



The University of Sydney  
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School of Electrical and Information Engineering

# Advanced Communication Networks

## Chapter 6

### *ISDN Network Layer*

Based on chapter 9 of Stallings ISDN-4e book

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## 6.1 Introduction

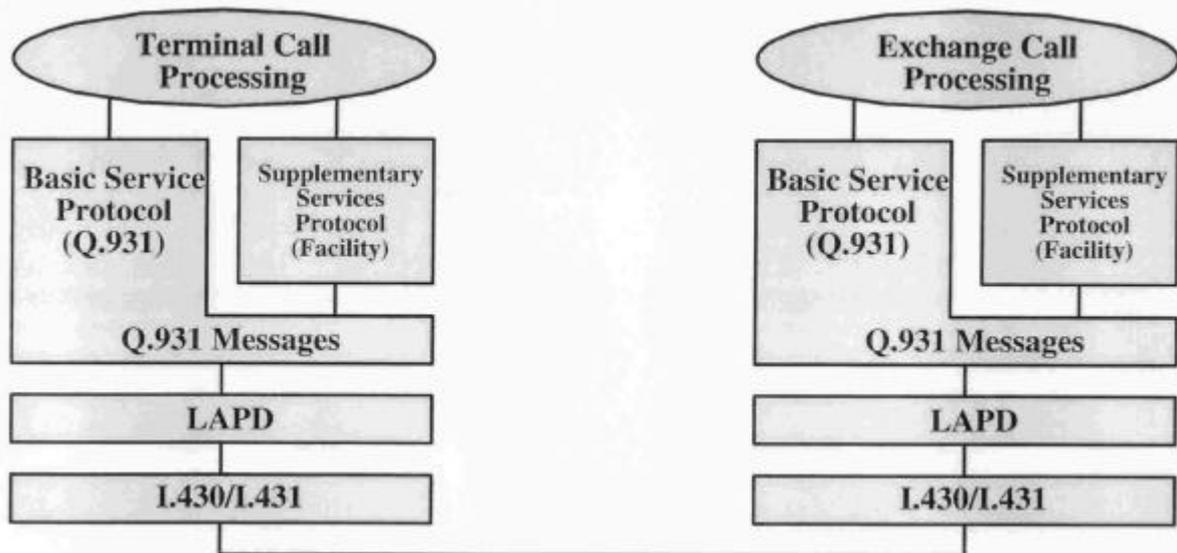
- **Q.931:** a new ISDN network-layer protocol
  - provides out-of-band call control for B and H channel traffic
  - makes use of the D channel; both for circuit- & packet-mode communication
- ISDN specification for call control are in recommendations:
  - **Q.930:** ISDN user-network interface layer 3–General aspects
  - **Q.931:** Specification for basic call control
  - **Q.932:** Generic procedures for control of ISDN supplementary services
  - **Q.933:** Specification for frame-mode basic call control
  - **Q.939:** Typical DSS service indicator codings for ISDN telecom services
  - **Q.950:** Supplementary service protocols–Structure and general principles
- Digital Subscriber Signaling System Number 1 (DSS 1)
  - collection of capabilities for providing call control signaling Over D channel

### Physical Layer

I.430: basic access  
 I.431: primary access  
 (supporting B and D channels traffic)

### Data Link Layer

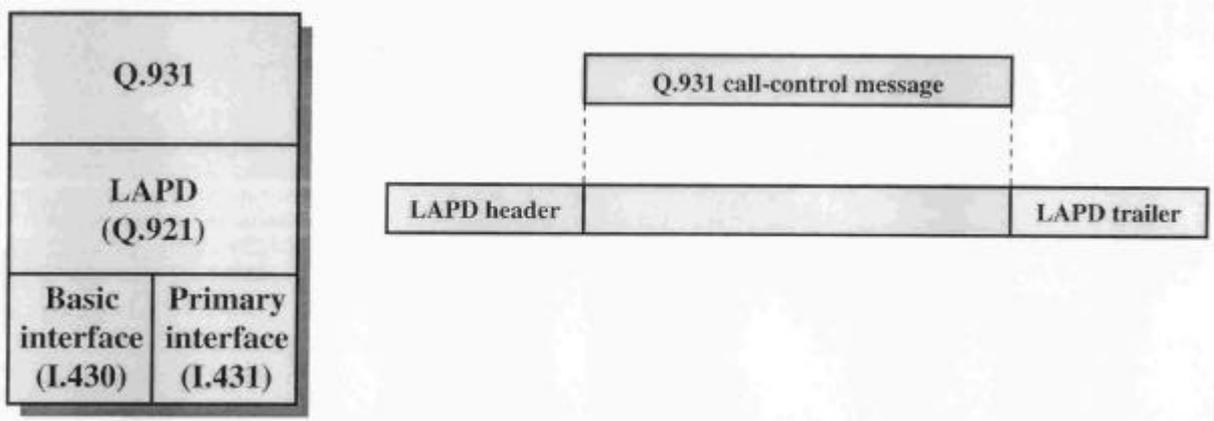
LAPD  
 (supporting D channel traffic)



