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 G2 Platforms

December 8, 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.

1.2 *Network Topology*

This section describes the generic AT&T supported topologies:.

- Please refer to the following documents 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/ (login: att, password: attvoip)).*
  - *"Customer Edge Router Customer Configuration Guide for Integrated CER/CUBE with AT&T Certified IP-PBX Solutions".* (*http://www.corp.att.com/bvoip/avpn/implementation/ (login: att, password: attvoip)).*

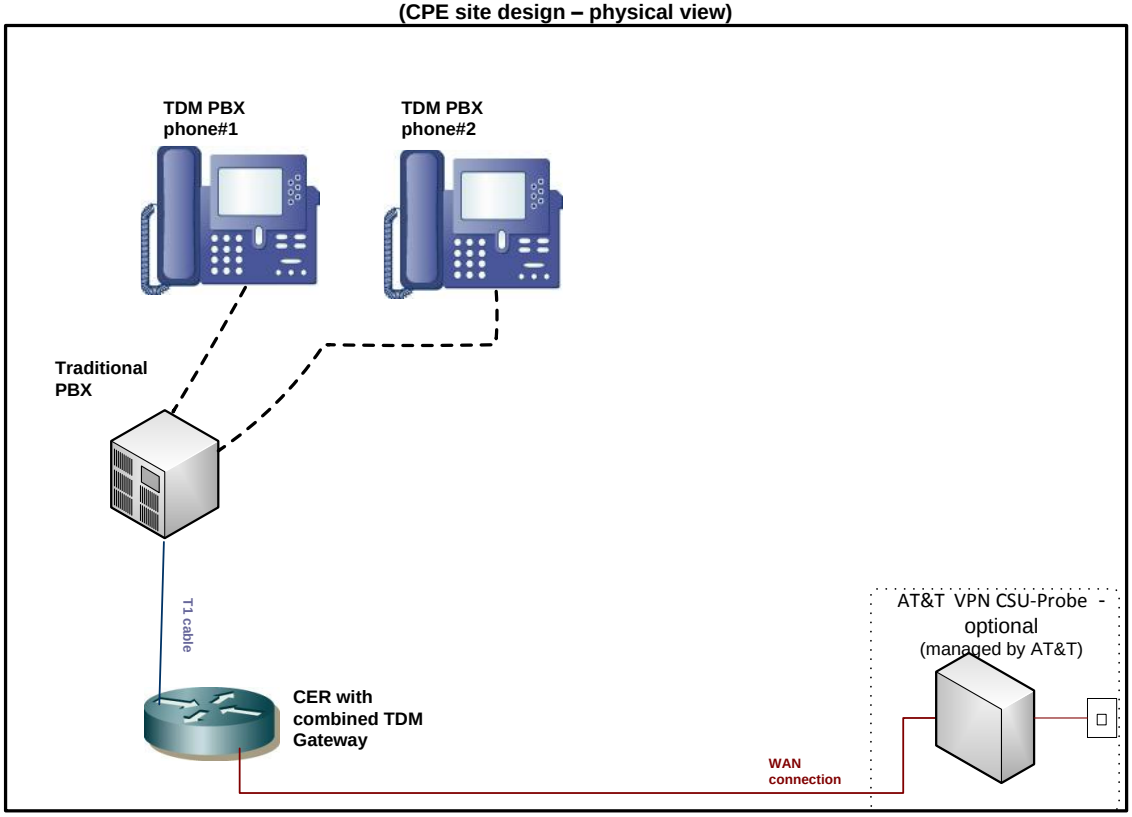
- Please refer to the following document for details on configuring a TDM Gateway: "TDM PBX Customer Configuration Guide" (*http://www.corp.att.com/bvoip/avpn/implementation/ (login: att, password: attvoip).* Use the appropriate guide for your router platform.

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)

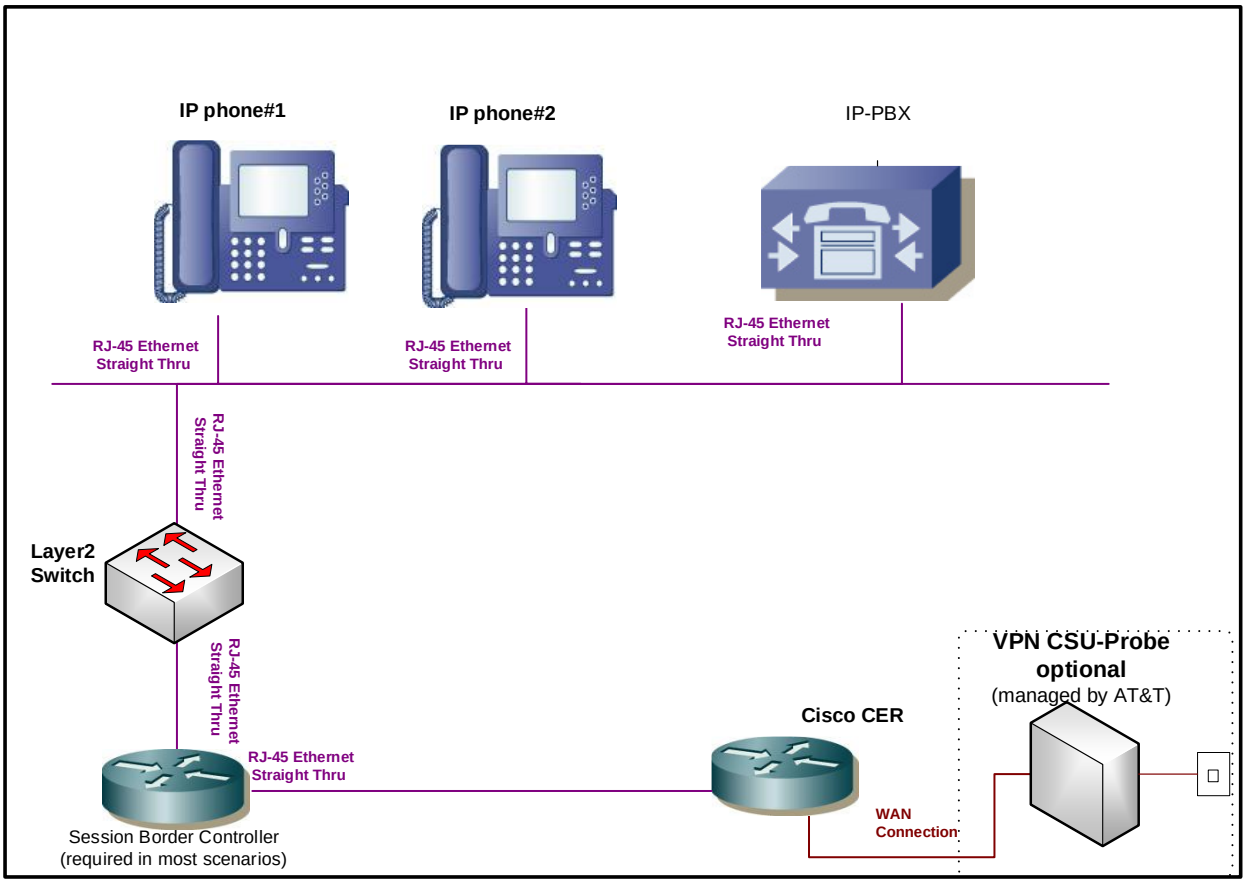


1.2.2 **AT&T Certified IP-PBX's**

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 devices. All other equipment is managed by the Customer.

