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 ASR 1001, 1002, 1002X, 1004, 1006 Platforms

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Version 2.5

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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 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.

1.1.1 **Access Types**

Following are the access types that can be ordered on the ASR Router:

Access Type	**Speed (bit/s)**	**Supported Platforms**
T3 PPP Access	5M to 45M	ASR 1001, 1002, 1004, 1006
E3 PPP Access	5M to 34M	ASR 1001, 1002, 1004, 1006
T3 Frame Relay Encapsulation	5M to 45M	ASR 1001, 1002, 1004, 1006
E3 Frame Relay Encapsulation	5M to 34M	ASR 1001, 1002, 1004, 1006
OC3 ATM	50M, 75M, 100M, 155M	ASR 1001, 1002, 1004, 1006
OC3 PPP access	50M, 75M, 100M, 155M	ASR 1001, 1002, 1004, 1006
OC3 Frame Relay Encapsulation	50M, 75M, 100M, 155M	ASR 1001, 1002, 1004, 1006
OC12 PPP access	100M, 200M, 300M, 400M, 622M	ASR 1001, 1002, 1004, 1006
OC12 Frame Relay Encapsulation	100M, 200M, 300M, 400M, 622M	ASR 1001, 1002, 1004, 1006
OC48 PPP access	2.4G	ASR 1004/1006 only
OC48 Frame Relay Encapsulation	2.4G	ASR 1004/1006 only

Ethernet Access types:

Access Type	**Speed (bit/s)**	**Supported Platforms**
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	ASR 1001, 1002
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	ASR 1001, 1002
1000 Base LX or SX	Access Link, VPN port and VLAN speeds (in Mbits): .5, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, 400, 400, 450, 500, 600, 700, 800, 900, 1000)	ASR 1001, 1002, 1002X, 1004, 1006
10 Gigabit Ethernet LX or SX	Access Link, VPN port and VLAN speeds:	ASR 1002X, 1004, 1006

1.1.2 Software Information

1.1.2.1 ASR 1001

ASR 1001 - CER only
ASR 1001 configurations in this guide were tested with Cisco IOS-XE Release 15.3.3S1 with ESP-2.5.
The ASR 1001 IOS XE files is asr1001-universalk9.03.10.01.S.153-3.S1-ext.bin.

OR

ASR 1001 - CER or combined CER/CUBE 1.4
ASR 1001 configurations in this guide were tested with Cisco IOS-XE Release 15.1.1S1 with ESP-2.5.
The ASR 1001 IOS XE file is asr1001-universalk9.03.02.01.S.151-1.S1.bin.

1.1.2.2 ASR 1002

ASR 1002 - CER only
ASR 1002 configurations in this guide were tested with Cisco IOS-XE Release 15.3.3S1 with ESP-5.
The 1002 IOS XE file is asr1000rp1-adventerprisek9.03.07.06.S.152-4.S6.bin

OR

ASR 1002 - CER or combined CER/CUBE1.4
ASR 1002 configurations in this guide were tested with Cisco IOS-XE Release 15.1.1S1 with ESP-5.
The 1002 IOS XE file is asr1000rp1-adventerprisek9.03.02.00.S.151-1.S1.bin

1.1.2.3 ASR 1002X

ASR 1002X – CER only
ASR 1002X configurations in this guide were tested with Cisco IOS-XE Release 15.3.3S1 with ESP-5.
The 1002X IOS XE file is asr1002x-universalk9.03.10.01.S.153-3.S1-ext.SPA.bin
The IOS XE is run from the bootflash, which is the internal compact flash memory.
The 1002X was tested with 4GB of DRAM.

1.1.2.4 ASR 1004/1006

ASR 1004/1006 - CER only
ASR 1004/1006 configurations in this guide were tested with Cisco IOS Software, IOS-XE Software (X86_64_LINUX_IOSD-ADVENTERPRISEK9-M), Version 15.3(3)S1. The 1004/1006 IOS XE file is asr1000rp1-adventerprisek9.03.10.01.S.153-3.S1-ext.bin

OR

ASR 1004/1006 - CER only
ASR 1004/1006 configurations in this guide were tested with Cisco IOS Software, IOS-XE Software (X86_64_LINUX_IOSD-ADVENTERPRISEK9-M), Version 15.1(3)S2, CUST-SPECIAL:V151_3_S2_SR617255895_3
The 1004/1006 IOS XE file is asr1000rp2-adventerprisek9.V151_3_S2_SR617255895_3.bin

1.1.3 Supported Hardware

1.1.3.1 ASR 1001

- ESP-2.5/5, SIP10, RP1
- Supported Interface Cards:
    - SPA-1XOC12-POS 1-port OC12/STM4 POS Shared Port Adapters
    - SPA-2XOC3-POS 2-port OC3/STM1 POS Shared Port Adapters
    - SPA-4XOC3-POS 4-port OC3/STM1 POS Shared Port Adapters
    - SPA-1XOC3-ATM-V2 1-port OC3/STM1 ATM Shared Port Adapter
    - SPA-2XT3/E3 2-port Clear Channel T3/E3 Shared Port Adapter
    - SPA-2X1GE-V2 Cisco 2-Port Gigabit Ethernet Shared Port Adapter
    - SPA-4X1FETX-V2 Cisco 4-Port Fast Ethernet (TX) Shared Port Adapter
    - SPA-8X1FETX-V2 Cisco 8-Port Fast Ethernet (TX) Shared Port Adapter
- The following SFPs are supported for Gigabit Ethernet ports:
    - SFP-GE-T
    - SFP-GE-S
    - SFP-GE-L
    - SFP-GE-Z

1.1.3.2 ASR 1002

- ESP-5, SIP10, RP1
- Supported Interface Cards:
    - SPA-1XOC12-POS 1-port OC12/STM4 POS Shared Port Adapters
    - SPA-2XOC3-POS 2-port OC3/STM1 POS Shared Port Adapters

    - SPA-4XOC3-POS 4-port OC3/STM1 POS Shared Port Adapters
    - SPA-1XOC3-ATM-V2 1-port OC3/STM1 ATM Shared Port Adapter
    - SPA-2XT3/E3 2-port Clear Channel T3/E3 Shared Port Adapter
    - SPA-2X1GE-V2 Cisco 2-Port Gigabit Ethernet Shared Port Adapter
    - SPA-4X1FETX-V2 Cisco 4-Port Fast Ethernet (TX) Shared Port Adapter
    - SPA-8X1FETX-V2 Cisco 8-Port Fast Ethernet (TX) Shared Port Adapter
- The following SFPs are supported for Gigabit Ethernet ports:
    - SFP-GE-T
    - SFP-GE-S
    - SFP-GE-L
    - SFP-GE-Z

1.1.3.3 ASR 1002X

- ESP-5, 10, 20 and 36; SIP40, and RP1
- Supported Interface Cards:
    - SPA-1x10GE-L-V2 or SPA-1x10GE-WL-V2: 1-Port 10-Gigabit Ethernet SPA (*Note: The SPA-1x10GE-WL-V2 card is used only if 192 framing is required at the customer location.)*
        - XFP-10G-MM-SR
        - XFP-10GLR-OC192SR
    - Six built-in Gigabit Ethernet SFP's
        - SFP-GE-T
        - SFP-GE-S

1.1.3.4 ASR 1004

- ESP-40, SIP40, and RP-2
- Supported Interface Cards:
    - SPA-1X10GE-L-V2 Cisco 1-Port 10 Gigabit Ethernet Shared Port Adapter, Version 2
        - XFP-10GLR-OC192SR
        - XFP-10GER-OC192IR
        - XFP-10GZR-OC192LR
        - XFP-10G-MM-SR
    - SPA-10X1GE-V2 Cisco 10-Port Gigabit Ethernet Shared Port Adapter, Version 2
        - SFP-GE-S
        - SFP-GE-L
        - SFP-GE-Z
    - SPA-2X1GE-V2 Cisco 2-Port Gigabit Ethernet Shared Port Adapter, Version 2
        - SFP-GE-S
        - SFP-GE-L
        - SFP-GE-Z

1.1.3.5 ASR 1006

- ESP-100, SIP40, and RP-2
- Supported Interface Cards:
  - SPA-1X10GE-L-V2 Cisco 1-Port 10 Gigabit Ethernet Shared Port Adapter, Version 2
    - XFP-10GLR-OC192SR
    - XFP-10GER-OC192IR
    - XFP-10GZR-OC192LR
    - XFP-10G-MM-SR
  - SPA-10X1GE-V2 Cisco 10-Port Gigabit Ethernet Shared Port Adapter, Version 2
    - SFP-GE-S
    - SFP-GE-L
    - SFP-GE-Z
  - SPA-2X1GE-V2 Cisco 2-Port Gigabit Ethernet Shared Port Adapter, Version 2
    - SFP-GE-S
    - SFP-GE-L
    - SFP-GE-Z

1.2 *Network Topology*

This section describes the generic AT&T supported topologies for various vendor IP–PBX's.

