MOTOTRBO™

Link Establishment Protocol Specification

Version 01.01

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.

REVISION HISTORY

Version	Date	Feature	Section	Page	Lines	Description
01.00	March 23, 2013		All	All	All	Initial version
01.01	Dec 5, 2013		2.0 3.2.1.4 4.8.4 4.8.14 4.9.4 4.9.7	11-12 26-28 64 89-90 92 93	101-130 375-391 881-884 1137-1153 1179 1200	**CCMPD01836815**-Update for R2.3 Digital Voting feature
			3.2.8	49-50	554-585	Clarify how the third party application peer shall handle the connection to all the peers.

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1.0 Introduction

1.1 Overview

This document describes the MOTOTRBO Link Establishment (LE) protocol definitions used in an IP Site Connect(IPSC) system or a Capacity Plus(CPC) system or a Linked Capacity Plus (LCP) System for communication between peers. The analog repeater and single site repeater supports the LE protocol. The IP Site Connect system links two or more MOTOTRBO repeaters over an IP network. It enables a wide area system access for voice and data service support. The Capacity Plus system links two or more MOTOTRBO repeaters at the same location over an IP network. It enables the trunking of channels from multiple repeaters, and reduces the waiting time to access the system. The Linked Capacity Plus System links one or more multi-channel trunked system to form a multisite system over an IP network. With the MOTOTRBO repeater LE protocol, a third party application can establish the connection, and register the interested service(s) with repeater peers. There are separate ADKs to define the message structure and sequence at each service interface. The MOTOTRBO repeater peers exchange LE messages with other peers in the repeater system and supports specific service messages with the 3rd party application. Some service are only available for certain system type, e.g. RDAC is available for all the system types, while RCM is only available for digital repeater system.. The LE protocol is “language-independent.” Developers may implement this protocol in any programming language, which supports bit stream manipulation.

1.2 Terminology

CPS	Customer Programming Software
CSBK	Control Signal Block
DPP	Digital Phone Patch
DMR	Digital Mobile Radio
ETSI	European Telecommunications and Standards Institute
FCC	Federal Communications Commission
HMAC	Hash Message Authentication Code
ID	Identity
IP	Internet Protocol
IPSC	IP Site Connect
CPC	Capacity Plus
LAN	Local Area Network
LCP	Linked Capacity Plus
LE	Link Establishment
MFID	Manufacturer’s ID
OACSU	Off Air Call Setup
OTA	Over the Air
PDU	Protocol Data Uint
PC	Personal Computer
RDAC	Repeater Diagnostics, Alarms and Controls

RDAC-IP APP	RDAC-IP Application
RF	Radio Frequency
RX	Receive
SHA-1	Secure Hash Algorithm
TX	Transmit
XCMP	Extended Control and Management Protocol

1.3 Assumptions

It is assumed that the reader of this document has the following domain knowledge:

- Principle of two-way radio communications
- Open Systems Interconnection (OSI) Model
- UDP/IP Protocol

The following domain knowledge is considered to be beneficial, but is not required:

- Digital two-way radio communications

1.4 References

[1] RFC 3174 – US Secure Hash Algorithm (SHA-1), September 2001, D. Eastlake, 3rd, http://www.faqs.org/rfcs/rfc3174.html

[2] MOTOTRBO™ Repeater XCMP Development Guide

[3] HMAC: http://en.wikipedia.org/wiki/HMAC

[4] MOTOTRBO™ System Planner

2.0 System Network Overview

An IP Site Connect system or a Capacity Plus or a Linked Capacity Plus system consists of two or more MOTOTRBO Peers (repeaters and 3rd party applications) linked together over an IP network. The IP network configuration may be the public internet or a private LAN. The term 'Peer' means a MOTOTRBO repeater, a RDAC-IP application or a 3rd party application. Figure 1 shows an example IP Site Connect system. Figure 2 shows an example Capacity Plus system.

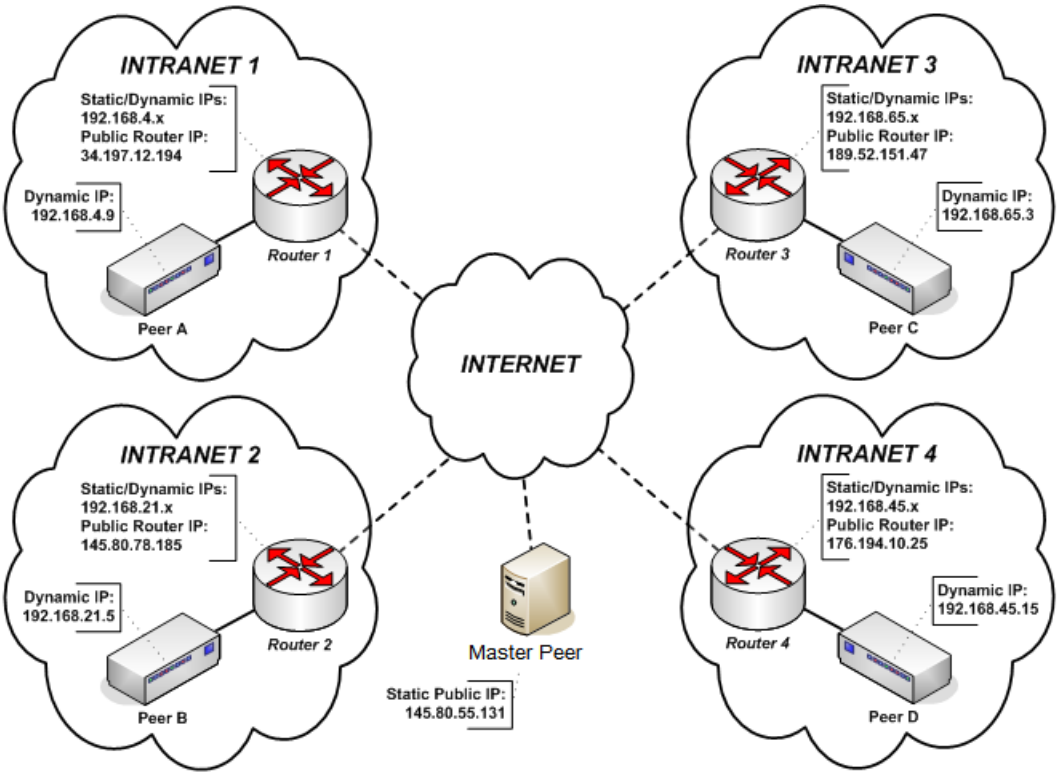


Figure 1 - IP Site Connect System Topology Configuration

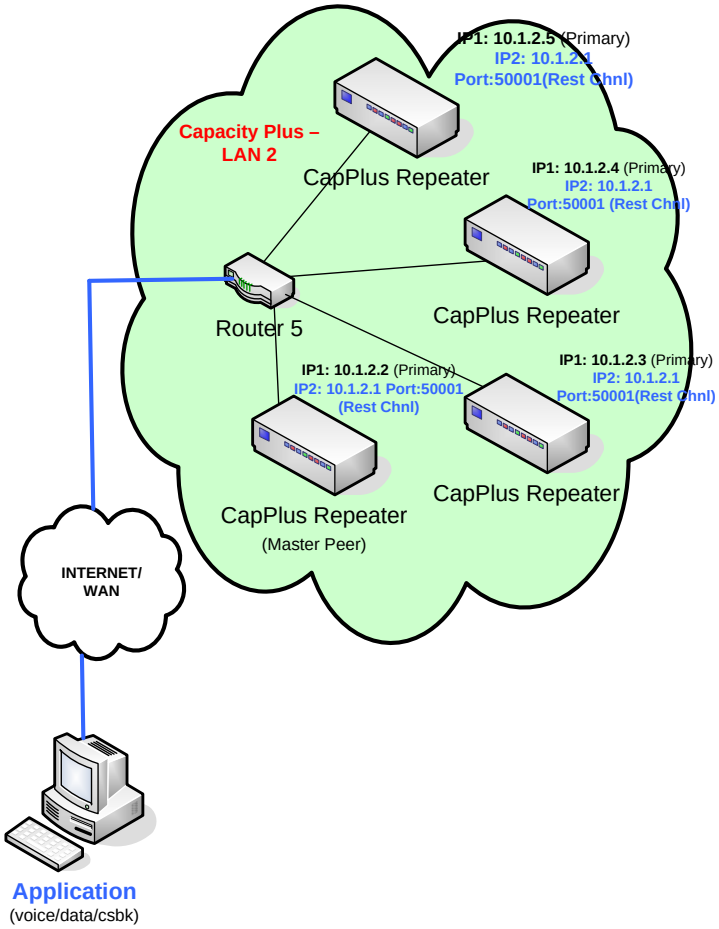


Figure 2 – Capacity Plus System Topology Configuration

In both the IP Site Connect system and the Capacity Plus system, there is a peer configured as the Master Peer. The Master Peer acts as the central point for a peer to find all other peers in the system. It has a static IP address and a UDP port number which are well known to all the peers in the system. When a peer powers up or intends to join the system, the peer begins the link establishment procedure by sending a registration request message to the Master Peer. The Master Peer maintains a map which is a registry of all the peers in the system. After establishing the link with the new joined peer, the Master Peer distributes the map to all peers currently linked in the system. Then all existing peers should create a link with the newly joined peer. Finally, each peer maintains a link with all other peers (including the Master Peer) in the system. This ensures that the system still works when there are any peers down, even the Master Peer.

In the IP Site Connect system, upon successful registration with the Master Peer, the repeater operates in IP Site Connect mode. When the repeater receives voice/data/control packets over the air on the IP Site Connect Wide Area Channel, it

sends the packets to all the peers in the IP Site Connect system. Therefore, the voice, data and control packets can be exchanged across disperse locations.

Note: The term 'wide area' indicates coverage across geographically separate areas that may span cities, states or even countries. This however does not imply a 'blanket' coverage. A system instantiation may provide coverage in two different locations but no coverage in the area between the two locations.

In the Capacity Plus system, upon successful registration with the Master Peer, the repeater operates in Capacity Plus mode. When the repeater receives voice/data/control packets over the air on the rest channel, it finds the new rest channel, and notifies all MOTOTRBO repeater peers through the IP interface and informs all the radios over the air about the new rest channel. To avoid the 3rd party application implementation on the rest channel scheduling, and to enable the third party interface at both WAN and LAN topology, the MOTOTRBO Capacity Plus repeater peer supports IP aliasing. This static IP address and UDP port seems to be another peer in the system. It is called Rest Channel IP and Rest Channel UDP Port in the MOTOTRBO CPS. Here we call it Virtual Peer or Site Peer. Each repeater peer in the Capacity Plus system has its unique IP address and UDP port to join the system, and also supports the IP address of the Site Peer. When a repeater peer owns the rest channel, it updates the router with the association of its MAC address and the Site Peer IP address through Address Resolution Protocol (ARP) protocol.

A Linked Capacity Plus system is based on Capacity Plus and IP Site Connect configurations of MOTOTRBO. It can be considered either as multiple Capacity Plus systems connected over an IP network with IP Site Connect rules or as multiple IP Site Connect systems where channels at each sites are trunked using Capacity Plus scheme. The Linked Capacity system topology configuration in **Figure 3** can be same as Figure 1 in system level and Figure 2 in site level. There is also only 1 master peer repeater in the whole Linked Capacity Plus system, which can be located in any site. It must have a public static IP address as in the IP Site Connect configurations in order to let all the repeater peers know the first registry destination. Each peer repeater has configured a Site IP address in CPS files as the Rest Channel IP address of Capacity Plus system, which shared by all the local site level peers. We call it the Site Peer. The application shall maintain link with each repeater in the Linked Capacity Plus system. If the application is only interested in call logging or repeater diagnose, maintaining the link with the Site Peer is NOT needed. For details, refer to [4].

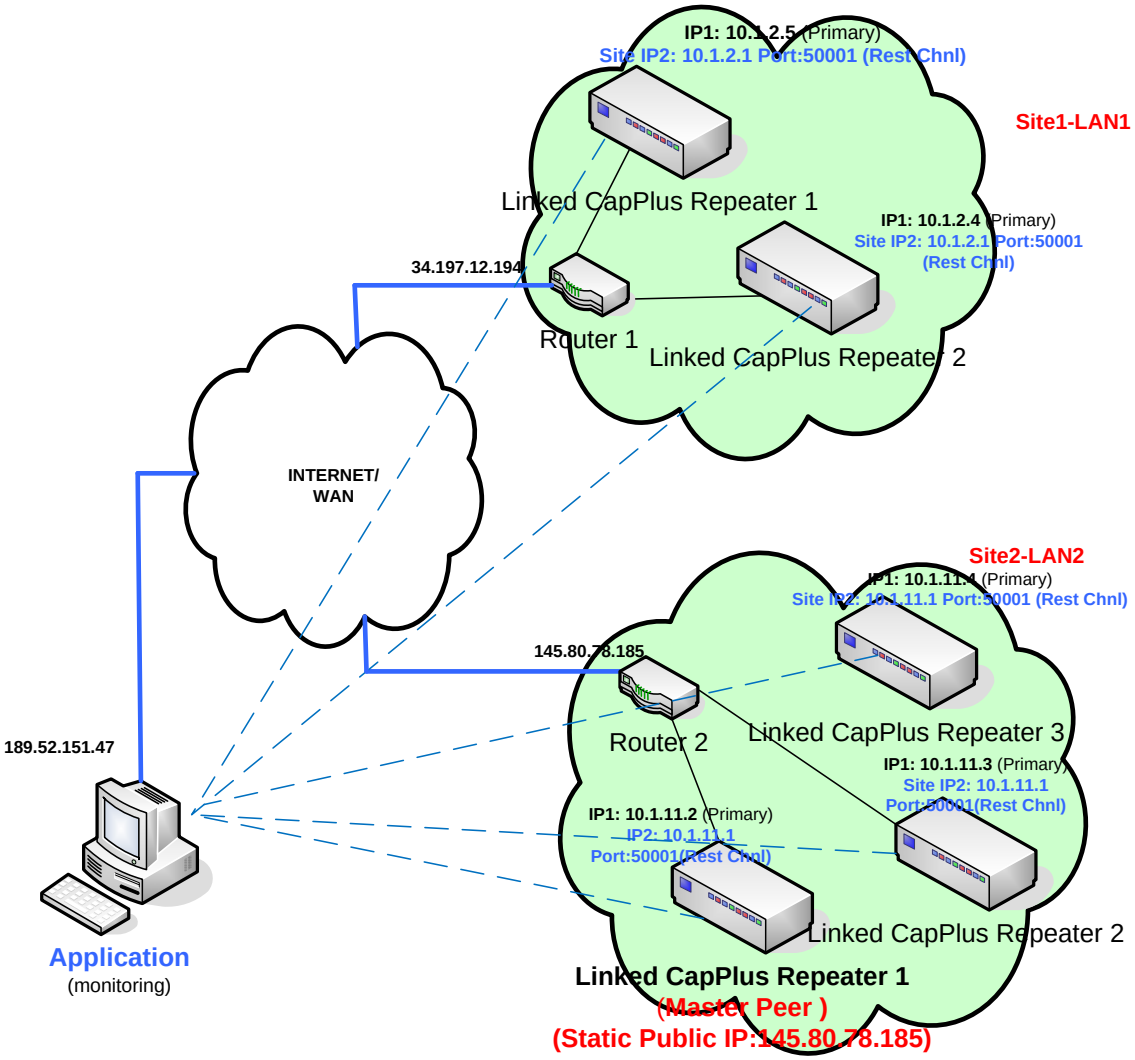
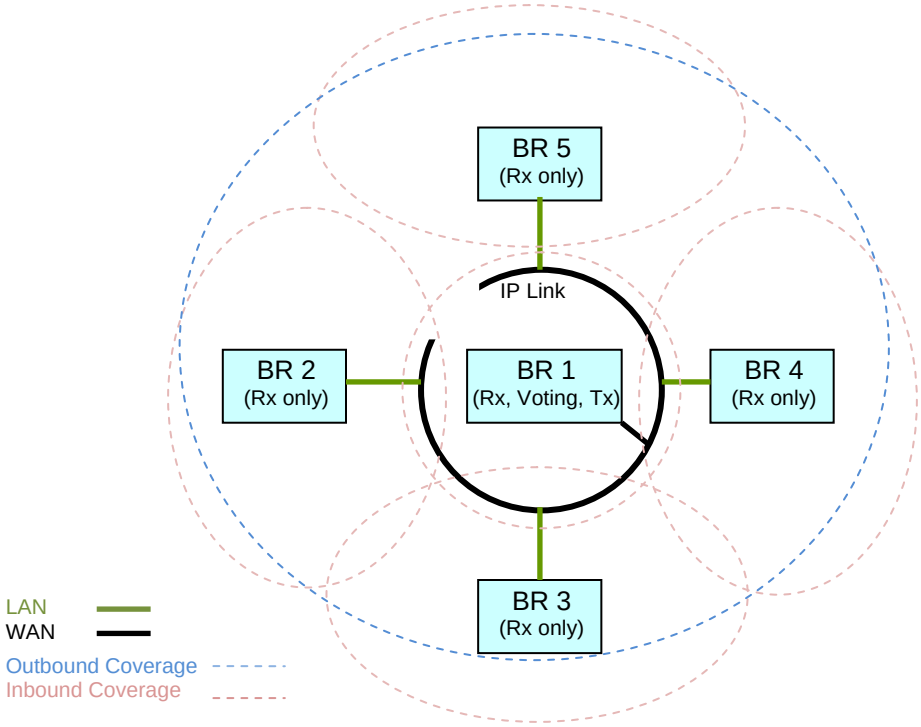


Figure 3 – Linked Capacity Plus System Topology Configuration

Since Paradise R2.3, MOTOROLA SOLUTIONS provide the Digital Voting System to extend subscribers' inbound reach range of a physical RF channel for all the existing call types (voice/data/CSBK/phone, etc) in digital conventional single site, IP Site Connect, Capacity Plus and LCP system.

The Digital Voting System consists of voting repeater and the associated satellite receivers. The satellite receivers receive the SU's transmission, verify and forward it to the voting repeater over an IP based network. The voting repeater selects the 'best' copy of the SU's transmission and repeats over the air.

The following diagram shows a Single site Conventional system with four satellite receivers.



From system view, voting calls are not different from the normal calls except that the inbound range is enlarged by adding more than one receiver for a local channel (without additional frequency resources).

For more detailed information about Digital Voting system, Please refer the [4].

2.1 System Model

Peers in the system form an overlay network on top of existing IP infrastructure. In other words, peers will not be connected directly (physically) to each other, instead they will use IP, as the connection fabric to communicate with each other.

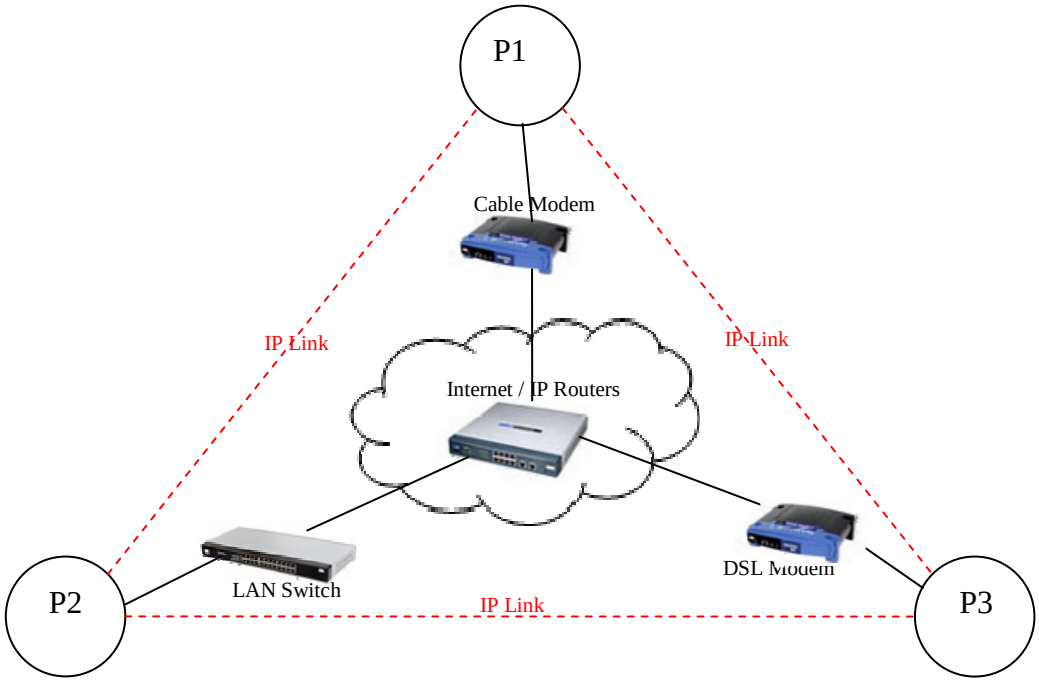


Figure 4 - IP Site Connect IP Network Topology Configuration

The IP Site Connect network will be a homogeneous network – capable of supporting mixed IP network configuration as depicted in Figure 4. All peers must support the LE protocol. In Capacity Plus system, all the repeater peers in one system have to be in the same LAN to avoid network delay impact on the rest channel movement. The Linked Capacity Plus system has the same network characteristic as IP Site Connect network among all the sites in Figure 4 , and has the same network characteristic as Capacity Plus system in each local site internally. It supports all the backend networks supported by the IP Site Connect except “dial-up” connection (due to small bandwidth) or Satellite Internet access (due to large delay).

The Master Peer has a well-known static IP address and source port number so that it is publicly visible to all other peers in the network topology. The Master Peer can be assigned an IP address through DHCP when located behind a network router. This router must be publicly visible to all other peers in the network topology. The router must have a well-known static IP address and leave open a well-known port number that it will use to forward traffic to the peer located behind the router. The IP Site UDP port of each peer in the system is utilized for exchanging all types of data between peers using the LE protocol.

A third party application can connect to the system through IPv4 based back-end network. The IPv4 back-end network can be either a private IP network or the public internet network provided by an Internet Service Provider (ISP). In the IP Site Connect system or Capacity Plus system or the Linked Capacity Plus System, besides the

MOTOTRBO repeaters , a third party application can join the system and become a peer.

2.2 System-wide Information

In keeping with the homogeneous network paradigm, the system as a whole ensures that all peers have a copy of the system-wide data that is required to support the expected features and services. The system-wide data includes each peer's ID, IP address and UDP port number. Every peer designates a UDP port on which it sends/receives the IP Site Connect traffic (both data and audio packets). This port number is determined by the peer at power-up and will not change as long as the peer remains powered up. This port number will be conveyed to other peers as part of the link establishment procedure. When a peer sends a data or audio packet to another peer, it sends the packet to this UDP port number.

A peer stores the IP addresses and port numbers of other peers. Table 1 depicts a snapshot of the map table from the Master Peer perspective from Figure 1 – when all links are established through the discovery algorithm and are in active state.

Peer ID	IP Address	Port Number
1	192.168.4.9	5400
2	192.168.21.5	3500
3	192.168.65.3	5400
4	192.168.45.15	2400

Table 1 - Peer-IP Address Map

There are two fundamental kinds of services supported in the IP Site Connect system – group and individual. Group services are directed at multiple recipients, for example, a group voice call. Individual services are directed at only one recipient, for example, an individual voice call. In either case, the peer does not track the presence of subscribers and talk groups on other peers. The peer just sends a copy of the voice / data message to all the other peers.

2.3 Recommended Router

Although MOTOTRBO repeater system will work through most off-the-shelf network devices, the following three router/NAT/firewalls have been validated and are therefore suggested for use:

- D-Link - EBR-2310
- CISCO - PIX 501

MOTOTRBO repeater system supports the ability to work through a Secure VPN (Virtual Private Network). It is important to note that VPN does add the need for additional bandwidth and may introduce additional delay.

There are different router requirement per the system type (IPSC, Capacity Plus or Linked Capacity Plus), network type (VPN or not), same subnet for the repeater network

based applications or not. The following list specifies the router requirement per system type.

Single Site, IPSC, Capacity Plus, and Linked Capacity Plus Systems:

- Hair pinning (NAT"[1] Loopback) router is **required** when the repeater network based applications (e.g. RDAC, MNIS or Call Monitoring) are installed on the same subnet or running on the same machine. Because the applications are using their external IP address from the Master Peer's system map to establish LE connection.

IPSC System:

- Hair pinning (NAT Loopback) router is **not required** for the subnet when the IPSC repeaters and repeater network based applications are connecting into the same subnet using VPN
- Hair pinning router is **required** for the subnet when VPN is not used, and more than one repeater network based applications *(such as MNIS, RDAC, or Voice console)* or repeaters are at the same subnet.

Capacity Plus System:

- Hair-pinning router is **not required** for the subnet when all the repeater network based applications and the repeaters are in the same subnet
- Hair-pinning router **is required** at the repeater subnet when the repeater network based applications are deployed on a different subnet.
- Hair-pinning router **is required** at a non-repeater subnet with more than one repeater network based applications.

LCP System:

- Hair-pinning router **is not required** at the Master repeater site when the repeaters have firmware beyond R2.2 and all the repeater network based applications and the repeaters are in the same subnet as the Master repeater. The non-Master repeater sites do not require hair-pinning routers. The UDP ports used by the applications must not be same as used by the repeaters at the same site.
- Hair-pinning router **is required** at non-Master repeater site when one or more repeater network based application is deployed at the non-Master repeater sites.
- Hair-pinning router **is required** at the non-repeater subnet with more than one repeater network based applications.

Please note LCP repeaters at the same site communicate using LAN broadcast address. If the repeater network based applications are deployed in the same LAN, they

[1] Basic NAT provides translation for IP addresses only (not the UDP port) and places the mapping into a NAT table. In other words, for packets outbound from the private network, the NAT router translates the source IP address and related fields (for example, IP, UDP, and ICMP header checksums). For inbound packets, the NAT router translates the destination IP address (and related checksums) for entries that it finds in its translation table.

become recipient of the repeater broadcast messages. This factor may impact the 3rd party applications (such as recording or data applications) performance. The MNIS and DDMS are known to work normally when deployed in the same LAN as the LCP repeaters. The 3rd party application **must** not generate the LAN broadcast traffic, which may affect the repeaters operation.

See Reference [4] section 4.8.3 Considerations for the Backend Network for detailed information on network bandwidth consideration and planning.

3.0 Link Establishment Protocol Introduction

The Link Establishment Protocol is for a MOTOTRBO station (repeater or application)to join or leave the MOTOTRBO repeater System. The LE protocol became available on the MOTOTRBO Repeater as of System Release 1.4.

3.1 Peer discovery and Protocol Stack

In each IP Site Connect system or Capacity Plus system or the Linked Capacity Plus System, one of the MOTOTRBO repeaters must be configured as the Master repeater. A static IP address is required for the Master repeater. The static IP address and the UDP port number where the Master repeater is listening for LE message are provided for all other peers in the system.

Each time a peer joins the system, it sends out a Link Establishment (LE) registration message encapsulated in the UDP/IP packet to the Master peer. Figure 5 shows the protocol stack for the LE message. For details, refer to section 4.0. Once the Master peer accepts the peer's LE registration message, it adds the new peer's information into its system map table. The table contains the existing peers' IP addresses, UDP port numbers, services provided, signal mode, and wide area time slot assignments. The Master peer sends the updated system map table to all the existing peers. The same sequence is applied when the peer's IP address is changed after it joins the system. For example, in Linked Capacity Plus System, the third party application can join the LCP by registering the master peer and get the system map which includes both the external UDP/IP address of all the repeater peers and the site IP address of all the sites. Using the UDP/IP address of the repeater peers provided in the Map, the third party application registers with the interested repeater in any site and keep alive with them through the repeater interface. If the 3rd party application only registers for monitoring service, the site peer can be ignored. After joining the system, repeater peers will also get the updated system map and try to register with the third party application and keep alive to make site firewall open. For detailed message sequence, refer to Section 3.2.1 in this document.

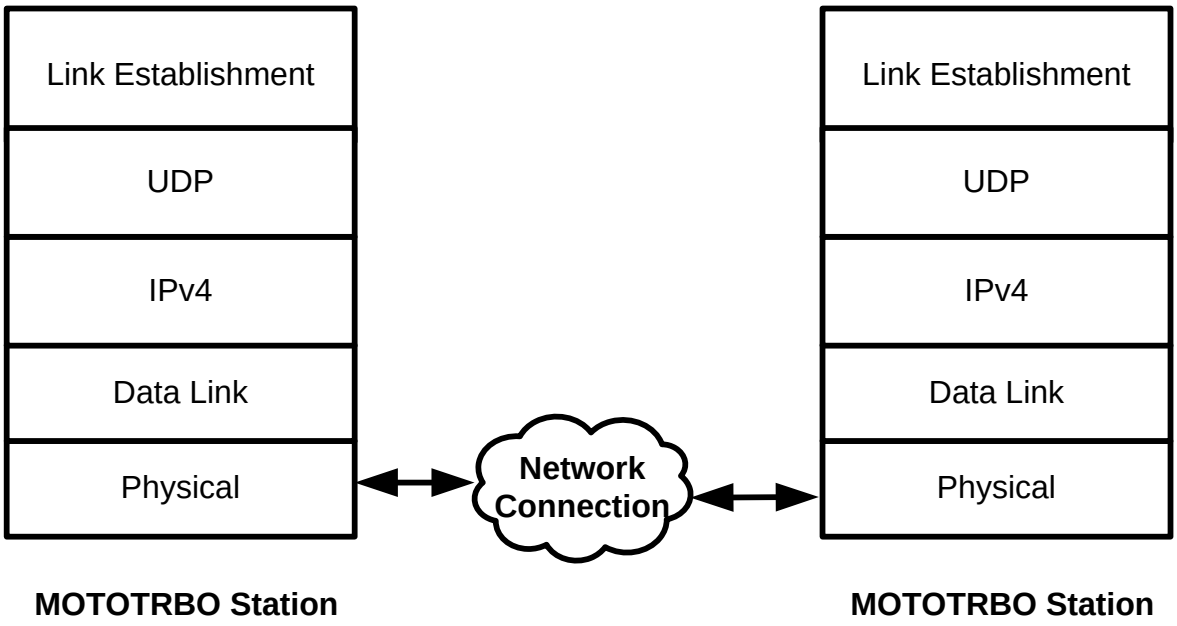


Figure 5: Protocol Stack of Link Establishment

The MOTOTRBO repeater in IP Site Connect mode can belong to one IP Site Connect system at one time. The MOTOTRBO repeater in Capacity Plus mode can belong to one Capacity Plus system at one time. A third party application becomes a peer in different IP Site Connect systems or Capacity Plus systems or a Linked Capacity Plus System at the same time when it can communicate with the Master peers through their different static IP addresses and port numbers. Pay attention that repeaters in Capacity Plus mode are not compatible with repeaters in Linked Capacity Plus mode. They are working in different systems. A repeater can only be a peer in either an IP Site Connect system, Capacity Plus system or Linked Capacity Plus system. It cannot join two systems at the same time.

The MOTOTRBO repeater system has no centralized control component, and is expected to function with the absence of any peer including the Master peer. After joining the system, each peer is required to maintain the links between all other peers in the system (including the Master peer) by periodically sending a LE Keep Alive Request message, and reply to the LE Keep Alive Request message from all the other peers. With that, each peer always has its own updated list of active peers in the system.

Having the peers send the LE Keep Alive messages to each other opens the peers' firewalls or routers. The peers may be behind routers as shown in Figure 6. For successful communication between two peers (Peer 1 and Peer 2), the router of Peer 1 must be open for messages from Peer 2 and vice versa. The Master peer's IP address is static. All other peers' IP addresses are dynamic. It is difficult to manually configure the routers for each peer. The router or firewall remains open for a period of time to receive messages from a source after it sends a message to that source, or keeps the

port open for incoming traffic after it sends a message from that port. Because of that, the periodic LE Keep Alive messages between the peers overcome the firewall blocking problem.

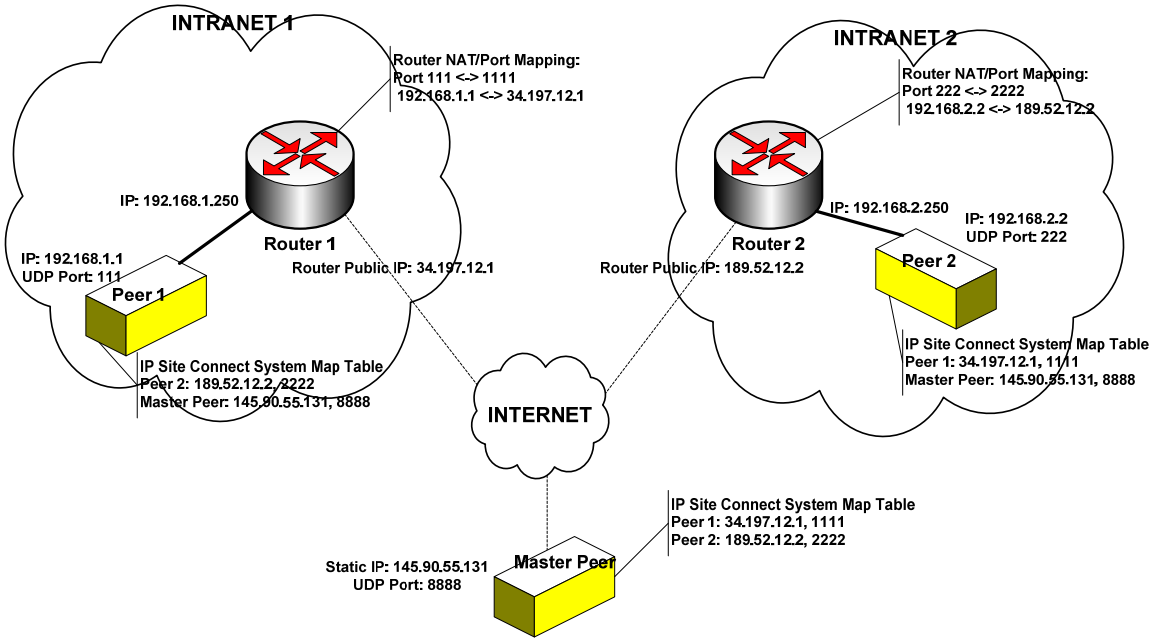


Figure 6: IP Site Connect system Connected through Router

Starting from R2.2, it is not required that both the application peer and the repeater peer send periodic keep alive request message as long as one of them is sending the keep alive request and the other party responds to the keep alive request.

3.2 Linked Establishment Procedures

This section presents the Linked Establishment procedures. This is accomplished via a series of scenarios presented as Message Sequence Charts.

3.2.1 Join Repeater System

The application peer uses the LE_MASTER_PEER_REGISTRATION_REQUEST and LE_MASTER_PEER_KEEP_ALIVE_REQUEST to register service with master peer , and uses the LE_PEER_KEEP_ALIVE_REQUEST to register service bit with other peers.

The application peer needs to register and maintain the LE connection with all the repeater peers including the data revert repeater peers. It also needs to register and maintain the LE link with all the RDAC peers, MOTOTRBO Network Interface Service (MNIS) peers to avoid the unnecessary peer re-discovery and system map broadcast messages.

3.2.1.1. Join IP Site Connect System/Single Site Conventional system

The peer must join the system before it can communicate to all other peers. The message sequence for the first peer to join the system is different from that for all other peers. The following use case explains the difference.

Use Case: Peer A as the first peer joins the IP Site Connect system. Peer B keeps trying to join the system while Peer A's registration is in progress. Appendix B: provides an example message trace for the first peer to join the IP Site Connect system.

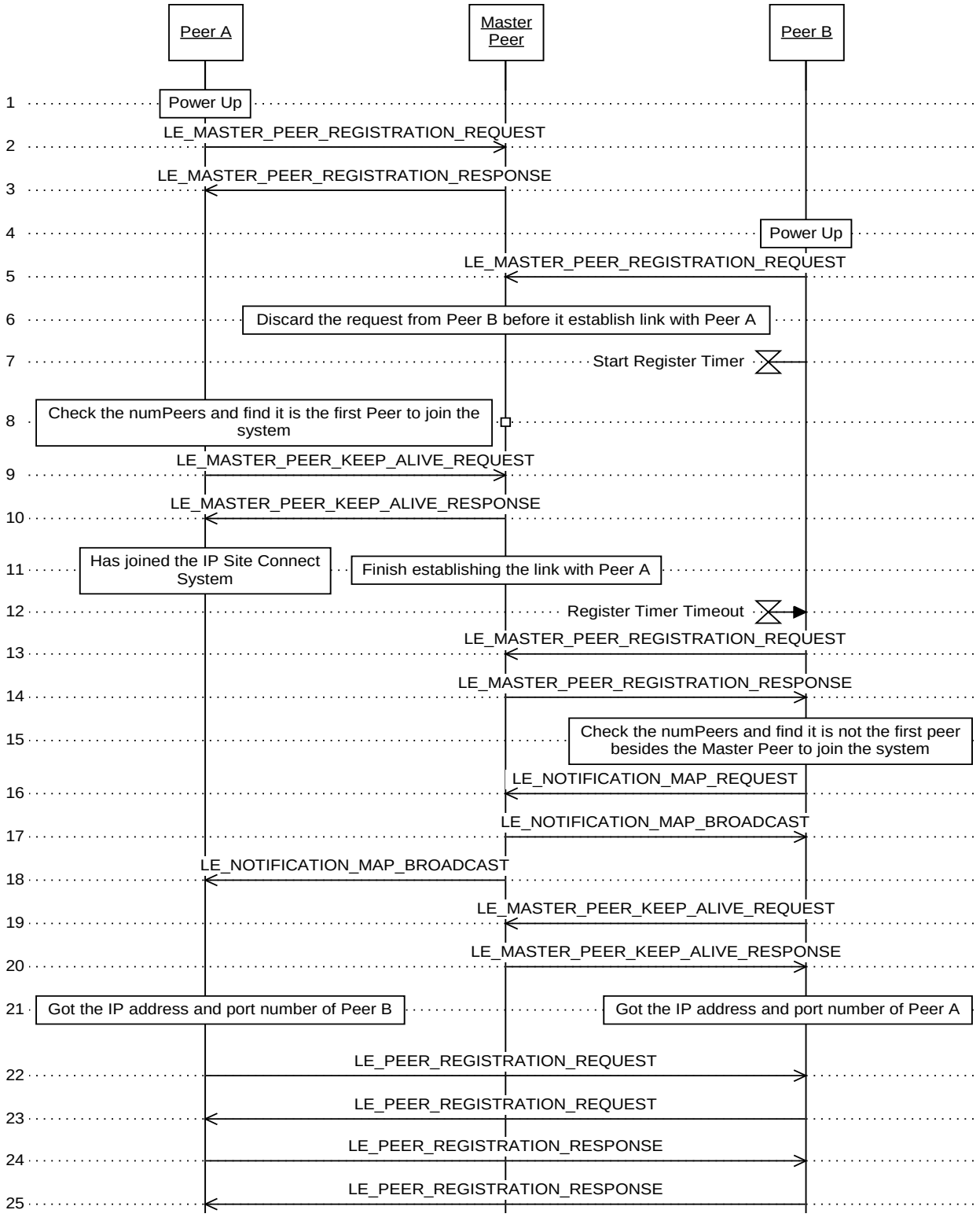


Figure 7: Join the IP Site Connect System

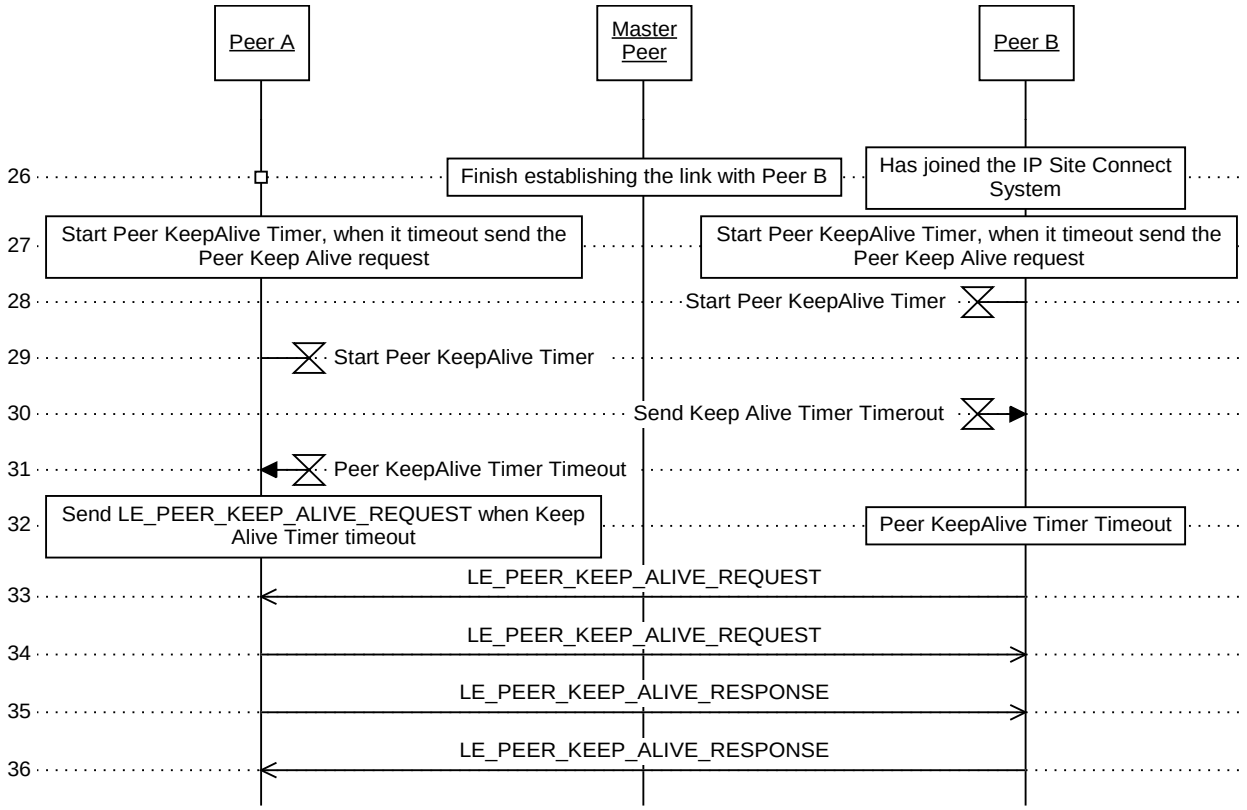


Figure 8: Join the IP Site Connect System (Continue)

3.2.1.2. Application Join Capacity Plus System

Application joins the Capacity Plus system using the same Link Establishment Protocol as the repeater peers in the IP Site Connect system. The same Rest Channel IP address and Port are configured in all the repeater peers in the system. Refer to Section 5.3.3 of this document for the Rest Channel IP address and Port configuration. The movement of the Rest Channel is transparent to the third party application.

The third party application shall also establish connection with the Site Peer.

Note: After power up the repeaters in the capacity plus system, it will take 1-2 minutes for the repeaters to decide the rest channel repeater. Therefore even the Master Peer accepts the LE registration from the application during that time, it only sends out the system map with the Site Peer (peer ID of 0x00) after the systems start up for 1-2 minute. In the LCP system, besides the 1-2minute delay, there is additional 15-second delay before the master peer sends the system map with the site peer. Application should eventually establish link with all the peers in the system including data revert repeaters.

340 The application peer shall register for the "Remote 3rd Party Console Application"
341 service in the LE messages with all the interested repeater peers. The application peer
342 shall register the same service with all the repeater peers in the Capacity Plus system.

343 Use case: Application joins the Capacity Plus system and maintains link with peers.

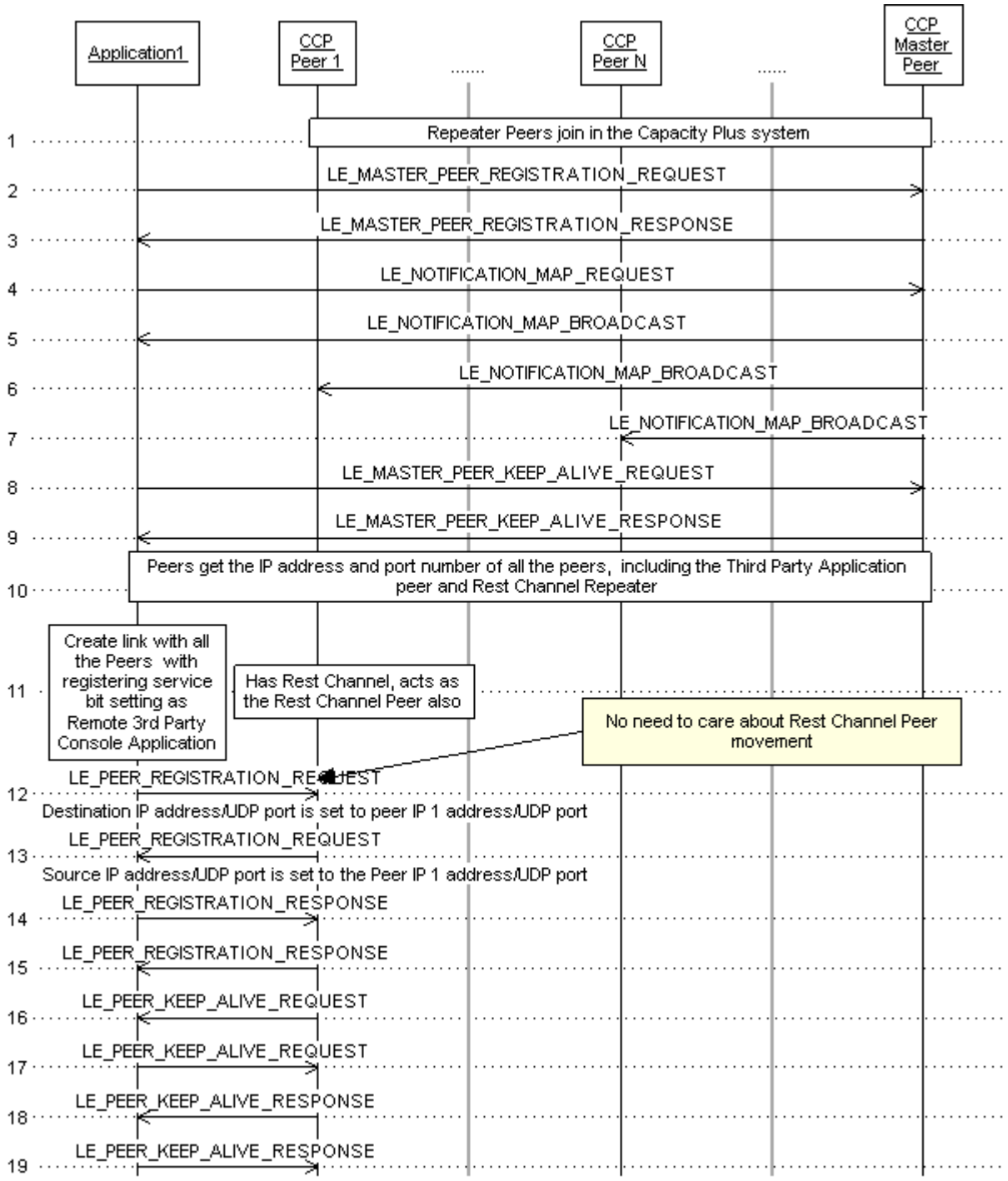


Figure 9: Application Joins Capacity Plus System and maintain link with Peers(Continue)

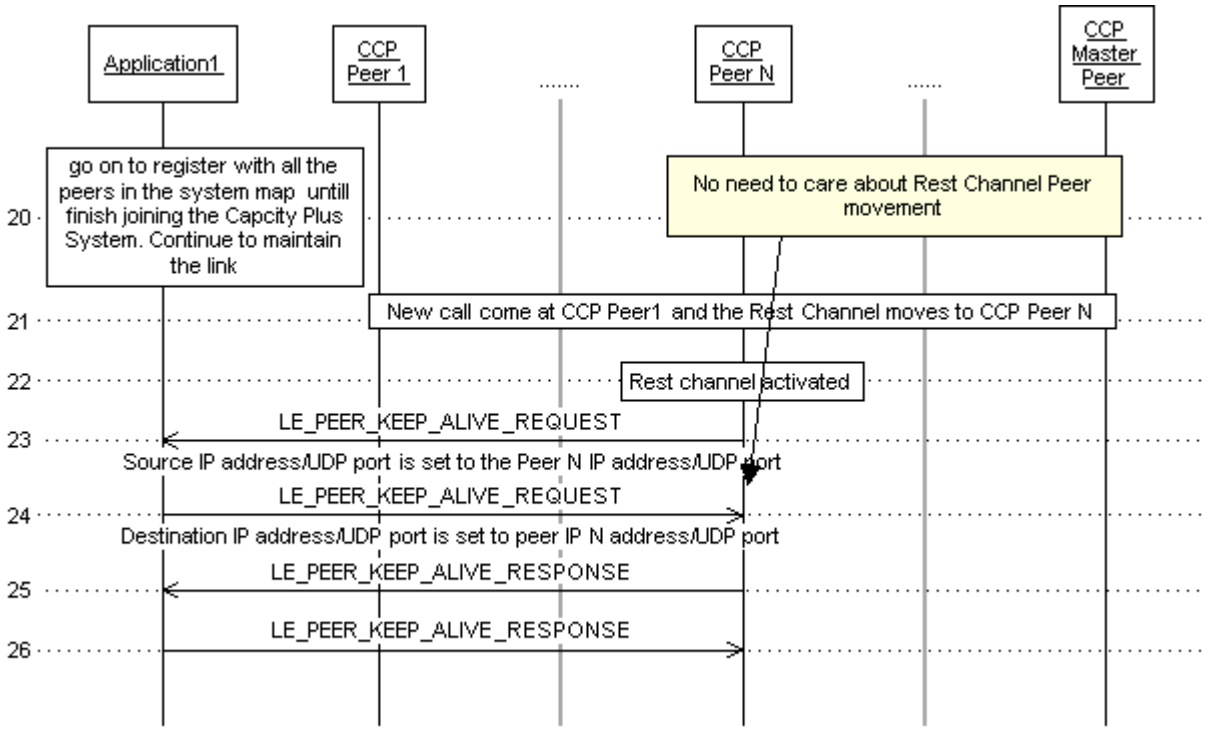


Figure 10: Application Joins Capacity Plus System and maintain link with Peers

3.2.1.3. Application Join Linked Capacity Plus System

Application joins the Linked Capacity Plus system using the same Link Establishment Protocol as the repeater peers in the IP Site Connect system (Refer to Figure 7). Application should eventually establish link with all the peers in the system including data revert repeaters. Application registers with each of the peers in the system map. The application also sends periodic Keep Alive messages to all the peers in which the application is interested in. Similarly, a peer also sends periodic Keep Alive messages to the application. These Keep Alive messages keep the communication path between the applications and the peers open.

The third party applications shall also establish connection with the Site Peers.

Use case: Application Join Linked Capacity Plus System and Maintain Link with all the Peers.

Note: If application is the first peer which registers with master peer, or master peer is busy and cannot respond, refer to Peer A/Peer B behavior in Figure 7: Join the IP Site Connect System.

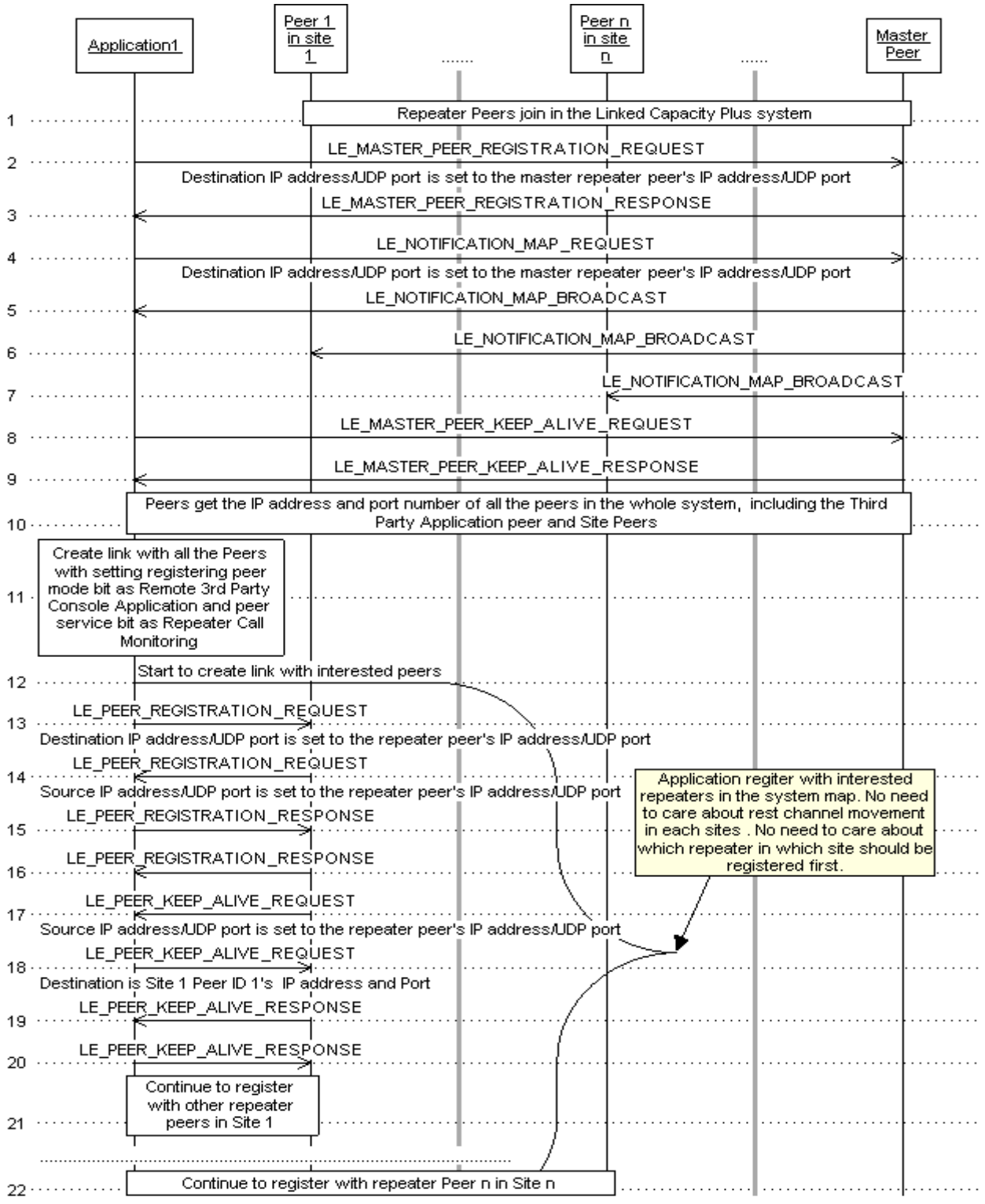


Figure 11: Application Joins Linked Capacity Plus System and Maintains Link with the all the Peers(Continue)

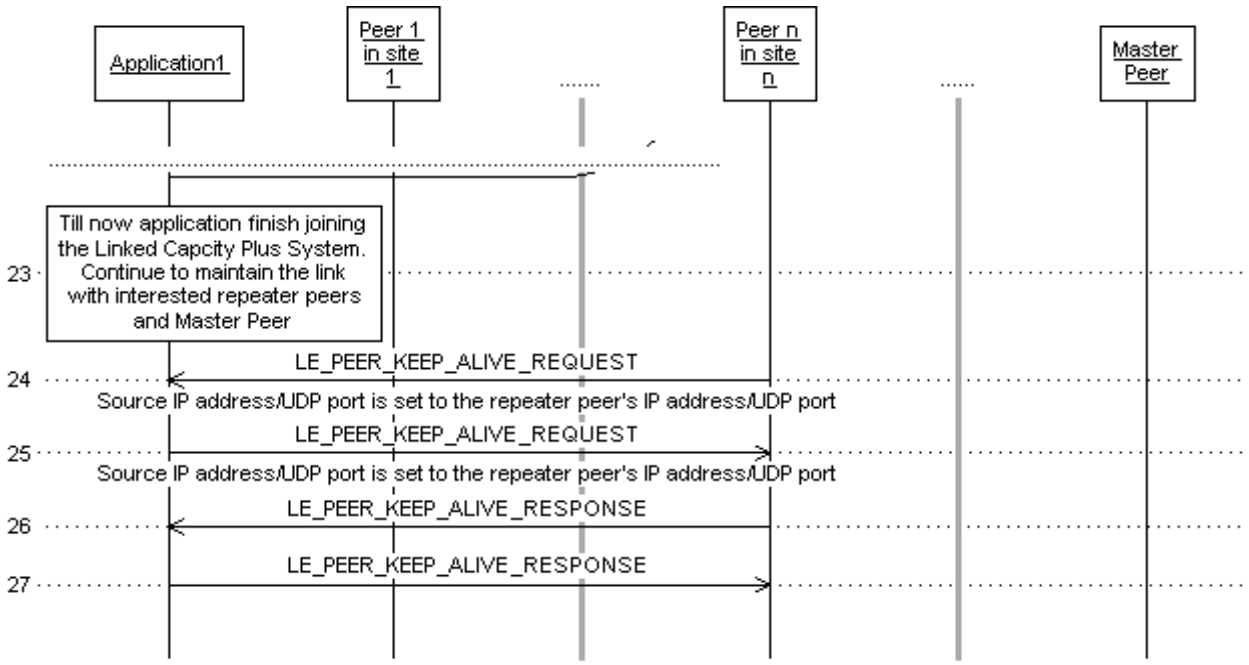


Figure 12: Application Joins Linked Capacity Plus System and Maintains Link with the all the Peers

3.2.1.4. RDAC Application Join Digital Voting System

RDAC Application connects with all voting repeater using the same Link Establishment Protocol as with the repeaters in the non-digital voting system.

The Voting Peer indicates itself as a digital voting capable repeater in the LE Registration message. After registering with the Voter Peer, the RDAC Application sends the LE_NOTIFICATION_MAP_REQUEST to Voting Peer to get the Voter Map. The Voter map contains IP addresses and port numbers for all the Satellite Receivers associated with this Voter Peer. The RDAC Application registers with each of the Satellite Receivers in the Voter map. The RDAC Application also sends periodic Keep Alive messages to Satellite Receivers. Similarly, the Satellite Receivers also send periodic Keep Alive messages to the RDAC application.

Use case: RDAC Application Join Digital Voting System and Maintain Link with all the Peers.

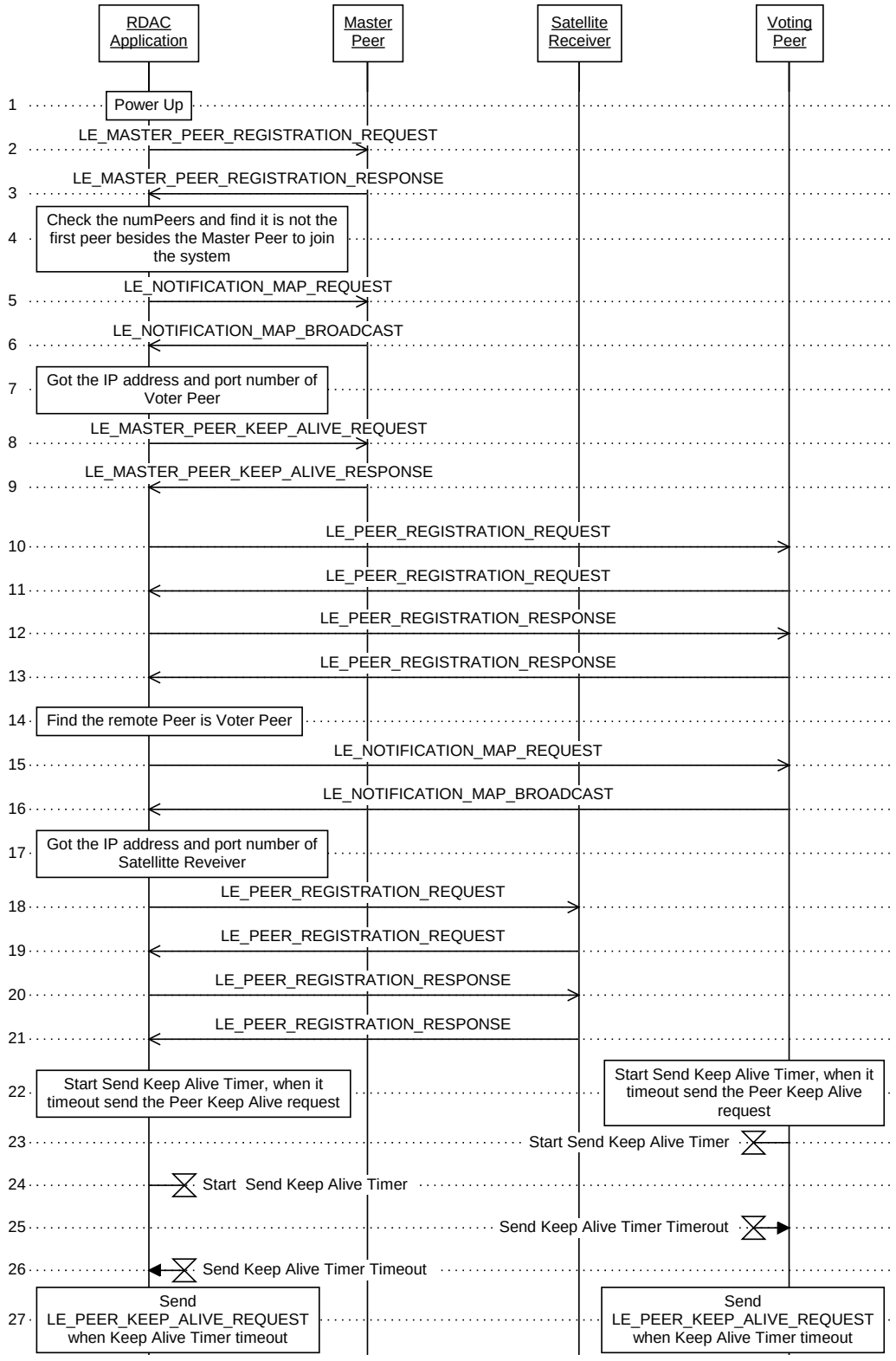
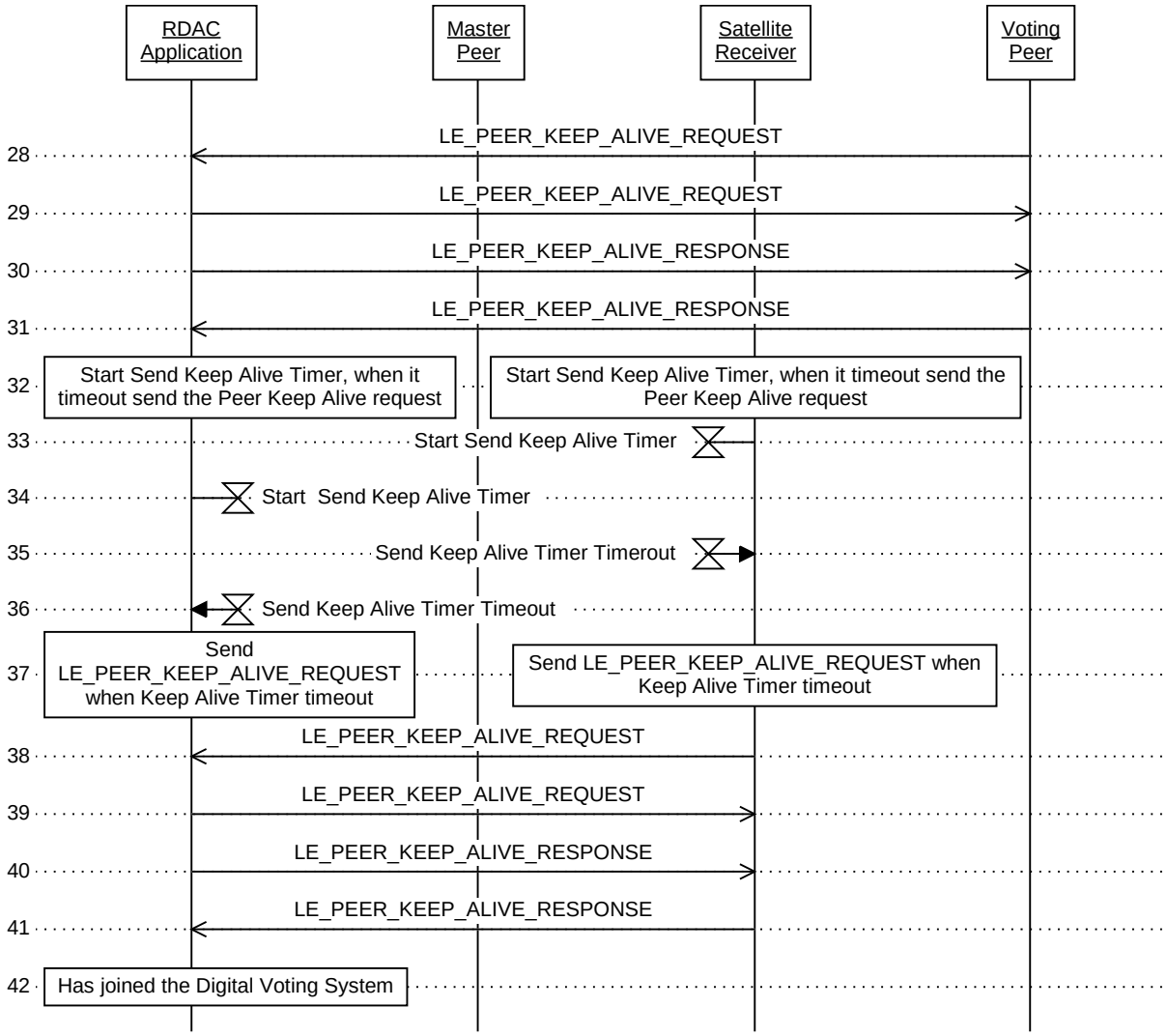


Figure 13: RDAC Application Joins the Digital Voting System



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387 **Figure 14: RDAC Application Joins the Digital Voting System (Continue)**

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3.2.2 Peer Status Change

A Peer can change its mode or service status. After finishing change, the Peer must be reset.

Use Case: Peer A changes its mode or service status.
System mode: Single site/IPSC/CPC/LCP/Analogue.

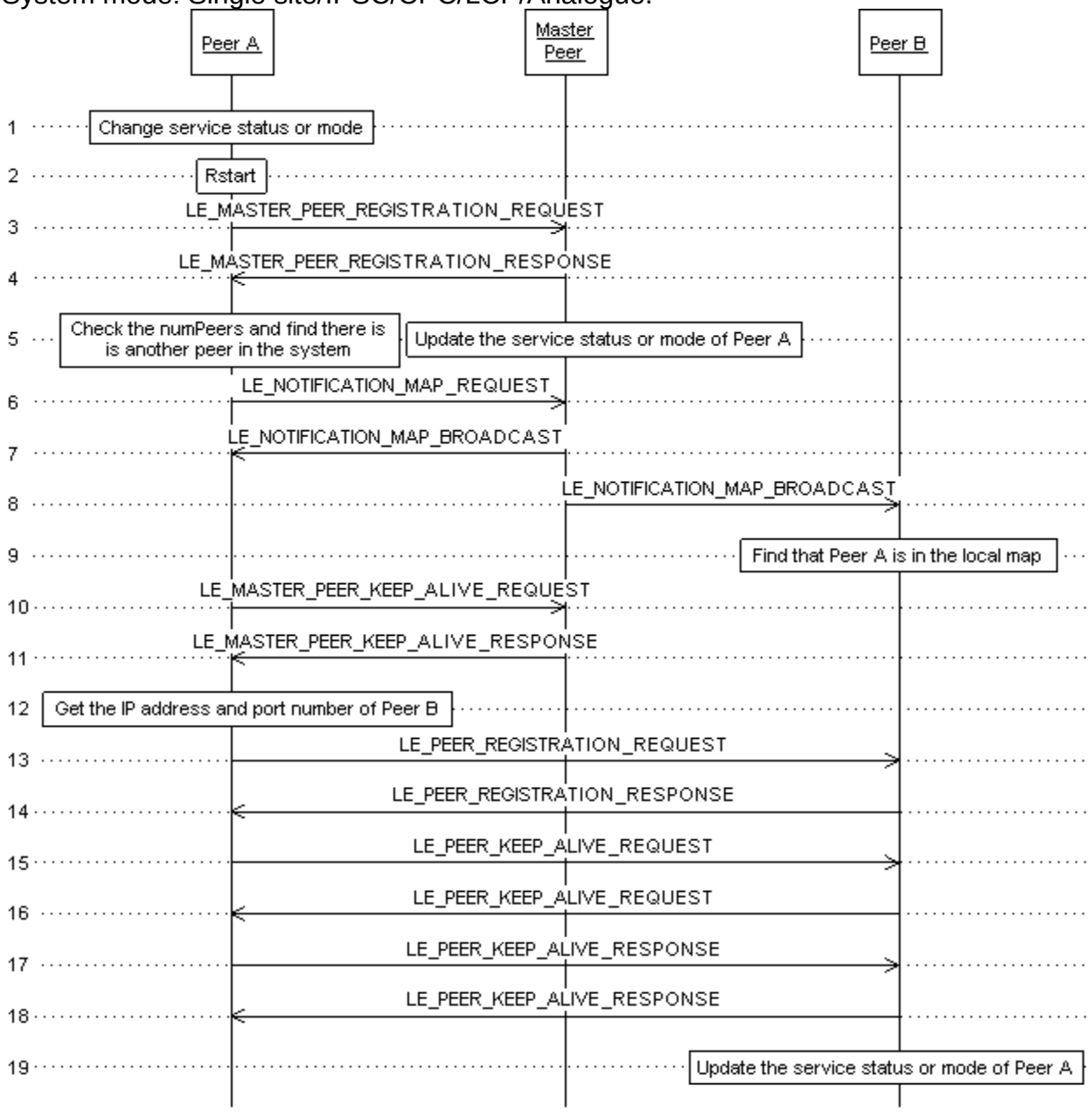


Figure 15: Peer's Mode or Status Service Change

3.2.3 Leave the System

A Peer has two ways to leave the repeater system - polite leave (only for a peer running on the PC) or impolite leave. The following two use cases illustrate the message sequences for the polite leave and impolite leave.

Use Case 1: Peer A leaves the MOTOTRBO Repeater System politely.

System mode: Single site/IPSC/CPC/LCP/Analogue.

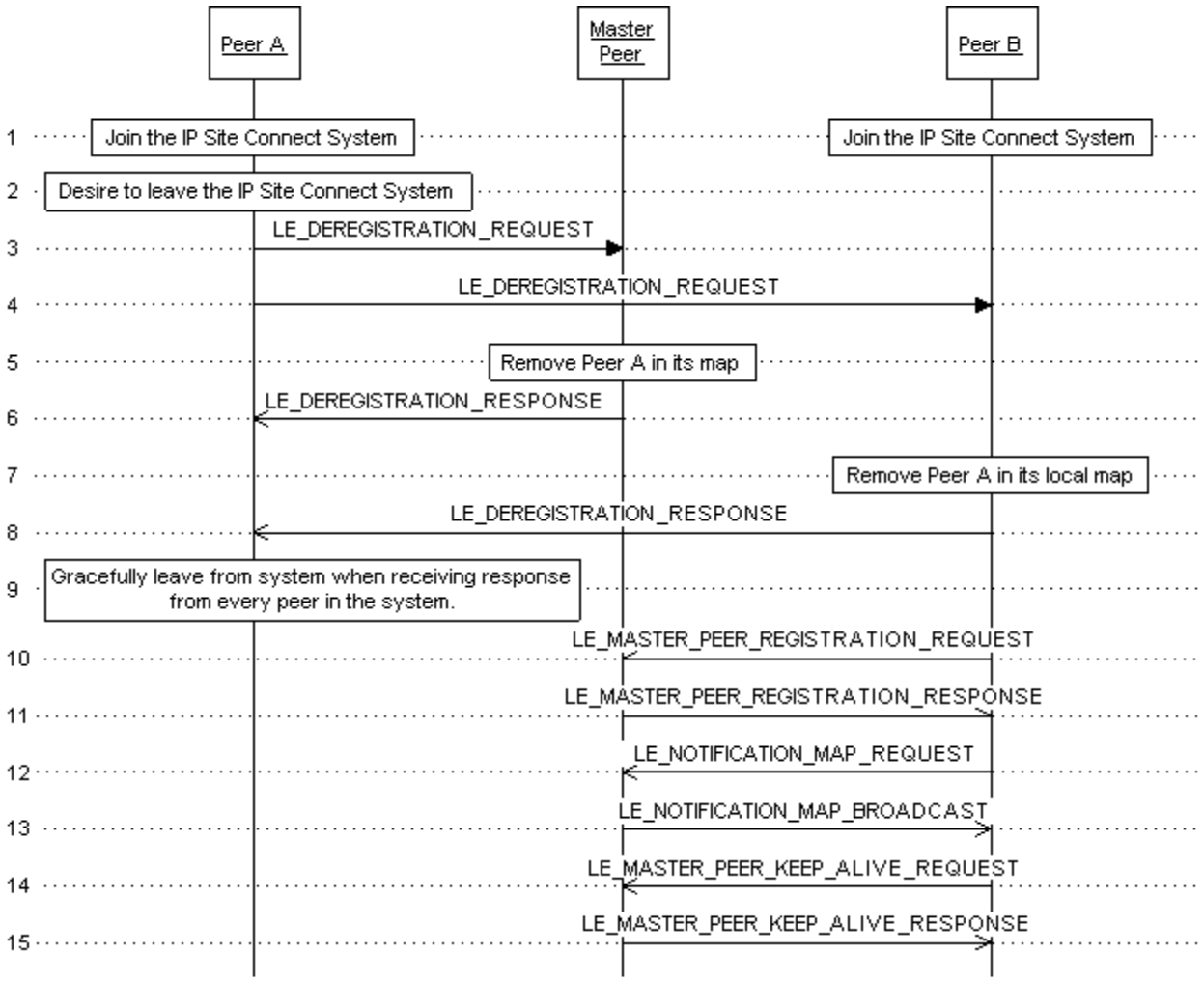


Figure 16: Peer Leave the Repeater System Politely

Use Case 2: Peer A leaves the repeater system impolitely.

System mode: Single site/IPSC/CPC/LCP/Analogue.

A periodic timer, called PeerKeepAlive Timer, with an interval of the Firewall Open Timer must be running in each peer. The Firewall Open Timer for the MOTOTRBO Repeater is configurable in the Customer Programming Software (CPS) with the range from 5 seconds to 60 seconds. The default value is 6 seconds.

Whenever the PeerKeepAlive Timer expires, if the peer does not receive the LE_PEER_KEEP_ALIVE_RESPONSE from a peer (say Peer B), and Peer B is not in the middle of transmitting a call over the repeater system network, a counter for Peer B's missing response is incremented by one; if Peer B is in the middle of transmitting a call, the counter for Peer B is set to 0.

When the peer receives the LE_PEER_KEEP_ALIVE_RESPONSE from Peer B, the counter for Peer B is set to 0. When the counter is not greater than a pre-defined number, which is equal to 60 seconds divided by the Firewall Open Timer, the peer continues to send LE_PEER_KEEP_ALIVE_REQUEST to Peer B. Otherwise; the peer considers the link to Peer B to be down and stops sending _PEER_KEEP_ALIVE_REQUEST to Peer B. See Figure 17, Figure 22 for detailed descriptions.

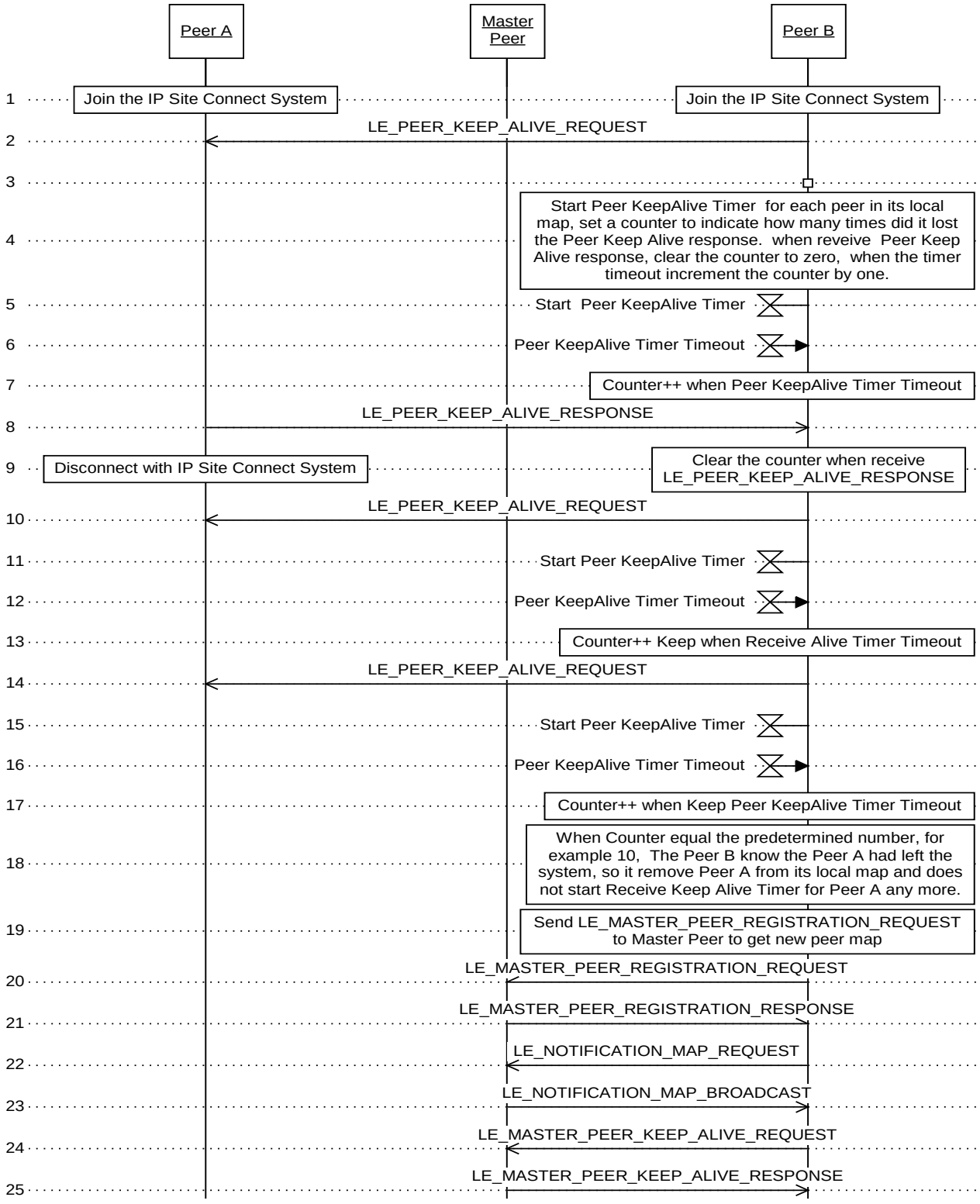


Figure 17: Peer Leave the Repeater System Impolitely

3.2.4 Master Recovery

The Master Peer encounters an error and powers down. The peers in the repeater system network can still communicate with each other even when they discover the Master Peer does not exist. But a new peer cannot join the repeater System without the Master Peer. When the Master Peer recovers, all the peers need to register to Master Peer again. However, the peers may not attempt to re-register with the Master Peer if the Master Peer is able to recover from the fault scenario before a peer notices the Master Peer being absent in the network.

A periodic timer, called MasterPeerKeepAlive Timer, is running in each peer.

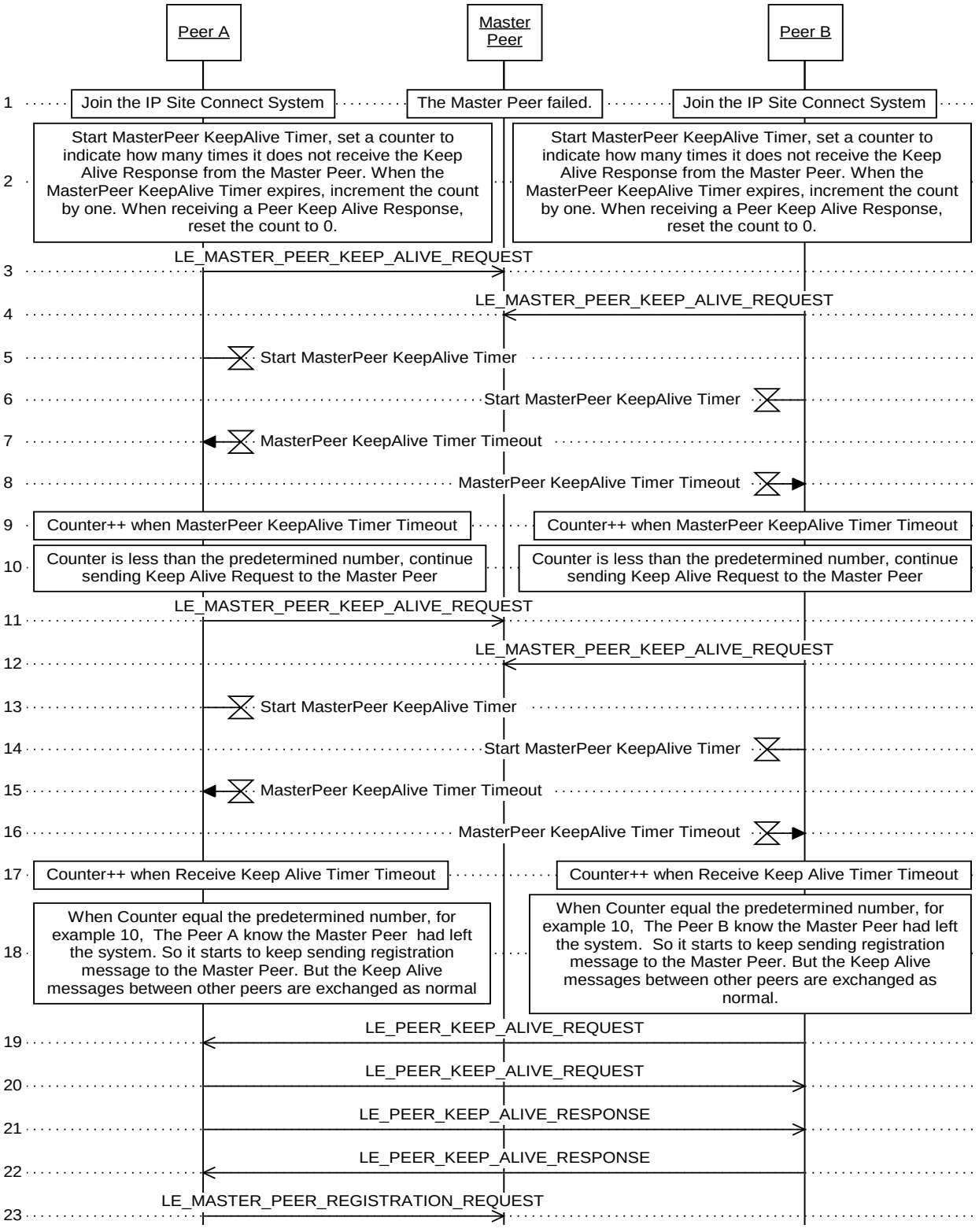
Whenever the MasterPeerKeepAlive Timer expires, if the peer does not receive the Keep Alive Response from the Master, and no call transmitted by the Master Peer is in progress, a counter for the Master Peer's missing response is incremented by one; if the Master Peer is not in the middle of transmitting a call over the repeater network, the counter for the Master Peer is set to 0.

When the peer receives the Master Keep Alive Response from the Master Peer, the counter for the Master Peer is set to 0. While the counter for the Master Peer is less or equal to a pre-defined number, which is equal to 3, the Peer continues to send LE_MASTER_KEEP_ALIVE_REQUEST to the Master Peer. Otherwise, it considers the link to the Master is down, stops sending the LE_MASTER_KEEP_ALIVE_REQUEST to the Master Peer, and starts sending the LE_MASTER_PEER_REGISTRATION_REQUEST until it receives the LE_MASTER_PEER_REGISTRATION_RESPONSE.

Use Case 1: The Master Peer recovers from the fault scenario after peers notice the Master Peer being absent in the network.

System mode: Single site/IPSC/CPC/LCP/Analogue.

Note: If the master peer cannot recover after line 25 in Figure 19, LE_MASTER_PEER_KEEP_ALIVE_REQUEST from all the peers cannot be handled by master peer so that a new added application or repeater peer cannot join the system. Specifically, a Linked Capacity Plus System will perform Graceful degradation: First, the system changes its mode of operation to "Multi-site Trunking without Master Peer". In this mode, the system continues to operate normally except that a repeater cannot join the LCP system. Secondly, in case of absence of messages from all other site's repeaters, a repeater assumes that its site is isolated and changes its mode of operation to "Single Site Trunking". Thirdly, in case of detecting failure of other repeaters at its site, a repeater assumes that it is isolated and changes its mode of operation to "Single Repeater Trunking".



463

464 **Figure 18: Master Recovery after Fault Detection by a Peer**

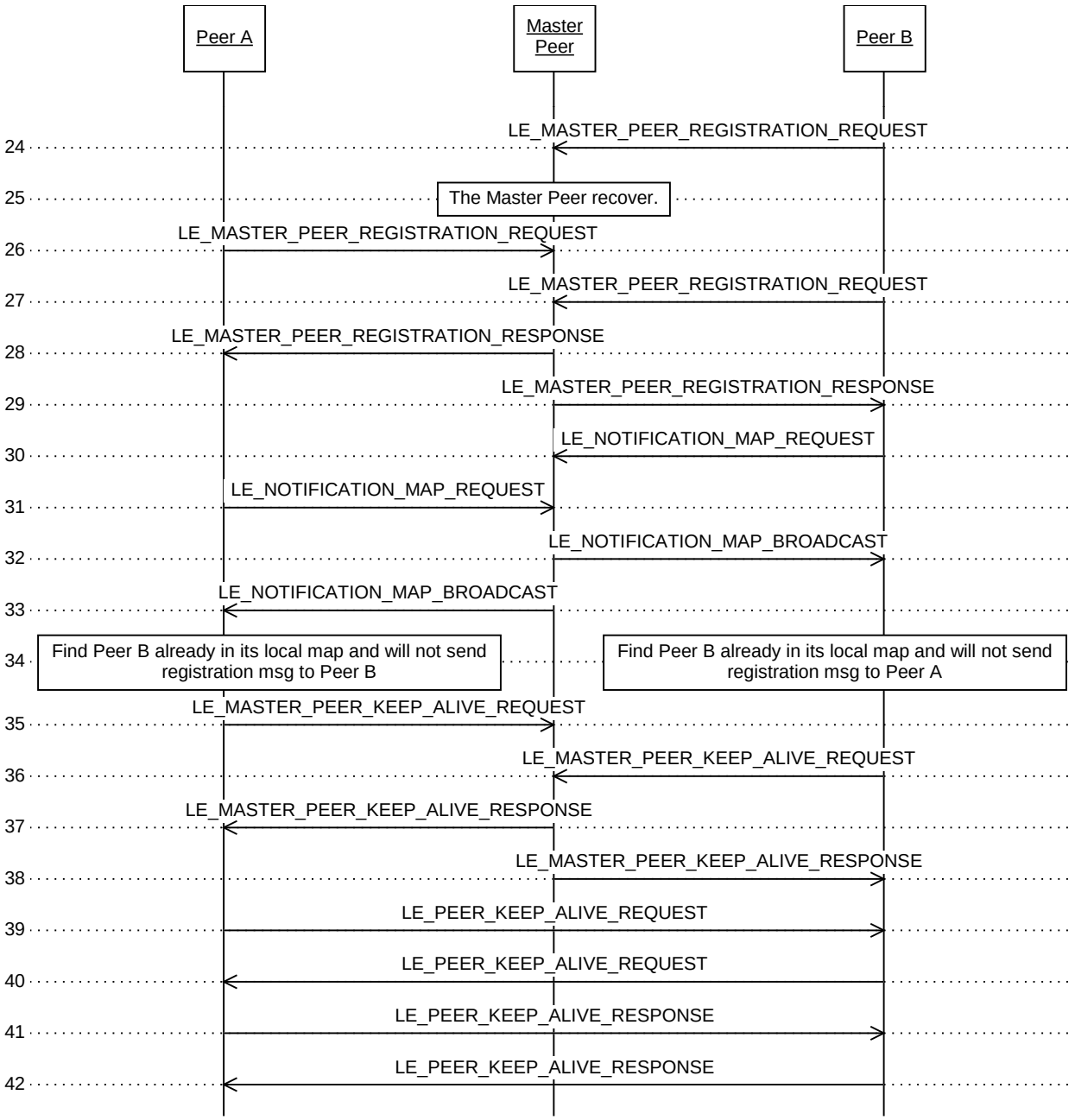


Figure 19: Master Recovery after Fault Detection by a Peer (Continue)

Use Case 2: The Master Peer recovers from the fault scenario before a peer notices the Master Peer being absent in the network.

