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An Analysis the Adaptive Routing Algorithm for Mobile Cloud Computing

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Abstract: Cloud management provides facilities to access and manage a shared pool of networking resources including servers' infrastructure, wide variety of web applications and services. The cloud service classification categorized in to three different ways, such as IaaS, PaaS and SaaS. Cloud computing provides flexible and virtualized services based on the user requirement. The scalability can be increased due to non-maintenance of servers and other required infrastructure. Mobile or smart phone usage had a significant growth from past years, and it is one of the daily needs for internet users. Recent advances in mobile development made a huge interest with cognitive capabilities, voice recognition, machine learning, virtual and augmented reality. In mobile cloud computing, it is very necessary to provide the user with the best possible seamless and cost-effective services. User satisfaction is the major goal of mobile cloud computing, the communication through mobile devices to the cloud can lead to long latencies over the wide area network (WAN) and it cannot be ignored. User satisfaction majorly depends on it. In this chapter the problem is identified as networking in MCC, so a new routing algorithm is proposed to solve the problem under high data traffic.

Keywords: Cloud Computing, MCC, Networking, Adaptive Routing Algorithm, WAN

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INTRODUCTION

Mobile cloud computing is one of the emerging fields in the recent trends which is suggested by Ronnie and Lee (2012). It is the logical integration of mobile computing and cloud computing. It enables data management from portable mobile devices to cloud environment. Cloud management provides facilities to access and manage a shared pool of networking resources including servers' infrastructure, wide variety of web applications and services. The cloud service classification categorized in to three different ways, such as IaaS, PaaS and SaaS. Cloud computing provides flexible and virtualized services based on the user requirement. The scalability can be increased due to non-maintenance of servers and other required infrastructure. Mobile or smart phone usage had a significant growth from past years, and it is one of the daily needs for internet users. Recent advances in mobile development made a huge interest with cognitive capabilities, voice recognition, machine learning, virtual and augmented reality. Even though it is popular, mobile users are unable to increase the computation, storage and battery power; smart devices are less capable than regular laptops or desktops in terms of storage and processing power. These limitations of mobile devices can lead them to depend on the cloud computing. Some researchers had made significant problem identification on accessing the cloud system through mobile, but it depending on the cellular data network, and it gives huge data charges for the user along with huge power consumption of the device. However, there are many problems that stopping the efficient utilization of cloud services, such as storage and computation capabilities of the mobile device, energy restrictions and network latency. In mobile cloud computing, it is very necessary to provide the user with the best possible seamless and cost effective services. User satisfaction is the major goal of mobile cloud computing, the communication through mobile devices to the cloud can lead to long latencies over the wide area network (WAN) and it cannot be ignored. User satisfaction majorly depends on it. In this chapter the problem is identified as networking in MCC, so a new routing algorithm is proposed to solve the problem under high data traffic. The algorithm considers the latency and network disconnection situations under radio intensive networks that are studied from Krishna et al (2009, and 2010), and Misra et al (2012, 2013, and 2014).

ROUTING IN MOBILE CLOUD COMPUTING

Routing is considered as a major research problem in the MCC. Heterogeneity in the MCC considered in different aspects like type of hardware, technologies used by the mobile devices, cloud, and type of wireless networks. The major problem in the MCC is heterogeneity in wireless networks. The basic communication requirements comes under the wireless network environment, which is heterogeneous in nature due to its vast number of technologies, cloud services and based on smart phone usage by Abolfazli et al (2012).

MCC NETWORK MODEL

The initialization of the network is done by the mobile user 'X' which is connected to the cloudlet or cloud by using the cellular network. The mobile user had a cloud task which has to be executed in the cloud for real time analysis. While at the time of task offloading process, the uploading traffic increases, and it exceeded the link capacity. The delay was increased due to the load on the transmission link. In the conventional model of MCC (client server model), this condition leads to the task failure. The mobile user disconnected from the cloud service providers and suffers from the channel congestion. To overcome this issue, the mobile user connects to the available neighbouring mobile devices with the help of high available bandwidth (Wi-Fi) to establish the virtual cloud. Figure 1 explains about how the virtual cloud will be created among mobile devices.

