Recommendation Q.50

SIGNALLING BETWEEN CIRCUIT MULTIPLICATION EQUIPMENTS (CME) AND INTERNATIONAL SWITCHING CENTRES (ISC)

1. Introduction

This Recommendation contains principles and examples of signalling between ISC (exchanges) and their associated circuit multiplication equipments.

Circuit multiplication equipments may have integral echo control and A/μ law converter functions. The information in this Recommendation is compatible with the control procedures for such devices.

2. Definitions relating to CME

For a complete description of additional definitions see Recommendation Q.dcme.

2.1 Digital circuit multiplication equipment (DCME) and CME

DCME and CME constitute a general class of equipment which permits concentration of a number of trunks on a reduced number of transmission channels. DCME in particular permits concentration of a number of 64 kbit/s PCM encoded trunks on a reduced number of digital transmission channels.

2.2 Speech interpolation; digital speech interpolation (DSI)

A method of profiting from the time instants when a speaker is not active, which is indicated by a speech detector. The channel is then used by another active connection. The signals carried by a transmission channel therefore represent interleaved bursts of speech signals derived from a number of different trunks.

2.3 Low rate encoding (LRE)

Speech coding methods with bit rates less than 64 kbit/s, e.g. the 32 kbit/s transcoding process defined in G.721 applied to speech coded according to G.711.

2.4 Speech activity

The ratio of the time speech and corresponding hangover occupies the trunk to the total measuring time, averaged over the total number of trunks carrying speech.

2.5 CME gain

The trunk channel to transmission channel multiplication ratio, which is achieved through application of CME, including LRE and/or speech interpolation (DSI).

FIGURE 1/Q.50

CME gain

2.6 Trunk

A bidirectional connection consisting of a forward channel and a backward channel between the ISC and CME not subject to LRE or DSI operation.

2.7 Transmission channel - bearer channel

One channel of the connection between the transmit unit and receive unit of corresponding CME.

2.8 Freeze-out

The temporary condition when a trunk channel becomes active and cannot immediately be assigned to a transmission channel, due to lack of available transmission capacity.

2.9 Freeze-out fraction

The ratio of the sum of the individual channel freeze-outs to the sum of the active signals and their corresponding hangover times and front end delays, for all trunk channels over a fixed interval of time, e.g. one minute.

2.10 Transmission overload

The condition when the freeze-out fraction or average bits per sample goes beyond the value set in accordance with speech quality requirements.

2.11 Operating modes

2.11.1 Point-to-point mode (see Figures 2a/Q.50 and 2b/Q.50)

Point-to-point - Using Figure 2a/Q.50 for reference, the transmit side CME concentrates N trunks into N/G transmission channels, where G is the CME gain.

At the receive side, the receiving CME simply reconstitutes the N trunks from the N/G transmission channels.

FIGURE 2a/Q.50

Point-to-point unidirectional

FIGURE 2b/Q.50

Point-to-point two origins unidirectional

FIGURE 2/Q.50

Multi-clique for two origins and two destinations unidirectional

The example in Figure 2b/Q.50 also shows a point-to-point mode. From the switching point of view there could be a difference between the configurations in Figures 2a/Q.50 and 2b/Q.50.

For transmission of alarms it has also to be considered, that different exchanges may be connected to one CME.

2.11.2 Multi-clique mode (see Figure 3/Q.50)

Multi-clique mode - in this mode the pool of transmission channels is sub-divided into several independent pools (cliques) of fixed capacity, each destination specific. If a part of the cliques capacity is not used, it cannot be used for another destination.

FIGURE 3/Q.50

Multi-clique mode (only one direction shown)

2.11.3 Multi-destination mode

A DCME operational mode where input trunk channel traffic is interpolated over a pool of available transmission channels for all destinations having traffic in the pool. The transmit trunk channels are designated to receive trunk channels at corresponding locations.

Figure 4/Q.50 shows a unidirectional system block diagram for a multi- destination mode with two transmit and two receive DCME units.

