NXDN®

NXDN Technical Specifications

Part 1:
Air Interface

Sub-part C:
Trunking Procedures (Type-C)

NXDN TS 1-C Version 1.3

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NXDN Forum

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1. Introduction

This document describes the procedures for a Subscriber Unit and a Trunking Controller that controls Subscriber Units in a Trunking Repeater Site, which implement the trunking function of NXDN Type-C trunked system using centralized control method.

2. References

Reference documents are listed below. This document and the references are mutually supplemented.

REF [1]	Part 1-A Common Air Interface	Version 1.3
REF [2]	Part 1-B Basic Operation	Version 1.3
REF [3]	Part 1-D Security	Version 1.3

3. Abbreviations

To help understand this document, abbreviations are listed below.

BCCH	Broadcast Control Channel
CAC	Common Access Channel
CCCH	Common Control Channel
CR	Conventional Repeater
CRS	Conventional Repeater Site
DMO	Direct Mode Operation
FACCH1	Fast Associated Control Channel 1
FACCH2	Fast Associated Control Channel 2
FS	Fixed Station
FDMA	Frequency Division Multiple Access
L1	Layer 1
L2	Layer 2
L3	Layer 3
LICH	Link Information Channel
MS	Mobile Station
PBX	Private Branch Exchange
PSTN	Public Switched Telephone Network
RAN	Radio Access Number
RCCH	RF Control Channel
RDCH	RF Direct Channel
RTCH	RF Traffic Channel
SCPC	Single Channel Per Carrier
SACCH	Slow Associated Control Channel
SU	Subscriber Unit
TC	Trunking Controller
TR	Trunking Repeater
TRS	Trunking Repeater Site
UDCH	User Data Channel
UPCH	User Packet Channel
USC	User Specific Channel
VCH	Voice Channel

4. Trunked Radio Systems

This section describes the basic concept of a trunked radio system.

4.1. Outline

A trunked radio system consists of a single or multiple TRSs that are connected together by a network. A trunked radio system consisting of one TRS is called a Single Site, and a system consisting of multiple sites is called a Multi Site.
A trunked radio system generally contains a database to store SU information, such as Unit ID or ESN, and another database to memorize the location registration information of SUs. The databases are stored in central control facility or dedicated database device. Configuration of databases and control equipments is dependent on the system, and are designed appropriately according to the system size or system requirements.

Each trunked radio system contains Location ID information that is allocated uniquely. A Location ID contains 3 information elements: Category, System Code, and Site Code. Category is the element related to the system size that can be identified in 3-stages size. System Code is unique identification information assigned to each Category, and its assignable range differs by Category. Site Code is the identification information which a system operator assigns individually to each site in the system.

To let a SU programmed with trunking mode work properly in a trunked radio system, 3 types of information shall be stored in a SU: a unique Unit ID assigned by a system operator, Location ID as Home System (except Site Code), and a unique ESN written by the manufacturer of the SU at the factory. A trunked radio system allows communication from only SU with identical Location ID, and a SU shall perform the connection process to only TRS with the identical Location ID.

Most trunked radio systems are intended to be operated independently from other systems. Depending on a system requirement, communications among different systems connected together might be needed. To support such multi-system operation, a different process from a single system operation is required in both a TRS and a SU.
Trunked radio systems require a database for visitors used to accept a SU with different Location ID and a means to exchange database information among systems. However, the implementation method depends on the system.
SUs require at least accessible non-home Location ID information in addition to the Home System Location ID.

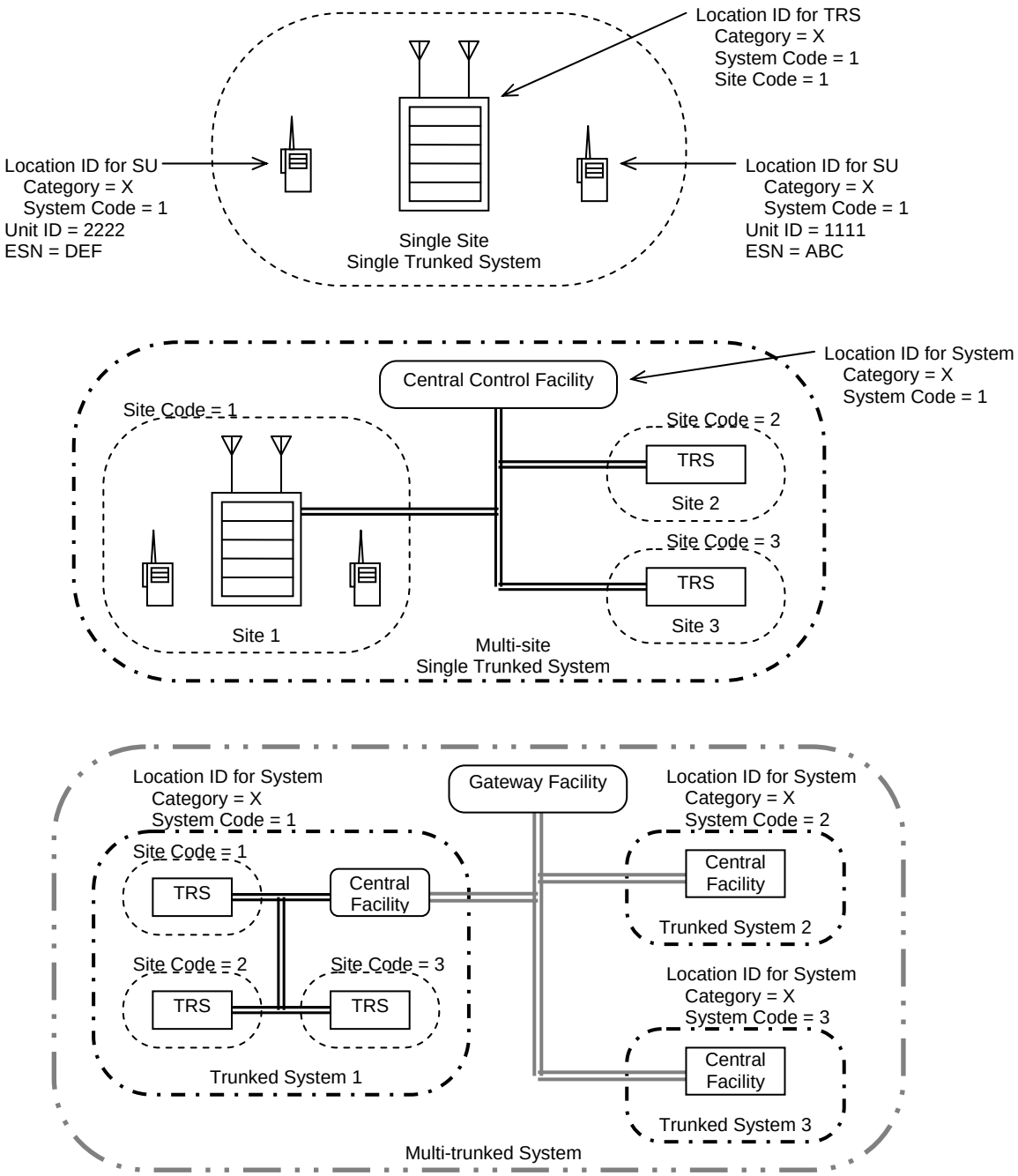


Figure 4.1-1 Trunked Radio System Configuration Outline

Figure 4.1-1 shows examples of 3 different types of system and their configuration outlines. The central control facility and the gateway facility shown in the figures are just used to describe the configuration concept. Those configuration elements may differ or not exist as a dedicated facility, depending on the system.

4.2. System Identification

Classed of identification about a trunked radio system are as follows.

- System identification by using Category field and System Code field in Location ID
- Site identification by using Site Code field in Location ID
- Co-channel interference detection by using RAN

By comparing Category / System Code configured in SU with Category / System Code sent from TRS, a SU can determine whether it resides within the area of Home system.
Additionally, by comparing Site Code stored in SU with Site Code sent from TRS, a SU can determine whether it moves to other site within the same system.
In a system consisting of multiple sites, if the same frequency is repeatedly used in different sites, a SU might receive signals from several sites which use the same frequency. This is a co-channel interference and color code is generally used as site identification in order to detect a co-channel interference. In NXDN system, Radio Access Number serves as color code and is used to detect a co-channel interference. The value of RAN is calculated from a Site Code and the same RAN is used by all of RF channels within a site. If a SU is affected from a co-channel signal, the SU can determine using RAN whether the receiving signal is an interference signal. Since a SU uses and transmits the same RAN as that of TRS, a site which is affected from a co-channel signal can also determine a situation of interference.

5. Control and Traffic Channels

This section provides the basic concepts of RCCH and RTCH.

5.1. Control Channel

RCCH broadcasts system information and informs of control information. Each site contains at least one RCCH, which can be used as a dedicated control channel or a composite control channel with both functions of control and communication.

To allow a SU searching for RCCH to identify the RCCH, a TC shall present a specified channel as RCCH that operates in full duplex. A SU can distinguish RCCH from RTCH by checking outbound messages sent from a TC and acquire RCCH.

5.1.1. Dedicated Control Channel

A dedicated control channel is defined by an outbound signal with the following feature:

a) Outbound signal where content of LICH represents RCCH

Furthermore, the Outbound Message used in a trunked radio system includes as such broadcasting messages not used in an Inbound Message. Due to this message, it is possible to distinguish RCCH from RTCH or an RF Direct Channel in a conventional system.

5.1.2. Composite Control Channel

A composite control channel can send speech information and user data information in addition to trunking control information. The composite control channel is defined by an outbound signal with the following feature:

a) Outbound Signal where content of LICH represents RTCH_C

If a SU detects a composite control channel while searching for RCCH, the composite control channel is handled as RCCH.

5.1.3. Multiple Control Channel

When a TRS has more than one RCCH, one shall be the first control channel and the other shall be the second control channel. Both the first and second control channels are used to inform of trunking control information. If the first control channel becomes out of order, the second control channel may be used as a backup control channel.

The first control channel and second control channel of a TRS is broadcasted by SITE_INFO or CCH_INFO, and the first control channel of the adjacent site is broadcasted by ADJ_SITE_INFO.

If a TRS includes multiple control channels, a SU belongs to either control channel as follows.

A SU which has an odd Unit ID belongs to the first control channel.
A SU which has an even Unit ID belongs to the second control channel

A SU performs a registration on the belonging control channel and migrates to an idle state. In case of a registration in multi system, a TRS shall allocate either an odd or an even Visitor ID to a Visitor SU in accordance with the control channel where the Visitor SU belongs to.

5.1.4. Control Channel Structure

RCCH comprises functional channels of BCCH, CCCH and UPCH and uses a superframe structure.

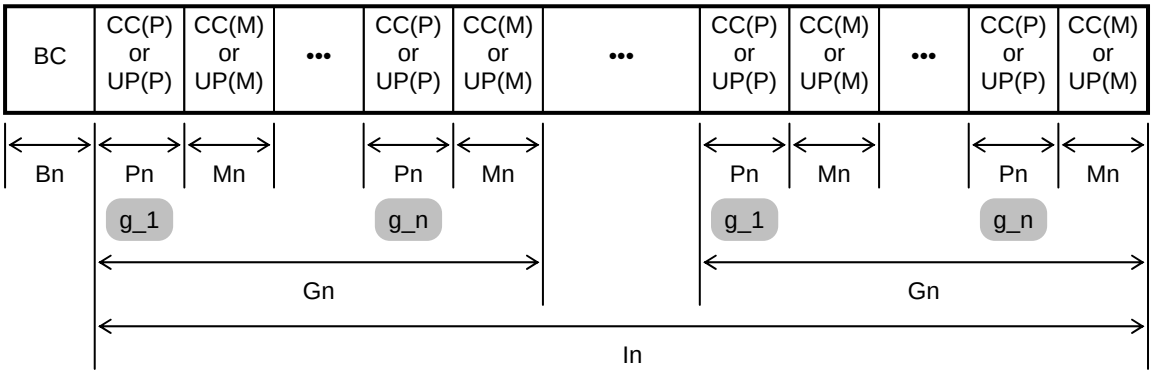
5.1.4.1. Arrangement of Functional Channel

The basic superframe structure of RCCH is represented in Figure 5.1-1. BCCH shall be placed at the beginning of the superframe, and the number of BCCH frames is assigned by Bn. When BCCH comprises more than 1 frame, SITE_INFO shall be placed at the first BCCH. CCCH and UPCH are divided into paging CH and multipurpose CH according to their purpose, and the number of frames for paging CCCH/UPCH and multipurpose CCCH/UPCH is assigned by Pn and Mn.

SUs and Talk Groups can be grouped for paging respectively, and Unit IDs and Group IDs are paged by paging CCCH/UPCH that corresponds to the paging group number. Multipurpose CCCH/UPCH follows paging CCCH/UPCH, and the set of these two are connected as many times as the number of groupings assigned by Gn. The connected frames are iterated as many times as assigned by In. The number of frames in a superframe, Ns, shall be represented in the following formula:

Ns = Bn + (Pn + Mn) x Gn x In

The information related to superframe structure is included in SITE_INFO sent by BCCH. When RCCH is detected, a SU can find the RCCH structure by receiving BCCH first.



BC: BCCH
CC(P) or UP(P) CCCH or UPCH for paging
CC(M) or UP(M) CCCH or UPCH for multipurpose use
Bn: Number of BCCH
Gn: Number of Paging Grouping (g_x is a grouping number)
Pn: Number of Paging Frame
Mn: Number of Multipurpose Frame
In: Number of Iteration

Figure 5.1-1 Basic Structure of RCCH

An example of the basic superframe structure without paging grouping is represented in Figure 5.1-2.
This example uses Bn = 1, Gn = 1, Pn = 2, Mn = 2 and In = 2.
This superframe comprises 9 frames and shall be sent repeatedly on RCCH.

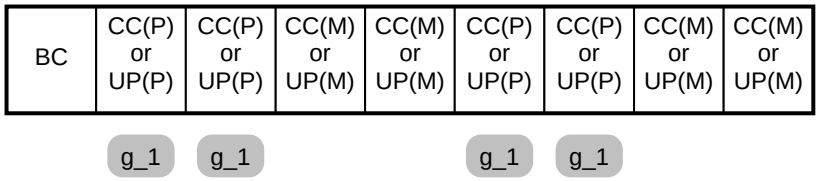


Figure 5.1-2 Example of Simple Superframe

5.1.4.2. Assignment of Paging Frame

A SU identifies the paging CCCH/UPCH frame to await its own Unit ID and Group ID. Grouping of Unit ID and Group ID are executed individually and each paging group number can be calculated using the following formula:

g_unit = UID mod Gn + 1
g_grp = GID mod Gn + 1

g_unit: Paging Group No. related to Unit ID
g_grp: Paging Group No. related to Group ID
UID: Value of Unit ID noted in base-10
GID: Value of Group ID noted in base-10

A TRS calls every paging group No, using a paging CCCH/UPCH frame. Therefore, the SU shall receive a paging CCCH/UPCH frame corresponding to the calculated g_unit and g_grp.

5.1.4.3. Message sent by Paging Frame

A paging frame is the frame used by the SU in the idle state on a control channel to recognize a receive message, and basically sends two kinds of messages: an assignment message for the traffic channel and a reception request message. However, a paging frame can send most of the messages including these. Meanwhile, a multipurpose frame is the frame used by a SU which has received such a reception request message and is not idle to continue to recognize the paging control message. Therefore, an assignment message for a traffic channel and messages other than reception requests shall be sent in a multipurpose frame.

The messages sent by paging frames are represented in Table 5.1-1. Any other messages may be sent in either a paging frame or multipurpose frame.

Message	Remark
CCH_INFO	If the control channel is changed, the paging frame shall be used. Otherwise, the multipurpose frame can be used.
ADJ_SITE_INFO	If a control channel of the adjacent site is changed, the paging frame shall be used. Otherwise, the multipurpose frame can be used.
SRV_INFO	If service information is changed, the paging frame shall be used. Otherwise, the multipurpose frame can be used.
REG_COMM	Paging frame only
AUTH_INQ_REQ	Paging frame only
VCALL_ASSGN	Paging frame only
VCALL_ASSGN_DUP	Paging frame only
VCALL_REC_REQ	Paging frame only
DCALL_ASSGN	Paging frame only
DCALL_ASSGN_DUP	Paging frame only
DCALL_REC_REQ	Paging frame only
STAT_INQ_REQ	Paging frame only
STAT_REQ	Paging frame only
SDCALL_REQ	The first message of the Header format uses the paging frame while all other User Data formats use the multipurpose frame.
REM_CON_REQ	Paging frame only
PROP_FORM	The type of message used for the paging frame is system dependent.

Table 5.1-1 List of Messages Sent in Paging Frame

5.1.4.4. Allocation to Frame of Broadcast Message

As described above, the first frame of a superframe is BCCH, with SITE_INFO setting required. In any other BCCH frame, paging CCCH/UPCH or multipurpose CCCH/UPCH, a broadcasting message may be sent with any frame if there is no message required to send. The recommended setting is that SRV_INFO and ADJ_SITE_INFO are mounted to the frame in the dual message format, and each ADJ_SITE_INFO informs its adjacent site in order. Also when using LICH bit setting, a paging CCCH/UPCH frame including a broadcasting message may be handled as the frame of which the reception is optional.

Refer to Section 16 for the details of allocation of messages to the superframe.

5.2. Traffic Channel

Voice calls and data calls are made on traffic channels. Trunking control data is sent, being mounted in SACCH, FACCH1 or FACCH2.

5.3. Channel Discipline

This section describes the basic discipline for a TRS and a SU regarding control channels and traffic channels. Refer to REF [1] for the discipline of timing.

5.3.1. Channel Discipline for TRS

At least one control channel shall be present in a TRS while a valid traffic channel is working.

When all the traffic channels are in use and a call request is sent from a SU, the TC can switch the control channel to composite control channel to respond to the request. Or it can send a message to the requesting SU to wait.

When a TRS switches the current RCCH to the other, new RCCH information shall be released long enough before switching, in order to avoid abnormal behavior of a SU monitoring current RCCH.

When a traffic channel is being used, the TC shall monitor the traffic channel. The TC shall interrupt the call, if a SU does not transmit within Tr_inact time after the message to assign a traffic channel is sent, or if the next transmission after the SU transmission has ended does not begin within Tr_hold time. Refer to Section 5.5.2 for details of terminating calls.

5.3.1.1. Late Entry

A TRS shall perform a process that a SU can join in a late entry while a traffic channel is in use. Late entry in a trunked radio system has two kind of meaning. Late entry basically means participating in an ongoing call like a late entry in a conventional system, however, there is a case of the meaning of notification of Unit ID or Group ID currently used at a traffic channel.
Late entry for participation to an ongoing call can work only in voice calls as well as a conventional system even if a trunked radio system. In case of data calls, since Header information including ID information can not be received in a late entry situation, the late entry operation in data calls is not guaranteed. Therefore, a late entry in data calls has the meaning of prevention of a service request addressing in-use ID by broadcasting ID information from RCCH currently used in a traffic channel.
Late entry operation in a TRS is periodically to send ASSGN or ASSGN_DUP message on a control channel while a traffic channel is in use. The use of ASSGN_DUP message is recommended to explicitly represent a late entry state. Unless stated otherwise, a late entry operation is described using ASSGN_DUP message.

The discipline for sending a channel assignment message related to a traffic channel in use is described as follows.

- In a group voice call, TRS shall send an assignment message.
- In an individual voice call, TRS should send an assignment message.
- In a broadcast data call, TRS may send an assignment message.

- In a unit to unit data call, TRS may send an assignment message.

5.3.2. Channel Discipline for SU

A SU searches for a control channel when no channel is assigned for a traffic channel. This behavior may be done based on information in a SU memory, or toward all channels available. When a traffic channel is freed after transmission ends, the control channel acquisition process shall be done to recover the last valid control channel as long as the channel was not switched during the transmission.

A SU shall not transmit on the control channel until it receives appropriate system information from the control channel.

While a SU is receiving on an Outbound traffic channel, layer 3 messages from the TC mounted in SACCH, FACCH1 or FACCH2 shall be decoded and the SU shall behave appropriately based on the message information.

5.3.2.1. Condition to Enter Idle State

A SU migrates to the idle state after registration is completed on a control channel. If the control channel contains both a paging frame and multipurpose frame, or uses the paging grouping, a SU shall enter the idle state after recognizing the paging frame to receive. To enter the idle state, the following conditions shall be satisfied.

a) SITE_INFO is being received and the superframe structure is recognized.
b) The number of adjacent sites is recognized from Adjacent Site Allocation.
c) The control channel information of all the adjacent sites is being acquired from Adjacent Site Option of ADJ_SITE_INFO.

5.3.2.2. Transition State to Traffic Channel

When a SU receives ASSGN or ASSGN_DUP on a control channel, it identifies Unit ID or Group ID included in the message and moves to the assigned traffic channel if the identifier is related to a SU.

When receiving an ASSGN message and moving to the traffic channel, it moves to a traffic channel either with transmission state or reception state, depending on its side (calling or called) and call type (Group Call or Individual Call). A SU which can move with transmission state in Group Call is the calling SU only. Any called SUs shall move with reception state. Since a SU which moves with transmission state changes depending on the connection procedure for Individual Calls, the SU shall diagnose the state to behave appropriately.

When moving to a traffic channel after receiving an ASSGN_DUP message, the SU shall move with the reception state in any condition.

5.3.3. Designation of Information Element

This section describes the designation of the value of information elements used by layer 3 messages.

The designation of the value of Call Type information element for each service is shown in Table 5.3-1. Settings of Call Type except the shaded cells are valid. If a Service has plural valid settings, Call type with “X” should be used basically.

Call Type / Service	Broadcast	Conference	Individual
Conference Group Voice Call		X	
Broadcast Group Voice Call	X		
Individual Voice Call			X
Broadcast Data Call		X	
Unit to Unit Data Call			X
Broadcast Short Data Call		X	
Unit to Unit Short Data Call			X
Broadcast Status Notice		X	
Status Notice			X

Table 5.3-1 Designation of Call Type information element

5.4. Call Cancel on Control Channel

This cancel process is the basis of the cancel process in each call procedure described in Section 10 or later. The cancel operation from the SU is required in the call procedure using a traffic channel. This operation is arbitrary in the call procedure not using a traffic channel.

5.4.1. Call Cancel Request from Subscriber Unit

If a user cancels a service before a SU sends a service request, a SU shall not send the service request but shall return to the idle state.

If a SU has already sent a service request, DISC_REQ shall be sent. Retry on layer 3 shall be repeated until the following conditions are satisfied:

a) If DISC showing that the TC accepts DISC_REQ is received, a SU shall return to the idle state.
b) If VCALL_RESP or DCALL_RESP with “Cause” for queuing interruption showing that the TC accepts DISC_REQ are received, a SU shall return to the idle state.
c) If a response from the TC cannot be received after a retransmission for Ns_ret times, a SU shall return to the idle state.

5.4.2. Call Cancel Response in Trunking Controller

If the TC receives DISC_REQ from a SU during Call Setup in response to the service request from a SU, it shall execute any of the following processes:

a) If DISC_REQ is accepted, the TC shall send DISC to a SU which sent DISC_REQ. Additionally, if the Reception Request message has already been sent, DISC shall be sent to a called SU, and
   if the Channel Assignment message has already been sent, DISC shall be sent on the assigned traffic channel.
b) If DISC_REQ is received on the queue state that is for reserving a traffic channel resource, VCALL_RESP or DCALL_RESP with “Cause” for queuing interruption shall be sent to the SU which sent DISC_REQ.

If the TC receives a cancel signal from PSTN which has sent a call, during its Call Setup, the TC shall execute the following processes:

a) Send back acknowledgement to PSTN through PSTN interface.
   Additionally, if a Reception Request message has already been sent to a SU, the TC shall send DISC to the SU, and
   if a Channel Assignment message has already been sent to the SU, the TC shall send DISC on the assigned traffic channel.

5.5. Call Termination on Traffic Channel

This section describes the call termination process on a traffic channel. This termination process is applied basically to all communications, and shall be the basis of the termination process in each procedure described in the following sections.

5.5.1. Call Termination of Subscriber Unit

If any of the following conditions are satisfied when a SU is on a traffic channel, a SU shall exit the traffic channel and return to the previous control channel:

a) DISC is received.
b) A message containing Unit ID or Group ID not related to a SU is received.
c) A message to let a SU engage in other communication is received.
d) A valid frame synchronization word cannot be received within the preconfigured time. (Time is not specified.)
e) Conditions for Synchronization Error specified in REF [1] are satisfied.

If a SU initiates a call termination process on a traffic channel, a SU shall perform any of the following processes:

a) A SU send DISC_REQ on a traffic channel within Ns_ret times of retransmission.
b) A SU carries out the process described in Section 5.4.1 after returning to a control channel.

5.5.2. Call Termination by Trunking Controller

A TC may terminate a call by sending either of the following messages on the traffic channel.

a) A DISC
b) A message containing a different Group ID or Unit ID to assign a traffic channel to another Group or SU.

A TC shall start the call termination process if any of the following conditions are satisfied:

a) Valid DISC_REQ for a call is received on an inbound traffic channel.
b) Valid DISC_REQ for a call is received on an inbound control channel.
c) Communication termination signal is received from any participant (such as PSTN) except a SU.
d) No traffic appears on the traffic channel during the period of Tr_inact after the traffic channel is assigned.
e) No traffic appears on the traffic channel during Tr_hold timer.
f) Desynchronization state remains for longer than given duration. (Time is not specified.)
g) Tr_tch Calling Restriction timer can be arbitrarily configured for a traffic channel and the configured time comes.

5.6. Outbound Signaling Reliability

When the TC sends an unconfirmed type message that a reply from a SU is not required, the same Outbound Message can be repeatedly sent to ensure the reliability of transmission. Regarding the message repetition, the same outbound message shall be sent as many times as specified by the Nr_ob counter at a frame interval of Tr_ob timer.

5.7. Call Queuing

If in either of the following conditions when a TC receives the service request from a SU, the reply message with “Cause” indicating the queue state may be sent to show that the request is in the queue:

a) No traffic channel resources are left.
b) The request is on standby until a called SU becomes accessible.

The SU that receives the reply message indicating the queue state shall continue to wait for a message from the TC during the period of Ts_busy timer.

6. Control Channel Acquisition and Retention

This section describes how to hunt for a channel for calling with more valid RCCH and RTCH. Since the validation standard depends on the usage environment of a SU, this section provides the procedure as a guideline and the appropriate specifications for its usage environment shall be adjusted for actual channel hunting in each system. The actual procedures depend on the system environment. Therefore, the parameters of hunt thresholds A, B and C, and signal strength difference D described below are arbitrary. Also, another hunt threshold can be added if needed. Parameters not described here like timers for the signal strength detection are arbitrary.

6.1. Control Channel Hunt Procedure

A SU searches for a RCCH according to the prescribed procedure in order to acquire a valid RCCH. A SU stores the acquired RCCH information in non-volatile memory and keeps it even in Power OFF state. A SU saves the hunt threshold A and B as the reference reception level of RCCH acquirement. The hunt threshold B is defined as the reception level at which a SU can hold minimum calling quality, and the hunt threshold A is defined as the level which has high enough quality to comfortably hold a call. These hunt thresholds are determined according to type and performance for SU, and a site's regional environment. Also, a SU sends a registration request to RCCH when needed in each hunting procedure. If RCCH rejects the registration request as a result, it is regarded as failure of the hunting test.

6.1.1. Resuming a Control Channel Sequence

When a SU is turned ON, the RCCH hunting test suspended before turning power OFF is executed first. The SU receives the RCCH successfully hunted last time and checks whether the reception level satisfies stop conditions with the hunt threshold B. The SU stays on the RCCH if the conditions are satisfied. If the hunting fails, the next hunting procedure should be started.

6.1.2. Preferential Hunt Sequence

As the channel hunting procedure starts, a SU should activate the RCCH hunting procedure with the highest priority. The SU starts its channel hunting test according to the priority sequence of channels stored in the non-volatile memory previously, and executes the hunting verification. If the hunting fails on the received channel, the SU migrates to the next priority channel for hunting. Afterward, hunting tests are executed taking the hunt threshold B as reference in the order of hunting priority starting at the highest. If all hunting test sequences for preferential RCCH result in failure, the next hunting procedure should be started.

6.1.3. Normal Hunt Sequence

The normal hunt procedure is a procedure to execute a hunting test for a channel which can be a normal RCCH. Hunting tests should be executed in order on candidates for normal RCCH saved in non-volatile memory of a SU. The hunting test is done by the hunting threshold value A at first. If the hunting test fails for all the normal RCCH with the threshold value A, then the SU starts another hunting test using the threshold value B. If all hunting test sequences for normal RCCH result in failure, the next hunting procedure should be started. In the normal hunt procedure, a

channel related to additional RCCH information memorized by broadcast messages from the system is also hunted.

6.1.4. Site Hunt Sequence

The site hunt procedure is a procedure to execute a hunting test for a channel which can be a normal RCCH, being connected to each site. Hunting tests should be executed in order of the candidates for the site RCCH saved in non-volatile memory of a SU. For each site, the hunting test is done with the threshold value A, and if all tests fail, another hunting test is done using the threshold value B. If the hunting test fails for all channels within the hunted site, the SU migrates to another site for hunting. After hunting tests are finished in all sites set up, the next hunt procedure should be started. It is recommended that the site to start the hunting test is chosen at random.

6.1.5. Comprehensive Hunt Sequence

A comprehensive hunt procedure is a procedure to execute a hunting test for all channels which can be used in a SU as an RCCH candidate. Hunting tests should be executed in order on the table of up to 1023 channels saved in non-volatile memory of a SU. It is recommended that the channel to start the hunting test is chosen at random. The hunt threshold B should be used in this test. If all RCCH hunt procedures fail, Preferential Hunt Sequence should be started again.

6.2. Background Search Sequence

A SU is in stationary state after acquiring RCCH. In stationary state, the SU receives paging messages or broadcasting information. Background Search Sequence is a procedure to hunt for RCCH information received in Adjacent Site Information or any channel better than the current RCCH such as one with higher priority. While receiving in stationary state, the SU regularly executes hunting tests for RCCH better than the current one. If a site is found in better condition than that of the current RCCH, the SU should migrate to the new RCCH and enter stationary state. The SU migrates if in either of the following conditions:

a) RCCH with priority higher than that of the current RCCH in Preferential Hunt Sequence is found with the hunt threshold B satisfied.
b) Reception signal strength of the channel received via Adjacent Site Information is more than “D” stronger than that of the current RCCH, which “D” is the signal strength difference in moving condition.

However, in the case of staying on an RCCH with the highest priority in Preferential Hunt Sequence, Background Search Sequence should not be activated.

6.3. Leaving a Control Channel

If the reception level falls below the hunt threshold C in stationary state where a SU stays on RCCH, the SU should exit the current RCCH and start a Control Channel Hunting Procedure.

7. Mode of Operation

7.1. Trunking Mode

For Trunking Mode, the TC can select Transmission Trunking Mode or Message Trunking Mode. Transmission Mode and Message Mode are different basically in the usage of traffic channel.

In Transmission Mode, a traffic channel is assigned by every transmission from a SU, and the TC cancels transmission immediately when a transmission from a SU is finished. When a SU on a traffic channel executes Talkback, it goes back to the control channel and sends a call request.

In Message Mode, the TC holds a traffic channel only during the period set as Hold Time when a transmission from a SU is finished. During the period, a SU currently transmitting can transmit as many times as possible on the same traffic channel. If no traffic on the traffic channel occurs during Hold Time, or DISC_REQ is sent from a SU, the TC cancels the traffic channel.

Therefore, Transmission Mode is suitable for unidirectional communications such as a transmission to a group, and Message Mode is suitable for bidirectional communications.

7.2. Link Time for Group Call

This section describes the timing of the process between a SU and a TRS when the SU makes a Group Call. This section describes an example where the process is executed at the ideal timing to provide the shortest link time.

The timing to make a Group Voice Call in the frame structure for 4800 bps is represented in Figure 7.2-1.

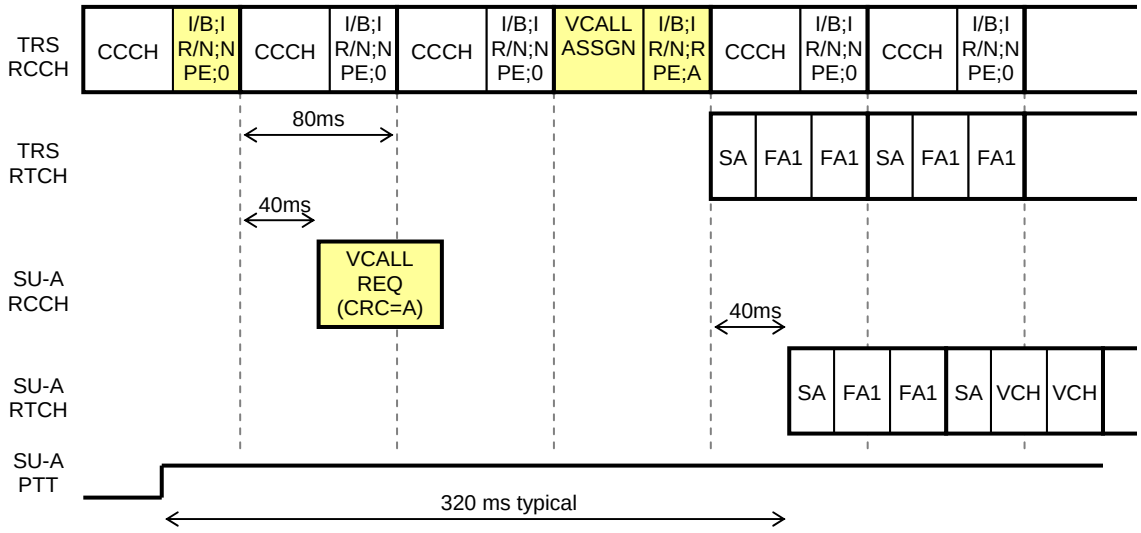


Figure 7.2-1 Link Time for Group Call in 4800bps

If the PTT of the SU-A is activated, the SU-A sends VCALL_REQ using random access on an Inbound RCCH. The TRS sends VCALL_ASSGN to assign RTCH and Collision Control Field indicating the success of VCALL_REQ in the following frame on the Outbound RCCH. The TRS also starts transmitting on the Outbound RTCH assigned by VCALL_ASSGN. When the SU-A receives Collision Control Field indicating success of VCALL_REQ and VCALL_ASSGN

indicating assignment of RTCH, the SU starts initiating a voice call by switching to the Inbound RTCH specified by VCALL_ASSGN. Although the actions of other SUs that participate in a Group Call are not shown, the involved SUs that received VCALL_ASSGN move to the specified RTCH, and then they start receiving at the same time as SU-A starts transmitting on RTCH.
In this example, the link time from when the PTT switch of the SU-A is activated until the SU-A starts transmitting on RTCH is approximately 320 ms. However, since Outbound RCCH uses a superframe structure, VCALL_ASSGN frame does not always come back immediately after VCALL_REQ and it depends on the relationship between the frame that sent VCALL_REQ and the superframe structure. Hence the link time may be longer than the duration shown here.