Modeling of basic and supplementary services

## 6.2 Basic Call Control

- Q.931 specifies procedures for establishing connections on B and H channels that share the same interface to ISDN as the D channel.
- Basic functions at the network layer:
  - interaction with the data link layer to transmit and receive messages
  - generation and interpretation of layer 3 messages
  - administration of timers and logical entities used in call control procedures
  - administration of access resources, including B and packet-layer logical chan's
  - verification that services provided are consistent with user requirements
- Additional functions at the network layer:
  - **routing and relaying**: for end system connected to different subnetworks
  - **network connection control**: mechanisms using data link connections
  - **conveying user-to-network and network-to-user information**
  - **network connection mux**: for call control inf. of multiple calls on one LAPD
  - **segmenting and reassembly**
  - **error detection**: for procedural errors in layer 3 protocol
  - **error recovery**: error recovery mechanisms from detected errors
  - **sequencing**: mechanisms for sequenced delivery of layer 3 information
  - **congestion control and user data flow control**
  - **restart**: returning channels and interfaces to an idle condition



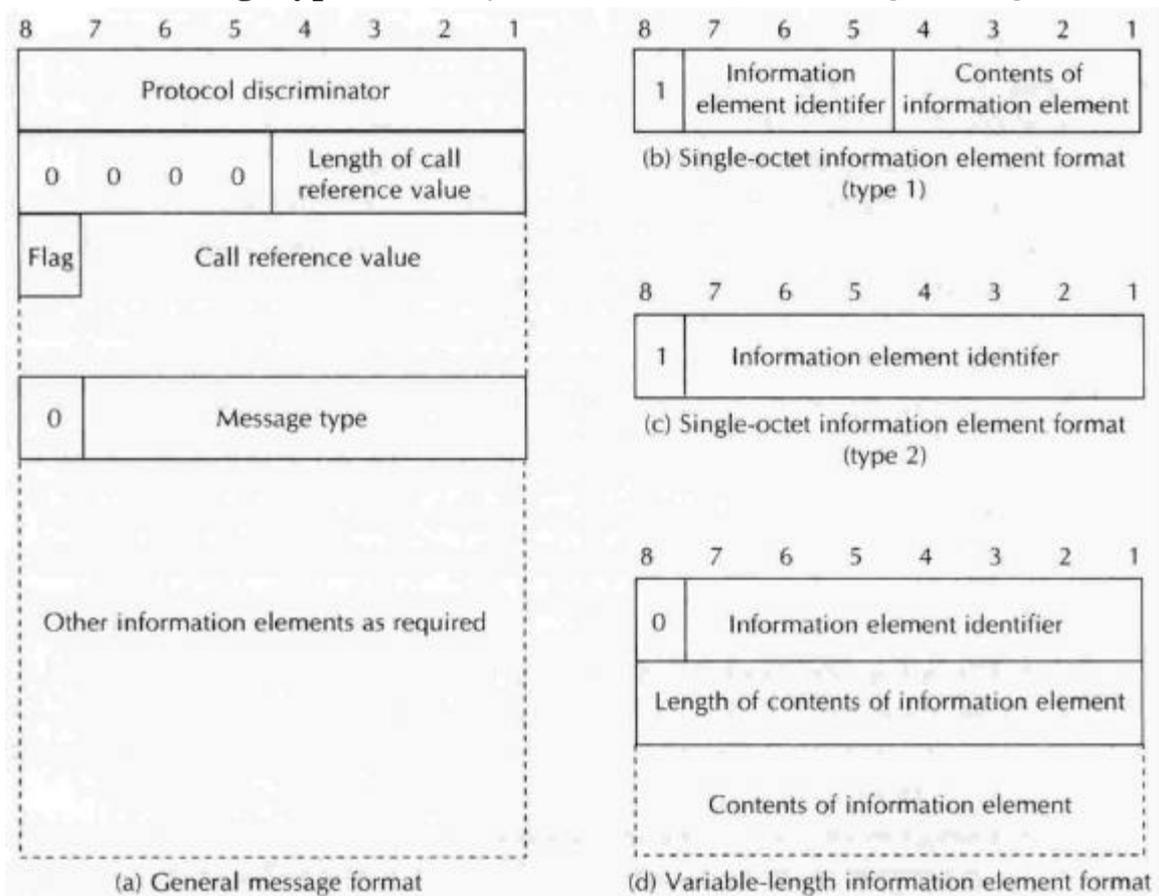
Call control protocol architecture

## Terminal Types

- Two basic types of user terminals
  - **Functional Terminals**—intelligent devices employing full range of Q.931 messages and parameters for call control
  - **Stimulus Terminals**—devices with a rudimentary signaling capability
- A digital telephone is a stimulus terminal.
  - transmits signaling information one event at a time
  - network sends instruction regarding operation to be done by term.

## Messages

- Common fields in Q.931 format
  - **Protocol discriminator:** to distinguish messages for user-network call control from other message types (binary 00001000)
  - **Call reference:** to identify B or H channel call to which the message refers
  - **Message type:** to identify which Q.931 or Q.932 message is being sent



- Three subfields in the *call reference* field:
  - *length*: specifies length of the field (1 byte for basic rate, 2 bytes for primary rate interface)
  - *call reference value*: the number assigned to the call specifies the connection
  - *flag*: indicates which end of LAPD logical connection initiated call
    - 0: the message is from the side that originated this call reference
    - 1: the message is to the side that originated this call reference
    - prevents conflict if both NT and TE select the same call reference value
- Types of Messages
  - **Circuit-mode connection control**: refers to functions to set up, maintain, and clear a circuit-switched connection on a B channel. This function corresponds to call control in existing circuit-switching telecom networks
