Performance Analysis of Congestion Control for Massive MTC Networks

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Abstract. This paper describes scheduling and processing of congested packets in massive Machine Type Communications (MTC). When there are too many uplink packets, it may cause congestions in the Radio Access Network (RAN) and the Evolved Packet Core (EPC). To solve this problem, we propose a Critical Random Early Detection (CRED) method to compute the current average queue length for each process to determine whether a packet needs to be discarded or not to prevent from congestions. The proposed method is evaluated through NS-2 simulations.

Keywords: Machine Type Communications (MTC) · Cellular network · Congestion

1 Introduction

The term, Machine Type Communications (MTC), comes from the 3GPP (Third Generation Partnership Project) specification [1]. Nowadays, sensors, actuators, and RFID/NFC, are used to collect information and to bring convenience to our daily life, making the number of these devices increases exponentially in recent years. Once generated sensed data, those devices are scheduled to report their data to an evolved NodeB (eNB). Given the number of the devices is large, it may cause significant congestions and latency in the network.

In this paper, we focus on designing the management mechanism of scheduling the MTC devices transferring the packets to eNBs and Packet Data Network Gateways (P-GWs). To achieve and solve the congestion problem, we propose the Critical Random Early Detection (CRED) Method to decide if an MTC packet should be discarded for releasing network congestion. Our method is based on three steps to prevent the network congestion: (i) According to the MTC devices at the fixed position periodically sends data to eNB and P-GW, the sender packet time must match service time at eNB and P-GW; (ii) According to the data urgent and real-time priority to give higher priority; and (iii) use Early Detection Gateways for Congestion Avoidance [4] to migrate the MME/S-GW by drop congestion MTC packets at the radio access network (eNBs). It drops congestion packets by computing the average queue length of the arriving packets.

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1.1 Related Works

About the scheduling related mechanism, we know that in Loss type queuing system queue space is zero and does not allow queuing, when the MTC device arrives OM2M gateway. If all channels (channel) are occupied, that is, the MTC device transmitted the data packet to be discarded, and assume no re-transmission.

Another scheduling related mechanism is waiting type queuing system; we list them as follows:

FCFS (First Come First Service): According to the order of the queue, the system first serves the jobs in front of the queue.

LCFS (Last Come First Service): According to the order of the queue, the system last serves the jobs in front of the queue.

PS (priority): The system serves the jobs based on their priority.

SIRO (Service in Random Order): The jobs are served randomly.

We also introduce congestion relate work as follows.

Backoff window method has some issues when the backoff time may lead to retransmit the information time and cause congestion.

ACB (Access Class Baring) [2] mechanism provides a way to bar a range to access class user. However, packets' priority cannot be identified by the ACB so that high priority packets are also banned by the ACB.

There are four drawbacks when adopting CAAC (Congestion-Aware Admission Control) [3]. First, we need to find new reference recalculated as a benchmark to calculate congestion level. Secondly, the method of calculation of required sample time of the first N times and Random Early Detection only need to calculate the percentage of the average size of a Queue. Thirdly, it will be put forward to reduce congestion level reject need to spend more time and computational complexity to calculate congestion level. Fourthly, from the calculation of the average length of Queue it will be able to determine the current congestion length and therefore do not take the time to calculate congestion level.

Mass MTC devices for the LTE network characteristics, taken in conjunction mixed queuing system, loss type and wait for type queuing system is an ideal network model, the main principle of this mechanism is to allow queued but not infinitely long queue time, so do not allow infinite queue space, mainly in the following ways:

Queue length is limited, limited waiting space. When the number of queued packets length of service or transmission of the MTC device exceeds a predetermined, based on the MTC device statistics do good Average Queue length packets discarded, and continue to wait for the next delay time to uplink the data.

In addition, MTC's sensors can sometimes detect some urgent data, the packet such as ETWS signal by priority, so the data for the characteristics of the urgency of the needs in the schedule to give a higher queue weights.

Longer needs about time for continuous transmission of real-time video streaming data given long service time, so the data for the characteristics of the needs in the schedule to give a higher queue weights. Therefore, Sect. 2, we adopt [4] to take the basic idea and adjust the function to suit the 3GPP-based cellular network environments, we called it Critical Random Early Detection Method (CRED).

2 Our Critical Red Method

In this section, we introduce our CRED method. We first describe where the congestion may happen in a 3GPP-cell network environment in Sect. 2.1. Then we will illustrate how to implement the method in Sect. 2.2.

2.1 Congestion Point Due to Massive MTC Devices

One big challenge is that a 3GPP-cellular network needs to process the bursty situation when there is a large number of data packets arriving at the same. It may cause congestion in Radio Access Network (RAN) and the Evolved Packet Core (EPC) [5] as shown in Fig. 1 and [6, 7].

