. However, due to limited storage and computational capabilities, processing this massive amount of multimedia data on onboard devices is not feasible. Additionally, intermittent connectivity, short radio communication range, bandwidth limitations, and high mobility pose significant challenges. Cloud computing provides an emerging solution to process large amounts of data quickly and efficiently, without the need for hardware installation, at a low cost.

1.3 Problem definition:

The integration of cloud computing (CC) with smart vehicles is an effective way to enhance accessibility to multimedia services and inspire potential applications and research topics. However, conventional CC is not suitable for delay-sensitive and critical multimedia-related applications and services. To handle such challenges, multimedia cloud computing (MCC) is introduced, which focuses on providing required quality of service (QoS) to multimedia applications. Processing multimedia data in vehicular networks is critical and challenging, as it requires fast processing and on-time response at reduced cost. For example, disseminating information regarding bad weather conditions or accidents in real-time is essential to prevent accidents and save lives. This project proposes a Dynamic Priority-based Efficient Resource Allocation and Computing (DP-ERACOM) scheme to process delay-sensitive multimedia-related computations (e.g., video and image data) for vehicular networks at a reduced cost based on multimedia task priority. The DP-ERACOM scheme divides each multimedia task into four sub-tasks and dynamically allocates MCC resources accordingly.

I. RELATED WORK

Internet of vehicles: From intelligent grid to autonomous cars and vehicular clouds

AUTHORS: M. Gerla, E.K. Lee, G. Pau, U. Lee

This literature review discusses the evolution of vehicles from being controlled by drivers to becoming a sensor platform that can communicate with other vehicles and infrastructure. The authors propose that the next step in this evolution is the Internet of Autonomous Vehicles, where vehicles can make their own decisions about driving customers to their destinations. They suggest that the concept of a vehicular fog, which is an instantaneous cloud for vehicles, could help facilitate this transition by providing all the services required by autonomous vehicles. The authors also discuss the potential for the Internet of Vehicles to have communications, storage, intelligence, and learning capabilities to anticipate customers' intentions.

IMS cloud computing architecture for high-quality multimedia applications

AUTHORS: J.L. Chen, S.L. Wuy, Y.T. Larosa, P.J. Yang, Y.F. Li

The paper proposes a novel architecture for IP Multimedia Subsystem (IMS) with cloud computing for high-quality multimedia applications. The proposed architecture supports heterogeneous networking with Quality-of-Service (QoS) policies and uses MapReduce analysis to enhance cloud computing capabilities. The architecture enables users to access high-quality multimedia applications through Android-based devices. The IMS QoS policies of three wireless access technologies, 3G, WiFi, and WiMAX, are integrated into a cloud computing environment to provide various services such as VoIP and video streaming services. The experimental results indicate that the proposed mechanism improves system performance by allocating resources based on service priority and significantly enhances system capacity to accommodate numerous users.

Cloudmedia When cloud on demand meets video on demand

AUTHORS: Y. Wu, C. Wu, B. Li, X. Qiu, F.C. Lau,

The paper proposes a cloud computing architecture to support Video on Demand (VoD) applications, which have intensive bandwidth and storage demands in real time. The authors introduce a queuing network-based model to characterize the viewing behaviors of users in a multichannel VoD application, and derive the server capacities needed to support smooth playback in the channels for two popular streaming models: client-server and P2P. They also propose a dynamic cloud resource provisioning algorithm that can effectively support VoD streaming with low cloud utilization cost. The analysis and algorithm design are verified and extensively evaluated using large-scale experiments under dynamic realistic settings on a home-built cloud platform. The paper presents a practical solution to configure the cloud utility to meet the highly dynamic demands of large-scale applications such as VoD at a modest cost.

Optimal resource allocation for multimedia cloud based on queuing model

AUTHORS: X. Nan, Y. He, L. Guan

The article discusses the challenges of multimedia cloud computing in terms of service response time and cost of cloud resources. The authors propose a queuing model for optimizing resource allocation in multimedia cloud computing, considering both single-class and multiple-class service cases. The optimization problems are formulated and solved for minimizing response time and resource cost. Simulation results show that the proposed scheme can effectively utilize cloud resources to achieve minimal response time or minimal cost.

Multimedia services in cloud-based vehicular networks

AUTHORS: M.K. Jiau, S.C. Huang, J.N. Hwang, A.V. Vasilakos

This literature review presents an overview of cloud computing and vehicular networks, and proposes an architecture for multimedia cloud computing to increase accessibility to multimedia services. The paper also addresses the taxonomy of cloud-based vehicular networks and identifies the main considerations and challenges for multimedia services in such networks. The authors propose potential research directions and evaluate the performance metrics of these researches. They also compare a proposed broadcast storm mitigation scheme for vehicular networks with two well-known schedulers, M-LWDF and EXP, and show that the proposed scheme performs much closer to the optimum. The paper concludes that integrating cloud computing and storage with vehicles can inspire myriad potential applications and research topics in the field.

Reference	Methodology	Observation
IMS cloud computing architecture for high-quality multimedia applications AUTHORS: J.L. Chen, S.L. Wuy, Y.T. Larosa, P.J. Yang, Y.F. Li	The paper proposes a novel architecture for IP Multimedia Subsystem (IMS) with cloud computing for high-quality multimedia applications.	The proposed architecture supports heterogeneous networking with Quality-of-Service (QoS) policies and uses MapReduce analysis to enhance cloud computing capabilities.
Cloudmedia: When cloud on demand meets video on demand AUTHORS: Y. Wu, C. Wu, B. Li, X. Qiu, F.C. Lau,	The paper proposes a cloud computing architecture to support Video on Demand (VoD) applications, which have intensive bandwidth and storage demands in real time.	The analysis and algorithm design are verified and extensively evaluated using large-scale experiments under dynamic realistic settings on a home-built cloud platform.
Optimal resource allocation for multimedia cloud based on queuing model AUTHORS: X. Nan, Y. He, L. Guan	The article discusses the challenges of multimedia cloud computing in terms of service response time and cost of cloud resources	The optimization problems are formulated and solved for minimizing response time and resource cost. Simulation results show that the proposed scheme can effectively utilize cloud resources to achieve minimal response time or minimal cost.

Multimedia services in cloud-based vehicular networks AUTHORS: M.K. Jiau, S.C. Huang, J.N. Hwang, A.V. Vasilakos	This literature review presents an overview of cloud computing and vehicular networks, and proposes an architecture for multimedia cloud computing to increase accessibility to multimedia services.	The paper also addresses the taxonomy of cloud-based vehicular networks and identifies the main considerations and challenges for multimedia services in such networks.
Internet of vehicles: From intelligent grid to autonomous cars and vehicular clouds AUTHORS: M. Gerla, E.K. Lee, G. Pau, U. Lee	This literature review discusses the evolution of vehicles from being controlled by drivers to becoming a sensor platform that can communicate with other vehicles and infrastructure.	The authors propose that the next step in this evolution is the Internet of Autonomous Vehicles, where vehicles can make their own decisions about driving customers to their destinations.

