KENWOOD

NEXEDGE® NXDN™

System Guide

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Revision History

Version	Edition
1.00	First edition
2.00	Amendments due to V2.00 release (System expansion by multicast, IP conventional, etc.)
2.50	Amendments due to V2.50 release (Addition Product Models, NEXEDGE Applications Enhancement, etc.)
2.51	ID capacity correction
3.00	Amendments due to V3.00 release (Addition NEXEDGE Generation 2, NEXEDGE Applications Enhancement, etc.)
4.00	GEN2 SYSTEM AND UPDATE
4.01	Error correction
5.00	Update each system information 1.3.5. Active Noise Reduction (ANR) 2.2.3. Multi-site - Added One-shot for Out of Range, and In-service tone 2.2.4. Security - Remote Control 2.3.1. Gen2 System - Multi-System Roaming Support - Call Priority & Management - Voice Codec conversion - Network Manager (KPG-1003NS/KPG-1004NC) - Geo / Local Redundancy 3.2.6. Dispatching solution - KAS-20 AVL & Dispatch Software 3.1.3. Voice Logging Interface support
6.00	Update Model information 2.1.2. Repeater Mode – Single Site Conventional - Radio Access Control 2.1.3. Conventional IP Network – Multi Site Conventional - Out of Range Indicator - DSCP 2.1.4. SIP Phone - Telephone Call 2.2.1. General - Group Registration Timer 2.6.1. Expected Down Time during System Programming 3.2.7. Multi Loader 3.2.8. Web Tool 3.2.9. Test Console 3.3.6. SNMP 3.3.8. IPRCI

Document Revision

This document shall from time to time be changed without notice. This document is created and published for the products having the following design specifications.

Firmware Version:

Item	Version	How to Verify
NXR-5700/ 5800/ 5900/ 5901	5.42.00	Can be viewed in the Tools > Repeater Information dialog box of KPG-D2.
NXR-1700/ 1800	2.30.00	Can be viewed in the Tools > Repeater Information dialog box of KPG-D7
NX-5200/ 5300/ 5400/ 5600 NX-5700/ 5800/ 5900	5.22.00	Can be viewed in the Tools > Transceiver Information dialog box of KPG-D1.
NX-3200/ 3220/ 3300/ 3320/ 3400/ 3420 NX-3720/ 3820/ 3920/ 3921	4.22.00	Can be viewed in the Read/Write> Transceiver Information dialog box of KPG-D3
NX-1200/1300	2.30.00	Can be viewed in the Tools > Transceiver Information dialog box of KPG-D6.
NX-1200/1300 Type-D	2.30.00	Can be viewed in the Tools > Transceiver Information dialog box of KPG-D6.
NX-1700/1800	1.16.00	Can be viewed in the Tools > Transceiver Information dialog box of KPG-D6.
NEXEDGE Gen2 System Firmware	1.92.00	Can be viewed in the Tools > Maintenance > System > Firmware Update for System Configuration Utility

PROGRAMMING SOFTWARE Version

Item	Version	How to Verify
KPG-D1	2.30	Can be viewed in the About KPG-D1 dialog box of KPG-D1.
KPG-D2	5.30	Can be viewed in the About KPG-D2 dialog box of KPG-D2.
KPG-D3	1.10	Can be viewed in the About KPG-D3 dialog box of KPG-D3.
KPG-D6	3.30	Can be viewed in the About KPG-D6 dialog box of KPG-D6.
KPG-D7	2.30	Can be viewed in the About KPG-D7 dialog box of KPG-D7.

Application Software Version

Item	Version	How to Verify
KPG-110SM	5.32	Can be viewed in the About KPG-110SM dialog box of KPG-110SM
KPG-1004NC	1.71	Can be viewed in the About KPG-1004NC dialog box of KPG-1004NC.
KPG-180AP	5.10	Can be viewed in the About KPG-180AP dialog box of KPG-180AP
KAS-20	3.17	Can be viewed in the About dialog box of KAS-20.
KPG-149RM	2.00	Can be viewed in the About KPG-149RM dialog box of KPG-149RM.
KPG-149SA	2.00	Can be viewed in the About NEXEDGE RM of KPG-149SA.

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1. NEXEDGE® Digital System

1.1. Introduction

NEXEDGE is Kenwood's cutting-edge digital conventional and trunked radio system, designed to meet high demands in today's competitive commercial and professional radio system environment.
Digital efficiency, compatibility with legacy systems to facilitate a simple and cost effective, and smooth migration from the analog radio world to the digital radio world are just a few advantages Kenwood NEXEDGE can deliver.
Kenwood's experience in radio design, audio quality, and outstanding quality have made NEXEDGE the best digital conventional and trunked system solution available today. This document describes the NEXEDGE® system configurations and provides in-depth information about the NEXEDGE® system and NEXEDGE® Generation 2 (Gen2) system.

1.2. NEXEDGE® and NXDN™

1.2.1. NEXEDGE®

In 2008, KENWOOD introduced the NEXEDGE series of advanced digital radios using the NXDN protocol.

NEXEDGE was the first system of its kind to offer trunking and the first with the ability to communicate with both analog and digital handsets, switching automatically. All NEXEDGE equipment can thus communicate with analog radios – either radio to radio, as a system, or even as a multi-site trunked network – providing a cost-effective solution to customers migrating from analog to the proven advantages of digital.
Benefitting from over thirty years of expertise in radio and audio technologies, NEXEDGE delivers clear voice quality, even in the noisiest of environments, while its digital encryption protects against casual eavesdropping.
NEXEDG has an advantage over rival digital systems: 6.25 kHz NXDN offers 15% wider coverage than the 12.5 kHz systems of competitors. Wider coverage means superior cost performance. No wonder NEXEDGE has proven so popular that there are now over one million devices in use around the world.

1.2.2. NXDN™

The NXDN protocol used by NEXEDGE is an open standard supported by many leading vendors. This means that the NEXEDGE systems are compatible with products of other companies that conform to the mandatory features and standard optional features specified by the NXDN Forum, which currently has over thirty members.

NXDN Forum: http://www.nxdn-forum.com/
Comms Site: http://comms.kenwood.com/

The NXDN Common Air Interface (CAI) was accepted at the Study Group 5 (SG5) meeting of the International Telecommunications Union Radiocommunications Sector (ITU-R) held in November 2016 and written in Report M.2014-3 published in February 2017. This is highly significant since it represents official recognition, by the organization in charge of international standards, of NXDN as an international digital land mobile system, paving the way for its even wider adoption on a global scale.

NXDN accepted by ITU-R: http://www.jvckenwood.com/en/press/2017/03/press_170330.html

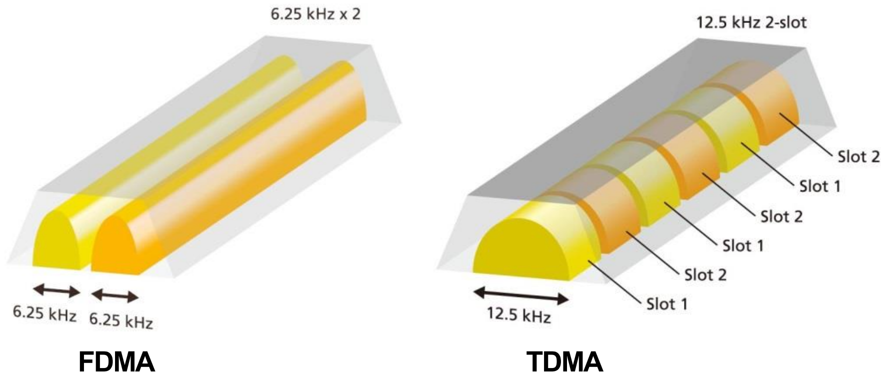
1.3. Digital Technology

1.3.1. FDMA and TDMA

NEXEDGE digital system is designed based on the FDMA access method. There are three major channel access methods for radio communication, FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access), and CDMA (Code Division Multiple Access). CDMA will not be explained in this document.
FDMA divides the spectrum into channels by frequency domain. Each call is allocated one channel for the entire duration of the call.
TDMA divides a frequency by time slot to share the same frequency channel by dividing the signal into different time slots. Each call is allocated a slot in the channel for a small amount of time.

FDMA (Frequency Division Multiple Access)
Enables 2-party communication in direct mode
Pure very narrow technology resolving frequency resource issue

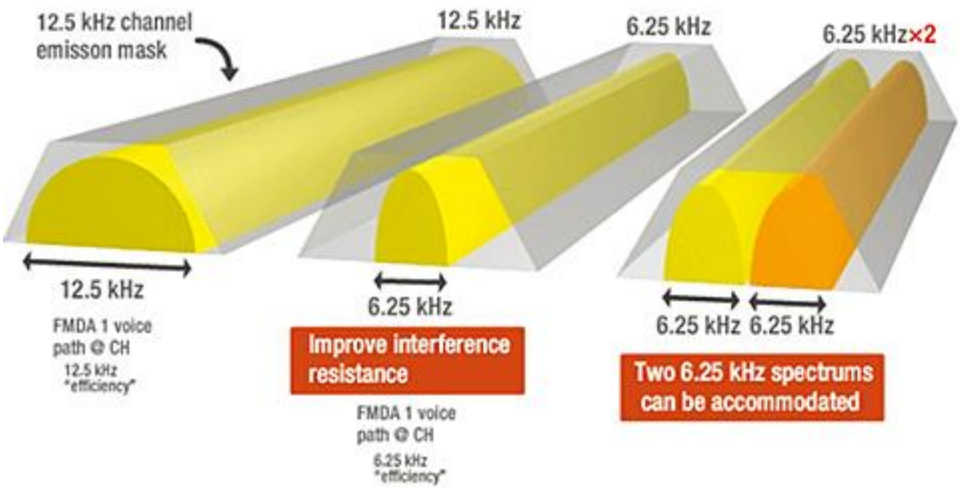
TDMA (Time Division Multiple Access)
Limited Communication distance due to time delay in the slot (TETRA: up to 35 km approximately)
Not physical 6.25 kHz technology (6.25 kHz equivalent)



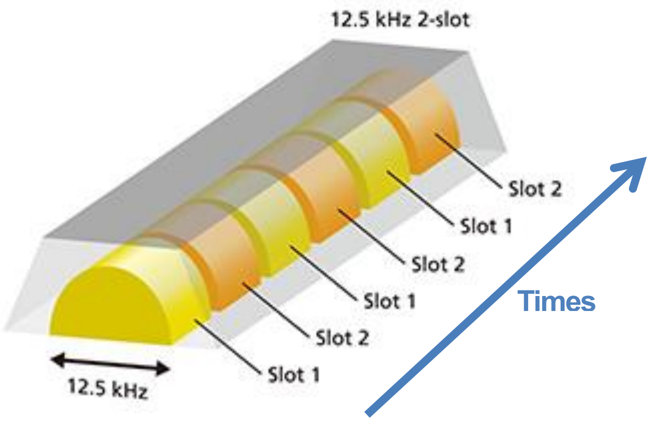
1.3.2. **Spectrum Efficiency**

The NXDN air interface fits into both narrow 12.5 kHz and very narrow 6.25 kHz bandwidth channels. As well as meeting the tightest spectrum efficiency requirements (occupied bandwidth: 9600 bps @ 8.3 kHz and 4800 bps @ 4 kHz, respectively), this exceeds all regulatory and emissions mask requirements in all frequency bands.

NXDN 6.25 kHz bandwidth – offering high receiver sensitivity compared with 12.5 kHz, both bandwidth and band-pass filters are narrower for 6.25 kHz mode, which reduces noise. As a result, the carrier-to-noise ratio (CNR) is improved, as is the bit error rate (BER). All of this contributes to raising receiver sensitivity, which in turn means an extended communications range and wider coverage.



In TDMA, the continuous transmission is divided into slots, which can be occupied by data or voice. TDMA needs time management and requires guard time between slots to prevent data collision. It could be a cause of the limitation of coverage area and data rate per slot.



1.3.3. FDMA 12.5 kHz or 6.25 kHz

Comparison

There are many of considerations to be made when selecting the appropriate bandwidth for the application. For data applications where considerations for throughput speed are important, 12.5 kHz is best suited since it offers a higher data rate than 6.25 kHz. The over-the-air data rate at a bandwidth of 12.5 kHz is 9600 bps, with a net data rate available for transparent data transmission of about 3700 bps.

The narrower bandwidth of 6.25 kHz offers improved coverage due to increased sensitivity and better resilience to interference. A sensitivity improvement of approximately three decibels can be observed for 6.25 kHz. The narrower bandwidth of 6.25 kHz for trunking operation does require the use of the KXK-3, a high-stability oscillator, to ensure long term frequency stability, and the proper synchronization of the control channels and traffic channels.

The decision on bandwidth operation is a system-wide decision since it is not possible to mix bandwidths.

The NEXEDGE radio system and subscriber units can be re-programmed and reconfigured at any time to suit customer requirements.

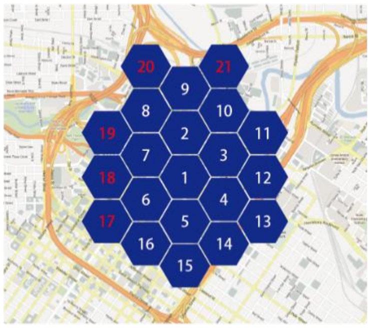
Coverage

As noted, NXDN at 6.25 kHz offers a higher degree of sensitivity and coverage compared to 12.5 kHz. The use of narrower bandpass filters reduces noise so that the carrier-to-noise ratio (CNR) can be improved. This improvement yields a better bit error rate (BER). This all extends the operational range and improves user experience.

As RF signal strength weakens with distance, analog reception becomes increasingly noisy and intermittent. The low BER of NXDN™ improves reception in fringe areas, thereby effectively increasing the range by as much as 20% over FM analog, resulting in a fifty percent increase in the coverage area for digital 6.25 kHz.

Furthermore, even compared to digital 12.5 kHz bandwidth operation, the narrower 6.25 kHz bandwidth enabled by the FDMA technology of NXDN™ extends the range by fifteen percent. Receiver filters are narrower and can thus reduce noise. The net result is superior clarity over a thirty percent wider coverage area.

For example, a system using 12.5 kHz digital would require 21 sites, the same as a 12.5 kHz analog system, to cover an area of two thousand one hundred and fifty square miles. If 6.25 kHz was employed, only sixty sites would be required to cover the same area.



6.25 kHz FDMA digital
A total of 2150 sq. miles coverage:
6.6-mile radius per site / only 16 sites in total

12.5 kHz digital system
A total of 2150 sq. miles coverage:
5.8-mile radius per site / only 21 sites in total

Note: Map and coverage areas shown are simulated picture and not to scale.

- Theoretical Calculation Conditions:

1. TX Power is set to 5W which is popular in existing handheld subscriber.
2. Height of Base Antenna is set to 98 feet (30m) above ground level.
3. Height of SU Antenna is set to 5 feet (1.5m) above ground level.

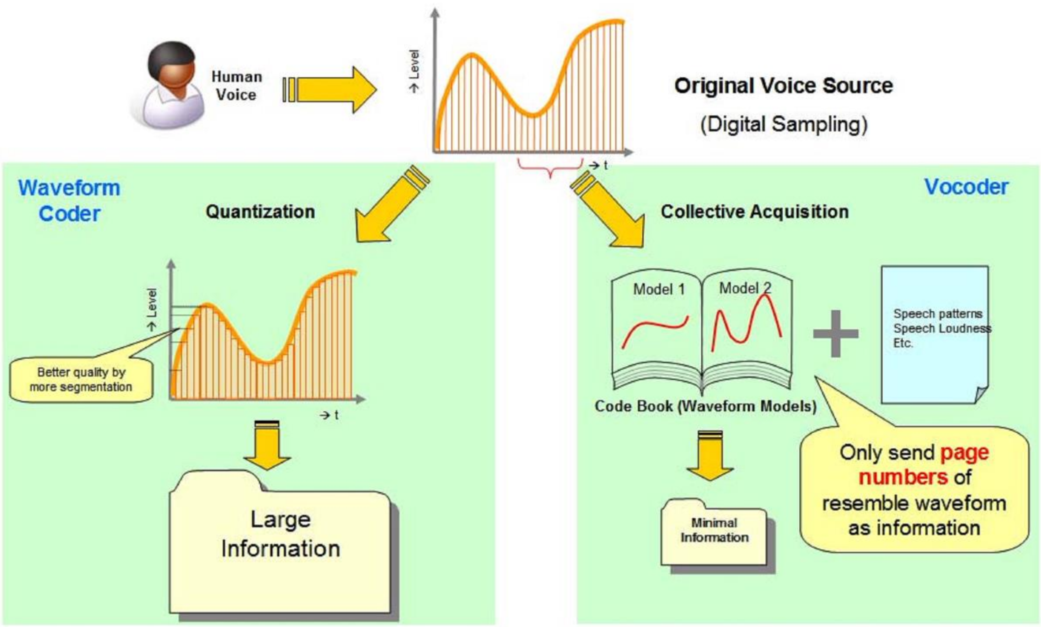
1.3.4. **Vocoder**

The Vocoder is a device or software object that converts baseband analog audio into digital data for transmission and back from digital to analog on reception. This digital data is a digital representation of the voice Audio Profile Feature. The vocoder has inherent noise reduction techniques as well as error correction techniques. They can be categorized into three types below.

Waveform coding
This coding method minimizes distortion between the source audio signal and the coded audio signal. The higher the bit rate, the better the audio quality. When the bit rate is not sufficient, audio quality drops exponentially. It is a low compression but has better audio loopback delay and low cost. For example, there are MBE (Multi-Band Excitation), LSP (Line Spectrum Pair), PARCCR (PARtial auto-CORrelation), WI (Waveform Interpolation), and MELP (Mixed Excitation Linear Prediction) coding methods.

Vocoder (Analysis-by-Synthesis Coding)
The vocoder extracts audio signal parameters as synthetic wave models by analyzing the digitalized voice audio signal at the coding stage and based on the parameters, it synthesizes the voice audio signal at the decoding stage. As the vocoder only transfers the extracted analyzed parameters and does not aim to precisely reproduce the source signal, it can drastically reduce the bit rate. However, on the other hand, the audio quality depends on the synthetic wave modeling, and even with the higher bit rate, the audio quality cannot be improved in general. As vocoder examples, there are MBE (Multi-Band Excitation), LSP (Line Spectrum Pair), PARCCR (PARtial auto-CORrelation), WI (Waveform Interpolation), and MELP (Mixed Excitation Linear Prediction).

Hybrid
In addition, hybrid coding will be introduced. This coding method also models the source audio's signal elements and by the A-b-S process (Analysis-by-Synthesis), it transfers both audio element parameters and the rest of the information which cannot be modeled in parameters by minimizing the distortion from the source waveform. For instance, CELP (Code Excited Linear Prediction coding), VSELP (Vector Sum Excited Linear Prediction), and PSI-CELP (Pitch Synchronous Innovation Code Excited Linear Prediction) are categorized as hybrid vocoders. Since the hybrid coding also models the source audio signal, it can be considered one of Vocoder coding. The AMBE+2™ can be placed in the Vocoder category.



As mentioned, a vocoder is a voice audio data compressor that leverages human acoustic characteristics. As it extracts and sends characteristic voice formants from the source audio, it can drastically reduce the data quantity as compared to the waveform coding types. However, due to artificial voice generators being used in the decoder stage, the output audio could sound like robot speech. Although vocoder technologies have improved the audio quality in these years, it is still noticeably different from analog.
Advantages of Digital processing against Analog will be described here again. The most conspicuous benefit is the "Narrow Band Transmission". It robustly conveys the message with minimal data. Thus, NXDN's AMBE+2 vocoder attains 6.25 kHz bandwidth communication which is only half the bandwidth of conventional analog 12.5 kHz technologies. And, the Vocoder is equipped with an error correction processing that improves voice clarity while maintaining high-quality communications even in extremely noisy environments and in areas where the subscriber unit is operating at its sensitivity limit.
In a sense, vocoder technologies for wireless telecommunication prioritize securely conveying key elements of the source audio sacrificing the fidelity of the interfered condition where errors occur.

1.3.5. Active Noise Reduction (ANR)

Active Noise Reduction (ANR) is the function to cancel the noise component of the collected audio to improve the transmitted audio quality. The noise cancellation function can be collectively configured according to the usage environment. Also, selecting "Custom" enables the detailed configuration of the noise cancellation function.
Each function of the noise cancellation characteristic is automatically configured according to the configuration of the ANR Preset.

1.4. Operating Modes

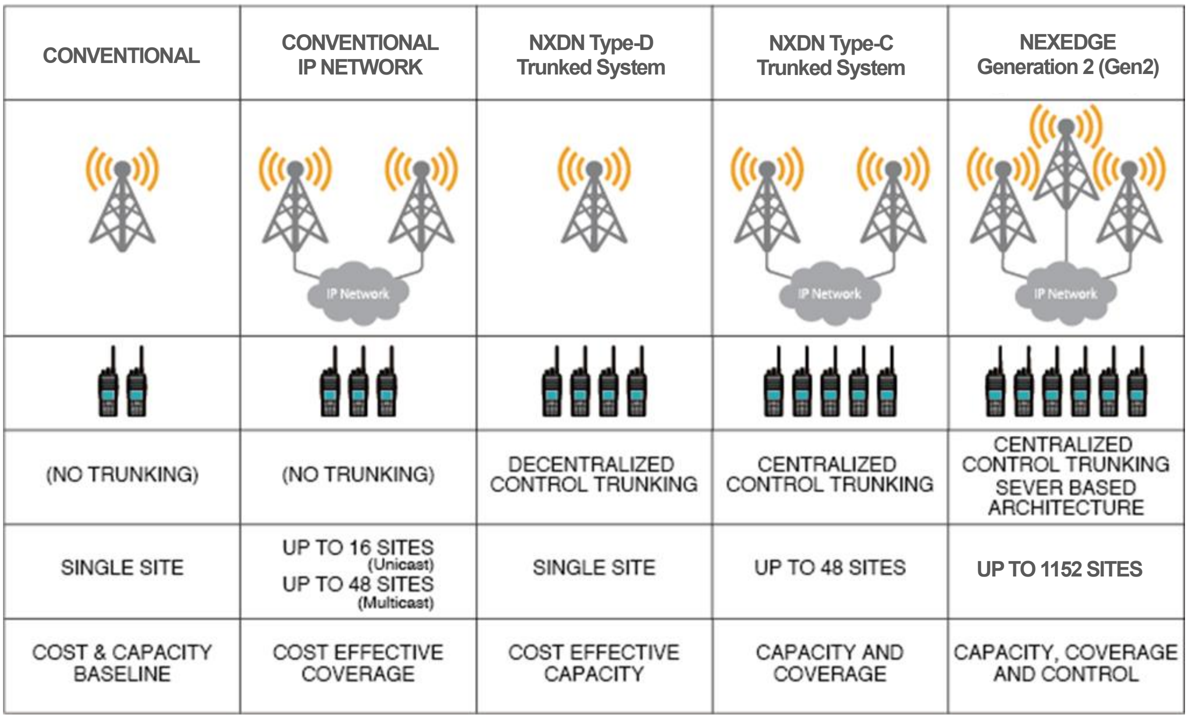
1.4.1. Conventional and Trunking

NEXEDGE supports both NXDN digital mode and analog mode via a common radio technology, which creates a self-paced migration path to accommodate budgetary, administrative, organization, and timeline demands. It provides several communication styles.

1. Conventional Direct Mode
2. Conventional Repeater Mode
3. Conventional IP Network Mode
4. Single Site Trunked Mode
5. Multi Site Trunked Mode

NEXEDGE equipment supports legacy analog mode for easy migration from analog to digital.

NEXEDGE SYSTEMS



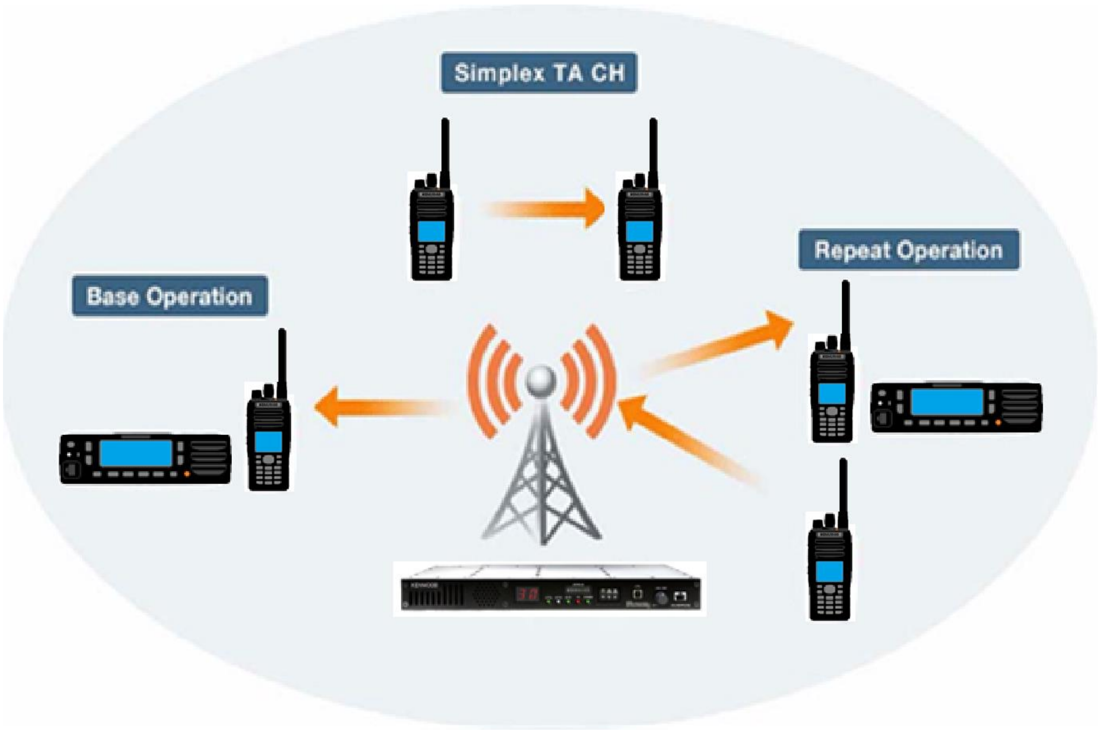
CONVENTIONAL	CONVENTIONAL IP NETWORK	NXDN Type-D Trunked System	NXDN Type-C Trunked System	NEXEDGE Generation 2 (Gen2)
(NO TRUNKING)	(NO TRUNKING)	DECENTRALIZED CONTROL TRUNKING	CENTRALIZED CONTROL TRUNKING	CENTRALIZED CONTROL TRUNKING SEVER BASED ARCHITECTURE
SINGLE SITE	UP TO 16 SITES (Unicast) UP TO 48 SITES (Multicast)	SINGLE SITE	UP TO 48 SITES	UP TO 1152 SITES
COST & CAPACITY BASELINE	COST EFFECTIVE COVERAGE	COST EFFECTIVE CAPACITY	CAPACITY AND COVERAGE	CAPACITY, COVERAGE AND CONTROL

1.4.2. Conventional Direct Mode

Direct Mode is the simplest and the most elementary operating style in radio communication. Communication that is made between radios using a simplex frequency is called P to P (Peer to Peer). Communication coverage is determined by transmission output power and receiving sensitivity of the subscribe unit. One or multiple radios could be a Base Station at a fixed location with a high-performance antenna system to obtain wide coverage. A single frequency, called a Channel is used essentially among radios in the field.