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

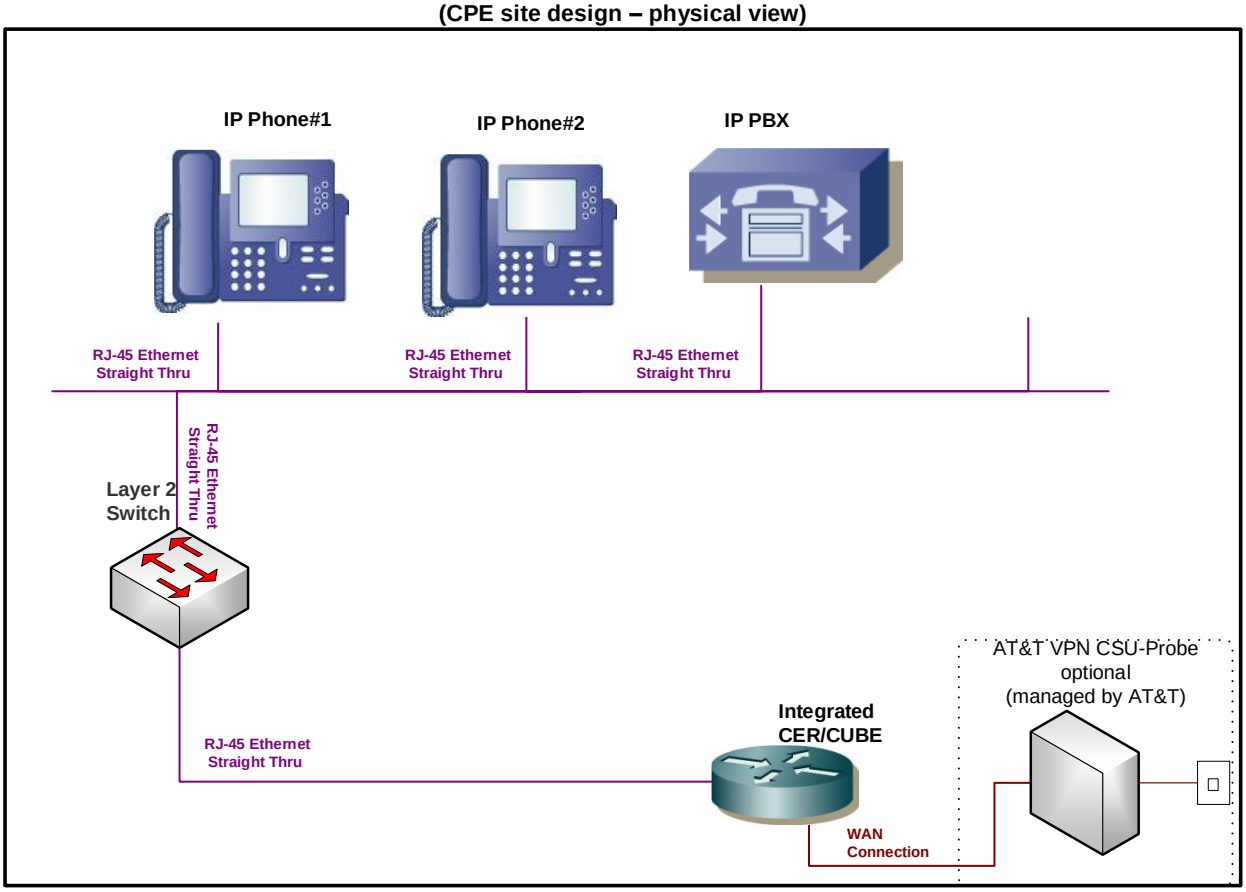
AT&T IP Flexible Reach Service or AT&T IP Toll-Free on AT&T VPN site
with AT&T VPN CSU-Probe, Generic IP-PBX and optional SBC
(CPE site design – physical view)



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 Cisco Unified Border Element (CUBE) Session Border Controller (SBC) are integrated into a single device. The AT&T VPN CSU-Probe is an AT&T managed devices. All other equipment is managed by the Customer. NOTE: This solution is only supported for specific scenarios. Please refer to the "*Customer Edge Router Customer Configuration Guide for Integrated CER/CUBE with AT&T Certified IP-PBX Solutions".* (*http://www.corp.att.com/bvoip/avpn/implementation/ (login: att, password: attvoip)*).

- 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 *Network Design*

The following section provides information about supported router hardware, access types and IOS.

1.3.1 Supported Router Platforms and Access Types

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

Access Type	Speed (bit/s)	Fragmentation	CRTP
DSL	100K, 1500K	no	no
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
NXT1/E1 MLPPP access	N = 2 to 8 T1/E1	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

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

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

- 1921
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – T1/E1

- DSL

- 2911 :
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n*T1 (up to 8 T1 MLPPP)
  - DSL

- 2921:
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n*T1 (up to 8 T1 MLPPP)
  - DSL

- 2951
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n*T1 (up to 8 T1 MLPPP)

- 3925:
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n*T1 (up to 8 T1 MLPPP)
  - Subrate T3/E3

- 3945:
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n*T1 (up to 8 T1 MLPPP)
  - Subrate T3/E3, T3/E3

- 3945E
  - Ethernet VLAN / Subrate
  - Frac T1/E1 – n*T1 (up to 6 T1 MLPPP)
  - Subrate T3/E3, T3/E3

1.3.2 IOS

Configurations in this guide were tested with Cisco IOS 15.2(1)T2ES and 15.3(3)M1ES.

The IOS files can be obtained from:
https://upload.cisco.com/cgi-bin/swc/fileexg/main.cgi?CONTYPES=ATT-Managed-Services

Note: CCO access is required to download these files.

IOS file names for the routers are as follows:

1900 routers:

c1900-universalk9-mz.SSA-eng-sp-152-1.T2ES

c1900-universalk9-mz.SSA-eng-sp-153-3.M1.bin

2900 routers:

c2900-universalk9-mz.SSA-eng-sp-152-1.T2ES

c2900-universalk9-mz.SSA-eng-sp-153-3.M1.bin

2951 router (only supported with 15.3(3)M1ES):
c2951-universalk9-mz.SSA-eng-sp-153-3.M1.bin

3925/45 routers:

c3900-universalk9-mz.SSA-eng-sp-152-1.T2ES

c3900-universalk9-mz.SSA-eng-sp-153-3.M1.bin

3945E router:

c3900e-universalk9-mz.SSA-eng-sp-152-1.T2ES

c3900e-universalk9-mz.SSA-eng-sp-153-3.M1.bin

CER only will require IP Base Technology Package License.

CER with combined TDM Gateway require UC (Unified Communications) Technology Package License.

1.4 *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.

2 Network Performance Design

Before implementing AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free over AT&T VPN as an underlying transport service, 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 Service and/or AT&T IP Toll-Free over AT&T VPN as an underlying transport service 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 as an underlying transport service 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.

AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free requires RTCP (Real Time Control Protocol) in order to collect Call Detail Records (CDRs). Use the bandwidth per call numbers listed with RTCP for COS1 calculations.

Access Type	Codec	ptime (ms)	Bandwidth per call (Kbit/s)	
			Without RTCP	With RTCP
DSL	G729 A	20	25.0	25.4
	G729 A	30	19.4	20.0
	G711	20	80.5	81.0
	G711	30	75.0	75.5
Ethernet	G729 A	20	29.8	30.3
	G729 A	30	22.6	23.2
	G711	20	85.4	86.0
	G711	30	78.3	78.8
Ethernet with VLAN	G729 A	20	31.4	31.9
	G729 A	30	23.7	24.2
	G711	20	87.1	87.6
	G711	30	79.3	79.9
Frame Relay	G729 A	20	25.7	25.9
	G729 A	30	19.9	20.4
	G711	20	81.4	81.9
	G711	30	75.5	76.0
NX T1/E1 MLPPP	G729 A	20	25.0	25.5
	G729 A	30	19.4	19.9
	G711	20	80.5	81.1
	G711	30	75.0	75.5
PPP or FR Encapsulation	G729 A	20	25.8	26.3
	G729 A	30	19.8	20.5
	G711	20	81.4	81.9
	G711	30	75.6	76.1

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.

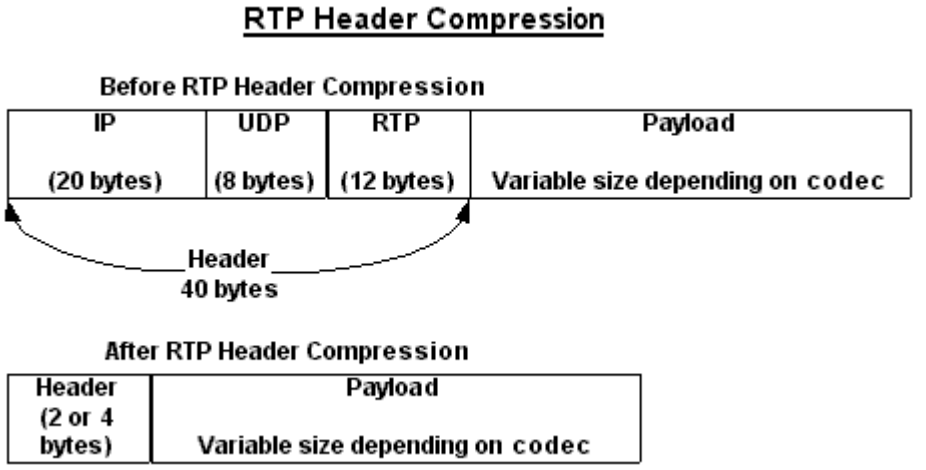
2.1.3 **Bandwidth Reduction Techniques**

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.

Another 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) on frame relay access at 768Kbit/s and below. 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.



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.

2.2 *Putting It Together*

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 signaling and media traffic. 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.

For details on configuring CERs for the basic AVPN transport service, independent of IP Flexible Reach Service and/or AT&T IP Toll-Free, reference:

AT&T VPN Service Customer Router Configuration Guide

This Guide is available on AT&T *BusinessDirect* under *Insight and News, Tech Specs* or from your Sale team.

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 11th call comes in. The 11th 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: CoS6 not supported on links with link fragmentation (LFI).

Note: Sizing of data requirements, possibly including video, is beyond the scope of this document but is covered in: *AT&T Network Services COS Customer Router Configuration Guide*

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.

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.

Due to the factors stated above, CoS1 bandwidth for Ethernet should not be more than 70% to compensate for unaccounted overhead. Shape rates should be configured for 99% of the access speed (see Ethernet Shaping Table in this section).

