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SERIES E: TELEPHONE NETWORK AND ISDN

Quality of service, network management and traffic engineering – Traffic engineering – Mobile network traffic engineering

Network grade of service parameters and target values for circuit-switched public land mobile services

ITU-T Recommendation E.771

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION E.771

NETWORK GRADE OF SERVICE PARAMETERS AND TARGET VALUES FOR CIRCUIT-SWITCHED PUBLIC LAND MOBILE SERVICES

Summary

This Recommendation proposes network Grade of Service (GOS) parameters for current and evolving land mobile services. These parameters are defined, and their target values specified, assuming that the network and the network components are operating in their normal mode (i.e. are fully operational). Further, the parameters and their target values assume normal (as opposed to distress or emergency) traffic.

Source

ITU-T Recommendation E.771 was revised by ITU-T Study Group 2 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 8th of October 1996.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation E.771

NETWORK GRADE OF SERVICE PARAMETERS AND TARGET VALUES FOR CIRCUIT-SWITCHED PUBLIC LAND MOBILE SERVICES

(revised in 1996)

1 Scope

This Recommendation proposes network Grade of Service (GOS) parameters for current and evolving land mobile services. These parameters are defined, and their target values specified, assuming that the network and the network components are operating in their normal mode (i.e. are fully operational). Further, the parameters and their target values assume normal (as opposed to distress or emergency) traffic.

The target values specified in this Recommendation apply primarily to second generation digital mobile systems. They should generally be considered as minimum requirements for evolving third generation systems, i.e. the target GOS for third generation systems should be equal to, if not more stringent than, the targets specified in this Recommendation.

2 Related Recommendations

The following Recommendations are the ones applicable at the time of publication of this Recommendation.

- CCITT Recommendation E.720 (1988), *ISDN grade of service concept.*
- CCITT Recommendation E.721 (1991), *Network grade of service parameters and target values for circuit-switched services in the evolving ISDN.*
- CCITT Recommendation E.723 (1992), *Grade of service parameters for Signalling System No. 7 networks*.
- ITU-T Recommendation E.751 (1996), *Reference connections for traffic engineering of land mobile networks*.
- ITU-T Recommendation I.352 (1993), *Network performance objectives for connection processing delays in an ISDN.*
- ITU-T Recommendation E.800 (1994), *Terms and definitions related to quality of service and network performance including dependability*.
- CCITT Recommendation Q.1001 (1988), *General aspects of public land mobile networks*.
- CCITT Recommendation Q.1002 (1988), *Network functions*.
- CCITT Recommendation Q.1003 (1988), *Location registration procedures*.
- ITU-R M.817 (1994), *Future Public Land Mobile Telecommunication Systems (FPLMTS).*
- ITU-R M.1079 (1994), *Speech and voiceband data performance requirements for Future Public Land Mobile Telecommunication Systems (FPLMTS).*

3 Abbreviations

For the purposes of this Recommendation, the following abbreviations are used.

AC Authentication Centre

ACM	Address Complete Message
ANS	Answer Message
BER	Bit Error Rate
BS	Base Station
BSS	Base Station System
CCS	Common Channel Signalling
CDMA	Code Division Multiple Access
CSMA-CD	Carrier Sense Multiple Access/Collision Detection
DSS 1	Digital Subscriber Signalling No. 1
FDMA	Frequency Division Multiple Access
F-F	Fixed-to-Fixed
F-M	Fixed-to-Mobile
FPLMTS	Future Public Land Mobile Telecommunication Systems
GSM	Global System for Mobile communication
GOS	Grade of Service
HDLC	High-level Data Link Control
HLR	Home Location Register
IAM	Initial Address Message
IN	Intelligent Network
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
LE	Local Exchange
MMF	Mobility Management Functions
MS	Mobile Station
MSC	Mobile Switching Centre
M-F	Mobile-to-Fixed
M-M	Mobile-to-Mobile
PABX	Private Automatic Branch Exchange
PDC	Personal Digital Cellular
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
SS No. 7	Signalling System No. 7
TDMA	Time Division Multiple Access
TE	Transit Exchange
UMTS	Universal Mobile Telecommunication System

UPT	Universal Personal Telecommunication

VLR	Visitor Location Register

4 Grade of service parameters

In this Recommendation, the following traffic GOS parameters are specified for mobile circuit-switched services:

- post-selection delay;
- answer signal delay;
- call release delay;
- probability of end-to-end blocking; this probability includes the following three components:
  - probability of blocking on radio links;
  - probability of blocking on PLMN-to-fixed network circuits;
  - probability of blocking in the fixed (transit) network,
- probability of unsuccessful land cellular handover.