  - **Packet-mode access connection control**: refers to functions to set up a circuit-switched connection to an ISDN packet-switching mode
  - **User-to-user signaling not associated with circuit-switched calls**: allows two users to communicate without setting up a circuit-switched connection. A temporary signaling connection is established and cleared in a manner similar to the control of circuit-switched connection. Signaling takes place over the D channel and thus does not consume B channel resources
  - **Messages used with the global call reference**: refers to functions that enable the user or network to return one or more channels to an idle condition
  - functions performed by messages:
    - Call establishment; services are:
      - set up a B channel call in response to user request
      - provide particular network facilities for this call
      - inform calling user of the progress of the call establishment process
    - Call information
    - Call clearing
    - Miscellaneous (e.g., to negotiate network features, supplementary serv.)

## Q.931 messages for circuit-mode connection control

Message	Significance	Direction	Function
<b>Call establishment messages</b>			
ALERTING	Global	Both	Indicates that user alerting has begun
CALL PROCEEDING	Local	Both	Indicates that call establishment has been initiated
CONNECT	Global	Both	Indicates call acceptance by called TE
CONNECT ACKNOWLEDGE	Local	Both	Indicates that user has been awarded the call
PROGRESS	Global	Both	Reports progress of a call
SETUP	Global	Both	Initiates call establishment
SETUP ACKNOWLEDGE	Local	Both	Indicates that call establishment has been initiated but requests more information
<b>Call information phase messages</b>			
RESUME	Local	u → n	Requests resumption of previously suspended call
RESUME ACKNOWLEDGE	Local	n → u	Indicates requested call has been reestablished
RESUME REJECT	Local	n → u	Indicates failure to resume suspended call
SUSPEND	Local	u → n	Requests suspension of a call
SUSPEND ACKNOWLEDGE	Local	n → u	Call has been suspended
SUSPEND REJECT	Local	n → u	Indicates failure of requested call suspension
<b>Call clearing messages</b>			
DISCONNECT	Global	Both	Sent by user to request connection clearing; sent by network to indicate connection clearing
RELEASE	Local	Both	Indicates intent to release channel and call reference
RELEASE COMPLETE	Local	Both	Indicates release of channel and call reference
INFORMATION	Local	Both	Provides additional information
NOTIFY	Access	Both	Indicates information pertaining to a call
STATUS	Local	Both	Sent in response to a STATUS ENQUIRY or at any time to report an error
STATUS ENQUIRY	Local	Both	Solicits STATUS message

## Definition of information elements for Q.931 messages

### **Bearer Capability**

Indicates provision, by the network, of one of the bearer capabilities defined in I.231 and I.232. It contains detailed information on protocol options at each layer to construct the desired service.

