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ITU-T Recommendation G.763 digital circuit multiplication equipment (DCME) tutorial and dimensioning

ITU-T G-series Recommendations – Supplement 37

(Previously CCITT Recommendations)

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

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SUPPLEMENT 37 TO ITU-T G-SERIES RECOMMENDATIONS

ITU-T RECOMMENDATION G.763 DIGITAL CIRCUIT MULTIPLICATION EQUIPMENT (DCME) TUTORIAL AND DIMENSIONING

Summary

This supplement gives tutorial information on DCME techniques and describes various DCME dimensioning methods for different route characteristics.

Source

Supplement 37 to ITU-T G-series Recommendations was prepared by ITU-T Study Group 15 (1997-2000) and was approved under the WTSC Resolution No. 5 procedure on the 13th of October 1998.

FOREWORD

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Supplement 37 to G-series Recommendations

ITU-T RECOMMENDATION G.763 DIGITAL CIRCUIT MULTIPLICATION EQUIPMENT (DCME) TUTORIAL AND DIMENSIONING

(Geneva, 1998)

1 DCME tutorial

1.1 Use of Digital Circuit Multiplication System (DCMS)

DCMS provide the means to reduce the cost of transmission (e.g. long distance transmission) by making use of the combination of Digital Speech Interpolation (DSI) and Low Rate Encoding (LRE) techniques.

DSI is used to concentrate a number of input channels (generally referred to as trunk channels) onto a smaller number of output channels (generally referred to as bearer channels). It does this by connecting a trunk channel to a bearer channel only for the period that the trunk channel is active, i.e. is carrying a burst of speech or voiceband data. Since in average conversations one direction of transmission is active only for 30% to 40% of the time, if the number of trunks is large the statistics of the speech and silence distributions will permit a significantly smaller number of bearer channels (bearer channel pool) to be used. Control information must also be passed between the terminals to make sure that bearer and trunk channel assignments at each end remain synchronized.

LRE uses digital filtering techniques to construct an estimate of the waveform at both the encoder and the decoder. Since the actual information rate of speech is much lower than the channel Nyquist rate, the link used between the LRE encoder and the decoder can operate at a rate which is dependent mainly on the quality of the models and the permissible amount of transmission degradation. The ITU-T has standardized in Recommendations G.726 and G.727 a type of LRE known as ADPCM, the performance of which has been extensively characterized. DCME uses the ADPCM defined in Recommendation G.726.

Facsimile demodulation/remodulation uses recognition and decoding of some or all of the voiceband signals sent by the modem to enable the sub-multiplexing of the digital information from a number of trunk channels onto a reduced number of bearer channels with the object of enhancing both the quality and the efficiency of transmission as compared to rate reduction of the signals using ADPCM.

The simplest way to use DCMS is in the single destination mode as shown in Figure 1/G.763. This mode of operation is most economic for the largest routes. For smaller routes there are two options:

– operation in multi-clique mode;

– operation in multi-destination mode.

Operation in multi-clique mode, see Figure 2/G.763, divides the bearer channels into a number of blocks or cliques, each associated with a different route. There is normally a fixed boundary between cliques, and trunk/bearer channel assignments are generally carried in a control channel within the clique to which they refer. This limits the dynamic processing of received channels to those which are contained in the wanted clique; selection of the wanted clique channels can be done using a simple static digital switch without reference to the assignment information. With a 2048 kbit/s bearer system in multi-clique DCMS the statistics of the DSI are unpromising with more than three routes. Recommendation G.763 provides for two cliques.

Operation in multi-destination mode, see Figure 3/G.763, permits any bearer channel to be associated with any trunk channel of any of a number of different routes. There is no segregation of routes on the bearer, and therefore at the receive terminal it is impossible to select the wanted channels without reference to the assignment information. Multi-destination mode is economic for very small routes via satellite, but practical difficulties limit the number of routes which it is desirable to have on a single DCMS.

1.2 Location

Location of DCME depends on its use. Equipment used in single destination mode or in multi-clique mode can in general be located at:

– ISC;

– earth station;

– cable head,

without significant restrictions. Equipment used in the multi-clique mode will typically be located at the ISC so that the advantages of DCMG can be extended over the national section. Equipment used in the multi-destination mode will typically be located at the earth station or cable head. The reason for this is that whereas in multi-clique mode the number of receive bearer channels at the DCME terminal is approximately equal to the number of transmit bearer channels, in multi-destination mode the number of receive bearer channels at the DCME terminal is the number of transmit bearer channels multiplied by the number of destinations. It therefore may be uneconomic to provide sufficient transmission capacity between earth station and ISC to permit location of multi-destination DCME at an ISC.