Separate GOS targets are considered for the following three call types:

- fixed network-to-mobile network calls (F-M);
- mobile network-to-fixed network calls (M-F);
- mobile network-to-mobile network calls utilizing the fixed network as transit network (M-M).

Pre-selection delay for M-F and M-M calls is not included because mobile stations originate calls by simply keying in the called number and pressing the "send" key.

The definitions of these traffic GOS parameters are given below. The delay GOS parameters are based on the message flows in Recommendation Q.931 (DSS 1) and Signalling System No. 7 (ISUP) protocols as indicated, for example, in Figure A.1/E.713.

4.1 Post-selection delay

Post-selection delay (*enbloc* sending) is defined as the time interval from the instant the first bit of the initial SETUP message containing all the selection digits is passed by the calling terminal to the access signalling system until the last bit of the first message indicating call disposition is received by the calling terminal (ALERTING message in case of successful call).

NOTES

1 In the case of mobile-originated (i.e. M-F or M-M) connections, the starting instant is the activation of the "Send" key in the calling terminal.

2 In case of automatic answering terminals, the ALERTING message is replaced by the CONNECT message.

The post-selection delays comprises delays associated with operations such as authentication, paging/alerting and transfer of routing number.

4.1.1 Authentication and privacy

Authentication of users and/or terminals in a public land mobile network is a key requirement to provide protection against unauthorized (fraudulent) access and misuse of information about subscribers, and to provide privacy during radio transmissions (protection against eavesdropping). In the second and third generation digital mobile system, the latter is achieved through encryption of voice, data and signalling information and requires exchange of encryption parameters (keys) during the authentication process.

The authentication procedure involves at least one set of challenge-response messages in order to exchange and compare appropriate authentication parameters and set up the encryption mode (privacy) over the radio path. It is assumed that the authentication procedure is invoked at call origination by a mobile station and will impact post-selection delays for M-F and M-M calls. For mobile terminated calls (F-M and M-M calls), the delay for paging/alerting includes the time required for authentication and cipher mode setting for the called mobile station (see 4.1.2).

4.1.2 Paging/alerting of a terminal/user

Before an incoming call can be established to a mobile user, the exact location (the current serving base station system) for the mobile station needs to be identified. This is achieved through the "paging procedure" whereby the current serving mobile switching centre pages the mobile station with a paging broadcast to all base station systems within its domain. The paged terminal (if in "attached" state) automatically responds to the page and establishes its current location. User alerting at the mobile station (ringing) and alerting message to the calling user (ring back) is applied only after the terminal has answered the page.

Though no database access is associated with the paging procedure itself, a number of operations need to be completed before the "alert" procedure can be invoked for the called and calling parties [e.g. authentication and cipher mode setting which requires interaction with the local database of a visited network (VLR) and possibly with the user's home network database (HLR), sending of call set-up message to the mobile station].

4.1.3 Routing number transfer

For every call terminating at a mobile station (from a fixed or mobile network), the home network database (HLR) of the called mobile user needs to be interrogated to obtain a "routing number". If the called mobile user is roaming in another mobile network (or the same network but within the domain of another HLR), the HLR in turn will interrogate the serving VLR for the called mobile station to obtain the routing number. Thus, in the worst case two database consultations will be required to obtain a routing number (Figure 3/E.751). The query/response delays involved in obtaining the routing number for the mobile station will contribute to the post-selection delays for F-M and M-M calls.

4.2 Answer signal delay

Answer signal delay is defined as the time interval from the instant that the called terminal passes the first bit of the CONNECT message to its access signalling system until the last bit of the CONNECT message is received by the calling terminal.

4.3 Call release delay

Call release delay is defined as the time interval from the instant the DISCONNECT message is passed by the user terminal which terminated the call to the access signalling system, until the RELEASE message is received by the same terminal (indicating that the terminals can initiate/receive a new call).

4.4 Probability of end-to-end blocking

The probability of end-to-end blocking is the probability that any call attempt will be unsuccessful due to a lack of network resources.

NOTE – The lack of control plane resources during the call set-up phase may also contribute to end-to-end blocking. This aspect is for further study.

