Hytera

DMR Conventional Radio

IP Multi-site Connect

Application Notes

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Contents

Documentation Information

This section describes the conventions and revision history of this document.

Conventions

Icon

Icon	Description
Tip	Indicates information that can help you make better use of your product.
Note	Indicates references that can further describe the related topics.
Caution	Indicates situations that could cause data loss or equipment damage.
Warning	Indicates situations that could cause minor personal injury.
Danger	Indicates situations that could cause major personal injury or even death.

Notation

Notation	Description
Bold	The text in boldface denotes the name of a hardware button or a software interface element. For example, press the **PTT** key.
->	The symbol directs you to access a multi-level menu. For example, to select “New” from the “File” menu, we will describe it as follows: “File -> New”.

Revision History

Version	Release Date	Description
R6.0	August 2017	Added the Analog IP Multi-site Connect feature to RD98XS. Firmware version: R8.5.
R5.0	December 2015	Modified the corresponding descriptions of the Customer Programming Software (CPS) configuration because parameters were modified. Firmware version: R7.6.
R4.0	April 2015	Modified the corresponding descriptions of the Customer Programming Software (CPS) configuration because new parameters were added.

Version	Release Date	Description
		Added updated descriptions of the Super Master. Firmware version: R7.0.
R3.1	November 2012	Modified the bandwidth of IP Multi-site Connect network.
R3.0	September 2011	Added FAQ. Added descriptions for new parameters of the CPS.
R2.0	May 2011	Added FAQ. Modified the corresponding descriptions of the CPS configuration as new parameters were added.
R1.0	January 2011	Initial release.

1. Overview

1.1 Introduction

IP Multi-site Connect is a feature that allows repeaters in dispersed locations to be connected to exchange voices, data and control packets to each other over TCP/IP protocol, extending the communication network. If necessary, IP Multi-site Connect networks can be connected via the Sub Master feature, so as to further extend the communication coverage.

Both DMR conventional repeaters and PDT conventional repeaters can support the IP Multi-site Connect feature. In this document, we take DMR conventional repeaters for example in illustration.

1.2 Application

IP Multi-site Connect can bring users these typical benefits:

- To connect two or more conventional communication systems in different areas

  For example, this feature can be used to connect two repeaters over a large geographic area.

- To construct more effective communication with wider coverage

  For example, multiple repeaters can be deployed in a large building to ensure seamless communication. This can help fight the problems from unfavorable terrains.

- To broadcast a message to all connected repeaters

  For example, when an emergency occurs, the dispatcher can send a command to a repeater, and the other repeaters in the same IP multi-site network can also receive the command.

- To Connect repeaters working with different frequency bands

  For example, UHF repeaters can be connected to VHF repeaters so that data and voices can be exchanged among them.

- To use IP-based applications

  For example, when IP Multi-site Connect is enabled, users can use multiple IP-based software (such as Dispatcher) as well as API-based software developed by any third party to realize more features.

  Please consult the dealer for the details of the supported IP-based software and API-based software.

1.3 Definition

There are three categories of repeaters in the IP Multi-site Connect network:

- Master repeater: it is used to manage other repeaters in the same IP Multi-site Connect network. Only one Master repeater is allowed in an IP Multi-site Connect network.

- Slave repeater: it is connected to and registers with the Master repeater, thus forming an IP Multi-site Connect network with the Master repeater. Multiple Slave repeaters can be supported in an IP Multi-site Connect network.
- Sub Master: it is a repeater used to connect two or more IP Multi-site Connect networks. A Sub Master plays the role as both the Master repeater and the Slave repeater.

Currently, a single (small-scale) digital IP Multi-site Connect network can accommodate a maximum of 30 repeaters including a Master repeater and multiple Slave repeaters, while a single (small-scale) analog IP Multi-site Connect network only 15. The Master repeater is only allowed to communicate with its Slave repeaters within the same network rather than other repeaters in other IP Multi-site Connect networks, making it difficult to extend communication coverage of the IP Multi-site Connect network.

To solve the problem, the Sub Master is applied. To be specific, the Sub Master connects multiple small-scale IP Multi-site Connect networks to make a large-scale one, so as to extend the communication coverage. Moreover, the Sub Master can also connect large-scale IP Multi-site Connect networks.

The figure below briefly describes how the Sub Master works in the IP Multi-site Connect networks. As can be seen from the figure, IP Network 1 and IP Network 2 are both the small-scale IP Multi-site Connect networks, and IP Network 3 is the large-scale one. IP Network 1 consists of Master repeater A and Slave repeater 1 and 2; IP Network 2 consists of Master repeater B and Slave repeater 3 and 4. To extend the communication coverage of both IP Network 1 and 2, Master repeater A can be used as the Sub Master to connect Master repeater B, in order to combine IP Network 1 and 2 to form a large-scale IP Multi-site Connect Network (IP Network 3). Then, for IP Network 1, A will still work as the Master repeater; while for the large-scale IP Network 3, A will turn to be a Slave repeater managed by Master repeater B.

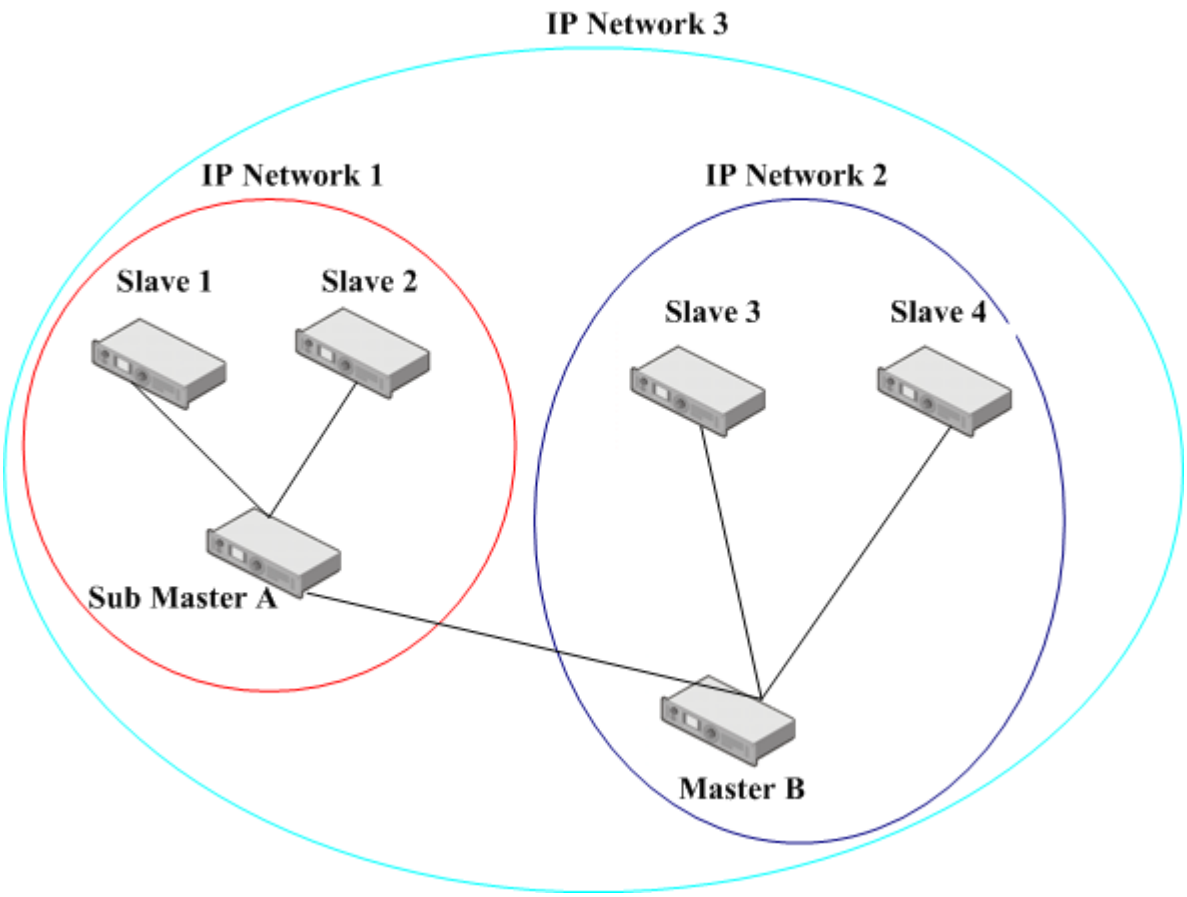


Figure 1-1 Sub Master Connection in IP Multi-site Connect Network

1.4 Principle

1.4.1 IP Multi-site Connect

IP Multi-site Connect is designed to extend the communication coverage by connecting multiple repeaters in dispersed locations over TCP/IP protocol.

In IP Multi-site Connect mode, DMR protocol is transported by TCP/IP protocol and a Hytera-owned protocol at Application layer. Accordingly, it is reasonable to conclude that this mode only changes the DMR transmission media without affecting the services of DMR radios/repeaters.

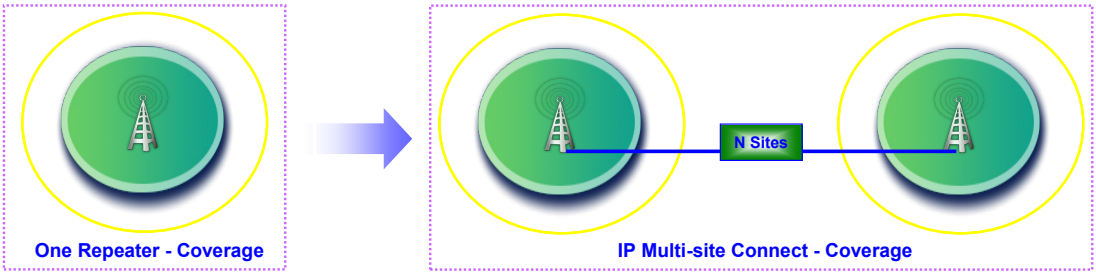


Figure 1-2 Wider Coverage in IP Multi-site Connect Mode

1.4.2 TCP/IP Model

The figure below describes how IP Multi-site Connect works in the TCP/IP model.

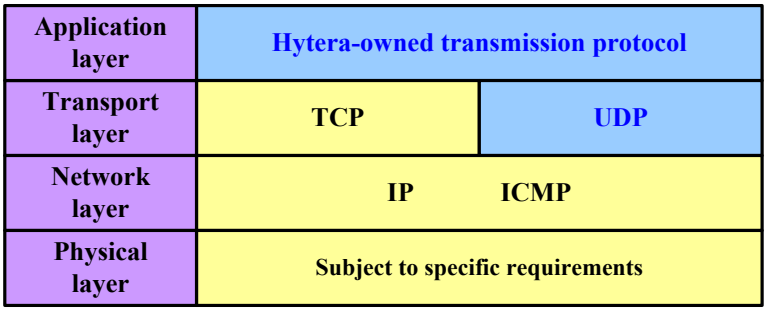


Figure 1-3 TCP/IP Model

- Physical layer: the lowest layer of TCP/IP.
- Network layer: also called IP layer. It is used to format data into IP datagrams, and perform routing of IP datagrams.
- Transport layer: to set up a session between the source host and the destination host. It consists of Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).
- Application layer: to combine and realize the function of Session Layer and Presentation Layer of the Open Systems Interconnection (OSI) model. It provides application-specific protocols.

As can be seen from the above figure, our IP Multi-site Connect feature uses UDP at Transport layer and self-owned transmission protocol at Application layer. At Network layer and Physical layer, different protocols and devices may apply depending on actual requirements.

1.4.3 Sub Master

The Sub Master feature is tailored for connecting multiple Master repeaters in the IP Multi-site Connect network, extending the communication coverage of IP Multi-site Connect network.

Compared to a single repeater, the IP Multi-site Connect network effectively extends the communication coverage, but it still has weakness. Currently, a single IP Multi-site Connect network can only accommodate a maximum of 30 repeaters, including a Master repeater and multiple Slave repeaters. As each IP Multi-site Connect network applies the monolayer structure, the Master repeater is only allowed to communicate with its Slave repeaters within the network rather than other repeaters in other IP Multi-site Connect networks. This greatly narrows the communication coverage of the IP Multi-site Connect network.

The Sub Master can address the above problem. When connected to a Master repeater that is in another IP Multi-site Connect network, the Sub Master will work as a Slave repeater for this Master repeater, so it can obtain the addresses of the other Slave repeaters connected to this Master repeater. By this means, the Sub Master enables the communication among its connected repeaters across the IP Multi-site Connect networks. Theoretically, via multiple Sub Masters, this IP Multi-site Connect network can accommodate an unlimited number of repeaters, thus unlimitedly extending its communication coverage.

1.5 Supported Digital Features

In IP Multi-site Connect mode, the following digital features are supported by the radios (including portable radios and mobile radios). For more details, see *Feature List*.

Voice Services	Control Services	Data Services	Emergency	Others
Private Call	PTT ID and Alias	Message	Emergency Alarm	Dual WACH (Slot 1 & Slot 2)
Private Call ACK	Radio Disable/ Enable	GPS	Alarm w/ Call	WACH and LACH
Group Call	Remote Monitor	ADK	Emergency call	Basic Encryption, Full Encryption, Random Key, Multiple Key Decryption, DMRA Encryption, Authentication, Authentication Key and Encryption Board.
All Call	Radio Check	Work Order	Emergency Revert Channel	Pseudo Trunking
All Call Talkback in Private mode	Alert Call	/	Lone Worker	Time-out Timer (TOT)
Computer Call	/	/	Man Down	Scan
/	/	/	/	One Touch Call

Table 1-1 Supported Digital Features of Radios in IP Multi-site Connect Network

1.6 Supported Analog Features

In IP Multi-site Connect mode, the following analog features are supported by the radio (including portable radios and mobile radios). For more details, see *Feature List*.

General	HDC 1200 Signaling	5-Tone Signaling	2-Tone Signaling
Monitor	PTT ID and PTT ID Display	PTT ID	Select Call
Scrambler	Private Call	Smart Call	Alert Call
Emp De-emp	Group Call	Private Call	Alert Call w/Voice

General	HDC 1200 Signaling	5-Tone Signaling	2-Tone Signaling
Flat Audio	All Call	Group Call	ACK
Receive Squelch (Carrier, CTCSS/CDCSS)	Emergency	ACK	/
Compandor	CTCSS Transmit	/	/
Emergency	Digital of Squelch (DOS)	/	/
TX/RX CTCSS/CDCSS Signaling	/	/	/
/	/	/	/

Table 1-2 Supported Analog Features of Radios in IP Multi-site Connect Network

1.7 Versions

- R8.5: Added the Analog IP Multi-site Connect feature to RD98XS.
- R7.5: Modified Super Master to Sub Master and some parameters' name.
- R4.5: Released the Super Master feature.
- R4.0: Released the IP Multi-site Access Management feature.
- R3.5: Improved the IP Multi-site Connect feature and released the Roaming feature and the application "Repeater Diagnostic and Control" (RDAC).
- R3.0: Released the IP Multi-site Connect feature.

For details, please refer to the corresponding *Release Notes*.

1.8 Restrictions

- RD98XS supports both the Digital IP Multi-site Connect and Analog IP Multi-site Connect features; while other repeaters only the Digital IP Multi-site Connect feature.
- As a paid feature, IP Multi-site Connect must be authorized to the user to come into use.
- The IP Multi-site Connect mode is subject to the repeater configuration.
- The IP Multi-site Connect mode is subject to the network type and the configuration of network devices.

2. References

- *CPS Help* (on-line)
- *Release Notes*

3. Requirements

3.1 Device Requirements

- Repeater: see Hytera device list for details. And consult your supplier for specific repeater models.
- Radio: see Hytera device list for details. And consult your supplier for specific radio models.
- Switch devices: Consult your supplier for details.
- Routing devices: such as Firewall, NAT, router (e.g. Cisco 1841), etc. Consult your supplier for details.
- Broadband wireless access devices: such as PTP, PMP, etc. Consult your supplier for details.
- Network cables
- Programming cables: choose the cables based on actual repeater type.

3.2 Network Requirements

- The IP network can be either a private network or an Internet provided by Internet Service Provider (ISP).

  A number of technologies, including dial-up, xDSL, cable modem, broadband wireless access, canopy, ISDN, satellite internet access, and so on can be used to access the IP network. Currently, the IP network is not applicable to dial-up connection due to narrow bandwidth or satellite internet access due to large delay.
- Sufficient bandwidth is required for IP Multi-site Connect system. For details, see 6.7 How to calculate the required bandwidth?.
- In IP Multi-site Connect system, the Master repeater must have a static IP address. Alternatively, it can use a domain name to reduce the use cost in the Wide Area Network (WAN). The Slave repeater can connect to Master repeater via IP address or domain name.

  If the Master repeater uses the domain name, it is required to specify the domain name of Master repeater when the user programs the Slave repeater via CPS. The domain name can be used by both the Sub Master and the Master repeater, if there is any Sub Master in the IP Multi-site Connect system.
- Either static IP address or dynamic IP address can be configured for Slave repeater through CPS.

  But it is not recommended to use the dynamic IP address. The reason is that the IP address allocated by the DHCP server can be used within the preset time. Once the time expires, DHCP server will assign a new IP address. Accordingly, communication between Slave repeater and Master repeater will be interrupted temporarily.
- The repeater can be located behind the firewall, router or NAT. However, each router can connect to one repeater only, and static mapping must be created between Master repeater and router. If Slave repeater cannot connect to Master repeater, be sure to create a static mapping between Slave repeater and router.

- The proxy server cannot be used to access the WAN in the IP Multi-site Connect system.

4. Network Architecture

4.1 Four Basic Schemes

4.1.1 Heavy Overlapping Coverage

This scheme is designed for communication services in the big city and densely populated area. It involves multiple sites and heavy overlapping coverage is present. In the overlapping areas, different frequencies are used; while in the non-overlapping areas, the same frequency is employed but different color codes are required for roaming service. In this scenario, a user may be in the coverage involving three to four sites at the same time, and it takes about 10 minutes to move from one site to another.