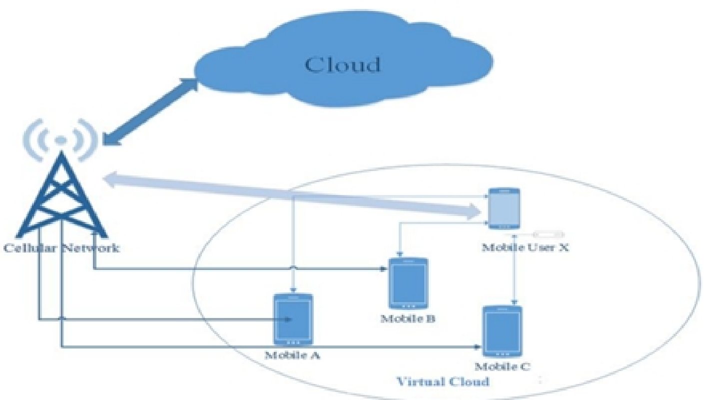

Figure 1. Virtual Cloud in MCC

The model assumes that the 'X' has the capacity to choose the virtual cloud by the available mobile nodes.

The task which has to be offloaded to the cloud for execution can be distributed among the available mobile devices based on the resources availability. To do the task offloading process to the available nodes the mobile user 'X' has the command and control to initiate offloading process.

SELECTION MODULE

A specified routing algorithm is needed for computing the data resources of the mobile nodes. The routing algorithm must and should identify the suitable resource nodes and the possible path from the source node to the destination. The selection of nodes is based on the cost of the path. The cost with respect to completion time and the energy consumption of the mobile nodes. The calculation of completion time and energy consumption of the task T at the mobile node is given as follows.

The T is the task executing on the Mobile node, the completion time of the task T is given as

$$\tau_{node}(T) = \delta(T) \times C_{node}^{-1} \quad (1)$$

Based on the notation above, the energy consumption function is defined as

$$\varepsilon_{node}(T) = P_{node} \times \tau_{node}(T) \quad (2)$$

Where δ (T) is the workload of the task T, Cnode is the computing capacity of the node, and Pnode is the power consumption of the node. For finding the optimal path from node 'X' to the node 'i' the model considering the shortest path routing algorithm.

Algorithm 1: Routing Algorithm for Selection of mobile Nodes

```
Begin
 Y → Degree(i)
S→ Source node X
D→ Destination node i
THε → Threshold Value for Energy
THc→ Threshold Value for Completion Time
O→ Optimal path
Step 1: Extract the node IDs from the list Listx(M)
Step 2: if (AvailRes(i) < ReqRes(T))
        {if (Y(i) >Bound)n{
        Remove the node 'i' from the list Listx(M);
        Goto step 1; } }
Step 3: Oτ→Shortest path (S, D,τ )
        if(Oτ) >THc then
        {return"link not Exist" }
Step 4: Oε →Shortest path (S, D,ε )
        if(Oε ) ≤ THε then
        {Assign (T) → i
        }
end
```

Algorithm 1 finds the optimal path from the source to destination based on the selection of mobile nodes. The procedure followed by the Algorithm1 is given below.

i) Select the node 'i' from the list which is already created by searching process at the mobile user 'X'

ii) Check the condition that the available resources at the node 'i' will satisfy the required resources for task execution.

iii) Check the degree of the node based on the boundary condition.

iv) If the node satisfies the above two conditions, calculate the energy consumption and completion time of the node i based on the eq. (1) and eq. (2).

v) If energy consumption and completion time of the node i satisfies the time deadline, then the mobile user 'X' establishes the connection with the node 'i' and assigns the task T for execution.

DECISION MODULE

The major research challenge in MCC networking is link stability. The mobile environment utilizes the cloud servers for task offloading. Hence, the reliability of the link for the mobile environment and cloud environment must be high. Assume that, link failure occurs at the time of task execution in the cloud environment, there must be some alternative to taken care of this issue from Misra et al (2013). To overcome the problem the decision module is involved in creating the virtual ad hoc network with available mobile nodes.

Algorithm 2: Decision making

```
Begin
w→ waiting time
TL→ Time limit
Step 1: if (link == 'stable')
        { return "data exchange"
        }
Step 2: if (link == 'unstable')
        { Wait for w seconds
        if (link(w) > TL)
                { Initialize Searching process
                } }
end
```

PARTITIONING MODULE

The partitioning of tasks for task offloading considers the graph model. The task presented as a directed acyclic graph G = (V, E) is composed of a set of n subtasks V = {S|S=1, 2… n} and set of resources E = {(S,R)|S,R ε V}. The remaining process for partitioning follows the same procedure in Yang et al (2013).

