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ORIGINAL RESEARCH ARTICLE

# AN EFFICIENT TECHNIQUE FOR THE REDUCTION OF PACKET LOSS IN WIRELESS SENSOR NETWORK

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**ABSTRACT**

*This paper, presents an efficient technique for the reduction of packet losses in wireless sensor network (WSN), which occurs because of buffer overflow and subsequently congestion. A key design feature for wireless sensor network is to have less packet loss, as more packet loss degrades the Quality of service (QoS) of the transmitted information and retransmitting such, a packet can use up the energy of the nodes. Regardless of a number of efforts made to alleviate this problem, networks still experiences packet losses because of congestion and topology change. A congestion avoidance algorithm, which is based on an active queue management technique, was proposed in this work. The new technique, called a Refined Adaptive Random Early Detection (RARED) technique was used to control the maximum packet drop probability to be within 0.01 and 0.5, which is equivalently between 1% and 50%, thereby reducing the rate of packet loss and increasing the throughput. Simulation results obtained using Network simulator 2, showed that the proposed algorithm attained a reduction in packet loss of 5.7% against the existing Priority-based Fairness Rate Control (PFRC) in WSN.*



## 1.0 Introduction

A wireless sensor networks (WSNs) possesses a lot of issues such as limited energy, heterogeneous traffic, finite bandwidth, finite memory capacity, finite processing time (Swain and Nanda, 2014) and congestion (Rezaee and Pasandideh, 2017). Congestion usually occurs when the traffic load introduced into the network exceeds the network handling capacity at a particular time. Congestion results in energy wastage, decrease in throughput, increase in collisions, retransmission and an increase in packet delay and packet loss (Antoniou et al., 2013). Congestion control and avoidance are the actions taken to manipulate the network traffic, to prevent congestion and eventually congestion collapse (Antoniou et al., 2013).

Techniques to mitigate congestion essentially involves congestion detection, congestion notification and finally congestion control (Narawade and Kokelar, 2017). Rate reduction (traffic control) and the establishment of a different route (Resource control), are the two basic methods of controlling congestion (Sergiou et al., 2014). Traffic control: congestion is mitigated using this method, by reducing the amount of traffic load infused into the network (Ghaffari, 2015). The different categories of traffic control techniques is shown in Figure 1 (Kafi et al., 2014).

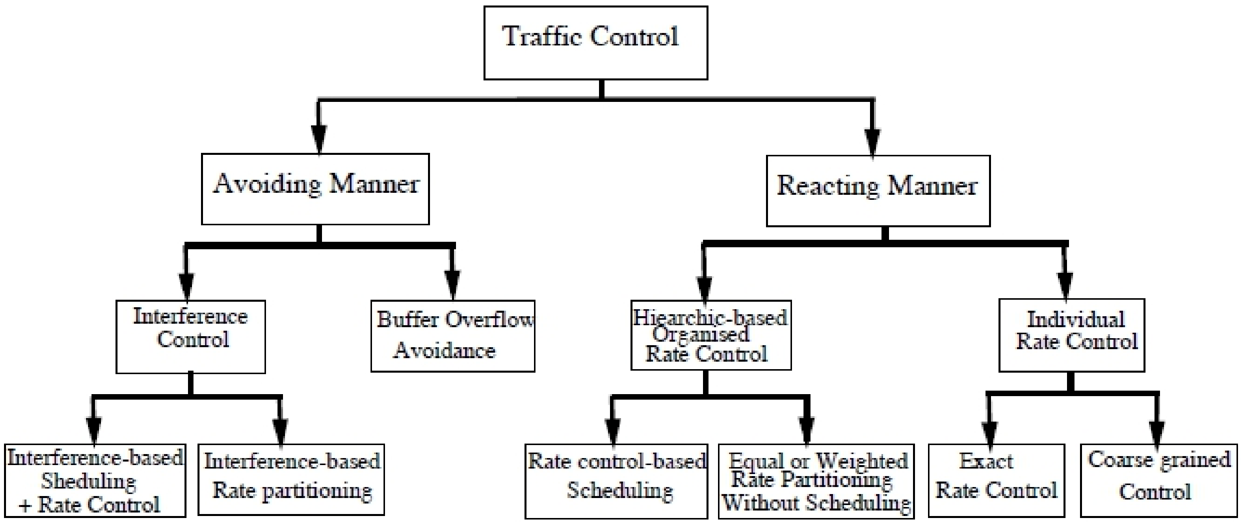


Figure 1: Traffic Control Categories (Kafi et al.,2014)