For additional details on configuring Ethernet for access to the AVPN service, reference: *AT&T VPN Ethernet Access Customer Router Guide.* This document is available on AT&T *BusinessDirect* under *Insight and News, Tech Specs* or from your Sale team.

Ethernet Shaping Table:

Port / Subrate / VLAN Access	Port / subrate / VLAN Speed	Shaped to 99% of Ethernet VLAN speed (*rounded DOWN to nearest 64K)
512K Ethernet	512K	448K
1M Ethernet	1000K	960K
1.5M Ethernet	1500K	1472K
2M Ethernet	2000K	1920K
3M Ethernet	3000K	2944K
4M Ethernet	4000K	3904K
5M Ethernet	5000K	4928K
6M Ethernet	6000K	5888K
7M Ethernet	7000K	6912K
8M Ethernet	8000K	7872K
9M Ethernet	9000K	8896K
10M Ethernet	10000K	9856K
20M Ethernet	20000K	19776K
30M Ethernet	30000K	29696K
40M Ethernet	40000K	39552K
50M Ethernet	50000K	49472K
60M Ethernet	60000K	59392K
70M Ethernet	70000K	69248K
80M Ethernet	80000K	79168K
90M Ethernet	90000K	89088K
100M Ethernet	100000K	98944K

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

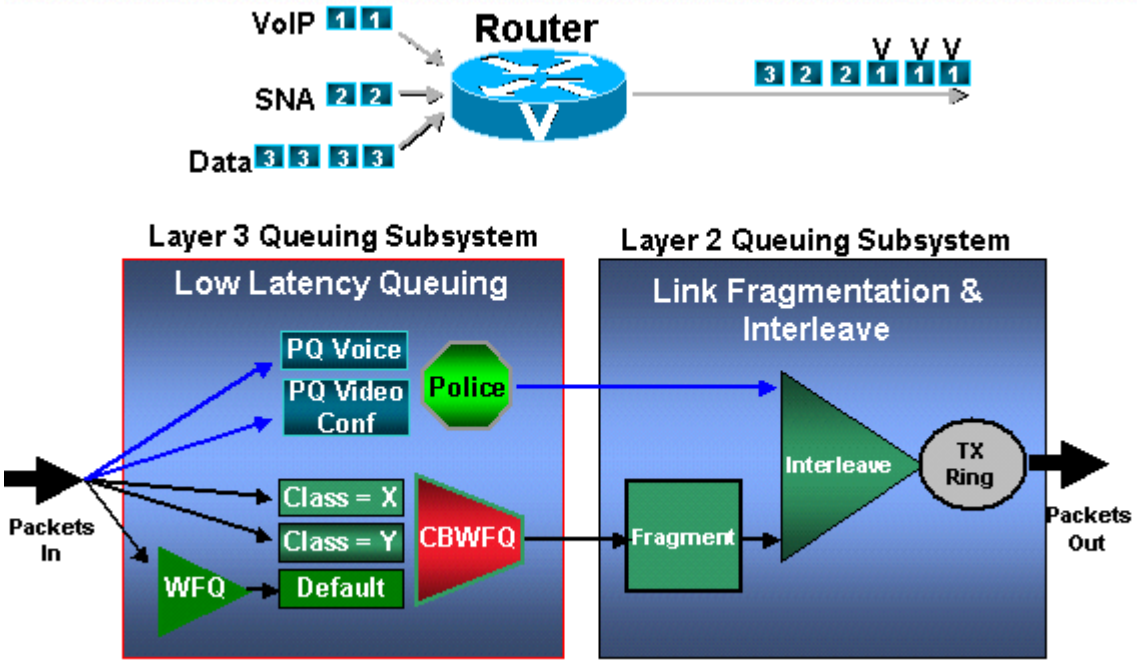
Additional Classes for CoS6:

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. AT&T VPN 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.



4 Customer Edge Router (CER) Configurations specific to CoS and 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 as the underlying transport service. The specific configurations tested were for ISR G2 routers running 15.2.1.T2ES. Sample configurations, relative to specific environments, have been provided for reference in Appendix A.

- Class of Service (CoS) specific considerations:
  - CoS1 should not be more than 70% for DSL or Ethernet access.
  - CoS6 is not supported on links with LFI.
  - COS1 should not be more than 70% for MLPPP access on a 1900 or 2900 router and not more than 80% on a 3900 router.

4.1 *Classification*

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

Access Lists for CoS4:

```
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), “SIP” and “SCCP” (required for sites with Cisco IP phones) 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 maps for CoS4:

```
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 policy-maps might be set up:

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

Fragmentation only

For MLPPP encapsulation, the policy-map, "SHAPE_FR" is applied to the virtual template interface.

Note: Burst interval for CoS1 should always be set to 1 second. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

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

```
 class COS1
    priority
    queue-limit 2048 packets
    police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
 class COS2
    bandwidth remaining percent <COS2 %>
    set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent <COS3 %>
    set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent <COS4 %>
    set ip dscp default
   queue-limit 64 packets
!
policy-map SHAPE_FR   **This policy map applied to Virtual-Template interface**
 class class-default
  shape average <Port Speed * .90>  <(Port Speed * .90)/100>  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 the BC value be divisible by 128 (rounded up).

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. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

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

```
!
policy-map COS
 class COS1
    priority
    queue-limit 2048 packets
    police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
    compress header ip rtp
 class COS2
    bandwidth remaining percent <COS2 %>
    set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent <COS3 %>
    set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent <COS4 %>
    set ip dscp default
   queue-limit 64 packets
!
policy-map SHAPE_FR   **This policy map applied to Virtual-Template interface**
 class class-default
  shape average <Port Speed * .90>  <(Port Speed * .90)/100>  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 the BC value be divisible by 128 (rounded up).

4.2.2 Standard Frame Relay interface (T1 port speeds 1024 to 1536Kbit/s; and T3 speeds)

Standard Frame Relay access requires a shaping policy map be applied to the Frame Relay sub-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 according to the port speed (see rules below).

Note: Burst interval for COS1 should always be set to 1 second. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

```
ip cef
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
!
policy-map COS
 class COS1
    priority
    queue-limit 2048 packets
    police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
 class COS2
    bandwidth remaining percent <COS2 %>
    set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent <COS3 %>
    set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent <COS4 %>
    set ip dscp default
   queue-limit 64 packets
```

For port speed greater than 2Mbit/s:

```
policy-map SHAPE_FR   **This policy map applied to Frame Relay sub- interface**
 class class-default
  shape average <Port Speed * .95>  <(Port Speed * .95)/250>  0
```

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

```
 service-policy COS
```

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

For port speed 2Mbit/s or less:

```
policy-map SHAPE_FR   **This policy map applied to Frame Relay sub- interface**
 class class-default
  shape average <Port Speed * .90>  <(Port Speed * .90)/100>  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 the BC value be divisible by 128 (rounded up).

4.2.3 PPP access (T1 port speeds 1024 to 1536Kbit/s; and T3 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. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

```
ip cef
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
!
policy-map COS
 class COS1
  priority
  queue-limit 2048 packets
  police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent <COS2 %>
  set ip dscp af31
  queue-limit 64 packets
```

```
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
  queue-limit 64 packets
class class-default
  bandwidth remaining percent <COS4 %>
  set ip dscp default
  queue-limit 64 packets
```

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**
   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**
  service-policy COS

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

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

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 **ADSL/ SHDSL**

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. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

```
ip cef
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
!
policy-map COS
 class COS1
  priority
  queue-limit 2048 packets
  police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent <COS2 %>
  set ip dscp af31
  queue-limit 64 packets
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
  queue-limit 64 packets
class class-default
  bandwidth remaining percent <COS4 %>
  set ip dscp default
  queue-limit 64 packets
```

4.2.5 **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.

Note: Burst interval for COS1 should always be set to 1 second. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

```
ip cef
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
!
policy-map COS
 class COS1
  priority
  queue-limit 2048 packets
  police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent <COS2 %>
  set ip dscp af31
  queue-limit 64 packets
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
  queue-limit 64 packets
class class-default
  bandwidth remaining percent <COS4 %>
  set ip dscp default
  queue-limit 64 packets
```

```
!
policy-map DSL-SHAPE
 class class-default
   shape average <Port Speed * .60>  <(Port Speed * .60)/100>
   service-policy COS
```

4.2.6 **NXT1 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. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

```
ip cef
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
!
policy-map COS_MLPPP
class COS1
  priority
  queue-limit 2048 packets
  police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
class COS2
  bandwidth remaining percent <COS2 %>
  set ip dscp af31
  queue-limit 64 packets
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
  queue-limit 64 packets
class class-default
  bandwidth remaining percent <COS4 %>
```

```
 set ip dscp default
 queue-limit 64 packets
```

4.2.7 **T3/E3 Frame Relay Encapsulation**

Multiple VPN connections over a single private line access are typically provided using Frame Relay encapsulation on the access link to provide L2 differentiation of the connections. Frame Encapsulation refers to a dedicated access ("ip port") rather than frame relay service access.

With Frame Relay encapsulation, a policy-map will be applied to each sub- interface (or one policy-map to each subinterface if there are multiple subinterfaces).

Note: Burst interval for COS1 should always be set to 1 second. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

```
ip cef
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
!
policy-map COS
class COS1
  priority
  queue-limit 2048 packets
  police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
class COS2
  bandwidth remaining percent <COS2 %>
  set ip dscp af31
  queue-limit 64 packets
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
  queue-limit 64 packets
class class-default
  bandwidth remaining percent <COS4 %>
```

```
 set ip dscp default
 queue-limit 64 packets


policy-map SHAPE_FR_ENCAP   **This policy map applied to serial 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 the BC value be divisible by 128 (rounded up).