EXPERIMENTAL EVALUATION

The proposed adaptive routing mechanism is simulated using the QualNet 4.5 simulator. The total number of mobile nodes participated in the network is taken as 9. The size of the area which is selected for conducting the simulations is 1500m *1500 m. The mobile nodes in the network are either static or dynamic which is referred by Krishna et al (2012). The speed of the mobile nodes is taken as 5 m/s, 10 m/s, 20 m/s. The mobility model for the nodes in the network follows the random waypoint model. The constant bit rate (CBR) sessions for each topology are considered as 20 and the data rates are considered as 0.5 p/sec, 1 p/sec and 2 p/sec. The different type of data rates such as low, medium and high loads are initialized. The size of the packet is initialized to 256 kilobytes and First in First out (FIFO) model is adopted for the queuing process. The IEEE 802.11n is utilized with data rate of 6 Mbps for communication in the network. The lifetime of the node defines with the n-of-n model followed from the Dietrich and Dressler (2009) and the designing of the battery model follows the linear model.

To evaluate the performance of the proposed adaptive routing protocol, the existing ad-hoc routing mechanisms in MCC are considered. Those are Ad-hoc based mobile cloud computing (AMCC) by Mohammad et al (2015), spontaneous ad-hoc routing protocol (SARP) by Raquel et al (2014), and Trust based routing protocol (TRP) by Patel et al (2015). One of the objectives of proposed adaptive routing protocol is to find the route with minimum energy consumption and having the maximum battery power at the destination node.

RESULTS EVALUATION FOR ROUTE SELECTION

The proposed adaptive routing algorithm is tested with the route selection procedure with the other existing algorithms such as AMCC, SARP and TRP. The proposed algorithm will focus on the battery power and computation capacity as the primary objectives to the route selection. The proposed model is tested under different conditions, such as maximum, average and minimum battery power of the mobile nodes. The proposed algorithm shows the convincible results while compared with the other existing algorithms which are shown in Figure 2 and Figure 3. By observing Figure 4, the proposed algorithm recorded the better results at the time of minimum battery power.

COMPARISON OF COMPUTATION CAPACITY

The computing capacity of the nodes is compared with the maximum and minimum computation capacity. Figures 5 and 6 shows the performance of all the nodes participated in the network. In Figure, it can be observed that all the protocols have the similar computation capacity. However, the adaptive routing protocol has the higher minimum computation capacity which is observed in Figure 6.