## 2. Review of Related Work

Brahma et al., (2012), presented traffic management in WSN: Decoupling congestion control and fairness. The congestion control algorithm adaptively determines a fair transmission rate to each node that is highly efficient. However, a prioritized architecture was not considered, which would have improved the throughput of the algorithm. Antoniou et al., (2013), presented congestion control in WSNs built on the flocking behavior of birds. The underlining idea is to direct packets to form flock and move in the direction of the sink node as the avoid obstacles on their paths (dying nodes and congested areas) in a robust manner. However, the node is passively listening to the channel, increasing the energy consumption of the network. This will ultimately lead to packets loss, when some of the nodes run out of energy, as there will be fewer nodes available to mitigate congestion. Jaiswal and Yadav (2013), studied fuzzy based adaptive congestion control (FBACC) in wireless sensor networks. The author made use of fuzzy logic system (FLS) for estimation of congestion and adapts to the changing traffic with low packet loss. Congestion was detected and mitigated by considering buffer occupancy, traffic rate and participants as input to the FLS. However, the use of fuzzy logic estimation involves difficult computations, which that needs a lot of processing energy. This causes energy loss and increased energy consumption. This eventually lead to loss of packets as there will be fewer number of number available for transmission of data. Rezaee et al., (2013), implemented an optimized congestion management protocol for healthcare wireless sensor networks. A novel Active Queue Management (AQM) technique is used to avoid congestion and to provide quality of service. However, congestion cannot be prevented for non-sensitive data. Rezaee et al., (2014), implemented HOCA: Healthcare Aware Optimized Congestion Avoidance and control protocol for wireless sensor networks. The author implemented a data centric congestion control scheme using an AQM technique. There are four phases of operation of HOCA, namely: request dissemination phase, event occurrence reporting phase, route establishment phase and data forwarding and rate adjustment stage. However, packets experience longer delays when they go through longer routes to the sink node. Swain and Nanda (2014), presented Priority-based Adaptive Rate Control for Wireless Sensor Networks. A tree topology was used Real time and Non-real time traffic classes were considered and higher priority was assigned to the real time traffic. However, fairness in the distribution of the available bandwidth was not considered, which would have improved the throughput. Narawade and Kokelar (2016), investigated ACSRO: Adaptive cuckoo search-based rate adjustment for optimized congestion avoidance and control in wireless sensor networks. Congestion was initially avoided, by the adaptation of the packet drop probability using a virtual queue, where less important packets are dropped. However, there is an increased complexity and delay encountered in solving the multi-objective objective function. Swain and Nanda (2017) studied Priority-Based Fairness Rate Control in Wireless Sensor Networks. The author presented a rate control technique that is concerned with the fair distribution of bandwidth, while considering the priority of the different traffic classes connected to various nodes. However, congestion cannot be detected in advance, which would have improved the quality of service of the algorithm.

## 3. Improved Algorithm: RARED

This work puts forward an efficient technique for reducing packet loss in WSN. To mitigate the issue of packet loss as a result of buffer overflow, which eventually leads to congestion. The developed technique, addressed the issue of packet loss by, detecting congestion in advance, when the congestion index exceeds a predefined threshold (maximum). This helps in reducing packet loss as a result of buffer overflow emanating from congestion.

