



# **AT&T IP Flexible Reach Service and AT&T IP Toll-Free on AT&T VPN Service**

## **Customer Edge Router (CER) Customer Configuration Guide for AT&T IP Flexible Reach Service and AT&T IP Toll-Free on AT&T VPN Service as the Underlying Transport Service**

### **Cisco ISR G1, 7200 and 7300 Platforms**

**November 25, 2015**

**Version 2.6**

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# 1 Introduction

This Customer Configuration Guide (“CCG”) provides recommended guidelines for configuring the Customer-managed Customer Edge Router (CER) for use with AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free, on AT&T VPN Service (“AT&T VPN”) as the Underlying Transport Service. CERs can be utilized for either one of those services or for both services simultaneously. Please ensure your system set-up is consistent with the recommended specifications provided in this document. AT&T reserves the right to modify or update its guidelines at any time without notice so please check the following link to be sure you have the latest version of this document (<http://www.corp.att.com/bvoip/avpn/implementation/> (login: att, password: attvoip)). You may also wish to consult with your AT&T technical sales representative.

## 1.1 Overview

AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free over AT&T VPN as the underlying transport, are AT&T Business Voice over IP (BVoIP) services. AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free on AT&T VPN support network based Class of Service (CoS) which will work in conjunction with edge router configurations to provide the Quality of Service (QoS) that voice traffic requires. Four classes or six classes are available, including a Real Time class that will strictly prioritize voice packets over other data packets. Prioritizing voice packets helps to assure low latency for voice to meet delay budget constraints.

This document should be used solely as a general configuration guideline. The Customer is solely responsible for determining the appropriate configuration of their specific environment; AT&T provides resources to assist with that configuration, please contact your AT&T technical support for assistance if needed.

Configuration examples in this guide are provided for informational purposes only. The example configurations may be mapped to a variety of vendor implementations, check with your AT&T technical support manager if you have any questions.

Note:

The configuration examples provided in this document are based upon Cisco IOS features, however, the features are NOT described in their entirety; and may vary across hardware platforms and versions of IOS. Please refer to the appropriate Cisco documentation relative to your IOS features.

The following are the access types that are supported and will be covered in this document.

Access Type	Speed (bit/s)	Fragmentation	CRTP
Standard T1/E1 Frame Relay with MLPPP encapsulation.	56K to 768K	yes	optional
Standard T1/E1 Frame Relay	1024K to 2M	no	no
T1/E1 PPP access	1024K to 2M	no	no
T1 ATM	1536K	no	no
DSL	1000K, 1500K	no	no

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Access Type	Speed (bit/s)	Fragmentation	CRTP
NXT1/E1 MLPPP access	N = 2 to 8 T1/E1s	no	no
NXT1 IMA	N = 2 to 8 T1s	no	no
Standard T3/E3 Frame Relay	5M to 45M	no	no
T3/E3 PPP Access	5M to 45M	no	no
T3/E3 Frame Relay encapsulation.	5M to 45M	no	no
T3/E3 ATM	5M to 45M	no	no
OC3 PPP access	50M, 75M, 100M, 155M	no	no
OC3 Frame Relay encapsulation	50M, 75M, 100M, 155M	no	no
OC12 PPP access	200M, 300M, 400M, 600M	no	no
OC12 Frame Relay encapsulation	200M, 300M, 400M, 600M	no	no

Ethernet Access types

Access Type	Speed (bit/s)	Fragmentation
10 Base-T	Access Link, VPN port and VLAN speeds (in Mbits): .5, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10	no
100 Base-T or FX	Access Link, VPN port and VLAN speeds (in Mbits): .5, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100	no
1000 Base LX or SX	Access Link, VPN port and VLAN speeds (in Mbits): .5, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, 400, 400, 450, 500, 600, 700, 800, 900, 1000)	no

CRTP significantly reduces the protocol overhead required for a VoIP call. CRTP is available with MLPPP on low speed Frame Relay (768K and less). With MLPPP encapsulation, large data packets can be fragmented to mitigate delay of voice packets on low speed (<= 768kbps) ports.

Cisco ISR and 7200 configurations in this guide were tested with Cisco IOS 12.4.(15)T13. The 7300 platform was tested with Cisco IOS 12.2(33)SB9.

The following list shows which access types are supported on each platform:

**ISR:**

- 1841
  - DSL
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n\*T1/E1 (up to 4 T1/E1 MLPPP)
- 2811 :
  - DSL
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n\*T1/E1 (up to 4XT1 IMA, up to 8 T1/E1 MLPPP)
- 2821:
  - DSL
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n\*T1/E1 (up to 4XT1 IMA, up to 8 T1/E1 MLPPP)
- 3825:
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n\*T1/E1 (up to 4XT1 IMA, up to 8 T1/E1 MLPPP)
  - Subrate T3/E3
- 3845:
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n\*T1/E1 (up to 4XT1 IMA, up to 8 T1/E1 MLPPP)
  - Subrate T3/E3, T3/E3
- **Non ISR:**
  - 720xVXR (NPE-G2):
    - Ethernet VLAN / Subrate

- n\*T1/E1 (6-8 NXT1 IMA, 2-8 T1/E1 MLPPP)
- Subrate T3/E3, T3/E3
- OC3
  
- 7300 (See appendix for configurations)
  - Ethernet up to full Gig
  - Subrate T3/E3, T3/E3
  - OC3
  - OC12

## 1.2 **Network Topology**

This section describes the generic AT&T supported topologies for a TDM Gateway and various vendor IP-PBX's.

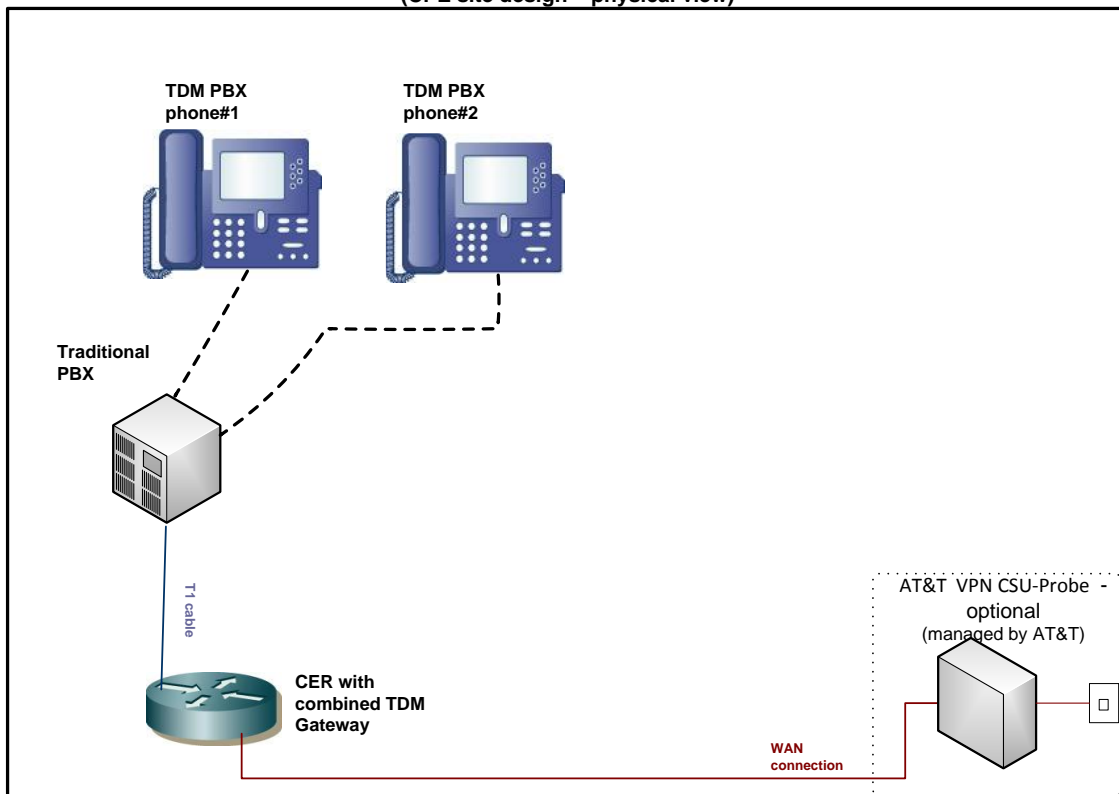
- Please refer to the following document for details on configuring vendor specific AT&T supported topologies and related configuration information for IP-PBX's:  
[Customer Edge Router Customer Configuration Guide for AT&T Certified IP-PBX Solutions.](http://www.corp.att.com/bvoip/avpn/implementation/) (<http://www.corp.att.com/bvoip/avpn/implementation/> login: att, password: attvoip)
  
- Please refer to the following document for details on configuring a TDM Gateway: [TDM PBX Customer Configuration Guide](http://www.corp.att.com/bvoip/avpn/implementation/), specific to your router platform.  
(<http://www.corp.att.com/bvoip/avpn/implementation/> login: att, password: attvoip)

### 1.2.1 CER combined with TDM Gateway

Following is a sample diagram of a network topology for a site with a CER combined with a TDM gateway . The AT&T VPN CSU-Probe is an AT&T managed device. All other equipment is managed by the customer.

- The AT&T VPN CSU-Probe is optional.

AT&T IP Flexible Reach Service or AT&T IP Toll-Free on AT&T VPN site  
with VPN CSU-Probe, CER with combined TDM Gateway Router  
(CPE site design – physical view)



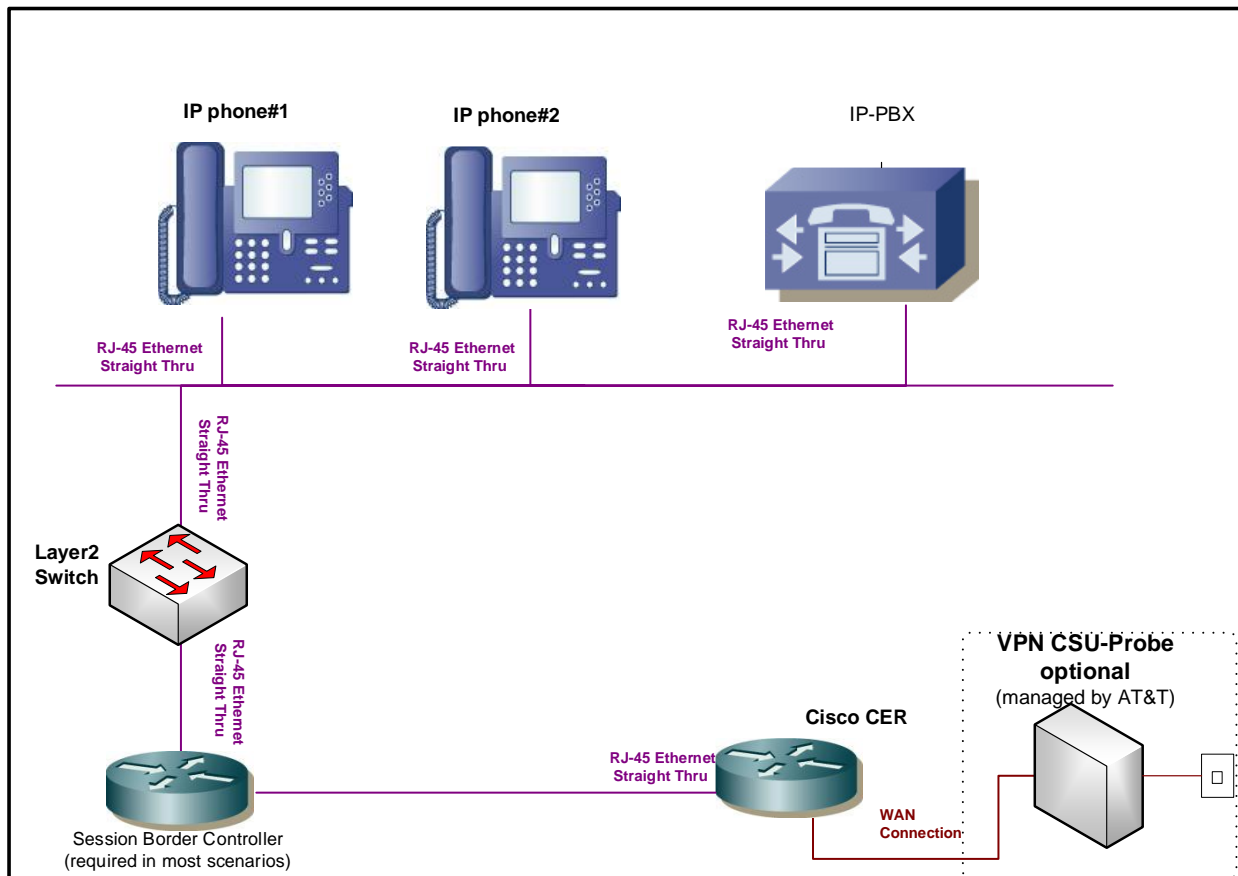


### 1.2.2 AT&T Certified IP-PBX's

Following is a sample diagram of a network topology for a site with an AT&T Certified IP-PBX. In this design, the Customer Edge Router (CER) and Session Border Controller (SBC) are two separate devices. The AT&T VPN CSU-Probe is an AT&T managed device. All other equipment is managed by the Customer.

- The AT&T VPN CSU-Probe is optional.

**AT&T IP Flexible Reach Service or AT&T IP Toll-Free on AT&T VPN site  
with AT&T VPN CSU-Probe, Generic IP-PBX and optional SBC  
(CPE site design – physical view)**



### 1.3 **Special Considerations**

- The following TCP/IP ports must not be blocked by firewall or access lists:
  - AT&T IP Border Element signaling and media addresses.
  - SIP signaling traffic (UDP port 5060).
  - RTP/RTCP traffic (UDP port range 16384-32767).
- The configuration information in this CCG assumes a single primary CER. Any alternate routing configurations or remote branch connectivity to other sites, within the same or other AT&T VPN, requires proper configuration of the signaling and media paths. Routing configurations in all customer routers need to be set up to assure that the routing in the primary CER is not affected.
- Class of Service (CoS) specific considerations:
  - CoS1 should not be more than 70% for ATM, DSL or Ethernet access.
  - CoS6 is not supported on links with LFI.
- cRTP (Compressed RTP) is not supported with Avaya Communications Manager 5.1.2 or 5.2
- T3/E3 ATM access is not currently supported on ISR routers. Further testing must be completed on the NM-1A-T3/E3 cards due to a change in the QOS mechanism of this new hardware.

## 2 **Network Design**

Before implementing AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free on AT&T VPN, it is critical to understand the voice requirements at each location and to plan accordingly. Improper design can ultimately lead to poor voice performance.

The two primary network attributes that must be determined are:

- The allocated bandwidth for voice at each site.
- The delay components and requirements for acceptable voice quality.

### 2.1 **Bandwidth Allocation**

Primary factors in determining the bandwidth design for AT&T IP Flexible Reach over AT&T VPN are:

1. The number of simultaneous voice calls.
2. The per call bandwidth (Codec type + overhead).
3. Whether or not bandwidth reduction techniques are required.

Based on the above, the Class of Service (CoS) package can be selected including the calculation of the Committed Information Rate (CIR) and Real Time percentages.

### 2.1.1 Simultaneous Voice Calls

One of the most important aspects in designing a network with AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free over AT&T VPN is allocating enough bandwidth for voice calls. The required bandwidth is determined by calculating the number of concurrent voice calls that must be supported at each location, and multiplying this by the bandwidth required per call. Concurrent call requirements may be simply based on the number of users at a site, or if the busy hour traffic load is known, the number of concurrent calls can be determined using the Erlang B formula. A web-based Erlang calculator, as well as more complex design tools, may be found at <http://www.erlang.com/>. Systems can be configured to accommodate up to the number of concurrent calls contracted for under their AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free contract. If the number of concurrent calls under contract is not sufficient, please contact AT&T to increase the number of concurrent calls under contract.

### 2.1.2 Per Call Bandwidth

Once the number of concurrent calls has been determined, the per-call bandwidth requirements need to be established. Bandwidth requirements are based on the codec as well as the Layer 2 protocol used to access the network. The most popular codec in use today is G.729; it is the default in Cisco voice equipment and can provide good quality, low bandwidth voice. The following table provides the bandwidth per call over various access types

While the G.729 codec is very popular today, it has limitations that should be investigated while designing the network. Certain call flows (like conference calls, voice mail applications) may require that a G.711 codec be used. Be aware that G.711 requires much higher bandwidth although it does support better call quality. If G.711 needs to be supported on the network, these higher bandwidth requirements should be taken into account in the design phase.

#### G.729 Codec : Bandwidth per call

Access Type	RTP or CRTP	20 byte payload	30 byte payload
Standard Frame Relay	RTP	28.4 Kbit/s	21.3 Kbit/s
Standard Frame Relay with PPP or MLPPP encapsulation	CRTP	12.8 Kbit/s	10.7 Kbit/s
PPP/Frame Relay encapsulation access	RTP	25.6 Kbit/s	19.7 Kbit/s
N X T1 MLPPP access	RTP	24.8 Kbit/s	19.2 Kbit/s
IMA/ATM	RTP	28.4 Kbit/s	22 Kbit/s
Ethernet	RTP	32.76 Kbit/s	24.64 Kbit/s
DSL	RTP	28.4 Kbit/s	22 Kbit/s

**G.711 Codec: Bandwidth per call (20 byte payload is the default for this codec):**

Access Type	RTP or CRTP	BW per call
Standard Frame Relay	RTP	82 Kbit/s
Standard Frame Relay with PPP or MLPPP encapsulation	CRTP	68 Kbit/s
PPP/Frame Relay encapsulation access	RTP	81.6 Kbit/s
N X T1 MLPPP access	RTP	80.8 Kbit/s
IMA/ATM	RTP	84 Kbits/
Ethernet	RTP	91.56 Kbit/s
DSL	RTP	84 Kbit/s

Note: A bandwidth calculator is available, currently at no charge to Cisco TAC users, that provides the exact layer 2 overhead calculations for voice over IP over Frame Relay and can be found at: [http://tools.cisco.com/Support/VBC/jsp/Codec\\_Calc1.jsp](http://tools.cisco.com/Support/VBC/jsp/Codec_Calc1.jsp) This calculator takes into account overhead and also provides recommendations for potentially changing the default payload size in order to get better per call bandwidth performance.

Note: T.38 is the recommended protocol for fax as it has reduced bandwidth compared to G.711 fax. Configured properly to a baud rate of 14400 (this speed required for certain Public Switched Telephone Network (PSTN) calls), the T.38 fax call will use approximately 25Kbit/s over Frame Relay.

### 2.1.3 Bandwidth Reduction Techniques

There are several techniques for lowering the per call bandwidth requirements.

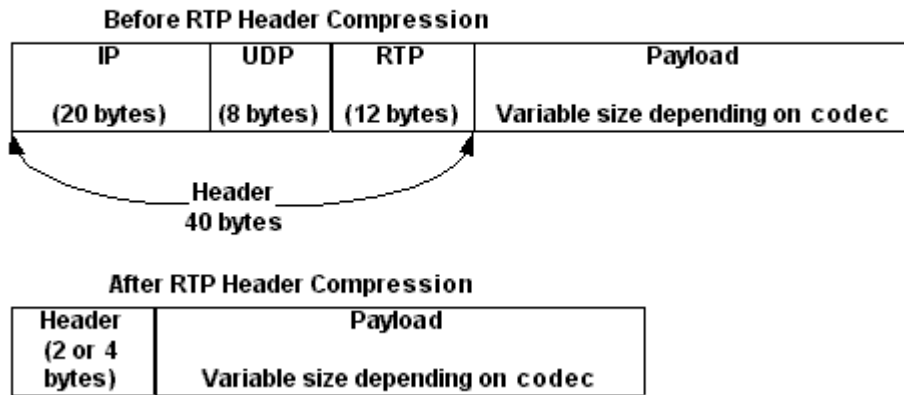
VAD or Voice Activity Detection (also known as silence suppression) may be turned on to take advantage of the fact that voice calls are “half duplex”— that is only one speaker in one direction is active at a time. Studies have shown that while theoretically VAD could reduce bandwidth consumption by 50%, a more conservative figure to use in design is 30%. Many users find that VAD can cause call impairment known as clipping — where the first word or words are cut off when a speaker starts and, therefore, they do not use VAD even though it might help with the bandwidth consumption. A “best practice”, conservative design approach would be to size the network without VAD, test calls with VAD once the network is in place and adjust the bandwidth accordingly assuming VAD works effectively.