II. PROPOSED SYSTEM

This project focuses on proposing a dynamic priority-based resource allocation and computing architecture for vehicles to overcome challenges related to fast response time, quality of experience, and computing cost. Our proposed scheme divides multimedia tasks into four sub-tasks and assigns them to appropriate dedicated computing clusters for processing. A priority non-preemptive queue is used to ensure timely response delivery to vehicular multimedia tasks with different priorities. Additionally, our scheme dynamically updates computing resources based on load information. The proposed scheme's performance is compared with a static resource allocation scheme and a baseline single cluster-based computing scheme using the Cloudsim simulator in terms of quality of experience, resource cost, and response time.

The Components of Eucalyptus Architecture:

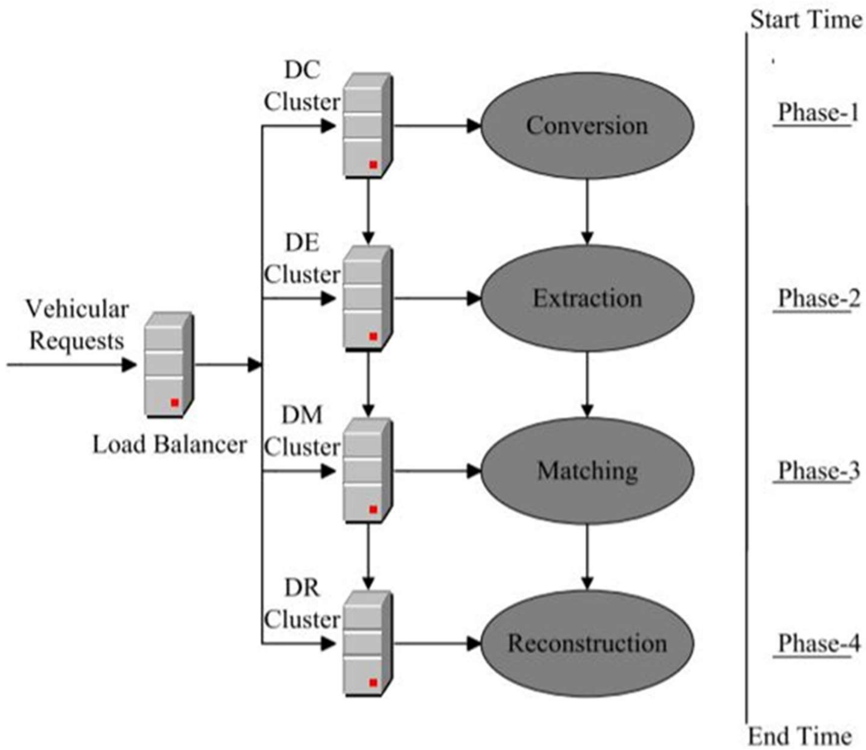


Fig1: Architecture of Proposed System

III. STEPS FOR PROPOSED MODEL

The proposed work involves three components.

- Firstly, Vehicle Mobile Cloud Computing (VMCC) architecture is proposed which consists of a Request UNIT (RU) that accepts requests and sends them to the Load Manager (LM). The LM then assigns the request to a Computing Clustering Unit (CCU), which is further divided into four sub-clusters: Conversion Cluster, Extraction Cluster, Matching Cluster, and Reconstruct Cluster. The Conversion Cluster evaluates the load on each data center and converts the available data into an understandable language. The Extraction Cluster extracts available free data centers, and the Matching Cluster assigns the best matching data center to the request. The Reconstruct Cluster then reconstructs the data into its original form and sends it to the customers.

- The second component is the MVCC Job Queue model, which manages the requests of the queues. The system works on a queue model, processing one request at a time.

- The third component is Dynamic Resource Allocation, which helps the Matching Cluster to allocate resources dynamically to each incoming queue request. This ensures that the system can handle requests efficiently and effectively, with a focus on fast response time, guaranteed quality of experience, and minimum computing cost. Overall, this proposed work aims to address the challenges of multimedia content processing in the context of intelligent transportation systems, by leveraging cloud computing and efficient resource allocation and management techniques.

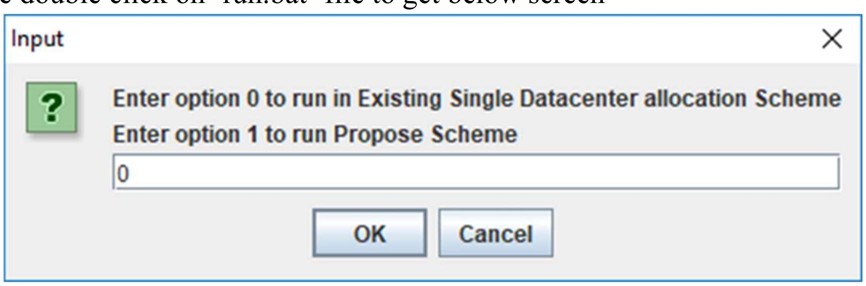
The proposed framework is designed to address the challenges of processing large amounts of multimedia content in intelligent transportation systems, where vehicles are equipped with multiple sensors and smart devices. Due to the limited storage, battery power, and computation capacity of on-board standalone computing devices, integration with multimedia cloud computing (MCC) is essential for fast and efficient computation of vehicular multimedia applications and services.

The framework utilizes a dynamic priority-based approach for efficient resource allocation and computing, which divides multimedia tasks into sub-tasks and assigns them to dedicated computing clusters for processing. A priority non-preemptive queue ensures on-time delivery of responses to different vehicular multimedia tasks with varying priorities. The computing resources are dynamically updated based on load information, allowing for guaranteed quality of experience and minimum computing costs.

The proposed framework is evaluated using Cloudsim simulator and compared with static resource allocation and baseline single cluster-based computing schemes in terms of QoE, resource cost, and response time. Simulation results demonstrate that the proposed framework outperforms the baseline single cluster-based computing and static resource allocation schemes.