The equation used to denote the packet loss is given below (Swain and Nanda, 2017):

$$Trx_{in}^{sink} = \sum_{i \in C(sink)} Trx_{out}^{i} \tag{1}$$

The equation, used in denoting the congestion index $I_c$ , is given as follows (Liu et al., 2013):

$$I_c = \begin{cases} 0, & q^{k(i)} \leq Min_{th}^{k(i)} \\ \frac{P_{max}\ (q^{k(i)} - Min_{th}^{k})}{Max_{th}^{k(i)} - Min_{th}^{k(i)}} & Min_{th}^{k(i)} < q^{k(i)} < Max_{th}^{k(i)} \\ 1, & q^{k(i)} \geq Max_{th}^{k(i)} \end{cases} \tag{2}$$

The new transmission rate from the sink node to the child node is given (Swain and Nanda, 2017):

$$Trx_{out}^{i} = \begin{cases} Trx_{out}^{i} + \frac{\Delta Trx^{sink}}{L^{sink}} \cdot \frac{P_{gl}^{i}}{P_{gl}^{sink}}, & if \Delta Trx^{sink} > 0 \\ \frac{Trx_{out}^{i}}{\Delta Trx^{sink}} \cdot \frac{P_{gl}^{i}}{P_{gl}^{sink}} & if \Delta Trx^{sink} < 0 \end{cases} \tag{3}$$

Equations (4) and (5) is used to keep the minimize the packet losses (Tahiliani et al., 2011):

$$\alpha = 0.25 \times \frac{q^{k(i)} - target}{target} \times P_{max} \tag{4}$$

$$\beta = 1 - \left(0.17 \times \frac{target - q_e{}^{k(i)}}{target - Min_{th}^{k(i)}}\right) \tag{5}$$

## 4.0 Simulation Environment

Network simulator 2.35 was used in the simulation of this work. Network simulator 2.35 was used to compare the performance of the RARED and the existing priority-based fairness rate control algorithm (PFRC). The simulation parameters used in this work are shown in Table 1. Furthermore; Figure 3 shows the flowchart of the RARED and the Network simulator 2 code used to design the RARED and PFRC respectively.

Table 1: Simulation Parameters Used in this Work (Swain and Nanda, 2017)

| Parameter | Value/Protocol |
| --- | --- |
| Simulator | NS-2 version 2.35 |
| Simulation area | 1000m *1000m |
| Mac layer | IEEE 802.11 |
| Number of sensor nodes | 11 |
| Data packet length | 129 bytes |
| IFQ length | 50 packets |
| Transmission range | 281.84mW |
| Operating frequency | 5 GHz |
| Traffic source | CBR |
| Routing protocol | Destination sequenced distance vector |
| B | 0.1 |
| Simulation time | 100s |
| Queue Type | RARED and Priority queueing |