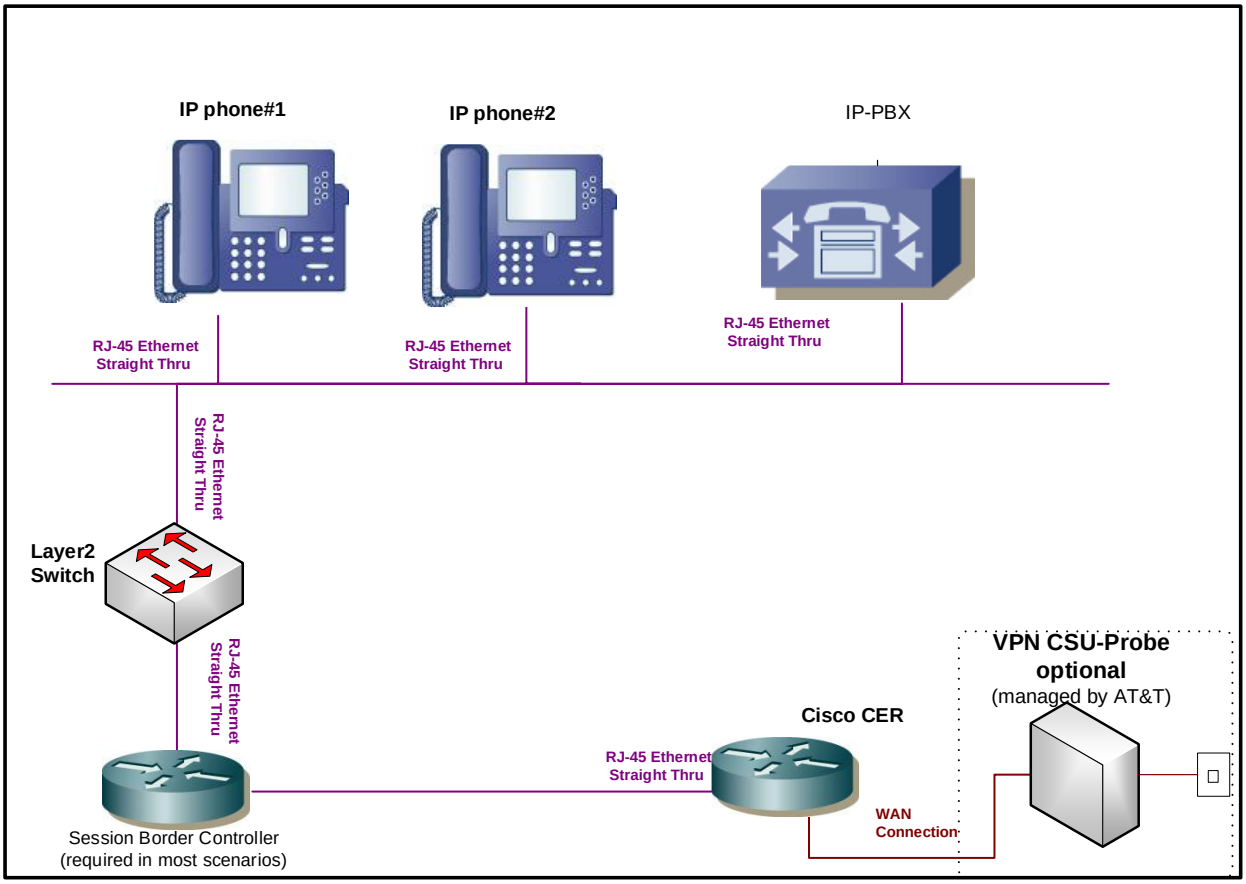
- Please refer to the following documents for details on configuring vendor specific AT&T supported topologies and related configuration information for IP-PBX's:
  - "*Customer Edge Router Customer Configuration Guide for AT&T Certified IP-PBX Solutions"*. (*http://www.corp.att.com/bvoip/avpn/implementation/ (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))*.

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

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

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

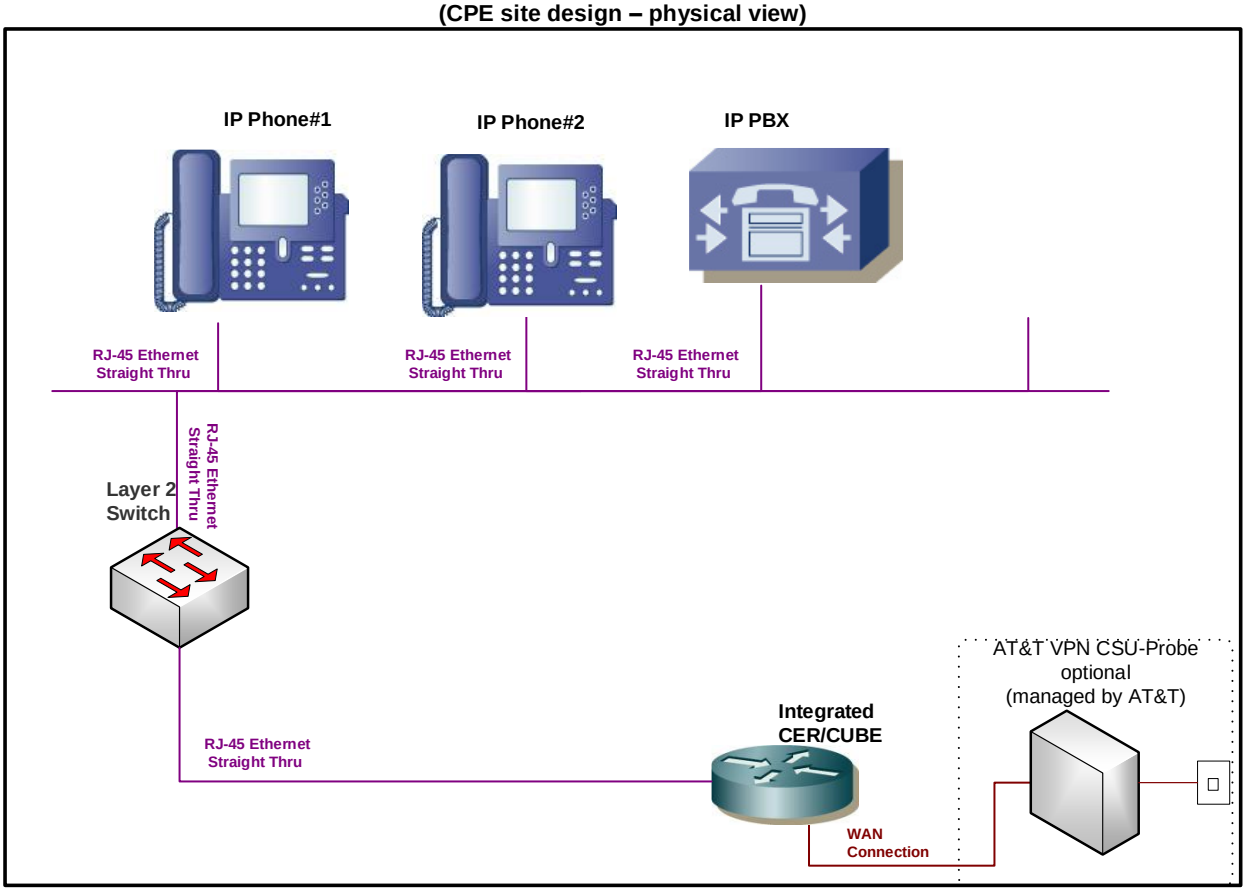
AT&T IP Flexible Reach Service or AT&T IP Toll-Free on AT&T VPN site
with AT&T VPN CSU-Probe, Generic IP-PBX and optional SBC
(CPE site design – physical view)



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 integrated CER/CUBE is only supported with the ASR 1001 and 1002. The AT&T VPN CSU-Probe is an AT&T managed device. 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 *Special Considerations*

- The following TCP/IP ports must not be blocked by firewall or access lists:
  - AT&T IP Border Element signaling and media addresses.
  - SIP signaling traffic (UDP port 5060).
  - RTP/RTCP traffic (UDP port range 16384-32767).
- The configuration information in this CCG assumes a single primary CER. Any alternate routing configurations or remote branch connectivity to other sites, within the same or other AT&T VPN, requires proper configuration of the signaling and media paths. Routing configurations in all customer routers need to be set up to assure that the routing in the primary CER is not affected.
- Class of Service (CoS) specific considerations:
  - CoS1 should not be more than 70% for ATM, Ethernet access.

