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Performance Evaluation of Adaptive Rate Control (ARC) Algorithm for Distributed Congestion Nodes of Mobile Ad Hoc Network

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Abstract :- Adaptive Rate Control (ARC) algorithm for distributed congested communication nodes in the area of Sky Train Routes (STR) is proposed. STR is also known by its official name of Bangkok Transportation System Network *(BTSnet)*. The ARC algorithm will improve the delivery of packets (throughput) over STR. STR can be implemented by using the advantages of Mobile Ad Hoc Networks (MANET). As Mobile Ad Hoc networks consist of nodes, which are randomly moving in unpredictable pattern. In practice, some communication nodes are congested causing dropped packets. The distributed congestion nodes will reflect the degradation of system performance. Then ARC is applied to those distributed congestion nodes. The ARC algorithm will take number of packets-drop and previous packet delay time into account for the adjustment of transmission rate. Several simulations are performed under the congestion of distributed nodes. The improvement of the proposed algorithm is discussed by comparing ours to performance by a traditional method. Results confirm the improvement rate ranges from 4 % up to 10 %.

Keywords :- Sky Train Routes, Mobile Ad Hoc network, simulation, ARC.

1. INTRODUCTION

Inter-vehicular communication systems are gaining much interest in the automotive industry as they could potentially provide the drivers with many services such as location based applications, information concerning localized real-time traffic conditions, parking information, vehicle to vehicle chats, etc. Examples of applications and implementations of IVCS had been shown in BUSnet[1], CarNet[2], FleetNet[6], IVCS[7].

In order to implement IVCS, low power radio transceivers are placed on board the vehicles. These transceivers interact with each other in an Ad Hoc fashion forming a MANET using routing algorithm like DSR[3], AODV[4], and LBR[8] to provide information about the route discovery, route maintenance and the transfer of data packets. While these routing protocols seem to work well in a scenario where nodes are basically random and mobile, the same could not be applied to IVCS as vehicular travel is often restricted by the road and the traffic patterns.

The research work [5] would be an alternative model to explore the effects of these regular patterns for Sky Train Routes as shown in figure 1.

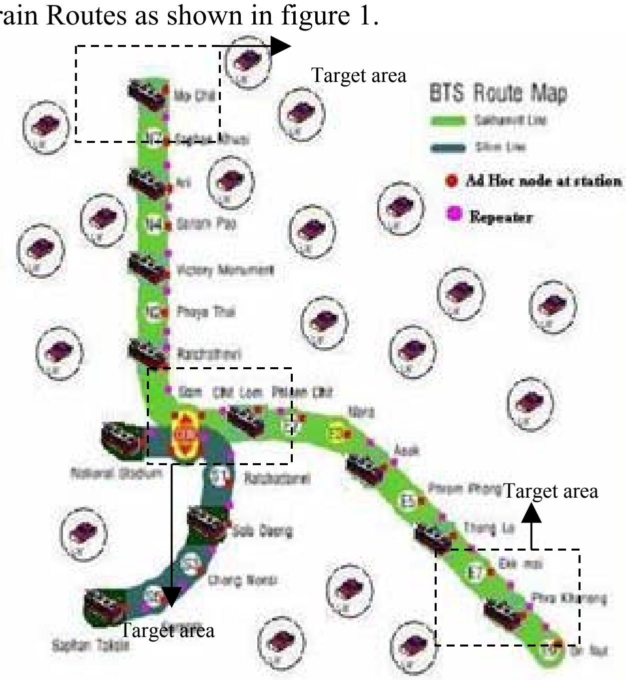

Figure 1. Sky Train Routes map with Ad Hoc nodes.

There exists a few metrics that can be used to gauge the performance of MANET based on NS-2 simulations. First is Data Delivery Percentage (DDP) and the other packet-drop (PD).