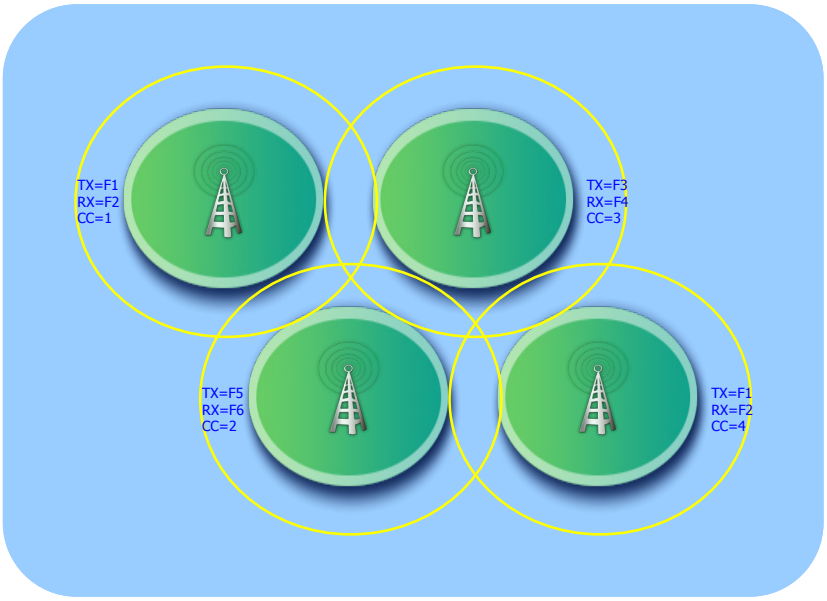


Figure 4-1 Heavy Overlapping Coverage

4.1.2 Non-overlapping Coverage

This scheme is designed for communication services in the countryside or a small city. It involves multiple separate sites and no overlapping coverage is present. In the non-overlapping areas, the same frequency is used while different color codes are required for roaming service. In this scenario, a user may be in the coverage of only one site at a time, and it takes about several hours to move from one site to another.

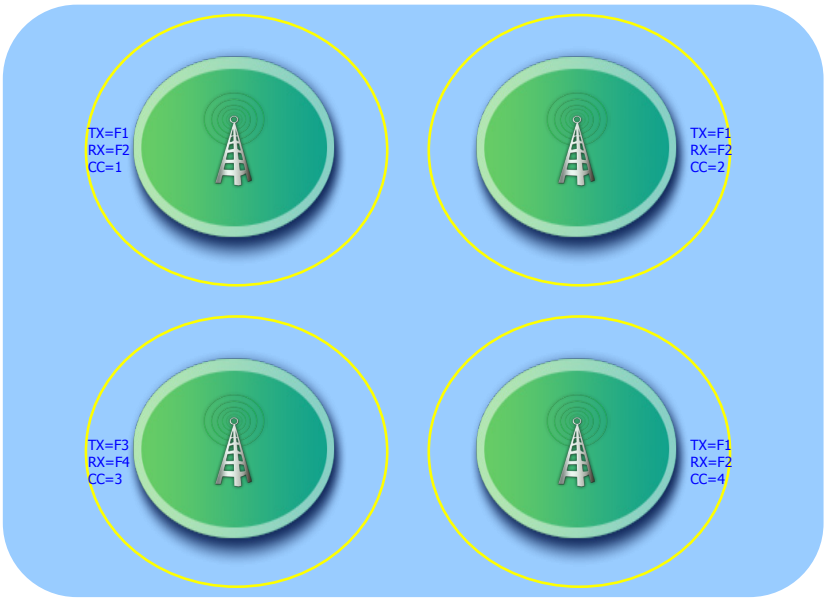


Figure 4-2 Non-overlapping Coverage

4.1.3 Minimal Overlapping Coverage

This scheme is designed for communication services along the road, railway, river or coastline. It involves multiple sites and minimal overlapping coverage. The overlapped areas share a single frequency, but different color codes are required for roaming service. In this scenario, a user can enjoy the coverage involving one or two sites at the same time, and it takes about an hour to move from one site to another.

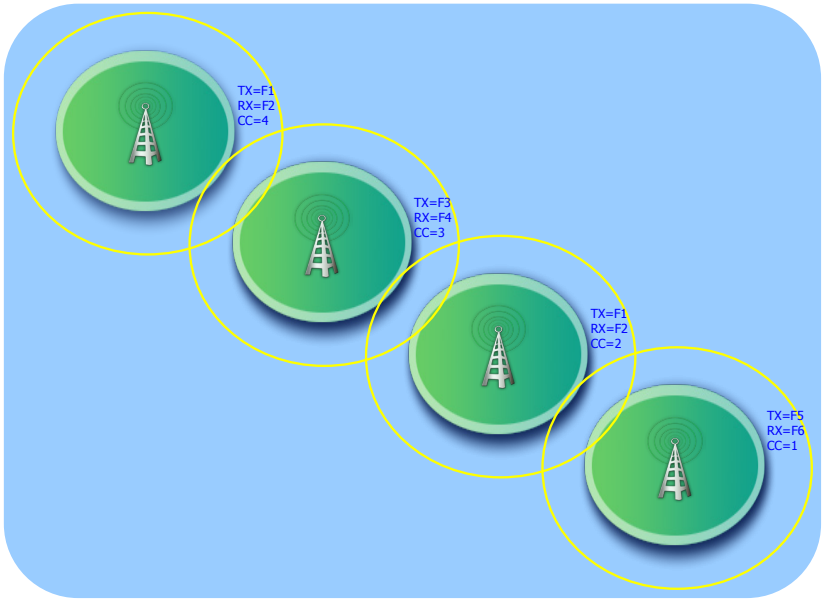


Figure 4-2 Minimal Overlapping Coverage

4.1.4 Multi-layer Overlapping Coverage

This scheme is designed for communication services in a high-rise building or a deep well. It involves multiple sites standing close from each other and multi-layer overlapping coverage. Since the coverage of each site is limited due to adverse geology conditions, frequency reuse is seldom available, and quick signal attenuation

occurs frequently. In this scenario, a user can enjoy the coverage from one or two sites at the same time, and it takes about a minute to move from one site to another.

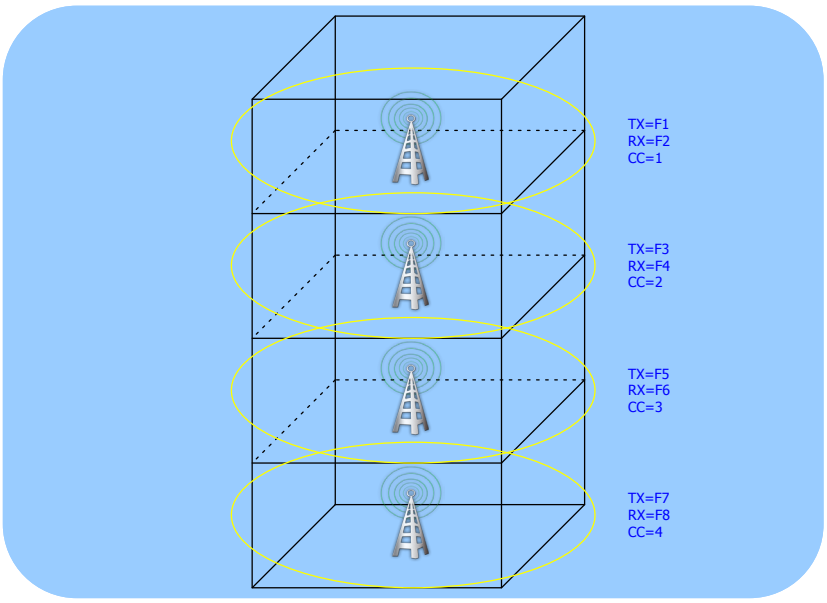


Figure 4-3 Multi-layer Overlapping Coverage

4.2 Network Topology of IP Multi-site Connect

The network topology of IP Multi-site Connect can operate with many networks or connect all wide area channels (WAC) via a physical network, depending on the repeater location and the network connection. Typically, there are two kinds of network topologies:

- Local area network (LAN)
- Wide area network (WAN)

In most cases, LAN and WAN together constitute the network topology. The following sections describe how to configure LAN and WAN respectively.

4.2.1 Local Area Network (LAN)

In IP Multi-site Connect mode, these networks are supported:

- Dedicated LAN
- A company's LAN
- Dedicated radio communication system

Despite variable LAN configurations, the IP Multi-site Connect system can work properly once all devices are in the same LAN. In order for the system to operate at its best, however, the technicians must have a good knowledge of bandwidth required on each device in this system.

The following figure shows an example of IP Multi-site Connect operating with LAN.

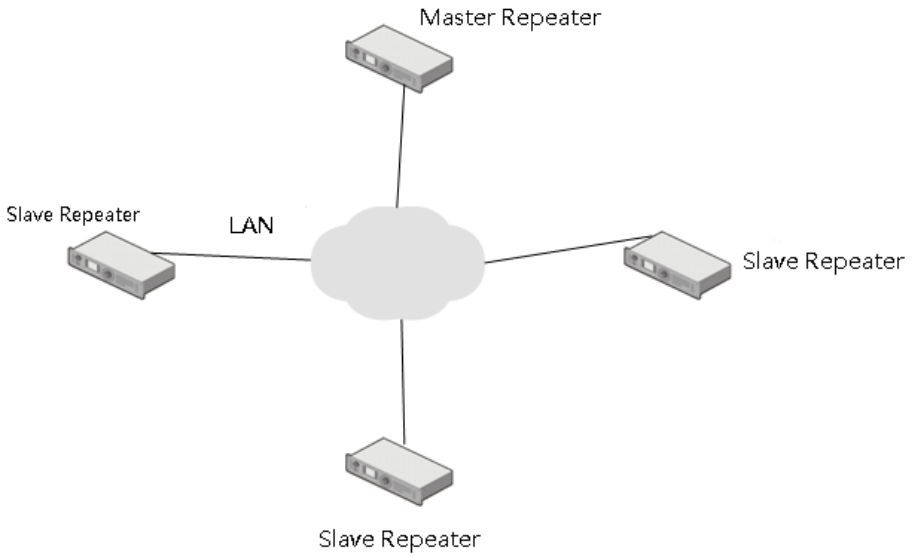


Figure 4-4 IP Multi-site Connect Network Operating with LAN

4.2.2 Wide Area Network (WAN)

The biggest advantage of IP Multi-site Connect lies in that it can connect dispersed sites quickly through the Internet provided by an ISP.

In order for the system to operate at its best, the technicians must have a good knowledge of bandwidth and time delay required for each device in the system. Also, they must consider the bandwidth and time delay between sites, especially between distant sites. The unacceptable time delay occurs in the event of using satellite access across continents, whereas this problem will be avoided with the optical fiber.

It is necessary to note that the bandwidth must be greater than or equal to the total bandwidth required for all network devices connected to the router. A repeater's communication request will be sent to all other repeaters in the same system. Suppose that the number of repeaters is N and the size of the data sent by Repeater A to each repeater in the system is S, thus the total data transmitted by Repeater A at a time is calculated by the formula: (N-1)*S. From this point of view, the total bandwidth required for a site depends on the number of repeaters in the IP Multi-site Connect system. Correspondingly, each newly added repeater will lead to the increase of the total bandwidth required for all sites.

Most routers have a useful function -- secure Virtual Private Network (VPN). The VPN will not pose a burden on the bandwidth but may result in time delay.

Additionally, it is required to configure the router, NAT or firewall connected to Master repeater. The routers must support “HairPinning”, a function that sends the source address a message indicating how to reach the destination.

The following figure shows an example of IP Multi-site Connect operating with WAN.

Note that the network devices may belong to different WANs.

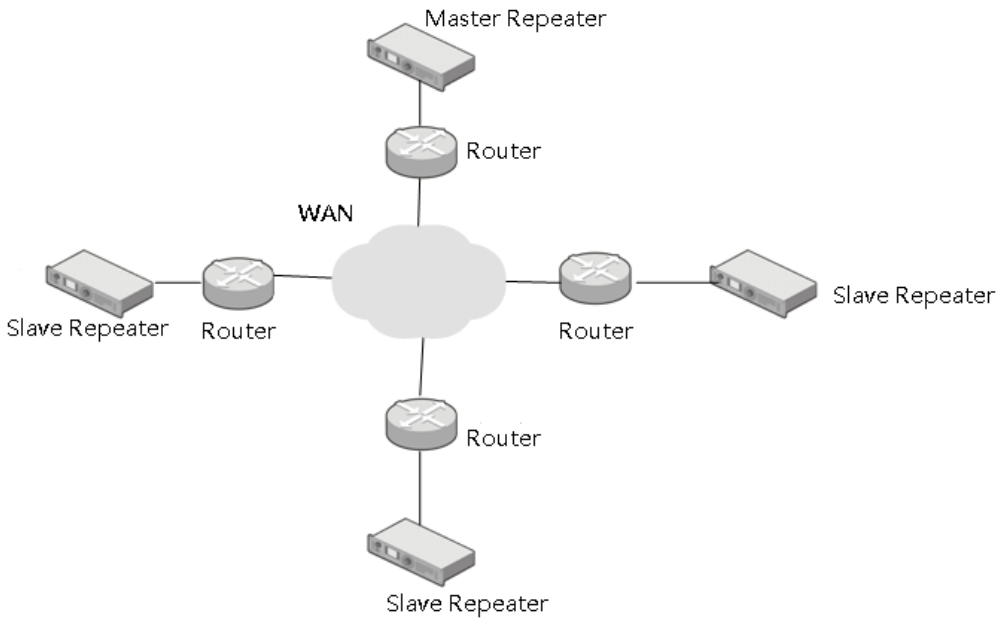


Figure 4-5 IP Multi-site Connect Network Operating with WAN

4.3 Sub Master

A Sub Master can act as a Master repeater and slave repeater. It is capable of forwarding the communication request from the current IP Multi-site Connect network to other network(s), and receiving the request from other network(s), in order to realize inter-system communication. With the Sub Master feature, multiple communication networks will be interconnected together to extend the communication coverage of IP Multi-site Connect system.

4.3.1 Double-layer Network Architecture

In the double-layer network, there is only one Master repeater available, which connects to two Sub Masters and two Slave repeaters. Any Master repeater can communicate with other Master repeaters. Due to the limited capacity of Master repeater, in a digital IP Multi-site Connect network, each Master repeater can connect at most 30 repeaters point to point, while each communication subnet can contain up to 30 repeaters, while in an analog IP Multi-site Connect network, only 15.

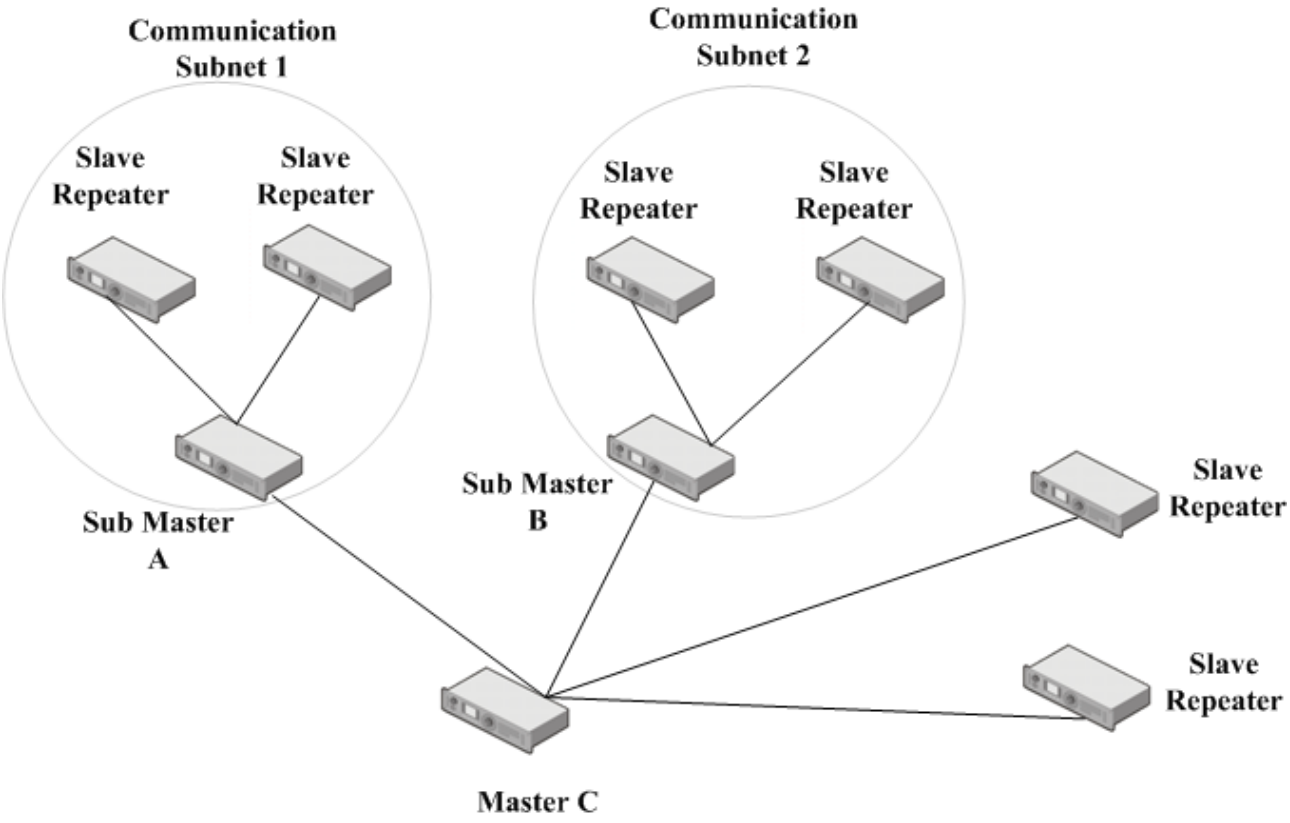


Figure 4-6 Double-layer Network Architecture

From the above figure, Sub Master A works as the Master repeater for Slave repeater 1 and Slave repeater 2 in the communication subnet 1, and as the Slave repeater for Master repeater C. Sub Master A can directly communicate with Master repeater C.

- In a digital IP Multi-site Connect network, one Master repeater can directly connect to the Slave repeaters and Sub Master whose quantity cannot exceed 30. As a result, the entire network can accommodate 225 (15 x 15) repeaters at most.
- In an analog IP Multi-site Connect network, one Master repeater can directly connect to the Slave repeaters and Sub Master whose quantity cannot exceed 15. As a result, the entire network can accommodate 49 (7 x 7) repeaters at most.

4.3.2 Multi-layer Network Architecture

In this network, repeaters can be interconnected via IP Multi-site Connect system, and some repeaters are set as Sub Master to realize inter-system communication.

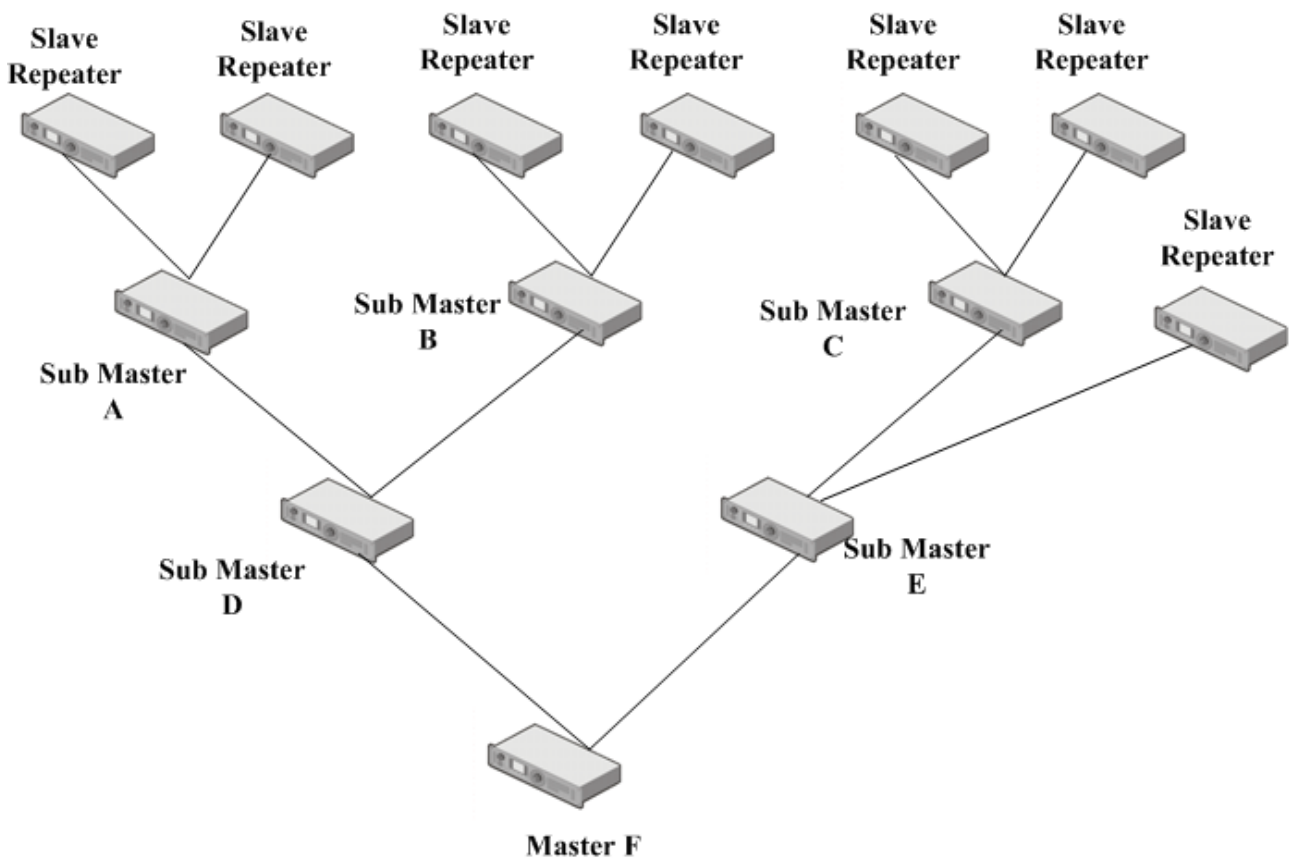


Figure 4-7 Multi-layer Network Architecture

As shown in the above figure, Repeater A acts as a Sub Master. It works as the Master repeater to its connected Slave repeaters on the one hand, and works as a Slave repeater managed by Master repeater D on the other hand. Likewise, Master repeater D acts as a Sub Master on the one hand, and works as a Slave repeater of Master repeater F on the other hand. Intercommunication can be realized between the IP Multi-site Connect system involving Master repeater D and that network involving Master repeater A.

Also, Master repeater D can connect to Master repeater F. If Master repeater D needs to communicate with Master repeater F and its slave repeaters, it is required to set Sub Master parameters on Master repeater D. In this case, Master repeater D becomes a Sub Master, and can communicate with other repeaters in the IP Multi-site Connect system involving Master repeater F. Accordingly, the communication coverage can be extended successfully.

4.4 Broadband Wireless Access

IP Multi-site Connect provides a number of schemes for broadband wireless access to meet varied needs.

The typical schemes are illustrated as below. You can contact your dealer for more information on how to use broadband wireless access devices (PTP, PMP SM, PMP AP, etc).

4.4.1 Point-to-Point (PTP) Connection via Ethernet Cable

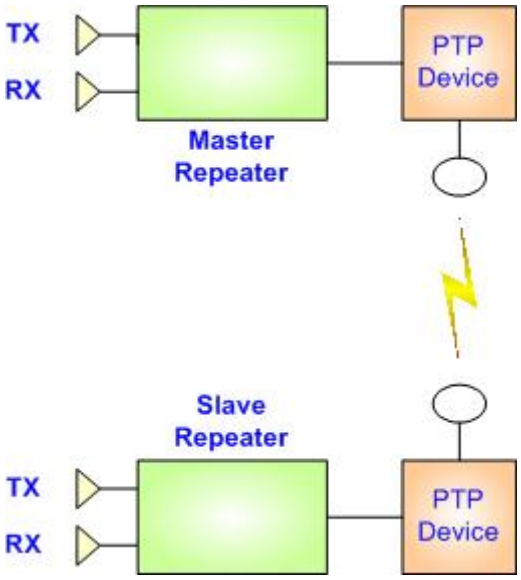


Figure 4-8 Point-to-Point (PTP) Connection via Ethernet Cable

4.4.2 Point-to-Point (PTP) and Local Area Network (LAN)

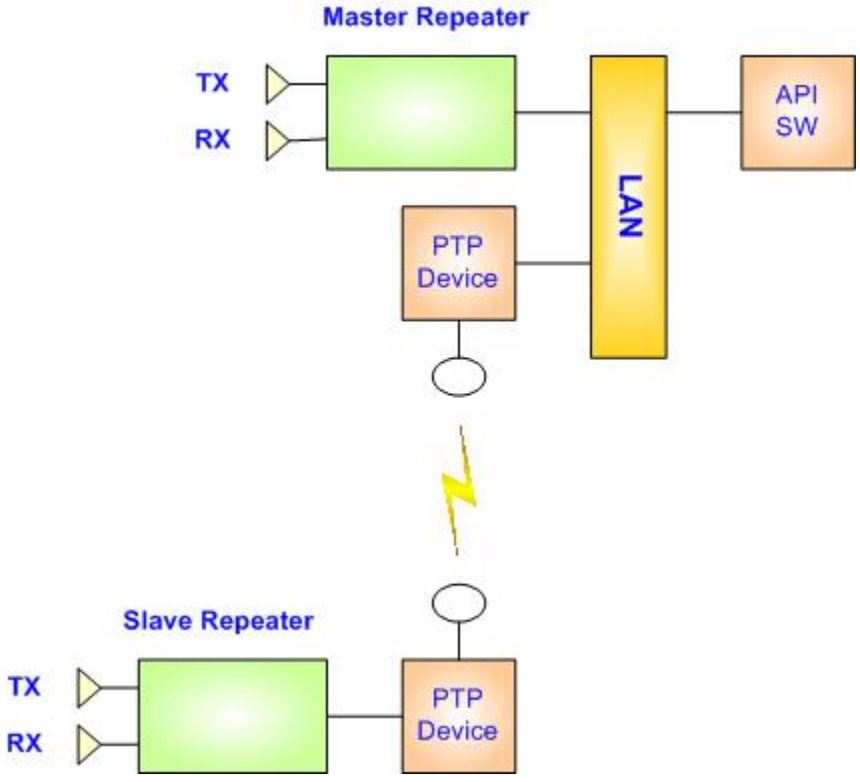


Figure 4-9 Point-to-Point (PTP) and Local Area Network (LAN)

4.4.3 Point-to-Point (PTP) Cluster and Local Area Network (LAN)

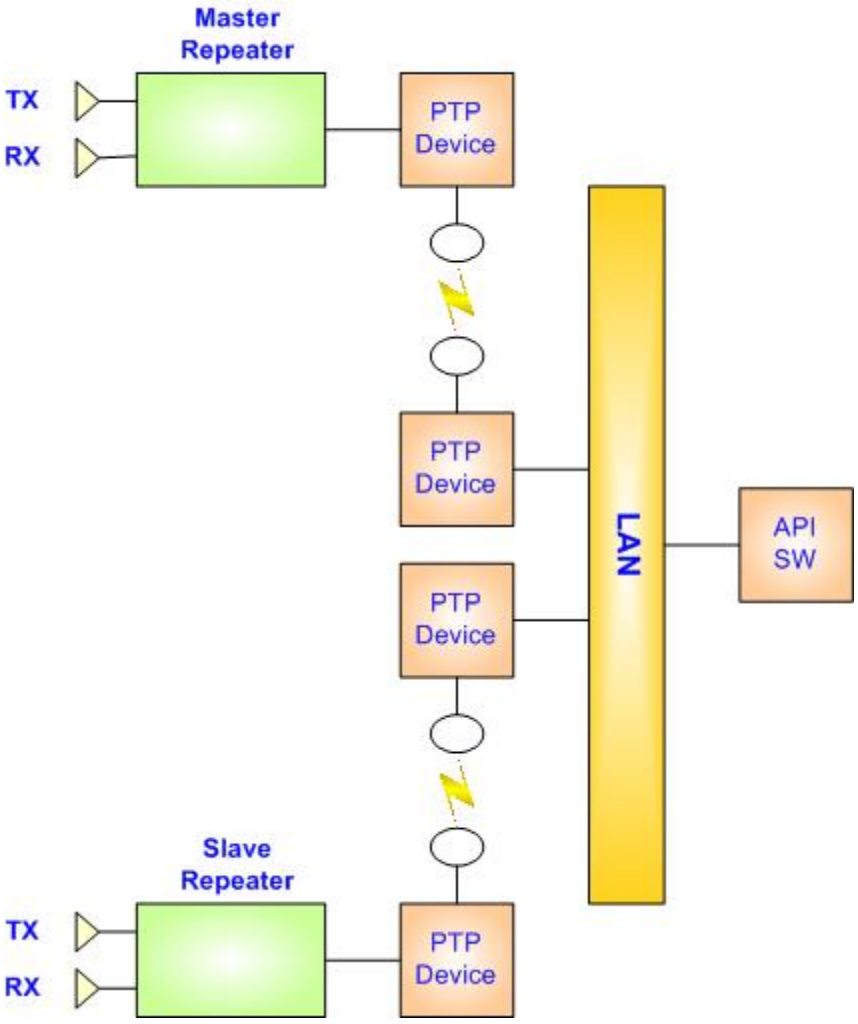


Figure 4-10 Point-to-Point (PTP) Cluster and Local Area Network (LAN)

4.4.4 Point-to-Point (PTP) and Wide Area Network (WAN)

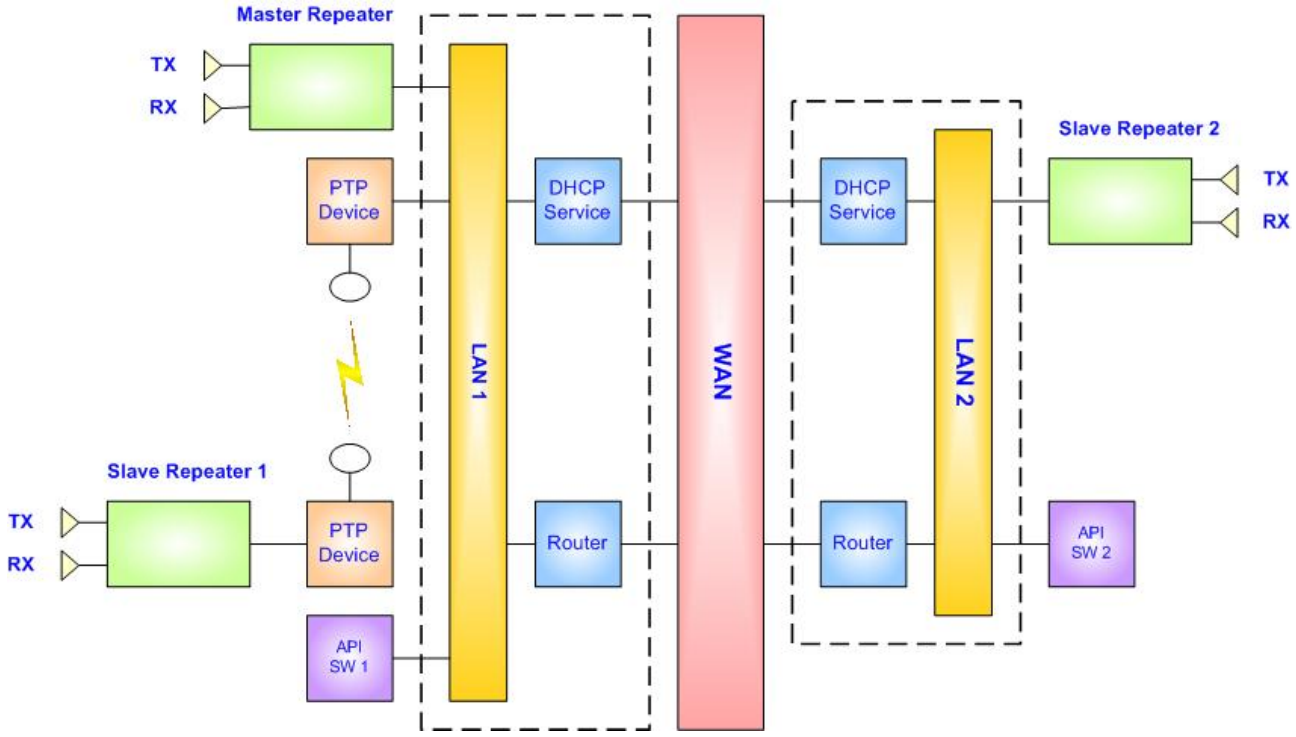


Figure 4-11 Point-to-Point (PTP) and Wide Area Network (WAN)

4.4.5 Point-to-Multipoint (PMP) and Wide Area Network (WAN)

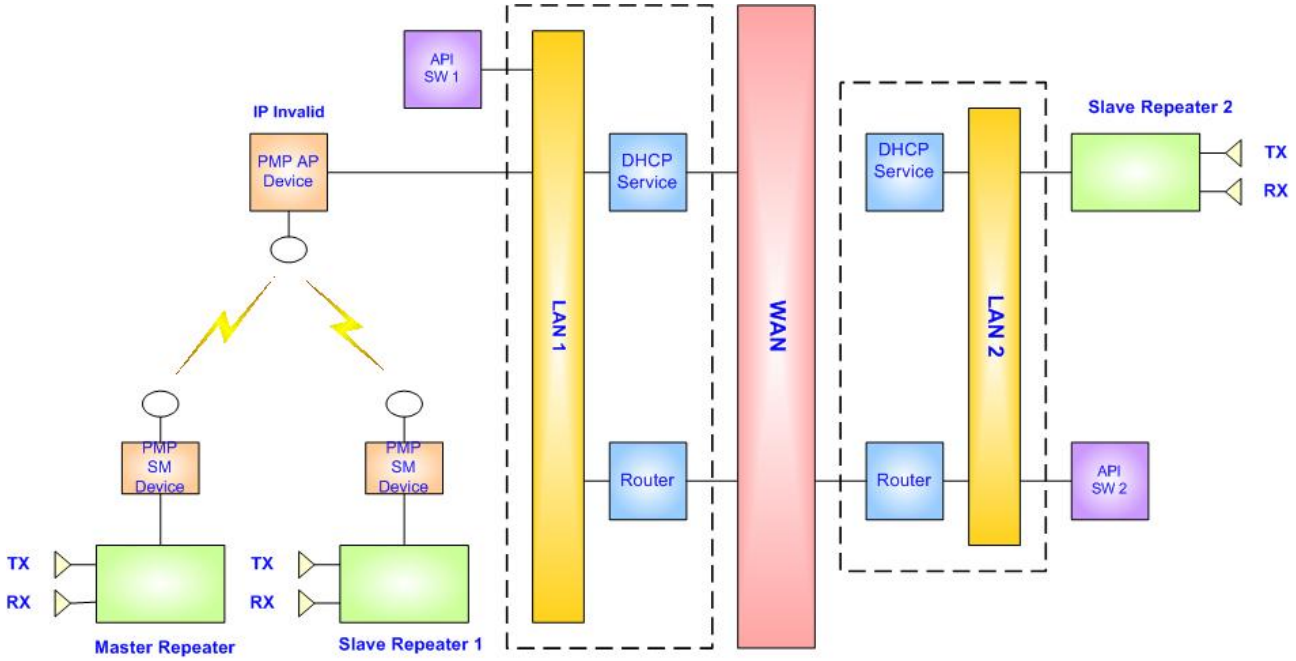


Figure 4-12 Point-to-Multipoint (PMP) and Wide Area Network (WAN)

4.4.6 Point-to-Multipoint (PMP) Cluster and Local Area Network (LAN)

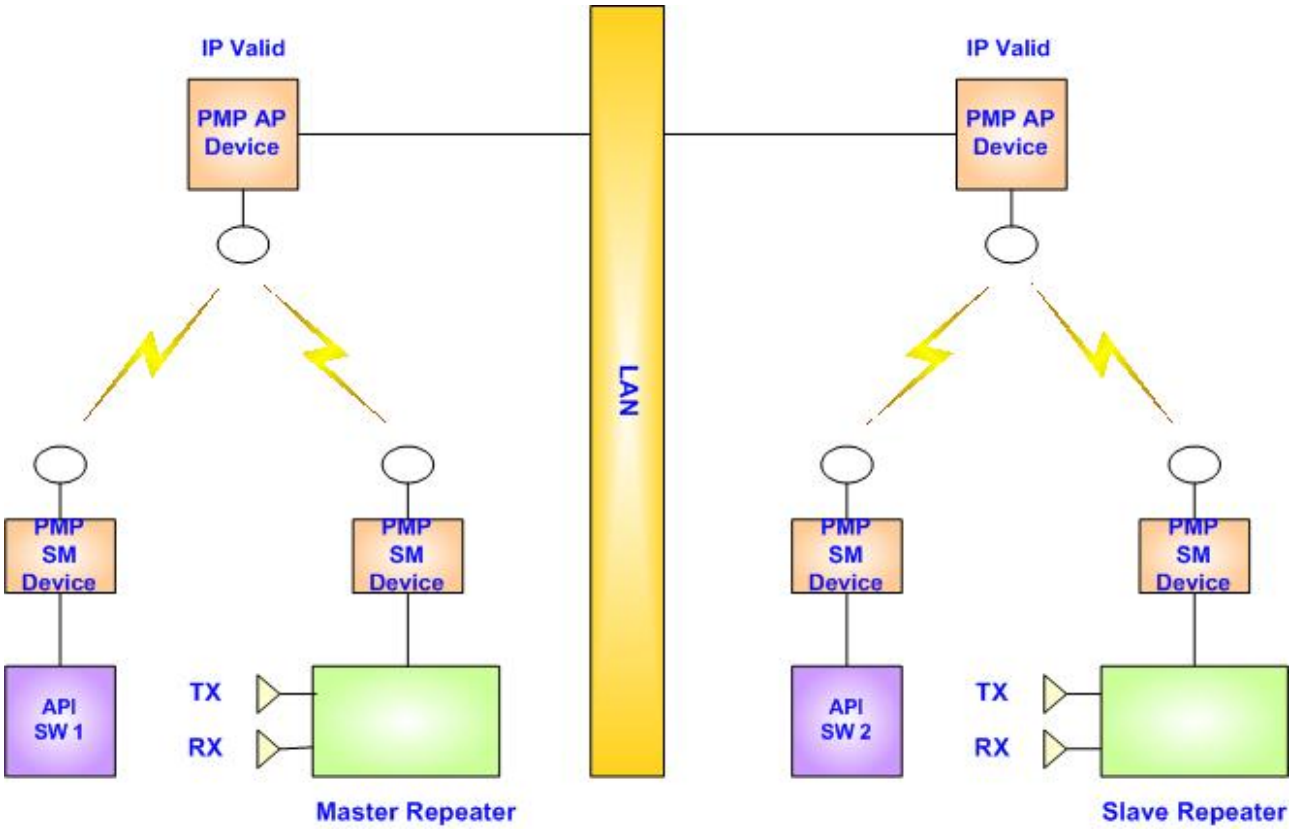


Figure 4-13 Point-to-Multipoint (PMP) Cluster and Local Area Network (LAN)

4.4.7 Point-to-Multipoint (PMP) Cluster and Wide Area Network (WAN)

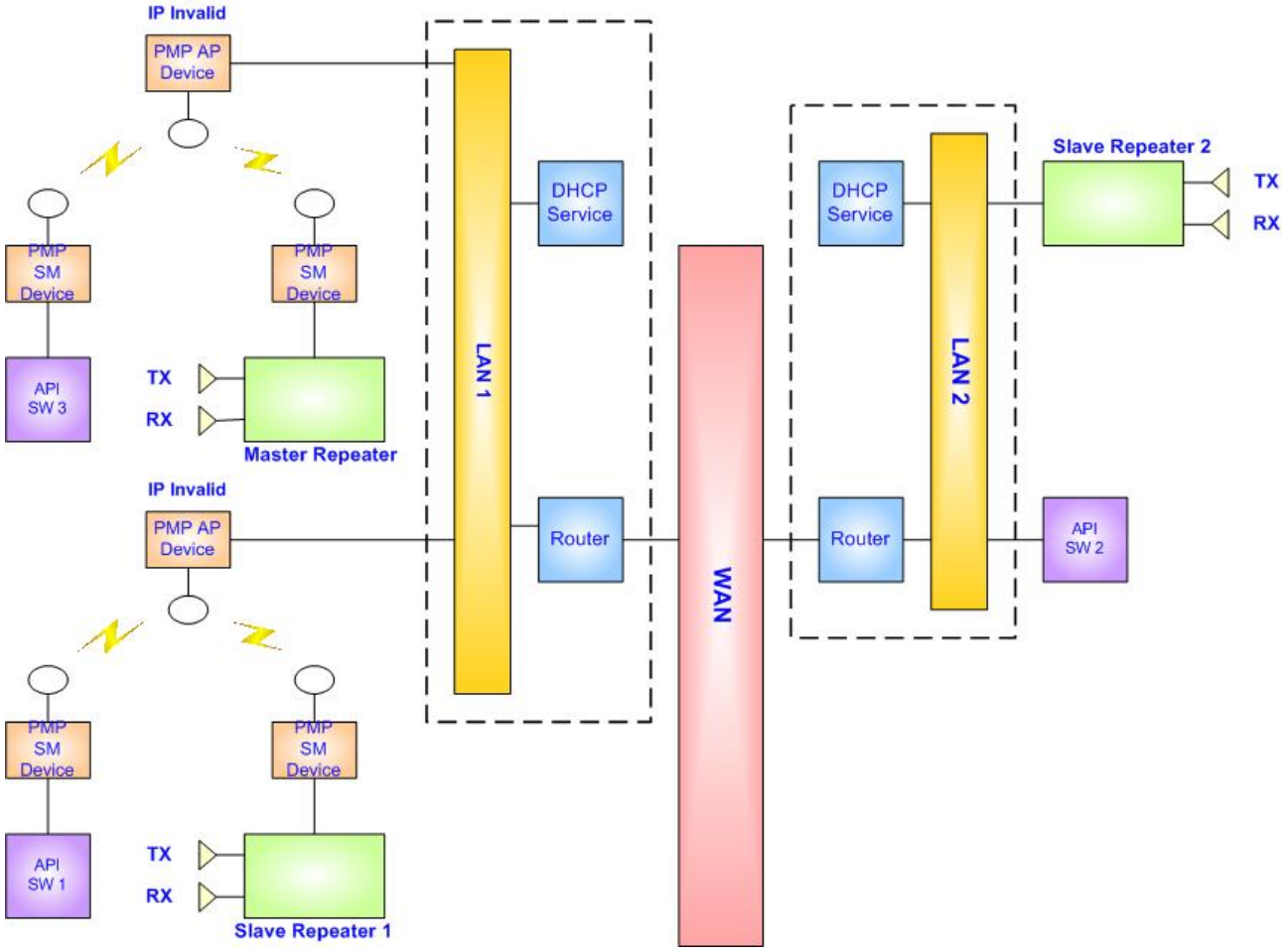


Figure 4-14 Point-to- Multipoint (PMP) Cluster and Wide Area Network (WAN)

5. Equipment Connection and Configuration

The radios mentioned in this chapter include portable radios and mobile radios.

5.1 Configuration Tools

The appropriate IP Multi-site Connect configuration scheme shall be chosen according to the network topology and the actual application. To make an IP Multi-site Connect scheme operating with WAN and LAN, the involved parameters generally include:

- Radio parameters (configured via CPS)
- Repeater parameters (configured via CPS)
- Switch/Router parameters (configured via switch/routing devices)

  Switch/Routing devices include switch, firewall, NAT, router and etc. You can contact the device provider for their specific configurations.
- Broadband wireless access parameters (configured via broadband wireless access devices)

  Broadband wireless access devices include Canopy and etc. You can contact the device provider for their specific configurations.

5.2 Ethernet Cable

The simplest IP Multi-site Connect network can be established by connecting two repeaters back to back via an Ethernet cable directly. Generally, this network is used for radios to communicate across two bands or for demonstrating the work principles of IP Multi-site connect.

5.2.1 Connecting the Hardware

An Ethernet cable is required to connect two repeaters in this scheme. The disadvantage of the scheme lies in poor expandability.

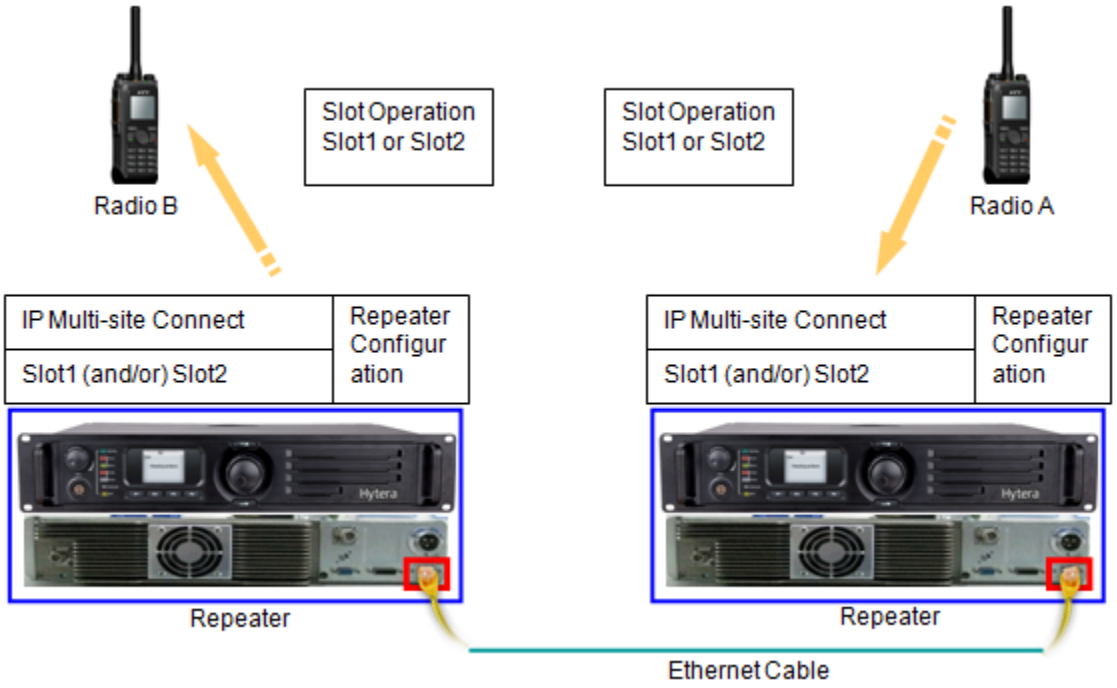


Figure 5-1 Ethernet Cable Connection

5.2.2 Configuring a Radio

As a radio works the same way in both IP Multi-site Connect mode and single repeater mode, user can refer to the parameter settings in the single repeater mode to configure it.

To configure a radio, do as follows:

- Configure the parameters applicable to the radio in the single repeater mode.
- Do define the “Slot Operation” option; otherwise, the radio only operates in DM mode. The options “Slot 1” and “Slot 2” must be set according to the IP Multi-site Connect parameter of the repeater; otherwise, the communication result will vary. See below:

Slot Operation of Radio	Slot Operation of Repeater for IP Multi-site Connect	Result
Slot 1	Slot 2	The radio only operates in single repeater mode rather than in IP Multi-site Connect mode.
Slot 1 or Slot 2	None	
Slot 1	Slot 1 or Slot1 & Slot2	The radio can operate in IP Multi-site Connect mode.

Table 5-1 Slot in IP Multi-site Connect Mode

- The “Color Code” of the radio must be consistent with that of the current repeater. Otherwise, the radio cannot work in the network.

  CPS Path: Conventional -> Channel -> Digital Channel -> CH DX

Parameters: Color Code and Slot Operation. Refer to *CPS Help* for parameter description.

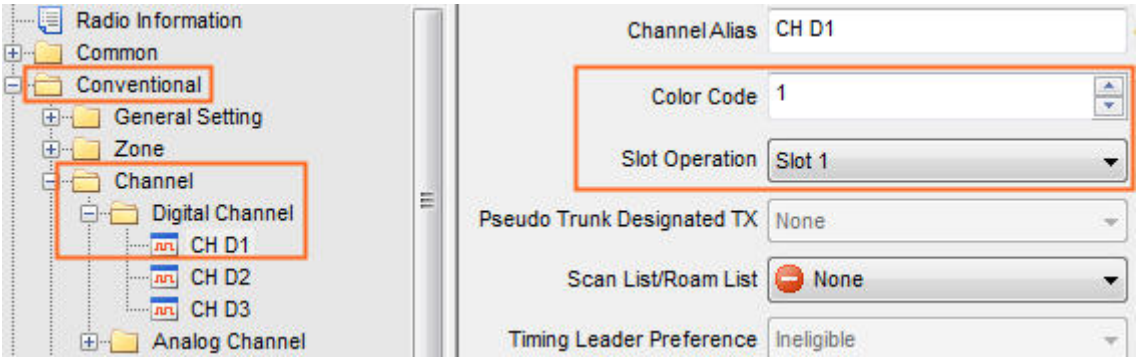


Figure 5-2 “Color Code” and “Slot Operation” Configuration

5.2.3 Configuring a Repeater

Configuring a Master Repeater

Step 1 Configure the Master repeater parameters such as frequency and color code via CPS.

Step 2 Configure the IP Multi-site Connect parameters.

CPS Path: Conventional -> General Setting -> Network

Parameters: See orange boxes in Figure 5-3. For parameters description, see Table 5-2.

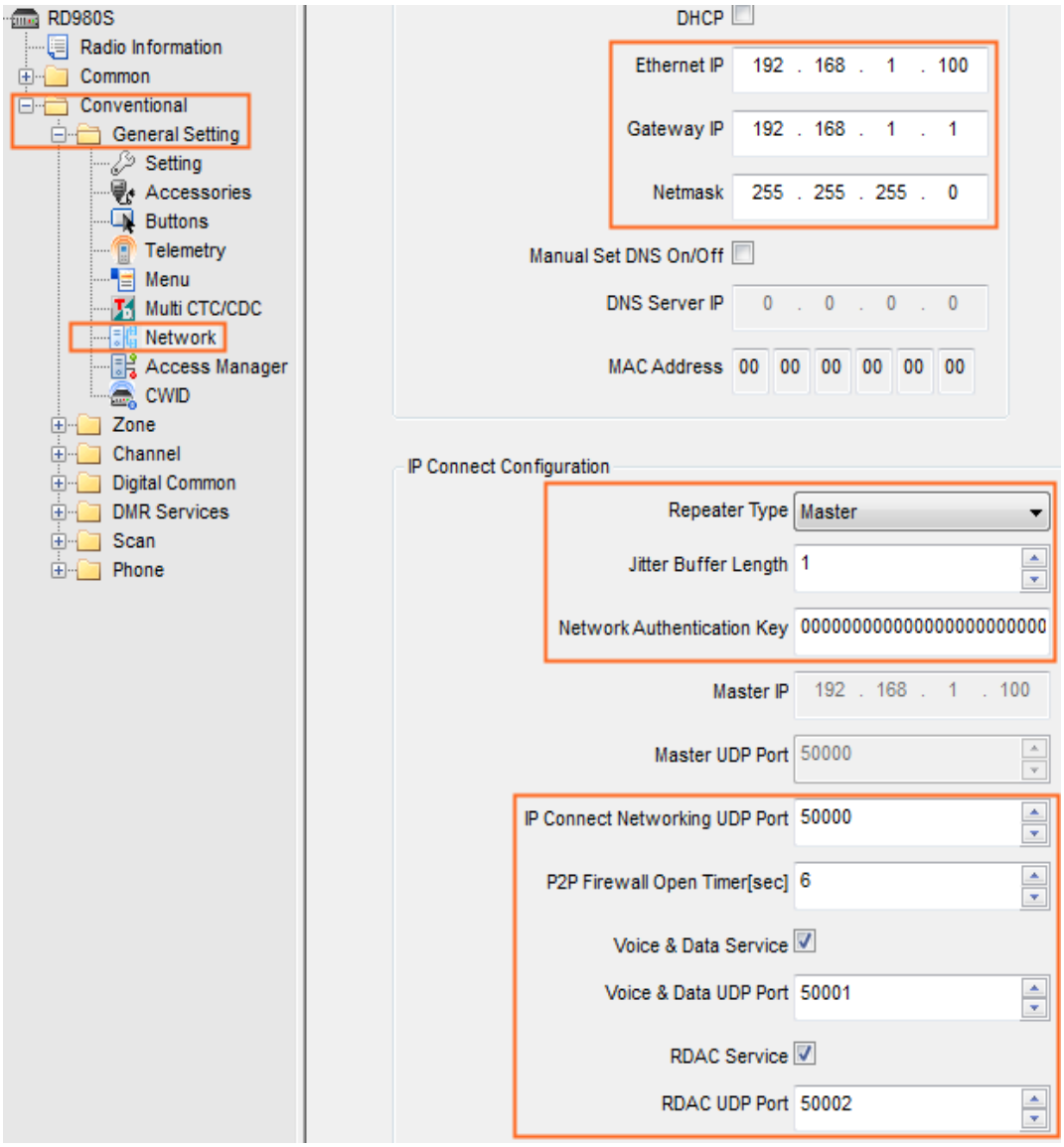


Figure 5-3 IP Multi-site Connect Parameter Configuration for Master Repeater

Parameter	Description
Related IP Network Parameters	
DHCP	Unchecked. As the Master repeater needs to use a fixed IP address for Slave repeater registration, DHCP is not applicable for Master repeater IP configuration.
Ethernet IP	The IP address of the repeater. When this scheme is employed, the Master repeater must use static IP address; otherwise, the Slave repeater will not be able to connect to the Master repeater. The static IP address of the Master repeater must be unique in the network.

Parameter	Description
Gateway IP	The gateway IP address of the subnet in which the repeater operates.
Netmask	The netmask of the subnet in which the repeater operates.
Master Repeater Parameters	
Repeater Type	For Master and Sub Master repeaters, this parameter shall be set to "Master"; for Slave repeater, this parameter shall be set to "Slave".
Jitter Buffer Length	The length of buffer area for the repeater to process the received voice and data in the IP network. When the network connectivity is poor, that is to say the network jittering is severe, the buffer length can be increased to improve the communication continuity. The voice and data receiving time will be extended by 60ms when the buffer length is increased by 1. Keep its default value unchanged. This parameter shall be modified by technicians only.
Master IP	The IP Address of the master in the IP network.
Master UDP Port	User Datagram Protocol (UDP) port number of the master in the IP network. UDP is a protocol used for peer-to-peer services within the IP network.
Network Authentication Key	The authentication key for accessing IP network. It is used to prevent unauthorized repeaters of other IP network in the same LAN from accessing the Master repeater's IP network. All repeaters within the same IP Multi-site Connect network must use this authentication key for authentication.
IP Connect Networking UDP Port	This port is used to establish and maintain the network connection between Master repeater and Slave repeaters. Keep its default value unchanged.
P2P Firewall Open Timer[sec]	Time interval for sending a "Keep Alive" message. After the router has assigned the public network IP address and port for the specific repeater, the router will automatically recover the public network IP address and port which have not been used for a

Parameter	Description
	long time. Therefore, all repeaters and RDAC must send a “Keep Alive” message at a regular interval. This interval must be smaller than the time period during which the router can keep the connection alive. Keep its default value unchanged.
Voice & Data Service	This parameter shall be checked for the radio to perform the DMR voice and data services.
Voice & Data UDP Port	This parameter is used to set the port which is used to perform the DMR voice and data services. Keep its default value unchanged.
Remote RDAC	This parameter shall be checked for the users to diagnose and control the repeater via RDAC software remotely.
Remote RDAC UDP Port	This parameter is used to set the port which is used to connect the repeater to RDAC software. Keep its default value unchanged.

Table 5-2 IP Multi-site Connect Parameter of Master Repeater

Caution

The Gateway IP must be unique, and its last digit should NOT be set to ‘0’

Step 3 Configure the repeating priority of the voice services and data services as per actual requirement.

CPS Path: Conventional -> General Setting -> Accessories -> Priority Control.

Parameters: Repeat Request Priority. For parameters description, see Table 5-3.

Figure 5-4 Repeating Priority

Priority	Description	Application Scenario
Local Repeating	The repeater will process the local repeating request first when the repeater receives local repeating request and IP Multi-site Connect repeating request at the same time.	When the local communications have larger amount and higher priority than the cross-network communications, user can set the “Repeat Request Priority” to “Local Repeating” to ensure that

Priority	Description	Application Scenario
		the local repeating requests can be processed promptly.
IP Connect Repeating	The repeater will process the IP Multi-site Connect repeating request first when the repeater receives local repeating request and IP Multi-site Connect repeating request at the same time.	When the local communications have smaller amount and lower priority than the cross-network communications, user can set the "Repeat Request Priority" to "IP Connect Repeating" to ensure that the IP Multi-site Connect repeating requests can be processed promptly.
First Come First Send	The repeater will process the repeating requests according to the receiving order when the repeater receives local repeating request and IP multi-site connect repeating request at the same time.	When the local communications have similar amount and same priority as the cross-network communications, user can set the "Repeat Request Priority" to "First Come First Send".

Table 5-3 Repeating Priority Description

Step 4 Select the operation slot for accessing the IP Multi-site Connect network.

CPS Path: Conventional -> General Setting -> Digital Channel -> CH DX.

Parameters: Digital IP Multi-site Connect. Refer to *CPS Help* for parameter description.

Figure 5-5 Digital IP Multi-site Connect

Note

To ensure the smooth cross-network communication, all repeaters in the same IP Multi-site Connect network must use the same IP Multi-site Connect slot.

Step 5 Enable the Analog IP Multi-site Connect feature.

Only RD98XS supports the Analog IP Multi-site Connect feature. With it enabled, the repeater forwards services on analog channel over the IP multi-site network to expand the communication coverage.

CPS Path: Conventional -> Channel -> Analog Channel -> CH AX

Parameters: Analog IP Multi-site Connect. Refer to *CPS Help* for parameter description.

Figure 5-6 Analog IP Multi-site Connect

Step 6 Enable the IP Multi-site Connect features on mixed channel.

CPS Path: Conventional -> Channel -> Mixed Channel -> CH MX

Parameters: Digital IP Multi-site Connect and Analog IP Multi-site Connect. Refer to *CPS Help* for parameter description.

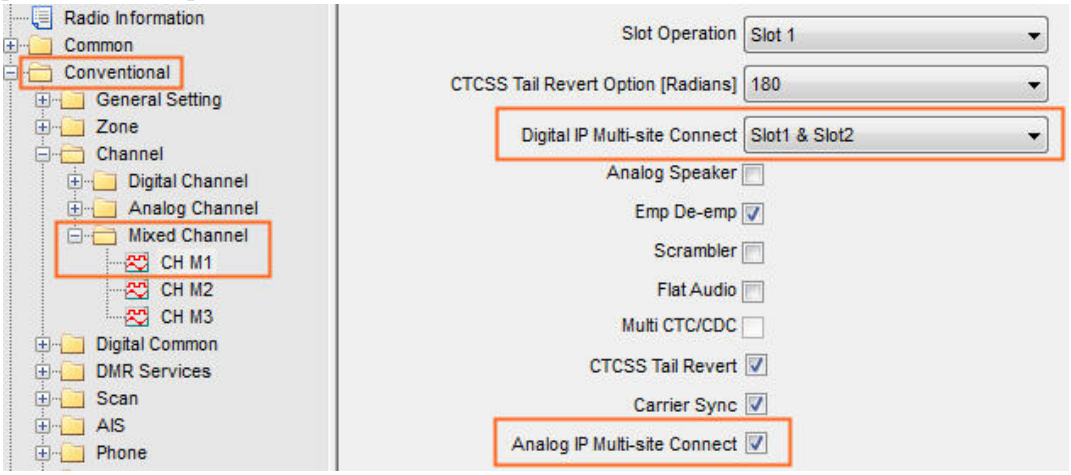


Figure 5-7 IP Multi-site Connect Features on Mixed Channel

Note

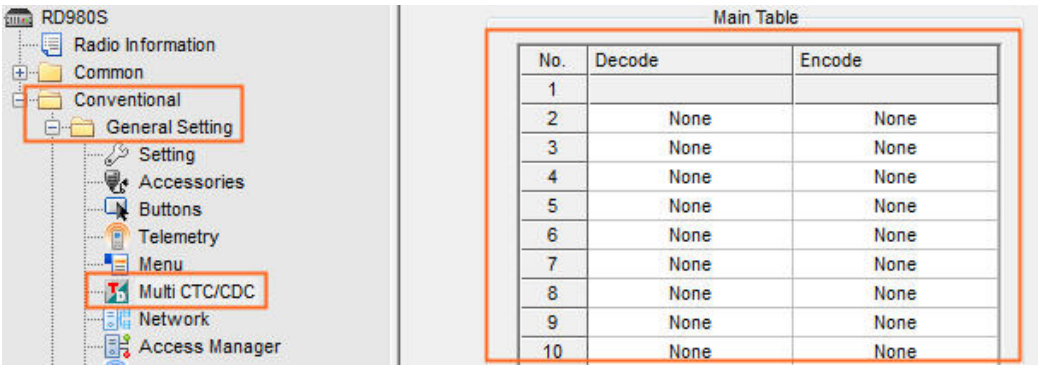
Only RD98XS supports the analog IP multi-site connect feature.

Step 7 (Optional) Configure the Multi CTC/CDC list.

CPS Path: Conventional -> General Setting -> Multi CTC/CDC.

Parameters: Decode and Encode. Refer to *CPS Help* for parameter description.

The Multi CTC/CDC list can be configured for the analog channel. The repeater only processes the signal that matches the predefined CTCSS/CDCSS.



Caution

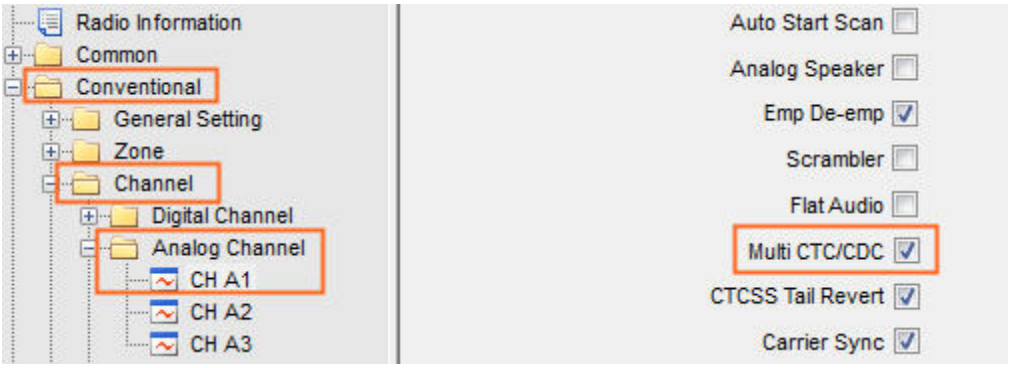
- The decode value must be unique and defined before the encode value.
- To avoid false decoding, don't select the CDCSS and CTCSS with similar pattern.

Step 8 (Optional) Enable the Multi CTC/CDC feature.

CPS Path: Conventional -> Channel -> Analog Channel -> CH AX

Parameters: Multi CTC/CDC. Refer to *CPS Help* for parameter description.

With this feature enabled, the repeater uses the Multi CTC/CDC list to encode or decode CTCSS/CDCSS for signal repeating on analog channel.



Note

- The Multi CTC/CDC list must be configured. See Step 7 for the operations.
- The Rx CTCSS/CDCSS Type cannot be set as "None".
- If this feature is disabled, the repeater forwards services according to the configurations of the analog channel.

Step 9 Go to "Conventional -> General Setting -> Access Manager -> Multi-site Access Management" to configure the IP Multi-site access management parameters.

The communication initiated by one repeater will be sent to every repeater in the network by default. When the network is busy and has plenty of repeaters, there will be a large amount of data transmitted in the network at one time.

To utilize the resource properly and build flexible networking, users can configure the radio ID and group ID of call services which can be repeated in IP Multi-site Connect network, so as to manage the IP Multi-site Connect network access of the radios. When the repeater receives the data package, it will decode the data package and obtain the DMR call information, then check whether the called radio or group is in the list. If yes, the repeater will be allowed to repeat or receive the call; if not, the repeater will discard the data package.

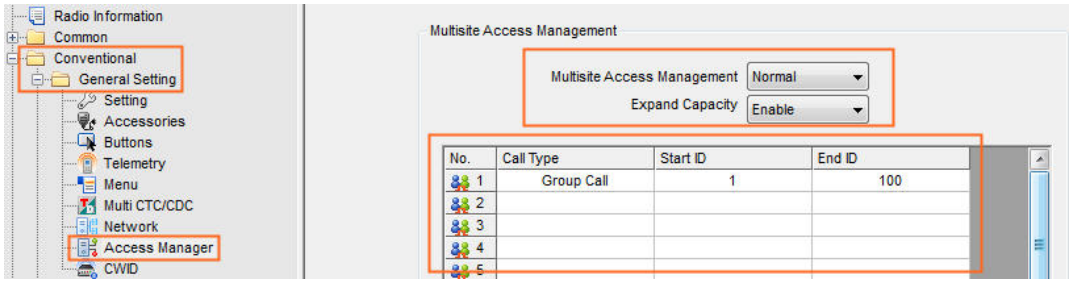


Figure 5-8 Multi-site Access Management

To enable the Multisite Access Management feature, set “Multisite Access Management” to “Normal” or "Enhanced”.

Then configure the “Call Type”, “Start ID” and “End ID” as per actual requirement. Please refer to *Access Management_Application Notes* for detailed description.

Please note that with the Multisite Access Management feature enabled, the network burden can be reduced, but the roaming radio may be adversely affected. When the radio roams to a new zone and it is not listed in the Multisite Access Management list of the repeater in this zone, this radio will not be able to receive voice or data from the network via this repeater. In this case, the solution is to add the radio ID into the Multisite Access Management list of each repeater in advance. It is recommended that the Multisite Access Management feature not be enabled when there are lots of roaming radios.

Configuring a Slave Repeater

Step 1 Configure the Slave repeater parameters such as frequency and color code via CPS.

Step 2 Configure the IP Multi-site Connect parameters.

CPS Path: Conventional -> General Setting-> Network.

Parameters: See orange boxes in Figure 5-9. For parameter description, see Table 5-2.

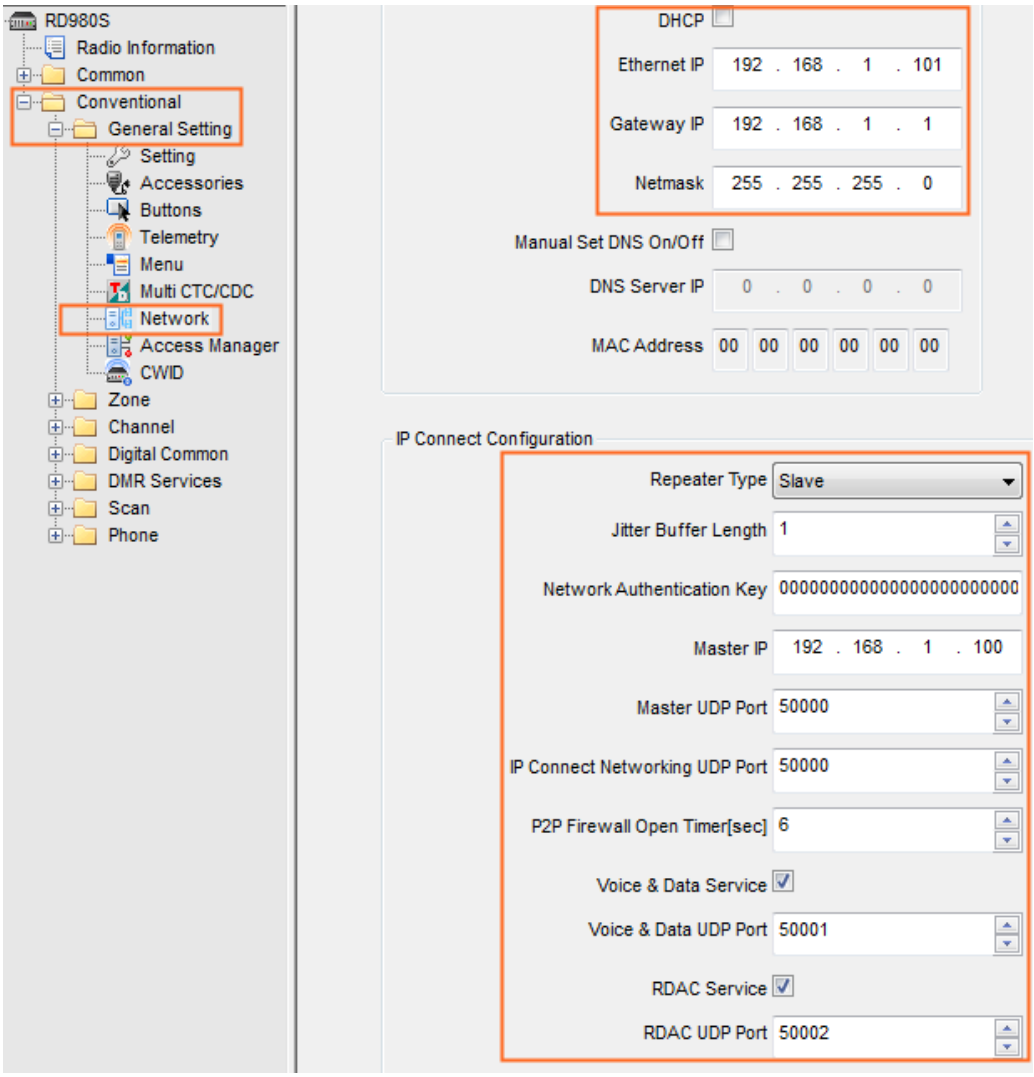


Figure 5-9 IP Multi-site Connect Parameter Configuration for Slave Repeater

- DHCP: Unchecked.
- The Slave repeater must be input with a unused static address of the subnet. Make sure that the Slave repeater and the Master repeater are in the same subnet.
  - Ethernet IP (192.168.1.101): The static IP address of the Slave repeater must be unique in the network.
  - Gateway IP (192.168.1.1): Be consistent with that of the Master repeater.
  - Netmask (255.255.255.0): Be consistent with that of the Master repeater.
- Set the “Repeater Type” to “Slave”.
- Input the IP address of the Master repeater in “Master IP” and input the IP Connect Networking UDP Port of the Master repeater in “Master UDP Port”.
- “P2P Firewall Timer[sec]”, “Voice & Data Service” and “RDAC Service” shall be consistent with the Master repeater.

- Set “IP Connect Networking UDP Port”, “Voice & Data UDP Port” and “RDAC UDP Port” to any unused local port. Range: 1024 - 65535

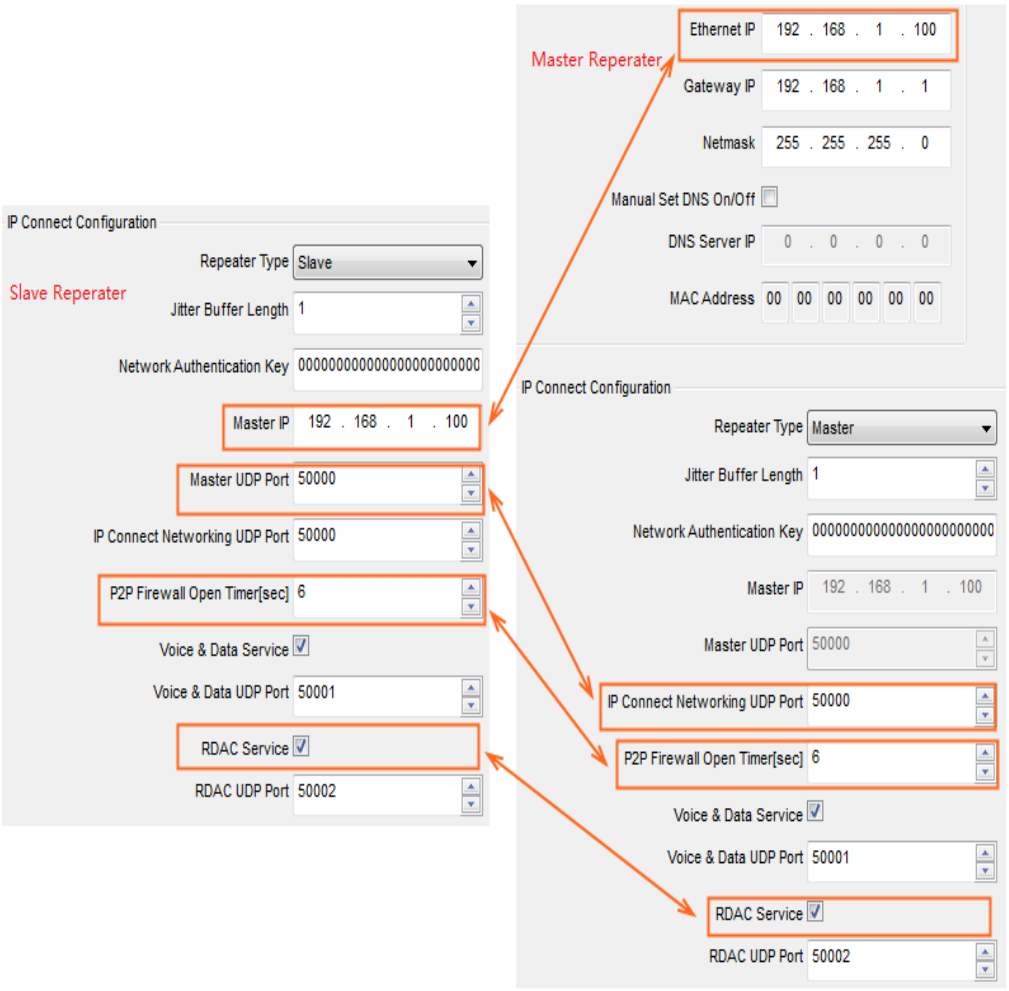


Figure 5-10 Diagram for Relationship between Master Repeater Parameters and Slave Repeater Parameters

Step 3 Configure the same IP Multi-site Connect operation slot as the Master repeater.

See Step 4 in section Configuring a Master Repeater.

Step 4 Enable the Analog IP Multi-site Connect feature.

Only RD98XS supports this feature. See Step 5 in section Configuring a Master Repeater.

Step 5 Enable the IP Multi-site Connect features on mixed channel.

See Step 6 in section Configuring a Master Repeater. Only RD98XS supports the Analog IP Multi-site Connect feature.

Step 6 (Optional) Configure the Multi CTC/CDC list.

The Multi CTC/CDC list can be configured for the analog channel. The repeater only processes the signal that matches the predefined CTCSS/CDCSS. See Step 7 in section Configuring a Master Repeater.

Step 7 (Optional) Enable the Multi CTC/CDC feature.

With this feature enabled, the repeater uses the Multi CTC/CDC list to encode or decode CTCSS/CDCSS for signal repeating on analog channel. See Step 8 in section Configuring a Master Repeater.

Step 8 Configure the Multisite Access Manager parameters.

See Step 9 in section Configuring a Master Repeater.

5.3 Local Area Network (LAN)

5.3.1 Connecting the Hardware

This scheme is used to connect a switch or multiple switches within the LAN, achieving seamless communication in the same area.

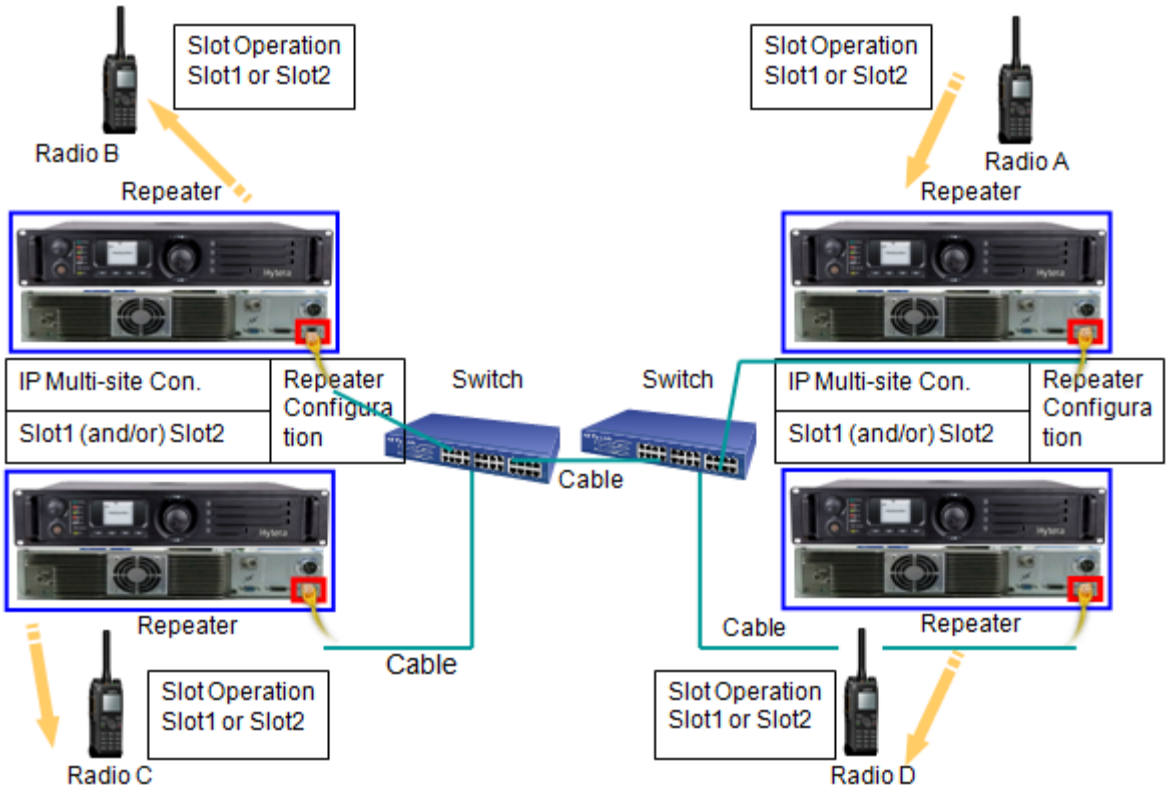


Figure 5-11 Local Area Network Connection

5.3.2 Configuring a Radio

In this connection method, the radio configurations are the same as Ethernet cable connection. Please refer to 5.2.2 Configuring a Radio for detailed configurations.

5.3.3 Configuring a Repeater

By adopting the Back to Back configuration, IP Multi-site Connect in the LAN can be achieved by a switch.

The advantage of this scheme is that more IP access devices, RDAC applications and PC applications can be

added to the system. In addition, it is useful for explaining network topologies.

Configuring a Master Repeater

Under this scheme, the Master repeater configurations are the same as Ethernet cable connection. Please refer to Configuring a Master Repeater for detailed configurations and pay attention to the following issues:

- The Master repeater shall be configured with **Network Authentication Key**, so as to avoid unauthorized accessing of repeaters from other IP Multi-site Connect network in the same LAN.

  CPS Path: Conventional -> General Setting -> Network -> IP Connect Configuration.

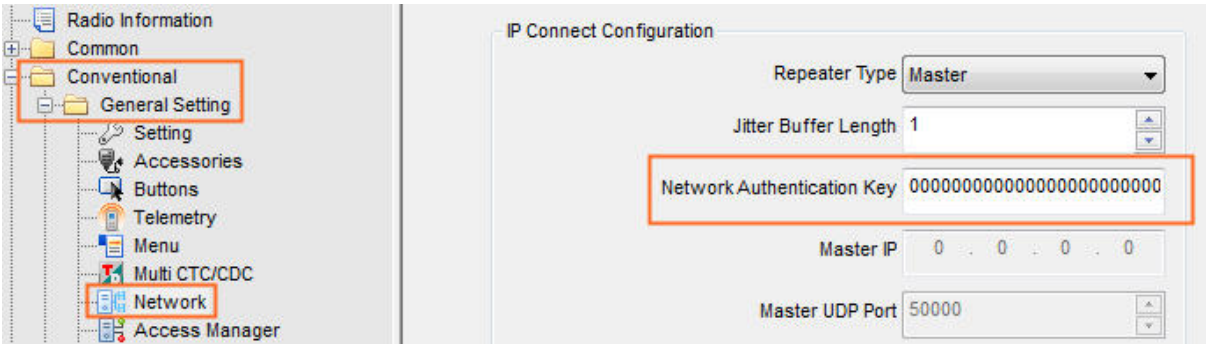


Figure 5-12 Network Authentication Key Configuration

- Either the IP address automatically via DHCP server or the static IP address can be used in the LAN. But the Master repeater can only use the static IP address.

  Any static IP addresses assigned to the repeater must be outside the range of dynamic IP addresses assigned by the DHCP Server, but within the range of IP addresses for the subnet.

Configuring a Slave Repeater

Under this scheme, the Slave repeater configurations are the same as Ethernet cable connection. Please refer to Configuring a Slave Repeater for detailed configurations and pay attention to the following issues:

- The “Network Authentication Keys” of the Master repeater, Slave repeater and RDAC application must be consistent.
- The Slave repeater can use either the static IP address or the IP address automatically allocated by DHCP server. It is recommended that the Slave repeater should not use the IP address automatically allocated by DHCP server, since the dynamic IP address may cause communication interruption.

  When the static IP address is used, the Slave repeater configurations are the same as that of Ethernet cable connection. “DHCP” must be checked, but “Ethernet IP”, “Gateway IP” and “Netmask” need not to be configured when the IP address is automatically allocated to the repeater by DHCP server. See the figure below. Please refer to Configuring a Slave Repeater for the configurations of the rest parameters.

  CPS Path: Conventional -> General Setting -> Network -> Basic Setting.

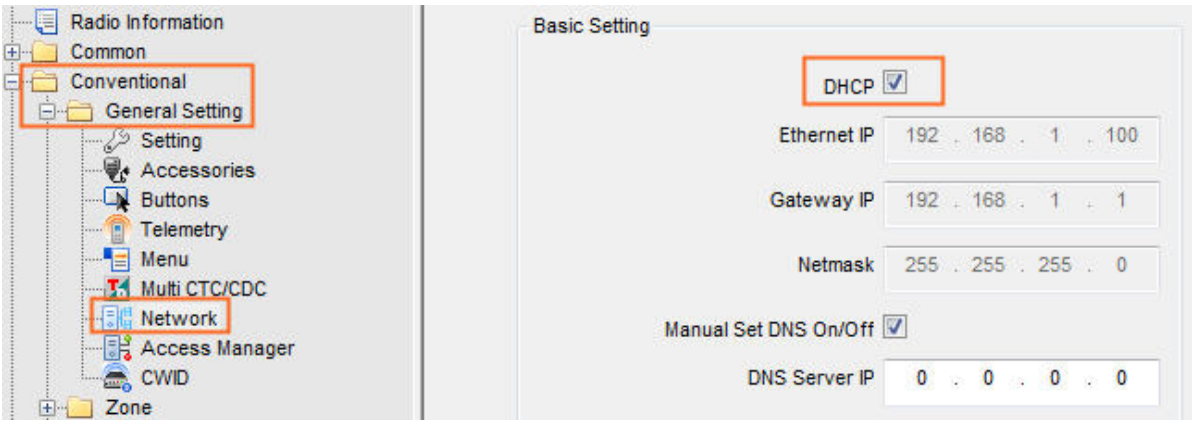


Figure 5-13 Assigning IP Address Dynamically by the DHCP Server

5.3.4 Configuring the Switch Device

Configurations vary with different switch devices. Please contact the device provider for detailed configurations.

5.4 Wide Area Network (WAN)

5.4.1 Connecting the Hardware

This scheme is used to connect multiple sites across different areas. The key to this scheme is the routing device, which can link with multiple repeaters in different locations to achieve IP Multi-site Connect in the WAN.

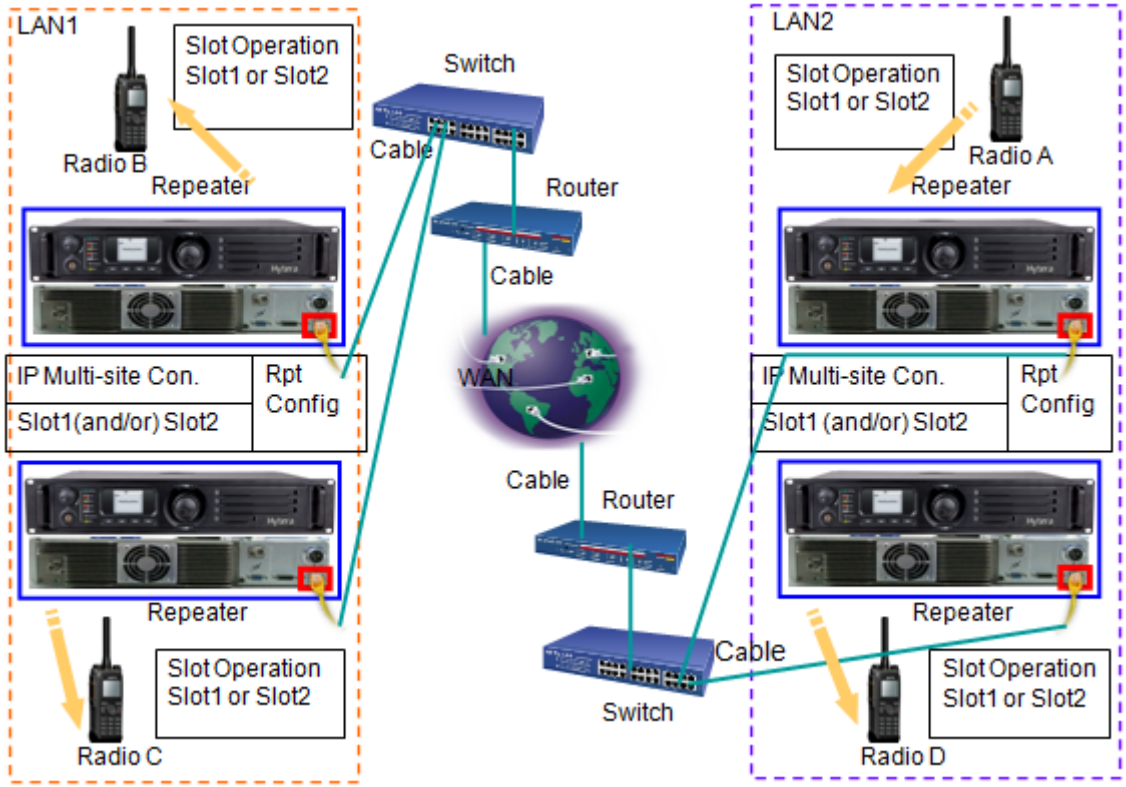


Figure 5-14 Wide Area Network

5.4.2 Configuring a Radio

In this connection method, the radio configurations are the same as Ethernet cable connection. Please refer to

5.2.2 Configuring a Radio for detailed configurations.

5.4.3 Configuring a Repeater

Generally, the IP Multi-site Connect network contains many Wide Area Networks and Local Area Networks linked by routers. The public network is a typical example, which is capable of connecting many LANs to the WAN by ADSL. Therefore, the IP Multi-site Connect network will cause a certain delay in communications.

Configuring a Master Repeater

In the above system, the IP address for the Master repeater is set as the static IP address of LAN1 in Figure 5-14 Wide Area Network, as the following figure shows.

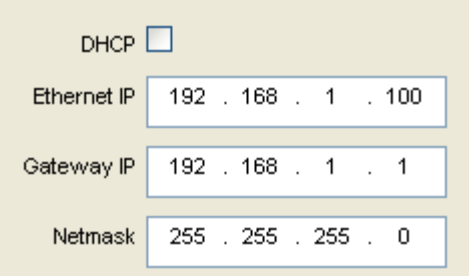


Figure 5-15 Setting IP Address for the Master Repeater

User can apply for and bind a domain name to the Master repeater to replace the static IP address, so as to reduce the building cost of the IP Multi-site Connect network.

The “Ethernet IP” (e.g. the Master repeater’s IP address) of the repeater is beyond the range of IP addresses assigned by the DHCP Server, but still within the range of IP addresses for the subnet (as specified by the Gateway Netmask for the devices on the LAN). Thus the Gateway IP address shall conform to the IP address of the router in the LAN1.