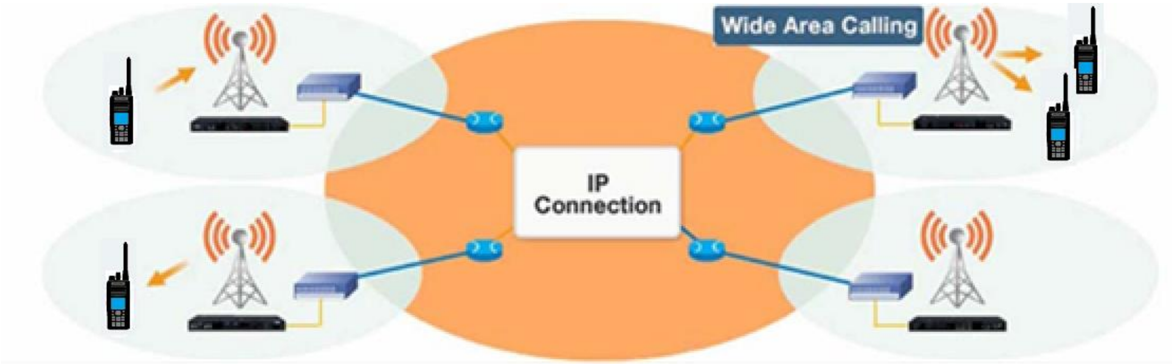
1.4.3. Conventional Repeater Mode

To expand coverage, repeaters are often installed on a high site. NEXEDGE repeaters can be used as a base radio by connecting a microphone on the panel. The transmission towards the repeater is called Uplink or Inbound while the other direction is called Downlink or Outbound and different frequencies are applied. Together with the Direct Mode operation, the Repeater Mode operation is also called Conventional operation as opposed to Trunking Mode operation.



1.4.4. **Conventional IP Network Mode**

NEXEDGE repeaters have IP link capability that enables up to forty-eight sites wide area repeater system. JVCKENWOOD calls it an IP Conventional System and provides roaming features that allow subscriber units to always operate on the best site.



1.4.5. **Trunked Mode Operation**

NXDN has two different types of trunking protocols, Type-C and Type-D. NXDN Type-D Trunked system or distributed trunk system is a system without specific control channels and all channels can be traffic channels. NXDN Type-C Trunked system or centralized trunk system is a system that manages all traffic channels using a dedicated control channel. NEXEDGE Generation 2 (Gen2) System is an enhanced version of the Type-C trunking system.
The Trunking system type can be selected according to the customer's requirement, system scale, availability of frequencies, and licensing.

1.5. Type of Trunking Method

Transmission Trunking;

A traffic channel is assigned for each transmission and released after the completion of the radio transmission. A new traffic channel is assigned for the next transmission. Since this method does not need a set Hold Time, the system can be utilized without wasting airtime. This method is supported both in NXDN Type-D Trunked System and NXDN Type-C Trunked System including NEXEDGE Gen2.

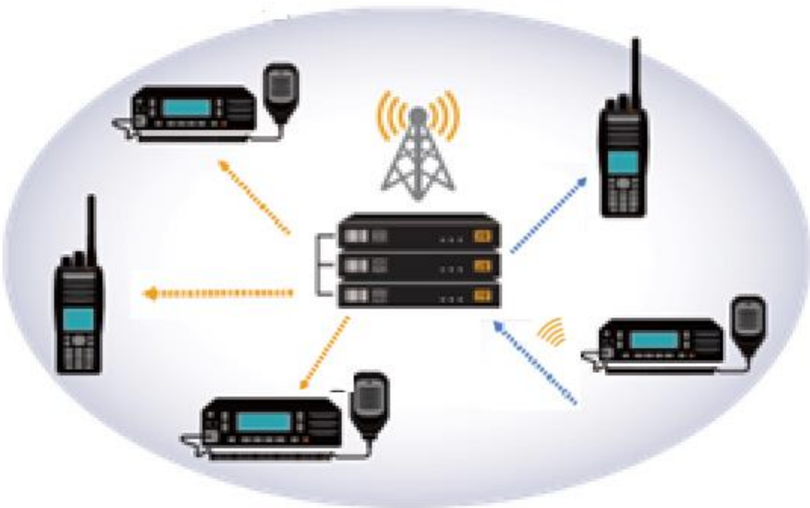
Message Trunking;

A traffic channel is assigned to a Talk Group for the conversation. The channel will not be released until the repeater's hold timer expires. The response time is improved using the hold timer since the traffic channel does not have to be reassigned on each push-to-talk. Even while holding the traffic channel, the continuity of the conversation is maintained. The trunking controller can cancel the hold and release the channel if a higher-priority call is initiated on the system. This method is supported in NXDN Type-C Trunked System and NEXEDGE Gen2.

Note: The configuration of the type of trunking method must be the same for both the system and the subscriber units. If not, Individual Calls might be unusable.

1.5.1. NXDN Type-D Trunked Mode Operation (Single Site)

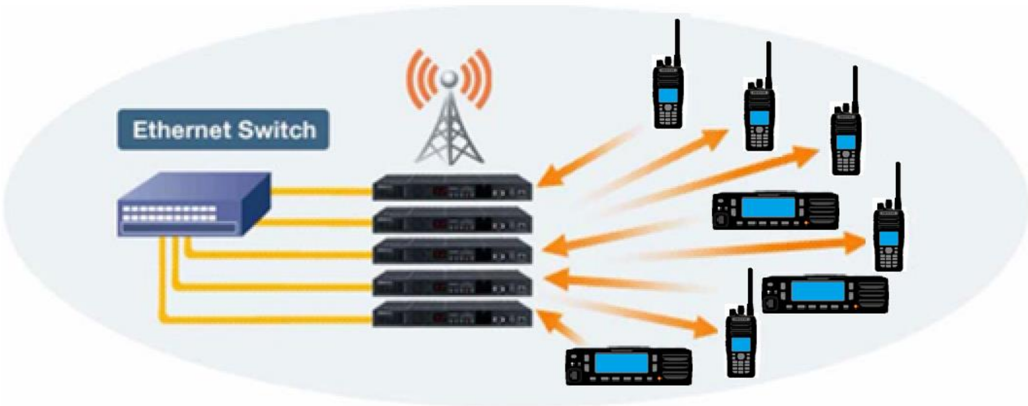
NXDN Type-D Trunked System is a low-cost single-site trunk radio system that does not have a Control Channel. All channels are to be used for traffic. The system consists of one or several Home Repeaters and non-home repeaters. The single-site system can be configured with up to thirty repeaters and uses up to sixty thousand (60000) Unit IDs and Talkgroup IDs (one to two thousand (1 to 2000) /Home repeater * thirty Home repeaters).



1.5.2. NXDN Type-C Trunked Mode Operation (Single Site)

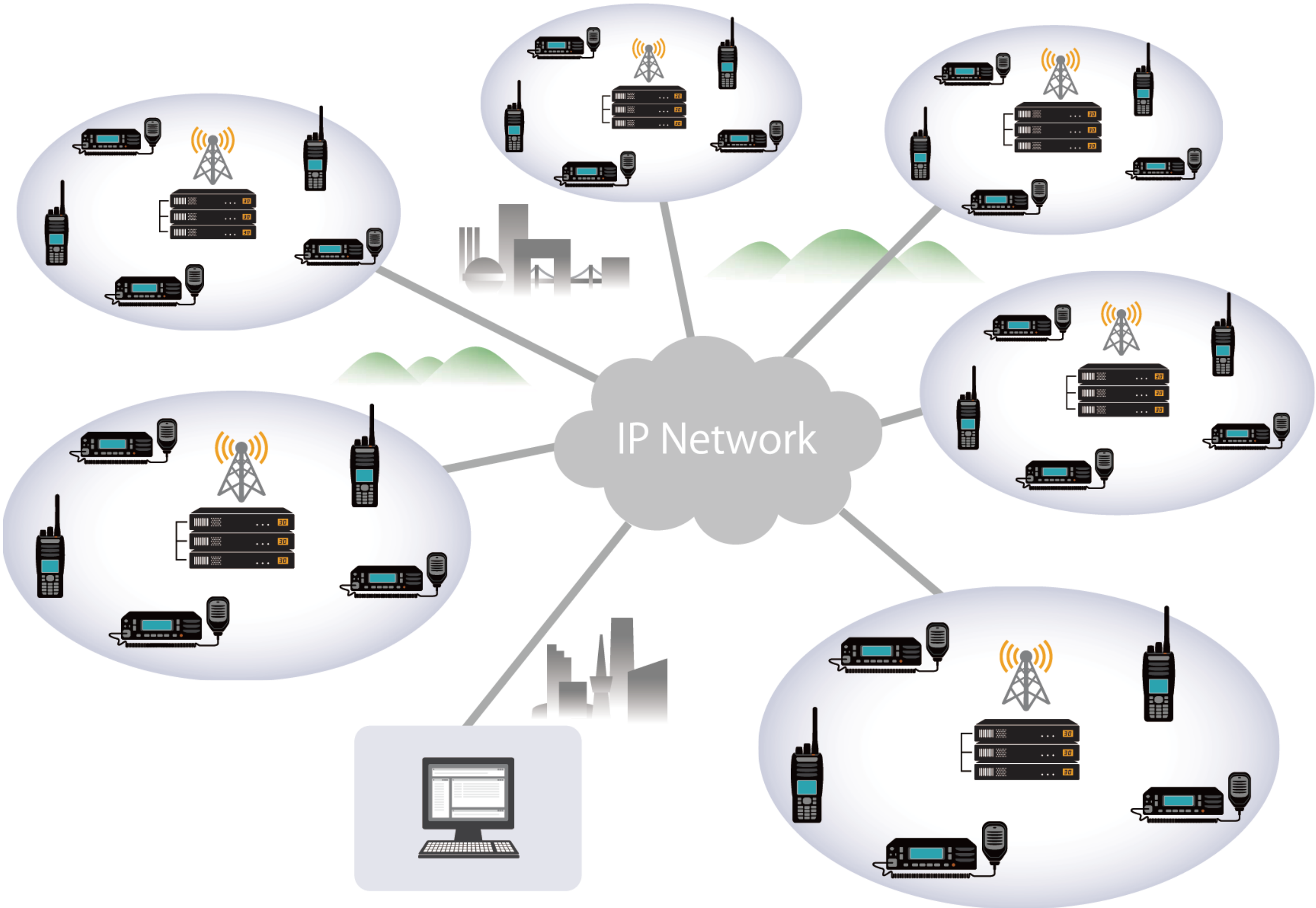
NEXEDGE Type-C trunked mode provides a larger capacity, enhanced call capabilities, improved security, and faster communications with simpler user operation than conventional systems and other types of trunking systems. The system automatically assigns channels for faster efficient use of spectrum.

Site capacities of up to three thousand (3000) Unit IDs and Group IDs allow enhanced unit and fleet organization. In Group and Individual calls, privacy is protected, and talk cannot be monitored by the other users on the system. The Priority Monitor feature monitors up to four high-prioritized talk groups so the users can participate in important and priority calls. During peak usage, system Call Queuing stacks call requests and processes calls when a channel becomes available. System operators can assign important individuals higher queue priority and even pre-empt lower-priority users for more critical dispatch and emergency calls. Well-known features, such as Late Entry, Broadcast Call, Remote Group Add, ESN validation, and remote Stun/ Kill/ Revive are all included and supported as standard features.



1.5.3. **NXDN Type-C Trunked Mode Operation (Multi-site)**

The network option leverages the power of IP to link up to forty-eight digital trunking sites for wide area roaming and calling capabilities. Scalable networks can be created using existing IT assets, private microwaves, spread spectrum links, or carrier services using standard 10Base-T /100Base-TX Ethernet switches and routers. IPSec VPN tunneling provides an encrypted secure communications link within any IP network. Subscriber units use advanced control channel hunting algorithms, RF signal strength, and digital signal quality to automatically determine the best sites to register to while moving throughout the network. The network capacity of sixty-five thousand five hundred and nineteen (65519) Group IDs and Unit IDs provides the capability for large organizations and multi-user system sharing.



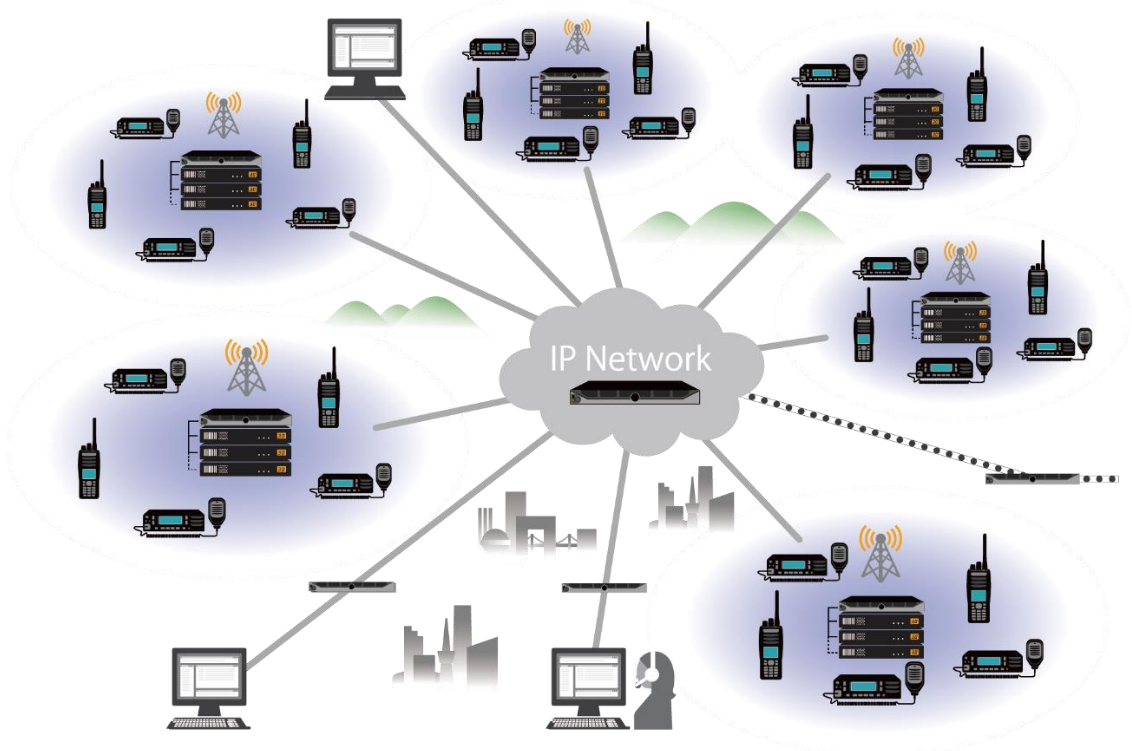
1.5.4. NEXEDGE Generation 2 Wide-Area Trunked System

The network option leverages the power of IP to link multiple digital trunked sites for wide area roaming and calling – across campus, city, county, or region. Scalable networks can be created over existing IT assets, private microwaves, spread-spectrum links, or carrier services using standard 10Base-T/100 Base-TX Ethernet switches and routers. The sixty thousand (60000) group ID and unit ID network capacity is sufficient for large organizations and multi-user system sharing.

Subscriber units use advanced control channel hunting algorithms, RF signal strength, and digital signal quality monitoring to automatically determine the best sites to make accurate and resource-sensitive roaming and registration decisions.

With Gen2, it is possible to build a system that consists of more than forty-eight sites (Up to one thousand one hundred and fifty-two (1152) sites) with an IP Network and connected to different systems with the same assigned system code. Direct Frequency Assignment (DFA) is supported. In a CCH report or TCH allocation message, the DFA method allows a frequency to be specified. By specifying the frequency information while adding a channel, the subscriber unit can use the added channels without reprogramming.

Gen2 provides increased GPS capacity compared to the conventional, other trunking systems, and NXDN Type-C systems.
The Gen2 system uses a server as a System Controller for control and system housekeeping. In addition, a server is required for Site Control when the number of repeaters at a site exceeds nine.
The following diagram shows an example of a Wide-Area System. A subscriber unit used in a NXDN Type-C system may be used in a Gen2 system maintaining its original functionality. No change to the firmware or programming data is required.



1.5.5. **Comparison of NXDN Trunked System**

The following table shows the difference between NXDN Type-D Trunked, Type-C Trunked, and NEXEDGE Gen2 system.

Function	NXDN Type-D Trunked System	NXDN Type-C Trunked System	NEXEDGE Gen2 System
Range of Selectable Unit ID	2000 per Home Repeater	65519 per system	65519 per system
Range of Selectable Group ID	2000 per Home Repeater	65519 per system	65519 per system
Number of Unit ID per System	60000 (2000 per Home Repeater)	60000 *1 (3000 per a site)	65519 *1
Number of Group ID per System	60000 (2000 per Home Repeater)	60000 *1 (3000 per a site)	65519 *1
Number of System	1	1	24
Number of Site per System	1	48 *1	1152
Maximum Channel per Site	30	30	30
Transmission Trunked Mode	✔	✔	✔
Message Trunked Mode	n/a	✔	✔
6.25kHz Channels (VN)	✔	✔	✔
12.5kHz Channels (N)	n/a	✔	✔
Control Channel	Not needed	Exclusive	Exclusive
Individual Call	✔	✔	✔
Group Call	✔	✔	✔
Inter-site group call	n/a	✔	✔
All Group Call	✔	✔	✔
Broadcast Call	n/a	✔	✔
Emergency Call	✔	✔	✔
Paging Call	✔	✔	✔
Remote Group Add	n/a	✔	✔
Status Messaging	✔	✔	✔
Short & Long Data Messages	n/a	✔	✔
NXDN Extended Short Message	n/a	✔	✔
GPS Data	n/a	✔	✔
Caller ID (PTT ID)	✔	✔	✔
Remote Stun/Kill	n/a	✔	✔
Registration	n/a	✔	✔
ESN Validation	✔	✔	✔
System Key File Security	n/a	✔	✔
NXDN Scrambler	✔	✔	✔
AES/DES Encryption	Not defined in protocol	✔	✔
Telephone Interconnect	n/a	✔	✔
Console Solution	n/a	✔	✔
Priority Monitor (Fixed ID)	2	4	4
Late Entry	✔	✔	✔
Fail-soft Mode	n/a	✔	✔
Over-the-Air Alias	✔ (w/o Late Entry)	✔	✔
Over-the-Air Programming (OTAP)	n/a	✔	✔
Direct Frequency Assignment (DFA)	n/a	n/a	✔
Communication Log	✔ (Optional)	✔	✔

Note: *1: Available number of each item is varied by the classification of Network Category defined by your Activation File.

2. System Design Consideration

2.1. Conventional

2.1.1. General

A Conventional System may provide wide-area communications either as a standalone site or enhanced coverage when multiple repeater sites are tied together via an IP network. The following sections describe key features and considerations for site implementation.

2.1.2. Repeater Mode – Single Site Conventional

Expanding coverage, a repeater is often installed on a high site. Transmission towards the repeater is called Uplink or Inbound while the other direction is called Downlink or Outbound and different frequencies are to be applied. Together with Direct Mode operation, Repeater Mode operation is also called Conventional operation compared with Trunking Mode operation.

Mixed Mode

For system owners or integrators, the migration plan from a current analog system is one of the biggest concerns from the investment perspective. NEXEDGE which uses the NXDN digital four-level FSK-based protocol for FDMA channel access also provides mixed-mode operation allowing both digital and analog operation and enabling smooth migration. Mixed Mode allows users to switch legacy analog and new digital modes seamlessly and automatically. The NEXEDGE repeater automatically changes the operational mode in response to the received mode. The repeater goes into digital mode when receiving a digital signal, and when an analog signal is received, it changes to analog mode.

RAN

RAN (Radio Access Number) works like analog QT/DQT for Talkgroup with sixty-three Digital Codes when different Talkgroups use the same channel. When a unique RAN is assigned, a radio will be muted when receiving audio from different talk groups. RAN code is contained in the conventional transmitted signal at any time and the radio can join the talk group in the middle of a conversation. The radio transmits the RAN code on the channel of which Transmit Mode is configured as NXDN and receives audio. The radio will be unmuted when the received RAN is correct.

Multiple Encode/Decode Table

Like the signaling features of analog, CTCSS, and DCS, NEXEDGE conventional systems use the digital signaling function known as RAN. The digital repeater can repeat an incoming signal when the RAN matches. In addition, the repeater can be configured with a multi-RAN table to allow multiple users with different RAN values. Like analog, the use of signaling multi-tables allows it to respond faster than channel scanning.

User List

NXR repeater has a User List that lists valid UID and GID. A repeater repeats a signal that comes from the listed UID/GID with a correct RAN, however a call from a different UID/GID will be refused. The repeater has a thousand ID for UID and GID usable in the User List and is capable of assigning ID list to a channel. If “None” is selected, any call is repeated.

Group ID List: Only group calls listed on the User List/ Group ID and any Individual calls are repeated.
Unit ID List: Only Individual calls listed on the User List/ Unit ID and any group calls are repeated.
Both: A repeater checks both the User Lists for Unit ID and Group ID. A call must be listed.

GID Scan / Persistent GID

This is a radio feature. The radio receives Group Calls listed on the Group ID list as a GID scan. In case the GID Scan is disabled, the radio only receives specific group calls that select GID from the GID list, assign SelCall on PTT on the channel and list the GID on the Persistent GID list. In this case, the GID list is used for selecting a target GID individually.
This is expected that a radio is assigned a specific ID to talk with a manager and receive an order message. For special cases, such as an urgent order, another ID should be assigned to the persistent GID list to receive.

GID Scan=on: receive any GID call listed GID List
GID Scan=off: receive only GID call from selecting GID, assigned to SelCall on PTT and Persistent GID List.

Radio Access Control

Radio Access Control is a function that prevents unauthorized access to repeaters by radios.
The radio and repeater communicate using a scramble code that is generated from the common Radio Access Control key.
If the radio access control key does not match between the radio and repeater, the scramble cannot be released, and communication cannot be established.

2.1.3. **Conventional IP Network – Multi Site Conventional**

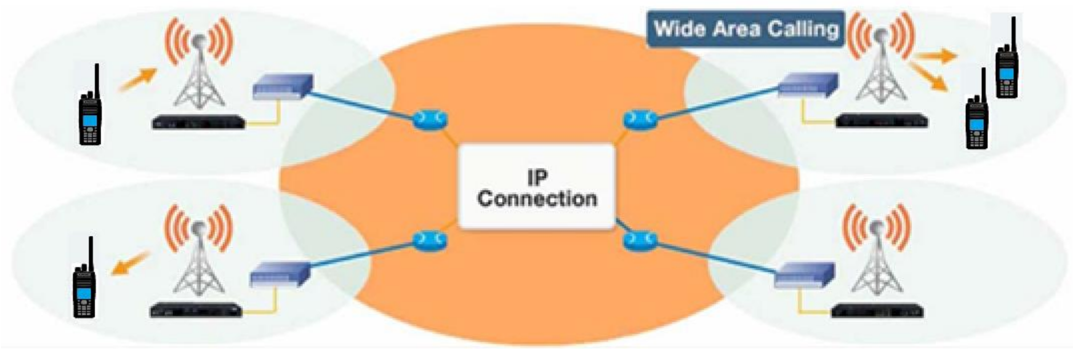
For multi-site operation, repeaters are connected via an IP to establish a multi-site conventional network.

Intersite Call

The Inter-site call allows end users to link two or more sites via IP backbone across large areas, throughout large buildings, or across large campuses such as an amusement park or college. A call at one site may be shared with other sites based on the configuration in a table for the channel. Group IDs and Unit IDs can be configured for which sites they are allowed to transmit.

Site List
Used to specify the site number to which a receiving site may transfer the voice frame over the IP connection.

Site Group Table
Specify the site number that starts a Group Call or a Unit Call. Used to specify the site number to which a Group Call or a Unit Call is to be transmitted.



NXIP Console Interface for Conventional

The NEXEDGE Repeater has a NXIP Console Interface for the NEXEDGE Conventional System. Regardless of the physical location of the IP Console, it can be connected to a repeater via an IP network, and transmit and receive digital audio and digital data messages. One console can be assigned to be associated with up to a hundred GIDs for NXR-5000/x00 and twenty GIDs for NXR-x10. A separate RAN can be used for each call.
Up to ten Console IDs can be assigned to one repeater and the priority level can be defined to get a channel. When the console with high priority initiates a call while a low-priority console is transmitting, the high-priority console will be assigned a channel as soon as the low-priority console finishes its call. To use the User List in the conventional system, the console ID needs to be applied also. Moreover, the Time-out Timer, the TOT Pre-Alert, the TOT Reset Time, the TOT Rekey Time, and the Repeat Hold Timer will also be applied.
By using a Cross-busy function and a Busy Channel Lockout function, the console can start transmission without interfering with another call from a subscriber unit.

Site Roaming (Voting)

The Site Roaming feature allows a radio to select the best signal from repeaters.
A radio scans all programmed channels checking the signal strength of the repeater on each channel to determine the best repeater site to be used. The radio will resume scanning channels if the receiving signal becomes lower than the configured level, changing channels to receive the strongest signal. During the repeater idle period (no traffic), all repeaters transmit a beacon signal simultaneously by being synchronized with the primary repeater via the IP connection. The radio receives the beacon signal and checks all channels within the site roaming zone memorizing the signal strength. After checking, a radio moves to the best signal channel and stands by for receiving and transmitting a call.
If the primary repeater is disconnected from the network, the secondary repeater sends a command via an IP to synchronize the timing. If both the primary and secondary repeaters are disconnected from the network, each repeater transmits a beacon signal with its own timing until it recovers. For proper Site Roaming operation, it is recommended to update the primary and secondary repeater firmware separately.

For efficient roaming operation, the configuration for both radio and repeater should be carefully considered. The interaction of each parameter such as the interval and transmission timing of the beacon and the received signal strength threshold of the subscriber must be considered. Field tests should be conducted for the appropriate settings.

Terminologies:
In the NEXEDGE system, terminologies such as “Site Roaming” and “Beacon Signal” are used for IP conventional digital operation. They are also known as “Voting” and “Heart Beat Signal” in the analog systems.

Out of Range Indicator

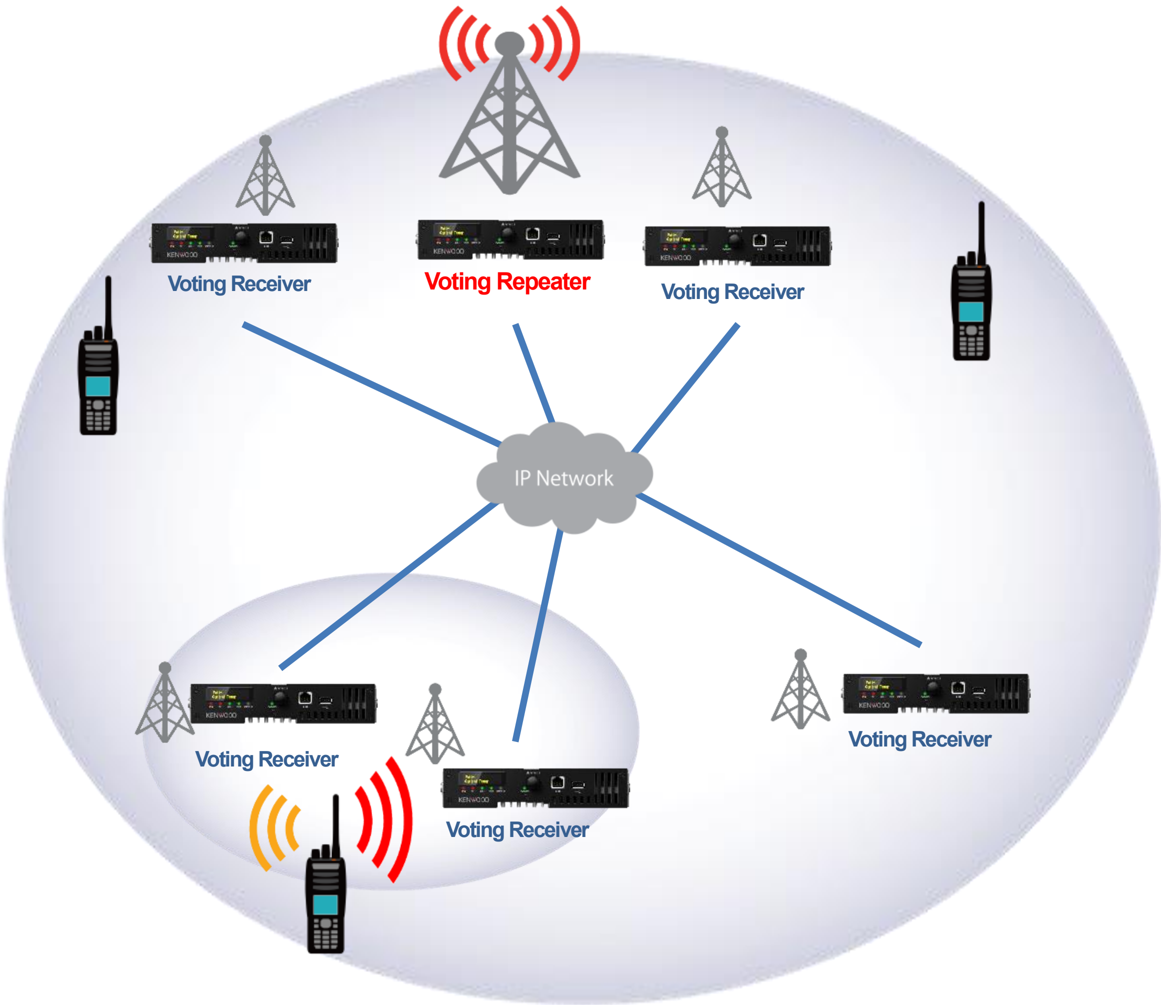
Out of Range Indicator is a function that notifies the user when the radio is outside the service area.
If the radio cannot receive a Beacon or other NXDN signals periodically sent by the repeater within a certain period of time, Out of Range Indicator actives.

