CHAPTER 5

Simulation Results

In this chapter, the simulation results of the algorithms proposed in the previous chapters. We first list the simulation parameters, and then validate our algorithms (SWEB and TAC). In scenario 1, we compare the network performance between the SWEB and other metrics. In scenario 2, the effect of TAC is presented.

5.1. Parameters

The detailed parameters of IEEE 802.16 mesh network are listed in Table 5.1.

Table 5.1: Parameters for Network Environments.

Modulation	QPSK 3/4
Frame Length	8 ms
OFDM Symbols per Frame	676
OFDM Symbols for Control Subframe	16
OFDM Symbols for Data Subframe	660
OFDM Symbols per Minislot	4
Number of Data Timeslots in a Frame	165
Capacity of a Timeslot	144 bytes

Table 5.2: Parameters for Network Traffics.

	CBR	VBR	BE
Packet size (bits)	960	16384	8000
Packet Interval (ms)	15	40	Every frame (8 ms)
Bandwidth	6.4 kbps	409 kbps	1 Mbps
Delay Requirements (ms)	40	80	--
Token Rate (bps)	120k	2M	750k
Bucket Size (bits)	64	4000	2000

The traffic flows in the network are divided into three types: CBR, VBR and BE. The corresponding parameter of each type is given in Table 5.2. Throughout all the experiments, we multiplex the CBR flows. The token rate is determined according to the mean packet rate of each class. Also, in our CAC algorithm, we set the minimum usage of each class as follows: CBR 10 timeslots, VBR 40 timeslots, and BE is 75 timeslots.

5.2. Routing

Our routing metrics is designed to achieve lower delay and good bandwidth performance. It is known that shortest path can achieve small delay, and ETX [10] can achieve high bandwidth. Therefore, we compare our metric against these two routing metrics under the original WiMax mesh mode.

In the simulation experiments, we assume that the packet error rate is proportional to the distance between two stations. The radio range is set as 1.5 km, (almost 1 mile). If the distance of any two stations bigger than the radio range, the two stations are considered as no direct connection between them. We produce the topology as Figure 5.1.

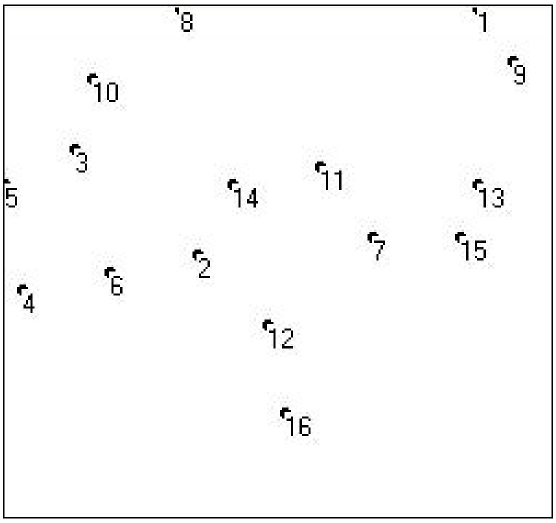

Figure 5.1: The Topology

Applying ETX and shortest path on the topology, the routing tree is in Figure 5.2. The figure on the left is ETX and shortest path is on the right of the figure.