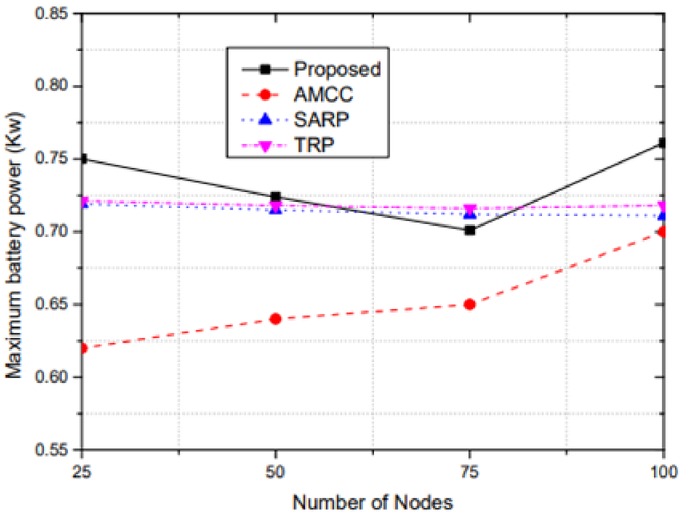

Figure 2. Maximum Battery Power Vs Nodes

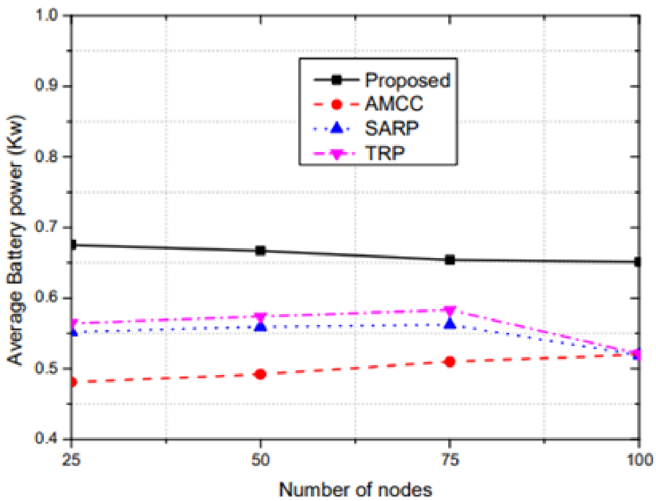

Figure 3. Average Battery Power Vs Nodes

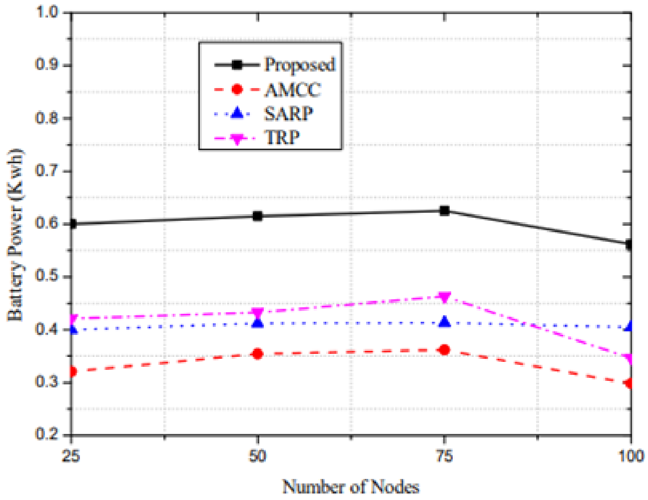

Figure 4. Minimum Battery Power Vs Number of Nodes

END TO END DELAY

Figure 7 shows the comparison of the end to end delay over the proposed and existing protocols. The proposed protocol had the shorter delay when compared with the other existing algorithms. In the route selection process, the proposed protocol decreases the impact of the delayed broadcast at the nodes. So, that the proposed protocol is more efficient and had the shorter delay.

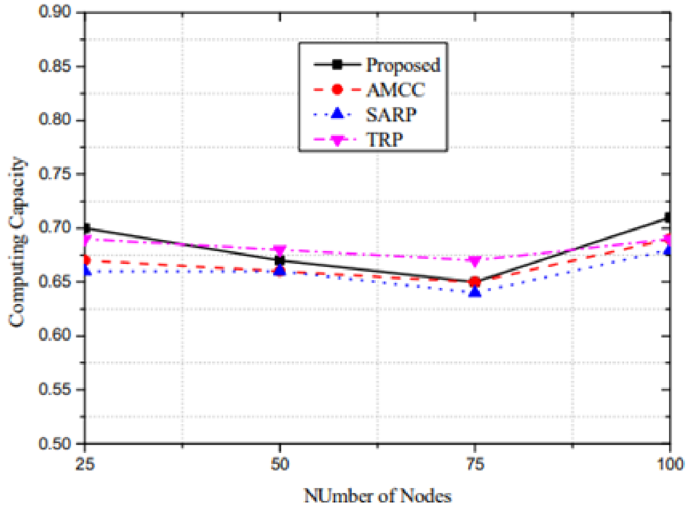

Figure 5. Maximum Computing Capacity Vs Number of Nodes

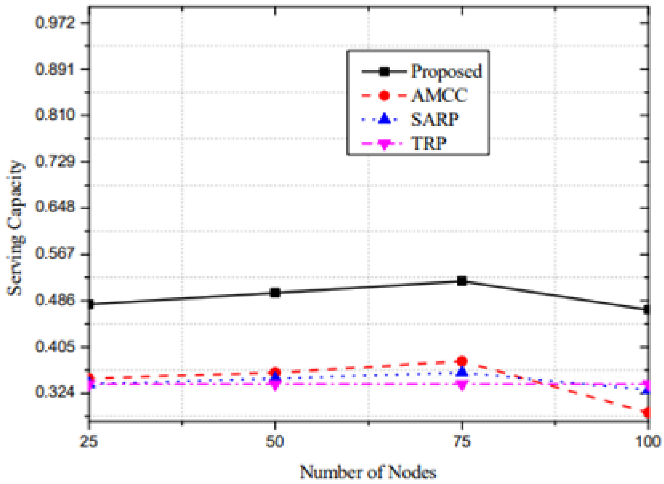

Figure 6. Minimum Computing Capacity Vs Number of Nodes

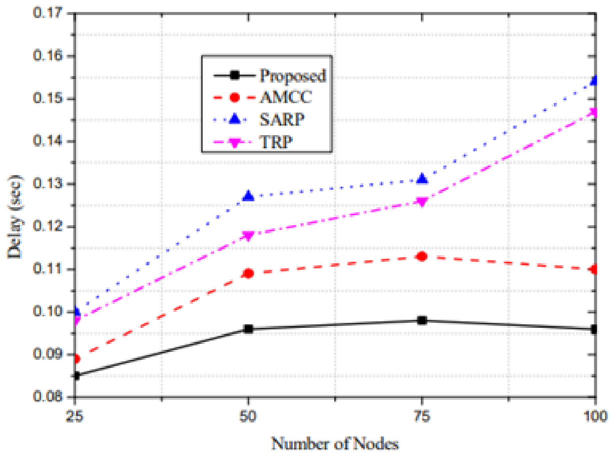

Figure 7. Comparison of Average End To End Delay

PROPOSED ROUTING ALGORITHM UNDER DIFFERENT DATA RATES

The proposed adaptive routing protocol is tested with three different data rates such as high, medium and low data rates. The environment is simulated under the fading channel to know how the channel variation affects the routing protocols. It is clear that the performance of all protocols in the fading channel is less when compared to the non-fading channel.