The timing to make a Group Voice Call in the frame structure for 9600 bps is represented in Figure 7.2-2. Messages are exchanged between the SU-A and TRS in the same manner as 4800 bps. Only the frame time and the offset amount between Inbound and Outbound are different.
In this example, the link time from when the PTT of the SU-A is activated until the SU-A starts transmitting on RTCH is approximately 220ms.

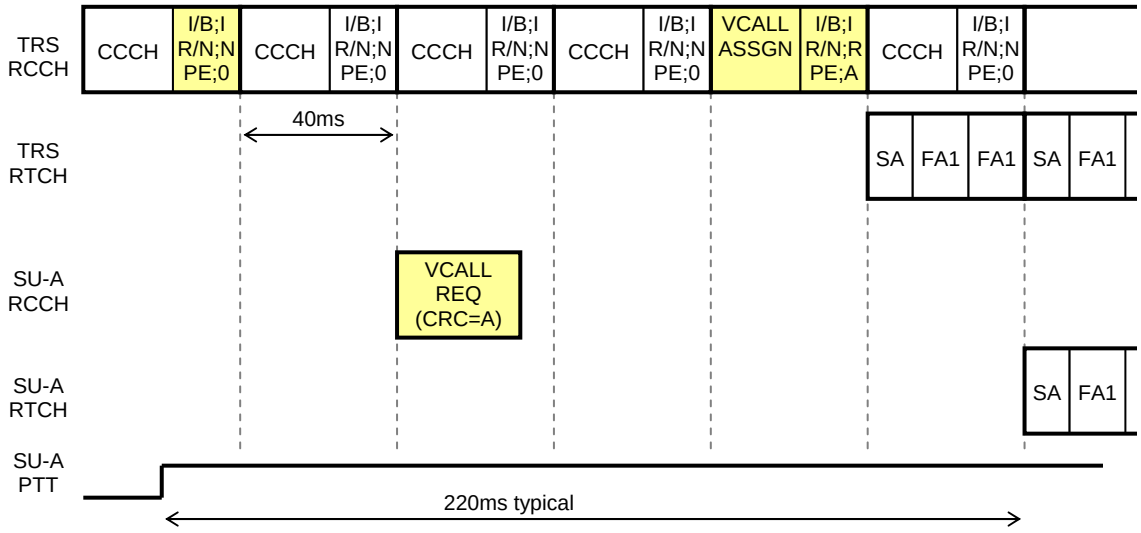


Figure 7.2-2 Link Time for Group Call in 9600bps

8. Registration

This section describes the procedure for SU and TC about the Registration process upon the detection of a valid control channel.

The main purpose of Registration is to provide service access only to a valid SU.

The second purpose of Registration is to record information as to which site in the network controls a SU. This information prevents a TC from searching a SU across the entire network, and can reduce Call Setup time and control channel loads.

There are two ways of registering as follows:

- Registering both SU location and participating group
- Registering SU participating group

Additionally, there are the Registration Clear process for when a SU leaves a registered site and the process for requesting a SU to perform Registration.

8.1. Registration Procedure

This section describes the procedure to register both the location and the group of a SU. A SU shall perform Registration in the following conditions:

a) Power is turned ON.
b) A SU migrates to another site.
c) REG_COMM is received.

In the conditions shown above, if the following conditions are satisfied, a SU can start Registration on a control channel:

a) RCCH with signal strength stronger than a given level is hunted for by the control channel hunting, and
b) At least one SITE_INFO is received, and
c) Its Location ID is identical with either of the registerable systems configured for a SU, and
d) Location & Group Registration Service is presented in Service Information, and
e) Access restriction is not valid in Restriction Information.

If Location Registration Service is not provided in Condition d), only Conditions a) to c) are required to be satisfied but Registration for a SU is not required. Also, if Group Registration Service is not provided, the group registration is not required. If access is restricted in Condition e), a SU shall perform Registration according to the limits of its restriction.

Location Registration sequence is shown in Figure 15.2-1.

8.1.1. Unit Request

If the conditions for Registration are satisfied, a SU sends REG_REQ to a control channel and wait for a reply from a TC.

8.1.2. Controller Actions

A TC shall carry out the following as valid replies to REG_REQ from a SU:

a) When permit both location registration and group registration, the TC sends REG_RESP containing Unit ID of the SU and “Cause” for permission.
b) When permit only location registration and reject group registration, the TC sends REG_RESP containing Unit ID of the SU and “Cause” for permission and rejection.
c) When permit only location registration while group registration is failed, the TC sends REG_RESP containing Unit ID of the SU and “Cause” for permission and failure.
d) When reject, the TC sends REG_RESP containing Unit ID of the SU and “Cause” for rejection.
e) When fail, the TC sends REG_RESP containing Unit ID of the SU and “Cause” for failure.

8.1.3. Unit Actions

A SU having sent REG_REQ shall carry out the following as valid replies to the messages from a TC:

a) If REG_RESP indicating permission is received:
   i) A SU updates the site information when its location is registered, and
   ii) proceeds to the idle state
b) If REG_RESP indicating permission for location registration and rejection for group registration is received:
   i) A SU updates information of rejected site, and
   ii) proceeds to the control channel hunt procedure.
c) If REG_RESP indicating permission for location registration and failure for group registration is received:
   i) A SU updates the site information when its location is registered, and
   ii) proceeds to Group Registration process.
d) If REG_RESP indicating rejection is received:
   i) A SU updates information of the rejected site, and
   ii) proceeds to the control channel hunt procedure.
e) If REG_RESP indicating failure is received:
   i) A SU proceeds to the idle state, or
   ii) proceeds to the control channel hunt procedure.
f) If REG_RESP cannot be received before Ts_ack timer expires:
   i) A SU proceeds to the control channel hunt procedure.

8.2. Registration Command Procedure

This section describes the process when the TC orders a SU to register. The TC may execute the Registration Command at any time as needed.

The Registration Command sequence is represented in Figure 15.3-1.

8.2.1. Controller Request

A TC sends REG_COMM to a control channel and waits for a reply from a SU.

8.2.2. Unit Actions

A SU checks for contents of REG_COMM sent by a TC, and the sequence described in Section 8.1 is started if the Location ID and Unit ID match those preconfigured for the SU.

8.3. Registration Clear Procedure

This section describes the procedure when a SU clears registration.

A SU can perform Registration Clear in the following conditions and the condition a) is mandatory:

a) To turn off the power.
b) To migrate to another site.

Sequence diagram for the Registration Clear procedure is shown in Figure 15.4-1.

8.3.1. Unit Request

When the condition for Registration Clear is satisfied, a SU sends REG_C_REQ to a control channel and wait for a response from the TC.

8.3.2. Controller Actions

A TC shall carry out the following as valid responses to REG_C_REQ from a SU.

a) When permit the request, the TC sends REG_C_RESP containing Unit ID of the SU and “Cause” for permission.
b) When reject the request, the TC sends REG_C_RESP containing Unit ID of the SU and “Cause” for rejection.
c) When fail, the TC sends REG_C_RESP containing Unit ID of the SU and “Cause” for failure.

8.3.3. Unit Actions

The SU that sent REG_C_REQ shall carry out the following as valid responses to the messages from a TC:

a) If REG_C_RESP indicating permission is received:
   i) The SU updates the record of the site information for where its location registration is cleared, and
   ii) migrates to another site to perform the location registration.
b) If REG_C_RESP indicating rejection is received:
   i) The SU updates the record of the site information for where its location registration is cleared, and
   ii) migrates to another site to perform the location registration.
c) If REG_C_RESP indicating failure is received:
   i) The SU updates the record of the site information for where its location registration is cleared, and
   ii) migrates to another site to perform the location registration.
d) If REG_C_RESP cannot be received before Ts_ack timer expires:
   i) The SU updates the record of the site information for where its location registration is

cleared, and

ii) migrates to another site to perform the location registration.

8.4. Group Registration Procedure

This section describes the procedure when a SU participates in a group.

By registering the affiliation group in a trunked radio system, a user of SU can make a group call with other units having the same Group ID. In a trunked radio system, the group registration information is used to determine which TRS is drawn into a group call.

A SU performs the group registration in the following conditions. The sequence diagram is shown in Figure 15.5-1.

a) A user selects a different Group ID.
b) A Group ID not group-registered is used to transmit.

In the conditions shown above, if the following conditions are satisfied, a SU can start group registration on a control channel:

a) Group Registration Service is presented in Service Information, and
b) Access restriction is not valid in Restriction Information.

When Group Registration Service is not provided in a), the group registration procedure shall not be required.

When access is restricted in b), a SU shall perform the group registration procedure according to the restriction.

8.4.1. Unit Request

When the condition for Group Registration is satisfied, a SU sends GRP_REG_REQ on a control channel and wait for a response from the TC.

8.4.2. Controller Actions

A TC shall carry out the following as valid responses to GRP_REG_REQ from a SU.

a) When permit, the TC sends GRP_REG_RESP containing “Cause” for permission.
b) When reject, the TC sends GRP_REG_RESP containing “Cause” for rejection.
c) When fail, the TC sends GRP_REG_RESP containing “Cause” for failure.

8.4.3. Unit Actions

A SU having sent GRP_REG_REQ shall carry out the following as valid responses to the messages from a TC:

a) If GRP_REG_RESP indicating the permission is received:
   i) The SU proceeds to the idle state.
b) If GRP_REG_RESP indicating the rejection is received:
   i) The SU updates information of the rejected site, and
   ii) proceeds to the control channel hunt procedure.

c) If GRP_REG_RESP indicating the failure is received:
   i) The SU proceeds to the idle state, or
   ii) proceeds to the control channel hunt procedure.
d) If GRP_REG_RESP cannot be received before Ts_ack timer expires:
   i) The SU proceeds to the control channel hunt procedure.

9. Authentication

This section describes the authentication procedures in a trunked radio system.

In trunked radio systems, only the TC can perform authentication and 2 types of authentication procedure are available for TC.

- Authentication procedure by TC to a SU during the Registration process
- Authentication procedure by TC to a SU when necessary

9.1. Authentication Procedure during Registration

If a TC (or a facility connected to the Controller) has an authentication process capability, it can process the authentication of a SU during the Registration process simultaneously. The sequence to start an authentication process during the Registration procedure is represented in Figure 15.6-1.

9.1.1. Controller Inquiry

The inquiring TC sends back AUTH_INQ_REQ on a control channel to start the authentication process by the SU which sent REG_REQ.

9.1.2. Controller Actions

A TC shall carry out the following operations as valid responses to the message from a SU:

a) If AUTH_INQ_RESP is received and the Authentication Value of the SU is qualified:
   i) The TC carries out the operation for REG_REQ and sends back REG_RESP according to the Registration procedure described in Section 8.1.
b) If AUTH_INQ_RESP is received and the Authentication Value of the SU is disqualified:
   i) The TC sends back REG_RESP which includes “Cause” for the rejection.
c) If AUTH_INQ_RESP cannot be received before Tr_ack timer expires:
   i) The TC sends back REG_RESP which includes “Cause” for the failure.

9.1.3. Unit Actions

A SU having sent REG_REQ shall carry out the following operations as valid responses to the messages from a TC:

a) If AUTH_INQ_REQ that includes SU’s Unit ID as Destination Unit ID is received:
   i) The SU calculates Authentication Value using Authentication Parameter, and
   ii) sends back AUTH_INQ_RESP embedding the calculated value.
   iii) If any valid REG_RESP cannot be received before the Ts_ack timer expires, the SU proceeds to the control channel hunt procedure.
b) If REG_RESP with includes SU’s Unit ID as Destination Unit ID is received, the SU follows the Registration procedure described in Section 8.1.
c) If AUTH_INQ_REQ or REG_RESP cannot be received before Ts_ack timer expires:
   i) The SU proceeds to the control channel hunt procedure.

9.2. Authentication Procedure in Normal Process

If a TC (or a facility connected to the Controller) has an authentication process capability, it can arbitrarily apply the authentication process to a location registered SU when needed. The sequence for a TC to arbitrarily start an authentication process is represented in Figure 15.7-1.

For a SU that received a command for authentication process, other service requests shall not be sent until sending the authentication request. If another service request is received from a SU during authentication process, the TC can ignore the request.

9.2.1. Controller Inquiry

The inquiring TC sends back AUTH_INQ_REQ on the control channel to the SU to start the authentication process.

9.2.2. Controller Actions

A TC shall carry out the following operations as valid responses to the message from a SU:

a) If AUTH_INQ_RESP is received and the Authentication Value of a SU is qualified:
   i) The TC updates the authentication information of a SU and gives available service authority.
b) If AUTH_INQ_RESP is received and the Authentication Value of a SU is disqualified:
   i) The TC updates the authentication information of a SU and gives available service authority.
   ii) Stun process may arbitrarily be used for a SU.
c) If AUTH_INQ_RESP cannot be received before Tr_ack timer expires:
   i) Location registration information of a SU may arbitrarily be cleared.

9.2.3. Unit Actions

A SU in the idle state shall carry out the following operations as valid responses to the message from a TC.

a) If AUTH_INQ_REQ that includes SU's Unit ID as Destination Unit ID is received:
   i) The SU calculates the Authentication Value using Authentication Parameter, and
   ii) sends back AUTH_INQ_RESP embedding the calculated value, and
   iii) proceeds to the idle state.

10. Voice Call

This section describes the procedure of Call Setup and Call Termination for voice calls.

10.1. Conference Group Call Procedure

This section describes the procedure to call a group from a SU. The sequence is shown in Figure 15.8-1.

10.1.1. Unit Request

The calling SU sends VCALL_REQ on a control channel.

10.1.2. Controller Actions

A TC shall carry out the following as valid responses to VCALL_REQ from a SU.

a) When permit a request, the TC sends VCALL_ASSGN to assign a traffic channel.
b) When queue the call because of insufficient traffic channel resources, the TC sends VCALL_RESP with “Cause” indicating queue state.
c) When reject a request, the TC sends VCALL_RESP with “Cause” indicating the rejection.
d) After sending VCALL_ASSGN, the TC sends VCALL_ASSGN_DUP to indicate a late entry state.

10.1.3. Unit Actions

The SU having sent VCALL_REQ and other SUs in the idle state shall carry out the following as valid responses to the message from a TC.

a) If VCALL_ASSGN is received:
   i) the SUs proceed to the judgment process of message information.
b) If VCALL_ASSGN_DUP is received:
   i) the SUs proceed to the judgment process of message information.
c) If a calling unit receives VCALL_RESP which indicates the queue state:
   i) the calling unit activates Ts_busy timer and waits for a message from the TC.
   ii) If a valid response cannot be received before the timer expires, the calling unit proceeds to the disconnect process described in Section 5.4.
d) If a calling unit receives VCALL_RESP which indicates the rejection state:
   i) the calling unit proceeds to the idle state.
e) If a calling unit cannot receive any valid response before Ts_grp timer expires:
   i) the calling unit proceeds to the idle state.

10.1.4. Traffic Channel Assignment

SUs that received VCALL_ASSGN shall move to the traffic channel designated in the message in the following conditions:

a) Unit ID and Group ID of the SU that has sent VCALL_REQ are identical with those in the message.
b) Group ID of a SU in the idle state is identical with Group ID in the message.

SUs that received VCALL_ASSGN_DUP shall move to the traffic channel designated in the message in the following condition:

a) Group ID of a SU is identical with Group ID in the message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

10.1.5. Traffic Channel Maintenance

On a traffic channel, a SU and TC transmit using VCALL.
While the traffic channel is in use, the TC continuously sends VCALL_ASSGN_DUP (or VCALL_ASSGN) on the control channel, at the interval of the Tr_dup timer.

A TC may work either in Transmission Trunking Mode or Message Trunking Mode.

10.1.6. Call Termination for Controller

Only the TC can terminate a Conference Group Call. A TC shall send DISC to traffic channel when the following states occur:

a) After the traffic channel is assigned, a SU does not transmit before Tr_inact timer expires.
b) After a SU transmission finishes, no traffic on the traffic channel occurs before Tr_hold timer expires.
c) Tr_tch Call Time timer expires.
d) A traffic channel is abandoned to another service request that has higher priority.

Additionally, the TC stops sending VCALL_ASSGN_DUP (or VCALL_ASSGN) on a control channel.

10.1.7. Call Termination for Unit

If a SU receives DISC on a traffic channel, the SU proceeds to the control channel hunt procedure.

10.2. Broadcast Group Call Procedure

This section describes the procedure to execute a unidirectional broadcast call from a SU to a group. In broadcasting, only a calling SU has authority to transmit, and the TC disconnects the traffic channel to quit service as soon as the transmission ends. The sequence is the same as one shown in Figure 15.8-1.

10.2.1. Unit Request

A SU sends VCALL_REQ on a control channel.

10.2.2. Controller Actions

A TC shall carry out the following as valid replies to VCALL_REQ from a SU:

a) When permit a request, the TC sends VCALL_ASSGN to assign a traffic channel.
b) When queue the call because of insufficient traffic channel resources, the TC sends VCALL_RESP with “Cause” indicating queue state.
c) When reject a request, the TC sends VCALL_RESP with “Cause” indicating the rejection.
d) After sending VCALL_ASSGN, the TC sends VCALL_ASSGN_DUP to indicate a late entry state.

10.2.3. Unit Actions

The SU having sent VCALL_REQ and other SUs in the idle state shall carry out the following as valid responses to the message from a TC.

a) If VCALL_ASSGN is received:
   i) the SUs proceed to the judgment process of message information.
b) If VCALL_ASSGN_DUP is received:
   i) the SUs proceed to the judgment process of message information.
c) If a calling unit receives VCALL_RESP which indicates the queue state:
   i) the calling unit activates Ts_busy timer and waits for a message from the Controller.
   ii) If a valid response cannot be received before the timer expires, the calling unit proceeds to the disconnect process described in Section 5.4
d) If a calling unit receives VCALL_RESP which indicates the rejection:
   i) the calling unit proceeds to the idle state.
e) If a calling unit cannot receive any valid response before Ts_grp timer expires:
   i) the calling unit proceeds to the idle state.

10.2.4. Traffic Channel Assignment

SUs that received VCALL_ASSGN shall move to the traffic channel designated in the message in the following condition:

a) Unit ID and Group ID of the SU having sent VCALL_REQ are identical with those in the message.

b) Group ID in a SU in the idle state is identical with Group ID in the message.

SUs that received VCALL_ASSGN_DUP shall move to the traffic channel designated in the message in the following condition:

a) Group ID of a SU is identical with Group ID in a message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

10.2.5. Traffic Channel Maintenance

On a traffic channel, a SU and TC transmit using VCALL.
While the traffic channel is in use, the TC continuously sends VCALL_ASSGN_DUP (or VCALL_ASSGN) on the control channel, at the interval of the Tr_dup timer.

The TC shall work in Transmission Trunking Mode.

10.2.6. Call Termination for Controller

Only the TC can terminate a Broadcast Group Call. A TC shall send DISC to the traffic channel when the following conditions occur:

a) After the traffic channel is assigned, a SU does not transmit before Tr_inact timer expires.
b) After a SU transmission finishes, no traffic on the traffic channel occurs before Tr_hold timer expires.
c) Tr_tch Call Time timer expires.
d) A traffic channel is abandoned to another service request that has higher priority.

Additionally, the TC stops sending VCALL_ASSGN_DUP (or VCALL_ASSGN) on a control channel.

10.2.7. Call Termination for Unit

If a SU receives DISC on a traffic channel, the SU proceeds to the control channel hunt procedure.

10.3. System Call Procedure

A System Call is a special case of a Broadcast Group Call. The difference from a Broadcast Group Call procedure is as follows:

a) A System Call uses a Special Group ID indicating All Group.

10.4. Individual Call Procedure

This section describes the procedure to call another SU from a SU. 3 types of operating sequences are shown in Figure 15.9-1 to Figure 15.11-5.

10.4.1. Calling Unit Request

A calling SU sends VCALL_REQ on a control channel.

10.4.2. Controller Actions

A TC shall carry out the following as valid replies to VCALL_REQ from a SU.

a) When permit a request and assign a traffic channel immediately, the TC sends VCALL_ASSGN.
b) When queue the calling unit because the traffic channel resources are insufficient or a called unit is being paged, the TC sends VCALL_RESP with “Cause” indicating the queue state.
c) When reject a request, the TC sends VCALL_RESP with “Cause” indicating the rejection.
d) After sending VCALL_ASSGN, the TC sends VCALL_ASSGN_DUP to indicate a late entry state.
e) When permit a request and check the validity of a called unit, the TC sends VCALL_REC_REQ.

10.4.3. Unit Actions

The SU having sent VCALL_REQ and other SUs in the idle state shall carry out the following as valid replies to the message from a TC.

a) If VCALL_ASSGN is received:
   i) the SUs proceed to the judgment process of message information.
b) If VCALL_ASSGN_DUP is received:
   i) the SUs proceed to the judgment process of message information.
c) If a calling unit receives VCALL_RESP which indicates the queue state:
   i) the calling unit activates Ts_busy timer and waits for a message from the controller.
   ii) If a valid response cannot be received before the timer expires, the calling unit proceeds to the disconnect process described in Section 5.4.
d) If a calling unit receives VCALL_RESP which indicates the rejection state of a called unit or TC:
   i) the calling unit proceeds to the idle state.
e) If a calling unit receives VCALL_RESP which indicates no response from a called unit:
   i) the calling unit proceeds to the idle state.
f) If a calling unit cannot receive any valid reply before Ts_Ind timer expires:
   i) the calling unit proceeds to the idle state.
g) If a called unit in the idle state receives VCALL_REC_REQ:
   i) the called unit sends VCALL_REC_RESP as described below.

10.4.4. Availability Check to Called Unit

When the TC receives VCALL_REQ, it may check the validity of a called SU by sending VCALL_REC_REQ. When a called SU receives VCALL_REC_REQ, it shall response with VCALL_REC_RESP. Then, a called SU shall carry out the following actions:

a) If a called unit has used “Cause” indicating the rejection state:
   i) the called unit proceeds to the idle state.
b) If a called unit has used “Cause” indicating the permission state:
   i) the called unit continues to wait for the response from the TC or the user of the called unit.

A TC shall reply as follows according to "Cause" field of VCALL_REC_RESP:

a) If "Cause" field shows rejection state:
   i) the TC sends VCALL_RESP which indicates the rejection state to a calling unit.
b) If "Cause" field shows permission state:
   i) when assign a traffic channel, the TC sends VCALL_ASSGN, or
   ii) when wait for the response from a user of a called SU, the TC sends VCALL_RESP which indicates the queue state to a calling unit.
c) If the TC cannot receive VCALL_REC_RESP before Tr_ack timer expires:
   i) the TC sends VCALL_RESP which indicates no response from a called unit to a calling unit.

10.4.5. Connection Response from Called Unit

After a called SU sends VCALL_REC_RESP with permission, the called SU and the TC may wait for a response from the user of the called SU.
When the user executes a connection operation, the called SU sends VCALL_CONN_REQ.
If the user executes a disconnect operation, or does not reply before Ts_ring timer expires, the called SU sends DISC_REQ.
A TC shall reply as follows according to what a called SU sent:

a) When assign the traffic channel after receiving VCALL_CONN_REQ:
   i) the TC sends VCALL_ASSGN.
b) When queue a called unit because of insufficient traffic channel resources after receiving VCALL_CONN_REQ:
   i) the TC sends VCALL_CONN_RESP which indicates the queue state to the called unit.
c) When receive and permit DISC_REQ,
   i) the TC sends DISC to a calling unit and a called unit.
d) If a valid reply message cannot be received from a called unit before Tr_ring timer expires,
   i) the TC sends DISC to a calling unit and a called unit.

10.4.6. Traffic Channel Assignment

SUs that received VCALL_ASSGN shall move to the traffic channel designated in the message in the following condition:

a) Unit ID of the calling SU is identical with Source Unit ID in the message.
b) Unit ID of a SU in the idle state is identical with Destination Unit ID in the message.

SUs that received VCALL_ASSGN_DUP shall move to the traffic channel designated in the message in the following condition:

a) Unit ID of a SU is identical with either Unit ID in the message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

10.4.7. Traffic Channel Maintenance

On a traffic channel, a SU and TC transmit using VCALL.
While the traffic channel is in use, the TC continuously sends VCALL_ASSGN_DUP (or VCALL_ASSGN) on the control channel, at the interval of Tr_dup timer.

A TC may work either in Transmission Trunking Mode or Message Trunking Mode.

10.4.8. Call Termination for Controller

The calling SU, the called SU, or the TC can terminate a call.
The TC shall send DISC to the traffic channel when the following states occur:

a) After the traffic channel is assigned, a SU does not transmit before Tr_inact timer expires.
b) After a SU transmission finishes, no traffic on the traffic channel occurs before Tr_hold timer expires.
c) Tr_tch Call Time timer expires.
d) A traffic channel is abandoned to another service request that has higher priority.
e) DISC_REQ is received from a SU.

Additionally, the TC stops sending VCALL_ASSGN_DUP (or VCALL_ASSGN) on a control channel.

10.4.9. Call Termination for Unit

If a SU terminates the call, the SU sends DISC_REQ according to Section 5.5.

Since a TC sends either of the following messages when receiving DISC_REQ, a SU shall behave according to the message:

a) If DISC is received:
   i) both SUs start the control channel hunt procedure.
b) If DISC cannot be received before Ts_ack timer expires:
   i) the SU that has sent DISC_REQ starts the control channel hunt procedure.

10.5. Unit to PSTN Voice Call Procedure

PSTN service has 2 kinds of service request formats: the explicit method to send a phone number and the implicit method to send an abbreviated number. In the explicit method, a SU sends all digits, and the TC connects to the PSTN by using those digits. In the implicit method, a SU sends an abbreviated number, and the TC connects to the PSTN after changing the received abbreviated number to a real phone number. The sequence is shown in Figure 15.12-1.

This section describes the procedure to call PSTN from a SU. The connect procedure to PSTN is not covered in this specification.

10.5.1. Unit Request

The calling SU sends VCALL_REQ on a control channel.

10.5.2. Controller Actions

A TC shall carry out the following as valid replies to VCALL_REQ from a SU:

a) When permit a request, the TC sends VCALL_ASSGN to assign a traffic channel.
b) When queue the calling unit because traffic channel resources are insufficient or a PSTN is in a call process, the TC sends VCALL_RESP with “Cause” indicating queue state.
c) When reject a request, the TC sends VCALL_RESP with “Cause” indicating the rejection.
d) After sending VCALL_ASSGN, the TC sends VCALL_ASSGN_DUP to indicate a late entry state.

10.5.3. Unit Actions

A SU having sent VCALL_REQ shall carry out the following as valid replies to the message from a TC:

a) If VCALL_ASSGN is received:
   i) the SU proceeds to the judgment process of message information.
b) If VCALL_ASSGN_DUP is received:
   i) the SU proceeds to the judgment process of message information.
c) If a calling unit receives VCALL_RESP which indicates the queue state:
   i) the calling unit activates Ts_busy timer and waits for a message from the controller.
   ii) If a valid response cannot be received before the timer expires, the calling unit proceeds to the disconnect process described in Section 5.4.
d) If a calling unit receives VCALL_RESP which indicates the rejection state:
   i) the calling unit proceeds to the idle state.
e) If a calling unit cannot receive any valid reply before Ts_ind timer expires:
   i) the calling unit proceeds to the idle state.

10.5.4. Traffic Channel Assignment

SUs that received VCALL_ASSGN shall move to the traffic channel designated in the message in the following condition:

a) Unit ID of a SU is identical with Source Unit ID in the message.

SUs that received VCALL_ASSGN_DUP shall move to the traffic channel designated in the message in the following condition.

a) Unit ID of a SU is identical with Source Unit ID in the message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

10.5.5. Traffic Channel Maintenance

On a traffic channel, a SU and TC transmit using VCALL.
While the traffic channel is in use, the TC continuously sends VCALL_ASSGN_DUP (or VCALL_ASSGN) on the control channel, at the interval of the Tr_dup timer.

The TC shall work in Message Trunking Mode.

10.5.6. Call Termination for Controller

The SU, the PSTN, or the TC can terminate a call. Since the TC does the disconnect process for a traffic channel even if terminating by the PSTN side, the call termination from the TC also includes the termination process by the PSTN.
A TC shall send DISC to the traffic channel when the following states occur:

a) Tr_tch Call Time timer expires.
b) A traffic channel is abandoned to another service request that has higher priority.
c) Disconnect signal is received from PSTN.
d) DISC_REQ is received from a SU.

Additionally, the TC stops sending VCALL_ASSGN_DUP (or VCALL_ASSGN) on a control channel.

10.5.7. Call Termination for Unit

If a SU terminates the call, it sends DISC_REQ according to Section 5.5.

Since a TC sends either of the following messages when receiving DISC_REQ, a SU shall behave according to the message:

a) If DISC is received:
   i) the SU starts the control channel hunt procedure.

b) If DISC cannot be received before Ts_ack timer expires:
i) the SU starts the control channel hunt procedure.

10.6. PSTN to Group Call Procedure

This section describes when the PSTN calls a SU group.

10.6.1. Controller Actions

It is assumed that a TC receives a call from the PSTN. The TC then shall carry out the following on the control channel:

a) When permit a request, the TC sends VCALL_ASSGN to assign a traffic channel.
b) After sending VCALL_ASSGN, the TC sends VCALL_ASSGN_DUP to indicate a late entry state.

10.6.2. Traffic Channel Assignment

SUs that received VCALL_ASSGN shall move to the traffic channel designated in the message in the following condition:

a) Group ID of a SU is identical with Group ID in the message.

SUs that received VCALL_ASSGN_DUP shall move to the traffic channel designated in the message in the following condition:

a) Group ID of a SU is identical with Group ID in a message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

10.6.3. Traffic Channel Maintenance

On a traffic channel, a SU and the TC transmit using VCALL.
While the traffic channel is in use, TC continuously sends VCALL_ASSGN_DUP (or VCALL_ASSGN) on the control channel, at the interval of Tr_dup timer.

A TC may work either in Transmission Trunking Mode or Message Trunking Mode.

10.6.4. Call Termination for Controller

Only the PSTN or the TC can terminate a call. A TC shall send DISC to the traffic channel when the following states occur:

a) Disconnect signal from the PSTN is received.
b) Tr_tch Call Time timer expires
c) A traffic channel is abandoned to another service request that has higher priority.

Additionally, the TC stops sending VCALL_ASSGN_DUP (or VCALL_ASSGN) on a control channel.

10.6.5. Call Termination for Unit

If a SU receives DISC on a traffic channel, it proceeds to the control channel hunt procedure.

10.7. PSTN to Unit Voice Call Procedure

This section describes the procedure to call a specified SU from the PSTN. The sequence is shown in Figure 15.13-1.

10.7.1. Controller Actions

It is assumed that a TC receives a call from the PSTN. The TC then shall carry out the following on the control channel:

a) When permit a request, the TC sends VCALL_ASSGN to assign a traffic channel.
b) After sending VCALL_ASSGN, the TC sends VCALL_ASSGN_DUP to indicate a late entry state.
c) When permit a request and check the validity of a called unit, the TC sends VCALL_REC_REQ.

10.7.2. Availability Check to Called Unit

When the TC receives a service request from the PSTN, it may check the validity of a called SU by sending VCALL_REC_REQ. At this time, the telephone number can be optionally set to VCALL_REC_REQ.

When a called SU receives VCALL_REC_REQ, it shall response with VCALL_REC_RESP. Then, a called SU shall carry out the following actions:

a) If a called unit has used “Cause” indicating the rejection state:
   i) the called unit proceeds to the idle state.
b) If a called unit has used “Cause” indicating the permission state:
   i) the called unit continues to wait for the response from the TC or the user of the called unit

A TC shall reply as follows according to the "Cause" field of VCALL_REC_RESP.

a) If "Cause" field shows rejection state:
   i) the TC sends a disconnect signal to the PSTN.
b) If "Cause" field shows permission state:
   i) the TC may indicate the state to the PSTN.
c) If the TC cannot receive VCALL_REC_RESP before Tr_ack timer expires:
   i) the TC sends DISC to a called unit, and
   ii) sends a disconnect signal to the PSTN.

10.7.3. Connection Response from Called Unit

After a called SU sends VCALL_REC_RESP with permission, the called SU and the TC may wait for a response from the user of the called SU.

When the user executes a connection operation, the called SU sends VCALL_CONN_REQ.

If the user executes a disconnect operation, or does not reply before Ts_ring timer expires, the called SU sends DISC_REQ.

A TC shall reply as follows according to what the called SU sent:

a) When assign the traffic channel after receiving VCALL_CONN_REQ:
   i) the TC sends VCALL_ASSGN, and
   ii) sends a response signal to the PSTN.
b) When queue a called unit because of insufficient traffic channel resources after receiving VCALL_CONN_REQ:
   i) the TC sends VCALL_CONN_RESP which indicates the queue state to the called unit.
c) When receive and permit DISC_REQ:
   i) the TC sends DISC to a called unit, and
   ii) sends a disconnect signal to the PSTN.
d) If a valid reply message cannot be received from a called unit before Tr_ring timer expires:
   i) the TC sends DISC to a called unit, and
   ii) sends a disconnect signal to the PSTN.

10.7.4. Traffic Channel Assignment

SUs that received VCALL_ASSGN shall move to the traffic channel designated in the message in the following condition:

a) Unit ID of a SU is identical with Destination Unit ID in the message.

SUs that received VCALL_ASSGN_DUP shall move to the traffic channel designated in the message in the following condition:

a) Unit ID of a SU is identical with Destination Unit ID in a message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

10.7.5. Traffic Channel Maintenance

On a traffic channel, a SU and TC transmit using VCALL.

While the traffic channel is in use, a TC continuously sends VCALL_ASSGN_DUP (or VCALL_ASSGN) on the control channel, at the interval of Tr_dup timer.

A TC shall work in Message Trunking Mode.

10.7.6. Call Termination for Controller

The SU, the PSTN, or the TC can terminate a call. Since a TC does the disconnect process for a traffic channel even if terminating by the PSTN side, the call termination from the TC also includes the termination process by the PSTN.