Most VoIP codecs can be modified from the default parameters to provide more efficient utilization of bandwidth for carrying voice traffic. One popular technique is to increase the number of voice samples in each IP packet. VoIP packets tend to be quite small, with a large percentage of the usable bandwidth consumed by protocol overhead (Layer 2, IP, UDP, RTP).

Typically, G.729 encodes two 10mS voice samples in each IP packet. Each voice sample is only 10 bytes. The codec can often be modified to pack 3 or even more voice samples in each IP packet, substantially reducing the overhead:payload ratio. The downside of this approach is that it increases the encoding/decoding delay proportionately and more stringent overall design relative to latency and jitter.

A second technique for reducing per call bandwidth consumption is using Compressed Real Time-Transport Protocol or cRTP, which will compress the packet header information. CRTP is negotiated and is used between the Customer Edge Router (CER) and AT&T Provider Edge Router (PER). With cRTP, the 40 bytes of IP, UDP, and RTP headers can be compressed to 2 or 4 bytes (depending on whether CRCs are included). This represents a dramatic bandwidth savings, however, there is a trade-off as compression algorithms can significantly add to the router processor load.

### RTP Header Compression



**IMPORTANT:** Cisco based cRTP recognizes RTP protocol based upon an assumed UDP port range of 16384-32767 (even port numbers only, odd port numbers are used for RTCP which is not compressed). If using non-Cisco VoIP equipment, be sure to configure it to use RTP port ranges that will be recognized. If RTP is sent outside of this range, the RTP protocol will remain uncompressed, greatly reducing the effectiveness of cRTP.

The routers at each end of a cRTP link participate in the compression/decompression process. The routers at each side of a flow, the compressor and decompressor, share a consistent state and use a CID (Context Identifier) in the compressed header to identify the flow. CRTP runs between the CER and PER only.

## 2.1.4 Putting It Together

### 2.1.4.1 CoS4

The AT&T VPN service provides for 4 Classes of Service to be run simultaneously from a customer site to provide differentiated service levels. The four classes are:

EF- Expedient Forwarding - Class of Service 1

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- BH – Bursty High – Class of Service 2
- BL – Bursty Low – Class of Service 3
- BE – Best Effort – Class of Service 4

Once concurrent calls and bandwidth consumption per call have been determined, the network requirements should be chosen. AT&T recommends using the Real Time (RT) Class of Service for voice calls. CoS packages are sold based on percentages of the CIR purchased. Two CoS packages support RT CoS—Multimedia High and Multimedia Low. If the percentage of RT traffic is 50% or lower than the CoS Package is Multi-Media Standard and if the percentage of RT is above 50% the CoS Package is Multi-Media High. Following are the profiles available for AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free over AT&T VPN.

Profile #	Profile Name	CoS1 %	CoS2 BWR%	CoS3 BWR%	CoS4 BWR%
101	90% RT, 0/0/100 Data	90	0	0	100
102	80% RT, 80/10/10 Data	80	80	10	10
103	80% RT, 60/30/10 Data	80	60	30	10
104	80% RT, 40/30/30 Data	80	40	30	30
105	60% RT, 80/10/10 Data	60	80	10	10
106	60% RT, 60/30/10 Data	60	60	30	10
107	60% RT, 40/30/30 Data	60	40	30	30
108	50% RT, 0/0/100 Data	50	0	0	100
109	40% RT, 80/10/10 Data	40	80	10	10
110	40% RT, 60/30/10 Data	40	60	30	10
111	40% RT, 40/30/30 Data	40	40	30	30
112	20% RT, 80/10/10 Data	20	80	10	10
113	20% RT, 60/30/10 Data	20	60	30	10
114	20% RT, 40/30/30 Data	20	40	30	30
115	10% RT, 80/10/10 Data	10	80	10	10
116	10% RT, 60/30/10 Data	10	60	30	10
117	10% RT, 40/30/30 Data	10	40	30	30
160	70% RT, 80/10/10 Data	70	80	10	10
161	70% RT, 60/30/10 Data	70	60	30	10
162	70% RT, 40/30/30 Data	70	40	30	30
163	50% RT, 80/10/10 Data	50	80	10	10
164	50% RT, 60/30/10 Data	50	60	30	10
165	50% RT, 40/30/30 Data	50	40	30	30
166	45% RT, 80/10/10 Data	45	80	10	10
167	45% RT, 60/30/10 Data	45	60	30	10
168	45% RT, 40/30/30 Data	45	40	30	30
169	35% RT, 80/10/10 Data	35	80	10	10
170	35% RT, 60/30/10 Data	35	60	30	10
171	35% RT, 40/30/30 Data	35	40	30	30

Profile #	Profile Name	CoS1 %	CoS2 BWR%	CoS3 BWR%	CoS4 BWR%
172	30% RT, 80/10/10 Data	30	80	10	10
173	30% RT, 60/30/10 Data	30	60	30	10
174	30% RT, 40/30/30 Data	30	40	30	30
175	25% RT, 80/10/10 Data	25	80	10	10
176	25% RT, 60/30/10 Data	25	60	30	10
177	25% RT, 40/30/30 Data	25	40	30	30
178	15% RT, 80/10/10 Data	15	80	10	10
179	15% RT, 60/30/10 Data	15	60	30	10
180	15% RT, 40/30/30 Data	15	40	30	30
181	5% RT, 80/10/10 Data	5	80	10	10
182	5% RT, 60/30/10 Data	5	60	30	10
183	5% RT, 40/30/30 Data	5	40	30	30

The bandwidth allocated to the RT class is very important because any traffic presented to RT over the allocation will be strictly policed and dropped in order to prevent queuing and additional delay. For instance, a link is designed for 10 calls and an 11<sup>th</sup> call comes in. The 11<sup>th</sup> call will not be denied but will cause packet drops across all calls. Those packet drops can cause voice quality degradation of the existing calls. To avoid this problem, RT sizing is critical. Note: AT&T recommends also assigning SIP signaling traffic to the RT class of service.

**Note: Even if no CoS2 traffic is ordered, a minimum percentage for CoS2 must be configured of at least 1% on the Customer Edge Router (CER) router if BGP routing is used, because BGP traffic falls into CoS2.**

Note: Sizing of data requirements, possibly including video, is beyond the scope of this document.

### 2.1.4.2 CoS6

The class of service markings relative to the 6 CoS feature are as follows:

- CoS1 – Real Time Class
- CoS2V – Video Class
- CoS2 – Bursty High Data
- CoS3 – Bursty Low Data
- CoS4 – Best Effort
- CoS5 – Flexible Data Class (Scavenger Class)

These Class of Service parameters will be available by allocating Service Packages similar to the 4 CoS packages at the AT&T VPN customer site.

As with the 4 CoS , Only 2 will be applicable to the Voice Over Service:

- Multi-Media High - 6 CoS
- Multi-Media Standard – 6 CoS

The following matrix shows the comparison of old (4 CoS) and new (6 CoS) packages

Package	COS1	COS2V	COS2	COS3	COS4	COS5	NMC
MM-High 6COS	60%, 70%, 80%, 90%	5-30%, 5% increments 30-80%, 10% increments	5-30%, 5% increments 30-80%, 10% increments	5-30%, 5% increments 30-80%, 10% increments	5-30%, 5% increments 30-80%, 10% increments	0% default (5- 20%, 5% increments)	Present
MM-High 4COS	60-90%, 10% Increments	Not Present	Not Present	Not Present	100%	Not present	Not present
	60%, 70%, 80%	Not Present	80	10	10	Not present	Not present
			60	30	10		
40			30	30			
MM-Standard 6COS	5-50%, 5% increments	5-20%, 5% increments 30-80%, 10% increments	5-20%, 5% increments 30-80%, 10% increments	5-20%, 5% increments 30-80%, 10% increments	5-20%, 5% increments 30-80%, 10% increments	0% default (5 20%, 5% increments)	Present
MM-Standard 4COS	5-50%, 5% Increments	Not present	Not present	Not present	100%	Not present	Not present
	5-50%, 5% Increments 10%, 20%, 40%	Not present	80	10	10	Not present	Not present
			60	30	10		
40			30	30			

Note: CoS6 not supported on links with LFI.

## 2.2 Designing To Meet Delay Requirements

Voice traffic is very sensitive to delay; the ITU-T G.114 guidelines recommend that one-way delay (referred to as a delay budget) be no more than 150 milliseconds (msec) for toll quality. These guidelines are somewhat conservative. In general it is advisable to keep the one-way delay in the 150-200 msec ranges for good quality. To maintain the range recommended, it is advisable to calculate a delay budget in the network design phase. A delay budget includes several types of delay:

**Encoding delay**—time to actually sample the voice packets and encode them. This delay is dependent on the type of codec selected.

**Serialization/Insertion delay**—time to serialize the actual packet out on the wire. This is a function of packet size and port speed and is calculated by dividing the packet size (bits) by the line speed (bits per second).

**Queuing delay**—time a packet has to wait in queue behind other packets on the same facility. This delay is exponentially proportionate to the utilization of the facility.

**Network/Propagation delay**— network delay is approximately 55 msec one-way from the network service interface to service interface. This is a “worst case scenario” that can be used for conservative delay budget calculations. The “rule of thumb” for physical layer (e.g. private line) propagation delay is 10 msec per 1000 miles.

**De-jitter buffer**—time for the receiver to play out the packets smoothly to the listener. Previously, jitter buffers would default to 50 msec; however, today most are dynamic.



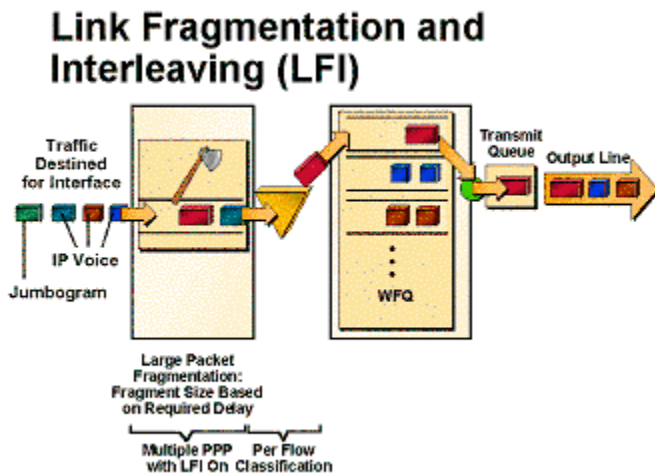
Since the encoding, network, and de-jitter buffer delays are essentially “fixed”, it is important to consider the delay that can be affected by design decisions, specifically serialization and queuing delays.

### 2.2.1 Serialization Delay

Serialization delay is an issue on low speed (less than T1) ports. A full Ethernet Maximum Transmission Unit (MTU) data packet is about 1500 bytes—if one of these packets is being sent out on the wire just as a voice packet arrives, the voice packet will have to wait for the data packet to be serialized. Worst case, on a 64kbps port, the serialization delay would be 188 msec ( $(1500 \text{ bytes} * 8 \text{ bits/byte})/64\text{kbps}$ )—this delay alone would go over the delay budget target for that voice call. AT&T recommends that voice packets not have to wait more than 10 msec behind a data packet. On a T1 port, the insertion delay of a 1500 byte packet is 7.8 msec, so no other techniques are necessary. Even if “sophisticated” queuing techniques are used, there is no capability to preempt a packet that has started to serialize on the wire. This problem is known as “head of line blocking.”

On low speed ports, some type of link fragmentation and interleaving (LFI) technique is required to get the data packets small enough such that the insertion delay is 10 msec.

MLPPP encapsulation is the preferred method for LFI. MLPPP encapsulation is defined in Request for Comment (RFC) 1990 and 2686. It has the capability to fragment, interleave and perhaps more importantly, reassemble the fragments at the far end. It is highly recommended for low speed ports carrying both voice and data traffic.



### 2.2.2 Queuing Delay

Queuing delay is another element of the delay budget that can be minimized by good design techniques. Queuing is a result of congestion or high utilization on network facilities such as ports. As port utilization during peak periods increases, the probability that packets will be delayed increases. Voice packets will receive strict priority in the RT class but if utilization is high, the probability is higher that a data packet that has just started serialization on the wire will delay the voice packet.

Proper bandwidth allocation and ensuring that delay budget constraints will be met across the network are the first steps in a successful voice implementation on any network.

### 2.3 *Special Engineering Guidelines for Ethernet Access*

Three basic types of Ethernet access will be supported: Full Port, single VLAN tag, and stacked dual VLAN tag (Q in Q) ports. Full port is setup the same as single VLAN tag.

Ethernet actually has the most protocol overhead of any supported transport including ATM. A 30 Byte payload needs 2 ATM cell @ 53 Bytes each for a total of 106 Bytes. Ethernet Line Rate requires 112 bytes for each 30 Byte payload. The Line Rate includes the inter-frame gap, preamble, start of frame delimiter, & CRC for each frame which adds to the total. So the protocol difference is about 1.6% more for Ethernet, at approximately 73% protocol overhead of all transported bytes. Many of its configuration options are unique, and are detailed below:

1. If the average packet size is less than 256 bytes, the 75% shaping configuration **MUST** be used. If the overhead is not compensated for by shaping, drops will occur at the CER interface or in the network. CoS1 is assumed to be for voice and uses very small packets (typically 70-byte IP packets. If CoS1 will accommodate large packets (256 bytes or larger), then shaping at the 90% value can be utilized.
2. CoS1 for Ethernet should not be > than 70% to compensate for unaccounted overhead.
3. For customer requirements where the value of CoS1/VLAN speed (or full Ethernet port with NO VLAN configured) is less than or equal to 20%, the shaping value can be 90% of VLAN speed (or full Ethernet port with NO VLAN configured). Where the value is greater than 20%, the shaping value is 75% of VLAN speed (or full Ethernet port with NO VLAN configured). This is because the shaping configuration does NOT include all Layer 2 Ethernet overhead. To ensure that class of service performs correctly, this must be taken into account by shaping. **Please Note: This rule supersedes rule #1 above.**

#### Ethernet Shaping Table:

**VLAN SHAPING TABLE**

VLAN SPEED (in Mbps)	Shaped to 75% of VLAN speed (rounded down to the nearest 8k) in bps	Shaped to 90% of VLAN speed (rounded down to the nearest 8k) in bps
1	744000	896000
2	1496000	1800000
3	2248000	2696000
4	3000000	3600000
5	3744000	4496000
6	4496000	5400000
7	5248000	6296000
8	6000000	7200000
9	6744000	8096000

VLAN SPEED (in Mbps)	Shaped to 75% of VLAN speed (rounded down to the nearest 8k) in bps	Shaped to 90% of VLAN speed (rounded down to the nearest 8k) in bps
10	7496000	9000000
20	15000000	18000000
30	22496000	27000000
40	30000000	36000000
50	37496000	45000000
60	45000000	54000000
70	52496000	63000000
80	60000000	72000000
90	67496000	81000000
100	75000000	90000000
155	116248000	139496000
200	150000000	180000000
300	225000000	270000000
400	300000000	360000000
500	375000000	450000000
600	450000000	540000000
700	525000000	630000000
800	600000000	720000000
900	675000000	810000000
1000	750000000	900000000
10, 100 & 1000 Mbps full Ethernet ports without VLAN configurations can be treated like similar VLAN speeds		

### 3 Traffic Classification and Queuing Techniques

Class of Service features operate in concert with customer router behaviors to provide end-to-end congestion management of application traffic flows. The Customer Edge Router (CER) has several roles in the process. First, it must recognize and categorize the different application types that are to receive differentiated service. Based on this recognition, queuing, fragmentation and interleaving techniques are used as appropriate to provide preferential treatment of priority traffic during congestion. In addition to the treatment within the CER, the network needs to recognize and provide differentiated treatment of customer application traffic. To accommodate this, the CER needs to mark the various application types with appropriate Differentiated Services (DiffServ) codepoints. This allows the network to recognize the different traffic types to provide the desired preferential treatment.

After determining bandwidth requirements and the techniques required to meet the delay budgets, CoS techniques should be applied in the CER to compliment the functionality in the network PER. CoS techniques will help minimize delay, jitter (variation in delay) and drops of

voice packets. These techniques include classifying and marking packets by traffic type, using queuing techniques, and traffic shaping.

### 3.1 **Classification**

The first step in traffic classification is to identify different traffic flows and mark them with the appropriate Differentiated Service Code Point (DSCP) bit. The following table defines the settings expected by the AT&T VPN network.

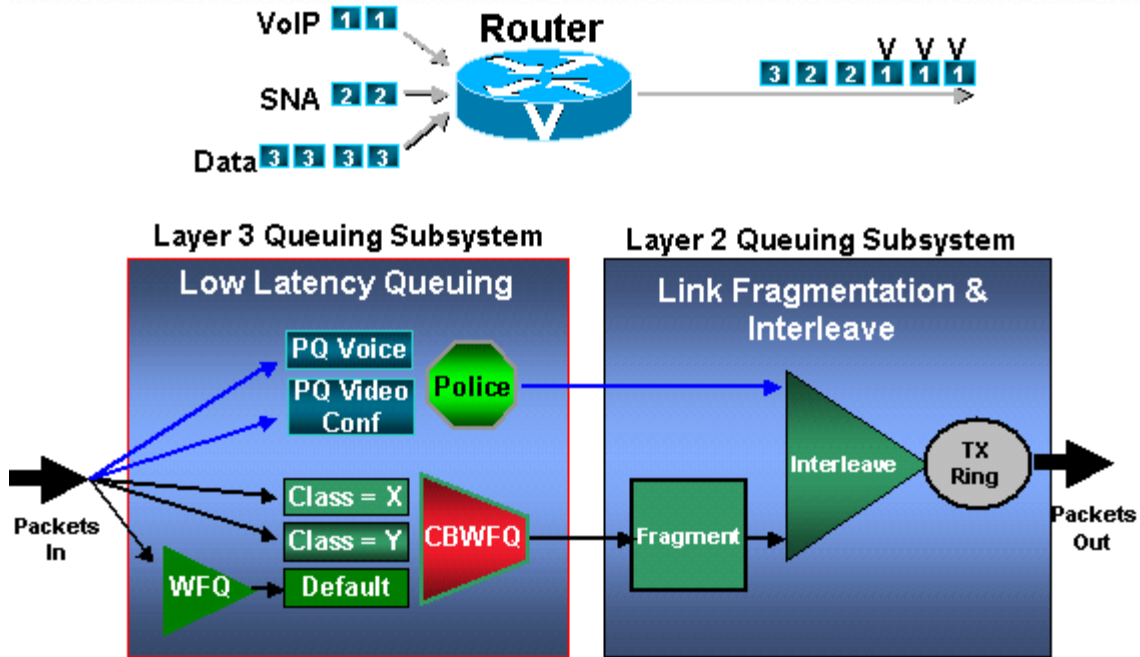
Class of Service	IP Precedence	DSCP	DSCP Decimal	DSCP Binary (In Contract)
Real Time	5	EF	46	101 110
Bursty High	3	AF31	26	011 010
Bursty Low	2	AF21	18	010 010
Best Effort	0	BE	0	000 000

Additional Classes for CoS6:

Class of Service	IP Precedence	DSCP	DSCP Decimal	DSCP Binary (In Contract)
Video (CoS2V)	4	AF41	34	100 010
Scavenger (CoS5)	1	AF11	10	001 010

### 3.2 **Queuing Options**

Queuing techniques and implementations have evolved over the past several years and include options that can strictly prioritize voice traffic over data traffic without starving out the data traffic. Strict priority queuing is a mechanism that will always immediately serve any packets in the priority queue before serving any other queue, ensuring the best possible delay characteristics. The AT&T VPN network uses Low Latency Queuing with Class Based Weighted Fair Queuing (LLQ/CBWFQ) and recommends that customers use the same techniques in their CERS. LLQ/CBWFQ is configured via a policy map where different classes of traffic are assigned a percentage or specific amount of bandwidth. The LLQ is established with the priority command and given a specific bandwidth in kilobits per second. The LLQ is sized based on the bandwidth allocation recommendations in section 2.1. Other queues are serviced based on the amount of bandwidth allocated to them.



### 3.3 Traffic Shaping

Typically with enhanced Permanent Virtual Circuits (ePVCs) on low speed frame relay ports, AT&T recommends traffic shaping for voice traffic by setting the CER's Committed Information Rate (CIR) slightly less than port speed, depending on how aggressive a strategy is desired. Also, excess bursting should be "turned off" by setting the Burst Excess (Be) parameter to 0. Set the committed burst rate (Bc) such that the time interval (Tc) is close to 10 msec—a good rule of thumb for this is to divide the CIR value by 1000. For example, if shaping to a CIR of 128kbps, set Bc to 1280.

