White Paper

PacketWave® Configuration Note:

Configuring CBR Service Flows for T1/E1 Circuit Traffic over IP

1. Introduction

TDM over IP (TDMoIP) is becoming an increasingly popular solution for transporting traditional circuit traffic (such as T1 or E1) over widely deployed IP-based networks. Aperto Networks PacketWave® (PW) system provides support for such applications via the Constant-Bit-Rate (CBR) class of service, as part of the ServiceQ® Technology suite. It is well known that voice quality in TDMoIP and/or VoIP packet networks is very sensitive to packet loss, packet latency and delay jitter. Thus, the CBR service class was created with the following set of features that help minimize packet loss, latency and jitter to maintain excellent voice quality:

- CBR flows are buffered separately from each other and from flows in the CIR and BE classes. In contrast, the majority of other products mix up voice and data in the same buffer, so that voice packets get queued up behind data.
- CBR service flows are given strictly higher priority versus CIR and BE service flows, which implies that the system serves CIR and BE packets only after it has finished transmitting all the outstanding CBR packets.
- In the upstream, the system uses an optimized mechanism for CBR, known as Unsolicited Grant Service. This mechanism bypasses the normal request-grant process for upstream traffic by having the BSU assign automatic grants (data transmission slots) to a CBR flow at fixed (configurable) time intervals.

This document is provided as a basic reference for configuring CBR service flows especially for TDMoIP deployments. For more details on the ServiceQ technology characteristics and QoS-related configuration parameters (including VoIP configuration) we refer the reader to *Aperto Networks ServiceQ White Paper*.

Aperto Networks has tested and verified interoperability of the PacketWave system with the IPmux product family by RAD Data Communications. IPmux systems implement TDMoIP technology to carry TDM transport over IP. In this document, whenever we refer to parameters related to the TDMoIP units we will use those configured in the IPmux products.

2. Configuration procedure

The general procedure for configuring CBR parameters for T1 or E1 over IP can be summarized in the following steps:

- Verify your TDMoIP parameters (Ethernet frame size and frame rate)
- Determine your CBR service flow parameters and create the SU configuration files.
- Reserve sufficient amount of bandwidth for the CBR class of service in your BSU configuration file.

In this section we describe in more detail these three items and provide some hints on how to optimally select the CBR configuration parameters as well as the E1/T1 over IP parameters. We assume that the user is familiar with the WaveCenter® Configuration Manager (CM) tool and possesses some basic knowledge on how to configure and handle service flows.

a) TDMoIP parameters

The TDMoIP unit (IPmux in our case) transmits fixed size packets at set intervals. The **Ethernet frame size** sent by the TDMoIP unit and the **Ethernet frame rate** (frames per second) must be known to the user in order to properly configure CBR parameters.
The Ethernet frame sent by the TDMoIP unit is a UDP datagram that transfers E1/T1 payload bytes over IP over Ethernet. Typically, the overhead is 46 bytes per Ethernet frame as shown in the figure below:

Ethernet Header	IP Header	UDP Header	Payload	CRC
14 Bytes	20 Bytes	8 Bytes	n x 48 Bytes	4 Bytes

IPmux units allow the user to configure the UDP Payload (also known as TDM bytes/frame). In fact, most IPmux units allow the TDM bytes/frame to be equal to *(n x 48)*, where n is any integer between n=1 and n=8. Encapsulating TDM frames into Ethernet packets introduces a variable amount of overhead (it depends on the TDM bytes payload), which increases the bandwidth usage. Clearly, higher values of n will result in lower overhead.

The second TDMoIP parameter needed is the Ethernet frame rate, which is usually provided in the TDMoIP unit configuration guide. The IPmux user manuals include tables with the frame rate (packets per second) associated with each TDM bytes/frame choice for unframed E1 and T1 channels. For framed E1/T1 channels, the manual provides the mathematical formulas for calculating the corresponding frame rate (which depends on the number of reserved time slots).

Before proceeding to the CBR service flow configuration, make sure that you know the Ethernet frame size and the frames/second sent by each TDMoIP unit in the wireless sector.

b) CBR service flow parameters

As explained in the introduction, CBR uses the unsolicited grant service mechanism to assign data grants to upstream flows at fixed time intervals. This is a key feature of the CBR service because it helps reduce latency and maintain low packet delay variation (jitter). In this section we describe how to determine the appropriate parameters of the CBR service flow, based on the Ethernet frame size and frame rate of the TDMoIP traffic.

