An Efficient Rate Control Protocol for Wireless Sensor Network Handling Diverse Traffic

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Abstract

Wireless Sensor Network typically incorporates diverse applications within the same network. A sensor node may have multiple sensors i.e. light, temperature, seismic etc with different transmission characteristics. Each application has different characteristics and requirements in terms of transmission rates, bandwidth, packet loss and delay demands may be initiated towards the sink. In this paper we propose Heterogeneous Traffic Oriented Rate Control Protocol (HTRCP) which ensures efficient rate control for diverse applications according to the priority specified by the sink. Moreover, HTRCP ensures the node priority based hop by hop dynamic rate adjustment for high link utilization.

1. Introduction

In present research train, lots of work is going on rate control for wireless sensor network [5]. But no other protocols except STCP [6] considered multiple sensing devices in a single node. Recently a node priority based control mechanism PCCP [2] has been proposed for WSN. It introduces an efficient congestion detection technique addressing both node and link level congestion. CCF (Congestion Control and Fairness) [3] is also a remarkable congestion control technique which uses packet service time to infer the available service rate.

With achieving the diverse rate for diverse application, we also performed the rate control when congestion occurs. Our congestion detection mechanism is based on packet service ratio and congestion notification is implicit. In our proposal we have also proposed node priority based hop by hop dynamic rate adjustment for high link utilization.
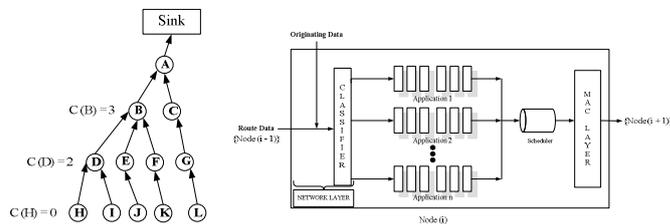
2. Design Considerations

Figure 1. (a) Network Model (b) Queuing Model

Figure 1 and 2 depicts the node and queuing model. We assume many to one multipath single path routing and used inter queue and intra queue priority for achieving desired rate while scheduling.

3. HTRCP Protocol

HTRCP uses implicit congestion notification. Each node i piggyback the packet scheduling rate, R_{sch}^i; packet service ratio, $r(i)$; total no. of child nodes, C_p; no. of active child node at time t, $A_t(C_p)$; average queue length at time t, $avg_q^i(t)$; and the average queue length of its active child nodes in its packet header. The Protocol works as follows:

1. Each node measure the congestion degree r(i) as $r(i) = R_s^i / R_{sch}^i$; When this ratio is equal to 1, it means the upcoming rate of packets at the MAC layer is equal to the packet service rate. So, The scheduling rate will remain unchanged.

2. Scheduling rate R_{sch}^i will also remain unchanged until the packet service ratio goes beneath a threshold.

3. When the ratio, $r(i)$ goes below a certain threshold, µ; the forwarding rate of a packet increases than the packet service rate in such a way that causes congestion. At that time, $R_{sch}^i = R_s^i$.

4. When $r(i)$ reaches above 1, it indicates the packet service rate is greater than the upcoming rate. At that time, $R_{sch}^i = \beta * R_s^i$

5. After determining the desired scheduling rate, each node i adjusts their scheduling rate according to the scheduling rate of their parent node.
   - When node i determines that all the child nodes of its parent are active node at time t, that is $A_t(C_{p^i}) = C_{p^i}$ then node i will adjust its scheduling rate as $R_{sch}^i = R_{sch}^{p^i} / C_{p^i}$
   - When node i determines that some of the child nodes of its parent are idle (Figure 5(b)) that is when $A_t(C_{p^i}) < C_{p^i}$, then it adjusts it scheduling rate as $R_{sch}^i = R_{sch}^i + \varphi_i(t)E(t)$; where $\varphi_i(t)$ is the node weight factor and $E(t)$ is the excess link capacity. $\varphi_i(t)$ can be calculated

     as: $$\varphi_i(t) = \begin{cases} \dfrac{avg_i^q(t)}{\sum_{i \in A_t(C_{p^i})} avg_i^q(t)} & i \in A_t(C_{p^i}) \\ 0 & otherwise \end{cases}$$ and $avg_i^q(t)$ can be calculated as

     $$avg_i^q(t) = \frac{\sum_{j=1}^{No.of\ queue} \alpha_j^i \times q_j^i}{total\ queue\ length}.$$

   - Just after calculating the scheduling rate, each node, i update their originating rate R_{or}^i as:

     $$R_{or}^i = \frac{R_{sch}^i(t) * \alpha_i}{\alpha_1 + \alpha_2 + \cdots + \alpha_n}$$

4. Conclusion:

In this paper, we have presented an efficient rate control mechanism for heterogeneous data originated from a single sensor node called HTRCP. We have demonstrated through the simulation that HTRCP achieves: i) Desired rate for diverse data according to the priority specified by the sink, ii) High link utilization, iii) Moderate queue length to reduce packet loss, iv) Lower packet drop rate and therefore it is energy efficient and provide lower delay.