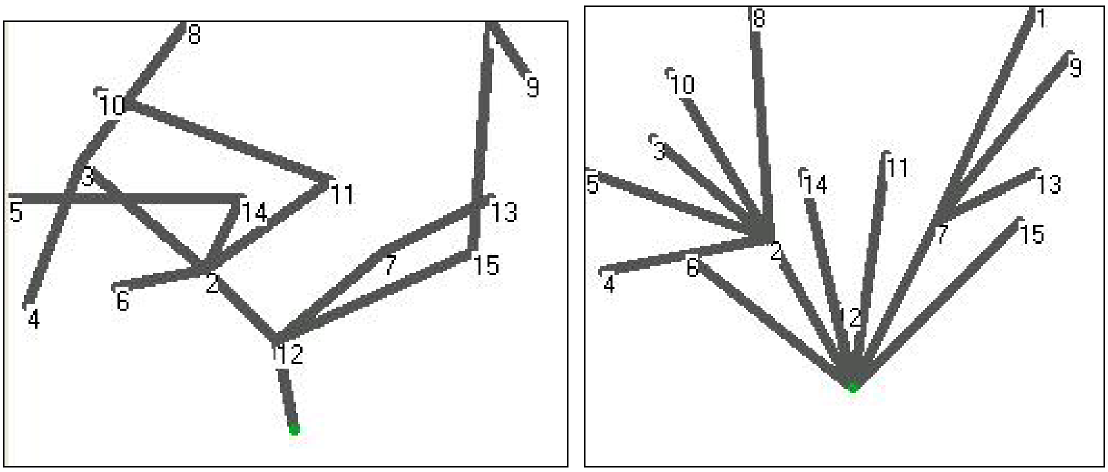

Figure 5.2: Routing Tree produced by ETX and Shortest Path

The routing tree produced by our routing metrics is in Figure 5.3.

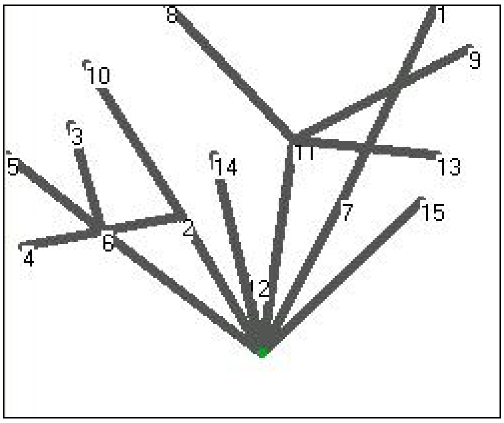

Figure 5.3: The Routing Tree produced by Our Routing Metrics

The simulations are carried out when number of flows is ranging from 5 to 25 on each routing tree. Since we primarily focus on the VBR traffics, in the following context, the throughput and delay of VBR traffics of all three routing trees shall be depicted.