High Data Rate (2 Packets/sec):

Figure 8 explains about the results of an average queuing length under high data rate. The queue length of proposed protocol is recorded as 0.38 at the maximum speed of the nodes. The proposed protocol outperforms the conventional protocols with the shortest average queue length. Figure 9 shows the comparison of a lifetime of all protocols. The lifetime of the nodes in the proposed protocol is high when compared to the rest of the protocols. Moreover, the rest of the protocols had similar lifetime. This might be due to the metrics adopted by the protocols favours the nodes to create unwanted communication with the other nodes. Thus, drains the battery of the nodes and leads to the decrease in the lifetime. The delivery ratio of all the protocols is shown in Figure 10.

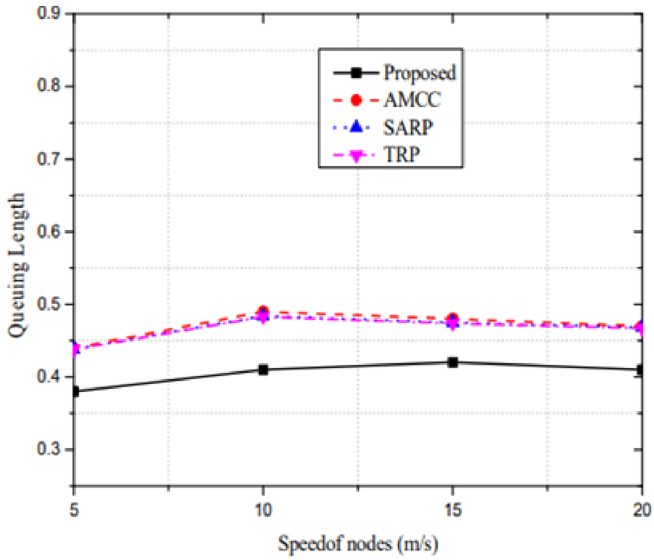

Figure 8. Comparison of Queue Length at High Data Rate

The influence of high traffic on the protocols will ultimately lead to the low delivery ratio. The delivery ratio of all the protocols is recorded as low and the proposed protocol delivery ratio is about 0.14. As shown in Figure 11, the shortest queue length of the nodes does not lead to the best end to end delay. The end to end delay is improved when the node speed is high. The proposed protocol end to end delay is good in the high data rate. The end to delay of the proposed method is almost 2 times less when compared to the AMCC, SARP and TRP. The proposed method utilizes the resources of the mobile nodes based on their availability. The nodes participating in the network are given their acknowledgement by specifying their resources such as remaining battery power, available bandwidth and remaining CPU. Therefore, end to end delay is low in proposed method.