## 4 Customer Edge Router (CER) Configurations specific to CoS, WAN interface

The router configurations in this section are partial configurations for AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free over AT&T VPN network. The specific configurations tested were for Cisco ISR G1 and 7200 with Cisco IOS 12.4.(15)T13. The 7300 platform was tested with Cisco IOS 12.2(33)SB9. Sample configurations, relative to specific environments, have been provided for reference in Appendix A.

### 4.1 *Classification*

Following are the access group list configurations. Data and video classes would be defined by the customer. RTP, SIP and BGP access-lists should be configured as they are shown. CoS4 (default class) does not need to be defined.

```
ip access-list extended RTP
  permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
  permit udp any eq 5060 any
  permit udp any any eq 5060
  permit tcp any eq 5060 any
  permit tcp any any eq 5060
ip access-list extended SCCP **Only needed for Cisco UCM solutions**
  permit tcp any range 2000 2003 any
  permit tcp any any range 2000 2003
ip access-list extended BGP
  permit tcp any eq bgp any
  permit tcp any any eq bgp
ip access-list extended COS2-Traffic
  permit udp any any eq 2082 <sample only – COS2 customer defined>
  permit udp any eq 2082 any <sample only – COS 2 customer defined>
ip access-list extended COS3-Traffic
  permit udp any any eq 2083 <sample only – COS3 customer defined>
  permit udp any eq 2083 any <sample only – COS3 customer defined>
```

Note: Even if no CoS2 traffic is ordered, a minimum percentage of CoS2 must be configured on the CER if BGP routing is used, because BGP traffic falls into CoS2.

Additional Access-Lists for CoS6:

```
ip access-list extended COS2V-Traffic
 permit tcp any any range 3230 3231 <sample only – COS2V customer defined>
 permit udp any any range 3230 3235 < sample only – COS2V customer defined>

ip access-list extended COS5-Traffic
 permit udp any any eq 110 <sample only – COS5 customer defined>
 permit udp any eq 110 any <sample only – COS5 customer defined>
```

In order to classify the traffic that will be put into different queues, the class-map statement is used to match access-groups. In this example, the voice traffic is matched from access group lists “RTP”(which includes Real Time Control Protocol (RTCP) traffic) and “SIP” and put into a class called CoS1 for real time traffic. Note that the names used in the class-map are the same names used in the policy map in section 4.2—this is critical to ensure that the right policy will be applied to the right class. Note: These classifications are the same for all access types.

```
class-map match-any COS1
 match access-group name RTP
 match access-group name SIP
 match access-group name SCCP
class-map match-any BGP
 match access-group name BGP
class-map match-any COS2
 match access-group name COS2-Traffic
 match access-group name BGP
class-map match-any COS3
 match access-group name COS3-Traffic
```

Additional Class-maps for CoS6:

```
class-map match-any COS2V
 match access-group name COS2V-Traffic
class-map match-any COS5
 match access-group name COS5-Traffic
```

## 4.2 ***LLQ/CBWFQ Set up and Packet Marking***

The Low Latency Queue is established through a priority statement. The class “CoS1” is put in the low latency queue. The packets are then marked with IP dscp of ‘ef’ to match the network’s expectation for real time service. The remaining bandwidth is distributed among the other classes—CoS2( bursty high traffic) and CoS3 (bursty low traffic) and marked with the appropriate IP Differentiated Services Code Point (DSCP) marking. Finally, the default class is set for Best Effort traffic. Note that IP Cisco Express Forwarding (CEF) must be enabled on the CER for the service policy to work. If RTP header compression is required, it will be applied the policy-map for RT (Real Time) service. This means that ONLY the RTP packets in that class will be compressed, saving CPU resources.

Following are examples of how the data queues might be set up:

### 4.2.1 **Standard Frame Relay interface with MLPPP encapsulation (T1/E1 port speeds: 768Kbit/s and less)**

#### **Fragmentation only**

For MLPPP encapsulation, the policy-map, “CoS” is applied to the virtual template interface.

Note: Burst interval for CoS1 should always be set to 1 second.

```
ip cef
!
policy-map MARK-BGP
class BGP
  set ip dscp cs6
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
class COS2
  bandwidth remaining percent <COS2 %>
  set ip dscp af31
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
class class-default
  bandwidth remaining percent <COS4 %>
  set ip dscp default
```



## **Fragmentation and CRTP**

For MLPPP encapsulation, the policy-map, “COS” is applied to the virtual template interface. The command to enable cRTP is “compress header ip rtp” and is applied to CoS1.

Note: Burst interval for CoS1 should always be set to 1 second.

```
ip cef
!
policy-map MARK-BGP
class BGP
  set ip dscp cs6
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
  compress header ip rtp
class COS2
  bandwidth remaining percent <COS2 %>>
  set ip dscp af31
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
class class-default
  bandwidth remaining percent <COS4 %>
  set ip dscp default
```

### **4.2.2 Standard Frame Relay interface (T1/E1 port speeds 1024 Kbit/s to 2 Mbit/s; and T3/E3 speeds)**

With standard Frame Relay, the policy-map “COS” is applied to the frame-relay map class.

Note: Burst interval for CoS1 should always be set to 1 second.

```
ip cef
!
```

```
policy-map MARK-BGP
class BGP
  set ip dscp cs6
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
class COS2
  bandwidth remaining percent <COS2 %>
  set ip dscp af31
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
class class-default
  bandwidth remaining percent <COS4 %>
  set ip dscp default
```

#### 4.2.3 **PPP access (T1/E1 port speeds 1024 Kbit/s to 2 Mbit/s; and T3/E3 speeds)**

PPP access requires a shaping policy map be applied to the Serial Interface. The policy map for the Quality of Service (QoS) is applied to the shaping policy map. The shape rate of the shaping policy map should be set to 95% of the port speed.

Note: Burst interval for CoS1 should always be set to 1 second

```
ip cef
!
policy-map MARK-BGP
class BGP
  set ip dscp cs6
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
```

```
class COS2
bandwidth remaining percent <COS2 %>
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent <COS3 %>
set ip dscp af21
class class-default
bandwidth remaining percent <COS4 %>
set ip dscp default
```

**For Port Speed Greater than 2Mbit/s:**

```
policy-map SHAPE_PPP **This policy map applied to serial interface**
class class-default
shape average <Port Speed * .95> <(Port Speed * .95)/250> 0
shape max-buffers 4096
service-policy COS
```

**Note – Voice only customers (no data) should not set the BE equal to 0. It should be left blank.**

**Note: Cisco recommends the BC value be divisible by 128 (rounded up).**

**For Port Speed 2Mbit/s or less:**

```
policy-map SHAPE_PPP **This policy map applied to serial interface**
class class-default
shape average <Port Speed * .95> <(Port Speed * .95)/100> 0
shape max-buffers 4096
service-policy COS
```

**Note – Voice only customers (no data) should not set the BE equal to 0. It should be left blank.**

**Note: Cisco recommends the BC value be divisible by 128 (rounded up).**

Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping is **merely the subrate speed instead of 95% of it.**

#### 4.2.4 ATM (T1 / T3)

Note: CoS1 greater than 70% not recommended for ATM access.

With ATM, the “COS” policy-map will be applied to the subinterface under the pvc statement.

Note: Burst interval for CoS1 should always be set to 1 second.

```
ip cef
!
policy-map MARK-BGP
class BGP
  set ip dscp cs6
!
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
class COS2
  bandwidth remaining percent <COS2%>
  set ip dscp af31
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
class class-default
  bandwidth remaining percent <COS4 %>
  set ip dscp default
```

#### 4.2.5 ADSL/ SHDSL

Note: CoS1 greater than 70% not recommended for DSL access.  
The "COS" policy-map should be applied to the ATM subinterface under the pvc statement.  
Note: Burst interval for CoS1 should always be set to 1 second.

```
ip cef
!
policy-map MARK-BGP
class BGP
  set ip dscp cs6
policy-map COS
class COS1
```

```
priority <COS1 BW > <Burst size>
set ip dscp ef
class COS2
bandwidth remaining percent <COS2%>
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent <COS3%>
set ip dscp af21
class class-default
bandwidth remaining percent <COS4%>
set ip dscp default
```

#### 4.2.6 DSL Modem

When using a DSL modem, the CER will normally contain a T1 Frame Relay interface. The T1 Frame Relay is then plugged into the DSL modem. When using a DSL modem, the Frame Relay interface must be shaped to 60% of T1 speed. In addition, CoS1 cannot be greater than 533Kbit/s (equivalent to 24 calls using G729 codec with 30 byte payload), For this configuration, use Frame Relay bandwidth per call numbers.

The policy-map, "DSL-SHAPE" is applied to the Frame Relay subinterface.

```
ip cef

policy-map MARK-BGP
class BGP
set ip dscp cs6
!
policy-map COS
class COS1
priority 533 66000 (max COS1 BW = 24 G.729 30 B payload calls)
set ip dscp ef
class COS2
bandwidth remaining percent <COS2%>
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent <COS3%>
set ip dscp af21
class class-default
bandwidth remaining percent <COS4%>
set ip dscp default
!
```

```
policy-map DSL-SHAPE (shape to 60 of T1 FR%)
class class-default
shape average 921000 9210
shape max-buffers 4096
service-policy COS
```

#### 4.2.7 **NXT1/E1 MLPPP Access**

With NXT1 MLPPP Access, the policy-map “COS\_MLPPP” is applied to the multilink interface.

Note: Burst interval for CoS1 should always be set to 1 second

```
ip cef
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
!
policy-map COS_MLPPP
class COS1
priority <COS1 BW > <Burst size>
set ip dscp ef
class COS2
bandwidth remaining percent <COS2 %>
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent <COS3 %>
set ip dscp af21
class class-default
bandwidth remaining percent <COS4%>
set ip dscp default
```

#### 4.2.8 **N X T1 IMA**

With NXT1 IMA Access, the policy-map “COS” is applied to the IMA subinterface.

Note: Burst interval for CoS1 should always be set to 1 second

```
ip cef
!
policy-map MARK-BGP
  class BGP
    set ip dscp cs6
!
policy-map COS
  class COS1
    priority <COS1 BW > <Burst size>
    set ip dscp ef
  class COS2
    bandwidth remaining percent <COS2%>
    set ip dscp af31
    service-policy MARK-BGP
  class COS3
    bandwidth remaining percent <COS3%>
    set ip dscp af21
  class class-default
    bandwidth remaining percent <COS4%>
    set ip dscp default
```

#### 4.2.9 T3/E3 Frame Relay Encapsulation

Multiple VPN connections over private line access are typically provided using Frame Relay encapsulation on the access link to provide L2 differentiation of the connections.

With Frame Relay encapsulation, the a Frame-Relay Map Class will be applied to the subinterface (or one Frame-Relay Map Class to each subinterface if there are multiple subinterfaces). The policy-map is applied to the sub-interface via the Frame-Relay Map Class (see section 4.3).

Note: Burst interval for CoS1 should always be set to 1 second.

```
ip cef
!
policy-map MARK-BGP
```

```
class BGP
  set ip dscp cs6
!
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
class COS2
  bandwidth remaining percent <COS2%>
  set ip dscp af31
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
```

#### 4.2.10 OC3/OC12 PPP access

OC3/OC12 PPP access requires a shaping policy map be applied to the POS interface. The policy map for the QOS is applied to the shaping policy map. The shape rate of the shaping policy map should be set to 95% of the port speed.

Note: Burst interval for CoS1 should always be set to 1 second

#### **Sample for OC3/OC12 PPP on 7200 Router:**

```
ip cef
!
policy-map MARK-BGP
class BGP
  set ip dscp cs6
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
```



```
set ip dscp ef
class COS2
bandwidth remaining percent <COS2 %>
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent <COS3 %>
set ip dscp af21
class class-default
bandwidth remaining percent <COS4%>
set ip dscp default
!
policy-map SHAPE_PPP    **This policy-map applied to POS interface**
class class-default
shape average <Port Speed * .95> <(Port Speed * .95)/250> 0
shape max-buffers 4096
service-policy COS
```

Note – Voice only customers (no data) should not set the BE equal to 0. It should be left blank.

Note: Cisco recommends this value be divisible by 128 (rounded up).

Note: Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping is merely the subrate speed instead of 95% of it.

### **Sample for OC3/OC12 PPP on 7300 Router:**

Note: All values used in the police statements are irrelevant for 7300 policy map configuration. These statements are used only for setting the dscp markings of the traffic (as the same action is done with both the transmit and exceed statements). Therefore the police value can really be set to any value.

```
ip cef
!
policy-map MARK-BGP
class BGP
police 8000 conform-action set-dscp-transmit cs6 exceed-action set-dscp-transmit cs6
class class-default
police 8000 conform-action set-dscp-transmit af31 exceed-action set-dscp-transmit af31
policy-map COS
class COS1
priority
```

```
police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
class COS2
  bandwidth remaining percent <COS2%>
service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3%>
police 8000 conform-action set-dscp-transmit af21 exceed-action set-dscp-transmit af21
class class-default
  bandwidth remaining percent 30
police 8000 conform-action set-dscp-transmit default exceed-action set-dscp-transmit
default
!
policy-map OCX-SHAPE **This policy-map applied to POS interface**
class class-default
  shape average <Port Speed * .95> <(Port Speed * .95) /250 > 0
service-policy COS
```

**Note – Voice only customers (no data) should not set the BE equal to 0. It should be left blank.**

**Note: Cisco recommends this value be divisible by 128 (rounded up)**

Note: Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping is merely the subrate speed instead of 95% of it.

#### 4.2.11 OC3/OC12 Frame Relay Encapsulation

Multiple VPN connections over private line access are typically provided using Frame Relay encapsulation on the access link to provide L2 differentiation of the connections.

The typical CoS configuration for Frame Relay encapsulation ports is called 'port level' CoS. This CoS applies a single CoS policy to the aggregate of all connections sharing the port. Because the CoS configuration is shared over multiple connections, it vital that the connections/QOS be sized correctly

OC3/OC12 PPP access requires a policy map be applied to each sub-interface.

Note: Burst interval for CoS1 should always be set to 1 second

#### **Sample for OC3/OC12 Frame Relay encapsulation on 7200 Router:**

```
ip cef
!
```

```
policy-map MARK-BGP
class BGP
  set ip dscp cs6
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
class COS2
  bandwidth remaining percent <COS2%>
  set ip dscp af31
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
!
policy-map OCX-SHAPE ** This policy-map applied to POS sub- interface**
class class-default
  shape average <Port Speed * .95> <(Port Speed * .95)/250> 0
  shape max-buffers 4096
  service-policy COS
```

**Note: Cisco recommends  
this value be divisible by  
128 (rounded up)**

Note: Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping is merely the subrate speed instead of 95% of it.

**Sample for OC3/OC12 Frame Relay encapsulation on 7300 Router:**

Note: All values used in the police statements are irrelevant for 7300 policy map configuration. These statements are used only for setting the dscp markings of the traffic (as the same action is done with both the transmit and exceed statements). Therefore the police value can really be set to any value.

```
ip cef
!
policy-map MARK-BGP
```

```
class BGP
  police 8000 conform-action set-dscp-transmit cs6 exceed-action set-dscp-transmit cs6
class class-default
  police 8000 conform-action set-dscp-transmit af31 exceed-action set-dscp-transmit af31
policy-map COS
  class COS1
    priority
    police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
  class COS2
    bandwidth remaining percent <COS2%>
    service-policy MARK-BGP
  class COS3
    bandwidth remaining percent <COS3%>
    police 8000 conform-action set-dscp-transmit af21 exceed-action set-dscp-transmit af21
  class class-default
    bandwidth remaining percent <COS4%>
    police 8000 conform-action set-dscp-transmit default exceed-action set-dscp-transmit
default
!
policy-map OCX-SHAPE  ** This policy-map applied to POS sub- interface**
  class class-default
    shape average <Port Speed * .95> <(Port Speed * .95)/250> 0
  service-policy COS
```

Note – Voice only customers (no data) should not set the BE equal to 0. It should be left blank.

Note: Cisco recommends this value be divisible by 128 (rounded up).

Note: Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping is merely the subrate speed instead of 95% of it.

#### 4.2.12 Ethernet Access

Ethernet access requires a shaping policy map be applied to the Ethernet interface. The policy map for the CoS is applied to the shaping policy map. The shape rate of the shaping policy map should be set to a percentage of the port speed. See section 2.3 Special Engineering Guidelines for Ethernet Access for the guidelines.

For Ethernet access with VLANs, a separate policy-map should be applied to each subinterface.

Note: Burst interval for COS1 should always be set to 1 second

```
ip cef
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
!
policy-map COS
class COS1
priority <COS1 BW > <Burst size>
set ip dscp ef
class COS2
bandwidth remaining percent <COS2%>
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent <COS3%>
set ip dscp af21
class class-default
set ip dscp default
bandwidth remaining percent <COS4%>
!
policy-map Ether-Shape **This policy-map applied to Ethernet interface**
class class-default
shape average <Shaping Rate– see section 2.3> <Shaping Rate/250> 0
shape max-buffers 4096
service-policy COS
```

Note – Voice only customers (no data) should not set the BE equal to 0. It should be left blank.

Note: Cisco recommends this value be divisible by 128 (rounded up).

#### 4.2.13 CoS6 Example

Following is an example of how to configure a service policy for a CoS6 configuration by adding on the “COS2V” and “COS5” classes.

Note: Burst interval for CoS1 should always be set to 1 second.

```
ip cef
!
policy-map MARK-BGP
class BGP
  set ip dscp cs6
!
policy-map COS
class COS1
  priority <COS1 BW > <Burst size>
  set ip dscp ef
class COS2V
  bandwidth remaining percent <COS2V%>
  set ip dscp af41
class COS2
  bandwidth remaining percent <COS2%>
  set ip dscp af31
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
class COS5
  bandwidth remaining percent <COS5%>
  set ip dscp af11
class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
```

#### 4.3 **Frame Relay traffic shaping for Frame Relay interfaces only**

To enable the queues required for LLQ/CBWFQ, traffic shaping is applied to the interface via a map-class. In this case, aggressive shaping was used, setting the Committed Information Rate (CIR) to slightly less than the port speed. Excess bursting is disabled by setting 'be' to 0. The committed burst rate is set so as to make the time interval (Tc) equal to 10 msec or 100 intervals per second. AT&T recommends turning off adaptive traffic shaping—this is important

in voice implementations, as the objective in traffic shaping is to keep a constant bandwidth stream available and to avoid being throttled back due to congestion.

Following are examples of traffic shaping:

#### 4.3.1 Standard Frame Relay interface with MLPPP encapsulation (T1/E1 port speeds: 768Kbit/s and less)

##### Sample config for 128Kbit/s CIR:

```
map-class frame-relay shape128
frame-relay cir 115000 < CIR * .90 >
frame-relay bc 1150 < (CIR * .90)/100 >
frame-relay be 0
frame-relay mincir 115000 < CIR * .90 >
```

Note – Voice only customers (no data) should not set the BE equal to 0. BE command should be omitted.

#### 4.3.2 Standard Frame Relay interface (T1/E1 port speeds 1024 Kbit/s to 2Mbit/s; and T3/E3 speeds, (including Frame Encapsulation))

With Frame Relay, the “COS” service policy is applied to the frame-relay map class.

##### Sample configuration for a 1536Kbit/s CIR:

```
map-class frame-relay shape1536K
frame-relay cir 1382000 <CIR * .90>
frame-relay bc 13820 < (CIR * .90) / 100 >
frame-relay be 0
frame-relay mincir 1382000 <CIR * .90>
service-policy output COS
```

Note – Voice only customers (no data) should not set the BE equal to 0. BE command should be omitted.

##### Sample configuration for 44.210 Mbit/s (T3) CIR:

```
map-class frame-relay shape44M
frame-relay cir 41999000 <CIR * .95>
frame-relay bc 168064 < (CIR * .95) / 250 , rounded up to the nearest 128>
frame-relay be 0
frame-relay mincir 41999000 <CIR * .95>
service-policy output COS
```

Note – Voice only customers (no data) should not set the BE equal to 0. BE command should be omitted.