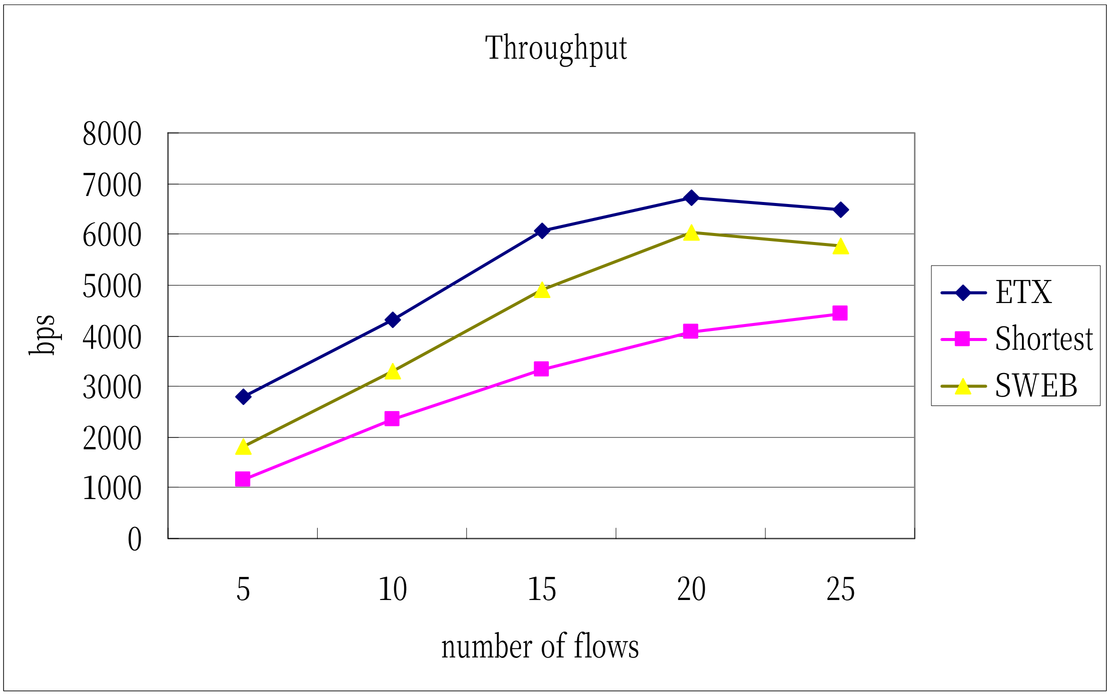

Figure 5.4: The Throughput of VBR Flows

The Figure 5.4 shows the throughput, and Figure 5.5 shows the delay of each network scenarios.

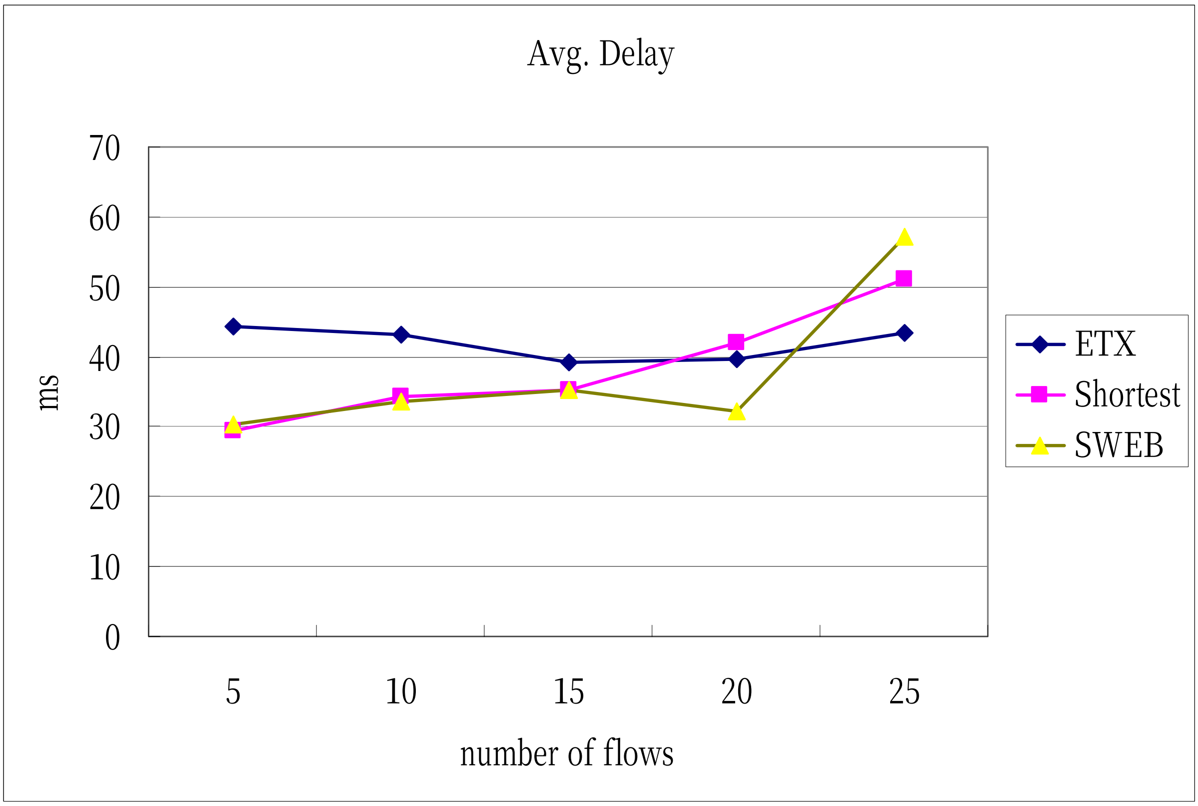

Figure 5.5: Delay of VBR flows

As what is shown in Figure 5.4 and Figure 5.5. When number of flows is reaching 25, the low-priority flows will be preempted, causing delay time arises non-linearly. Also, as we shall see in Figure 5.6, the new-coming BE traffics will have bigger chance to be rejected.