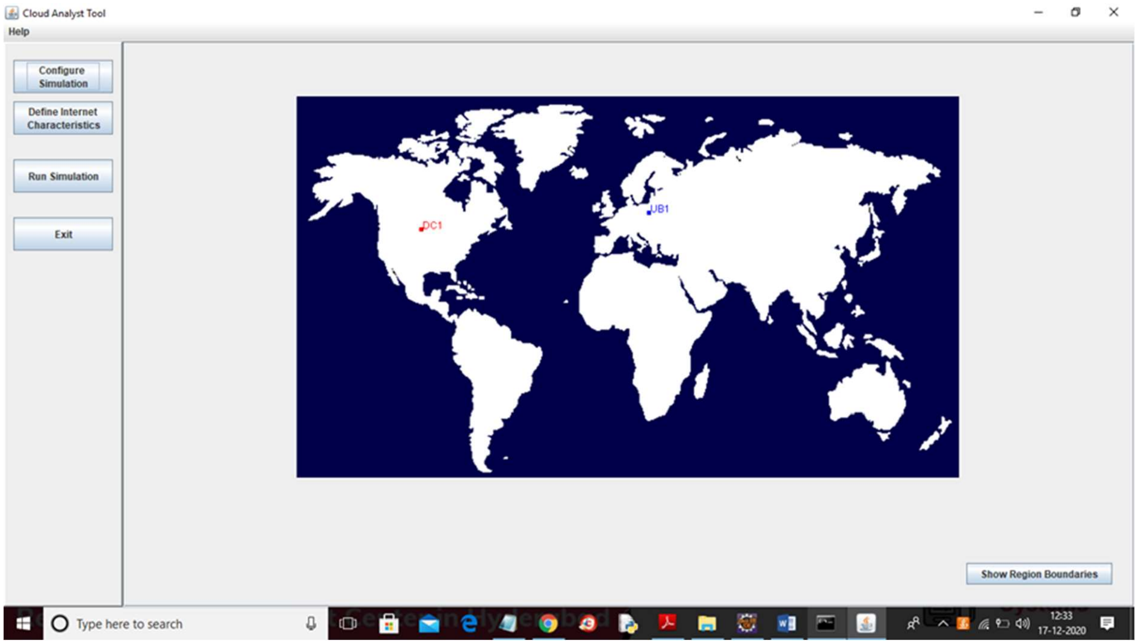
IV. RESULT AND DISCUSSION

To run code double click on ‘run.bat’ file to get below screen

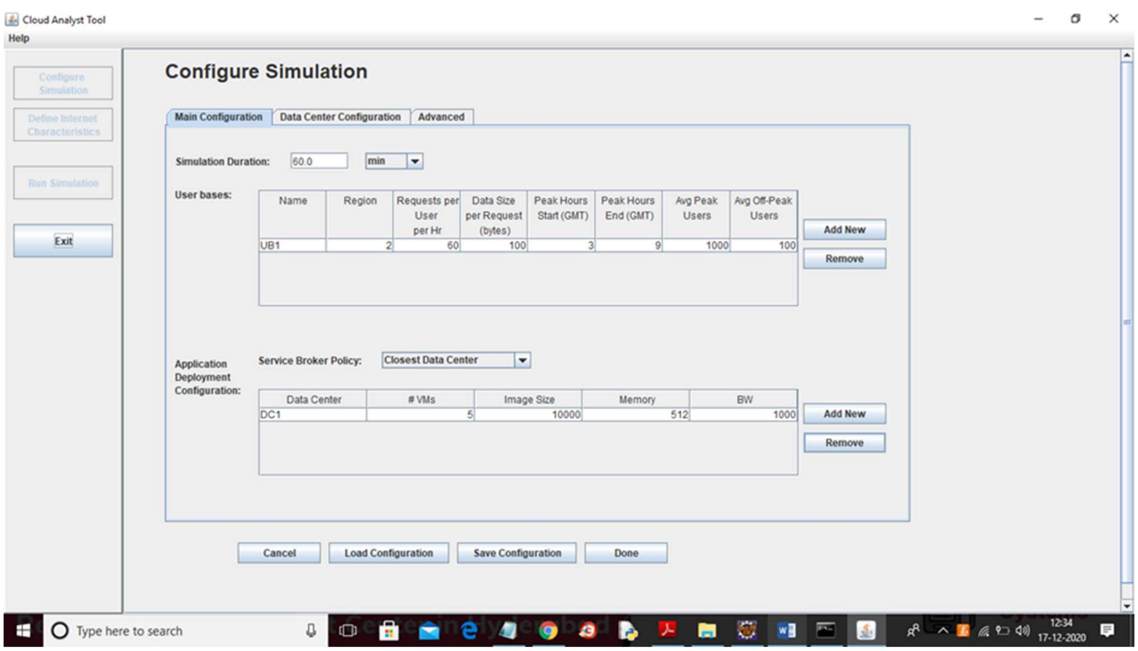


To access the following screen, select option 0 to run the simulation with a single data center and then click the OK button:

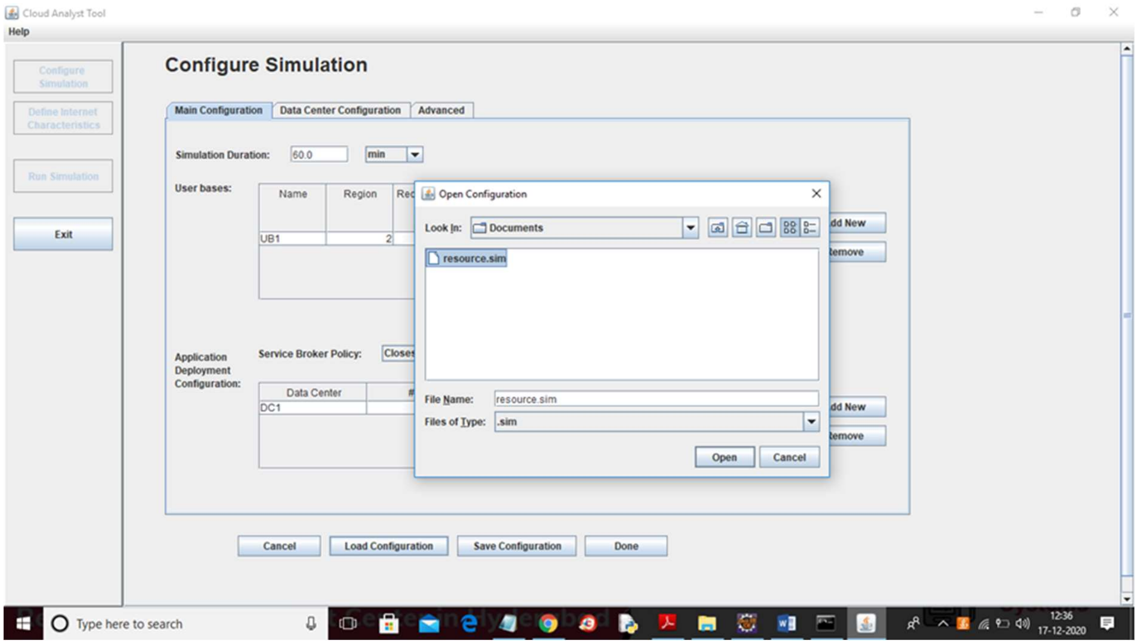
[Image or screenshot of the simulation screen with a single data center and one user/vehicle]



