# Heuristic Algorithms for Mobile Edge Computing Recovery System Based on Ad-Hoc Relay Nodes

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**ABSTRACT**

Mobile edge computing (MEC) is used to aid networking, to enhance the computing power of edge computers. In order to compensate for the limitations of cloud storage, MEC offers low latency, location-based services, and accessibility support. However, the Quality of Experience (QoE) is significantly reduced and MEC benefits are ignored when the MEC system is overloaded or malfunctions in some other way. To optimize the efficiency of unencrypted data for mobile communications, this article proposes a MEC-assisted computing and Adhoc relaying system. To find the best transmission and compression strategy for the relay node and the numerous devices, a cost function that weighs the trade-off between energy consumption and latency time was examined. The suggested approach uses the consumer machines of a nearby MEC next to an overloaded MEC as ad-hoc relay nodes in order to handle the transition disconnection between two MECs. The efficiency was illustrated by numerical tests and the probability of the suggested techniques was tested, offering high efficiency for possible future work.

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## 1. INTRODUCTION

Many organizations and institutes have already created software that uses cloud storage to manage big data operations or to provide customers with services [1]. This trend would build an immense burden on the current centralized network infrastructure, as all resource-limited devices depend on remote cloud storage assistance [2]. Cloud infrastructure can have scalable tools, allowing platform vendors to scale their systems are exposed. They will use cloud storage and user engagement platforms and businesses to offer customer experiences depending on their requirements, interests, or search history. In providing the customers with high-security networks, cloud infrastructure should include multi-level authentication as a feature. While cloud infrastructure includes a lot with many advantages, it introduces some drawbacks and threats [3]. For delay-sensitive systems, a few of the problems occur as consumers need fast responses from the device. The current cloud computing does not fulfill low latency, standards, knowledge of venues, and mobility aid. In order to overcome the drawbacks of cloud computing, the mobile edge computing framework—also known as fog computing—has emerged in recent years.

In several cases [4], such as live video processing, smart video enhancement, computing assists, and IoT device, the MEC principle, first suggested by Cisco and ETSI, has also been implemented[5]. In these cases, edge computer computing activities are outsourced to MEC servers, or data streams are modified to improve transmission by MEC servers. Smart surveillance optimization is also accomplished by collectively analyzing and retrieving multi bit-rate video on MEC servers [6]. Thus, MEC's main research challenges are both device offloading and connectivity speed.

Depending on the ETSI standard, MEC implementation might take place at an aggregation point within a radio access network (RAN) or inside the base station. The implementation of the MEC framework within the base station helps in reduced delay for smartphone devices since this is the smartphone network's nearest point to them. Improving a MEC network at an integrated stage has benefits because several base stations are tightly placed together by the system. By using only one MEC server to minimize deployment costs, such a technique can support various wireless networks. Figure 1 depicts the Mobile Edge Computing architecture.