In the "Service Flow" Tab of the SU Configuration Manager the user has to create a new flow and set the class of service to CBR. No change is required in the "Downstream" Tab settings as the system infers the CBR data rate from the Upstream parameters. In the "Upstream" Tab, the following three parameters in the CBR section have to be set according to the TDMoIP parameters: **Nominal grant interval**, **Unsolicited grant size** and **Grants per interval**. The corresponding fields are shown in the figure below (highlighted in yellow).

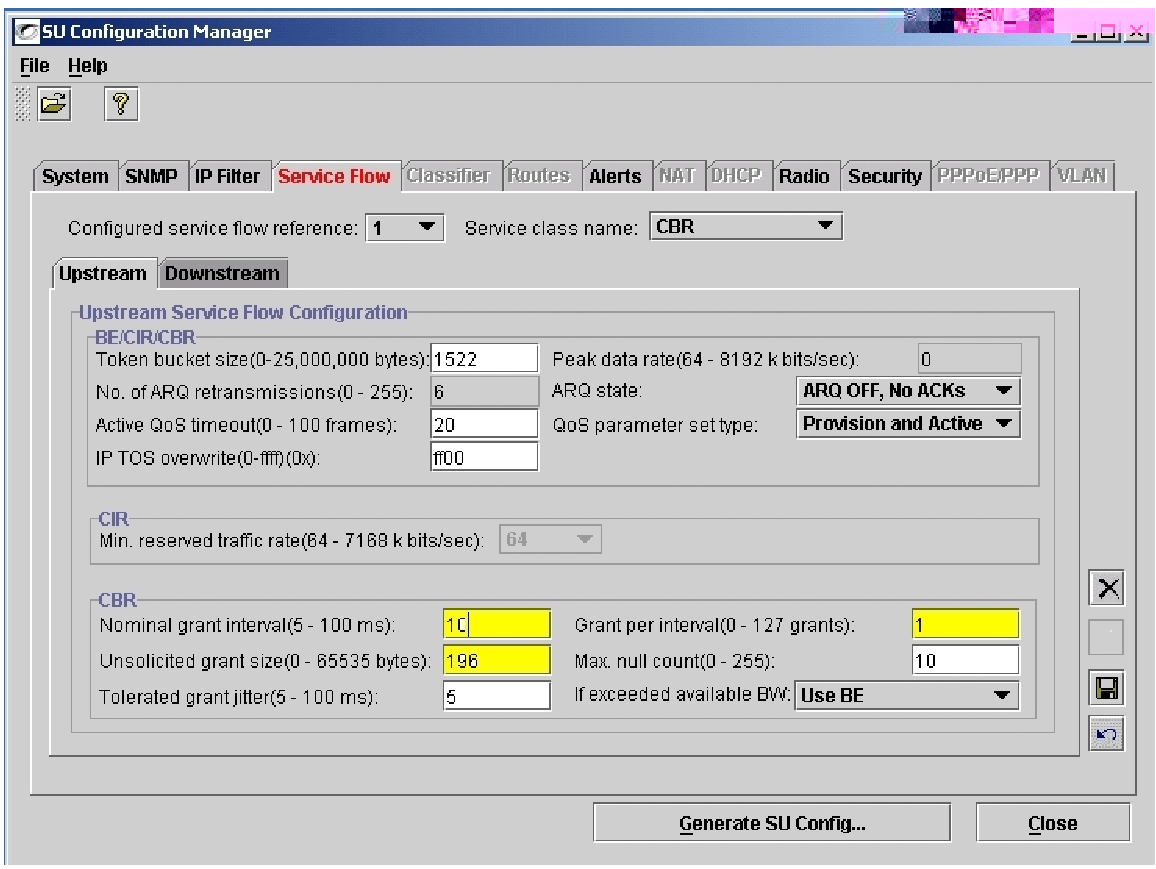

Figure 1: SU Configuration Manager - Upstream CBR Service Flow Parameters

Next we explain the significance of these parameters and describe how to properly configure them:

Nominal Grant Interval (5 – 100ms): This parameter specifies the time interval at which the scheduler will allocate transmission slots for the service flow and it must be a multiple of 5ms. In most cases it should be set equal to the TDD frame size (which defaults to 5ms) so that latency is kept low. In some cases however, the Ethernet frame rate may be very low such that the inter-packet gap is larger than 5ms. This might be the case for example if a fractional T1/E1 is being used with very few timeslots reserved. In such a case, it is recommended that the Grant Interval be set to higher values (for example 10ms for inter-packet gap between 5 and 10ms) so that bandwidth is conserved.