FIGURE 4/Q.50

Multi-destination mode (only one direction shown)

3. Requirements for control

3.1 Reasons for use of circuit multiplication equipments (CME)

Circuit multiplication equipments are used in order to reduce the bandwith required for transmission of a given set of calls. This can be achieved by reducing the redundancy which is inherent in speech communications. CME gains of up to 5:1 can be achieved using DSI + LRE with subjectively acceptable quality. Thus, the amount of line plant required between switching points and hence the cost of provision can be minimized.

3.2 Integration of CMEs into the telephone network

Normally, when an exchange needs an outgoing circuit, the circuit selection is based on circuit availability. In this example, the call may be blocked if all of the circuits are unavailable due to traffic or maintenance. If the same call encounters a CME, the possible outcomes are more complex.

From the point of view of call set-up, two CME aspects may necessitate information transfer between the exchange and the CME.

a) Transmission Capacity - The circuit multiplication characteristics of a CME result in a lower total transmission capacity for the CME as compared to the transmission capacity of all of the input trunks. A call may find a free (unseized) circuit from the exchange to the CME but no available transmission channels between two CMEs. For systems employing speech interpolation, allowing additional calls could lead to unacceptable speech quality degradation due to freeze-out. The probability of freeze-out can be reduced by the creation of overload channels using bit-stealing

techniques. Additional quality control is achieved if the exchange knows, through a Transmission Resource Management System, if the CME has available capacity to complete a new call.

b) Call Set-Up/Release - Depending on the bearer service type of the call to be set-up, and on whether or not the CME is able by itself to establish the inter-CME connections, the seizing/releasing actions in the exchange may need to be extended to the CME by means of out-of-band information transfer. For example, in DSI systems, speech connections are made dynamically on detection of channel activity performed by built-in speech detectors. For 64 kbit/s unrestricted on-demand connections (and for 3.1 kHz audio, if appropriate) through DSI systems (i.e., not through internal pre-assignment), the establishment and disestablishment of connections between the CMEs have to be initiated from the outgoing exchange.

In general, these two aspects are strictly independent from each other as each serves a different purpose. However, depending on the design criteria in the CME and the call set-up procedures in the exchange and the CME associated with one aspect may be related to that of the other.

3.3 Factors for signalling functions determination

The functional requirements for signalling between CMEs and exchanges are determined by the type of CME with its capabilities and limitations, and by the types of bearer services it supports.

The remote control of echo control devices and A/μ-law converters, if they are integrated into the CME, is accomplished either by the terminal or test equipment or directly from the ISC (based on call set up information/signalling information).

Requirements and actions for control of ECD are described in CCITT Recommendation Q.115.

3.3.1 Circuit multiplication equipment and physical location

There are different types of CME which are being used or will most likely be used in the international telephone network, each with its own capabilities and limitations:

a) 32 kbit/s low rate encoding (LRE);

b) analogue speech interpolation equipment;

c) digital speech interpolation (DSI) with 64 kbit/s PCM;

d) combined 32 kbit/s LRE and DSI

e) 16 kbit/s LRE.

The location of certain types of CME relative to the exchange determines the choice of signalling interface. These CMEs can be located at the ISC or remote from the ISC (e.g., at an earth station). Certain types of signalling interfaces may be more practical when these CMEs are co-located with the ISC, and others may be more practical when they are remote from the ISC. Therefore, the location of the CME needs to be considered when choosing the signalling between ISC and CME.

When the CME is remote from the ISC, the link between the ISC and CME could be composed of digital or analogue transmission path. Both conditions have different equipment configurations and different signalling requirements (see section 7).

3.3.2 Bearer services supported on CME links

Up to four basic bearer service types are supported or will likely be supported by CMEs in the international network:

- speech bearer service (full duplex, analogue or digital);

- 3.1 kHz audio bearer service (full duplex);

- 64 kbit/s unrestricted bearer service (full duplex);

- alternate speech/64 kbit/s unrestricted bearer service (full duplex) (in call modification is for further study).

Each CME type supports one or more bearer services depending on special facilities or functional options built in the equipment.

Different LRE algorithms will also have different levels of performance, for instance, in terms of voiceband data. Since certain speech optimized algorithms have limited transparency to voice band data, the CME has internal facilities (e.g., data detectors combined with route around mechanisms and/or special algorithms) to overcome its inherent limitations. This approach clearly separates the CME transmission problems from the ISC switching functions as much as possible to allow independent developments.