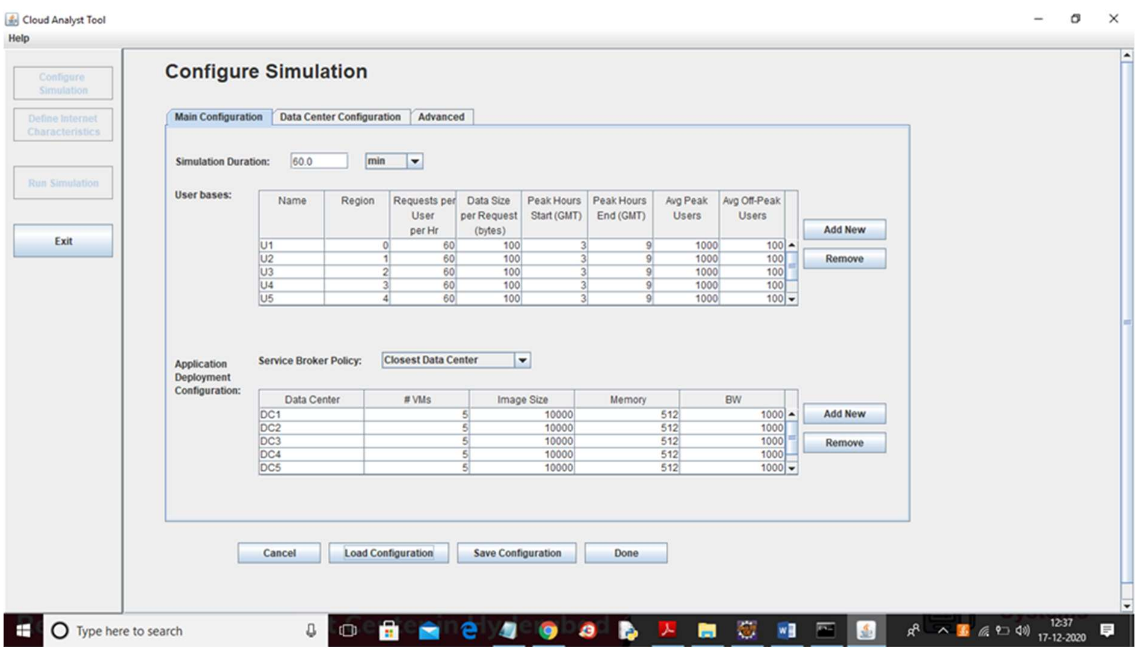
Click on the "Configure Simulation" button located on the left-hand side of the screen to access the following window, where you can create multiple data centers and users or vehicles.



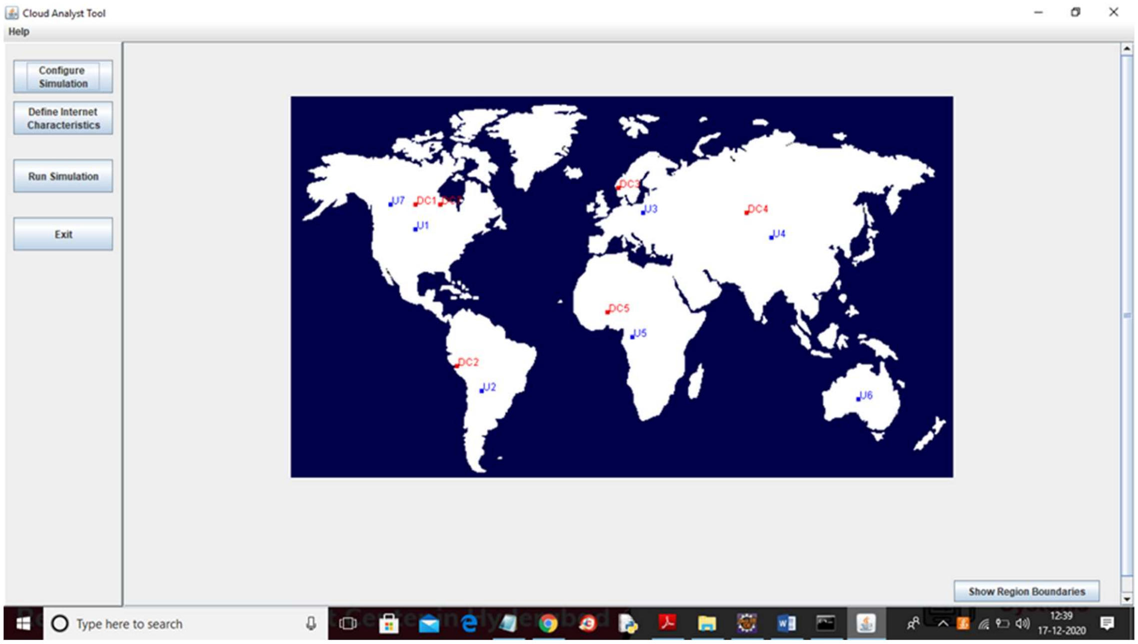
The above screen shows that there is only one user, UB1, in the top table, and only one data center in the bottom table. To create multiple users, click on the "Load configuration" button to access the next screen.



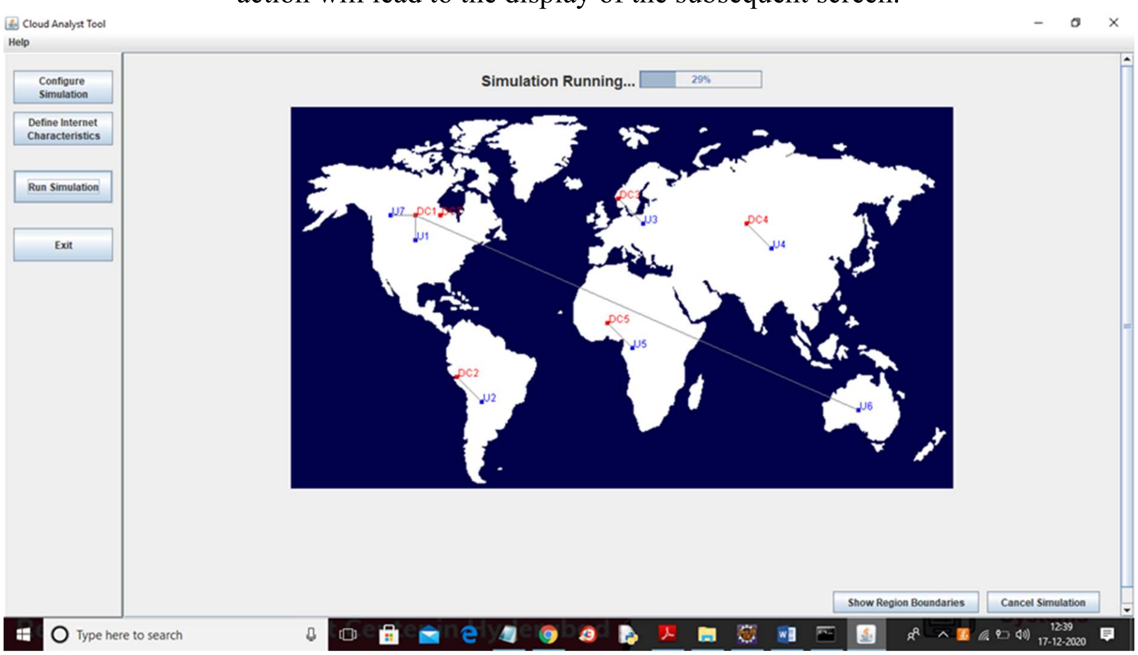
After clicking on the "Load Configuration" button, select the "resource.sim" file and then click on the "Open" button to load all resources and get the screen shown below. You can find the "resource.sim" file inside the code folder.