2. Adaptive Rate Control (ARC) Algorithm

The proposed ARC algorithm works like a gate to control the arriving packets. When packets arrive at the node and if a packet-drop is not present, the transmission is completed without delay. If packet-drop is present, the dropped packets will form a packet queue (Qc), waiting to be retransmitted when ARC finishes adjusting the new windows size in order to overcome the blocked packets. At the same time to maintain quality of service (QoS), the packets have been waiting in the packet queue longer than the maximum packet delay time (DT) will be discarded finally. Figure 2 illustrates the above situation according to the packet arriving process, two states of problem for ARC. In case that the arrival traffic (average arrival packet rate or traffic (λa) is less than the packet-drop rate (λp) and packet-drop is not yet present. ARC will set windows size to be one (the minimum size). On the other hand, if (λa) is larger than (λp) , ARC will adjust the window size with reference to packet-drop rate (λp) and arrival traffic rate (λa).In our assumption, ARC will adjust the window size between one to five. ARC algorithm can be described as shown in figure 3.

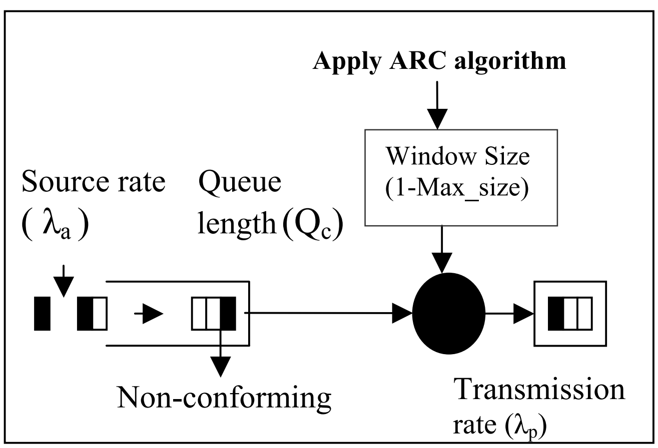

Figure 2. ARC model.

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/*********** ARC Algorithm ************/

PROCEDURE
/****** Window Size Calculation ******/

 All predecessor nodes (P_all) ;
 Current allocation rate Pi(Ai) ;
 Current window size (Wi) ;
 RTT (Round Trip Time) ;
 Current packet-drop (Di) ;
 Available Bandwidth (ABW) ;
DO WHILE Transmission is Ongoing ;
 {
    IF  Packet-Drop exists   THEN  {
    FOR ( i =0 to P_all-1)    DO {;
    Calculate new allocation rate Pi(An) ;
    Calculate new win_size (Wn) ;
       Pi(Ai) <= Pi(An) ;
       Wi <= Wn ;  }  END_DO ;    }
    ELSE {
    FOR ( i =0 to P_all-1)    DO {;
       Pi(Ai) <= ABW  ;
       Wi <= Wn ;  }   END_DO ;   }
  }   END_DO  ;
/*** Calculate new allocation rate (An) ***/
Pi(An) <= Wi * packet_size/RTT*( D_{i-1})^{1/2} ;
/*** Calculate current win_ size (Wn) ***/
IF  Packet-Drop exists  THEN
{
 Wn <= Wn ++ ;
IF Wn  >  Win_max THEN Wn <= Win_max  ;
}
ELSE { Wn <= Wn – –;
IF Wn  ≤  0  THEN Wn = 1  ; }
/*** Calculate available BW (ABW) ***/
ABW <= Max_BW – Used_BW;

/******* END OF ARC Algorithm *******/
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Figure 3. ARC Algorithm.

3.Simulation Parameters

For the NS-2 simulation, node was set to 100 as maximum. Some of them would be traveling at an arbitrary speed of 5m/s to 20 m/s until they reach the destination and the nodes would pause for 0 to 20 seconds before they select another random destination and speed. Other nodes are fixed by location of STR or repeaters. This process is then repeated until the end of

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the simulation. In order to examine the effect of vehicular nodes and its environment on MANET, all scenarios are set up for carrying out the simulations. The basic model for a Bangkok metropolitan environment consists of road and junction in form of 9 x 12 (=108) square kilometers area. The scenario with mobile units located at STR stations, the train and another 5 repeaters are investigated as shown in figure 4. Note that among those mobile nodes, three distributed congestion nodes are assumed, Siam, Mo Chit and On Nut stations and then these nodes are eased by applying the proposed ARC as shown in figure 3. In practice, these 3 nodes are located in the business-oriented area which would cause an intensive communication usage.