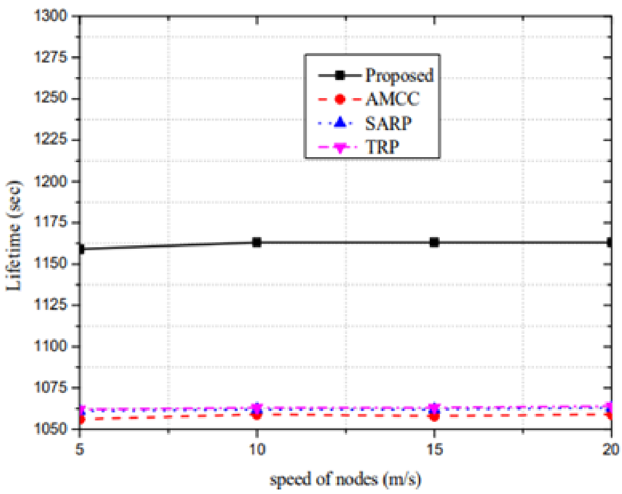

Figure 9. Comparison of Lifetime at High Data Rate

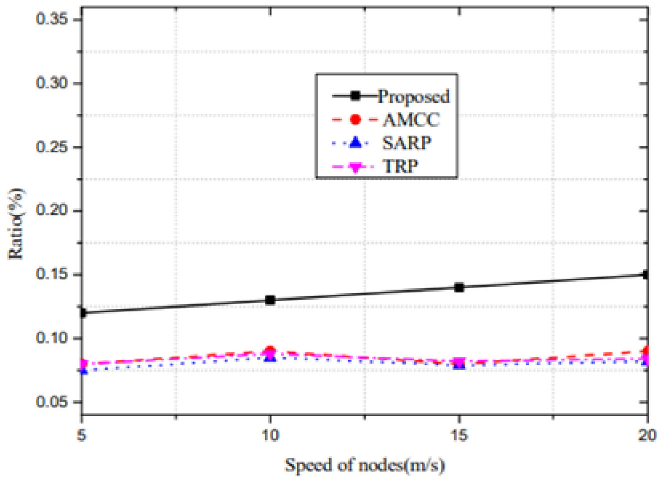

Figure 10.Comparison of Delivery Ratio at High Data

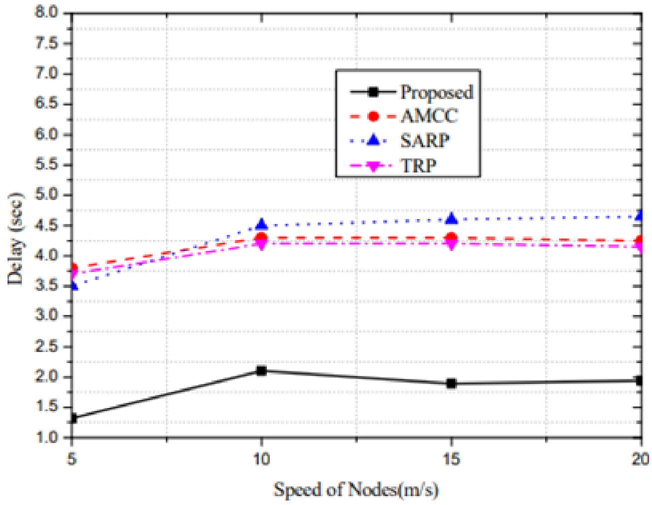

Figure 11.Comparison of the End To End Delay at High Data Rate

Medium Data rate (1 packet/sec):

The comparison of queue length of all the protocol under the medium data rate is shown in Figure 12. The queue length of the protocols is recorded as low when compared at high data rates. Figure 13 shows the average lifetime of the nodes in all protocols, where lifetime of the nodes increases due to the medium data rate. But, the lifetime of the other protocols is observed less when compared to the proposed protocol. The delivery ratio in the fading channel is observed as low to the all protocols, which is shown in Figure 14. But, it is noticeable that the proposed protocol performs better with respect to delivery ratio. The end to end delay of the proposed protocol has the smallest value among all the protocols and it is observed in Figure 15.