NOTE:

- For port speeds 2Mbit/s and lower, set the frame-relay bc to  $(CIR * .9) / 100$ .
- For port speeds higher than 2Mbit/s, set the frame-relay bc to  $(CIR * .95) / 250$  (rounded up to nearest multiple of 128)
- For Frame Relay Encapsulation, each subinterface will require its own Frame-Relay Map Class, shaped to the proper speed.

## 4.4 **Interface Configuration**

This section gives examples of how to configure the various interface types.

### 4.4.1 **Standard Frame Relay interface with MLPPP encapsulation (T1/E1 port speeds: 768Kbit/s and less)**

On low speed ports, MLPPP is required to support fragmentation (CRTP is optional). MLPPP is turned on via a virtual template that is applied to the subinterface. The bandwidth statement in the virtual template is critical for the proper fragment setting. The router will use the bandwidth statement here to calculate the actual packet size based on the fragment-delay setting. The bandwidth should be set to slightly less than the CIR of the interface, which is typically port speed. The fragment-delay is set according to port speed (see Fragment Delay Guidelines table in this section). Fragmenting and interleaving are turned on. The IP address statement configures the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link. The LLQ/CBWFQ policy "CoS" is applied to the virtual template as a service-policy output.

#### **Example of T1 speed (768Kbit/s and less) on ISR:**

```
interface Serial0/2/0
no ip address
encapsulation frame-relay IETF
frame-relay traffic-shaping

interface Serial0/2/0.1 point-to-point
bandwidth <(CIR * .90)/1000>
frame-relay class <frame-relay map class name>
frame-relay interface-dlci 99 ppp Virtual-Template1

interface Virtual-Template1
bandwidth <(CIR * .90)/1000>
ip address <ip address> <mask>
load-interval 30
ppp multilink
ppp multilink interleave
ppp multilink fragment delay X <see chart on fragment delay guidelines in this
section>
max-reserved-bandwidth 100
service-policy output COS
```



The actual size of fragmented packets is a function of the 'bandwidth' statement and the 'fragment delay' within the virtual template. The core of the network uses ATM cell transport. When using small packets, such as in a fragmentation and interleaving configuration, it is important to make efficient utilization of the underlying ATM cells. To facilitate this, the following settings should be used for the MLPPP bandwidth and fragment delay.

#### Fragment Delay Guidelines

Port speed in Kbps	Fragment delay in msec
64	10
128	11
192	11
256	10
320	10
384	10
448	10
512	10
576	10
640	10
704	10
768	10

#### 4.4.2 Standard Frame Relay interface (T1/E1 speeds: 1024 Kbit/s to 2 Mbit/s; and T3/E3 speeds)

On the standard frame-relay interface, encapsulation is set to frame-relay and traffic shaping is turned on. In this case, the max-reserved-bandwidth statement set at 100 will insure that the service policy is properly applied to the interface.

On the sub-interface, the bandwidth should be set to slightly less than the CIR of the interface, which is typically the port speed. The IP address statement configures the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link. The map-class is applied as shown below.

#### **Example of T1 FR interface on ISR:**

```
interface Serial0/2/0
no ip address
encapsulation frame-relay
```

```
load-interval 30
frame-relay traffic-shaping
max-reserved-bandwidth 100

interface Serial0/2/0.1 point-to-point
bandwidth <(CIR * .90)/1000>
ip address <ip address> <mask>
frame-relay class <frame-relay map class name>
frame-relay interface-dlci <dlci number> IETF
```

### **Example of T3 interface on ISR:**

Note: Using the NM-1T3/E3 module in an ISR (router) with an T3/E3 Frame Relay circuit gives you Receiver Loss of Signal when you attempt to bring up the Frame Relay circuit with IOS 12.4(15)T13 advanced-enterprise version (c3845-adventerprisek9-mz.124-15.T13.bin). However – the Frame Relay circuit does come up normally when used with the spservices version of 12.4(15) T13 IOS (c3845-spservicesk9-mz.124-15.T13.bin).

For T3 Frame Relay configuration on an ISR, the NM1T3/E3 “card type” must be configured for T3. The DSU bandwidth should be configured for the proper speed.

```
card type t3 2

interface Serial2/0
no ip address
encapsulation frame-relay
framing c-bit
load-interval 30
dsu bandwidth <interface BW in Kbps>
frame-relay traffic-shaping
frame-relay lmi-type cisco
!
interface Serial2/0.1 point-to-point
bandwidth <(CIR * .95)/1000>
ip address <ip address> <mask>
frame-relay class <frame-relay map class name>
frame-relay interface-dlci <dlci number> IETF
```

**Example of E3 Interface on ISR:**

```
card type e3 2

interface Serial2/0
no ip address
encapsulation frame-relay
load-interval 30
dsu bandwidth <interface BW in Kbps>
frame-relay traffic-shaping
frame-relay lmi-type cisco
max-reserved-bandwidth 100
!
interface Serial2/0.1 point-to-point
bandwidth <(CIR * .95)/1000>
ip address <ip address> <mask>
frame-relay class <frame-relay map class name>
frame-relay interface-dlci <dlci number> IETF
```

**Example of T3 Frame Relay on 7200:**

For T3 Frame Relay configuration on a 7200, the configuration of the card includes the following commands. On the serial interface the DSU bandwidth should be configured for the proper speed. C-bit framing must be enabled.

```
interface Serial4/0
no ip address
encapsulation frame-relay
load-interval 30
dsu bandwidth <interface BW in Kbps>
framing c-bit
cablelength 10
frame-relay traffic-shaping
frame-relay lmi-type cisco
```

```
max-reserved-bandwidth 100
!
interface Serial4/0.1 point-to-point
bandwidth <(CIR * .95)/1000>
ip address <ip address> <mask>
no cdp enable
frame-relay class <frame-relay map class name>
frame-relay interface-dlci <dlci number> IETF
```

### **Example of E3 Frame Relay on 7200**

```
interface Serial4/0
mtu 1500
no ip address
encapsulation frame-relay
load-interval 30
framing g751
dsu bandwidth <interface BW in Kbps>
frame-relay traffic-shaping
frame-relay lmi-type cisco
max-reserved-bandwidth 100
!
interface Serial4/0.1 point-to-point
bandwidth <(CIR * .95)/1000>
ip address <ip address> <mask>
snmp trap link-status
no cdp enable
frame-relay class <frame-relay map class name>
frame-relay interface-dlci <dlci number> IETF
```

#### 4.4.3 PPP access (T1/E1 speeds: 1024 Kbits/ to 2 Mbit/s; and T3/E3 speeds)

For T1 PPP access configuration, The IP address is configured which should be the CER side of the /30 subnet assigned for the CER/PER link. The CoS policy "SHAPE\_PPP" is applied to the serial interface. In this case, the max-reserved-bandwidth statement set at 100 will help insure that the service policy is properly applied to the interface.

##### **Example of T1 PPP Access on ISR with external DSU ( HWIC-1T or 2T):**

```
interface Serial0/1/0
bandwidth <port speed * 95%>
ip address <ip address> <mask>
max-reserved-bandwidth 100
encapsulation ppp
service-policy output SHAPE_PPP
```

##### **Example of T1 PPP Access on ISR with internal DSU (HWIC-1DSU-T1):**

```
interface Serial0/1/0
bandwidth <port speed * 95%>
ip address <ip address> <subnet mask>
max-reserved-bandwidth 100
encapsulation ppp
service-module t1 framing esf
service-module t1 linecode b8zs
service-module t1 timeslots 1-24 speed 64
service-policy output SHAPE_PPP
```

# of T1 timeslots. This example uses full T1

##### **Example of E1 PPP on ISR with internal DSU (VWIC2-1(or2)MFT-T1/E1 or VWIC2-1(or2)MFT-T1/E1-G.703:**

These configurations require configuration of a E1 controller and a serial interface.. A channel group must also be configured and should be numbered starting with 0. The number of timeslots required is determined by the ordered circuit.

The first command identifies the card as a E1 controller. The syntax is card type e1 <WIC slot #>. Example: card type e1 0 2

For full E1, the framing is UNFRAMED. **Only the VWIC2-1MFT-T1/E1-G.703 supports UNFRAMED E1 in the ISR routers.** The default linecode for E1 is HDB3.

```
controller E1 0/2/0
```

# of DS0 timeslots.  
This example uses  
full E1 unframed

```
channel-group 0 unframed
```

Channel group number  
starting with 0

For channelized E1 using 31 DS0s, define the DS0 slot numbers. The Cisco router interface begins numbering at slot 0. For 31 DS0 E1 the **VWIC2-1MFT-T1/E1-G.703 may be used**. CRC-4 framing is the default for channelized E1. To specify the No-CRC4 framing, add the framing command in the following configuration:

```
controller E1 0/2/0
channel-group 0 timeslots 1-31 speed 64
framing no-crc4
```

Optional – default is CRC4

For channelized E1 using 30 DS0s, define the DS0 slot numbers. The Cisco router interface begins numbering at slot 0. For 30 DS0 E1 the **VWIC2-1MFT-T1/E1-G.703**. CRC-4 framing is the default for channelized E1. To specify the No-CRC4 framing, add the framing command in the following configuration:

```
controller E1 0/2/0
channel-group 0 timeslots 2-31 speed 64
framing no-crc4
```

After configuring the E1 controller, the serial interface is configured as in the previous example. The serial interface numbering is serial 0/<t1 cont slot # / port # : channel-group #>:

```
interface Serial0/1/0:0
bandwidth <port speed * 95%>
encapsulation ppp
ip address 10.10.20.1 255.255.255.0
max-reserved-bandwidth 100
```

### **Example of T3 PPP access on ISR with internal DSU NM1T3/E3 card:**

For T3 PPP access configuration on an ISR, the NM1T3/E3 “card type” must be set to T3. Then the T3 controller must be configured for c-bit framing. On the serial interface, the DSU bandwidth should be configured for the proper speed. Scrambling should be enabled.

```
card type t3 1
```

```
controller t3 1/0
```

```
framing c-bit

interface Serial1/0
ip address <ip address> <mask>
encapsulation ppp
crc 32
load-interval 30
dsu bandwidth <interface BW in Kbps>
scramble
max-reserved-bandwidth 100
service-policy output SHAPE_PPP
```

### **E3 PPP on ISR with internal DSU ( NM-1T3/E3)**

The configuration of the NM-1T3/E3 includes the following commands. The NM-1T3/E3 requires an additional configuration command to set the card type to E3. PPP encapsulation must be set and the DSU bandwidth is automatically set in the IOS to allow for use of the full port. The framing is g.751 by default and does not need to be changed. **Scrambling should NOT be enabled and the DSU mode must be set to 1 (kentrox interoperability mode).**

```
card type e3 2

interface Serial2/0
ip address <ip address> <subnet>
encapsulation ppp
dsu bandwidth 34010 - this is inserted by default
dsu mode 1 - required to interoperate with MoW Juniper PE
max-reserved-bandwidth 100
service-policy output SHAPE_PPP
```

### **Example of T3 PPP access on 7200 with internal DSU (PA-T3+ or PA-T3/E3-EC):**

The configuration of the PA-T3+ or PA-T3/E3-EC in a 7200VXR includes the following commands. The PA-T3/E3-EC requires an additional configuration command to set the card type to T3. PPP encapsulation must be set and the DSU bandwidth to allow for use of the full port. The framing is c-bit by default. Scrambling should be enabled to match the default configuration of the network T3 port.

```
card type t3 2 – only required for PA-T3/E3-EC
```

```
interface Serial4/0
ip address <ip address> <mask>
encapsulation ppp
crc 32
load-interval 30
dsu bandwidth <interface BW in Kbps>
scramble
framing c-bit
max-reserved-bandwidth 100
service-policy output SHAPE_PPP
```

### **E3 PPP on 7200 with internal DSU (PA-E3 and PA-T3/E3-EC):**

The configuration of the PA-E3 or PA-T3/E3-EC in a 7200VXR includes the following commands. The PA-T3/E3-EC requires an additional configuration command to set the card type to E3. PPP encapsulation must be set and the DSU bandwidth is automatically set in the IOS to allow for use of the full port. The framing is g.751 by default and does not need to be changed. **Scrambling should NOT be enabled and the DSU mode must be set to 1 (kentrox interoperability mode).**

```
card type e3 2 - only required for PA-T3/E3-EC

interface Serial2/0
ip address <ip address> <subnet>
encapsulation ppp
dsu bandwidth 34010 - this is inserted by default.
dsu mode 1 - required to interoperate with MoW Juniper PE
max-reserved-bandwidth 100

service-policy output SHAPE_PPP
```

### **E3 PPP on 7300 with internal DSU (SPA-2XT3/E3):**

The configuration of the SPA-2XT3/E3 in the 7304 with 12.2(33)SB3 includes the following commands. The SPA-2XT3/E3 requires an additional configuration command to set the card type to E3. PPP encapsulation must be set and the DSU bandwidth is automatically set in the IOS to allow for use of the full port. The framing is g.751 by default and does not need to be changed. **Scrambling should NOT be enabled and the DSU mode must be set to kentrox interoperability mode.**



```
card type e3 2
!
interface Serial2/0
 ip address <ip address> <subnet>
 encapsulation ppp
 dsu bandwidth 34010 - this is inserted by default.
 dsu mode kentrox - required to interoperate w/ MoW Juniper PE
 max-reserved-bandwidth 100

 service-policy output SHAPE_PPP
```

#### 4.4.4 ATM (T1/T3/E3)

**Note:** At this time T3/E3 ATM access is not supported on the ISR routers. Further testing must be completed on the NM-1A-T3/E3 cards due to a change in the QOS mechanism of this new hardware.

##### Example of T1 ATM on ISR:

1. Define the VWIC2-(1 or 2) MFT-T1/E1 as T1 cards with the command “**card type t1 <slot #>**”.
2. Clocking is performed on the controllers, not the ATM interfaces.
3. T1 parameters are set on the T1 controller lines in the configuration. Line encoding and framing must match your provider’s specifications. Controller must be used in conjunction with an AIM card.
4. Once the controller card is configured, an atm interface which matches the T1 controller numbers will appear. ATM interface should be set for mtu of 1500, framing esf and linecode b8zs.
5. Define a point-to-point atm sub-interface for the ATM PVC (i.e. VPI/VCI).
6. PCR and SCR of the vbr-nrt statement should be 95% of the port speed.
7. TX ring limit for T1 should be equal to 3.
8. Encapsulation should be set to aal5snap
9. The service policy is applied at the subinterface under the pvc statement. Max reserved bandwidth must be set to 100.

```
card type t1 0 1

controller T1 0/1/0
 mode atm aim 0
 framing esf
 linecode b8zs
```

```
cablelength long 0db

interface ATM0/1/0
mtu 1500
no ip address
no scrambling-payload
no atm ilmi-keepalive
!
interface ATM0/1/0.1 point-to-point
ip address <ip address> <subnet>
pvc <vpi./vci>
vbr-nrt <port speed * .95 > <port speed * .95> 1
tx-ring-limit 3
vc-hold-queue 2048
oam-pvc manage
oam retry 3 5 1
oam ais-rdi 10 3
encapsulation aal5snap
protocol ip inarp
service-policy output COS
max-reserved-bandwidth 100
```

!

### **Example of T3 ATM on 7200:**

1. Enable scrambling on atm interfaces.
2. Use a point-to-point sub-interface type for the ATM PVC (*i.e.*, VPI/VCI).
3. Apply policy map to subinterface under pvc

The configuration of the 7200 router includes the following commands:

```
interface ATM6/0
no ip address
load-interval 30
atm scrambling cell-payload
no atm ilmi-keepalive
```

```
!  
interface ATM6/0.1 point-to-point  
  mtu 1500  
  ip address <ip address> <mask>  
  ip virtual-reassembly  
  pvc <vpi>/<vci>  
    vbr-nrt <port speed * .95 > <port speed * .95> 1  
    tx-ring-limit 10  
    vc-hold-queue 2048  
  oam-pvc manage  
  oam retry 3 5 1  
  oam ais-rdi 10 3  
  encapsulation aal5snap  
  service-policy output COS  
  max-reserved-bandwidth 100
```

**Example of T3 ATM on 7300:**

```
interface ATM5/0  
  no ip address  
  load-interval 30  
  no atm scrambling cell-payload  
  no atm ilmi-keepalive  
  no atm enable-ilmi-trap  
  max-reserved-bandwidth 100  
!  
interface ATM5/0.1 point-to-point  
  mtu 1500  
  ip address <ip address> <mask>  
  no atm enable-ilmi-trap  
  pvc <vpi>/<vci>  
    vbr-nrt <port speed * .95 > <port speed * .95> 1  
  oam-pvc 0  
  encapsulation aal5snap
```

service-policy out COS

#### 4.4.4.1 SHDSL

The only card supported for SHDSL is the HWIC-2SHDSL (2-wire or 4-wire)

##### HWIC-2SHDSL:

When utilizing the HWIC-2SHDSL hardware in 2-wire mode, certain DSL specific parameters must be set properly in order for the interface to operate. First the controller must be configured. Once the controller is configured, an ATM interface is automatically created.

On the ATM interface, mtu must be set to 1500.

An ATM subinterface is configured using the AT&T supplied IP address & PVC with a VPI/VCI. The mtu MUST be set to 1500. Max reserved bandwidth should be set to 100.

##### Sample configuration of HWIC-2SHDSL 2-Wire:

```
controller SHDSL 0/1/0
dsl-group 0 pairs 0
shdsl annex <A, B or A-B>
shdsl rate <PCR or SCR in Kbps>

interface ATM0/1/0
mtu 1500
bandwidth <PCR or SCR in Kbps>
no ip address
load-interval 30
no atm ilmi-keepalive
!
interface ATM0/1/0.35 point-to-point
mtu 1500
bandwidth < Network CIR in Kbps>
ip address <ip address> <subnet mask>
no snmp trap link-status
pvc <vpi/vci>
vbr-rt <PCR in Kbps> <SCR in Kbps>
max-reserved-bandwidth 100
tx-ring-limit <3 or 10 depending on shape rate>
oam-pvc manage 0
oam retry 3 5 1
oam ais-rdi 10 3
encapsulation aal5snap
```

```
service-policy output COS
max-reserved-bandwidth 100
!
```

When utilizing the HWIC-2SHDSL hardware in 4-wire mode, certain DSL specific parameters must be set properly in order for the interface to operate. First the controller must be configured. Once the controller is configured, an ATM interface is automatically created.

On the ATM interface, mtu must be set to 1500.

An ATM subinterface is configured using the AT&T supplied IP address & PVC with a VPI/VCI. The mtu MUST be set to 1500. Max reserved bandwidth should be set to 100.

### **Sample configuration of HWIC-2SHDSL 4-Wire:**

```
controller SHDSL 0/1/0
dsl-group 0 pairs 0, 1
shdsl 4-wire mode enhanced
shdsl annex <A, B or A-B>
shdsl rate <port speed>

!

interface ATM0/1/0
mtu 1500
bandwidth <PCR or SCR in Kbps>
no ip address
load-interval 30
no atm ilmi-keepalive
!
interface ATM0/1/0.35 point-to-point
mtu 1500
bandwidth < Network CIR in Kbps>
ip address <ip address> <subnet>
no snmp trap link-status
pvc <vpi/vci >
vbr-rt <PCR in Kbps> <SCR in Kbps>
oam-pvc manage
encapsulation aal5snap
service-policy output COS
max-reserved-bandwidth 100
```

In order to verify the speed being received from the network, use the command “show controller shdsl”. This rate should be used to configure the PCR. The link rate is shown in bold below:

```
Router#show controller shdsl
Controller SHDSL 0/1/0 is UP
Hardware is HWIC-2SHDSL, rev 1 on slot 0, hwic slot 1
Capabilities: 2/4 wire, Annex A, B, F & G, CPE termination
cdb=0x47910BB0, plugin=0x477C77E0, ds=0x478F5798 base=0xB0200000
FPGA Version is REL.3.4.0, NIOSII FW:Ver 3.2, status Running
SDFE-2 HW:Rev 1.3, status UP FW:Ver 1.1-1.5.8__002           , status Running
NIOSII Firmware image: System
SDFE2 Firmware image: System
Number of pairs 2, number of groups configured 1
Ignored CLI cmds(0), Event buffer: in use(0), failed(0)
Group (0) info:
  Type: 2-wire g.shdsl, status: UP
  Interface: ATM0/1/0, hwidb: 0x47910D18, UTOPIA phy 0
  Configured/active num links: 1/1, bit map: 0x1/0x1
  Line termination: CPE, line mode: 2-wire, Annex-A-B, PMMS disabled
  Line coding: 16-TCPAM, configured/actual rate: AUTO/384 kbps
  SHDSL wire-pair (0) is in DSL UP state
  Termination: CPE, line mode: 2-wire, Annex-A-B
  Line coding: 16-TCPAM, configured/actual rate: AUTO/384 kbps
  CONNECT state: MAIN_DATA_MODE, cond: GHS_TRANSFER, reason:
ERR_NONE
  Power back off: 6dB, FE power back off: 6dB
  LoopAttn: 1dB, SnrMargin: 8dB, Status noDefect
  Current 15 minute statistics (Time Elapsed 119 seconds):
    ES: 0, SES: 0, CRC: 0, LOSWS: 0, UAS: 0
  Previous 15 minute statistics:
    ES: 0, SES: 0, CRC: 0, LOSWS: 0, UAS: 0
  Current 24 hr statistics:
    ES: 0, SES: 0, CRC: 0, LOSWS: 24, UAS: 6
  Previous 24 hr statistics:
    ES: 0, SES: 0, CRC: 0, LOSWS: 0, UAS: 0
  ATM-TC Tx: data cells: 1067512, Idle/Unassigned: 110
  ATM-TC Rx: data cells: 261, uncorr HEC: 6, corr HEC: 0
  ATM-TC Rx: OCD: 0, LCD start: 0, LCD end: 0
Group (1) is Not configured.
```

#### 4.4.4.2 DSL Modem

When using a DSL modem, the CER will normally contain a T1 Frame Relay interface. The T1 Frame Relay is then plugged into the DSL modem. When using a DSL modem, the Frame Relay interface must be shaped to 60% of T1 speed. In addition, CoS1 cannot be greater than 533Kbit/s (equivalent to 24 calls using G729 codec with 30 byte payload). For this configuration, use Frame Relay bandwidth per call numbers.