4.2.8 **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.

Note: Burst interval for COS1 should always be set to 1 second. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

For Ethernet access, the shaping rate typically is 99% of port or VLAN speed. Refer to the Ethernet Shaping Table in section 2.3.

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

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

```
  queue-limit 2048 packets
  police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
class COS2
  bandwidth remaining percent <COS2 %> account user-defined 28
  set ip dscp af31
  queue-limit 64 packets
  service-policy MARK-BGP
class COS3
  bandwidth remaining percent <COS3 %> account user-defined 28
  set ip dscp af21
  queue-limit 64 packets
class class-default
  bandwidth remaining percent <COS4 %>  account user-defined 28
  set ip dscp default
  queue-limit 64 packets
!
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 account user-defined 28
   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).

4.2.9 **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. Burst of 1 second is equal to the COS1 Bandwidth (BW) / 8.

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

```
 class BGP
  set ip dscp cs6
!
policy-map COS
 class COS1
  priority
  queue-limit 2048 packets
  police <COS1 BW > <Burst size> conform-action set-dscp-transmit ef exceed-action drop
class COS2V
  bandwidth remaining percent <COS2V%>
  set ip dscp af41
  queue-limit 64 packets
 class COS2
  bandwidth remaining percent <COS2%>
  set ip dscp af31
  queue-limit 64 packets
  service-policy MARK-BGP
  class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 64 packets
 class COS5
  bandwidth remaining percent <COS5%>
  set ip dscp af11
   queue-limit 64 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 64 packets
```

4.3 *Interface Configuration*

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

Special Considerations:

- T3/E3 ATM access is not currently supported on ISR G2 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.
- IMA (Inverse Multiplexing over ATM) interfaces are not supported on ISR G2 platforms

4.3.1 Standard Frame Relay interface with MLPPP encapsulation (T1 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.

On the main frame-relay interface:

- Set encapsulation to “frame-relay IETF”.
- Configure “frame-relay lmi-type” for cisco
- Configure “hold-queue 32768 out”.

On the subinterface:

- Configure “frame-relay interface-dlci <#> ppp virtual-template #”

On the Virtual Template Interface

- Configure the bandwidth to 90% of the CIR
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Configure “ppp multilink”
- Configure “ppp multilink interleave”
- Configure “ppp multilink fragment delay” with the appropriate number (see fragment delay guidelines in this section)
- Configure the output service policy (SHAPE_FR in this example)

Example of T1 speed (768Kbit/s and less) on ISR G2:

```
interface Serial0/2/0
 no ip address
 encapsulation frame-relay IETF
 frame-relay lmi-type cisco
 hold-queue 32768 out

interface Serial0/2/0.1 point-to-point
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>
service-policy output SHAPE_FR
```

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 peed 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

4.3.2 Standard Frame Relay Interface (T1 speeds: 1024 to 1536Kbit/s; and T3 speeds)

On the main frame-relay interface:

- The bandwidth should be set to slightly less than the CIR of the interface, which is typically port speed.
- Set encapsulation to "frame-relay".
- Configure "frame-relay lmi-type" for cisco
- Configure "hold-queue 32768 out".

On the subinterface:

- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Configure the Frame-Relay DLCI number.
- Apply the shaping service policy (SHAPE_FR in this example).

Example of T1 FR interface on ISR G2:

```
interface Serial0/2/0
 bandwidth <(CIR * .90)/1000>
 no ip address
 encapsulation frame-relay
 frame-relay lmi-type cisco
 load-interval 30
 hold-queue 32768 out
!
interface Serial0/2/0.1 point-to-point
 ip address <ip address> <mask>
 frame-relay interface-dlci <dlci number> IETF
 service-policy output SHAPE_FR
```

Example of T3 FR interface on ISR G2:

For T3/E3 Frame Relay configuration on an ISR G2, the NM1T3/E3 “card type” must be configured for the appropriate type. The DSU bandwidth should be configured for the proper speed.

```
card type <t3/e3>  <slot#>
!
interface Serial2/0
 bandwidth <(CIR * .95)/1000>
 no ip address
 encapsulation frame-relay
 framing c-bit
 load-interval 30
 dsu bandwidth <interface BW in Kbps>
 frame-relay lmi-type cisco
```

```
 hold-queue 32768 out
 !
interface Serial2/0.1 point-to-point
 ip address <ip address> <mask>
 frame-relay interface-dlci <dlci number> IETF
 service-policy output SHAPE_FR
```

4.3.3 PPP access (T1 speeds: 1024 to 1536Kbit/s; and T3 speeds)

On the main interface:

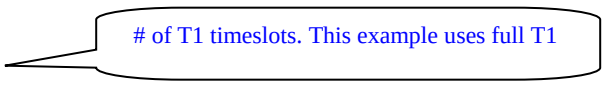
- Configure the bandwidth to slightly less than the CIR of the interface, which is typically port speed
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Set encapsulation to “ppp”.
- Configure “hold-queue 32768 out” under the main interface.
- Apply the CoS policy “SHAPE_PPP”.

Example of T1 PPP Access on ISR-G2 with external DSU (HWIC-1T or 2T):

```
interface Serial0/1/0
 bandwidth <port speed * 95%>
  ip address <ip address> <mask>
  encapsulation ppp
 service-policy output SHAPE_PPP
 hold-queue 32768 out
```

Example of T1 PPP Access on ISR-G2 with internal DSU (HWIC-1DSU-T1):

```
 interface Serial0/1/0
bandwidth <port speed * 95%>
ip address <ip address> <subnet mask>
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
hold-queue 32768 out
```



Example of T3 PPP access on ISR-G2 with internal DSU NM1T3/E3 card:

For T3 PPP access configuration on an ISR-G2, 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/e3> <slot#>


controller t3 1/0
framing c-bit


interface Serial1/0
 bandwidth <port speed * 95%>
 ip address <ip address> <mask>
 encapsulation ppp
 crc 32
 load-interval 30
 dsu bandwidth <interface BW in Kbps>
 scramble
 service-policy output SHAPE_PPP
 hold-queue 32768 out
```

4.3.4 **DSL**

Three flavors of DSL will be supported on AT&T VPN as an underlying transport service: ADSL, SHDSL and DSL modem.

Each provider in each country has their own offerings with respect to DSL type and speeds. For ADSL, the current maximum speeds are 8M/832K DOWNSTREAM/UPSTREAM respectively. For SHDSL, the maximum speed is

2304K/2304K in two wire mode and 4608K/4608K in four-wire mode. Actual orderable speeds will vary from provider to provider and also will be limited by systems support.

4.3.4.1 ADSL

There are 2 different cards that are supported with ADSL: 1) HWIC-1ADSL, and 2) HWIC-1ADSLI.

HWIC-1ADSL:

On the main interface:

- The mtu MUST be set to 1500 .
- "DSL operating-mode" should be set to auto.

On the subinterface:

- The mtu MUST be set to 1500
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Configure the PVC with a VPI/VCI.
- Create "vbr-rt" statement for shaping under ATM PVC.
- The tx-ring-limit must be set to 3 for shaped rates less than or equal to 2048 kbps, otherwise set to 10.
- Configure "vc-hold-queue" to 2048.
- "Oam-pvc manage" should be set to 0.
- Configure encapsulation type (typically aal5snap)
- Apply output service policy, "COS" in this example

Sample HWIC-1ADSL or HWIC-1ADSLI configuration:

```
interface ATM0/1/0
 mtu 1500
 no ip address
 load-interval 30
 no atm ilmi-keepalive
 dsl operating-mode auto
!
interface ATM0/1/0.35 point-to-point
 mtu 1500
 ip address <ip address> <subnet>
```

```
no snmp trap link-status
pvc <vpi/vci>
 vbr-rt <PCR in Kbps> <SCR in Kbps>
 tx-ring-limit <3 or 10 depending on scr>
 vc-hold-queue 2048
 oam-pvc manage 0
 encapsulation aal5snap
 service-policy output COS
```