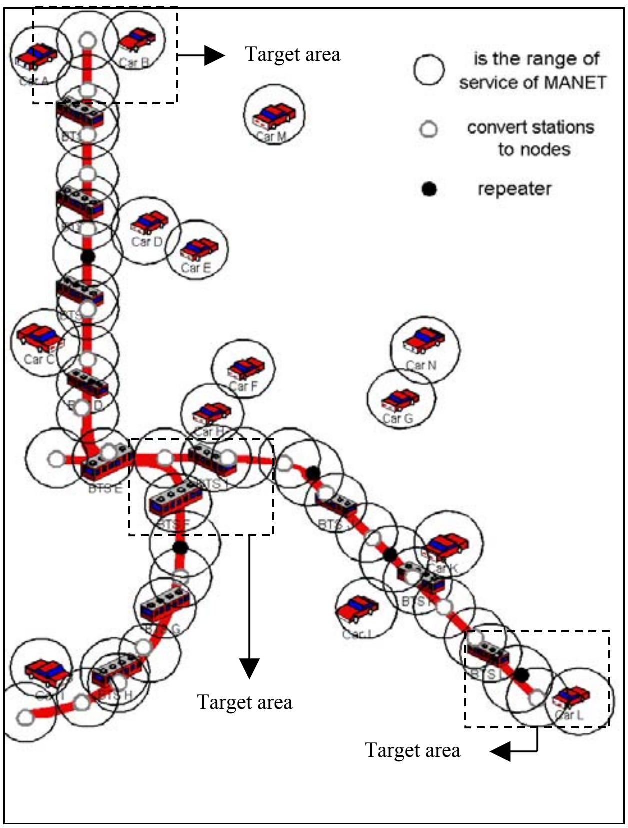

Figure 4. STR-Train-Repeater (S-T-R) scenario.

3. Simulation Results and Analysis

In this section results from the simulation, representing scenario as mentioned in figure 4 above are collected. First the connection graph at elapsed time 350 and 500 seconds is shown in figure 5 and 6 respectively.

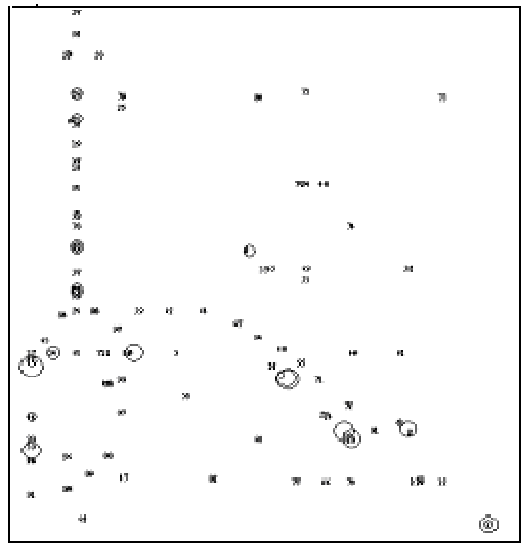

Figure 5. Connection graph at elapsed time 350s.

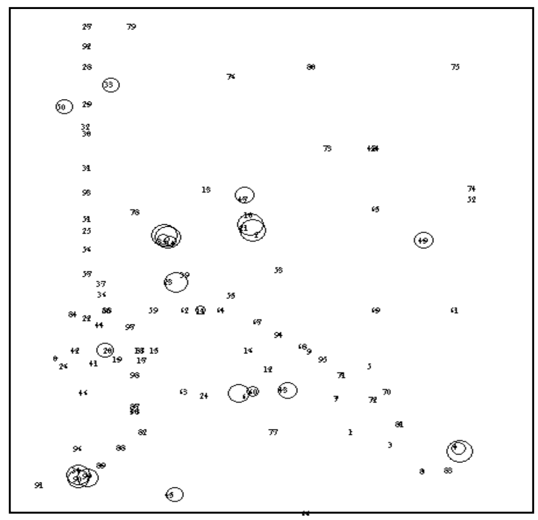

Figure 6. Connection graph at elapsed time 500s.