The policy-map, “DSL-SHAPE” is applied to the Frame Relay subinterface. .

```
interface Serial0/1/0
description - SDSL (DSL Modem) Link
no ip address
encapsulation frame-relay IETF
load-interval 30
!
interface Serial0/1/0.1 point-to-point
ip address <ip address> <subnet>
snmp trap link-status
frame-relay interface-dlci <DCLI> IETF
service-policy output DSL-SHAPE
```

#### 4.4.5 NXT1/E1 MLPPP Access (2 – 8 T1s)

For N X T1 MLPPP access, each individual T1 interface will need to be configured as part of a multilink group.

On an ISR, the first step is define the VWIC2-(1 or 2) MFT-T1/E1 as T1 cards with the command “**card type t1 <slot #>**”. Then the T1 controllers must be configured as shown below. Once the controller cards are configured, serial interfaces which match the T1 controller numbers will appear. Each of these serial interfaces must be configured to be part of a multilink group/interface.

The multilink interface is created first. The IP address and CoS policy, “COS\_MLPPP”, are applied to the multilink interface. The bandwidth statement on the multilink interface is equal to the derived port speed depending on the number of T1 interfaces. In this case, the max-reserved-bandwidth statement set at 100 will insure that the service policy is properly applied to the interface. PPP CHAP is used with the IP address of the Multilink interface.

Then the serial interfaces are configured. The multilink and PPP CHAP commands are applied to each the serial interface into the multilink group.

#### **Example of 4 X T1 MLPPP on ISR:**

```
card type t1 0 0
card type t1 0 1
!
!
controller T1 0/0/0
framing esf
linecode b8zs
```

```
channel-group 0 timeslots 1-24
!
controller T1 0/0/1
framing esf
linecode b8zs
channel-group 0 timeslots 1-24
!
controller T1 0/1/0
framing esf
linecode b8zs
channel-group 0 timeslots 1-24
!
controller T1 0/1/1
framing esf
linecode b8zs
channel-group 0 timeslots 1-24

interface Multilink1
bandwidth <1536 X # of T1s>
ip address <ip address> <mask>
load-interval 30
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
ppp multilink fragment disable
max-reserved-bandwidth 100
service-policy output COS_MLPPP
no peer neighbor-route

interface Serial0/0/0:0
no ip address
encapsulation ppp
load-interval 30
tx-ring-limit 2
```



```
tx-queue-limit 2
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
!
interface Serial0/0/1:0
no ip address
encapsulation ppp
load-interval 30
tx-ring-limit 2
tx-queue-limit 2
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
!
interface Serial0/1/0:0
no ip address
encapsulation ppp
tx-ring-limit 2
tx-queue-limit 2
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
!
interface Serial0/1/1:0
no ip address
encapsulation ppp
tx-ring-limit 2
tx-queue-limit 2
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
```

**Example of 4XT1 MLPPP on 7200:**

```
controller T1 5/0
framing esf
service-type ccs-voice
linecode b8zs
cablelength long 0db
channel-group 0 timeslots 1-24
!
controller T1 5/1
framing esf
service-type ccs-voice
linecode b8zs
cablelength long 0db
channel-group 0 timeslots 1-24
!
controller T1 5/2
framing esf
service-type ccs-voice
linecode b8zs
cablelength long 0db
channel-group 0 timeslots 1-24
!
controller T1 5/3
framing esf
service-type ccs-voice
linecode b8zs
cablelength long 0db
channel-group 0 timeslots 1-24
!

interface Multilink1
bandwidth <1536 X # of T1s>
ip address <ip address> <mask>
load-interval 30
```

```
tx-ring-limit 2
no cdp enable
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
ppp multilink fragment disable
max-reserved-bandwidth 100
service-policy output COS_MLPPP
no peer neighbor-route
!
interface Serial5/0:0
no ip address
encapsulation ppp
load-interval 30
tx-ring-limit 2
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
!
interface Serial5/1:0
no ip address
encapsulation ppp
load-interval 30
tx-ring-limit 2
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
max-reserved-bandwidth 100
!
interface Serial5/2:0
no ip address
encapsulation ppp
load-interval 30
tx-ring-limit 2
```

```
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
!
interface Serial5/3:0
no ip address
encapsulation ppp
load-interval 30
tx-ring-limit 2
ppp chap hostname <CER IP address>
ppp multilink
ppp multilink group 1
```

#### 4.4.6 N X T1 IMA

##### N X T1 IMA on ISR :

1. For N X T1 IMA, each individual T1 interface will need to be configured as part of a multilink group. Define the VWIC2-(1 or 2) MFT-T1/E1 as T1 cards with the command “**card type t1 <slot #>**”.
2. Clocking is performed on the controllers, not the ATM interfaces.
3. T1 parameters are set on the T1 controller lines in the configuration. Line encoding and framing must match your provider’s specifications. Once the controller cards are configured, atm interfaces which match the T1 controller numbers will appear. Each of these atm interfaces must be configured to be part of the IMA group.
4. Use ima-group 0 to identify the first IMA group. This is because the AIM-ATM module, which provides the ATM and IMA features, resides on the router’s processor board and is considered to be “Slot 0”.
5. Keep all T1s in a shutdown state until the IMA group is created.
6. Keep the configuration parameters for all T1 interfaces that belong to the IMA group the same.
7. Define a point-to-point ima group sub-interface for the ATM PVC (i.e. VPI/VCI).
8. Bandwidth applied to the ATM/IMA interface should be 95% of the port speed.
9. The service policy is applied at the subinterface under the pvc statement.
10. PCR and SCR of the vbr-nrt statement should be 95% of the port speed.

##### Example of 4 X T1 IMA on ISR:

```
card type t1 0 1
card type t1 0 3
network-clock-participate wic 1
network-clock-participate wic 3
no network-clock-participate aim 0
```

```
network-clock-select 1 T1 0/1/0
network-clock-select 2 T1 0/3/0
!
controller T1 0/1/0
mode atm aim 0
framing esf
linecode b8zs
cablelength long 0db
!
controller T1 0/1/1
mode atm aim 0
framing esf
linecode b8zs
cablelength long 0db
!
controller T1 0/3/0
mode atm aim 0
framing esf
linecode b8zs
cablelength long 0db
!
controller T1 0/3/1
mode atm aim 0
framing esf
linecode b8zs
cablelength long 0db
!
interface ATM0/1/0
no ip address
no scrambling-payload
ima-group 0
no atm ilmi-keepalive
!
interface ATM0/1/1
```

```
no ip address
no scrambling-payload
ima-group 0
no atm ilmi-keepalive
!
interface ATM0/3/0
no ip address
no scrambling-payload
ima-group 0
no atm ilmi-keepalive
!
interface ATM0/3/1
no ip address
no scrambling-payload
ima-group 0
no atm ilmi-keepalive
!
interface ATM0/IMA0
bandwidth <port speed * .95>
no ip address
ip virtual-reassembly
load-interval 30
ima differential-delay-maximum 50
no atm ilmi-keepalive
!
interface ATM0/IMA0.1 point-to-point
ip address <ip address> <mask>
mtu 1500
ip virtual-reassembly
pvc 1/223
vbr-nrt <port speed * .95> <port speed * .95> 1
tx-ring-limit 3
oam-pvc manage
oam retry 3 5 1
```

```
oam ais-rdi 10 3
encapsulation aal5snap
service-policy output COS
max-reserved-bandwidth 100
```

**N X T1 IMA on 7200:**

1. Use ima-group 0 to identify the first IMA group.
2. Keep all T1s in a shutdown state until the IMA group is created.
3. Define a point-to-point ima group sub-interface for the ATM PVC (i.e. VPI/VCI).
4. Keep the configuration parameters for all interfaces that belong to the IMA group the same.
5. Bandwidth applied to the ATM/IMA interface should be 95% of the port speed.
6. The service policy is applied at the subinterface under the pvc statement.
7. SCR and PCR of the vbr-nrt statement should be 95% of the port speed.

**Example of 4 X T1 IMA on 7200:**

```
interface ATM2/0
no ip address
ima-group 0
!
interface ATM2/1
no ip address
ima-group 0
!
interface ATM2/2
no ip address
ima-group 0
!
interface ATM2/3
no ip address
ima-group 0
!
interface ATM2/ima0
no ip address
ip virtual-reassembly
```

```
load-interval 30
ima active-links-minimum 3
no atm ilmi-keepalive
!
interface ATM2/ima0.1 point-to-point
bandwidth <port speed * .95>
mtu 1500
ip address <ip address> <mask>

ip virtual-reassembly
pvc 1/223
vbr-nrt <port speed * .95> <port speed * .95> 1
tx-ring-limit 3
oam-pvc manage
encapsulation aal5snap
service-policy output COS
```

#### 4.4.7 T3/E3 Frame Relay Encapsulation

For Frame Relay encapsulation configuration, the bandwidth statement must be configured to slightly less than the access speed. Encapsulation should be set to frame-relay. LMI type should be set to Cisco. Configure “frame-relay traffic shaping” under the main interface.

Under the main interface, each subinterface will be configured. Each IP address is configured which should be the CER side of the /30 subnet assigned for the CER/PER link. Each subinterface will be configured with a Frame-Relay Map Class.

#### **Example of T3 Frame Relay encapsulation on ISR with internal DSU (NM-1T3/E3):**

For T3 Frame Relay encapsulation access configuration on an ISR, the NM1T3/E3 “card type” must be set to T3. On the serial interface the DSU bandwidth should be configured for the proper speed. Scrambling should be enabled.

```
card type t3 2
!
controller T3 2/0
framing c-bit
```



```
!  
interface Serial2/0  
bandwidth <Access speed * 98%>  
no ip address  
encapsulation frame-relay  
frame-relay traffic-shaping  
load-interval 30  
dsu bandwidth <interface BW in Kbps>  
scramble  
serial restart-delay 0  
frame-relay lmi-type cisco  
  
!  
interface Serial2/0.1 point-to-point  
ip address <ip address> <mask>  
frame-relay interface-dlci <DLCI> IETF  
frame-relay class <frame-relay map class name #1>  
  
!  
interface Serial2/0.2 point-to-point  
ip address <ip address> <mask>  
frame-relay interface-dlci <DLCI> IETF  
frame-relay class <frame-relay map class name #2>
```

**Example of T3 Frame Relay encapsulation access on 7200 with internal DSU (PA-T3+):**

For T3 Frame Relay encapsulation configuration on a 7200, the configuration of the PA-T3+ card includes the following commands. On the serial interface the DSU bandwidth should be configured for the proper speed. Scrambling and C-bit framing must be enabled.

```
interface Serial4/0  
bandwidth <Access speed * 98%>  
no ip address  
encapsulation frame-relay
```

```
frame-relay traffic-shaping
load-interval 30
dsu bandwidth <interface BW in Kbps>
scramble
framing c-bit
cablelength 10
serial restart-delay 0
frame-relay lmi-type cisco
service-policy output COS
!
interface Serial4/0.1 point-to-point
ip address <ip address> <mask>
frame-relay interface-dlci <DLCI> IETF
frame-relay class <frame-relay map class name #1>
!
interface Serial4/0.2 point-to-point
ip address <ip address> <mask>
frame-relay interface-dlci <DLCI> IETF
frame-relay class <frame-relay map class name #2>
```

#### 4.4.8 OC3/OC12 PPP Access

1. The IP address is configured which should be the CER side of the /30 subnet assigned for the CER/PER link.
2. Encapsulation must be set to PPP.
3. The shaping policy, "PPP\_Shape" is applied to the serial interface.
4. Configure Cyclic Redundancy Check equal to 16 for OC3 and 32 for OC12
5. Sonet framing is enabled by default. This value is sonet in the U.S. and sdh in MoW.
6. Enable the POS scrambling command to allow scrambling of the POS SPE (synchronous payload envelope) payload.
7. Pos Flag should be set to "s1s0 2"

Note: **Sonet framing is enabled by default. This value is sonet in the U.S. and sdh in MoW.**

**Sample OC3/OC12 PPP Configuration for 7200 and 7300 router:**

```
interface POS1/0
ip address <ip address> <subnet mask>
encapsulation ppp
load-interval 30
crc <16 or 32>
post framing <sonet or sdh>
pos scramble-atm
pos flag s1s0 2
max-reserved-bandwidth 100
service-policy output OCX_SHAPE
hold-queue 125 in
```

#### 4.4.9 OC3/OC12 Frame Relay encapsulation

1. The interface bandwidth statement must be configured to the access or VLAN speed.
2. Encapsulation must set to frame-relay.
3. The IP address is configured which should be the CER side of the /30 subnet assigned for the CER/PER link.
4. Configure Cyclic Redundancy Check equal to 16 for OC3 and 32 for OC12
5. Enable the POS scrambling command to allow scrambling of the POS SPE (synchronous payload envelope) payload.

#### **Sample OC3/OC12 Frame Relay encapsulation Configuration for 7200 and 7300 router:**

```
interface POS3/1/0
bandwidth <access or vlan speed>
no ip address
encapsulation frame-relay
load-interval 30
crc 32
pos scramble-atm
max-reserved-bandwidth 100
hold-queue 125 in
!
interface POS3/1/0.1 point-to-point
bandwidth <vlan speed>
ip address 195.18.31.41 255.255.255.252
snmp trap link-status
frame-relay interface-dlci 100 IETF
service-policy output OCX-SHAPE
```

#### 4.4.10 Ethernet Access

For Ethernet access configuration, the interface bandwidth statement must be configured to the access or VLAN speed. The IP address is configured which should be the CER side of the /30 subnet assigned for the CER/PER link. The shaping policy, “Ether-Shape” is applied to the serial interface.

##### **Full port Ethernet:**

Following is a sample port configuration for full port Ethernet:

```
interface GigabitEthernet0/0
bandwidth <Access speed>
ip address <ip address> <mask>
load-interval 30

duplex full    (do not use auto – force full duplex operation)
speed 1000    (10 or 100 are also selectable)
media-type rj45 (default setting – optional sfp or gbic for fiber connectivity)
service-policy output Ether-Shape
```

##### **Single Stack VLAN Tag:**

From testing, this is example using the 2821. A VLAN subinterface is configured using the AT&T supplied VLAN ID tag in the encapsulation command.

```
interface GigabitEthernet0/1
bandwidth <Access or VLAN speed>
no ip address
load-interval 30
duplex full (do not use auto – force full duplex operation)
speed 100 (10 or 1000 are also selectable)
media-type rj45 (default setting – optional sfp or gbic for fiber connectivity)

!
interface GigabitEthernet0/1.201
encapsulation dot1Q <VLAN tag>
ip address <ip address> <mask>
ip virtual-reassembly
service-policy output <policy-map name>
```

\*Note: Shaping % calculations based on this variable.

##### **Dual Stack VLAN Tag:**

A VLAN subinterface is configured using the AT&T supplied VLAN ID tag in the inner tag encapsulation command. The subinterface should also be numbered with the inner VLAN ID tag. The outer tag as supplied by the ESP is added to the encapsulation command. The commands required are as follows:

```
interface GigabitEthernet0/0
no ip address
load-interval 30
duplex full    (do not use auto – force full duplex operation)
speed 1000    (10 or 100 are also selectable)
media-type rj45 (default setting – optional sfp or gbic for fiber connectivity)

interface GigabitEthernet0/0.2004    (set the subinterface numbering to the VLAN tag ID)
encapsulation dot1Q <inner VLAN tag> second-dot1q <outer VLAN tag>
ip address <ip address> <mask>
service-policy output <policy-map name>
```

## 5 Customer Edge Router configurations specific to TDM Gateway

There is configuration required on the CER for both IP–PBX and TDM Gateway solutions. The information below will assist in configuring the CER to insure interoperability with your TDM Gateway environment. For details on configuring a TDM Gateway please refer to the following document: *TDM Gateway Customer Configuration Guide*, specific to your router platform. (<http://www.corp.att.com/bvoip/avpn/implementation/> (login: att, password: attvoip)).

For AT&T certified IP-PBX solution configuration information please reference: *Customer Edge Router Customer Configuration Guide for AT&T Certified IP-PBX Solutions*. (<http://www.corp.att.com/bvoip/avpn/implementation/> (login: att, password: attvoip)).

### 5.1 TDM Gateway combined within CER

The following will assist in configuring the correct routing on the CER with a combined TDM Gateway.

Step 1:

A loopback interface on the CER/TDM Gateway must be configured as the AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free Signaling and Media address. For TDM Gateways, signaling and media use the same IP address, which is a loopback IP address. That loopback address must be advertised by the CER via a BGP network statement:

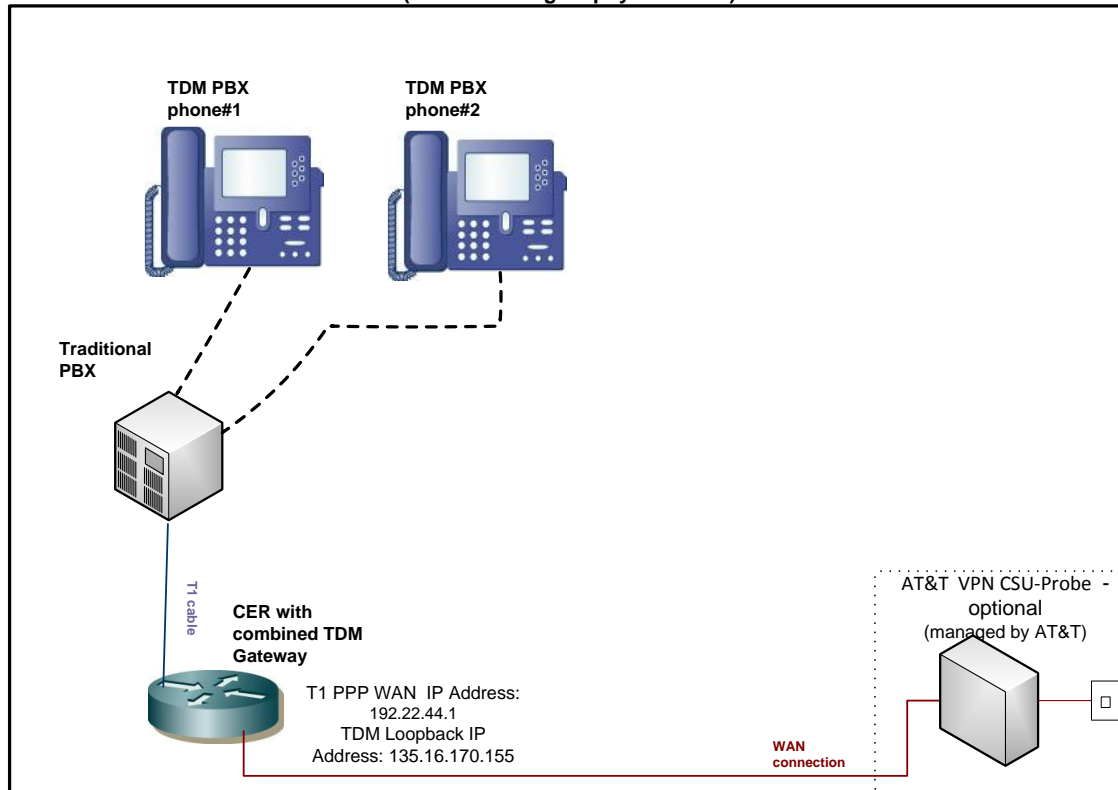
```
router bgp <your AS number>
no synchronization
bgp log-neighbor-changes
network <TDM loopback IP Address> mask 255.255.255.255
neighbor <PER IP address> remote-as <remote AS>
```

AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free on AT&T VPN  
Customer Edge Router Customer Configuration Guide (November 25, 2015, Version 2.6)

```
neighbor <PER IP address> allowas-in  
no auto-summary
```

TDM gateway example diagram:

AT&T IP Flexible Reach Service or AT&T IP Toll-Free on AT&T VPN site  
with VPN CSU-Probe, CER with combined TDM Gateway Router  
(CPE site design – physical view)



CER configuration example: static route and BGP statements:

```
router bgp 6500  
no synchronization  
bgp log-neighbor-changes  
network 135.16.170.155 mask 255.255.255.255  
neighbor 192.22.44.2 remote-as 34000  
neighbor 192.22.44.2 allowas-in  
no auto-summary
```

## Appendix A: Sample ISR and 7200 Router Configurations

In these configurations, commands required for proper voice configuration are bolded.