In order to verify the speed being received from the network, use the command “show dsl interface”. The lower US (upstream) rate (as opposed to the DS (downstream) rate)should be used as the PCR. In this example, the US rate is 380 Kbit/s (which should be used to configure PCR). The link speed is shown in bold below:

```
 Router#show dsl int
ATM0/3/0
Alcatel 20190 chipset information
              ATU-R (DS)                    ATU-C (US)
Modem Status:    Showtime (DMTDSL_SHOWTIME)
DSL Mode:        ITU G.992.5 (ADSL2+) Annex A
ITU STD NUM:     0x03                          0x2
Chip Vendor ID:  'STMI'                        'BDCM'
Chip Vendor Specific:  0x0000                  0x6206
Chip Vendor Country:   0x0F                    0xB5
Modem Vendor ID: 'CSCO'                        '    '
Modem Vendor Specific: 0x0000                  0x0000
Modem Vendor Country:  0xB5                    0x00
Serial Number Near:    FOC10162LHZCISCO73993205
Serial Number Far:  Chip ID:     C196 (0)
DFE BOM:         DFE3.0 Annex A (1)
Capacity Used:   11%                           100%
Noise Margin:    48.0 dB                       31.0 dB
Output Power:    11.0 dBm                      7.0 dBm
Attenuation:     2.0 dB                        0.0 dB
Defect Status:   None                          None
Last Fail Code:  None
Watchdog Counter: 0xAC
```

```
Watchdog Resets: 0
Selftest Result: 0x00
Subfunction:     0x00
Interrupts:      28967 (0 spurious)
PHY Access Err:  0
Activations:     6
LED Status:      OFF
```

```
LED On Time:     0
LED Off Time:    0
Init FW:         init_AMR-3.0.014_no_bist.bin
Operation FW:    AMR-3.0.014.bin
FW Source:       embedded
FW Version:      3.0.14

                DS Channel1     DS Channel0   US Channel1     US Channel0
Speed (kbps):         0            2200            0              380
Cells:                0             110            0            136496
Reed-Solomon EC:      0               0            0                 0
CRC Errors:           0               0            0                 0
Header Errors:        0               0            0                 0
Total BER:          0E-0            0E-0
Leakage Average BER:      0E-0            0E-0
Interleave Delay:         0               12             0               24
                      ATU-R (DS)      ATU-C (US)
Bitswap:              enabled         enabled
Bitswap success:          0               0
Bitswap failure:          0               0

LOM Monitoring : Disabled
```

4.3.4.2 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 main interface:

- Configure the mtu for 1500

On the subinterface:

- Configure the mtu for 1500.
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.

- Configure the PVC with a VPI/VCI.
- Create “vbr-rt” statement for shaping under ATM PVC.
- The tx-ring-limit must be set to 3 for shaped rates less than or equal to 2048 kbps, otherwise set to 10.
- Configure “vc-hold-queue” to 2048.
- “Oam-pvc manage” should be set to 0.
- Configure encapsulation type (typically aal5snap)
- Apply output service policy, “COS” in this example

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
 no ip address
 load-interval 30
 no atm ilmi-keepalive
!
interface ATM0/1/0.35 point-to-point
 mtu 1500
 ip address <ip address> <subnet mask>
 no snmp trap link-status
 pvc <vpi/vci>
  vbr-rt <PCR in Kbps> <SCR in Kbps>
   tx-ring-limit <3 or 10 depending on shape rate>
   vc-hold-queue 2048
  oam-pvc manage 0
  oam retry 3 5 1
  oam ais-rdi 10 3
  encapsulation aal5snap
  service-policy output COS
```

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.

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
 no ip address
 load-interval 30
 no atm ilmi-keepalive
!
interface ATM0/1/0.35 point-to-point
 mtu 1500
 ip address <ip address> <subnet>
 no snmp trap link-status
 pvc <vpi/vci >
  vbr-rt <PCR in Kbps> <SCR in Kbps>
  tx-ring-limit <3 or 10 depending on shape rate>
  vc-hold-queue 2048
  oam-pvc manage 0
  encapsulation aal5snap
  service-policy output COS
```

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.
```

4.3.4.3 DSL Modem

When using a DSL modem, the CER will contain a Frame Relay interface. The 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.

On the main frame-relay interface:

- The bandwidth should be set to slightly less than the CIR of the interface, which is typically port speed.
- Set encapsulation to “frame-relay”.
- Configure “hold-queue 32768 out”.

On the subinterface:

- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Configure the Frame-Relay DLCI number.
- Apply the shaping service policy (DSL-SHAPE in this example).

```
interface Serial0/1/0
 description - SDSL (DSL Modem) Link
 bandwidth <(CIR * .90)/1000>
 no ip address
 encapsulation frame-relay IETF
 load-interval 30
 hold-queue 32768 out
!
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
```

4.3.5 NXT1 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.

- Define the VWIC2-(1 or 2) MFT-T1/E1 as T1 or E1 cards with the command "**card type <t1 or e1> <slot #>"**.
- Configure each controller with the following:
  - framing esf
  - linecode b8zs
  - channel-group 0 timeslots 1-24
- Once the controller cards are configured, serial interfaces which match the controller numbers will appear. Each of these serial interfaces must be configured to be part of a multilink group/interface with the following commands:
  - no ip address
  - encapsulation ppp
  - load-interval 30
  - ppp chap hostname <CER IP address>
  - ppp multilink
  - ppp multilink group 1
- The multilink interface should be configured with:
  - Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
  - PPP CHAP must be used with the IP address of the CER.
  - Configure "ppp multilink"
  - Configure "ppp multilink 1"
  - Configure "ppp multilink fragment disable"
  - Apply the output service policy (COS_MLPPP in this example)
  - Configure the "hold-queue" to 32768

Example of 4 X T1 MLPPP on ISR G2:

```
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
 ip address <ip address> <mask>
  load-interval 30
 ppp chap hostname <CER IP address>
 ppp multilink
 ppp multilink group 1
 ppp multilink fragment disable
```

```
 service-policy output COS_MLPPP
 hold-queue 32768 out
!
interface Serial0/0/0:0
 no ip address
 encapsulation ppp
 load-interval 30
 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
 ppp chap hostname <CER IP address>
 ppp multilink
 ppp multilink group 1
!
interface Serial0/1/0:0
 no ip address
 encapsulation ppp
 load-interval 30
 ppp chap hostname <CER IP address>
 ppp multilink
 ppp multilink group 1

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

4.3.6 **T3 Frame Relay Encapsulation**

- Configure the NM1T3/E3 “card type” for the appropriate type and slot number:
  - “card type <t3/e3> <slot#> “

- A T3/E3 controller interface will be created. Set the framing to “c-bit”.

- On the main Serial interface:
  - Configure the bandwidth to slightly less than the CIR of the interface, which is typically port speed
  - Set encapsulation to “frame-relay”.
  - Set the DSU bandwidth for the proper speed.
  - Set the frame-relay lmi-type (typically set to “cisco”)
  - Configure “hold-queue 32768 out”.

- Each subinterface will be configured with:
  - IP address which should be the CER side of the /30 subnet assigned for the CER/PER link.
  - The Frame-Relay DLCI number.
  - Outbound service policy

Example of T3 Frame Relay encapsulation on ISR G2 with internal DSU (NM-1T3/E3):

```
card type <t3/e3> <slot#>
!
controller T3 2/0
 framing c-bit
!
interface Serial2/0
 bandwidth <Access speed * 95%>
 no ip address
 encapsulation frame-relay
 load-interval 30
 dsu bandwidth <interface BW in Kbps>
```

```
 serial restart-delay 0
 frame-relay lmi-type cisco
  hold-queue 32768 out
!
interface Serial2/0.1 point-to-point
 ip address <ip address> <mask>
 frame-relay interface-dlci <DLCI> IETF
 service-policy output COS1
!
interface Serial2/0.2 point-to-point
 ip address <ip address> <mask>
 frame-relay interface-dlci <DLCI>  IETF
 service-policy output COS2
```

4.3.7 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.

On the main interface:

- Configure IP address which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Set duplex to full
- Set interface speed appropriate to the speed ordered
- Configure the service policy name (Ether-Shape in the following example)
- Configure "hold-queue 32768 out"

Full port Ethernet:

Following is a sample port configuration for full port Ethernet:

```
interface GigabitEthernet0/0
 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)
 service-policy output Ether-Shape
```

```
hold-queue 32768 out
```

Single Stack VLAN Tag:

Following is an example of a single stack VLAN tag configuration. A VLAN subinterface is configured using the AT&T supplied VLAN ID tag in the encapsulation command.

Follow commands shown previously in this section for the main Ethernet interface, except do not configure the IP address. IP addresses will be configured on each subinterface.

For each subinterface:

- Configure "encapsulation dot1Q" with the appropriate VLAN tag number.
- Configure IP address for the subinterface which should be the CER side of the /30 subnet assigned for the CER/PER link
- Configure the service policy name (Ether-Shape in the following example)

```
interface GigabitEthernet0/1
 no ip address
 load-interval 30
 duplex full (do not use auto – force full duplex operation)
 speed 100 (10 or 1000  are also selectable)
 hold-queue 32768 out
!
interface GigabitEthernet0/1.201
 encapsulation dot1Q <VLAN tag>
 ip address <ip address> <mask>
 ip virtual-reassembly
 service-policy output Ether-Shape
```

Dual Stack VLAN Tag:

Following is an example of a dual stack VLAN tag configuration. 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.