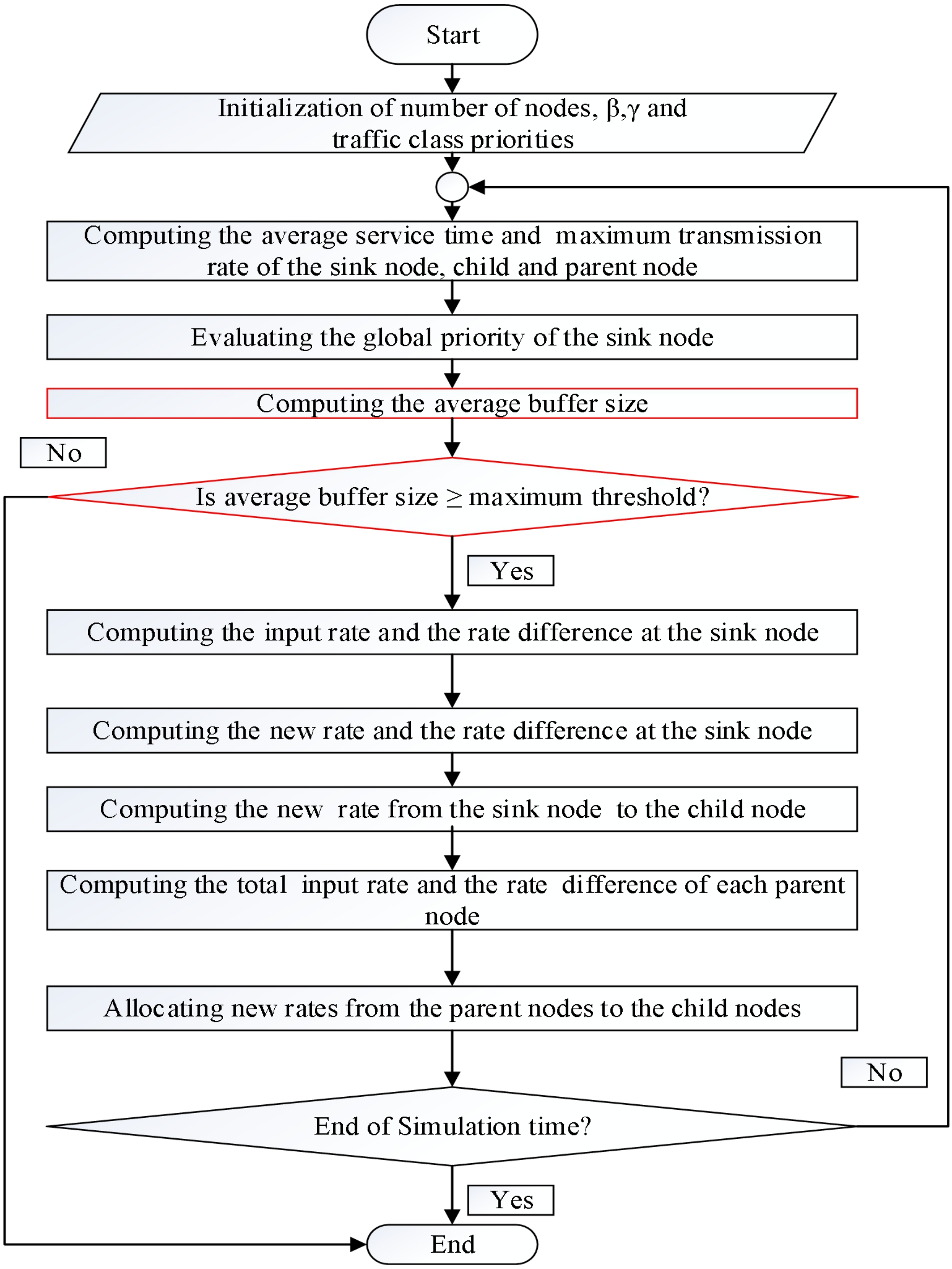


Figure 3: Flowchart of the developed RARED algorithm (Swain & Nanda (2017)

```
Average service time at the sink node
#############################################################################
        $stime = (1-$val(l))*$val(stime) + $val(l)*$val(stime)
Maximum transmission rate of the parent node and child node
#############################################
                $outTx_rate = $agv_serviceTime_sinkNode{$landa}
                $maxTx_rate = $outTx_rate * $globalPriority_sinkNode{$contact_nodes} /
$globalPriority_sinkNode{$contact_nodes} * $val(qssl) / $val(qscnl)
- Implementation of Refined ARED - Start **********************************************/
 void REDQueue::updateMaxP_refined_adaptive(double new_ave, double now)
        double part = 0.48*(edp_.th_max - edp_.th_min);
        // AIMD rule to keep target Q~1/2(th_min+th_max)
        if ( new_ave < edp_.th_min + part && edv_.cur_max_p > edp_.bottom) {
                // we increase the average queue size, so decrease max_p
                edv_.cur_max_p = edv_.cur_max_p * (1.0 - (0.17 * ((edp_.th_min + part) -
new_ave) / ((edp_.th_min + part) - edp_.th_min)));
                edv_.lastset = now;
                double maxp = edv_.cur_max_p;
```

Figure 4: Network simulator Code for Designing the RARED and the PFRC (Swain & Nanda, 2017)

## 5. Results and Discussion

The packet loss was calculated using equation 1. From the plot, it can be observed that the developed RARED scheme displayed less amount of packet loss compared to the existing PFRC scheme. This was as a result of the RARED algorithm that detects congestion before the overflows, thereby preventing reducing packet loss as a result of congestion. The packet loss is also reduced by using the RARED algorithm, by ensuring that the average queue size is between the minimum and maximum thresholds respectively. Equation (6) shows the mathematical expression for obtaining the percentage reduction in packet loss from the plot shown in figure 5.