Grants per Interval (0 – 127): This is the number of data grants per interval allocated by the scheduler. In the case of TDMoIP it should be equal to the number of Ethernet frames per interval generated by the TDMoIP unit. For example if the Grant Interval is 5ms and the Ethernet frame rate is 400 frames/sec, Grants per Interval = 2. In general, the following formula can be used to calculate this parameter:

$$\textbf{Grants per Interval} = \lceil (\textbf{frames/sec}) \times (\textbf{Grant interval}) \rceil$$

Note that the Grants per Interval parameter has to be an integer therefore we use a *ceiling* function to round up any decimal values returned by the formula. Alternatively, the user may want to adjust the frames/sec (by carefully selecting the TDM bytes/frame setting on the IPmux) so that the overhead introduced by rounding up the Grants per Interval is minimal. This will become more clear in our example at the end of the paper.

Unsolicited Grant Size (0 – 65535 bytes): This parameter represents the size of each data grant allocated by the scheduler. It should be set equal to the Ethernet frame size of the TDMoIP unit. <u>It is very important that the value includes the payload (TDM bytes/frame), the UDP and IP headers and the Layer 2 Headers (Ethernet Header and CRC)</u> (typically 46 bytes of overhead as explained in (a).

c) Bandwidth calculations

The third and final step is to calculate the bandwidth “consumed” by a CBR service flow and estimate the percentage of the total capacity that needs to be reserved for CBR (assuming we know the exact number of CBR flows in the sector and their associated parameters). The actual bandwidth that a CBR flow occupies is always larger than the “net” bit rate, due to overhead. For example, consider an unframed T1 channel which has a “net” bit rate of 1.544

Mbps. The Ethernet throughput rate (generated by the IPmux) can range between 1.76 Mbps and 3.08 Mbps, depending on the TDM bytes/frame configuration. Moreover, the effective bit rate of the CBR service flow may also be larger than the actual Ethernet throughput in the case we have to round up the Grants per Interval (as explained in item (b) earlier). These observations are particularly important for configuring the QoS link parameters in the BSU.

The data rate of a CBR service flow (also referred to as "bandwidth" in the remaining of the document) can be calculated as follows:

$$\textbf{BW (kbps)} = \frac{\textbf{Unsolicited Grant Size(bits)} \times \textbf{Grants per Interval}}{\textbf{Grant interval (ms)}}$$

Once we have configured all the CBR service flows and we know their effective bandwidth, we need to allocate a percentage of the sector bandwidth to the CBR class of service. This is part of the BSU Configuration procedure as shown in the following snapshot of the BSU CM (WSS -> Channel Parameters Tab):