Follow commands shown previously in this section for the main Ethernet interface, except do not configure the IP address. IP addresses will be configured on each subinterface.

For each subinterface:

- Configure "encapsulation dot1Q <inner VLAN tag number> second-dot1Q <outer VLAN tag number>
- Configure IP address for the subinterface which should be the CER side of the /30 subnet assigned for the CER/PER link
- Configure the service policy name (Ether-Shape in the following example)

```
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)
 hold-queue 32768 out

interface GigabitEthernet0/0.2004     (recommend  to 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 Ether-Shape
```

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**.

4.4 *Frame Relay Traffic Shaping for Frame Relay Interfaces only*

Frame Relay traffic shaping is no longer supported on ISR G2 routers.

5 Customer Edge Router configurations specific to a TDM Gateway

There is configuration required on the CER for TDM Gateway solutions. The information below will assist in configuring the CER to insure interoperability with your TDM Gateway environment.

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/ (login: att, password: attvoip)*. Use the appropriate guide for your router platform.

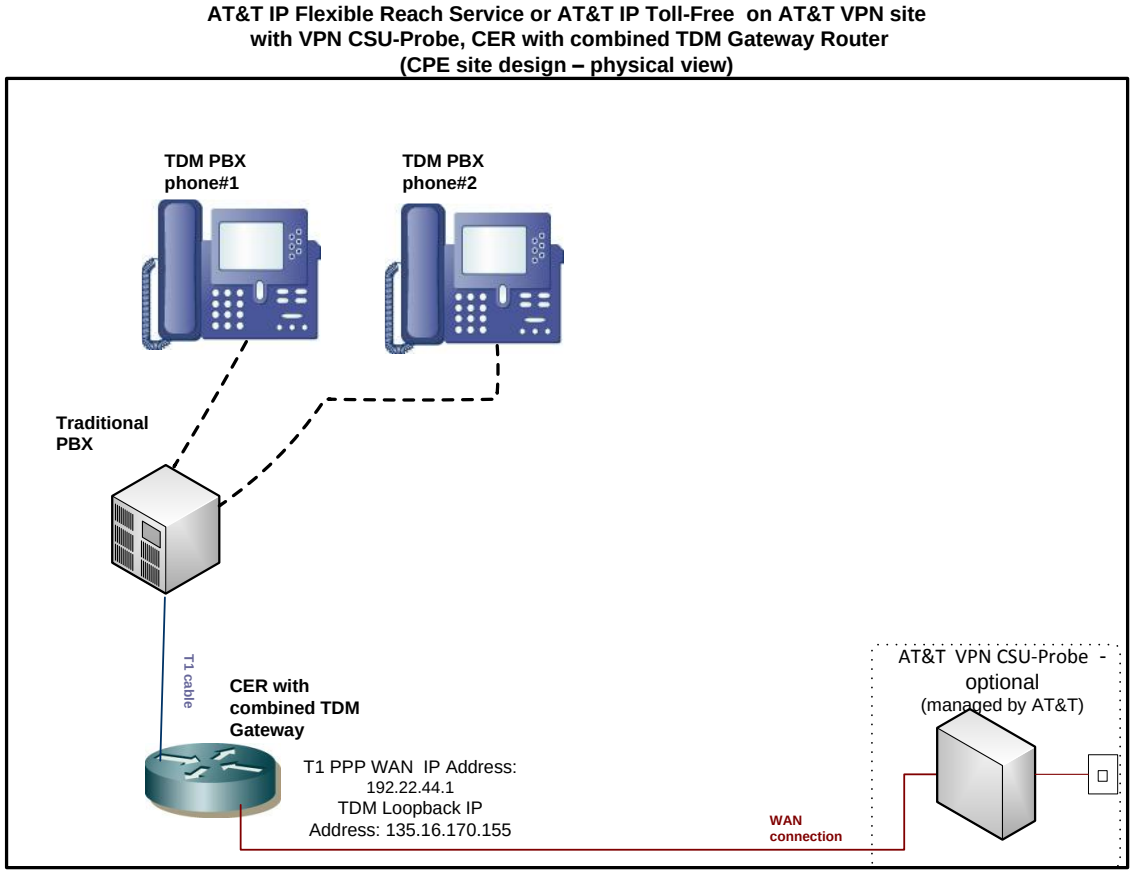
5.1 *TDM Gateway combined in CER*

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

A loopback interface on the CER/TDM Gateway must be configured as the IP Flexible Reach Service and/or AT&T IP Toll-Free Signaling and Media address. For TDM Gateway, signaling and media use the same 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>
 neighbor <PER IP address>  allowas-in
no auto-summary
```

TDM gateway example diagram:



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 G2 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)

```
Current configuration : 13623 bytes
!
! Last configuration change at 10:51:53 EDST Wed Apr 13 2011 by cisco
! NVRAM config last updated at 11:45:01 EDST Mon Apr 11 2011 by cisco
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 3925B-Dallas
!
boot-start-marker
boot system flash:c3900-universalk9-mz.SPA.152-1.T2ES
boot-end-marker
!
!
logging buffered 2000000
no logging console
enable password 7 1511021F0725
!
no aaa new-model
clock timezone EST -5 0
clock summer-time EDST recurring
clock calendar-valid
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
!
no ip domain lookup
ip domain name hawaii
multilink bundle-name authenticated
!
!
!
username admin password 7 05080F1C2243
username vinny privilege 15 secret 5 $1$R6YO$Fwu2KYGdeFGsbgGJviSGt1
username cisco password 7 030752180500
```

```
!
redundancy
!
!
!
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
  set ip dscp cs6
policy-map COS
 class COS1
    priority
    queue-limit 2048 packets
    police 616000 77000 conform-action set-dscp-transmit ef exceed-action
drop
   compress header ip rtp
 class COS2
    bandwidth remaining percent 40
  set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent 30
  set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent 30
  set ip dscp default
    queue-limit 64 packets
policy-map SHAPE_FR
 class class-default
  shape average 690000 6900 0
  service-policy COS
!
!
interface GigabitEthernet0/0
 description Faces SBC
 ip address 172.22.16.1 255.255.255.0
 duplex full
 speed 100
 no keepalive
!
interface GigabitEthernet0/1
 no ip address
```

```
 load-interval 30
 duplex full
 speed auto
!
!
interface GigabitEthernet0/2
 no ip address
!
interface Serial0/0/0
 no ip address
 encapsulation frame-relay IETF
 load-interval 30
 frame-relay lmi-type cisco
 hold-queue 32768 out
!
interface Serial0/0/0.1 point-to-point
 bandwidth 690
 snmp trap link-status
 frame-relay interface-dlci 237 ppp Virtual-Template1
!
!
interface Virtual-Template1
 bandwidth 690
 ip address 192.166.201.1 255.255.255.252
 load-interval 30
 ppp multilink
 ppp multilink interleave
 ppp multilink fragment delay 10
 service-policy output SHAPE_FR
!
router bgp 65000
 bgp router-id 196.96.1.9
 bgp log-neighbor-changes
 network 135.16.170.2 mask 255.255.255.255
 network 32.252.97.40 mask 255.255.255.252
 neighbor 192.166.201.2 remote-as 13979
 neighbor 192.166.201.2 allowas-in
 no auto-summary
!

!
ip route 135.16.170.2 255.255.255.255 172.22.16.2
*** Static Route to SBC IP Flexible Reach Signaling IP address***

!