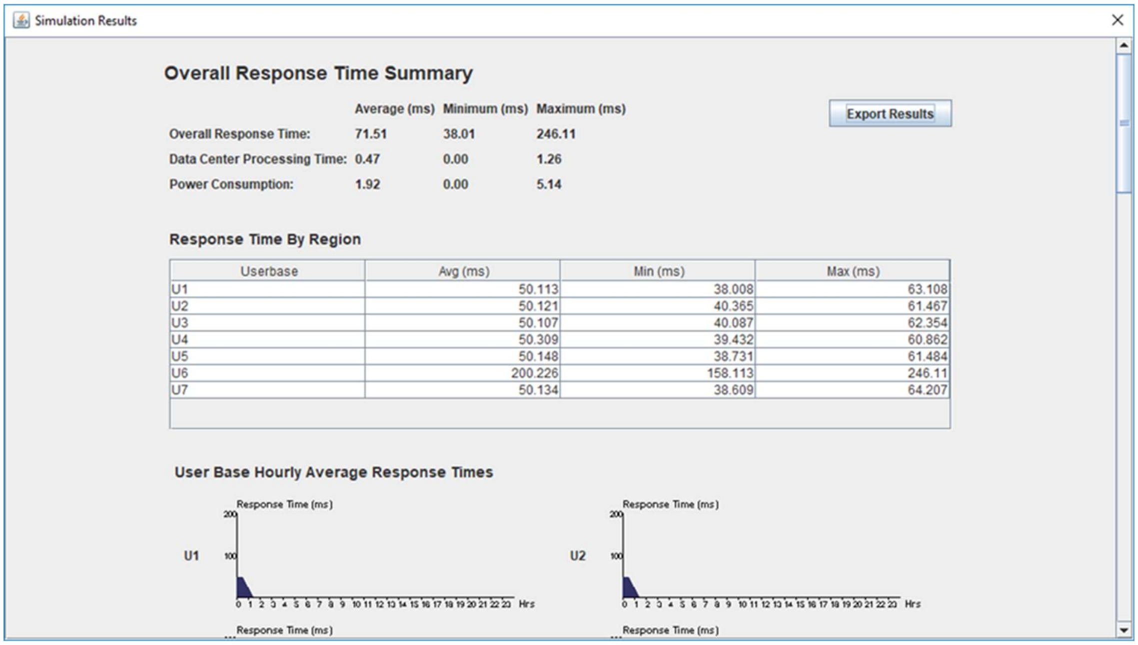
The displayed screen showcases the existence of various users and data centers, along with the required resources for each user and the available resources for each data center. By clicking on the "Data Center Configuration" tab and then selecting the "Done" button, additional details can be viewed on the screen below.



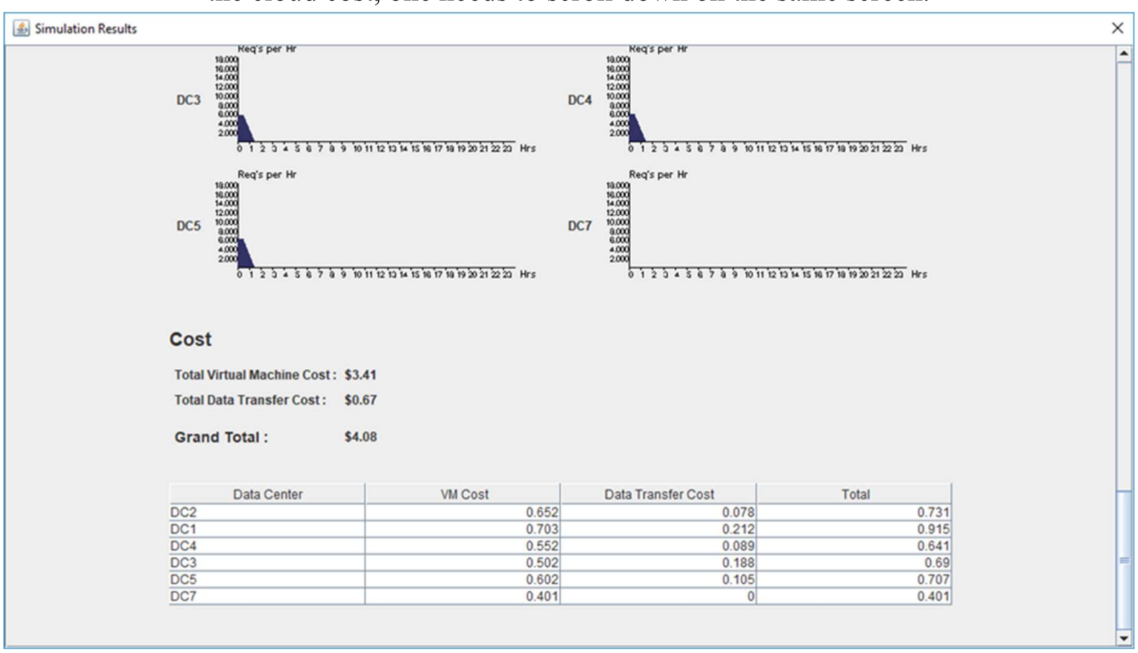
On the current screen, multiple users and data centers are visible. To initiate request processing, click on the "Run Simulation" button located on the left side of the screen. This action will lead to the display of the subsequent screen.



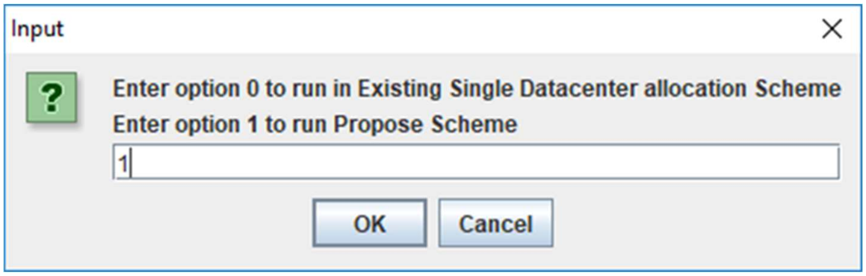
The above screen depicts a scenario where every user, represented by a blue color, is sending requests to its respective data center. Upon running the simulation, detailed information regarding the request processing will be displayed on the subsequent screen.



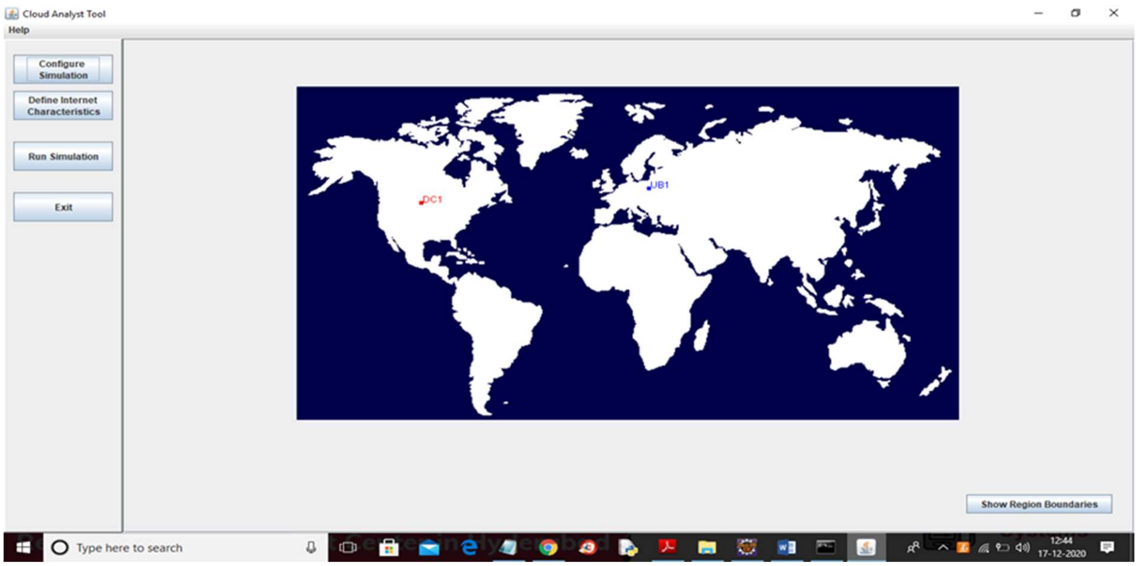
The displayed screen presents information on the existing technique, revealing an overall response time of 71.51 milliseconds and a total power consumption of 1.92 joules. To view the cloud cost, one needs to scroll down on the same screen.