A TC shall send DISC to the traffic channel when the following states occur.

a) Tr_tch Call Time timer expires.
b) A traffic channel is abandoned to another service request that has higher priority.
c) Disconnect signal from the PSTN is received.
d) DISC_REQ is received from a SU.

Additionally, the TC stops sending VCALL_ASSGN_DUP (or VCALL_ASSGN) on a control channel.

10.7.7. Call Termination for Unit

If a SU terminates the call, the SU sends DISC_REQ according to Section 5.5.

Since a TC sends either of the following messages when receiving DISC_REQ, a SU shall behave according to the message:

a) If DISC is received:
   i) A SU starts the control channel hunt procedure.
b) If DISC cannot be received before Ts_ack timer expires:
   i) A SU starts the control channel hunt procedure.

10.8. Simultaneous Data Call Procedure

Simultaneous Data Call uses the procedures of Conference Group Call in Section 10.1, Broadcast Group Call in Section 10.2 or Individual Call in Section 10.4.

The difference between these procedures and the procedure of Simultaneous Data Call is only behavior on a traffic channel. The procedure for sending low speed data with voice data on a traffic channel complies with the procedure of Simultaneous Data Call in REF [2].

11. Data Call

This section describes the procedures of Call Setup and Call Termination for a data call.

11.1. Broadcast Data Call Procedure

This section describes the procedure to call a group from a SU. The sequence is shown in Figure 15.14-1.

11.1.1. Unit Request

The calling SU sends DCALL_REQ on a control channel.

11.1.2. Controller Actions

A TC shall carry out the following as valid replies to DCALL_REQ from a SU:

a) When permit a request, the TC sends DCALL_ASSGN to assign a traffic channel.
b) When queue the call because of insufficient traffic channel resources, the TC sends DCALL_RESP with “Cause” indicating queue state.
c) When reject a request, the TC sends DCALL_RESP with “Cause” indicating the rejection.
d) (Option) After sending DCALL_ASSGN, the TC sends DCALL_ASSGN_DUP to indicate a late entry state.

11.1.3. Unit Actions

The SU having sent DCALL_REQ and other SUs in the idle state shall carry out the following as valid replies to the message from a TC.

a) If DCALL_ASSGN is received:
   i) The SUs proceed to the judgment process of message information.
b) If DCALL_ASSGN_DUP is received:
   i) The SUs proceed to the judgment process of message information.
c) If a calling unit receives DCALL_RESP which indicates the queue state:
   i) The calling unit activates Ts_busy timer and waits for a message from the TC.
   ii) If a valid response cannot be received before the timer expires, the calling unit proceeds to the disconnect process described in Section 5.4.
d) If a calling unit receives DCALL_RESP which indicates the rejection state:
   i) The calling unit proceeds to the idle state.
e) If a calling unit cannot receive any valid reply before Ts_grp timer expires:
   i) The calling unit proceeds to the idle state.

11.1.4. Traffic Channel Assignment

SUs that received DCALL_ASSGN shall move to a traffic channel designated in the message in the following condition:

a) Unit ID and Group ID of the SU having sent DCALL_REQ are identical with those in the message.
b) Group ID of a SU in the idle state is identical with Group ID in the message.

SUs that received DCALL_ASSGN_DUP shall move to a traffic channel designated in the message in the following condition:

a) Group ID of a SU is identical with Group ID in a message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

11.1.5. Traffic Channel Maintenance

On a traffic channel, a SU and the TC transmit using DCALL.
While a traffic channel is in use, the TC sends DCALL_ASSGN_DUP (or DCALL_ASSGN) on the control channel at the interval of Tr_dup timer.

A TC shall work in Message Trunking Mode.

11.1.6. Call Termination for Controller

Only the TC can terminate a Broadcast Data Call. A TC shall send DISC to the traffic channel when the following states occur:

a) After the traffic channel is assigned, a SU does not transmit before Tr_inact timer expires.
b) After a SU transmission finishes, no traffic on the traffic channel occurs before Tr_hold timer expires.
c) Tr_tch Call Time timer expires.
d) A traffic channel is abandoned to another service request that has higher priority.

Additionally, the TC stops sending DCALL_ASSGN_DUP (or DCALL_ASSGN) on a control channel.

11.1.7. Call Termination for Unit

As a SU receives DISC on traffic channel, the SU proceeds to the control channel hunt procedure.

11.2. Unit to Unit Data Call Procedure

This section describes the procedure to call another SU from a SU. The sequence is shown in Figure 15.15-1 and Figure 15.15-2.

11.2.1. Calling Unit Request

A calling SU sends DCALL_REQ on a control channel.

11.2.2. Controller Actions

A TC shall carry out the following as valid replies to DCALL_REQ from a SU:

a) When permit a request and assign a traffic channel immediately, the TC sends DCALL_ASSGN.
b) When queue the call because the traffic channel resources are insufficient or a called unit is being paged, the TC sends DCALL_RESP with “Cause” indicating queue state.
c) When reject a request, the TC sends DCALL_RESP with "Cause" indicating the rejection.
d) (Option) After sending DCALL_ASSGN, the TC sends DCALL_ASSGN_DUP to indicate a late entry state.
e) When permit a request and check the validity of a called unit, the TC sends DCALL_REC_REQ.

11.2.3. Unit Actions

The SU having sent DCALL_REQ and other SUs in the idle state shall carry out the following as valid replies to the message from a TC:

a) If DCALL_ASSGN is received:
   i) the SUs proceed to the judgment process of message information.
b) If it receives DCALL_ASSGN_DUP is received:
   i) the SUs proceed to the judgment process of message information.
c) If a calling unit receives DCALL_RESP which indicates the queue state:
   i) the calling unit activates Ts_busy timer and waits for a message from the controller.
   ii) If a valid response cannot be received before the timer expires, the calling unit proceeds to the disconnect process described in Section 5.4.
d) If a calling unit receives DCALL_RESP which indicates the rejection state of a called unit or TC:
   i) the calling unit proceeds to the idle state.
e) If a calling unit receives DCALL_RESP which indicates no response from a called unit:
   i) the calling unit proceeds to the idle state.
f) If a calling unit cannot receive any valid reply before Ts_ind timer expires:
   i) the calling unit proceeds to the idle state.
g) If a called unit in the idle state receives DCALL_REC_REQ:
   i) the calling unit sends DCALL_REC_RESP as described below.

11.2.4. Availability Check to Called Unit

When a TC receives DCALL_REQ, it may check the validity of a called SU by sending DCALL_REC_REQ. When a called SU receives DCALL_REC_REQ, it shall response with DCALL_REC_RESP. Then, a called SU shall carry out the following actions:

a) If a called unit has used “Cause” indicating the rejection state:
   i) the called unit proceeds to the idle state.
b) If a called unit has used “Cause” indicating the permission state:
   i) the called unit continues to wait for the response from the TC or a peripheral data device of the called unit.

A TC shall reply as follows according to "Cause" field of DCALL_REC_RESP:

a) If "Cause" field shows rejection state:
   i) the TC sends DCALL_RESP which indicates the rejection state to a calling unit.
b) If "Cause" field shows permission state:
   i) the TC sends DCALL_ASSGN to assign a traffic channel.
c) If the TC cannot receive DCALL_REC_RESP before Tr_ack timer expires:
   i) the TC sends DCALL_RESP which indicates no response from a called unit to a calling unit.

11.2.5. Traffic Channel Assignment

SUs that received DCALL_ASSGN shall move to the traffic channel designated in the message in the following conditions:

a) Unit ID of the calling SU is identical with Source Unit ID in the message.
b) Unit ID of a SU in the idle state is identical with Destination Unit ID in the message.

SUs that received DCALL_ASSGN_DUP shall move to the traffic channel designated in the message in the following conditions:

a) Unit ID of a SU is identical with either of Unit ID in the message.

Refer to Section 5.3.2.2 for the state of a SU when it moves to a traffic channel.

11.2.6. Traffic Channel Maintenance

On a traffic channel, a SU and the TC transmit using DCALL and DCALL_ACK.
While the traffic channel is in use, the TC continuously sends DCALL_ASSGN_DUP (or DCALL_ASSGN) on the control channel, at the interval of Tr_dup timer.

The TC shall work in Message Trunking Mode.

11.2.7. Call Termination for Controller

The calling SU, the called SU, or the TC can terminate a call.

The TC shall send DISC to traffic channel when the following states occur:

a) After the traffic channel is assigned, a SU does not transmit before Tr_inact timer expires.
b) After a SU transmission finishes, no traffic on the traffic channel occurs before Tr_hold timer expires.
c) Tr_tch Call Time timer expires.
d) A traffic channel is abandoned to another service request that has higher priority.
e) DISC_REQ is received from a SU.

Additionally, the TC stops sending DCALL_ASSGN_DUP (or DCALL_ASSGN) on a control channel.

11.2.8. Call Termination for Unit

If a SU terminates the call, it sends DISC_REQ according to Section 5.5.

Since a TC sends either of following messages when receiving DISC_REQ, a SU shall behave according to the message:

a) If DISC is received:
   i) both SUs start the control channel hunt procedure.
b) If a SU cannot receive DISC before Ts_ack timer expires:
   i) the SU that has sent DISC_REQ starts the control channel hunt procedure.

12. Short Data Call

This section describes the procedures for Call Setup and Call Termination for short data call on control channels.

12.1. Broadcast Short Data Call Procedure

This section describes the procedure to send short data from a SU to a group. The sequence is shown in Figure 15.16-1.

12.1.1. Calling Unit Request

A calling SU sends SDCALL_REQ on a control channel.

12.1.2. Controller Actions

A TC shall carry out the following as valid replies to SDCALL_REQ from a SU.

a) If the request is permitted and the short data is successfully stored to the controller:
   i) the TC sends SDCALL_RESP to a calling unit, and
   ii) sends SDCALL_REQ to the target Group to transfer the short data.
b) If the request cannot be permitted, the TC sends SDCALL_RESP with “Cause” indicating the rejection state.

To make a short data call on a control channel, the TC stores SDCALL_REQ from the calling unit once, and sends an outbound message by using the stored information.
At first, the calling unit and the controller make a short data call. The controller stores SDCALL_REQ from the calling unit, then the controller sends SDCALL_RESP with Source Unit ID set as the controller Unit ID to the calling unit. Then using the stored information by the controller, the controller sends SDCALL_REQ to the target Group.

12.1.3. Calling Unit Actions

The SU having sent SDCALL_REQ shall carry out the following as valid replies to the message from a TC:

a) If SDCALL_RESP indicating the success state at the TC is received:
   i) the SU proceeds to the idle state.
b) If SDCALL_RESP indicating the rejection state at the TC is received:
   i) the SU proceeds to the idle state.
c) If any valid reply cannot be received before Ts_ack_sh1 timer expires:
   i) the SU proceeds to the idle state.

12.1.4. Called Unit Actions

A SU in the idle state shall carry out the following when its Group ID and the Destination Group ID in the message from a TC are matched:

a) If SDCALL_REQ is accepted:
   i) the SU stores the received short data, and
   ii) proceeds to the idle state.

12.2. Unit to Unit Short Data Call Procedure

This section describes the procedure to send short data from a SU to another SU. The sequence is shown in Figure 15.17-1.

12.2.1. Calling Unit Request

A calling SU sends SDCALL_REQ on a control channel.

12.2.2. Controller Actions

A TC shall carry out the following as valid replies to SDCALL_REQ from a SU:

a) If the request is permitted and the short data is successfully stored to the controller:
   i) the TC sends SDCALL_RESP to a calling unit, and
   ii) sends SDCALL_REQ to a called unit to transfer the short data.
b) If the request cannot be permitted, the TC sends SDCALL_RESP with “Cause” indicating the rejection state.

To make a short data call on a control channel, the TC stores SDCALL_REQ from the calling unit once, and sends an outbound message by using the stored information.
At first, the calling unit and the controller make a short data call. The controller stores SDCALL_REQ from the calling unit, then the controller sends SDCALL_RESP to the calling unit. Next, the controller sends SDCALL_REQ to the calling unit according to the stored information. When the called unit receives SDCALL_REQ from the controller, it sends back SDCALL_RESP. When the controller receives SDCALL_RESP from the called unit, it transfers the SDCALL_RESP to the calling unit.

A TC shall send either of the following outbound messages as a valid reply to SDCALL_RESP from the called unit:

a) When transfer the reply to the calling unit, the TC sends SDCALL_RESP.
b) If SDCALL_RESP cannot be received from a called SU before Tr_ack timer expires:
   i) the TC sends SDCALL_RESP which indicates no response from a called unit to a calling unit.

12.2.3. Calling Unit Actions

A SU having sent SDCALL_REQ shall carry out the following as valid replies to the message from a TC:

a) If SDCALL_RESP indicating the successful data reception at the controller is received:
   i) the SU activates Ts_ack_sh2 timer to wait for the response (SDCALL_RESP) from a called unit.
   ii) If SDCALL_RESP cannot be received before the timer expires, the SU proceeds to the idle state.
b) If SDCALL_RESP indicating the rejection state of a called unit or TC is received:
   i) the SU proceeds to the idle state.
c) If SDCALL_RESP indicating no response from a called SU is received:
   i) the SU proceeds to the idle state.
d) If any valid reply cannot be received before Ts_ack_sh1 timer expires:
   i) the SU proceeds to the idle state.
e) If SDCALL_RESP indicating successful data reception at a called unit is received:
   i) the SU proceeds to the idle state.

12.2.4. Called Unit Actions

A SU in the idle state shall carry out the following when its Unit ID and the Destination Unit ID in the message from the TC are matched:

a) If SDCALL_REQ is accepted:
   i) the SU stores the received short data, and
   ii) sends SDCALL_RESP with “Cause” indicating the successful state, and
   iii) proceeds to the idle state.
b) If SDCALL_REQ is rejected:
   i) the SU sends SDCALL_RESP with “Cause” indicating the rejection state, and
   ii) proceeds to the idle state.

13. Supplementary Services

This section describes the following supplementary services:

a) Status Notice
b) Status Inquiry
c) Emergency Alarm
d) Remote Control

It is also possible to perform these supplementary services on RTCH. In the case of an RTCH, these supplementary services are used with Voice Call usually. Therefore, the procedures for performing these supplementary services on RTCH are the same as the procedures of Section 10. And details of behavior on RTCH in the procedures are shown in REF [2].

13.1. Status Notice Procedure

This section describes the procedure to notify the current status of a SU to another SU in a confirmed delivery type. As another format, the procedure to inform the status from a SU to a TC is also described. The sequence is shown in Figure 15.18-1.
In an unconfirmed type, the response from a called unit is not required. The sequence used in an unconfirmed type is the same as that used for Broadcast Status Notice.

13.1.1. Calling Unit Request

A SU sends STAT_REQ on a control channel.

13.1.2. Controller Actions

A TC shall carry out the following operations as valid replies to the message from a SU:

a) If the request is permitted and received successfully at the controller;
   i) the TC sends STAT_RESP with “Cause” indicating the successful state to a calling unit, and
   ii) sends STAT_REQ to a called unit to transfer the status.
b) If the request cannot be permitted, the TC sends STAT_RESP with “Cause” indicating the rejection state.

A TC shall send one of the following outbound messages as a valid reply to STAT_RESP from a called unit:

a) When transfer the reply to the calling unit, the TC sends STAT_RESP.
b) If STAT_RESP cannot be received from the called SU before Tr_ack timer expires:
   i) the TC sends STAT_RESP which indicates no response from a called unit to a calling unit.

13.1.3. Calling Unit Actions

A SU having sent STAT_REQ shall carry out the following as valid replies to the message from a TC:

a) If STAT_RESP indicating the successful data reception at the controller is received:
   i) the SU activates Ts_ack_st2 timer to wait for the response (STAT_RESP) from a called unit.
   ii) If STAT_RESP cannot be received before the timer expires, the SU proceeds to the idle state.
b) If STAT_RESP indicating the rejection state of a called unit or the TC is received:
   i) the SU proceeds to the idle state.
c) If STAT_RESP indicating no response from a called unit is received:
   i) the SU proceeds to the idle state.
d) If any valid reply cannot be received before Ts_ack_st1 timer expires:
   i) the SU proceeds to the idle state.
e) If STAT_RESP indicating the successful data reception of a called unit is received:
   i) the SU proceeds to the idle state.

13.1.4. Called Unit Actions

A SU in the idle state shall carry out the following when its Unit ID and the Destination Unit ID in the message from a TC are matched:

a) If STAT_REQ is accepted:
   i) the SU stores the received status information, and
   ii) sends STAT_RESP with “Cause” indicating the successful state, and
   iii) proceeds to the idle state.
b) If STAT_REQ is rejected:
   i) the SU sends STAT_RESP with “Cause” indicating the rejection state, and
   ii) proceeds to the idle state.

13.1.5. Unit Updates Controller

There is also the procedure to notify the status from a SU to a TC as a different one from the above procedure to notify from a SU to another SU.
Differences from the procedure above are the following:

a) As a called unit is the controller, Unit ID representing the controller is used.
b) The controller performs the same behavior as a called unit.

13.2. Broadcast Status Notice Procedure

This section describes the procedure to notify the current status of a SU to a Group. The sequence is shown in Figure 15.20-1.

13.2.1. Calling Unit Request

A SU sends STAT_REQ on a control channel.

13.2.2. Controller Actions

A TC shall carry out the following operations as valid replies to the message from a SU.

a) If the request is permitted and received successfully at the controller:
   i) the TC sends STAT_RESP with “Cause” indicating the successful state to a calling unit, and
   ii) sends STAT_REQ to the target Group to transfer the status.
b) If the request cannot be permitted, the TC sends STAT_RESP with “Cause” indicating the rejection state.

13.2.3. Calling Unit Actions

A SU having sent STAT_REQ shall carry out the following as valid replies to the message from TC:

a) If STAT_RESP indicating the successful state at the TC is received:
   i) the SU proceeds to the idle state
b) If STAT_RESP indicating the rejection state at the TC is received:
   i) the SU proceeds to the idle state
c) If any valid reply cannot be received before Ts_ack_st1 timer expires:
   i) the SU proceeds to the idle state

13.2.4. Called Unit Actions

A SU in the idle state shall carry out the following when its Group ID and the Destination Group ID in the message from a TC are matched:

a) If STAT_REQ is accepted:
   i) the SU stores the received status information, and
   ii) proceeds to the idle state.

13.3. Status Inquiry Procedure

This section describes the procedure when a SU inquires the current status of another SU. As another format, the procedure to inquire the status of a SU from a TC is also described. The sequence is shown in Figure 15.19-1.

13.3.1. Calling Unit Inquiry

A calling SU sends STAT_INQ_REQ on a control channel.

13.3.2. Controller Actions

A TC shall carry out the following operations as valid replies to the message from a SU:

a) If the request is permitted and received successfully at the controller:
   i) the TC sends STAT_INQ_RESP with “Cause” indicating the successful state to a calling unit, and
   ii) sends STAT_INQ_REQ to a called unit to transfer the inquiry request.
b) If the request cannot be permitted, the TC sends STAT_INQ_RESP with “Cause” indicating the rejection state.

A TC shall send one of the following outbound messages as a valid reply to STAT_INQ_RESP from the called unit:

a) When transfer the reply to a calling Unit, the TC sends STAT_INQ_RESP.
b) If STAT_INQ_RESP cannot be received from a called SU before Tr_ack timer expires:
   i) the TC sends STAT_INQ_RESP which indicates no response from the called unit to the calling unit.

13.3.3. Calling Unit Actions

A SU having sent STAT_INQ_REQ shall carry out the following as valid replies to the message from a TC.

a) If STAT_INQ_RESP indicating that the controller received data successfully is received:
   i) the SU activates Ts_ack_st2 timer to wait for the response (STAT_INQ_RESP) from a called unit.
   ii) If STAT_INQ_RESP is not received before the timer expires, the SU proceeds to the idle state.
b) If STAT_INQ_RESP indicating the rejection state at a called unit or the TC is received:
   i) the SU proceeds to the idle state.
c) If STAT_INQ_RESP indicating no response from a called unit is received:
   i) the SU proceeds to the idle state.
d) If any valid reply cannot be received before Ts_ack_st1 timer expires:
   i) the SU proceeds to the idle state.

e) If STAT_INQ_RESP indicating successful data reception at a called unit is received:
i) the SU proceeds to the idle state.

13.3.4. Called Unit Actions

A SU in the idle state shall carry out the following when its Unit ID and the Destination Unit ID in the message from a TC are matched.

a) If STAT_INQ_REQ is accepted:
i) the SU sends STAT_INQ_RESP, and
ii) proceeds to the idle state.
b) If STAT_INQ_REQ is rejected:
i) the SU sends STAT_INQ_RESP with “Cause” indicating the rejection state, and
ii) proceeds to the idle state.

13.3.5. Controller to Unit Inquires

There is also the procedure to inquire the status of a SU from a TC as a different one from the above procedure to inquire the status of another SU from a SU.
Differences from the procedure above are as follows:

a) As a calling unit is the controller, Unit ID representing the controller is used.
b) The controller performs the same behavior as a calling unit.

13.4. Emergency Alarm Procedure

A user can notify an emergency condition to a dispatcher. There are two procedures: a notification from a SU to a SU, and a notification from a SU to a TC.

Emergency Alarm is a special status of Status Notice, and its procedure is basically the same as that of Status Notice. The difference is the following:

a) The predefined Emergency values are used as Status.

13.5. Remote Control Procedure

This section describes the procedure that a SU remotely controls another SU. As another procedure, the procedure for a TC to remotely control a SU is also described. The following 4 cases can be considered for this procedure. Although the 4 cases use the same procedures on a control channel, final behaviors varies depending on the contents of Remote Command. The Stun/Revival/Kill sequence is shown in Figure 15.21-1 and the Remote Monitor sequence is shown in Figure 15.22-1. These procedures are basically provided for unit to unit and the procedure for Broadcast is system-dependent.

a) Stun
b) Revival
c) Kill
d) Remote Monitor

13.5.1. Calling Unit Request

A SU sends REM_CON_REQ on a control channel.

13.5.2. Controller Actions

A TC shall carry out the following operations as valid replies to the message from a SU:

a) If the request is permitted and received successfully at the controller:
   i) the TC sends REM_CON_RESP with “Cause” indicating the successful state to a calling unit, and
   ii) sends REM_CON_REQ to a called unit to transfer the request.
b) If the request cannot be permitted, the TC sends REM_CON_RESP with “Cause” indicating the rejection state.

A TC shall send one of the following outbound messages as the valid reply to REM_CON_RESP from a called unit:

a) When transfer the reply to a calling unit, the TC sends REM_CON_RESP.
b) If REM_CON_RESP cannot be received from a called SU before Tr_ack timer expires:
   i) the TC sends REM_CON_RESP which indicates no response from a called unit to a calling unit.

13.5.3. Calling Unit Actions

A SU having sent REM_CON_REQ shall carry out the following operations as valid replies to the messages from a TC:

a) If REM_CON_RESP indicating the successful data reception at the controller is received:
   i) the SU activates Ts_ack_st2 timer to wait for the response (REM_CON_RESP) from a called unit.

ii) If REM_CON_RESP cannot be received before the timer expires, the SU proceeds to the idle state.

b) If REM_CON_RESP indicating the rejection state at a called unit or the TC is received:
   i) the SU proceeds to the idle state.

c) If REM_CON_RESP indicating no response from a called unit is received:
   i) the SU proceeds to the idle state.

d) If any valid reply cannot be received before Ts_ack_st1 timer expires:
   i) the SU proceeds to the idle state.

e) If REM_CON_RESP indicating the successful data reception of a called unit is received:
   i) the SU proceeds to the idle state.

13.5.4. Called Unit Actions

A SU in the idle state shall carry out the following when its Unit ID and the Destination Unit ID in the message from a TC are matched.

a) If REM_CON_REQ is accepted:
   i) the SU stores the received Remote Command and Source Unit ID, and
   ii) sends REM_CON_RESP, and
   iii) starts the operation corresponding to Remote Command described in the following sections.

b) If REM_CON_REQ is rejected:
   i) the SU sends REM_CON_RESP with “Cause” indicating the rejection state, and
   ii) proceeds to the idle state.

13.5.5. Subsequent Actions when Command = Stun/Revival/Kill

A SU shall perform the following operations if the received Remote Command of REM_CON_REQ is one of Stun, Revival and Kill commands:

a) The SU switches the internal state according to the meaning of Stun, Revival or Kill, and then proceeds to the idle state.

13.5.6. Subsequent Actions when Command = Remote Monitor

A SU shall perform the following operations if the received Remote Command of REM_CON_REQ is Remote Monitor:

a) The SU performs the individual call procedure described in Section 10.4. Unit IDs are set as below:
   Source Unit ID = Destination Unit ID contained in REM_CON_REQ
   Destination Unit ID = Source Unit ID contained in REM_CON_REQ

13.5.7. Controller Remotely Controls Unit

There is also the procedure where a TC remotely controls a SU as a different format from the above procedure where a SU remotely controls another SU.

Differences from the procedure above are the following:

a) As a calling unit is the controller, Unit ID representing the controller is used.
b) The controller performs the same behavior as a calling unit.

14. System Information Broadcast

A TC sends broadcast information to all SUs on a control channel. The messages do not have the specified address field so that they are applied to all SUs. A SU can recognize the current condition of system resources by receiving the messages.

14.1. Site Information

A TC informs various construction information of a TRS using SITE_INFO. A SU can get information such as control channel structure, access conditions to a control channel and supported and restricted services from this message.

This message shall be sent at the beginning of a superframe.

14.2. Service Information

A TC informs the service information of a TRS using SRV_INFO. A SU can get the supported service information from this message.

This message is always sent with ADJ_SITE_INFO when there is no call message to be sent.

14.3. Control Channel Information

A TC informs current control channel information using CCH_INFO. A SU can get the control channel information to use in the control channel hunt procedure from this message. This message is also used to inform information regarding switching from the current control channel to another, so that a SU can get new control channel information. Furthermore, this message is used to inform information of the control channel added or deleted on any site and a SU can update the control channel list on the site.

14.4. Adjacent Site Information

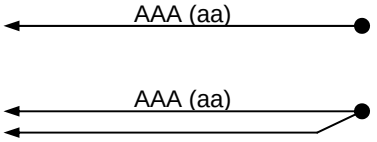
A TC informs the control channel information in adjacent sites using ADJ_SITE_INFO. A SU can get the control channel information of other sites to use in the control channel hunt procedure.

This message is always sent with SRV_INFO when there is no call message to be sent.

15. Sequence Diagrams

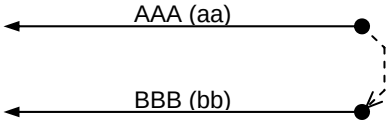
This section describes basic control sequence diagrams for each procedure.

The following symbols are used in control sequence diagrams.

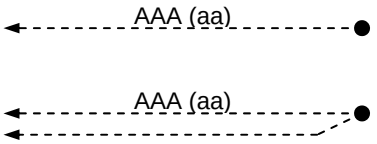


: Normal Message (Single transmission)
This indicates that the message is transmitted once.

: Normal Message (Multiple transmission)
As for outbound, the message is transmitted for the number of specified times.
In the case of outbound UPCH, this indicates that the message is sent for the number of specified times or transmission of multiple frames.
In the case of inbound UPCH, this indicates the transmission of multiple frames.

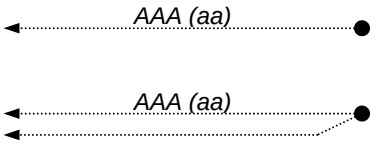


: Normal message (Continuous transmission)
This indicates that the message is continuously sent until the next message.



: Quasi-normal message (Single transmission)
This indicates that the message is transmitted once.

: Quasi-normal message (Multiple transmission)
This is used only for outbound and indicates that the message is sent for the number of specified times.



: Optional message (Single transmission)
This indicates that the message is optionally sent once.

: Optional message (Multiple transmission)
This is used only for outbound and indicates that the message is optionally sent for the number of specified times.

In notation of XXX (xx), “XXX” represents the name of abbreviated layer 3 message and “xx” represents the name of a functional channel. The solid line represents a normal message that is always used in each procedure and the dotted line represents a optional message that is optionally used in each procedure depending on the condition.

The sequence diagrams shown here are control sequences for the typical procedure. In addition, the described functional channel is a typical functional channel, and the layer 3 message does not necessarily use only the functional channel.

15.1. Parameter

This section describes parameters used by a TRS and a SU in a trunked radio system.

Nr and Tr are the parameters used by a Trunking Repeater Site.

Ns and Ts are the parameters used by a Subscriber Unit.

Counter	Min	Default	Max	Description
Nr_ob	1	3	-	The number of times to send the outbound message for multiple times. The number of times can be changed depending on the message type.
Nr_ret	0	0	5	The maximum number of times to resend the outbound paging message when a valid inbound response message cannot be received When reaches Tr_ack, the outbound paging message is resent.
Ns_ret	0	0	5	The maximum number of times to resend the inbound request message when a valid outbound response message cannot be received. When reaches Ts_grp / Ts_ind / Ts_ack / Ts_ack_st / Ts_ack_sh1, the inbound request message is resent.

Table 15.1-1 List of Counters

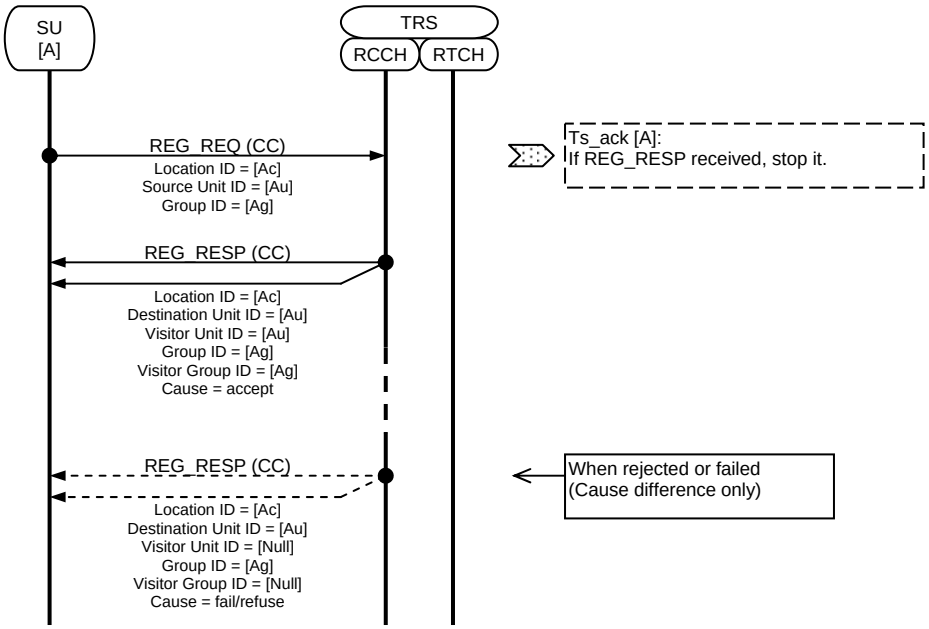
Timer	Min	Default	Max	Description
Tr_spr	-	-	-	The superframe period for the outbound control channel. This period is calculated using the Channel Structure Information value.
Tr_ob	0ms	250ms	500ms	The interval for sending the outbound message for multiple times. However, a paging message might not be processed according to Tr_ob depending on the number of paging grouping since a paging message uses a paging CCCH frame. When multiple messages are generated at the same time, the interval to send these messages becomes longer and might be out of range of Tr_ob. Therefore, this interval time is considered as a base time and may vary depending on the situation.
Tr_dup	0 s	0.5 s	3 s	The interval of sending a traffic channel assignment message for late entry. The messages for late entry use a paging CCCH frame and if paging grouping is used, those use the paging CCCH frame allocated to each paging group. Therefore, since the message might not be processed according to Tr_dup depending on relationship between the number of messages and grouping, this interval time is considered as a base time and may vary depending on the situation.
Tr_hold	0 s	1 s	10 s	Hold Timer for a group call on a traffic channel
	0 s	7 s	30 s	Hold Timer for an individual call on a traffic channel
Tr_tch	-	60 s	-	The call duration timer that a traffic channel can be occupied
Tr_inact	0 s	1 s	10 s	The inactivity timer for detecting idle after assigning a traffic channel
Tr_ring	-	60 s	-	The maximum wait time from the reception request is sent until reception response is sent back in individual call.
Tr_ack	-	5 s	-	The maximum wait time to receive a valid inbound response message
Ts_grp	-	5 s	-	The maximum connection wait time after requesting a group call
Ts_ind	-	10 s	-	The maximum connection wait time after requesting an individual call
Ts_busy	-	30 s	-	The maximum connection wait time after entering queue state in a group call
	-	60 s	-	The maximum connection wait time after entering queue state in an individual call
Ts_ring	-	60 s	-	The maximum response wait time after receiving an individual call
Ts_ack	-	5 s	-	The maximum wait time to receive a valid outbound response message
Ts_ack_st1	-	5 s	-	The maximum wait time to receive a response from a TRS after sending STAT_REQ, STAT_INQ_REQ or REM_CON_REQ
Ts_ack_st2	-	10 s	-	The maximum wait time to receive a response from a SU after sending STAT_REQ, STAT_INQ_REQ or REM_CON_REQ
Ts_ack_sh1	-	5 s	-	The maximum wait time to receive a response from a TRS after requesting a short data call
Ts_ack_sh2	-	10 s	-	The maximum wait time to receive a response from a SU after requesting a short data call

Table 15.1-2 Timer List

The following control sequence diagrams show layer 3 messages used in procedures and those contents and conditions to activate or deactivate the counters and timers.

15.2. Registration

The following figure shows the control sequence when SU [A] (Location ID = Ac, Unit ID = Au, Group ID = Ag) registers at a TRS.



Notes:

1) Visitor Unit ID and Visitor Group ID in REG_RESP shall not be used in the registration process on a Home system.
2) If a SU is a visitor which has different Location ID from a TRS, a TRS arbitrarily assigns unused Visitor Unit ID and Visitor Group ID to a SU. After assigning Visitor Unit ID and Visitor Group ID, a SU shall use these IDs for call processing including call requests.
3) If rejection or failure occurs, TC shall set null to Visitor Unit ID or Visitor Group ID in accordance with the rejection and failure state.

Figure 15.2-1 Sequence Diagram for Registration

15.3. Registration Command

The following figure shows the control sequence when a Trunking Controller (Unit ID = TCu) commands SU [A] (Location ID = Ac and Unit ID = Au) to initiate the registration process.