Voting Repeater & Receiver

Voting Repeater & Receiver is a system feature to receive signals from multiple sites and transmit the best signal from the Voting repeater. When comparing the RF signal strength from the subscriber unit and the repeater, there may be a large difference between talk-in and talk-out. The receiving subscriber may be able to receive the signal but have difficulty talking back to the repeater. In this case, the repeater has a large coverage area and another receiver is used to improve the talk-back capability of the subscriber unit thus the use of the voting receiver. Multiple voting receivers may be installed in a service area so the radio signal from the subscriber is transferred from the receiver via the IP to the repeater. The strongest signal is voted and rebroadcasted by the repeater.

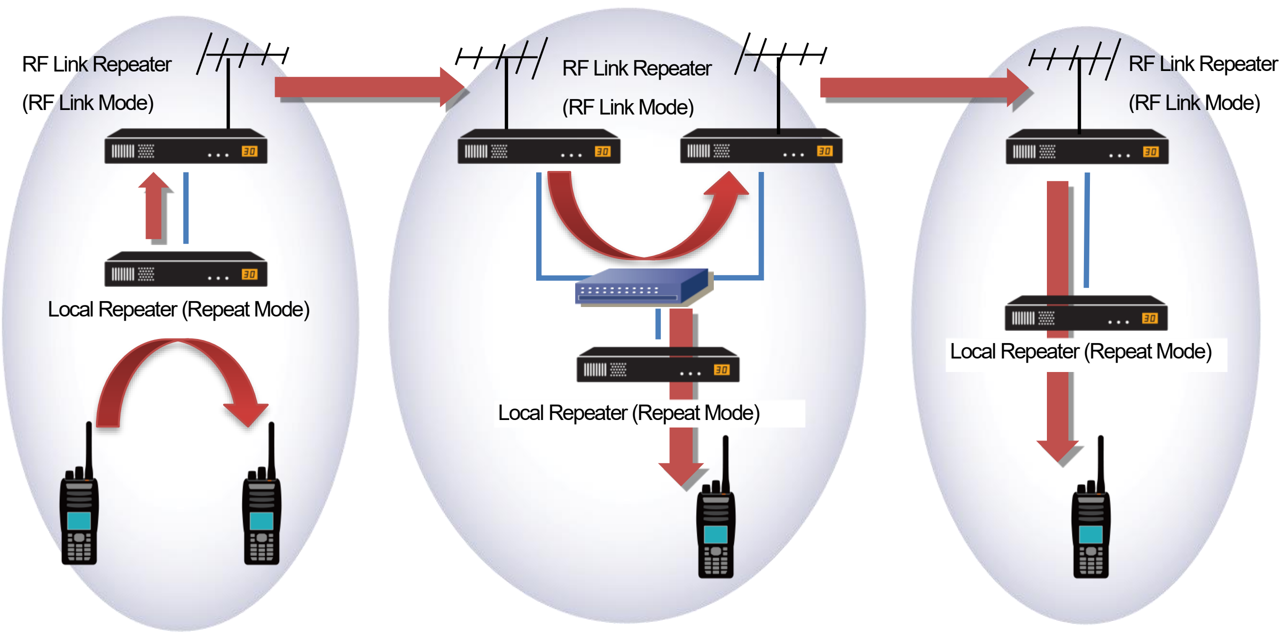
In such cases, a repeater station having high transmission power to cover the service area and a receiver station that receives a transmission signal from the subscriber unit can be used.

Multiple voting receivers installed in the service area receive the radio signal from a subscriber unit and send RSSI information to the voting repeater via the IP. Based on the RSSI information from the voting receivers and the voting repeater, the voting repeater will repeat the received signal which has the best RSSI level.



RF Link

In the analog system, it is possible to link the sites using an RF so that the RF Link feature in NEXEDGE provides the RF link in the digital mode and may be used to replace a conventional IP connection. At the repeater site in addition to the site repeater, another digital repeater is used to bridge to another site using the RF Link Mode.
If the received RAN code matches the RAN code preconfigured for the repeater, the repeater sends the received signal to the conventional IP network. Although the signal sent to the conventional IP network is the same as the one transmitted by the repeater relaying the received signal, this signal is not transmitted using the transmit frequency. However, if the repeater receives a signal from the conventional IP network, the repeater transmits the received signal using the transmit frequency.
This function can be used only by the repeater in which the Intersite Call is enabled.
The diagram shows an example of an RF Link network using a directional antenna.



When the local repeater receives a signal from a subscriber unit, it repeats the signal over the local repeater and sends an IP frame to the RF Link repeater. The RF Link repeater receives a data frame through an Ethernet cable and transfers all information which includes source ID and destination ID information to the RF Link repeater on the next site. This RF Link repeater sends all the information to the Local repeater without transmitting an RF signal via the sync connection. Simultaneously, the same information is sent to next the RF Link repeater to transmit to the next site.

Note:

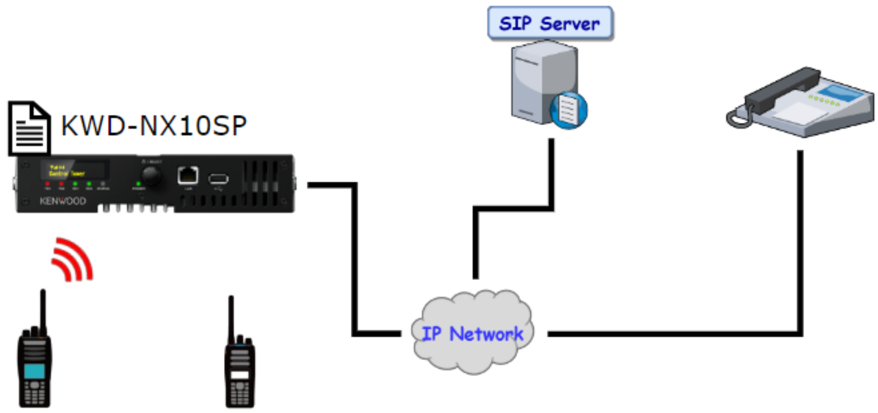
- NEXEDGE repeaters can use coexistence on the IP network.
- NXR-710/ NXR-810 require the Network Interface Unit (KTI-3) to be connected to the IP-network.
- The delay of audio will be longer when sending the audio data through the RF Link. An additional delay of forty milliseconds (Narrow) or eighty milliseconds (Very Narrow) occurs when sending data from a repeater to the IP network. Another eighty-millisecond delay occurs when sending data from the repeater to the next repeater or SU over the RF. Further delays such as transmission process time will also occur.

DSCP

The NXR-1700/1800 allows network switches and routers to prioritize packets, including those from repeaters, by assigning DSCP values to the packets sent by the repeaters. DSCP value is assigned as PHB (Per-Hop Behavior) of the designated communication. This allows queuing and scheduling of packets according to the prioritizing settings of the switches and the routers in the network, which can prevent communication delay, fluctuation, and loss.

2.1.4. SIP Phone

By connecting the repeater to the SIP phone server, communication between the repeater and SIP phones is enabled, allowing a radio to communicate with PABX and PSTN SIP Phones.
The Repeaters are connected to the SIP Phone Server by SIP Session/TLS Session to relay voice.



Telephone Call

This function allows users to make calls to SIP phones through their own repeater.
A call can be made from a radio to a SIP phone using Individual Call, or from a SIP phone to a radio using either Individual Call or Group Call.

2.2. NXDN Type-C trunked system

2.2.1. General

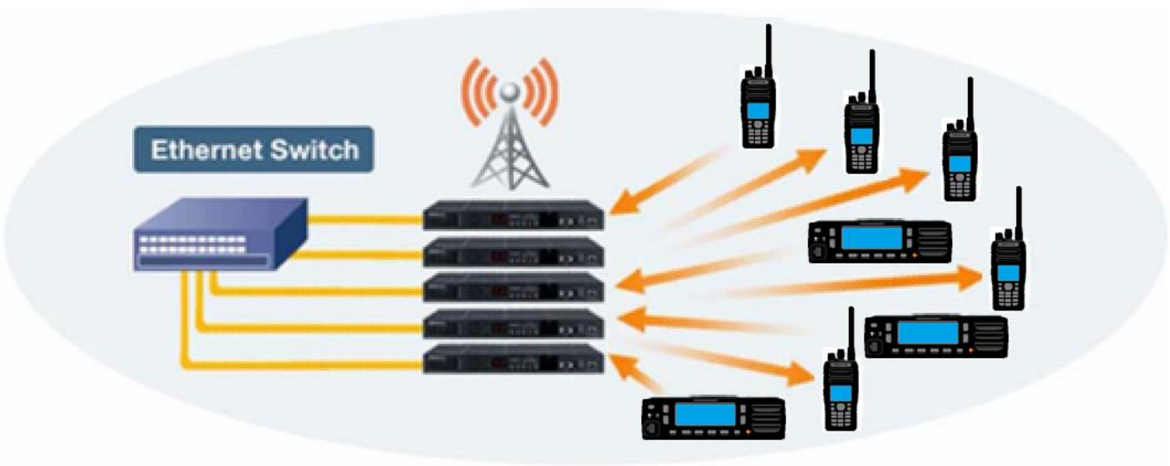
The NXDN Type-C Trunked System is the managed system. It consists of one Control Channel and up to twenty-nine Traffic Channels per site. A radio requires registration to use the system. According to a call request, the Control Channel assigns a free Traffic Channel to start a voice Call. It uses free channels efficiently and is more flexible than the Conventional System.

The NXDN Type-C trunking mode provides larger capacity, enhanced call capabilities, improved security, and faster communications with simpler user operation than conventional systems. The system automatically assigns channels for faster efficient use of spectrum, allowing users to concentrate on the job at hand. This site capacity having three thousand (3000) Unit IDs and Group IDs each per site provides ample unit and fleet organization capabilities. In Group and Individual calls, privacy is protected and the calls cannot be monitored by other users in the system. The Priority Monitor feature monitors up to four high-prioritized talk groups so the users can participate in important and priority calls. During peak usage hours, system Call Queuing stacks call requests and processes calls when a channel becomes available. System operators can assign important individuals higher queue priority and even pre-empt lower-priority users for more important dispatch and emergency calls. Well-known features, such as Late Entry, Broadcast Call, Remote Group Add, ESN validation, and remote Stun/ Kill/ Revive are all included and supported as standard.

2.2.2. **Single-site**

Single Site Trunked System is a basic system structure. It is constructed with a Control Channel and 29 Traffic Channels connecting a switching Hub through an Ethernet cable. The Site manages three thousand (3000) Unit IDs and three thousand (3000) Group IDs to provide ample unit and fleet organization capabilities. A frame Sync cable and a 10MHz reference input located at the back side synchronize frame timing and keep frequencies stable between channels to keep proper trunking operation.
Control Channel keeps transmitting unique information and several service information to the broadcast system. When powering on the radio, it starts searching for an available CCH signal and checks the broadcast information. If the system information is the same as data written into the radio, it starts location registration to register a Unit ID (UID) and group registration for selecting a Group ID (GID).

In Group and Individual calls, privacy is protected and the calls cannot be monitored by other users in the system. The Priority Monitor feature monitors up to four high-prioritized talk groups so the users can participate in important and priority calls. During peak usage hours, system Call Queuing stacks call requests and processes calls when a channel becomes available. System operators can assign important individuals higher queue priority and even pre-empt lower-priority users for more important dispatch and emergency calls. Well-known features, such as Late Entry, Broadcast Call, Remote Group Add, ESN validation, and remote Stun/ Kill/ Revive are all included and supported as standard.



Out of Range Tone, In-Service Tone
A radio sounds Out of Range Tone to notice the status that the Control Channel cannot be found and is out of service. It is possible to choose the “One-shot” or continuous tone for Out of Range. The “One-shot” emits a single tone only when SU is Out of Range.
Furthermore, SU implements the In-service Tone that notifies of returning to its service area and finds a valid Control Channel. In-service Tone sounds a single tone three times, which allows the user to know whether the SU is In-service without looking at the LCD.

Location Registration

All Radios, IP Consoles, and Telephone Interconnect Units require registration to the system.
When powering on the radio, it searches for an available CCH and conducts Unit ID registration to register its site location. It allows the system to recognize where the UID is located and transfer an Individual call to it, which can avoid taking time to search for a target radio to establish a call.

ESN Validation

ESN Validation is a function to restrict system access from unauthorized radios.
ESN (Electrical Serial Number) is a unique number that is embedded into an inaccessible area of radio memory. ESN contains a Manufacturer code managed by NXDN Forum and each manufacturer uses a different manufacturer code. Using the Manufacturer Limitation enables restriction in specific manufacturer radios to access and keep the system safe and secure.

When powering on the radio and starting the registration process, the system requests ESN information as well if the ESN Validation is enabled. A system checks the ESN and the Manufacturer code, then sends a success message to allow the radio to access. If failed, a deny message will be sent to the radio.

Late Entry

Late Entry is a function to join a call that has already been started.
When the radio starts a group call, it sends call request message on CCH. When the system accepts the request, the calling radio and the target group radios get a channel assignment message from CCH and a group call will be started. If a radio is powered on or comes from a neighboring site in the middle of the group call, the channel assignment message cannot be received. If Late Entry is enabled for the group call, the Control Channel broadcasts a current call status and channel information periodically. According to the information, the radio moves to the traffic channel to join the group call.

Priority Monitor

With a Priority Monitor function, the Traffic Channel informs other group call statuses allowing the radio to join a higher priority group call.
When the system receives a group call request, it assigns a traffic channel and informs the radio to move the channel to start the group call. The information of the group call is announced as Priority Monitor information from the traffic channel that conducts the group call.

A radio has several normal GIDs and four priorities IDs for each Zone. Priority 1 has the highest priority than the others. When the radio receives Priority Monitor information on a traffic channel, it changes the channel if the Priority Monitor information is higher than the current group call. It might be better to set Emergency ID to Priority 1 to receive calls anytime.
The Priority Monitor works only for voice group calls. When receiving individual calls, emergency calls, or data messages on a traffic channel, the priority monitor ID will be ignored.

Queue/Preemption

Queue and Preemption are functions in which a radio waits for a free channel or gets a channel after canceling the ongoing call.
When the system is occupied with all channels and receives call requests from radios, the system announces a Queue message and memorizes the order. When the channels become free, the system assigns the traffic channels to the call-queuing radios in order. The Higher Queue Level radio is placed in the front Queue and gets a channel preferentially. The Emergency Calls have the highest priority than other Queue Levels. It is recommended to set other higher priority calls such as a console call to Queue Level 1 to have an available channel even on a busy system.

Note:

- This Queueing is not effective on a site that enables the Non-Dedicated Control Channel because CCH works as TCH and never transmits the Queue messages.
- The Queue request can be canceled after thirty seconds or when releasing the PTT or pressing the Clear Down key.

The Queue Level can be configured by two operations: Queue and Preemption.

Queue:
A system assigns a free channel when a call is terminated, and the channel becomes free when the repeater Hold Timer expires.
Preemption:
A system cancels the TCH repeater Hold Timer for the existing call and assigns a channel. A lower priority level radio keeps the TCH as long as PTT is being pressed. But, once released, the radio will release the TCH and back to the CCH to start sending a call request again. If the call request comes from the IP console, the TCH is released immediately and replaced by a downlink signal for the IP Console even when the PTT button is being pressed.

Channel Allocation

Channel Allocation is a function to allocate the call service to Traffic Channels in the NEXEDGE Trunking System. The system reserves Traffic Channels and allocates them for specific services. Other Traffic Channels are counted as General Channels. Five call services can be set to the Traffic Channels as Channel Allocation.

- **Voice Call**
  This specific usage channel is used for the Voice Call service. When an IP Console Call, Telephone Call, or Emergency Call does not have a specific usage channel assigned, those calls are assigned to Voice Call.
- **Emergency Call**
  This specific usage channel is used for the Emergency Call service.
- **IP Console Call**
  This specific usage channel is used for the IP Console Call service. However, it is not allocated for calls to the IP Console.
- Telephone Call
- This specific usage channel is used for the Telephone Call service.
- **Long Data Call**
  This specific usage channel is used for the Long Data Call service.

Fail-soft mode

Fail-soft mode is a function to provide a radio minimum communication service when a problem occurs with the CCH or network equipment. In the channel enabling Fail-soft mode, the transmission will be restarted and maintained even when the connection is lost and the radio is isolated from the CCH or the TCH due to an IP switch trouble. During Fail-soft mode, the channel accepts voice group calls and sends broadcast messages to inform that it works in the Fail-soft mode and Adjacent Channel Information periodically. If a Fail-soft mode channel detects valid channels, it restarts and back to the trunked operation automatically.

A radio should be configured on the channel on the Hunt Table or enable the Comprehensive Hunt option to find the Fail-soft Channel. When the radio receives the signal from the Fail-soft mode channel, it stops the Hunt sequence to stay on the channel and shows “Fail-soft” on its display. The radio tries finding available site signals by background hunt every Search Interval timer.
It is recommended to have only one Fail-soft mode channel per site, otherwise, the radios will be assigned to different channels.

Automatic CCH Channel rollover

Automatic Control Channel Rollover is a function that automatically switches the CCH to another CCH or a Dual Function Channel. It gives equal transmission time and a load of control channels so that it prolongs the life cycle of the external equipment such as the power amplifier.
Automatic CCH changes CCH once a day automatically, which should be done when the system is not busy. A control channel of the lower channel number and a free Dual function configured for Channel Mode take over the CCH of the site. Rollover interval time defines the time to conduct Automatic Channel Rollover once a day. Gen2 system can be defined hour timer to switch CCH more flexibility.
To execute the CCH channel hunt properly, all of the CCH candidates of the sites must be listed on the CCH Hunt list of Subscriber Unit.

Failure Control Channel Switching

Failure Control Channel Switch is a function that changes the CCH to keep the system operating if an error occurs to the current CCH such as disconnection of the IP or DC power failure. Also, the system skips the Traffic Channel to assign a call if it has trouble.
The channel with PLL Unlock, no frequency configuration, Pin6 (AUX3) activation, activation of the Take Over function, and IP disconnection will be detected as an error.

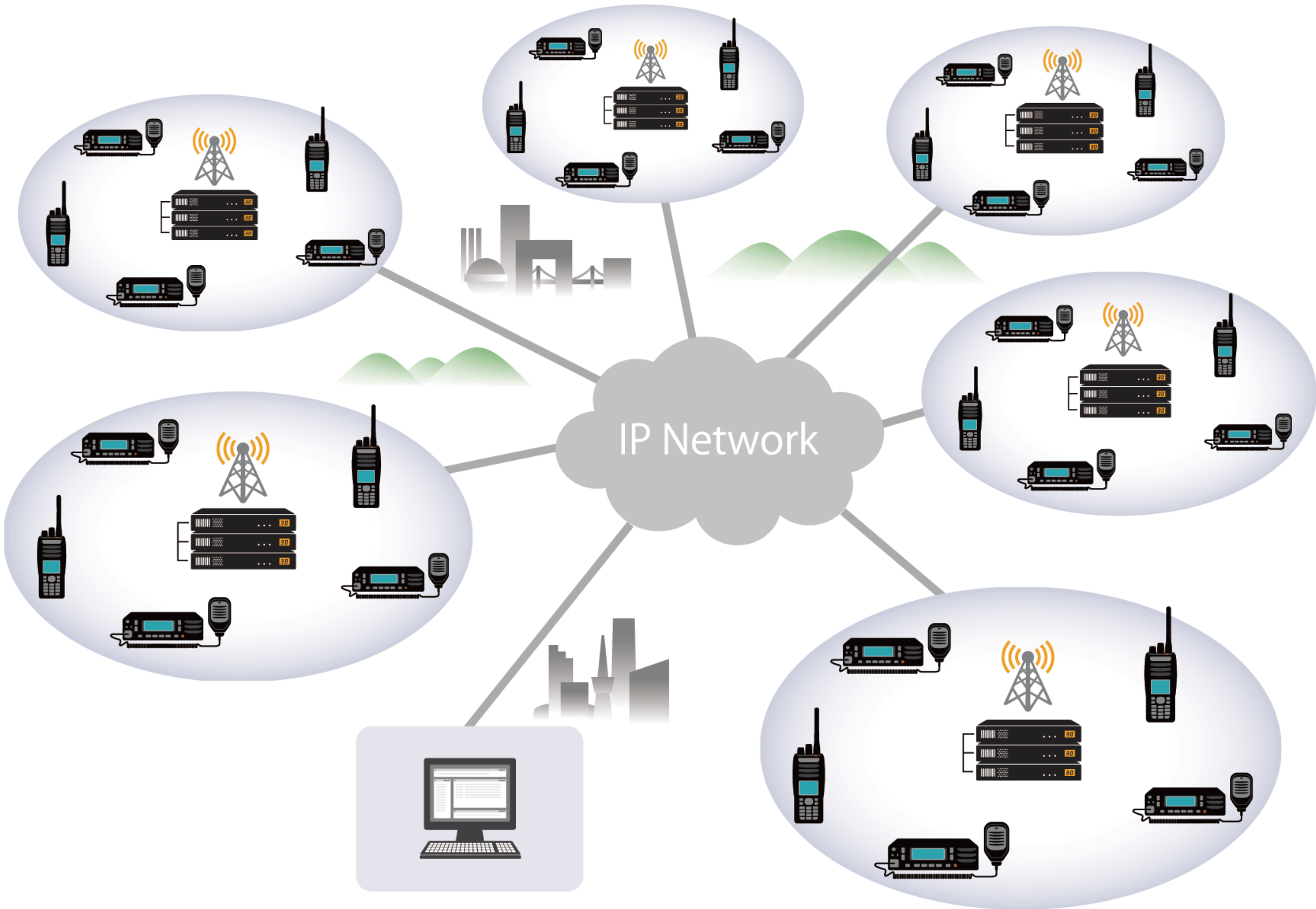
Non-Dedicated CCH

Non-dedicated CCH is a function in which the Control Channel works as a Traffic Channel for a call when all traffic channels are in use. It can use all channels efficiently on the managed Trunked system having a dedicated control channel. The Non-Dedicated CCH also works when the site has only one channel. One channel operates the CCH at the beginning to broadcast a control message and accepts a call request, then starts repeating the call as the Traffic Channel.

The Non-Dedicated CCH works on the Dual Function Channel. If the channel is configured as the “Control Channel” for Channel Type, it does not start as a Traffic Channel. While the CCH is occupied and works as a Traffic Channel, new registrations will not be accepted, and broadcast messages, Late Entry, Queue, etc.., will be suspended which normally are informed to the Subscriber Units from the CCH. During the Non-Dedicated CCH operation, the channel cancels the Hold time to restart as the CCH and when another TCH is available, the next call will be assigned to the channel.

2.2.3. **Multi-site**

The network option leverages the power of IP to link up to forty-eight digital trunking sites together for wide area roaming and calling capabilities. Scalable networks can be created over existing IT assets, private microwaves, spread spectrum links, or carrier services using standard 10/100 Base-T Ethernet switches and routers. IPSec VPN tunneling provides an encrypted secure communications link within any IP network. The Subscriber units use advanced control channel hunting algorithms, RF signal strength, and digital signal quality to automatically determine the best site to register while moving throughout the network. The forty-eight thousand (48000) Group IDs and Unit IDs network capacity provides ample scope for large organizations and multi-user system sharing.



Group Registration

When the system offers an inter-site group call service, it will be possible to save the resources of repeaters by managing the location of the target GID. When the SU initiates an inter-site group call, the system will not transmit an RF at the site where the target GID does not exist (Dynamic Allocation).
To realize such intelligent inter-site group calls, the subscriber unit must register GID information by accessing via the CCH of a site. Basically, the Group Registration procedure is a voluntary action taken by the subscriber unit. The group registration information may not be cleared from the subscriber unit when it is out of the service area. However, the system will clear it if the system service is not used for a certain period of time. Moreover, the system offers the Registration Monitor feature to verify the site and system where the selected GID is registered.

GID Registration Expiry

This function is for the trigger stations (fixed-location radios) such as the taxi base stations or fire stations. These stations need to keep their radios turned on at all times, but there may be periods of over twelve hours with no radioactivity. If the fixed radio has not been active for twelve hours and then it is called, it cannot be paged because the GID record is cleared.

Recommendation;

- "Dynamic Allocation" should not be used in the site where the trigger station is registered at all times. It is also advisable to use "Site Lock" to ensure that the trigger station remains registered on the same site constantly.
- Power cycle exercise is highly encouraged, particularly for vehicle radio users who may not power off their devices overnight or over the weekend. Using “Ignition Sense” should help reduce the risk of this issue.

These settings can be applied to each GID CoS.

Group Registration Timer

The Group Registration Timer is used to perform group registration again at the time of expiration.
The system uses the Group Registration Reset Timer to automatically erase unused group ID registration information to save communication CH. However, some radios want to maintain the validity of the Group ID even when it is used only for reception. In this case, this Timer is used to perform group registration again before the system erases the group ID registration information so that the registered status of the Group ID continues.

Intersite Group Call

In the Multi-site system, a group call between multiple sites is available.
In the Unicast network system, an inter-site group call between up to sixteen sites is available. In the Multicast network system, an inter-site group call between up to forty-eight sites is available.

Group Refusal

According to the Intersite table of GID Class of Service, the site will either accept group registration and respond with an ACK message or refuse and respond with a refusal message if the Group Refusal is active, or with a deny message if the Group Refusal is inactive.
If the subscriber unit receives the refusal message, it moves to another valid site and attempts the group registration. The service area for each GID can be controlled.
In the case of the inactive Group Refusal function, the site broadcasts the deny message and the group registration will fail.
If the Deny message is received, the subscriber unit stays on the site to receive an individual call.

GID Association

GID Association is a function that enables the subscriber units selecting different GIDs to participate in the same communication. Using the Dynamic Allocation, the roaming site does not assign the channel if there is no subscriber unit selecting the GID. However, the GID Association allows the site to start a Group call to receive the call as GID Scan at the subscriber unit.
When the system starts a Group Call to a Target GID, the Target GID can be called from both sites which calls as the Target GID and calls as the Associated GID. This enables the subscriber unit to select the Associated GID to participate in a traffic channel assigned for the Group Call with the Target GID. To use this function, it is necessary to include the Target GID to the targets for scanning or to configure the Target GID as a Priority Monitor ID in the subscriber unit selecting the Associated GID.

Dynamic Allocation

In the Intersite Call Table, a system operator can define an operational service site by checking the "Valid" checkbox for each GID. This configuration can be done in the GID Class of Service. In the meantime, by enabling the Dynamic Allocation NEXEDGE, the multi-site system allocates a traffic channel resource only for the site where the Group Call subscriber unit exists.

Broadcast Message

The Control Channel broadcasts the system information, the managed messages, and other functionality of the system constantly or repeats them with a specific interval.

Adjacent CCH Information
The control channel informs the adjacent CCH information for site roaming of subscriber units. The Control Channel of the site transmits a control channel frequency number to its neighboring site. Three adjacent CCH frequency numbers are broadcasted at once and others are after the Adjacent Site Information Interval Timer, and repeated. According to the information, the subscriber units check the adjacent site CCH signal by the Background Hunt. If the signal strength is stronger than the current CCH, the subscriber unit changes the site and starts the registration.

Add/Delete CCH Information
Additional Control Channel information is a broadcast message to inform that a new CCH has been added to the site. If the subscriber unit receives the information, it memorizes the channel into its own memory and backs it up to use the Normal Hunt sequence. It saves time for reprogramming all subscriber units in the field.
Delete Control Channel information is a message that informs its adjacent site that the channel is deleted. The Subscriber unit skips the channel during the CCH Hunt sequence. The Delete CCH information will be cleared when powering off the subscriber unit. This is applied to the Preferential Hunt Sequence, the Normal Hunt Sequence, and the Site Hunt Sequence.
The Add/Delete CCH information is broadcast every sixty seconds.

Network Failure Information

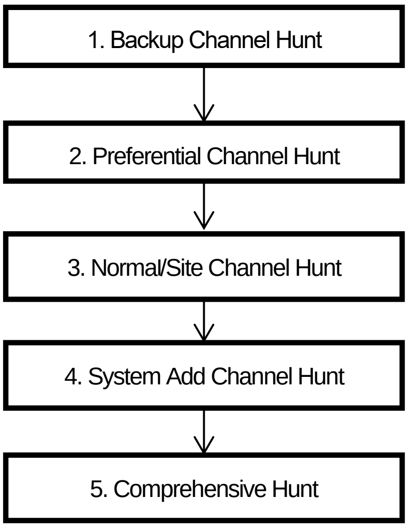
Network Failure Information is a broadcast message to inform that the site is isolated from other sites due to a network failure. The site checks connections between sites every thirty seconds. If it detects disconnection, the CCH announces the Network Failure.
When the subscriber unit receives it, "Network Fail" will be indicated on its display and emit an alert to notify that the call has not arrived/achieved from/to another site.

Site/Channel Hunting

The system has a unique System Code number. Also, the subscriber unit shares the same System Code contained in an SKF file which is used for programming the system on the FPU. The subscriber unit stays on the site if the embedded system code broadcasted from the CCH of the site is correct.
CCH Hunt is started when powering on the subscriber unit, selecting an NXDN Trunking zone, losing the current CCH, or the like.
Using the CCH Hunt table a subscriber unit scans channels and checks the broadcast message which contains the system information transmitted from a site. Once the subscriber unit finds an available CCH, it stops scanning and checks the system information to stay on the channel. If the system information is correct, the subscriber unit starts the registration and shows an RSSI bar on the display. After the successful registration, it moves to the better site by the Background Hunt with the Adjacent CCH information after the Background Hunt Interval timer.
The subscriber unit shows “Out of Range” and flashes the RSSI bar on the display if any CCH cannot be found in 10 seconds.

CCH hunt Sequence

The Subscriber unit starts the CCH Hunt sequence to find an available Site. The Hunt sequence order is written below and repeated if no signal is found.



CCH hunt Sequence

(1) Backup Channel Hunt

The subscriber unit checks a channel that stays when powered off. If there is a signal from the channel, it checks its system information and starts to register its Unit ID (Location Registration), then if it is unsuccessful, the Group registration will be started.

(2) Preferential Channel Hunt

The subscriber unit checks the channel if it is listed as a Preferential Hunt Control Channel. If the subscriber unit would stay on the specific site as much as possible, the site must be listed to be scanned with a higher priority.
For example, in a multi-site system in which its service area is overlapping, for example, it is possible to select a particular channel number for each subscriber unit. Hence, the system design makes it possible to register the subscriber units to each site dispersedly.

(3) Normal/Site Channel Hunt

The subscriber unit checks all CCH listed on the Normal Hunt Table or the Site Hunt Table. If the signal and the system information are found correct, it starts the registration.
The Normal Hunt Table is a common table within the system. It is possible to register the CH number up to forty-eight channels.
The Site Hunt table is an individual table per site. It is possible to register CH numbers up to thirty channels.

(4) Add Channel Hunt

The subscriber unit checks up to forty-eight CCHs which are broadcasted from the System as additional CCH information.

(5) Comprehensive Hunt

The subscriber unit checks all channels listed on the Frequency Table. It scans sixty-four channels from frequency number 1 each time. If there is no available channel, it returns to the Preference Channel Hunt sequence.

System Search policy

In the hunt sequence, the subscriber unit (SU) searches for an appropriate channel with the selected search policy.
The subscriber unit evaluates the error rate of the signal frame and the signal strength of the CCH. The subscriber unit can select three types of criteria. The appropriate settings should be selected according to the system coverage area.

System Search Policy	RSSI Level	Error Frame
Roaming Preferential	-100 dBm to -105 dBm	6 frame
Normal	-115 dBm to -120 dBm	6 frame
Site Preferential	-	12 frame

Normal:

This is the recommended condition. This policy is middle between the Roaming Preferential and the Site referential.
The subscriber unit stops searching for a CCH when the signal level is better than -115dBm and resumes the CCH Hunt if the signal level is weaker than -120dBm or detects six error frames continuously. This gives good quality communication without minimum error which may be caused by distorted sounds.

Roaming Preferential:

This is good for the system which is designed to be overwrapped to each site area. The subscriber unit moves to another site while keeping a good signal condition. The subscriber unit stays on the site if the signal level is better than -100dBm, and moves to another site if the current signal level is weaker than -105dBm or detects six error frames continuously. It allows good communication without any error frame at all times.

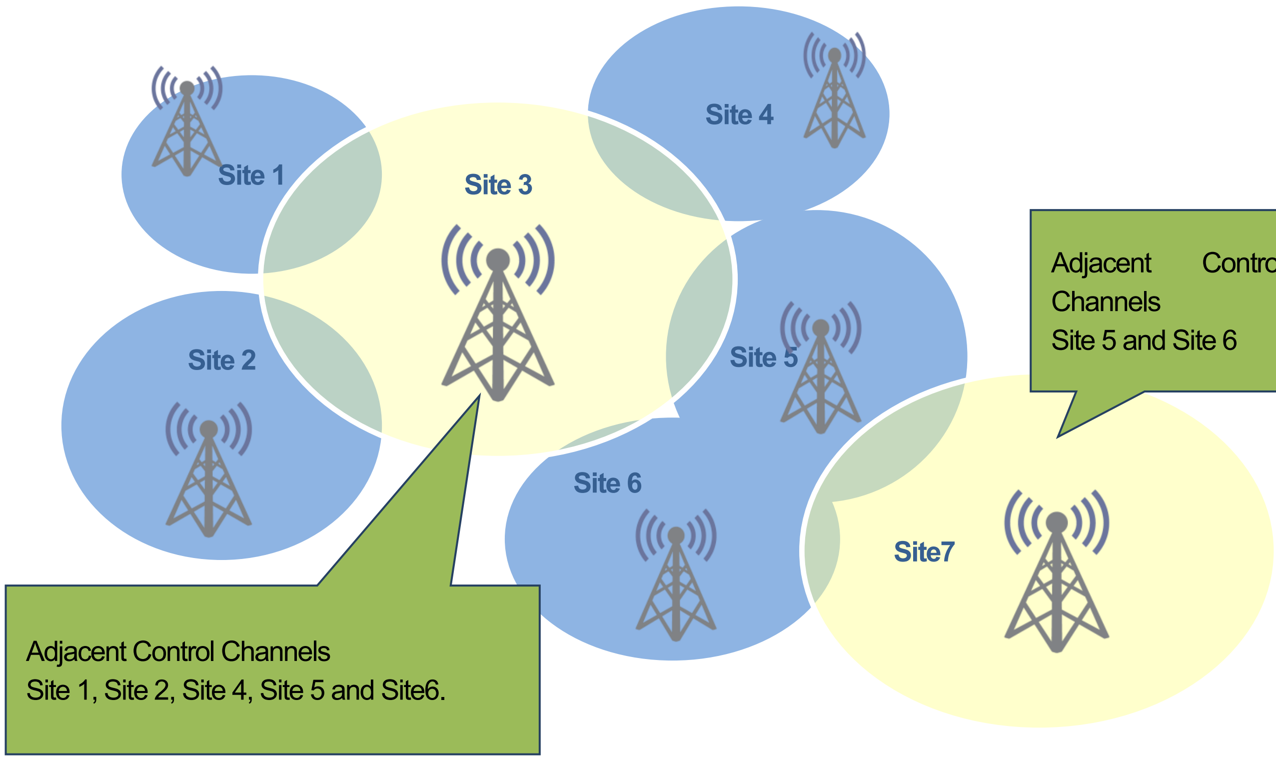
Site Preferential:

This is good for the system which is designed for a wider area for each site. The subscriber unit keeps staying on the current site until it detects twelve error frames. At the edge of the coverage area, you may hear sound unnaturally due to the high error rate but it can keep in-service as much as possible like the legacy analog system.

Background Hunt

Background Hunt is a function that allows a subscriber unit to periodically search for neighboring control channels to acquire a control channel with a higher signal strength while the subscriber unit is in the standby state on the control channel.
It gives seamless site roaming to better sites.

The subscriber unit starts counting the Background Hunt Interval timer when it receives the Adjacent CCH information. When the timer expires, the subscriber unit quickly checks the adjacent CCH in the short term if it is not receiving valuable information from the current CCH. If a new CCH is stronger than the Level Margin configured in the subscriber unit, it changes the CCH and starts the registration. If the Adjacent CCH is the Preferential CCH, the subscriber unit ignores the Level Margin and stays on the CCH immediately.

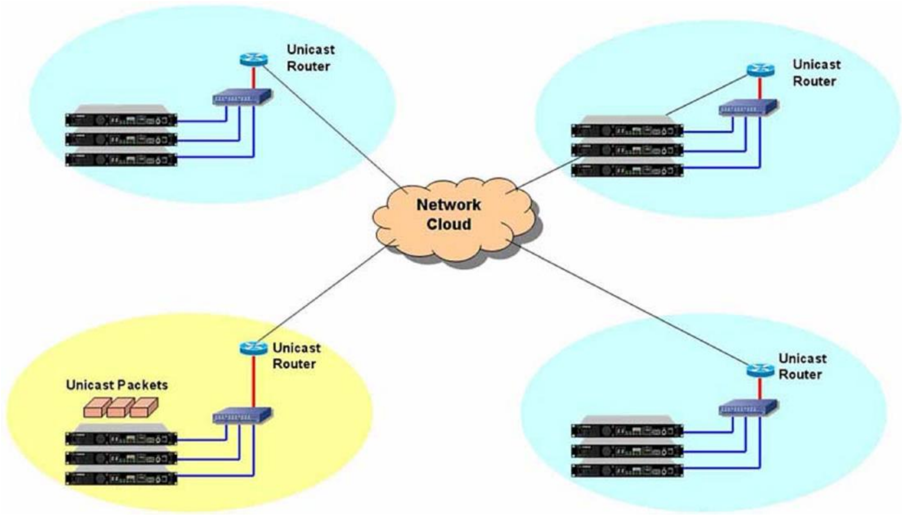


Depending on the system design, the Broadcast interval timer and the Background Hunt interval timer should be considered. For instance, if the system is designed mainly for mobiles, the timer should be shorter to move to another site quickly. But if the system is designed mainly for portables, the timer can be longer because they do not move so much.

Multicast Routing

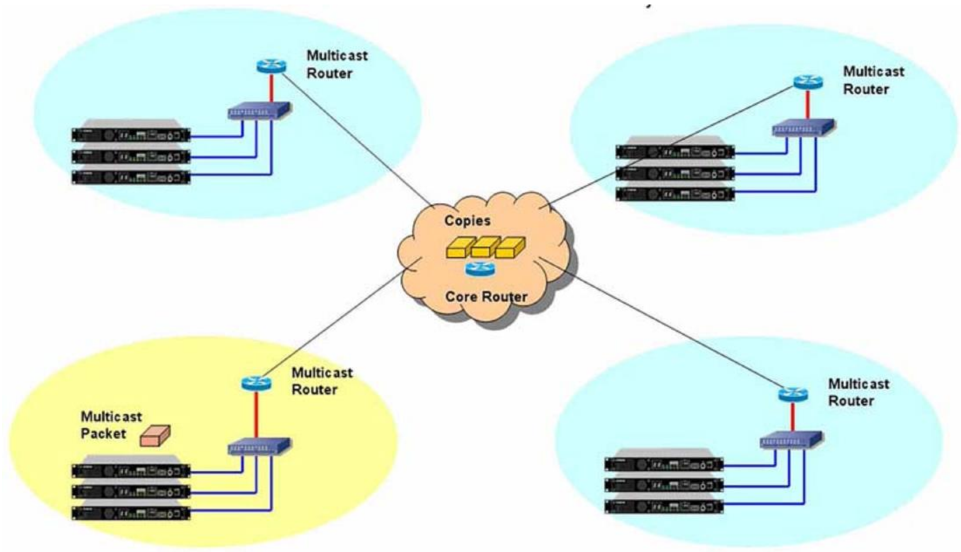
In the unicast scheme, a packet is delivered only to a specific single host. In the multicast scheme, a packet is delivered to a group of hosts that have an interest in receiving the packet. With the multicast, the host can send only one copy of the packet into the network (i.e. Multicast router), and the network will make copies of the packet and deliver one of them to the hosts with the interest.

■ Unicast Scheme



- Host repeater creates a number of copy packets for target sites
- Heavy traffic as sites increase

■ Multicast Scheme



- Host repeater only sends a single packet to the core router
- Core router copies packets for the targets
- Traffic volume dramatically reduced

2.2.4. Security

The System offers security features such as the System Key files (SKF) and the ESN Validation so that the illegal subscriber unit cannot use the system. Those who do not have the SKF are unable to configure the trunked radio, which allows to prevent the system from being used by the unauthorized.

Hardware Dongle and Activation file for KPG-110SM

KPG-110SM, system programming software is protected by a USB dongle provided with KPG-110SM. It has unique information and an encrypted key to open the activation file provided by JVCKENWOOD. KPG-110SM cannot be started without a proper activation file. The activation file is made with system information, system code, number of site/CH, and repeater information such as ESN.
Within the information, you can build the NEXEDGE Trunked system. Without a valid activation file, it is impossible to neither make any system nor duplicate it.

System Key File

The System Key File (SKF) created by the System Manager contains system information and it is needed when configuring the Trunking feature to a subscriber unit by Programming Software (FPU). When creating an SKF by the System Manager, an administrator needs to get the information of the License ID of SU Programming Software.
For example, when the SKF files for the KPG-D1 and KPG-D3 are created, the license ID of each Programming Software must be obtained and the configurable range of UID and GID must be specified.
Even if the SKF leaks to other people, the system will not work without the same Programming Software with the same License ID. Even more, the range out of the configurable UID & GID which has been specified by the System Manager cannot be configured. The issuance history of SKF will be recorded in the log file.

ESN Validation

ESN is a unique number for each subscriber unit assigned by the manufacturer and is inaccessible. The ESN Validation is a feature to block illegal subscriber unit users by comparing the registered ESN information with the ESN information of the illegal subscriber unit. By using the ESN Validation feature, the system can refuse the registration of the illegal subscriber unit.
The system that enables the ESN validation requests the ESN information when the subscriber unit asks for registration to the site. The system checks the list if the ESN is included. If not, the CCH denies the request. As a result, the subscriber unit never succeeded in registration and the Hunt sequence will be resumed.

Remote Control

NX-5000 and NX-3000 allow transmitting Remote Control commands (Stun/Revive/Kill/Monitor/Radio Check) by keypad operation same as the DMR mode. To enable the Remote Control command transmission, the radio must be enhanced with a software option, KWD-5007RC, or KWD-3505RC.
We strongly recommend that only the radio managing purposes should be enabled to avoid unexpected radio stun and kill from unauthorized radio.

2.2.5. Maintenance

KPG-110SM is programming software for the system as well as providing some maintenance functions to keep the system properly, monitoring the system/channels, channel analyzing, and requiring several logs from the site. According to the information, the site and system must be considered to maintain the system performance.

- System Overview
- Channel State
- Channel Load
- Communication Log
- Statistics
- Backup (Call Detail)
- Restore (Call Detail)
- System Log
- Diagnostic Log

The System Overview window shows network information and hardware information of the channels. The Channel State window gives real-time monitoring of channels for each site to show channel conditions and call details, ID numbers, call types, duration time, and so on. They can help to check the condition.
The Channel Load window shows the status of the channel usage rate graph of the site. The usage rate is calculated based on data from the last twenty-four hours and refreshed every ten minutes. Based on the information, the site has to be considered to maintain.

The Communication Log window shows all communication logs of the site. Logs can be loaded to the file for air-time analysis or call history. It also shows the cause number for each call. The cause number helps to find out the problem of the system. The Statistics window shows statistics of calls using the call information acquired from each repeater by referring to the Communication Log.

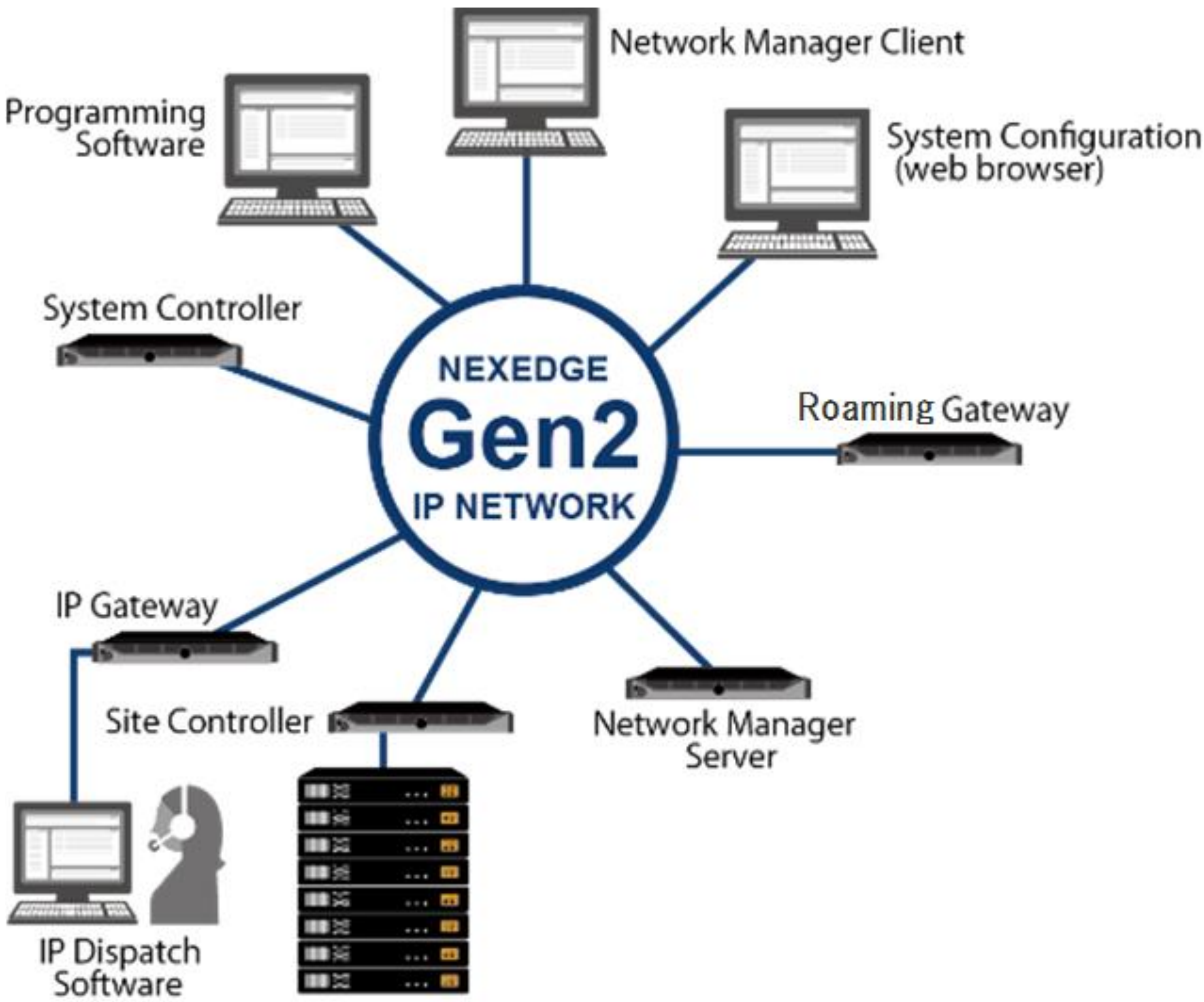
The Backup (Call Detail) and the Restore (Call Detail) transfer communication logs to the replaced channel. All logs are stored in the lowest channel. If the channel has a failure and needs to be replaced, the communication log should be backed up and restored to a new channel.

System Log and Diagnostic Log are used for analyzing the system problem. Looking at the log will help find out the cause of the problem and phenomenon of the system. Once the problem happens, you can get the logs and send them to KENWOOD.

2.3. NEXEDGE Generation 2 (Gen2) Trunking System

2.3.1. General

The sophisticated server-based architecture enhances the Type-C Trunked System to serve users with even greater capability. It covers up to one thousand one hundred and fifty-two (1152) sites, realizing interstate, cross-border, or nationwide networks, which are now all under control. Also, extended advanced security, access management, and privacy options ensure wide-area communications. Gen2 is a smart way to reduce the task load of control channels. Large-scale System building and stable system movements are achieved by implementing the System and the Site Controller in the Server with high processing power. The basic function follows the NXDN Type-C System, and repeaters used in the NXDN Type-C Trunked System can be used as is by updating the firmware.
Moreover, it is improved so that the system will not stop to the utmost in case of setting changes and firmware changes.



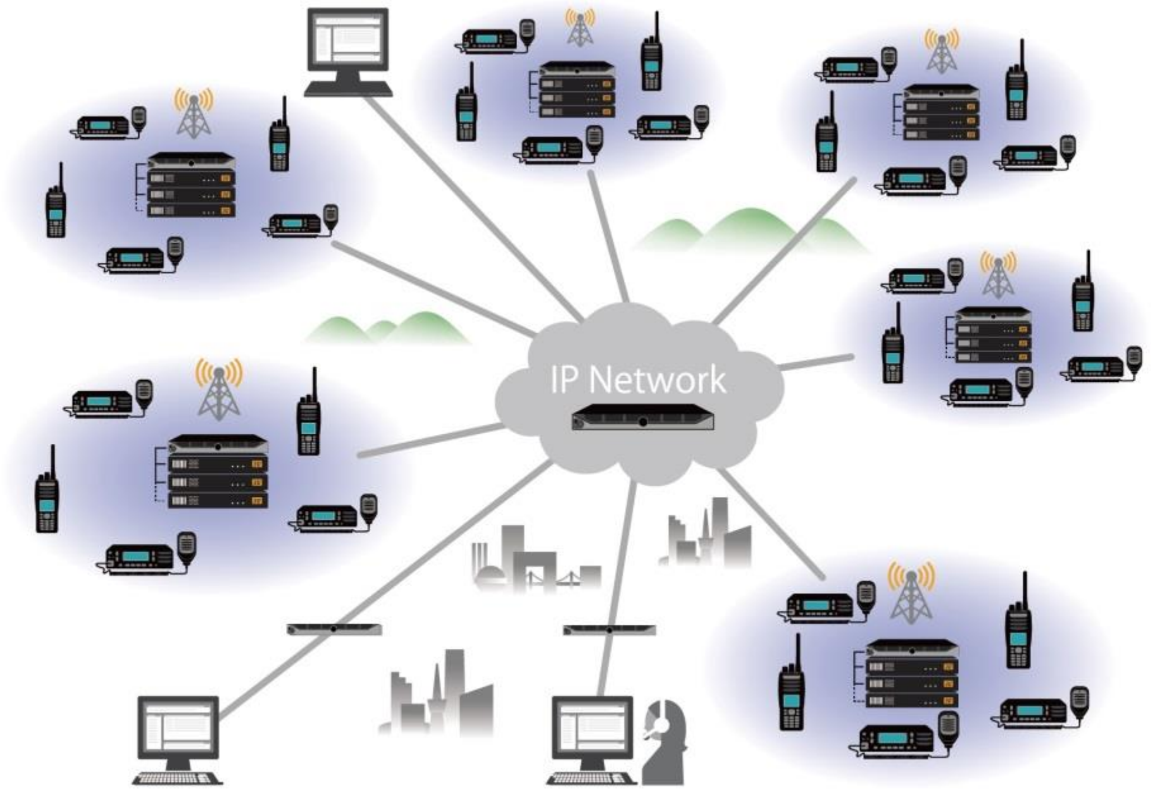
2.3.1. Gen2 System

Single-Site System

The single-site system using multiple repeaters is the simplest form of the Gen2 system. It requires one single server as the system controller and one site controller if there are more than nine repeaters at a site. If there are fewer than nine repeaters, an additional server for site control will not be required since one of the repeaters will perform this function. If NXR-x00 and NXR-5xxx are used in a site where less than nine repeaters are in operation, then the site controller shall be assigned to the NXR-5xxx repeater.

Multi-Site System

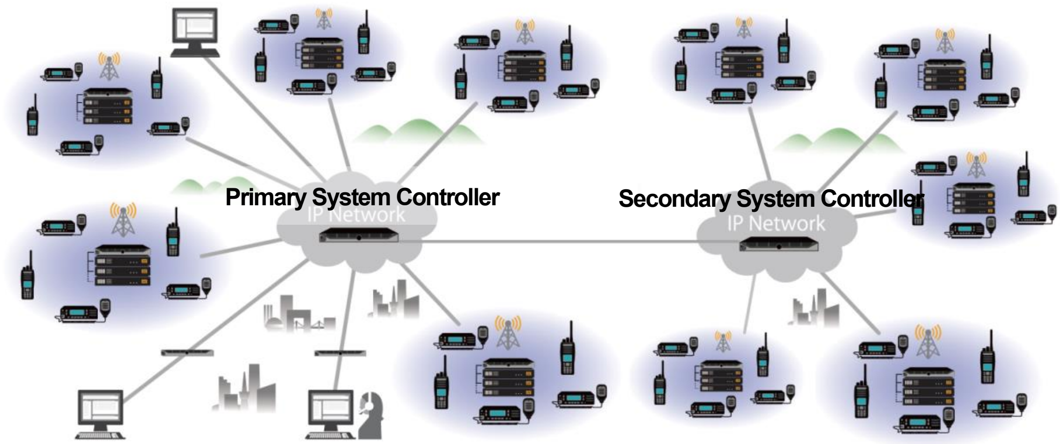
A multi-site system is generally used to cover a wide area where extended coverage is needed. It consists of up to forty-eight sites that are IP-connected. The system, in addition to the necessary repeaters and network hardware, requires a System Controller and Site Controllers for each site. If a site consists of nine repeaters or less, then one of the repeaters may serve as a site controller.



Wide-Area System

A Wide-Area System extends over a greater area than that of the Multi-Site System as does the site capability. This system type may be built out with up to one thousand one hundred and fifty-two (1152) sites compared to the 48 sites of the Multi-Site System. A multi-site system can be considered as a system of systems in that Gen2 allows the System Code to be used over a collection of Multi-Site Systems to extend the system capability. Each Multi-Site System will require a System Controller.

These System Controllers work in conjunction to handle and share registration, call routing, and logging across the Wide-Area System. One of the System Controllers in a Wide-Area System will be assigned as the Primary Site Controller. This Primary Controller will be a master controller in the system and will be the point at which the entire system is configured through the System Configuration Utility (SCU). The Primary System Controller should be installed in the most stable area of the network to reduce outages. In addition, a Secondary System Controller may be employed for redundancy.



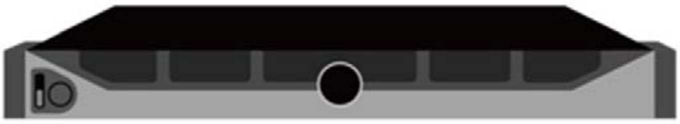
The following are the features of the Gen2 System:

- Based on the functions of a Type-C Trunked System, the basic functions correspond with a large-scale system exceeding forty-eight sites.
- Current NXR-x00 hardware can be used in a Gen2 System by updating the firmware. NXR-5000 is fully compatible.
- A PC server is used as a System Controller to improve the processing ability.
- The conditions for restart occurrence are minimized, and the improvement is made to enable configuration changes without stopping system operation.
- System configuration through the Web allowing multiple system operators from different locations to change configurations in parallel is enabled.
- The capability to automatically adjust time for the whole system is enabled, supporting the NTP server.
- The recording of communication is changed from per-site recording to centralized recording per communication.
- Improved convenience, such as billing.
- Direct Frequency Assignment is supported. In a CCH report or TCH allocation message, the method to directly specify the frequency is supported. By specifying the frequency information from the system when adding a system channel, a subscriber unit enables the use of the added channel without overwriting the FPU data even if the added frequency information is not registered in the subscriber unit.
- Compared with the Gen1 Type-C Trunked System, an increased number of subscriber units using a GPS can be included by installing a GPS-dedicated channel.
- The automatic acquisition of the ESN of the subscriber unit is supported, eliminating the manual input by a system operator.
- Registration Monitor is equipped, which enables to confirm which UID is currently registered and which UID is registered to the GID. The current call area status for each GID can be displayed.

The subscriber unit used in the Type-C Trunked System can be used in the Gen2 System if the pre-existing functions remain. No change needs to be made to the firmware or FPU data.

2.3.2. **Gen2 System Component**

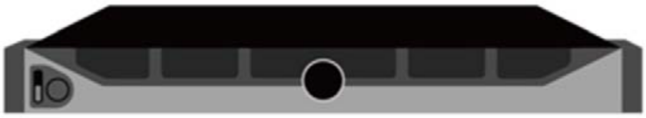
System Controller (KPG-1000SY)



System Controller

A system controller takes the key role of system control and management. It controls the entire call process and interconnectivity between each site. In addition, it also takes on a central role as a Site Controller, an IP Gateway, and a Network Manager. One System controller must be installed for each system. System configuration information and frequency settings for each repeater can be programmed by the web-based tool named System Configuration Utility (SCU) in the System Controller.

Site Controller (KPG-1001ST or Repeater)



Site Controller

A site control server manages to bundle repeaters within a site for assignment and communicates with the system controller. The site controller does not require server equipment if less than nine repeaters are included in one site. In this case, one of the repeaters takes on the role of the Site Controller. A repeater that has the role of Site Controller can be assigned by the SCU.

Repeater

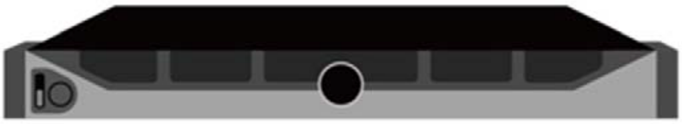
Repeater

The NXR-x00-series repeaters may be used in the Gen2 system but require conversion firmware for operation. Once the conversion process is completed, the repeaters may only be used in the Gen2 system without converting back to the NXDN Type-C System via firmware. The NXR-5xxx-seres may be used in the Gen2 system without conversion. They are configured to be used for the Gen2 operation in advance. It should be noted that repeater configuration is not required in the traditional Gen2 system programming software. All configurations are accomplished using the SCU.

Note:

The traditional programming software is required for confirming the repeater MAC address or using a test mode. KPG-109D for the NXR-x00-series and KPG-D2 for the NXR-5xxx-series.

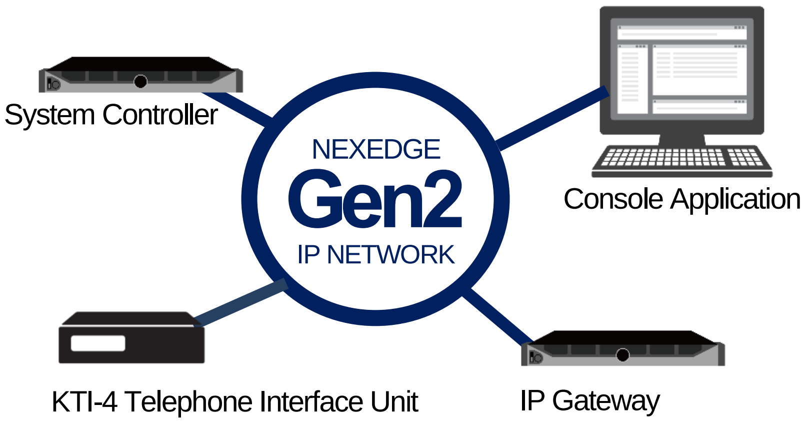
IP Gateway (KPG-1002GW)



IP Gateway

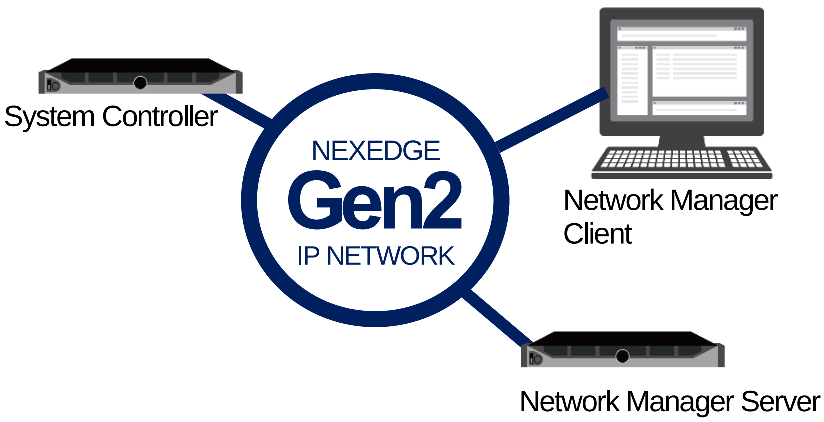
The IP Gateway Server is used to connect peripheral equipment conforming to the NXIP console interface to the Gen2 system. Unlike the NXDN Type-C System, the peripheral equipment is not required to be tied to the repeater or the subscriber unit directly.

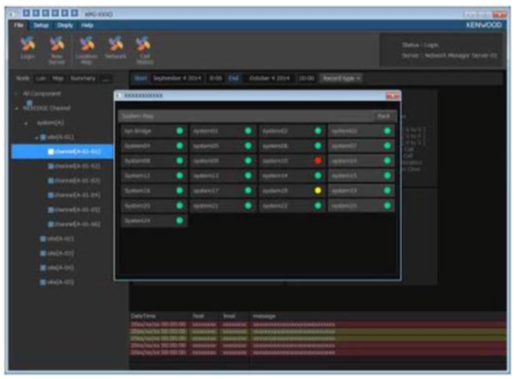
The IP Gateway is IP connected to the System Controller. Up to ten IP Gateway Servers may be connected to one System Controller and up to a hundred pieces of peripheral equipment may be connected to one Gateway Server. This allows for up to a thousand pieces of peripheral equipment to be attached to a single System Controller.



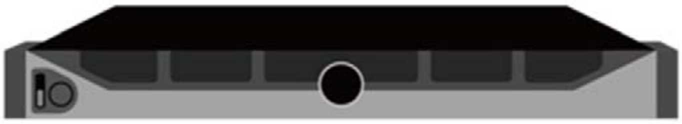
Network Manager (KPG-1003NS / KPG-1004NC)

Network Manager is a monitoring application that monitors the Gen2 System and notifies when a failure occurs. The Network Manager Client and the Network Manager Server work together in monitoring. The Network Manager can also configure devices, such as repeaters, System Controllers, or routers to be monitored. If the number of monitoring targets is a hundred or less, the System Controller gives the same functionality without the Network Manager Server software installation. If the number of monitoring targets exceeds a hundred units, a Network Manager Server needs to be installed separately. A maximum of 1000 monitoring targets can be specified if the Network Manager Server is installed.



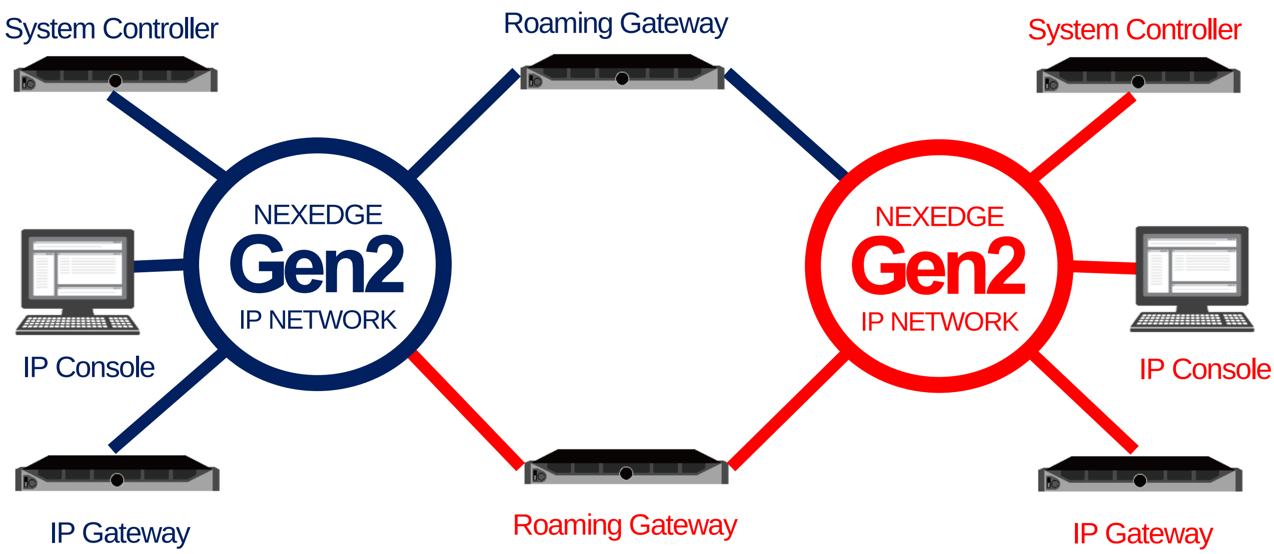


Roaming Gateway (KPG-1005RG)



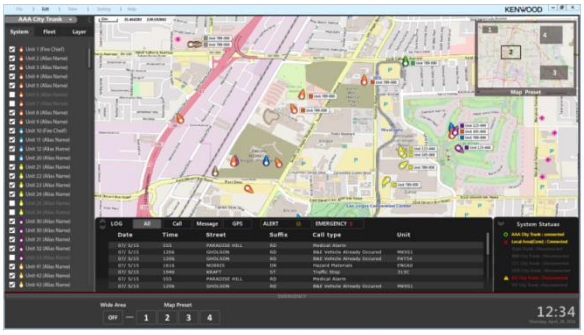
Roaming Gateway

The Roaming Gateway is a device that connects different systems, the Home System, and the Roaming System.
It is possible to communicate with up to twenty-four Roaming Systems with different system codes through the Roaming Gateway.
The subscriber unit is registered as a Guest to the roaming system. The Roaming system controller transfers every call to the Roaming Gateway of the Home system. The subscriber unit that locates the Roaming System can be called from the Home System. The call is transferred from the Home System Controller to the Roaming Gateway in the Roaming System.



Console

In the NXDN Type-C Trunked System, the console is connected to the repeater via an IP connection with the repeater serving the role of a console interface. Console equipment is connected to the system via the IP Gateway in Gen2. Up to a hundred consoles may be attached to a single Gateway. The Gen2 system prevents unnecessary transmission from the repeater when the console transmits and receives because the IP Gateway Server executes the console-related control. Traffic Channel is an additional feature assigned to the console that will preempt ongoing traffic on the selected channel. This ensures the console always has a communications path into the system.



Telephone Interconnect

The Gen2 System has the ability for telephone interconnect operation using the IP Gateway Server and an external interconnect interface, KTI-4 and Zetron Model30/735.

The following interconnect features are supported:

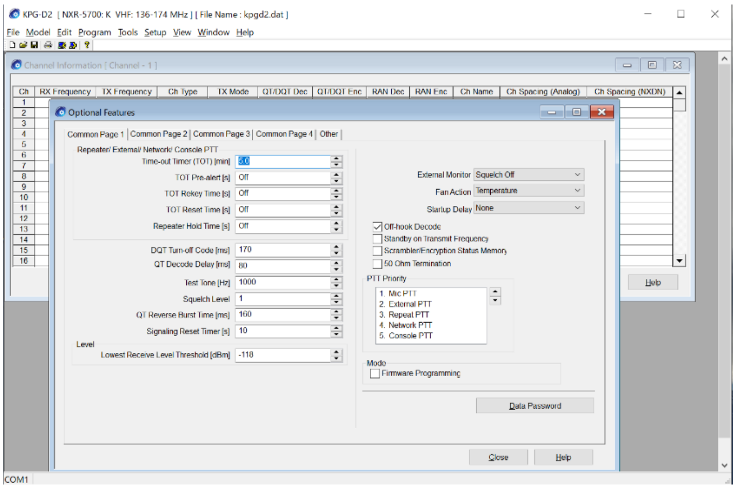
Subscriber initiated phone calls
Incoming targeted subscriber using Individual Call
Incoming targeted talk group using Group Call

KTI-4 Telephone Interface Unit

Zetron Model30

Zetron Model735 for EU

Programming Software (FPU)



KPG-D2 (Screen Sample)

The Gen2 System enables the capability to make all configurations on SCU. Therefore, configuration using KPG-D2/D2N, such as the configuration of frequencies, is not required. However, KPG-D2/D2N are required when using the adjustment mode. Also, KPG-D2/D2N is used when confirming the MAC Address of the repeater.

System Configuration Utility (SCU)

System Configuration Utility (SCU) is a web-based system configuration tool. It configures all system parameters including repeater frequency and gives some support tools.
Open the web browser and type in the IP address of the System Controller. It shows a window to enter your ID and password.
By using SCU, multiple system operators can access the system from a remote location. In addition, the SCU has several access privilege levels and a password per user to restrict access to several configuration items.

System Configuration Utility (SCU)

System Configuration
All system configuration is done by SCU including frequencies, all parameters of the system, and IP address of channels. SCU recognizes the channels of the system with the MAC Address of the repeaters.

2.3.3. Gen2 Function

Features both NXDN Type-C System and Gen2 System

In the case of the Type-C trunked system, a traffic channel is assigned by the system and notified by the control channel automatically. Subscriber units do not need to check the availability of a traffic channel. Due to the control channel, it becomes possible to assign calls from the subscriber units to a traffic channel efficiently. It is possible to support up to thirty channels at a single site. The system may be further expanded beyond a single site to multiple sites using an IP network for site connectivity.

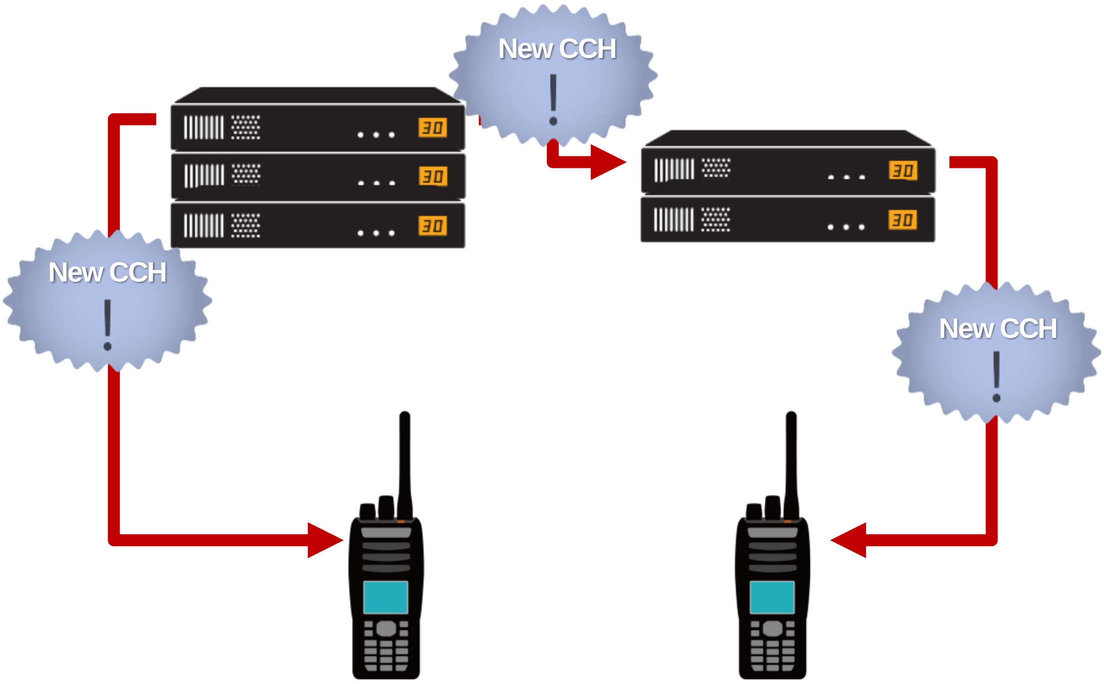
This system provides a call reservation function (Call Queuing) to the subscriber unit when there is no available traffic channel. This allows the user to gain access as soon as a traffic channel becomes available based on the queue ranking if the priority has been set to gain access as soon as a channel becomes available. The subscriber unit can distinguish a high-priority Group Call (Priority Monitor) based on the Group ID information supplied by the system.

This system provides a “Late Entry” function that allows the subscriber unit to receive the call even when the subscriber unit was on another call or just powered on and was not available when the call had been started. The system provides the function that gathers the subscriber units to a specific Group Call by remote operation (Remote Regroup).

There is a function that allows support when site-to-site connectivity fails or repeater failure occurs and the Fail Soft allows the subscriber unit to continue its communication. The Fail soft allows an operational repeater site to operate in Site Trunking mode if connectivity between sites is lost and back to the simple repeater operation if trunking fails.

Direct Frequency Assignment (DFA)

The Direct Frequency Assignment (DFA) does not require the radio to be back and program new or amended frequency information. This feature sends the frequency information to all subscriber units over-the-air. In a CCH report or TCH allocation message, the DFA method allows a frequency to be specified. The system specifies the frequency information when adding a channel so that the subscriber unit can use the added channel without reprogramming. The DFA function reduces the time and expense of adding new channels and sites.



When a channel is added to the site where the subscriber unit is registered, the subscriber unit receives the information from the control channel. Upon receipt, the subscriber unit updates its channel table. When a channel is added to its adjacent site, the subscriber unit receives the new channel information by the Adjacent Message as well.
Since the DFA function occurs over the air during a transmit cycle, some available subscriber functions will not display the information if used. These functions are as follows.

- Maintenance Mode, Channel Number/Frequency – the channel number/frequency added by DFA cannot be verified in maintenance mode.
- Site Select – a site added by the DFA function, the site name cannot be selected only the site number.

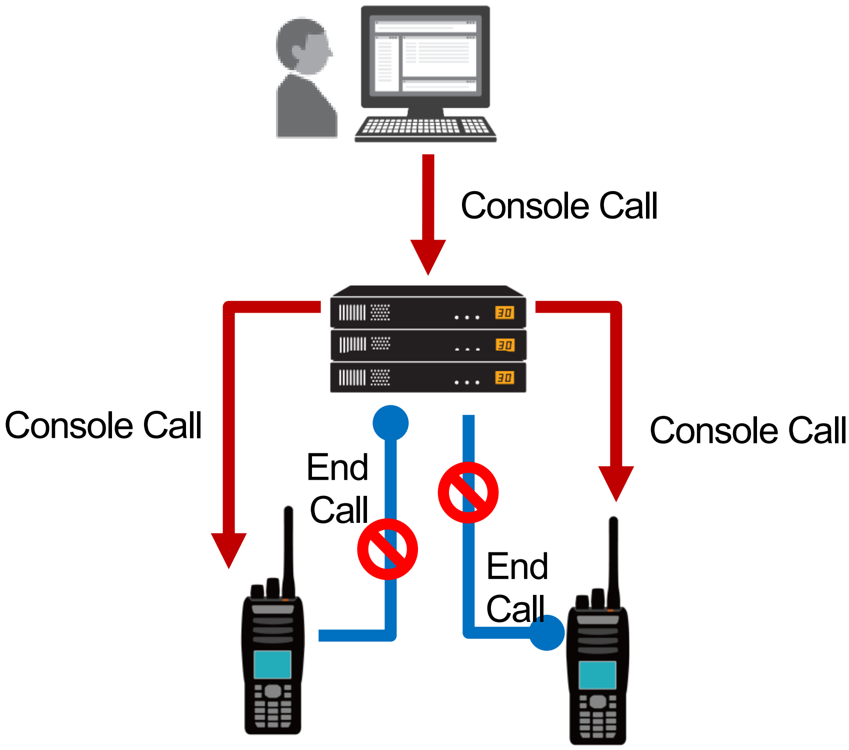
Note:
Since the added channel information is sent on the control channel, SU must have the control channel information programmed in the frequency table.

Call Priority & Management

Call Pre-emption/Interruption for Consoles

Supervisors and console operators – for example, in airport control towers and taxi dispatch centers – will certainly welcome this feature, since it gives priority to console calls. If there is no traffic channel available, the console can take over a channel: radios in operation will automatically stop ongoing call transmission/reception, and the console will be able to communicate directly with its users. The Call interruption enables emergency alerts or instructions to be issued, making this ideal for public safety/work applications.

By assigning preemption to a console, the console can initiate a call even if all traffic channels are used and provide an emergency call service when required.



Restriction Control

The Restriction Control is a function to restrict transmitting temporally when congestion happens at the site. In case of disaster or big event, a lot of calls occur to the site and create conflict.
The system with the enabled Restriction Control manages calls and broadcasts to restrict transmission of the subscriber unit. The Call Restriction Condition only allows the subscriber unit that is prioritized in the Priority Subscriber Class for transmission. Other subscriber units with "General" configuration hold the call and start transmission only at the timing that is announced by the system. When the traffic becomes slow, the site cancels the Restriction Control.
The restriction rate will be changed dynamically to 50, 75, and 87.5% according to loading conditions at the site.
NX-x00/20 Ver5.10 adapts the Restriction Control function and restricts calls.

Restrict Service

- Registration Request
- Voice Call Request
- Status Request
- Status Inquiry Request
- Remote Control Request
- Data Call Request
- Short Data Call Request

Note:

- Emergency call is not restricted at any time.
- When the PTT is pressed during the restriction control, the call will be held and call initiation will be delayed. After the emission of the Processing Tone, communication can be started.
- The Restriction Control is configurable from the SCU. The configuration on the subscriber unit is unnecessary.
- During the Restriction Control, the subscriber unit receives Priority Subscriber Class information from the system.
- “2nd Generation Trunking” system option is required.

Dynamic Non-Dedicated Control Channel

The Non-Dedicated Control Channel is a function that switches CCH to TCH when all TCH are occupied.

While CCH works as TCH, the site operates without CCH, and new a call request is not assigned to TCH and the Late Entry information is stopped until the channel is released. To reduce the time during which these functions are unavailable, the Gen2 system may dynamically assign an available open channel to be a control channel.
Selecting “Dynamic CCH” as the Non-Dedicated CCH, the free Dual Function channel starts working as the CCH instead of the previous CCH. The subscriber unit moves to a new CCH and waits to receive a call.

Channel Allocation

Fleet Priority Channel Allocation

For demanding mission/operation-critical users, it is essential to have a system that offers top-notch security 24/7. And they can put their full trust in the NEXEDGE® Gen2 system, not least because one can assign a secured priority channel to a specific TCH – for a group, console, or other peripheral. Members of such a group will have access at all times – ideal for public safety applications. As well as enabling private system applications, this facilitates the development of new solutions – for example, using a Secured Priority Channel for SMR network channel leasing to end users.

In the Gen2 system, the System Operator may allocate exclusive traffic channels for particular call types. The following is a list of the call types.

- GPS REPORTING CHANNEL (GRCH) *1
- VOICE *2
- LONG DATA CALL *3
- EMERGENCY CALL *3
- IP CONSOLE CALL
- TELEPHONE INTERCONNECT CALL
- SPECIFIED FLEET
- GENERAL

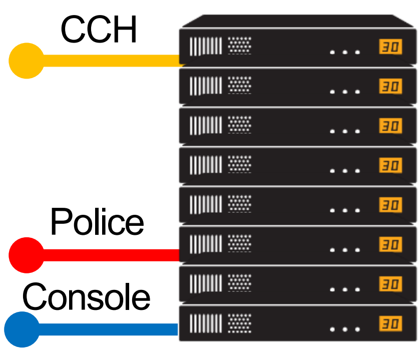
*1: The GRCH will be the first available

*2: When there is no exclusive channel for IP console operation, interconnect, or emergency calling then the setting is the General assignment although priority will be given to these call types.

*3: An IP console call has higher priority than a subscriber unit call

In programming, the admin can reserve a traffic channel for a particular use case. Actual channel use will be decided based on available channels in the trunking pool, but the assignment will make channels available for exclusive use. For example, in a site with four traffic channels and no exclusive assignment, all types of communications can be established as long as a channel is available. If the assignment is made for a voice call then a channel allocation will be fixed and used for voice only. The other three channels can be used for a voice call, but the fourth channel is used only for a voice call.

This functionality improves the priority call handling such as emergency calls when the system is very busy. If a channel assignment is fixed for emergency only, then the emergency call will go through unimpeded by other traffic. Similarly, a system that has mixed types of users, one of which is law enforcement, will be given an available channel at any time by using the fleet assignment. This feature limits the number of available traffic channels and at the same time, allows the system administrator to give customers system access when needed.