The IP addresses of all devices are configured within the router subnet, so they cannot be identified in the WAN. Thus, “Port Mapping” must be configured for all LAN1 routers, forwarding the incoming packet from the defined port of the WAN to the Master repeater.

Configuring a Slave Repeater

All Slave repeaters and RDAC applications can use the static IP address. Also, they can be configured with the IP address assigned by their respective LAN DHCP servers. But the assigned IP address is not recommended.

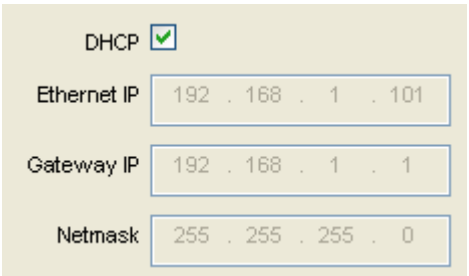


Figure 5-16 Assigning IP Address Dynamically by the DHCP Server

The “Master IP” of all Slave repeaters and RDAC applications must be the WAN address used by the Master repeater, which is also the WAN address of routers in the LAN1.

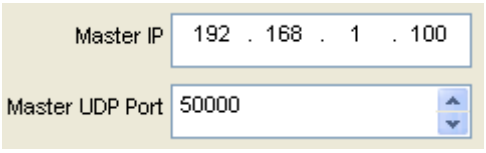


Figure 5-17 Setting Master IP for the Slave Repeater

If the Master repeater is bound with a domain name, the Master IP of the Slave repeater needs not to be set. Instead, select the “Master Domain Name On/Off” option and input the domain name of Master repeater in the “Domain Names” field. See the figure below:

Figure 5-18 Setting Master Domain Name for Slave Repeater

After the Master repeater is bound with a domain name, the Slave repeaters can get the Master repeater IP address via DNS server in respective LAN, and also can use the specific DNS server. See below:

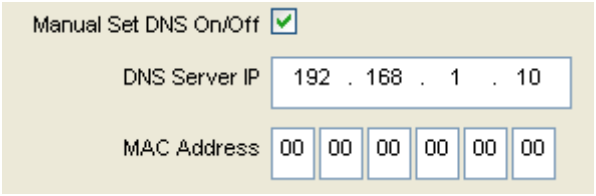


Figure 5-19 Setting DNS Server

In the above settings, the UDP port in the WAN shall be identical with that in the Master repeater. If not, modify the **Master UDP Port** of all Slave repeaters and RDAC respectively.

Please refer to Configuring a Slave Repeater for the configurations of the rest parameters.

Attentions

- There is no need to configure "Port Mapping" for the Slave repeater and RDAC applications, since their routers can perform it automatically.
- The public IP addresses for all Slave repeaters and RDAC applications are notified by the Master repeater upon connecting the Slave repeaters.
- The Slave repeaters on a certain LAN do not need to be configured with different UDP ports, as the router will distribute a unique port during forwarding.
- As for all the Slave repeaters and RDAC applications which are in the Master repeater’s LAN, their Master IP must be set to the WAN address rather than the LAN address. Otherwise, they will not be able to connect to the Slave repeaters and RDAC applications from other LANs.

- The routers in the LAN 1 and LAN 2 (Figure 5-14 Wide Area Network) must support “HairPinning”, which ensures that the WAN address cannot be replaced by the subnet address.

  Some routers that support partial “HairPinning” may not support all repeaters and RDAC applications on the Master repeater’s LAN. But they can still support other repeaters and RDAC applications, which are not in the same LAN as the Master repeater.

- Some private network (such as Intranets) is capable of addressing all devices by their IP addresses. When a device is connected to such network, the DHCP server will assign the IP address to it and adjust the router to map the packet to the appropriate Master repeater. Meanwhile, a static IP address is still required for the Master repeater.

5.4.4 Configuring the Switch Device

Configurations vary with different switch devices. Please contact the device provider for detailed configurations.

5.4.5 Configuring the Routing Device

Configurations vary with different routing devices. Please contact the device provider for detailed configurations.

5.5 Sub Master

5.5.1 Connecting the Hardware

Connection method of Sub Master scheme is similar to that of WAN scheme.

Sub Master scheme is suitable for cross-network IP Multi-site Connect network. In this scheme, the key device is a Sub Master repeater, which is responsible for connecting multiple repeaters in different subnet to realize IP multi-site connect network.

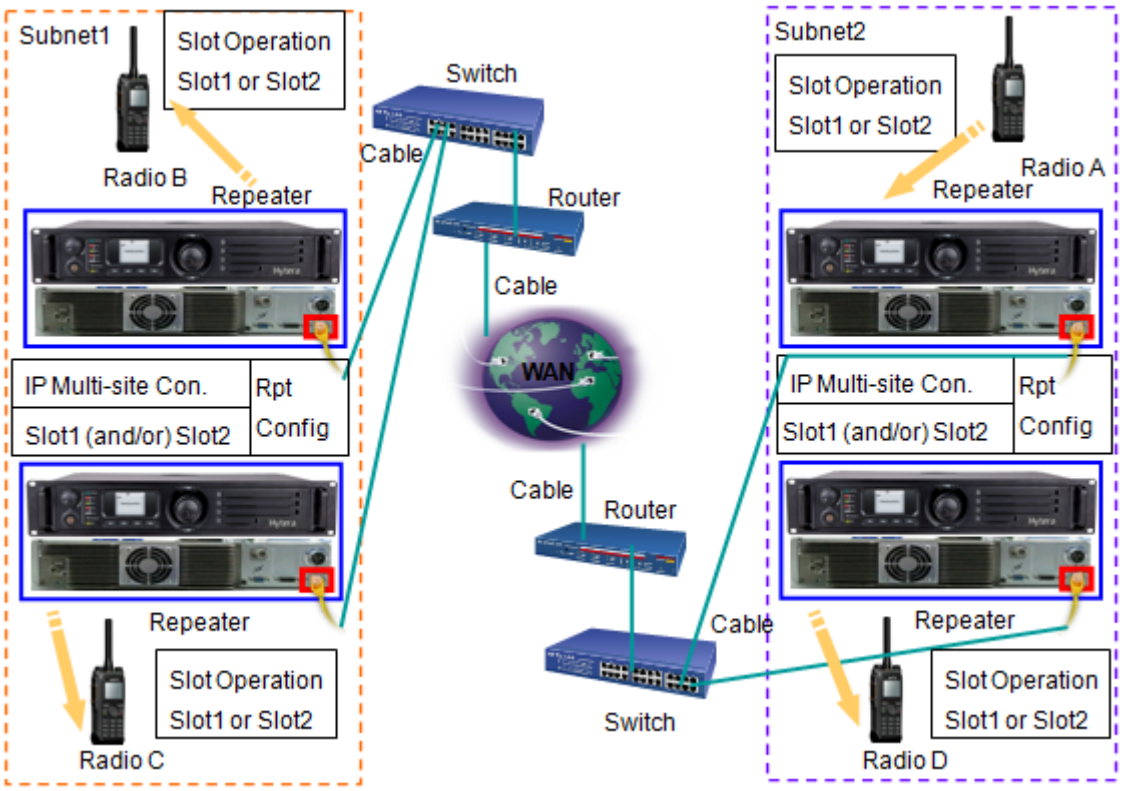


Figure 5-20 Sub Master

5.5.2 Configuring a Radio

In this connection method, the radio configurations are the same as Ethernet cable connection. Please refer to 5.2.2 Configuring a Radio for detailed configurations.

5.5.3 Configuring a Repeater

Master Repeater

Please refer to Configuring a Master Repeater in 5.4 Wide Area Network (WAN) for the configurations of the Master repeater which is connected to Sub Master repeater.

Sub Master Repeater

To configure the Sub Master repeater, do as follows:

Step 1 Set the Repeater Type to SubMaster.

Step 2 Configure the master parameters (Excluding the Repeater Type parameter) of the Sub Master repeater according to the configuration procedures of Master Repeater. Please Refer to Configuring a Master Repeater.

Step 3 Configure the Sub Master parameters.

CPS Path: Conventional -> General Setting -> Network -> SubMaster/Slave Parameters

Parameters: See orange boxes in Figure 5-21. For parameters description, see Table 5-4.

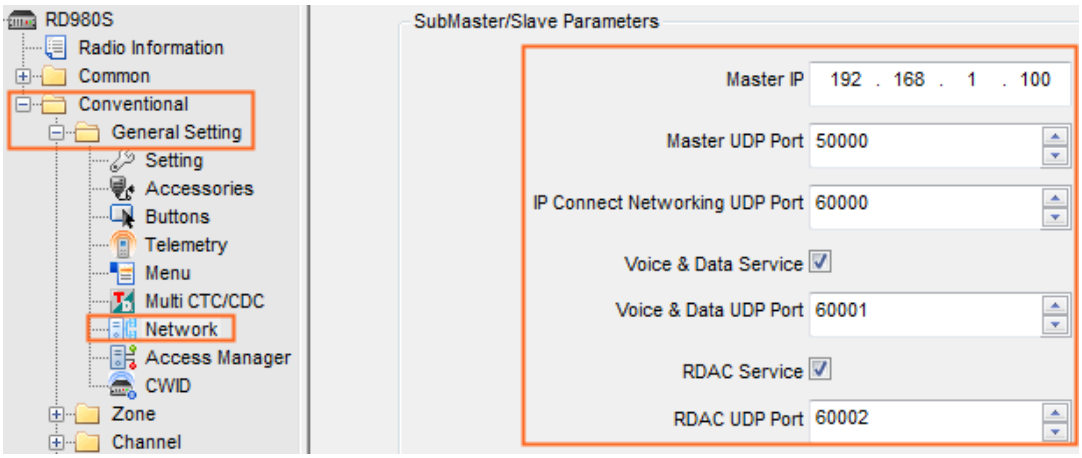


Figure 5-21 Setting the Sub Master Parameters

Parameter	Description
Master IP	This parameter defines the IP address of the Master repeater to be connected. If the Master repeater is bound with a domain name, user can check the "Master Domain Name On/Off" option and input the domain name for connection. The configuration of the Sub Master IP can be skipped.
Master UDP Port	This port is used to address the Master repeater connected to the Sub Master repeater, and maintain the network as well. The value of this port must be consistent with that of IP Connect Networking UDP Port of the Master repeater; otherwise, the Sub Master repeater will not be able to connect to the Master repeater. Range: 1024 - 65535 Default: 50000
IP Connect Networking UDP Port	This port is used to maintain the connection between the Sub Master repeater's IP network and the Master repeater's IP network. This port shall be a unused port of the Sub Master repeater. Range: 1024 - 65535 Default: 60000
Voice & Data Service	To enable or disable the Sub Master Multi-site Service feature. With this feature enabled, the radios can perform voice services, data services, emergency services and control services in the IP Multi-site Connect network formed by different Master repeaters.
Voice & Data	This port is used to perform the digital services among the Master repeaters.

Parameter	Description
UDP Port	This port shall be a unused port of the Sub Master repeater. Range: 1024 - 65535 Default: 60001
RDAC Service	To enable or disable the Sub Master RDAC Service feature. With this feature enabled, users can remotely diagnose and control the Master repeater connected to the Sub Master repeater via RDAC applications.
RDAC UDP Port	This port is used to perform the remote RDAC functions of the Sub Master repeater. This port shall be a unused port of the Sub Master repeater. Range: 1024 - 65535 Default: 60002

Table 5-4 Descriptions on the Sub Master Parameters

Slave Repeater

Please refer to Configuring a Slave Repeater in 5.4 Wide Area Network (WAN) for the configurations of the Slave repeater.

5.5.4 Configuring the Switch Device

Configurations vary with different switch devices. Please contact the device provider for detailed configurations.

5.5.5 Configuring the Routing Device

When configuring the routing devices, ensure that the communication between the Master repeater and the Slave repeater as well as between the Sub Master and the connected Master repeater is smooth and proper; otherwise, the cross-network communication cannot be established.

Configurations vary with different routing devices. Please contact the device provider for detailed configurations.

5.6 Broadband Wireless Access

5.6.1 Connecting the Hardware

This scheme is used for cross-regional multi-site broadband wireless access. The key to this solution is that broadband wireless access devices (such as Canopy) are employed to facilitate the communication of multiple repeaters in dispersed locations. For instance, communication can be achieved by means of the wireless link including microwave, WiFi, 3G and 4G. It is an ideal solution for emergency communication.

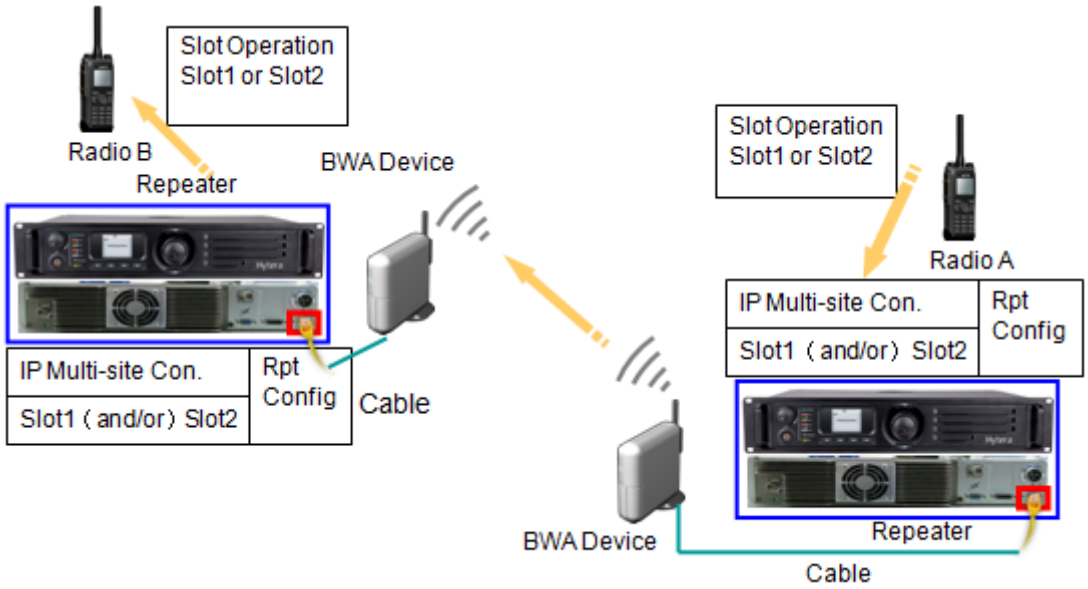


Figure 5-22 Broadband Wireless Access

5.6.2 Configuring a Radio

In this connection method, the radio configurations are the same as that of Ethernet cable connection. Please refer to 5.2.2 Configuring a Radio for detailed configurations.

5.6.3 Configuring a Repeater

The repeater is configured as per the specific network used in broadband wireless access mode. Please refer to 5.2 Ethernet Cable, 5.3 Local Area Network (LAN), 5.4 Wide Area Network (WAN) and 5.5 Sub Master for detailed configurations.

If you have any question, please contact your dealer.

5.6.4 Configuring the Broadband Wireless Access

Configurations vary with different broadband wireless access devices. Please contact the device provider for detailed configurations.

6. FAQ

6.1 Can other repeaters work normally when one of the repeaters fails?

Yes. The entire network is similar to a peer-to-peer network. The Master repeater is used for registration and broadcasting address. If a Slave repeater disconnects, the Master repeater can detect and broadcast it to other Slave repeaters; if the Master repeater disconnects, all Slave repeaters still can work. However, new address cannot be added and the status of other repeaters cannot be acquired until the Master repeater restores to normal operation.

6.2 How to select frequency and color code in IP Multi-site Connect network?

The networking scheme is subject to actual requirements. In the overlapping area, it is recommended to use different frequencies for the repeater, but the color code can be the same or varied. For adjacent repeaters sharing the same frequency, it is better to use different color codes to avoid probable interference.

6.3 What is the difference between IP Multi-site Connect network system and simulcast system?

The difference is described below:

- In a simulcast system, the Switch center or server is a must, which is used to receive and transmit data and determine time sequence. And the repeater acts as a transceiver. Therefore, the Switch center or server shall be available at any time, and a hot backup is required If necessary.

  For IP Multi-site Connect network, there is no independent Switch center or server. One repeater operates as the master one and other repeaters as the slave ones. Each works independently.
- The simulcast system is capable of time sequence synchronization, enabling the transceiver to use the same frequency in overlapping area, but in IP Multi-site Connect network, different repeaters shall use different frequencies to achieve quality communication.

6.4 How to upgrade a single repeater system to IP Multi-site Connect network system?

Radios (portable radio and mobile radio) in single site mode can communicate with those in IP Multi-site Connect mode. If you want to upgrade the single repeater system, you just need to upgrade the existing software and configure all parameters again for the repeater and terminal.

The API configured for the terminal in single repeater system can work normally in IP Multi-site Network.

6.5 What factors shall be considered when establishing an IP Multi-site Connect network?

The network establishment and configuration are subject to the specific devices and IP network. It's better to get help from the local network administrator due to the complicate networking environments.

Some common factors are listed below:

- Ensure that there is no conflicting IP address, which can break off communication. If the DHCP option is selected, the static IP address might as well be outside the range of the addresses which are available to be allocated.
- The Quality of Service (QoS) can be introduced to the router in the Ethernet network to ensure quality communication, provided that there are other networking devices acting as IP networking ones in IP Multi-site Connect network. In addition, it is necessary to enhance the communication priority and reserve adequate bandwidth.
- Be sure that the UDP port is free from restriction of the firewall. Otherwise, it can block the IP address or the UDP port operated in IP network. For more information, please consult the local network administrator or ISP.
- It is better to choose an ISP who can provide unlimited traffic services, because the voice transmission over internet may lead to heavy traffic. For an IP Multi-site Connect network containing 5/15 repeaters, 20/65 GB traffic is required per month.