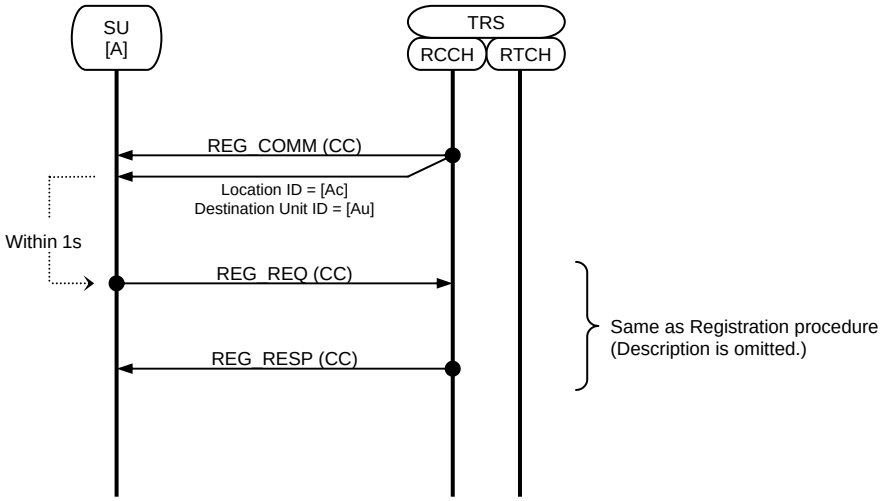


Figure 15.3-1 Sequence Diagram for Registration Command

15.4. Registration Clear

The following figure shows the control sequence when SU [A] (Location ID = Ac, Unit ID = Au) requests to clear the registration at a TRS.

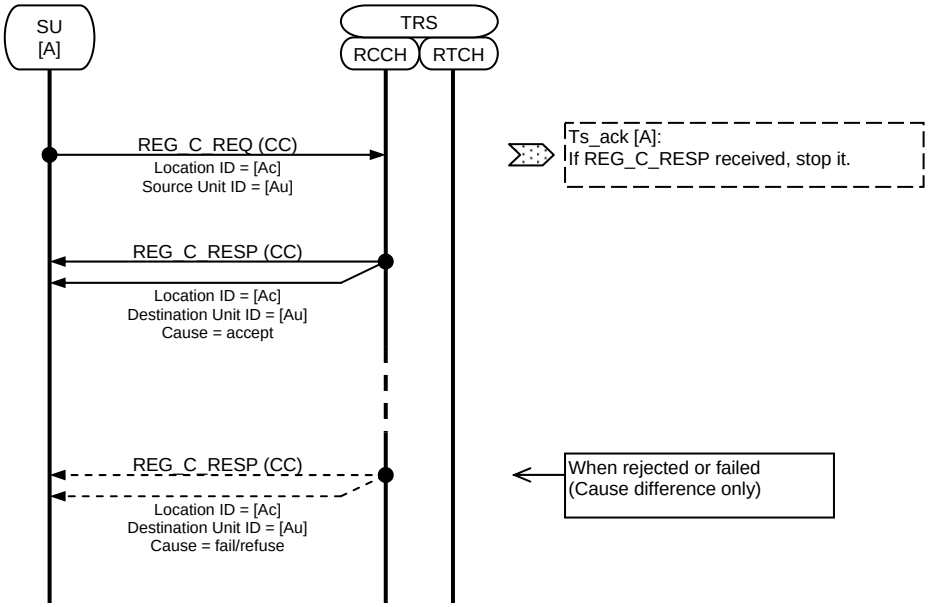
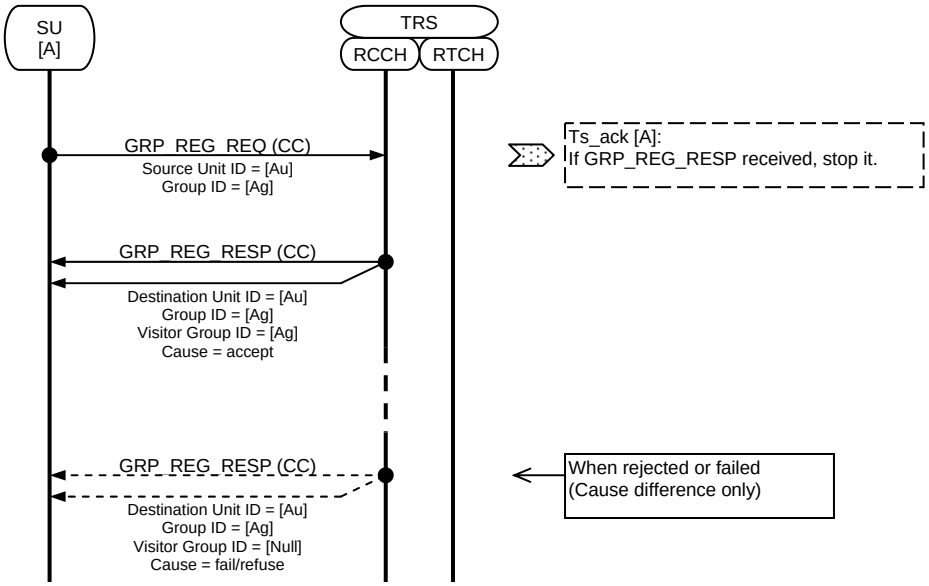


Figure 15.4-1 Sequence Diagram for Registration Clear

15.5. Group Registration

The following figure shows the control sequence when SU [A] (Unit ID = Au, Group ID = Ag) registers to a group at a TRS.



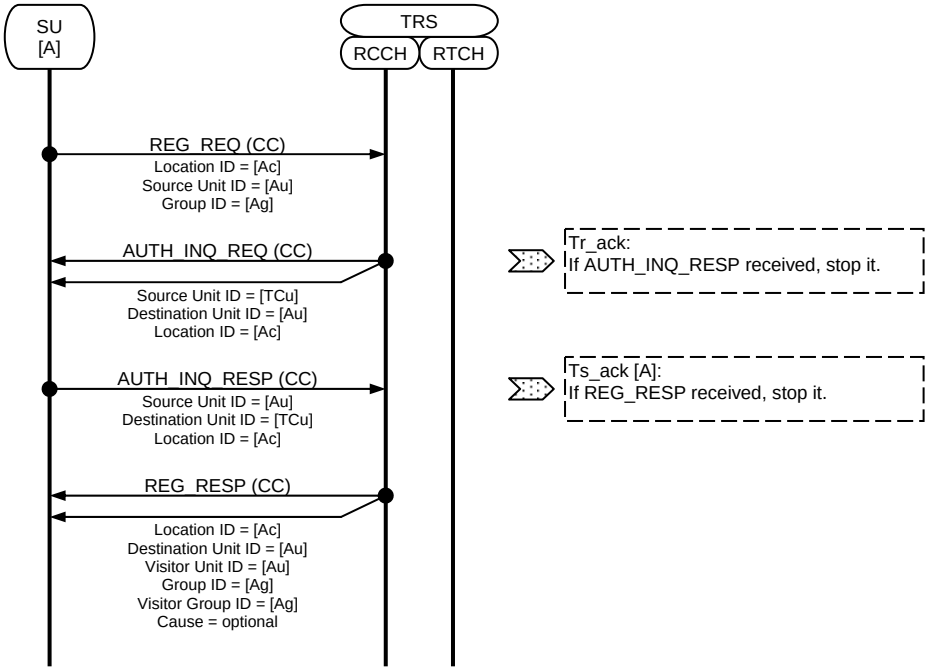
Notes:

1) Visitor Group ID in GRP_REG_RESP shall not be used in the group registration process on a Home system.
2) If a SU is a visitor which has different Location ID from a TRS, a TRS arbitrarily assigns unused Visitor Group ID to a SU, after that a SU shall use the assigned Visitor Group ID for subsequent group call requests.
3) If rejection or failure occurs, TC shall set null to Visitor Group ID.

Figure 15.5-1 Sequence Diagram for Group Registration

15.6. Authentication during Registration Process

The following figure shows the control sequence when a Trunking Controller (Unit ID = TCu) authenticates SU [A] while the SU [A] (Location ID = Ac, Unit ID = Au) carries out the registration process.



Notes:

1) Usage of Visitor Unit ID and Visitor Group ID in REG_RESP refers to the Registration procedure.

Figure 15.6-1 Sequence Diagram for Authentication during Registration

15.7. Authentication in Normal Process

The following figure shows the control sequence when a Trunking Controller (Unit ID = TCu) optionally authenticates SU [A] (Unit ID = Au) that has already completed its registration.

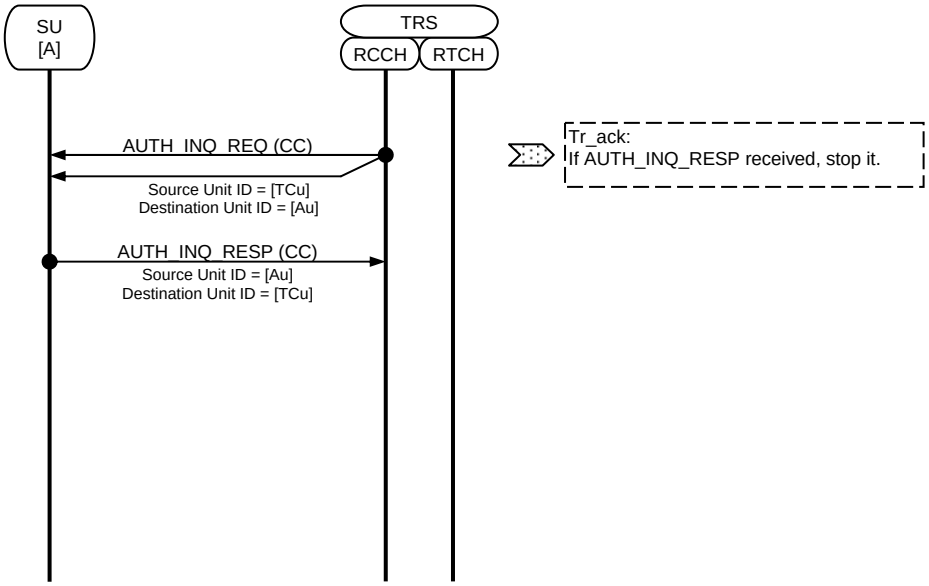


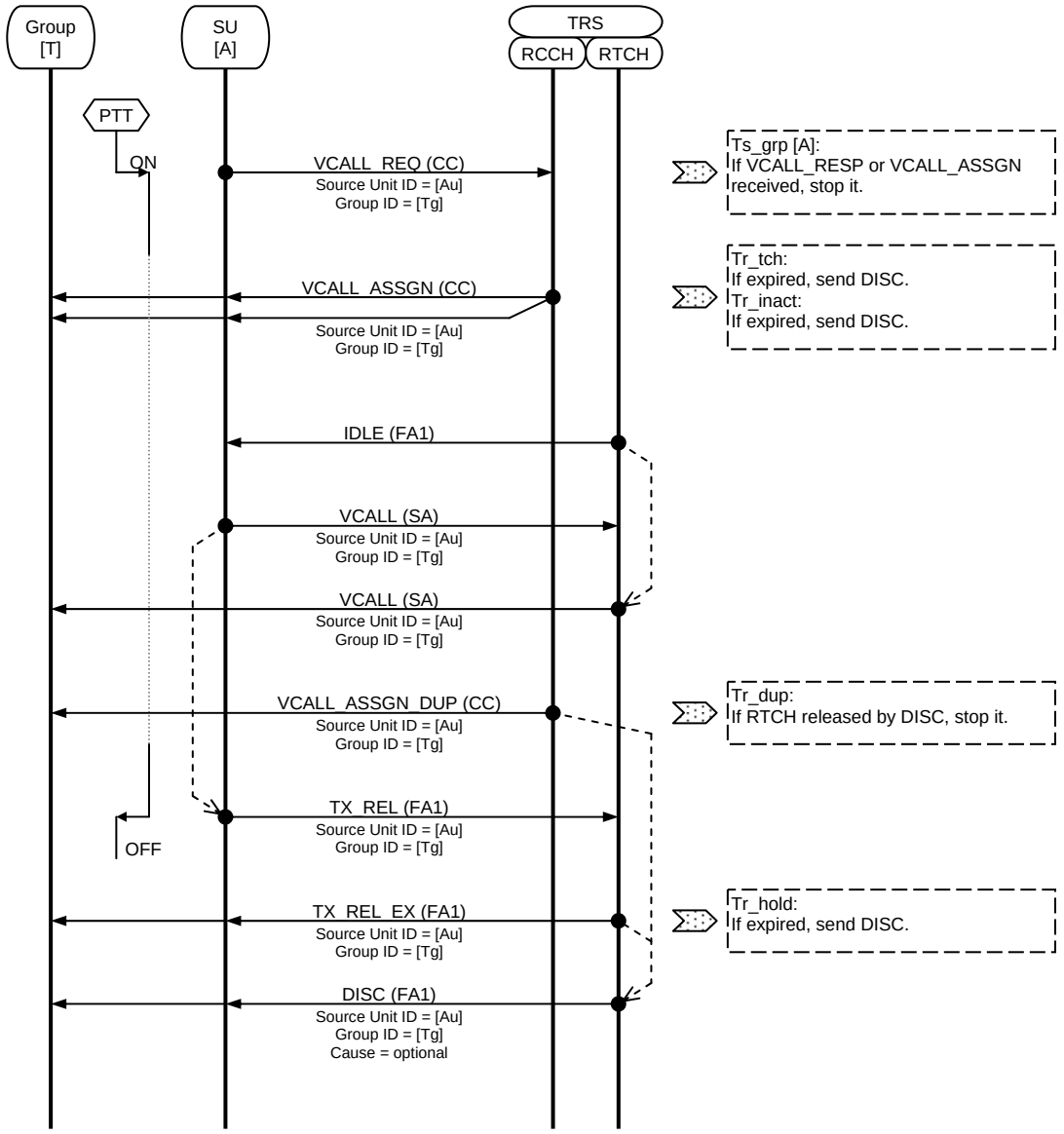
Figure 15.7-1 Sequence Diagram for Authentication in Normal Process

15.8. Conference Group Call

The following figure shows the control sequence when SU [A] (Unit ID = Au) makes a Conference Group Call to Talk Group [T] (Group ID = Tg). The TRS uses Unit ID = TCu.

15.8.1. Connection Phase → Communication Phase → Termination Phase

The following is the sequence until the call on RTCH is terminated after SU [A] initiates the call.



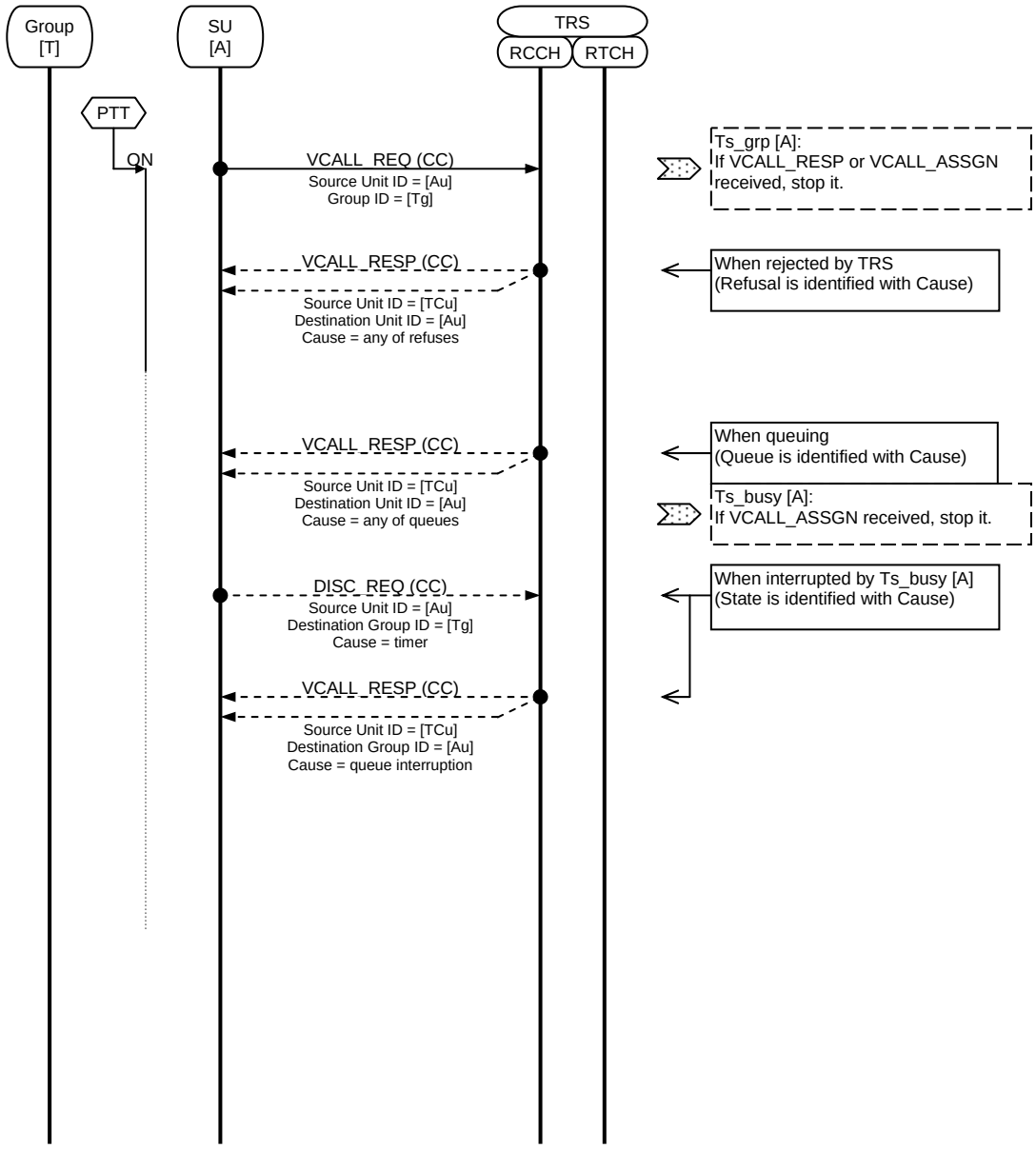
Notes:

1) Source/Dest. ID settings in VCALL_ASSGN and DISC on RTCH refer to ID configuration of VCALL_REQ.

Figure 15.8-1 Sequence Diagram for Conference Group Call - 1

15.8.2. Connection Phase → Connection Refusal or Cancel Phase

The following is the sequence until RTCH is assigned after SU [A] initiates a call.



Notes:

1) This sequence shows 2 types of refusal and cancel states. When the quasi-normal message relevant to these states is sent, the sequence is terminated.

Figure 15.8-2 Sequence Diagram for Conference Group Call - 2

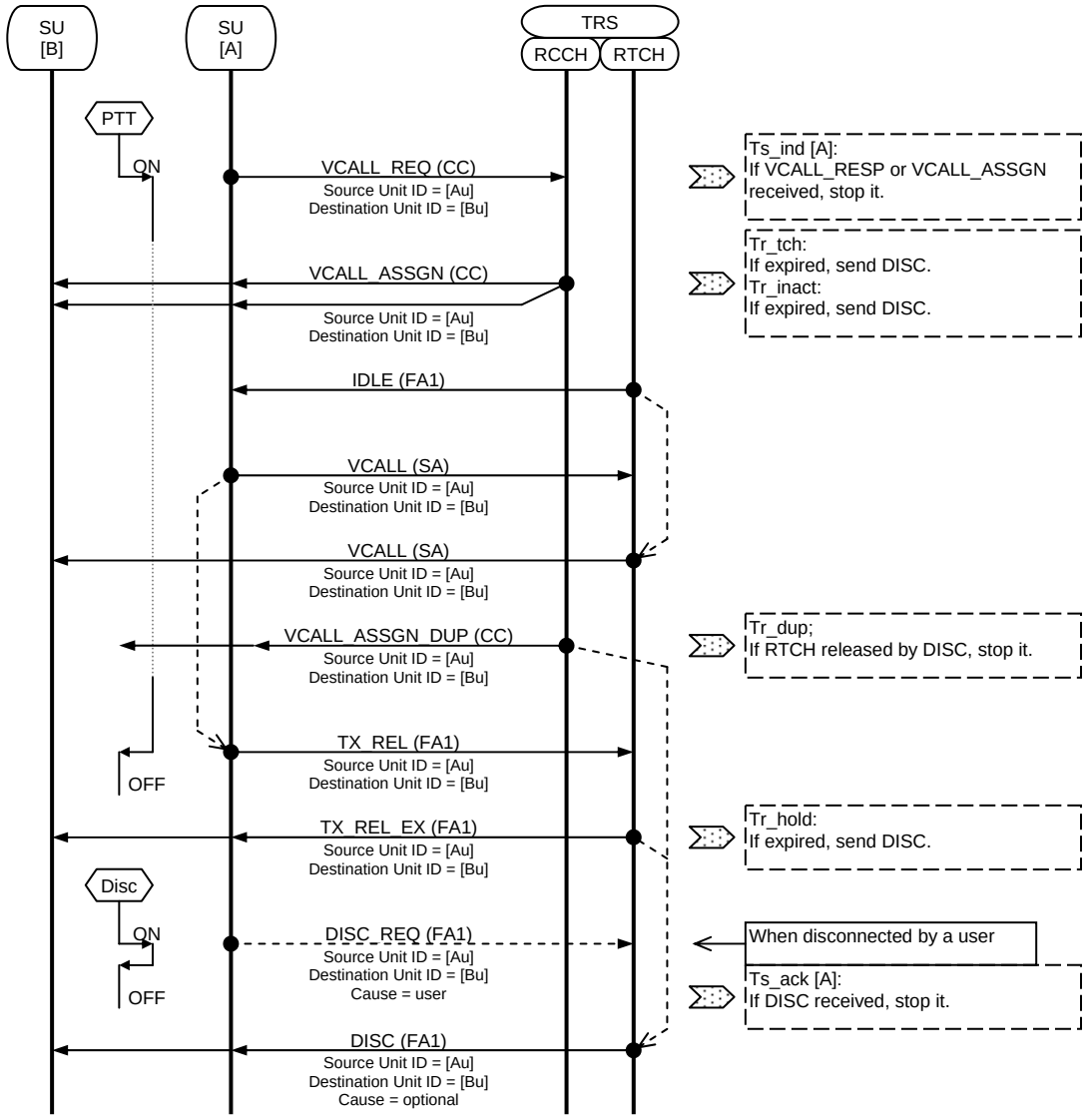
15.9. Individual Call (Example 1)

The following figure shows the control sequence when SU [A] (Unit ID = Au) makes an Individual Call to SU [B] (Unit ID = Bu).

Example 1: This is the same sequence as a Group Call (No availability check to a called party)

15.9.1. Connection Phase → Communication Phase → Termination Phase

The following is the sequence until the call on RTCH is terminated by the user operation after SU [A] initiates the call.



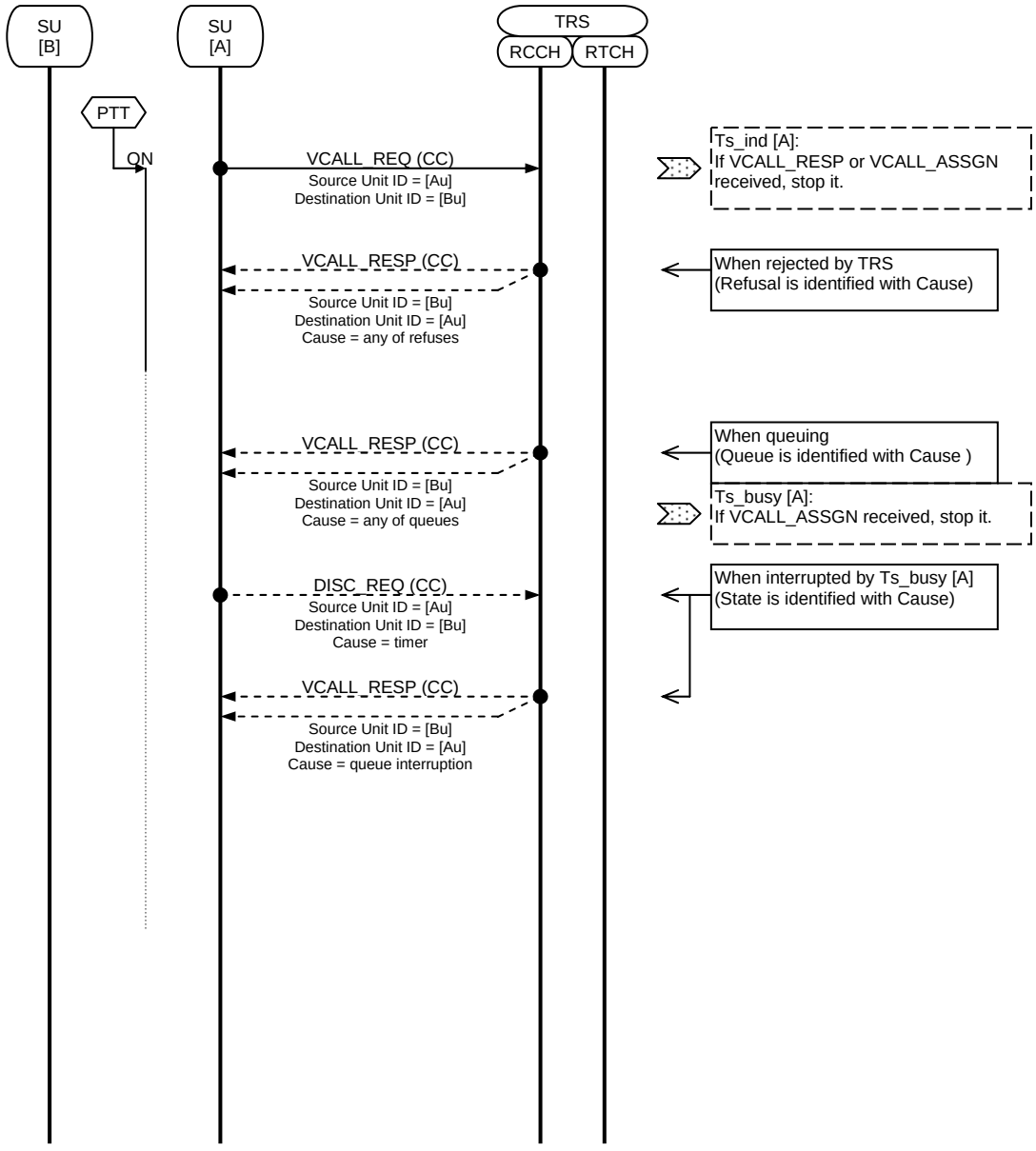
Notes:

1) Source/Dest. ID settings in VCALL_ASSGN and DISC on RTCH refer ID configuration of VCALL_REQ.

Figure 15.9-1 Sequence Diagram for Individual Call (Ex. 1) - 1

15.9.2. Connection Phase → Connection Refusal or Cancel Phase

The following is the sequence until the request is refused by a TRS or canceled by the timer of a SU after SU [A] initiates the call.



Notes:

1) This sequence shows 2 types of refusal and cancel states. When the quasi-normal message relevant to these states is sent, the sequence is terminated.

Figure 15.9-2 Sequence Diagram for Individual Call (Ex. 1) - 2

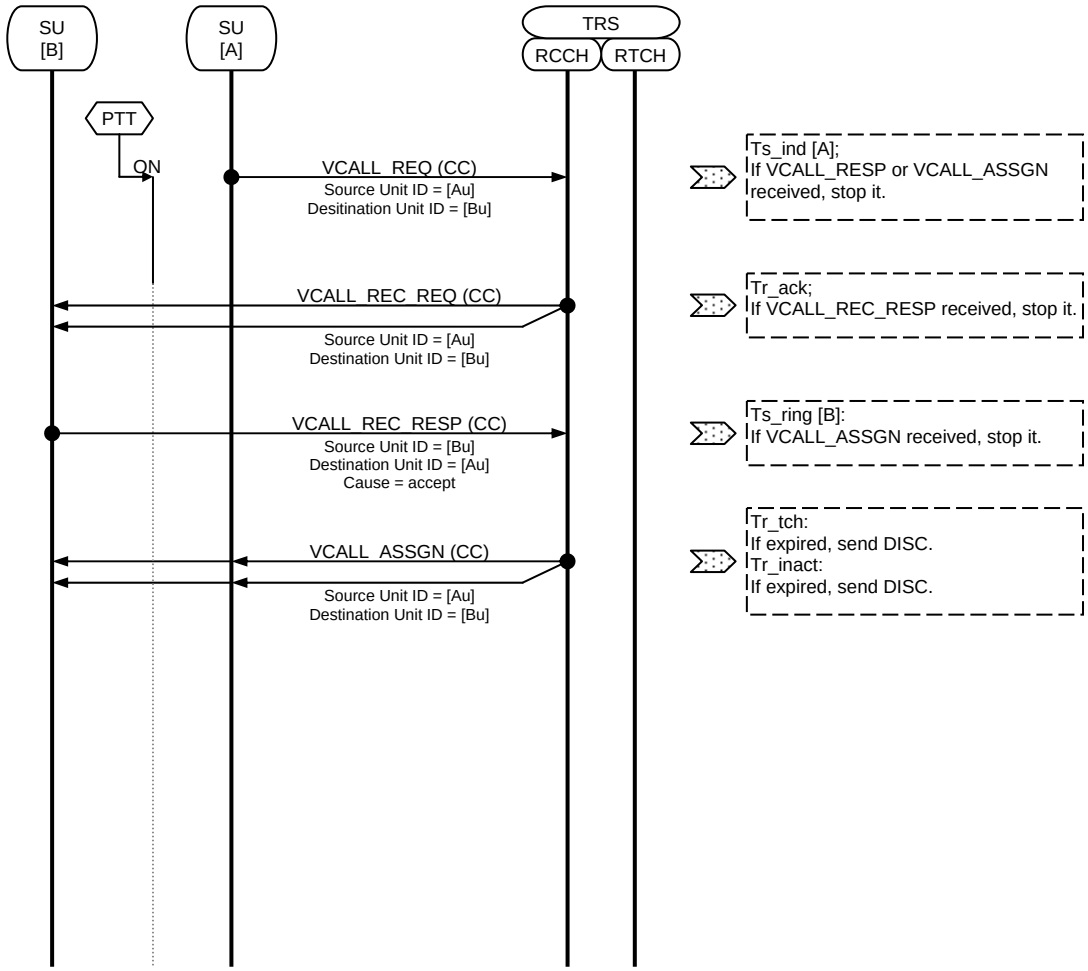
15.10. Individual Call (Example 2)

The following figure shows the control sequence when SU [A] (Unit ID = Au) makes an Individual Call to SU [B] (Unit ID = Bu).

Example 2: This is a sequence appended an availability check to a called party to the Group Call sequence

15.10.1. Connection Phase → Communication Phase

The following is the sequence until RTCH is assigned after SU [A] initiates a call.



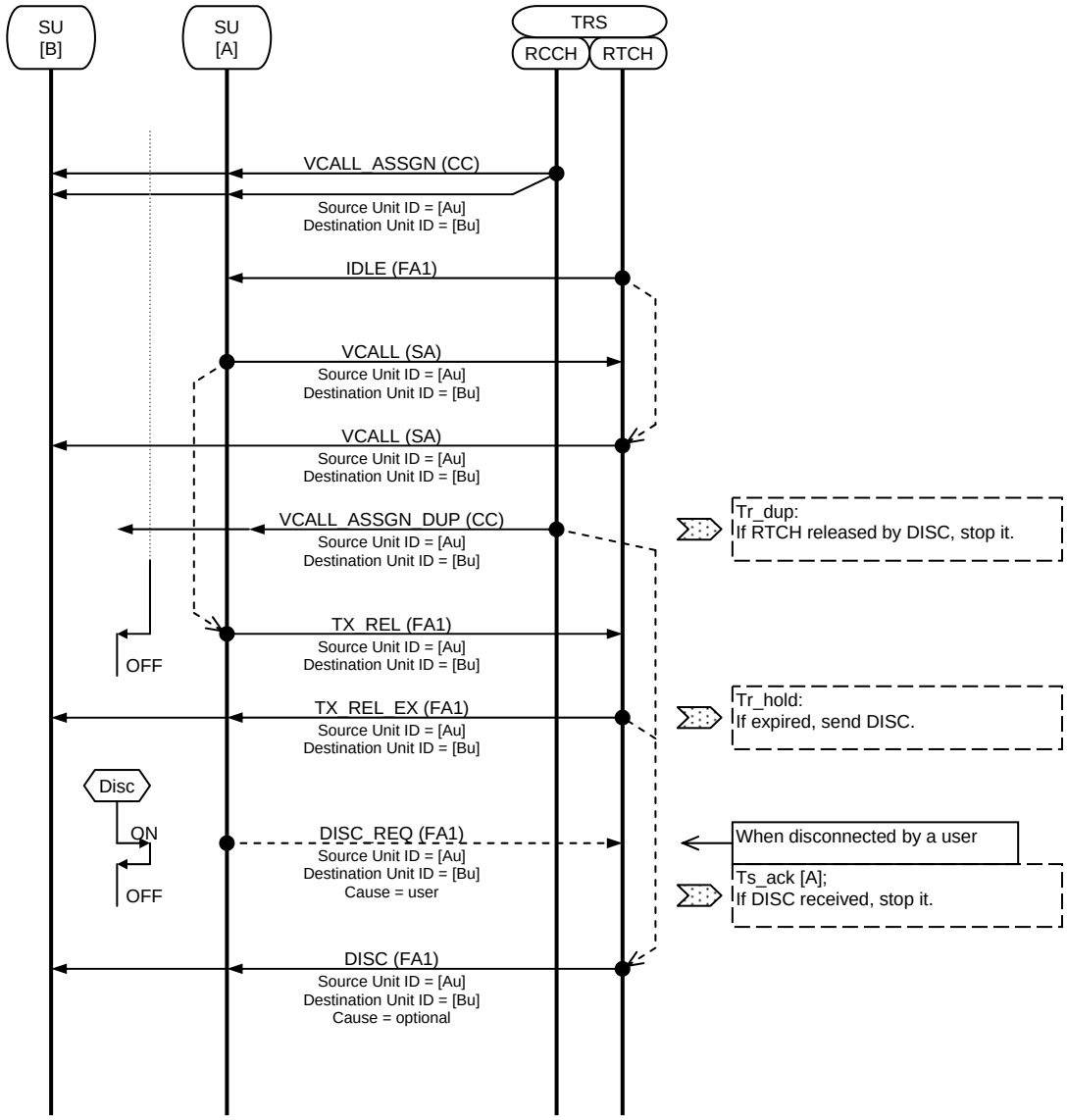
Notes:

1) In the case to check the presence of called party, VCALL_ASSGN is sent after sending VCALL_REC_REQ/RESP. VCALL_RESP is sent to SU [A] if Cause of VCALL_REC_RESP indicates anything other than the acceptance of incoming call.

Figure 15.10-1 Sequence Diagram for Individual Call (Ex. 2) - 1

15.10.2. Communication Phase → Termination Phase

The following is the sequence until the call is terminated by user operation after RTCH is assigned.



Notes:

1) Refer to Section 15.9 and 15.11 for procedures to cancel the communication establishment and to reject a call.
2) Source/Dest. ID setting in VCALL_ASSGN and DISC on RTCH refer to ID configuration of VCALL_REQ.

Figure 15.10-2 Sequence Diagram for Individual Call (Ex. 2) - 2

15.11. Individual Call (Example 3)

The following figure shows the control sequence when SU [A] (Unit ID = Au) makes an Individual Call to SU [B] (Unit ID = Bu).

Example 3: The called SU [B] starts transmitting on a traffic channel first in the same manner as a interconnect call.

15.11.1. Connection Phase → Communication Phase

The following is the sequence until RTCH is assigned after SU [A] initiates a call.

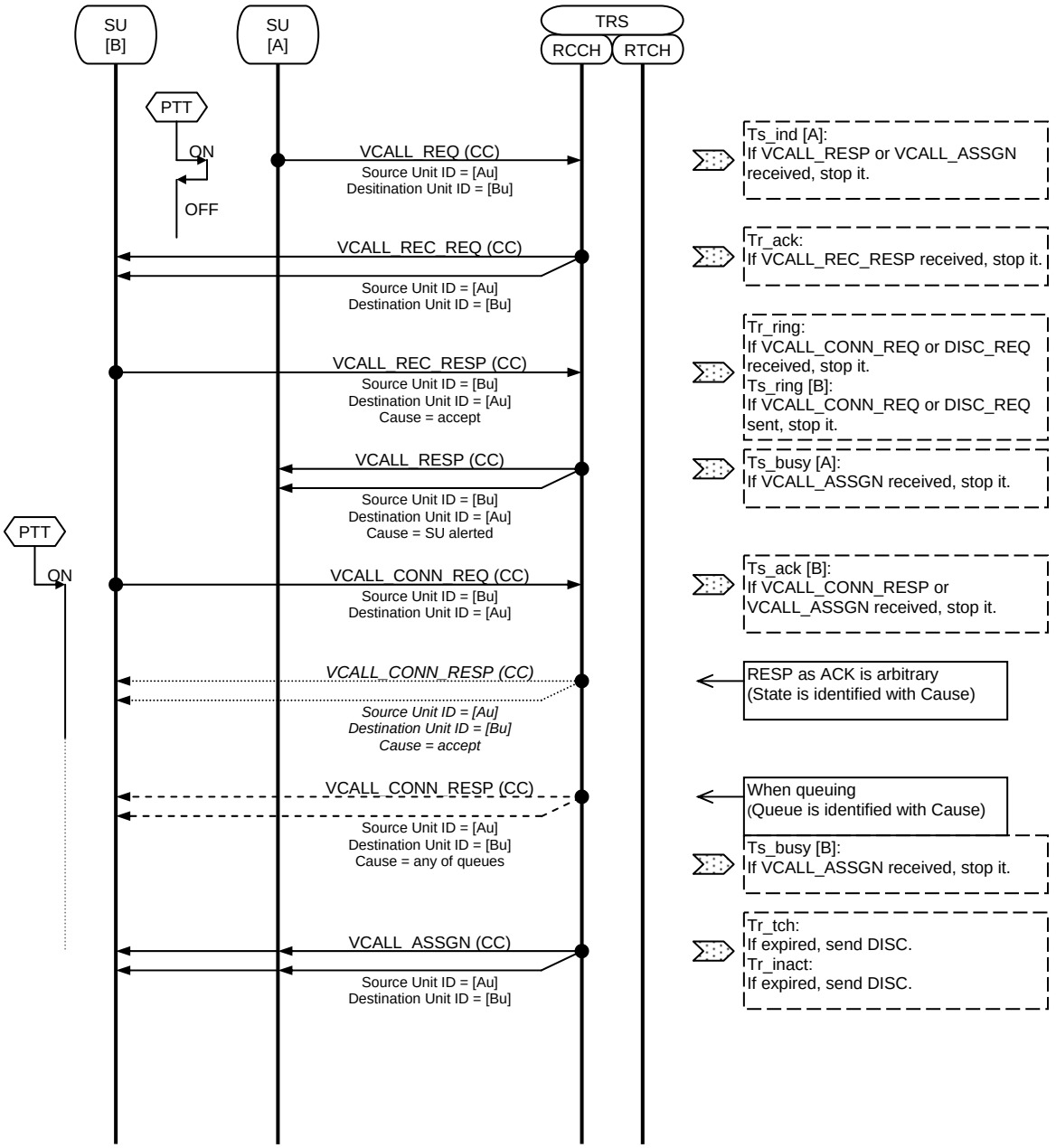
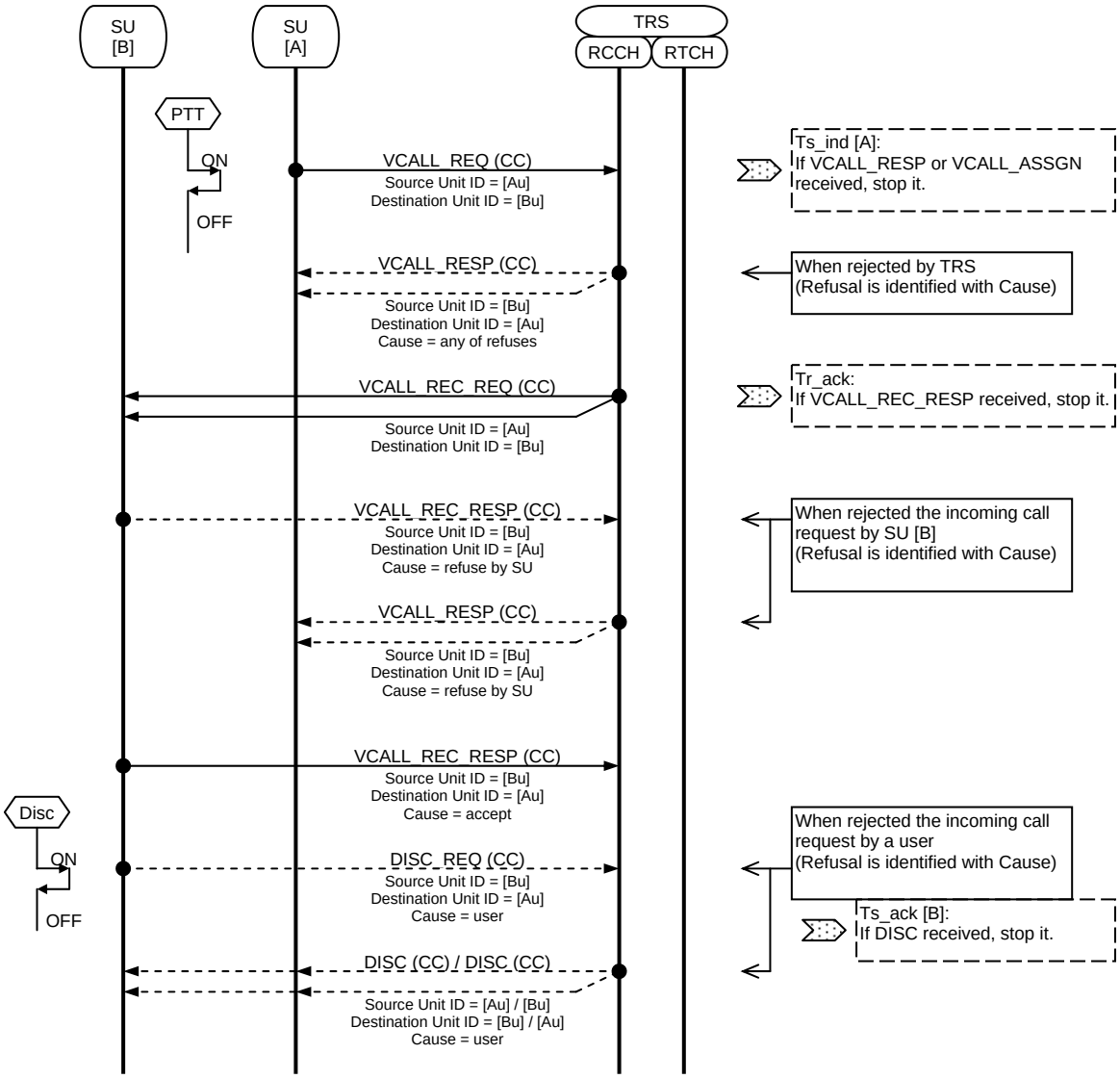


Figure 15.11-1 Sequence Diagram for Individual Call (Ex. 3) - 1

15.11.2. Connection Phase → Connection Refusal Phase

The following is the sequence until the request is refused by a TRS or the incoming call is refused by SU [B] or a user after SU [A] initiates a call.



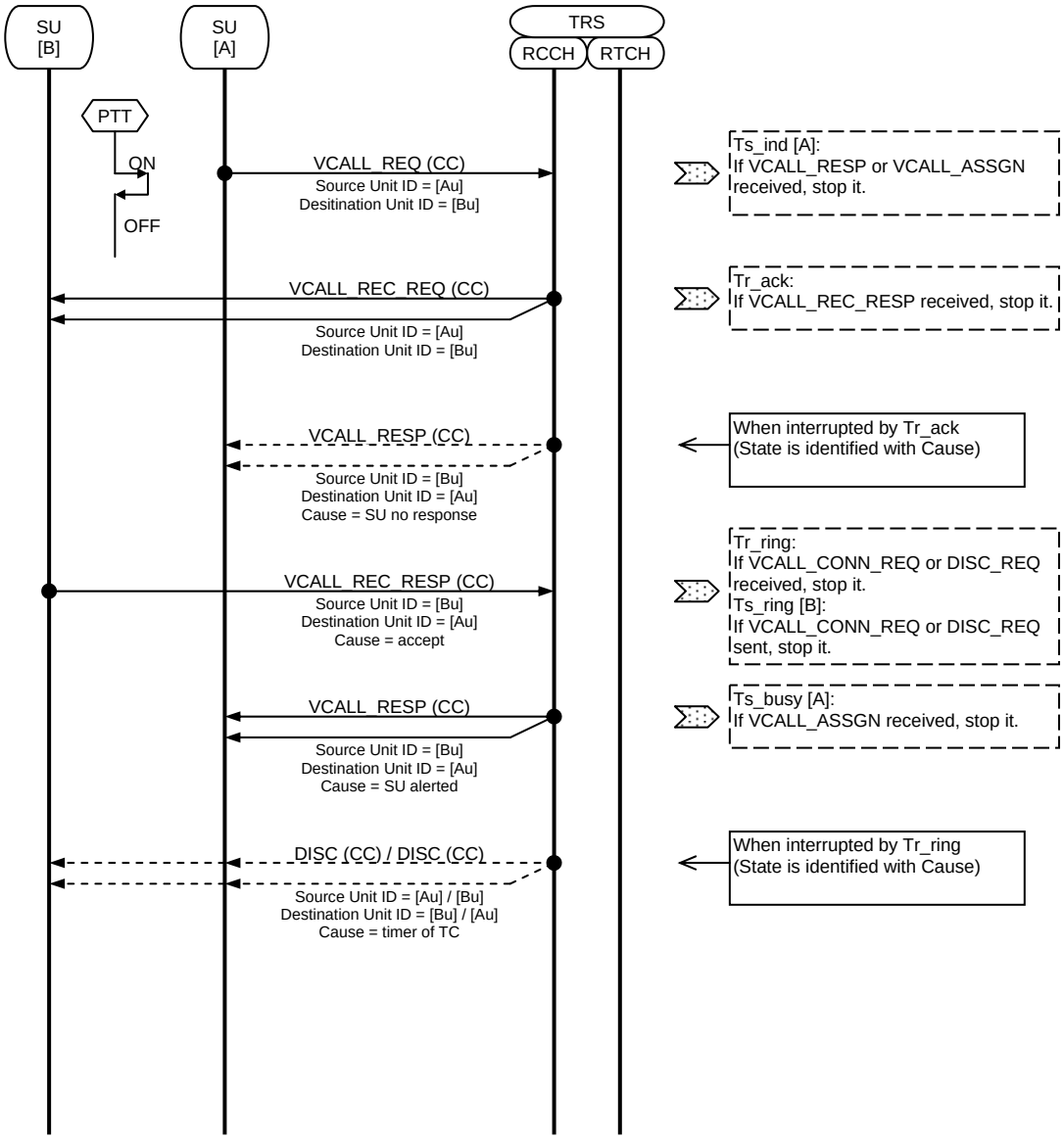
Notes:

1) This sequence shows 3 types of refusal states. When the quasi-normal message relevant to these states is sent, the sequence is terminated. The procedure to refuse an incoming call by SU [B] is different from the procedure to refuse an incoming call by a user.
2) The refusal state of incoming call by SU [B] is determined according to Cause of VCALL_REC_RESP and notified to SU [A] by using Cause of VCALL_RESP.
3) After a called SU is paged, the cancel process uses DISC. DISC is individually sent to SU [A] and SU [B].

Figure 15.11-2 Sequence Diagram for Individual Call (Ex. 3) - 2

15.11.3. Connection Phase → Connection Cancel Phase by TRS

The following is the sequence until the call is canceled by the timer of a TRS after SU [A] initiates a call.



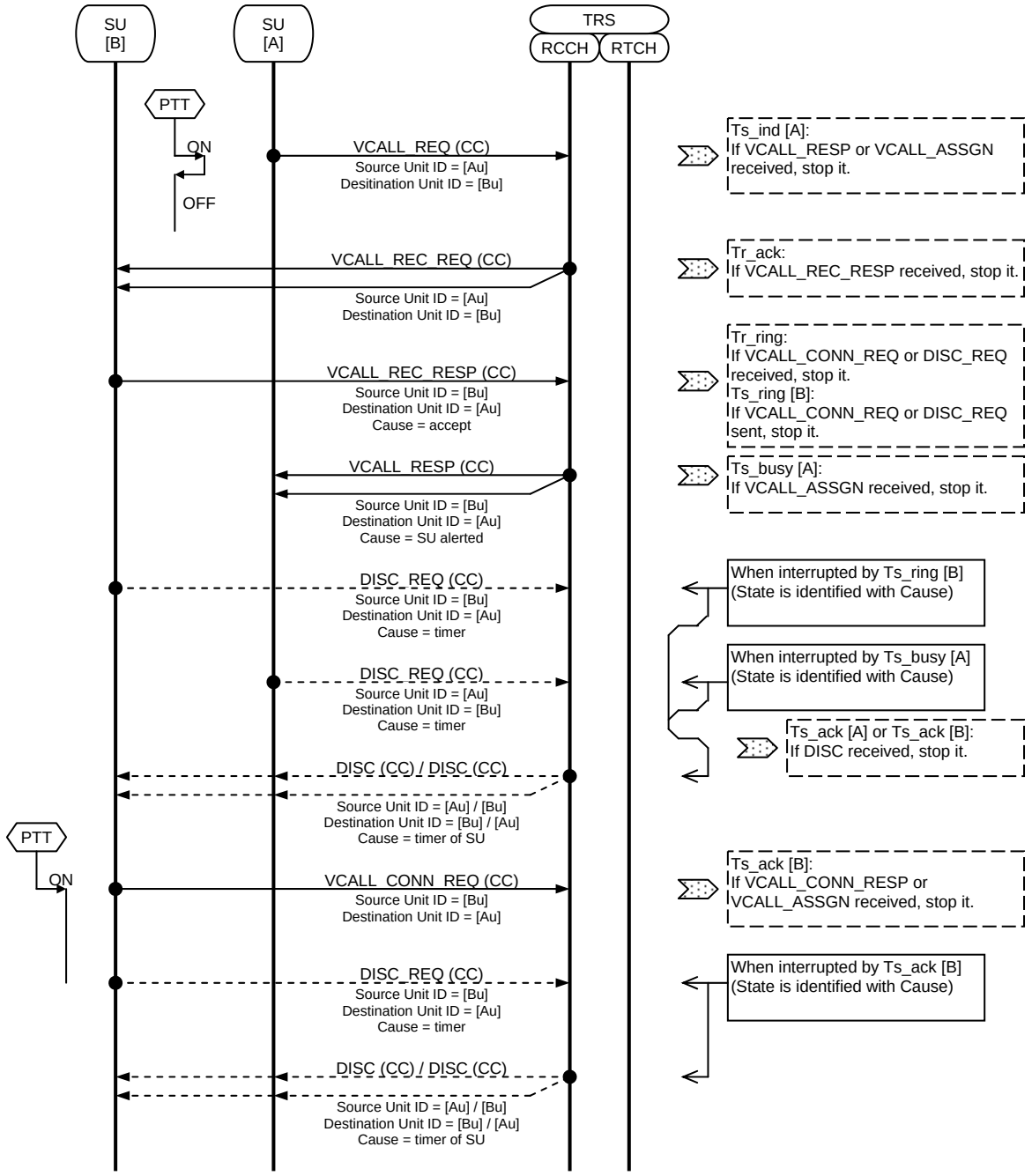
Notes:

1) This sequence shows 2 types of processes canceled by the timer of a TRS. When the quasi-normal message relevant to these states is sent, the sequence is terminated.
2) After a called SU is paged, the termination process uses DISC. DISC is individually sent to SU [A] and SU [B].

Figure 15.11-3 Sequence Diagram for Individual Call (Ex. 3) - 3

15.11.4. Connection Phase to Connection Cancel Phase by a SU

The following is the sequence until the call is canceled by a timer in a SU after SU [A] initiates a call.



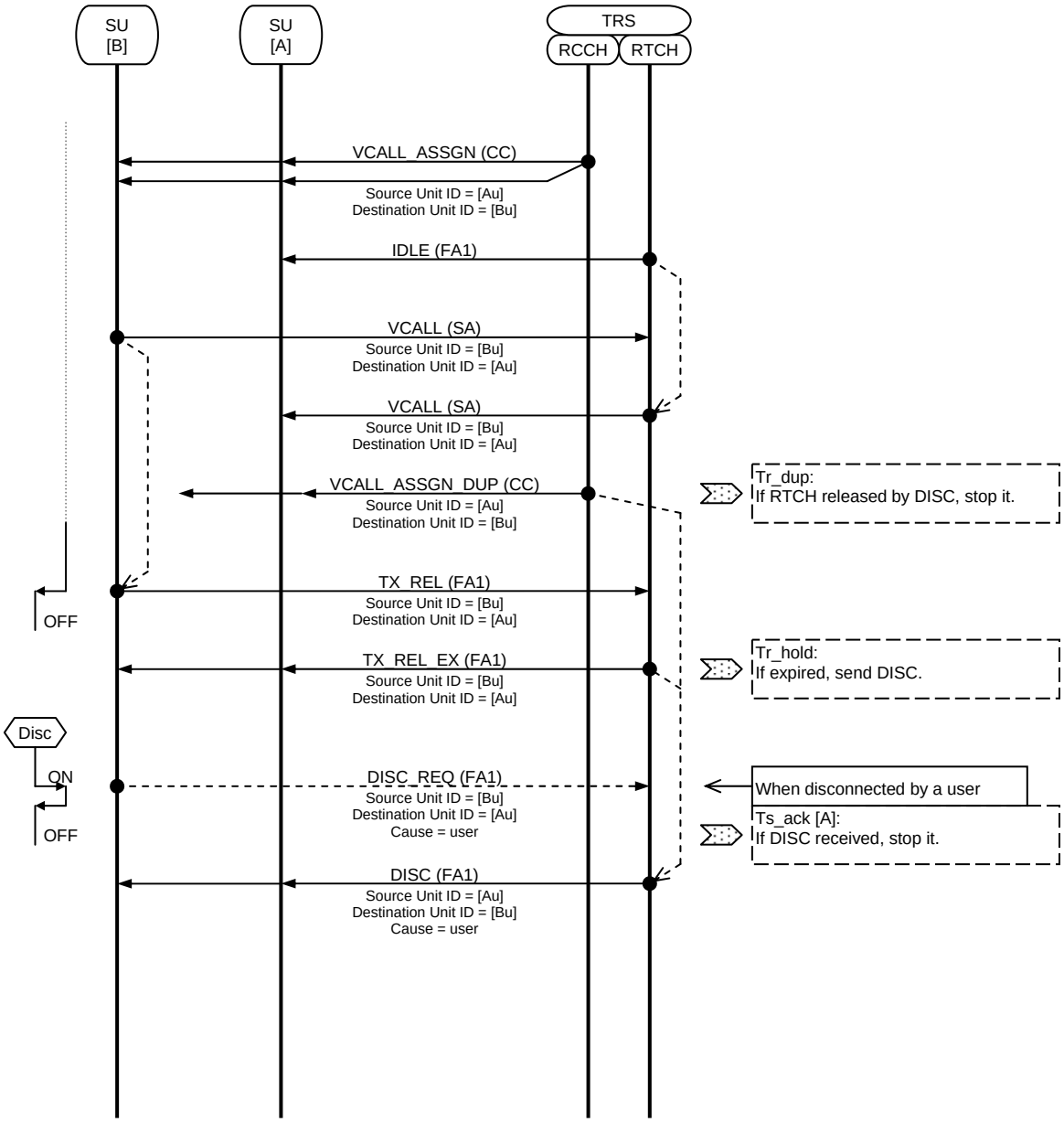
Notes:

1) This sequence represents 3 types of processes canceled by a timer in a SU. When the quasi-normal message relevant to these states is sent, the sequence is terminated.

Figure 15.11-4 Sequence Diagram for Individual Call (Ex. 3) - 4

15.11.5. Communication Phase → Termination Phase

The following is the sequence until the call is terminated by user operation after RTCH is assigned.



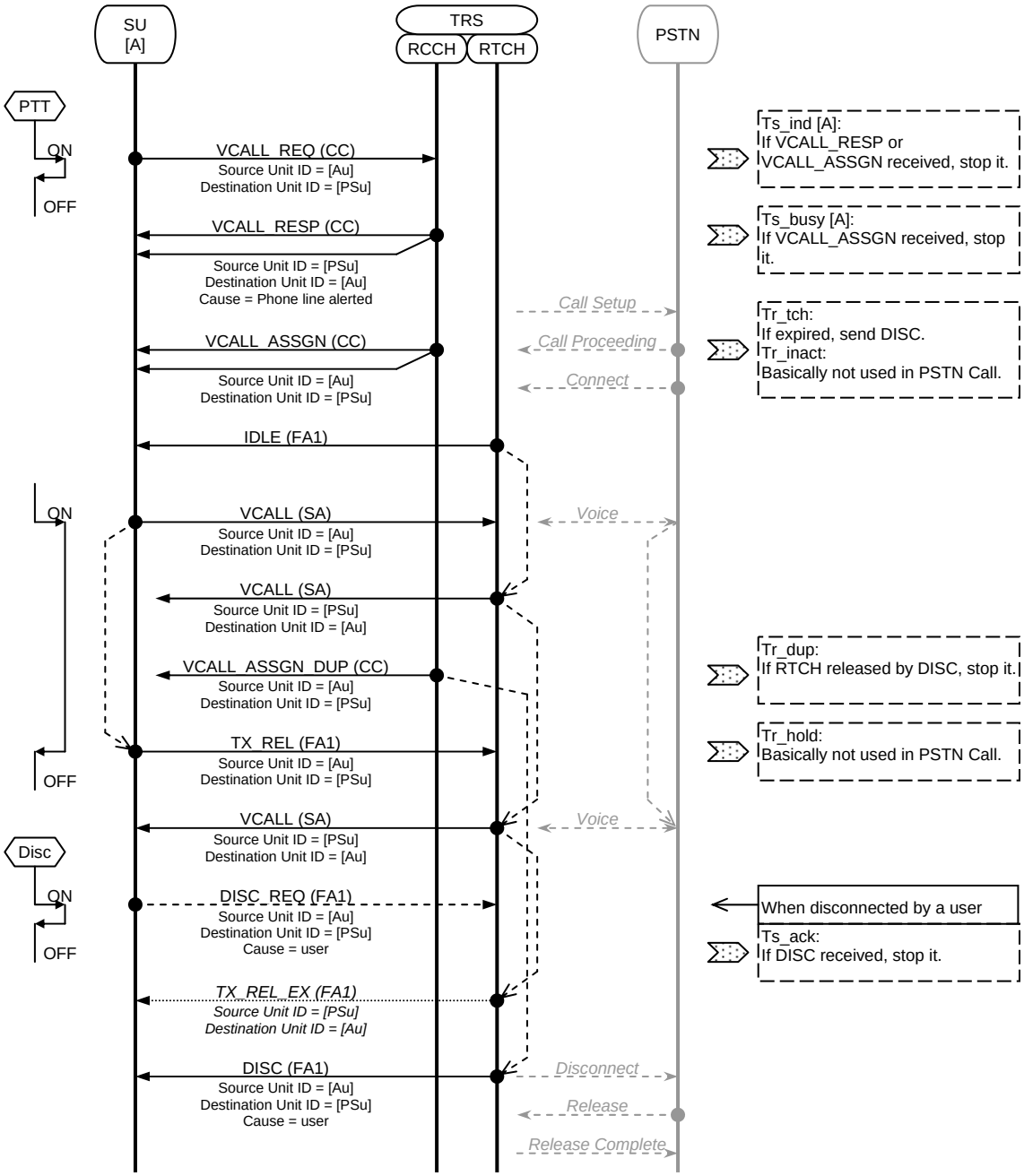
Notes:

1) Content of Cause shall be changed to an appropriate content when DISC is sent from a TC by Tr_hold, etc.
2) Source/Dest. ID setting in VCALL_ASSGN and DISC on RTCH refer to ID configuration of VCALL_REQ.

Figure 15.11-5 Sequence Diagram for Individual Call (Ex. 3) - 5

15.12. Unit to PSTN Voice Call

The following figure shows the control sequence when SU [A] (Unit ID = Au) make a PSTN Call to the telephone line (Unit ID = PSu) connected to a TRS. TRS uses Unit ID = TCu.



Notes:

1) Since the outbound RTCH continues sending audio signal from PSTN, TX_REL_EX on the outbound RTCH is arbitrarily sent out.
2) Refer to Section 15.9 for procedures to cancel a communication establishment and refuse a call.

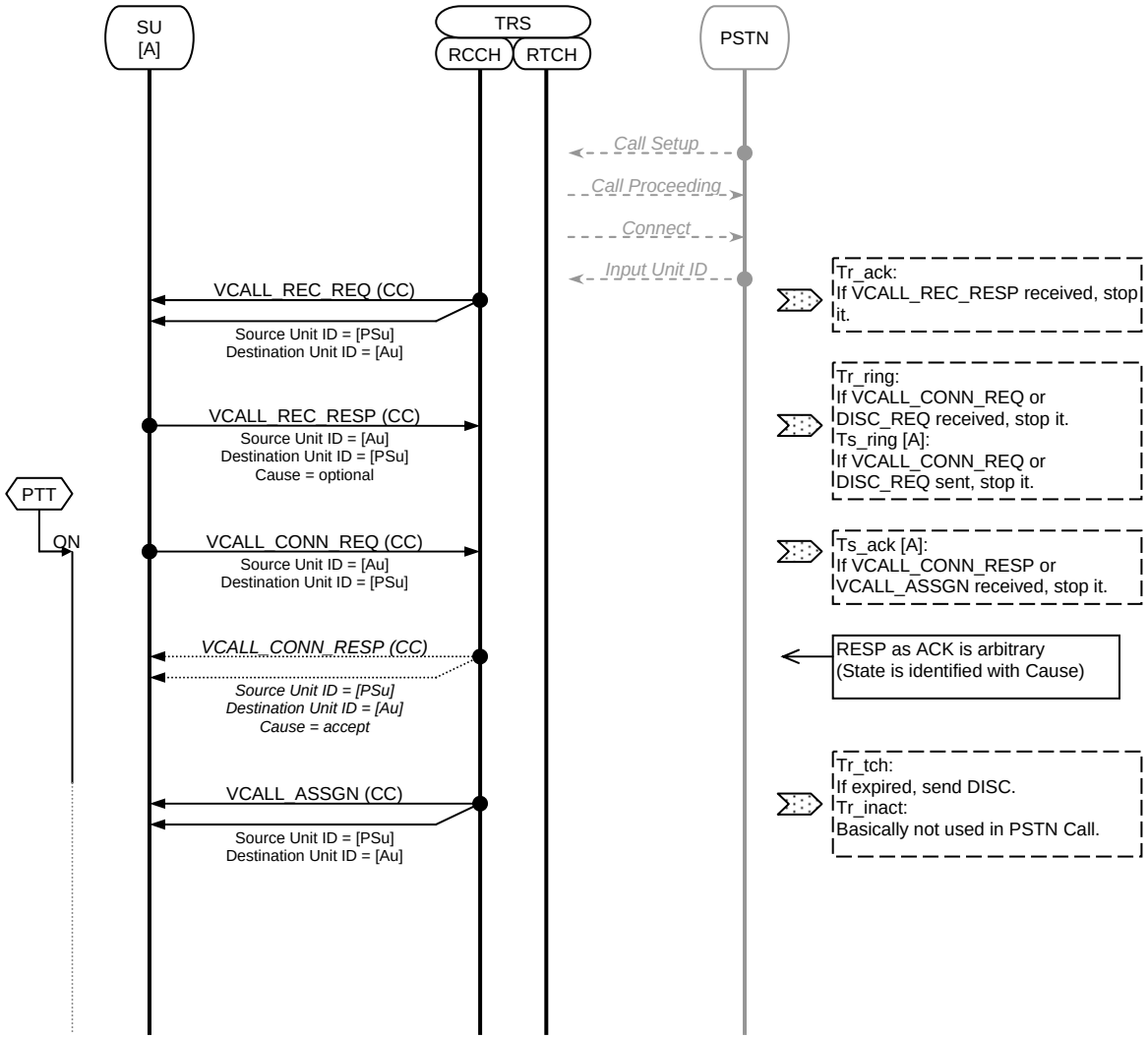
Figure 15.12-1 Sequence Diagram for Unit to PSTN Voice Call

15.13. PSTN to Unit Voice Call

The following figure shows the control sequence when a voice call is initiated from the telephone line (Unit ID = PSu) connected to a TRS to SU [A] (Unit ID = Au).

15.13.1. Connection Phase → Communication Phase

The following is the sequence until RTCH is assigned after PSTN initiates a call.



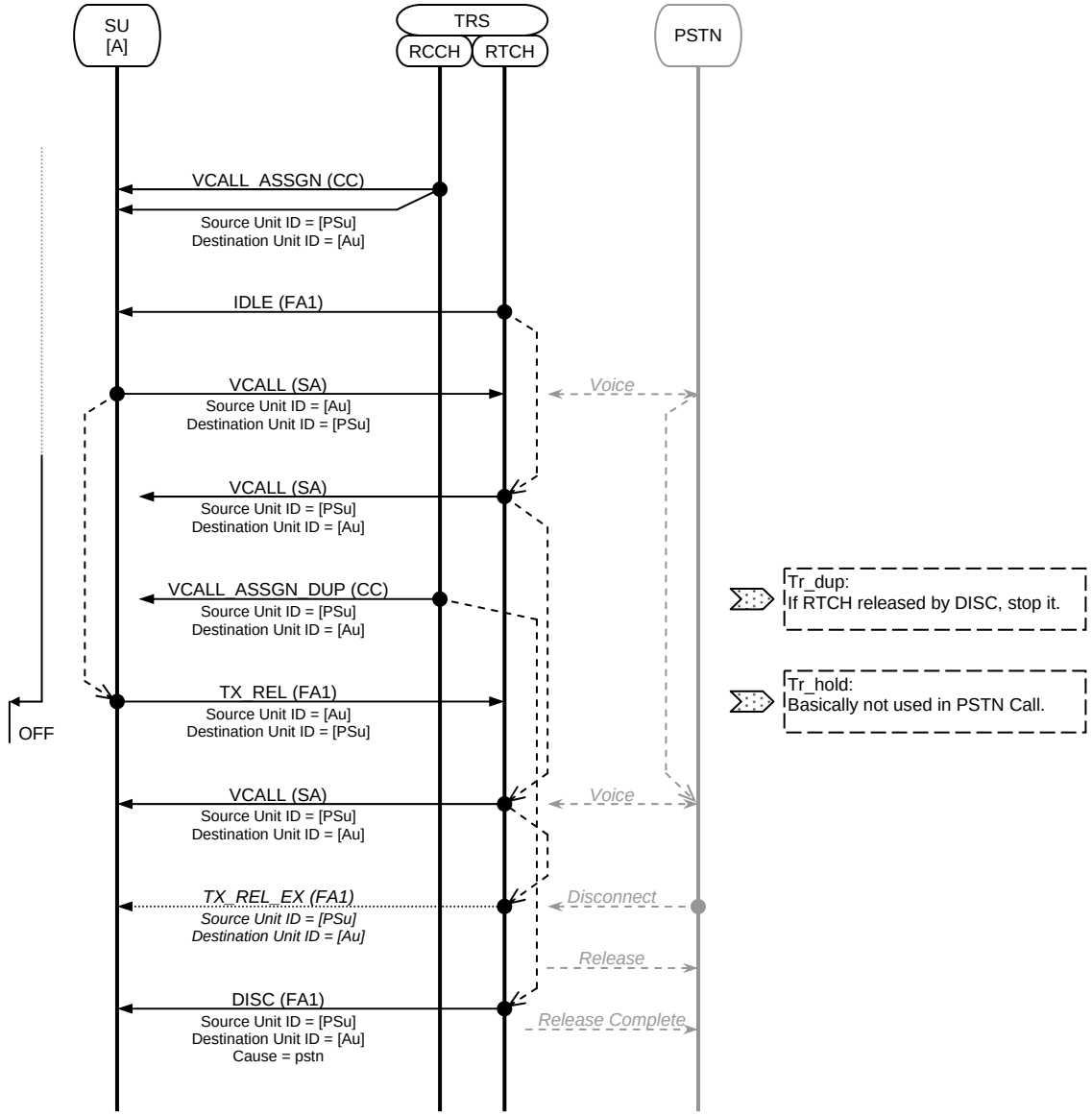
Notes:

1) Procedure between a TRS and a PSTN is not specified.
2) Refer to Section 15.9 for procedures to cancel a communication establishment and refuse a call.

Figure 15.13-1 Sequence Diagram for PSTN to Unit Voice Call - 1

15.13.2. Communication Phase → Termination Phase

The following is the sequence from an assignment of RTCH until end of call by PSTN.



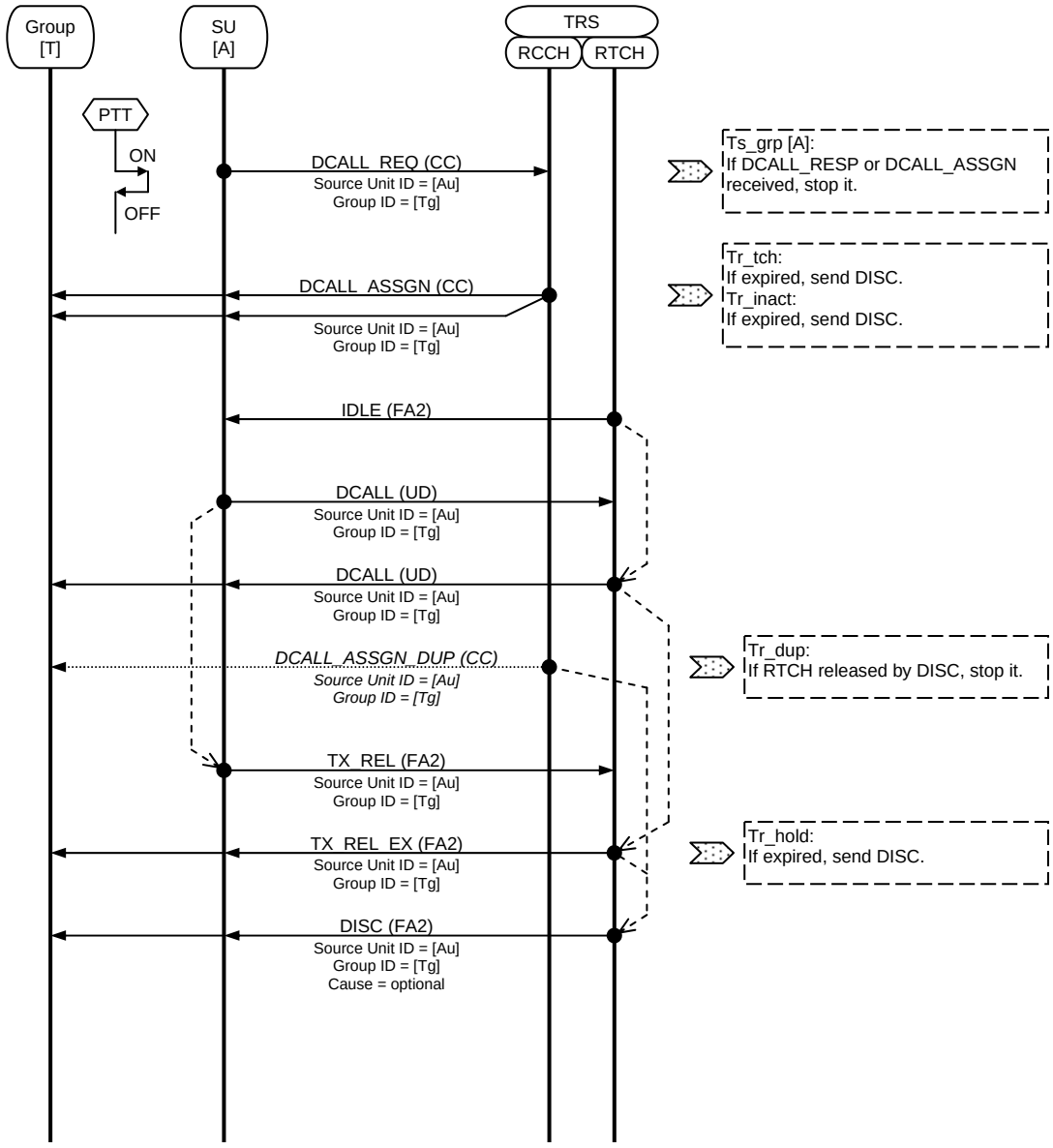
Notes:

1) Since the outbound RTCH continues sending audio signals from PSTN, TX_REL_EX on the outbound RTCH is arbitrarily sent out.
2) For a PSTN Call, Tr_inact and Tr_hold timers are not basically used. Use of these timers is optional.

Figure 15.13-2 Sequence Diagram for PSTN to Unit Voice Call - 2

15.14. Broadcast Data Call

The following sequence shows the control sequence when SU [A] (Unit ID = Au) makes a Broadcast Data Call to Talk Group [T] (Group ID = Tg). TRS uses Unit ID = TCu.



Notes:

1) Refer to Section 15.8 for procedures to cancel a communication establishment and refuse a call. However, different messages relevant to Data Call are used.
2) The configuration of Source and Destination IDs in DCALL_ASSGN and DISC on RTCH refer to ID configuration of DCALL_REQ.

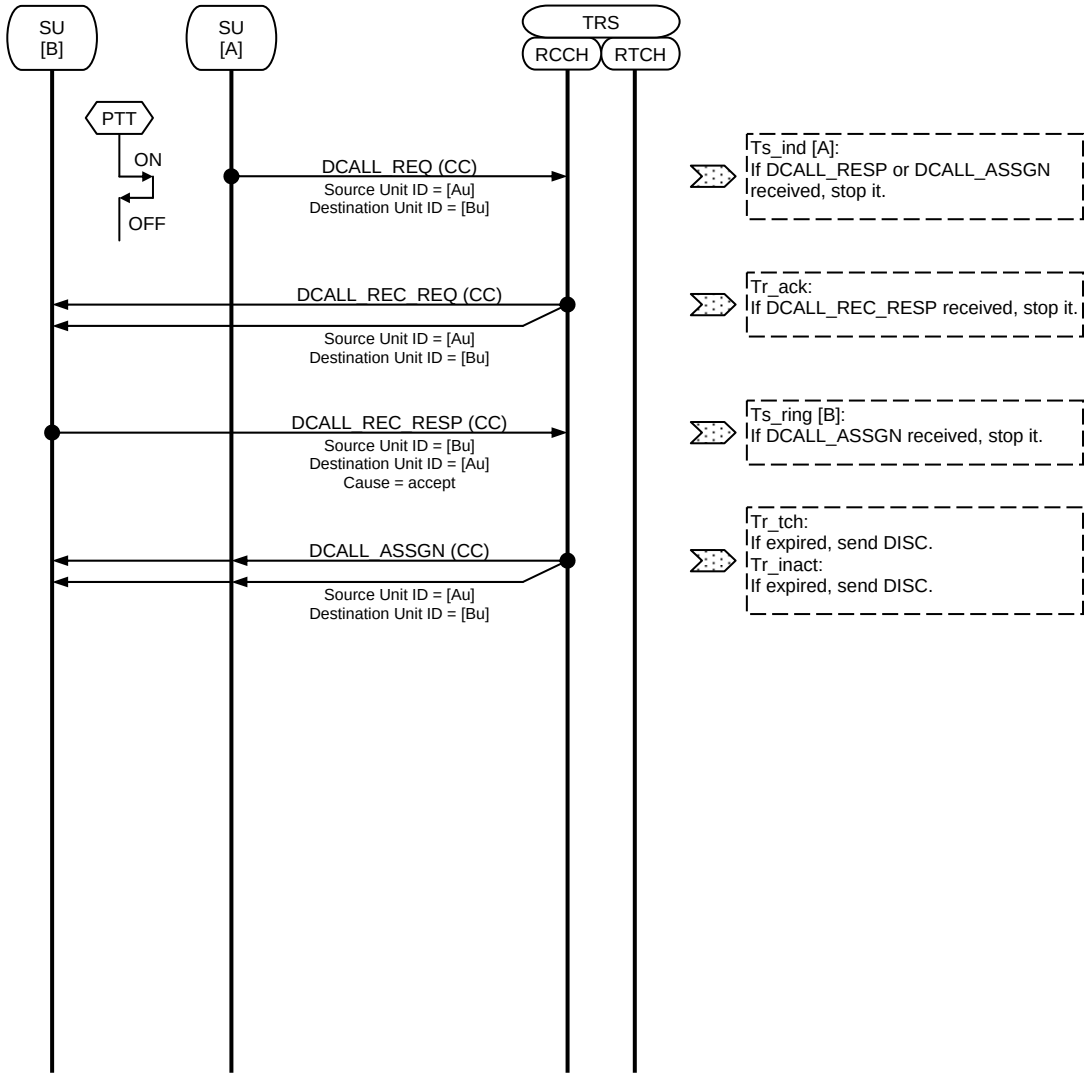
Figure 15.14-1 Sequence Diagram for Broadcast Data Call

15.15. Unit to Unit Data Call

The following figure shows the control sequence when SU [A] (Unit ID = Au) makes a Unit to Unit Data Call to SU [B] (Unit ID = Bu). In the case of a Data Call, the sequence of an Individual Call in the Section 15.10 Example 2 is applied in principle.

15.15.1. Connection Phase → Communication Phase

The following is the sequence from a call request of SU [A] until an assignment of RTCH.



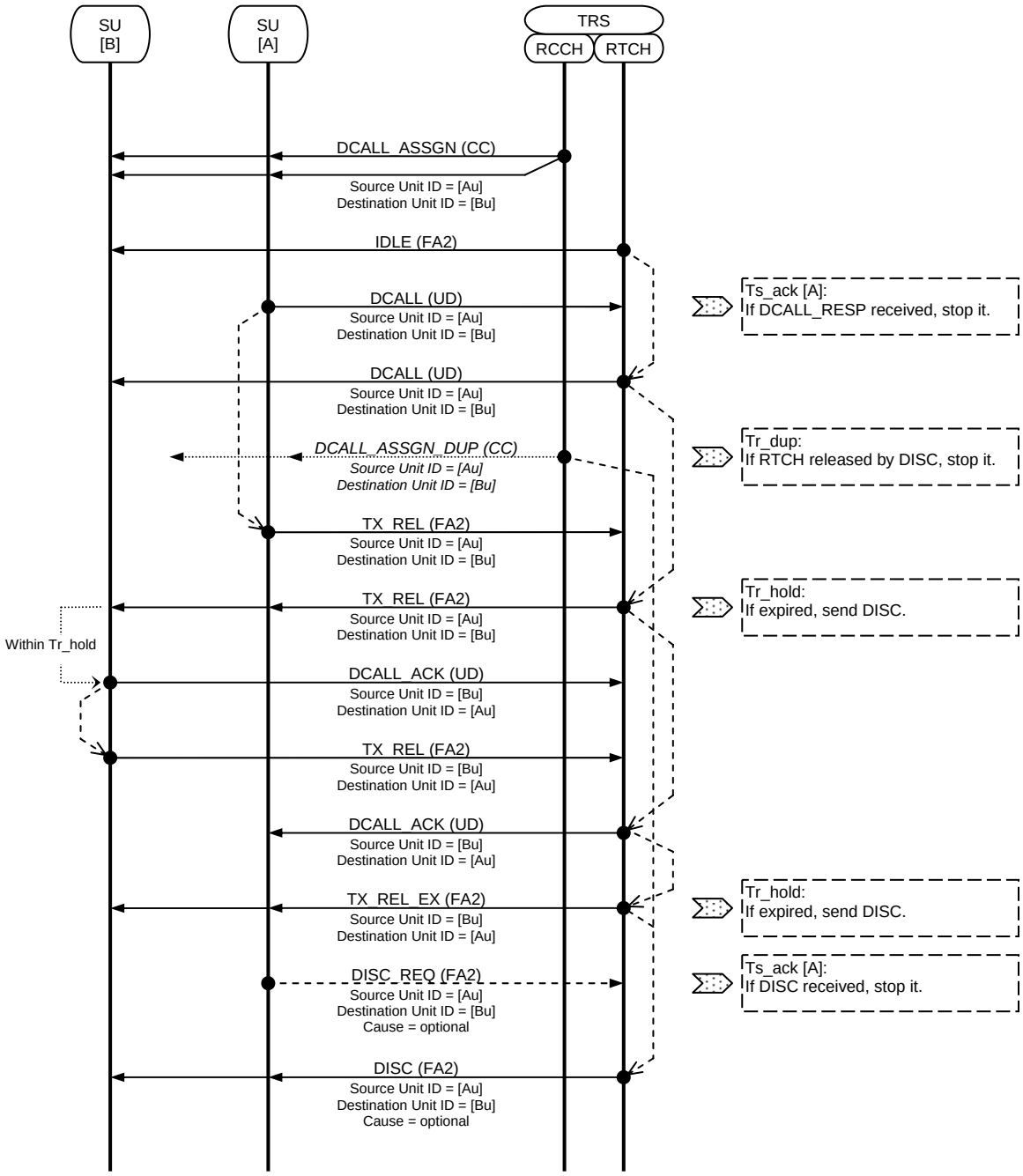
Notes:

1) Refer to Section 15.10 for procedures to cancel a communication establishment and refuse a call. However, different messages relevant to Data Call are used.

Figure 15.15-1 Sequence Diagram for Unit to Unit Data Call - 1

15.15.2. Communication Phase → Termination Phase

The following is the sequence from an assignment of RTCH until end of call.



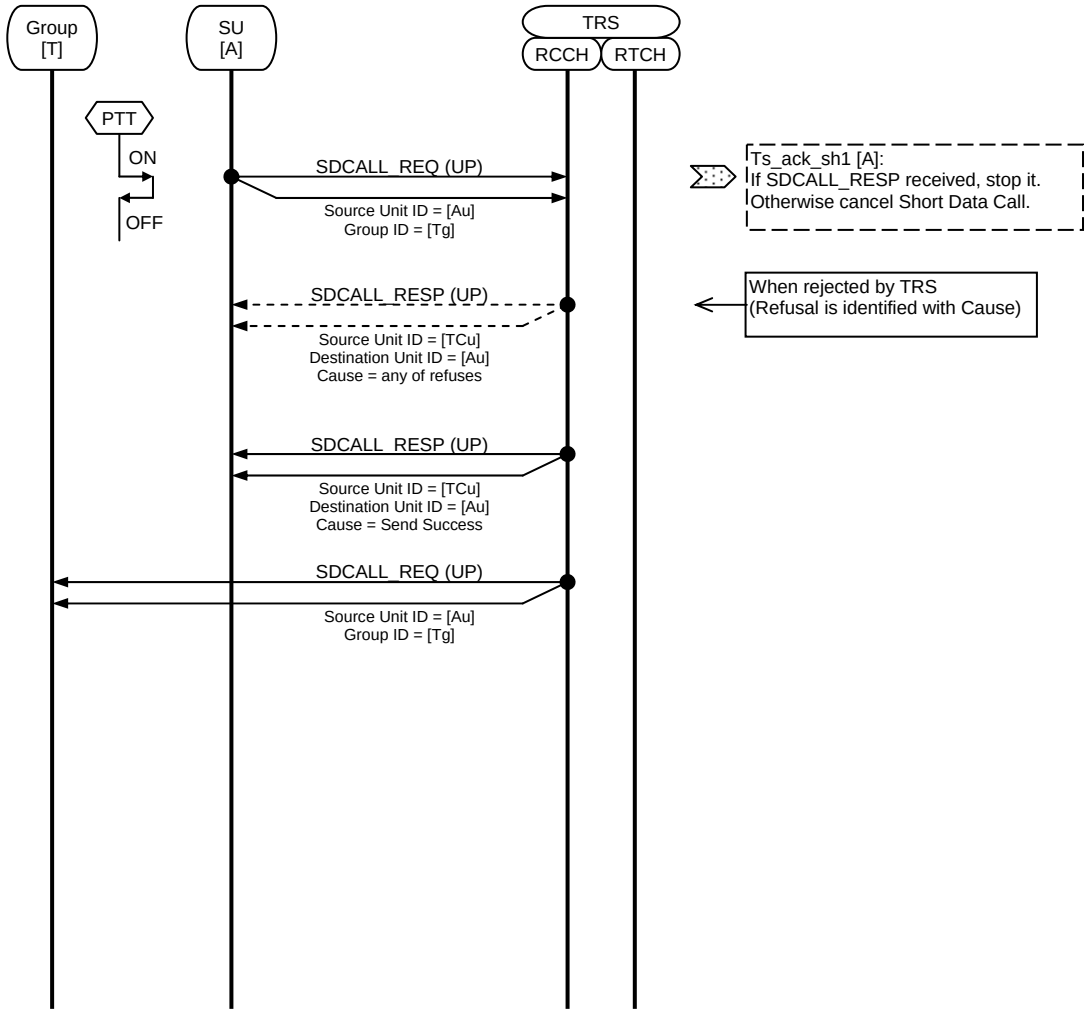
Notes:

1) Content of Cause shall be changed to an appropriate content when DISC is sent from a TC by Tr_hold, etc.
2) The configuration of Source and Destination IDs in DCALL_ASSGN and DISC on RTCH refer to ID configuration of DCALL_REQ.

Figure 15.15-2 Sequence Diagram for Unit to Unit Data Call - 2

15.16. Broadcast Short Data Call

The following figure shows the control sequence where SU [A] (Unit ID = Au) makes a Broadcast Short Data Call to Talk Group [T] (Group ID = Tg). TRS uses Unit ID = TCu.



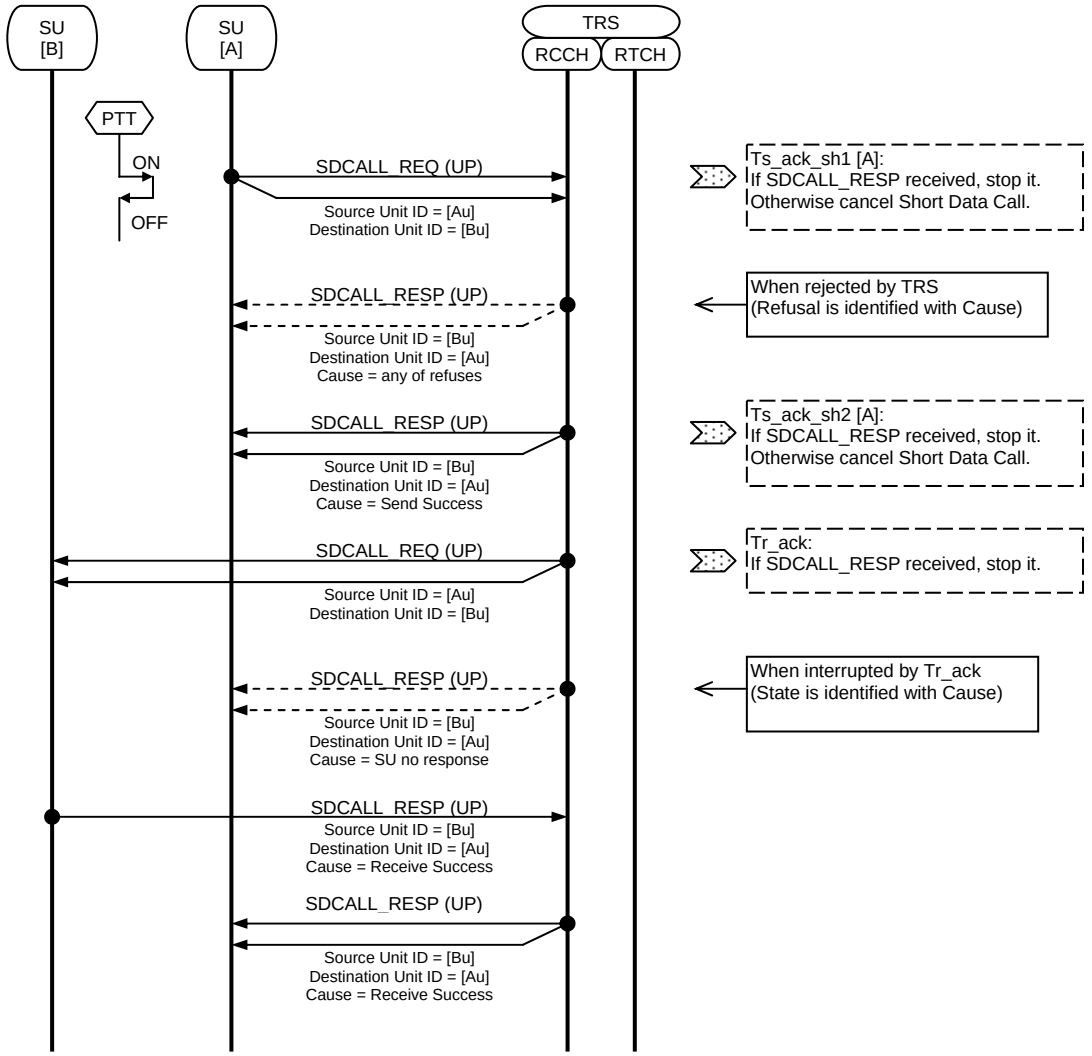
Notes:

1) A SU sends SDCALL_REQ by using the random access for multiple frames.
2) In the case of Broadcast Call, SU [A] completes the procedure when SU [A] receives the response from a TC.
3) A condition of SDCALL_RESP sent from a TC is determined according to content of Cause.

Figure 15.16-1 Sequence Diagram for Broadcast Short Data Call

15.17. Unit to Unit Short Data Call

The following figure shows the control sequence when SU [A] (Unit ID = Au) makes a Unit to Unit Short Data Call to SU [B] (Unit ID = Bu). TRS uses Unit ID = TCu.



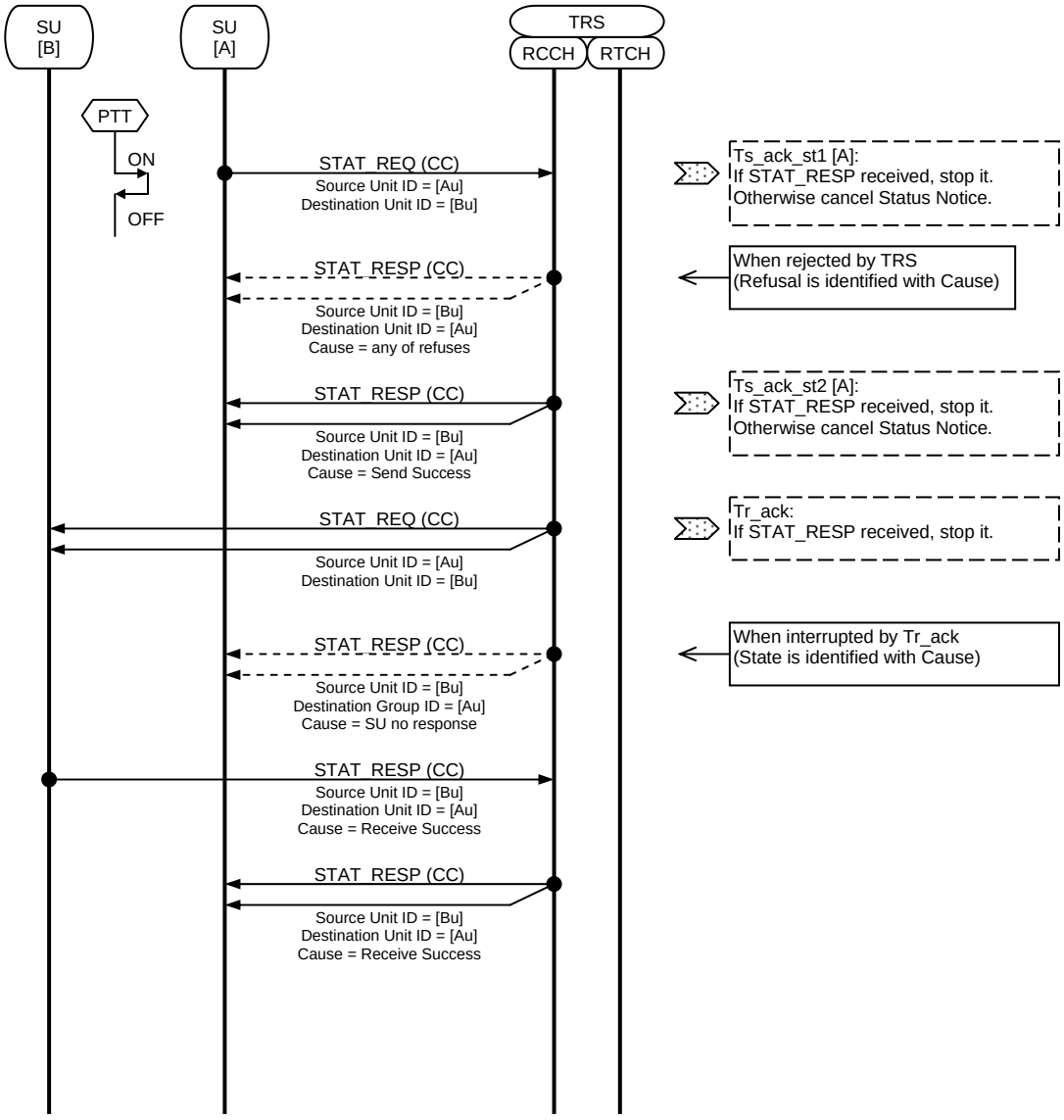
Notes:

1) In the case of Unit to Unit Call, SU [A] completes the procedure when SU [A] receives the response from SU [B].
2) The refusal state of incoming call by SU [B] is determined according to Cause of SDCALL_RESP from SU [B], and the Cause of SDCALL_RESP that is transferred to SU [A] shall have the same contents.

Figure 15.17-1 Sequence Diagram for Unit to Unit Short Data Call

15.18. Status Notice

The following figure shows the control sequence when SU [A] (Unit ID = Au) performs a Status Notice to SU [B] (Unit ID = Bu). TRS uses Unit ID = TCu.



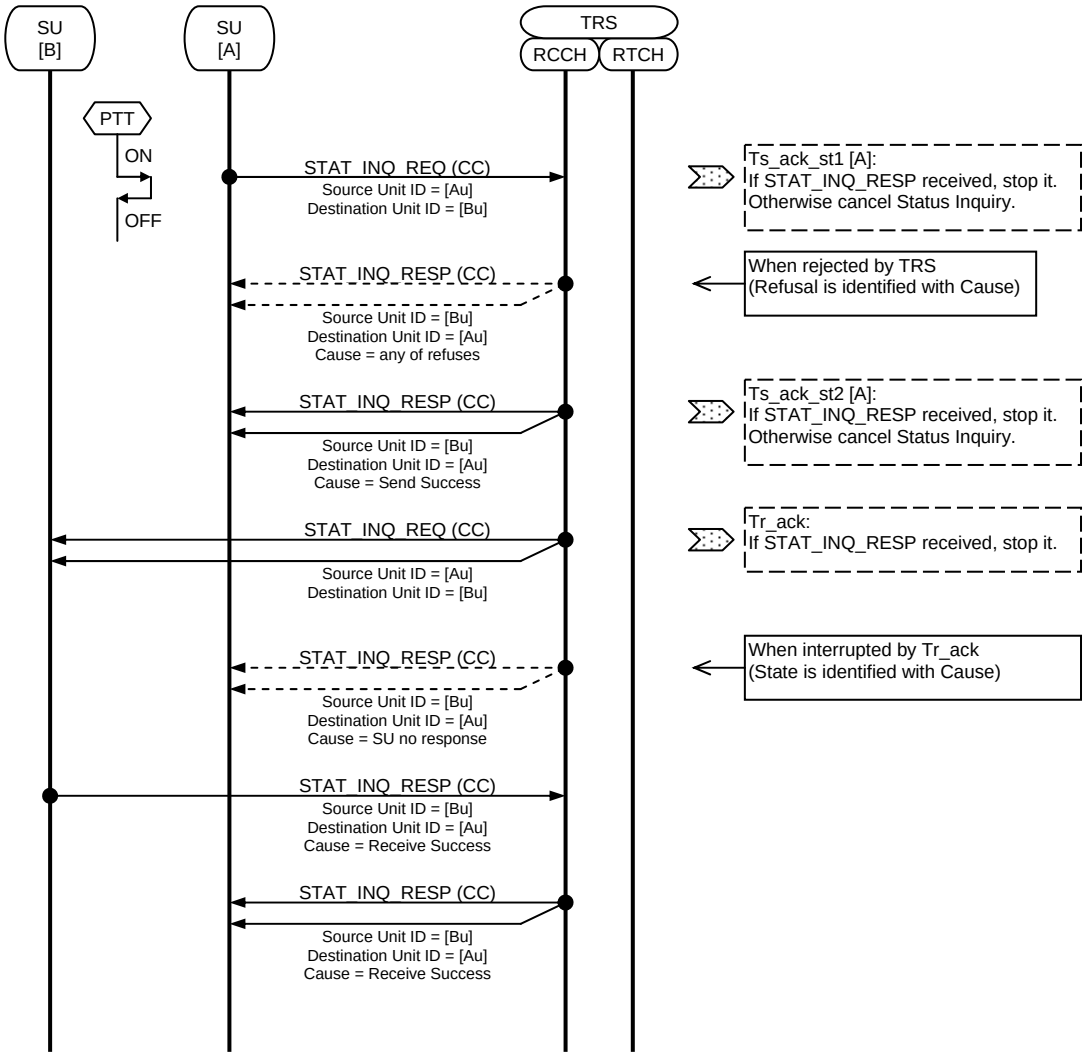
Notes:

1) The refusal state of incoming call by SU [B] is determined according to contents of Cause of STAT_RESP from SU [B], and the Cause of STAT_RESP that is transferred to SU [A] shall have the same contents.
2) The condition of STAT_RESP sent from a TC is determined according to content of Cause.

Figure 15.18-1 Sequence Diagram for Status Notice

15.19. Status Inquiry

The following figure shows the control sequence when SU [A] (Unit ID = Au) performs a Status Inquiry to SU [B] (Unit ID = Bu).



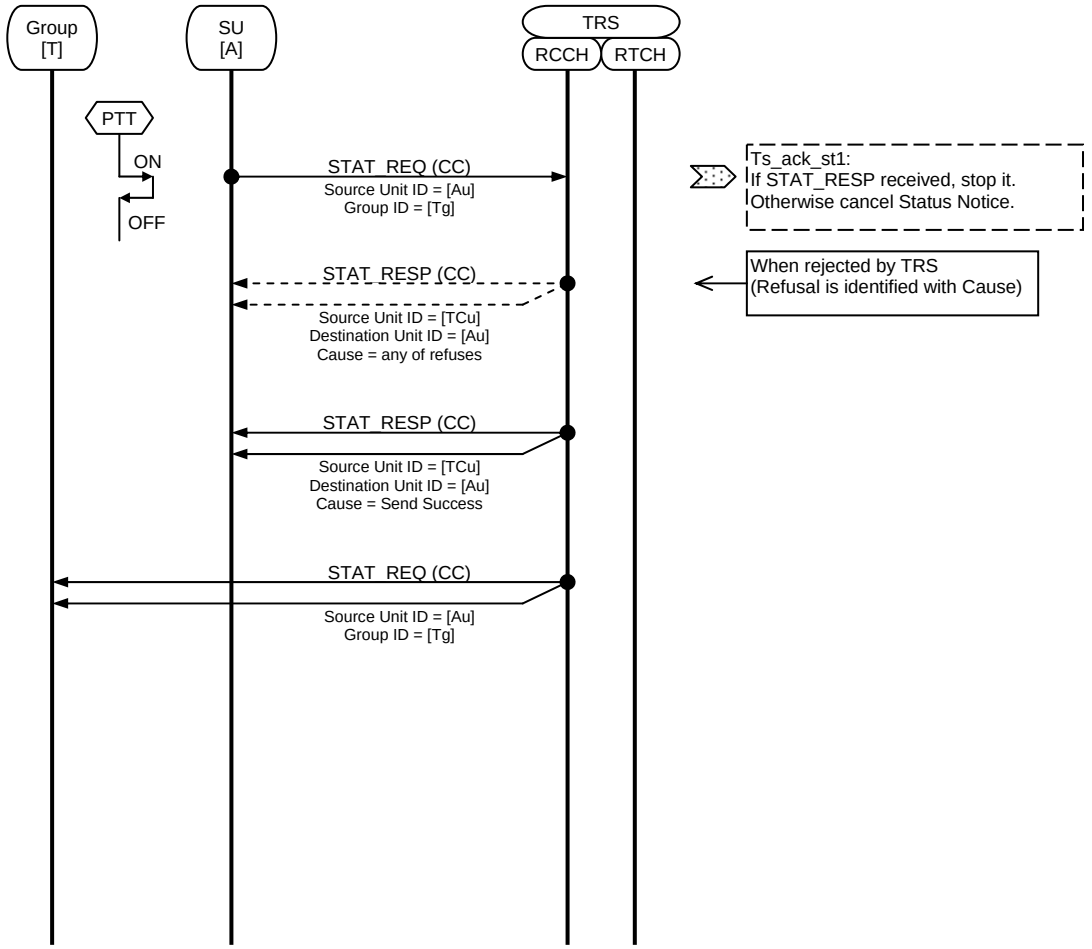
Notes:

1) The refusal state of incoming call by SU [B] is determined according to contents of Cause of STAT_INQ_RESP from SU [B], and the Cause of STAT_INQ_RESP that is transferred to SU [A] shall have the same contents.
2) The condition of STAT_INQ_RESP sent from a TC is determined according to contents of Cause.

Figure 15.19-1 Sequence Diagram for Status Inquiry

15.20. Broadcast Status Notice

The following figure shows the control sequence where SU [A] (Unit ID = Au) performs a Status Notice to Talk Group [T] (Group ID = Tg). TRS uses Unit ID = TCu.



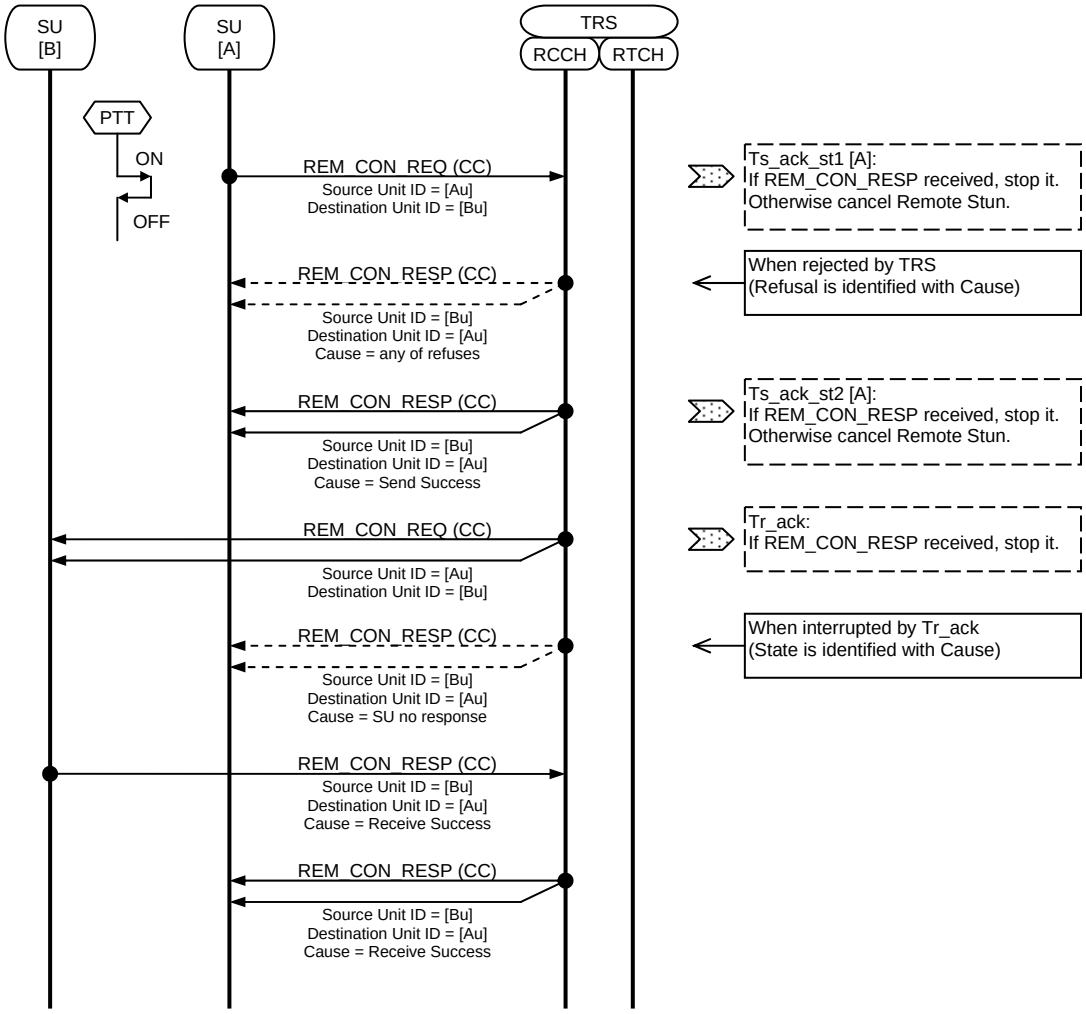
Notes:

1) In the case of Broadcast Call, SU [A] completes the procedure when the SU [A] receives STAT_RESP from a TC. As well, if unconfirmed type is used in Section 15.18 Status Notice, the same procedure as Broadcast shall be also applied to the unconfirmed Status Notice.
2) The condition of STAT_RESP sent from a TC is determined according to contents of Cause.

Figure 15.20-1 Sequence Diagram for Broadcast Status Notice

15.21. Remote Stun

The following figure shows the control sequence when SU [A] (Unit ID = Au) performs Remote Stun to SU [B] (Unit ID = Bu).



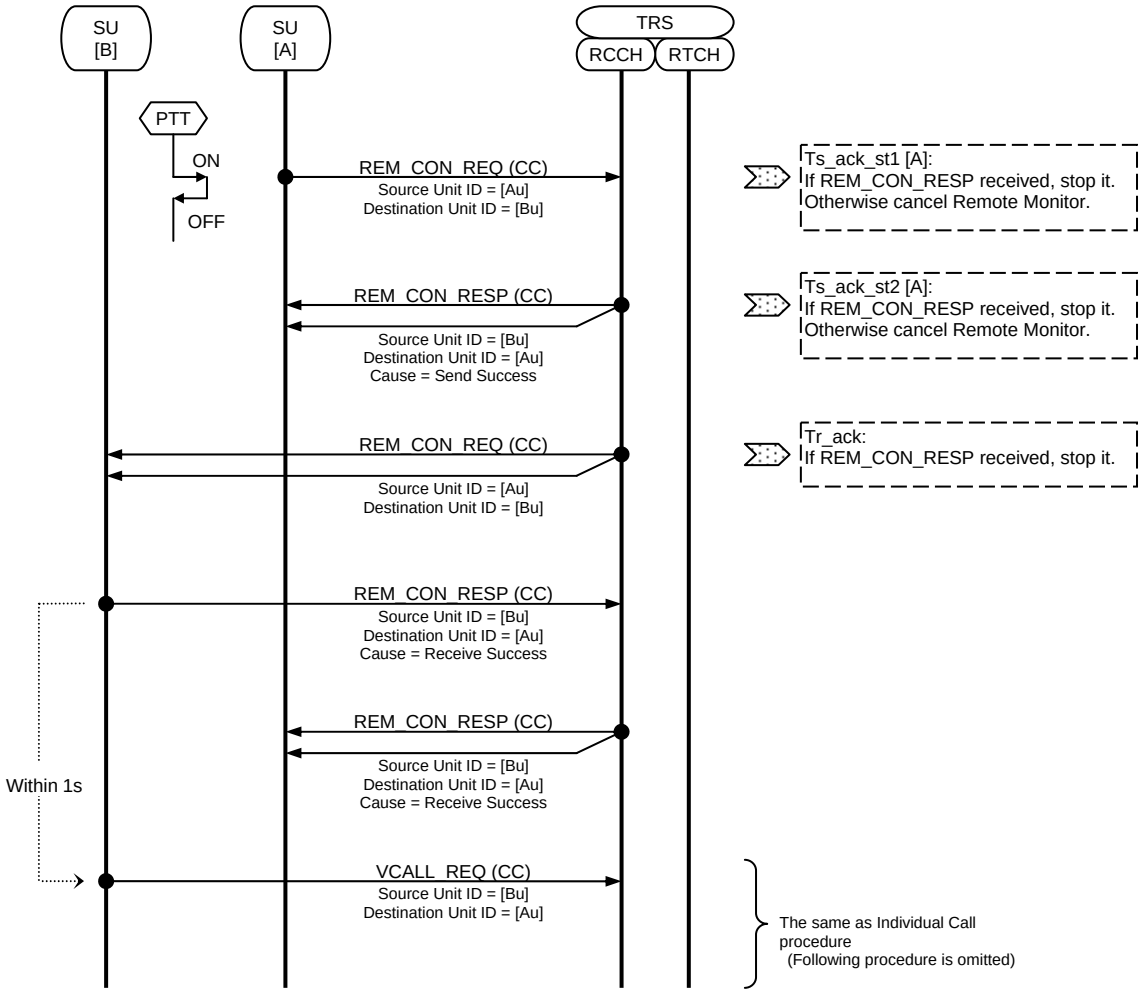
Notes:

1) In cases of Broadcast Call and unconfirmed type, SU [A] completes the procedure when the SU [A] receives REM_CON_RESP from a TC.
2) The state of REM_CON_RESP sent from a TC is determined according to contents of Cause.
3) The same procedure is used regardless whether the Control Command information element is Stun, Revival or Kill.

Figure 15.21-1 Sequence Diagram for Remote Stun

15.22. Remote Monitor

The following figure shows the control sequence when SU [A] (Unit ID = Au) performs Remote Monitor to SU [B] (Unit ID = Bu).



Notes:

1) In the case of unconfirmed type, SU [A] completes the procedure when the SU [A] receives REM_CON_RESP from a TC.
2) Refer to Section 15.21 for procedures to cancel and refuse a call.
3) If RTCH is assigned to VCALL_REQ sent from SU [B], the SU [B] transmits on an RTCH for the duration specified by the Control Parameter element in REM_CON_REQ. After the transmission ends, it is recommended that SU [B] sends DISC_REQ to disconnect RTCH.

Figure 15.22-1 Sequence Diagram for Remote Monitor

16. Appendices

Supplementary information about trunking procedures is provided in this section.

16.1. Superframe Structure

16.1.1. Parameters

The detailed usage of the RCCH superframe structure is represented in this section.

The following values are recommended as a default of RCCH structure.

Field	Minimum Value	Default Value (40ms)	Default Value (80ms)	Maximum Value	Description (in a 40 ms frame)
Bn	1	1	1	3	In most of cases, a value of 1 is used. Note that a call may get delayed due to existence of BCCH.
Pn	1	2	2	15	The frame proportion to Mn shall be larger than 1 to prevent the link from getting slow.
Mn	0	2	1	7	40 ms is too short for checking for adjacent sites. A value of 0 is supposed to be used for special usages such as dynamical changes, etc.
Gn	1	1	1	7	A value of 1 is selected when most of calls are Group Call. Note that use of other values needs attention
In	1	5	4	15	The superframe cycle is adjusted to be at less than 1 second.

Table 16.1-1 Recommended Values for RCCH Structure

If the recommended default is used, the length of superframe Nr_spr and Cycle Tr_spr can be obtained with the following formula.

In the case that the frame length is 80 ms:

Nr_spr = 1 + (2 + 1) x 1 x 4 = 13 frames

Tr_spr = 13 x 0.08 = 1.04 seconds

In the case that the frame length is 40 ms:

Nr_spr = 1 + (2 + 2) x 1 x 5 = 21 frames

Tr_spr = 21 x 0.04 = 0.84 seconds

An example of the basic superframe structure without paging grouping is represented.

This example uses Bn = 1, Gn = 1, Pn = 2 Mn = 2, In = 2.

A superframe comprises 9 frames, and it is sent repeatedly on RCCH.

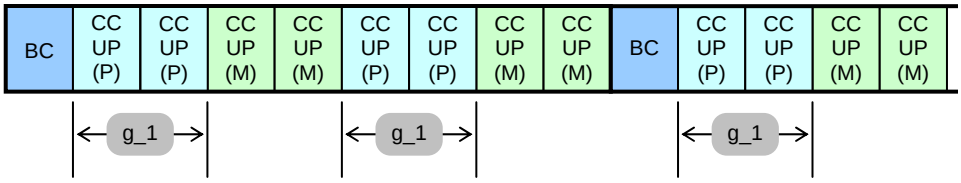


Figure 16.1-1 Example 1 of Superframe

In the next example, Bn = 2, Gn = 3, Pn = 2, Mn = 1 and In = 1 are used.
A superframe comprises 11 frames, and it is sent repeatedly on RCCH.

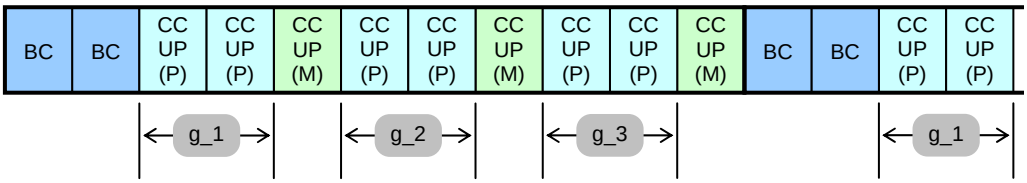


Figure 16.1-2 Example 2 of Superframe

16.1.2. Intermittent Reception

The method of intermittent receive operation by a SU to receive a paging frame in its own group and BCCH is represented in this section.
The ratio Ron for the duration while a SU is active can be obtained by using the following formula:

Ron = (Bn + Pn x In) / (Bn + (Pn + Mn) x Gn x In)

In the example of superframe in Figure 16.1-1, the ratio of active time is 5/9.

Ron = (1 + 2 x 2) / (1 + (2 + 2) x 1 x 2) = 5/9

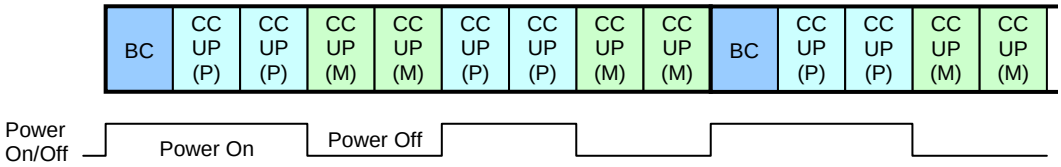


Figure 16.1-3 Timing for Intermittent Reception

Also, in the example of superframe in Figure 16.1-2, the ratio of active time is 4/11.

Ron = (2 + 2 x 1) / (2 + (2 + 1) x 3 x 1) = 4/11

In stationary mode, the contents of BCCH do not change, and the superframe structure remains stable. Once a SU receives BCCH, it is not mandatory to receive BCCH thereafter, and the ratio of active duration can be arbitrarily lowered by skipping the reception of BCCH.

As mentioned in Section 5.1.4.4, the active duration of SU can be further shortened by using Data Flag of LICH. Because the content of broadcast messages sent by the outbound control channel rarely changes, a SU need not receive broadcast messages which contain the same content. When there is little traffic on TRS and most messages of the outbound control channel are broadcast messages, it is recommended that TRS often stops sending any valid messages so that SU can stop the frame reception operation. By using Data Flag, a SU can stop the reception operation for the area of CAC in the frame.

In REF [1], the setting of Data Flag is defined as follows.

Bit 2	Bit 1	CAC (Outbound)	
0	0	Normal Data	shows the normal control data
0	1	Idle Data	shows data not required to receive.
1	0	Common Data	shows data to receive optionally such as additional information.
1	1	Reserved	

The control method of Figure 16.1-3 shows a typical method of using a fixed value as Data Flag of LICH, and intends the use of Data Flag = “00". The control method of Figure 16.1-4 shows a more complex method of utilizing Data Flag. When Data Flag =“10" is received with the paging frame, the operation of SU varies according to the state of SU. Figure 16.1-4 shows two kinds of intermittent operation of SU; State that the transition to idle state of Section 5.3.2.1 is completed and state immediately after registration process. The combination of the setting of Data Flag and layer 3 messages depends on control manner of TC.

In Idle state

Because a SU in this state has acquired information for adjacent sites, it need not receive broadcast messages. Therefore, if Data Flag =“10", the SU judges that TC sends a broadcast message, and can stop the reception operation of the area of CAC.

If Data Flag =“01", the SU judges that TC sends a message not needed to receive, and can stop the reception operation of the area of CAC.

In state immediately after registration

Because a SU in this state can not completely acquire information for adjacent sites, it has to perform the reception operation of the multipurpose frame to receive the broadcast message. Therefore, only if Data Flag =“01", the SU can stop the reception operation of the area of CAC.

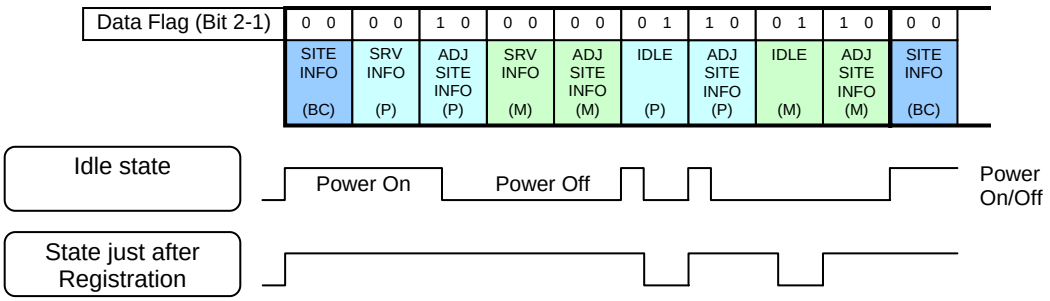


Figure 16.1-4 Timing for Intermittent Reception with Data Flag

16.1.3. Level Check of Current Site and Adjacent Site

The reception level detection method of the current site where a location has been registered and the adjacent sites is represented in this section.

The reception level for the current site is detected using BCCH frames and the paging frames in its own group. The reception level for adjacent site is detected among other frames.

The number of available adjacent sites is notified using a broadcast message such as SITE_INFO, and the frequency of the control channel of an adjacent site is notified using ADJ_SITE_INFO. The SU stores this information and checks for a control channel of an adjacent site in the level detection period for the adjacent site. The sequence, intervals, level detection duration and the number of level detection in case that a SU checks multiple adjacent sites are not specified. Also, frames that can be used for checking for adjacent sites can be arbitrarily selected from frames which are anything other than BCCH and paging frame.

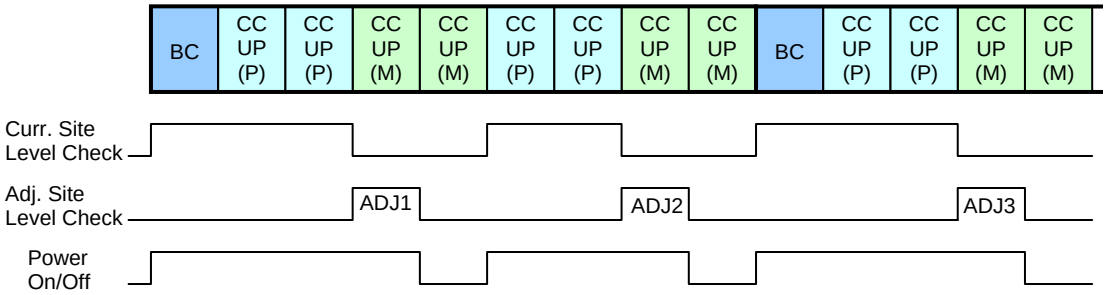


Figure 16.1-5 Level Check Timing for Current Site and Adjacent Site

16.1.4. Arrangement of UPCH

SDCALL_REQ message and SDCALL_RESP message used in a Short Data Call are sent using UPCH. There are two formats in SDCALL_REQ; Header format and User Data format, and the Header format uses paging frame, and the User Data format uses a multipurpose frame.

The allocation method of the message when SDCALL_REQ consisting of 6 frames is sent on the inbound control channel in the superframe structure as defined in Figure 16.1-1 is represented in Figure 16.1-6. SDCALL_REQ in Header format is allocated in the paging frame and SDCALL_REQ in User Data format is allocated in the multipurpose frame. The paging frame and multipurpose frame are used as CCCH since other Short Data Calls cannot be sent while a Short Data Call is being sent on the outbound control channel. Also, since SDCALL_REQ in User Data format uses the multipurpose frame, a value larger than the value of 1 shall be configured for Mn on the control channel providing Short Data Call service.

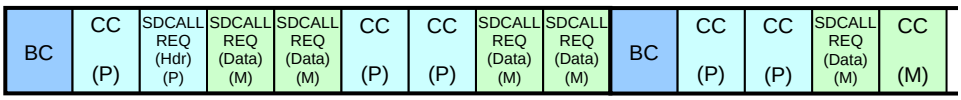


Figure 16.1-6 UPCH Arrangement into Superframe

16.2. Multiple Transmissions of RCCH Outbound Message

Outbound message of RCCH can be sent multiple times, and the operation, usage of parameters and exceptional conditions for multiple transmissions are represented in this section. The following two parameters relevant to multiple transmissions are used:

Number of times for transmissions: Nr_ob

Intervals of transmissions: Tr_ob

Using these two parameters, a TRS sends the same outbound message for the number of times configured for Nr_ob at intervals configured for Tr_ob. If the outbound message is a request message, Tr_ack and Nr_ob and Tr_ob are stopped when a TRS receives a valid response message sent from a SU before the duration for Tr_ack elapses. If a TRS cannot receive a valid response message from a SU, the TRS can repeat the multiple transmissions for the number of times configured for Nr_ret. The processing of multiple transmissions and Tr_ack are an independent action. If the timer Tr_ack expires before the multiple transmissions completes, a retransmission by Nr_ret starts and the number of times for multiple transmission is reset.

16.2.1. Basic Multiple Transmissions

This section describes the operation subject to basic conditions where Nr_ob = 3 times, Tr_ob = 1 frame (80 ms), and RCCH structure without paging grouping, all CCCH as paging frame and Dual CCCH format are used.

Basic operations of multiple transmissions for sending an outbound message are described in this section. If there is no particular outbound message to be sent, SRV_INFO and ADJ_SITE_INFO are repeatedly sent on Dual CCCH of RCCH. When an ASSGN message is raised in that state, the operations of multiple transmissions are represented in Figure 16.2-1. ASSGN message is inserted into 3 continuous frames in accordance with Nr_ob = 3 and Tr_ob = 1 frame.

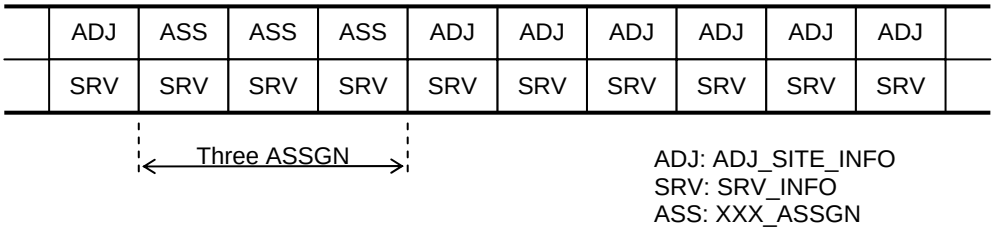


Figure 16.2-1 Basic Multiple Transmissions

The operation of multiple transmissions of when 3 ASSGN messages are placed around the same time is represented in Figure 16.2-2. In order to rapidly assign a traffic channel to each message and average the delay, 3 ASSGN messages are alternately sent. In the case that 3 or more messages are placed at the same time, , it is expressed that this time interval as Tr_ob = 1 frame can not be retained.

	ADJ	ASS1	ASS3	ASS2	ASS1	ASS3	ADJ	ADJ	ADJ	ADJ	
	SRV	ASS2	ASS1	ASS3	ASS2	SRV	SRV	SRV	SRV	SRV	

Figure 16.2-2 Multiple Transmissions Operation for 3 Messages

Method of multiple transmissions of ASSGN message during a RTCH assignment is represented in the above example. However, the method of multiple transmissions of ASSGN_DUP message for late entry which is placed periodically while RTCH is in use varies depending on the combination of paging frame and multipurpose frame which reside in each group in the superframe using a paging grouping. Therefore, this section only describes the concept of multiple transmissions and a concrete method of multiple transmissions is system-dependent.

16.3. Control Channel Communication

While a TRS normally has at least one dedicated RCCH, if a new call request is placed when all of RTCHs are busy, a TRS can accept the call by switching RCCH to a composite control channel.

Since a composite control channel has the same frame structure as RTCH and cannot send messages sent on RCCH, a SU that is in the idle state on RCCH or that is searching for an RCCH shall take appropriate actions when the composite control channel is detected.

This section represents the guidelines for switching to a composite control channel at a TRS, and detailed actions are system-dependent.

16.3.1. Frame Structure

This section represents the frame structure of a composite control channel. On a composite control channel, voice calls and data calls can be made in the same manner as RTCH and the frame structure is dependent on communication format. An outbound channel transmitted from a TRS uses the composite control channel and an inbound channel transmitted from a SU uses RTCH.

In the case of Voice Call:

Functional Channel	Description
LICH	RF Channel Type is set to “RTCH_C”. Other bit setting depends on contents of voice call.
SACCH	Conforms to a normal processing of voice call.
FACCH1	Conforms to a normal processing of voice call.
VCH	Conforms to a normal processing of voice call.

In the case of Data Call:

Functional Channel	Description
LICH	RF Channel Type is set to “RTCH_C”. Other bit setting depends on contents of data call.
UDCH	Conforms to normal processing of data call.
FACCH2	Conforms to normal processing of data call.

16.3.2. Behavior as a Control Channel

The behavior of a TC and a SU on a composite control channel is represented from the aspect of a control channel.

16.3.2.1. Transmission of Broadcast Message by Trunking Controller

On a composite control channel, it is necessary to send Broadcast messages by using FACCH1 during a voice call and Hold Time or by using FACCH2 during Hold Time for data call. The following Broadcast messages are sent using these functional channels:

- SRV_INFO
- CCH_INFO
- ADJ_SITE_INFO

Using FACCH1 and FACCH2 during the Hold Time, it is recommended that these 3 Broadcast messages are sent in an appropriate order and the number of times.
Using FACCH1 during a voice call, it is recommended that at least SRV_INFO and CCH_INFO are sent at appropriate intervals.

16.3.2.2. Control Channel Acquisition by Subscriber Unit

Even if the switchover of a composite control channel arises, a SU that is in the idle state on RCCH remains in the idle state as long as the SU is not involved in a call. However, behaviors to check for a control channel in another site are not specified.

If the SU searching for the control channel detects a composite control channel, the SU may abort the acquisition process of control channel and wait until the detected composite control channel restores to the dedicated control channel. Or the SU may continue the control channel acquisition without aborting the process.

16.3.3. Switching the RF Channel

This section describes the switching actions of the radio channel for which RCCH is switched to a composite control channel when a call request from a SU and the composite control channel is switched to RCCH.

(1) Switching RCCH to a Composite Control Channel

If no communication, such as a Short Data Call, is ongoing on RCCH, an ASSGN message is sent to a SU at given number of times which is system-dependent. An RF channel to send ASSGN message may use any of RCCH only, composite control channel only or both of them. The channel number designated by the ASSGN message is same as the channel number of RCCH. The switch timing from the RCCH structure to the composite control channel structure depends on usage of RF channel to send ASSGN message.

(2) Switching a Composite Control Channel to RCCH

The frame structure is switched to the structure for RCCH from the frame just after a SU finishes transmitting and the Hold Time has expired.
The timing of superframe when restoring to RCCH is not specified.

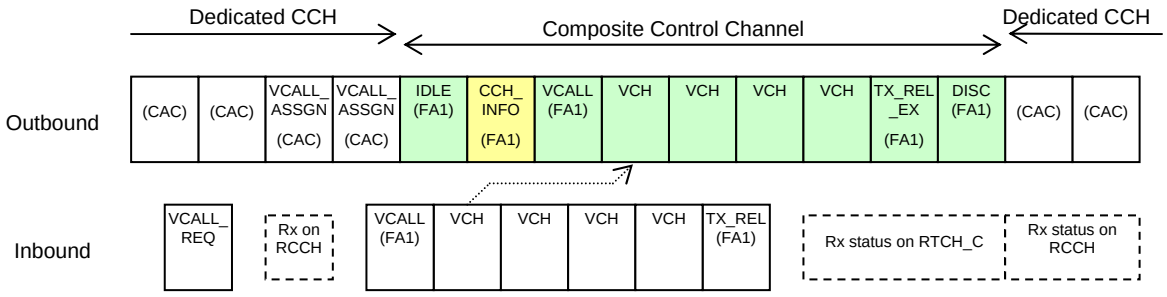


Figure 16.3-1 Example-1 of Control Channel Communication

Figure 16.3-1 shows an example of Control Channel Communication when ASSGN messages are sent on an RCCH.

If a TRS determines that all RTCHs are in use when a SU sends VCALL_REQ, the TRS sends VCALL_ASSGN which designates the channel number of RCCH. When a SU receives VCALL_ASSGN, the SU starts transmission with the same procedure as the normal voice call procedure on RTCH. The TRS switches to the frame structure for voice calls after sending VCALL_ASSGN, and relays the signals transmitted from a SU with the same manner as the process used on RTCH. However, RF channel type field of LICH is different between a normal outbound RTCH and outbound composite control channel. After the SU has finished transmitting, the TRS switches the frame structure to that of RCCH and starts a normal RCCH operation.

If a TRS is in a composite control channel state, the TRS shall properly send broadcast messages using an associated control channel as shown in Figure 16.3-1.

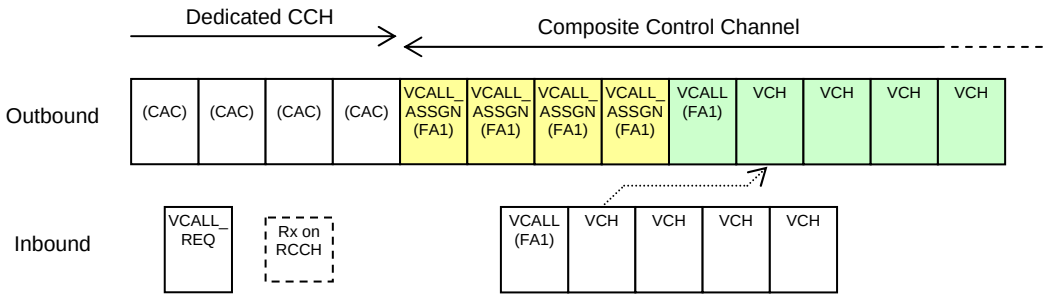


Figure 16.3-2 Example-2 of Control Channel Communication

Figure 16.3-2 shows an example of Control Channel Communication when ASSGN messages are sent on a composite control channel.

If a TRS determines that all RTCHs are in use when a SU sends VCALL_REQ, the TRS switches to the frame structure for voice calls first and then sends VCALL_ASSGN which designates the channel number of RCCH by using FACCH1. When a SU receives VCALL_ASSGN on the composite control channel, the SU starts transmission of voice call with

the specified frame offset timing. When the TRS has received the inbound signal from a SU, the TRS stops sending VCALL_ASSGN and relays the inbound signal.

16.3.4. Call Judgment by Subscriber Unit

This section describes criteria for call judgment which a SU uses in the idle state. There are two states of call judgments; one is to receive the ASSGN message as usual, the other is to receive a message in the Late Entry state after switching the channel to a composite control channel.

(1) In case the ASSGN message is received on RCCH:

When a SU receives the ASSGN message which contains the ID addressing it, since the Channel field of the message is equal to the channel number of RCCH, the SU waits until the frame structure is changed to a composite control channel on the same RF channel. When the channel is switched to a composite control channel, the SU performs reception process using the frame structure according to message contents.

(2) In case the ASSGN message is receiving on a composite control channel:

By judging the LICH information, a SU can recognize that the channel has been switched to a composite control channel and its frame structure. A SU decodes the message sent on a functional channel with the same manner as the reception process of direct mode operation. When a SU receives the ASSGN message which contains the ID addressing it, since the Channel field of the message is equal to the channel number of RCCH, the SU stays on the same RF channel and performs reception process according to message contents.

(3) In case of judging the message received on a composite control channel:

When the ASSGN message has not been received while in the idle state on RCCH, or when the control channel to which a SU returns after ending a call on RTCH has been switched to a composite control channel, a SU enters the late entry state.

By judging the LICH information, a SU can recognize that the channel has been switched to a composite control channel and its frame structure. A SU decodes the message sent on a functional channel with the same manner as the reception process of direct mode operation and can join the call if the ID contained in the message matches the valid ID in a SU.

16.4. Transmission Right Control on Traffic Channel

Transmission right control on RTCH is the control in order to avoid the occurrence of crossed calls caused by time lag between a TRS and a SU in Message Trunking Mode.

In the case of Message Trunking Mode, which is normally used for an Individual Call, two SUs alternately transmit in remaining on RTCH. Since there is an offset between outbound slot and inbound slot on RTCH, there is a possibility that a SU may start transmitting on the previous or the same slot which is used to send the DISC message for disconnection after the expiration of Hold Time. At that time, if a TC continues the disconnect process, the receiving SU returns to RCCH, but the transmitting SU remains in the transmission state; hence it brings results that communication cannot be established.

To prevent such crossed calls, TX_REL_EX which is used only on the outbound RTCH controls a SU by informing of the states of “Transmit Permit” or “Transmit Inhibit”.

16.4.1. Scope of Transmission Right Control

Transmission right control is applied to all of calls made on RTCH in simplex mode.

This control is not applied to a PSTN Call which a TRS operates in duplex mode, or a case when SUs having duplex mode capability make a call in duplex mode.

16.4.2. Example of Transmission Right Control

This section represents the behavior for transmission right control. However, the following example is intended to provide the basic concept of Transmit Permit/ Inhibit and a message sent on a functional channel is not limited to the message used in the example.

The example of Figure 16.4-1 shows the behavior where the called SU can talk back on the same RTCH by sending TX_REL_EX with "Transmit Permit" from TC. When SU-a finishes transmitting, a TC activates the Tr_hold timer and sends TX_REL_EX with Transmit Permit if the Tr_tch timer is enabled. In this example, Tr_hold is set to the amount of time for 7 frames. When the PTT switch on SU-b is pressed, SU-b can transmit on RTCH since SU-b has already received TX_REL_EX with Transmit Permit. Since a SU starts transmission within the duration configured for Tr_hold, the TC deactivates Tr_hold and starts relaying signals transmitted from SU-b.

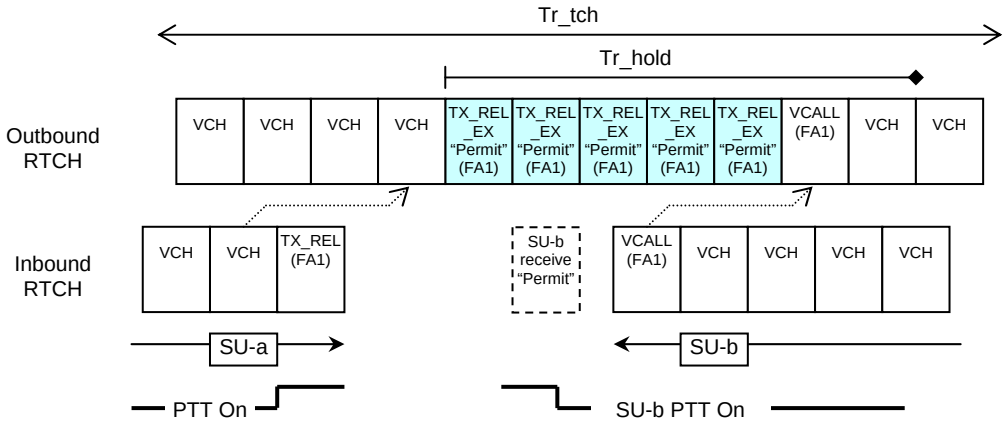


Figure 16.4-1 Example of Talkback in Message Mode

The example of Figure 16.4-2 shows the operation suppressing crossed calls between a TC and a SU when Tr_hold timer expires.

When the PTT switch on SU-b is pressed, SU-b transmits on RTCH since SU-b has received TX_REL_EX with Transmit Permit. In this case, though the TC has switched to TX_REL_EX with Transmit Inhibit due to expiry of the Tr_hold timer, the TC relays outbound signals transmitted from SU-b because DISC for disconnect has not been transmitted yet and the Tr_tch timer is enabled. Thus, the crossed calls between the TC and a SU can be prevented by temporarily disabling a transmission before sending DISC.