2 Network Design

Before implementing AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free over AT&T VPN as the 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 the 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 the 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.

Access Type	Codec	ptime (ms)	Bandwidth per call (Kbit/s)	
			Without RTCP	With RTCP
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
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
ATM	G729 A	20	27.4	27.9
	G729 A	30	21.1	21.6
	G711	20	83.1	83.6
	G711	30	76.6	77.2

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 PSTN calls.

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

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

2.1.3 **Bandwidth Reduction Techniques**

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

VAD or Voice Activity Detection (also known as silence suppression) may be turned on to take advantage of the fact that voice calls are “half duplex”— that is only one speaker in one direction is active at a time. Studies have shown that while theoretically VAD could reduce bandwidth consumption by 50%, a more conservative figure to use in design is 30%. Many users find that VAD can cause call impairment known as clipping — where the first word or

words are cut off when a speaker starts and, therefore, they do not use VAD even though it might help with the bandwidth consumption. A "best practice", conservative design approach would be to size the network without VAD, test calls with VAD once the network is in place and adjust the bandwidth accordingly assuming VAD works effectively.

Most VoIP codecs can be modified from the default parameters to provide more efficient utilization of bandwidth for carrying voice traffic. One popular technique is to increase the number of voice samples in each IP packet. VoIP packets tend to be quite small, with a large percentage of the usable bandwidth consumed by protocol overhead (Layer 2, IP, UDP, RTP). Typically, G.729 encodes two 10mS voice samples in each IP packet. Each voice sample is only 10 bytes. The codec can often be modified to pack 3 or even more voice samples in each IP packet, substantially reducing the overhead:payload ratio. The downside of this approach is that it increases the encoding/decoding delay proportionately and more stringent overall design relative to latency and jitter.

2.1.4 **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: 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*

2.2 *Special Engineering Guidelines for Ethernet Access*

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

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

1. CoS1 for Ethernet should not be > than 70% to compensate for overhead.
2. Shaping Rates should be computed to 99% of Port speed – rounded down to the next 64K – per the table below.

Ethernet Shaping Table:

Access Type/Speed	Port Speed	Shaped to 99% of Ethernet VLAN speed *rounded down to nearest 64k
512k VLAN Ethernet	512k	**448k***
1M VLAN Ethernet	1000k	**960k***
1.5M VLAN Ethernet	1500k	**1472k***
2M VLAN Ethernet	2000k	**1920k***
3M VLAN Ethernet	3000k	**2944k***
4M VLAN Ethernet	4000k	**3904k***
5M VLAN Ethernet	5000k	**4928k***
6M VLAN Ethernet	6000k	**5888k***
7M VLAN Ethernet	7000k	**6912k***
8M VLAN Ethernet	8000k	**7872k***
9M VLAN Ethernet	9000k	**8896k***
10M VLAN Ethernet	10000k	**9856k***
20M VLAN Ethernet	20000k	**19776k***
30M VLAN Ethernet	30000k	**29696k***
40M VLAN Ethernet	40000k	**39552k***
50M VLAN Ethernet	50000k	**49472k***
60M VLAN Ethernet	60000k	**59392k***
70M VLAN Ethernet	70000k	**69248k***

Access Type/Speed	Port Speed	Shaped to 99% of Ethernet VLAN speed *rounded down to nearest 64k
80M VLAN Ethernet	80000k	**79168k***
90M VLAN Ethernet	90000k	**89088k***
100M VLAN Ethernet	100000k	**98944k***
150M VLAN Ethernet	150000k	**148480k***
200M VLAN Ethernet	200000k	**197952k***
250M VLAN Ethernet	250000k	**247488k***
300M VLAN Ethernet	300000k	**296960k***
400M VLAN Ethernet	400000k	**395968k***
450M VLAN Ethernet	450000k	**445440k***
500M VLAN Ethernet	500000k	**494976k***
600M VLAN Ethernet	600000k	**593984k***
700M VLAN Ethernet	700000k	**692992k***
800M VLAN Ethernet	800000k	**792000k***
900M VLAN Ethernet	900000k	**890944k***
1000M VLAN Ethernet	1000000k	**989952k***
2.5Gig VLAN Ethernet	2500000k	**2474944k***

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.

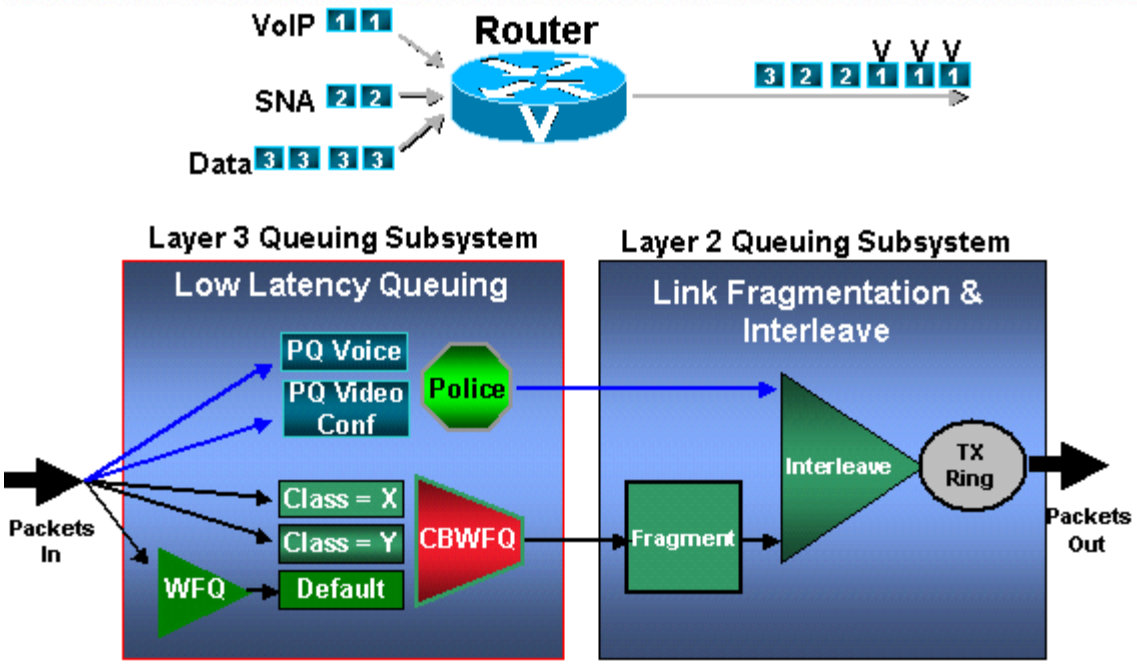
Class of Service	IP Precedence	**DSCP**	**DSCP Decimal**	**DSCP Binary (In Contract)**
Real Time	5	EF	46	101 110
Bursty High	3	AF31	26	011 010
Bursty Low	2	AF21	18	010 010
Best Effort	0	BE	0	000 000

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. In the AT&T IP Flexible Reach Service and/or AT&T IP Toll-Free over AT&T VPN as the Underlying Transport Service, AT&T uses Low Latency Queuing with Class Based Weighted Fair Queuing (LLQ/CBWFQ) and recommends that customers use the same techniques in their CERs. LLQ/CBWFQ is configured via a policy map where different classes of traffic are assigned a percentage or specific amount of bandwidth. The LLQ is established with the priority command and given a specific bandwidth in kilobits per second. The LLQ is sized based on the bandwidth allocation recommendations in section 2.1. Other queues are serviced based on the amount of bandwidth allocated to them.



3.3 *Traffic Shaping*

Traffic shaping on high speed circuits is done by setting a "service-policy" on the interface (or sub-interface) as shown in the examples in Appendix A. The shape rate is set by taking 99% of the available bandwidth (rounded down to the nearest 64k) for a particular circuit type (or the subrate speed in the case of subrates). The table below shows the available bandwidth along with the shape rate for some of the larger access circuits.