6.6 What is the application scenario of router, switch and firewall?

A: Routers operate at the third layer of the OSI architecture, namely, the network layer, which is responsible for logic addressing including routing functions and corresponding IP protocol. Accordingly, routers are usually deployed on the edge of the networks to connect different networks. For instance, routers are required for communication between sub-networks, as shown in the following diagram.

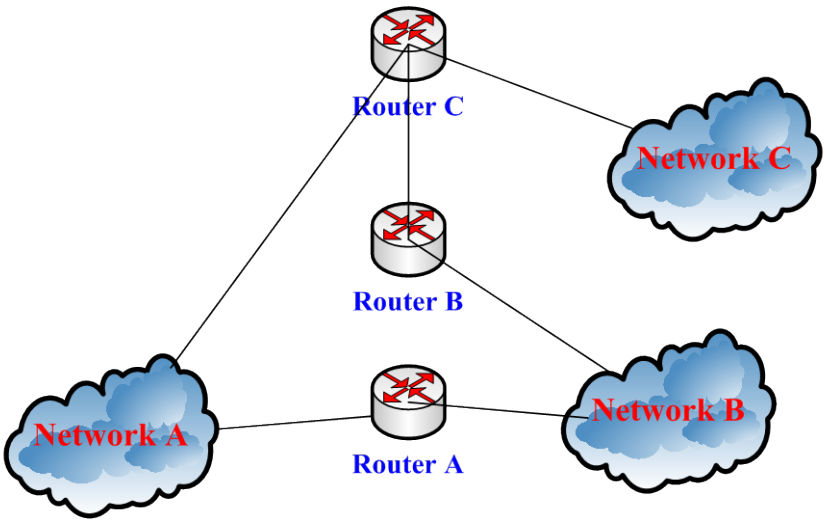


Figure 6-1 Application of Routers

The router is required under the following scenarios for networking:

- Used for accessing other network: for example, to access public network via special line, XDSL or via PPPoE.
- Used for connecting one sub-network to another: For example, if 192.168.2.X is attached to 192.168.1.X, the router is required for communication between edges of these two networks.

Switch operates at the second layer of the OSI architecture, namely, link layer, which is responsible for connecting desired network function units as per the user's requirements. For example, to establish a local area network, connect the computers and other network devices via Switch. In this way, data can be normally transmitted between these devices.

A firewall is a kind of barrier to access between the LAN and WAN, or between the private network and public network. It can permit data transmissions based upon a set of rules. To some extent, the firewall can also perform basic routing functions.

6.7 How to calculate the required bandwidth?

Generally, the required bandwidth is calculated on the basis of the amount of data transferred by one repeater. In two time slot mode, such amount of data (including some additional data) is about 70Kbps. If the number of the repeaters in the system is N, the required bandwidth can be calculated according to the expression: (N - 1) * 70Kbps.

6.8 How about the compatibility between Ethernet and other links?

There are various links (such as microwave, optical fiber, T1 and E1) for networking, subject to the environment and resource available. Most of the links are compatible with the Ethernet. Therefore, what we generally need to do is to add a bridge between Ethernet and other links. The following figure shows an example of Microwave Bridge:

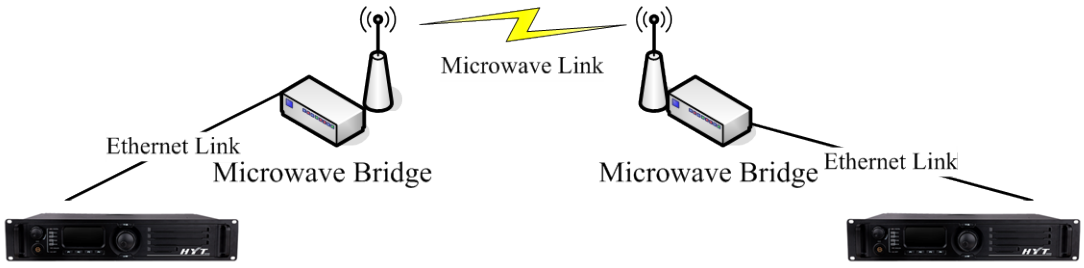


Figure 6-2 Ethernet and Microwave Linking

6.9 What are the recommended router and switch?

- Router: CISCO 1841, CISCO 2801
- Switch: H3C S2 series

6.10 How about the system communication security?

The system communication security is guaranteed by a set of security mechanism: data encryption, authorization code for registration, application layer protocol compliance and communication protocol command encryption. To connect the terminal via public network, it is recommended to use a firewall.

6.11 How many repeaters are supported in a wide area system?

For DMR Tier II protocol, a time slot has a length of 30ms (dual slots = 60ms). In the IP Multi-site Connect system, each repeater needs to transfer all the voice/data to other repeaters within 30ms. With a 30% reserve margin for the system to run other tasks, only 21ms is available for each repeater to transfer voice or data. Considering this fact, we have been working to enhance the repeater capacity. Now it is increased from 16 (R3.0) to 22 (R3.5) and to 30 (R4.0). (Note: the repeater capacity in single time slot mode has reached 44).

6.12 How to access Internet via ADSL?

The way of accessing Internet via ADSL is shown in the figure above. That is how IP Multi-site Connect works.

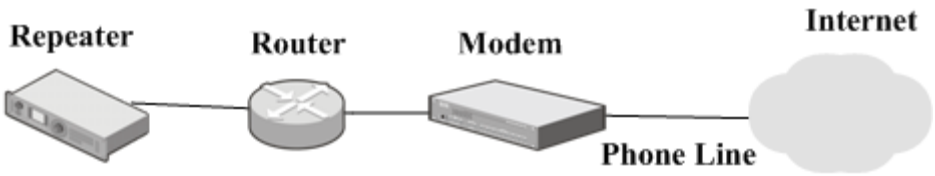


Figure 6-3 Internet Access via ADSL

To achieve Internet access, these configurations are required:

Step 1 Connect the repeater with other devices, as shown above.

Please note that the master repeater can access the Internet directly via a modem, namely, no router is required.

Step 2 Configure the repeater.

For master repeater, the Ethernet IP and Gateway IP shall be configured manually; but for slave repeater, you can use DHCP to assign the Ethernet IP automatically. Please note that the Master IP under IP Multisite Master and IP Multisite Slave must be consistent. In addition, a static public network IP shall be provided. See 5 Equipment Connection and Configuration for details.

Step 3 Configure the router and modem.

See the following section for details. Generally, default configurations are recommended.

Step 4 When the above configurations are done, make dial-up access to Internet.

To ensure normal Internet access, it is recommended to use CISCO router (model: CISCO 1841). The modem is supplied by your Internet Service Provider.

FE0/1 WAN address is obtained via dial-up, and FE 0/0 address is 192.168.1.1. The dynamic IP address of slave repeater is configured by DHCP. Its range is 192.168.1.2 - 192.168.1.255.

When the router is connected to a computer, power it up and do as follows:

Step 5 To configure VPDN.

```
HyteraRouter1>enable
//to enter administrator mode
HyteraRouter1#configure terminal
//to enter configuration mode
HyteraRouter1(config)#vpdn enable
//to enable the router's virtual private dial-up network (VPDN)
HyteraRouter1(config)#vpdn-group office
//to create a VPDN group
HyteraRouter1(config-vpdn)#request-dialin
//to initialize a VPDN tunnel and to create a VPDN subgroup for dial-in request
HyteraRouter1(config-vpdn-req-in)#
HyteraRouter1(config-vpdn-req-in)#exit
HyteraRouter1(config-vpdn)#exit
```

Step 6 To configure the router interface for connecting ADSL modem.

```
HyteraRouter1(config)#interface fastEthernet 0/1
//to configure external network interface "FE 0/1"
HyteraRouter1(config-if)#no ip address
//not to configure any IP address
HyteraRouter1(config-if)#pppoe enable
//to enable pppoe protocol
HyteraRouter1(config-if)#pppoe-client dial-pool-number 1
//to add pppoe dial-up client to dial-up pool 1
```

Step 7 To configure logic dial-up interface.

```
HyteraRouter1(config-if)#interface dialer1
//to configure virtual interface dialer1
HyteraRouter1(config-if)#ip address negotiated
//to get IP address from ADSL service provider
HyteraRouter1(config-if)#ip nat outside
//to enable NAT
```

```
HyteraRouter1(config-if)#encapsulation ppp
//to encapsulate PPP protocol for this interface
HyteraRouter1(config-if)#dialer pool 1
//to dial up with dial-up pool 1
HyteraRouter1(config-if)#dialer-group 1
HyteraRouter1(config-if)#ppp authentication pap callin
//to enable PPP PAP authentication. When CHAP is used here, “username” in the command below shall be changed to “hostname”
HyteraRouter1(config-if)#ppp pap sent-username xxxxxx passworkd 0 yyyyyy
//to use the existing user name and password; “0” indicates encryption strength.
HyteraRouter1(config-if)#exit
```

Step 8 To configure internal network interface.

```
HyteraRouter1(config)#interface fastEthernet 0/0
//to configure internal network interface “FE 0/0”
HyteraRouter1(config-if)#ip address 192.168.1.1 255.255.255.0
//to configure the IP address
HyteraRouter1(config-if)#ip nat inside
//to enable NAT
HyteraRouter1(config-if)#exit
```

Step 9 To configure the router to provide DHCP services for slave repeater.

```
HyteraRouter1(config)#ip dhcp excluded-address 192.168.1.1
//to exclude unnecessary address
HyteraRouter1(config)#ip dhcp pool ABC
//to define the address pool
HyteraRouter1(dhcp-config)#import all
//to import DNS and WINS server
HyteraRouter1(dhcp-config)#network 192.168.1.0 255.255.255.0
HyteraRouter1(dhcp-config)#default-router 192.168.1.1
//to set the default gateway
HyteraRouter1(dhcp-config)#exit
```

Step 10 To configure NAT

```
HyteraRouter1(config)#access-list 1 permit 192.168.1.0 0.0.0.255
HyteraRouter1(config)#ip nat inside source list 1 interface dialer1 overload
```

```
//to translate the address
```

Step 11 To configure default route.

```
HyteraRouter1(config)#ip route 0.0.0.0 0.0.0.0 dialer1
//to define the default route, and the next hop is dialer1
```

When another type of router is used, see the specific manual for details.

6.13 What factors shall be considered when accessing Internet via LAN?

When port mapping is not needed, an Ethernet IP address is not required in the internal network. For the slave repeater, it can obtain the IP address dynamically from DHCP. When port mapping is needed, an Ethernet IP address and port mapping among IP multi-site service UDP port, IP multi-site networking UDP port, and remote RDAC UDP port are required for the master repeater and slave repeater.

Whether the port mapping is needed depends on the selected router. When IP multi-site networking fails, port mapping will be a must. However, as for our recommended router, neither port mapping nor an Ethernet IP address for the slave repeater is required.

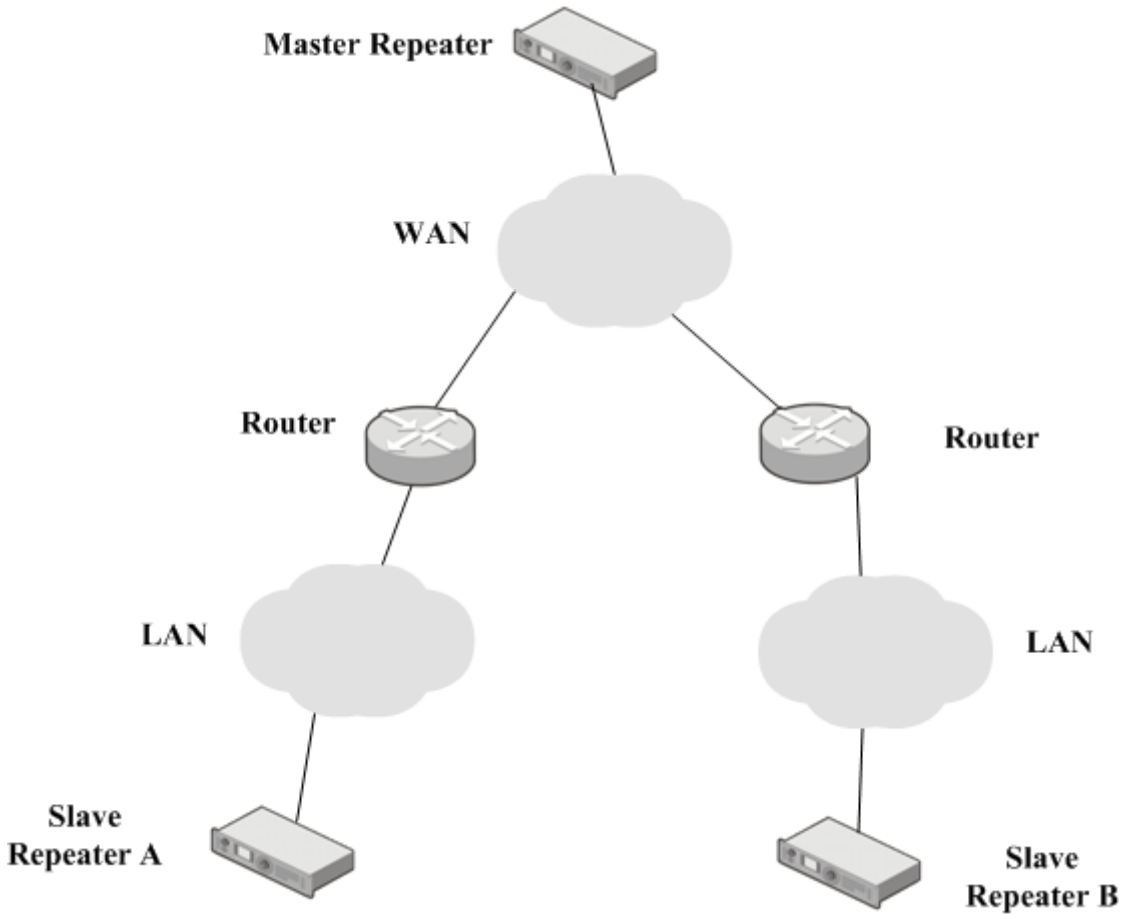


Figure 6-4 LAN Connection

As shown in the figure above, the slave repeater A and slave repeater B locate in different LANs, which have different network addresses. In this case, the slave repeater must have an Ethernet IP address for port mapping via the router, so as to connect to the master repeater and other slave repeaters. Please refer to the appropriate router manual for details.

As the designated IP address may conflict with the IP address of other devices in the LAN, you can use DHCP to assign an Ethernet IP address dynamically. Such IP address and MAC address must be set in the router. Please refer to the appropriate router manual for details.

6.14 What's the function of jitter buffer and How to handle poor communication caused by network transmission delay?

The UPD protocol, used for peer-to-peer service, is adopted for IP Multi-site Connect feature at the transmission layer. It has no acknowledgements or re-transmissions mechanism from the receiver to the sender. During transmission, as the UDP data packet from the same node goes through different intermediate nodes to reach different destination nodes, the packet jitter and disorder will occur. In addition, the data packet may be lost when the network communication is poor.

The role of Jitter Buffer feature is to re-order the UDP data packet, buffer it and send it later, which has no impact on signal. This is because the frame is sent or received at a regular interval benefiting from the TDMA technology.

A UDP data packet is deemed to be lost if the time gap between it and last UDP data packet arriving at the same node is over the threshold value. The buffer duration shall be over this threshold. You can configure this duration according to the number of jitter buffer.

The buffer duration ranges from 1*60 ms (default) to 8*60 ms.

You shall set the buffer duration according to the actual network transmission quality. Shorter buffer duration means fewer packets to be buffered and less network delay to be tolerated; on the contrary, more packets will be buffered and more network delay will be tolerated, but this causes longer retransmission duration. Judging from this, buffer duration increase is a double-edged sword. On the one hand, it improves UDP data packet loss; on the other hand, it increases network transmission delay, which may affect the digital or analog services with acknowledgement required.

Currently, the network delay is measured by using Ping command. In a LAN or private network where the network delay is generally less than 60ms, it is recommended to use the default duration of jitter buffer. However, in other network where the network delay is greater than 60ms, the duration is subject to actual requirements.

When the IP Multi-site Connect feature is utilized in a WAN, the jitter buffer may not help a lot due to bandwidth limitation and network resource preemption. Considering this case, it is recommended to use the public network

or establish your private network for better communication.

6.15 How does the voice or data packet delay or loss affect the communication quality?

In IP Multi-site Connect mode, the repeater will add a silent frame as compensation to the voice or data packet lost during transmission. Accordingly, the communication with a terminal will be discontinuous. In case two voice and data packets are lost consecutively, the repeater will judge the call as abnormal and abort it automatically. Then no repeating is available unless new voice and data packet or call request is received.

If the data packet delay occurs to the digital service for more than the duration defined in the Jitter Buffer, the packet will be lost, resulting in service acknowledgement failure.

6.16 Why does the master repeater fail to communicate with the Sub master?

In order for normal communication between the Sub master and master repeater, the **Master Port** and **Master IP** shall be consistent with those of master repeater connected to the sub master. In addition, make sure the Voice & Data Service is activated.

6.17 What's the difference between Sub Master Service and IP Multi-site Connect in settings?

The IP Multi-site Connect settings of repeater are used for communicating with the slave repeaters, and different ports are responsible for different services, but the port and settings of Sub Master Service are used for communicating with the master repeaters.

6.18 What's the difference between Sub master and master repeater?

Two master repeaters cannot be connected directly unless one of them is set as Sub master. Please note that the Master IP and Master Port must be consistent with those of master repeater connected to the sub master.

Abbreviations

Abbreviation	Full Name
CPS	Customer Programming Software
DHCP	Dynamic Host Configuration Protocol
DMR	Digital Mobile Radio
DNS	Domain Name Server
IP	Internet Protocol
NAT	Network Address Translation
PDT	Professional Digital Trunking
RDAC	Repeater Diagnostics and Control
TCP	Transmission Control Protocol
UDP	User Datagram Protocol

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