The results were collected for the scenario S-T-R as shown in figure 4. Before and after applying ARC algorithm to those congested nodes, results are then compared as summarized in table 1 to table 3. From table 1, it can be seen that after applying ARC to the same scenario, 1.4 % of the DDP can be improved while number of dropped packets can be reduced 4.3 %. This will show the robustness of the ARC algorithm in the case of congested node as such. Similarly, the improvement in higher DDP and lower packet-drop are apparent in table 2 and 3.

Scenario	DDP	PD @ Siam Station (packets)
S-T-R-NonARC	14.2	8,244
S-T-R-ARC	14.4	7,894
Improvement	**+1.4 %**	**- 4.3 %**

Table 1. An improvement between non ARC and ARC for S-T-R scenario at Siam.

Scenario	DDP	PD @ Mo Chit Station (packets)
S-T-R-NonARC	14.1	2884
S-T-R-ARC	14.2	2715
Improvement	**+ 0.8 %**	**- 5.9%**

Table 2. An improvement between non ARC and ARC for S-T-R scenario at Mo Chit.

Scenario	DDP	PD @ On Nut Station (packets)
S-T-R-NonARC	14.2	3457
S-T-R-ARC	14.3	3287
Improvement	**+ 0.7%**	**- 5%**

Table 3. An improvement between non ARC and ARC for S-T-R scenario at On Nut.

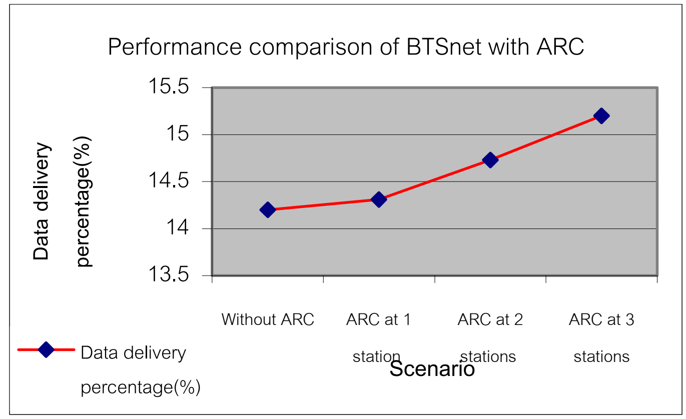

Figure 7. Performance comparison against number of node with ARC application.

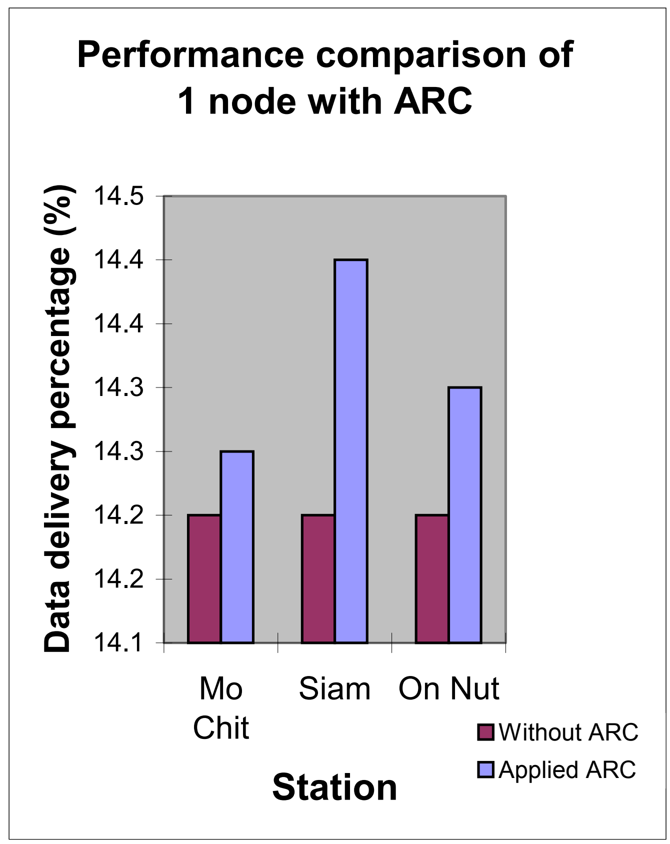

Figure 8. Results before and after applying ARC algorithm to one node.