System mode: Single site/IPSC/CPC/LCP/Analogue.

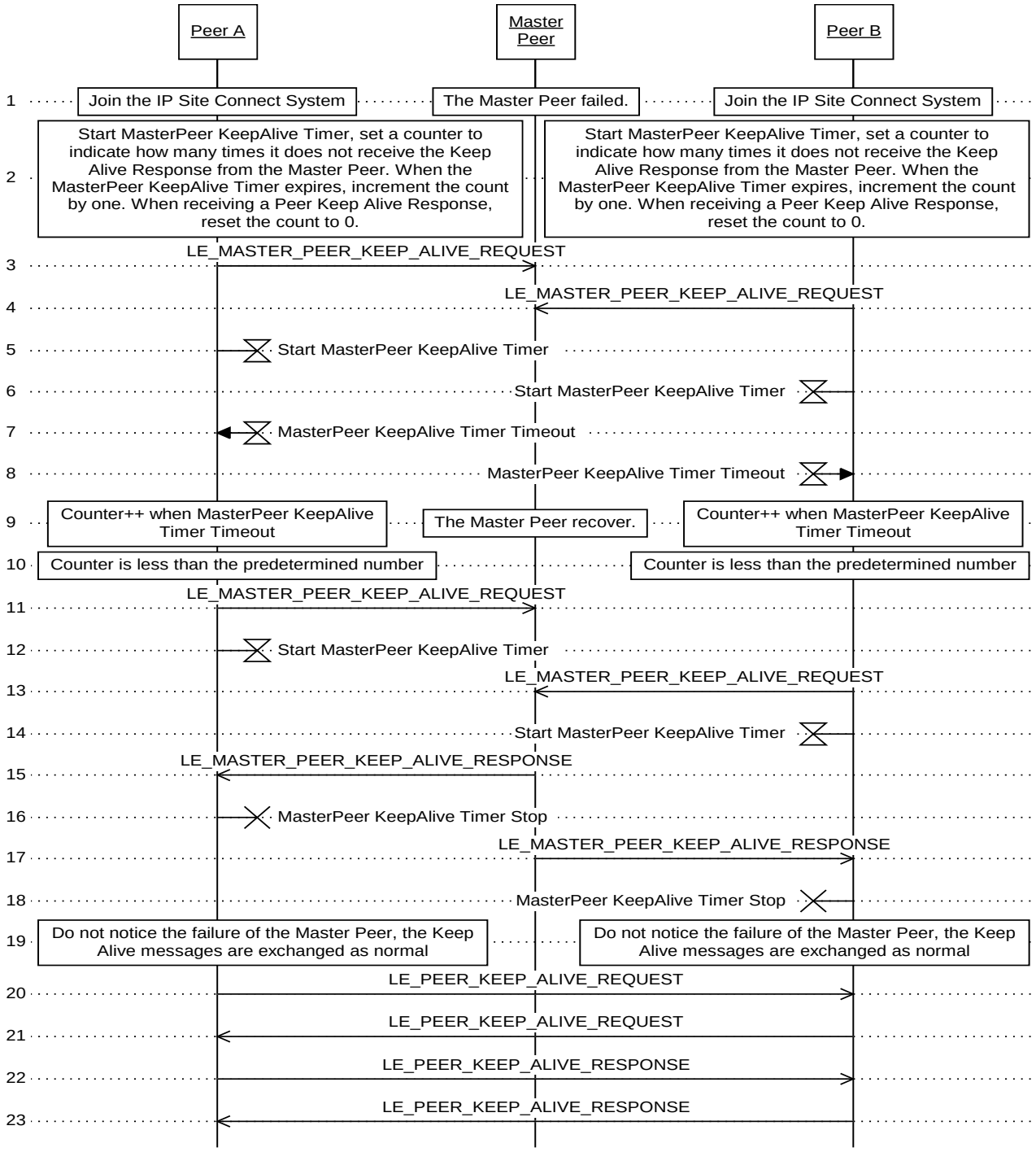
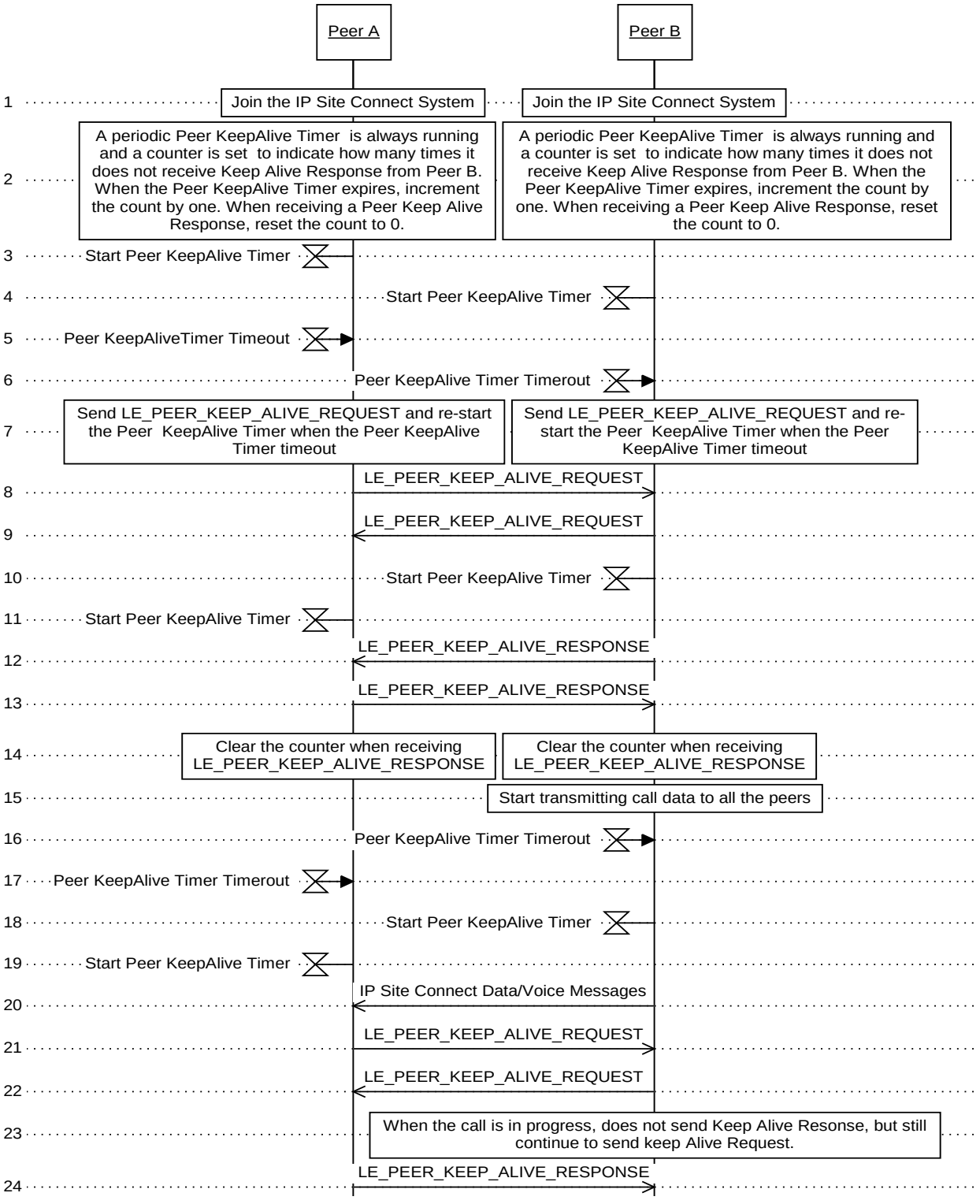


Figure 20: Master Recovery before Fault Detection by a Peer

3.2.5 Keep Alive Request/Response during a Call

When a call is in progress in the repeater system, the sending peer sends Peer Keep Alive Requests to the receiving peers, and the receiving peer sends Keep Alive Responses to keep their firewall open. The receiving peer sends Keep Alive Requests to the sending peer. But as long as the sending peer is transmitting the call, it does not send Keep Alive Response to the receiving peers.

Use Case: The Peer B transmits a call in the repeater system
System mode: Single site/IPSC/CPC/LCP/Analogue.



485

486 **Figure 21: Keep Alive Request and Keep Alive Response during a Call(Continue)**

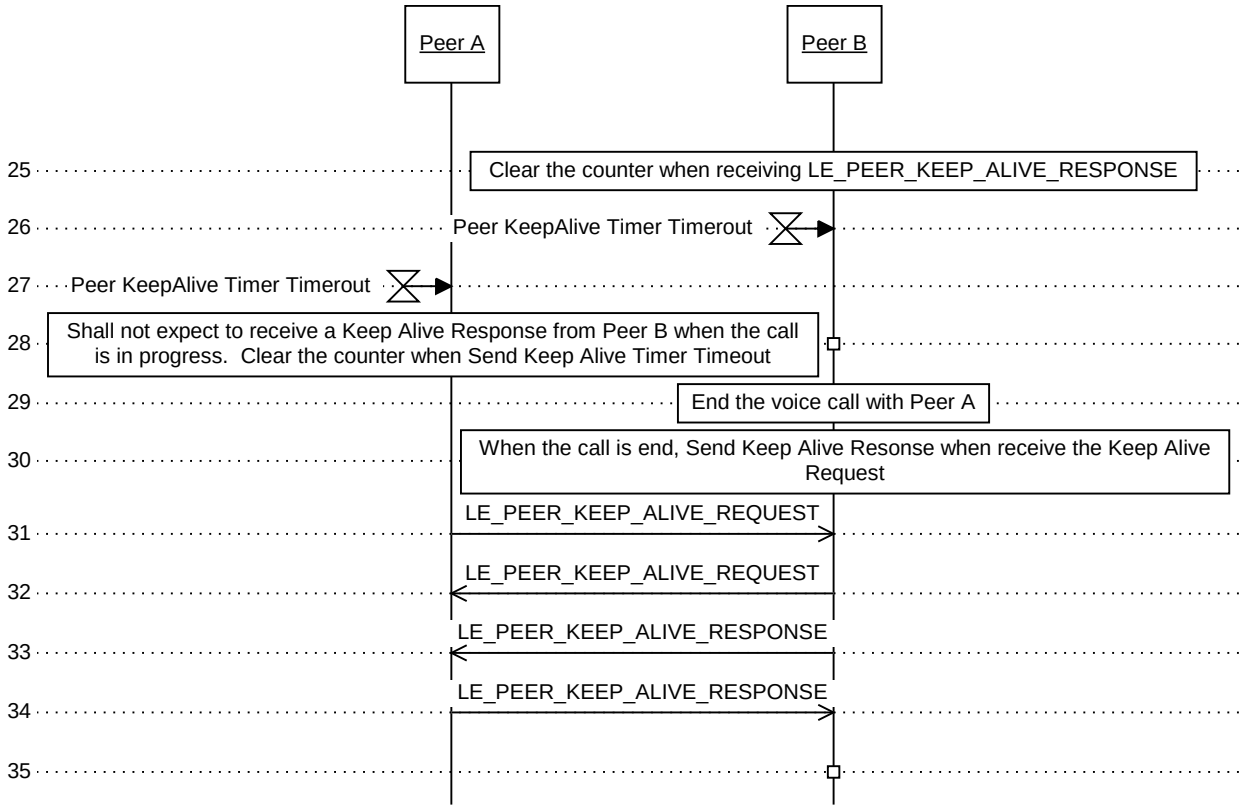


Figure 22: Keep Alive Request and Keep Alive Response during a Call

3.2.6 Peer lost and System map refreshed in Linked Capacity Plus System

Sometimes application or repeater peers may get failure to keep alive with other peers in the system.

Use Case 1: An application may leave the system directly by stopping to send the Keep Alive messages to the master and the peers. This will subsequently remove the application from the System Wide Map and the peers will stop sending Keep Alive to the application. For details, refer to Peer A behavior in Figure 17 in section 3.2.2 Use Case 2.

Use Case 2: An application may find that a repeater peer cannot response its keep alive messages. After some unsuccessful retrying, application considers that the peer is lost so that it initiatives request to master peer to send new system map. For details, refer to Peer B behavior in Figure 17 in section 3.2.2 Use Case 2.

Use Case 3: Peer lost can also be discovered directly by the master peer ,whatever lost peer is repeater peer or application peer. For example, when peer n in site n is powered down but application do not register with it, master peer can know the situation because Master Peer Keep Alive messages from this peer are lost. Thus Master peer initiates updating the system map and broadcasting to the system. All the peers including 3rd party application can get the latest system map by this way. This case is very simple and no special action is needed for 3rd party application except waiting(No reference figure).

3.2.7 Link Protocol Version Support

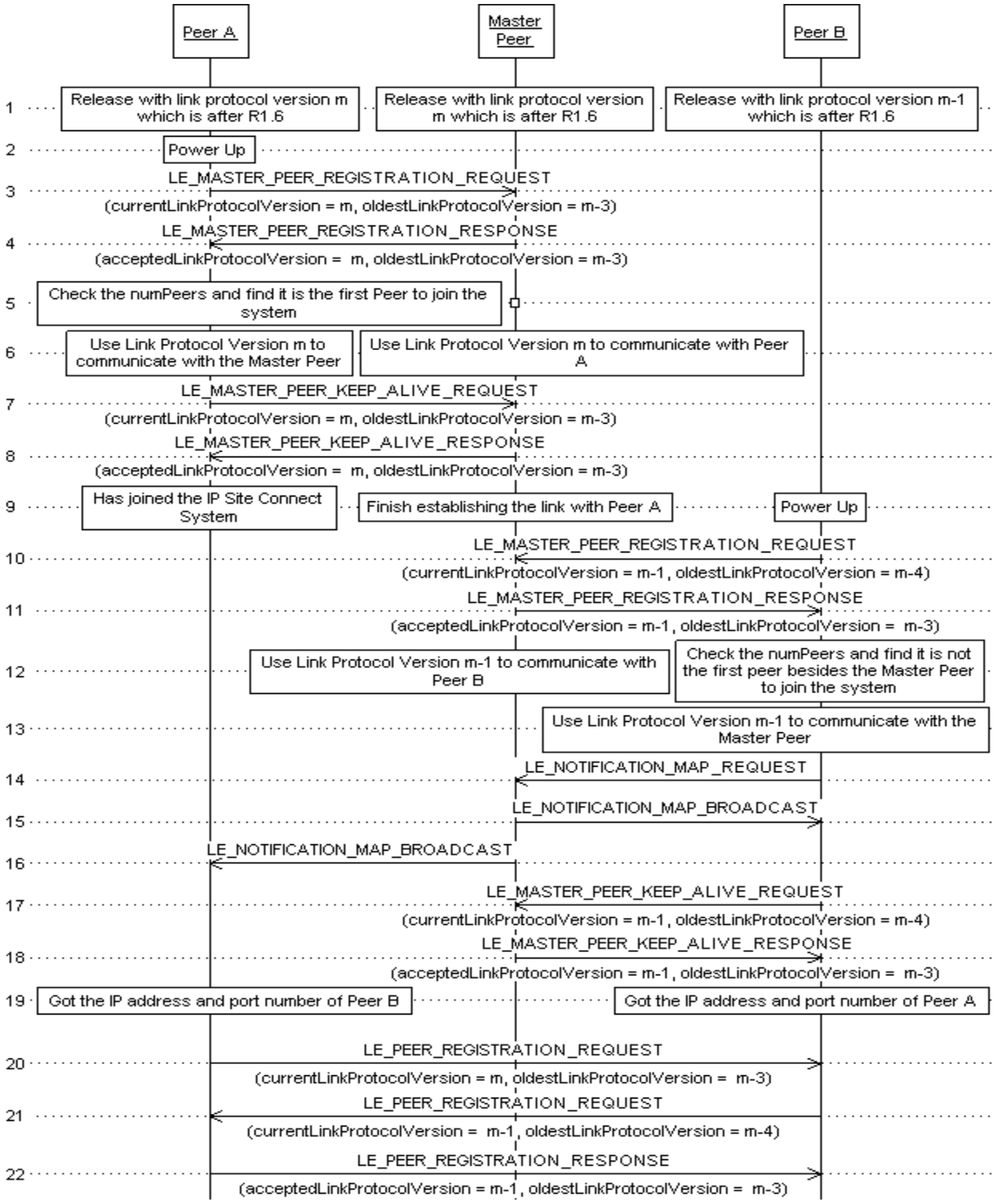
From MOTOTRBO R1.6, the Link Protocol Version is introduced in the Link Establishment protocol to support firmware backward compatibilities and identify the system type that the peers join.

The peers use the Link Protocol Version fields to communicate their supported protocol range and agree on a common version during link establishment. When the peers have the same current link protocol version, they choose the current link protocol version. When the peers do not have the same current link protocol version, they compare the versions. If the peer with the greater current link protocol version supports the smaller current link protocol version used by the other peer, both peers use the smaller current link protocol version for the LE communication between these two peers. If the peer cannot support the version range used by the other peer, it silently discards the LE registration message from the other peer.

When interoperating with the peers of pre-R1.6 firmware that do not have the link protocol version, the peer needs the intelligence to recognize them based on the message structure and uses the pre-R1.6 message structure to communicate with those peers.

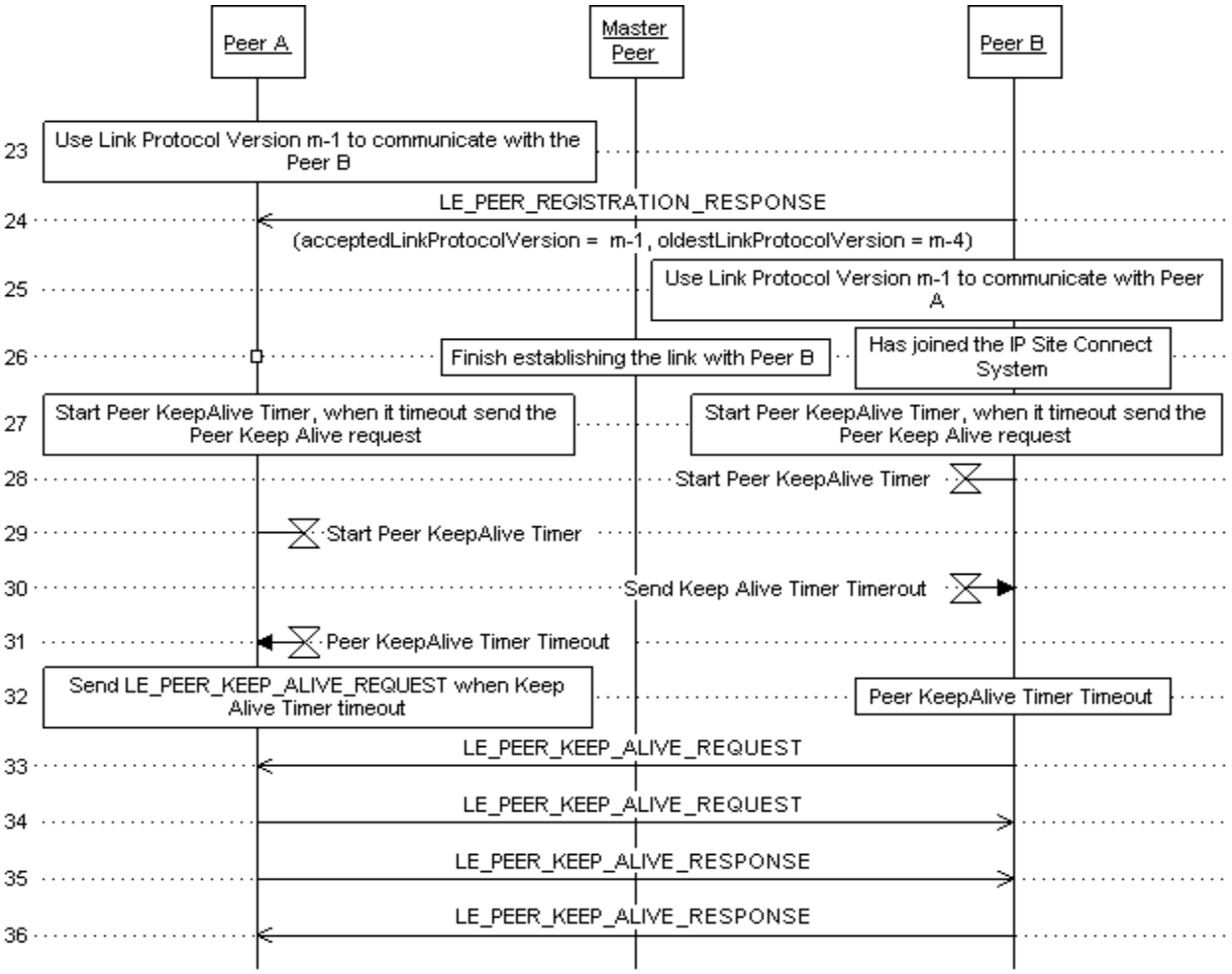
529 Below cases gives some of the sequence for Link protocol version negotiation. For
530 more details, refer to section 4.5 Link Protocol Version Support.

531 Use Case 1: Link protocol version negotiation between peers after R1.6



532

533 **Figure 23: Link Protocol Version Negotiation between Peers after R1.6**



534

535 **Figure 24: Link Protocol Version Negotiation between Peers after R1.6 (Continue)**

536

Use Case 2: Link protocol version negotiation when the Master Peer and other peer are at a release before R1.6

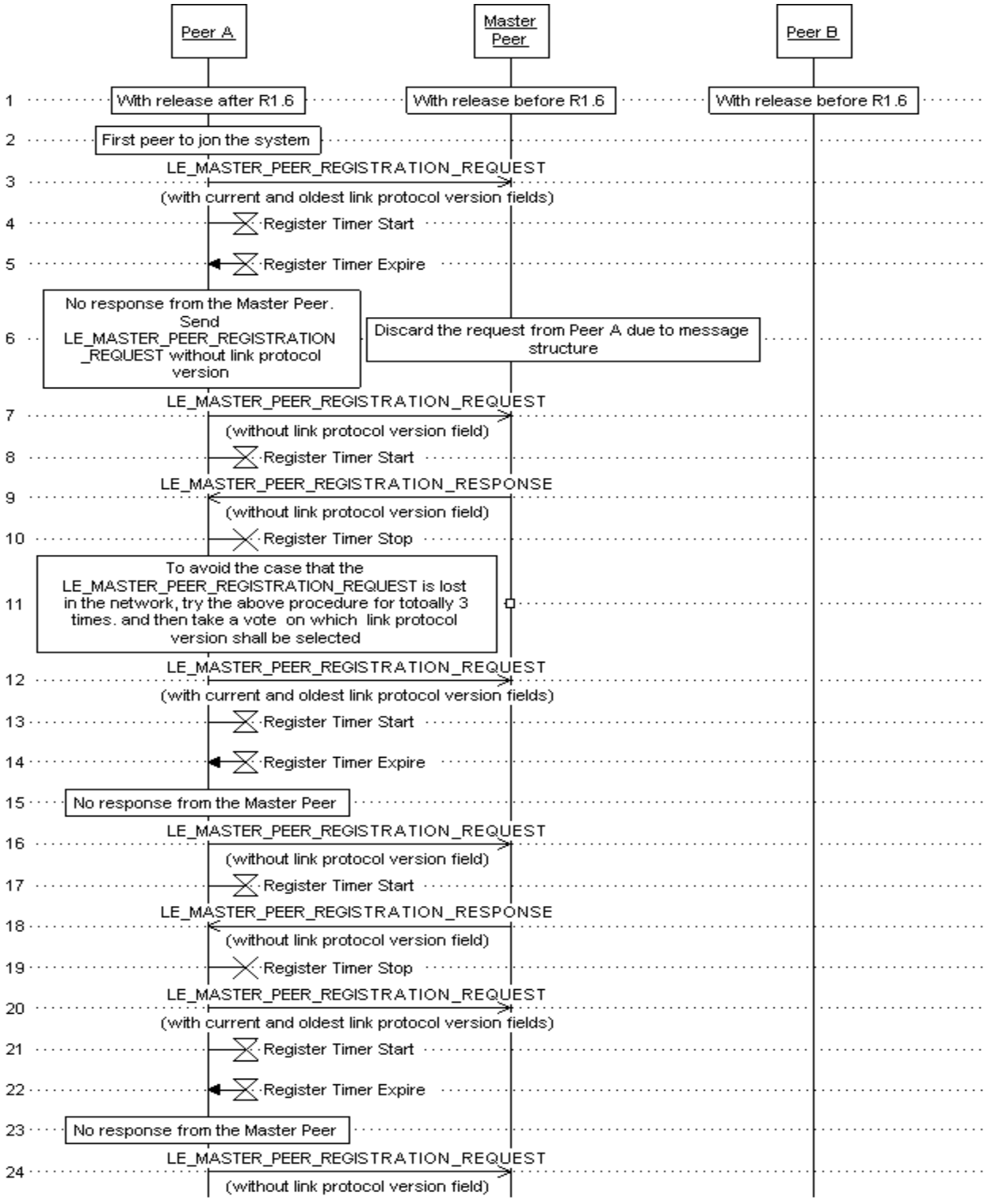


Figure 25: Link Protocol Version Negotiation with Peers before R1.6

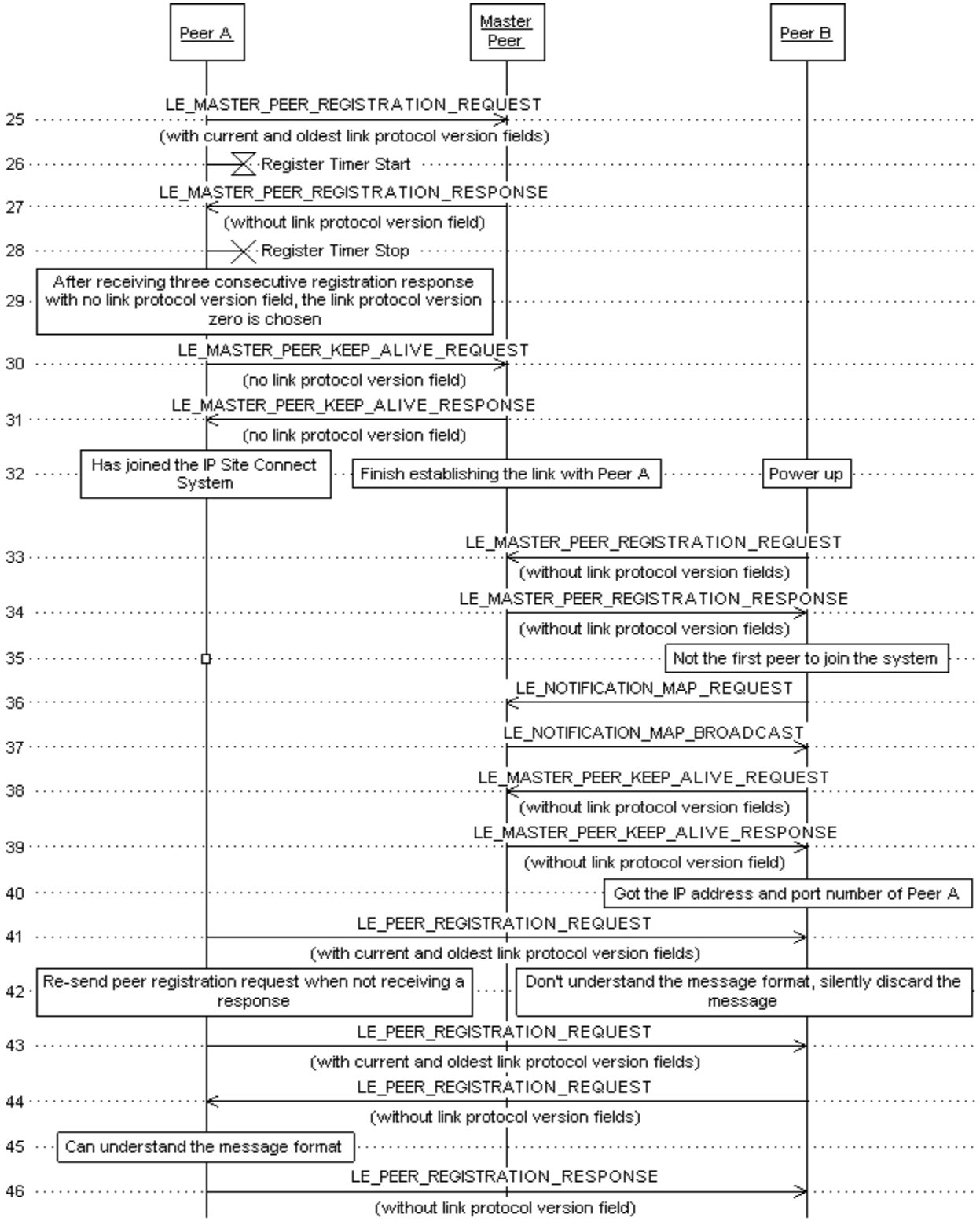
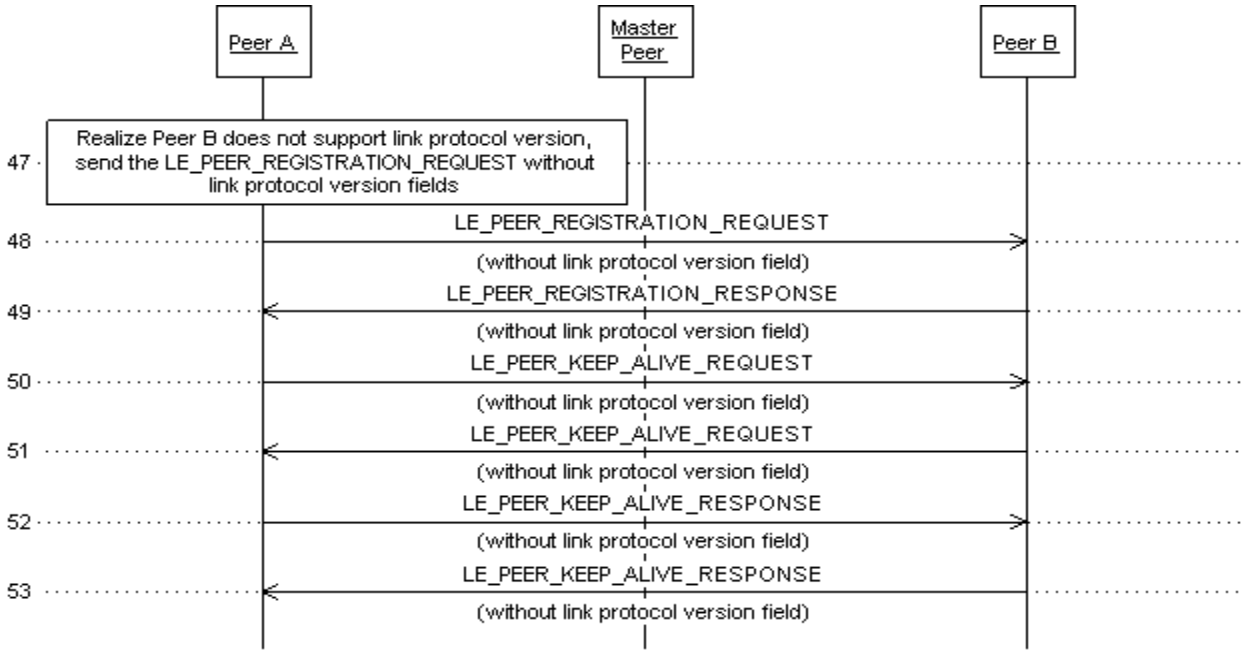


Figure 26: Link Protocol Version Negotiation when the Master Peer is before R1.6 (Continue)



543

544 **Figure 27: Link Protocol Version Negotiation with Peers before R1.6 (Continue)**

545

Use Case 3: Link protocol version negotiation when the peer is at a release before R1.6

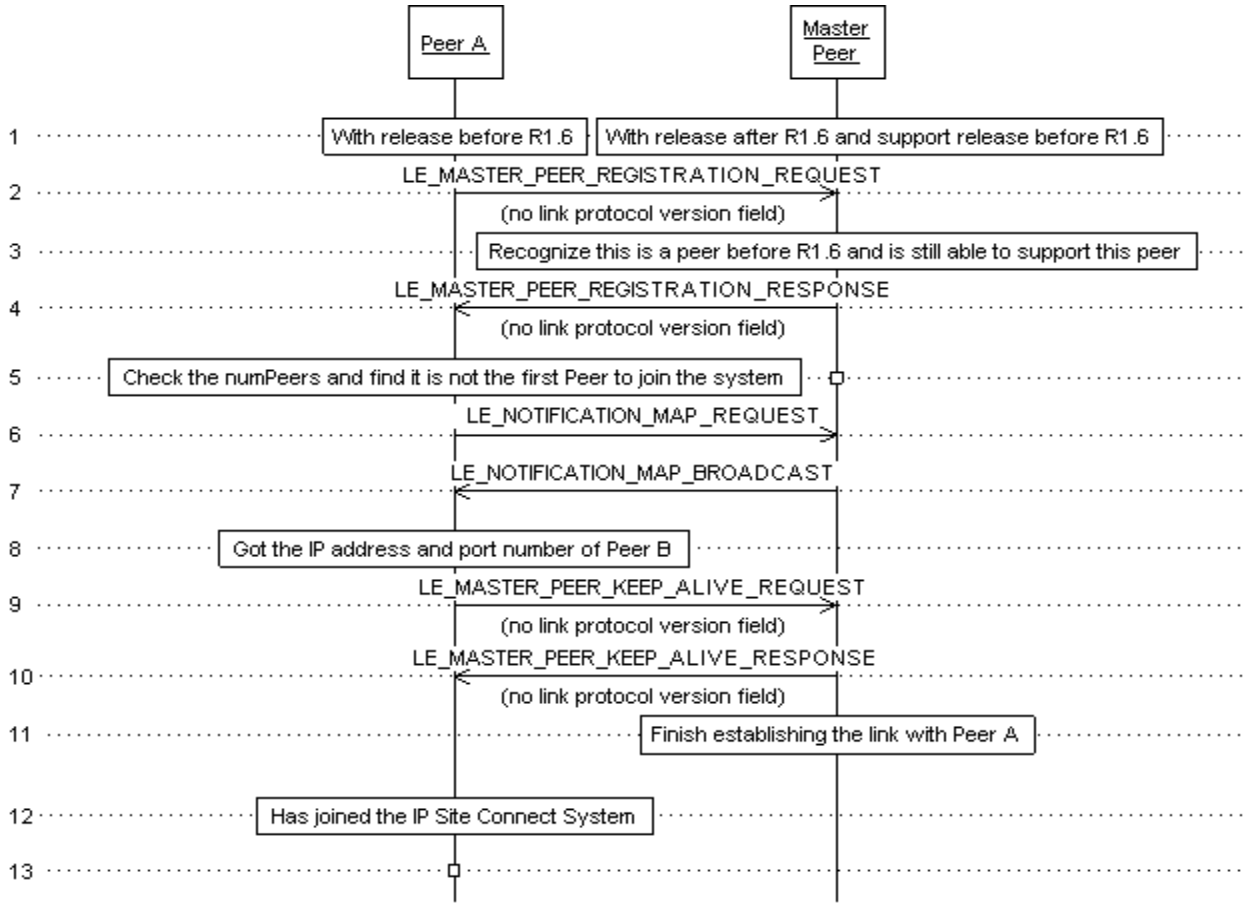


Figure 28: Link Protocol Version Negotiation when the Peer is before R1.6

3.2.8 Connection with Application Peers

It is possible to have multiple application peers co-exist in the same repeater system. Because we do not have enforced rules on how the application peers shall connect with each other before, different applications may have different behaviors. For example, MNIS with the version of R2.3 or before will try to connect with all the peers in the system map. If for some reason the application peer does not respond to MNIS' LE connection, MNIS will keep requesting system map from the Master peer, which will result in unnecessary system map broadcast messages in the network. However, the Motorola RDAC application with the version of R2.3 or before will accept connection request from either the repeater peers or the MNIS peer.

In the LCP system map, the MNIS can be identified with both the "Remote 3rd Party Console Application" bit and the "MNIS" bit set to 1 in the peerMode field. The Motorola

RDAC application peer can be identified with the “Remote 3rd Party Console Application” bit set to 0 and the “XNL Slave Device” bit set to 1 in the peerMode field. The third party application peer shall establish the LE connection with MNIS. It does not have to connect with the Motorola RDAC application peer. In general, the third party application shall try to connect with all the peers in the LCP system map. The keep alive timeout is recommended to be 60s. However, if the other application peers do not respond to the LE Registration Request or the keep alive message times out, the third party application shall not request the system map from the Master peer. It can re-send the LE Registration Request to the other application peer every 60s until the connection is re-established.

In the IPSC and Capacity Plus system map, the peerMode field cannot contain the “MNIS” bit, the “Remote 3rd Party Console Application“ bit, nor the “XNL Slave Device” bit. The third party application shall try to connect with all the peers in the system map. If it can’t connect with one of the peers, the third party application peer can initiate the retry process by requesting the system map from the Master peer and re-establishing the link with the peer which has not connected yet. However, the interval of this retry process is recommended to start with 1-minute and increased at the subsequent retries. By doing that we can avoid the flooding of the system map broadcast messages in the network.

4.0 Link Establishment Protocol and Definitions

The section is to define the Link Establishment Protocol Message that is used by the MOTOTRBO Peers in the repeater system. The Link Establishment Protocol is supported by the MOTOTRBO repeaters based on MOTOTRBO 1.4 release and higher, regardless of which mode the repeater operates on.

4.1 Optional Authentication Footer

The IP Site Connect system has an optional configuration scheme to support protocol authentication based on SHA-1 for computing a condensed representation of a protocol message, refer to Reference [1] for more details. In cryptography, a keyed-Hash Message Authentication Code (HMAC), is a type of message authentication code (MAC) calculated using a specific algorithm involving a cryptographic hash function in combination with a secret key. As with any MAC, it may be used to simultaneously verify both the data integrity and the authenticity of a message. Any iterative cryptographic hash function, such as SHA-1, may be used in the calculation of an HMAC; the resulting MAC algorithm is termed HMAC-SHA-1 accordingly. The HMAC key is a programmable entity(for more details, refer to section 5.4 Authentication Key) for each MOTOTRBO peerconfiguration and requires them to be identical for link establishment. The authentication Footer will be a truncated 10 bytes (10 most significant bytes) field based on the SHA-1 and HMAC.

The authentication footer is appended to the end of each IP Site Connect packet when authentication is enabled.

Note the releases of MOTOTRBO repeater R1.4, R1.5 and R1.5A use an alternative byte-ordering schema when calculating the HMAC-SHA1 hash, which makes the final computed hash value is different from the standard HMAC-SHA1 calculation. See Appendix A for the detailed MOTOTRBO byte-ordering schema.

Since Release 1.6, the MOTOTRBO repeater complies with the standard HMAC-SHA1 calculation by removing the alternative byte-ordering schema from its implementation.

4.2 Message Structure/Message Classes

Figure 29 shows the LE message packet format. The LE message packet contains no addressing information, message length, or frame check sequence. The LE protocol depends on the UDP/IP transport layer to provide these services.

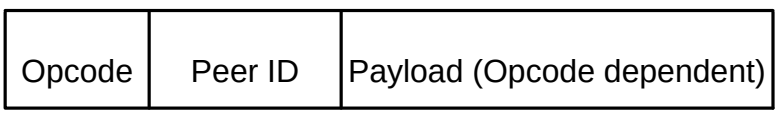


Figure 29 LE Message Format

All LE messages have a one-byte opcode that specifies the type of the message, and a four-byte ID of the peer that is sending the message. The payload is entirely dependent on the opcode.

Table 2 shows all LE Opcodes definition.

Opcode	Value	Class	Reference
LE_MASTER_PEER_REGISTRATION_REQUEST	0x90	Link Establishment	4.8.2
LE_MASTER_PEER_REGISTRATION_RESPONSE	0x91	Link Establishment	4.8.4
LE_NOTIFICATION_MAP_REQUEST	0x92	Link Establishment	4.8.4
LE_NOTIFICATION_MAP_BROADCAST	0x93	Link Establishment	4.8.5
LE_PEER_REGISTRATION_REQUEST	0x94	Link Establishment	4.8.6
LE_PEER_REGISTRATION_RESPONSE	0x95	Link Establishment	4.8.7
LE_MASTER_KEEP_ALIVE_REQUEST	0x96	Link Establishment	4.8.8
LE_MASTER_KEEP_ALIVE_RESPONSE	0x97	Link Establishment	4.8.9
LE_PEER_KEEP_ALIVE_REQUEST	0x98	Link Establishment	4.8.10
LE_PEER_KEEP_ALIVE_RESPONSE	0x99	Link Establishment	4.8.11
LE_DEREGISTRATION_REQUEST	0x9A	Link Establishment	4.8.12
LE_DEREGISTRATION_RESPONSE	0x9B	Link Establishment	4.8.13
LE_DIGITALVOTING_MAP_BROADCAST	0x33	Link Establishment	4.8.14

Table 2 – IP Site Connect Opcode

4.3 Byte Order

The protocol definitions formatted in this document are based on the most significant bit (as depict below).

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

As a general rule, all fields in an IP Site Connect message will use the integer data type (either signed or unsigned) and they will be transmitted in network byte order (big Endian).

4.4 Opcode Support

The LE protocol defines a set of opcodes to be used for the exchange of information between peers in the system topology. These opcodes are used for maintaining links. Regardless of the opcode type, if a peer receives a UDP packet with an opcode not defined by the LE protocol, then the peer shall drop the packet and take no further actions based on the receipt of the packet.

4.5 Link Protocol Version Support

Starting from R1.6, MOTOTRBO repeater utilizes the link protocol version in the LE protocol to support firmware backward compatibility and identify the system type that the peers join. The link protocol version provides a more robust software release migration for upcoming releases. The peers use the link protocol version automatically at the detection of multiple software release loads. During link establishment, all the peers exchange the link protocol version, and validate the interoperability support. For example, in a MOTOTRBO R1.5 IP Site Connect system, one of the repeaters upgrades to MOTOTRBO R1.6 version, the MOTOTRBO R1.6 repeater uses the R1.5 protocol information to communicate with the MOTOTRBO R1.5 repeater after exchanging link protocol version with the R1.5 repeaters.

Even though the MOTOTRBO repeater releases before R1.6 do not support the link protocol version, the R1.6 and later releases use the link protocol version information of zero to internally identify the peers with these early releases.

The MOTOTRBO repeater supports a maximum depth of current and its three previous major releases. The minor releases between the major releases are counted as part of their associated major release when considering backward compatibility. Beyond this maximum release depth, incompatibility and connectivity issues may happen. In such abnormal scenarios, the non-compatible repeaters have to upgrade to fit in the maximum software release depth. Slight service degradation occurs when multiple MOTOTRBO repeater firmware versions are running in the system.

When upgrading peers to the new software release, since the Master Peer is an autonomous centralized entity in the system, we highly recommend to upgrade the Master Peer first in order to minimize the system downtime, optimize IP link connectivity and improve system access time across the IP network. Otherwise, the peer link establishments can become very lengthy, e.g. 30 minutes (worse case) in a fully loaded IP Site Connect system.

Table 3 shows the link protocol version assignment for each MOTOTRBO system release and the supported versions in each system release. This table is updated at each major system release.

System Release Number	System	Protocol Version	Supported Versions
R1.4	IP Site Connect	0	0
R1.5	IP Site Connect	0	0
	Capacity Plus	0	0
R1.5A	IP Site Connect	0	0
	Capacity Plus	0	0
R1.6	IP Site Connect	1	0, 1
	Capacity Plus	1	0, 1
R1.7, R1.8, R1.9	IP Site Connect	2	0, 1, 2
R1.7, R1.8, R1.9, R1.9A	Capacity Plus	2	0, 1, 2
R1.9,R1.9A	Linked Capacity Plus	3	3
R1.9A	IP Site Connect	3	0,1,2,3
R2.2,R2.2A,R2.2B,R2.2C	IP Site Connect	4	0,1,2,3,4
	Capacity Plus	3	0,1,2,3
	Linked Capacity Plus	4	3,4
R2.3	IP Site Connect	5	0,1,2,3,4,5
	Capacity Plus	5	0,1,2,3,5
	Linked Capacity Plus	5	3,4,5
…	…		

Table 3: Link Protocol Version Supported in Each Release

Under the same major release, all the sub-releases share the same link protocol version. For example, the MOTOTRBO repeater R1.4.1 and R1.4.2 have the same link protocol version of zero.

R1.4, R1.5 and R1.5a repeater firmware have the same link protocol version of zero since the LE protocol is the same across these releases. R1.6 firmware is backwards compatible with R1.4, R1.5 and R1.5a since its oldest supported link protocol version is zero.

The Capacity Plus repeater IP interface is available for Link since R1.5..

The Linked Capacity Plus repeater IP interface is available for Link Establishment since MOTOTRBO R1.9.

The link protocol version has two components: system type and protocol version. In the following message definition sections, a link protocol version table is added at the top of each packet format table. Refer to section 4.9.9 for the detailed definition on link protocol version.

4.6 Key to Message Specification

This section defines the IP Site Connect message specification template that is used to describe each command.

4.6.1 Message Dashboard

Class	Link Establishment	Type	Request
Opcode	0x90	Command	LE_MASTER_REGISTRATION_REQUEST
Description	Master Registration Request		

At the top of each specification is a dashboard depicting the key characteristics of the IP Site Connect message. The sections of the dashboard are described below:

- Class – Category of the messages that share common properties, operations. The major defined classes are Link Establishment, Repeater Call Monitoring, and XCMP/XNL.
- Type – Indicates whether the message is a Request, Reply, or Broadcast message type.
- Opcode – Static enumerated value assigned to the message; the size of this value is 1 byte.
- Command – Common alphabetic alias for the message.
- Description – Elaborated definition of the Command assigned to the message.

4.6.2 Message Field Types

Uint8 – A 8-bit unsigned integer.

Uint16 - A 16-bit unsigned integer.

Uint24 – A 24-bit unsigned integer.

Uint32 - A 32-bit unsigned integer.

String – A NULL terminated array of UCS-2 Unicode characters, unless otherwise specified in the message

4.6.3 Reserved Fields

Some IP Site Connect messages may have reserved fields identified in the message structure. These fields have been identified for future use and should not be utilized in any way. For any fields marked as “(Reserved)”, the value assigned to that field must be 0x00 up to the length / size of the reserved field. Failure to do so may result in unexpected operation or behavior.

4.6.4 Packet Format per Link Protocol Version

System	Version Introduced
IP Site Connect	1

At the top of each packet format table is a overhead table identifying its link protocol version.

As described in section 4.5, the message format can be different based on the link protocol version, which has two fields: system ID and protocol version. The MOTOTRBO repeater can only support the current link protocol version and the previous three versions. The third party application shall follow the same backward compatibility depth as the MOTOTRBO repeater peer.

- Version Introduced – The protocol version at which the packet format starts. The Version Introduced is the version protocol field in the link protocol version. If the packet format changes, a separate message format table shows the new format in the new protocol version.

  Note: For Release R1.4, R1.5 and R1.5A, the link protocol version does not exist in the protocol. Protocol version of zero is assigned to these releases, which is used by the R1.6 and later releases to internally identify the peers with these early releases.

- System – The system at which the packet format is supported. It is the system ID in the link protocol version.

4.7 Link Establishment Protocol

The basic format of an LE packet is shown below:

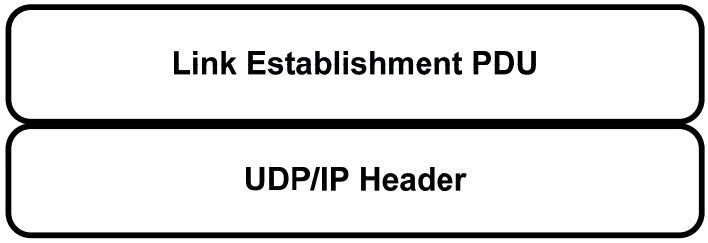


Figure 30 – Basic Link Establishment Packet Format

The enhanced format of LE packet is shown below which is used when authentication is enabled in MOTOTRBO CPS:

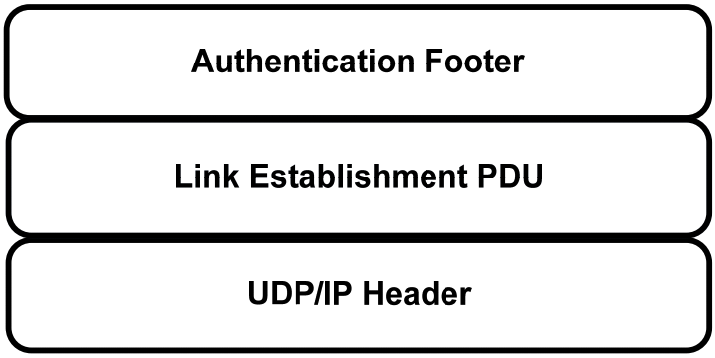


Figure 31– Enhanced Link Establishment Packet Format

4.7.1 Transaction Types/Message Types

The Link Establishment Protocol allows two transaction types:

- **Request/Response** – a peer makes a request to a Master Peer or another peer, which sends a corresponding response.
- **Broadcast –**sends a message to all linked peers by unicast.

4.7.2 Message Interleaving

The Link Establishment Protocol does not define constraints on when messages can be sent. This means that a peer including the Master Peer is not restricted on what it can send or receive while waiting on a reply to a request.

4.7.3 Message Timeout

Developer should employ timeout mechanisms for the condition in which a peer does not respond to a request message in a timely fashion. This would be considered an error condition in a peer. A timeout allows the device to minimize the time spent waiting before recovery procedures are attempted.

765 The recommended timer values in this section are based on the IP Site Connect
766 network with the routers listed in section 2.3.

767

4.8 Link Establishment Message Definitions

4.8.1 Basic Message Format

The basic structure for a Link Establishment Message is shown below.

Field	Type	Description
opcode	Uint8	Specifies the type of the PDU
peerID	Uint32	The ID of the sending peer
Opcode Specific Field 1		
……..		
……..		
Opcode Specific Field N		

All Link Establishment Messages opcodes specify the type of the Message and the ID of the peer sending the Message.

4.8.2 0x90 – LE_MASTER_PEER_REGISTRATION_REQUEST

Class	Link Establishment	Type	Request
Opcode	0x90	Command	LE_MASTER_PEER_REGISTRATION_REQUEST
Description	Master Peer Registration Request		

4.8.2.1. Description

This message is used to register with the Master Peer.

A peer sends out an LE_MASTER_PEER_REGISTRATION_REQUEST in one of the following situations:

1) When the peer first powers up
2) When a peer stops receiving keep alive data from another peer
3) When a peer stops receiving keep alive data from the Master Peer
4) When the Master Peer fails to respond to a LE_MASTER_PEER_REGISTRATION_REQUEST

The LE_MASTER_PEER_REGISTRATION_REQUEST is only sent from a peer to the Master Peer. If a peer stops sending keep alive data, the other peers send a registration request to the Master Peer to re-register. After getting the updated information, the sending peer proceeds based on the number of peers currently in the system. The Master Peer subsequently sends a notification map broadcast containing the latest peer information.

After the peer sends LE_MASTER_PEER_REGISTRATION_REQUEST, it starts the MasterPeerRegister Timer. If the Master Peer fails to respond the LE_MASTER_PEER_REGISTRATION_REQUEST before timeout, the peer resends the LE_MASTER_PEER_REGISTRATION_REQUEST. If the peer's current link protocol version is higher than zero and the peer can support the link protocol version of zero, it shall resends the LE_MASTER_PEER_REGISTRATION_REQUEST with link protocol version of zero, which does not have the protocol version field. After the peer receives the LE_MASTER_PEER_REGISTRATION_RESPONSE with link protocol version of zero, it sends the LE_MASTER_PEER_REGISTRATION_REQUEST with the current link protocol version again. This process stops when one of the following conditions is met:

1) The peer receives three consecutive LE_MASTER_PEER_REGISTRATION_RESPONSE messages with link protocol version of zero. The peer uses the IPSC message with link protocol version of zero to communicate with the Master Peer.
2) The peer receives a LE_MASTER_PEER_REGISTRATION_RESPONSE message with link protocol version field. The peer uses the IPSC message with link protocol version of acceptedLinkProtocolVersion in the LE_MASTER_PEER_REGISTRATION_RESPONSE to communicate with the Master Peer.

There is no limit on the setting of the MasterPeerRegister Timer. The MOTOTRBO repeaters use 10 seconds for this timer.

4.8.2.2. Cautions / Warnings

None

4.8.2.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x90	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint16	The services supports of the sending peer.	4.9.8

System	Version Introduced
IP Site Connect	1
Capacity Plus	1

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x90	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint32	The services supports of the sending peer.	4.9.8
10	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
12	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x90	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint16	The current operating modes of the sending peer	4.9.7
7	peerServices	Uint32	The services supports of the sending peer.	4.9.8

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
11	leadingChannelID	Uint8	The channel ID for slot 1 on trunked and data revert repeaters. It can be left unpopulated for non-repeater peers.	Refer to CPS configuration.
12	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
14	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.3 0x91 – LE_MASTER_PEER_REGISTRATION_RESPONSE

Class	Link Establishment	Type	Response
Opcode	0x91	Command	LE_MASTER_PEER_REGISTRATION_RESPONSE
Description	Master Peer Registration Response		

4.8.3.1. Description

This message is used to respond the register request of the sending peer.

The Master Peer sends out an LE_MASTER_PEER_REGISTRATION_RESPONSE in the following situation:

1) Upon receiving an LE_MASTER_PEER_REGISTRATION_REQUEST

The LE_MASTER_PEER_REGISTRATION_ RESPONSE is sent from the Master back to the requesting peer only. If the Master Peer is attempting to establish a link with another peer when it receives an LE_MASTER_PEER_REGISTRATION_REQUEST, it does not respond. After the Master Peer has finished establishing the link, it responds to the next LE_MASTER_PEER_REGISTRATION_REQUEST issued by the sending peer.

The LE_MASTER_PEER_REGISTRATION_RESPONSE contains the current operating modes and supported services of the Master Peer. The receiving peer shall use this information to update its local map with information about the Master Peer.

When receiving a LE_MASTER_PEER_REGISTRATION_REQUEST with link protocol version field, if the Master Peer can support at least one of the protocol versions from the LE_MASTER_PEER_REGISTRATION_REQUEST, it chooses the biggest common protocol version as the acceptedLinkProtocolVersion in the LE_MASTER_PEER_REGISTRATION_RESPONSE.

If the Master Peer does not support the message format of the LE_MASTER_PEER_REGISTRATION_REQUEST or the range of the link protocol version in the LE_MASTER_PEER_REGISTRATION_REQUEST, the Master Peer silently discards the LE_MASTER_PEER_REGISTRATION_REQUEST without sending LE_MASTER_PEER_REGISTRATION_RESPONSE.

The MOTOTRBO repeater can support the repeater peers with the current software release and three previous major releases. We recommend the third party application peers to use the current link protocol version and three previous link protocol versions as their version support range.

4.8.3.2. Cautions / Warnings

None.

850 #### 4.8.3.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x91	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint16	Services supports of the sending peer	4.9.8
8	numPeers	Uint16	The number of peers that have established links with the Master Peer	0

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System	Version Introduced
IP Site Connect	1
Capacity Plus	1

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x91	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint32	Services supports of the sending peer	4.9.8
10	numPeers	Uint16	The number of peers that have established links with the Master Peer	
12	acceptedLinkProtocolVersion	uint16	The field that represents the common protocol version accepted for messaging between peers.	4.9.9
14	oldestLinkProtocolVersion	uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x91	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint16	The current operating modes of the sending peer	4.9.7
7	peerServices	Uint32	Services supports of the sending peer	4.9.8

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
11	leadingChannelID	Uint8	The channel ID for slot 1 on trunked and data revert repeaters. It can be left unpopulated for non-repeater peers.	Refer to CPS configuration.
12	numPeers	Uint16	The number of peers that have established links with the Master Peer	
14	acceptedLinkProtocolVersion	uint16	The field that represents the common protocol version accepted for messaging between peers.	4.9.9
16	oldestLinkProtocolVersion	uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.4 0x92 – LE_NOTIFICATION_MAP_REQUEST

Class	Link Establishment	Type	Request
Opcode	0x92	Command	LE_NOTIFICATION_MAP_REQUEST
Description	Master Peer Map Request		

4.8.4.1. Description

This message is used to request the IP Site Connect System Map, Satellite Map or Vote Map information.

A peer sends out an LE_NOTIFICATION_MAP_REQUEST in the following situation:

1) When it receives an LE_MASTER_PEER_REGISTRATION_RESPONSE where the number of linked peers value is greater than zero.
2) When it is 3rd Party RDAC Application and established a connection with the Mast Peer.

For normal Peer, The LE_NOTIFICATION_MAP_REQUEST is sent from a peer to the Master Peer. The request normally follows an LE_MASTER_PEER_REGISTRATION_RESPONSE when there are one or more linked peers in the system. Otherwise, when the linking peer is the first peer in the system, then notification of the current peer map is not requested.

The peer map is only requested when updated information about the state of the linked peers is needed. For example, when a peer stops receiving keep alive data from another peer for a predetermined amount of time (typical 60s) it sends LE_MASTER_PEER_REGISTRATION_REQUEST and gets a new peer map to decide whether this peer has actually become disconnected from the network or simply changed its IP address or port number.

For RDAC Application, the LE_NOTIFICATION_MAP_REQUEST is send to the Voting Peer after it has established a connection with the Mast Peer and has received the Voting Peer's information. A RDAC Application can get on this map by having the Digital Voting Enabled Mode (LCP system) or Service (IPSC/CPC system).

4.8.4.2. Cautions / Warnings

None.

4.8.4.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x92	
1	peerID	Uint32	The ID of the sending peer	4.9.1

884

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x92	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	mapType	Uint8	The map type of the request	4.9.4
6	acceptedLinkProtocolVersion	Uint16	The field that represents the common protocol version accepted for messaging between peers.	4.9.9
8	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.5 0x93 – LE_NOTIFICATION_MAP_BROADCAST

Class	Link Establishment	Type	Broadcast
Opcode	0x93	Command	LE_NOTIFICATION_MAP_BROADCAST
Description	Master Peer Map Broadcast		

4.8.5.1. Description

This message is used to broadcast the IP Site Connect System Map information.

The Master Peer sends out an LE_NOTIFICATION_MAP_BROADCAST in one of the following situations:

1) Upon receiving an LE_NOTIFICATION_MAP_REQUEST
2) After sending an LE_MASTER_PEER_DEREGISTRATION_RESPONSE

The LE_NOTIFICATION_MAP_BROADCAST is always sent from the Master Peer to all linked peers in the system including the peer currently establishing a link to the Master Peer. The receiving peers then update their peer map and establish links to any newly identified peers. Or, they re-establish links with peers containing updated information (i.e. new IP address, different port).

When the Master Peer receives a Deregistration Request, it sends a Deregistration Response to the requesting peer followed by an updated peer map to all of the peers in the system with the requesting peer removed from the map. However, peers shall only remove peers from their local map when they receive a Deregistration Request or they fail to receive Peer Keep Alive Responses after a predetermined number of Peer Keep Alive Requests are sent.

Note the System Map in the LE_NOTIFICATION_MAP_BROADCAST does not contain an entry for the Master Peer.

