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Probabilistic Prediction based Scheduling for Delay Sensitive Traffic in Internet of Things

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Abstract

This paper proposes a probabilistic prediction based approach for providing Quality of Service (QoS) to delay sensitive traffic for Internet of Things (IoT). A joint packet scheduling and dynamic bandwidth allocation scheme is proposed to provide service differentiation and preferential treatment to delay sensitive traffic. The scheduler focuses on reducing the waiting time of high priority delay sensitive services in the queue and simultaneously keeping the waiting time of other services within tolerable limits. The scheme uses the difference in probability of average queue length of high priority packets at previous cycle and current cycle to determine the probability of average weight required in the current cycle. This offers optimized bandwidth allocation to all the services by avoiding distribution of excess resources for high priority services and yet guaranteeing the services for it. The performance of the algorithm is investigated using MPEG-4 traffic traces under different system loading. The results show the improved performance with respect to waiting time for scheduling high priority packets and simultaneously keeping tolerable limits for waiting time and packet loss for other services.

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1. Introduction

Internet of Things (IoT) is the next evolution of the Internet where devices of different types and capabilities are connected through Internet protocol (IP) and web services to make intelligent decision and to exchange information

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without much relying on the human association[1]. Various intelligent devices in smart home[2] and industry are usually connected with personal mobile devices through GSM, GPRS or 3G networks[3]. This resulted in exponential increase in the volume of Internet data and thus created a challenge for buffer management. At the same time the need for a scheduling scheme to ensure instant communication without queuing delays and packet losses especially for the sensitive data. The smart devices like wireless cameras used in closed camera television (CCTV) and home network with limited buffer capacity needs effective buffer management, packet scheduling and service differentiation to provide preferential treatment to delay sensitive traffic. Also, offering sufficient transmission opportunity within tolerable delay for the multi user video transmission applications is challenging.

For example, an intelligent CCTV camera takes a picture of an intruder and instantly sends a priority message together with the photograph of the intruder to the owner's mobile device. In this perspective, it is of vital importance to develop service models that guarantees QoS for delay sensitive applications in IoT[1]. Current approaches provide unsatisfactory solutions for delay sensitive applications because it is observed that more video contents are captured than human can possibly handle[4]. It becomes more critical if the resources available are not sufficient. Furthermore, most of the existing slot allocation policies of scheduling such as round-robin or rate-adaptive round-robin are stationary because the allocation of the current slot does not depend on the allocation of previous slots[5] . In this paper, we propose a model to consider IoT applications which are more sensitive to delay.

Here, we propose a novel approach based on round robin policies and additionally, a unique characteristic of allocation of number of serviced packets in current slot is made dependent on the allocation of number of serviced packets in previous slot. This characteristic is implemented by calculating difference in probability of average queue length of high priority packets in consecutive cycles and allocating bandwidth to each service class based on this difference. The proposed model analyses finite capacity queues with service differentiation[6] and provides a solution to evaluate the performance of traffic generated by smart devices under varying traffic conditions so as to ensure preferential treatment of high priority delay sensitive traffic. The algorithm is tested for different buffer sizes to understand the effect on currently small buffer in smart devices in IoT and prospective bigger sizes in the future. Also, for variable buffer size, it becomes important to record the increased queue length to approximate the required resources in the next round (cycle).

The rest of the paper is organized as follows. System model and assumptions are described in Section 2. In Section 3, the prediction model is formulated and solved to attain the desired performance. Results are presented in section 4, while section 5 states the conclusion and future work.

2. Probabilistic Model and Its Assumptions

In the proposed model it is assumed that the arriving traffic is classified into highest priority (emergency traffic), medium priority (constant rate traffic) and low priority (normal traffic) traffic and is stored in different queues. In this policy a unique characteristic of calculation of current departure packets from each priority queue is proposed. Increase/decrease in average queue length of high priority queue is predicted in consecutive cycles and based on this, the required bandwidth for each service class is calculated. In other words, it determines a weighting coefficient[7] for each queue to calculate the average number of packet departures from the queue before moving to the next queue. The weighted round robin scheduler serves all the queues in one cycle. Scheduling is performed at the beginning of each cycle.

Let the highest priority queue has a buffer queue size of B1 and other service classes have a buffer queue size of B2. We assume that packet arrivals occur independently for each service class and follow a Poisson process with a mean arrival rate of $\lambda = \sum_{n=0}^{nmax} n.P(n)$ packets per cycle as shown in Fig.1, where *P(n)* represents the probability of n packet arrivals in a cycle and n_{max} denotes the maximum number of packet arrivals. Let $\lambda_{HA}, \lambda_{HQ}, \lambda_{HL}$ are respectively the number of packets arrived, packet stored in the queue and packet lost from high priority queue. Similarly, $\lambda_{MA}, \lambda_{MQ}, \lambda_{ML}$ are respectively the number of packets arrived, packet stored in the queue and packet lost from medium priority queue and $\lambda_{LA}, \lambda_{LQ}, \lambda_{LL}$ are respectively the number of packets arrived, packet stored in the queue and packet lost from low priority queue. We consider a probabilistic Markov Chain Based Model to describe the system.

The following points illustrate the design approach: