Avaya Solution & Interoperability Test Lab

Application Notes for VoIP over Frame Relay Link with Quality of Service using Kentrox Q-Series Routers with Avaya IP Office - Issue 1.0

Abstract

These Application Notes describe a configuration for supporting Voice over IP (VoIP) over a Frame Relay link with Quality of Service (QoS) on Kentrox Q-Series routers connected to an Avaya IP Telephony infrastructure intended for small office scenarios using low traffic serial T-1 links. The Kentrox Q-Series Q2400 and the Q2200 routers were compliance-tested with an Avaya IP Office. Emphasis was placed on verifying voice quality in a small office scenario using low traffic serial T-1 links in a converged network. QoS based on Layer 3 Differentiated Services was implemented across the network to prioritize voice traffic over the WAN. Information in these Application Notes has been obtained through compliance testing and additional technical discussions. Testing was conducted via the Developer*Connection* Program at the Avaya Solution and Interoperability Test Lab.

1. Introduction

These Application Notes describe a configuration for supporting Voice over IP (VoIP) over a Frame Relay link with Quality of Service (QoS) on Kentrox Q-Series routers connected to an Avaya IP Telephony infrastructure. The Kentrox Q-Series Q2400 and the Q2200 routers were compliance-tested with an Avaya IP Office.

Q-Series Q2200 T1 QoS Access Router
The Q-Series Q2200 Access Router provides VPN functionality and supports QoS based on DiffServ over its WAN link. The Q2200 supports PPP and Frame Relay encapsulation.

Q-Series Q2400 QoS Access Router
The Q-Series Q2400 Access Router is a multi-port router with two T1 ports and one Ethernet WAN port. It provides the same functionality as the Q2200.

Compliance testing emphasis was placed on verifying voice quality in a small office scenario using low traffic serial T-1 links in a converged network. QoS based on Layer 3 Differentiated Services was implemented across the network to prioritize voice traffic over the WAN.

The configuration in **Figure 1** shows a corporate site connected to a branch office site via a Frame Relay link. The corporate site consists of an Avaya IP Office 412 connected to the Kentrox Q2400 router, which in turn is connected to the WAN. The branch office site consists of an Avaya IP Office 403 and it is also connected to the WAN via a Kentrox Q2200 router. Each site contains a Layer-2 managed Ethernet switch to connect the Avaya IP Telephones and the Avaya IP Office. The corporate site also provides a DHCP server for assigning IP network parameters, VLAN information, and Option 176 settings to the Avaya IP Telephones. DHCP was used to exercise DHCP relay on the Kentrox Q-Series router at the branch office. The voice and data traffic were separated onto different VLANs.

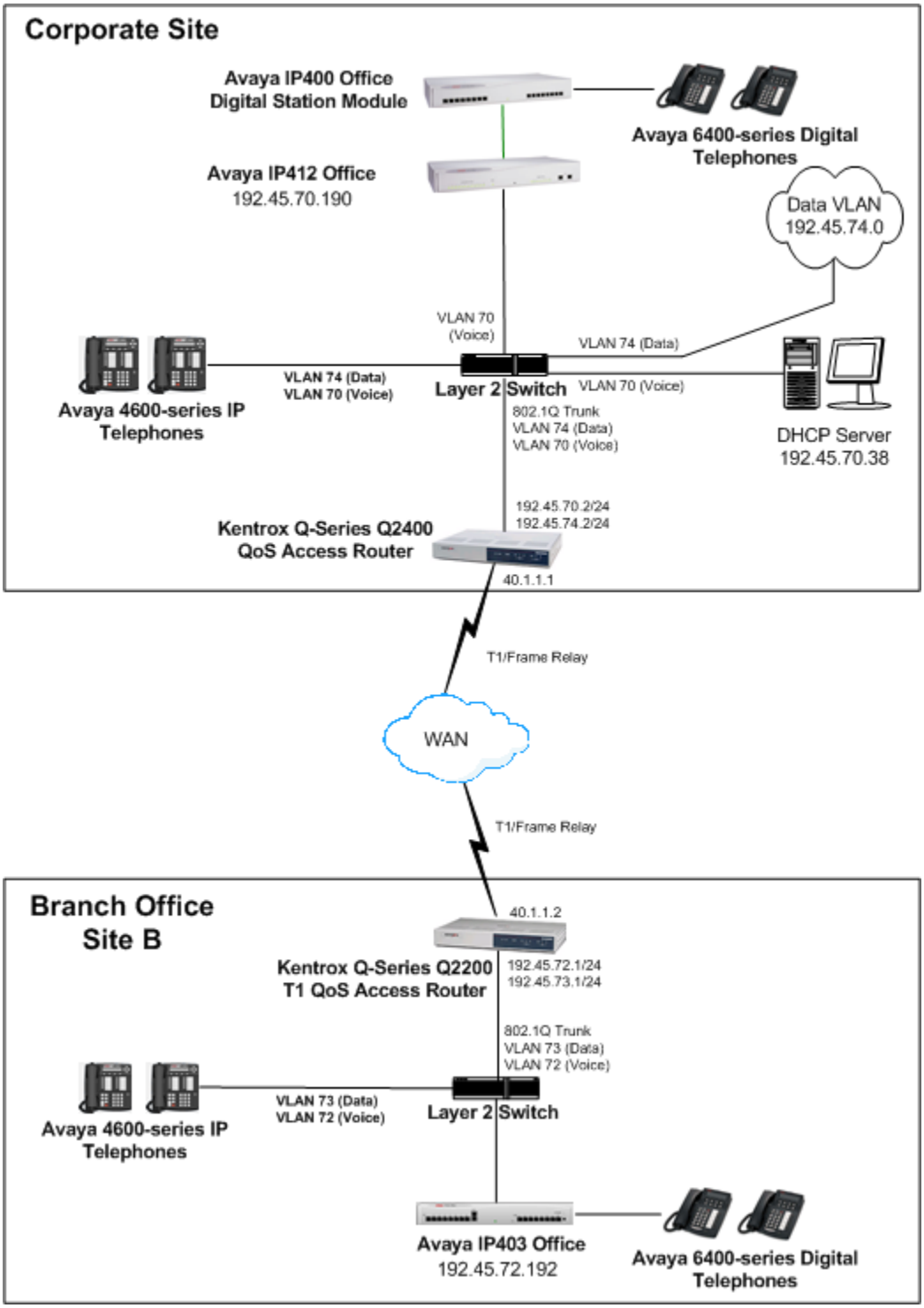


Figure 1: Network Configuration

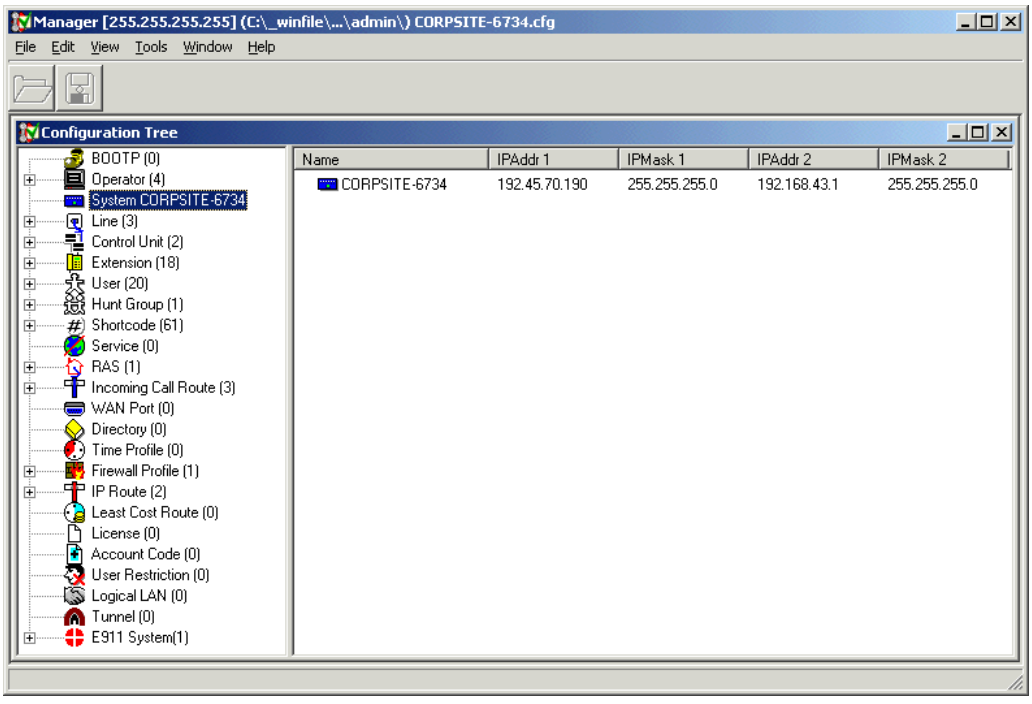
2. Equipment and Software Validated

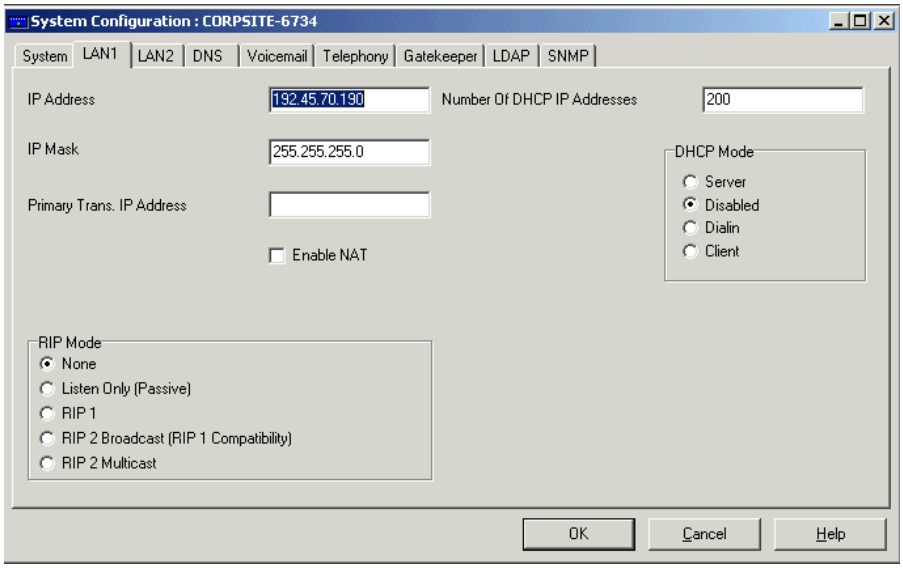
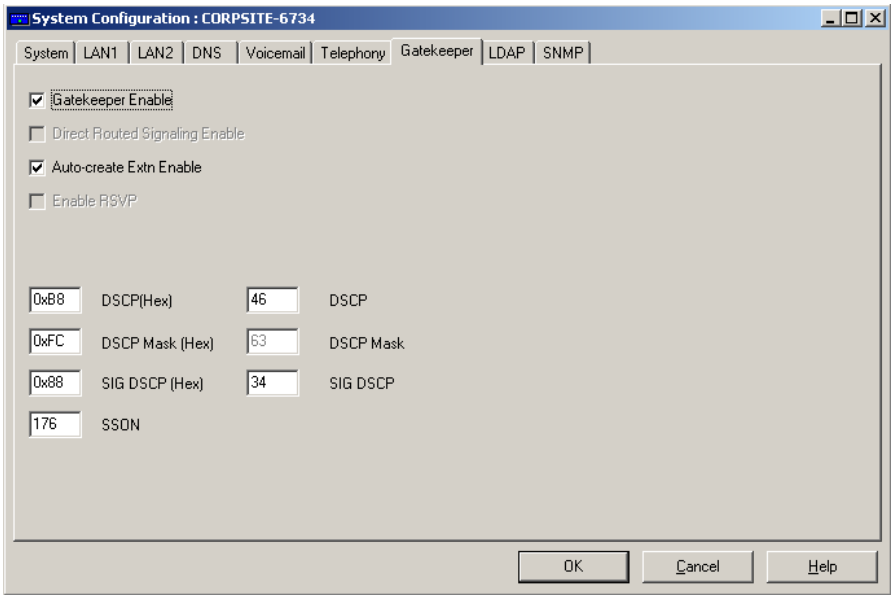
The following equipment and software were used for the sample configuration provided:

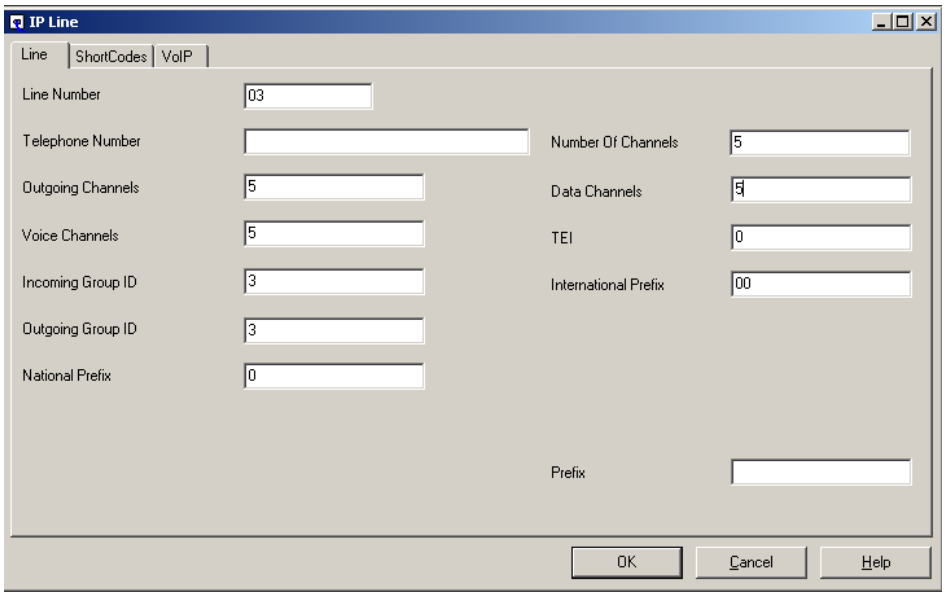
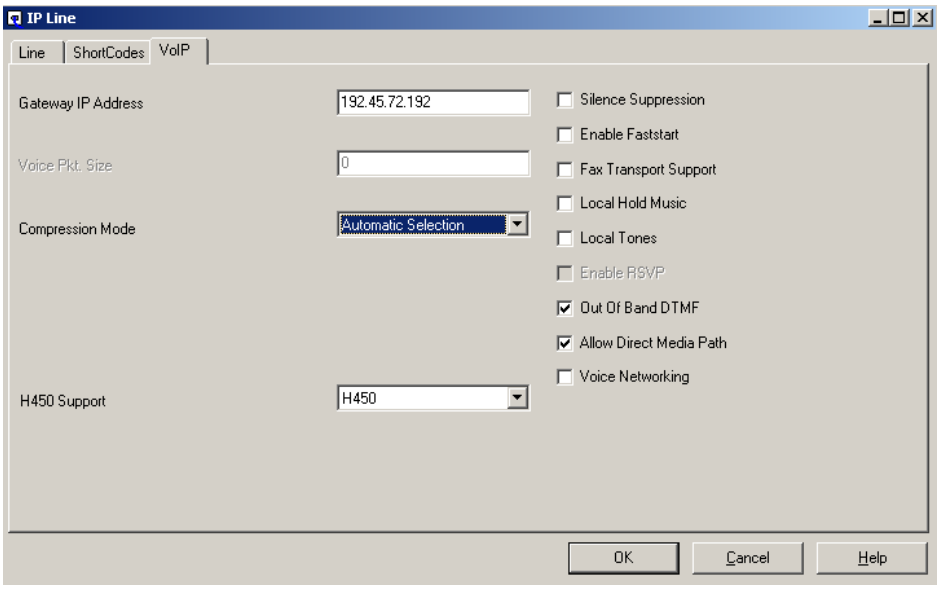
Equipment	Software
Avaya IP403 Office	2.1(27)
Avaya IP412 Office	2.1(27)
Avaya 4612, 4624 IP Telephones	1.81
Avaya 6400 Series Digital Telephones	--
Kentrox Q-Series Q2400 QoS Access Router	1.3
Kentrox Q-Series Q2200 T1 QoS Access Router	1.3

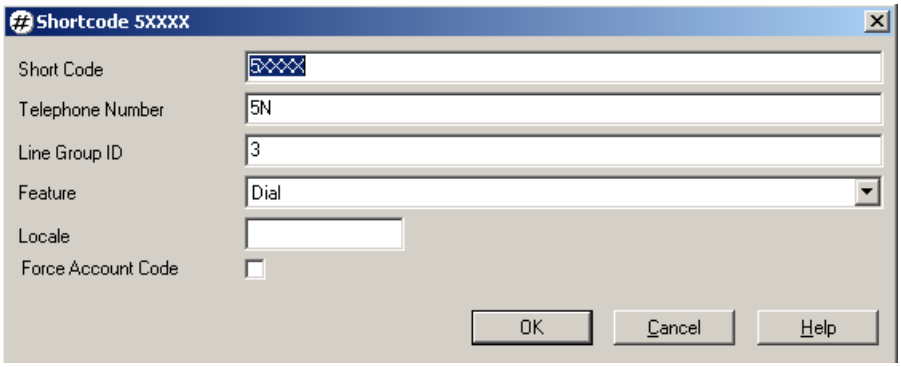
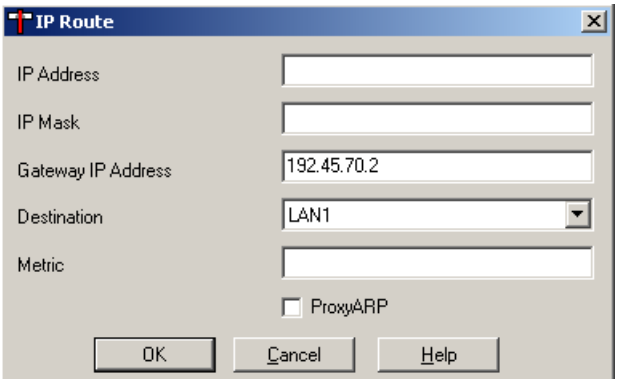
3. Configure the Avaya IP412 Office

This section describes the configuration steps for providing the Avaya IP Office, located in the corporate site, with an IP configuration, DSCP values for VoIP traffic, IP trunks to the branch site, short codes for routing VoIP calls, and a default route. The IP Office was configured using the **Avaya IP Office Manager** application.

Step	Description
1.	To configure the Avaya IP Office, open the **Manager** application from a PC connected to the IP Office via IP. Initially, the IP Office is assigned IP address 192.168.42.1 with a subnet mask of 255.255.255.0. The **Manager** main window is displayed. All of the configuration options are selected from the tree view of the **Manager** window. 

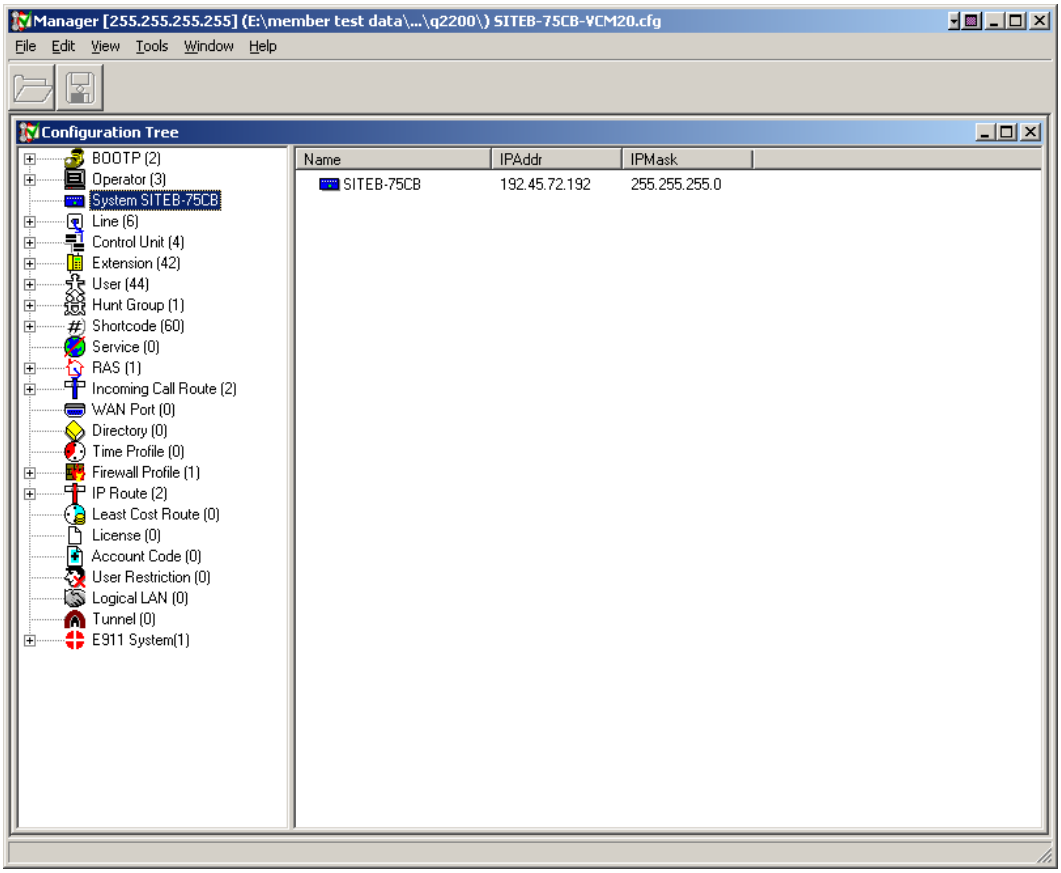
Step	Description
2.	To configure an IP address on the IP Office, select the **System** option. In the **LAN1** tab, set the **IP Address** and **IP Mask** to values that correspond to the customer's network and select **Disabled** for DHCP Mode. 
3.	In the **Gatekeeper** tab, verify that the DSCP values for VoIP media and signaling traffic are set to **46** and **34**, respectively. The Avaya IP Telephones that register with the Avaya IP Office need to be configured manually to use these DSCP values. These are the DSCP values used in the configuration described in these Application Notes. 

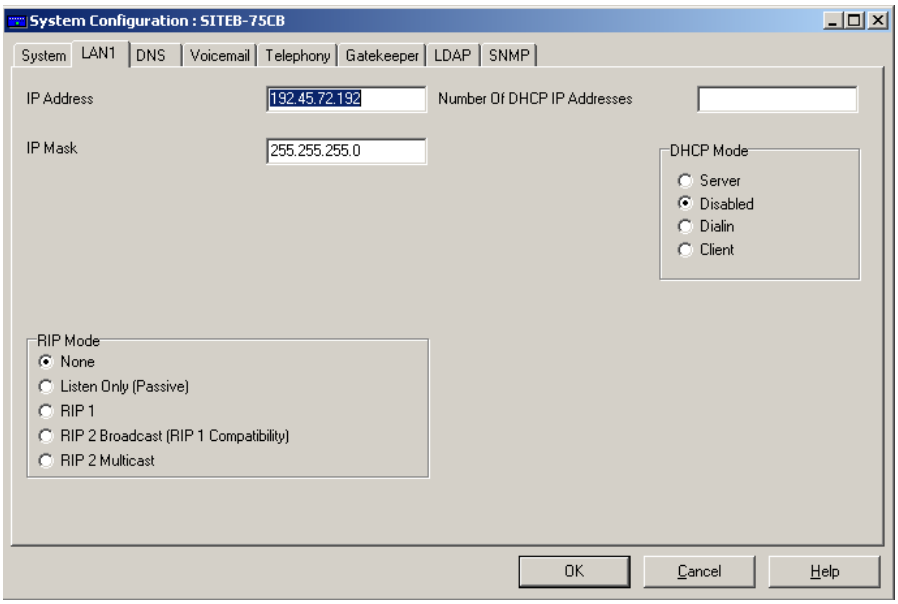
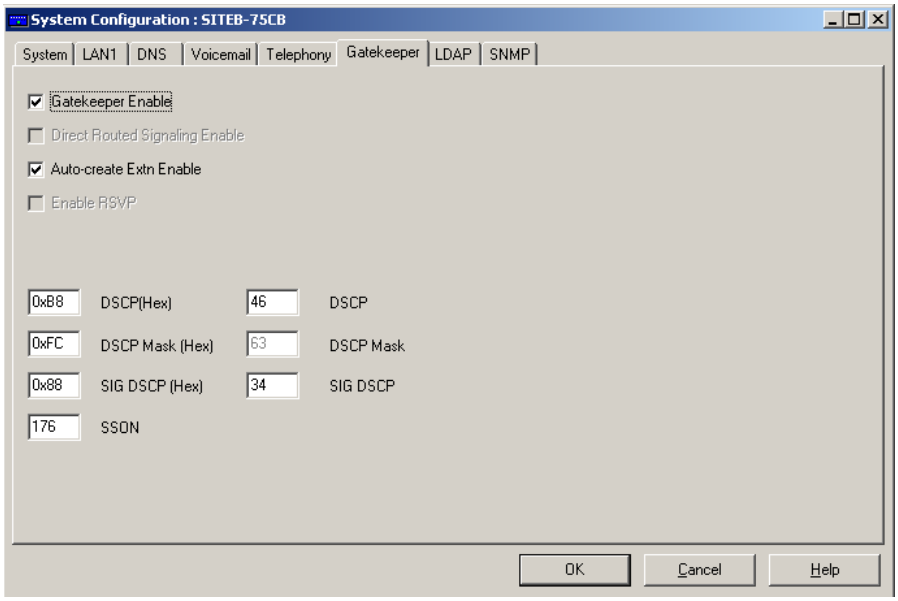
Step	Description
4.	Next, create an IP trunk to the Avaya IP Office 403 at the branch site. Select the **Line** option from the **Manager** tree view and add an **IP Line**. Specify the **Line Number**, the number of **Outgoing Channels** and **Voice Channels** in this IP line, and the **Incoming** and **Outgoing Group ID**. The **Outgoing Group ID** is specified in the short code that routes outgoing calls to the branch site. 
5.	Under the **VoIP** tab of the **IP Line** form, set the **Gateway IP Address** to the IP address of the Avaya IP Office 403 at the branch site. The **Compression Mode** was set to **Automatic Selection** so that the codec type used for the call would be negotiated during call setup. 

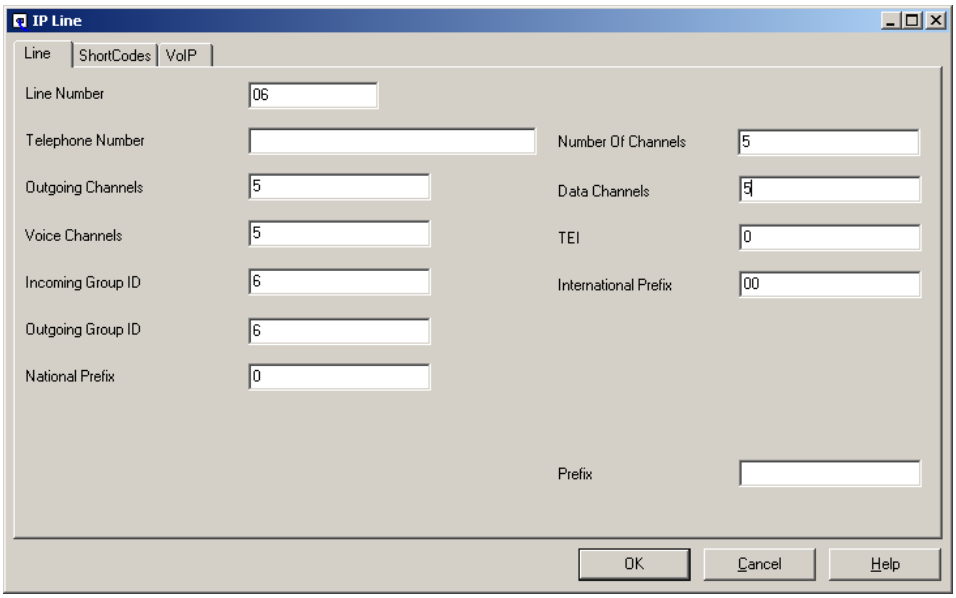
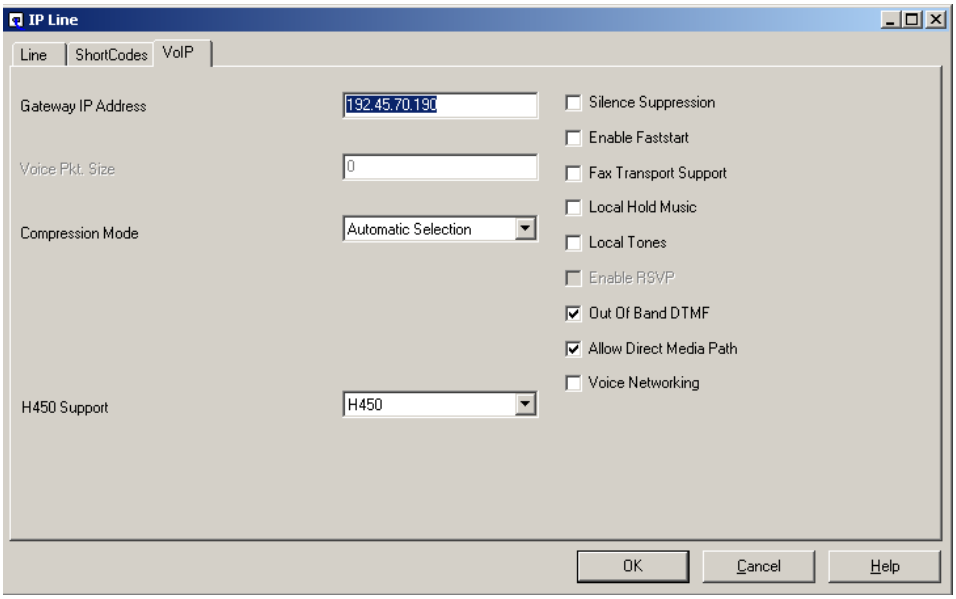
Step	Description
6.	To route calls to the IP telephones at the branch site, create a short code by selecting the **Shortcode** option from the **Manager** tree view. The extensions at the branch site begin with the digit '5' and are 5-digits in length. In this example, the short code specifies that calls with dialed digits in the format **5xxxx**, where 'x' denotes a wildcard, be routed over **Line Group ID 3** that was configured in **Step 4**. The **Telephone Number** field was set to **5N**, which means that the 5xxxx digits dialed are sent over the IP trunk. 
7.	Next, select the **IP Route** option from the left panel of the **Manager Main Window** to add a default route. The **IP Route** form specifies the Q2400 at the corporate office as the default gateway. IP address 192.45.70.2 belongs to the Ethernet port on the Q2400 router associated with the voice VLAN (VLAN ID 70). This route is used to route VoIP media and signaling packets to the branch site. 
8.	Add **IP Extensions** and **Users** for the IP telephones that will register with the IP Office. The reader should consult the Avaya IP Office documentation listed in Section 10 for instructions on adding IP stations.

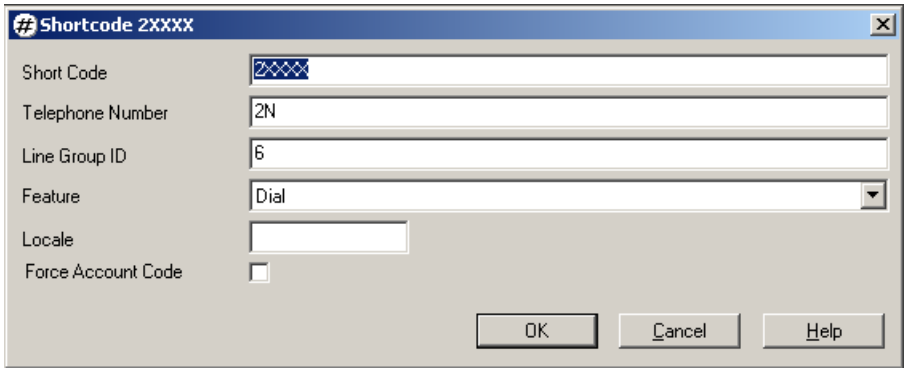
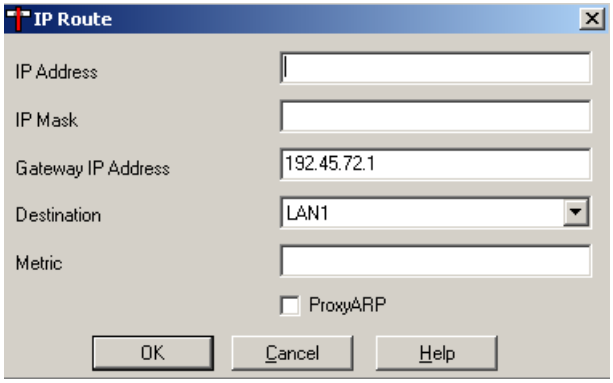
4. Configure the Avaya IP403 Office

This section describes the configuration steps for providing the Avaya IP Office, located in the branch site, with an IP configuration, DSCP values for VoIP traffic, IP trunks to the corporate site, short codes for routing VoIP calls, and a default route. The IP Office was configured using the **Avaya IP Office Manager** application.

Step	Description
1.	To configure the Avaya IP Office, open the **Manager** application from a PC connected to the IP Office via IP. Initially, the IP Office is assigned IP address 192.168.42.1 with a subnet mask of 255.255.255.0. The **Manager** main window is displayed. All of the configuration options are selected from the tree view of the **Manager** window. 

Step	Description
2.	To configure an IP address on the IP Office, select the **System** option. In the **LAN1** tab, set the **IP Address** and **IP Mask**. In the field, specify the IP configuration that corresponds to the customer's network. Select **Disabled** for DHCP Mode. Although the integrated DHCP server in the IP Office could have been used, DHCP relay to the corporate site was used for illustrative purposes. 
3.	In the **Gatekeeper** tab, verify that the DSCP values for VoIP media and signaling traffic are set to **46** and **34**, respectively. The Avaya IP Telephones that register with the Avaya IP Office need to be manually configured to use these DSCP values. These are the DSCP values used in the configuration described in these Application Notes. 

Step	Description
4.	Next, create an IP trunk to the Avaya IP Office at the corporate site. Select the **Line** option from the **Manager** tree view and add an **IP Line**. Specify the **Line Number**, the number of **Outgoing Channels** and **Voice Channels** in this IP line, and the **Incoming** and **Outgoing Group ID**. The **Outgoing Group ID** is specified in the short code that routes outgoing calls to the corporate site. 
5.	Under the **VoIP** tab of the **IP Line** form, set the **Gateway IP Address** to the IP address of the Avaya IP Office at the corporate site. The **Compression Mode** was set to **Automatic Selection** so that the codec type used for the call would be negotiated during call setup. 

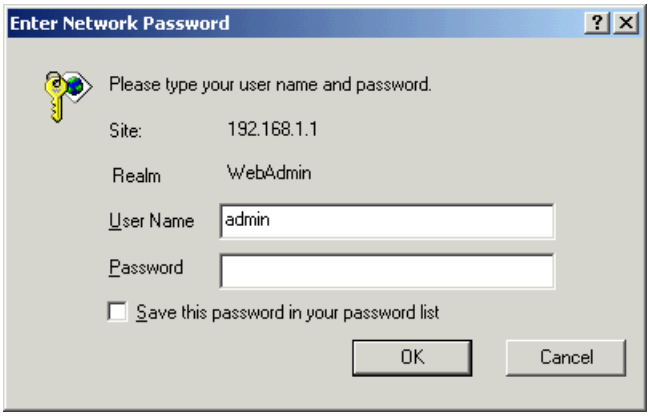
Step	Description
6.	To route calls to the IP telephones at the corporate site, create a short code by selecting the **Shortcode** option from the **Manager** tree view. The extensions at the corporate site begin with the digit '2' and are 5-digits in length. In this example, the short code specifies that calls with dialed digits in the format **2xxxx**, where 'x' denotes a wildcard, be routed over **Line Group ID 6** that was configured in **Step 4**. The **Telephone Number** field was set to **2N**, which means that the 2xxxx digits dialed are sent over the IP trunk. 
7.	Next, select the **IP Route** option from the left panel of the **Manager Main Window** to add a default route. The **IP Route** form specifies the Q2200 at the branch office as the default gateway. IP address 192.45.72.1 belongs to the Ethernet port on the Q2200 router associated with the voice VLAN (VLAN ID 72). This route is used to route VoIP media and signaling packets to the corporate site. 
8.	Add **IP Extensions** and **Users** for the IP telephones that will register with the IP Office. The reader should consult the Avaya IP Office documentation listed in Section 10 for instructions on adding IP stations.

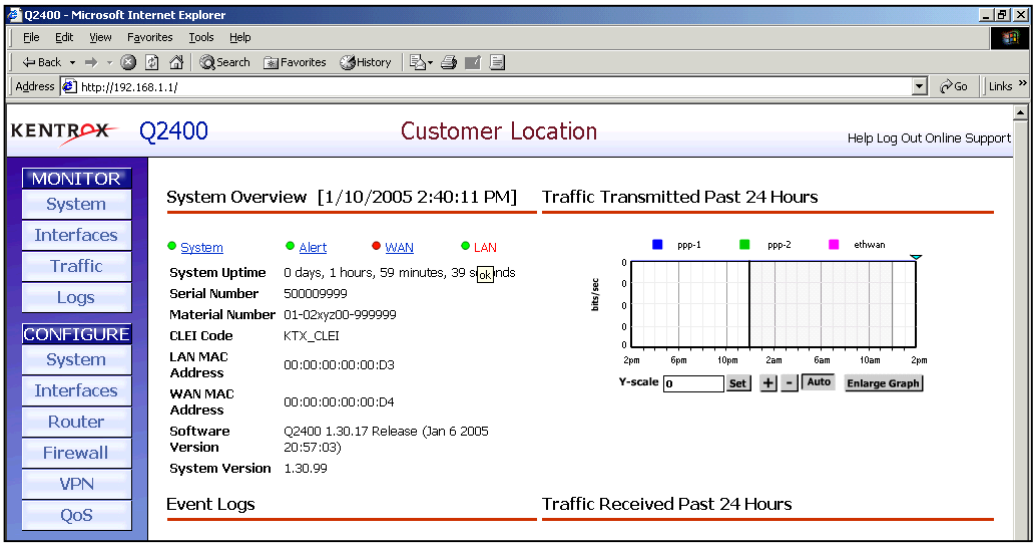
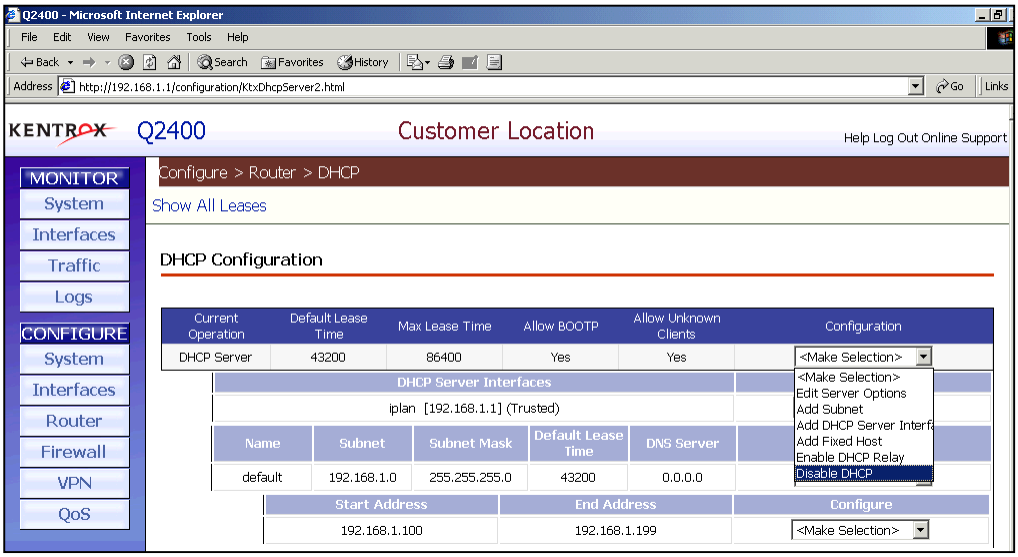
5. Configure the Kentrox Q-Series Routers for Frame Relay

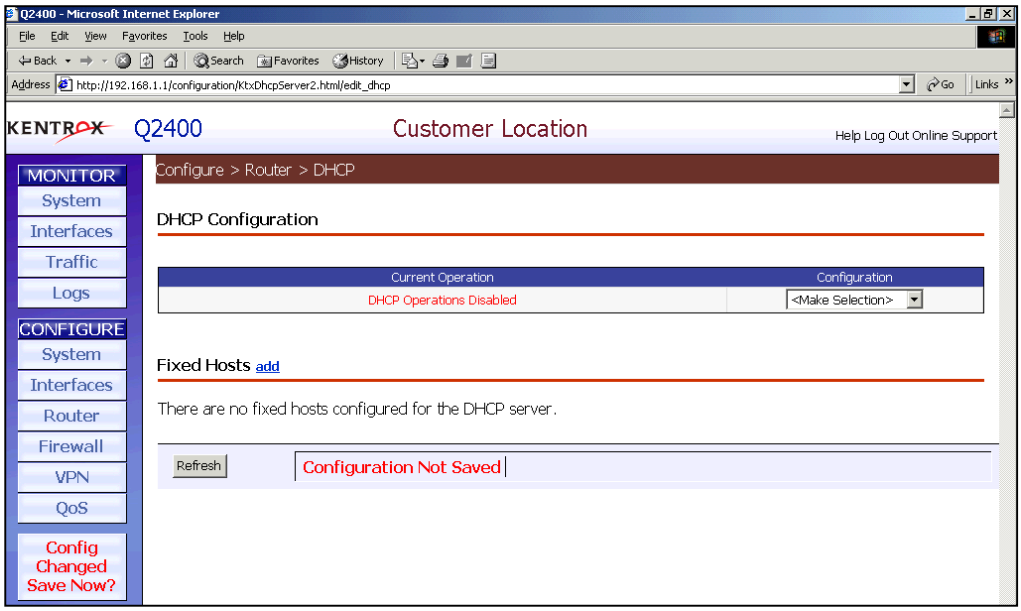
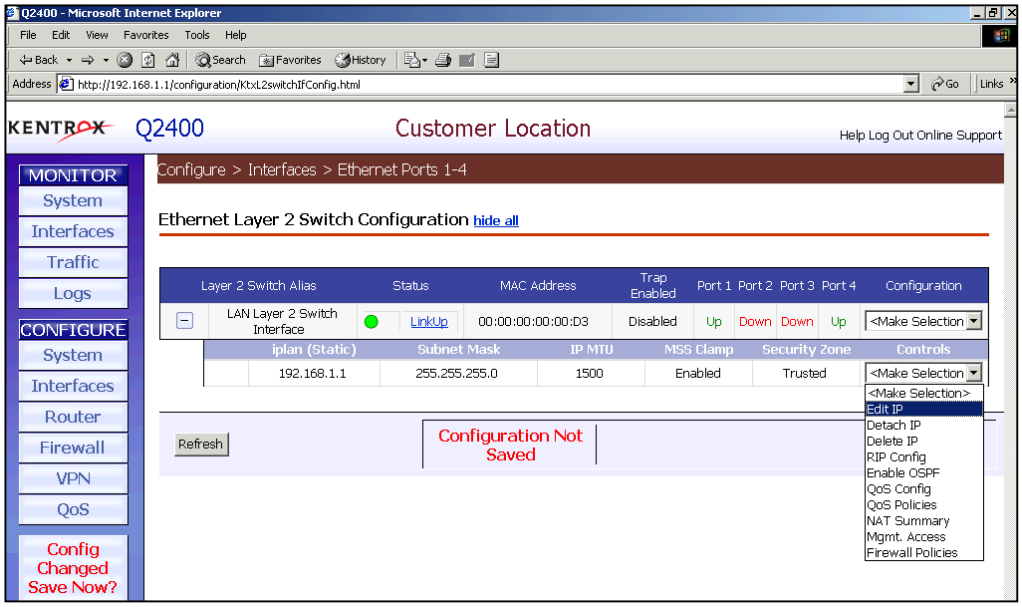
The Kentrox Q-Series routers provide WAN connectivity for the corporate and branch office sites using Frame Relay links. The Q2400 at the corporate site and the Q2200 at the branch site both connect to the public network.

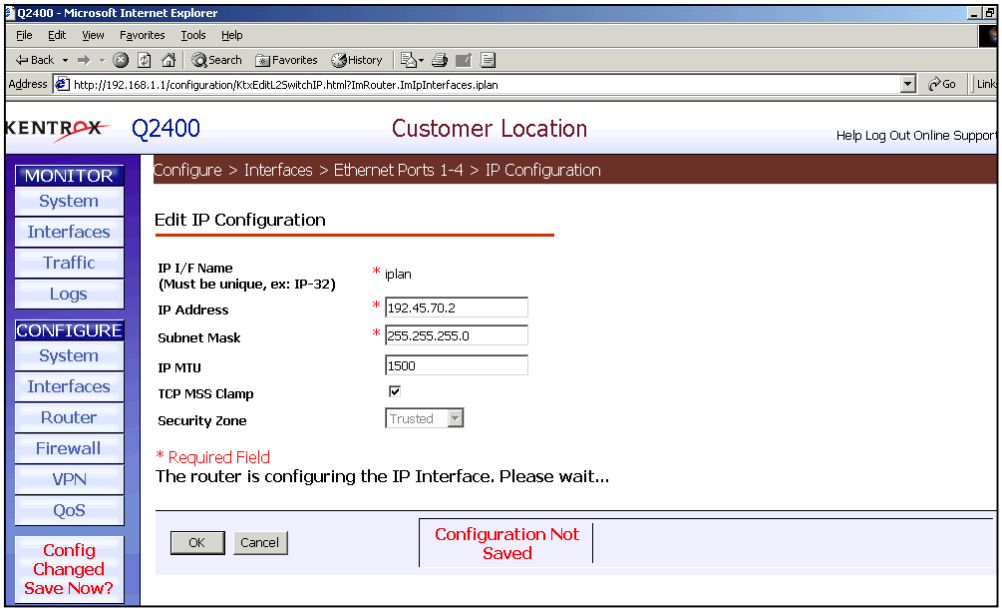
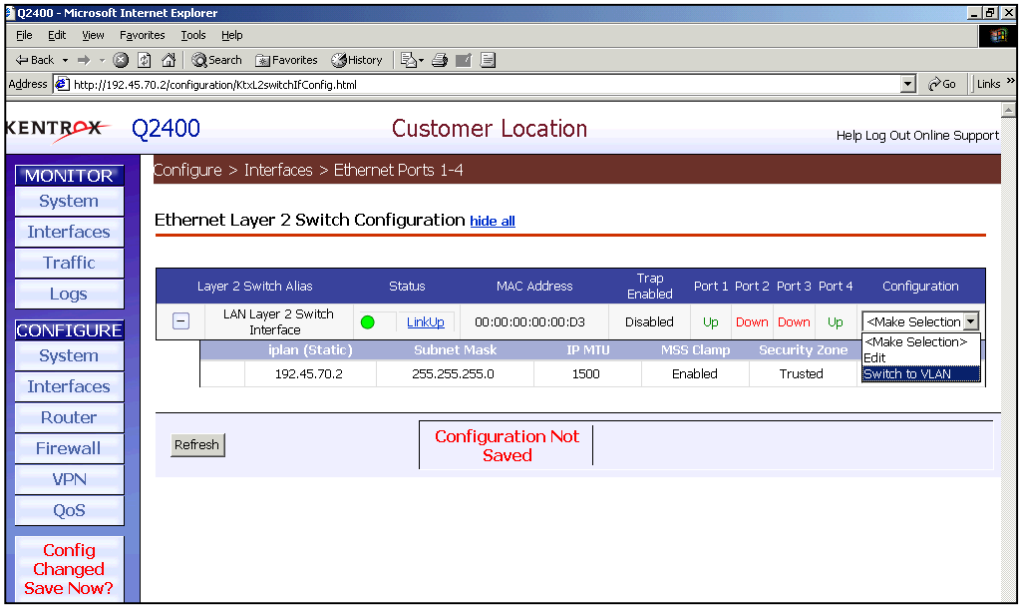
5.1. Kentrox Q2400 in the Corporate Site

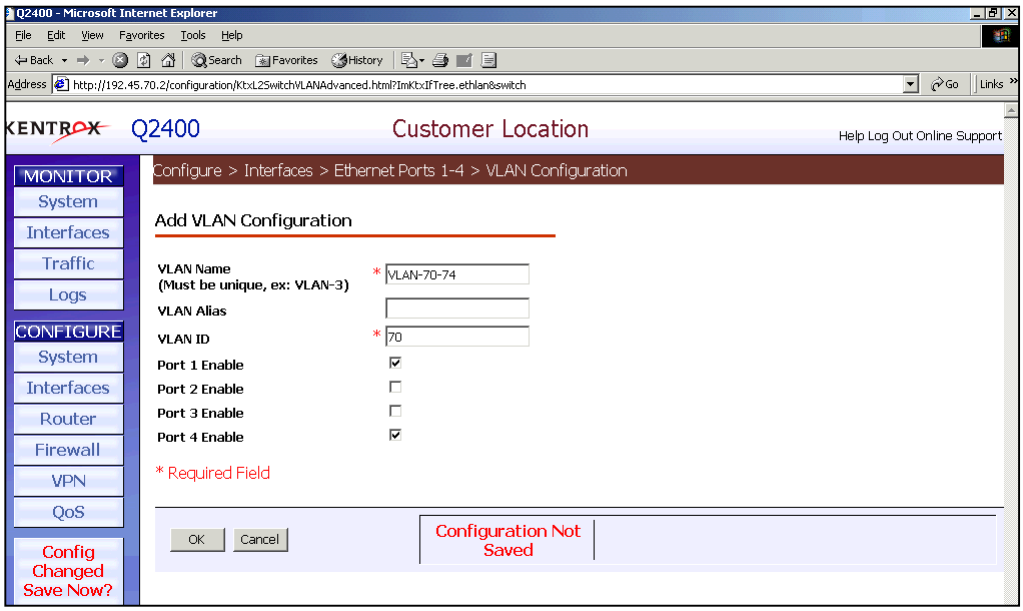
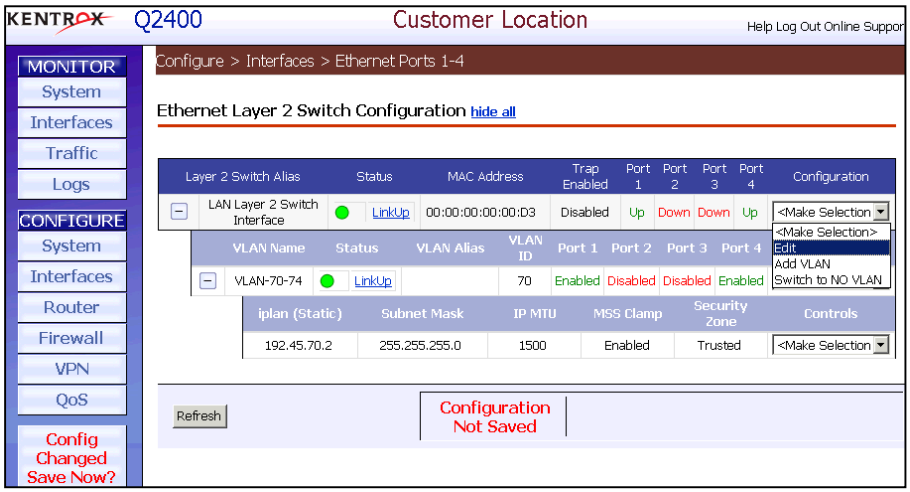
This section provides the configuration of the Q2400 in the corporate site. The Q2400 connects to the Avaya IP412 Office via a Layer-2 switch.

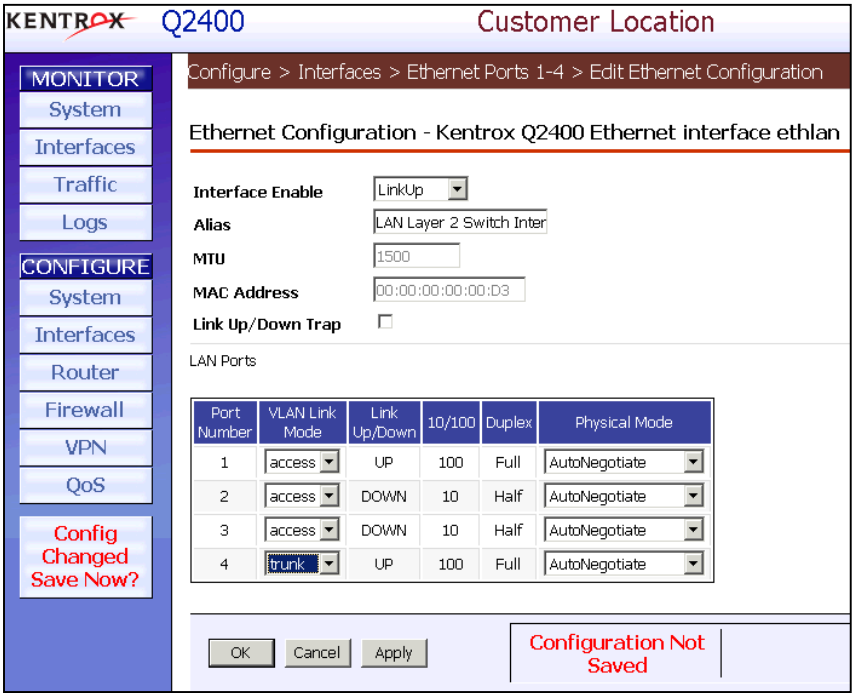
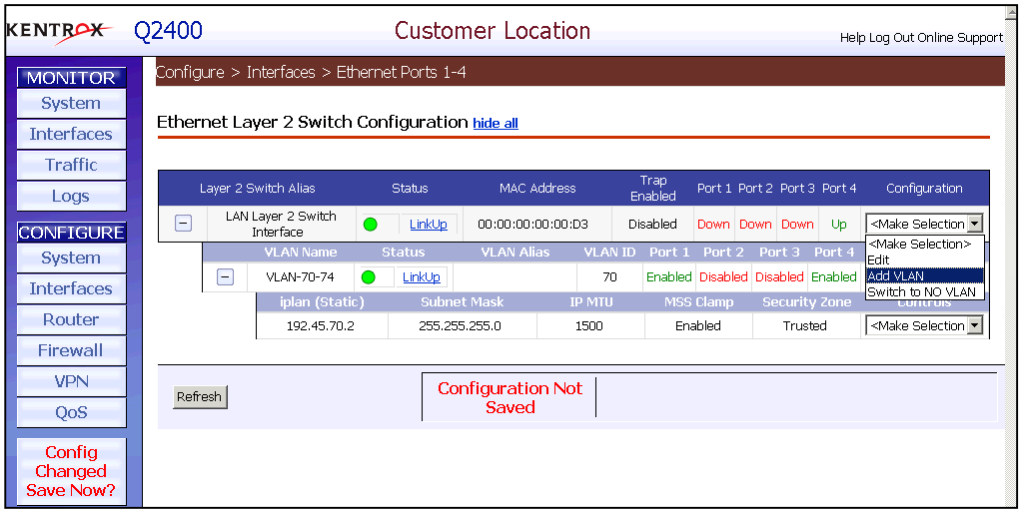
Step	Description
1.	To configure the Kentrox Q2400, launch Internet Explorer from a PC directly connected to the Q2400. Initially, the Q2400 is assigned an IP address 192.168.1.1 with a subnet mask of 255.255.255.0. Log into the Q2400 using the appropriate credentials when the Q2400 authentication window appears. 

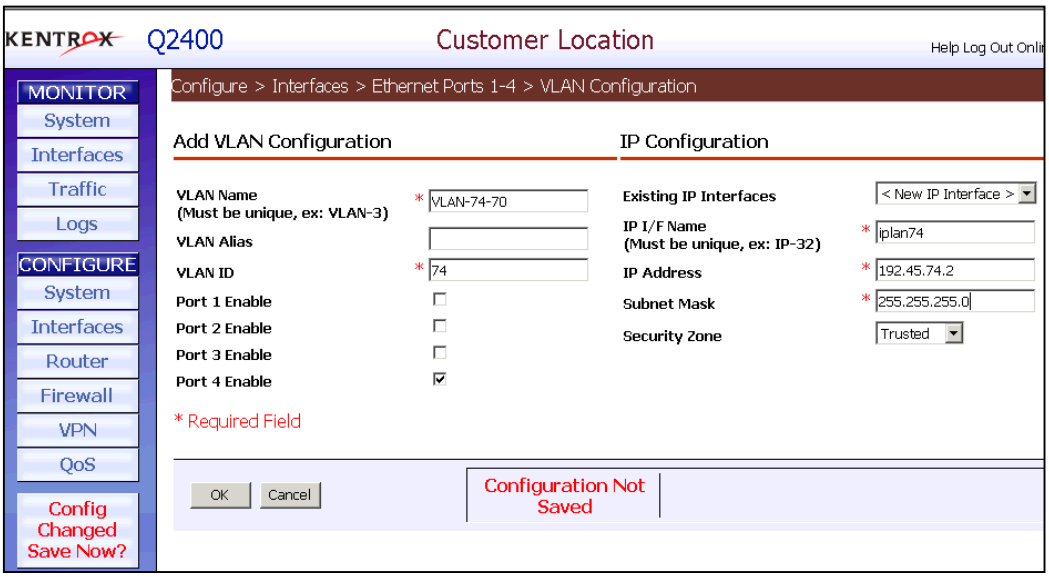
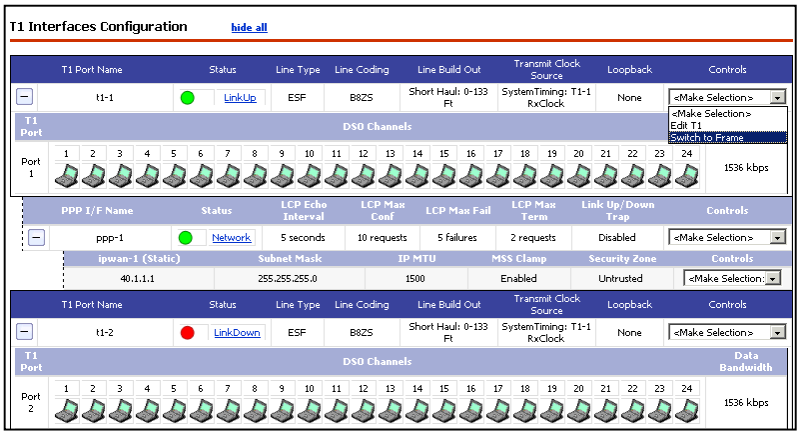
Step	Description
2.	Once successfully authenticated, the Q2400 main window is displayed. All of the configuration options are selected from the tree view on the left side of the Q2400 main window. 
3.	To disable the Q2400 DHCP Server, select **Router → DHCP** under CONFIGURE in the tree view. In the Configure > Router > DHCP page that appears, select **Disable DHCP** from the Configuration pull-down menu for the DHCP Server. 
4.	Click **OK** at the 'This will disable DHCP. Are you sure?' popup that appears.