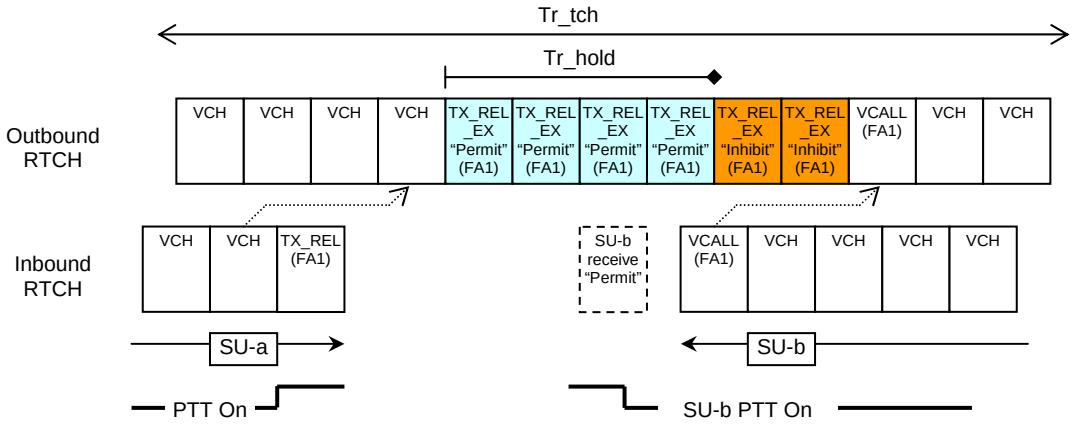


Figure 16.4-2 Example for Suppressing the Crossed Calls in Message Mode

The example in Figure 16.4-3 shows the behaviors of the transmission right control in Transmission Mode.

When SU-a finishes transmitting, a TC activates the Tr_hold timer and sends TX_REL_EX with Transmit Inhibit during the duration of the timer. Since SU-b already receives TX_REL_EX representing Transmit Inhibit, SU-b cannot transmit even when the PTT switch on SU-b is

pressed since SU-b has received TX_REL_EX with Transmit Inhibit. Then, the TC sends DISC and stops sending the outbound RTCH when Tr_hold (4 frames in the figure) expires.
The behaviors similar to this example are applied also when the Tr_tch timer expires in Message Mode. For instance in Figure 16.4-3, if the Tr_tch timer has expired while SU-a is transmitting, the TC sends TX_REL_EX with Transmit Inhibit instead of TX_REL_EX with Transmit Permit as shown in Figure 16.4-1 after SU-a finished transmitting.

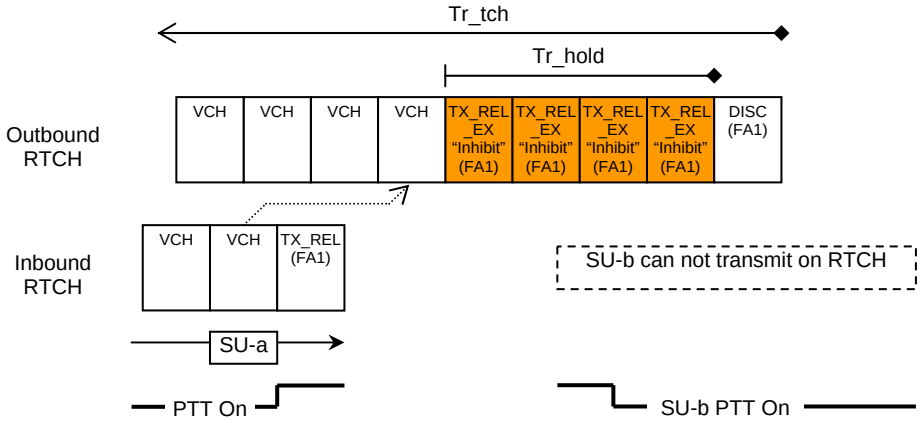


Figure 16.4-3 Example of Transmission Right Control in Transmission Mode

16.4.3. Judging Criteria for Transmission Right by Subscriber Unit

Not only TX_REL_EX and DISC are sent during the Hold Time for inbound RTCH, or a SU may face a case which does not allow receiving a message properly due to a low signal level. To properly control the transmission even in such a case, the judging criteria under conditions that a SU cannot receive or has not yet received TX_REL_EX is defined.

When a SU moves to RTCH in the receive state, or when a SU restores to the receive state after finishing transmission on RTCH, the state of “Transmit Inhibit” is used as a default in a SU. Therefore, a SU cannot transmit when the PTT switch is pressed without receiving TX_REL_EX since transmission is disabled as a default. A SU can retransmit on RTCH only if a SU receives TX_REL_EX with Transmit Permit.

Hence, a SU can transmit on the RTCH in the following states:

- In the case the calling SU moves from RCCH to RTCH in transmitting state.
- In the case a SU has already received TX_REL_EX with Transmit Permit when the PTT switch on a SU is pressed on RTCH.

16.4.3.1. Exceptional Transactions during Transmit Inhibit

This section represents exceptional transactions during transmit inhibit. The disconnection of RTCH in an Individual Call is explicitly caused by sending DISC_REQ from SU or is caused by the timer expiry of TC side. Normally, the disconnection is explicitly caused by a SU sending

DISC_REQ with a key operation made by a user. Therefore, a SU is allowed to exceptionally send DISC_REQ even if transmission is inhibited.

16.5. Control Channel Switching

Since RCCH always functions for outbound transmissions, the load of the transmission circuit in a Repeater Unit will increase if the same RCCH is always used. To disperse the load of the transmission circuit, RCCH should be switched periodically.

If the RCCH which multiple SUs are normally monitoring RCCH is suddenly switched, there are possibilities that a SU may proceed to an unnecessary control channel hunt or a ongoing call may be interrupted midway. To suppress these side reactions, this section provides an example of proper RCCH switching procedure.

Switching Procedure

1. Ensure that there is no communication on the current RCCH.
2. Prohibit a SU from beginning a random access by configuring “B” for the I/B bit in the Collision Control Field.
3. Activate an arbitrary radio channel in a TRS using the RCCH frame structure.
4. Broadcast the channel number of the new RCCH on the current RCCH by using CCH_INFO at the same time or after I/B is set to B.
   If any RTCHs are in use, the same CCH_INFO is broadcasted on the RTCHs in use.
5. Retain I/B = B for the amount of time arbitrarily configured, and broadcast CCH_INFO repeatedly.
6. Terminate the transmission on the current RCCH when the amount of configured time expires.

If a trunked radio system consists of multiple sites, the TRS informs adjacent sites that its RCCH has been switched, and the adjacent sites broadcast the new channel number using ADJ_SITE_INFO.

16.6. Failsoft

Failsoft can be used to provide the minimum communication capabilities to SUs in the TRS area by doing a simple relay operation on certain radio channel in the TRS if the given trunking control function cannot be provided due to failure of network equipment in the TRS.

Basic specifications of Failsoft are as follows, however, they are not limited only to these specifications:

- RCCH is assigned to a channel for Failsoft.
- A Failsoft channel is used as a composite control channel.
- Only Group Voice Calls can be made on the Failsoft channel.
- Functions provided on a dedicated control channel, such as location registration, are not provided on the Failsoft channel.

16.6.1. TRS Action

By setting a radio channel designated to Failsoft to the following conditions, a TRS that has gone into the Failsoft state informs SUs within the area of its state:

- Configure RTCH_C for Radio Channel Type of LICH, and then switch to the frame structure for a traffic channel.
- Send FAIL_STAT_INFO on an associated control channel to broadcast that a TRS is in the Failsoft state.

The judging criteria for activating or deactivating relay operation of a TRS when a SU makes a Group Voice Call on a Failsoft channel are not defined.

16.6.1.1. Conditions for Switching to the Failsoft State

A TRS can go into the Failsoft state when the TRS cannot provide the given trunking control functions, but the specific conditions are not specified. Also a TRS may go into the Failsoft state by manual operation.

If conditions for going into the Failsoft state have been resolved, a TRS is automatically restored to its former state. A TRS may be also restored by manual operation.

16.6.2. SU Action

A SU can recognize the radio channel as a composite control channel via the Radio Chanel Type of LICH, and carries out the receiving process using the frame structure for a traffic channel according to the LICH information. When a SU receives FAIL_STAT_INFO on an associated control channel, the SU recognizes that a TRS has gone into the Failsoft state, and then the SU enters Failsoft Mode. In this state, a SU transmits on the Failsoft channel using the Group Voice Call procedure which is equivalent to that for a conventional system.

In the case of a Multi-Site Trunked System, a SU may perform the reception level detection of adjacent sites on a Failsoft channel as well as on RCCH. However, the method for checking adjacent sites on a Failsoft channel is not specified.

When a SU registers its location at another site or when the SU detects that the TRS in the Failsoft state is restored and resumes its location registration in the TRS, a SU can abort the Failsoft Mode.

16.6.3. Behavior in Failsoft

This section represents an outline of behavior of a TRS and a SU in Failsoft state. However, detailed behaviors, such as timing to switch the frame structure, are not specified.
Switching procedures of outbound frames in a TRS at which any failure for going into the Failsoft state has occurred and transmitting procedures on a Failsoft channel in a SU are represented in Figure 16.6-1. When the failure occurs in a TRS, the TRS switches the radio channel operated as an RCCH to a composite control channel and starts sending FAIL_STAT_INFO on the associated control channel. A SU being in the idle state on RCCH recognizes that a TRS has gone into the Failsoft state by receiving FAIL_STAT_INFO. In this case, when the PTT switch of a SU is pressed, the SU transmits on the Failsoft channel using the Group Voice Call procedure that is equivalent to that for a conventional system without proceeding to a random access operation on RCCH.

The frame switching procedures in a TRS which is restored to the normal state from the Failsoft state and the behavior of location registration in a SU which has detected the restoration of the TRS are presented in Figure 16.6-2. When a SU finishes transmitting on a Failsoft channel, a TRS sends FAIL_STAT_INFO on an associated control channel again. If a failure on a TRS is restored, a TRS is restored to a normal control channel state by switching a composite control channel to the dedicated control channel. If a SU detects that a TRS has been restored to the normal state, the SU sends REG_REQ in order to proceed to a location registration. Conditions for a SU to send REG_REQ are the same as those for when a new site is found. However, since descriptions about superframe structure and BCCH are omitted in Figure 16.6-2, the timing to send REG_REQ from a SU may differ from the real timing.

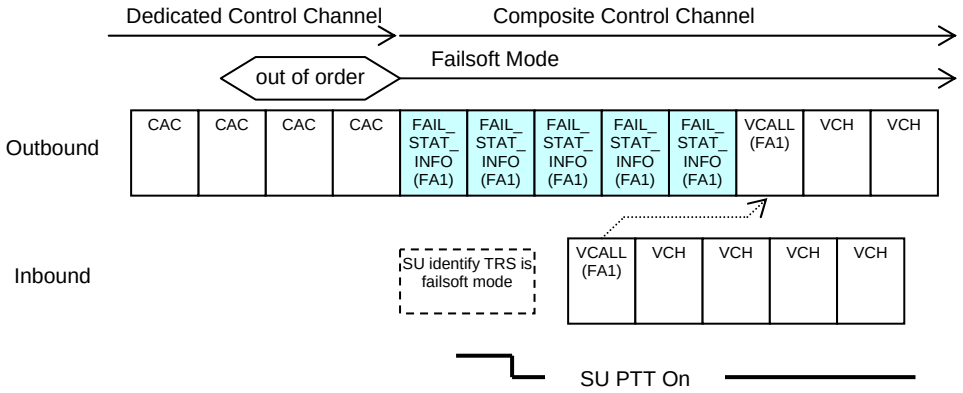


Figure 16.6-1 Outline of Operation when Entering Failsoft State

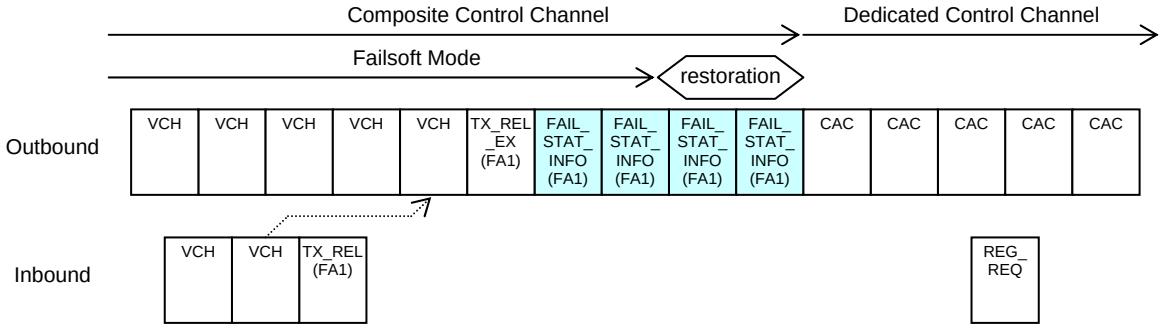


Figure 16.6-2 Outline of Operation when Restoring from Failsoft State

16.7. Restriction Control

Restriction control is used as a means to restrict a SU from accessing RCCH. With the restriction, the traffic density in a TRS can be controlled to avoid congestion, and stable operation can be realized. Also, Emergency calls can be preferentially accepted by performing a priority control to a SU. Restriction control is conducted by the Restriction Information information element contained in SITE_INFO and SRV_INFO.

16.7.1. Type of Restriction Control

This section describes types of restrictions that can be configured using Restriction Information information element.

(1) Access Group Restriction

Access Group Restriction divides the Unit ID of the SU into 4 groups, and prohibits the SUs belonging to the restricted group from making a location registration or an outgoing call. Since this restriction restricts the number of SUs permitted to initiate a location registration or an outgoing call, the amount of traffic can be reduced. It is also possible to restrict multiple groups at the same time or to change the group to be restricted in a superframe unit.

(2) Location Registration Restriction

Location Registration Restriction prohibits the SUs belonging to the restricted group from initiating a location registration.

(3) Call Restriction

Call Restriction prohibits the SUs belonging to the restricted group from initiating a outgoing call.

(4) Access Cycle Restriction

Access Cycle Restriction restricts the time interval for making a location registration or an outgoing call from a SU to an appropriate cycle. As soon as the restriction to SU is canceled, a number of SUs initiate location registrations or outgoing calls and RCCH might become an overloaded state. To avoid this situation, the number of accesses is dispersed by setting the time intervals for access.

(5) Maintenance Restriction

Maintenance Restriction is used to permit only SUs for maintenance to access the site where no service is offered due to site constructions, tests, etc. Since general SUs search for sites except the restricted site, this restriction prevents the SUs from doing false operation. However, the definition of the maintenance SU is system-dependent.

(6) General Mobile Station Restriction

General Mobile Station Restriction prohibits general SUs from initiating a location registration and an outgoing call. With this restriction, access from a higher priority SU such as Emergency

can be preferentially accepted. A priority mobile station means a SU in the Emergency state and a SU that is defined as priority in each system.

16.7.2. Description of Operation

This section describes the behavior of each restriction.

16.7.2.1. Access Group Restriction

A TRS broadcasts Restriction Information in which access restriction (Octet 0, Bit 7) is in effect and general station location registration restriction / call restriction (Octet 1, Bit 3-2) and restriction group specification (Octet 1, Bit 7-4) are set appropriately.
When a general mobile station recognizes that access restriction is in effect, the general mobile station judges whether its own mobile station is included in the restricted group. If included, the general mobile station disables the corresponding functions to the restriction contents (call/ location registration) of broadcast information. While access group restriction is in effect, the restricted group is periodically changed to prevent mobile stations in a specific group from being restricted. An example of changing restriction groups is presented in Figure 16.7-1.

If the value obtained by adding 1 to the remainder of when Unit ID in decimal is divided by 4 matches the group number to be restricted, the SUs having the Unit ID are subject to restriction.

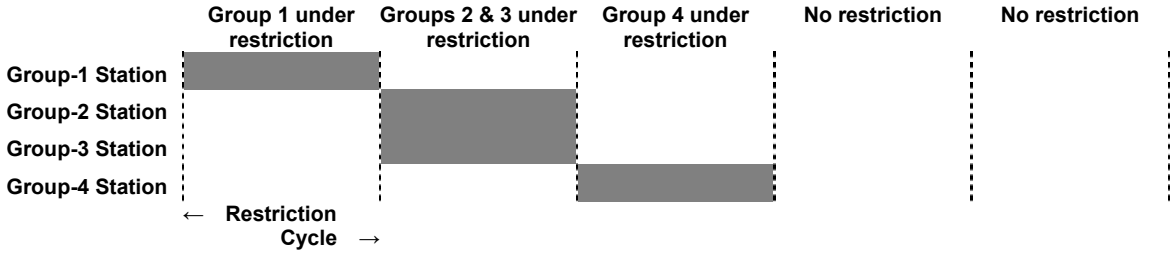


Figure 16.7-1 Example of Changing Restriction Group

If Access Group Restriction is in effect, if a SU ignores the restrictions and makes an outgoing call or location registration, a TRS detects and interrupts the process by SU.

16.7.2.2. Access Cycle Restriction

A TRS broadcasts Restriction Information in which access restriction (Octet 0, Bit 7) is in effect and access cycle intervals (Octet 0, Bit 3-0) is set appropriately. When a general mobile station recognizes that access restriction is in effect, it judges a setting time for the access cycle intervals. Except no restriction, the general mobile station is inhibited from accessing a TRS during the specified cycle intervals as a starting point when requests of an outgoing call or location registration have arisen.

When a TRS has canceled the restriction, SUs which have been released from the restriction access the TRS at the same time and RCCH might become an overloaded state. To avoid this

situation, the Access Cycle Restriction to SU is applied to disperse the number of accesses when a restriction is canceled. An example that overload of RCCH is dispersed by applying the Access Cycle Restriction when the restriction is canceled is represented in Figure 16.7-2.

An example of SU behavior while Access Cycle Restriction is in effect is represented in Figure 16.7-3. This example assumes the state that a TRS applies a call / location registration restriction to SUs in Group 1 as well as Access Cycle Restriction. A SU recognizes the Access Group Restriction and Access Cycle Restriction from Restriction Information. If a SU belonging to Group 1 intends to send a request for an outgoing call or location registration, the outgoing call and location registration are prohibited by Access Group Restriction and an access to a TRS is prohibited until end of the access cycle interval time from occurrence of the request regardless of Access Group Restriction. Accordingly, since the SUs under restriction do not concurrently access to a TRS when the Access Group Restriction is canceled, the utilization ratio of RCCH does not drastically increase. However, the Access Cycle Restriction is independent from other restrictions, therefore once a SU which does not belong to Group 1 accesses a TRS, the SU can not access again for the duration of Access Cycle Intervals.

Access Cycle Restriction is effective for general mobile stations, but not effective for the priority mobile stations.

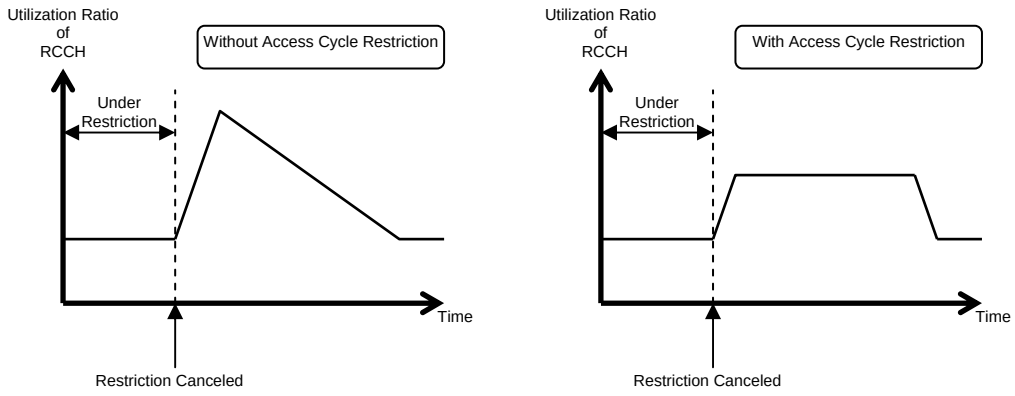


Figure 16.7-2 Utilization Ratio of RCCH when Access Restriction is Canceled

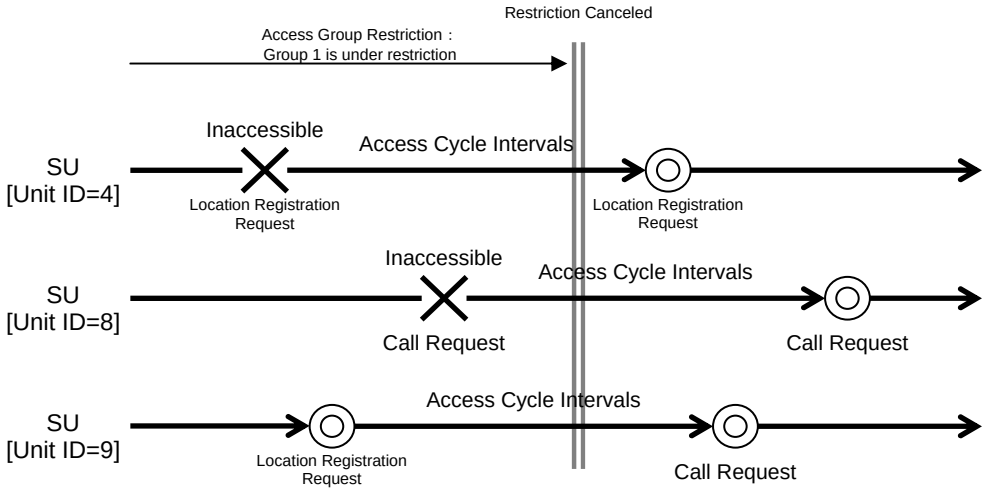


Figure 16.7-3 SU Behavior under Access Cycle & Access Group Restriction

16.7.2.3. Maintenance Restriction

A TRS broadcasts Restriction Information in which maintenance restriction (Octet 0, Bit 6) is in effect. If any SU other than the maintenance mobile station recognizes the maintenance restriction, the SU starts a control channel hunt and then proceeds to the idle state in other TRS.

16.7.2.4. General Mobile Station Restriction

A TRS broadcasts Restriction Information in which location restriction/ call restriction (Octet 1, Bit 3-2) is set appropriately. By recognizing the location registration/ call restriction, the behaviors of a general mobile station related to contents of the restriction is inhibited.

16.7.3. Procedure for SU Behavior

The behavior of SU corresponding to contents of the restriction is presented in Figure 16.7-4 and Figure 16.7-5.

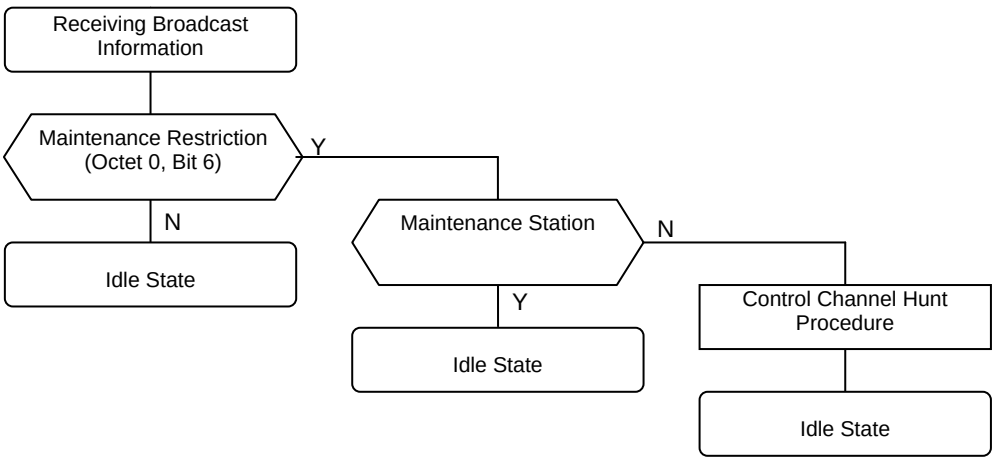
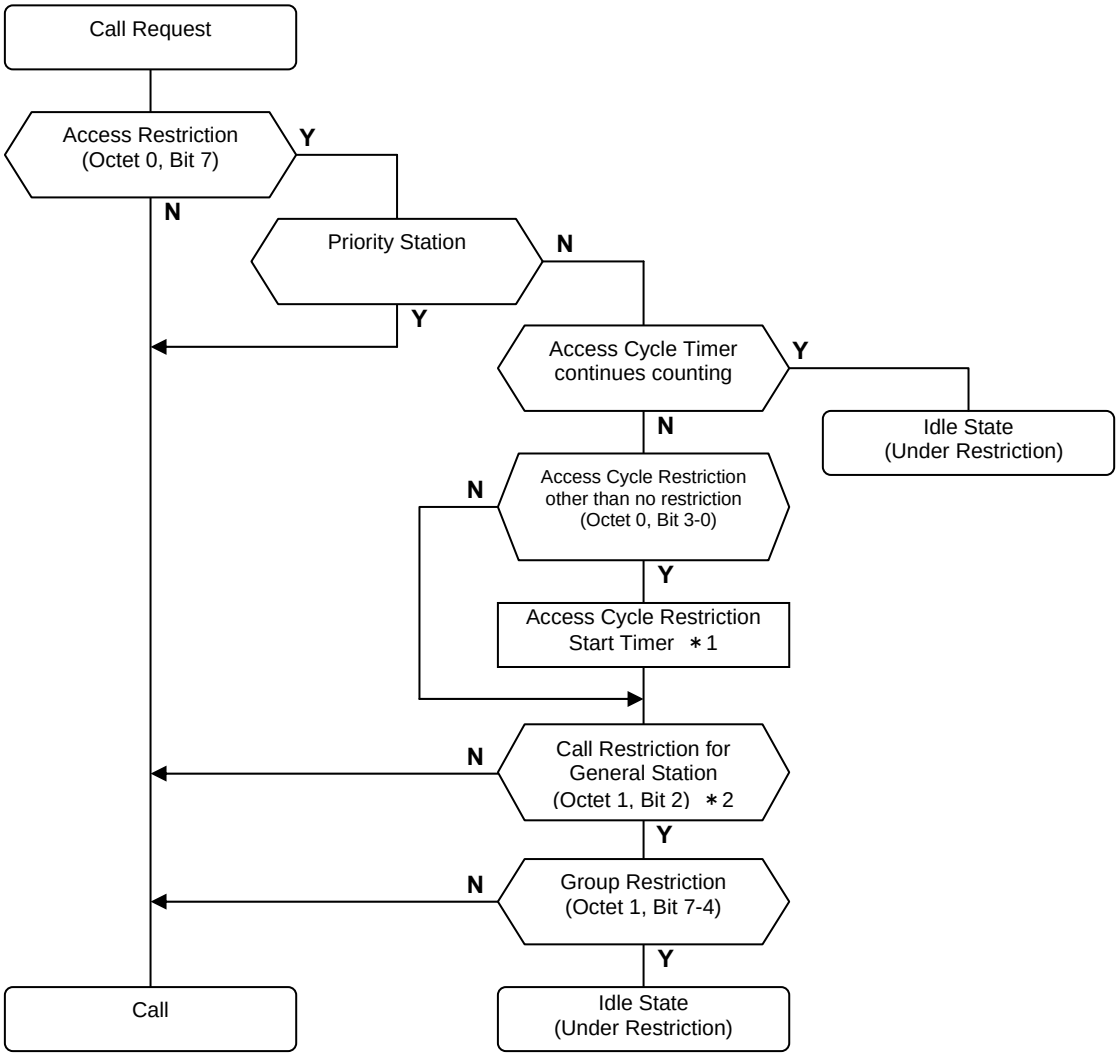


Figure 16.7-4 SU Behavior when Receiving Broadcast Information



*1 The timer expires when the duration configured for access cycle intervals elapses.

*2 The case of a location registration request, the location registration restriction for a general mobile station (Octet 1, Bit 3) is applied.

Figure 16.7-5 SU Behavior in Call Request

16.8. Priority Monitor

Priority Monitor allows a SU engaged in communication on a RTCH to migrate to a higher-priority communication which has begun on other RTCH.

Priority Monitor is a sort of Group Scan function for a trunked radio system and is conducted according to the level of priority configured for Group ID in group call. However, the method for configuring the level of priority is not specified.

16.8.1. TRS Behavior

A TRS is supposed to have the Group ID list and priority list data.

When a group call with Group ID = 10 which has higher priority than Group ID = 1 is initiated on another RTCH while a group call with Group ID = 1 is ongoing on an RTCH, a TRS carries out the following:

- VCALL_ASSGN_DUP (or VCALL_ASSGN) containing Group ID = 10 is sent out at intervals of Tr_dup on RCCH,.
- VCALL_ASSGN_DUP which has the same information as that of message sent on RCCH is sent out on RTCH on which group call with Group ID = 1 is ongoing. An associated control channel used and transmission cycle are arbitrary.
- When group call with Group ID = 10 is finished and its RTCH is released, transmission of the assignment message which is being sent on RCCH and RTCH is terminated.

A TRS shall not interrupt a group call made on RTCH using Group ID = 1.

A TRS processes a group call made on RTCH using Group ID = 10 under the normal procedure.

The above description assumes a use of one normal Group ID and one preferential Group ID. When multiple normal group calls are ongoing and/or multiple group calls at a higher priority are initiated, a TRS conducts the same process as described above according to the number of related calls.

16.8.2. SU Action

A SU is supposed to have a Group ID list and priority list data as with a TRS.

If a SU engaged in a group call using a normal Group ID receives VCALL_ASSGN_DUP, the SU proceeds to the following:

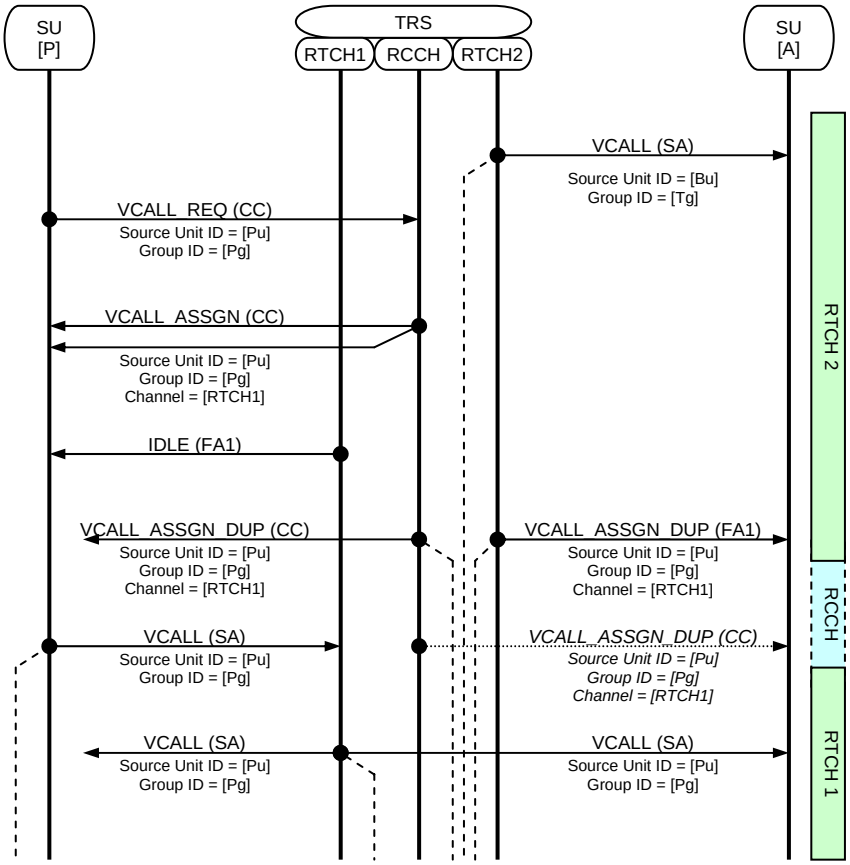
1. The SU judges the level difference between Group ID in use and Group ID contained in VCALL_ASSGN_DUP.
2. If the Group ID in use has the same or higher priority compared with the Group ID contained in VCALL_ASSGN_DUP, the SU remains on the current RTCH.
3. If the Group ID contained in VCALL_ASSGN_DUP has a higher priority level compared with the Group ID in use, the SU returns to RCCH and waits to receive VCALL_ASSGN_DUP (or VCALL_ASSGN). However, the behavior for returning to RCCH is arbitrary and a SU may directly move to another RTCH as below.

4. If the Group ID contained in VCALL_ASSGN_DUP has a higher priority level compared with the Group ID in use, the SU moves to RTCH designated by VCALL_ASSGN_DUP and then engages in the group call.
5. The SU returns to RCCH when RTCH is released at the end of the group call.

16.8.3. Sequence Diagram

The sequence of Priority Monitor is represented in Figure 16.8-1. SU [A] is receiving a group call using Group ID = [Tg] which is ongoing on RTCH2. This sequence represents that SU [P] sends a call request using Group ID = [Pg] with a higher priority level, a TRS assigns RTCH1 to the call request and then the SU [P] begins transmitting for group call on the designated RTCH1.

A TRS periodically sends VCALL_ASSGN_DUP on RCCH for Late Entry and also periodically sends VCALL_ASSGN_DUP on RTCH2. If SU [A] recognizes that the Group ID contained in VCALL_ASSGN_DUP is Group ID = [Pg] with a higher priority, SU [A] moves to RTCH1 designated by the Channel number contained in the message. However, a SU may return to RCCH as necessary and receive VCALL_ASSGN_DUP periodically broadcasted on RCCH. SU [A] starts receiving the group call originated by SU [P] after migrating to RTCH1.
As a result, SU [A] can be engaged in group call with a higher priority level even if SU [A] is engaged in a group call.



Notes:

1) Timing to start transmitting VCALL_ASSGN_DUP on RCCH and RTCH is arbitrary and does not need to be synchronized between RCCH and RTCH.
2) Intervals for sending VCALL_ASSGN_DUP on RTCH are not specified.

Figure 16.8-1 Sequence Diagram for Priority Monitor

17. Revision History

Version	Date	Revised Contents
1.0	Oct 26 2007	Version 1.0 release
1.1	Dec 12 2008	Section 3: Added the item. Section 5.4: Modified the description for cancel process. Section 15.1: Revised the incorrect description for the Timer List in Parameter. Section 16.3 and 16.8: Deleted the term SACCH. Section 16.7: Revised the incorrect description for group restriction.
1.2	Jul 7 2008	Copyright added. Section 4.2: System Identification added. Section 5.1.3: Modified the description for multi RCCH. Section 5.3.1.1: Late Entry added. Section 5.5.1: Modified the description for SU termination process. Section 10 & 11: Modified call termination for unit. Section 10 & 11 & 16.8: Modified RTCH maintenance method. Section 15.1: Modified Nr_ob and Tr_dup. Section 16.3: Modified the example for CCH communication.
1.3	Nov 11 2011	Section 1.1: Add the description of Type-C. Section 3: Delete unused abbreviations. Section 5.3.3: Add the description for designation of info element. Section 8.3: Modify the condition of Registration Clear. Section 10.8: Add the procedure for simultaneous data call. Section 16.1.2: Add the description for intermittent operation using LICH. Various errors in writing are corrected.