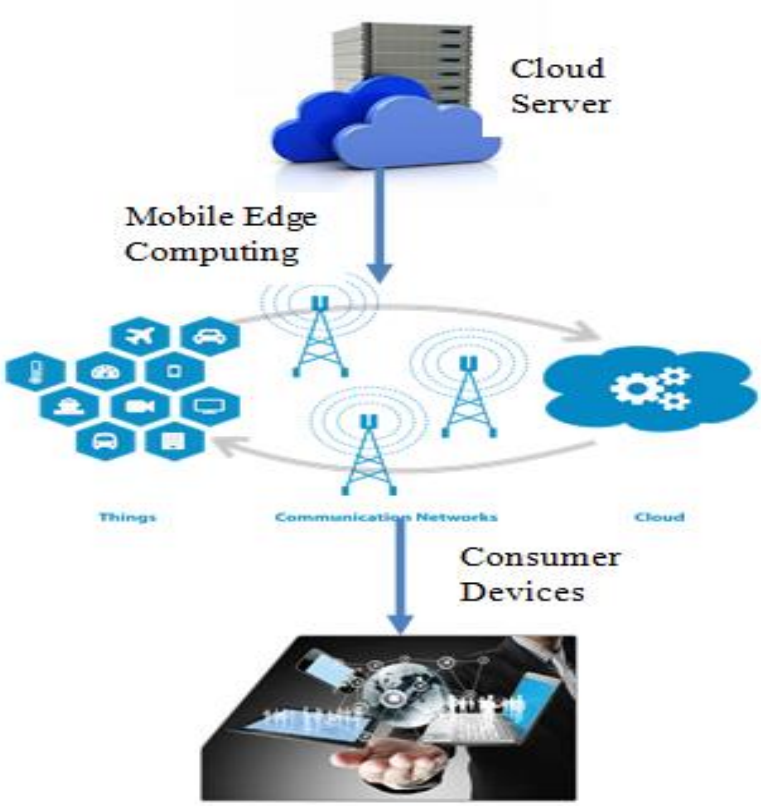


Figure 1. Architecture for Mobile Edge Computing

For real-time computing service providers in specific areas, MEC should play a greater role. Virtual reality, recognition of facial features, fully immersive games, autonomous helicopters, intelligent traffic control systems, surveillance devices, and natural language processing are a few smartphone technologies that are currently of great interest. These technologies would greatly benefit from the accelerated computation of smartphone edge computing [7]. As such, MEC device failure may be triggered by hardware failure, program disintegration, or the overload of MEC resources. MEC device failure impacts the users' level of service (QoE) and eliminates MEC benefits. Failure of the MEC device can make it unable to satisfy service requests; or worse, the MEC connection would be lost to all users. For businesses, the expense of MEC interruption may be expensive as they rely on MEC to operate their companies.

Therefore, to address the MEC failure issue, this paper proposes a heuristic algorithm for recovery systems. The first recovery system, named the recovery system I, is intended for when at least one neighboring MEC is usable within the wireless transition spectrum of an overloaded MEC. The next phase is designed for cases where a nearby MEC beyond the wireless transmission scope of the overloaded MEC is not usable. This study links O-MEC mobile user devices to an accessible nearby MEC by using their mobile user devices as ad hoc relay nodes for recovery system II. Depending on the location of the OMEC, neighboring MECs are grouped into a spatial position-based cluster in both systems. For both recovery schemes, the MECs are installed in the base station at the boundary between the IP and mobile networks. These are using the first-ever MEC recovery, as far as possible determine. This article has findings of computational simulation explaining the opportunities of our planned recovery systems.

In this work, users are only performing a simulation for recovery scheme II because it is also more complex and realistic. Recovery system II develops a multi-objective strategy for defining ad-hoc relay nodes to meet the data transfer needs of the disconnected mobile user devices of the overloaded MEC. The numerical findings demonstrate the benefits of our suggested recovery systems in addition to providing informative future study issues. The rest of the paper is implemented as follows. The related work is discussed in Section 2. The suggested work using heuristic methods is presented in Section 3. The findings of the simulation are presented in Section 4. This research project is summed up and concluded in Section 5.

## 2. RELATED WORKS

As far as we are aware, no previous research has been done on failure recovery systems for mobile edge computing. A similar study is not unique to MEC, but the techniques connect to MEC failure recovery. A multi-hop device-to-device (D2D) communications wireless network with a highly centralized post-disaster development and implementation digital communication system was proposed by Nishiyama et al. in 2014 [8]. The suggested method may be able to identify the best routing strategies between delay/disrupt-tolerant (DTN) and MANET depending on the particular and user process. Their design can transmit messages beyond any shared services by relaying individual via many cellular networks.

Reddy et al., suggested path recovery in vehicle-to-vehicle (V2V) communications in 2012 to securely distribute the data to the destination[9]. A network's high node mobility from the accessible network region causes link failures frequently. There are regular connection failures in a network related to the high mobility of nodes from the network that are open. Frequent loss of connection stops packets from accessing their destination Their framework's main goal is to reduce losses and deliver the systems safely to their destinations by building parallel routes for real-time application instances during connection failures.

In 2013, in an analysis to define the risk of failure, Kenington and Westberg suggested a failure indicator for the base stations by evaluating the magnitude of the heterogeneity of alerts and warnings [1]. A technique for Virtual Machine Provisioning (VMP) to adjust workload fluctuations in cloud computing was proposed by Li et al. in 2015 [10]. To forecast the response time of incoming workers, they followed the exponential smoothing (ES) prediction. Scheduling computing resources is anticipated to be a crucial component in optimizing the provider's earnings and safeguarding cloud users' quality of service (QoS). An empirical framework of context-aware structures in sensor cloudlets and context-cloudlets was presented by Loke in 2012 [11]. The cloudlets depend on and react to the available tools when sensors, reasoning components, and part mapping backgrounds are employed in activities. The finding also shows the structure of detectors and key elements that assist a mix-and-match platform to develop a context-aware framework for the module of services.