### **A.1 Frame Relay interface with MLPPP encapsulation & fragmentation (768Kbit/s and less) in front of TDM gateway**

#### **Example on an ISR:**

```
Building configuration...

Current configuration : 10673 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 2811
!
boot-start-marker
boot system flash:c2800-spservicesk9-mz.124-15.T13a.bin
boot-end-marker
!
logging buffered 4096 debugging
enable password 7 070C285F4D06
!
no aaa new-model
!
resource policy
!
ip cef
!
!
!
ip tcp path-mtu-discovery
no ip domain lookup
ip domain name hawaii
ip ssh authentication-retries 5
ip ssh version 2
isdn switch-type primary-4ess
!
!
!
!
!
!
!
username cisco password 7 121A0C041104
username admin privilege 15 password 7 045A1F1203204E5D
```

```
archive
log config
hidekeys
!
!
!
class-map match-any BGP
match access-group name BGP
class-map match-any COS1
match access-group name RTP
match access-group name SIP
class-map match-any COS2
match access-group name COS2-Traffic
match access-group name BGP
class-map match-any COS3
match access-group name COS3-Traffic
!
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
policy-map COS
class COS1
priority 32 4000
set ip dscp ef
compress header ip rtp
class COS2
bandwidth remaining percent 40
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 30
set ip dscp af21
class class-default
bandwidth remaining percent 30
set ip dscp default
!
!
interface FastEthernet0/0 *Faces SBC*
ip address 172.22.16.1 255.255.255.0
load-interval 30
speed 100
full-duplex
!
!
interface Serial0/2/0
no ip address
encapsulation frame-relay IETF
no ip mroute-cache
load-interval 30
frame-relay traffic-shaping
frame-relay lmi-type cisco
hold-queue 32 out
!
interface Serial0/2/0.1 point-to-point
```



```
bandwidth 115
frame-relay class shape128
frame-relay interface-dlci 99 ppp Virtual-Template1
!
interface Serial0/2/1
no ip address
clock rate 2000000
!
interface Virtual-Template1
bandwidth 115
ip address 195.18.40.2 255.255.255.252
load-interval 30
ppp multilink
ppp multilink interleave
ppp multilink fragment delay 11
max-reserved-bandwidth 100
service-policy output COS
!
router bgp 65000
no synchronization
bgp router-id 195.18.40.2
bgp log-neighbor-changes
network 135.16.170.2 mask 255.255.255.255
network 172.22.16.0 mask 255.255.255.0
network 32.252.97.40 mask 255.255.255.252
neighbor 195.18.40.1 remote-as 13979
neighbor 195.18.40.1 allowas-in
no auto-summary
!
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2 *Route to SBC*
!
!
!
ip http server
ip http authentication local
no ip http secure-server
!
!
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
ip access-list extended COS2-Traffic
permit udp any any eq 2082
permit udp any eq 2082 any
ip access-list extended COS3-Traffic
permit udp any any eq 2083
permit udp any eq 2083 any
```

```
!  
!  
map-class frame-relay shape128  
frame-relay cir 115000  
frame-relay bc 1150  
frame-relay be 0  
frame-relay mincir 115000  
disable-eadi  
!  
!  
control-plane  
!  
!  
line con 0  
exec-timeout 300 0  
line aux 0  
line vty 0 4  
privilege level 15  
password 7 0207104F07070D32  
login local  
transport input ssh  
!  
scheduler allocate 20000 1000  
end
```

## ***A.2 Standard Frame Relay interface (T1 speeds: 1024 to 1536Kbit/s; and T3 speeds) in front of TDM gateway***

### **Example of T1 Speed on ISR:**

```
Building configuration...

Current configuration : 9113 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 2821
!
boot-start-marker
boot system flash:c2800nm-spservicesk9-mz.124-15.T13a.bin
boot-end-marker
!
enable password 7 1511021F0725
!
no aaa new-model
!
resource policy
!
network-clock-switch never never
ip tcp path-mtu-discovery
!
!
ip cef
!
!
no ip domain lookup
ip domain name hawaii
ip ssh authentication-retries 5
ip ssh version 2
isdn switch-type primary-5ess
!
!
!
!
username admin privilege 15 password 7 11080D111B13091F
!
!
!
!
class-map match-any BGP
match access-group name BGP
class-map match-any COS1
match access-group name RTP
```

```
match access-group name SIP
class-map match-any COS2
match access-group name COS2-Traffic
match access-group name BGP
class-map match-any COS3
match access-group name COS3-Traffic
!
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
policy-map COS
class COS1
priority 160 20000
set ip dscp ef
class COS2
bandwidth remaining percent 40
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 30
set ip dscp af21
class class-default
bandwidth remaining percent 30
set ip dscp default
!
!
!
!
!
!
interface GigabitEthernet0/0  **faces TDM GW**
ip address 172.22.16.1 255.255.255.0
duplex full
speed 100
!
!
interface Serial0/2/0
no ip address
encapsulation frame-relay IETF
no ip mroute-cache
load-interval 30
tx-ring-limit 2
tx-queue-limit 2
no fair-queue
frame-relay traffic-shaping
max-reserved-bandwidth 100
hold-queue 32 out
!
interface Serial0/2/0.1 point-to-point
bandwidth 1382
ip address 196.96.1.17 255.255.255.252
ip nat outside
frame-relay class shape1536K
frame-relay interface-dlci 103 IETF
```

```
!  
!  
!  
router bgp 65000  
no synchronization  
bgp router-id 196.96.1.17  
bgp log-neighbor-changes  
network 135.16.170.2 mask 255.255.255.255  
network 172.22.16.0 mask 255.255.255.0  
network 32.252.97.1 mask 255.255.255.255  
neighbor 196.96.1.18 remote-as 13979  
neighbor 196.96.1.18 allowas-in  
no auto-summary  
!  
!  
ip route 135.16.170.2 255.255.255.255 172.22.16.2 *Route to TDM GW loopback*  
!  
!  
ip access-list extended BGP  
permit tcp any eq bgp any  
permit tcp any any eq bgp  
ip access-list extended RTP  
permit udp any range 16384 32767 any range 16384 32767  
ip access-list extended SIP  
permit udp any eq 5060 any  
permit udp any any eq 5060  
permit tcp any eq 5060 any  
permit tcp any any eq 5060  
ip access-list extended COS2-Traffic  
permit udp any any eq 2082  
permit udp any eq 2082 any  
ip access-list extended COS3-Traffic  
permit udp any any eq 2083  
permit udp any eq 2083 any  
!  
!  
map-class frame-relay shape1536K  
frame-relay cir 1382000  
frame-relay bc 13820  
frame-relay be 0  
frame-relay mincir 1382000  
service-policy output COS  
!  
!  
!  
control-plane  
!  
!  
!  
!
```

Note: Frame Relay BC for port speeds 2Mbit/s and lower is  $(CIR*.9)/100$ . FR BC for port speeds higher than 2Mbit/s is  $(CIR*.95)/250$  – rounded up to nearest 128.

```
line con 0
exec-timeout 0 0
password 7 070C285F4D06
line aux 0
line vty 0 4
exec-timeout 300 0
password 7 1416061F00052838
login local
transport input ssh
!
scheduler allocate 20000 1000
!
end
```

### Example of T3 Speed on ISR:

```
Building configuration...

Current configuration : 3408 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname 3825
!
boot-start-marker
boot-end-marker
!
card type t3 2
!
no aaa new-model
!
resource policy
!
!
!
ip cef
!
!
no ip domain lookup
!
!
!
!
controller T3 2/0
!
class-map match-any BGP
match access-group name BGP
class-map match-any COS3
match access-group name COS3-Traffic
class-map match-any COS2
match access-group name COS2-Traffic
```

```
match access-group name BGP
class-map match-any COS1
match access-group name RTP
match access-group name SIP
!
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
policy-map COS
class COS1
priority 4400 550000
set ip dscp ef
class COS2
bandwidth remaining percent 40
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 30
set ip dscp af21
class class-default
bandwidth remaining percent 30
set ip dscp default
!
!
!
interface GigabitEthernet0/1 *Facing TDM gateway*
ip address 172.22.16.1 255.255.255.0
duplex full
speed 100
media-type rj45
no negotiation auto
no keepalive
!
!
interface Serial2/0
no ip address
encapsulation frame-relay
load-interval 30
dsu bandwidth 44210
frame-relay traffic-shaping
frame-relay lmi-type cisco
max-reserved-bandwidth 100
!
interface Serial2/0.1 point-to-point
bandwidth 41999
ip address 192.168.200.5 255.255.255.252
ip nat outside
no cdp enable
frame-relay class shape_44M
frame-relay interface-dlci 120 IETF
!
router bgp 65000
no synchronization
```

```
bgp router-id 192.168.200.5
bgp log-neighbor-changes
network 135.16.170.2 mask 255.255.255.255
network 172.22.16.0 mask 255.255.255.0
network 32.252.97.1 mask 255.255.255.255
neighbor 192.168.200.6 remote-as 13979
neighbor 192.168.200.6 allowas-in
no auto-summary
!
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2 **Route to TDM gateway loopback**
!
ip http server
no ip http secure-server
!
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended COS2-Traffic
permit udp any any eq 2082
permit udp any eq 2082 any
ip access-list extended COS3-Traffic
permit udp any any eq 2083
permit udp any eq 2083 any
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
!
!
map-class frame-relay shape_44M
frame-relay cir 41999000
frame-relay bc 168064
frame-relay be 0
frame-relay mincir 41999000
service-policy output COS
!
!
control-plane
!
!
!
line con 0
line aux 0
line 194
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
```

Note: Frame Relay BC for port speeds 2Mbit/s and lower is  $(CIR * .9) / 100$ . FR BC for port speeds higher than 2Mbit/s is  $(CIR * .95) / 250$  – rounded up to nearest 128.



```
line vty 0 4
 login
 !
 scheduler allocate 20000 1000
 !
 end
```

### Example of T3 Speed on 7200:

```
Building configuration...

Current configuration : 3092 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname 7200
!
boot-start-marker
boot system disk2:c7200-spservicesk9-mz.124-15.T13a.bin
boot-end-marker
!
enable password cisco
!
no aaa new-model
!
resource policy
!
ip cef
!
!
!
class-map match-any BGP
  match access-group name BGP
class-map match-any COS3
  match access-group name COS3-Traffic
class-map match-any COS2
  match access-group name COS2-Traffic
  match access-group name BGP
class-map match-any COS1
  match access-group name RTP
  match access-group name SIP
!
!
policy-map MARK-BGP
  class BGP
    set ip dscp cs6
policy-map COS
  class COS1
    priority 4400 550000
    set ip dscp ef
  class COS2
    bandwidth remaining percent 40
```

```
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 30
set ip dscp af21
class class-default
bandwidth remaining percent 30
set ip dscp default

!
!
!
!
interface FastEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface FastEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1 **Facing TDM gateway**
ip address 172.22.16.1 255.255.255.0
duplex full
speed 100
media-type rj45
negotiation auto
!
!
interface GigabitEthernet0/3
no ip address
shutdown
duplex auto
speed auto
media-type rj45
no negotiation auto
!
interface Serial4/0
no ip address
encapsulation frame-relay
load-interval 30
dsu bandwidth 44210
framing c-bit
cablelength 10
frame-relay traffic-shaping
frame-relay lmi-type cisco
max-reserved-bandwidth 100
!
interface Serial4/0.1 point-to-point
bandwidth 41999
ip address 192.168.200.5 255.255.255.252
```

```
ip nat outside
no cdp enable
frame-relay class shape_44M
frame-relay interface-dlci 120 IETF
!
router bgp 65000
no synchronization
bgp router-id 192.168.200.5
bgp log-neighbor-changes
network 135.16.170.2 mask 255.255.255.255
network 172.22.16.0 mask 255.255.255.0
network 32.252.97.1 mask 255.255.255.255
neighbor 192.168.200.6 remote-as 13979
neighbor 192.168.200.6 allowas-in
no auto-summary
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2 *Route to TDM gateway loopback**
!
!
!
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended COS2-Traffic
permit udp any any eq 2082
permit udp any eq 2082 any
ip access-list extended COS3-Traffic
permit udp any any eq 2083
permit udp any eq 2083 any
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
!
!
map-class frame-relay shape_44M
frame-relay cir 41999000
frame-relay bc 168064
frame-relay be 0
frame-relay mincir 41999000
service-policy output COS
logging alarm informational
!
!
control-plane
!
!
!gatekeeper
shutdown
!
!
line con 0
```

Note: Frame Relay BC for port speeds 2Mbit/s and lower is  $(CIR*.9)/100$ . FR BC for port speeds higher than 2Mbit/s is  $(CIR*.95)/250$  – rounded up to nearest 128.

```
stopbits 1
line aux 0
stopbits 1
line vty 0 4
login
!
!
```

### **A.3 N X T1 MLPPP Access (2-4 T1s) in front of TDM gateway**

#### **Example of 4 X T1 MLPPP on ISR:**

```
Building configuration...

Current configuration : 11100 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 2821
!
boot-start-marker
boot system flash:c2800nm-adventerprisek9-mz.124-15.T13a.bin
boot-end-marker
!
card type t1 0 0
card type t1 0 1
logging buffered 51200 warnings
enable password 7 0820585A05180704
!
no aaa new-model
!
resource policy
!
no network-clock-participate wic 0
no network-clock-participate wic 1
ip tcp path-mtu-discovery
!
!
ip cef
!
!
no ip domain lookup
ip ssh authentication-retries 5
ip ssh version 2
!
!
voice-card 0
no dspfarm
!
voice-card 1
```

```
no dspfarm
!  
!  
!  
controller T1 0/0/0  
framing esf  
linecode b8zs  
channel-group 0 timeslots 1-24  
!  
controller T1 0/0/1  
framing esf  
linecode b8zs  
channel-group 0 timeslots 1-24  
!  
controller T1 0/1/0  
framing esf  
linecode b8zs  
channel-group 0 timeslots 1-24  
!  
controller T1 0/1/1  
framing esf  
linecode b8zs  
channel-group 0 timeslots 1-24  
!  
class-map match-any BGP  
match access-group name BGP  
class-map match-any COS3  
match access-group name COS3-Traffic  
class-map match-any COS2  
match access-group name COS2-Traffic  
match access-group name BGP  
class-map match-any COS1  
match access-group name RTP  
match access-group name SIP  
match access-group name SCCP  
match access-group name H323  
!  
!  
policy-map MARK-BGP  
class BGP  
set ip dscp cs6  
policy-map COS_MLPPP  
class COS1  
priority 4928 616000  
set ip dscp ef  
class COS2  
bandwidth remaining percent 60  
set ip dscp af31  
service-policy MARK-BGP  
class COS3  
bandwidth remaining percent 30  
set ip dscp af21  
class class-default  
bandwidth remaining percent 30  
set ip dscp default
```

```
!  
!  
!  
interface Multilink1  
bandwidth 6144  
ip address 192.168.200.1 255.255.255.252  
ip nat outside  
ip virtual-reassembly  
load-interval 30  
no cdp enable  
ppp chap hostname 192.168.200.1  
ppp multilink  
ppp multilink group 1  
ppp multilink fragment disable  
max-reserved-bandwidth 100  
service-policy output COS_MLPPP  
!  
interface GigabitEthernet0/0 **Facing TDM gateway**  
ip address 172.22.16.1 255.255.0.0  
ip virtual-reassembly  
duplex full  
speed 100  
no keepalive  
!  
!  
interface Serial0/0/0:0  
no ip address  
ip virtual-reassembly  
encapsulation ppp  
load-interval 30  
tx-ring-limit 2  
tx-queue-limit 2  
ppp chap hostname 192.168.200.1  
ppp multilink  
ppp multilink group 1  
max-reserved-bandwidth 100  
!  
interface Serial0/0/1:0  
no ip address  
ip virtual-reassembly  
encapsulation ppp  
load-interval 30  
tx-ring-limit 2  
tx-queue-limit 2  
ppp chap hostname 192.168.200.1  
ppp multilink  
ppp multilink group 1  
max-reserved-bandwidth 100  
!  
interface Serial0/1/0:0  
no ip address  
ip virtual-reassembly  
encapsulation ppp  
tx-ring-limit 2
```

```
tx-queue-limit 2
ppp chap hostname 192.168.200.1
ppp multilink
ppp multilink group 1
max-reserved-bandwidth 100
!
interface Serial0/1/1:0
no ip address
ip virtual-reassembly
encapsulation ppp
tx-ring-limit 2
tx-queue-limit 2
ppp chap hostname 192.168.200.1
ppp multilink
ppp multilink group 1
max-reserved-bandwidth 100
!
!
router bgp 65000
no synchronization
bgp router-id 192.168.200.1
bgp log-neighbor-changes
network 135.16.170.2 mask 255.255.255.255
network 172.22.16.0 mask 255.255.255.0
network 32.252.97.1 mask 255.255.255.255
neighbor 192.168.200.2 remote-as 13979
neighbor 192.168.200.2 allowas-in
no auto-summary
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2 **Route to TDM gateway loopback**
!
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended COS2-Traffic
permit udp any any eq 2082
permit udp any eq 2082 any
ip access-list extended COS3-Traffic
permit udp any any eq 2083
permit udp any eq 2083 any
ip access-list extended COS4-Traffic
permit ip any any
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
!
!
control-plane
!
!
```

```
!  
!  
!  
line con 0  
line aux 0  
session-timeout 120  
exec-timeout 120 0  
line vty 0 4  
exec-timeout 300 0  
password 7 00050712085A0915  
login local  
transport input telnet ssh  
!  
scheduler allocate 20000 1000  
!  
webvpn context Default_context  
ssl authenticate verify all  
!  
no inservice  
!  
!  
end
```



#### **A.4 PPP Access (T1 speeds: 1024 to 1536Kbit/s; and T3 speeds) in front of TDM gateway**

##### **Example of T1 speed on ISR:**

```
Building configuration...

Current configuration : 6585 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 2821
!
boot-start-marker
boot system flash:c2800nm-spservicesk9-mz.124-15.T13a.bin
boot-end-marker
!
enable password 7 121811031E0A0E17
!
no aaa new-model
!
resource policy
!
ip tcp path-mtu-discovery
!
!
ip cef
!
!
no ip domain lookup
ip domain name hawaii
ip ssh authentication-retries 5
ip ssh version 2
!
!
!
!
!
username admin password 7 050A121B2D4D4C1A
!
!
class-map match-any BGP
match access-group name BGP
class-map match-any COS3
match access-group name COS3-Traffic
class-map match-any COS2
match access-group name COS2-Traffic
match access-group name BGP
class-map match-any COS1
match access-group name RTP
```

```
match access-group name SIP
!
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
policy-map COSPPP
class COS1
priority 1280 160000
set ip dscp ef
class COS2
bandwidth remaining percent 40
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 30
set ip dscp af21
class class-default
bandwidth remaining percent 30
set ip dscp default
policy-map PPP
class class-default
shape average 1456000 14560 0
shape max-buffers 4096
service-policy COSPPP
!
!
interface GigabitEthernet0/0 **Facing TDM gateway**
ip address 172.22.16.1 255.255.255.0
load-interval 30
duplex full
speed 100
max-reserved-bandwidth 100
!
!
interface Serial0/1/0
ip address 192.168.100.1 255.255.255.252
ip nat outside
no ip redirects
encapsulation ppp
no ip mroute-cache
load-interval 30
max-reserved-bandwidth 100
service-policy output PPP
!
!
interface Serial0/1/1
no ip address
load-interval 30
shutdown
no fair-queue
!
router bgp 65000
no synchronization
```

Shape Average Bits per interval for port speeds 2Mbit/s and lower is  $(CIR*.95)/100$ . Bits per interval for port speeds higher than 2Mbit/s is  $(CIR*.95)/250$  – rounded up to nearest 128.

```
bgp router-id 192.168.100.1
bgp log-neighbor-changes
network 135.16.170.2 mask 255.255.255.255
network 172.22.16.0 mask 255.255.255.0
network 32.252.97.1 mask 255.255.255.255
neighbor 192.168.100.2 remote-as 13979
neighbor 192.168.100.2 allowas-in
no auto-summary
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2 **Route to TDM gateway loopback**
!
!
!
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended COS2-Traffic
permit udp any any eq 2082
permit udp any eq 2082 any
ip access-list extended COS3-Traffic
permit udp any any eq 2083
permit udp any eq 2083 any
ip access-list extended COS4-Traffic
permit ip any any
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
!
!
!
!
control-plane
!
!
!
line con 0
line aux 0
line vty 0 4
exec-timeout 300 0
password 7 121811031E0A0E17
login local
transport input ssh
!
scheduler allocate 20000 1000
!
end
```

**Example of T3 Speed on ISR:**

Building configuration...