By the simulation results, we claim that our routing metrics outperforms ETX when the delay is being concerned, and our routing metrics also outperforms shortest path when the throughput is being concerned. Generally speaking, our routing metrics is a compromise between delay and throughput. In other words, this routing metrics is designed to have small delay and good throughput performance.

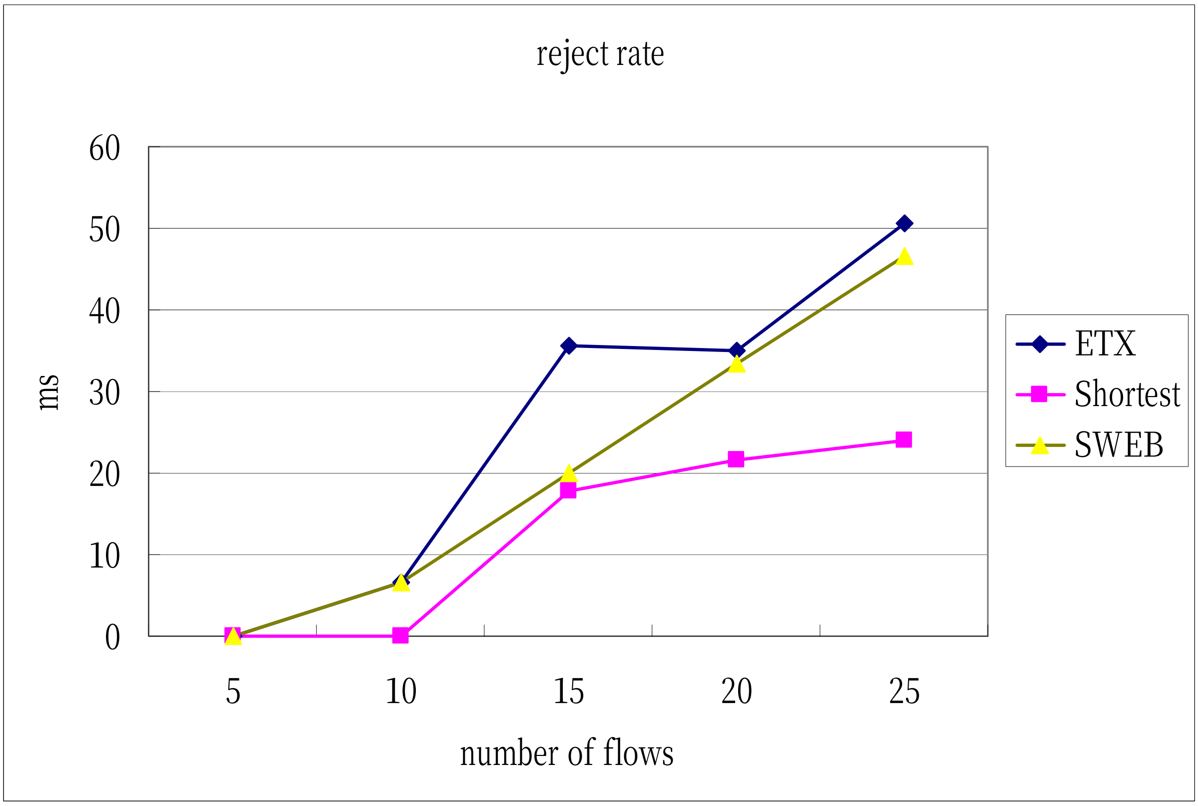

Figure 5.6: Reject Rate

5.3. Call Admission Control Algorithm

We apply the proposed TAC algorithm on the routing tree by our routing metrics. The statistics and figures are compared between the original IEEE 802.16 mesh mode and the TAC algorithm is added. First, we compare the throughput of the both scenarios. The throughput of the original IEEE 802.16 mesh mode is in Figure 5.7. From the figure, when number of flow increases, the BE flows are preempted, causing the starvation. Also, when number of flow is 20, the VBR flows are preempted by the CBR flows as well.