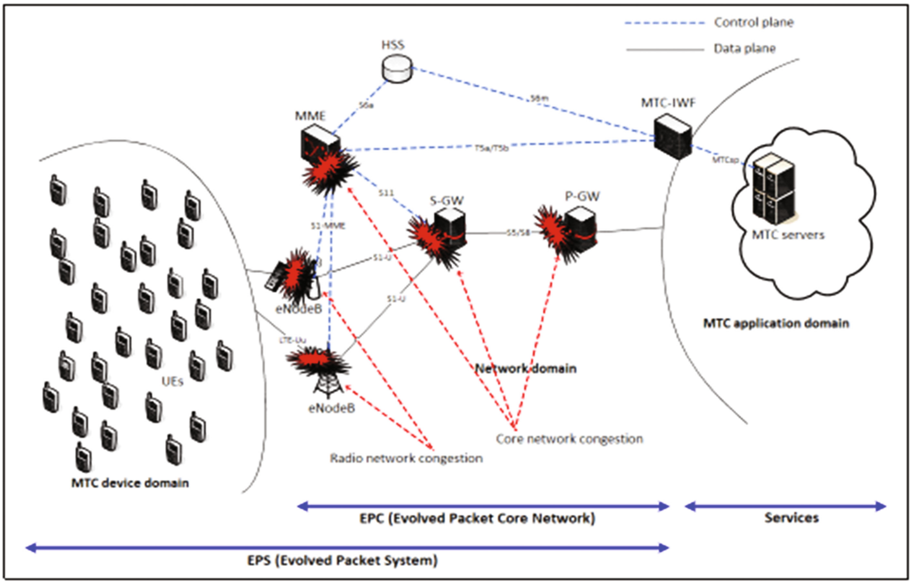

Fig. 1. Congestion in Radio Access Network (RAN) and the Evolved Packet Core (EPC)

2.2 Critical Random Early Detection (CRED) Method

MTC devices at the fixed position periodically send data to eNB and P-GW. In order to avoid congestion, the packet arrival rate should be less than the service rate of eNB and P-GW. CRED drops packets before the queue is full, according to the data urgent and real-time priority. It reduces queue delay and increases utilization. CRED also uses average queue length to predict impending network congestion and randomly discard packets. CRED calculates the average queue length using exponential weighted average approach, that is

$$MTCq_{avg} = (1 - w_q) \times MTCq_{avg} + w_q \times q \tag{1}$$

The following notation explains the meaning of (1) formula,

$$\begin{aligned}
&MTCq_{avg} : \text{Average Queue Length}\\
&q : \text{Current Queue Length}\\
&w_q : \text{for mMTC device emerengency data}\\
&\text{and Realtime data Weights, range is}\\
&0 < w_q < 1
\end{aligned}$$

Also, we decide to discard packets based on two thresholds $\min_{th}, \max_{th}$. If $MTCq_{avg} < \min_{th}$, all packets are allowed to enter queue and if $MTCq_{avg} > \max_{th}$, all packets are discarded. If $\min_{th} < MTCq_{avg} < \max_{th}$, packets are discarded by Eq. (2)

$$P_{real} = P_{now} \div (1 - \sum Packet \times P_{now}) \tag{2}$$

The following notation explains Eq. (2),

$$P_{now} = P_{operator} \times (MTCq_{avg} - \min_{th}) \div (\max_{th} - \min_{th})$$

$$\begin{aligned}
&\mathrm{P_{now}} : \text{Current Drop Packet Probability}\\
&\mathrm{Max_p} : \text{Operator Default Packet Probability}\\
&\mathrm{P_{real}} : \mathrm{P_{now}} \div (1 - \sum \text{Packet} \times \mathrm{P_{now}})\\
&\sum \text{Packet} : \text{After last Packet Drop,}\\
&\text{the total paket number of entering queueing}
\end{aligned}$$

3 Simulation

3.1 Simulation Settings

We implemented the CRED method by using the NS-2 simulator. In the simulation, the network topology consists of one MME, one S-GW, one eNB, 100 Mb Bandwith and 75 ms delay. We considered two scenarios with 1000 and 10000 devices, respectively. For the simulation, the huge packets come at the same time, when 1000 devices under one eNB, send packets range from 4 to 9 packets. Our simulations performance for 1000 devices is shown in Table 1.

3.2 Throughput

Table 1. Simulate 1000 devices throughput

No.	Sent packet	Lost packet	Throughput	Retry	Utilization
996	8	4	0.0016005722792832168	3	0.020007153491040208
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998	4	2	0.00053352409309440562	2	0.01333810232736014
999	9	4	0.0021340963723776225	3	0.023712181915306916
1000	6	3	0.0010670481861888112	3	0.017784136436480188

4 Conclusion

In this paper, we proposed CRED to avoid network congestion. The CRED takes network statistics, e.g., average queue length into consideration and then design algorithm to drop packets. Throught extensive NS-2 simulations, the results show that CRED can reduce network congestions.

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