Current configuration : 2895 bytes

```
!  
version 12.4  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname 3825  
!  
boot-start-marker  
boot-end-marker  
!  
card type t3 1  
enable password cisco  
!  
no aaa new-model  
!  
resource policy  
!  
no network-clock-participate wic 3  
no network-clock-participate aim 0  
!  
!  
ip cef  
!  
!  
no ip domain lookup  
voice-card 0  
no dspfarm  
!  
!  
!  
!  
controller T3 1/0  
!  
class-map match-any BGP  
  match access-group name BGP  
class-map match-any COS3  
  match access-group name COS3-Traffic  
class-map match-any COS2  
  match access-group name COS2-Traffic  
  match access-group name BGP  
class-map match-any COS1  
  match access-group name RTP  
  match access-group name SIP  
!  
!  
policy-map MARK-BGP  
  class BGP  
    set ip dscp cs6  
policy-map COS  
  class COS1
```

```
priority 26560 2000000
set ip dscp ef
class COS2
bandwidth remaining percent 40
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 30
set ip dscp af21
class class-default
bandwidth remaining percent 30
set ip dscp default
policy-map SHAPE_PPP
class class-default
shape average 41992000 168064 0
shape max-buffers 4096
service-policy COS
```

Shape Average Bits per interval for port speeds 2Mbit/s and lower is  $(CIR*.95)/100$ . Bits per interval for port speeds higher than 2Mbit/s is  $(CIR*.95)/250$

```
!
!
!
interface GigabitEthernet0/0 **Facing TDM gateway**
ip address 172.22.16.1 255.255.255.0
duplex full
speed 100
media-type rj45
negotiation auto
!
!
interface Serial1/0
ip address 192.168.200.9 255.255.255.252
ip nat outside
encapsulation ppp
crc 32
load-interval 30
dsu bandwidth 44210
scramble
max-reserved-bandwidth 100
service-policy output SHAPE_PPP
!
router bgp 65000
no synchronization
bgp router-id 192.168.200.9
bgp log-neighbor-changes
network 135.16.170.2 mask 255.255.255.255
network 172.22.16.0 mask 255.255.255.0
network 32.252.97.1 mask 255.255.255.255
neighbor 192.168.200.10 remote-as 13979
neighbor 192.168.200.10 allowas-in
no auto-summary
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2 **Route to TDM gateway loopback**
!
!
ip access-list extended BGP
permit tcp any eq bgp any
```

```
permit tcp any any eq bgp
ip access-list extended COS2-Traffic
permit udp any any eq 2082
permit udp any eq 2082 any
ip access-list extended COS3-Traffic
permit udp any any eq 2083
permit udp any eq 2083 any
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
!
!
control-plane
!
!
!
!
line con 0
line aux 0
line vty 0 4
password cisco
login
!
scheduler allocate 20000 1000
!
end
```

### Example of T3 Speed on 7200:

```
Building configuration...

Current configuration : 3107 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname 7200
!
boot-start-marker
boot system disk2:c7200-spservicesk9-mz.124-15.T13a.bin
boot-end-marker
!
enable password cisco
!
no aaa new-model
!
```

```
resource policy
!
ip cef
!
!
!
!
class-map match-any BGP
match access-group name BGP
class-map match-any COS3
match access-group name COS3-Traffic
class-map match-any COS2
match access-group name COS2-Traffic
match access-group name BGP
class-map match-any COS1
match access-group name RTP
match access-group name SIP
!
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
policy-map COS
class COS1
priority 26560 2000000
set ip dscp ef
class COS2
bandwidth remaining percent 40
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 30
set ip dscp af21
class class-default
bandwidth remaining percent 30
set ip dscp default
policy-map SHAPE_PPP
class class-default
shape average 41992000 168064 0
shape max-buffers 4096
service-policy COS
!
!
!
!
interface FastEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface FastEthernet0/1
no ip address
shutdown
duplex auto
```

Shape Average Bits per interval for port speeds 2Mbit/s and lower is  $(CIR \cdot .95) / 100$ . Bits per interval for port speeds higher than 2Mbit/s is  $(CIR \cdot .95) / 250$  – rounded up to nearest 128.

```
speed auto
!  
interface GigabitEthernet0/1 **Facing TDM gateway**  
ip address 172.22.16.1 255.255.255.0  
duplex full  
speed 100  
media-type rj45  
negotiation auto  
!  
interface GigabitEthernet0/3  
no ip address  
shutdown  
duplex auto  
speed auto  
media-type rj45  
no negotiation auto  
!  
interface Serial4/0  
ip address 192.168.200.9 255.255.255.252  
ip nat outside  
encapsulation ppp  
load-interval 30  
dsu bandwidth 44210  
scramble  
framing c-bit  
cablelength 10  
serial restart-delay 0  
max-reserved-bandwidth 100  
service-policy output SHAPE_PPP  
!  
router bgp 65000  
no synchronization  
bgp log-neighbor-changes  
network 135.16.170.2 mask 255.255.255.255  
network 172.22.16.0 mask 255.255.255.0  
network 32.252.97.1 mask 255.255.255.255  
neighbor 192.168.200.10 remote-as 13979  
neighbor 192.168.200.10 allowas-in  
no auto-summary  
!  
ip route 135.16.170.2 255.255.255.255 172.22.16.2 **Route to TDM gateway loopback**  
!  
!  
!  
ip access-list extended BGP  
permit tcp any eq bgp any  
permit tcp any any eq bgp  
ip access-list extended COS2-Traffic  
permit udp any any eq 2082  
permit udp any eq 2082 any  
ip access-list extended COS3-Traffic  
permit udp any any eq 2083  
permit udp any eq 2083 any  
ip access-list extended RTP  
permit udp any range 16384 32767 any range 16384 32767
```



```
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
!
!
control-plane
!
!
!
!
!
!
gatekeeper
shutdown
!
!
line con 0
stopbits 1
line aux 0
stopbits 1
line vty 0 4
login
!
!
end
```

### **A.5 COS6 sample configuration in front of TDM gateway**

```
Building configuration...

Current configuration : 5969 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
!
boot-start-marker
boot system disk2:c7200-adventerprisek9-mz.124-15.T13a.bin
boot-end-marker
!
!
no aaa new-model
dspint DSPfarm2/0
!
dspint DSPfarm3/0
!
ip cef
!
!
!
!
class-map match-any BGP
match access-group name BGP
class-map match-any COS1
match access-group name RTP
match access-group name SIP
class-map match-any COS2
match access-group name COS2-Traffic
match access-group name BGP
class-map match-any COS2V
match access-group name COS2V-Traffic
class-map match-any COS3
match access-group name COS3-Traffic
class-map match-any COS5
match access-group name COS5-Traffic
!
!
policy-map MARK-BGP
class BGP
set ip dscp cs6
policy-map ATM_T3
class COS1
priority 3000 375000
set ip dscp ef
class COS2V
bandwidth remaining percent 25
set ip dscp af41
class COS2
```

```
bandwidth remaining percent 50
set ip dscp af31
service-policy MARK-BGP
class COS3
bandwidth remaining percent 15
set ip dscp af21
class COS5
bandwidth remaining percent 1
set ip dscp af11
class class-default
bandwidth remaining percent 9
set ip dscp default
!
!
!
!
interface FastEthernet0/0
no ip address
duplex full
speed 100
!
interface FastEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
description Facing TDM gateway
ip address 172.22.16.1 255.255.255.0
duplex full
speed 100
media-type rj45
no negotiation auto
!
!
interface GigabitEthernet0/3
no ip address
duplex full
speed 100
media-type rj45
no negotiation auto
!
!
!
interface ATM6/0
no ip address
load-interval 30
atm scrambling cell-payload
no atm ilmi-keepalive
!
interface ATM6/0.1 point-to-point
mtu 1500
ip address 195.18.18.2 255.255.255.0
ip nat outside
```

```
ip virtual-reassembly
pvc 1/313
vbr-nrt 5000 5000 1
tx-ring-limit 10
vc-hold-queue 2048
oam-pvc manage
oam retry 3 5 1
oam ais-rdi 10 3
encapsulation aal5snap
service-policy output ATM_T3
max-reserved-bandwidth 100
!
!
router bgp 65000
no synchronization
bgp log-neighbor-changes
network 135.16.170.2 mask 255.255.255.255
network 172.22.16.0 mask 255.255.255.0
network 32.252.97.1 mask 255.255.255.255
neighbor 195.18.18.1 remote-as 13979
neighbor 195.18.18.1 allowas-in
no auto-summary
!
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2 **Route to TDM gateway loopback**
!
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
ip access-list extended COS2-Traffic
permit udp any any eq 2082
permit udp any eq 2082 any
permit tcp any any eq www
permit tcp any eq www any
ip access-list extended COS2V-Traffic
permit tcp any any range 3230 3231
permit udp any any range 3230 3235
ip access-list extended COS3-Traffic
permit udp any any eq 2083
permit udp any eq 2083 any
permit tcp any any eq smtp
permit tcp any eq smtp any
ip access-list extended COS5-Traffic
permit udp any any eq 110
permit udp any eq 110 any
permit tcp any any eq pop3
permit tcp any eq pop3 any
!
```

AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free on AT&T VPN  
Customer Edge Router Customer Configuration Guide (November 25, 2015, Version 2.6)

```
!  
!  
gatekeeper  
shutdown  
!  
!  
line con 0  
stopbits 1  
line aux 0  
stopbits 1  
line vty 0 4  
password cisco  
login  
!  
!  
end
```

## Appendix B : Sample 7300 Router Configurations

7300 routers are unique devices and therefore warrant their own section. 7300 routers were tested with 12.2.(33) SB9. Note that QOS configs for 7300 are different than for ISR/7200 routers.

### B.1 Example of E3/T3 ATM

```
ip access-list extended BGP
 permit tcp any eq bgp any
 permit tcp any any eq bgp
ip access-list extended RTP
 permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SCCP
 permit tcp any range 2000 2003 any
 permit tcp any any range 2000 2003
ip access-list extended SIP
 permit udp any eq 5060 any
 permit udp any any eq 5060
 permit tcp any eq 5060 any
 permit tcp any any eq 5060
ip access-list extended COS2-Traffic
 permit tcp any any eq www <sample only – COS2 customer defined>
 permit tcp any eq www any <sample only – COS2 customer defined>
ip access-list extended COS3-Traffic
 permit tcp any any eq smtp <sample only – COS3 customer defined>
 permit tcp any eq smtp any <sample only – COS3 customer defined>
!
class-map match-any BGP
 match access-group name BGP
class-map match-any COS1
 match access-group name RTP
 match access-group name SIP
 match access-group name SCCP
class-map match-any COS2
```

```
match access-group name COS2-Traffic
match access-group name BGP
class-map match-any COS3
  match access-group name COS3-Traffic
!
policy-map MARK-BGP
  class BGP
    police 8000 8000 8000 conform-action set-dscp-transmit cs6 exceed-action set-dscp-
transmit cs6 violate-action set-dscp-transmit cs6
policy-map COS
  class COS1
    priority
    police <COS1 Bandwidth> <Burst Size> conform-action set-dscp-transmit ef exceed-action
drop
  class COS2
    bandwidth remaining percent <COS2%>
    set ip dscp af31
    service-policy MARK-BGP
  class COS3
    bandwidth remaining percent <COS3%>
    set ip dscp af21
  class class-default
    bandwidth remaining percent <COS4%>
    set ip dscp default
!
interface ATM5/0
  bandwidth <port speed * .95>
  no ip address
  load-interval 30
  no atm scrambling cell-payload
  no atm ilmi-keepalive
  no atm enable-ilmi-trap
  max-reserved-bandwidth 100
!
interface ATM5/0.1 point-to-point
```

Police rate of 8000 for BGP traffic is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

Burst interval for COS1 should always be set to 1 second.

```
mtu 1500
ip address <ip address> <mask>
ip nat outside
no atm enable-ilmi-trap
pvc 0/311
vbr-nrt <port speed * .95> <port speed * .95> 1
oam-pvc manage
oam ais-rdi 10 3
encapsulation aal5snap
service-policy out COS
```

## B.2 Example of T3 PPP

For T3 PPP access, a shaping policy map is applied directly to the PPP interface. The COS policy map is then applied to the shaping policy map.

```
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SCCP
permit tcp any range 2000 2003 any
permit tcp any any range 2000 2003
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
ip access-list extended COS2-Traffic
permit tcp any any eq www <sample only – COS2 customer defined>
permit tcp any eq www any <sample only – COS2 customer defined>
ip access-list extended COS3-Traffic
permit tcp any any eq smtp <sample only – COS3 customer defined>
permit tcp any eq smtp any <sample only – COS2 customer defined>
!
```



```
!  
class-map match-any BGP  
  match access-group name BGP  
class-map match-any COS3  
  match access-group name COS3-Traffic  
class-map match-any COS2  
  match access-group name COS2-Traffic  
  match access-group name BGP  
class-map match-any COS1  
  match access-group name RTP  
  match access-group name SIP  
  match access-group name SCCP  
  
policy-map MARK-BGP  
  class BGP  
    police 8000 conform-action set-dscp-transmit cs6 exceed-action set-dscp-transmit cs6  
    violate-action set-dscp-transmit cs6  
  class class-default  
    police 8000 conform-action set-dscp-transmit af31 exceed-action set-dscp-transmit af31  
  
policy-map COS_DS3  
  class COS1  
    priority  
    police <COS1 Bandwidth> <Burst Size> conform-action set-dscp-transmit ef exceed-action  
drop  
  class COS2  
    bandwidth remaining percent <COS2%>  
  service-policy MARK-BGP  
  class COS3  
    bandwidth remaining percent <COS3%>  
    police 8000 conform-action set-dscp-transmit af21 exceed-action set-dscp-transmit af21  
  class class-default  
    bandwidth remaining percent <COS4%>  
    police 8000 conform-action set-dscp-transmit default exceed-action set-dscp-transmit  
default  
!
```

Police rate of 8000 for BGP traffic is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

Police rate of 8000 for COS2 default traffic is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

Police rate of 8000 for COS3 traffic is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

Police rate of 8000 for COS4 traffic is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

```
policy-map Shaping_PPP
class class-default
  shape average <Port Speed * .95> <(Port Speed * .95) / 250> 0
  service-policy COS_DS3
!
interface Serial5/0
ip address <ip address> <mask>
encapsulation ppp
load-interval 30
keepalive 10 3
dsu bandwidth <interface BW in Kbps>
framing c-bit
cablelength 10
max-reserved-bandwidth 100
service-policy output Shaping_PPP
```

!

### B.3 Example of T3/E3 Frame Relay

```
ip access-list extended BGP
permit tcp any eq bgp any
permit tcp any any eq bgp
ip access-list extended RTP
permit udp any range 16384 32767 any range 16384 32767
ip access-list extended SCCP
permit tcp any range 2000 2003 any
permit tcp any any range 2000 2003
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
ip access-list extended COS2-Traffic
permit tcp any any eq www <sample only – COS2 customer defined>
permit tcp any eq www any <sample only – COS2 customer defined>
```

```
ip access-list extended COS3-Traffic
permit tcp any any eq smtp <sample only – COS3 customer defined>
permit tcp any eq smtp any <sample only – COS3 customer defined>
!
class-map match-any BGP
  match access-group name BGP
class-map match-any COS1
  match access-group name RTP
  match access-group name SIP
  match access-group name SCCP
class-map match-any COS2
  match access-group name COS2-Traffic
  match access-group name BGP
class-map match-any COS3
  match access-group name COS3-Traffic
!
policy-map MARK-BGP
  class BGP
    police 8000 conform-action set-dscp-transmit cs6 exceed-action set-dscp-transmit cs6
  class class-default
    police 8000 conform-action set-dscp-transmit af31 exceed-action set-dscp-transmit af31
policy-map COS
  class COS1
    priority
    police <COS1 BW> <Burst size> conform-action set-dscp-transmit ef exceed-action drop
  class COS2
    bandwidth remaining percent <COS2%>
    service-policy MARK-BGP
  class COS3
    bandwidth remaining percent <COS3%>
    police 8000 conform-action set-dscp-transmit af21 exceed-action set-dscp-transmit af21
  class class-default
    bandwidth remaining percent <COS4%>
    police 8000 conform-action set-dscp-transmit default exceed-action set-dscp-transmit
    default
```

Police rate of 8000 for BGP traffic is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

Police rate of 8000 is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

```
!  
policy-map 7304-test  
  class class-default  
    shape average <Port Speed * .95> <(Port Speed * .95)/250> 0  
    service-policy COS  
!  
interface Serial5/0  
  mtu 1500  
  no ip address  
  encapsulation frame-relay  
  load-interval 30  
  framing g751 *required for E3 FR*  
  dsu bandwidth <interface BW in kbps>  
  frame-relay lmi-type cisco  
  max-reserved-bandwidth 100  
!  
interface Serial5/0.1 point-to-point  
  bandwidth <Port Speed * .95>  
  ip address <ip address> <mask>  
  no cdp enable  
  frame-relay interface-dlci <dlci #> IETF  
  service-policy output 7304-test
```

#### B.4 Example of Ethernet Access

```
ip access-list extended BGP  
  permit tcp any eq bgp any  
  permit tcp any any eq bgp  
ip access-list extended RTP  
  permit udp any range 16384 32767 any range 16384 32767  
ip access-list extended SCCP
```

```
permit tcp any range 2000 2003 any
permit tcp any any range 2000 2003
ip access-list extended SIP
permit udp any eq 5060 any
permit udp any any eq 5060
permit tcp any eq 5060 any
permit tcp any any eq 5060
ip access-list extended COS2-Traffic
permit tcp any any eq www <sample only – COS2 customer defined>
permit tcp any eq www any <sample only – COS2 customer defined>
ip access-list extended COS3-Traffic
permit tcp any any eq smtp <sample only – COS3 customer defined>
permit tcp any eq smtp any <sample only – COS3 customer defined>
!
class-map match-any BGP
  match access-group name BGP
class-map match-any COS1
  match access-group name RTP
  match access-group name SIP
  match access-group name SCCP
class-map match-any COS2
  match access-group name COS2-Traffic
  match access-group name BGP
class-map match-any COS3
  match access-group name COS3-Traffic
!
policy-map MARK-BGP
  class BGP
    police 8000 conform-action set-dscp-transmit cs6 exceed-action set-dscp-transmit cs6
  class class-default
    police 8000 conform-action set-dscp-transmit af31 exceed-action set-dscp-transmit af31
!
policy-map COS-ether
  class COS1
```

Police rate of 8000 for BGP traffic is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

Police rate of 8000 is not effective as the set and exceed actions are the same. Only used to mark traffic with appropriate dscp.

```
priority
police <COS1 BW> <Burst size> conform-action set-dscp-transmit ef exceed-action drop
class COS2
  bandwidth remaining percent <COS2%>
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3%>
  police 8000 conform-action set-dscp-transmit af21 exceed-action set-dscp-transmit af21
class class-default
  bandwidth remaining percent <COS4%>
  police 8000 conform-action set-dscp-transmit default exceed-action set-dscp-transmit
default

policy-map 7304-test
  class class-default
    shape average <Shaping Percentage of interface BW– see section 2.3>
  service-policy COS-ether
!
interface GigabitEthernet0.301
  encapsulation dot1Q <VLAN tag>
  ip address <ip address> <mask>
  no ip route-cache
  service-policy output 7304-test
```

## Appendix C: Inbound Alternate Routing

The Inbound Alternate Routing [IAR] feature enhances AT&T IP Flexible Reach service by providing customers the capability to have an alternate way to complete calls for the purpose of adding a backup path.