In 2016, Liu et al., suggested energy-efficient scheduling of activities in which the mobile computer, through a Wi-Fi connection point, offloads suitable activities with time constraints to the cloud [12]. Concurrent, mixed, and concurrent tasks can all be offloaded to the cloud. The goals of the proposed work are to speed up deployment and save the energy usage of mobile devices.

A mobile cloud-based depressive evaluation system was created in 2015 by Chang et al. [13]. To evaluate the possibility of being sad, the method combines an ontology and a Bayesian network. To incorporate the diagnostic environment, the device integrates mobile agent technologies and the cloud environment. Saleem et al. (2014) proposed resource management in wireless sensor networks (WSN) with an emphasis on cloud computing and mobile sinks (MS) [14]. Some frameworks are defined that combine wireless sensors and cloud computing. The researchers also established mobile sink patterns to analyze data from sensor nodes and transfer the data to the cloud in an energy-efficient way. In 2014, Ghafoor et al. suggested an effective route prototype for WSN 's mobile sink [15]. The route is dependent on the Hilbert Curve Order, which, depending on the density of the network to obtain a stronger packet distribution ratio for maximum node distribution.

Ahmed et al. examined the province-of-the-art cloud-based mobile application execution frameworks (CMAEFs) in 2015 in terms of integrated mobile cloud computing system execution [16]. To develop a taxonomy, the study examined the effortless user requests. The concepts of linear CMAEF architecture of mobile cloud computing and main problems for linear application implementation are discussed.In 2015, Ahmed et al., efficiently researched the execution process for mobile apps with certain optimization techniques relevant to the architecture, implementation, and execution of device transition in mobile cloud computing[17]. They also provided many implementation problems involving optimization of query processing about mobile cloud computing. Evaluation measures are addressed about optimum application execution, namely mobile device, network, software, tool, user expectations, and cost.

To address resource constraints in 2014, Saleem et al., proposed the incorporation of Cognitive Radio Sensor Networks (CRSNs) with cloud computing [18]. The convergence of such devices enables CRSNs to a system that reflects the spectrum offer greater support for storage and computing. For cloud-based CRSN, the researchers addressed the difficulties and problems. Shaukat et al. published a detailed mobile cloudlet technology study in 2015 [19]. To demonstrate the capabilities and limitations of the implementations, the paper addresses the essential features of the existing cloudlet implementations in mobile cloud computing. In 2015, Rehmani and Pathan introduced various kinds of evolving communication technology focused on WSNs [20]. The various operational approaches of WSNs with their functionality are presented. The researchers have described many WSN-related systems, such as energy-efficient data collection, delivery structures, algorithms for distributed data collection for mobile WSNs, and mobility systems. A cloud resource allocation technique based on an incorrect Stackelberg knowledge game (CSAMIISG) employing the Hidden Markov (HMM) model was proposed by Wei et al. in 2016 [21]. The current framework is expected to address the issue of resource allocation in cloud computing by using a multilayered resource allocation which lacks rewards and equality. HMM is used to estimate an existing price due to the historical resource requirements of the service providers. In addition to accurately predicting the sale, the incomplete Stackelberg game model of knowledge can motivate service providers to omit the most effective marketing tactics. But none of the earlier experiments were for MEC. Furthermore, this paper introducing a new heuristic approach to recovery using mobile consumers, computers as ad-hoc relay nodes (ARNs).

## 3. PROPOSED WORK

Failure of the MEC device may occur after this MEC is overloaded and/or damaged. MEC can run out of energy if they take on too much work, maintain too many resources, filter data, or handle too many service requests. In a certain restricted region, MECs are dispersed at the base station or at a point of aggregation close to users. The available nearby MECs in the cluster can support O-MEC(s) by offloading workloads when they are clustered within the radio transfer range. One MEC in the cluster takes on the role of cluster head in order to oversee the recovery mechanism, ensuring that it functions correctly and determining whether each MEC is overloaded or disabled. Both MECs within the cluster use wireless internet connectivity to link. But it is often difficult to cluster MECs that are beyond the transition spectrum since that is the recovery system II situation. Furthermore, it is possible to group MECs that are close to an exhausted MEC for as short a distance as possible in order to identify possible ad hoc relay nodes. The state of MECs is regularly sent via the head of the MEC cluster to the cloud server. So, in the MEC method, the system administrator will automatically notice some issues.