4.5 Probability of unsuccessful land cellular handover

One of the requirements of cellular systems is the ability to hand over calls in progress as the mobile terminal/user moves between cells (inter-cell handover[1]). When a call is in progress, an analogue of the transmission quality of the radio channel – e.g. radio channel power level, BER (Bit Error Rate), etc. – associated with a mobile is monitored by the active BS controller. If the transmission quality drops below a predetermined level, indicating that the mobile may be leaving the cell, an automatic sequence of operations is initiated to hand over the call to a new cell/channel combination. Cells are usually not regularly shaped in practice due to terrain and radio signal factors and their radio coverage must overlap to some extent. This overlap provides a window during which the handover should be completed without substantially affecting the quality of the connection in a predetermined time interval.

Handover requests may be issued for a variety of reasons, including load balancing, inter-operator arrangements, emergency calls, and requirements on minimum transmission quality. In the latter case, the technical provisions by which a handover is performed depend on the radio access technique, e.g. whether TDMA or CDMA based.

For certain types of multiple access and of channel allocation (e.g. TDMA combined with Dynamic Channel Allocation) handover between channels of the same cell may be required, i.e. intra-cell handover. For certain other types of multiple access schemes (e.g. CDMA) intra-cell handover is not called for; however, the signal strength tolerance and the timeliness of the inter-cell handover may be more demanding.

The course of actions following an unsuccessful handover attempt depend on system operation and user behaviour. Some systems are operated such that unsuccessful handover attempts are queued or reattempted after a specified time. If the conditions which led to issue a handover attempt persist (e.g. as measured through radio channel power level, BER, etc.), users experience continued deteriorated service quality. In some systems, when a handover request is queued (reattempted) for more than a certain delay time (number of times), the call is released. These limits take into consideration both efficient network resource usage and inconvenience to the user through exposure to the low quality of the radio channel. In some other systems, no call release is automatically initiated and eventually the users abandon the calls if inconvenience is excessive or quality perceived as not matching the subscribed/negotiated levels. The relationship between resource usage and user inconvenience is an important design issue which impacts traffic engineering. This relationship is for further study.

Another reason for a handover to fail is if excessive transmission errors are encountered during the handover signalling. However this is a radio system design problem and not a concern for traffic engineering.

Handovers which involve moving from one MSC to another MSC, possibly making use of the fixed network facilities, are for further study.

NOTE – The probability of an unsuccessful handover is a critical parameter in a cellular system, as an unsuccessful handover affects a call already in progress. Future cellular systems will involve cells of much smaller size than those in current systems and hence more frequent handovers are likely to occur. The frequency of handovers will depend on factors such as cell size, average call holding time, average speed of the mobile user (which could vary with the time of the day, the area of the city, etc.), and geographical distribution and mobility behaviour of mobiles within the cells. The GOS specifications for the handover

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[1] A definition of handover for teletraffic purposes is given in Recommendation E.600.

parameters need to be quite stringent, and how well and easily these requirements are met by a cellular system will depend on the efficiency and sophistication of the handover algorithm(s) and the processing capacity.

4.5.1 Definition of probability of unsuccessful land cellular handover

This parameter is the probability that a handover attempt fails because of lack of radio resources in the target cell, or because of a lack of free resources for establishing the new network connection. The failure condition is based either on a specified time interval since the handover request was first issued or on a threshold on signal strength.

5 Target values for GOS parameters – cellular systems

5.1 Post-selection delay

Depending on the call type (F-M, M-F or M-M), the post-selection delay will be an aggregation of the following components:

- base post-selection delay in the fixed network;
- delay for authentication and cipher mode setting;
- delay for paging/alerting; and
- delay in obtaining the routing number.

5.1.1 Post-selection delay in the fixed network

Recommendation E.721 provides targets for average post-selection delays in the evolving ISDN/PSTN networks for normal traffic loads. The delays are specified for short (local), medium (toll) and long (international) connections. The specified values are 3.0, 5.0 and 8.0 seconds, respectively, for the above three connection lengths. These values can be used as the base contribution of the fixed transit network in a mobile originated and/or mobile terminated call.

5.1.2 Delay in authentication and cipher mode setting

Depending on system design, the authentication procedure may involve a database access (for retrieving the authentication and privacy parameters) as well as additional messaging and real-time processing of authentication response and encryption keys. The delay contribution for this procedure should therefore include the target value assigned for average query-response delays (e.g. 1.5 seconds) and additional delay of 1.0 second to reflect the messaging and computation delays, with a total (average) authentication delay of 2.5 seconds.

5.1.3 Paging/alerting delay

Besides the database access delay for authentication and cipher mode setting for the called mobile station, paging/alerting involves additional procedures. In some second generation systems (e.g. GSM) the target for maximum time to alert is 4 seconds for successful first page (assumed probability equal to 0.85) and 15 seconds for final attempt (assumed probability equal to 0.15). Further, in some systems, a timer of 3 to 6 seconds is applied for the first page so that subsequent pages cannot be activated before the expiration of this timer. An average delay of 4.0 seconds may be considered suitable for paging/alerting.

5.1.4 Delay in obtaining routing number

For routing number transfer, one database lookup (interrogating the HLR) is always required, and a second database access (interrogating the VLR for roamers) is required if the called mobile station is a roamer. Assuming that the probability that the called mobile station is a roamer (e.g. probability equal to 0.33), an average delay of 2.0 seconds (e.g. 1.5 plus 0.5 seconds) for obtaining a routing number can be used as a suitable target.

5.1.5 Target values for post-selection delays

Table 1 gives the target values for post-selection delays in second generation mobile systems and their immediate derivatives.

TABLE 1/E.771

Proposed (average) target values for post-selection delays

Post-selection delay (secs)			
Call type	F-M	M-F	M-M
Authentication/ ciphering	0.0	2.5	2.5
Paging/alerting	4.0	0.0	4.0
Routing number transfer	2.0	0.0	2.0
Post-selection delay (fixed network)			
local connection	3.0	3.0	3.0
toll connection	5.0	5.0	5.0
international connection	8.0	8.0	8.0
Total			
local connection	9.0	5.5	11.5
toll connection	11.0	7.5	13.5
international connection	14.0	10.5	16.5

NOTES

1 The following assumptions apply:
- all values represent mean delays;
- an M-M call uses PSTN/ISDN as the transit network;
- for F-M and M-M calls the called terminal is already authenticated;
- the percentage of M-M calls is generally very low (less than 10%).

2 Values in the table relate to normal traffic conditions. Target values for overload conditions are for further study.

3 The influence of the satellite segment in satellite-based land mobile networks is for further study.

4 Individual component delays for authentication, paging, routing number transfer are for reference only and do not represent GOS limits, only the total post selection delay values are GOS targets.

The values in Table 1 include the time consumed in acquiring the radio resources. Typical (average) times for acquiring radio resources in second generation systems, as related to the whole post-selection process range from 2 to 3 seconds, depending on the operating environment[2].

[2] Support of personal mobility within FPLMTS environments (so-called "FPLMTS user mobility") may involve significant database interrogation and extended use of IN capabilities.

5.2 Answer signal delay

It is proposed that the target values provided in Recommendation E.721 be used as a basis for this parameter with additional allowance of 0.25 sec for the delay introduced by the radio part (i.e. radio components and the signalling across the radio interface). The answer signal delay target values are indicated in Table 2.

TABLE 2/E.771

Proposed (average) target values for answer signal delays

Answer signal delay (secs)			
Call type	F-M	M-F	M-M
local connection	1.0	1.0	1.25
toll connection	1.75	1.75	2.0
international connection	2.75	2.75	3.0

NOTES

1 The following assumptions apply:

- all values represent mean delays;
- an M-M call uses PSTN/ISDN as the transit network;
- target values apply to first and second generation public land mobile networks;
- the percentage of M-M calls is generally very low (less than 10%).

2 Values in the table relate to normal traffic conditions. Target values for overload conditions are for further study.

3 The influence of the satellite segment in satellite-based land mobile networks is for further study.

5.3 Call release delay

5.3.1 Target values for call release delay

This parameter captures the delay encountered within the PLMN radio part (radio interface and radio components) for sending and receiving call release-related messages (e.g. DISCONNECT, RELEASE/CLEAR, ACK) and for actual release of radio resources. For example, if a mobile station is the calling party and initiates call release (Calling Party Release), it will initiate a DISCONNECT message when the "end" button is pressed. On receiving the DISCONNECT message, the MSC initiates the release of the connection towards the called party, and also instructs the mobile station to clear. Once the mobile station has cleared and sent an ACK message, the MSC instructs the BSS to release the dedicated resources and initiates the release of the terrestrial channel. The release procedure is complete when the BSS sends an ACK message indicating that it has cleared the dedicated resources for the call.

It is proposed that a target value of 1.0 sec (average at normal load) be assigned to this parameter. (The corresponding target for ISDN in Recommendation E.721 is 0.4 sec), see Table 3.

TABLE 3/E.771

Proposed (average) target values for call release delay

Call release delay (secs)	
Call type	F-M, M-F, M-M
Calling, or called, party clears	1.0
NOTES 1 Values in the table relate to mean values; percentile values, where applicable, are for further study. 2 Values in the table relate to normal traffic conditions. Target values for overload conditions are for further study. 3 The influence of the satellite segment in satellite based land mobile networks is for further study.	

5.4 Probability of end-to-end blocking

The contribution of cellular systems to the probability of end-to-end blocking includes two components particular to the mobile systems. These are:

- probability of blocking on the radio channels; and
- probability of blocking on PLMN-to-fixed network circuits.

In existing mobile systems, blocking on radio channels is typically in the order of 5-10% and PLMN to fixed network circuits have been engineered to 1%.

Mobile systems should evolve towards a situation in which the contribution of the mobile network is comparable to the existing standards for fixed network trunk groups. For example:

- radio channel blocking less than 1%;
- PLMN to fixed network circuit blocking less than 0.5%.

With these values, the blocking contribution of the mobile system would provide M-F and F-M connections with a medium length fixed network extension with an end-to-end blocking increase similar to the increase that would be experienced by adding a remote switching unit to the fixed network.

5.4.1 Probability of blocking on the radio channels

The basic dimensioning problem in cellular systems is to decide how many radio channels are required in each cell to provide a pre-specified blocking GOS. Independently of how channels are assigned to cells, a cell is provided with a pool of radio channels and four streams of arriving traffic, representing F-M, M-F, M-M calls, and handover attempts competing for the channels. In general, most cellular systems give preference to handover attempts either by assigning them higher priority or by serving them on a delay basis. The other calls (i.e. F-M, M-F and M-M) are normally served on a loss basis.

The two main factors that have an impact on radio channel blocking performance are:

- characteristics (e.g. mean and variance) of traffic offered to each cell;
- characteristics of handover traffic into and out of each of the cells (e.g. mean and variance).

The numerical limits of radio channel blocking standards will depend upon the type of call. Blocking for M-F (F-M) calls within a cellular system is defined as the probability that no free radio channel is available to provide a path between the calling mobile and the network (the network and the called mobile). Blocking for M-M calls is the probability that no free radio channel is available to establish a path either between the calling mobile and the MSC or between the MSC and the called mobile, or both.

Traffic characteristics in PLMN differ considerably from those of fixed networks because of both time and space dimensions to traffic variations in PLMNs. Measurement issues and methods for mobile traffic characterization are for further study.

5.4.2 Target values for blocking on the radio channels

See Table 4.

TABLE 4/E.771

Proposed (average) target values for blocking on the radio channels

Probability of blocking on the radio channels		
Call type	F-M, M-F	M-M
Probability of blocking on the radio links	(10^{-2})	f.s.
NOTES 1 Values in the table relate to mean values; percentile values, where applicable, are for further study. 2 Values in the table relate to normal traffic conditions. Target values for overload conditions are for further study. 3 The influence of satellite-based land mobile domain is for further study. f.s. Further study		

5.4.3 Probability of blocking on PLMN-to-fixed network circuits

A very large proportion of cellular calls must pass through the PSTN or ISDN. There are a number of alternative architectures for the landline segment of the PLMN serving a metropolitan network. Among them are: MSC being treated like a PABX, connected by a dedicated trunk group to a single local exchange; MSC serving the area with the status of a local exchange; MSC being treated like a local exchange and connected to a transit exchange (see Recommendation E.220). Standard teletraffic methods apply to these situations, provided the number and locations of the MSC and the BS controllers are pre-specified. Blocking in the PLMN to PSTN, or ISDN circuits is the probability that no free circuit is available to establish a path between the PLMN and the PSTN, or ISDN. The blocking of the PLMN-PSTN, or PLMN-ISDN interconnection trunks basically depends on the volume of traffic that is offered to the trunk group. This traffic is usually smooth (i.e. a peakedness factor of less than one).

Technically, there is no difference between the PLMN to PSTN, or ISDN interconnecting circuits and the interexchange circuits in the PSTN or ISDN.

5.4.4 Target values for blocking on PLMN-to-fixed network circuits

Table 5 gives the target values for blocking on PLMN-to-fixed network circuits. These values are suggested to be considered for existing or near-term mobile systems. Future mobile systems under study, such as FPLMTS or UMTS, are targeted to perform generally better than existing or near-term systems. The target values in Table 5 are then to be considered as upper bounds for future mobile systems.