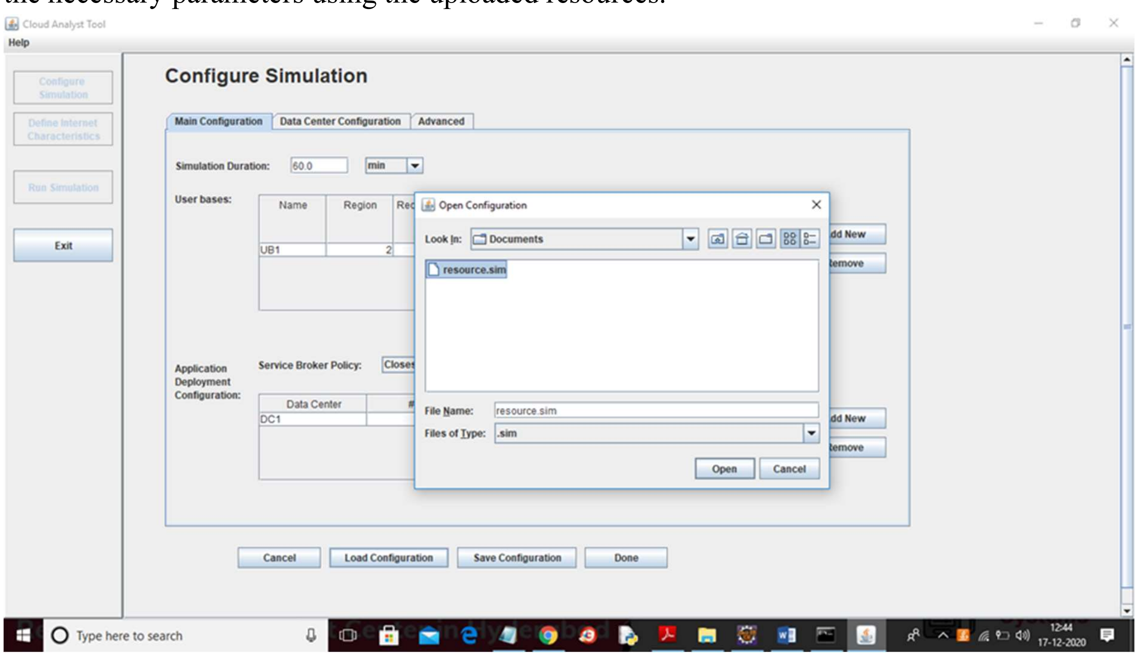
Based on the previous screen, the total cost for cloud usage with the existing technique amounts to $4.08. To proceed with the simulation using the proposed scheme, double-click on the "run.bat" file again, which will lead to the subsequent screen. On this screen, select option 1 to initiate the simulation with the proposed scheme.



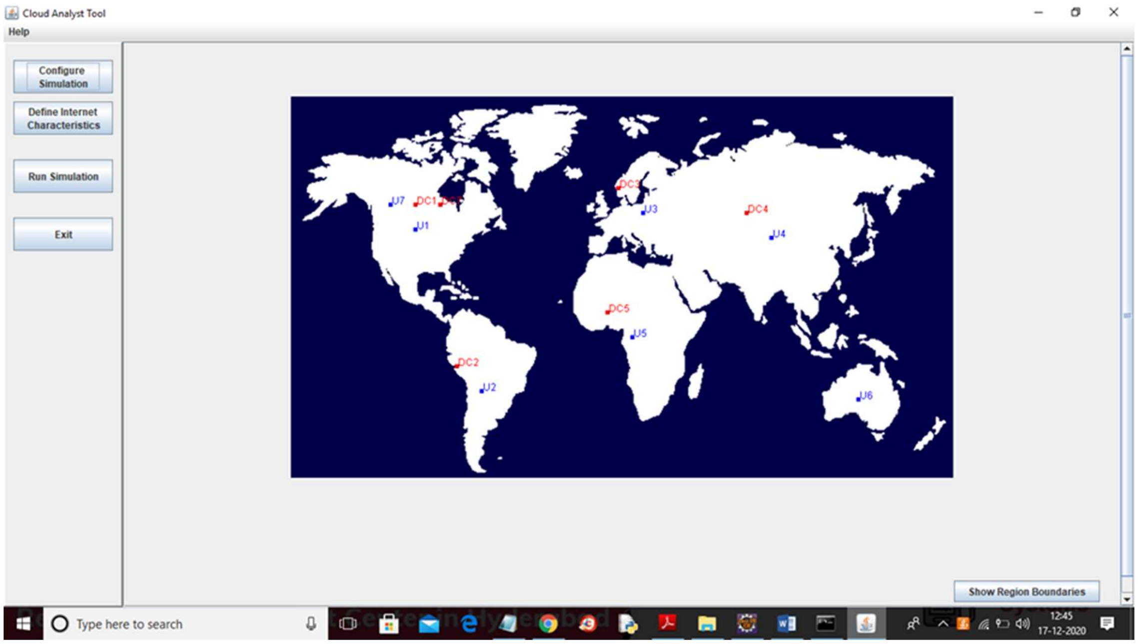
By selecting option 1 on the screen above and clicking the OK button, you will be directed to the screen below.