TABLE 1/Q.50

Bearer services supported in CMEs in relation to CME-exchange signalling

List of abbreviations:

TRM = transmission resource management
CSM = call set-up messages between CME and ISC

NS = bearer service not supported
NX = bearer service supported without message exchange
FS = further study

1) message exchange not necessarily implemented
2) supported through pre-assignments (e.g., Recommendation G.761 transcoder DNI)
3) supported in a limited fashion (e.g., Recommendation G.761)
4) CSM not needed with internal CME special handling facilities

4. Bearer services and CME techniques in the context of signalling

Table 1/Q.50 gives the relationship between CME techniques and the four bearer services identified in § 3.3.2 with regard to their supportability and the need for CME-exchange message transfer.

The signalling function requirements are categorized on the basis of bearer services supported by the different CME techniques. For speech bearer services, transmission resource management (TRM) information alone is adequate especially for CMEs employing speech interpolation. The objective of this provision is to maintain the reduction of transmission quality within tolerable limits. In addition to TRM information, external call set-up message (CSM) exchange is needed for bearer services involving on-demand 64 kbit/s unrestricted service in contemporary digital circuit multiplication equipment (32 kbit/s LRE and DSI).

5. Division of functionality between the ISC and the CME

5.1 CME dynamic load control process

Transmission resource management (TRM) information is based on traffic load measurements at the local and distant CMEs. Therefore in the multi- destination and multi-clique mode of operation, TRM information is provided for each destination/clique separately.

A universal arrangement is used for handling TRM information between CME and an ISC. The TRM information is dynamically presented to the exchange in one of two states for each bearer service. The states are called "available" and "not available". Logic within the CME is used to determine which of the two states should be indicated to the exchange regardless of any condition at the exchange.

When a CME encounters a "not available" state for a bearer service (either locally or remotely), it presents this indication to the exchange so it will stop routing new calls to the CME for that bearer service even if there are free, unseized circuits available. The exchange will continue to prohibit calls to the CME until it receives an "available" indication for the bearer service when in both, local and remote CMEs, there is no overload.

This dynamic load control information is therefore directly influencing the circuit selection process in the exchange during call set-up for each bearer service separately. The circuit selection in the exchange is a check whether or not a free unseized circuit is suitable for a certain bearer service type, for which a new call is to be accommodated. For example, the exchange would select a free circuit for a speech call if "speech capacity available" is indicated, irrespective of the indications for other bearer service types. If the DCME link is unable to accommodate additional new 64 kbit/s calls, all free unseized circuits within the exchange will be marked accordingly. Even though the generation of bearer service related TRM information with DCMEs may be in part mutually dependent (i.e., no capacity for speech implies no capacity for any other bearer service types but not necessarily vice-versa), separate signalling and processing for each bearer service type are necessary to allow different future CMEs to develop independently.

5.2 Call set-up process

According to Table 1/Q.50, the contemporary digital circuit multiplication equipment, having the capability to support on-demand all four identified bearer services, in addition to providing TRM to the exchange, requires call set-up messages (CSM) (from the exchange) for selecting bearer services.

For the 64 kbit/s unrestricted bearer service, a circuit is selected if "unrestricted capacity available" is indicated, and a CSM in the form of Seizure/Select request is forwarded to the DCME. An acknowledgement (positive or negative) is sent upon recognition of a 64 kbit/s request even if capacity is available.

The positive acknowledgement can be used by the ISC to initiate the interexchange signalling to the next ISC (e.g. transmission of the IAM of Signalling System No. 7). A failure to establish a 64 kbit/s circuit between CMEs must be reported to the ISC as soon as the condition has been identified by the CME by using an out-of-service message.

The out-of-service message is considered by the ISC to be equivalent to the alarm signal defined in Recommendation Q.33. The ISC will take release actions (if appropriate) as specified in Recommendation Q.33, § 4.

The released 64 kbit/s message from the ISC will be positively acknowledged after proper completion of the DCME circuit disestablishment process. Failure to complete this process shall be notified to the ISC using an out-of-service message and the DCME will put the circuit in a blocked condition. After the failure condition is removed, this circuit will be in idle condition and a back-in-service message shall be sent to the ISC.

Under a 64 kbit/s unrestricted dual seizure situation, the non- controlling ISC will initiate a release of the DCME connection using procedures defined in the appropriate inter ISC signalling system protocol. If the DCME is unable to re-establish a remotely released 64 kbit/s duplex connection, it shall indicate this abnormal situation to the appropriate ISC by an out-of- service message.

The information elements and procedures necessary to support the alternate 64 kbit/s speech bearer services are for further study.

FIGURE 5/Q.50

Typical ISC/CME information flows

5.3 Inter-dependency between dynamic load control and call set-up process

To allow a standard method of interworking with inter-exchange signalling systems it is important to adopt the functional interdependency between TRM and CSM as described above.

6. Control information elements between ISC and CME

The amount of control information elements utilized between the ISC and the CME depends on the capabilities of the CME and the ISC. Two categories of CME signalling capabilities are recognized. The first category of CME (Type 1) is capable of only transmitting signals from the CME to the ISC (e.g. Dynamic Load Control, see paragraph 6.1). The second category of CME (Type 2) is able to transmit and receive signals to/from the ISC. Tables 2/Q.50, 3/Q.50 and 4/Q.50 give a set of information elements and their flow on the control link between the ISC and the CME for the second category of CME.

6.1 Information elements for Type 1 CME

Type 1 CME only should use the following types of information elements. The "m" indicates mandatory use, the "o" optional use.

1. No capacity for speech available (m)

2. Channel(s) available for speech (m)
(speech includes 3.1 kHz audio)

3. Out-of-service (o)

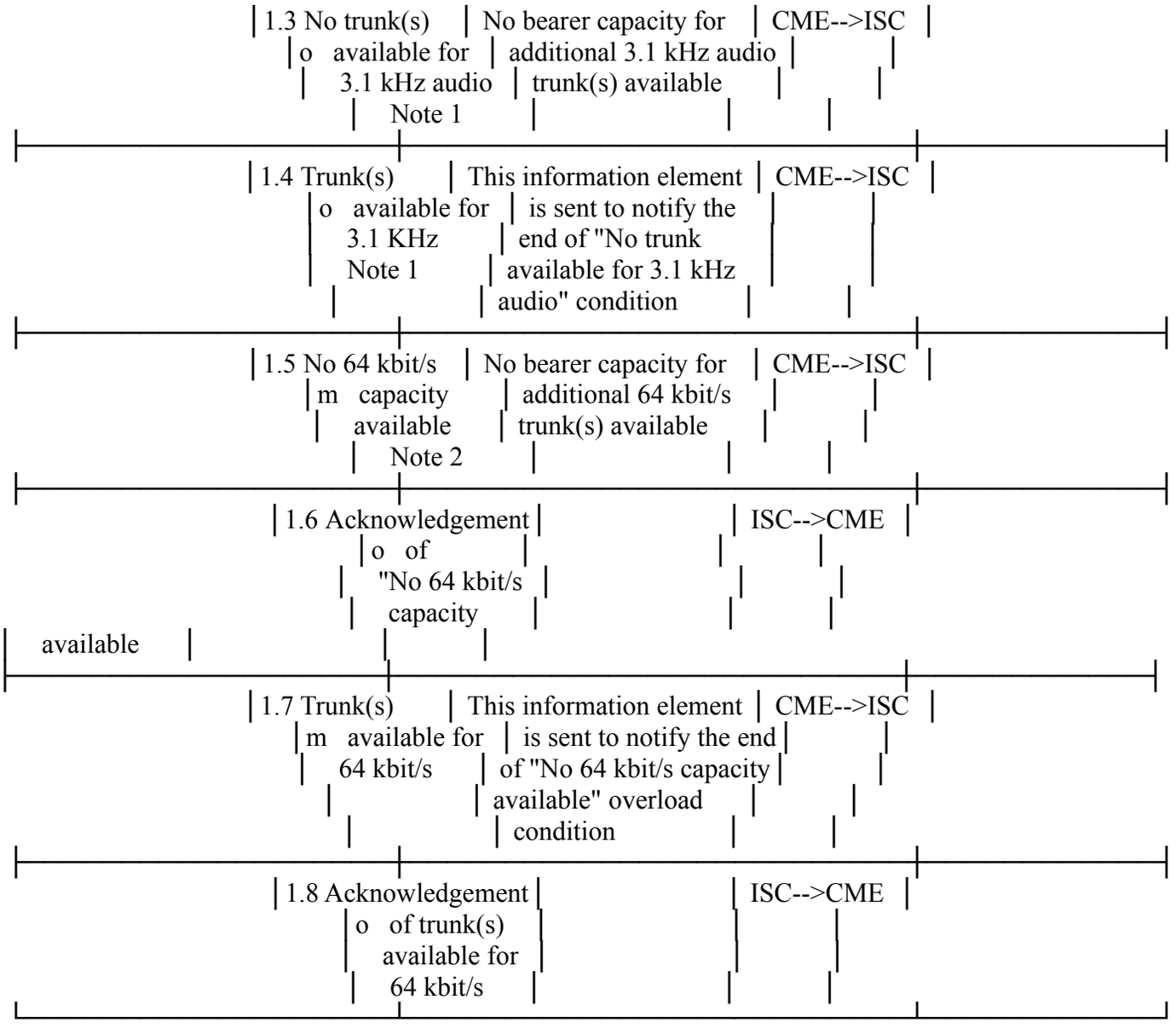
4. Back-in-service (o)