TABLE 5/E.771

Proposed (average) target values for blocking on PLMN-to-fixed network circuits

Probability of blocking on PLMN to fixed network circuits		
Call type	F-M and M-F	M-M
Probability of blocking on PLMN to fixed network circuits	$(5)(10^{-3})$	f.s.

NOTES

1 Values in the table relate to mean values; percentile values, where applicable, are for further study.

2 Values in the table relate to normal traffic conditions. Target values for overload conditions are for further study.

3 The influence of satellite-based land mobile domain is for further study.

f.s. Further study

5.5 Probability of unsuccessful land cellular handover

5.5.1 Target values for probability of unsuccessful handover handling

Table 6 gives the target values for unsuccessful handover handling. These values are suggested to be considered for existing or near-term mobile systems.

The current PLMN provide a probability of unsuccessful handover failure equal to 0.01 which is comparable to the blocking probability on call originations. However, since handover failure affects calls already in progress and since many systems are starting to use dynamic or adaptive channel assignments to improve handover performance, it is proposed that a target value of 0.005 be assigned to this parameter (normal traffic load and radio transmission conditions).

Future mobile systems under study, such as FPLMTS or UMTS, are targeted to perform generally better than existing or near-term systems. The target values in Table 6 are then to be considered as upper bounds for future mobile systems.

TABLE 6/E.771

Proposed (average) target values for unsuccessful land cellular handover

Probability of unsuccessful land cellular handover	
Call type	F-M, M-F, M-M
Probability of unsuccessful land cellular handover	$(5)(10^{-3})$

NOTES

1 Values in the table relate to mean values; percentile values, where applicable, are for further study.

2 Values in the table relate to normal traffic conditions. Target values for overload conditions are for further study.

3 The influence of satellite-based land mobile domain is for further study.

f.s. Further study

6 Target values for GOS parameters – non-cellular systems

For further study.

7 History

Recommendation E.771 was first published in 1993 and revised in 1996.

Bibliography

– AVELLANEDA (O.A.), PANDYA (R.N.): Traffic Grade of Service Standards for Cellular Mobile Radio Systems – Issues and Approaches, *12th Int. Teletraffic Congress*, paper No. 5.2B.6, Turin, 1-8 June, 1988.

Annex A

Handover process

A.1 Example of handover process

A typical sequence of how events and times associated with handover determination, request, and handling could be inter-related in TDMA-based systems for facing deterioration of channel quality is represented in Figure A.1.