Circuit Type	**Available Bandwidth (AB)**	**Shape Rate (99% of AB) (rounded down to nearest 64k)**	**Encapsulation Type**
T3	44210 kbps / Subrate speed	43712 kbps / Subrate speed	PPP / Frame Relay
OC3	149759 kbps / Subrate speed	148224 kbps / Subrate speed	PPP / Frame Relay
OC12	599040 kbps / Subrate speed	593024 kbps / Subrate speed	PPP / Frame Relay
OC48	2396120 kbps (no Subrates)	2372096 kbps (no Subrates)	PPP / Frame Relay
1/10Gigabit Ethernet	Port or Subrate Speed	99% of AB (rounded down to nearest 64k)	

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. Sample configurations, relative to specific environments, have been provided for reference in Appendix A.

4.1 *Classification*

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

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

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

Additional Access-Lists for CoS6:

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

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

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

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

Additional Class-maps for CoS6:

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

4.2 *LLQ/CBWFQ Set up and Packet Marking*

The Low Latency Queue is established through a priority statement. The class "CoS1" is put in the low latency queue. The packets are then marked with IP dscp of 'ef' to match the network's expectation for real time service. The remaining bandwidth is distributed among the other classes—CoS2(bursty high traffic) and CoS3 (bursty low traffic) and marked with the appropriate IP Differentiated Services Code Point (DSCP) marking. Finally, the default class is set for Best Effort traffic. Note that IP Cisco Express Forwarding (CEF) must be enabled on the CER for the service policy to work

In the following section bandwidth is referred to as BW.

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

4.2.1 **PPP access (T3/E3 speeds)**

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

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

Example for T3/E3 PPP Access:

```
!
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 256 packets
   service-policy MARK-BGP
class COS3
   bandwidth remaining percent <COS3 %>
   set ip dscp af21
  queue-limit 256 packets
class class-default
   bandwidth remaining percent <COS4 %>
   set ip dscp default
  queue-limit 256 packets
```

```
policy-map SHAPE_PPP    **This policy map applied to serial interface**
 class class-default
  shape average <Available BW * .99 (rounded down to nearest 64K)>  <(Available BW * .99)/250
(rounded up to nearest 128) >  0
   service-policy COS
```

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

Note: Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping **is merely the subrate speed instead of 99% of it**.

4.2.2 OC3 ATM

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

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

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

Example for OC3 ATM:

```
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 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 256 packets
```

4.2.3 T3/E3 Frame Relay Encapsulation

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

With Frame Relay encapsulation, 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.

Example for T3/E3 Frame Relay Encapsulation :

```
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 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 256 packets

policy-map SHAPE_FR_ENCAP   **This policy map applied to serialsub- interface**
 class class-default
  shape average <Available BW * .99 (rounded down to nearest 64K)>   <(Available BW * .99)/250
(rounded up to nearest 128) >  0
   service-policy COS
```

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

4.2.4 OC3/OC12/OC48 POS access

OC3/OC12/OC48 POS access requires a shaping policy map be applied to the POS interface. The policy map for the QOS is applied to the shaping policy map. The shape rate of the shaping policy map should be set to 99% of the available bandwidth.

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

Example for OC3 POS:

```
!
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 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 256 packets
policy-map POS-SHAPE
 class class-default
  shape average <Available BW * .99 (rounded down to nearest 64K)>  <(Available BW * .99)/250
(rounded up to nearest 128) > account user-defined 3
  service-policy COS
```

Note: Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping is merely the subrate speed instead of 99% of it.

Example for OC12 POS:

```
!
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 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 256 packets
policy-map POS-SHAPE
 class class-default
  shape average <Available BW * .99 (rounded down to nearest 64K)>  <(Available BW * .99)/250
(rounded up to nearest 128) > account user-defined 5
  service-policy COS
```

Note: Subrates are treated differently than full port configurations with regards to shaping. For subrate speeds, shaping is merely the subrate speed instead of 99% of it.

Example for OC48 POS/Frame Relay Encapsulation:

```
!
policy-map MARK-BGP
 class BGP
  set ip dscp cs6
policy-map COS
 class COS1
  priority
  queue-limit 16384 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 1024 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 1024 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 1024 packets
policy-map POS-SHAPE
 class class-default
  shape average <Available BW * .99 (rounded down to nearest 64K)>  <(Available BW * .99)/250
(rounded up to nearest 128) > account user-defined 5
```

```
 service-policy COS
```

*OC48 subrate speeds are currently not supported.

4.2.5 OC3/OC12 Frame Relay Encapsulation

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

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

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

Example for OC3/OC12 Frame Relay encapsulation:

```
!
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 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3 %>
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 256 packets
!
policy-map POS-SHAPE_FR_ENCAP
 class class-default
  shape average <Available BW * .99 (rounded down to nearest 64K)>  <(Available BW * .99)/250
(rounded up to nearest 128) > account user-defined  <"3" for OC3, "5" for OC12>
  service-policy COS
```

4.2.6 Ethernet Access

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

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

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

Example for Ethernet Access:

```
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 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 256 packets
policy-map Ethernet-SHAPE
 class class-default
  shape average <Shaping Rate – see section 2.3> <(Available BW * .99)/250  (rounded up to nearest
128) > account user-defined 24
  service-policy COS
```

4.2.7 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.

Example for CoS6:

```
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 256 packets
class COS2
  bandwidth remaining percent <COS2%>
  set ip dscp af31
  queue-limit 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent <COS3%>
  set ip dscp af21
  queue-limit 256 packets
class COS5
  bandwidth remaining percent <COS5%>
  set ip dscp af11
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent <COS4%>
  set ip dscp default
  queue-limit 256 packets
```

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

Frame Relay traffic shaping is not supported on ASR routers.

4.4 *Interface Configuration*

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

4.4.1 PPP access (T3/E3 speeds)

Follow these steps for a T3 PPP circuit:

Global Configuration:

- First, set the "card type" to the appropriate type (T3). After the t3 keyword, specify the slot and subslot location of the SPA.

On the Main Interface:

- 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"
- Set the "dsu bandwidth" to the proper speed (44210 for T3 full rate)
- Configure "framing c-bit"
- Configure "cablelength" in feet.
- Apply the CoS policy map .
- Configure "hold-queue 4096 out" under the main interface.

Example:

```
card type t3 <slot #> <subslot #>


interface Serial0/2/0
 ip address <IP address> <mask>
 encapsulation ppp
 load-interval 30
 dsu bandwidth 44210
 framing c-bit
 cablelength <cable length in feet>
 service-policy output SHAPE_PPP
 hold-queue 4096 out
```

Follow these steps for an E3 PPP circuit:

Global Configuration:

- First, set the "card type" to the appropriate type (E3). After the e3 keyword, specify the slot and subslot location of the SPA.

On the Main Interface:

- 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 “framing g751”
- Configure “dsu mode 1”
- Apply the CoS policy map .
- Configure “hold-queue 4096 out” under the main interface.

Example:

```
card type E3 <slot #> <subslot #>!

interface Serial0/3/0
 ip address <IP Address> <mask>
 encapsulation ppp
 framing g751
 dsu mode 1
 service-policy output SHAPE_PPP
 hold-queue 4096 out
```

4.4.2 OC3 ATM

Use the following steps to configure an OC3 ATM interface:

On the main interface:

- Configure “no atm ilmi-keepalive”
- Configure “hold-queue 4096 out”

On the subinterface:

- Set “mtu” 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 “PVC <VPI> <VCI>” with the appropriate numbers for the PVC.
- Configure the “vbr-nrt” statement
- Configure the following oam statements:
  - oam-pvc manage
  - oam retry 3 5 1
  - oam ais-rdi 10 3
- Set “encapsulation” to aal5snap
- Apply the outbound policy map

Example:

```
interface ATM0/3/0
no ip address
 load-interval 30
 no atm ilmi-keepalive
 hold-queue 4096 out
```

```
!
interface ATM0/3/0.1 point-to-point
 mtu 1500
 ip address <IP address> <mask>
pvc <VPI>/<VCI>
 vbr-nrt <Port speed *.95> <Port speed * .95>  1
 oam-pvc manage
 oam  retry 3 5 1
 oam ais-rdi 10 3
 encapsulation aal5snap
 service-policy out COS
```

4.4.3 **T3/E3 Frame Relay Encapsulation**

Following are the steps to configure T3 Frame Encapsulation:

Global Configuration:

- First, set the "card type" to the appropriate type (T3). After the t3 keyword, specify the slot and subslot location of the SPA.

On the main interface:

- Configure "encapsulation frame-relay IETF"
- Set the dsu bandwidth to the appropriate access speed.
- Configure "scramble"
- Set the "framing" to "c-bit".
- Configure "cablelength" in feet
- "Frame-relay lmi-type" must be set to "ansi".
- Configure "hold-queue 4096 out".

On each 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 interface-dlci" with the appropriate DLCI number
- Apply the output policy-map

Example:

```
card type t3 <slot #> <subslot #>

interface Serial0/3/0
 encapsulation frame-relay IETF
 dsu bandwidth 44210
 scramble
```

```
 framing c-bit
 cablelength <length of  cable in feet>
 frame-relay lmi-type ansi
 hold-queue out 4096
!
interface Serial0/3/0.200 point-to-point
 ip address <IP Address> <mask>
 no cdp enable
 frame-relay interface-dlci <DLCI #>
 service-policy output SHAPE_FR_ENCAP
```

Following are the steps to configure E3 Frame Encapsulation:

Global Configuration:

- First, set the "card type" to the appropriate type (T3). After the t3 keyword, specify the slot and subslot location of the SPA.

On the main interface:

- Configure "encapsulation frame-relay IETF"
- Configure "framing g751"
- Configure "scramble"
- Set the "dsu mode 1"
- "Frame-relay lmi-type" must be set to "ansi".
- Configure "hold-queue 4096 out".

On each 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 interface-dlci" with the appropriate DLCI number
- Apply the output policy-map

Example:

```
card type e3 <slot #> <subslot #>
!
interface Serial0/3/0
 no ip address
 encapsulation frame-relay IETF
 framing g751
 dsu mode 1
 frame-relay lmi-type ansi
 hold-queue out 4096
!
interface Serial0/3/0.200 point-to-point
 ip address <IP Address> <mask>
 no cdp enable
 frame-relay interface-dlci <DLCI #>
 service-policy output SHAPE_FR_ENCAP
```

4.4.4 OC3 PPP Access

Follow these steps for an OC3 PPP Circuit:

On the main interface:

- 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”
- Set “pos scramble-atm”
- Configure “pos flag s1s0 2”
- Apply the output service policy.
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 out”

Example:

```
interface POS0/3/0
 ip address <IP Address> <mask>
 encapsulation ppp
 load-interval 30
 pos scramble-atm
 pos flag s1s0 2
 service-policy output POS-SHAPE
 hold-queue 1024 in
 hold-queue 4096 out
```

Follow these steps for an OC12/OC48 PPP circuit:

On the main interface:

- 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 “crc” for 32
- Set “pos scramble-atm”
- Configure “pos flag s1s0 2”
- Apply the output service policy.
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 out”

Example:

```
interface POS0/2/0
 ip address <IP Address> <mask>
 encapsulation ppp
 load-interval 30
 crc 32
 pos scramble-atm
```

```
 pos flag s1s0 2
 service-policy output POS-SHAPE
 hold-queue 1024 in
 hold-queue 4096 out
hold-queue 32768 out [OC48 only]
```

4.4.5 **OC3/OC12 Frame Relay Encapsulation**

Follow these steps for an OC3 Frame Relay Encapsulation circuit:

On the main interface:

- Set encapsulation to "frame-relay IETF"
- Configure "frame-relay lmi-type ansi"
- Set "pos scramble-atm"
- Apply the output service policy.
- Configure "hold-queue 1024 in"
- Configure "hold-queue 4096 out"

On each 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 "frame-relay interface-dlci" with the appropriate DLCI number
- Apply the output policy-map

Example:

```
interface POS0/3/0
 no ip address
 encapsulation frame-relay IETF
 frame-relay lmi-type ansi
 load-interval 30
 pos scramble-atm
 hold-queue 1024 in
 hold-queue 4096 out

interface POS0/3/0.1 point-to-point
 ip address <IP Address> <mask>
 frame-relay interface-dlci <DLCI #>
 service-policy output POS-SHAPE_FR_ENCAP
```

Follow these steps for an OC12 Frame Relay Encapsulation circuit:

On the main interface:

- Set encapsulation to "frame-relay IETF"
- Configure "frame-relay lmi-type ansi"

- Configure “crc 32”
- Set “pos scramble-atm”
- Apply the output service policy.
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 out”

On each 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 “frame-relay interface-dlci” with the appropriate DLCI number
- Apply the output policy-map

Example:

```
interface POS0/3/0
 no ip address
 encapsulation frame-relay IETF
 frame-relay lmi-type ansi
 load-interval 30
 crc 32
 pos scramble-atm
 hold-queue 1024 in
 hold-queue 4096 out

interface POS0/3/0.1 point-to-point
 ip address <IP Address> <mask>
 frame-relay interface-dlci <DLCI #>
 service-policy output POS-SHAPE_FR_ENCAP
```

4.4.6 OC48 Frame Relay Encapsulation (Port-Based COS)

Follow these steps for an OC48 Frame Relay Encapsulation circuit (Port-based COS):

On the main interface:

- Set encapsulation to “frame-relay”
- Configure “frame-relay lmi-type ansi”
- Configure “crc 32”
- Set “pos scramble-atm”
- Apply the output service policy.
- Configure “hold-queue 1024 in”
- Configure “hold-queue 32768 out”

On each 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 “frame-relay interface-dlci” with the appropriate DLCI number

Example:

```
interface POS0/1/0
 description - OC48 Link To DCXRPE3 - POS0/5/1/0
 no ip address
 encapsulation frame-relay
 load-interval 30
 crc 32
 pos scramble-atm
 pos flag s1s0 2
 frame-relay lmi-type ansi
 service-policy output OC48-SHAPE
 hold-queue 1024 in
 hold-queue 32768 out
!
interface POS0/1/0.100 point-to-point
 description – Logical Channel #1 To Voice VRF
 ip address 195.18.32.45 255.255.255.252
 frame-relay interface-dlci 100
!
interface POS0/1/0.105 point-to-point
 description – Logical Channel#2 To Data VRF
 ip address 195.18.32.49 255.255.255.252
 frame-relay interface-dlci 105
```

4.4.7 **10 or 100 Mbit/s Ethernet Access**

Note: The Fast Ethernet SPA card for the ASR can negotiate at 10 or 100 Mbit/s.

Follow these steps for Full Port:

On the main interface:

- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Configure negotiation for auto.
- Apply the output service policy
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 out”

Example:

```
interface FastEthernet0/0/1
 ip address <IP Address> <mask>
 load-interval 30
```

```
negotiation auto
service-policy output Ethernet-SHAPE
hold-queue 1024 in
hold-queue 4096 out
```

Follow these steps for Single Stack VLAN Tag:

On the main interface:

- Configure negotiation for auto.
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 out”

On the subinterface:

- Configure “encapsulation dot1q” command with the appropriate VLAN tag number.
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Apply the output service policy

Example:

```
interface FastEthernet0/0/1
 load-interval 30
 negotiation auto
 hold-queue 1024 in
 hold-queue 4096 out

interface FastEthernet0/1.201  (recommend to set the subinterface numbering to the VLAN tag ID)
 encapsulation dot1Q <VLAN tag>
 ip address <ip address> <mask>
 ip virtual-reassembly
 service-policy output Ether-Shape
```

Follow these steps for Dual Stack VLAN Tag:

On the main interface:

- Configure negotiation for auto.
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 out”

On the subinterface:

- Configure “encapsulation dot1q <inner VLAN tag #> second-dot1q <outer VLAN tag #>”
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Apply the output service policy

Example:

```
interface FastEthernet0/0/1
 load-interval 30
 negotiation auto
 hold-queue 1024 in
 hold-queue 4096 out

interface FastEthernet0/0.2004   (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
```

4.4.8 Gigabit Ethernet Access

Follow these steps for full port Gigabit Ethernet/10 Gigabit Ethernet:

On the main interface:

- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Configure negotiation for auto.
- Apply the output service policy
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 [16384 – for 10G access] out”

Example:

```
interface GigabitEthernet0/0/1
 ip address <IP Address> <mask>
 load-interval 30
 negotiation auto
 service-policy output GIGE-SHAPE
 hold-queue 1024 in
 hold-queue [4096/16384] out
```

Follow these steps for Single Stack VLAN Tag:

On the main interface:

- Configure negotiation for auto.
- Configure “hold-queue 1024 in”
- Configure “hold-queue 4096 [16384 – for 10G access] out”

On the subinterface:

- Configure “encapsulation dot1q” command with the appropriate VLAN tag number.
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.