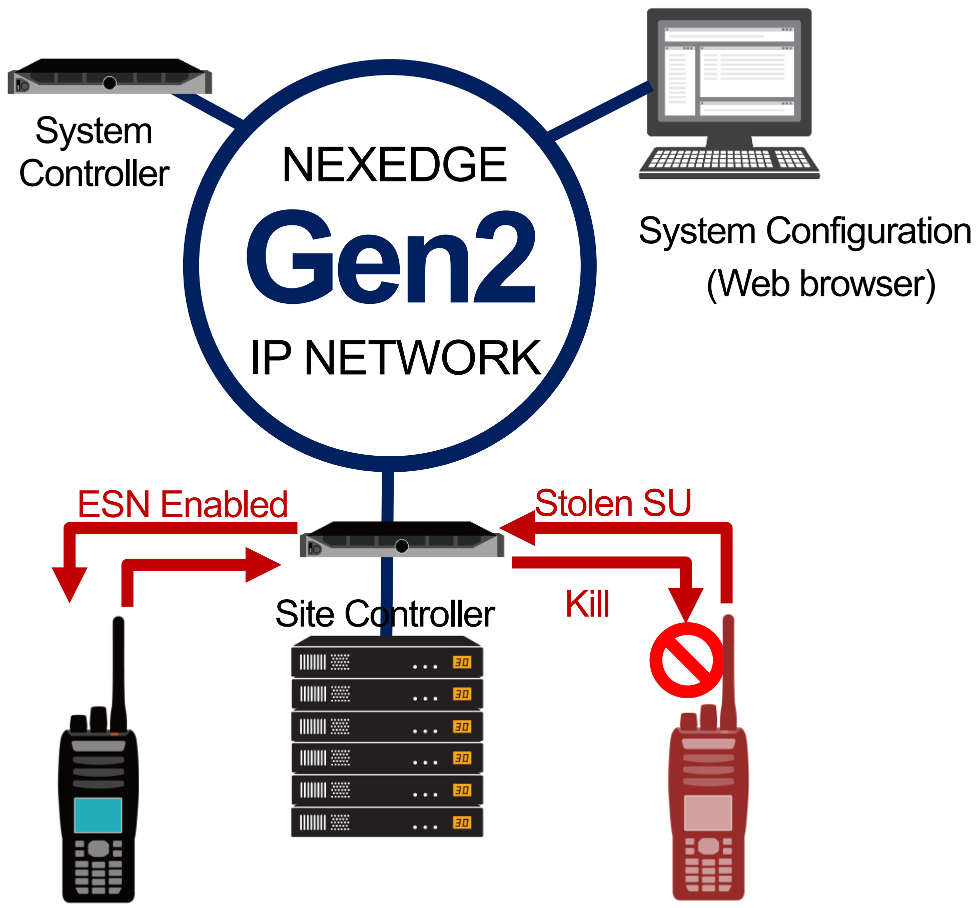


Automatic Acquisition of ESN

NEXEDGE System has a function to refuse calls from an unregistered subscriber unit by checking an ESN (Electronic Serial Number). This function prevents unauthorized access, calls, and interception of system information. In the case of the monthly payment business model, this function is effective for default of payment. The System Operator can stop the service until payments are made.

In the Gen1 Type-C Trunked system, the ESN list must be manually updated. The system operators are required to take a great deal of time and effort to manage this list and ensure its accuracy. If not properly managed, the system may be compromised or access of authorized users may be denied.

The ESN Automatic Acquisition feature in Gen2 allows the automatic update of the ESN list, which saves time for the system operator and ensures the accuracy of the list. When a newly added radio accesses the system for the first time, this function updates the ESN list automatically. If a radio has an existing ID with an unmatched ESN and attempts to access the system, the system can refuse its registration by checking the ESN list. The system operator can search the unauthorized subscriber unit using the system log and remove all ESNs or a single ESN of a specific ID from the ESN list.



Voice Codec conversion

The NEXEDGE Gen2 System IP Gateway (KPG-1002GW) supports G.711 (PCMU/PCMA) data format voice data conversion for third vendor applications.
When the IP console registers the Console ID to the system, it specifies a vocoder format. According to registration information, the IP Gateway converts AMBE+2 to/from G.711, the general vocoder format, for easy management using the general console application. This would help JVCKENWOOD partner to develop the NEXEDGE application.

Note:
To enable Vocoder conversion, IP Gateway must have the enhanced software option KPG-1011VP for each voice path.
The Vocoder conversion works for only non-encrypted voice calls.

System Configuration Utility (SCU)

System Configuration Unit (SCU) is an application to configure the Gen2 System parameters same as KPG-110SM for Gen1 Type-C Trunking, and additional unique functions below.

Firmware Update / Software Update
With the appropriate privileges, firmware and software updates of the system equipment will be possible using the SCU. This includes a repeater, a system controller, a site controller, an IP gateway, and a network manager. This may be done using a single packaged file. When the update is executed via the SCU, the System Controller checks the firmware and software version of each piece of equipment and automatically updates the firmware and software of equipment being operated with different versions. If the equipment is in the power-off condition, the System Controller updates the firmware and software automatically when it is powered on. With this feature, the system operator is no longer necessary to consider the operation condition and firmware version of the equipment when executing the update. It greatly reduces the time taken with this operation compared to the NXDN Type-C system since the update can be executed without much of the work of the administrators.

The SCU updates the Firmware of the target sites. Select target sites and conduct Firmware updates. Considering the site location and updating the selected site will keep the SU operation in its neighboring sites.

The Message feature
The message feature is effective when multiple users access the SCU simultaneously. It exchanges messages to and from the SCU which is similar to an Internet discussion board or a desktop messaging client. When a message is sent, the date and time are appended to it for reference. The message requires color-coding that is used to indicate the response level. The levels are Urgent (red), Important (Green), Priority (Blue), and Normal (Black). A maximum of a thousand messages and one hundred and fifty characters can be recorded.

Backup & Restore
Backup & Restore saves and restores all configuration data loaded from the system controller. It is recommended to save configuration data with some comments periodically if multiple users manage the system.

Import & Export
SCU Import and Export GID (Fleet)/UID (Fleet, Device List) from/to CVS file makes it easy to manage.

Available ID Map Search
When the System Operator registers a new UID and GID, the Available ID Map Searching Function shows continuous free area mapping of ID. Input the number of IDs in SCU and click the search button to check the minimum ID and maximum ID by SCU. When there are some free spaces, all the available areas will be displayed.

Log

The SCU has a function to get communication logs, System logs, and Diagnostic logs.
The Communication Log is a record of all call events in the system. For example, a Recode Type (e.g. Voice Call/ Short Data Call/ Long Data Call), a Call Type (e.g. Individual/ Broadcast/ Conference), an Emergency, and so on will be recorded in the log file.
The System Log is the Type-C Trunked System operation recording feature used for system failure analysis. The System operation activities such as an error termination (e.g. ESN error), a Hardware error (e.g. PLL error and Heat error), a system update, and so on are recorded in a log file. A Network Log and a Hardware Log will be recorded individually.
They are downloadable in the CSV format to manage the system.
A Diagnostic log will be used for analyzing the trouble in the system. Please acquire the log and send it to JVCKENWOOD for investigation.

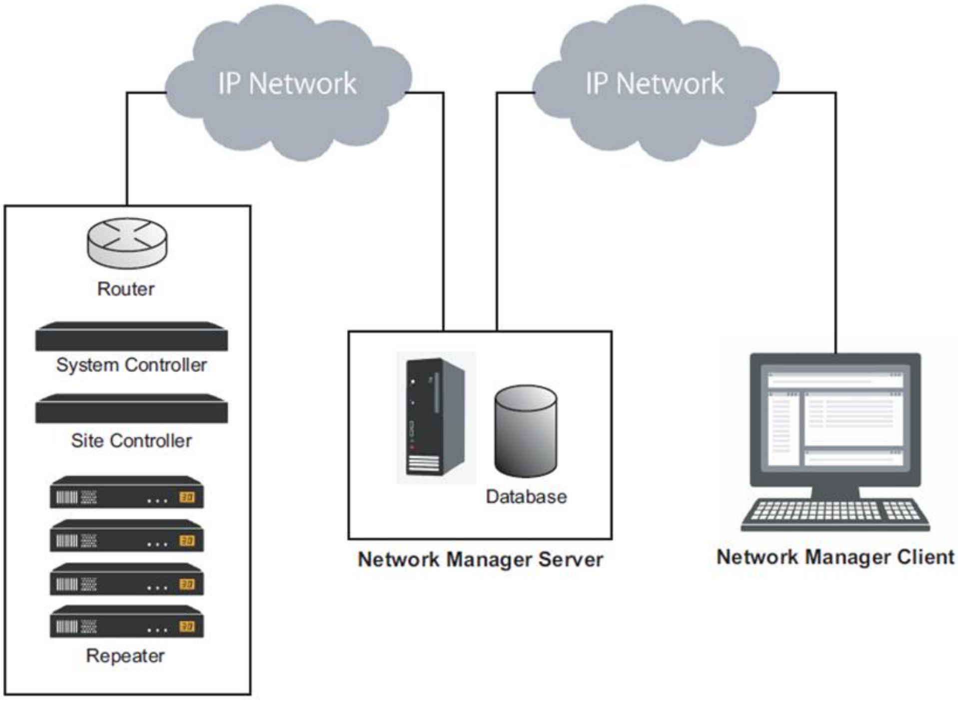
Registration Monitor

The Registration Monitor function may be used to confirm the location of the subscriber unit. The operator may query the system for the subscriber unit based on the Network Category, System Code, and number of sites.

Network Manager (KPG-1003NS/KPG-1004NC)

The Network Manager utility tool offers Windows applications for monitoring and alerting the Gen2 system. The Network Manager Client software and the Network Manager Server software are designed to cooperate when monitoring. The System Operator may observe the monitoring equipment (Repeater, Site Controller, and System Controller in server equipment, etc.) for up to a thousand devices when the installed Network Manager Server Software is operating on a PC-based server. If the number of monitoring targets is a hundred or less, the System Controller gives the same functionality without the Network Manager Server software installation.

The Network Manager provides advanced features that are not available in the SCU. Failure information for analysis is provided in a graphical form. When a failure occurs, error information is transmitted by IP via the SMTP server, and the System Operator may receive error information without logging into the system via an E-mail. The Network Manager offers centralized control and analysis of the system and communication logs from the SCU. It also supports server-based SNMP capability for monitoring the traffic rate of the System Controller, Site Controller, and IP Gateway over the network and provides usage information of the CPU, RAM, and Hard Drive. The Network Manager Application consists of the Network Manager Server installed on a server. The Network Manager Client application may be installed on a client PC. Please refer to the following figure.



Network Manager Server

Operational Management

The Network Manager offers the following real-time monitoring features.

- The Channel usage rate transition of a specific site and the Current Repeater status.
- The usage time statistics per channel (i.e. Channel load feature)
- The Statistical Information of Repeater Status (i.e. Channel Hardware)
- The Transition of the Number of Subscriber Units registered in each site
- The site location map (i.e. Location Map feature)
- The accumulated logs in a times series collectively across the equipment.
- Monitoring results can be confirmed per device. (Device)
  - The system controller/ the Site Controller in server equipment.
  - Repeater equipment (NEXEDGE channel)
  - Network equipment (e.g. router or switch equipment)

Real-time Display (Channel Status & Channel Hardware Status feature, UID/GID Registration)
Network Manager Client monitors and shows channel status (Up to one hundred and fifty channels) or hardware information of the repeaters on a real-time basis. Multiple sites channel state in ten different windows simultaneously. Furthermore, the lists of all Unit IDs and Group IDs registered in a specified site can be displayed.

Failure check
A standard feature of the SCU is the ability to search the system and communication logs as a part of failure analysis. The Network Manager offers a variety of services for easy failure analysis, reducing the Engineer's time and effort.

- Failure condition display
- The Network Latency between the monitored device and the Network Manager Server (i.e. Latency)
- Repeater hardware condition statistics
- Event logs (Type/Priority/Time/Device Type/System/Site/Device/IP Address/Message)
- Communication Log (Record Type/Call Type/EMG/System Code/Calling ID)
- Send a message to the SMTP server when a failure has occurred.

Geo / Local Redundancy

Geo Redundancy

NEXEDGE Gen2 System provides System Controller redundancy.

The system is an installable dual system controller placed at different locations, which has a System Controller (Main) and a System Controller (Sub). They always are synchronized with each other through the IP to share information and conditions such as system configuration and registration information. If the System Controller (Main) has trouble and is disconnected from the IP connection, the System Controller (Sub) takes over to manage the system automatically. After fixing the trouble on the System Controller (Main), the management role should be switched back to SCU manually. The Communication Log will be saved to each of the system controllers, and the Network Manager Server can download the logs from both system controllers and merge them as one communication Log.

If the Network Manager Client detects the System Controller (Main) problem, it shows a caution message window for 60 seconds, then automatically switches and connects to the Sub and shows an error condition on the home screen.

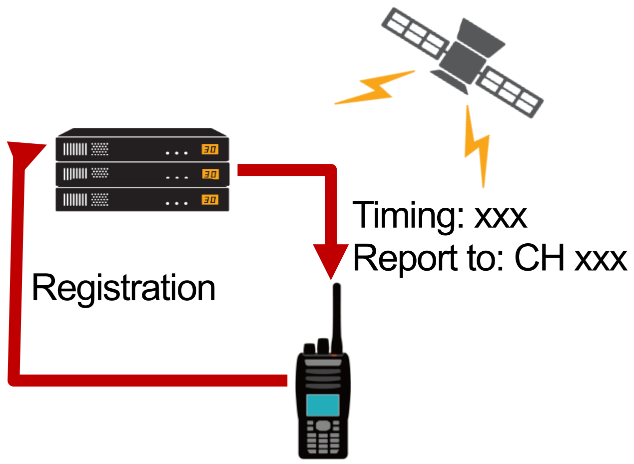
Local Redundancy

The Open-Source Software (OSS) realizes Local Redundancy for the NEXEDGE Gen2 System PC servers which are installed at the same location. Using OSS, they are synchronized and have completely duplicated configurations and records. Once a problem is detected, it automatically switches to the server PC.

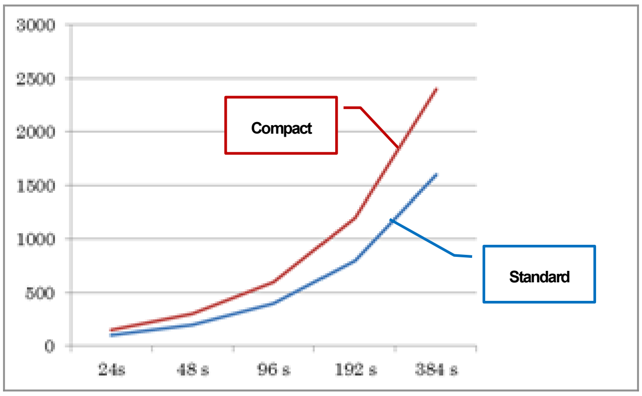
- Automatic switch from Primary Controller to Secondary Controller
- Synchronize configuration and Log records are taken over from Primary to Secondary.
- The calls conducted during switching controllers are not taken over to Secondary.
- Primary and Secondary Controllers have the same IP address. All equipment connecting the controllers has not to reconnect the cables for switching.

GPS/AVL data capacity

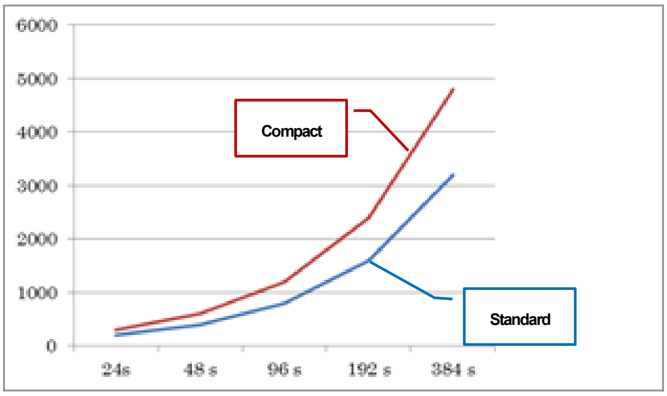
The NXDN Type-C Trunked System requires access to the control channel when the subscriber unit sends GPS data. This means that data contention is occurring on the channel due to the number of subscriber units attempting to send. To prevent this, the subscriber units are required to send GPS data at different times. However, this will be difficult if there are many users.
To resolve this problem, the NEXEDGE Gen2 System sends the GPS data directly to a defined GPS Report Channel (GRCH) without going through the Control Channel. The System assigns the channel and time slot on which the subscriber is to report its GPS data.
This makes it possible for the subscriber units to send GPS data at intervals of several hundred milliseconds, which greatly increases the number of the subscriber units whose position data can be managed.
Using the GPS Reporting Capacity function enables the users to know the number of subscriber units of which position can be managed on a site. The GPS Report Format (Short or Very Short) and the GPS Transmission Capacity mode (Standard Mode or Compact Mode) need to be configured as well. Note that the Compact Mode is only available when the GPS Report Format is Very Short and without DES/AES encryption. The number of subscriber units that can be managed by a single repeater varies due to this setting as shown in the following graph.



The longer the interval time, the more the number of subscriber units of which position data can be managed. Please optimize the parameters based on your system configurations.
The channels used for the GPS data must always be in transmission. Whereas by stopping the transmission at ratios of twenty to eighty percent of the GPS functions can be used on non-exclusive license channels. However, in this case, the number of position-manageable subscriber units will decrease.
The continuous transmission period of GRCH can be configured by the SCU.



Number of Radio vs Interval Time per Repeater
Very Narrow

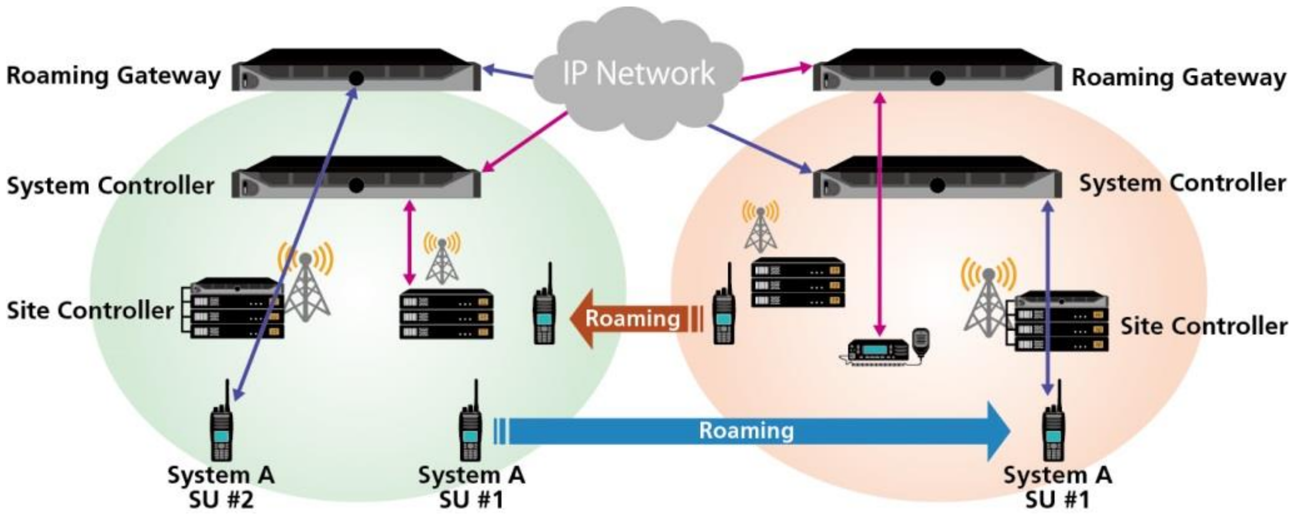


Number of Radio vs Interval Time per Repeater
Narrow

GPS data capacity

Multi-System Roaming Support

KPG-1005RG is the Roaming Gateway Software for the NEXEDGE Multiple Network System.
The Roaming Gateway Software (KPG-1005RG) connects a System Controller in the Home system and a System controller in the Roaming System will allow communication of the Subscriber Units in the Home System even when the Subscriber Unit moves to the Roaming System. Up to twenty-four Multi-System Networks can be constructed. The call initiated at the Roaming system will be transferred from the System Controller in the Roaming System to the Roaming Gateway in the Home System, and then to the target radios. And the radio can receive calls from the Home System.



A Specialized Mobile Radio (SMR) business can be launched by connecting multiple NEXEDGE Gen2 systems with different system codes with the roaming gateways to expand the calling area and charge optional fees for calls that go beyond its system infrastructure.
Communication cannot be established between subscriber units having different system codes.
For example, even when subscriber unit #1 in System A moves to System B, it cannot make a call to subscriber unit #2 in System B. To make a call to a subscriber unit in System B from subscriber unit #1, its configuration must be considered as the multi-system and its zone must be changed manually or automatically to System B.

The Multi-system Roaming feature allows users to provide the following services of different system.

- Group Call
- Individual Call
- Status Call
- Short/Long Data Message
- GPS Data Transmission
  - ✧ GPS data transmission using the Advanced GPS Report Mode feature
  - ✧ GPS data transmission using the Send the GPS Data feature
  - ✧ GPS data transmission by receiving a GPS Data Single Polling Request

Note:

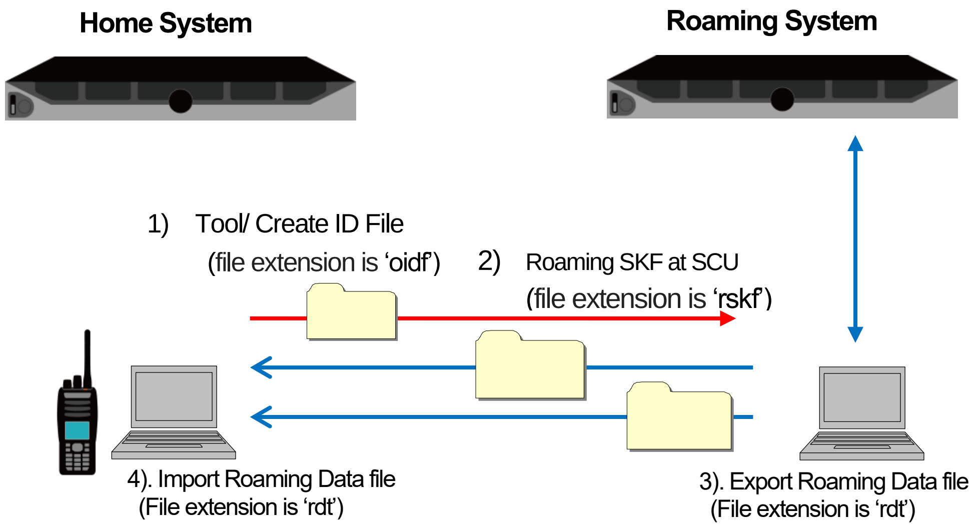
1. Subscriber units in System A can use the roaming service in another system if a roaming gateway set (server equipment + KPG-1005RG license) is installed in System A. However, the roaming gateway set is required to be installed in System B as well to enable subscriber units in System B to use the roaming service in both Systems as shown in the above figure. In this case, two roaming gateway sets are required, one for each system.
2. The Fail-soft Mode feature is not supported in other systems.

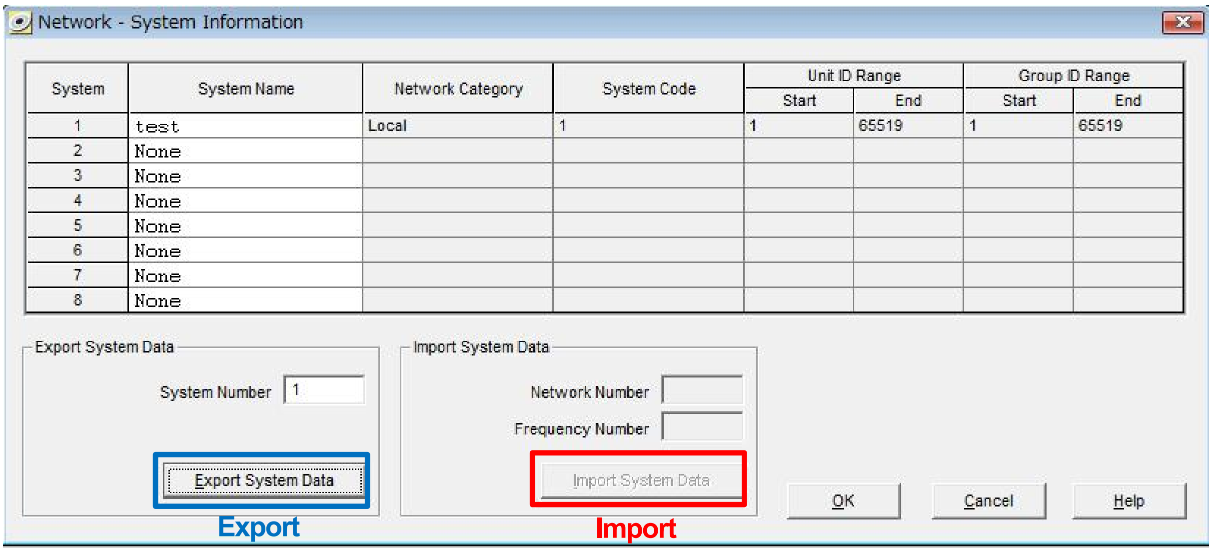
3. The following GPS data transmission is not supported in other systems.
   - ✧ Automatic GPS data transmission (automatic transmission when Auto is set in GPS Report Mode)
   - ✧ GPS data transmission together with voice communications, Status Messages, and Emergency Calls (GPS Combination feature)
   - ✧ GPS data transmission during voice communications (Data with Voice feature)
   - ✧ GPS data transmission linked with travel distance (GPS Distance Change feature)
   - ✧ Preferred GPS data transmission when receiving a group call (GPS Report Priority (Over Group Call) feature)
   - ✧ GPS data transmission by the following requests
     - ✧ GPS Data Multiple Polling Request
     - ✧ GPS Data Period Query Request
     - ✧ GPS Data Auto Report Start Request
     - ✧ GPS Data Auto Report Stop Request

Roaming SKF & Roaming Data File

Roaming SKF and Roaming Data files are encrypted files that contain System Information.

For Multi-System Roaming, it needs to provide all information of the Home System to the Roaming System and subscriber unit for successful registration. In this case, users may not want to show all information such as network configuration to keep the Home System secure.





The Create ID file does not show the License ID of FPU. Using the Create ID file, SCU at Roaming System makes a roaming SKF. This SKF contains all system information and is encrypted like a normal SKF, but the difference is that it does not show any information except for the system name.
The Roaming data file contains all information such Trunking Site frequency table to find the control channel in the Roaming System, and it can also be encrypted. Just import the Roaming data file to the subscriber unit, and no additional configuration is required for the subscriber unit.

SNMP (Simple Network Management Protocol)

The server in the Gen2 system provides SNMP support. Using commonly available SNMP software, the system operator can monitor the system to ensure proper operation and note outages or failures as they occur. The software allows direct access to equipment monitoring without accessing the system controller. SNMP traps may be set to route alarms and alerts to necessary support personnel.

NTP (Network Time Protocol)

The NTP support in the Gen2 system synchronizes date and time automatically. The System Configuration Utility (SCU) enables the NTP server configuration by accessing up to three NTP servers. The System Controller uses the information to adjust the date and time, and also daylight saving time if necessary.

2.4. NXDN Type-D trunked system

2.4.1. General

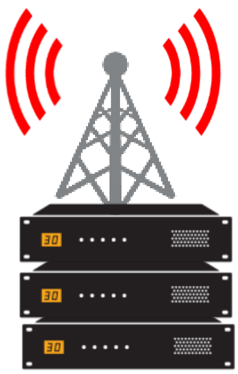
Type- D Trunked System is a simple Single-site Trunked System that consists of a Home Repeater and a Trunkout Repeater. This System does not need a Control Channel and is usable with a FB6 license. The Maximum Channel number is 30 channels.

2.4.2. System composition

Home Repeater

The Home Repeater in the Type-D trunked system transmits information to the Subscriber Units. The Subscriber Units always initiate transmission and reception on the Home Repeater and receive trunk-out messages. If the Home Repeater is not in use, then the Subscriber Units communicate using the Home Repeater and are not trunked out to another repeater.

Home Repeater Beacon



If the Home Repeater is currently in use and another Subscriber attempts to use it, then the radio will be trunked out to an available repeater based on data being sent by the Home Repeater.

Trunkout Repeater

After finishing the call, the Subscriber Units go back to the Home Repeater.

The Home Repeater must be configured per every Subscriber Unit. The Subscriber Units communicate with each other through the Home Repeater. If they have the same Group ID but different Home Repeaters are assigned, they cannot communicate with each other. If communications between fleets are not required, it is recommended to assign a home repeater per fleet for load distribution.