6.2 Information elements for Type 2 CME

TABLE 2/Q.50

Information elements for transmission resource management
(load control) CME/ISC (Type 2)

Type of information element (Note a)	Notes	Direction of the information element
1.1 No capacity for speech available	m	No bearer capacity for additional trunk(s) available	CME-->ISC
1.2 Trunk(s) available for speech	m	This information element is sent to notify the end of "No capacity for speech available" condition	CME-->ISC


1.3 No trunk(s) available for 3.1 kHz audio Note 1
No bearer capacity for additional 3.1 kHz audio trunk(s) available
CME-->ISC
1.4 Trunk(s) available for 3.1 KHz Note 1
This information element is sent to notify the end of "No trunk available for 3.1 kHz audio" condition
CME-->ISC
1.5 No 64 kbit/s capacity available Note 2
No bearer capacity for additional 64 kbit/s trunk(s) available
CME-->ISC
1.6 Acknowledgement of "No 64 kbit/s capacity available
ISC-->CME
1.7 Trunk(s) available for 64 kbit/s
This information element is sent to notify the end of "No 64 kbit/s capacity available" overload condition
CME-->ISC
1.8 Acknowledgement of trunk(s) available for 64 kbit/s
ISC-->CME

Note a - Each information element may be sent as a message or may be implicit by the lack of a signal (e.g. the CME may send a signal for no capacity for speech available and remove the same signal to indicate trunks available for speech).

m = mandatory for this type of CME
o = optional for this type of CME

TABLE 3/Q.50

Information elements for seizure/release (CME/ISC (Type 2))

Type of information elements		Notes	Direction of the information element
2.1 64 kbit/s select/ seizure	m	Sent when 64 kbit/s circuit is required via the DCME (Note 3)	ISC-->CME
2.2 Trunk identity	m	Explicit or implicit information to assign an information element to a specific trunk	ISC-->CME CME-->ISC
2.3 64 kbit/s pos. Acknowlegement	m	Sent if 64 kbit/s request can be satisfied (Note 4)(Note 5)	CME-->ISC
2.4 64 kbit/s negative Acknowledgement	m	Sent if a 64 kbit/s request cannot be satisfied (Note 5)	CME-->ISC
2.5 Release 64 kbit/s	m	Sent by the originating ISC to indicate that a 64 kbit/s circuit is not	ISC-->CME
2.6 Release 64 kbit/s pos. Acknowledgement	m	Sent to indicate successful completion of Release (Note 5)	CME-->ISC
2.7 3.1 kHz service/select seizure	o	Request to allocate data optimized facilities	ISC-->CME
2.8 3.1 kHz service, pos. Acknowledgement	o	Sent if 3.1 kHz service request can be satisfied	CME-->ISC
2.9 3.1 kHz service/ negative	o	Sent if 3.1 kHz service request cannot be satisfied	CME-->ISC