### **Call Identity**

Identifies a suspended call. It is assigned at the start of call suspension.

### **Call State**

Describes the current state of a call, such as active, detached, or disconnect.

### **Called/Calling Party Number**

Identifies the ISDN address of the called or calling party.

### **Called/Calling Party Subaddress**

Identifies the subaddress of the called or calling party.

### **Cause**

Describes the reason for generating certain messages, to provide diagnostic information in the event of procedural errors, and to indicate the location of the cause originator. The location is specified in terms of which network originated the cause.

### **Channel Identification**

Identifies the channel/subchannel within the interface (e.g., which B channel) that is controlled by these signaling procedures.

### **Date/Time**

Indicates when the message was generated by the network.

### **Display**

Supplies additional information coded in IA5 (International Alphabet 5, which is the same as ASCII) characters. Intended for display on user terminal.

### **High-Layer Compatibility**

Specifies the terminal type or application that is on the user side of an S/T interface (e.g., telephony, Teletex, X.400 message-handling system). The network transports this information transparently end-to-end to enable the remote user to perform compatibility checking.

### **Keypad Facility**

Conveys IA5 characters entered by means of a terminal input.

### **Low-Layer Compatibility**

Used for end-to-end compatibility checking. It includes information-transfer capability, information-transfer rate, and protocol identification at layers 1 through 3.

### **Network-Specific Facilities**

Specifies facilities peculiar to a particular network.

### **Notification Indicator**

Provides information pertaining to a call. The values currently defined are user suspended, user resumed, and bearer service charge.

### **Progress Indicator**

Describes an event that has occurred during the life of a call.

### **Repeat Indicator**

Indicates that one possibility should be selected from repeated information elements.

### **Sending Complete**

Indicates completion of called party number.

### **Signal**

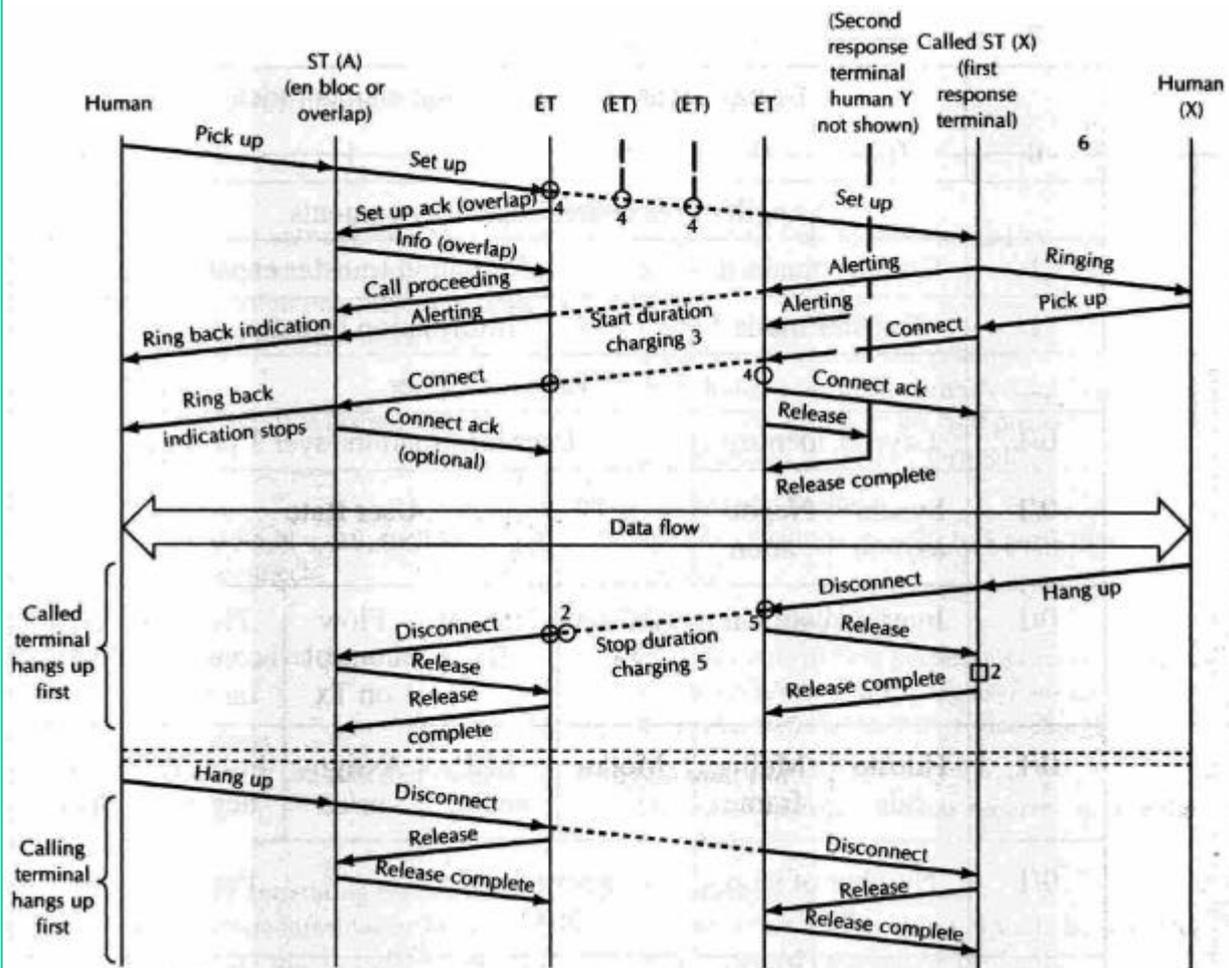
Conveys information causing a stimulus mode terminal to generate tones and alerting signals. Example values are dial tone on, ring back tone on, busy tone on, and tones off.