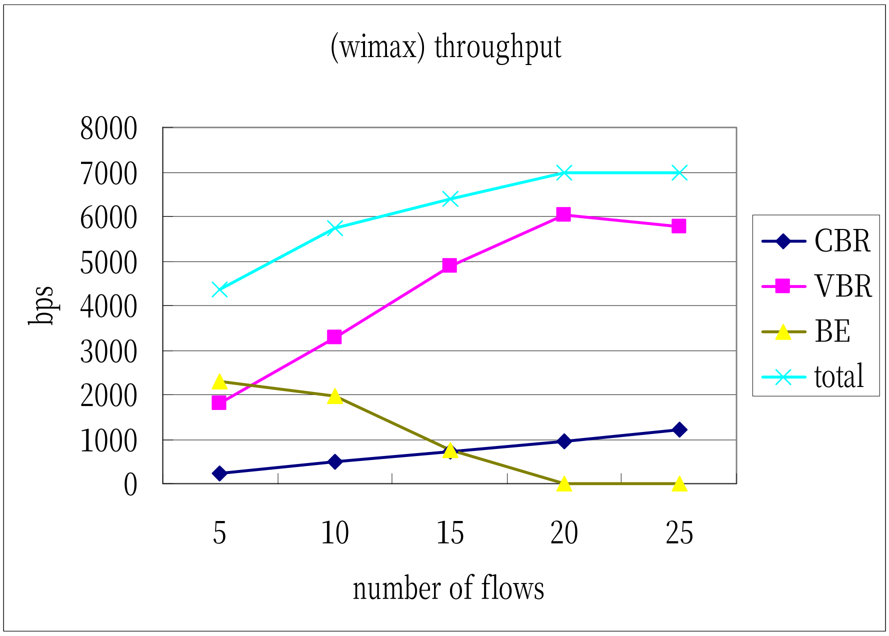

Figure 5.7: Throughput When No CAC

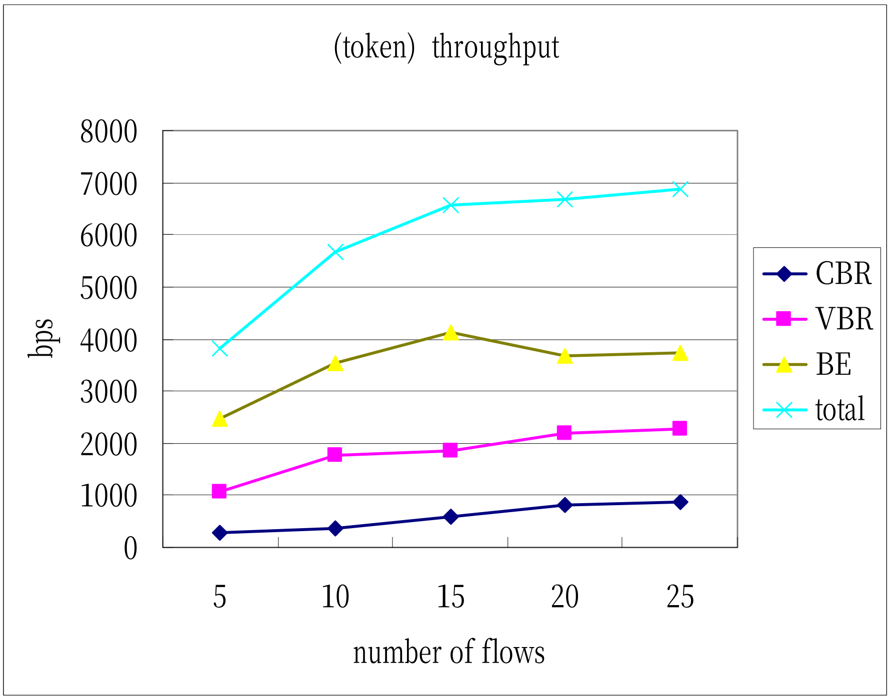

Figure 5.8: Throughput When TAC is Added

When TAC is added, each traffic type has its own minimum usage of timeslots,. Therefore, when the number of flows increases, each traffic type has its own timeslots to send data packets. As Figure 5.8 shows, all three types of traffic have their bandwidth throughput, unlike the starvation in Figure 5.7.