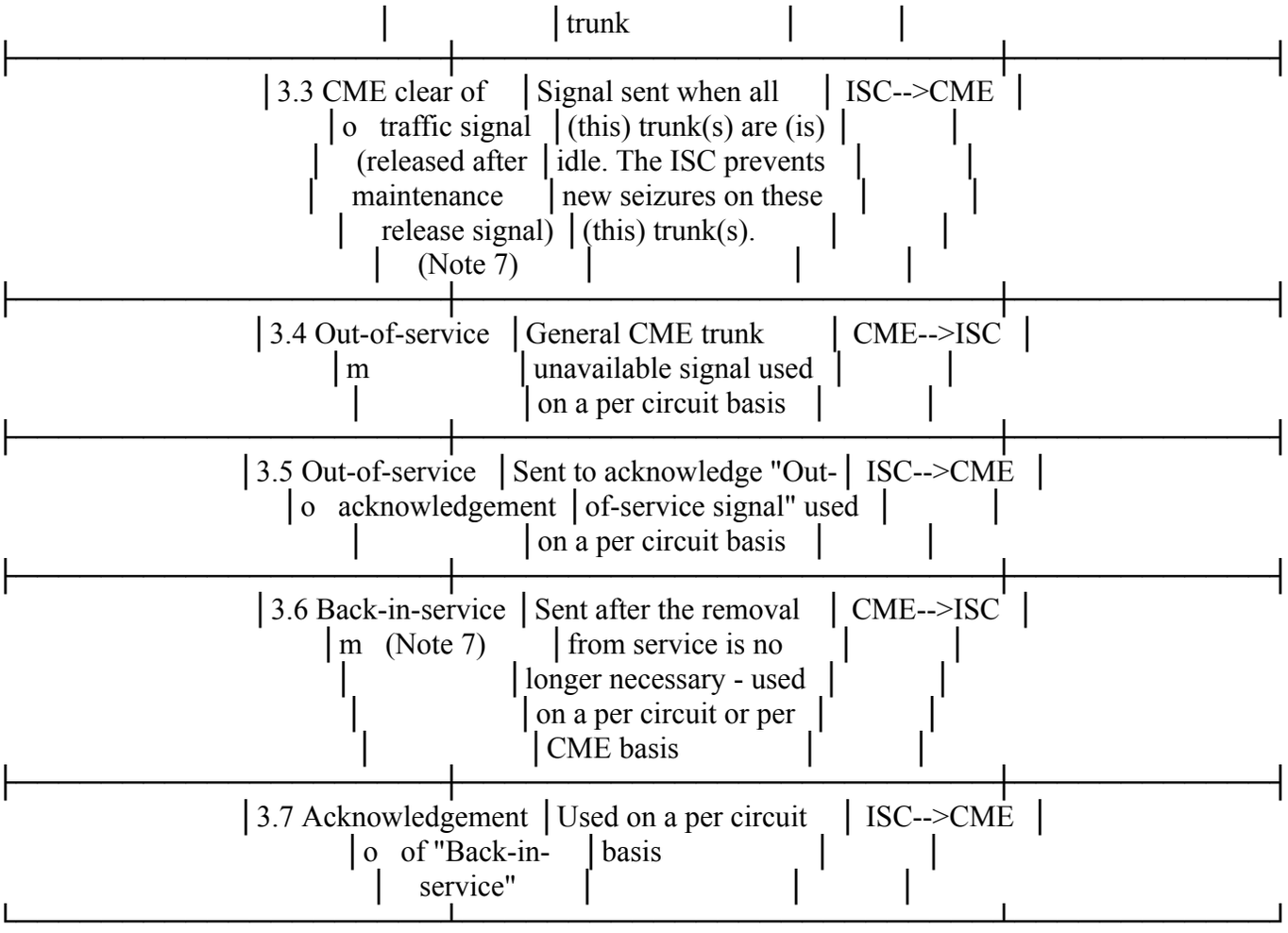
Acknowledgement			
2.10 Release o 3.1 kHz service	Sent to indicate termination of the call	ISC-->CME	