4.8.5.2. Cautions / Warnings

The master peer in the LCP system always sends two LE_NOTIFICATION_MAP_BROADCAST messages: one for the system wide map, and the other for the master peer programming map.

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4.8.5.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x93	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	mapLength	Uint16	The number of bytes that will be contained in the following peer map	4.9.3
7	remotePeerID (1)	Uint32	The ID of the peer that established a link to the Master Peer	4.9.1
11	remoteIPAddr (1)	Uint32	The IP address of this peer as seen to the public internet (i.e. router address)	4.9.5
15	remotePort (1)	Uint16	The port address of this peer as seen to the public internet (i.e. router port)	4.9.6
17	peerMode(1)	Uint8	The field represents the current operating modes of the peer	4.9.7
	……..			
	……..			
(N-1) *11+7	remotePeerID (N)	Uint32	The ID of this peer that established a link to the Master Peer	4.9.1
(N-1) *11+11	remoteIPAddr (N)	Uint32	The IP address of this peer as seen to the public internet (i.e. router address)	4.9.5
(N-1) *11+15	remotePort (N)	Uint16	The port address of this peer as seen to the public internet (i.e. router port)	4.9.6
(N-1) *11+17	peerMode(N)	Uint8	The field represents the current operating modes of the peer	4.9.7

914

System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x93	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	mapType	Uint8	The map type of the request	4.9.4
6	mapLength	Uint16	The number of bytes that will be contained in the following peer map	4.9.3
	……..		Map Payload	4.8.5.4
	……..			
MapLength+7	acceptedLinkProtocolVersion	Uint16	The field that represents the common protocol version accepted for messaging between peers.	4.9.9

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
MapLength+9	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

915 #### 4.8.5.4. Packet PayLoad

916 4.8.5.4.1 System Wide Map

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
0	remotePeerID (1)	Uint32	The ID of the peer that established a link to the Master Peer	4.9.1
4	remoteIPAddr (1)	Uint32	The IP address of this peer as seen to the public internet (i.e. router address)	4.9.5
8	remotePort (1)	Uint16	The port address of this peer as seen to the public internet (i.e. router port)	4.9.6
10	peerMode(1)	Uint16	The field represents the current operating modes of the peer	4.9.7
12	leadingChannelID(1)	Uint8	The channel ID for slot 1 on trunked and data revert repeaters. It can be left unpopulated for non-repeater peers.	Refer to CPS configuration.
	……..			
	……..			
(N-1) *13	remotePeerID (N)	Uint32	The ID of this peer that established a link to the Master Peer	4.9.1
(N-1) *13+4	remoteIPAddr (N)	Uint32	The IP address of this peer as seen to the public internet (i.e. router address)	4.9.5
(N-1) *13+8	remotePort (N)	Uint16	The port address of this peer as seen to the public internet (i.e. router port)	4.9.6
(N-1) *13+10	peerMode(N)	Uint16	The field represents the current operating modes of the peer	4.9.7
(N-1) *13+12	leadingChannelID(N)	Uint8	The channel ID for slot 1 on trunked and data revert repeaters. It can be left unpopulated for non-repeater peers.	Refer to CPS configuration.

917 4.8.5.4.2 Master Peer Programming Map

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
0	numConfiguredTalkgroups	Uint8	The number of configured talkgroup entries in this map.	Refer to CPS configuration.
1	talkgroupID (1)	Uint8	The ID of the wide area talkgroup.	Refer to CPS configuration.
2	configuredSiteBits(1)	Uint16	These bits each represent the 15 possible sites for the system. A site that does not support this talkgroup ID will be 0 and a site that does is 1. The zero bit is not used.	Refer to CPS configuration
	……..			
	……..			
(N-1)*3+1	talkgroupID (N)	Uint8	The ID of the wide area talkgroup.	Refer to CPS configuration.
(N-1)*3+2	configuredSiteBits (N)	Uint16	These bits each represent the 15 possible sites for the system. A site that does not support this talkgroup ID will be 0 and a site that does is 1. The zero bit is not used.	Refer to CPS configuration
mapLength-((N-1)*3+2)-1	Reserved fields	…	Reserved for internal usage. Variable length .	

4.8.6 0x94 – LE_PEER_REGISTRATION_REQUEST

Class	Link Establishment	Type	Request
Opcode	0x94	Command	LE_PEER _REGISTRATION_REQUEST
Description	Peer Registration Request		

4.8.6.1. Description

This message is used to register with another peer.

A peer sends out an LE_PEER_REGISTRATION_REQUEST to another peer in the following situation:

1) Upon receiving an LE_NOTIFICATION_MAP_BROADCAST identifying new or updated peers

The LE_PEER_REGISTRATION_REQUEST is only sent from one peer to another peer, but not to the Master Peer. When a new peer map from the Master Peer identifies a newly linked peer or a peer with new IP address or port number, it shall attempt to establish a link based on the latest information.

After the peer sends LE_PEER_REGISTRATION_REQUEST, it starts the PeerRegister Timer. If another peer fails to respond the LE_PEER_REGISTRATION_REQUEST before timeout, the peer will resend the LE_PEER_REGISTRATION_REQUEST.

If the peer's current link protocol version is higher than zero and supports the link protocol version of zero, when it receives LE_PEER_REGISTRATION_REQUEST without link protocol version field, it shall take the following actions:

1) Send the LE_PEER_REGISTRATION_RESP without link protocol version field
2) Stop the current PeerRegister Timer for the LE_PEER_REGISTRATION_REQUEST with link protocol version field
3) Send the LE_PEER_REGISTRATION_REQUEST without link protocol version field.
4) Start the PeerRegister Timer

There is no limit on the setting of the PeerRegister Timer. The MOTOTRBO repeaters use 1 second for this timer.

4.8.6.2. Cautions / Warnings

None.

948 #### 4.8.6.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x94	
1	peerID	Uint32	The ID of the sending peer	4.9.1

949

System	Version Introduced
IP Site Connect	1
Capacity Plus	1
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x94	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	currentLinkProtocolVersion	uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
7	oldestLinkProtocolVersion	uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.7 0x95 – LE_PEER_REGISTRATION_RESPONSE

Class	Link Establishment	Type	Response
Opcode	0x95	Command	LE_PEER_REGISTRATION_RESPONSE
Description	Peer Registration Response		

4.8.7.1. Description

This message is used to respond the register request of a peer.

A peer sends out an LE_PEER_REGISTRATION_RESPONSE in the following situation:

1) Upon receiving an LE_PEER_REGISTRATION_REQUEST

The LE_PEER_REGISTRATION_RESPONSE is only sent from a peer back to the requesting peer. When the requesting peer receives an LE_PEER_REGISTRATION_RESPONSE, it shall consider that a link has been established with the responding peer.

When receiving a LE_PEER_REGISTRATION_REQUEST with link protocol version field, if the receiving peer can support at least one of the protocol versions from the LE_PEER_REGISTRATION_REQUEST, it chooses the biggest common protocol version as the acceptedLinkProtocolVersion in the LE_PEER_REGISTRATION_RESPONSE.

If the receiving peer does not support the message format of the LE_PEER_REGISTRATION_REQUEST or the range of the link protocol version in the LE_PEER_REGISTRATION_REQUEST, the receiving peer silently discards the LE_PEER_REGISTRATION_REQUEST without sending LE_PEER_REGISTRATION_RESPONSE.

The MOTOTRBO repeater supports the repeater peers with the current software release and three previous major releases. We recommend the third party application peer to use the current link protocol version and three previous link protocol versions as their version support range.

4.8.7.2. Cautions / Warnings

None.

977 #### 4.8.7.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x95	
1	peerID	Uint32	The ID of the sending peer	4.9.1

978

System	Version Introduced
IP Site Connect	1
Capacity Plus	1
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x95	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	acceptedLinkProtocolVersion	Uint16	The field that represents the common protocol version accepted for messaging between peers.	4.9.9
7	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.8 0x96 – LE_MASTER_PEER_KEEP_ALIVE_REQUEST

Class	Link Establishment	Type	Request
Opcode	0x96	Command	LE_MASTER_PEER_KEEP_ALIVE_REQUEST
Description	Master Peer Keep Alive Request		

4.8.8.1. Description

This message is used to request the keep alive with the Master Peer.

A peer sends out this message in one of the following situations:

1) Upon receiving an LE_NOTIFICATION_MAP_BROADCAST from the Master Peer
2) Upon receiving an LE_MASTER_PEER_REGISTRATION_RESPONSE from the Master Peer when the number of linked peers is less than one
3) Upon receiving an LE_MASTER_PEER_KEEP_ALIVE_RESPONSE from the Master Peer.
4) Upon the MasterPeer KeepAlive Timer times out.

The LE_MASTER_PEER_KEEP_ALIVE_REQUEST is only sent from a peer to the Master Peer. However, the LE_MASTER_PEER_KEEP_ALIVE_REQUEST is not immediately sent following the above messages. Instead, the peer waits a predetermined amount of time (typical 15s) before proceeding to send the Keep Alive Request.

The LE_MASTER_PEER_KEEP_ALIVE_REQUEST also contains the peer mode and peer services fields. The Master Peer uses this information to rebuild the peer map when it encounters a fault and resets. A peer can also use this information to re-register with the Master Peer after the fault occurs.

When a peer encounters a fault scenario and resets at the same time as the Master Peer, it shall attempt to re-register with the Master Peer after resetting. The same is true for the case when the peer changes its peer mode and/or peer service bits at the same time as the Master Peer encounters a fault scenario and resets.

After the peer joins the IP Site Connect system, it starts the MasterPeerKeepAlive Timer. When the MasterPeerKeepAlive Timer times out, the peer sends LE_MASTER_PEER_KEEP_ALIVE_REQUEST to the Master Peer. After the peer does not receive the LE_MASTER_PEER_KEEP_ALIVE_RESPONSE for 3 times continuously from the Master Peer, the peer considers the link is down and starts the registration process by sending the LE_MASTER_PEER_REGISTRATION_REQUEST to the Master Peer.

There is no limit on the setting of the MasterPeerKeepAlive Timer. The MOTOTRBO repeaters use 15 seconds for this timer.

4.8.8.2. Cautions / Warnings

None.

1016 #### 4.8.8.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x96	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint16	Services supports of the sending peer	4.9.8

1017

System	Version Introduced
IP Site Connect	1
Capacity Plus	1

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x96	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint32	Services supports of the sending peer	4.9.8
10	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
12	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

1018

System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x96	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint16	The current operating modes of the sending peer	4.9.7
7	peerServices	Uint32	The services supports of the sending peer.	4.9.8
11	leadingChannelID	Uint8	The channel ID for slot 1 on trunked and data revert repeaters. It can be left unpopulated for non-repeater peers.	Refer to CPS configuration.
12	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
14	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.9 0x97 – LE_MASTER_PEER_KEEP_ALIVE_RESPONSE

Class	Link Establishment	Type	Response
Opcode	0x97	Command	LE_MASTER_PEER_KEEP_ALVIE _RESPONSE
Description	Master Peer Keep Alive Response		

4.8.9.1. Description

This message is used to respond the request of a peer.

The Master Peer sends out an LE_MASTER_PEER_KEEP_ALIVE_RESPONSE in the following situation:

1) Upon receiving an LE_MASTER_PEER_KEEP_ALIVE_REQUEST

The LE_MASTER_PEER_KEEP_ALIVE_RESPONSE is only to be sent from the Master Peer back to the requesting peer. When a peer receives the LE_MASTER_PEER_KEEP_ALIVE_RESPONSE from the Master Peer, it confirms that a link has been established with the Master Peer.

The LE_MASTER_PEER_KEEP_ALIVE_RESPONSE contains the current operating modes, and supporting services of the Master Peer. The receiving peer uses this information as necessary to update its local map with information about the Master Peer.

4.8.9.2. Cautions / Warnings

None.

1038

4.8.9.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x97	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint16	Services supports of the sending peer	4.9.8

1039

System	Version Introduced
IP Site Connect	1
Capacity Plus	1

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x97	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint32	Services supports of the sending peer	4.9.8
10	acceptedLinkProtocolVersion	Uint16	The field that represents the common protocol version accepted for messaging between peers.	4.9.9
12	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

1040

System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x97	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint16	The current operating modes of the sending peer	4.9.7
7	peerServices	Uint32	The services supports of the sending peer.	4.9.8
11	leadingChannelID	Uint8	The channel ID for slot 1 on trunked and data revert repeaters. It can be left unpopulated for non-repeater peers.	Refer to CPS configuration.

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
12	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
14	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.10 0x98 – LE_PEER_KEEP_ALIVE_REQUEST

Class	Link Establishment	Type	Request
Opcode	0x98	Command	LE_PEER_KEEP_ALIVE_REQUEST
Description	Peer Keep Alive Request		

4.8.10.1. Description

This message is used to request the keep alive with the peer.

A peer sends out an LE_PEER_KEEP_ALIVE_REQUEST to another peer in the following situation:

1) Upon receiving an LE_PEER_REGISTRATION_RESPONSE from another peer

A peer sends a LE_PEER_KEEP_ALIVE_REQUEST to another peer after receiving the LE_PEER_REGISTRATION_RESPONSE from another peer. However, the LE_PEER_KEEP_ALIVE_REQUEST is not immediately sent following the receipt of any LE protocol messages. Instead, the peer waits a predetermined amount of time (typical 6s) before proceeding to send the next LE_PEER_KEEP_ALIVE_REQUEST.

After the peer joins the IP Site Connect system, it starts the PeerKeepAlive Timer for each non-Master peer in the system. When the PeerKeepAlive Timer times out, the peer sends LE_PEER_KEEP_ALIVE_REQUEST to another peer in the system. After the peer does not receive the LE_PEER_KEEP_ALIVE_RESPONSE for 10 times continuously from another peer, the peer considers the link is down and starts the registration process by sending the LE_MASTER_PEER_REGISTRATION_REQUEST to the Master Peer.

There is no limit on the setting of the PeerKeepAlive Timer. The MOTOTRBO repeaters use 6 seconds for this timer.

4.8.10.2. Cautions / Warnings

None.

1066 #### 4.8.10.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x98	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint16	Services supports of the sending peer	4.9.8

1067

System	Version Introduced
IP Site Connect	1
Capacity Plus	1

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x98	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint32	Services supports of the sending peer	4.9.8

1068

System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x98	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint16	The current operating modes of the sending peer	4.9.7
7	peerServices	Uint32	The services supports of the sending peer.	4.9.8
11	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
13	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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1071 ### 4.8.11 0x99 – LE_PEER_KEEP_ALIVE_RESPONSE

Class	Link Establishment	Type	Response
Opcode	0x99	Command	LE_PEER_KEEP_ALVIE_RESPONSE
Description	Peer Keep Alive Response		

1072 #### 4.8.11.1. Description

1073 This message is used to respond the request of a peer.

1074 A peer sends out an LE_PEER_KEEP_ALIVE_RESPONSE in the following situation:

1075 1) Upon receiving an LE_PEER_KEEP_ALIVE_REQUEST

1076 The LE_PEER_KEEP_ALIVE_RESPONSE is only sent from a peer back to the
1077 requesting peer. A peer stops receiving a LE_PEER_KEEP_ALIVE_RESPONSE when
1078 its link with another peer goes down.

1079 #### 4.8.11.2. Cautions / Warnings

1080 None.

1081 #### 4.8.11.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x99	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint16	Services supports of the sending peer	4.9.8

1082

System	Version Introduced
IP Site Connect	1
Capacity Plus	1

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x99	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	peerMode	Uint8	The current operating modes of the sending peer	4.9.7
6	peerServices	Uint32	Services supports of the sending peer	4.9.8

1083

System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x99	
1	peerID	Uint32	The ID of the sending peer	4.9.1

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
5	peerMode	Uint16	The current operating modes of the sending peer	4.9.7
7	peerServices	Uint32	The services supports of the sending peer.	4.9.8
11	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
13	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.12 0x9A – LE_DEREGISTRATION_REQUEST

Class	Link Establishment	Type	Request
Opcode	0x9A	Command	LE_DEREGISTRATION_REQUEST
Description	Deregistration Request		

4.8.12.1. Description

This message is used to deregister with the Master Peer or other peer.

A peer sends out an LE_DEREGISTRATION_REQUEST in the following situation:

1) Whenever it desires to remove itself from the IP Site Connect system

The LE_DEREGISTRATION_REQUEST is sent from a peer to the Master Peer or other peers. A peer only sends a LE_DEREGISTRATION_REQUEST when it wants to be immediately removed from the system and to notify all peers to stop sending packets to it. This is normally only utilized by peers that are running on a PC environment. The MOTOTRBO repeater does not send the LE_DEREGISTRATION_REQUEST.

Without this message a peer is automatically removed from the peer maps in each linked peer after a predetermined inactivity timeout period (typical 60s) by the Master Peer or other peers. This is important to note that an updated peer map from the Master Peer with a peer removed does not cause the others peers to remove the peer from their map just because communications with the Master Peer failed and the peer was removed the Master Peer map. Instead, each peer shall independently decide whether a peer is to be removed from its peer map either by inactivity timeout or the use of the deregistration request.

It is recommended that this message shall be sent to the Master Peer first and then to all non-Master Peers. Otherwise, the Master Peer could send out a peer map with the to-be-removed peer to a peer that just updated its own peer map based on the deregistration message. When this happens, the receiving peer identifies the to-be-removed peer as a new peer in the system and attempts to re-establish a link with this peer even though it just removes the to-be-removed peer from its map table. Deregistration of the peer still occurs, but is less efficient.

4.8.12.2. Cautions / Warnings

None.

4.8.12.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x9A	
1	peerID	Uint32	The ID of the sending peer	4.9.1

System		Version Introduced		
Linked Capacity Plus		3		
Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x9A	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
7	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

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4.8.13 0x9B – LE_DEREGISTRATION_RESPONSE

Class	Link Establishment	Type	Response
Opcode	0x9B	Command	LE_DEREGISTRATION_RESPONSE
Description	Deregistration Response		

4.8.13.1. Description

This message is used to respond the request of a peer.

The Master Peer or a peer will send out an LE_DEREGISTRATION_RESPONSE in the following situation:

1) Upon receiving an LE_DEREGISTRATION_REQUEST

The LE_DEREGISTRATION_RESPONSE is only sent from the Master Peer or a peer back to the requesting peer. Once the requesting peer receives LE_DEREGISTRATION_RESPONSE from every linked peer in the system, it can be safely removed from the system. It then proceeds with any other shutdown procedures. When the requesting peer fails to receive the LE_DEREGISTRATION_RESPONSE from all other peers, it may optionally retry or proceed with shutting down.

4.8.13.2. Cautions / Warnings

None.

4.8.13.3. Packet Format

System	Version Introduced
IP Site Connect	0
Capacity Plus	0

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x9B	
1	peerID	Uint32	The ID of the sending peer	4.9.1

System	Version Introduced
Linked Capacity Plus	3

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x9B	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
7	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

4.8.14 0x33 – LE_DIGITALVOTING_MAP_BROADCAST

Class	Link Establishment	Type	Broadcast
Opcode	0x33	Command	LE-DIGITALVOTING_MAP_BROADCAST
Description	Digital Voting Map Broadcast		

4.8.14.1. Description

This message is used for Digital Voting relative peer map broadcast.

The Voting Peer would send out Voter Map to RDAC peers in the following situations:

1. Upon receiving an LE_NOTIFICATION_MAP_REQUEST with map type of Voter Map from a RDAC Peer.
2. Change in status of a Satellite Peer or RDAC Peer

4.8.14.2. Cautions / Warnings

None.

4.8.14.3. Packet Format

System	Version Introduced
IP Site Connect	5
Capacity Plus	5
Linked Capacity Plus	5

Offset	Field	Type	Description	Information Field
0	Opcode	Uint8	Value = 0x33	
1	peerID	Uint32	The ID of the sending peer	4.9.1
5	mapType	uint8	This field defines the type of map being sent in this message.	4.9.4
6	mapLength	uint16	The number of bytes that will be contained in the following map	
8	mapPayload		The Map Payload, refer the tables below.	
	currentLinkProtocolVersion	Uint16	The field that represents the current working protocol version that the peer supports for messaging between peers.	4.9.9
	oldestLinkProtocolVersion	Uint16	The field that represents the oldest working protocol version that the peer can support exchanging with another peer.	4.9.9

The Map Payload format is:

Offset	Field	Type	Description	Information Field

8	numRDACPeer	uint8	The number of RDAC Peers in the system requesting Digital Voting Information	
9	nubSatellitePeers	uint8	The number of Satellite Peers that the Voter Peers responding has associated with it.	
10	RDACPeerID (1)	uint32	The ID of the 1st RDAC Peer requested	4.9.1
14	RDACIPAddr (1)	uint32	The IP address of the 1st RDAC Peer as seen to the public internet (i.e. router address)	4.9.5
18	RDACPort (1)	uint16	The port number of the 1st RDAC Peer as seen to the public internet (i.e. router port)	4.9.6
20	RDACMode (1)	uint8(16)	The field represents the current operating modes of the 1st RDAC Peer. IPSC/Cap+ will be 8 bits while LCP will be 16.	4.9.7
	……..			
	……..			
10+N*11 (10+N*12)	RDACPeerID (N)	uint32	The ID of the Nth RDAC Peer requested	4.9.1
14+N*11 (14+N*12)	RDACIPAddr (N)	uint32	The IP address of the Nth RDAC Peer as seen to the public internet (i.e. router address)	4.9.5
18+N*11 (18+N*12)	RDACPort (N)	uint16	The port number of the Nth RDAC Peer as seen to the public internet (i.e. router port)	4.9.6
20+N*11 (20+N*12)	RDACMode(N)	uint8(16)	The field represents the current operating modes of the Nth RDAC Peer. IPSC/Cap+ will be 8 bits while LCP will be 16.	4.9.7
21+N*11 (22+N*12)	SatellitePeerID (1)	uint32	The ID of the 1st Satellite Peer	4.9.1
26+N*11 (27+N*12)	SatelliteIPAddr (1)	uint32	The IP address of the 1st Satellite Peer as seen to the public internet (i.e. router address)	4.9.5
30+N*11 (31+N*12)	SatellitePort (1)	uint16	The port number of the 1st Satellite Peer as seen to the public internet (i.e. router port)	4.9.6
32+N*11 (33+N*12)	SatelliteMode (1)	uint8(16)	The field represents the current operating modes of the 1st Satellite Peer. IPSC/Cap+ will be 8 bits while LCP will be 16 bits.	4.9.7
	……..			
	……..			
10+N*22 (10+N*24)	SatellitePeerID (N)	uint32	The ID of the Nth Satellite Peer	4.9.1
14+N*22 (14+N*24)	SatelliteIPAddr (N)	uint32	The IP address of the Nth Satellite Peer as seen to the public internet (i.e. router address)	4.9.5
18+N*22 (18+N*24)	SatellitePort (N)	uint16	The port number of the Nth Satellite Peer as seen to the public internet (i.e. router port)	4.9.6
20+N*22 (20+N*24)	SatelliteMode(N)	uint8(16)	The field represents the current operating modes of the Nth Satellite Peer. IPSC/Cap+ will be 8 bits while LCP will be 16 bits.	4.9.7

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4.9 Information Field

4.9.1 Unique Master or Peer Identifier (peerID and remotePeerID)

This field specifies the identity of a peer or the Master Peer. It is a 32-bit unsigned integer in network byte order.

System	Version Introduced
IP Site Connect	0
Capacity Plus	0
Peer ID Value	**Allocation**
0x00000000	RESERVED
0x00000001 to 0x00FFFCDF	Valid Range
0x00FFFCE0 to 0xFFFFFFFF	RESERVED

Table 4 - Peer ID Allocation

System		Version Introduced		
Linked Capacity Plus		3		
Offset	**Field**	**Type**	**Information Field**	**Description**
0	siteID	Uint8	0x00: Allocated by system for application only; 0x01 to 0x15: Configured by CPS	The ID of the site where the sending peer situated.
1	peerID	Uint24	0x000001 to 0x0x00FFFCDF: Same as **Table 4** except a smaller range.	The ID of the sending peer

Table 5 – Peer ID Allocation for Linked Capacity Plus System

Note: The Peer ID in LCP is different with that field in IPSC/CPC. Specially it has two parts: site ID and peer ID. Make sure the 3rd party application peer has the specified site ID of 0x00 while its peerID can be determined by 3rd party themselves.

4.9.2 Number of Linked Peers (numPeers)

This field indicates the number of peers that have established a links with the Master Peer. Since the IPv4 Protocol limits the UDP data length to 65,507 bytes, the maximum number peers is limited to 5,037 (or 0x13AD). This value is calculated by taking the maximum UDP data length (65,507) and subtracting the LE Header size (5) and map length (4) and then dividing this value by the number of bytes per peer map entry (13).

Number of Peers Value	Allocation
0x0000 to 0x13AD	Valid Range
0x13AE to 0xFFFF	RESERVED

Table 6 - Number of Linked Peers Allocation

4.9.3 Peer Map Length (mapLength)

This field indicates the total length of the Peer Map sent from the Master Peer. Due to packet fragmentation and processing limits, the size of each UDP packet is limited to 1,500 bytes. Therefore, the maximum map length is actually only 1,478 (0x05C6) after leaving space for the headers and footers.

Map Length Values	Allocation
0x0000 to 0x05C6	Valid Range
0x05C6to 0xFFFF	RESERVED

Table 7 - Map Length Allocation

4.9.4 Peer Map Type (mapType)

Map Type Bit	Description
0	System Wide Map
1	RESERVED
2	Master Peer Programming Map
3	RESERVED
4	Voter Map
5	RESERVED
6	RESERVED
7	Map Continuation Indicator

Table 8 - Map Type Bit Allocation

4.9.5 Peer IP Address (remoteIPAddr)

This field identifies the IP Address of a peer in the system. The actual allocation for the IP address shall adhere to that defined by the IPv4 Protocol. The following is an example of how the common logical decimal representation compares to the physical packet representation in hexadecimal.

If the peer is behind a firewall, the Peer IP Address is router's IP Address.

Physical Representation	Logical Representation
0x0A029636	10.2.150.54

Table 9 - Peer IP Address Representation

4.9.6 Peer IP Port Address (remotePort)

This field represents UDP IPv4 Port Address/Number used by a peer or the Master Peer in the system. The IPv4 Protocol limits the port address range to be from 0 to 65,535. Port addresses 0 to 49,151 are already reserved for the Well Known Ports or the Registered Ports. So the Link Establishment protocol will use port addresses 49,152 to 65,535 (also used for temporary usage between clients and servers).

If the peer is behind a firewall, the peer IP Port Address is router's IP Port Address.

Map Length Values	Allocation
0x0000 to 0xBFFF	RESERVED

0xC000 to 0xFFFF	Valid Range

Table 10 - IP Port Address Allocation

4.9.7 Peer Mode Bit Field (peerMode)

This field specifies current operating mode information associated with this peer. There are four different modes specified in this field. Each mode indicator represents 2 bits.

System	Version Introduced
IP Site Connect	0
Capacity Plus	0
Peer Mode Bit	**Peer Mode Bit Name**
0	Slot 2 Assignment[1]
1	Slot 2 Assignment[2]
2	Slot 1 Assignment[1]
3	Slot 1 Assignment[2]
4	Current Signaling Mode[1]
5	Current Signaling Mode[2]
6	Peer Status[1]
7	Peer Status[2]

Table 11 - Peer Mode Bit Allocation

System	Version Introduced
Linked Capacity Plus	3
Peer Mode Bit	**Peer Mode Bit Name**
0	Slot 2 Assignment[1]
1	Slot 2 Assignment[2]
2	Slot 1 Assignment[1]
3	Slot 1 Assignment[2]
4	Peer Status[1]
5	Peer Status[2]
6	Primary Master Peer
7	Remote 3rd Party Console Application
	RESERVED
	RESERVED
10	RESERVED
11	RESERVED
12	RESERVED
13	No Link Establishment with Data Revert Repeater. When set then data revert repeater do not send keep alives to the peer.
14	MOTOTRBO Network Interface Service (MNIS)
15	Digital Voting Enabled

Table 12 - Peer Mode Bit Allocation for Linked Capacity Plus System

MOTOTRBO Network Interface Service (MNIS) is a Motorola software which enables an IP data connection between a MOTOTRBO™ repeater network and a third party data application. MNIS joins the repeater systems as a peer and identifies itself with the

MNIS bit in the PeerMode field for LCP system or MNIS bit in the peerService field for conventional system and Capacity Plus system.
The Slot Assignment fields are located near the least significant bit position, and the Peer Status fields are located near the most significant bit position.

4.9.7.1. Slot Assignment

This field will contain two bits to indicate the slot assignment information regarding use for IP Site Connect call support, local site call support only, or no call support on this peer (i.e. an RDAC peer).

System	Version Introduced
IP Site Connect	0
Capacity Plus	0
Value	**Allocation**
0b00	No Call Support
0b01	Local Site Call Support Only
0b10	IP Site Connect Call Support
0b11	RESERVED

Table 13 - Slot Assignment Bit Allocation

System	Version Introduced
Linked Capacity Plus	3
Value	**Allocation**
0b00	No Call Support
0b01	LCP Trunked Channel
0b10	LCP Local Area Data Revert Channel
0b11	LCP Wide Area Data Revert Channel

Table 14 - Slot Assignment Bit Allocation for Linked Capacity Plus System

4.9.7.2. Current Signaling Mode

This field will contain two bits to indicate the current RF signaling mode information pertaining to the Analog or Digital modes of operation. A peer can also indicate that it has no RF support.

Value	Allocation
0b00	No RF Support
0b01	Analog Mode
0b10	Digital Mode
0b11	RESERVED

Table 15 - Current Signaling Mode Bit Allocation

4.9.7.3. Peer Status

This field contains two bits to indicate whether a peer is currently disabled or enabled. When a peer is disabled, it only supports Link Establishment and some peer services (i.e. RDAC and other XCMP/XNL services). It does not support voice, data, or CSBK calls when disabled.