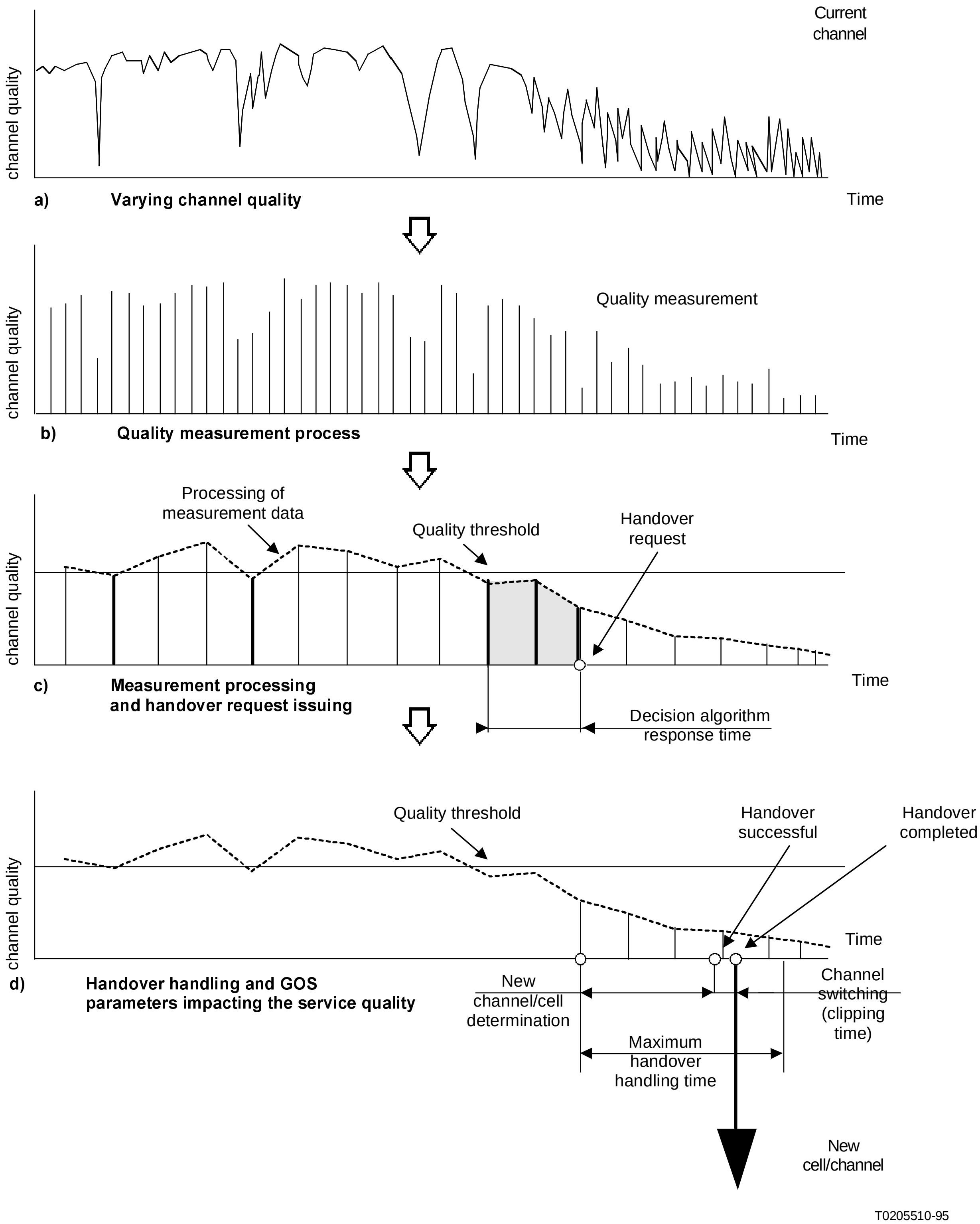

FIGURE A.1/E.771

Example of typical events and times associated with handover handling in TDMA-based systems for combating channel quality deterioration

Annex B

Cellular systems

B.1 Post-selection delay

A mobile subscriber who wants to communicate with another party in the PSTN, or ISDN, i.e. establish a Mobile-to-Fixed (M-F) call, or to another mobile, i.e. a Mobile-to-Mobile (M-M) call, must be assigned one channel (e.g. FDMA or TDMA) at his serving base station in order to complete his call. This is normally accomplished by a signalling sequence which is sent first over one of several dedicated access channels[3] (radio data links) common to all subscribers in the system and, next, over a land data link which connects the subscriber's BS controller to the home MSC[4]. The random access signalling protocol is usually similar to the carrier sense multiple access with collision detection (CSMA-CD) scheme. Due to the nature of the access channel, it is possible to observe congestion and capacity waste when collisions occur. In the case of a mobile-terminated (i.e. F-M or M-M) call, a paging message is simultaneously sent by the MSC over the land data links to all BS controllers in the location area of the MSC registered in the HLR/VLR databases. The controllers relay the paging message over the paging channels assigned to their cells and, once the called mobile has recognized its page, it responds over the access channel.

In any PLMN, post-selection delay is one of the most important system performance criteria. The numerical limits of post-selection delay standards would depend on the type of call (i.e. F-M, M-M or M-F). The main factors which determine the delays experienced by a call being routed through the PLMN are (depending on the architecture of the PLMN):

- transmission delays for call initiation signals generated by mobile units (including retransmissions to resolve collisions);
- signalling delays on the land data link joining the MSC and each BS controller;
- switching and processing delays in the MSCs;
- signalling delays on the Common Channel System connection between MSC and location/registration databases.

The data link connection is usually based on the HDLC protocol with full duplex. Since contention exists in the data path, heavily loaded systems will experience higher delays. An important consideration is that large call set-up delays on mobile-terminated calls (F-M and M-M) can result in non-productive use of PSTN, or ISDN, resources.

Figure B.1 shows an example of the call set-up phases for an M-F connection in the case of interconnection of fixed and "stand-alone" cellular mobile networks (see Figure l/E.751); for an integrated fixed/mobile network a somewhat different call set-up sequence may apply.