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 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
!
!
map-class frame-relay shape768
 frame-relay cir 691000
 frame-relay bc 6910
 frame-relay be 0
 frame-relay mincir 691000
!
!
!
!
!
control-plane
!
!
!
line con 0
 exec-timeout 600 0
 login local
line aux 0
line vty 0 4
 exec-timeout 300 0
 privilege level 15
 login local
 transport input telnet
line vty 5 15
 access-class 23 in
 privilege level 15
 login local
 transport input telnet ssh
!
exception data-corruption buffer truncate
scheduler allocate 20000 1000
end
```

A.2 N X T1 MLPPP Access (4 T1s)

```
3925C-Miami#show run
Building configuration...
```

```
Current configuration : 13444 bytes
!
! Last configuration change at 14:49:06 EDST Thu Apr 7 2011 by cisco
! NVRAM config last updated at 14:49:08 EDST Thu Apr 7 2011 by cisco
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 3925C-Miami
!
boot-start-marker
boot system flash:c3900-universalk9-mz.SPA.152-1.T2ES
boot-end-marker
!
!
card type t1 0 2
card type t1 0 3
logging buffered 51200 warnings
enable password 7 060506324F41
!
no aaa new-model
clock timezone EST -5 0
clock summer-time EDST recurring
clock calendar-valid
no network-clock-participate wic 2
no network-clock-participate wic 3
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
!
no ip domain lookup
multilink bundle-name authenticated
!
!
!
!
username admin password 7 070C285F4D06
username vinny privilege 15 secret 5 $1$EL3i$PAYezSnlq1qvDcSe4MbVt1
username cisco password 7 01100F175804
!
redundancy
!
!
controller T1 0/2/0
 framing esf
 linecode b8zs
 channel-group 0 timeslots 1-24
!
controller T1 0/2/1
```

```
 framing esf
 linecode b8zs

 channel-group 0 timeslots 1-24
!
controller T1 0/3/0
 framing esf
 linecode b8zs
 channel-group 0 timeslots 1-24
!
controller T1 0/3/1
 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
!
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
policy-map COS
 class COS1
    priority
      queue-limit 2048 packets
    police 27000000 3375000 conform-action set-dscp-transmit ef exceed-
action drop
 class COS2
    bandwidth remaining percent 40
  set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent 30
  set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent 30
  set ip dscp default
    queue-limit 64 packets
!
!
interface Multilink1
 ip address 192.168.200.1 255.255.255.252
 load-interval 30
```

```
 ppp chap hostname 192.168.200.2
 ppp multilink
 ppp multilink group 1
 ppp multilink fragment disable
 service-policy output COS_MLPPP
 hold-queue 32768 out
!
interface GigabitEthernet0/0
 description Faces SBC
 ip address 172.22.16.1 255.255.255.0
 duplex full
 speed 100
 no keepalive

!
interface GigabitEthernet0/1
 no ip address
 load-interval 30
 duplex full
 speed 100
!
!
interface GigabitEthernet0/2
 no ip address
!
interface Serial0/2/0:0
 no ip address
 encapsulation ppp
 load-interval 30
 ppp chap hostname 192.168.200.2
 ppp multilink
 ppp multilink group 1
!
interface Serial0/2/1:0
 no ip address
 encapsulation ppp
 load-interval 30
 ppp chap hostname 192.168.200.2
 ppp multilink
 ppp multilink group 1
!
interface Serial0/3/0:0
 no ip address
 encapsulation ppp
 load-interval 30
 ppp chap hostname 192.168.200.2
 ppp multilink
 ppp multilink group 1
!
interface Serial0/3/1:0
 no ip address
 encapsulation ppp
 load-interval 30
 ppp chap hostname 192.168.200.2
 ppp multilink
 ppp multilink group 1
```

```
!
!
router bgp 65000
 bgp router-id 192.168.200.2
 bgp log-neighbor-changes
 network 135.16.170.2 mask 255.255.255.255
 network 32.252.97.40 mask 255.255.255.252
 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
*** Static Route to SBC – IP Flexible Reach Signaling IP address***

!
!
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
 permit tcp any any eq www
 permit tcp any eq www any
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 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 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
!
!
!
control-plane
!
!
!
line con 0
 exec-timeout 600 0
 login local
line aux 0
line vty 0 4
 exec-timeout 300 0
 privilege level 15
 login local
```

```
 transport input telnet
line vty 5 15
 access-class 23 in
 privilege level 15
 login local
 transport input telnet ssh
!
scheduler allocate 20000 1000
end
```

A.3 T1 PPP Access

```
2921A-Tokyo#sh run

Building configuration...


Current configuration : 13755 bytes

!

! Last configuration change at 09:23:46 EDST Wed May 11 2011 by cisco

! NVRAM config last updated at 14:40:06 EDST Thu Apr 28 2011 by vinny

!

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

service password-encryption

!

hostname 2921A-Tokyo

!

boot-start-marker

boot system flash:c2900-universalk9-mz.SPA.152-1.T2ES

!

!

logging buffered 51200 warnings
```

```
enable password 7 05080F1C2243
!
memory-size iomem 15
clock timezone EST -5 0
clock summer-time EDST recurring
clock calendar-valid
!
no ipv6 cef
ip source-route
ip cef
!
no ip domain lookup
!
multilink bundle-name authenticated
!
!
username admin password 7 05080F1C2243
username vinny privilege 15 secret 5 $1$TtBY$qS0vL0o7LN7WRKlBvP6BY0
username cisco password 7 070C285F4D06
!
redundancy
!
!
!
!
!
!
policy-map MARK-BGP
```

```
 class BGP
  set ip dscp cs6
policy-map COS
 class COS1
    priority
    queue-limit 2048 packets
    police 768000 96000 conform-action set-dscp-transmit ef exceed-action
drop
 class COS2
    bandwidth remaining percent 40
  set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent 30
  set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent 30
  set ip dscp default
    queue-limit 64 packets
policy-map 100M-SHAPE
 class class-default
    shape average 1456000 14560
  service-policy COS
!
!
interface GigabitEthernet0/0
```

```
 description Faces SBC
 ip address 172.22.16.1 255.255.255.0
 duplex full
 speed 100
 no keepalive
!
!
interface GigabitEthernet0/1
 no ip address
 load-interval 30
 duplex full
 speed auto
 media-type rj45
 no keepalive
!
!
interface GigabitEthernet0/2
 no ip address
!
!
interface Serial0/2/0
 bandwidth 1456
 ip address 192.168.100.1 255.255.255.252
 encapsulation ppp
 load-interval 30
 hold-queue 32768 out
!
!
```

```
router bgp 65000
 bgp router-id 192.168.0.40
 bgp log-neighbor-changes
 network 135.16.170.2 mask 255.255.255.255
 network 32.252.97.40 mask 255.255.255.252
 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
*** Static Route to SBC***

!
!
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
 permit tcp any any eq www
 permit tcp any eq www any
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 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 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
!
!
!
!
!
!
line con 0
 exec-timeout 600 0
line aux 0
 exec-timeout 600 0
line vty 0 4
 exec-timeout 600 0
 privilege level 15
 transport input telnet
line vty 5 15
 access-class 23 in
```

```
 privilege level 15

 transport input telnet ssh

!

scheduler allocate 20000 1000

end
```

A.4 T3 PPP Access

```
Current configuration : 11726 bytes
!
! Last configuration change at 12:10:22 EDST Tue Mar 29 2011 by vinny
! NVRAM config last updated at 12:10:23 EDST Tue Mar 29 2011 by vinny
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 3945C-San-Francisco
!
boot-start-marker
boot system flash:c3900-universalk9-mz.SPA.152-1.T2ES
boot-end-marker
!
!
card type t3 2
logging buffered 51200 warnings
enable password 7 110A1016141D
!
no aaa new-model
clock timezone EST -5 0
clock summer-time EDST recurring
clock calendar-valid
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
!
no ip domain lookup
multilink bundle-name authenticated
!
!
!
```

```
!
username admin password 7 1511021F0725
username cisco password 7 045802150C2E
username vinny privilege 15 secret 5 $1$D1PK$TL4O4nKY6THRZnpGUfuK50
!
redundancy
!
!
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
 match access-group name SCCP
 !
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
policy-map COS
 class COS1
    priority
    queue-limit 2048 packets
    police 39808000 4976000 conform-action set-dscp-transmit ef exceed-
action drop
 class COS2
    bandwidth remaining percent 40
  set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent 30
  set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent 30
  set ip dscp default
    queue-limit 64 packets
policy-map T3-SHAPE
 class class-default
    shape average 41992000 168064
  service-policy COS
!
!
!
!
!
interface GigabitEthernet0/0
 description Faces SBC
```

```
 ip address 172.22.16.1 255.255.255.0
 duplex full
 speed 100
 no keepalive
!
interface GigabitEthernet0/1
 no ip address
 load-interval 30
 duplex full
 speed auto
 hold-queue 768 in
!
interface GigabitEthernet0/2
 no ip address
!
interface Serial2/0
 bandwidth 41992
 description - T3 PPP
 ip address 192.168.200.9 255.255.255.252
encapsulation ppp
 load-interval 30
 dsu bandwidth 44210
 scramble
 serial restart-delay 0
 service-policy output T3-SHAPE
 hold-queue 32768 out
!
router bgp 65000
 bgp log-neighbor-changes
 network 135.16.170.2 mask 255.255.255.255
 network 32.252.97.40 mask 255.255.255.252
 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
*** Static Route to SBC***

!
!
!
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
 permit tcp any any eq www
 permit tcp any eq www any
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 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 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
!
!
!
!
control-plane
!
!
!
line con 0
 exec-timeout 600 0
 login local
line aux 0
line vty 0 4
 exec-timeout 400 0
 privilege level 15
 login local
 transport input telnet
line vty 5 15
 access-class 23 in
 privilege level 15
 login local
 transport input telnet ssh
!
end
```

A.5 Ethernet Access

```
Current configuration : 11879 bytes
!
! No configuration change since last restart
! NVRAM config last updated at 15:25:53 EDST Mon Apr 4 2011
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname 3945C-San-Francisco
!
boot-start-marker
boot system flash:c3900-universalk9-mz.152-1.T2ES
```