With the IAR feature, we define a primary site as a site that is an AT&T IP Flexible Reach location with an active dial plan and is defined with the appropriate calling plan. We define a secondary site (alternate route site) where calls will be routed to in the case where the primary site is unavailable. The secondary site would mirror the dial plan of the primary site.

IAR will be triggered based on the following conditions -

1. No response from the primary site, triggering a time-out (SIP error 408)
2. Error conditions that result in call failure
3. Concurrent call limit has been reached (IPBE signals a SIP error 503).
4. Network Busy (also a SIP 503).
5. Busy out of the trunks at TDM/IP PBX signaling a SIP error 503.

## Appendix D: Branch Office Extension (BOE)

### D.1 Introduction to BOE

**The configuration information in this CCG assumes a single primary CER. Any use by customers of alternate routing configurations or remote branch connectivity to other sites within the same or other AT&T VPN requires proper configuration of the signaling and media paths of the primary CER per this CCG so the AT&T IP Flexible Reach Service works properly. The routing configurations in other customer routers needs to be set up to assure that the routing in their primary CER is not affected. Contact your AT&T technical sales team for further advice in these cases.**

While AT&T BVoIP service offers multiple calling plans, the Branch Office IP PBX Extensions capability is supported with two calling plans: Local and Long Distance (plan B) and Local and Long Distance Package (plan C).

The Branch Office IP PBX Extensions option provides the capability to deliver telephone numbers for all the Branch Office sites supported by customer's single centralized IP PBX. This configuration uses the

AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free on AT&T VPN  
Customer Edge Router Customer Configuration Guide (November 25, 2015, Version 2.6)

IP PBX to support IP phones in a "plug-and-play" manner and does not require any additional premises-based hardware. The customer is able to use the AT&T VPN network or their existing data network to distribute calls to their branch office sites and normal local calling capability can be assigned. Only Branch Office sites with fixed locations are supported by the option.

AT&T collects the address data on the Branch Office site so the appropriate directory listing, taxing, regulatory fees, E911 and telephone number (TN) assignments can be associated with the Branch Office site. Branch office sites must be within the footprint of the local service area for AT&T BVoIP with Calling Plans B or C. The customer must provide correct information to AT&T regarding the address and telephone numbers of its Branch Offices and customer's IP PBX must transmit the necessary address information to permit AT&T to route Branch Office E911 calls to the proper PSAP.

Customers choose the calling capacity they require in units of **Concurrent Calls** which are similar to simultaneous calls and can be engineered using standard voice traffic tools (including Class of Service considerations or by using the customer's existing voice channel capacity).

The components required for the service include:

- An existing AT&T VoIP router at the hub site connected via AT&T VPN
- An IP PBX at the hub site.
- A branch office site that may be connected via either 1) AT&T VPN network or 2) private customer data network.

**Outbound** voice and fax calling is supported between:

- US VoIP-enabled locations (On-net)
- PSTN connected locations (Off-net)

**Inbound** service from the PSTN is supported with Calling Plans B or C.

Note that the management and maintenance of the Branch Office site and router is the responsibility of the customer. AT&T support for data transmission for AT&T Flexible Reach ends at the customer's IP PBX.

### **Branch Office site**

The branch office site is defined as a site on the customer data network with IP phones. If the IP phones at the Branch Office site need access to AT&T IP Flexible Reach Service, then the Branch Office will be defined as having as having Branch Office IP PBX Extensions service. A Branch Office site with Internet access is not supported unless end-end IP VPN tunneling is used. A branch office site may be connected via either 1) AT&T VPN network or 2) private customer data network.

Note: The branch office must have an IP route to the hub site in order for signaling and media to be exchanged.

### **Hub site**

The hub site is the client's centralized IP PBX Flexible Reach site. The hub site will have a customer managed CER connected to the AT&T VPN network. The customer may reach the remote branch



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office sites via this CER (over the AT&T VPN network) or they can deploy a second customer managed router that provides their own connectivity to the customer's data network.

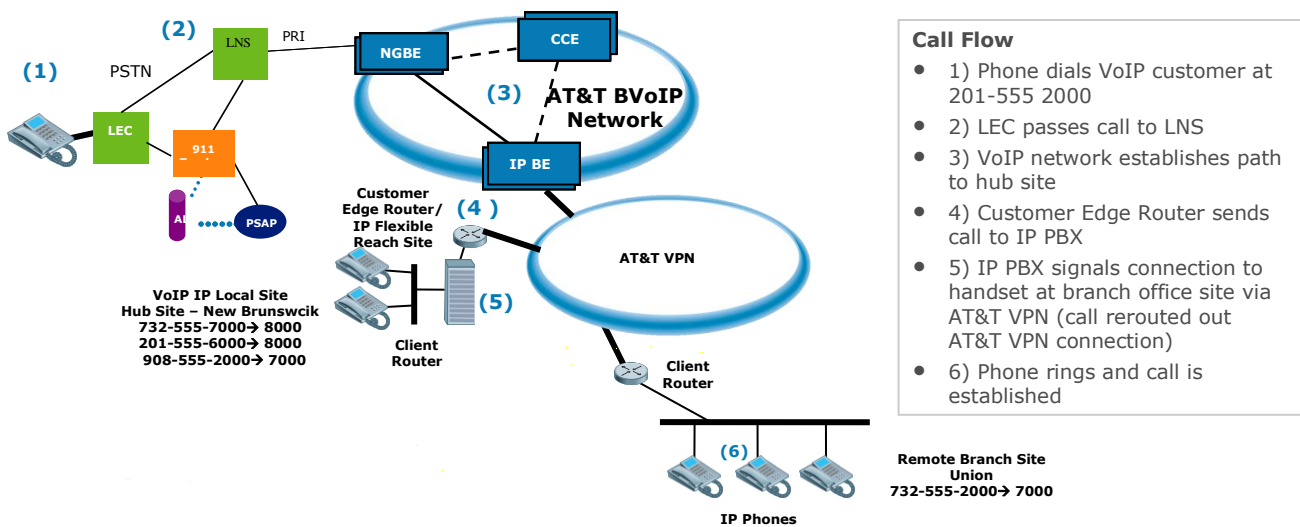
**Important Note:** The number of concurrent calls at the Hub site must be engineered for all voice traffic originating and terminating at the Hub and Branch Office sites. Concurrent calls are the number of VoIP calls expected to occur at the same time at the Hub site. Be aware if BOE calls are hairpinned through the existing hub site router over the AT&T VPN network, then the bandwidth required at the hub site for the BOE calls must be doubled (as the RTP for a BOE call traverses the WAN at the hub site twice). Also it is important to take growth at the BOE sites in mind when determining bandwidth requirements.

If the number of concurrent calls needs to be increased, a separate order must be placed and completed prior to initiating the Branch Office order.

See section 2.1.2 for Bandwidth Per Call Requirements.

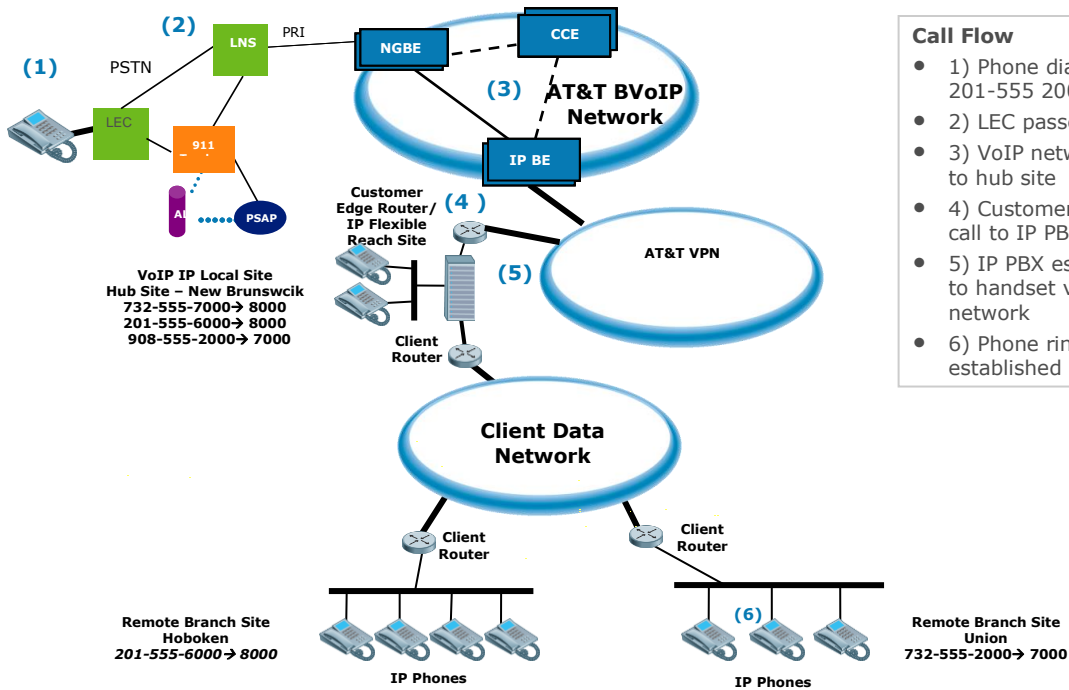
Note: The hub office must have an IP route to the branch office site in order for signaling and media to be exchanged.

**AT&T IP BVoIP Branch Office Extension (BOE) using AT&T VPN network to connect to BOE site:**



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**AT&T BVoIP Branch Office Extension (BOE) using Client Data Network to connect to BOE site:**



- Call Flow**
- 1) Phone dials VoIP customer at 201-555-2000
  - 2) LEC passes call to LNS
  - 3) VoIP network establishes path to hub site
  - 4) Customer Edge Router sends call to IP PBX
  - 5) IP PBX establishes connection to handset via client data network
  - 6) Phone rings and call is established

**D.2 Implementation Checklist**

- 1) If porting in telephone numbers from another carrier, please ensure that site(s) will be ready on the date of the scheduled service activation:
  - a. Failure to ensure that the site is ready on the activation date will result in an out-of-service condition for the ported telephone numbers.
  - b. If a delay in activation is required for any reason, contact AT&T at least five business days prior to the service activation.
- 2) The Customer Administrator should verify that the Branch Office site can communicate to the hub site by placing test telephone and fax calls.
  - a. Ensure that the Branch Office is able to make a call to the hub site. (Note: If this does not work, the customer needs to contact their local or third-party data and voice network administrator)
  - b. Ensure that the hub site is able to make a call to the Branch Office. (Note: If this does not work, the customer needs to contact their local or third-party data and voice network administrator.)
  - c. Ensure that the hub site is able to make a Long Distance call.

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- 1.3) Make sure the proper bandwidth is in place for the amount of concurrent calls required.
- 4) The customer is responsible for testing all the Branch Office locations after the service activation is done. Customer Administrator is responsible for performing self testing that will include placing test telephone and fax calls to on-net VoIP sites and to off-net numbers.

Special Note for site with Avaya Communications Manager if IP phones are PATed at the CER: The private IP address space of the additional BOE IP phones must be added to the access list referenced to in the PAT statement to ensure the phones are translated to a public IP address.

### D.3 Emergency Services

AT&T Flexible Reach service plans B and C, including Branch Office IP PBX Extensions, are limited to locations where AT&T can provide 911/E911 service. The 911 service provided is based on the site registered location information provided to AT&T by the customer. The customer must provide AT&T with the correct business name and address information for each AT&T IP Flexible Reach Service location including all Branch Offices. The customer must also ensure that AT&T AT&T IP Flexible Reach Service telephone numbers are assigned to the appropriate service location (identified during service ordering) and not assigned or used from another service location.

The customer premises equipment should be configured to use the telephone number of the phone device making the 911 call as the calling party number. This ensures both, AT&T will route the call to the appropriate public emergency service agency and that the correct address information will be displayed to emergency service agent handling the call. In addition, should the call be terminated inadvertently the agent will have a call back number to re-establish communication with the person seeking emergency services.

Should the customer choose to configure premises equipment to send a single telephone number as the calling party number on all 911 calls originating from a particular site, the customer must ensure the calling party number used is an AT&T IP Flexible Reach Service telephone number assigned to the site and the telephone is manned to handle potential call back from the emergency service agent.

### D.4 Troubleshooting

If the customer is not able to make calls, then perform the following steps:

- Ensure that the Branch Office is able to make a call to the hub site.
  - If the above step is not successful, the customer needs to contact their local or third-party data and voice network administrator.
- Ensure that the hub site is able to make a call to the Branch Office.
  - If the above step is not successful, the customer needs to contact their local or third-party data and voice network administrator.
- Ensure that the hub site is able to make a Long Distance call.
  - If the above step is not successful, the customer needs to contact AT&T Professional Services by contacting your sales representative.
- Ensure that the Branch Office is able to make an offnet call.

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- If the above step is not successful, then ping and trace from the Branch Office to the router at the Hub site. Check to see where the trace stops and contact the local Administrator to check ACL on corresponding routers and/or firewalls.
  
- If the above test calls work, the customer will be able to make off-net calls from the Branch Office. The number of simultaneous calls from Branch Office and hub site are subject to the purchased Concurrent Call limit.

## Appendix E: Anomalies

- Using the NM-1T3/E3 module in an ISR (router) with an TE/E3 Frame Relay circuit gives you Receiver Loss of Signal when you attempt to bring up the E3 Frame Relay circuit with IOS 12.4(15) T13 advanced-enterprise version (c3845-adventerprisek9-mz.124-15.T10.bin). However – the E3 Frame Relay circuit does come up normally when used with the spservices version of 12.4(15) T10 IOS (c3845-spservicesk9-mz.124-15.T10.bin).
- Using the 7304 router with the NSE-150 processor – the on-board GIG-E ports experience Input Queue flushes – which cause packet loss and VoIP SIP timeouts (calls not being setup). Make sure “ip route-cache cef” command is applied to the Gig interface.
- Call quality problems have been seen in the field when a TDM GW site, configured with crtp, retrieves a voice mail from a site with Cisco Unity Voice Mail. Unity’s silence suppression utilizes a marker bit in the RTP header seem to be what triggers the incompatibility—but other applications that use RTP could cause the same problem. This problem only occurs with on crtp links to an RPM-XF PER. There is no fix at this time.
- Using the NM-1T3/E3 module in an ISR (router) with a T3/E3 Frame Relay circuit gives you Receiver Loss of Signal when you attempt to bring up the T3/E3 Frame Relay circuit with IOS 12.4(15) T13 advanced-enterprise version (c3845-adventerprisek9-mz.124-15.T13.bin). The E3 Frame Relay circuit does come up normally when used with the “spservices” version of 12.4(15) T10 IOS (c3845-spservicesk9-mz.124-15.T13.bin).

### Workaround

To prevent the T3 or E3 circuit not coming up when configuring an ISR router with the components and IOS versions outlined above – use the suggested Cisco router CLI configuration addition.

#### memory-size iomem 25

When applying this command you may receive the following message:

```
router(config)#memory-size iomem 25
```

*Maximum IO percent supported for 768MB memory is 15 (115MB)*

```
router(config)#memory-size iomem 15
```

*Smart-init will be disabled and new I/O memory size will take effect upon reload.*

```
router(config)#^Z
```

If you receive the above message when applying the memory-size command, reduce the percentage for the iomem to the maximum allowed by the router. This number will be determined by the total amount of memory installed on the router.

## Appedix F: Acronymns

<b>Acronym</b>	<b>Translation</b>
ADSL	Asymmetric Digital Subscriber Line
AIM	Advanced Integration Module A
AS	Autonomous System
ATM	Asynchronous Transfer Mode
AT&T VPN	AT&T Virtual Private Network
BC	Committed Burst
BE	Excess Burst or Best Effort
BGP	Border Gateway Protocol
BH	Bursty High
BL	Bursty Low
BOE	Branch Office Extension
BVoIP	Business Voice over Internet Protocol
CAS	Channel Associated Signaling
CBWFQ	Class Based Weighted Fair Queuing
CCG	Customer Configuration Guide
CCS	Common Channel Signaling
CDR	Committed Data Rate
CEF	Cisco Express Forwarding
CER	Customer Edge Router
CHAP	Challenge Handshake Authentication Protocol
CIR	Committed Information Rate
CLI	Command Line Interface
CM	Communications Manager
COS	Class of Service
CPE	Customer Premise Equipment
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CRTP	Compress Real Time Protocol
CSU/DSU	Channel Service Unit / Data Service Unit
CUBE	Cisco Unified Border Element
CUCM	Cisco Unified Communications Manager
DID	Direct Inward Dial
DS	Down Stream
DSCP	Differentiated Service Code Point
DSL	Digital Subscriber Line
DSP	Digital Signal Processors
DTMF	Dual Tone Multi Frequency
E&M	Ear & Mouth

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<b>Acronym</b>	<b>Translation</b>
EF	Expedient Forwarding
ePVC	Enhanced Permanent Virtual Circuit
FR	Frame Relay
FXO	Foreign Exchange Office
FXS	Foreign Exchange Station
GSM FR	Global System for Mobile communications Full Rate
HDV	High Density Voice
HWIC	High-speed WAN Interface Card
IAR	Inbound Alternate Routing
IETF	Internet Engineering Task Force
IMA	Inverse Multiplexing over ATM
IOS	Internetwork Operation System
IP	Internet Protocol
IPBE	Internet Protocol Border Element
IPSEC	Internet Protocol Security
ISR	Integrated Services Router
ITU-T	International Telecommunication Union - Telecommunications
GW	Gateway
LAN	Local Area Network
LFI	Link Fragmentation and Interleaving
LLQ	Low Latency Queuing
LD	Long Distance
MLPPP	Multi-Link Point-to-Point Protocol
MM	Multi Media
MOW	Most Of World
MTU	Maximum Transmission Unit
NAT	Network Address Translation
NET	Network Equipment Technologies
NM	Network Module
NPE	Network Processing Engine
OAM	Operation Administration & Maintenance
OCS	Office Communication Server
PA	Port Adapter
PAT	Port Address Translation
PBX	Private Branch Exchange
PC	Personal Computer
PCR	Peak Cell Rate
PER	Provider Edge Router
POS	Packet over SONET
POTS	Plain Old Telephone Service
PPP	Point-to-Point Protocol
PQ	Priority Queue



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<b>Acronym</b>	<b>Translation</b>
PRI	Primary Rate Interface
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Network
PVC	Permanent Virtual Circuit
PVDM	Packet Voice DSP Module
QOS	Quality of Service
QSIG	Q Signaling
RC	Receive
RFC	Request for Comment
RT	Real Time
RTCP	Real Time Control Protocol
RTP	Real Time Protocol
SBC	Session Border Controller
SCCP	Skinny Call Control Protocol
SCR	Sustainable Cell Rate
SHDSL	Single-Pair High-Speed Digital Subscriber Line
SIP	Session Initiation Protocol
SM	Session Manager
SPE	Synchronous Payload Envelope
TAC	Technical Assistance Center
TC	Time Interval
TDM	Time Division Multiplexing
TN	Telephone Number
TX	Transmit
UDP	User Datagram Protocol
US	Up Stream or United States
VAD	Voice Activity Detection
VCI	Virtual Circuit Identifier
VLAN	Virtual Local Area Network
VNI	Voice Network Infrastructure
VoIP	Voice over Internet Protocol
VPI	Virtual Path Identifier
VPN	Virtual Private Network
VT	Virtual Template
WAN	Wide Area Network
WFQ	Weighted Fair Queuing
WIC	WAN Interface Card

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