### **Transit Network Selection**

Identifies network that connection should use to get to final destination. This information element may be repeated within a message to select a sequence of networks through which a call must pass.

## Circuit-Mode Example

- SETUP message includes dest. no, channel id, any requested net. services
- SETUP message triggers two activities at the local exchange
  - local exchange to send a message for designating a route and allocating resources for that call
  - exchange sends back a CALL PROC message showing that call setup is underway



- Note 1: The sequence for overlap sending is not represented in this diagram.  
 Note 2: A terminal should not release the D channel connection and power until after this point.  
 Note 3: A proposal for further study (it may be a national matter).  
 Note 4: Proposed switch-through points and the sequence in which they occur.  
 Note 5: Proposed network release points and the sequences.  
 Note 6: The interactions between the human and the terminal are shown for illustration only.

## *Packet-Mode Connection Control*

- Three alternatives for packet-mode communications
  - circuit-switched access to a PSPDN over a B channel
  - packet-switched access to an ISDN virtual circuit service over B ch.
  - Packet-switched access to an ISDN virtual circuit service over D ch.
    - In this case, no Q.931 procedures are required. The user has access to the D channel VC service by sending X.25 packets inside LAPD frames
- In each case, the user uses X.25 call control procedure to set up VCs to other end users that are connected to the same PSN.
- Differences with circuit-mode connection control
  - SETUP ACK message is not used; no additional information is required.
  - no call information phase messages are supported (i.e., no suspend/resume).
  - INFORMATION and NOTIFY messages are not supported.

### Q.931 messages for packet-mode access connection control

Message	Significance	Direction	Function
<b>Access connection establishment messages</b>			
ALERTING	Local	u → n	Indicates that user alerting has begun
CALL PROCEEDING	Local	Both	Indicates that access connection establishment has been initiated
CONNECT	Local	Both	Indicates access connection acceptance by called TE
CONNECT ACKNOWLEDGE	Local	Both	Indicates that user has been awarded the access connection
PROGRESS	Local	u → n	Reports progress of an access connection in the event of interworking with a private network
SETUP	Local	Both	Initiates access connection establishment
<b>Access connection clearing messages</b>			
DISCONNECT	Local	Both	Sent by user to request connection clearing; sent by network to indicate connection clearing
RELEASE	Local	Both	Indicates intent to release channel and call reference
RELEASE COMPLETE	Local	Both	Indicates release of channel and call reference
<b>Miscellaneous messages</b>			
STATUS	Local	Both	Sent in response to a STATUS ENQUIRY or at any time to report an error
STATUS ENQUIRY	Local	Both	Solicits STATUS message