```
boot-end-marker
!
!
logging buffered 51200 warnings
enable password 7 110A1016141D
!
no aaa new-model
clock timezone EST -5 0
clock summer-time EDST recurring
clock calendar-valid
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
!
no ip domain lookup
multilink bundle-name authenticated
!
!
!
!
!
!
license udi pid C3900-SPE150/K9 sn FOC14176S38
hw-module pvdm 0/0
!
!
!
username admin password 7 1511021F0725
username cisco password 7 045802150C2E
username vinny privilege 15 secret 5 $1$D1PK$TL4O4nKY6THRZnpGUfuK50
!
redundancy
!
!
!
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
  set ip dscp cs6
```

```
policy-map COS
 class COS1
    priority
    queue-limit 2048 packets
    police 70016000 8752000 conform-action set-dscp-transmit ef exceed-
action drop
 class COS2
    bandwidth remaining percent 40 account user-defined 28
  set ip dscp af31
    queue-limit 64 packets
  service-policy MARK-BGP
 class COS3
    bandwidth remaining percent 30 account user-defined 28
  set ip dscp af21
    queue-limit 64 packets
 class class-default
    bandwidth remaining percent 30 account user-defined 28
  set ip dscp default
    queue-limit 64 packets
policy-map 100M-SHAPE
 class class-default
    shape average 9894400 300032 account user-defined 28
  service-policy COS
!
!
!
interface GigabitEthernet0/0
 bandwidth 75000
 description - WAN Link
 no ip address
 load-interval 30
 duplex full
 speed 1000
 hold-queue 32768 out
!
interface GigabitEthernet0/0.203
 description - Link to mse 5 PE router - Gig10/0.2013
 encapsulation dot1Q 203
 ip address 195.18.31.105 255.255.255.252
 service-policy output 100M-SHAPE
!
interface GigabitEthernet0/1
 description Faces SBC
 ip address 172.22.16.1 255.255.255.0
 duplex full
 speed 100
 no keepalive
!
!
interface GigabitEthernet0/2
 no ip address
!
!
router bgp 65000
 bgp log-neighbor-changes
 network 135.16.170.2 mask 255.255.255.255
```

```
 network 32.252.97.40 mask 255.255.255.252
 neighbor 195.18.31.106 remote-as 13979
 neighbor 195.18.31.106 allowas-in
 no auto-summary
!
ip route 135.16.170.2 255.255.255.255 172.22.16.2
*** Static Route to SBC – IP Flexible Reach Signaling IP address***

!
!
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
 permit tcp any any eq www
 permit tcp any eq www any
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 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 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
!
!
line con 0
 exec-timeout 600 0
 login local
line aux 0
line vty 0 4
 exec-timeout 400 0
 privilege level 15
 login local
 transport input telnet
line vty 5 15
 access-class 23 in
 privilege level 15
 login local
 transport input telnet ssh
!

end
```

Appendix B: 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 C: Branch Office Extension (BOE)

C.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 as an underlying transport service 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 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 transport 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 AT&T's BVoIP 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 as an underlying transport service.
- An IP PBX at the hub site.
- A branch office site that may be connected via either 1) AT&T VPN as an underlying transport service 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 as an underlying transport service 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 as an underlying transport service. The customer may reach the remote branch office sites via this CER (over the AT&T VPN as an underlying transport

service) or they can deploy a second customer managed router that provides their own connectivity to the customer's data network.

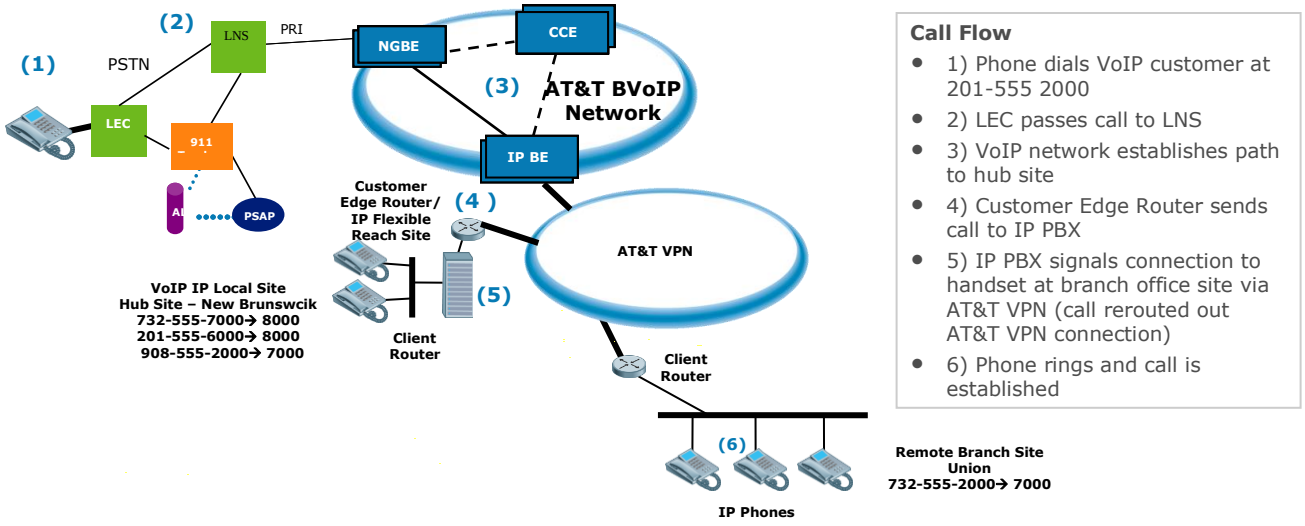
Important Note: The number of concurrent calls at the Hub site must be engineered for all voice traffic originating and terminating at the Hub and Branch Office sites. Concurrent calls are the number of VoIP calls expected to occur at the same time at the Hub site. Be aware if BOE calls are hairpinned through the existing hub site router over the AT&T VPN as an underlying transport service, 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 places and completed prior to initiating the Branch Office order.

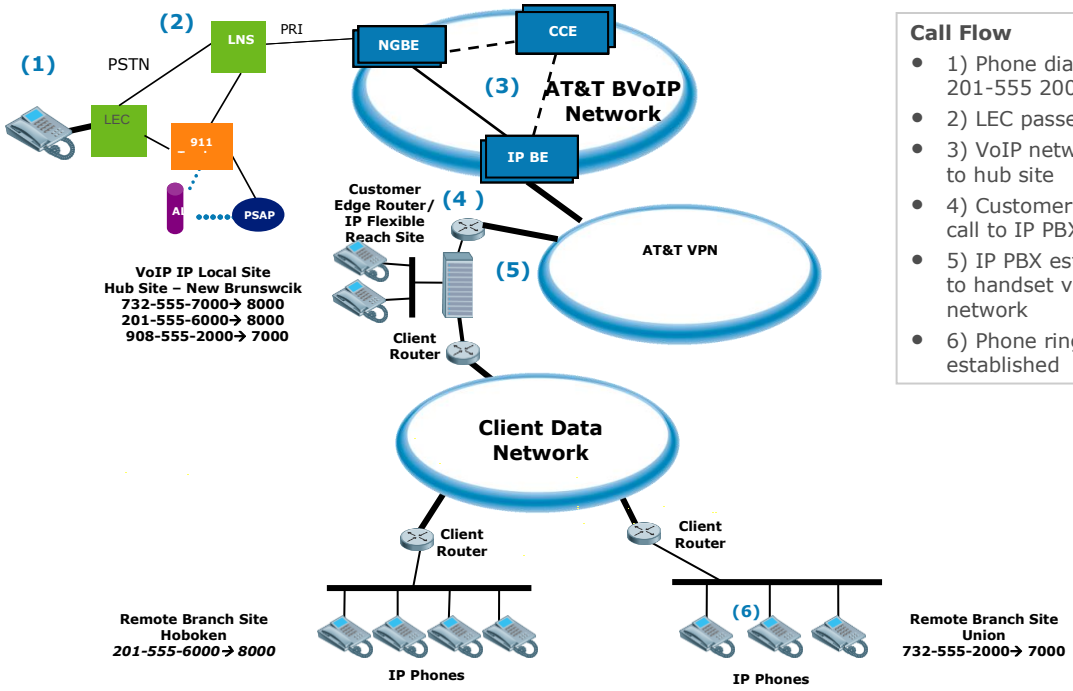
See section 2.1.2 for Bandwidth Per Call Requirements.

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 Flexible Reach Branch Office Extension (BOE) using AT&T VPN network to connect to BOE site:



AT&T IP Flexible Reach 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

C.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.

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.

C.3 Emergency Services

AT&T Flexible Reach service plans B and C, including AT&T BVoIP 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 BVoIP location including all Branch Offices. The customer must also ensure that AT&T BVoIP 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 BVoIP telephone number assigned to the site and the telephone is manned to handle potential call back from the emergency service agent.

C.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.

- 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 D: Acronymns

Acronym	Translation
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
EF	Expedient Forwarding

Acronym	Translation
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
PRI	Primary Rate Interface

Acronym	Translation
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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