- Apply the output service policy

Example:

```
interface GigabitEthernet0/0/1
 load-interval 30
 negotiation auto
 hold-queue 1024 in
 hold-queue [4096/16384] out

interface GigabitEthernet0/1.201  (recommend to set the subinterface numbering to the VLAN tag ID)
 encapsulation dot1Q <VLAN tag>
 ip address <ip address> <mask>
 ip virtual-reassembly
 service-policy output Ether-Shape
```

Follow these steps for Dual Stack VLAN Tag:

On the main interface:

- Configure negotiation for auto.
- Configure "hold-queue 1024 in"
- Configure "hold-queue 4096 [16384 – for 10G access] out"

On the subinterface:

- Configure "encapsulation dot1q <inner VLAN tag #> second-dot1q <outer VLAN tag #>"
- Configure the IP address of the interface which should be the CER side of the /30 subnet assigned for the CER/PER link.
- Apply the output service policy

Example:

```
interface GigabitEthernet0/0/1
 load-interval 30
 negotiation auto
 hold-queue 1024 in
 hold-queue [4096/16384] 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
```

Appendix A: Sample ASR Configurations

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

A.1 Sample T3 PPP Router Configuration

```
ASR-Vancouver#show run
Building configuration...

Current configuration : 8075 bytes
!
! Last configuration change at 14:58:12 EST Fri Jan 14 2011 by vinny
! NVRAM config last updated at 14:14:52 EST Fri Jan 14 2011 by vinny
!
version 15.1
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
!
hostname ASR-Vancouver
!
boot-start-marker
boot system flash bootflash:asr1000rp1-adventerprisek9.03.02.00.S.151-1.S1.bin
boot-end-marker
!
!
vrf definition Mgmt-intf
 !
 address-family ipv4
 exit-address-family
 !
 address-family ipv6
 exit-address-family
!
card type t3 0 2
enable password cisco
!
no aaa new-model
!
!
!
clock timezone EST -5 0
clock summer-time EDST recurring
ip source-route
!
!
!
no ip domain lookup
```

```
!
!
multilink bundle-name authenticated
!
!
username cisco password 0 cisco
username admin password 0 cisco
!
redundancy
 mode none
!
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 39792000 4974000 conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent 40
  set ip dscp af31
  queue-limit 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent 30
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent 30
  set ip dscp default
  queue-limit 256 packets
policy-map T3-SHAPE
 class class-default
  shape average 43712000 174848
  service-policy COS
!
!
```

```
interface GigabitEthernet0/0/0
 description – Faces SBC
 ip address 172.22.16.1 255.255.255.0
 load-interval 30
 negotiation auto
!
interface GigabitEthernet0/0/1
 no ip address
 shutdown
 negotiation auto
!
interface GigabitEthernet0/0/2
no ip address
 shutdown
 negotiation auto
!
!
interface GigabitEthernet0/0/3
 no ip address
 shutdown
 negotiation auto
!
!
interface Serial0/2/0
 ip address 192.168.200.9 255.255.255.252
 encapsulation ppp
 load-interval 30
 dsu bandwidth 44210
 framing c-bit
 cablelength 10
 service-policy output T3-SHAPE
 hold-queue 4096 out
!
!
router bgp 65000
 bgp router-id 192.168.0.1
 bgp log-neighbor-changes
 network 135.16.170.2 mask 255.255.255.255
 network 32.252.97.40 mask 255.255.255.255
 neighbor 192.168.200.10 remote-as 13979
 neighbor 192.168.200.10 allowas-in
!
!
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
!
logging esm config
cdp run
!
!
control-plane
!
!
line con 0
 exec-timeout 600 0
 privilege level 15
 login local
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 300 0
 privilege level 15
 login local
!
ntp clock-period 17179842
ntp server 135.16.205.66
end
```

A.2 Sample OC3 PPP Router Configuration

```
Current configuration : 7994 bytes

!

! Last configuration change at 13:34:11 EST Fri Jan 21 2011 by vinny
! NVRAM config last updated at 12:24:54 EST Fri Jan 21 2011 by vinny

!

version 15.1
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
!
hostname ASR-Vancouver
!
boot-start-marker
boot system flash bootflash:asr1000rp1-adventerprisek9.03.02.00.S.151-1.S1.bin
boot-end-marker
!
!
vrf definition Mgmt-intf
 !
 address-family ipv4
 exit-address-family
 !
 address-family ipv6
 exit-address-family
!
enable password cisco
!
no aaa new-model
!
clock timezone EST -5 0
clock summer-time EDST recurring
ip source-route
!
no ip domain lookup
!
!
multilink bundle-name authenticated
!
!
username cisco password 0 cisco
username admin password 0 cisco
 !
redundancy
 mode none
```

```
!
!

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 134784000 16848000 conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent 40
  set ip dscp af31
  queue-limit 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent 30
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent 30
  set ip dscp default
  queue-limit 256 packets
policy-map OC3-SHAPE
 class class-default
  shape average 148224000 592896 account user-defined 3
  service-policy COS
!
!
interface GigabitEthernet0/0/0
 description – Faces SBC
 ip address 172.22.16.1 255.255.255.0
 load-interval 30
 negotiation auto
!
!
interface GigabitEthernet0/0/2
```

```
 no ip address
 shutdown
 negotiation auto
!
interface GigabitEthernet0/0/3
 no ip address
 shutdown
 negotiation auto
!
interface POS0/3/0
 ip address 195.18.31.25 255.255.255.252
 encapsulation ppp
 load-interval 30
 crc 32
 pos scramble-atm
 pos flag s1s0 2
 service-policy output OC3-SHAPE
 hold-queue 1024 in
 hold-queue 4096 out
!
router bgp 65000
 bgp router-id 192.168.0.1
 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 195.18.31.26 remote-as 13979
 neighbor 195.18.31.26 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
 privilege level 15
 login local
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 300 0
 privilege level 15
 login local
!
ntp clock-period 17178884
ntp server 135.16.205.66

end
```

A.3 Sample Gigabit Ethernet Router Configuration

```
Current configuration : 8953 bytes
!
! Last configuration change at 15:22:42 EST Tue Feb 15 2011 by vinny
! NVRAM config last updated at 15:24:01 EST Tue Feb 15 2011 by vinny
!
version 15.1
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
!
hostname ASR-Vancouver
!
boot-start-marker
boot system flash bootflash:asr1000rp1-adventerprisek9.03.02.00.S.151-1.S1.bin
boot-end-marker
```

```
!
!
vrf definition Mgmt-intf
 !
 address-family ipv4
 exit-address-family
 !
 address-family ipv6
 exit-address-family
!
enable password cisco
!
no aaa new-model
!
!
!
clock timezone EST -5 0
clock summer-time EDST recurring
ip source-route
!
no ip domain lookup
!
multilink bundle-name authenticated
!
!
!
!
!
username cisco password 0 cisco
username admin password 0 cisco
!
redundancy
 mode none
!
!
!
!
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 700000000 87500000 conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent 40
  set ip dscp af31
  queue-limit 256 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent 30
  set ip dscp af21
  queue-limit 256 packets
 class class-default
  bandwidth remaining percent 30
  set ip dscp default
  queue-limit 256 packets
policy-map GIGE-SHAPE
 class class-default
  shape average 989952000 3959808 account user-defined 24
  service-policy COS
!
!
!
!
!
!
!
!
!
interface GigabitEthernet0/0/0
 description – Faces SBC
 ip address 172.22.16.1 255.255.255.0
 load-interval 30
 negotiation auto

!
interface GigabitEthernet0/0/1
 description - Gig-Wan Link
 ip address 195.18.31.117 255.255.255.252
 load-interval 30
 negotiation auto
service-policy output GIGE-SHAPE
 hold-queue 1024 in
 hold-queue 4096 out
!
!
```

```
interface GigabitEthernet0/0/3
 no ip address
 shutdown
 negotiation auto
!
!
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
!
router bgp 65000
 bgp router-id 192.168.0.1
 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 195.18.31.118 remote-as 13979
  neighbor 195.18.31.118 allowas-in

!
ip route 135.16.170.2 255.255.255.255 172.22.16.2
*** Static Route to Cascaded TDM GW Loopback***


no ip http server
no ip http secure-server
!
ip access-list extended BGP
 permit tcp any eq bgp any
 permit tcp any any eq bgp
ip access-list extended COS2-Traffic
 permit udp any any eq 2082
 permit udp any eq 2082 any
 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
!
logging esm config
cdp run
!
!
!
control-plane
!
!
!
line con 0
 exec-timeout 600 0
 privilege level 15
 login local
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 300 0
 privilege level 15
 login local
!
ntp clock-period 17176517
ntp server 135.16.205.66
end
```