For each MEC, the suggested recovery system utilizes a traffic counter to compensate for system malfunction instances.Traffic countermeasures in real-time the number of users who are related to the MEC. For the multiple network topology conditions, the recovery system for MEC loss decides various scheduling techniques. The resource condition is reviewed by its MEC to decide if it is overwhelmed. When a MEC is overwhelmed, it provides a control signal to the head of the MEC cluster to develop strategies for other MECs that are open. The Recovery System will be caused by the MEC failure recovery technique if there are any neighboring MECs from the same cluster that are present across the O-MEC and outside of the mobile and wireless radio transmission. The Recovery System helps the O-MEC to offload function inside the same cluster to other MECs. If there are no neighboring MECs nearby, the O-MEC can use ad-hoc relay nodes to carry out the recovery system and offload functions to them.

**Algorithm for Mobile Edge Computing (Recovery) [1]**

Get data from traffic counters.

- Total Service Req = GetTotal Service Req()

Find the status and recovery systems of MECs.

- MEC Res.status = GetRes.Status()
- if ((MECRes.Status==overload) || (TotalServiceReq>=totalServiceThreshold))
- Update the MEC cluster head of the state of the MEC
- if (offloading directly to neighboring MEC’s == open)

**Recovery System I**

- Get information from the Cluster Head regarding active MEC’s
- Sharing the load with the other MEC's open
- else
- Offloading by ad-hoc relay nodes to nearby MEC's
- if (Workload offloading by Adhoc relay nodes == open)

**Recovery System II**

- Execute multi-hop communication
- End if
- End if
- End if

Other MECs inside the same cluster may support by providing their specific services for the workload while a MEC is out of operation.MEC P analyses the MEC tools that, because of unnecessary workload, demonstrate that MEC P has struggled. MEC P will send a message to the head of the cluster, MEC R. MEC R is looking for an active MEC in the same cluster inside the wireless operational limits to support MEC P. MEC R then notifies MEC P of the identifier of the MEC required for offloading. In this scenario, to recover from the system failure, MEC P transfers the enhance the existing effectively to the other MEC open.

There could be no adjacent MECs open across the O-MEC since they are above the wireless communication network or as those adjacent MECs run at optimum speed. The O-MEC would, however, no longer be able to deliver facilities. This paper suggests that the consumer products of an accessible MEC adjacent to the O-MEC remain ad-hoc RNs to improve the situation. Thus, consumers are removed from the O-MEC and no longer offer support from that MEC.

## 4. HEURISTIC RELAY NODE SELECTION

Disconnected O-MEC user devices are clustered based on a special role highly similar to the positioning of neighboring MEC recovery mobile networks. A disassociated user system known as an adjacent disassociated node, which is comparable to an ad-hoc relay node, and a disassociated user system known as a routinely disconnected node next to an ad-hoc relay node are two examples of disassociated user devices. Every other disconnected user interface cluster head transmits signals to its adjacent ad-hoc RNs to decide if they will be linked to any usable MEC recovery. When the nearby ad-hoc RNs are connected to an accessible recovery MEC, the disassociated user devices in the O-MEC may employ the Particle Swarm Optimization (PSO) [22] technique in a multi-hop wireless network system to search for possible paths from across all pairs of devices.

Particle swarm optimization (PSO) is a simplistic and computer-efficient population-based stochastic optimization technique. In the proposed approach for selecting the optimal route for data packet transmission, PSO, a swarm-based technique, is included. Nodes within ICR are provided for PSO as the current solutions. The best relay node for transmitting data packets selects from all neighboring nodes. It serves as a source node until the data is transmitted to the relay node and searches again for another optimal relay node to transmit the network node. This works before the destination node is reached by the node. In this method, by choosing optimal relay nodes from the intermediate nodes before the packet is received the nodes in the network, an optimal route is identified using PSO.