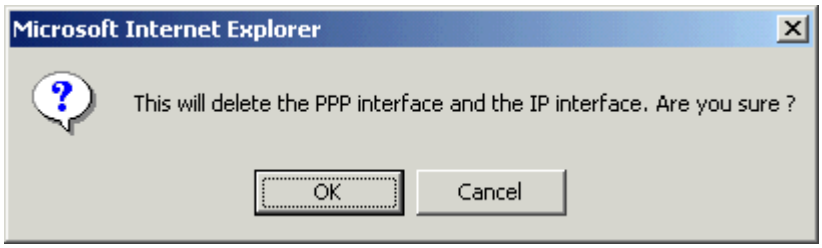
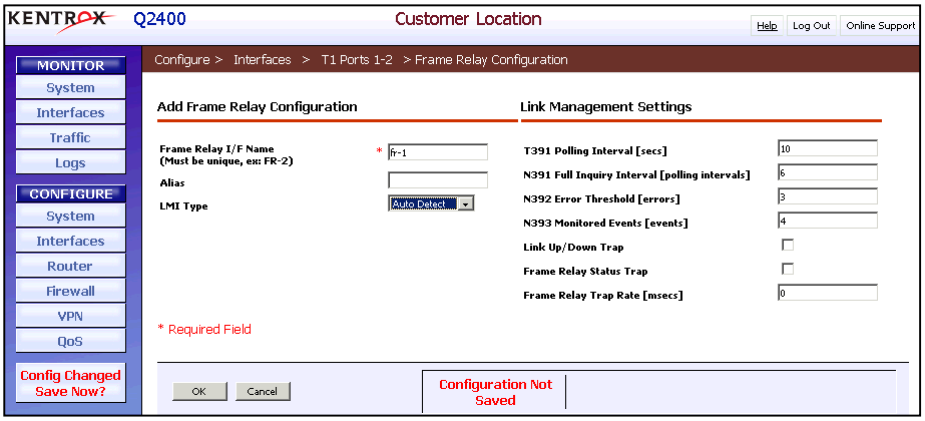
Step	Description
5.	The message 'DHCP Operations Disabled' now appears for the DHCP Configuration. 
6.	To configure the IP address on the Q2400, select **Interfaces → Ethernet Ports 1-4** under CONFIGURE in the tree view. In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Edit IP** in the Controls pull-down menu for IP address 192.168.1.1.  **NOTE**: In the configuration used for these Application Notes, the PC used to initially configure the Q2400 was directly connected to Port 1 and the Layer 2 switch connected to the Q2400 was connected to Port 4.

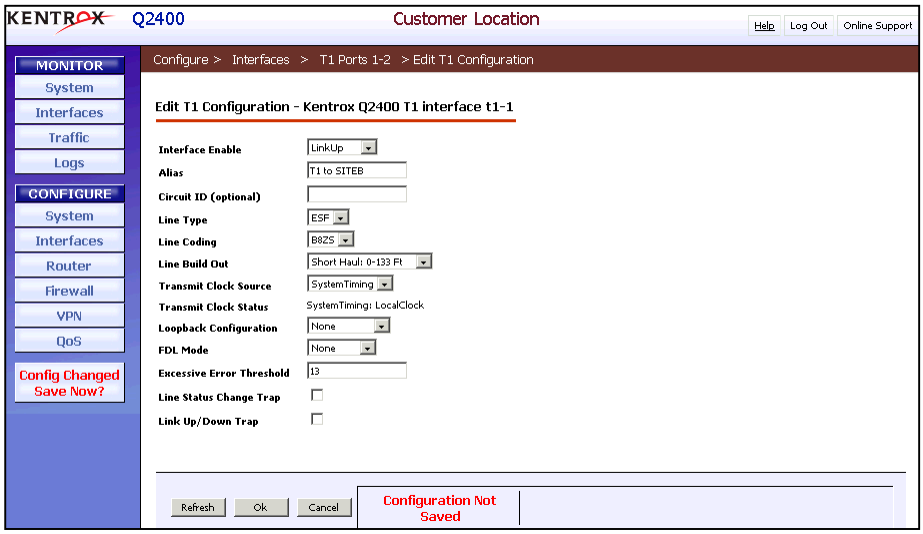
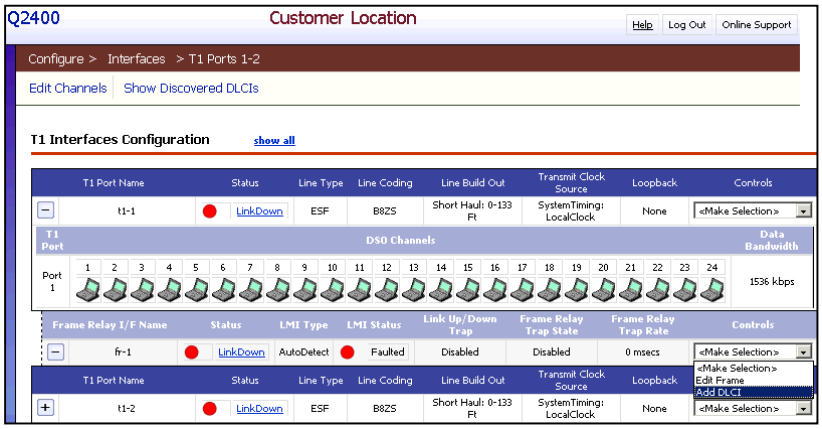
Step	Description
7.	In the Configure > Interfaces > Ethernet Ports 1-4 > IP Configuration page that appears, set *IP Address* to **192.45.70.2**, *Subnet Mask* to **255.255.255.0** and click **OK**. 
8.	Change the IP address of the PC directly connected to the Q2400, browse to 192.45.70.2 and log in again into the Q2400.
9.	Select **Interfaces → Ethernet Ports 1-4** under CONFIGURE in the tree view. In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Switch to VLAN** in the Configuration pull-down menu for LAN Layer 2 Switch Interface. 

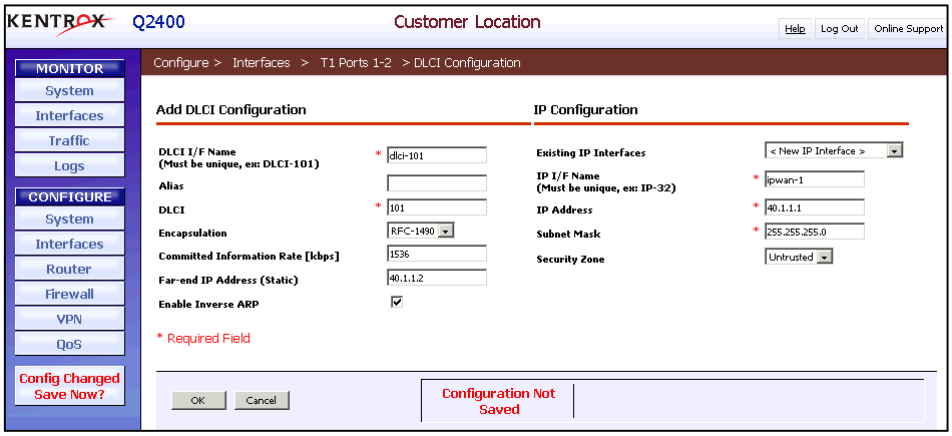
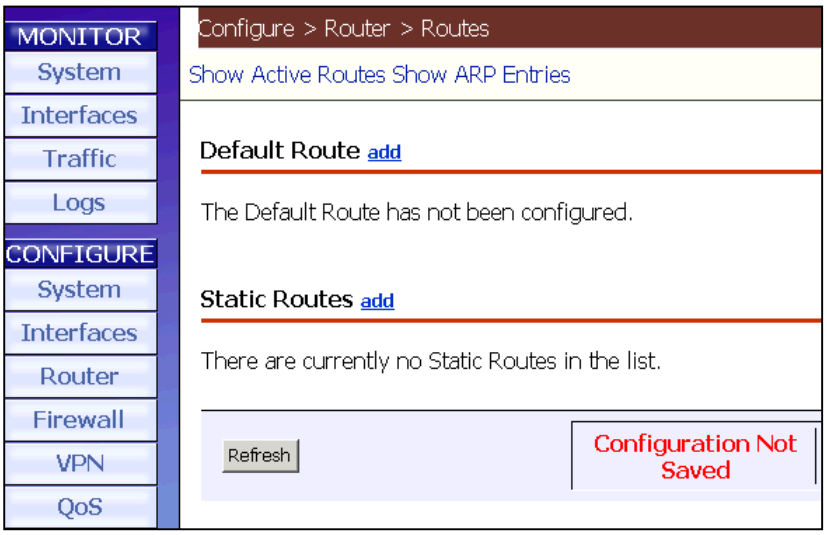
Step	Description
10.	Click **OK** at the 'This will detach the IP interface and disrupt traffic. Are you sure?' popup that appears.
11.	Configure VLAN 70 in the Configure > Interfaces > Ethernet Ports 1-4 > VLAN Configuration page that appears. Set *VLAN Name* to **VLAN-70-74**, *VLAN ID* to **70**, check **Port 1 Enable**, check **Port 4 Enable**, and click **OK**. 
12.	This change causes the connection to the browser to drop. Browse to 192.45.70.2 and log in again into the Q2400.
13.	Select **Interfaces → Ethernet Ports 1-4** under CONFIGURE in the tree view. In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Edit** in the Configuration pull-down menu for LAN Layer 2 Switch Interface. 

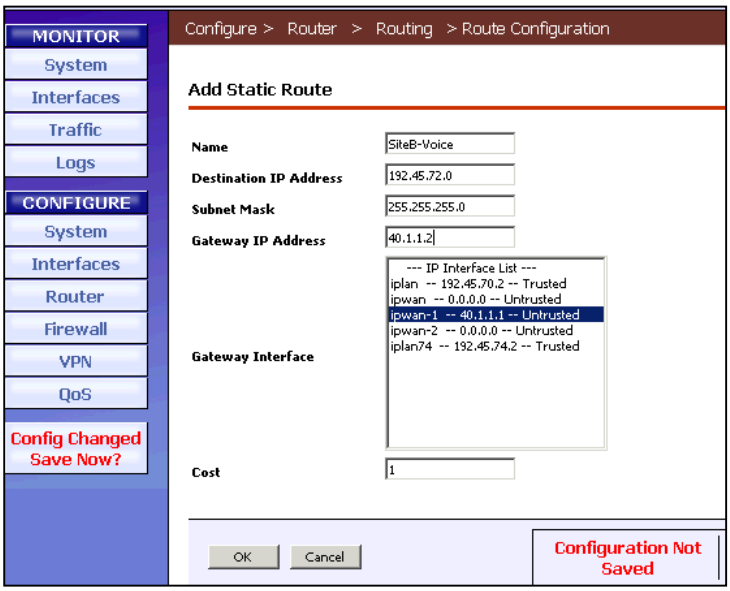
Step	Description
14.	In the Configure > Interfaces > Ethernet Ports 1-4 > Edit Ethernet Configuration page that appears, set Port 4 *VLAN Link Mode* to **trunk** and click **OK**.  **NOTE**: The port on the Layer-2 switch connecting to port 4 on the Q2400 was configured for 802.1q (VLAN) mode. This allows VLAN header information to be exchanged between the switch at the corporate site and the Q2400. The corporate site contains voice VLAN 70 and data VLAN 72.
15.	In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Add VLAN** in the Configuration pull-down menu for LAN Layer 2 Switch Interface. 

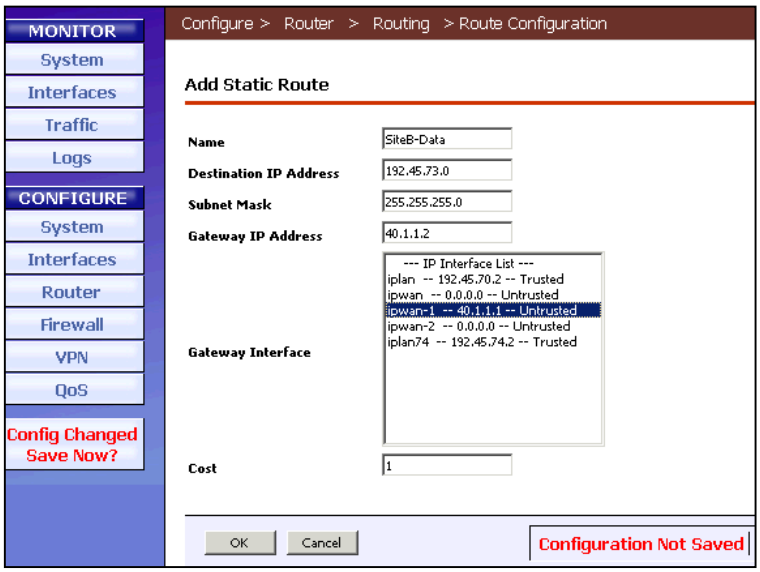
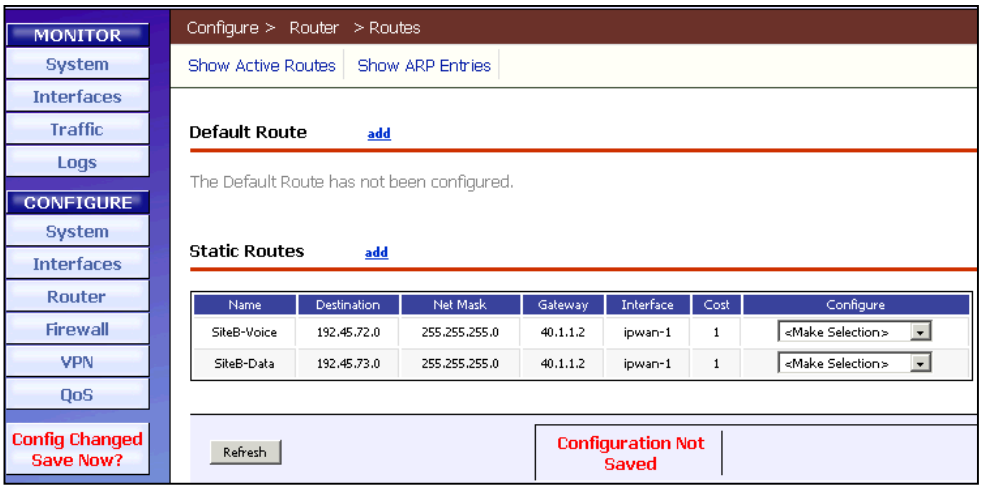
Step	Description
16.	Configure VLAN 74 in the Configure > Interfaces > Ethernet Ports 1-4 > VLAN Configuration page that appears. Set *VLAN Name* to **VLAN-74-70**, *VLAN ID* to **74**, check **Port 4 Enable**, *IP I/F Name* to **iplan74**, *IP Address* to **192.45.74.2**, *Subnet Mask* to **255.255.255.0**, and click **OK**. 
17.	Select **Interfaces → T1 Ports 1-2** under CONFIGURE in the tree view. In the Configure > Interfaces > T1 Ports 1-2 page that appears, select **Switch to Frame** in the Controls pull-down menu for T1 Port Name **t1-1**. 