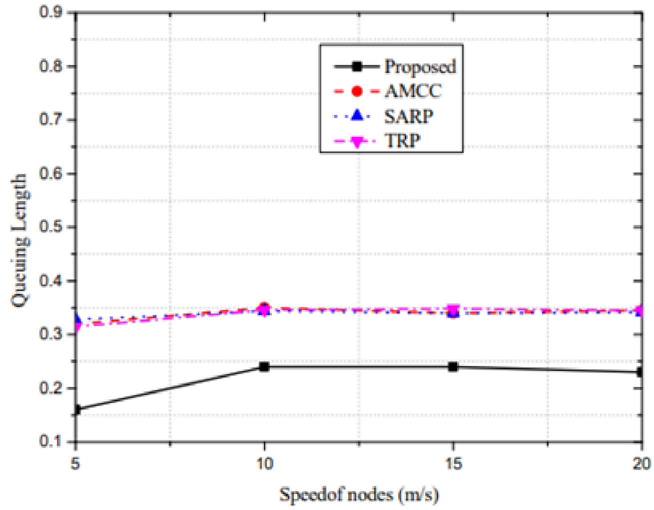

Figure 12. Comparison of Queue Lengthat Medium Data Rate

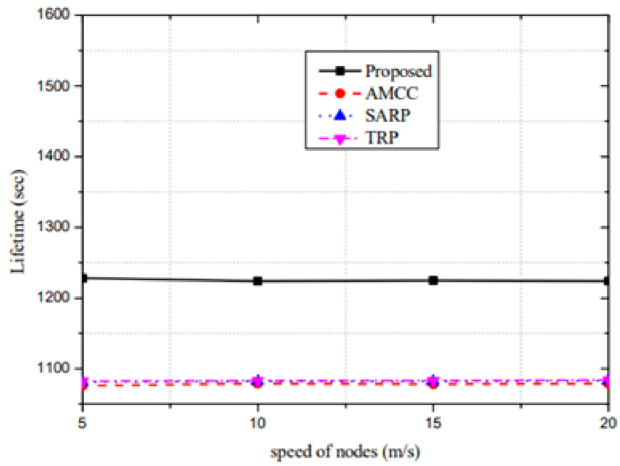

Figure 13. Comparison of Lifetime at Medium Data Rate

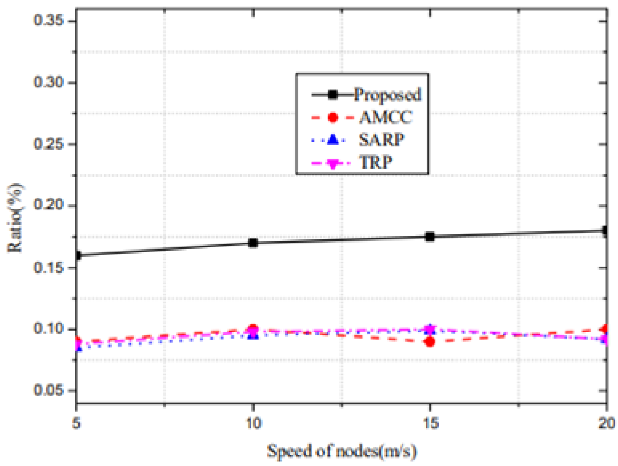

Figure 14. Comparison of the Delivery Delay at Medium Data Rate

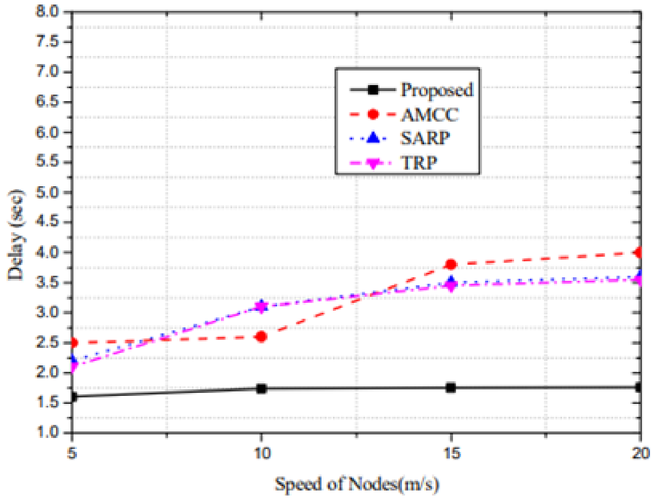

Figure 15. Comparison of the End To End Ratio at Medium Data Rate

Low Data Rate (0.5 packet/sec):

The simulation results of the average queue length at low data rated under the fading channel is shown in Figure 16. The proposed protocol had better performance with respect to queue length when compared with other protocols. Figure 17 shows the lifetime of nodes in low data rates under fading channel. The lifetime of the nodes decreases in the network due to the retransmission of packets. The proposed protocol is observed with better lifetime. Figure 18 shows the delivery ratio of the protocols. From the simulation results, it is clear that the delivery ratio in the fading channel is quite low due to the number of retransmission of packets. A packet stays at the queue for longer times. Figure 19 shows the end to end delay of the protocols. The proposed protocol is not suitable for low data rates and slightly better when the data rate is high.