A.4 Sample OC48 PPP Router Configuration – Port-Based COS (ASR 1004 / 1006 only)

```
version 15.1
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
!
hostname ASR1006-Winnipeg
!
boot-start-marker
boot system flash bootflash:asr1000rp2-adventerprisek9.V151_3_S2_SR617255895_3.bin
boot system flash bootflash:asr1000rp2-adventerprisek9.03.04.02.S.151-3.S2.bin
boot-end-marker
!
!
vrf definition Mgmt-intf
 !
 address-family ipv4
 exit-address-family
 !
 address-family ipv6
 exit-address-family
!
enable password cisco
!
no aaa new-model
clock timezone EST -5 0
clock summer-time EDST recurring
no ip source-route
!
!
!
no ip domain lookup
!
!
!
multilink bundle-name authenticated
!
!
!
username cisco password 0 cisco
!
redundancy
 mode sso
!
!
!
ip tftp source-interface GigabitEthernet0
```

```
!
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 16384 packets
  police 2156512000 269564000 conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent 40 account user-defined 5
  set ip dscp af31
  queue-limit 1024 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent 30 account user-defined 5
  set ip dscp af21
  queue-limit 1024 packets
 class class-default
  bandwidth remaining percent 30 account user-defined 5
  set ip dscp default
  queue-limit 1024 packets
policy-map OC48-SHAPE
 class class-default
  shape average 2372096000 9488384 account user-defined 5
  service-policy COS
!
!
!
interface POS0/1/0
 description - OC48 Link To DCXRPE3 - POS0/5/1/0
 ip address 195.18.32.29 255.255.255.252
 encapsulation ppp
 load-interval 30
 crc 32
 pos scramble-atm
 pos flag s1s0 2
 service-policy output OC48-SHAPE
```

```
 hold-queue 1024 in
 hold-queue 16384 out
!
interface TenGigabitEthernet1/0/0
 description - Link to LAN
 ip address 172.41.0.1 255.255.0.0
 load-interval 30
 hold-queue 1024 in
!
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
!
router bgp 65000
 bgp router-id 192.168.0.96
 bgp log-neighbor-changes
 neighbor 195.18.32.30 remote-as 13979
 !
 address-family ipv4
  network 172.41.0.0
  network 192.168.0.96 mask 255.255.255.255
  network 195.18.32.28 mask 255.255.255.252
  neighbor 195.18.32.30 activate
  neighbor 195.18.32.30 allowas-in
 exit-address-family
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip access-list extended BGP
 permit tcp any eq bgp any
 permit tcp any any eq bgp
ip access-list extended COS2-Traffic
 permit udp any any eq 2082
 permit udp any eq 2082 any
 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
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 600 0
 login local
!
ntp source Loopback0
ntp server 135.16.205.66
end
```

A.5 Sample OC48 Frame Encap Config (multi-vrf) – Port-Based COS (ASR 1004 / 1006 only)

```
!
version 15.1
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
!
hostname ASR1006-Winnipeg
!
boot-start-marker
boot system flash bootflash:asr1000rp2-adventerprisek9.V151_3_S2_SR617255895_3.bin
boot system flash bootflash:asr1000rp2-adventerprisek9.03.04.02.S.151-3.S2.bin
boot-end-marker
!
!
vrf definition Mgmt-intf
 !
 address-family ipv4
 exit-address-family
 !
 address-family ipv6
 exit-address-family
!
enable password cisco
!
no aaa new-model
clock timezone EST -5 0
clock summer-time EDST recurring
no ip source-route
!
!
!
no ip domain lookup
!
!
!
multilink bundle-name authenticated
!
!
!
username cisco password 0 cisco
!
redundancy
 mode sso
```

```
!
!
!
ip tftp source-interface GigabitEthernet0
!
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 16384 packets
  police 2156512000 269564000 conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent 40 account user-defined 5
  set ip dscp af31
  queue-limit 1024 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent 30 account user-defined 5
  set ip dscp af21
  queue-limit 1024 packets
 class class-default
  bandwidth remaining percent 30 account user-defined 5
  set ip dscp default
  queue-limit 1024 packets
policy-map OC48-SHAPE
 class class-default
  shape average 2372096000 9488384 account user-defined 5
  service-policy COS
!
!
!
!
!
interface POS0/1/0
 description - OC48 Link To DCXRPE3 - POS0/5/1/0
 no ip address
```

```
 encapsulation frame-relay
 load-interval 30
 crc 32
 pos scramble-atm
 pos flag s1s0 2
 frame-relay lmi-type ansi
 service-policy output OC48-SHAPE
 hold-queue 1024 in
 hold-queue 16384 out
!
interface POS0/1/0.100 point-to-point
 description – Logical Channel#1 To Voice VRF
 ip address 195.18.32.45 255.255.255.252
 frame-relay interface-dlci 100
!
interface POS0/1/0.105 point-to-point
 description – Logical Channel #2 To Data VRF
 ip address 195.18.32.49 255.255.255.252
 frame-relay interface-dlci 105
!
interface TenGigabitEthernet1/0/0
 description - Link To LAN
 ip address 172.42.1.1 255.255.0.0 secondary
 ip address 172.41.0.1 255.255.0.0
 ip policy route-map Outbound_PBR_map
 load-interval 30
 hold-queue 1024 in
!
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 ip address 10.10.27.96 255.255.255.0
 speed 100
 no negotiation auto
!
router bgp 65000
 bgp router-id 192.168.0.96
 bgp log-neighbor-changes
 neighbor 195.18.32.46 remote-as 13979
 neighbor 195.18.32.50 remote-as 13979
 !
 address-family ipv4
  network 172.41.0.0
  network 172.42.0.0
  network 192.168.0.96 mask 255.255.255.255
  network 195.18.32.44 mask 255.255.255.252
  network 195.18.32.48 mask 255.255.255.252
  neighbor 195.18.32.46 activate
  neighbor 195.18.32.46 allowas-in
  neighbor 195.18.32.46 route-map Advertised_Customer_Networks_voice_vrf out
  neighbor 195.18.32.50 activate
```

```
 neighbor 195.18.32.50 allowas-in
 neighbor 195.18.32.50 route-map Advertised_Customer_Networks_data_vrf out
exit-address-family
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
ip route vrf Mgmt-intf 0.0.0.0 0.0.0.0 10.10.27.1
!
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
!
!
ip prefix-list voice_vrf description - Advertised Networks For voice VRF
ip prefix-list voice_vrf seq 5 permit 192.168.0.96/32
ip prefix-list voice_vrf seq 10 permit 172.41.0.0/16
!
ip prefix-list data_vrf description - Advertised Networks For data VRF
ip prefix-list data_vrf seq 5 permit 172.42.0.0/16
access-list 101 permit ip 172.41.0.0 0.0.255.255 any
access-list 101 permit ip host 192.168.0.96 any
access-list 102 permit ip 172.42.0.0 0.0.255.255 any
!
route-map Outbound_PBR_map permit 10
 match ip address 101
 set ip next-hop 195.18.32.46
```

```
!
route-map Outbound_PBR_map permit 20
 match ip address 102
 set ip next-hop 195.18.32.50
!
route-map Advertised_Customer_Networks_data_vrf permit 10
 match ip address prefix-list data_vrf
!
route-map Advertised_Customer_Networks_voice_vrf permit 10
 match ip address prefix-list voice_vrf
!
!
!
control-plane
!
!
!
!
!
line con 0
 exec-timeout 600 0
 login local
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 600 0
 login local
!
ntp source Loopback0
ntp server 135.16.205.66
end
```