Q.931 messages for user-to-user signaling not associated with circuit-switched calls

Message	Significance	Direction	Function
<b>Call establishment messages</b>			
ALERTING	Global	Both	Indicates that user alerting has begun
CALL PROCEEDING	Local	Both	Indicates that call establishment has been initiated
CONNECT	Global	Both	Indicates call acceptance by called TE
CONNECT ACKNOWLEDGE	Local	Both	Indicates that user has been awarded the call
SETUP	Global	Both	Initiates call establishment
SETUP ACKNOWLEDGE	Local	Both	Indicates that call establishment has been initiated but requests more information
<b>Call information phase messages</b>			
USER INFORMATION	Access	Both	Transfers information from one user to another
<b>Call clearing messages</b>			
RELEASE	Local	Both	Indicates intent to release channel and call reference
RELEASE COMPLETE	Local	Both	Indicates release of channel and call reference
<b>Miscellaneous messages</b>			
CONGESTION CONTROL INFORMATION	Local	Both	Sets or releases flow control on USER INFORMATION messages
STATUS	Local	Both	Sent in response to a STATUS ENQUIRY or at any time to report an error
STATUS ENQUIRY	Local	Both	Solicits STATUS message

Q.931 messages used with the global call reference

Message	Significance	Direction	Function
RESTART	Local	Both	Requests the recipient to restart the indicated channel(s) or interface
RESTART ACKNOWLEDGE	Local	Both	Indicates that the requested restart is complete
STATUS	Local	Both	Reports an error condition

## 6.3 Supplementary Services Control

- **Recomm. Q.932:** procedure for control of supplementary services
- Major methods for the control identified by Q.932
  - keypad protocol; for stimulus terminals
  - feature key management protocol; for stimulus terminals
  - functional protocol; for more sophisticated services

### *Keypad Protocol*

- Supports suppl. Service invocation in user-to-network direction
  - Keypad facility information element in SETUP and INFORMATION Q.931 messages in the user-network direction
  - Display information element in any Q.931 message in network-user direction
- Typically user enters a service request at a keypad which is translated into a keypad facility information element.
- Network uses the display information element to give an indication to the local user (displayed or heard at user terminal).

### *Feature Key Management Protocol*

- Assumed that the user terminal has function keys or a similar facility that allows him to select and services.
- The protocol makes use of these information elements:
  - Feature activation information element in SETUP and INFORMATION Q.931 messages in the user-network direction
  - Feature indication information element in any Q.931 message in net-user direct.
- For each terminal there is a user's service profile. The network maps a numeric identifier came from the terminal into corresponding service.
- Network response to this request includes the status of the service, which may be one of these:
  - » **deactivated**
  - » **activated**
  - » **prompt**
  - » **pending**

## *Functional Protocol*

- Based on a number of specific messages designed for this protocol
- Control of supplementary services includes:
  - invocation of supplementary services during establishment of a call
  - invocation of supplementary services during clearing of a call
  - invocation of call-related services during active state of a call
  - activation, deactivation, interrogation, or registration of services independent from an active call
  - invocation of multiple, different services within a single message
  - invocation of services related to different calls
  - cancellation of invoked services and notification to the initiator of the supplementary service
- Two categories of procedures in functional protocol
  - **separate message approach**
  - **common information element procedure**

Message	Direction	Function	Information Elements
<b>Separate Message Approach</b>			
HOLD	Both	Requests the hold function for an existing call	Display
HOLD ACKNOWLEDGE	Both	Indicates that the hold function has been successfully performed	Display
HOLD REJECT	Both	Indicates the denial of a request to hold a call	Cause, Display
RETRIEVE	Both	Requests the retrieval of a held call	Channel identification, Display
RETRIEVE ACKNOWLEDGE	Both	Indicates that the retrieve function has been successfully performed	Channel identification, Display
RETRIEVE REJECT	Both	Indicates the inability to perform the requested retrieve function	Cause, Display
<b>Common Information Element Procedure</b>			
FACILITY	Both	Requests or acknowledges a supplementary service	Facility, Display
REGISTER	Both	Assigns a new call reference for non-call-associated transactions	Facility, Display