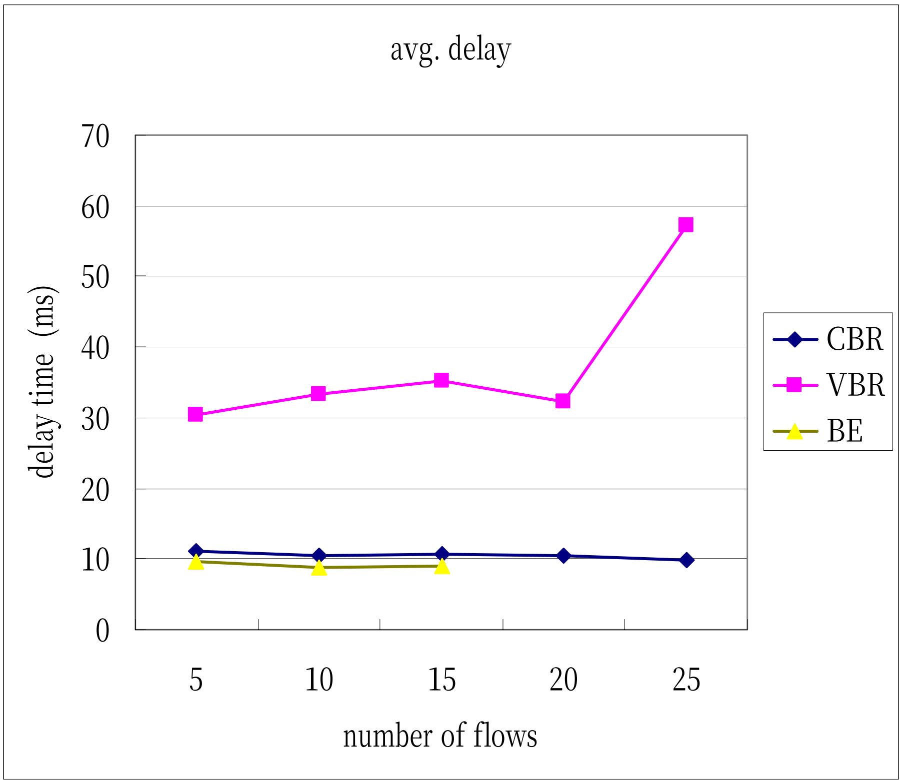

Figure 5.9: Delay When No CAC

With the simulation results on delay, the effects of TAC algorithm can be confirmed: In Figure 5.9, as BE flows is preempted, the delay is not available when the number of flows is above 15. Furthermore, when the number of flows is above 20, the VBR flows will be preempted, causing the delay time increases non-linearly. After TAC is added, as shown in Figure 5.10, the starvation happens only on VBR_downgraded and BE_downgraded flows. Therefore, not all BE traffics are being preempted.