1.3 Transmission requirements

DCMSs are usually required to carry any traffic which can be carried on ordinary General Switched Telephone Network (GSTN) connections. That includes voiceband data using V-series Recommendation GSTN modems, facsimile calls following Recommendations T.4 and T.30 and using V.29 modems. In addition, in the ISDN 64 kbit/s unrestricted on-demand digital data and alternate speech/64 kbit/s unrestricted bearer services must be carried.

DCMSs are primarily designed to maximize the efficiency of speech transmission. Use with voiceband data, especially at high rates, presents problems. These problems are mainly due to the difficulty for 32 kbit/s ADPCM of encoding voiceband data waveforms.

1.4 DCME gain (DCMG)

The gain of DCME is the input trunk channel transmission multiplication ratio, which is achieved through application of DCME, including LRE and DSI (for a specified speech quality at a certain level of bearer channel activity). The maximum available gain depends on:

– number of trunk channels;

– number of bearer channels;

– trunk channel occupancy;

– speech activity;

– voiceband data traffic;

– ratio of half duplex to full duplex voiceband data;

– type of signalling;

– 64 kbit/s traffic;

– minimum acceptable speech quality;

– dynamic load control threshold.

Of these the factor which has the greatest significance is the percentage of 64 kbit/s digital data traffic. This is because a trunk channel carrying 64 kbit/s traffic requires two 32 kbit/s bearer channels to be removed from the pool of channels available to the DSI process.

The peak percentage of voiceband data may vary between 5 and 30 per cent, depending on route. This is discussed in greater detail in clause 2.

The type of signalling system used on the route can significantly affect the gain. Continuously compelled signalling systems hold channels active for undesirably long periods. In the case of ITU-T R2 digital signalling via a DCMS used on a satellite, the channel might be active for 5 to 14 seconds.

The measured speech activity depends on the characteristics of the activity detector. It is usual to assume 35 to 40 per cent. Channels with high ambient background noise can increase this activity factor. Outside of the route busy hour, the occupancy of the trunk channels by traffic will be lower than in the route busy hour. The effect of this is to reduce the ensemble activity measured by the activity detector to about 27 per cent outside the route busy hour, whereas it will be close to the speech activity factor, i.e. about 40 per cent during the route busy hour.

The speech quality is governed by two main factors: the LRE encoding rate, and the amount of speech lost while a newly active trunk channel is awaiting connection to a bearer channel. If there are a great many newly active trunk channels in competition, the beginning of a burst of speech is more likely to be clipped or frozen out than if relatively few trunk channels are active.

The speech quality of a DCME in a network with echo control devices may be affected by clipping introduced by echo control devices and by a possible noise contrast effect. In particular when echo suppressors or echo cancellers are used on circuits where the near end generated noise is high with respect to the noise generated in the remainder of the link, suppression of the far end noise may be objectionable due to noise contrast. Possible means of eliminating this problem are use of echo control devices which insert idle line noise at the appropriate level during suppression periods, or insertion of idle line noise at the DCME during the relevant period when the echo control device is integrated in the DCME. Another approach is discussed in I.5/G.763.

When commissioning a new DCMS, observations should be made of the type and characteristics of the traffic which will use it. It is unwise to rely solely on customer complaints to indicate when a system is poorly dimensioned. This is because interactions between the DCMS and echo control (see Note) may obscure the true problem. Furthermore the consequence of trying to concentrate too many trunk channels onto too few bearers may be simply to increase the calling rate and to reduce the call holding time. This may result in greatly reduced quality, especially where continuously compelled signalling systems are used, and levels of trunk channel activity occur far above what was envisaged in the original system dimensioning.

NOTE – This highest speech quality is obtained when echo cancellers conforming to Recommendation G.165 (1993) or G.168 (1998) are used for echo control. However echo suppressors conforming to Recommendations G.164 (1988) may be used.

Two possible criteria for acceptable speech performance are an average of 3.7 bits per sample and less than 2.0% probability of clipping exceeding 50 ms, or alternatively that less than 0.5% of speech should be lost due to clipping if the 2-bit overload mode is not used.

Using the above criteria, approximations have been derived that relate the percentage of voiceband data and the number of trunk channels to the gain of a DCME. Approximations intended for use in initial system dimensioning are given in clause 2.

If a more accurate representation is required, then it will be necessary to do the first order Markov chain analyses referred to in the literature on DSI [1], [2] and [3].

1.5 ISDN bearer services

DCMSs are generally required to carry the full range of ISDN bearer services which can be provided on a 64 kbit/s channel as specified in Recommendation I.230 (1988). These are:

– Circuit mode 64 kbit/s unrestricted, 8 kHz structured bearer service category.