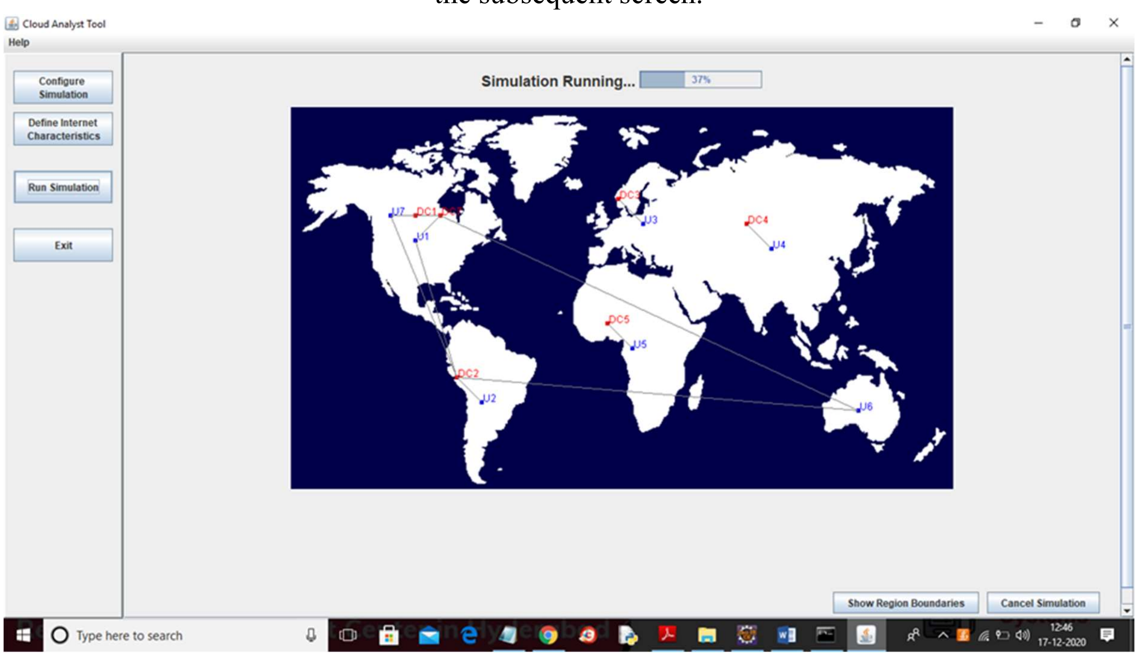
To create multiple users and cloud DC's, you can click on the 'Configure Simulation' button and load the resources file again. This will allow you to set up the simulation by configuring the necessary parameters using the uploaded resources.



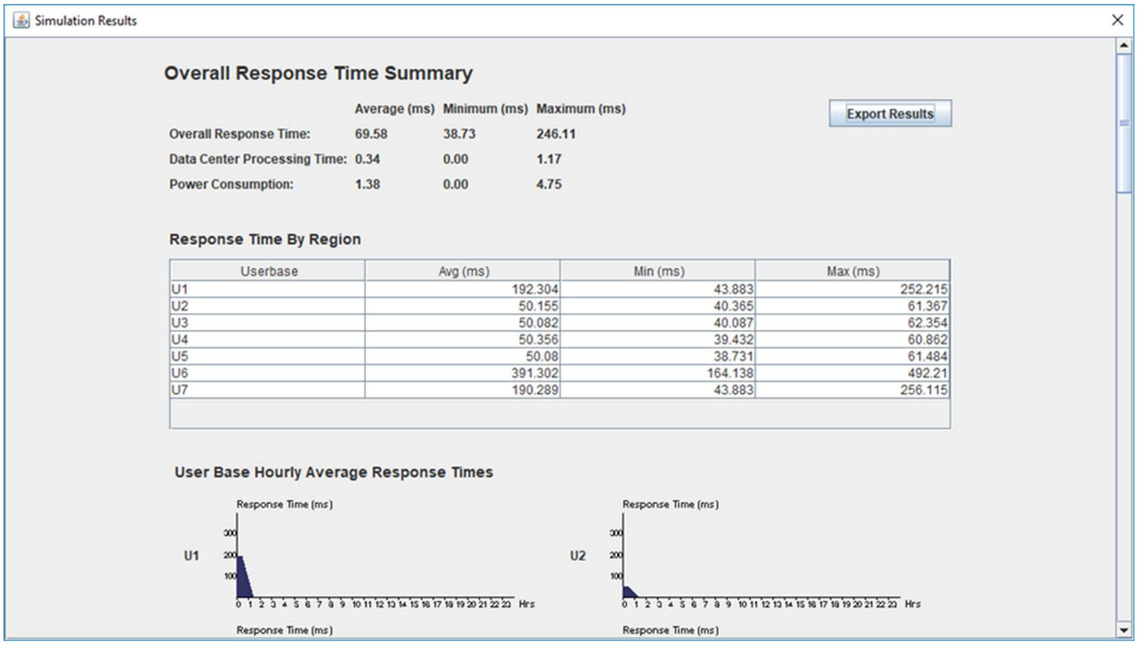
To access the screen shown below, you need to select and upload the 'resource.sim' file. Once you have uploaded the file, click on the 'Open' button to load the resources, and the screen will be displayed.



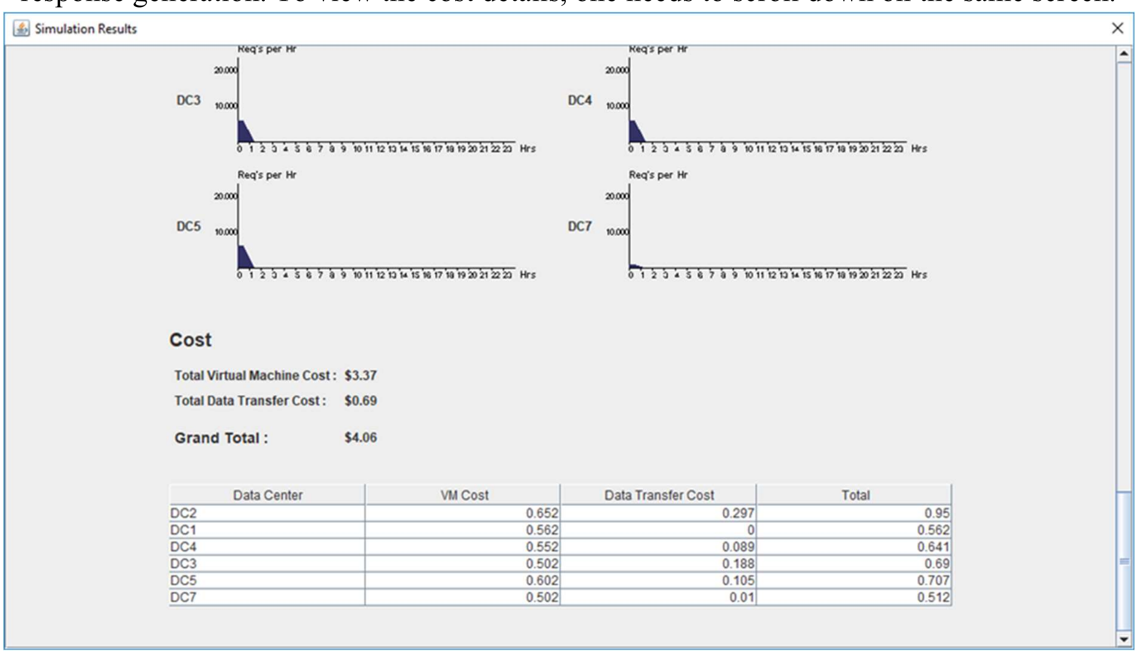
On the current screen, multiple users and cloud data centers are created. To send and process requests using the proposed scheme, click on the "Run Simulation" button, which will lead to the subsequent screen.



On the above screen, users are observed sending requests to multiple data centers. After allocation using the proposed scheme, the subsequent results will be displayed on the screen.