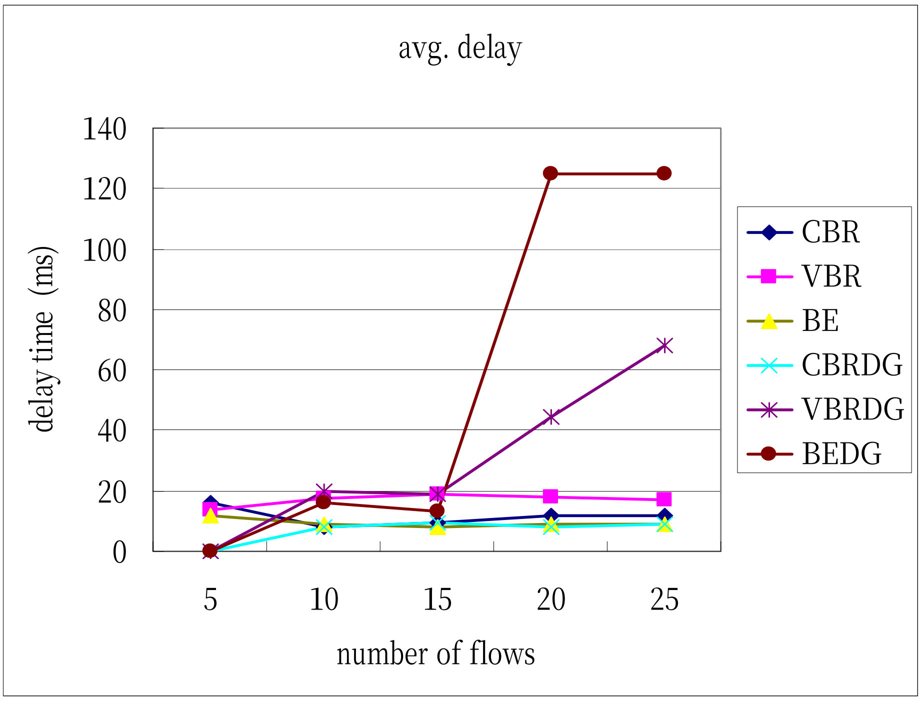

Figure 5.10: Delay When TAC is Added

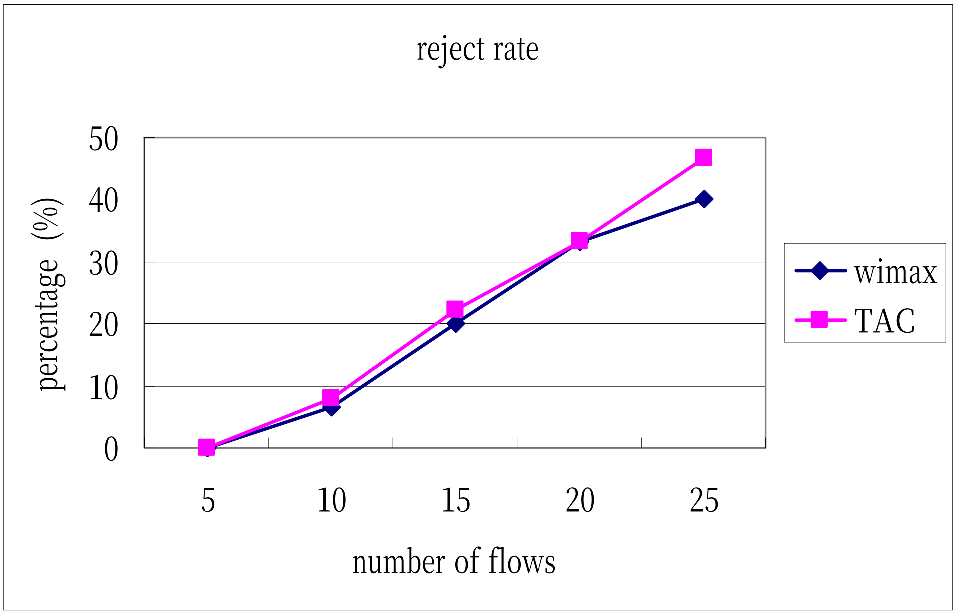

Figure 5.11: Reject Rate Comparison

Figure 5.11 shows the reject rate of the original WiMax mesh mode and the reject rate when CAC is added. The reject rate is slightly higher when the TAC is adopted.