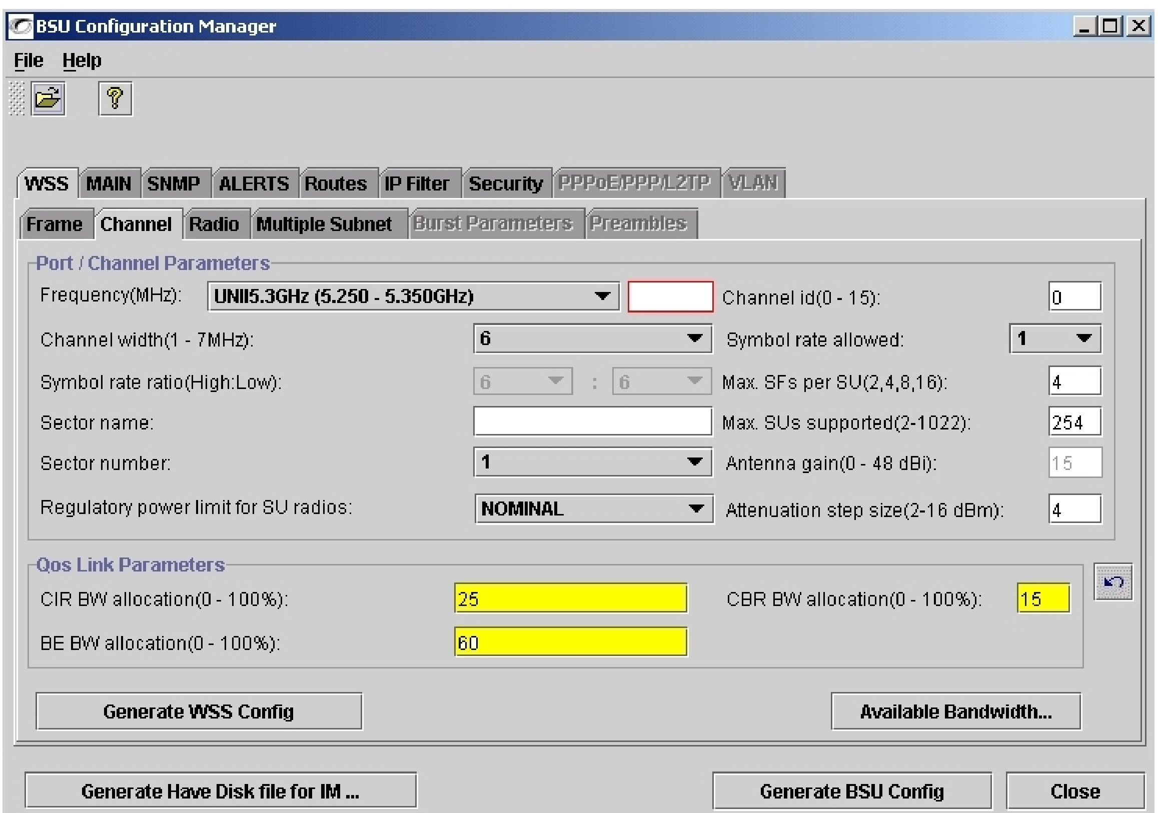

Figure 2: BSU Configuration Manager - QoS Link Parameters

In the QoS Link Parameters section of this Tab, the % of CBR, CIR and BE bandwidth must be specified. The % applies to the total available bandwidth (net throughput), which can be checked by clicking on the “Available Bandwidth” button. In cells where CBR traffic represents a significant portion of the total traffic it is recommended that the DS/US allocation is 50/50, to account for the symmetrical CBR traffic.

As a final remark, note that CBR flows are subject to admission control. For example, when a CBR flow tries to send traffic, the PacketWave system determines if there is enough available CBR bandwidth to accommodate this flow. If so, the service flow is admitted and awarded a bandwidth reservation, and the total available CBR bandwidth is decreased by the amount of the reservation. If there is not enough available CBR bandwidth, then the service flow is denied admission and will either be dropped or placed in Best Effort Service (depending on the selection in the “If exceeded available BW” field of the CBR Upstream Service Flow Parameters – see Figure 1).

Admission control works seamlessly with the Adaptive Coding and Modulation scheme, such that the bandwidth guarantees continue to be met even when the modulation or coding for the link changes. For example, a 1 Mbps CBR flow whose SU’s link drops from 16QAM to QPSK will end up taking up 2 Mbps worth of the available bandwidth, and the admission control algorithm will account for this accordingly. Since this can increase the bandwidth being used, providers should take this possibility into account when allocating their available bandwidth to the different classes of service.

3. Configuration Example

In this example we want to configure a CBR service flow to be used for transporting a full (unframed) E1 stream.

We assume that the "TDM bytes per frame" parameter of the TDMoIP unit has been configured to 336 bytes/frame.

Step (a): Note down the necessary information related to the E1 to IP encapsulation. The checklist that follows summarizes what we need to know in order to proceed with the CBR service flow configuration:

- TDM bytes/frame = 336
- Frame Length (bytes) = 336 + 46 = 382
- Ethernet frames/second = 778 *(for Unframed E1 per IPMux manual)*
- PacketWave TDD Frame Size (ms) = 5

Step (b): Based on this information we can select the Upstream CBR parameters of the corresponding service flow as follows:

- Unsolicited Grant Size (bytes)= 382 *(equal to the Ethernet Frame Length)*
- Grant Interval (ms) = 5 *(equal to the TDD frame size to reduce latency)*
- Grants per Interval = 4

Grants per Interval (GPI) is the number of Ethernet frames per 5ms interval. It is calculated as follows:

$$\textbf{Grants per Interval} = \lceil (778 \textbf{ frames/sec}) \times (5 \textbf{ ms}) \rceil = \lceil 3.89 \rceil = 4$$

Since the system can only accept an integer value, it has to be rounded up to 4.

[Note that in this example we do not introduce a lot of overhead by rounding up 3.89 to 4 GPI. If that is not the case however (e.g. if the resulting number is 3.5 rounded up to 4) it may be a good idea to experiment with different values of Ethernet frame size (and frame rate) to minimize the introduced overhead].

Step (c): The bandwidth required by this CBR service flow can now be calculated as follows:

BW (kbps) =(UGS(bits) x GPI) / GI(ms) = [(382 x 8) x 4] / 5 = 2445 kbps

CBR flows are by default symmetrical therefore we will need to allocate 2445 kbps in each traffic direction (downstream and upstream).

In our example, assuming that a 50/50 DS/US allocation was selected and that the available bandwidth is 6500 kbps in each direction, a 40% CBR allocation would be sufficient for the CBR service flow configured.

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