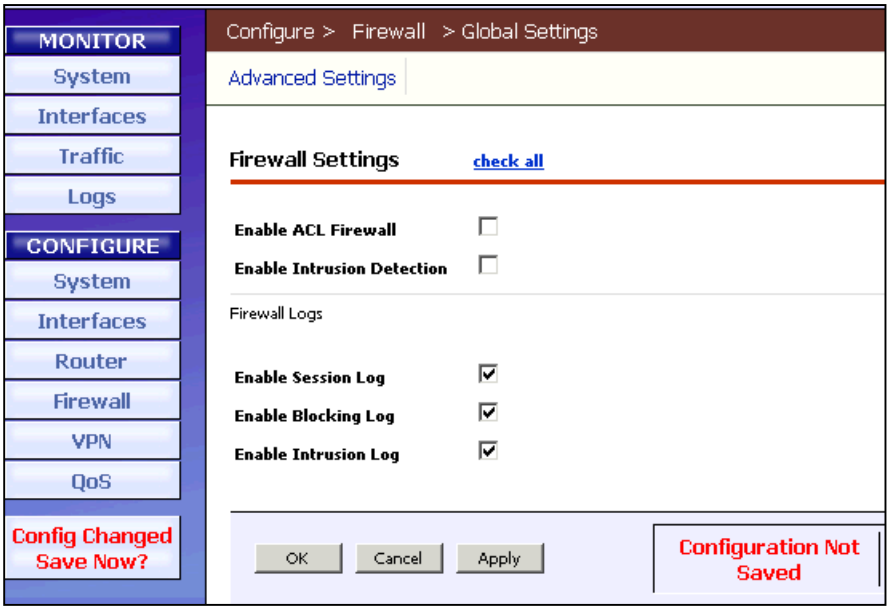
Step	Description
18.	In the "This will delete the PPP interface and the IP interface. Are you sure?" popup that appears, click **OK**. 
19.	In the Configure > Interfaces > T1 Ports 1-2 > Frame Relay Configuration page that appears, configure the frame relay settings needed to connect the T1 to the WAN and click **OK**. 
20.	In the Configure > Interfaces > T1 Ports 1-2 page, select **Edit T1** in the Controls pull-down menu for T1 Port Name **t1-1**.

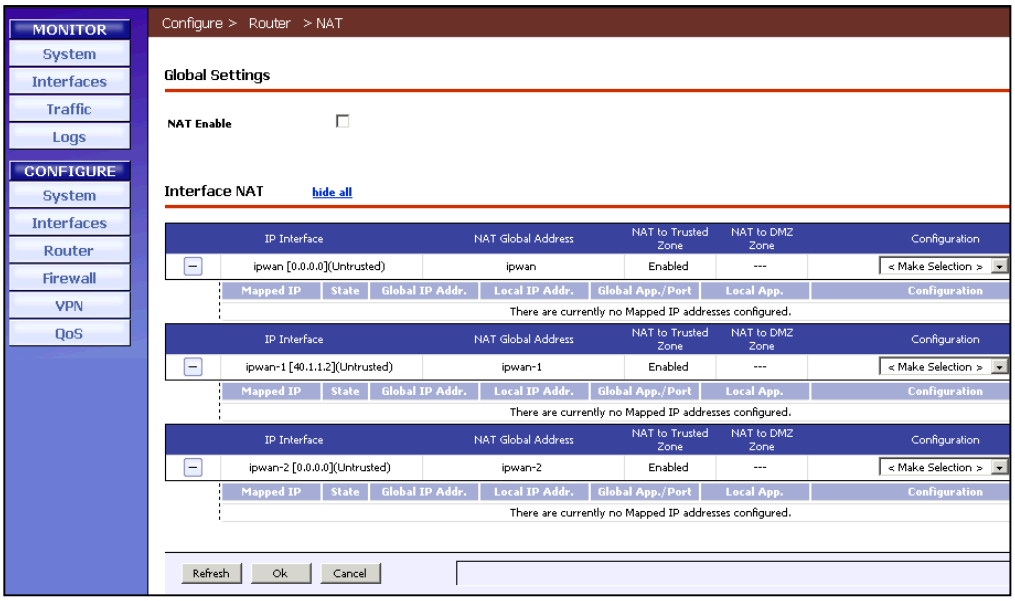
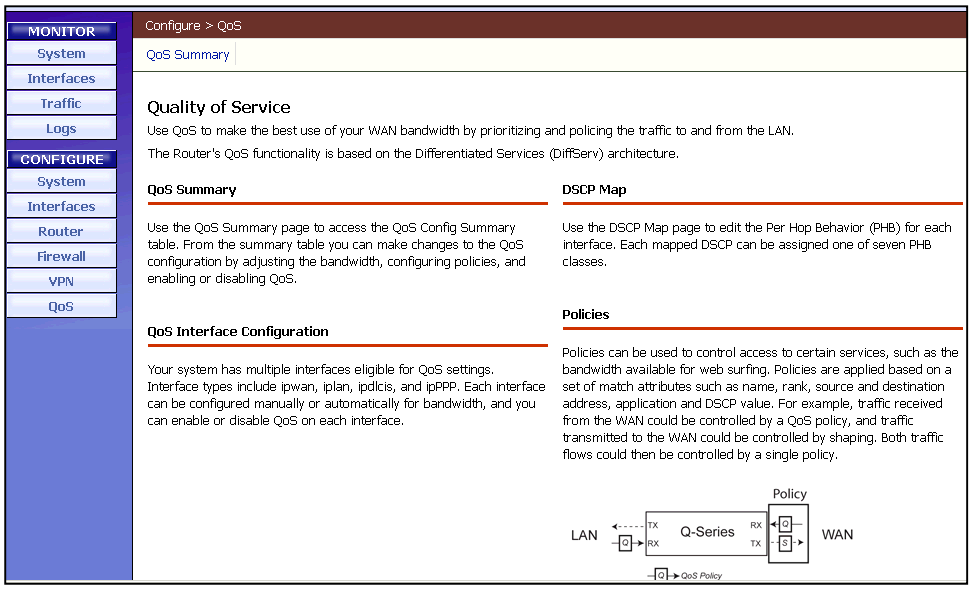
Step	Description
21.	In the Configure > Interfaces > T1 Ports 1-2 > Edit T1 Configuration page that appears, configure the line settings needed to connect the T1 to the WAN and click **OK**. 
22.	In the Configure > Interfaces > T1 Ports 1-2 page, select **Add DLCI** in the Controls pull-down menu for Frame Relay I/F Name **fr-1**. 

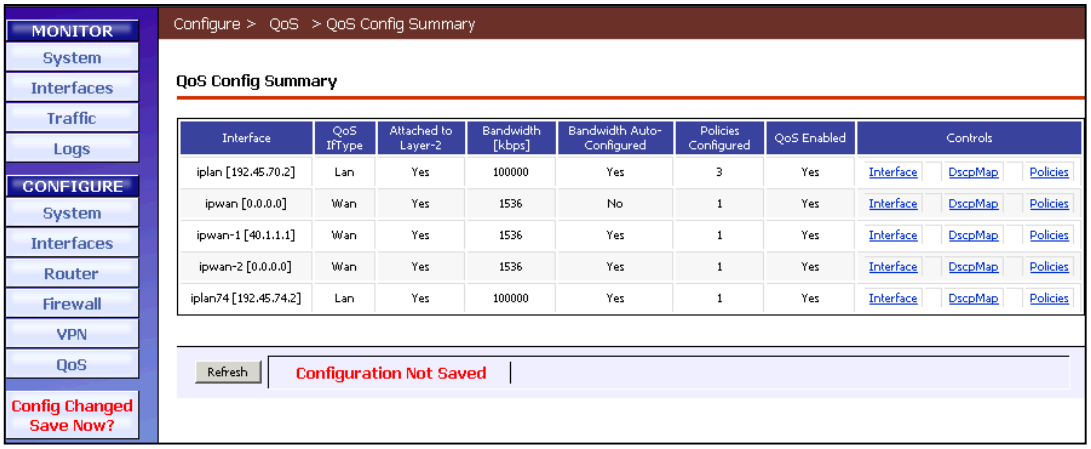
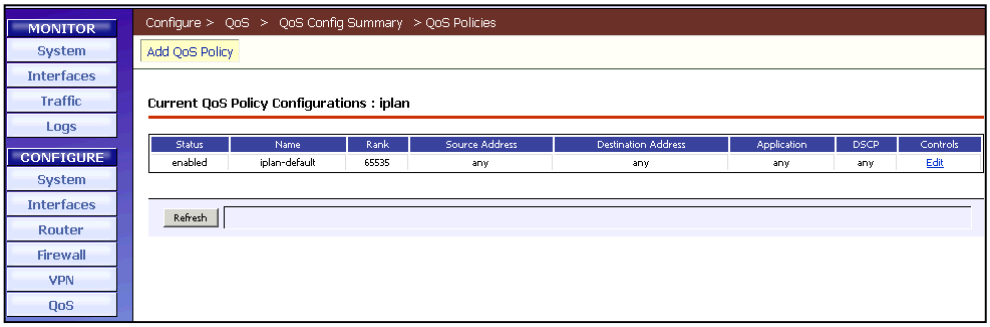
Step	Description
23.	In the Configure > Interfaces > T1 Ports 1-2 > DLCI Configuration page that appears, set *DLCI I/F Name* to **dlci-101**, *DLCI* to **101**, *Encapsulation* to **RFC-1490**, *Committed Information Rate [kbps]* to **1536**, *Far-End IP Address (Static)* to **40.1.1.2**, *IP I/F Name* to **ipwan-1**, *IP Address* to **40.1.1.1**, *Subnet Mask* to **255.255.255.0**, check **Enable Inverse ARP** and click **OK**. 
24.	Select **Router → Routes** under CONFIGURE in the tree view. In the Configure > Router > Routes page that appears, click **Add** for Static Routes. 

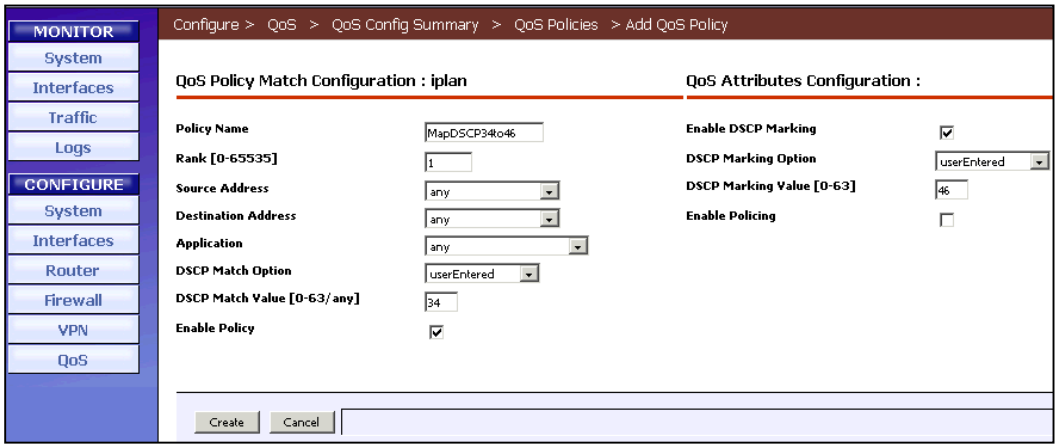
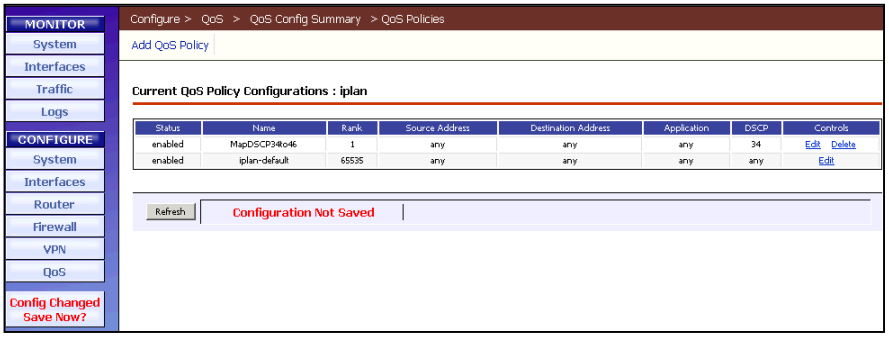
Step	Description
25.	In the Configure > Router > Routing > Route Configuration page that appears, set *Name* to **SiteB-Voice**, *Destination IP Address* to **192.45.72.0**, *Subnet Mask* to **255.255.255.0**, *Gateway IP Address* to **40.1.1.2**, select **ipwan-1** in the *Gateway Interface* list and click **OK**. 
26.	In the Configure > Router > Routes page that appears again, click **Add** for Static Routes.

Step	Description
27.	In the Configure > Router > Routing > Route Configuration page that appears, set *Name* to **SiteB-Data**, *Destination IP Address* to **192.45.73.0**, *Subnet Mask* to **255.255.255.0**, *Gateway IP Address* to **40.1.1.2**, select **ipwan-1** in the *Gateway Interface* list and click **OK**. 
28.	In the Configure > Router > Routes pages that appears, the newly defined static routes are listed. 

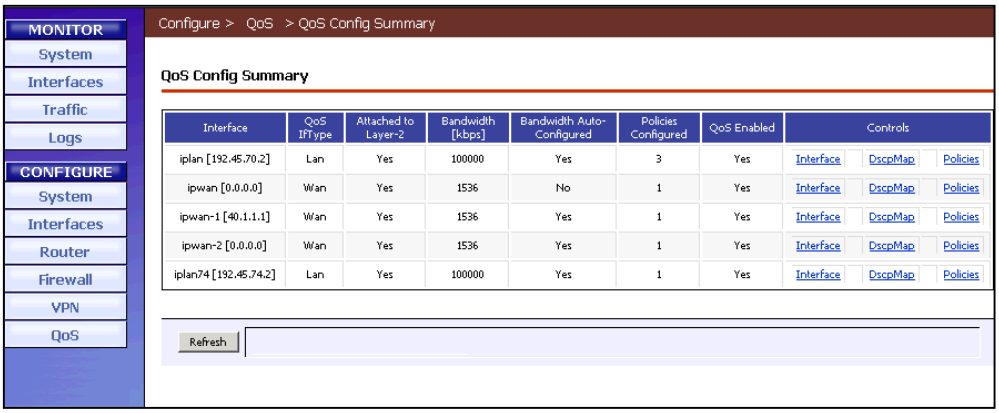
Step	Description
29.	Select **Firewall → Global Settings** under CONFIGURE in the tree view. In the Configure > Firewall > Global Settings page that appears, uncheck **Enable ACL Firewall**, uncheck **Enable Intrusion Detection** and click **OK**.  **NOTE**: The firewall settings were disabled for the purposes of the test configuration and these Application Notes therefore document this step. However, it is not necessary to do so.
30.	Click **OK** at the 'Disabling the Firewall leaves the LAN and the Router unprotected.' popup that appears.