If the source node needs to send a Route request to its neighbor nodes, RREP will be sent in response by the appropriate neighbor nodes inside the ICR. The neighboring list is modified with the Route reply packet communication block results, and the fitness function estimation continues.After a certain number of opportunities, if the connection fails. Depending on trust capabilities, the PSO would be able to locate the optimum relay node. Based on confidence capacity, the PSO is used to choose the relay node. If the relation between the nodes breaks, it is an unnatural state. The PSO will also be launched to execute local search analysis to find a trustworthy relay node efficiently. The confidence potential of the neighboring node will be determined based on 2 phases [23]:

'$T_r$' trust-based routing information: it offers details on why the routing operations on the specific node may impact the trust.

$$T_r = V_{Rrequest} * \left(R_{request} \middle| R_{requestTrust}\right) + V_{Rreqply} * \left(R_{reply} \middle| R_{replyTrust}\right) + V_{RreR} * \left(R_{repR} \middle| R_{reRTrust}\right) + V_{RAck} * \left(R_{rAck} | R_{rAckTrust}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Trust-based data packets '$T_{dp}$':

$$T_{dp} = V_d * \left(\frac{P}{P_t}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Dependent on trade, including $T_r$, $T_{dp}$, and T will be changed after the node receives each packet.The $V_{Rrequest}$, $V_{Rreqply}$, $V_{RreR}$, $V_{RAck}$, and $V_d$, factors are coefficients that describe the confidence value by the load.

Depending on the attack form, such constant values vary.The $R_{requestTrust}$, $R_{replyTrust}$, $R_{reRTrust}$, $R_{rAckTrust}$, and $P_t$, values, one on either side, includes the overall data packets because of all the received nodes.The $R_{request}$, $R_{reply}$, $R_{repR}$, $R_{rAck}$, and $P$ attributes are the results of the individual packets obtained from the requesting node. Then the Equation would be used to measure the total trust potential T of the particular node. (3), that is viewed by the PSO as an analytical function.

$$T = T_r + T_{dp} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In the mobile search PSO, the phases included are described as follows [24];

**Phase 1: Initialization:** Initializes all values of surrounding nodes, like $T_r$, and $T_{dp}$. Using Eq, the $T_r$, and $T_{dp}$, could be measured. (1), and the following Eq. (2), correspondingly. The simple prediction equations for calculating $T_r$, and $T_{dp}$, which be derived from the modified routing protocol.The speed (s) and direction (d) of entities in the implementation of PSOs are assumed to be these variables.

**Phase 2: Fitness Evaluation:** The confidence, power of the network paths would be determined on this basis using Eq. (20). The best or latest particle value ($l_{Best}$), and general best value ($w_{Best}$), would be chosen depending on the fitness value. The greater confidence value would be considered as the stronger fitness, so the optimum solution would be considered by the particle with the greatest fitness.

**Phase 3: Update:** At this point, the particle's speed and direction will be modified based on the traditional PSO technique and would be provided in Eqs. (4), and (5), respectively.

$S_x^{m+1} = \theta S_x^m + l_1 w_1 \, ({l_{Best}}_x^m - D_x^m) + l_2 w_2 \, ({w_{Best}}_x^m - D_x^m)$……………………..(4)

$D_x^{m+1} = D_x^m + S_x^m$ . m……………………..(5)

In which the local best position and best world position are denoted by $l_{Best}$, and $w_{Best}$, and the dimensions θ, $l_1$, $w_1 l_2$, $w_2$, are weight vector, two signed values, and completely different variables within [0, 1], collectively. The optimization algorithm for particle swarm is chosen as a unit in the base, but an enhancement of the algorithm is identified using [0.3 0.6] in its magnetic field execution. Maximum and minimum density rates are generally often specified and the fragments are immediately dispersed uniformly to enable the search at all potential destinations. This method is used to locate the optimal relay nodes before the destination node is reached by the encrypted messages.

## 5. EXPERIMENTAL RESULTS AND DISCUSSION

The more complicated recovery system was simulated by the above. The simulation was conducted using Python and Matlab on a PC running Windows 10 pro with an Intel (R), Pentium (R) CPU G640 @ 2.80 GHz processor and 4 GB of memory. From the LTE downlink estimate in [25], can presume how an ad-hoc RN has the potential to transmit 1, 2, or 3 frequency bands (RBs) with Feature extraction under LTE at one point, using 64 quadrature phase shift amplification. For our simulation, users believe that include one considered adequate MEC enabled in the recovery system.