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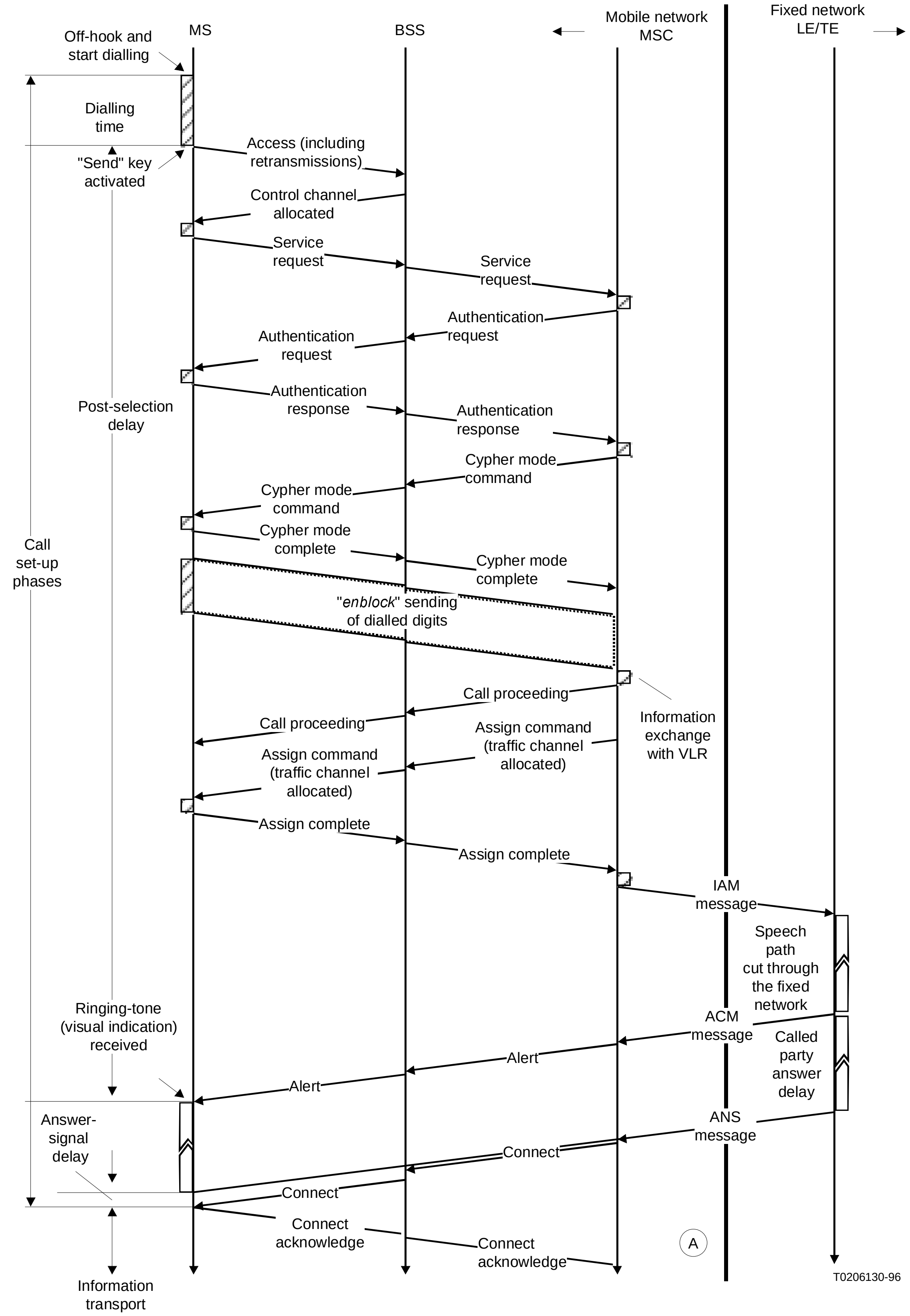
[3] Also, the access function may use a "marked idle" concept, to gain flexibility of assigning resources; the TDMA concept is especially suited to this type of logical operation.

[4] The MSC function may be only conceptual; in physical form, this may be a digital central office with Intelligent Network capabilities, as in the case of integrated mobile-fixed network operation.



MS	Mobile Station	LE	Local Exchange
IAM	Initial Address Message	BSS	Base Station System
TE	Transit Exchange	ACM	Address Complete Message
MSC	Mobile Switching Centre	A	Teletraffic interface
ANS	Answer Message		

NOTE – The scheme applies in the case the MS is powered on and its current location is known to the system.

FIGURE B.1/E.771

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