# A Load Adaptive Rate Control Scheme for Wireless Sensor Networks

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## Abstract

This paper presents a load adaptive solution in order to control the source rate in wireless sensor networks (WSNs). Unlike existing protocols, the proposed work incorporates a new traffic load estimation technique based on the ratio between load and capacity utilization. The simulation result establishes the effectiveness of the proposed work.

## Ⅰ. Introduction

The wireless sensor networks (WSNs) are emerged and applied broadly in different environments for remote sensing. The wide spread use of active and passive sensors increasingly evolves multiple class of applications for WSN. Such applications include monitoring structural health and habitat life, surveillance, target estimation and tracking for military purpose. The traffic from these applications mostly demand congestion free continuous data transmission, which needs to be stable at sustainable high-rate to maximize capacity utilization. Hence, rate control is obvious to avoid congestion collapse [1] and provide higher goodput [2], thereby, necessitates designing an efficient rate control protocol for WSN.

Based on the rate control policy the existing solutions for WSN can be divided mainly into two broad categories: centralized and distributed schemes. In centralized schemes [3,4,5], the base station (or sink) allocates and assigns the rate to each node according to the received feedbacks from the sensors. However, the centralized protocols are seemed to be ineffective during congestion collapse [1], since in such state of the network no source can forward any feedback toward the sink and vice versa. Conversely in distributed solutions [1,6], each node is individually responsible to adjust the rate depending upon the given rate control policy, thereby, has the flexibility to quickly adapt with any kind of change in traffic load of the network.

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This paper presents an efficient rate control protocol that takes traffic load into account while sourcing data into the network. This is a distributed solution and able to maintain a moderate queue length avoiding congestion and buffer drop. Moreover, the proposed work significantly reduces collision drop due to its load adaptive policy. The simulation results show the effectiveness of the proposed rate control.

## Ⅱ. Load Adaptive Rate Control

### A. Network Model

We assume a WSN having a number of sensor nodes, with a sink (i.e., receiver) and multiple source nodes. The network scenario is many-to-one that converges to a tree-topology rooted at the sink, and all the other nodes places on different levels of the tree. In the ensuing sections we use the notations: let, each sensor node is denoted by $n_i$. A pre-established bi-directional path is assumed between each node and sink. Let consider, at time $t$ the traffic sourcing or originating rate of node $n_i$ is denoted by $r_i(t)$.

### B. Traffic Load Estimation and Notification

The proposed work includes simplified load estimation technique, in which each node measures the load based on the capacity utilization. Due to the variation in network traffic each sensor node needs to measure the load over an appropriate time interval. To do so, we use a load update interval, denoted by $T$, and the load of node $n_i$ is denoted by $L_i$:

$$L_i = \frac{T \times (a_i + f_i + c_i)}{T \times C \times \eta} = \frac{(a_i + f_i + c_i)}{C \times \eta}, \quad (1)$$

where, $a_i$ and $f_i$ is node $n_i$'s successful arrival and forwarding rate respectively, and $c_i$ is the collision rate.

Moreover, $C$ is the radio capacity and $\eta$ is the capacity utilization factor. Based on the measured value of $L_i$ we classify the node's traffic load status in any of the four categories, namely: low-load, neutral-load, high-load and over-load as given in the table.

| Load Value | Load Category |
|---|---|
| $L_i \leq 0.74$ | Low-load |
| $0.74 < L_i \leq 0.83$ | Neutral-load |
| $0.83 < L_i \leq 0.92$ | High-load |
| $L_i > 0.92$ | Over-load |

The proposed work assumes that if a node has $L_i \leq 0.74$, then it is in low-load state; in contrast if $L_i > 0.92$, then the node is in over-load state. The neutral-load and high-load categories are chosen in between the considered minimum and maximum bound for $L_i$. Upon detecting the load, each node encodes the load information in every transmitted data packets. Thus, getting the load status of the neighbors (by overhearing) a node $n_i$ updates its status if and only if it has a higher value for load status; otherwise, it keeps it unchanged. Eventually, the bottleneck status of any particular region of the network would be available to the surrounding nodes and to the source nodes as well.

C. Source Rate Control

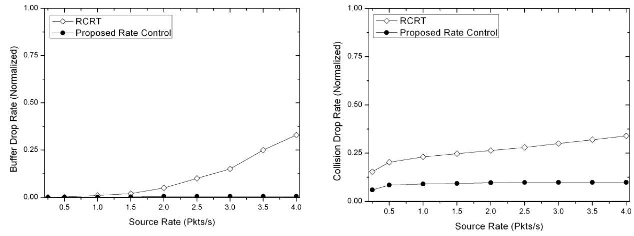
The source rate control avoids congestion and assigns a rate to each source of a flow considering the network load. In Algorithm 1, we describe the proposed rate control technique, where $T$ is used as the rate update interval. The choice of $T$ is very critical and for the successful propagation of the load and rate control information within the whole network, the average round-trip time (RTT) of the nodes is used as $T$. We use the parameters $\alpha$ and $\beta$ for rate increase, and $\phi$ for rate decrease.

**Algorithm 1:** Source Rate Control at node $n_i$

```
while {Low-load}
      r_i(t+T) = r_i(t) + r_i(t)
end while
while {Neutral-load}
      r_i(t+T) = r_i(t) + α
end while
while {High-load}
      r_i(t+2T) = r_i(t) + β
end while
while {Over-load}
      r_i(t+δ) = r_i(t) – φ     \\ here, δ → 0
end while
```

## III. Simulation Results

We have performed extensive simulations, and the performance of the proposed protocol is compared with RCRT [3]. As in Figure 1 (a) and (b), our proposed rate control completely outperforms the RCRT protocol in terms of buffer drop and collision drop rate respectively.




(a) (b)

**Figure 1:** (a) Buffer drop rate, (b) Collision drop rate.

## IV. Conclusion and Future Work

The proposed rate control is a load adaptive distributed data transport solution for WSN, where congestion avoidance is ensured. In future we will extend this work to a complete data transport protocol for WSN.

## References

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