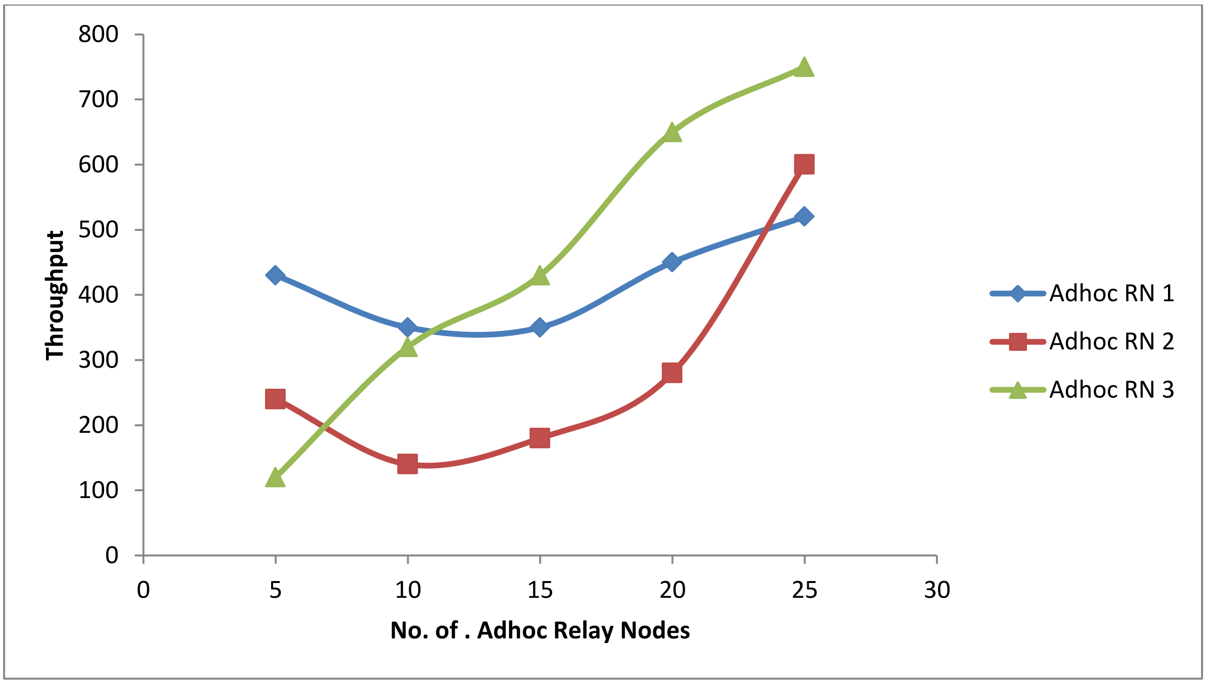


Figure 2. Performance of ad-hoc RNs according to the number of ad-hoc RNs

The effective throughput of all the ad-hoc RNs as seen in cycles per second in Figure 2. Given the importance of both congestion and the connection between the opposing layers, an ad hoc RN's efficiency is crucial. The effectiveness of ad-hoc RNs can be used to determine the overall MEC recovery system's efficiency. Figure 2 shows that throughput increases proportionately to the rate of ad hoc RNs. Similar to how energy frames enhance an ad-hoc RN's performance, they may also result in higher throughput.