Value	Allocation
0b00	Disabled
0b01	Enabled
0b10	Knocked Down
0b11	Locked

Table 16 - Peer Status Bit Allocation

Enabled Status: Repeater is in the normal mode of transmitting, receiving and repeating. Repeater is capable of transmitting, receiving and repeating operations.

Knocked Down Status: Repeater does not repeat received signals, but is capable of receiving and transmitting through an external PTT.

Disabled Status: Repeater does not perform transmitting, receiving and repeating operations.

Locked Status: Repeater is in a failure mode, in which transmitting, receiving and/or repeating capabilities have failed.

4.9.8 Peer Services Bit Field (peerServices)

System	Version Introduced	
IP Site Connect	0	
Capacity Plus	0	
Peer Services Bit	**Peer Service Name**	**Description**
The following 16 bits are allocated or reserved for support by all releases		
0	Primary Master Peer	Indicates a peer acts as a Master Peer for the system.
1-3	RESERVED	
4	Packet Authentication	This bit should indicate whether Authentication is enabled on the peer. If this bit does not match that of the Master Peer, then a peer should not be allowed to join the IP Site Connect Network.
5-7	RESERVED	
8	Slot 1 Assignment in Capacity Plus	Only applicable for Capacity Plus repeater peer. This bit indicates whether this peer supports Capacity Plus channel in slot 1.
9		

10 11	Slot 2 Assignment in Capacity Plus	Only applicable for Capacity Plus repeater peer.,This bit indicates whether this peer supports Capacity Plus channel in slot 2
12	RESERVED	
13	Remote 3rd Party Console Application	This bits indicates that the peer is a remote 3rd party application peer.
14-15	RESERVED	
The following 16-bits are reserved for usage by releases post-R1.6		
16-18	RESERVED	
19	Slot 1 Phone Gateway	This bit indicates if this peer is configured as Phone Gateway at slot 1. 1 – Phone Gateway Enabled; 0 – Phone Gateway Disabled.
20	Slot 2 Phone Gateway	This bit indicates if this peer is configured as Phone Gateway at slot 2. 1 – Phone Gateway Enabled; 0 – Phone Gateway Disabled.
21-22	RESERVED	
23	MNIS	This bit indicates if this peer is a MNIS or not.
24	MNIS Status [1]	This is LSB bit of the MNIS Status field
25	MNIS Status [2]	This is MSB bit of the MNIS Status field
30	Digital Voting	This bit is set if a Repeater is Voting-enabled or a RDAC Application supports a Digital Voting system
others	RESERVED	

Table 17 - Peer Services Bit Allocation

System	Version Introduced	
Linked Capacity Plus	3	
Peer Services Bit	**Peer Service Name**	**Description**
0-3	RESERVED	
4	Packet Authentication	This bit should indicate whether Authentication is enabled on the peer. If this bit does not match that of the Master Peer, then a peer should not be allowed to join the IP Site Connect Network.
5	RESERVED	
6	Slot 1 Phone Gateway	This bit indicates if this peer is configured as Phone Gateway at slot 1. 1 – Phone Gateway Enabled; 0 – Phone Gateway Disabled.
7	Slot 2 Phone Gateway	This bit indicates if this peer is configured as Phone Gateway at slot 2. 1 – Phone Gateway Enabled; 0 – Phone Gateway Disabled.
8	RESERVED	
9	MNIS Status [1]	This is LSB bit of the MNIS Status field
10	MNIS Status [2]	This is MSB bit of the MNIS Status field
11-31	RESERVED	

Table 18 - Peer Services Bit Allocation

4.9.8.1. MNIS Status

This field will contain two bits to indicate the health of MNIS. The bits are set to 0b00 only when the MNIS has successfully established connection with the Device Discovery and Mobility Service (DDMS), and the MNIS's MOTOTRBO Tunnel is in connected state. If one of the two connection is broken, the bits are set to 0b01. Please keep in mind these bits cannot indicate the MNIS network connection to the repeater peers.

Value	Allocation

0b00	Normal Condition
0b01	Fault Condition
0b10	RESERVED
0b11	RESERVED

4.9.9 Link Protocol Version Bit Field (Link Protocol Version)

This field is used to exchange link protocol version information for the accepted, current, and oldest supported versions. The link protocol version has two components: system ID and version information, which are used to determine the message structure and procedure in the multi-software-version system interactions. Each PDU is defined to support a specific system ID and protocol in section 4.8.

The overall field size is 16 bits that is broken into the 10-bit version information field and 6-bit system ID field as shown in Figure 32:

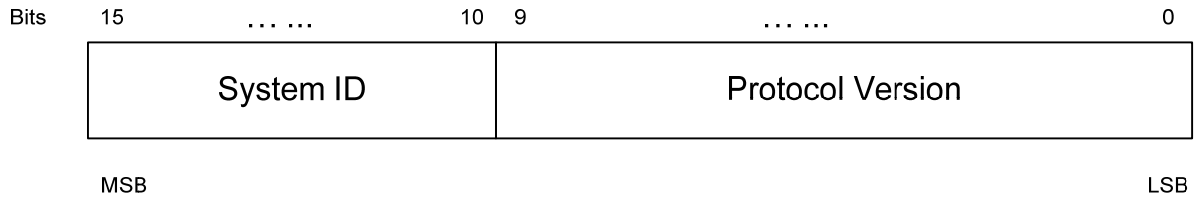

Figure 32: Link Protocol Version Bits

A bit mask of 0xFC00 can be used to derive the System ID from the Link Protocol Version field. A bit mask of 0x03FF can be used to derive the version information value from the Link Protocol Version field. The system ID field allows for the definition of up to 63 unique systems. The version information field allows for 1023 possible versions of the protocol for each system ID.

Link Protocol Version Bits	Link Protocol Version Name	Description
0-9	Protocol Version	0b00 0000 0000 = R1.4, R1.5, R1.5a 0b00 0000 0001 = R1.6 0b00 0000 0010 = R1.7, R1.8, R1.9 (CPC,IPSC) 0b00 0000 0011 = R1.9(LCP),R2.2(CPC) 0b00 0000 0100 = R2.2(LCP, IPSC) 0b00 0000 0101 = R2.3(LCP, IPSC,CPC)
10-15	System ID	0b0000 00 = RESERVED 0b0000 01 = IP Site Connect, Analogue, Single Site 0b0000 10 = Capacity Plus 0b0001 00 = Linked Capacity Plus

Table 19: Link Protocol Version Bit Allocation

The MOTOTRBO repeater peers in analog mode shall use the system type of IP Site Connect in the LE registration. A MOTOTRBO repeater peer can only exist in one system at one time. It can only have one System ID. A third party application can have multiple system IDs to support different types of system at the same time, e.g. a Capacity Plus system and an IP Site Connect system. It has to use the same system ID as the MOTOTRBO repeater peers to establish the connection. It has to use system ID of 1 to communicate with the peers in the IP Site Connect system, and use system ID of 2 to communicate with the peers in the Capacity Plus system.

5.0 CPS Provisioning

In an IP Site Connect system or Capacity Plus system or Linked Capacity Plus system, each peer has a Peer ID, an IP address and a UDP port. The Peer ID is used to uniquely identify an IP Site peer. The IP address and UDP port are used to communicate with other peers over an IP network. This section describes the IP Site Connect/Capacity Plus system/Linked Capacity Plus system configuration in a MOTOTRBO repeater. The third party application must have configuration settings for these parameters just like a MOTOTRBO repeater..

5.1 Peer ID

The “Radio ID” is used as a MOTOTRBO repeater’s Peer ID in the IP Site Connect system or Capacity Plus system or Linked Capacity Plus system. Figure 33 shows the configuration of “Radio ID”. Note that each peer in the IP Site Connect system or Capacity Plus system or Linked Capacity Plus system must have a unique “Radio ID”.

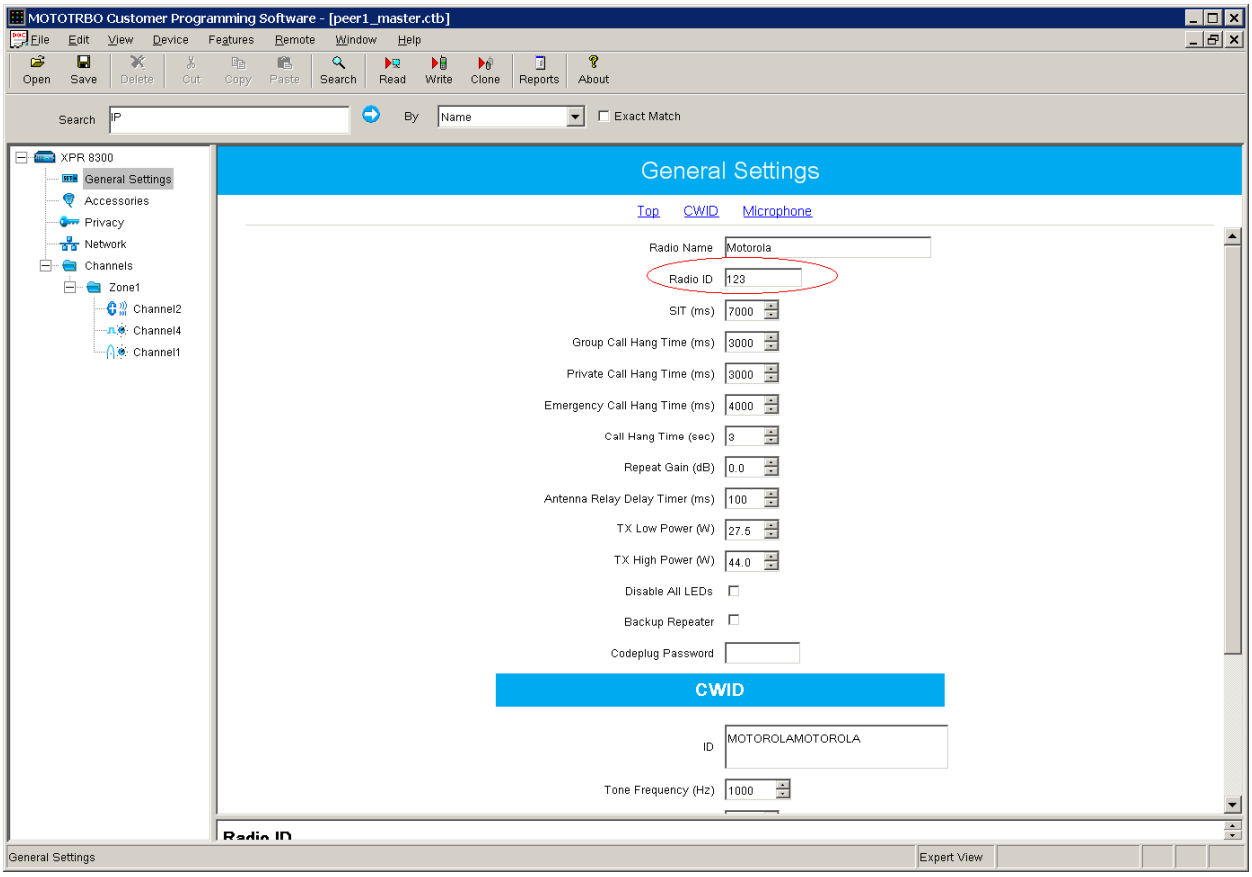

Figure 33 – Peer ID Configuration

Note that the repeater's Radio ID has no relationship with the Subscriber's Radio ID. If the third party application peer needs to operate as a Subscriber to initiate a voice/data/control call, it must have both the Peer ID and the Radio ID configuration.

5.2 Wide Area Talkgroup ID and Reserved Wide Area Channels in Linked Capacity Plus System

In a Linked Capacity Plus system, a wide-area talkgroup call is transmitted over-the-air at multiple sites. A customer needs to configure the following items for wide-area talkgroups:

- Ids of all the wide-area talkgroups; by default, the rest of the talkgroup Ids are treated as Local Talkgroup ID.
- Associated sites for each wide-area talkgroup, a list of the sites where the wide-area talkgroup needs to be supported. A wide area call cannot be set up successfully during arbitration time if there is one associated site which has consumed all its available channels.

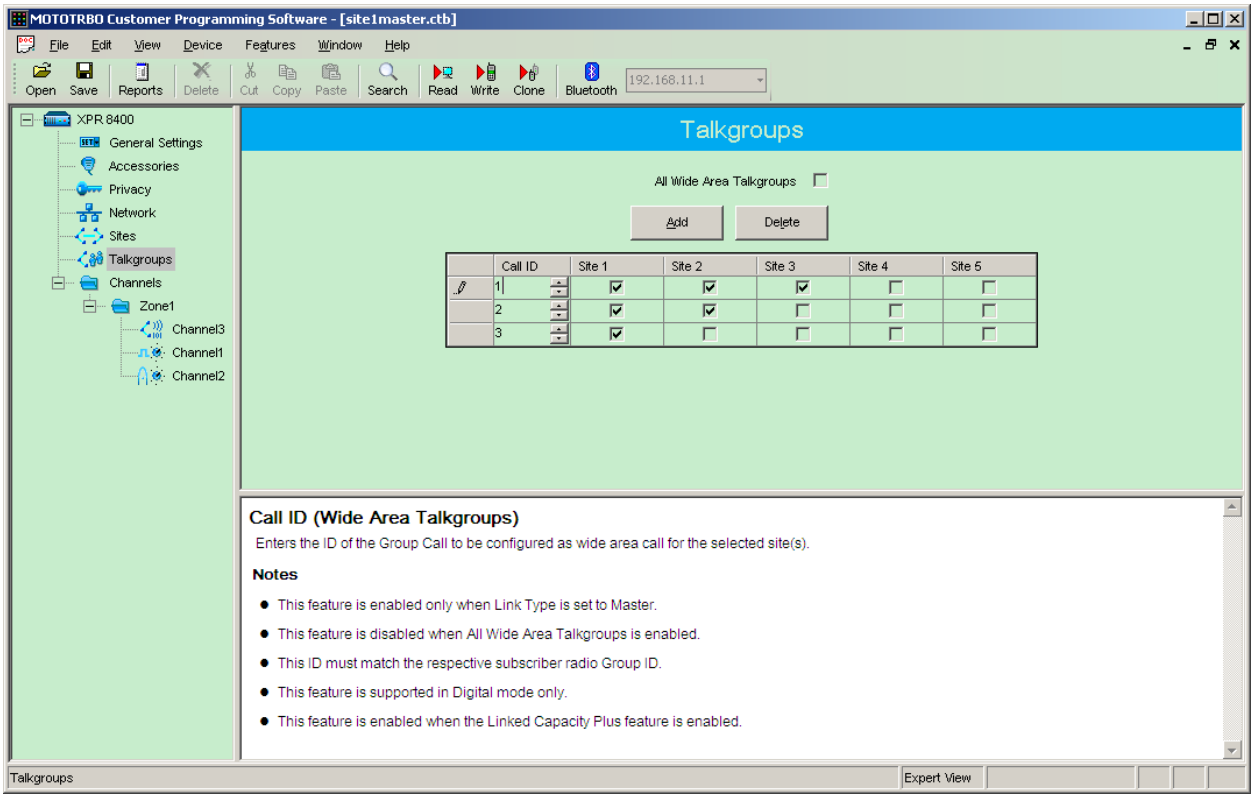

Figure 34 – Wide Area Talk Group Id and Associated Sites Configuration

- Reserved Wide Area Channels in each site. When channels in a site are not very busy, the channels can be used for either local call or wide-area call. But when a site has only number of "reserved channel" left, the site can accept only wide-area group

call and LCP individual call but deny local call. For example, in case some of the sites have consumed up their idle channels, an individual call is initiated by radioA to radioB. Even when radio A and radioB are at the same site where idle channels are available, the call cannot be set up.

- Neighbor sites in each site, used for site roaming and site searching.

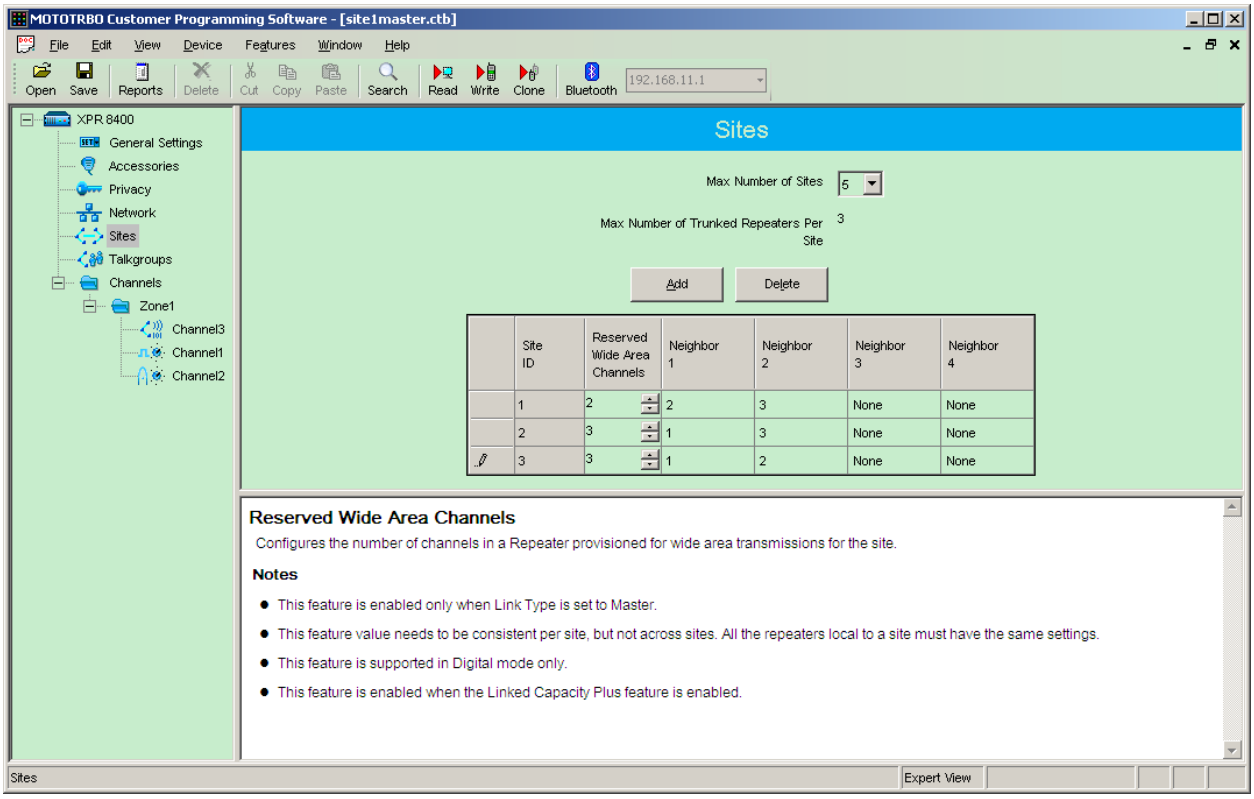

Figure 35 – Reserved Wide Area Channels Configuration

Note: The wide area group list and the number of reserved wide area channels only needs to be configured in the master peer. The master peer distributes the wide area group list in the LE map broadcast message as Master Peer Programming Map as defined in section 4.8.5.4.1.

5.3 Network Configuration

The “Link Type” determines the type of peer in an IP Site Connect system or Capacity Plus system. A MOTOTRBO Repeater can be either a Master or a Peer in an IP Site Connect system or Capacity Plus system.

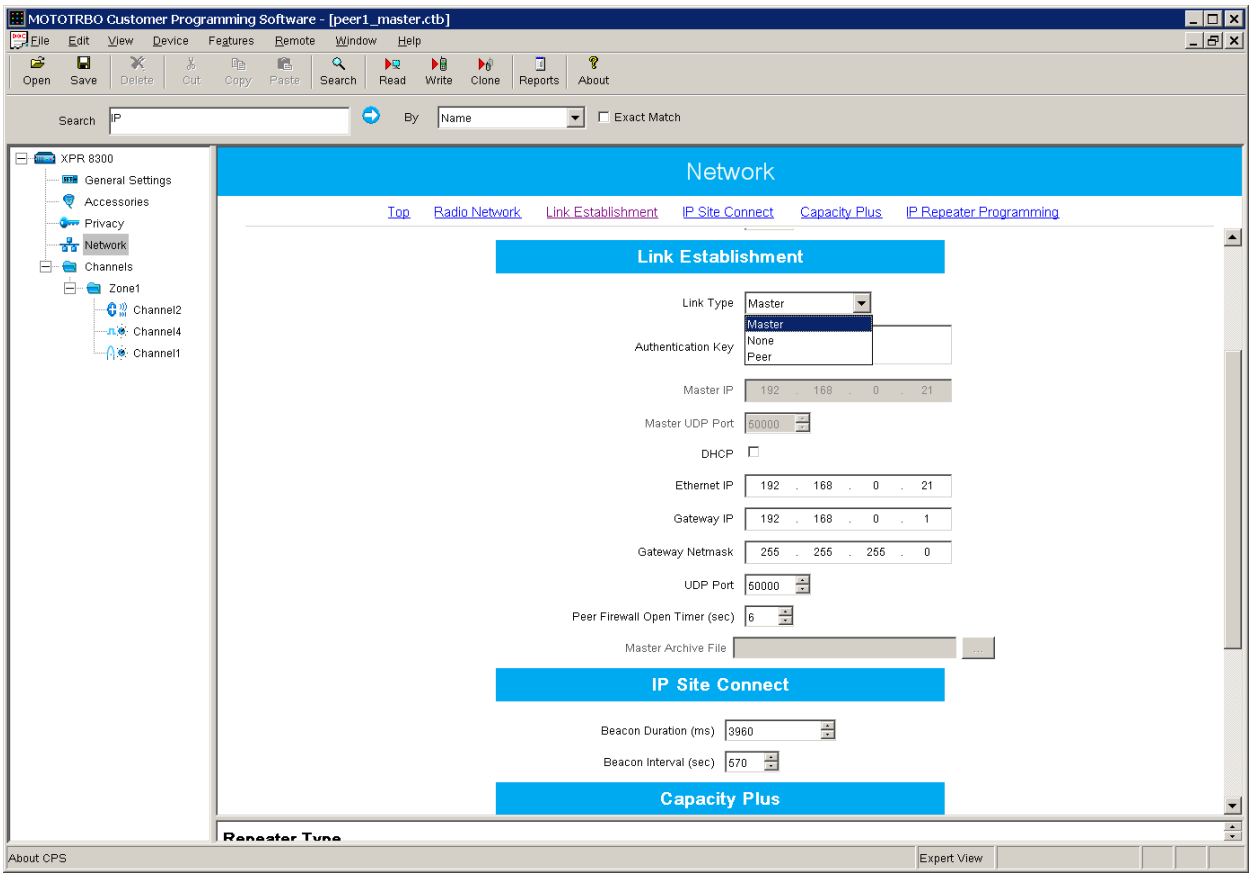

Figure 36 – Link Type Configuration

5.3.1 Master Repeater Peer

When a MOTOTRBO repeater is configured as “Master”, it must have a well known static IP address and source port number.

Figure 37 shows a Master Repeater Peer’s network configuration. The “Ethernet IP” field specifies the Master’s IP address. The UDP port is configured as 50000 by default. The MOTOTRBO repeater allows port ranges between 1024 and 65535. Use of the default port number is recommended. If the default UDP port is not used, it is suggested to use a port in the range from 49152 to 65532 since 0 – 49151 are well known ports for other applications.

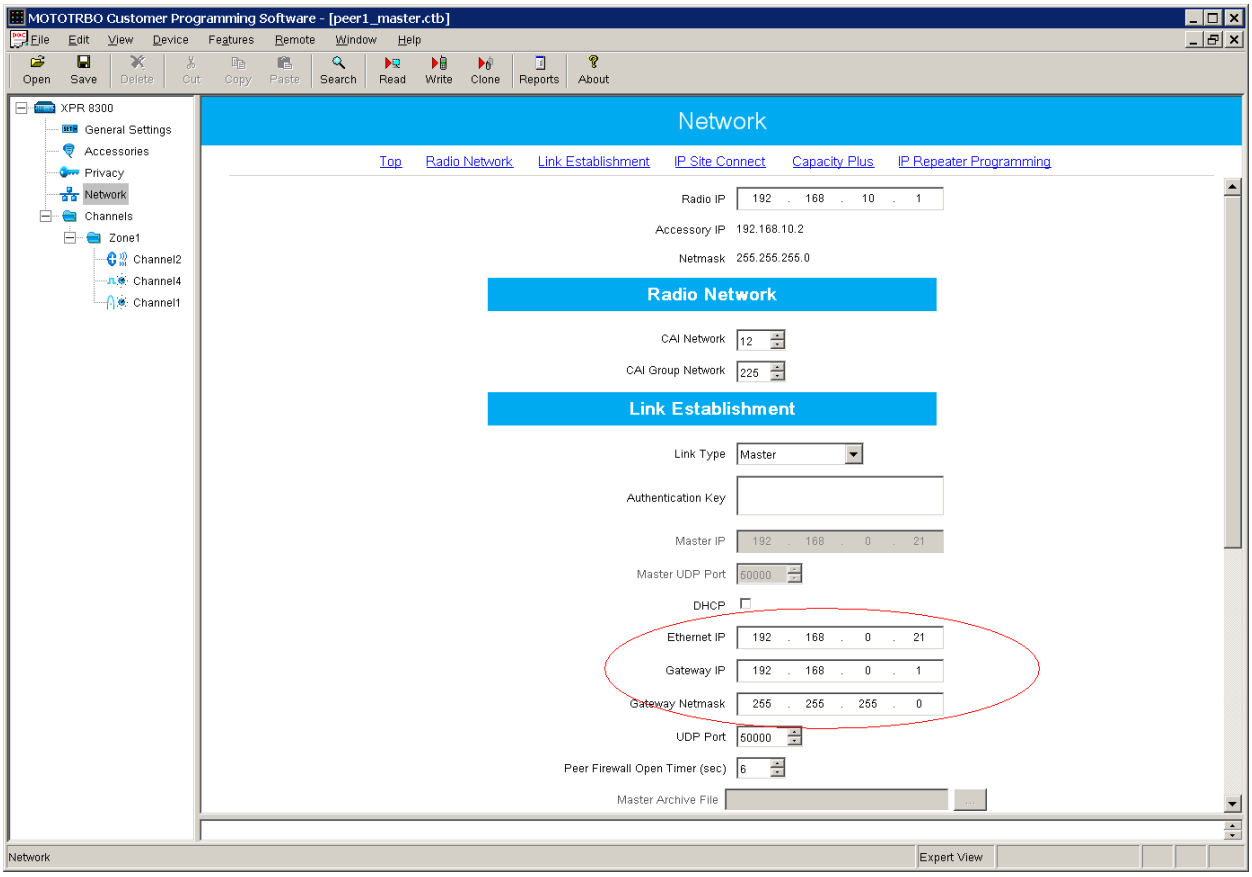

Figure 37 – Master Repeater Peer Network Configuration

Note that this Master configuration example is not for the peer behind the firewall.

5.3.2 Repeater Peer

When a MOTOTRBO repeater is configured as “Peer”, both the Master and the peer’s IP address and UDP port must be configured. The peer can be either assigned a static IP address or assigned an IP address through DHCP.

Figure 38 shows a Repeater Peer’s network configuration with DHCP enabled. Since the peer’s IP address is assigned through DHCP, only the Master’s IP address and UDP port must be configured. The peer’s UDP port is configured as 50000 by default.

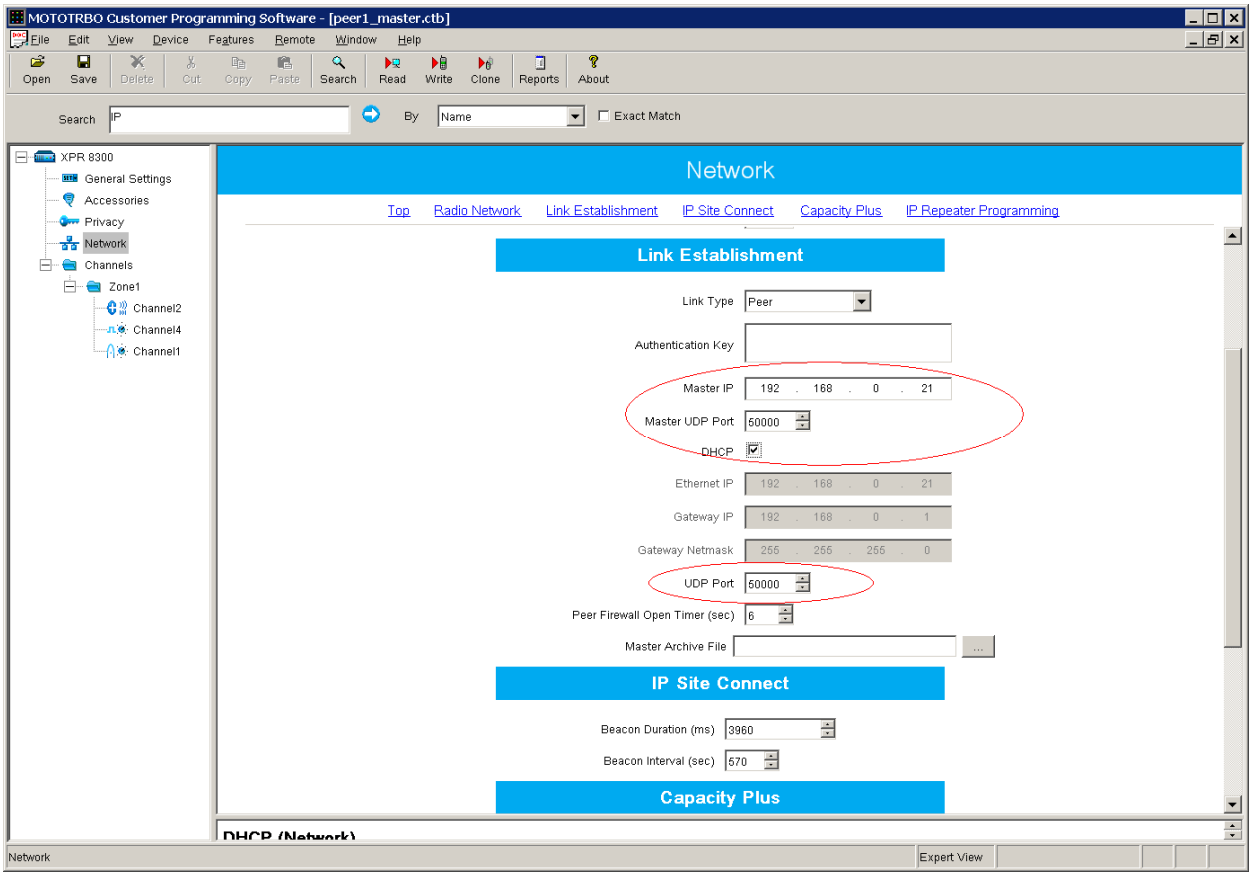

Figure 38 – Repeater Peer’s Network Configuration with DHCP Enabled

Figure 39 shows a Repeater Peer’s network configuration when DHCP is unchecked. In this case, both the Master and the peer’s IP address and UDP port must be configured. The “Ethernet IP” field specifies the peer’s IP address.