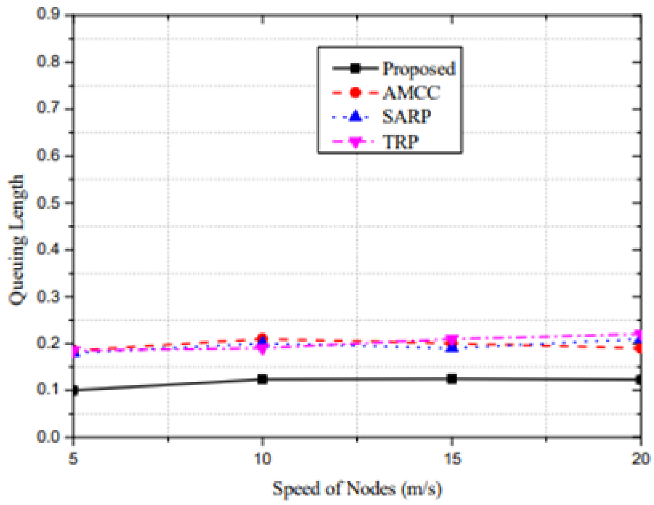

Figure 16. Comparison of the Queue Length at Low Data Rate

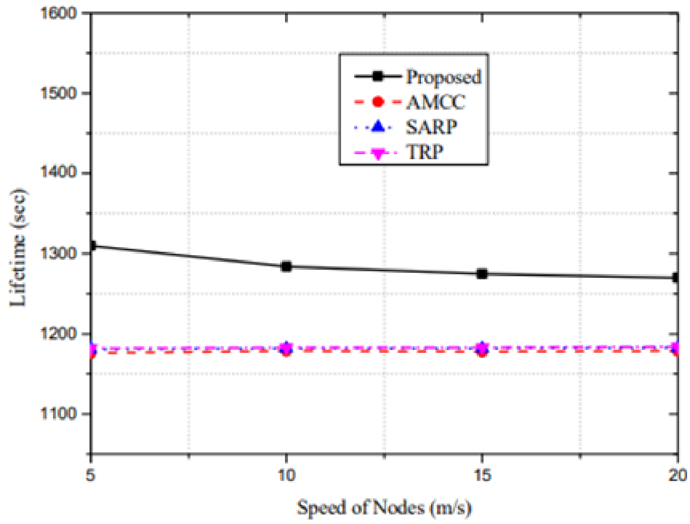

Figure 17. Comparison of a Lifetime at Low Data Rate

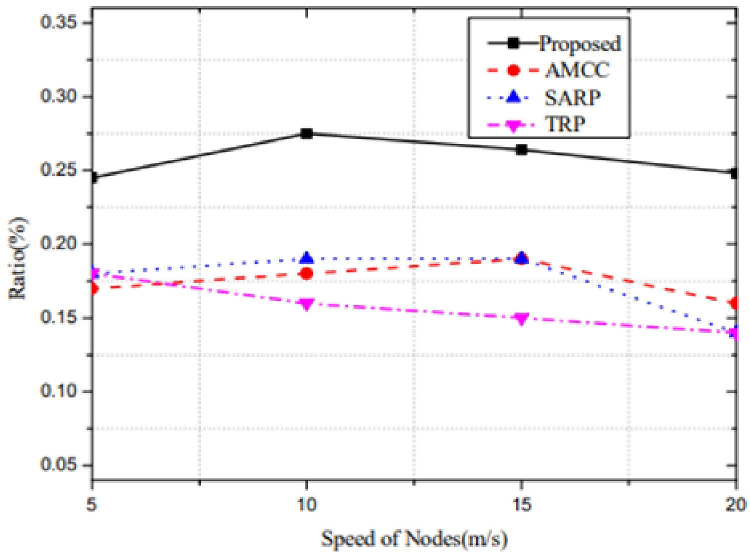

Figure 18. Comparison of Delivery RatioEnd Delay at Low Data Rate

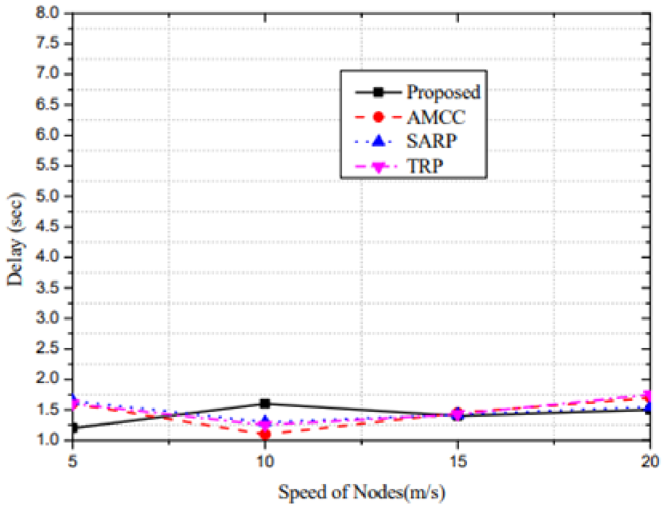

Figure 19. Comparison of the End To at Low Data Rate

CONCLUSION

The problem is investigated based on the communication failure between the mobile devices and cloud. To address the communication failure, this chapter proposed a virtual ad hoc networking model. An adaptive routing algorithm is proposed for the connection establishment between mobile devices with respect to battery power and computation capacity of the mobile nodes. The algorithm is initialized with searching, selection decision and partitioning modules. The proposed routing algorithm is simulated under different conditions with different parameters. The results are evaluated with three different cases such as high data rate, medium data rate and low data rate. The proposed routing algorithm is performed well under the fading channel when compared to the existing routing algorithms.

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