The displayed screen shows that the proposed scheme has an average response time of 69.58 milliseconds and a power consumption of 1.38 joules, which is lower than the existing technique. A lower response time signifies more efficient request processing and faster response generation. To view the cost details, one needs to scroll down on the same screen.



To execute the code, the user needs to double click on the 'run.bat' file, which will display a window with various options. To run the simulation with a single data center, the user must select option 0 and click the 'OK' button, which will display a screen with a red-colored data center and a blue-colored user. If the user wants to create multiple data centers and users, they can click on the 'Configure Simulation' button, which will lead to a screen where they can load a configuration file to add more users and data centers.

After loading the configuration file, the user can see multiple users and data centers on the screen. They can then click on the 'Run Simulation' button to process requests, and the simulation will display the processing details. With the existing technique, the total response time is 71.51 milliseconds, and the total power consumed is 1.92 joules. The cloud cost for this simulation is $4.08.

To run the simulation with the proposed scheme, the user needs to double click on the 'run.bat' file again and select option 1. After clicking 'OK', the user can configure the simulation to create multiple users and data centers, as before. The simulation will display the processing details with the proposed scheme, which shows an average response time of 69.58 milliseconds and power consumption of 1.38 joules, both of which are lower than the existing technique. The cloud cost for this simulation is $4.06, which is also less than the existing scheme.

V. CONCLUSION

By providing better QoE, faster response time, and lower resource cost. The proposed dynamic priority-based efficient resource allocation and computing architecture for vehicles effectively addresses the challenges of multimedia content processing in intelligent transportation systems by utilizing the power of cloud computing and optimizing the allocation of computing resources based on load information. This architecture can potentially enhance the performance of vehicular multimedia communication systems and provide better user experiences for drivers and passengers in smart vehicles.

REFERENCES

[1] T. Mekki, I. Jabri, A. Rachedi, M. ben Jemaa, “Vehicular cloud networks: Challenges, architectures, and future directions,” Vehicular Communications, vol. 9, pp. 268–280, 2017.

[2] S. Midya, A. Roy, K. Majumder, S. Phadikar,“Multi-objective optimization technique for resource allocation and task scheduling in vehicular cloud architecture: A hybrid adaptive nature inspired approach,” Journal of Network and Computer Applications, vol. 103, pp. 58–84, 2018.

[3] M. Gerla, E.K. Lee, G. Pau, U. Lee, “Internet of vehicles: From intelligent grid to autonomous cars and vehicular clouds,” In Proceedings of IEEE World Forum on Internet of Things (WF-IoT), Seoul, South Korea, March 2014, pp. 241–246.

[4]https://www.gsa.europa.eu/newsroom/news/central-role-robust-gnssautonomous-driving; accessed 23 March 2020.

[5] J.L. Chen, S.L. Wuy, Y.T. Larosa, P.J. Yang, Y.F. Li,“IMS cloud computing architecture for high-quality multimedia applications,” In Proceedings of 7th IEEE International Conference on Wireless Communications and Mobile Computing (IWCMC), Istanbul, Turkey, July 2011, pp. 1463–1468.

[6] Y. Wu, C. Wu, B. Li, X. Qiu, F.C. Lau, “Cloudmedia: When cloud on demand meets video on demand,” In Proceedings of IEEE 31st International Conference on Distributed Computing Systems (ICDCS), Minneapolis, MN, USA, June 2011, pp. 268–277.

[7] X. Nan, Y. He, L. Guan, “Optimal resource allocation for multimedia cloud based on queuing model,” In Proceedings of IEEE 13th International workshop on Multimedia signal processing (MMSP), Hangzhou, China, October 2011, pp. 1–6.

[8] W. Zhu, C. Luo, J. Wang, S. Li, “Multimedia cloud computing,” IEEE Signal Processing Magazine, vol. 28, pp. 59–69, 2011.

[9] M.K. Jiau, S.C. Huang, J.N. Hwang, A.V. Vasilakos, “Multimedia services in cloud-based vehicular networks,” IEEE Intelligent Transportation Systems Magazine, vol. 7, pp. 62–79, 2015.

[10] A. Ali, H. Liu, A.K. Bashir, S. El-Sappagh, F. Ali, A. Baig, D. Park, K.S. Kwak, “Priority-Based Cloud Computing Architecture for MultimediaEnabled Heterogeneous Vehicular Users,” Journal of Advanced Transportation, vol. 2018, pp. 1–12, 2018.

[11] G. Zhang, W. Zhang, W. Zuo, Y. Tian, and F. Zhang, "Dynamic Resource Allocation for Vehicular Cloud Computing Based on Vehicular Data," IEEE Transactions on Vehicular Technology, vol. 66, no. 10, pp. 8775-8788, Oct. 2017.

[12] Q. Zhang, W. Liu, Y. Liu, and Y. Zhang, "Dynamic Resource Allocation for Multimedia Cloud Computing in Vehicular Networks," IEEE Transactions on Multimedia, vol. 20, no. 6, pp. 1577-1588, Jun. 2018.

[13] S. Tang, Z. Guo, S. Li, J. Li, and Z. Wang, "A Dynamic Resource Allocation Strategy Based on User Requirements for Vehicular Cloud Computing," Mobile Information Systems, vol. 2018, Article ID 2546101, 10 pages, 2018.

[14] J. Li, Y. Liu, X. Zhao, Y. Xiang, and J. Zhang, "A Priority-based Resource Allocation Scheme for Vehicular Cloud Computing," IEEE Access, vol. 6, pp. 30348-30355, May 2018.

[15] H. He, X. Chen, L. Liu, Y. Ma, and W. Wang, "An Efficient Resource Allocation Scheme for Vehicular Cloud Computing," in Proceedings of the IEEE International Conference on Cloud Computing, San Francisco, CA, USA, 2017, pp. 536-543.

[16] W. Chen, X. Su, H. Yu, and C. Chen, "Efficient Resource Allocation for Vehicular Multimedia Cloud Computing," in Proceedings of the IEEE Global Communications Conference, Singapore, 2017, pp. 1-6.

[17] L. Zhang, Z. Li, Y. Liu, and Y. Liu, "A Dynamic Resource Allocation Scheme Based on QoS Requirements for Vehicular Cloud Computing," in Proceedings of the IEEE International Conference on Communications, Paris, France, 2017, pp. 1-6.

[18] X. Zhang, X. Qiao, and H. Li, "Dynamic Resource Allocation for Vehicular Cloud Computing Using Fuzzy Logic and Genetic Algorithm," in Proceedings of the IEEE International Conference on Fuzzy Systems, Naples, Italy, 2017, pp. 1-6.

[19] S. Wang, Y. Yang, H. Li, and J. Liu, "A Dynamic Resource Allocation Scheme Based on QoS and Energy Efficiency for Vehicular Cloud Computing," in Proceedings of the IEEE International Conference on Green Computing and Communications, Liverpool, UK, 2018, pp. 233-240.

[20] M. Ma, W. Wang, X. Chen, and Y. Liu, "Efficient Resource Allocation Scheme for Multimedia Services in Vehicular Cloud Computing," Journal of Network and Computer Applications, vol. 119, pp. 55-64, Aug. 2018.