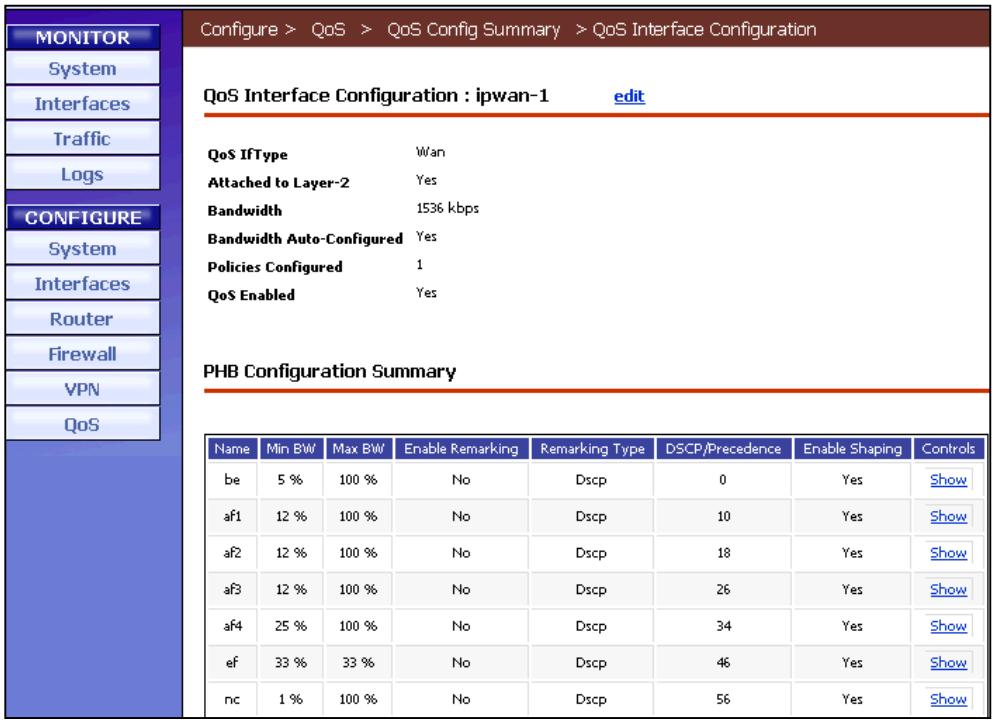
Step	Description
31.	Select **Router → NAT** under CONFIGURE in the tree view. In the Configure > Router > NAT page that appears, uncheck **NAT** and click **OK**.  **NOTE**: The NAT settings were disabled for the purposes of the test configuration and these Application Notes therefore document this step. However, it is not necessary to do so.
32.	Click **OK** at the 'Changing the NAT configuration will terminate the session. Do you want to continue?' popup that appears.
33.	Select **QoS** under CONFIGURE in the tree view. In the Configure > QoS page that appears, click **QoS Summary**. 

Step	Description
34.	In the Configure > QoS > QoS Config Summary page that appears, click **Policies** for the Interface **iplan [192.45.70.2]**. 
35.	In the Configure > QoS > QoS Config Summary > QoS Policies page that appears, click **Add QoS Policy**. 

Step	Description
36.	In the Configure > QoS > QoS Config Summary > QoS Policies > Add QoS Policy page that appears, set *Policy Name* to **MapDSCP34to46**, *Rank* to **1**, *Source Address* to **any**, *Destination Address* to **any**, *Application* to **any**, *DSCP Match Option* to **userEntered**, *DSCP Match Value* to **34**, *DSCP Marking Option* to **userEntered**, *DSCP Marking Value* to **46**, check **Enable Policy**, check **Enable DSCP Marking** and click **Create**.  **NOTE**: The Q-Series routers keep traffic marked with DSCP 46 (EF) in its own priority queue. However, DSCP 34 (AF4) marked traffic is kept in a Weighted Fair Queue (WFQ) with all other DSCP values. High traffic scenarios negatively impact call-signaling traffic when it is kept in the WFQ. To ensure highest priority for both signaling and audio, a policy was created to map DSCP 34 to 46 at both the corporate and branch sites Q-Series routers. This ensures that signaling and audio packets are transmitted using the priority queue, instead of the WFQ. However, this is not required for most non-VoIP installations.
37.	In the Configure > QoS > QoS Config Summary > QoS Policies page that appears, the newly added policy is listed. 
38.	Select **System → Save Config** under CONFIGURE in the tree view to save the configuration.

Step	Description
39.	Select **QoS → QoS Summary** under CONFIGURE in the tree view. In the Configure > QoS > QoS Config Summary page that appears, click **Interface** for the Interface **ipwan-1 [40.1.1.1]**.



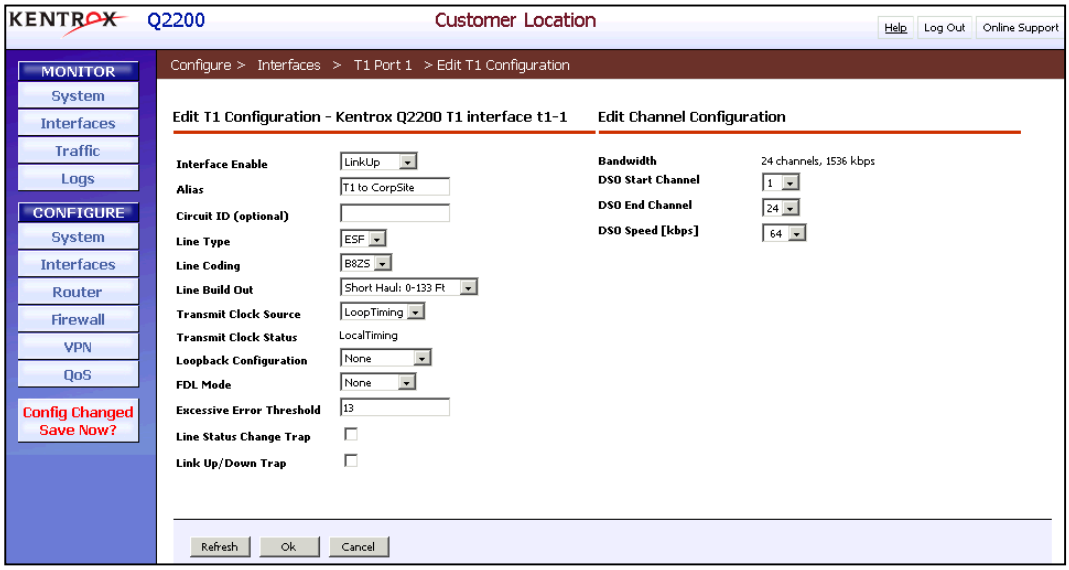
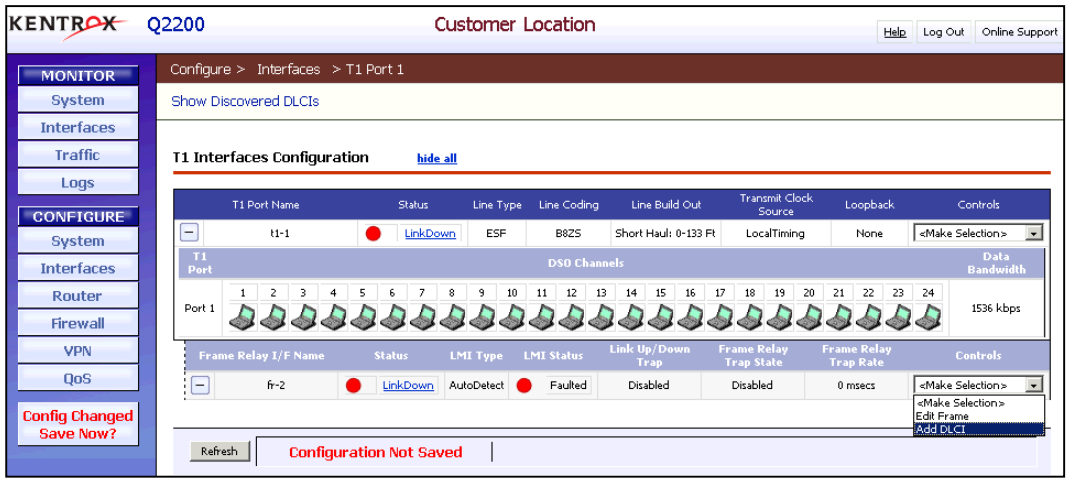
Step	Description
40.	In the Configure > QoS > QoS Config Summary > QoS Interface Configuration page that appears, the QoS configuration for the ipwan-1 interface is listed. Modify the Bandwidth for the link and/or each DSCP value as necessary.  **NOTE**: By default, the Q-Series routers perform traffic shaping on the traffic going through the WAN interface. DSCP 46 (EF) traffic is limited to 33% of the bandwidth. According to Kentrox, these default settings are optimal for the targeted small and/or low traffic configurations the products are intended for. The reader is advised to make the appropriate modifications for their own environment.

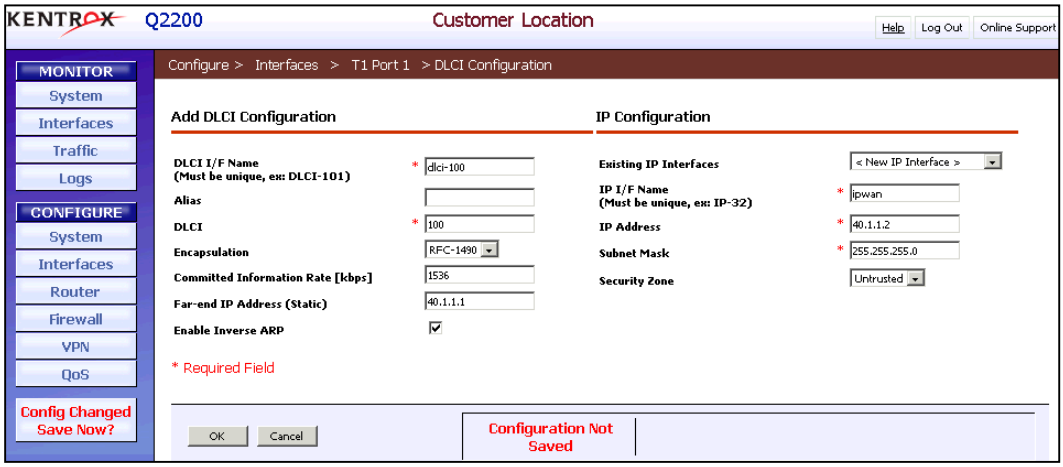
5.2. Kentrox Q2200 in Branch Office Site

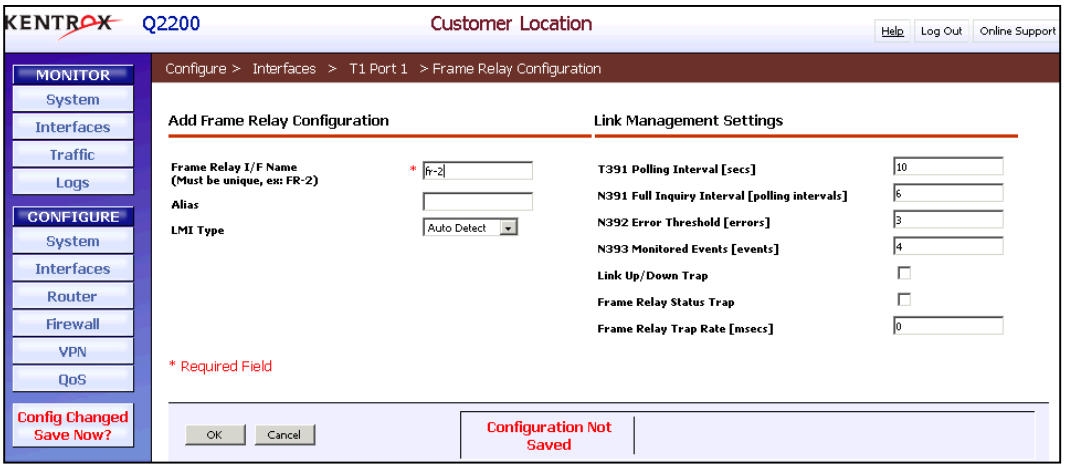
This section provides the configuration of the Q2200 in the branch Office Site. The Q2400 browser based administrative interface is the same for the Q2200. Therefore, screenshots have been omitted for most steps in this section.

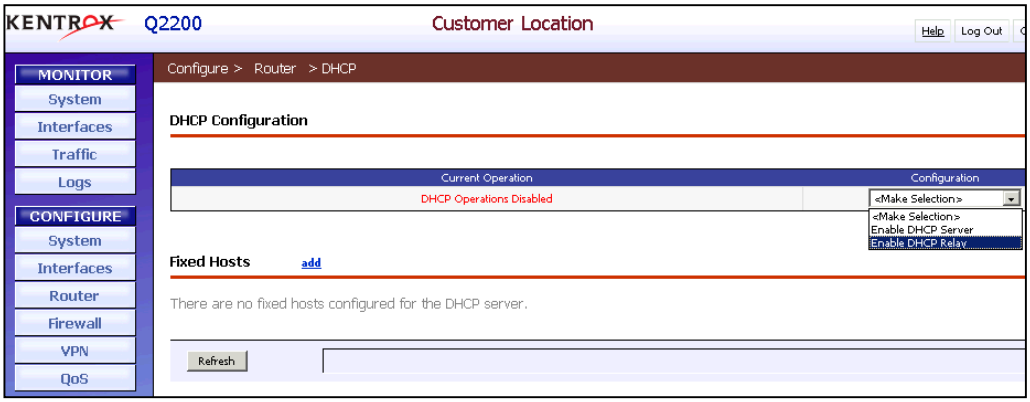
Step	Description
1.	To configure the Kentrox Q2200, launch Internet Explorer from a PC directly connected to the Q2200. Initially, the Q2200 is assigned an IP address 192.168.1.1 with a subnet mask of 255.255.255.0. Log into the Q2200 using the appropriate credentials when the Q2200 authentication window appears.