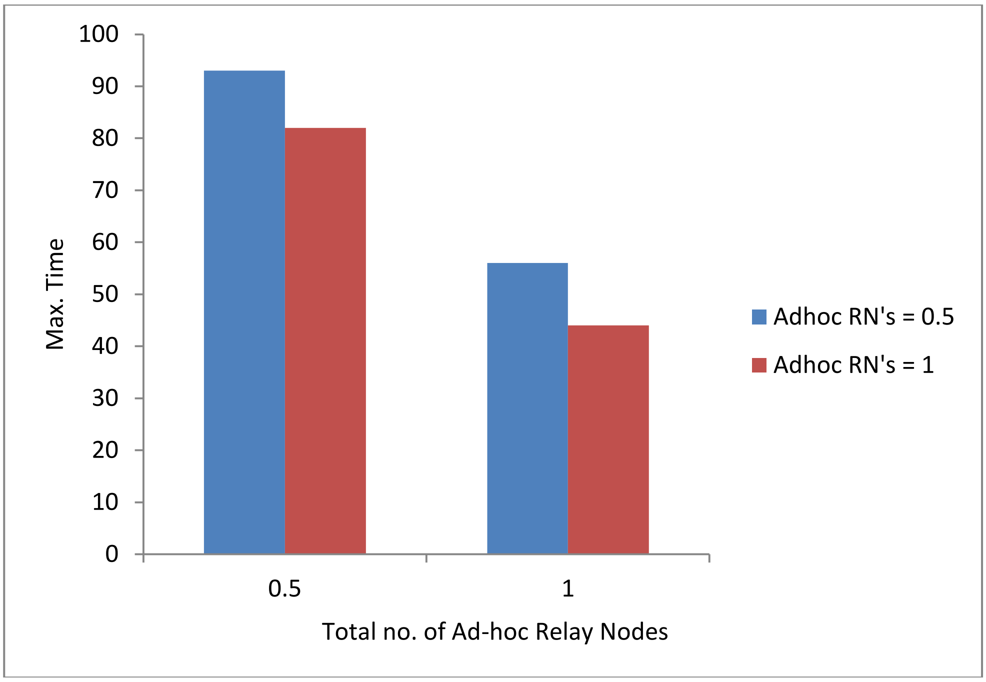


Figure 3.Total data transmission schedule from the MEC recovery to a disconnected user with multiple user devices disconnected.

This provides detail as to the value of ability as ad-hoc RNs in mobile computing devices. Figure 3, indicates the maximum transmission time for 1000 disconnected users, with 50, 100, 250, 500, and 1000 disconnected neighboring nodes including both in total. Table 1 displays the execution time in seconds for data allocation estimation for different numbers of nearby unconnected nodes and ad hoc RNs. In this simulation, two entirely different percentages of ad-hoc RNs are used: half of all neighboring unconnected nodes and one-fifth of all adjacent disconnected nodes, respectively. The execution times for the data distribution estimation for this analysis are presented in table1. The data allocation estimation with 50 adjacent unconnected nodes and 2 ad hoc RNs takes 0.99 seconds for 1000 cross-entropy process variations and 0.49 percent distribution error. It involves a much longer time for completing as the equation combines vast numbers of adjoining disconnected points and ad-hoc RNs.

Table 1.Data allocation estimation execution time in seconds, for various numbers of neighboring disconnected nodes and ad-hoc RNs

| **No. of Disconnected Nodes** | **Ad-hoc Relay Nodes = 0.5** | **Ad-hoc Relay Nodes = 1** |
|---|---|---|
| 50 | 0.38 | 0.45 |
| 100 | 0.97 | 1.08 |
| 250 | 1.64 | 6.18 |
| 500 | 8.53 | 20.7 |
| 1000 | 106.5 | 372.4 |

Our suggested MEC recovery system is supposed to be better tailored to user-dense areas including urban settings, while most new users linked to a recovery MEC can use a larger number of ad hoc RNs. In our proposed MEC recovery method, it may see the relevance of ad-hoc RNs. Furthermore, it would seem that the ability of ad-hoc RNs can impact throughput. Since mobile device capability has recently improved significantly, our planned MEC recovery system will be better in the future.

## 6. CONCLUSION

It discusses the problem of recovery in this journal when MEC has exploded. Since MEC offers real-time services in other various applications, the failure of MEC is major. Thus, in this article, it suggests two MEC recovery systems and the simulation carried out confirms the probability of our proposed technique in this study. It is shown that the cluster's neighboring recovery MECs may minimize the overloaded MEC issue by workload offloading. The simulated results of offloading by ad-hoc relay nodes to neighboring recovery MECs studies suggest our proposed MEC recovery system is supposed to operate well in congested areas. Additionally, researchers have found that the evolution of the MEC recovery system is significantly impacted by the capability of ad-hoc relay nodes. These results give us useful motivation to use ad-hoc relay nodes in the future to boost the MEC recovery system's throughput.

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