9. Fairness

9.1 Overview

9.2 Fairness procedures

9.3 Terminology specific to this clause

9.4 Fairness state machine

9.5 Fairness round trip time

The fairness round trip time (FRTT) is initially calculated whenever a station finds itself to be a head of a congestion domain. It is recalculated every 10 ms, and smoothed over the last 4 results. The smoothing is performed as long as the head and the tail of the congestion domain remain the same. Whenever either the head or the tail changes, the FRTT is reset to the next calculated value.

The FRTT is calculated by means of the fairness control timing request and the fairness control timing response frames, as described in 9.5.1 and 9.5.2.

The fairness control timing request frame is processed by only the fairness instance that recognizes the source station as being the head of the congestion domain in which the receiving station is currently located, and recognizes itself as being the tail of said congestion domain. All other fairness instances will ignore the timing request frame. The fairness instance that views itself as the tail of the congestion domain for which the source station is the head, replies with a fairness control timing response frame.

Upon receipt of a fairness control timing response frame, the head of the congestion domain subtracts the received value of the *fairnessTimestamp* field from its current local timestamp. The local copy of the FRTT is then set to this difference, plus a fixed delay of *hops* * *advertisementInterval* / 2, where *hops* is the number of hops to the tail.

In order to reduce the amount of error in measurement, the response frame should be transmitted as quickly as possible after receipt of the request frame. While the processing can be done with hardware or software, the amount of time for processing should be kept to as small an amount of time as possible. The tail station may measure or estimate the amount of latency added between reception of the timing request frame and transmission of the timing response frame, and return that latency amount with the response frame.

9.5.1 Fairness control timing request frame format

Fairness control timing request frames are identified by the 2-bit *ft* field (described in 8.2.2.3) being set to FT_CONTROL and the 8-bit *controlType* field (described in 8.3.8) being set to CT_FRTT_REQ. The generation of fairness control timing request frames is mandatory for stations using the conservative congestion detection. The receipt processing of fairness control timing request frames is mandatory for all stations.

The size of a fairness control timing request frame is 36 bytes. This control frame is sent with *sc* set to CLASS_A0, *da* set to the broadcast address, *we* set the same as for fairness frames sent from this station,

controlType set to CT_FRTT_REQ, and *controlVersion* set to 0. The *controlDataUnit* field is structured as shown in Figure 9.1.

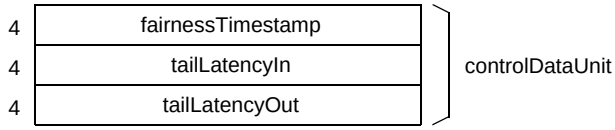

Figure 9.1—Fairness control timing request frame *controlDataUnit* format

9.5.1.1 *fairnessTimestamp*

The 32-bit *fairnessTimestamp* field contains a local timestamp generated by the source station at the time of transmitting this frame. The interpretation of this field is local only to the head station and has no meaning to any other station.

9.5.1.2 *tailLatencyIn*

The 32-bit *tailLatencyIn* field is provided for the tail station's use when reflecting the frame as a response frame. The head station shall fill this field with a value of all zeros.

9.5.1.3 *tailLatencyOut*

The 32-bit *tailLatencyOut* field is provided for the tail station's use when reflecting the frame as a response frame. The head station shall fill this field with a value of all zeros.

9.5.2 Fairness control timing response frame format

Fairness control timing response frames are identified by the 2-bit *ft* field (described in 8.2.2.3) being set to FT_CONTROL and the 8-bit *controlType* field (described in 8.3.8) being set to CT_FRTT_RSP. The generation of fairness control timing response frames is mandatory.

The size of a fairness control timing response frame is 36 bytes. This control frame is sent with *sc* set to CLASS_C, *da* set to the MAC address of the source station of the last received fairness control timing request frame, *we* set the same as for fairness frames sent from this station, *controlType* set to CT_FRTT_RSP, and *controlVersion* set to 0. The *controlDataUnit* field is structured as shown in Figure 9.2.

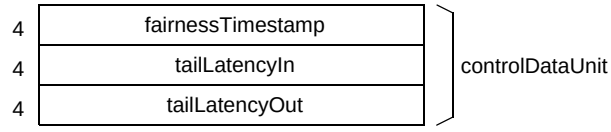

Figure 9.2—Fairness control timing response frame *controlDataUnit* format

9.5.2.1 *fairnessTimestamp*

The 32-bit *fairnessTimestamp* field contains the timestamp in the *fairnessTimestamp* field of the last received fairness control timing request frame. This field is not interpreted by the tail station, and has meaning only to the head station.

9.5.2.2 *tailLatencyIn*

The 32-bit *tailLatencyIn* field is provided to allow a receiving tail station to mark the time at which it received the fairness control timing request frame for which this is a response, in order to improve the estimate of the amount of latency incurred in processing the frame at the tail station. If the tail station has the ability to place a timestamp in the frame at the time of receipt, then this field will contain a timestamp expressed in microseconds from an epoch local to the tail station. If the tail station is unable to place a timestamp in the frame on receipt, then it shall fill this field with a value of all zeros.

9.5.2.3 *tailLatencyOut*

The 32-bit *tailLatencyOut* field is provided to allow a transmitting tail station to mark the time at which it transmitted the fairness control timing request frame, in order to improve the estimate of the amount of latency incurred in processing the frame at the tail station. If the tail station placed a non-zero timestamp in the *tailLatencyIn* field at the time of receipt, then this field will contain a timestamp at the time of transmission, expressed in microseconds from an epoch local to the tail station. If the tail station placed a value of zero in the *tailLatencyIn* field at the time of receipt, then this field will contain an estimate of the total latency incurred by this frame at the tail station, expressed in microseconds. If the tail station is unable to estimate or measure the latency incurred, it shall fill this field with a value of all zeros.

NOTE—While the latency is best kept as close to 0 as possible, and the measurement or estimate of the latency is best kept as accurate as possible, estimations that overestimate the latency yield better fairness response than estimations that underestimate the latency.

9.5.3 Fairness control timing response frame processing

Upon receipt of a fairness control timing response frame, the head station calculates the FRTT for this last measurement as given in Equation 9.1:

$$lastRcvdFRTT = (currentTimestamp - fairnessTimestamp) - (tailLatencyOut - tailLatencyIn) \quad (9.1)$$

The FRTT used by the head station is smoothed by each received fairness control timing response frame using the smoothing algorithm given in Equation 9.2:

$$FRTT = (FRTT * (ageCoef - 1) / ageCoef) + (lastRcvdFRTT / ageCoef) \quad (9.2)$$