$$\text{Percentage Improvement} = \frac{\text{RARED} - \text{PFRC}}{\text{RARED}} \times 100 \quad (6)$$

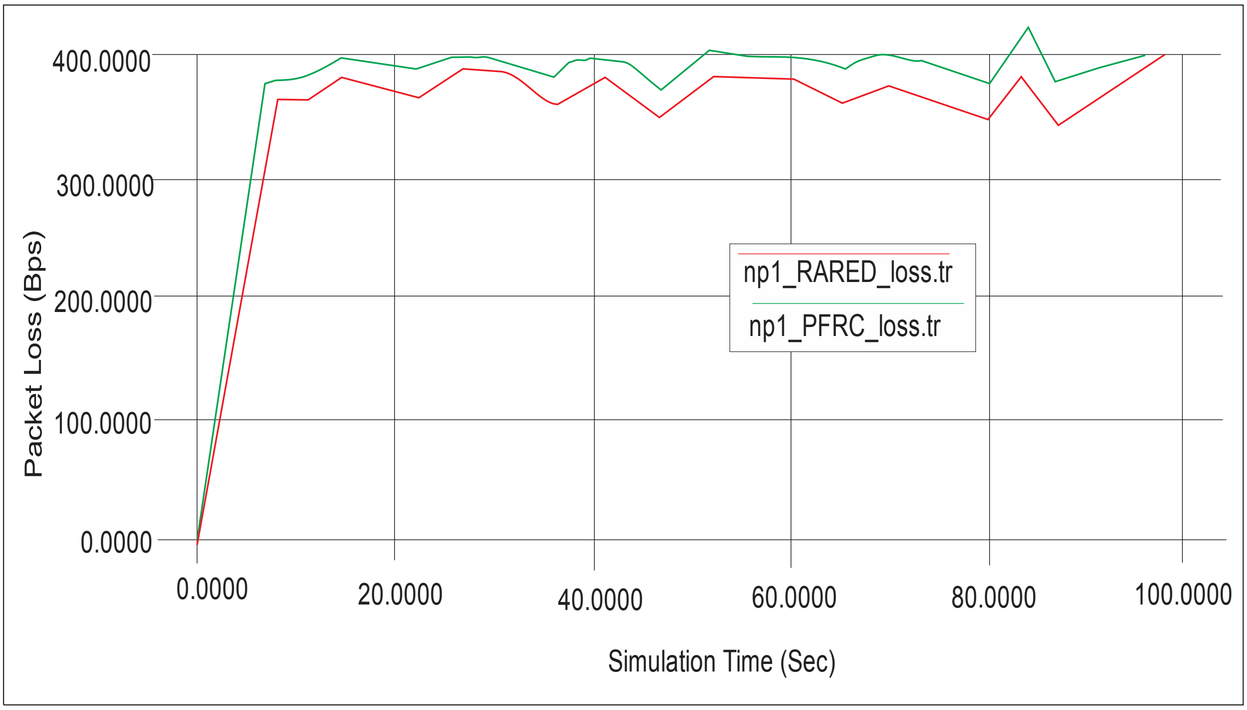


Figure 5: Plot of packet loss for the two protocols against simulation time

Figure 5 shows the result for the performance of PFRC and RARED in terms of packet loss against simulation time. The loss of the network was tested against simulation time from 0 to 100seconds. Equation 1 is used to generate Figure 5. From the result, it can be observed that the RARED experienced lower packet loss when compared to the existing PFRC. This is as a result of RARED algorithm that detects congestion in advance before buffer overflow, thereby resulting in lower packet loss. The fluctuations as evident in the plot are as a result of the varying conditions of the network.