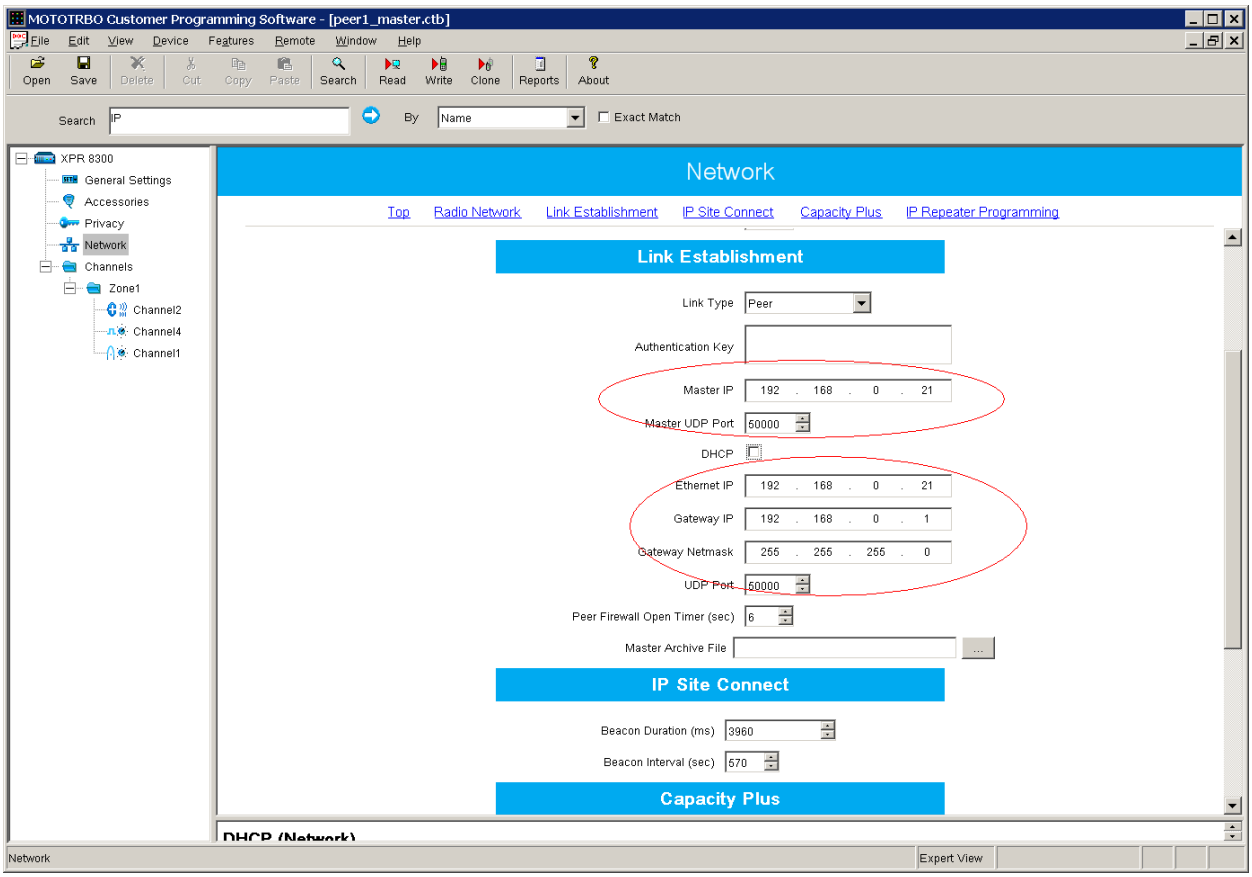

Figure 39 - Repeater Peer's Network Configuration with DHCP Disabled

Another setting for a Repeater Peer is "Peer Firewall Open Timer". This configuration determines the time interval that the peer sends a next LE_KEEP_ALIVE_REQUEST. Figure 40 shows the "Peer Firewall Open Timer" configuration. This timer is not required to be same in all peers in the system.

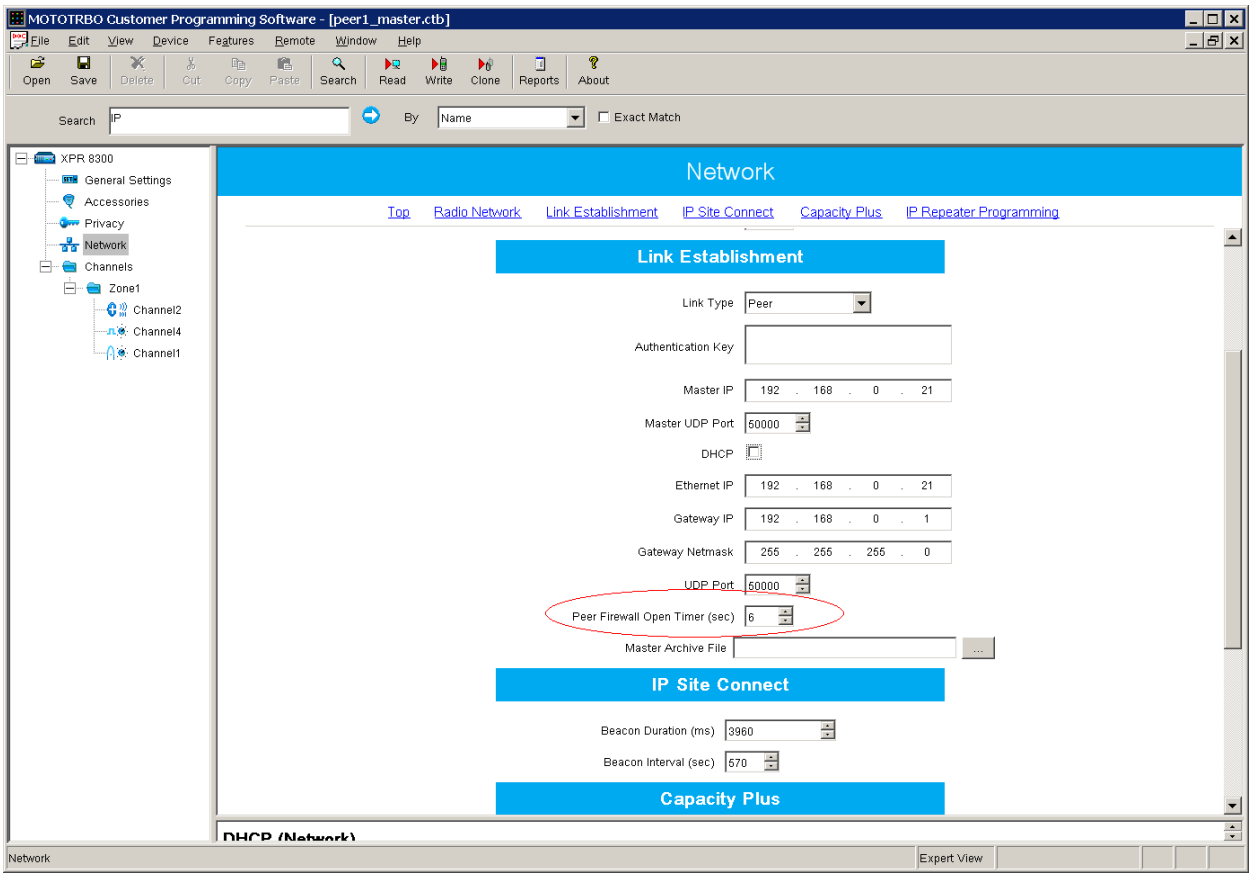

Figure 40 – Peer Firewall Open Timer Configuration

5.3.3 CPC/LCP Rest Channel IP Address / UDP Port

In the Capacity Plus system and Linked Capacity Plus system, a fixed IP address and a fixed UDP port are assigned to the Rest Channel. This static IP address and UDP port of the Rest Channel is associated with a repeater only for the duration for which one of its logical channels is the Rest Channel. Every repeater in the same Capacity Plus system or in the same site of a Linked Capacity Plus system has to configure the same Rest Channel IP address and port number. The application can get the Rest Channel IP address and port number from the LE system map.

Figure 41 shows the Rest Channel IP/UDP Port Configuration.

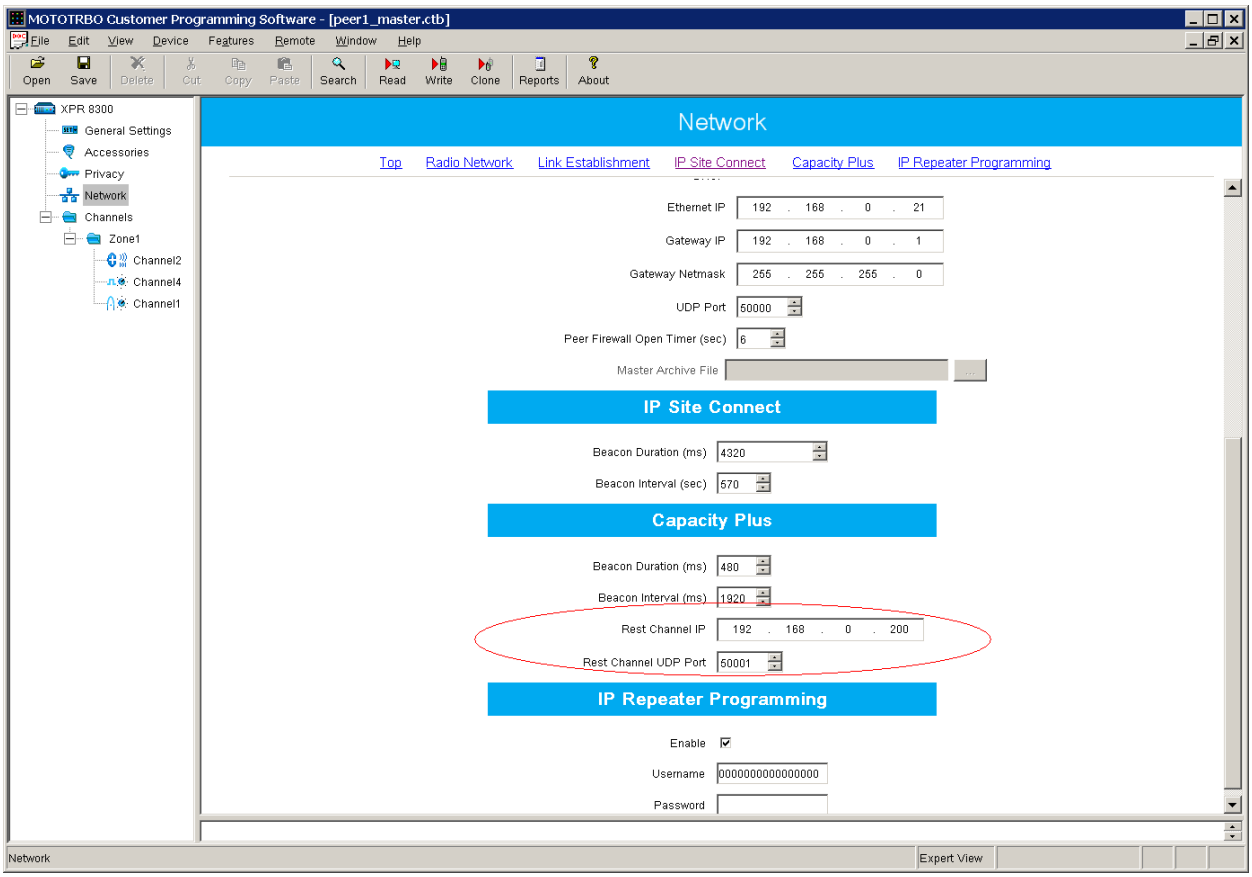

Figure 41: Rest Channel IP/UDP Port Configuration

5.4 Authentication Key

The IP Site Connect system or Capacity Plus system has an optional configuration scheme to support protocol authentication based on SHA-1 for computing a condensed representation of a protocol message. The configuration allows the developer to specify the private authentication key in a MOTOTRBO repeater peer. All peers within the same IP Site Connect system or Capacity Plus system must share the same authentication key. The third party application also needs to have the ability to enter an IP Site Connect Authentication Key into the application that is up to 40 characters in length whenever the IP Site Connect system or Capacity Plus system requires an authentication key to gain access. The authentication is disabled when the authentication key is set to blank.

Figure 42 shows the Authentication Key configuration.

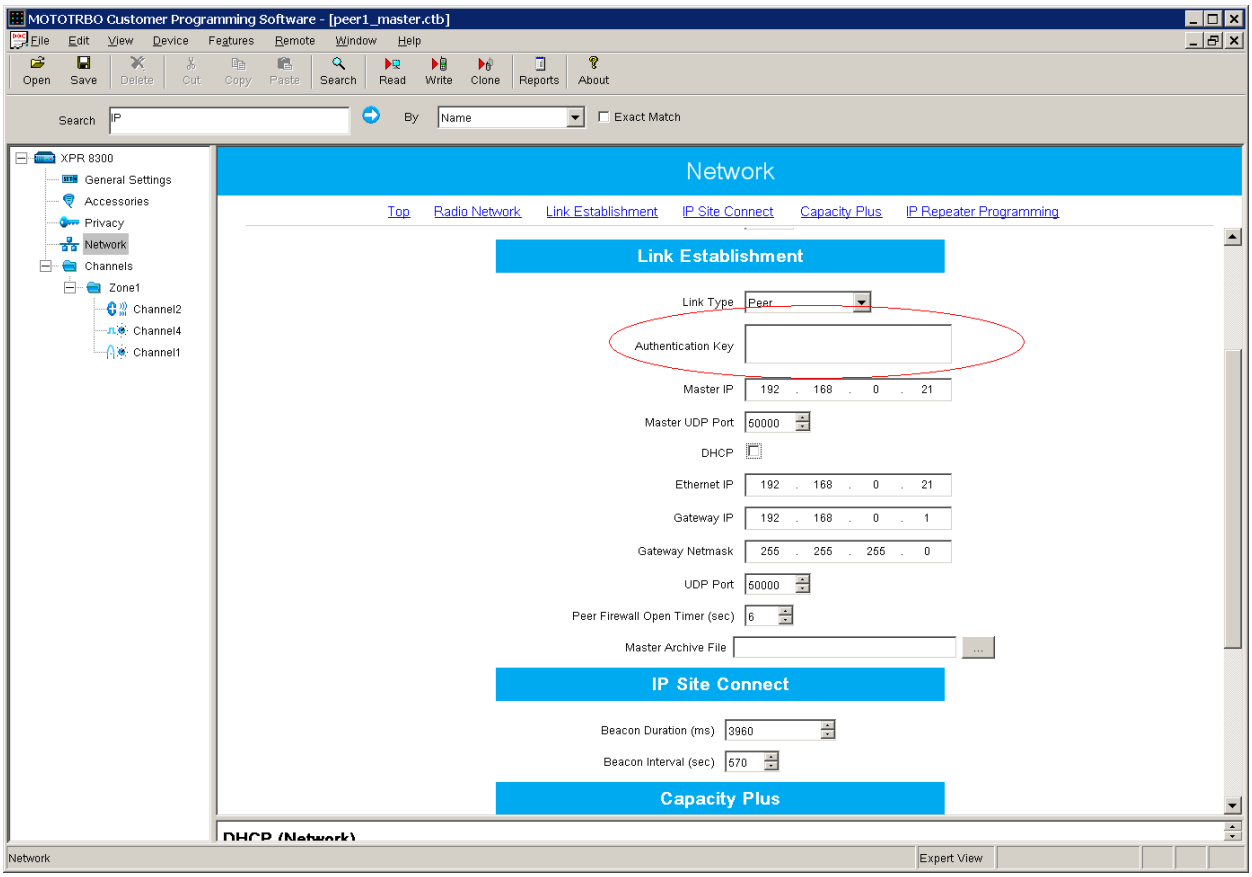

Figure 42: Authentication Key Configuration

5.5 IP Site Connect Slot Configuration

There are two IP Site Connect channels (slot 1 and slot 2) available in an IP Site Connect system. Both slot 1 and slot 2 can be configured as an IP Site Connect channel. The “IP Site Connect” control specifies which slot is used for IP Site Connect. There are four options available for the IP Site Connect configuration:

- None – Indicates both Slot 1 and Slot 2 work in single site mode.
- Slot 1 – Indicates only Slot 1 works in IP Site Connect mode.
- Slot 2 – Indicates only Slot 2 works in IP Site Connect mode.
- Slot 1 & Slot 2 – Indicates both Slot 1 and Slot 2 work in IP Site Connect mode.

The “IP Site Connect” control is enabled only when the “Repeater Type” is set to IP Site Peer or IP Site Master. It is a per channel configuration and is supported in Digital channel only. It is possible that there is no channel configured as IP Site Connect Mode even the Repeater Type is “IP Site Peer” or “IP Site Master”

Figure 43 shows an “IP Site Connect” configuration for a digital channel.

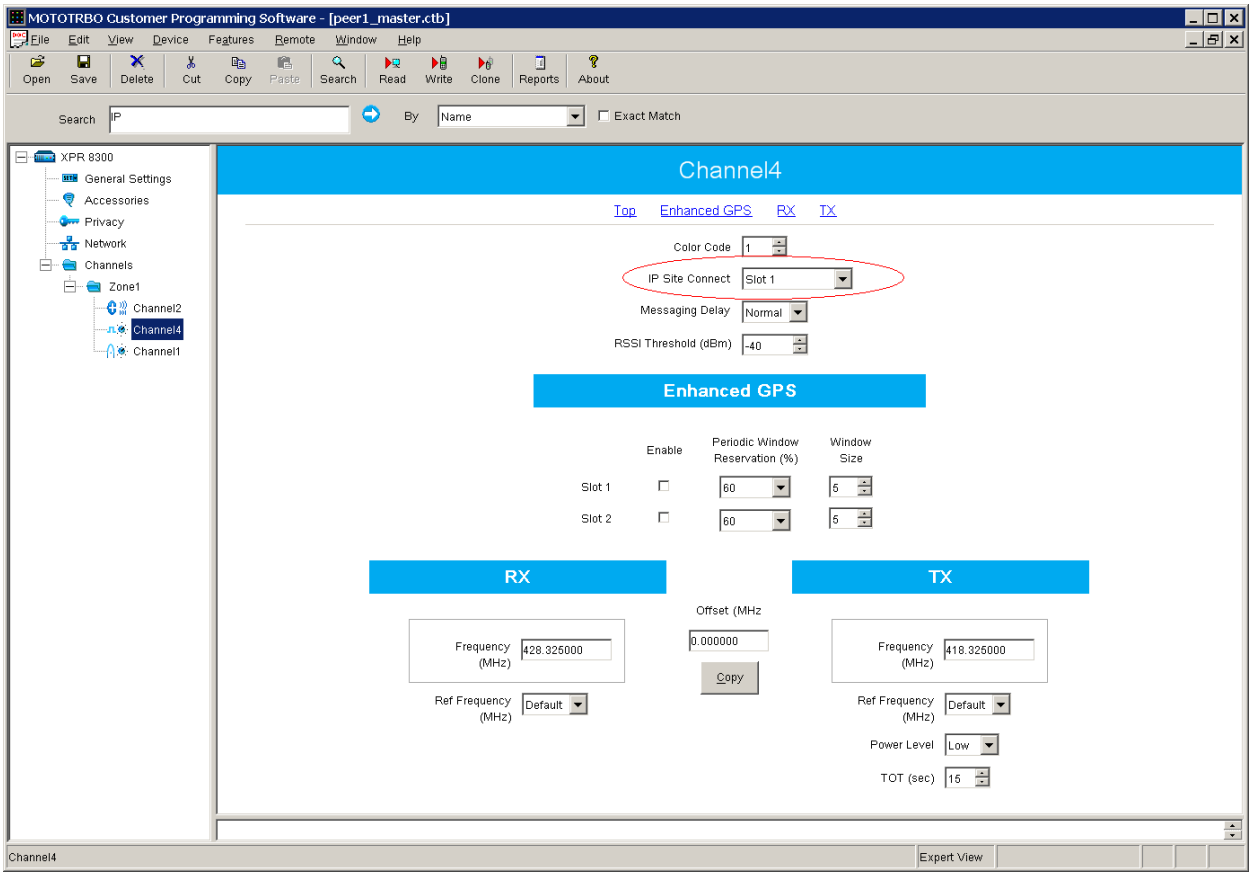

Figure 43: IP Site Connect Slot Configuration

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Appendix A: MOTOTRBO Byte-Ordering Schema Variation in HMAC-SHA1 Hash Calculation

The MOTOTRBO R1.4, R1.5 and R1.5A releases use an alternative byte-order schema in the HMAC-SHA1 hash calculation, which makes the final hash output value from the standard HMAC-SHA1 calculation.

As described in Reference [3], there are two-stage hash calculations in the HMAC-SHA1:

- Stage-One Hash = H ((k ⊕ ipad) || m)
- Stage-Two Hash = H ((k ⊕ opad) || Stage-one hash)

The MOTOTRBO R1.4, R1.5 and R1.5A releases apply the special byte-order schema in the output of stage-one hash before using it in the Stage-Two hash calculation. As shown in Figure 44, the 20-byte Stage-One output is divided into 5 4-byte units. Within each 4-byte unit, the lower 2-byte is swapped with the higher 2-byte. And the two bytes are swapped in each 2-byte unit.

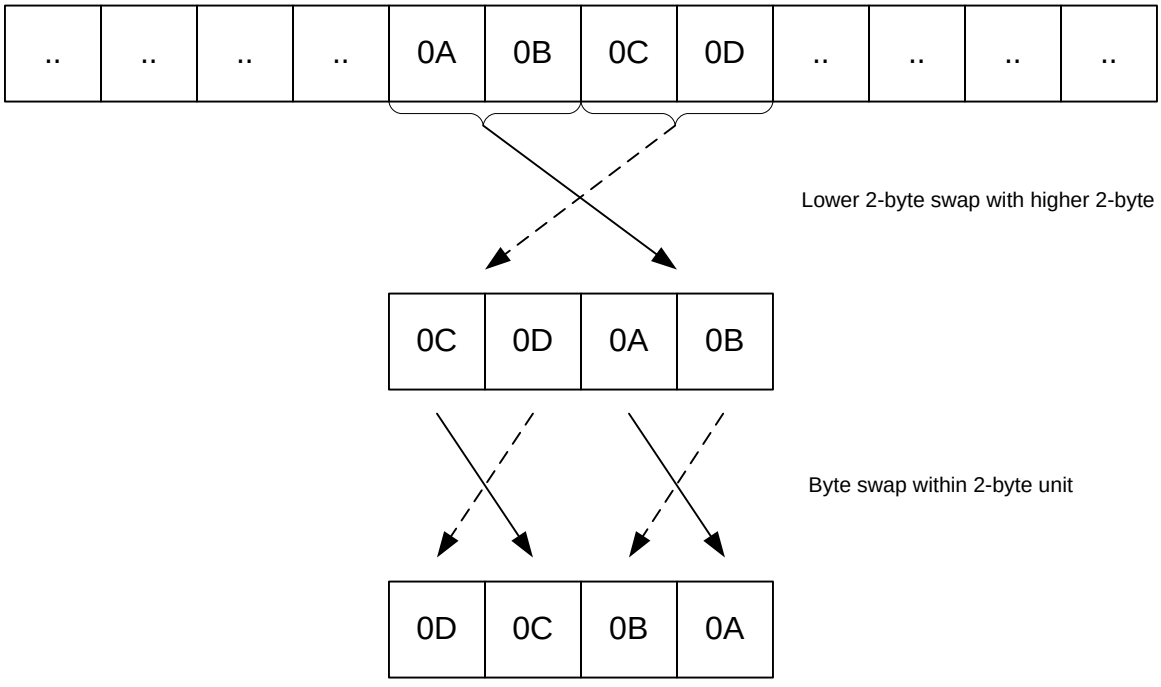

Figure 44: Motorola Solutions HMAC Byte Ordering

Below is a working example for the byte-order schema used in MOTOTRBO R1.4, R1.5 and R1.5A releases.

Assume the input message is a LE_MASTER_PEER_REGISTRATION_REQUEST in hex:

90 00 00 00 19 40 00 10.

If the authentication key is configured in CPS as

1111111111111111111111111111111111111111, the radio uses it as a hex string of 0x1111111111111111111111111111111111111111 in the hash calculation..

	Standard HMAC Calculation	HMAC Calculation with Motorola Solutions byte-ordering
Stage-One Hash Value	05 95 8a c3 08 89 c7 33 62 b3 93 35 36 7b 8e c5 c8 97 85 b7	c3 8a 95 05 33 c7 89 08 35 93 b3 62 c5 8e 7b 36 b7 85 97 c8
Stage-Two Hash Value	91 03 d8 ae 2e 01 65 74 55 ae b0 e1 3f c7 42 23 1a ba 13 38	9f a1 39 40 ac 52 f5 d2 d0 9f b2 29 dc 52 2e 5e e4 46 2e 69
Message with Authentication Footer (10-byte HMAC output)	90 00 00 00 19 40 00 10 91 03 d8 ae 2e 01 65 74 55 ae	90 00 00 00 19 40 00 10 9F A1 39 40 AC 52 F5 D2 D0 9F

Note: If the authentication key configured in the CPS is less than 40 characters, CPS pads the authentication key to full 40 characters with zeros before the HEX conversation. For example, if configured as ABCDE in CPS, the authentication key value is HEX 0x0000000000000000000000000000000000ABCDE.

Appendix B: Message Trace for First Peer's Link Establishment

The following is an example message sequence for the first peer to join the IP Site Connect network. A PC application is the Master Peer with peer ID of 100. A MOTOTRBO Repeater is the peer to join the network and its peer ID is 3. The Link Establishment protocol version is 2.

MOTOTRBO Repeater: 0x90 0x00 0x00 0x00 0x03 0x6a 0x00 0x4c 0x04 0x02 0x04 0x00

Opcode: 0x90 (LE_MASTER_REGISTRATION_REQUEST)
Peer ID: 0x00 0x00 0x00 0x03
Peer Mode: 0x6a
Peer Status: %01.. …. (Enabled)
Current Signalling Mode: %..10 …. (Digital)
Slot 1 Assignment: %…. 10.. (IP Site Connect support)
Slot 2 Assignment: %.... ..10 (IP Site Connect support)

AcceptedLinkProtocolVersion: 0x04 0x02
System ID: %0000 01..(IP Site Connect)
Protocol Version: %..00 0000 0010
OldestLinkProtocolVersion: 0x04 0x00
System ID: %0000 01..(IP Site Connect)
Protocol Version: %..00 0000 0000

Master Peer: 0x91 0x00 0x00 0x00 0x64 0x6a 0x00 0x0d 0x00 0x04 0x02 0x04 0x00

Opcode: 0x90 (LE_MASTER_REGISTRATION_RESPONSE)
Peer ID: 0x00 0x00 0x00 0x64
Peer Mode: 0x6a
Peer Status: %01.. …. (Enabled)
Current Signalling Mode: %..10 …. (Digital)
Slot 1 Assignment: %…. 10.. (IP Site Connect support)
Slot 2 Assignment: %.... ..10 (IP Site Connect support)

Num of Peers: 0x00
AcceptedLinkProtocolVersion: 0x04 0x02
System ID: %0000 01..(IP Site Connect)
Protocol Version: %..00 0000 0010
OldestLinkProtocolVersion: 0x04 0x00
System ID: %0000 01..(IP Site Connect)
Protocol Version: %..00 0000 0000

MOTOTRBO Repeater: 0x96 0x00 0x00 0x00 0x03 0x6a 0x00 0x4c 0x04 0x02 0x04 0x00

Opcode: 0x96 (LE_MASTER_KEEP_ALIVE_REQUEST)
Peer ID: 0x00 0x00 0x00 0x03
Peer Mode: 0x6a
Peer Service: 0x00 0x00 0x00 0x4c
AcceptedLinkProtocolVersion: 0x04 0x02
OldestLinkProtocolVersion: 0x04 0x00

Master Peer: 0x97 0x00 0x00 0x00 0x64 0x6a 0x00 0x00 0x00 0x0d 0x04 0x02 0x04 0x00

Opcode: 0x97 (LE_MASTER_KEEP_ALIVE_RESPONSE)
Peer ID: 0x00 0x00 0x00 0x64
Peer Mode: 0x6a
Peer Service: 0x00 0x00 0x00 0x0d
AcceptedLinkProtocolVersion: 0x04 0x02
OldestLinkProtocolVersion: 0x04 0x00

RA-SW-1750

RA-SW-1750