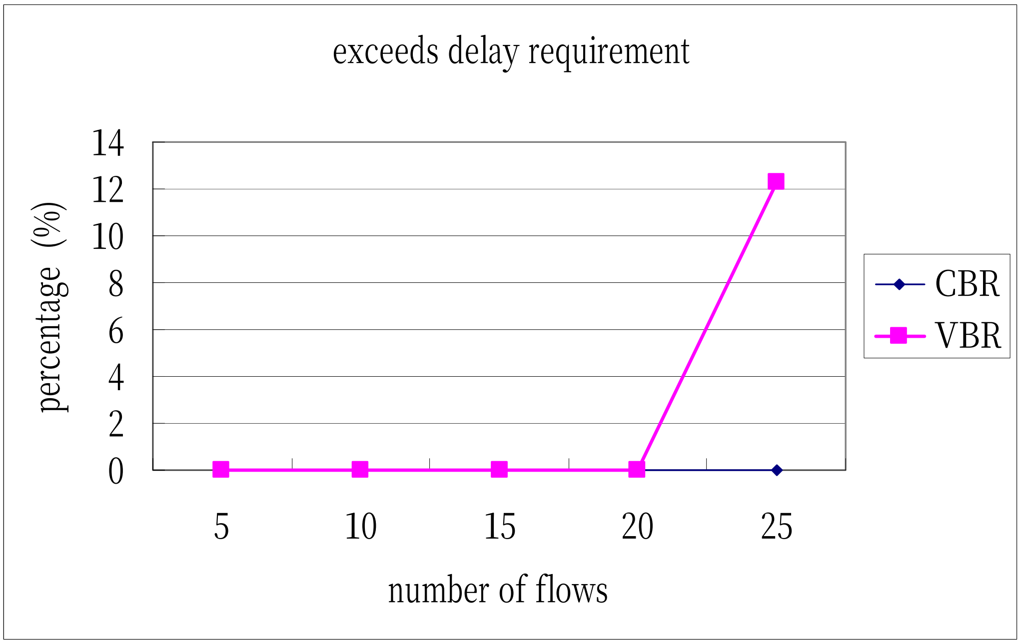

Figure 5.12: The Ratio of Exceeding the Delay Requirement in IEEE 802.16 Mesh Mode

Finally, we show the rate of the packets whose delay time is bigger than its delay requirements. As mentioned in 5.1, we set the delay requirement of CBR traffics as 40 ms, and 80 ms for VBR traffics. In the original IEEE 802.16 mesh mode, 12% of VBR packets exceed the delay requirement, as in Figure 5.12. Yet, the rate is reduced to around 7% when CAC is used, as shown in Figure 5.13. These 7% packets are considered from the VBR_downgraded flows only.

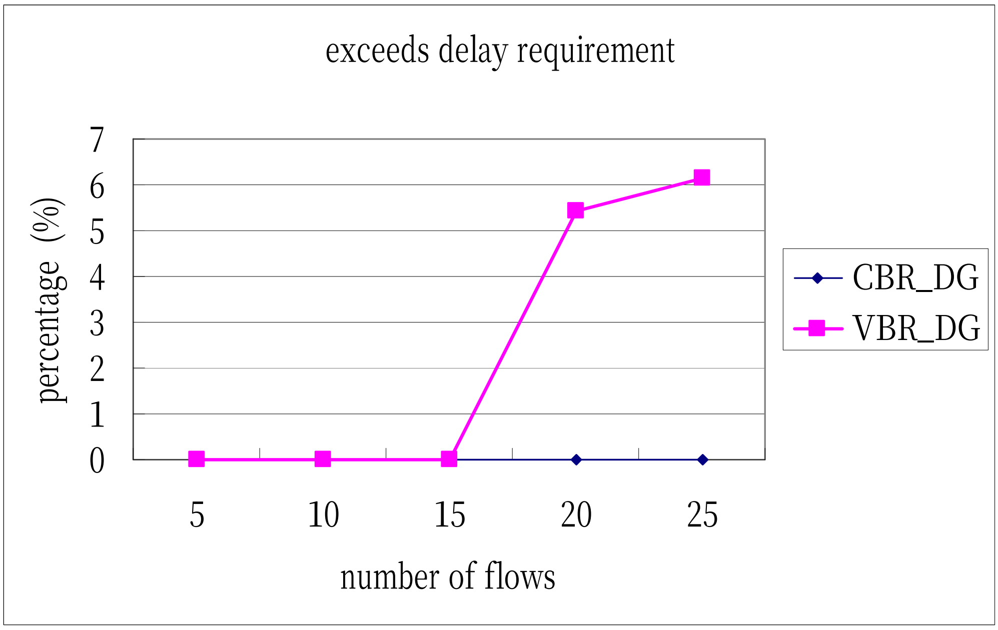

Figure 5.13: The Ratio of Exceeding the Delay Requirement When TAC is Added