Type of information elements	Notes	Direction of the information element
2.11 Speech service o select/seizure	Sent to indicate speech service request (Note 6)	ISC-->CME
2.12 Speech, pos. Acknowledgement o	Sent if speech request can be satisfied (Note 6)	CME-->ISC
2.13 Speech negative Acknowledgement o	Sent if speech request cannot be satisfied (Note 6)	CME-->ISC
2.14 Release speech o (Note 6)	Sent to indicate that the speech circuit is not required any longer	ISC-->CME

TABLE 4/Q.50

Information elements for maintenance (CME/ISC) Type 2

Type of information elements	Notes	Direction of the information element
3.1 Maintenance o Release Signal	Sent for manual control, planned removal from service (Note 7)	CME-->ISC
3.2 Maintenance o Release Acknowledgement	Sent to acknowledge reception of Maintenance Release, ISC is waiting for the release of the (Note 7)	ISC-->CME


trunk
3.3 CME clear of traffic signal (released after maintenance release signal) (Note 7)
Signal sent when all (this) trunk(s) are (is) idle. The ISC prevents new seizures on these (this) trunk(s).
ISC-->CME
3.4 Out-of-service
m
General CME trunk unavailable signal used on a per circuit basis
CME-->ISC
3.5 Out-of-service acknowledgement
Sent to acknowledge "Out-of-service signal" used on a per circuit basis
ISC-->CME
3.6 Back-in-service
m (Note 7)
Sent after the removal from service is no longer necessary - used on a per circuit or per CME basis
CME-->ISC
3.7 Acknowledgement of "Back-in-service"
Used on a per circuit basis
ISC-->CME

Notes to Table 2/Q.50

Note 1 - This information may be implicit in information element 1.1 (e.g. because 3.1 kHz audio data and speech may be supported by the same LRE algorithm or 3.1 kHz audio data is detected by the CME using inband signals (2 100 Hz) from the data terminal).

Note 2 - If a defined portion of the bearer capacity is used for special call types (definition of minimum and/or maximum number of channels per call type, e.g. for 3.1 kHz audio or 64 kbit/s), a special load control information is needed for each of these call types.

Notes to Table 3/Q.50

Note 3 - Preassigned digital non-interpolated (DNI) 64 kbit/s channels do not need this information element.

A 64 kbit/s select/seizure information element between CME and ISC is mandatory for type 2 CME equipment, if 64 kbit/s channels are used on a demand basis.

Note 4 - Dependent on the realization of the CME there could be a longer or shorter delay for 64 kbit/s channel acknowledgement.

Note 5 - "Mandatory" refers to the presence of these information elements at the signalling interface between ISC and CME. The use of these elements is optional, however these elements are preferred to provide safeguards for proper operation.

Note 6 - The request for speech service may be implicit, that means, that a discrete information flow may not be required.

For indication of termination (not interruption) of a call, select/seizure and release may be necessary on a per call basis.

Notes to Table 4/Q.50

Note 7 - Information elements 3.1, 3.2, 3.3 and 3.6 are a set of elements that should only be used together.

Information element 3.6 could also be used after "out-of-service" - information without 3.1, 3.2 and 3.3.

7. Transmission techniques for ISC-CME signalling

The selection of a transmission technique (signalling protocol) for transferring CME control information between the CME and the ISC will be determined by each administration and it will be based on numerous factors.

Some of the key factors are:

- location of the CME and the ISC(s)
- type of facility between the CME and the ISC (e.g. analogue, digital)
- performance of the signalling link
- electrical interface with the ISC
- software capabilities of the ISC

- and the complexity of the desired signalling.

All these functions need to be considered when selecting a transmission technique.
The choice of a transmission technique is for further study.

7.1 External data path

Examples of separate data paths are:

- V 24 interface,

- copper loop

7.2 Channel associated signalling

Examples of channel associated links are:

- TS 16 of PCM 2 Mbit/s

- outband signalling, e.g., 3 825 Hz

- a nominated 64 kbit/s PCM timeslot

7.3 Common channel signalling in the PCM access stream

Examples of common channel signalling are:

- use of specialized messages integrated into the common channel signalling systems to be interpreted by the CME;

- one dedicated common channel signalling link for exchange of information elements between ISC and CME.

8. Recommendation for signalling system

For further study.

9. Example systems

Two example systems can be found in Annexes A and B to this Recommendation.