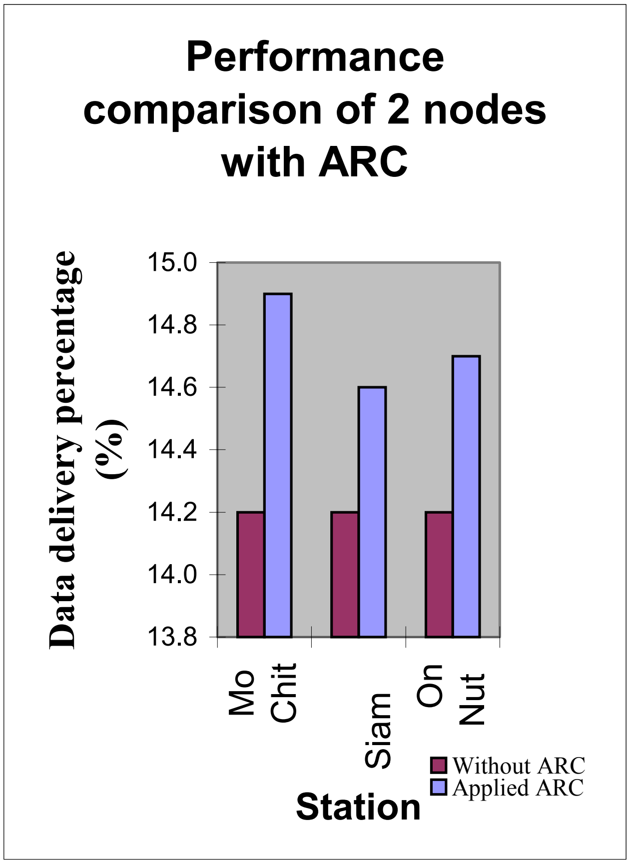

Figure 9. Results before and after applying ARC algorithm to two nodes.

The improvement will vary almost linearly with the number of nodes we apply ARC algorithm as indicated in figure 7. Figure 8 and 9 also confirm this improvement. These are results compared before and after applying ARC algorithm to one and two nodes in each experiment.

4.Conclusion and Discussion

In simulation, ARC algorithm had been applied to node 64 , 51,and 83 which are the locations of 3 congested nodes (Siam, Mo Chit and On Nut stations) along the STR. IEEE802.11.b protocol for MANET had been utilized as a physical wireless medium to communicate among nodes. Results had been collected as, the Data Delivery Percentage (DDP) from any pair of nodes that take node 64, 51, and 83 into the route.

The results show that S-T-R scenario with ARC algorithm improve the DDP metrics compared to ones without ARC. In addition, the packet-drop (PD) metrics are also reducible. The major reason of this improvement is that STR per se can maintain backbone network to support a data transmission. Since nodes will try to communicate before the transmission of packets, their routes along the backbone, especially, via Siam station, Mo Chit station, and On Nut station will be selected. This route selection will create a lot of communication traffic both in and out. In addition, these nodes per se are always congested due to the business-oriented area. However, the mobility and limitation on IEEE 802.11b can cause the performance degradation.

Besides, the number of DDP increases while number of nodes with ARC algorithm increases. This discovery supports the key solution to practical point of view that beyond the limitation of mobility and wireless communication drawbacks, ARC will help ease the problem of congestion more or less. The results after applying ARC to one node, DDP will increase by about 0.2%. But in case of ARC for 2 nodes, DDP will rise to about 0.5%. Lastly, if 3 nodes were applied with ARC, DDP increases by about 1.0 %. In conclusion, with this linear ratio (as shown in figure 7), if 100 nodes were applied with ARC, the DDP may increase by at least 33%.

5.Future Works

The S-T-R scenario with all nodes applied with ARC algorithm is currently undergoing observation. Parameters to compare the results such as mean queue time, mean queue length and residual time in each node are also being investigated.

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