A.6 Sample 10Gig Ethernet Router Configuration – PVC-Based COS (ASR1004 / 1006 only)

```
version 15.1
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
!
hostname ASR1006-Winnipeg
!
boot-start-marker
boot system flash bootflash:asr1000rp2-adventerprisek9.V151_3_S2_SR617255895_3.bin
boot system flash bootflash:asr1000rp2-adventerprisek9.03.04.02.S.151-3.S2.bin
boot-end-marker
!
!
vrf definition Mgmt-intf
 !
 address-family ipv4
 exit-address-family
 !
 address-family ipv6
 exit-address-family
!
enable password cisco
!
no aaa new-model
clock timezone EST -5 0
clock summer-time EDST recurring
no ip source-route
!
!
!
no ip domain lookup
!
!
!
multilink bundle-name authenticated
!
!
!
username cisco password 0 cisco
!
redundancy
 mode sso
```

```
!
!
!
ip tftp source-interface GigabitEthernet0
!
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 10Gig-COS
 class COS1
  priority
  queue-limit 16384 packets
  police 1750000000 218750000 conform-action set-dscp-transmit ef exceed-action drop
 class COS2
  bandwidth remaining percent 40 account user-defined 24
  set ip dscp af31
  queue-limit 1024 packets
  service-policy MARK-BGP
 class COS3
  bandwidth remaining percent 30 account user-defined 24
  set ip dscp af21
  queue-limit 1024 packets
 class class-default
  bandwidth remaining percent 30 account user-defined 24
  set ip dscp default
  queue-limit 1024 packets
policy-map 10Gig-SHAPE
 class class-default
  shape average 2474944000 9899776 account user-defined 24
  service-policy 10Gig-COS
!
!
!
!
```

```
interface TenGigabitEthernet0/0/0
 description - 10GIG-WAN Link To CHPJAR1 - XE-5/0/0
 no ip address
 load-interval 30
 hold-queue 2048 in
 hold-queue 16384 out
!
interface TenGigabitEthernet0/0/0.550
 description Link To CHPJAR1 - 2.5G VPN - xe-5/0/0.550
 encapsulation dot1Q 550
 ip address 195.18.32.33 255.255.255.252
 service-policy output 10Gig-SHAPE
!
interface TenGigabitEthernet1/0/0
 description - Link to LAN
 ip address 172.41.0.1 255.255.0.0
 load-interval 30
 hold-queue 1024 in
!
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
!
router bgp 65000
 bgp router-id 192.168.0.96
 bgp log-neighbor-changes
 neighbor 195.18.32.30 remote-as 13979
 !
 address-family ipv4
  network 172.41.0.0
  network 192.168.0.96 mask 255.255.255.255
  network 195.18.32.28 mask 255.255.255.252
  neighbor 195.18.32.30 activate
  neighbor 195.18.32.30 allowas-in
 exit-address-family
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip access-list extended BGP
 permit tcp any eq bgp any
 permit tcp any any eq bgp
```

```
ip access-list extended COS2-Traffic
 permit udp any any eq 2082
 permit udp any eq 2082 any
 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
!
cdp run
!
!
!
control-plane
!
!
!
!
line con 0
 exec-timeout 600 0
 login local
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 600 0
 login local
!
ntp source Loopback0
ntp server 135.16.205.66
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 requires proper configuration of the signaling and media paths of the primary CER per this CCG so the AT&T IP Flexible Reach Service on AT&T VPN 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).

AT&T IP Flexible Reach Service on AT&T VPN with 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 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 the 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 the 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 on AT&T VPN, 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 the 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 the underlying transport service. The customer may reach the remote branch office sites via this CER (over the AT&T VPN as the underlying transport service) or they can deploy a second customer managed router that provides their own connectivity to the customer's data network.

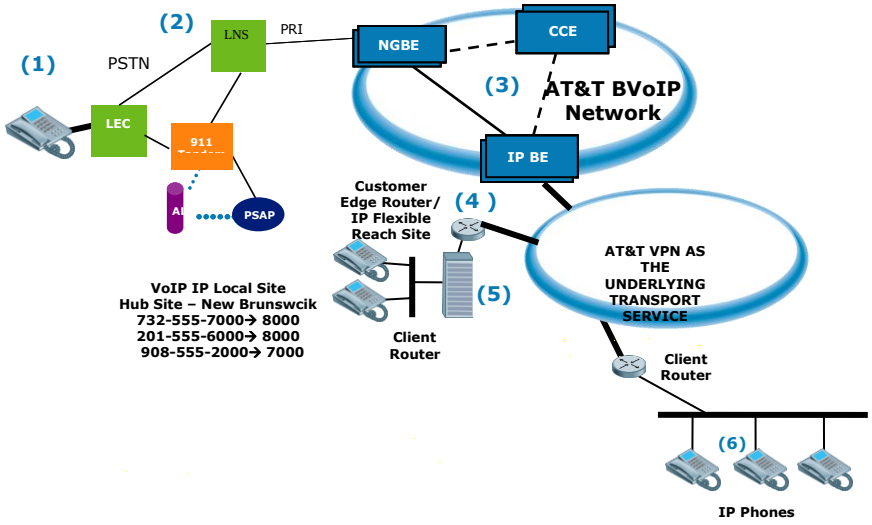
Important Note: The number of concurrent calls at the Hub site must be engineered for all voice traffic originating and terminating at the Hub and Branch Office sites. Concurrent calls are the number of VoIP calls expected to occur at the same time at the Hub site. Be aware if BOE calls are hairpinned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

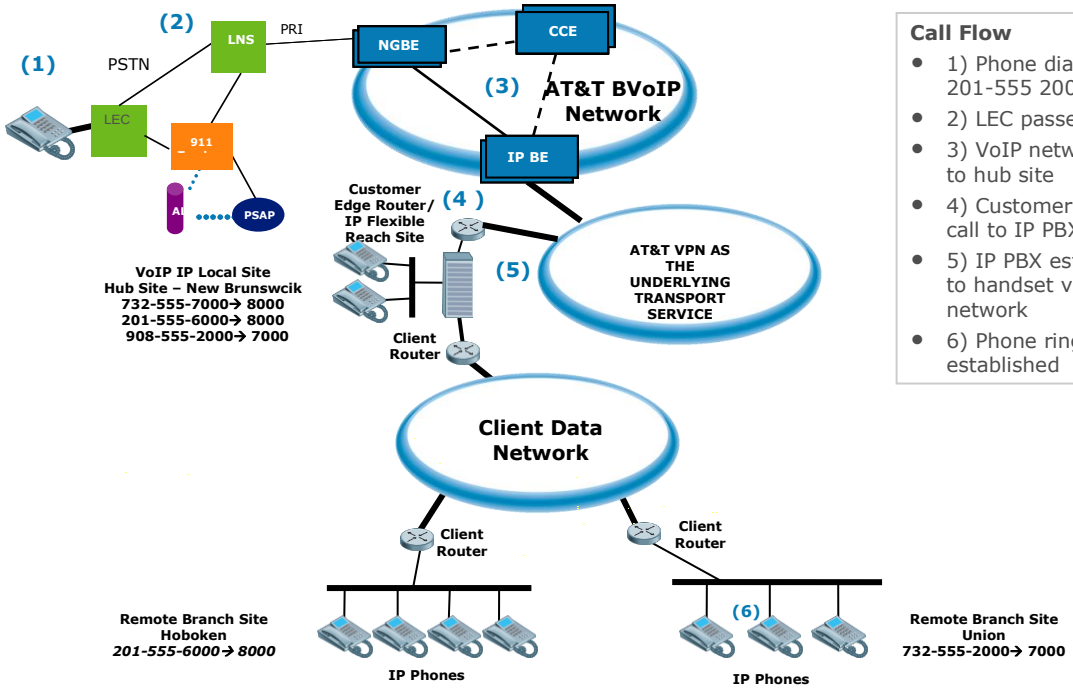
AT&T BVoIP Branch Office Extension (BOE) using AT&T VPN AS THE UNDERLYING TRANSPORT SERVICE network to connect to BOE site:



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 signals connection to handset at branch office site via AT&T VPN AS THE UNDERLYING TRANSPORT SERVICE (call rerouted out AT&T VPN AS THE UNDERLYING TRANSPORT SERVICE connection)
- 6) Phone rings and call is established

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



Call Flow

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

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 Branch Office IP PBX Extensions, are limited to locations where AT&T can provide 911/E911 service. The 911 service provided is based on the site registered location information provided to AT&T by the customer. The customer must provide AT&T with the correct business name and address information for each AT&T IP Flexible Reach Service on AT&T VPN 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: Acronyms

Acronym	Translation
ADSL	Asymmetric Digital Subscriber Line
AIM	Advanced Integration Module A
AS	Autonomous System
ASR	Aggregation Services Router
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

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

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

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