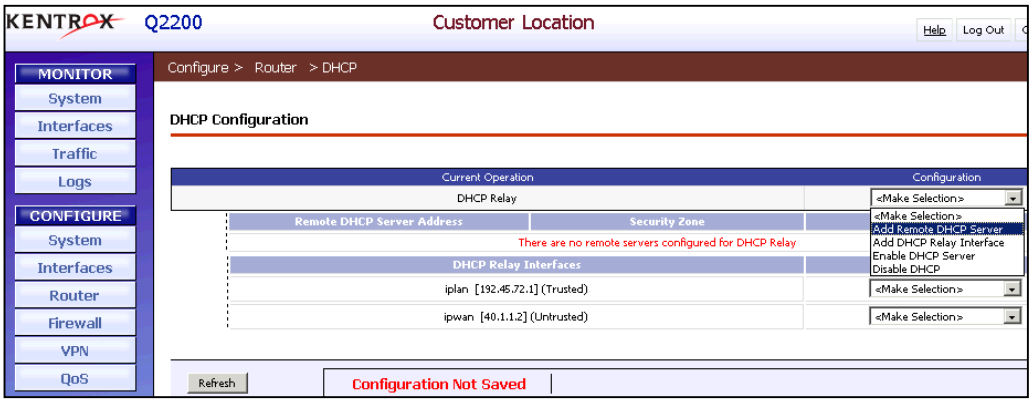
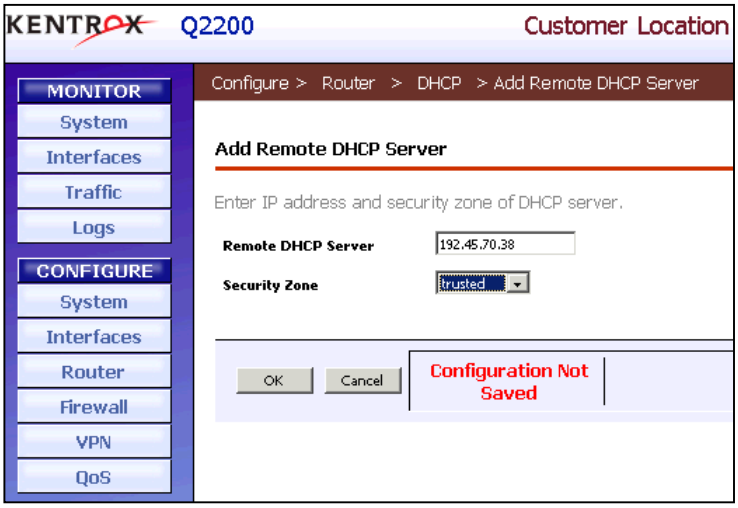
Step	Description
2.	Once successfully authenticated, the Q2200 main window is displayed. All of the configuration options are selected from the tree view on the left side of the Q2200 main window.
3.	To disable the Q2200 DHCP Server, select **Router → DHCP** under CONFIGURE in the tree view. In the Configure > Router > DHCP page that appears, select **Disable DHCP** from the Configuration pull-down menu for the DHCP Server.
4.	Click **OK** at the 'This will disable DHCP. Are you sure?' popup that appears.
5.	In the Configure > Router > DHCP page that appears, the message 'DHCP Operations Disabled' now appears for the DHCP Configuration.
6.	To configure the IP address on the Q2200, select **Interfaces → Ethernet Ports 1-4** under CONFIGURE in the tree view. In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Edit IP** in the Controls pull-down menu for IP address 192.168.1.1. **NOTE**: In the configuration used for these Application Notes, the PC used to initially configure the Q2200 was directly connected to Port 1 and the Layer 2 switch connected to the Q2200 was connected to Port 4.
7.	In the Configure > Interfaces > Ethernet Ports 1-4 > IP Configuration page that appears, set *IP Address* to **192.45.72.1**, *Subnet Mask* to **255.255.255.0** and click **OK**.
8.	Change the IP address of the PC directly connected to the Q2200, browse to 192.45.72.1 and log in again into the Q2200.
9.	Select **Interfaces → Ethernet Ports 1-4** under CONFIGURE in the tree view. In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Switch to VLAN** in the Configuration pull-down menu for LAN Layer 2 Switch Interface.
10.	Click **OK** at the 'This will detach the IP interface and disrupt traffic. Are you sure?' popup that appears.
11.	Configure VLAN 72 in the Configure > Interfaces > Ethernet Ports 1-4 > VLAN Configuration page that appears. Set *VLAN Name* to **VLAN-72-73**, *VLAN ID* to **72**, check **Port 1 Enable**, check **Port 4 Enable**, and click **OK**.
12.	This change causes the connection to the browser to drop. Browse to 192.45.72.1 and log in again into the Q2200.
13.	Select **Interfaces → Ethernet Ports 1-4** under CONFIGURE in the tree view. In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Edit** in the Configuration pull-down menu for LAN Layer 2 Switch Interface.
14.	In the Configure > Interfaces > Ethernet Ports 1-4 > Edit Ethernet Configuration page that appears, set Port 4 *VLAN Link Mode* to **trunk** and click **OK**. **NOTE**: The port on the Layer-2 switch connecting to port 4 on the Q2200 was configured for 802.1q (VLAN) mode. This allows VLAN header information to be exchanged between the switch at the branch site and the Q2200. The branch site contains voice VLAN 72 and data VLAN 73.
15.	In the Configure > Interfaces > Ethernet Ports 1-4 page that appears, select **Add VLAN** in the Configuration pull-down menu for LAN Layer 2 Switch Interface.

Step	Description
16.	Configure VLAN 73 in the Configure > Interfaces > Ethernet Ports 1-4 > VLAN Configuration page that appears. Set *VLAN Name* to **VLAN-73-72**, *VLAN ID* to **73**, check **Port 4 Enable**, *IP I/F Name* to **iplan73**, *IP Address* to **192.45.73.1**, *Subnet Mask* to **255.255.255.0**, and click **OK**.
17.	In the Configure > Interfaces > T1 Port 1 page, select **Edit T1** in the Controls pull-down menu for T1 Port Name **t1-1**.
18.	In the Configure > Interfaces > T1 Port 1 > Edit T1 Configuration page that appears, configure the line settings needed to connect the T1 to the WAN and click **OK**. 
19.	In the Configure > Interfaces > T1 Ports 1-2 page, select **Add DLCI** in the Controls pull-down menu for Frame Relay I/F Name **fr-2**. 

Step	Description
20.	In the Configure > Interfaces > T1 Port 1 > DLCI Configuration page that appears, set *DLCI I/F Name* to **dlci-100**, *DLCI* to **100**, *Encapsulation* to **RFC-1490**, *Committed Information Rate [kbps]* to **1536**, *Far-End IP Address (Static)* to **40.1.1.1**, *IP I/F Name* to **ipwan**, *IP Address* to **40.1.1.2**, *Subnet Mask* to **255.255.255.0**, check **Enable Inverse ARP** and click **OK**. 
21.	Select **Router → Routes** under CONFIGURE in the tree view. In the Configure > Router > Routes page that appears, click **Add** for Default Route.
22.	In the Configure > Router > Routing > Route Configuration page that appears, set *Name* to **default**, *Gateway IP Address* to **40.1.1.1**, select **ipwan** in the *Gateway Interface* list and click **OK**.
23.	Select **Interfaces → T1 Port 1** under CONFIGURE in the tree view. In the Configure > Interfaces > T1 Port 1 page that appears, select **Switch to Frame** in the Controls pull-down menu for T1 Port Name **t1-1**.
24.	In the "This will delete the PPP interface and the IP interface. Are you sure?" popup that appears, click **OK**.

Step	Description
25.	In the Configure > Interfaces > T1 Port 1 > Frame Relay Configuration page that appears, configure the frame relay settings needed to connect the T1 to the WAN and click **OK**. 
26.	Select **Firewall → Global Settings** under CONFIGURE in the tree view. In the Configure > Firewall > Global Settings page that appears, uncheck **Enable ACL Firewall**, uncheck **Enable Intrusion Detection** and click **OK**. **NOTE**: The firewall settings were disabled for the purposes of the test configuration and these Application Notes therefore document this step. However, it is not necessary to do so.
27.	Click **OK** at the 'Disabling the Firewall leaves the LAN and the Router unprotected.' popup that appears.
28.	Select **Router → NAT** under CONFIGURE in the tree view. In the Configure > Router > NAT page that appears, uncheck **NAT** and click **OK**. **NOTE**: The NAT settings were disabled for the purposes of the test configuration and these Application Notes therefore document this step. However, it is not necessary to do so.
29.	Click **OK** at the 'Changing the NAT configuration will terminate the session. Do you want to continue?' popup that appears.
30.	Select **QoS** under CONFIGURE in the tree view. In the Configure > QoS page that appears, click **QoS Summary**.
31.	In the Configure > QoS > QoS Config Summary page that appears, click **Policies** for the Interface **iplan [192.45.72.1]**.
32.	In the Configure > QoS > QoS Config Summary > QoS Policies page that appears, click **Add QoS Policy**.

Step	Description
33.	In the Configure > QoS > QoS Config Summary > QoS Policies > Add QoS Policy page that appears, set *Policy Name* to **MapDSCP34to46**, *Rank* to **1**, *Source Address* to **any**, *Destination Address* to **any**, *Application* to **any**, *DSCP Match Option* to **userEntered**, *DSCP Match Value* to **34**, *DSCP Marking Option* to **userEntered**, *DSCP Marking Value* to **46**, check **Enable Policy**, check **Enable DSCP Marking** and click **Create**. **NOTE**: The Q-Series routers keep traffic marked with DSCP 46 (EF) in its own priority queue. However, DSCP 34 (AF4) marked traffic is kept in a Weighted Fair Queue (WFQ) with all other DSCP values. High traffic scenarios negatively impact call-signaling traffic when it is kept in the WFQ. To ensure highest priority for both signaling and audio, a policy was created to map DSCP 34 to 46 at both the corporate and branch sites Q-Series routers. This ensures that signaling and audio packets are transmitted using the priority queue, instead of the WFQ. However, this is not required for most non-VoIP installations.
34.	In the Configure > QoS > QoS Config Summary > QoS Policies page that appears, the newly added policy is listed.
35.	Select **Router → DHCP** under CONFIGURE in the tree view. In the Configure > Router > DHCP page that appears, the message 'DHCP Operations Disabled' now appears for the DHCP Configuration. Select **Enable DHCP Relay** from the Configuration pull-down menu.  NOTE: DHCP was used to exercise DHCP relay on the Kentrox Q-Series router at the branch office.
36.	Click **OK** at the 'This will clear all DHCP configuration. Are you sure?' popup that appears.

Step	Description
37.	In the Configure > Router > DHCP page that appears, the message 'There are no remote servers configured for DHCP Relay' now appears for the DHCP Configuration. Select **Add Remote DHCP Server** from the Configuration pull-down menu. 
38.	In the Configure > Router > DHCP > Add Remote DHCP Server page that appears, set *Remote DHCP Server* to **192.45.70.38** and click **OK**. 
39.	Select **System → System Restart** under CONFIGURE in the tree view. In the Configure > System > System Restart page that appears, click **OK** to save the configuration and restart the Q2200.
40.	This change causes the connection to the browser to drop. Browse to 192.45.72.1 and log in again into the Q2200.
41.	Select **QoS → QoS Summary** under CONFIGURE in the tree view. In the Configure > QoS > QoS Config Summary page that appears, click **Interface** for the Interface **ipwan [40.1.1.2]**.

Step	Description
42.	In the Configure > QoS > QoS Config Summary > QoS Interface Configuration page that appears, the QoS configuration for the ipwan interface is listed. Modify the Bandwidth for the link and/or each DSCP value as necessary. **NOTE**: By default, the Q-Series routers perform traffic shaping on the traffic going through the WAN interface. DSCP 46 (EF) traffic is limited to 33% of the bandwidth. According to Kentrox, these default settings are optimal for the targeted small and/or low traffic configurations the products are intended for. The reader is advised to make the appropriate modifications for their own environment.

6. Interoperability Compliance Testing

Interoperability compliance testing covered feature functionality and performance testing. Feature functionality testing focused on the QoS and VLAN implementation in the Avaya/Kentrox configuration. Specifically, compliance testing verified that VoIP media and signaling traffic could be carried together with low priority data traffic on a low traffic serial T-1 link while still achieving good voice quality. Prioritization of voice traffic was achieved by implementing DiffServ-based QoS on a Frame Relay link. Voice and data traffic were segmented in the enterprise network using VLANs.

Performance testing was conducted by generating voice calls with a bulk call generator and data traffic with a data traffic generator to simulate a converged network for a prolonged period of time. The bulk call generator was also used to quantify the speech quality of the VoIP calls. At the end of the performance test, it was verified that the network devices continued to operate successfully for small office scenarios using low traffic serial T-1 links.

6.1. General Test Approach

All feature functionality test cases were performed manually. The general test approach entailed verifying the following:

- LAN/WAN connectivity between the Avaya and Kentrox products,
- Registration of Avaya IP Telephones with the Avaya IP Office,
- Verification of the DHCP relay configuration,
- VoIP calls between the corporate and the branch office sites using IP trunks between the sites,
- Inter-office calls using G.711 mu-law and G.729 codec sets, and conferencing, and
- Sending low priority data traffic over the WAN links and verifying that QoS directed the voice signaling and voice media to the higher priority egress queue based on the packets' DSCP value.

The performance tests were performed with a bulk call generator and data traffic generator running simultaneously. The most important verification step was checking voice quality while transmitting low priority data traffic for small office scenarios using low traffic serial T-1 links.

6.2. Test Results

All feature functionality and performance test cases passed. The Q-Series QoS implementation (including the signaling packet DSCP remarking) over the Frame Relay link yielded good voice quality. The stability of the Avaya/Kentrox solution was successfully verified through performance tests.

7. Verification Steps

This section provides the steps for verifying end-to-end network connectivity and QoS in the field from the perspective of the Q-Series routers. In general, the verification steps include:

1. Verify IP communication from the Q-Series router to the following network devices and interfaces by using the **ping** command.

    - Ping the Avaya IP Office.
    - Ping the Avaya IP telephones registered to the Avaya IP Office.
    - Ping the DHCP server.

2. Check that the Avaya IP Telephones have successfully registered using the IP Office **System Monitor**.

3. If a Q-Series router is unable to communicate with any of the aforementioned IP devices and interfaces, check the routing and status of the Ethernet and WAN interfaces through the Q-Series browser interface.

4. Place calls between the DCP and IP telephones at each site. If the call cannot be established, check the status of the IP trunks on the IP Offices using the IP Office **System Monitor**.

5. If the voice quality is poor, check the QoS configuration in the Q-Series routers.

8. Support

For technical support on the Kentrox Q-Series routers, contact Kentrox Technical Support using any of the following options:

- Toll-free: (800) 733-5511
- Direct: (503) 643-1681
- Email: care@kentrox.com

9. Conclusion

These Application Notes describe the configuration steps required for integrating the Kentrox Q-Series Q2400 and Q2200 routers into a small office and/or low traffic/bandwidth Avaya IP Office infrastructure. For the configuration described in these Application Notes, the Q-Series routers were responsible for enforcing QoS using DiffServ. The Avaya IP Offices delivered the voice traffic to the routers for transmission over the WAN together with data traffic. Good voice quality was successfully achieved in the Avaya/Kentrox configuration described herein.

10. Additional References

This section references the Avaya and Kentrox product documentation that are relevant to these Application Notes. The Avaya product documentation can be found at http://support.avaya.com and the Kentrox product documentation can be found at http://www.kentrox.com.

[1] Avaya IP Office 2.1 Manager, Issue 15c, May 2004.
[2] Kentrox QoS Access Router User's Guide, Software Release 1.3, Document #650-00319-03.

Please e-mail any questions or comments pertaining to these Application Notes along with the full title name and filename, located in the lower right corner, directly to the Avaya Developer*Connection* Program at devconnect@avaya.com.