Table 2: Packet loss against simulation time

| Time(s) | 0 | 20 | 40 | 60 | 80 | 100 | Average |
|---|---|---|---|---|---|---|---|
| PFRC | 0 | 390 | 395 | 398 | 380 | 400 | 327.2 |
| RARED | 0 | 365 | 368 | 370 | 355 | 400 | 309.7 |

The data in Table 2 were obtained through Network Simulator version 2.35. The values in Table 2 is computed by using equation 6. From Table 2, it can be observed that the packet loss of the RARED showed a reduction of 5.7% when compared to PFRC.

## 6. Conclusion

From the discussed results, it can be seen that the developed RARED technique successfully improved the performance of the existing Priority-based Fairness Rate Control algorithm. The developed RARED algorithm outperformed the existing priority-based fairness rate control algorithm, in terms of packet loss. The developed RARED algorithm achieved a reduction in packet loss of 5.7%. This reduction in packet loss was made possible by the use of RARED technique, which functions proactively by detecting congestion in advance congestion before the buffer overflows.

## References


Antoniou, P., Andreas, P., Tim, B., Andries, E. and Loizos, M. 2013. Congestion control in wireless sensor networks based on bird flocking behavior. Computer Networks, 57(5): 1167-1191.

Brahma, S., Chatterjee, M., Kwiat, K. and Varshney, PK. 2012. Traffic management in wireless sensor networks: Decoupling congestion control and fairness.Computer Communications, 35(6):670-681.

Ghaffari, A. 2015. Congestion control mechanisms in wireless sensor networks: A survey Journal of Network and Computer Applications, 52:101-115.

Kafi, MA., Djenouri, D., Ben-Othman, J. and Badache, N. 2014. Congestion control protocols in wireless sensor networks: A survey. IEEE communications surveys & tutorials, 16(3):1369-1390.

Liu, Z., Zhang,Y and Philip, CC. 2013. Adaptive mechanism-based congestion control for networked systems. International Journal of Systems Science, 44(3): 533-544.

Narawade, VE and Kolekar, UD. 2016. ACSRO: Adaptive cuckoo search based rate adjustment for optimized congestion avoidance and control in wireless sensor networks, Alexandria Engineering Journal, 57(1):131-145.

Narawade, VE and Kolekar, UD. 2017. EACSRO: Epsilon constraint-based Adaptive Cuckoo Search algorithm for rate optimized congestion avoidance and control in wireless sensor networks. Proceedings of a symposium held in Coimbatore, India, 10-11 February 2017. I-SMAC proceedings no.3:715-720.

Rezaee, AA., Yaghmaee, MH., and Rahmani, AM. 2013. Optimized congestion management protocol for healthcare wireless sensor networks. Wireless personal communications, 75(1): 11-34.

Rezaee, AA., Yaghmaee, MH. Rahmani, AM. and Mohajerzadeh, A H. 2014. HOCA: Healthcare Aware Optimized Congestion Avoidance and control protocol for wireless sensor networks. Journal of Network and Computer Applications, 37: 216-228.

Rezaee, AA and Pasandideh, F. 2017. A fuzzy congestion control protocol based on active queue management in wireless sensor networks with medical applications.Wireless Personal Communications, 98(1):815-842.

Sergiou, C., Vassiliou, V and Paphitis, A. 2014. Congestion control in Wireless Sensor Networks through dynamic alternative path selection. Computer networks, 75: 226-238.

Sergiou, C., Antoniou, P., and Vassiliou, V. 2014. A comprehensive survey of congestion control protocols in wireless sensor networks. IEEE communications surveys & tutorials,16 (4):1839-1859.

Swain, S. K. and Nanda, PK. 2014. Priority-based adaptive rate control for wireless sensor networks. Proceedings of a symposium held in Guargaon, India, 21-22 February 2014. IACC proceedings no.8: 370-374.

Swain, S. K. and Nanda, PK. 2017. Priority based fairness rate control in wireless sensor networks. Proceedings of a symposium held in Chennai, India, 22-24 March 2017. WISPNET proceedings no. 9:2206-2210.

Tahiliani, MP., Shet, KC. and Basavaraju, TG. 2012. CARED: Cautious Adaptive RED gateways for TCP/IP networks, Journal of Network and Computer Applications, 35(2) :857-864


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