2.5. Network

The system may be built out as a Unicast network environment of up to sixteen sites. If more than sixteen sites are required to make Group Calls to the system, then the IP structure must be multi-cast to support the additional site requirement. The IP network will require the use of third-party products such as a hub/switch or router equipment. If site connectivity is provided using the public Internet, VPN technology is required for security and operation. It is also recommended for private IP networks unless the system is the sole user of the network. It is highly recommended to ask network engineers to configure the network.

2.5.1. Network Infrastructure

Several network configurations may be considered for interconnecting sites. This configuration will be dictated by the system administrator based on their needs and requirements of the system in terms of bandwidth, environment, and existing infrastructure. The following are several possible configurations that could be employed.

Internet (ADSL)
The system can be supported using the Internet, however, it is not recommended due to the lack of guaranteed connectivity. If the connectivity between sites is lost, the administrators and the end-users will fail to get satisfactory results. The service restoration may take a long time and be completely dependent on the Internet Service Provider (ISP) in use.

To use this method, adequate bandwidth for supporting the system and methods for mitigating outages such as alternate routing must be guaranteed. Router equipment with VPN capability should be used to protect the system and its users from malicious activities such as denial of service attacks. This method is not suitable for public safety level users.

Microwave
Point-to-point microwave links may be used to establish a private network for the system. This is commonly used in land mobile systems to establish connectivity between sites. Due to the line-of-site nature of the microwaves, careful siting of the microwave links and choice of frequency bands are extremely important. This closed system of site connectivity will offer the highest level of security and is the least prone to outside influences such as malicious network attacks. It does have its own set of challenges that the system administrator must understand.

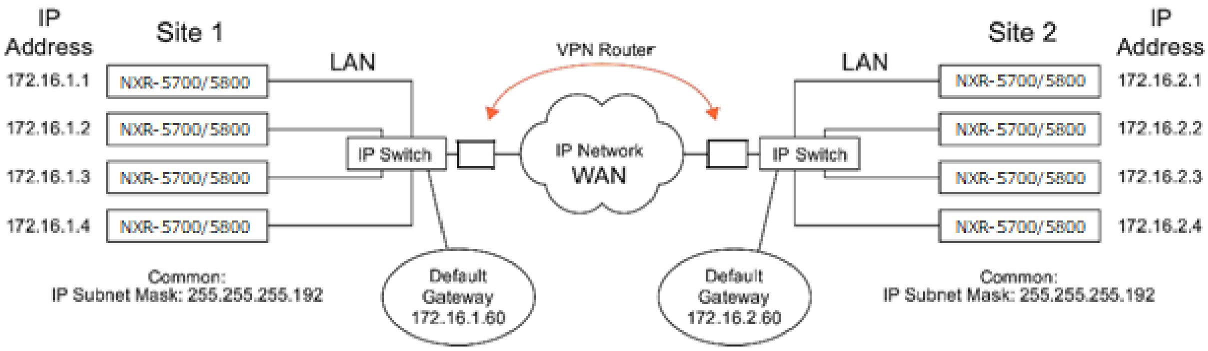
IP-VPN service
A closed IP network with a VPN is independent from the public Internet. Not using the public Internet improves security. A closed company or agency Wide Area Network (WAN) is considered part of this methodology. To use this method, close attention must be paid to the other users on the network to ensure that the system provides adequate bandwidth and quality of service required by the radio system. If not, issues will arise.

2.5.2. IP Network Connection

Hubs, switches, and routers

Hubs, switches, and routers are all devices that allow the connection of one or more computers and other computers, networked devices, or other networks. Two or more connectors called ports into which the cables are plugged are provided for connection. Various levels of switching and routing are executed inside the devices, and therein lies the difference.

Most of the time, a hub is typically the least expensive, least intelligent, and least complicated of the three. Its job is very simple: anything that comes in a port will be sent out to the others. Every computer connected to the hub "sees" everything that every other computer on the hub sees. The hub itself is not aware of the data being transmitted.
A switch does essentially what a hub does but more efficiently. By paying attention to the traffic that comes across it, it can "learn" where addresses are. For example, if it sees traffic from Machine A coming in on Port #2, it now knows that Machine A is connected to that port and that traffic to the machine needs only to be sent to that port and not to any of the others. The net result of using a switch over a hub is that most of the network traffic only goes where it needs to go rather than to every port. On busy networks, this can make the network significantly faster.
A simple way to think of a router is a computer that can be programmed to understand, possibly manipulate, and route the data it is being asked to handle. For example, broadband routers include the ability to "hide" computers behind a type of firewall which involves slight modification of the packets of network traffic as they traverse the device. All routers include some kind of user interface for configuring how the router will treat traffic. The extremely large routers include the equivalent of a full-blown programming language to describe how they should operate as well as the ability to communicate with other routers to describe or determine the best way to get network traffic from point A to point B.
For the NEXEDGE single-site and multi-site connection, we will only look at switches and routers.



IP Links

When connecting the multi-site NEXEDGE system via the IP link, the following circumstances should be considered.
There are many different variations of available wireless or wired IP links. Some of which are more suited to a mission-critical radio system application than others.
Below is a non-exhaustive list of possible IP networks.

- Customers' internal, own IP network
- Commercial ISP (Internet Service Provider)
- IP sections within a bigger IP network – so-called Virtual Networks
- Radio IP links
- Microwave IP links

Public IP Networks

Public IP Networks are available for a reasonable commercial value in most areas. Internet Service Providers (ISPs) offer various services that can range from 128 kbps to 10 Mbps or more.
While these offers present a good commercial value, they do have potential drawbacks.
The system integrator/ installer and end user have no direct influence on the quality of service offered through these ISPs.

If a technical fault occurs with the ISP hardware, software, or other components, the system integrators and end-users are required to wait until the ISP or responsible party rectifies that fault.
Potential loss of income, certainly loss of intersite service, and operational problems could be the result. A service level agreement (SLA) should be a part of the contract with a public ISP, whenever possible.

Private IP Networks
It costs more than a solution based on Public IP Networks, they offer a better and more controllable quality of service to the NEXEDGE multi-site digital trunked radio system.
There are several options. What is best depends entirely on the budget, available resources, and the customer's requirements.

Some of the examples:

Use of customers' existing IP network

- Consider network capacity required and security implications.
- Use IP switch with VPN facility to secure radio networks IP access.
- Consider a Virtual IP Network within the customer IP network.

Build a new IP interlink network.

- Wireless network.
- Consider network capacity requirements.
- Consider security requirements.
- Consider network redundancy requirements.
- Consider obstacles existing and not yet existing!
- Wire or GBN (Ground Based Network) based network.
- Consider network capacity requirements.
- Consider security requirements.
- Consider network redundancy requirements.

2.5.3. IP Bandwidth Requirement

The NEXEDGE IP bandwidth calculation should be done not only for voice communication (VoIP) but also for a console call session initiation process (SIP) which occurs every time a console call is made. In this section, calculation formulas are introduced by network types. Basically, for the multicast network, the required bandwidth is just one voice session for the Core Router.

Network bandwidth calculations must be discussed in the system design phase considering network type, system size, and future system expansion.

In the case of a VPN connection, the amount of data varies by Encryption and Authentication methods. Therefore, the VPN connection is not in the scope of this section.

Conventional

In the case of Conventional System, it does not require SIP to negotiate between sites. Thus, the formulas are as shown below.

Unicast Network Requirements

Bandwidth Calculation (6.25 kHz Very Narrow)

Voice Packet Upstream

BW = 21.75 * y [kbps]

Voice Packet Downstream

BW = 21.75 [kbps]

Bandwidth Calculation (12.5 kHz Narrow)

Voice Packet Upstream

BW = 41.5 * y [kbps]

Voice Packet Downstream

BW = 41.5 [kbps]

Multicast Network Requirement

Star Network Bandwidth Calculation (6.25 kHz Very Narrow)

Voice Packet Upstream

BW = 21.75 [kbps]

Voice Packet Downstream

BW = 21.75 [kbps]

Star Network Bandwidth Calculation (12.5 kHz Narrow)

Voice Packet Upstream

BW = 41.5 [kbps]

Voice Packet Downstream

BW = 41.5 [kbps]

Required network bandwidth can be calculated with formulas above where...
y stands for “Number of Intersite Call available sites” -1

NXDN Type-C Trunked System

In the case of the Trunking System, it requires bandwidth for all Traffic Channels at the Site and SIP for the Control Channel to negotiate between sites. Thus, the formulas are as shown below.

Unicast Network Requirements

Bandwidth Calculation (6.25 kHz Very Narrow)

Voice Packet Upstream

BW = 21.75 *x * y [kbps]

Voice Packet Downstream

BW = 21.75 *x [kbps]

SIP Packet Upstream

BW = (17.32 + 29.86 * y) *x [kbps]

SIP Packet Downstream

BW = (34.24 + 18.86 * y) *x [kbps]

Bandwidth Calculation (12.5 kHz Narrow)

Voice Packet Upstream

BW = 41.5 *x * y [kbps]

Voice Packet Downstream

BW = 41.5 *x [kbps]

SIP Packet Upstream

BW = (17.32 + 29.86 * y) *x [kbps]

SIP Packet Downstream

BW = (34.24 + 18.86 * y) *x [kbps]

Multicast Network Requirement

Star Network Bandwidth Calculation (6.25 kHz Very Narrow)

Voice Packet Upstream

BW = 21.75 *x [kbps]

Voice Packet Downstream

BW = 21.75 *x [kbps]

SIP Packet Upstream

BW = (17.32 + 29.86 * y) *x [kbps]

SIP Packet Downstream

BW = (34.24 + 18.86 * y) *x [kbps]

Star Network Bandwidth Calculation (12.5 kHz Narrow)

Voice Packet Upstream

BW = 41.5 *x [kbps]

Voice Packet Downstream

BW = 41.5 *x [kbps]

SIP Packet Upstream

BW = (17.32 + 29.86 * y) *x [kbps]

SIP Packet Downstream

BW = (34.24 + 18.86 * y) *x [kbps]

Required network bandwidth can be calculated with formulas above where...

x stands for “Number of traffic channels”

y stands for “Number of Intersite Call available sites” -1

NEXEDGE Generation 2 (Gen2 System)

For integrated control of the processing in the system, the System Controller requires the greatest bandwidth. Therefore, when calculating the required bandwidth for the Gen2 system, the System Controller needs to calculate the bandwidth. Since the required bandwidth will be changed according to conditions such as the Site and Call number of conditions, it is difficult to produce accurate values by the calculation. However, with the following calculation formula, an approximate value can be calculated.
Also, when the administrator considers the network bandwidth of the system construction, bandwidth needs to be calculated roughly. And, the administrator must confirm the bandwidth by actually operating the system.

Bandwidth Calculation (12.5 kHz Narrow)
Voice Packet Stream

In the case of Group Call:

Bandwidth (BW) = 26.2kbps * (Site number of delivered from Group Call) * (simultaneously performed by call number)

Note:
At the same time, the number of possible sites to be called is the maximum number of channels in the site.

Ex. 5 Sites System

One Site has ten channels.
By the Inter-site call, caller radio makes a group call to all five sites.
The Group IDs have a three-way distinction; they can be called at the same time.
BW = 26.2kbps * 5 *3 = 393.00 kbps

In the case of Individual Call:

Bandwidth (BW) = 26.2kbps (Call number to be carried out at the same time)

Ex. 5Site System

One Site is ten channels.
System has 100 radios. The radios can make an individual Call up to 3 radios at same time.
BW = 26.2kbps * 3 = 78.6 kbps

Bandwidth Calculation (6.25 kHz Narrow)

In the case of Group Call:

Bandwidth (BW) = 14.3kbps * (Site number of delivered from Group Call) * (simultaneously performed by call number)

Note:
At the same time, the number of possible sites to be called is the maximum number of channels in the site.

Ex. 5Site System

One Site has ten channels.
By the Inter-site call, caller radio makes a group call to all five sites.
The Group IDs has a three-way distinction; they can be called at the same time.
BW = 14.3kbps * 5 *3 = 214.5 kbps

In the case of Individual Call:

Bandwidth (BW) = 14.3kbps * (Call number to be carried out at the same time)

Ex. 5Site System

One Site is ten channels.
System has 100 radios. The radios can make an individual Call up to 3 radios at same time.
BW = 14.3kbps * 3 = 42.9 kbps

2.6. Down Time

2.6.1. Expected Down Time during System Programming

A system will experience limited downtime during site configuration changes, adding to/deleting from the system, or changing/updating user parameters. Downtime is triggered when data is written to targeted repeaters and firmware is updated. Upon execution of these operations, the repeaters will be rebooted sequentially except when the firmware is written from a COM or a USB port.
Upon execution of these operations, a repeater will reboot sequentially except when the firmware was written from a COM or a USB port. The time listed in the next tables is the approximate maximum time experienced.
The target site goes into "PC" Mode and conventional operation will be held. The other sites continue to work normally.

NXR-5700/NXR-5800/NXR-5900

Trigger	PC I/F	Condition	Reboot Time
Firmware Update	LAN	By SCU	2 min 13 seconds
	USB	By KFL	1 min 51 seconds
Programming data Update	LAN	By KPG-D2/KPG-D2N	9 seconds
	USB		7 seconds
Power Cycle	-		25 seconds

NXR-1700/NXR-1800

Trigger	PC I/F	Condition	Reboot Time
Firmware Update	LAN	By Web tool, Multi Loader	1 min 45 seconds
Programming data Update	LAN	By Web tool, KPG-D7	2 seconds
Power Cycle	-		34 seconds

Note:
The same firmware version shall be used by each system repeater. If the repeaters have different firmware versions, the system may fail to provide stable operation.

3. Application

3.1. General

NEXEDGE System supports several applications.
This section will review the applications, which are currently available and usable to enhance the NEXEDGE system and offer additional value.

3.2. Application Software

3.2.1. Firmware Programming tools

There are several firmware programming software tools contained in an FPU folder. Once receiving new firmware, connect a programming cable and upgrade your radio.

3.2.2. KFL

KFL (Kenwood Firmware Loader) is an USB/ RS-232C serial programming tool to update the NX-5000/3000 series and the NXR-5000 series contained in a KPG-D1/KPG-D3 and KPG-D2. Open KFL.exe and select a new firmware (.kfl file). The firmware is transferred through a selected COM port.

3.2.3. **KPG-110SM (System Manager)**

System Manager is system programming software that provides various System Monitoring functions for system operators to check system conditions.

System Overview

System Overview is a function to see the real-time channel status of repeaters available in each site. Repeater IP address and its operating status are shown in the list. By pressing “Hardware” or “Network”, further information will be indicated as follows:

System Overview - Network
Network-related information can be displayed in this window. LAN connecting status is indicated on the right top by 3 color indicators.

System Overview - Hardware
Hardware-related information can be displayed in this window. Parameters are shown in 8-bit (256 levels) values except for temperatures. These figures are raw data for internal circuitries and nominal values depend on repeater individual variability or configurations. Therefore, Kenwood does not guarantee a nominal range, hence use this function to detect failure in comparison to normal conditions under customer responsibility.

Channel State

Live call status can be monitored in the Channel State window. Caller ID, Called ID, Call Type (Broadcast/ Conference/Individual/Interconnect), and Call Status (Control/Traffic/Composite/Idle/Failure) are displayed with call duration by channel in a site.

Channel Load

The Channel Load graph shows the usage rate of a channel for the last 10 minutes. The usage rate is calculated based on data for twenty-four hours and updated every ten minutes. Since the system always retains data for twenty-four hours, the dispatcher can monitor the usage status for twenty-four hours before the time when the dispatcher starts monitoring. This data is not stored in the repeater memory.

Communication Log

The Communication Log is a communication record of all the call events that occurred in a site. The following information is recorded in the log file.

- Record Type: Voice Call/ Short Data Call/ Long Data Call
- Call Type: Individual/ Broadcast/ Conference
- Emergency: Emergency/ Normal
- Caller ID, Receiver ID
- Call Duration, Date
- Cause of the termination
- Call Direction: Intra (Closed in a site)/ src (Outgoing)/ dst (Incoming call with site #)
- Channel Number

System Log - System, Hardware

The System Log is a Trunked System operation recording feature for system failure analysis. System operation activities such as error termination, system update, and so on are recorded in the log file. The Network Log and the Hardware Log are recoded individually. Please forward them to Kenwood technical personnel and failure analysis support will be available.

Diagnostic Log

The Diagnostic Log can record further detailed system activity, then the System Log explained in the earlier section. In unforeseen system trouble that the System Log cannot detect the cause, please send the Diagnostic Log to Kenwood technical personnel, and troubleshooting support will be available. Note that the Diagnostic Log is designed only for the Kenwood design center and not for failure analysis of the field engineers, therefore it is unreadable by the application software.

Statistics - Airtime Accumulation

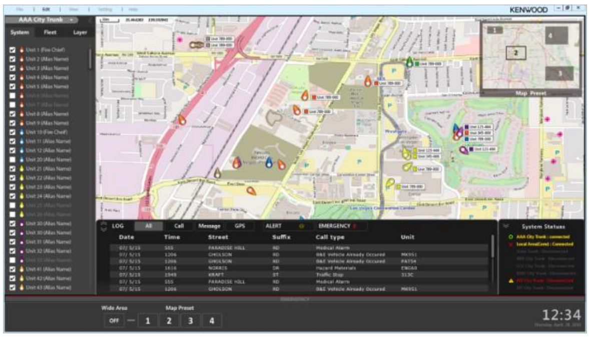
By Airtime Accumulation, the Communication Log file extracted in the previous section is statistically analyzed and displayed. Time-oriented Communication can be converted into ID-based call time accumulation data by this feature.
Converted Airtime Accumulation data can be saved as a CSV file.

3.2.4. **Dispatching solution - KAS-20 AVL & Dispatch Software**

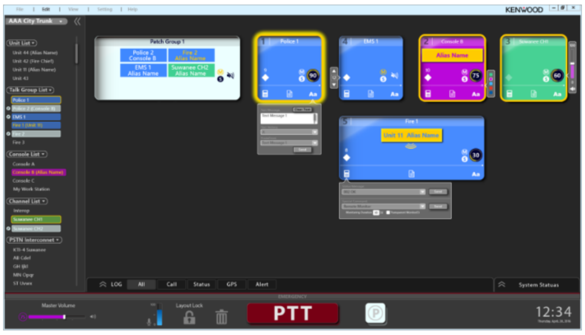
The KAS-20 AVL/ Dispatch system tracks and manages mobile stations by connecting the KAS-20S/ KAS-20C application software with a digital wireless communication system via an IP network. It can be used in Analog/Digital Conventional and Trunked Systems including the NEXEDGE Generation 2 (Gen2) Trunking System. KAS-20 AVL & Dispatch software consists of two software, KAS-20S and KAS-20C.

Main features and functions

- Available OpenStreetMap (Require Internet Connection)
- Using AMBE+2 software library (DVSI's "USB-3000" Hardware Dongle is NOT required)
- Selectable either Standalone or Server-Client Configuration (Server: KAS-20S, Client: KAS-20C)
- Support to DMR Conventional system and Multiple RF System
- Dispatch simultaneously when receiving voice calls (Up to eight calls)
- Support "Group Patch" feature
- Available AVL "Layer" Map feature and AVL "Emergency direction" indicator



Main AVL Screen



Main Dispatch Screen

Software

Overview of KAS-20S

KAS-20S is a server software program that performs tasks such as acquiring positional information of the radio via the IP network and managing voice call logs initiated by the KAS-20C and other information with a database. The KAS-20S can be installed on the same PC that is installed with the KAS-20C or on a different PC.

By gaining access to the KAS-20S, the KAS-20C can save or browse voice call logs and acquire the positional information of the radio. At the same time, by accessing the KAS-20S and sharing the database of multiple KAS-20C units, information such as the positional data and voice call logs can be shared. Settings for the system to be connected and those for users to access from the KAS-20C are configured on the KAS-20C, and settings data are saved in the database of the KAS-20S.

Overview of KAS-20C

The KAS-20C is client software equipped with multiple consoles including functions for initiating voice calls via the IP network and for managing the positional information of the radios. By establishing a connection with a wireless system through the IP network, functions related to voice calls, text messages, and remote control can be performed. By gaining access to the KAS-20S, communication logs can be saved or browsed and the positional information of the radio can be acquired from the KAS-20S.

Licenses and Options

Application	License Key	Description
KAS-20C (Client)	LOCATION MANAGEMENT LICENSE (KWD-20C-LM)	License for enabling the use of the AVL function.
	VOICE DISPATCH LICENSE (KWD-20C-VD)	License for enabling the use of the Dispatch function.
	VOICE PATH LICENSE (KWD-20C-VP)	License for enabling sending and receiving of audio data. To play back multiple audio data simultaneously, it is necessary to authenticate a number of VOICE PATH LICENSES according to the number of audio data. Up to 8 additional RF System licenses can be added.
KAS-20S (Server)	VOICE RECORD LICENSE (KWD-20S-VR)	License for enabling recording and playback of audio data.
	MULTI-CLIENT LICENSE (KWD-20S-MC)	This license enables access from an external PC and multiple users.
	RF SYSTEM LICENSE (KWD-20S-RS)	License for enabling connection to multiple communication systems at the same time. To add a second or subsequent communication system, it is necessary to authenticate a number of RF SYSTEM LICENSES according to the number of communication systems. Up to 7 additional RF System licenses can be added.

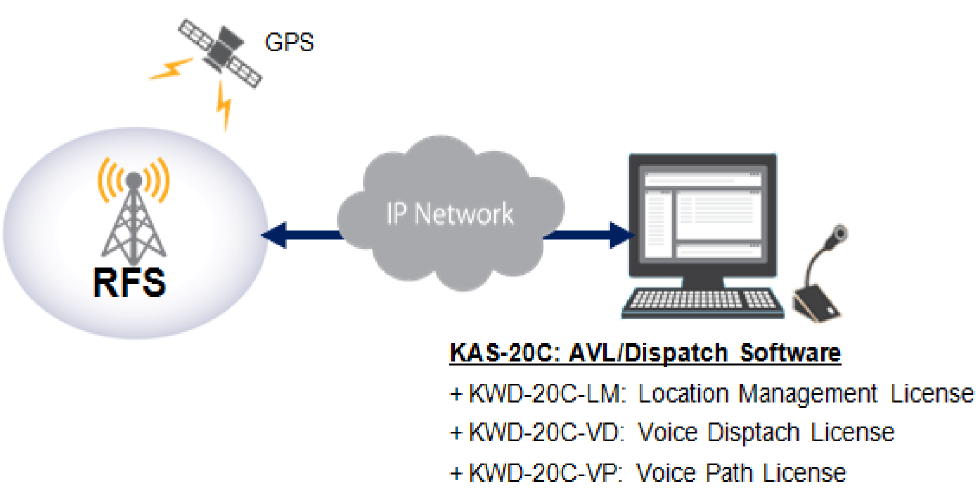
Type	Item	Standalone configuration	Server-Client Configuration (Client side)	Server-Client Configuration (Server side)
Software	KAS-20C	Mandatory	Mandatory	
	KAS-20S	Mandatory		Mandatory
License	KWD-20C-LM	Optional	Optional	
	KWD-20C-VD	Optional	Optional	
	KWD-20C-VP	Optional	Optional	
	KWD-20S-VR	Optional		Optional
	KWD-20S-MC			Mandatory
	KWD-20S-RS	Optional		Optional

System Configurations

The KAS-20 AVL/ Dispatch system is made up of the KAS-20C, a client application software, and KAS-20S, a server application software.

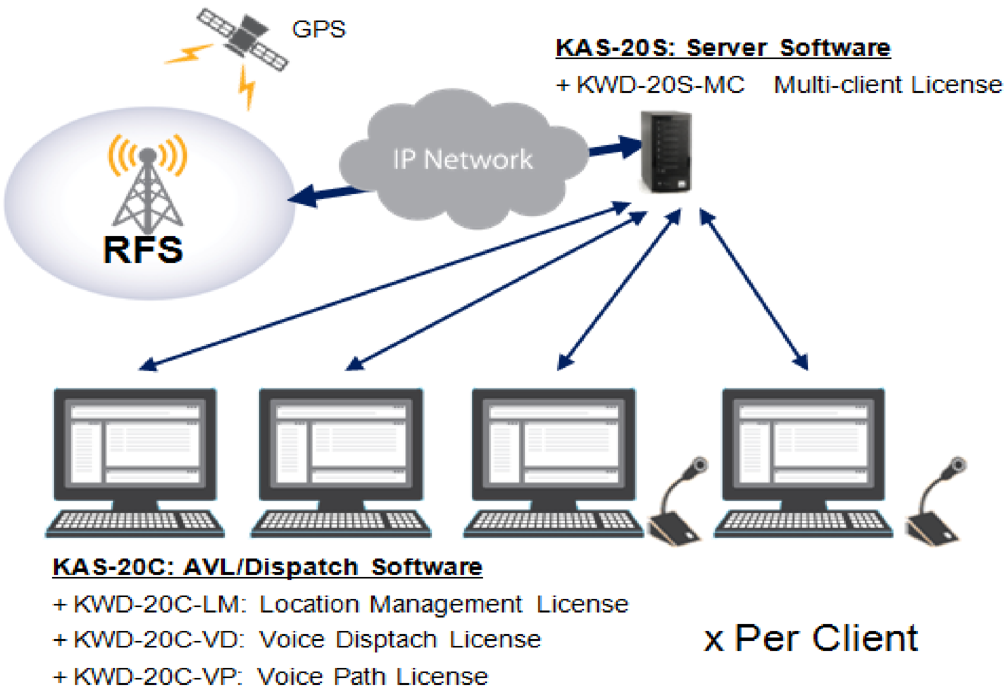
- **Standalone Configuration**

By installing the KAS-20C and KAS-20S on the same PC, the KAS-20 can be used as a standalone configuration.



- **Server-Client Configuration**

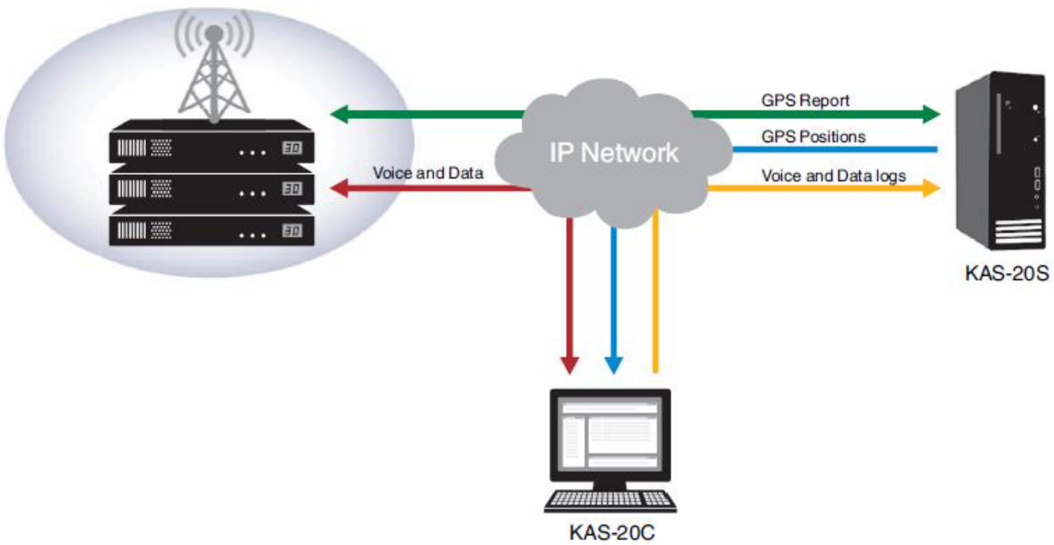
By installing the KAS-20S and KAS-20C on two separate PCs, KAS-20 can execute central management of data. KAS-20C supports the concurrent use of up to ten clients per Server.



Data Flow

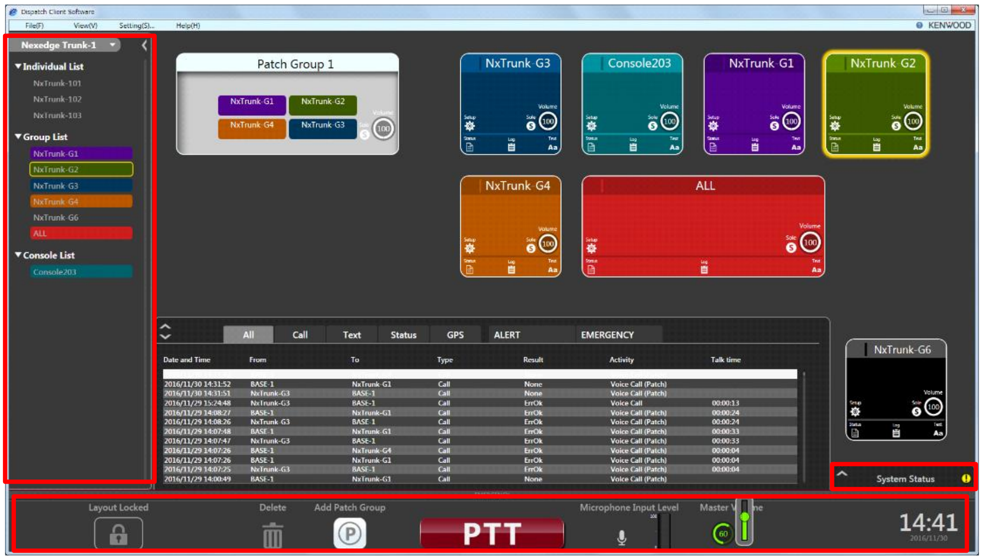
Mobile location data coming from the system will be forwarded to the base ID of KAS-20S and make a location data database. Each client takes GPS data from the database. It can manage a large number of location data simultaneously.

Voice data will be forwarded to the base ID assigned to each client. All received and transmitted voice data will be forwarded and stored in the shared KAS-20S server database or individual server for security.

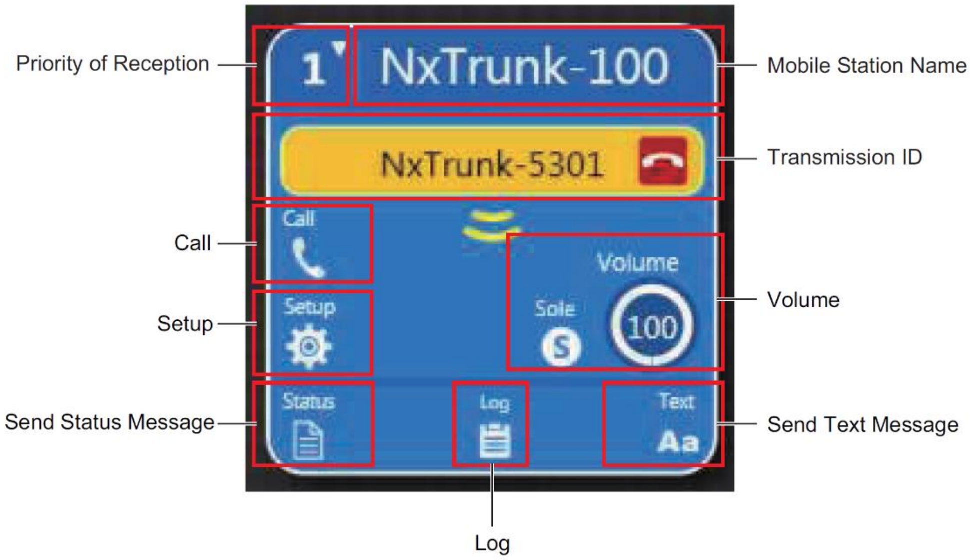


Dispatch Window

Selectable from various call methods including ALL calls, group calls, and individual calls. You can place the UI for operation as "BOX" on the screen for each ID. Patch function can be used by registering ID in Patch Group.



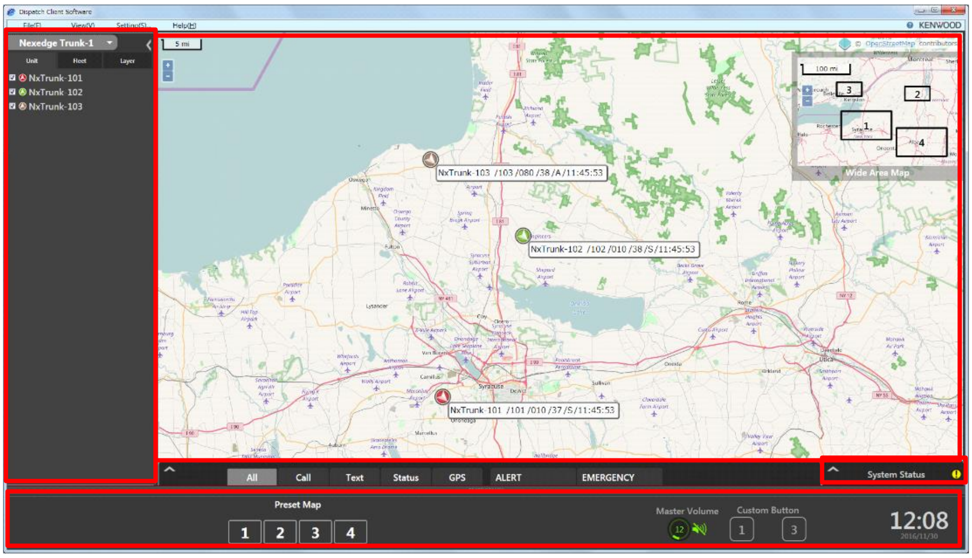
Call Box

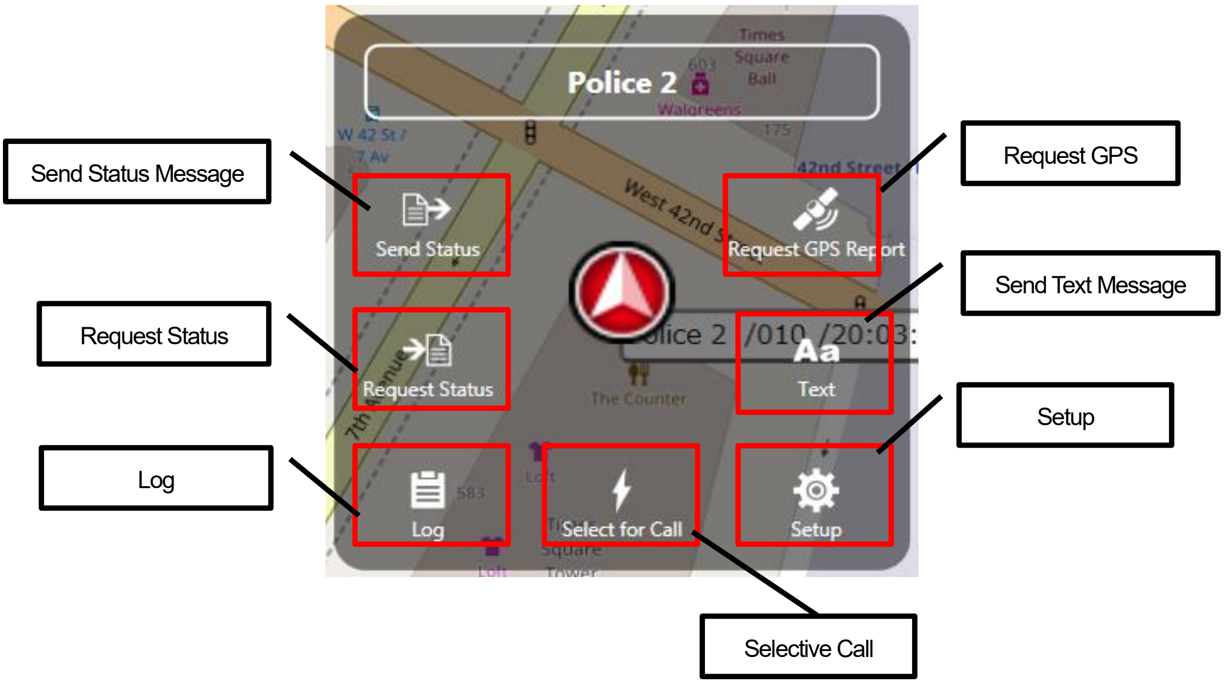


AVL Window

The AVL screen displays the location information of the radio on the map, OpenStreetMap, and Scanned Map. When you select the radio to be displayed on the map from the list pane, an icon is displayed on the map.

AVL functions include Auto & manual polling, Loneworker, GPS time mark, GeoFencing, Track units, Go to home positions, etc.



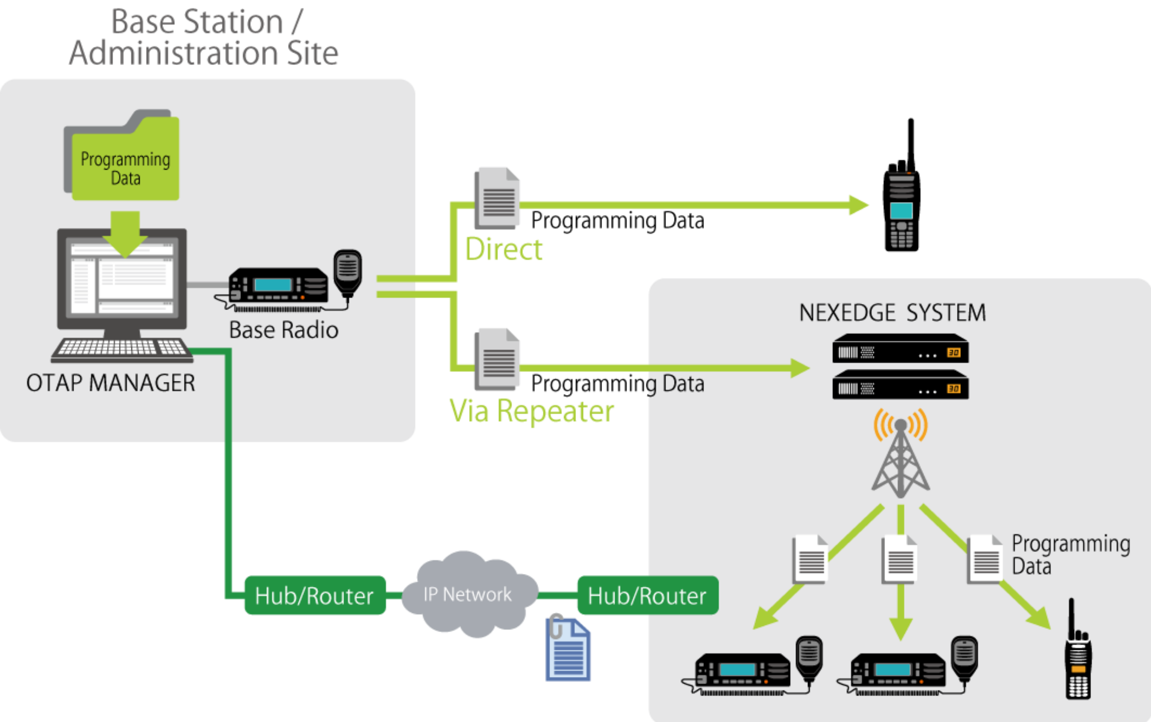


3.2.5. **Over the Air Programming - KPG-180AP**

Normally, settings made using the programming software must be reflected on the subscriber unit through a direct connection with a programming cable. If the settings of the subscriber unit must be changed, it should be returned to a physical location for re-programming.
The Over-the-Air-programing (OTAP) Manager overwrites the settings of an individual subscriber unit without a programming cable. Select a programming data file by the OTAP software so that it can be sent to the target subscriber unit over the air. The OTAP Manager can also provide a structure of centrally managed systems to system operators.
The Over-the-Air-programing (OTAP) Manager supports Conventional Systems and Type-C Trunked Systems including Gen2.

- Main features and functions
  - Programming data management
  - KPG-180AP: Supporting a programming data file for NX-5x00/ NX-3x00 subscriber units.
  - Simple programming interface
  - Efficient data control
  - Efficient data transfer
  - Single data file for large fleets
  - Over-the-air management
  - Un-manned Sessions
  - Fail safe OTAP process
  - OTAP session logging

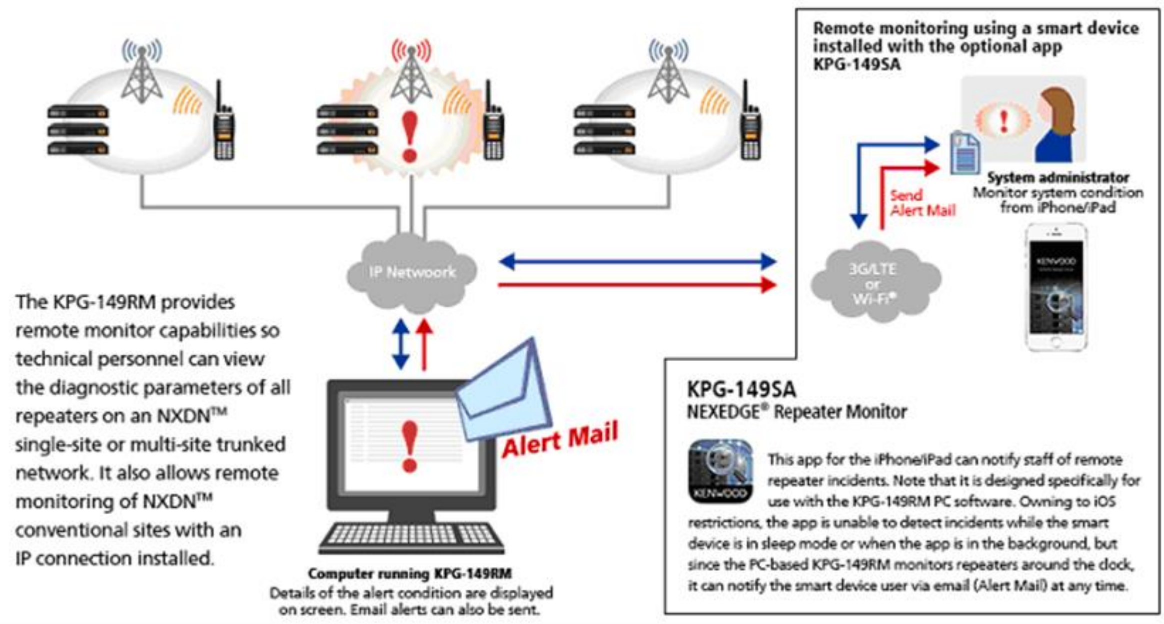
The OTAP Manager can be connected to a subscriber unit via a serial port or to a repeater via an IP network.



Note:
An additional license is required if an IP connection with KPG-180AP is used.
The OTAP Manager sends programming data to an individual subscriber unit sequentially. The time required to overwrite the programming data depends on the amount of modification applied to the programming data. Hence, it is preferable to install the OTAP applications if you have large numbers of the subscriber units to be re-programmed using the OTAP Manager.
To use the OTAP, it is required to extend the Time-out Timer of the repeater on the Conventional System or the occupation timer on the Trunking system.

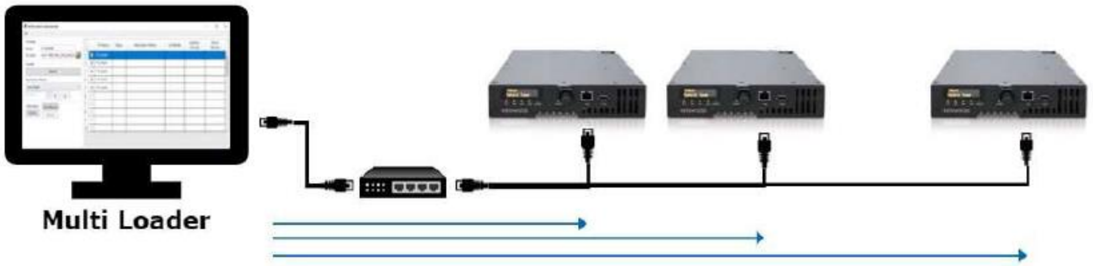
3.2.6. Maintenance tools - KPG-149RM/KPG-149SA

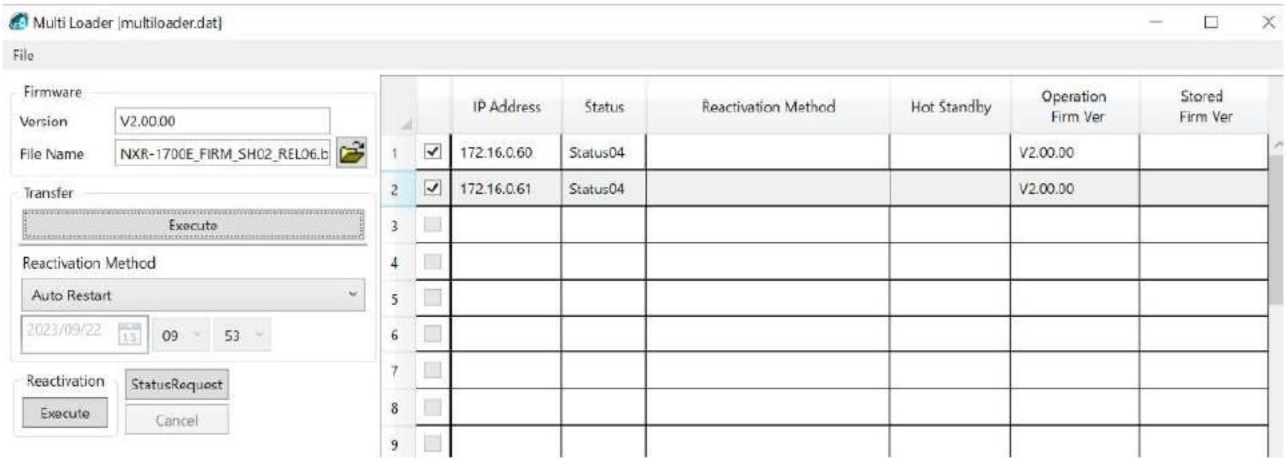
One of the most important concerns is that the system runs at a hundred percent operation at all times. The KPG-149RM/ KPG-149SA software can provide remote monitoring capability of the NEXEDGE repeaters via an IP Network.
Using this software allows the system operator to check the repeater condition without accessing the actual site.
If an error occurs in the system connected to the IP network, the system operator is alerted by a tone and a message display. Additionally, the KPG-149RM can send an error message to an SMTP email server when an error is detected. The system operator or engineer receives the message via the SMTP email server. The KPG-149RM/ KPG-149SA records a log into all repeaters periodically.
Any failures can be detected at an early stage to prevent any problems from affecting the system performance and operation. KPG-149RM/ KPG-149SA can be used in the IP Conventional system and Type-C Trunked System including Gen2.



3.2.7. **Multi Loader**

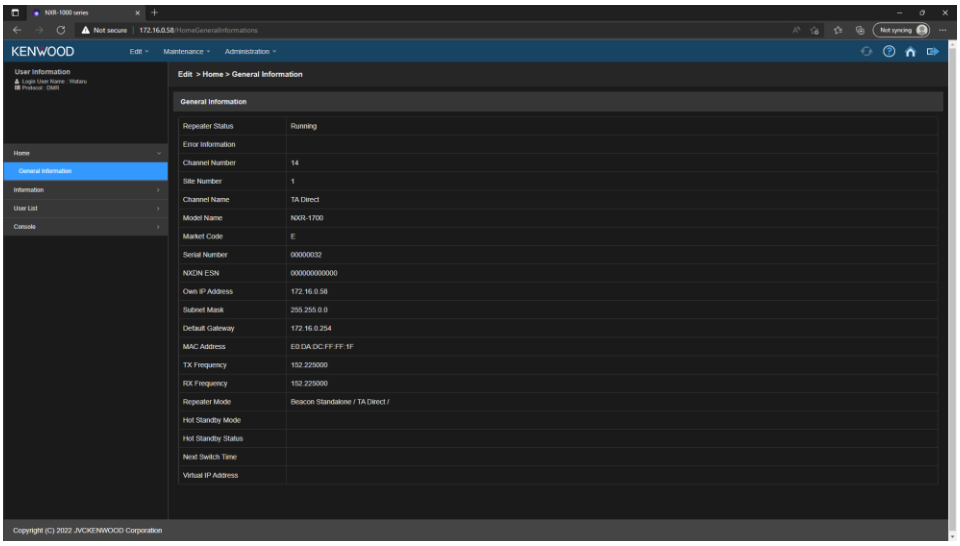
The NXR-1700/1800 Multi Loader is an application that runs on Windows and supports Windows 10/11.
It is distributed with the Programming Software (KPG-D7) installer and is usable without any License.
This application is to write firmware to the Repeater via the IP Network and is writable into a batch of several units of Repeaters.





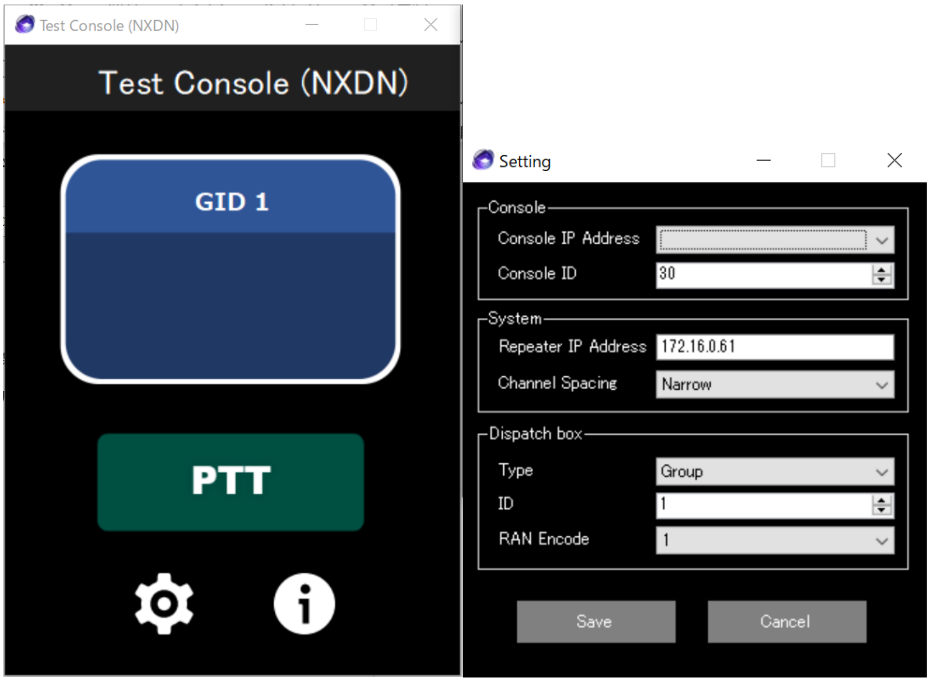
3.2.8. **Web Tool**

The Web Tool is used for setting changes without restarting the repeater.
This tool also enables handling of Firmware Update, Hot Standby, Monitor, Remoter Control, and Log.



3.2.9. **Test Console**

To perform a simple Communication Test for NXR-1700/1800, a Test Console needs to be prepared as an application to check Repeater transmission and reception sound using the PC.
The Test Console application can be downloaded from the Web Tool. We have dedicated Applications for NXDN and DMR.



3.3. Development tools

For the system integrator or local solution developer, JVCKENWOOD provides a software development kit. By using the tools, many applications such as special console applications, messaging, and AVL can be developed quickly and without spending much time investigating specific protocols.

3.3.1. PC Command

The subscriber unit of the NEXEDGE brand has a digital data RS-232 interface. The interface protocol document describes the available commands and how to use them. To name a few available functions; calls can be set up and cleared, messages can be sent and received, and radio channels can be altered via the PC Protocol.

3.3.2. NXIP Console Interface

NXIP Console Interface document describes the IP frame structure to connect the NEXEDGE Conventional and Trunking system. This document is made for third Vendor developers to develop their software applications such as the Console and the SIP Phone application. The document should be protected under NDA. Please contact JVCKENWOOD in your region for details.
NXIP Console Interface: V2.60

3.3.3. Voice Logging Interface support

NEXEDGE System has a Voice Logging Interface (VLI). Using a third vendor product developed with VLI, all communication such as Group Calls, Individual Calls, and Console Calls are recorded through an IP.
A Voice Logger is connected to the IP Gateway (KPG-1002GW) and registered to the system. If it succeeds, the IP Gateway forwards all voice data to the IP address assigned to the Voice Logger.
It is also possible to install multiple Voice Loggers into each Fleet for Gen2. Suppose the system is used by multiple user groups of a Police station or Fire station, for example. In that case, their communication will be recorded to an individual voice logger which belongs to the Fleet for the target ID to be secured. For All Calls, the voice will be recorded to the voice logger which belongs to the Fleet for calling UID.
Select IP Gateway for Fleet to register IP Voice Logger. One IP Gateway can manage up to a thousand voice calls simultaneously. Please note that several calls including Console calls, Telephone calls, and Voice Loggers for one IP Gateway cannot exceed 1000.
Voice Logging Interface: V1.40

3.3.4. KPT-110SDK Software Development Kit

The KPT-110SDK Software Development Kit for NEXEDGE facilitates the development of applications for the Microsoft® Windows® framework for dispatch, AVL, etc. that communicate with NEXEDGE systems using an IP network.
The KPT-110SDK enables software developers, who have a basic understanding of the IP interface, to write NXIP-conform software applications. Using the KPT-110SDK effectively reduces the amount of code and time required to write the NXIP protocol, thus making the development easier, less time-consuming, and shorter time-to-market. The KPT-110SDK contains a Class Library, Sample Source Code, and a program written in C# for simple NEXEDGE voice and data communications.

3.3.5. NEXEDGE 3rd Vender Application

NEXEDGE applications which have been developed by third parties can be found here:

https://devprogram.kenwood.com/site/global/home/index.gsp

3.3.6. **SNMP**

The server equipment in the Gen2 system and NXR-1700/ 1800 supports the SNMP Interface. Using commonly marketed SNMP software enables monitoring of the working situation of the equipment. The SNMP software will allow direct access to the equipment for monitoring without accessing the System Controller.

SNMP Trap is one of the functions that monitors and manages network devices. It is typical in SNMP that a management station polls the network and agents to collect necessary information in response to the poll. However, SNMP Trap enables the agent to notify the management station actively by way of an SNMP message. Up to four destinations can be registered, and IP addresses can be configured for each destination. Repeater as the agent sends SNMP Traps to management stations having the respective registered IP addresses. Each Trap data is sent at an approximate interval of one second. However, the SNMP Traps will be sent only when a condition that generates an alert similar to the one generated when using KPG-149RM is satisfied.
Customers using the SNMP to manage the network servers and switching hubs have previously requested to manage repeater agents similarly. This function is thus added to satisfy the requirement. Repeater information could still be collected but as JVC KENWOOD proprietary protocol was used, devices could only be monitored using KENWOOD software such as KPG-149RM.
Note: KPG-149RM is not available for NXR-1700/1800. By providing Kenwood's own MIB, it can be monitored with commercial SNMP software.

3.3.7. **NNPP**

The NNPP (NEXEDGE Network Private Protocol) is a protocol that monitors the real-time equipment conditions of the Conventional System and the Type-C Trunking System. When an NNPP request is sent through an IP, the target repeater responds with proper information. KPG-149RM and KPG-149SA have been developed with NNPP.

3.3.8. **IPRCI**

NXR-1700/1800 IPRCI is required compatible IP console when using this function in the actual environment. In the previous models, PC serial interface commands were exchanged over the Serial Connection, however, this feature allows the PC serial interface commands to be used over the IP network. By executing Control Commands over the network, information can be obtained, and the NXR series devices can remotely be controlled.