  This may be used among other things for speech, multiple subrate information streams multiplexed by the user, or for transparent access to an X.25 public network.

– Circuit mode 64 kbit/s, 8 kHz structured bearer service category, usable for speech information transfer.

  This is broadly similar to the preceding category, but with different access protocols.

– Circuit mode 64 kbit/s, 8 kHz structured bearer service category, usable for 3.1 kHz audio information transfer.

  This bearer service provides the transfer of 3.1 kHz bandwidth audio information, such as for example voiceband data via modems, Group I, II and III facsimile information, and speech.

1.6 Restoration of services

For most applications, the loss of traffic under failure conditions would be such that it would be insufficient to install a single pair of terminals on a route without a means of rapid changeover to spare equipment in the event of failure. This means that DCME is often used in a cluster of N active DCMEs for one standby. Automatic changeover permits the standby to be loaded with the configuration and synchronization information of the failed terminal. Other automatic fallback modes may be considered.

Failure of the transmission system between DCME terminals can be handled by normal transmission system restoration procedures. Failure of the transmission systems entering the DCME terminals from the exchanges may result in a wide range of different alarm conditions being experienced particularly where a multi-destination DCME terminal serves more than one exchange and more than one route. It is desirable to limit the generation of alarm conditions to the channels which have actually failed.

1.7 Control of transmission overload

The reduction in the number of bearer channels available to the interpolation process, due to the high activities of voiceband and 64 kbit/s data services or statistical variations in the ensemble input speech activity can occur when the number of instantaneously active trunk channels exceeds the number of available bearer channels. Either event requires action to be taken to safeguard speech quality. There are four possible solutions:

– The system can be dimensioned so that with the maximum anticipated short-term trunk channel activities there is negligible probability of violating the speech quality criteria. This employs the DCMS very inefficiently outside the busy hour.

– A multi-destination system can be made to carry routes with widely different busy hours, so that though the trunk channels might have relatively low non-busy hour occupancy, the bearer channels would always be well loaded.

– Signals can be sent from the DCME to the exchange to busy out part of the route when the quality criteria are violated. This is known as Dynamic Load Control (DLC), and can be an effective control method, but it cannot be retrospective and it is slow to take effect. Furthermore care must be taken to ensure that when circuits are returned to service the increase in bearer channel activity is not sufficient to result in the immediate reapplication of DLC.
– The signal to quantization performance can be traded against the clipping of speech bursts. By using variable rate ADPCM algorithms, it is possible to quantize to three or two rather than four bits on individual speech channels on a pseudo-cyclic basis for a given number of samples. In this way the system can be given a gradual degradation characteristic, rather than suddenly overloading.

  In a DCME conforming to Recommendation G.763, all of these techniques may be used.

1.8 Transmission link performance monitoring

Experience with DCMEs has shown the value of using cyclic redundancy check information in the detection and tracing of certain faults. In order to provide a comprehensive set of long-term and short-term indicators, the DCME should provide the following means of monitoring the performance of any digital path(s) terminated upon it:

– Cyclic Redundancy Check (CRC);
– Frame Alignment Signal (FAS);
– other primary rate alarms;
– Far End Block Error information of distant CRC (FEBE);
– DCME control channel FAS;
– violations of the Golay FEC of the control channel(s).

1.9 References

[1] KOU (K.Y.), O'NEAL (J.B.), NILSON (A.A.): Computations of DSI (TASI) overload as a function of the traffic offered, *IEEE Trans. on Communications*, Vol. COM-33, No. 2, February 1985.

[2] BRADY (P.T.): A model for generating on-off speech patterns in 2-way conversation, *Bell System Technical Journal*, page 2445 *et seq*, September 1969.

[3] AARON (M.R.), TAYANT (N.S.), Guest Editors: Special issue on bit rate reduction and speech interpolation, *IEEE Trans. on communications*, Vol. COM-30, No. 4, April 1982.

2 DCME dimensioning methods for different route characteristics

2.1 Scope

This clause draws attention to the implications of the measurements of channel occupancy and voiceband data levels which have been done on particular routes for which the number of voiceband data calls is either large in absolute terms, or large compared to the total number of calls.

It is primarily intended for dimensioning DCMEs conforming to Recommendation G.763 (pre-January 1994).

This supplement may be used to dimension DCMEs conforming to Recommendation G.763 (post-January 1994), but it is recognized that these DCMEs use additional parameters that are stated in Recommendation G.766 for facsimile demodulation and remodulation. It is also recognized that these DCMEs offer 2-bit overload capability which improves the subjective voice quality under high load conditions.

2.2 Route profiles

Figure 1 shows the kind of profile which has been obtained from measurements on an FDM route between the United Kingdom and a country for which the proportion of voiceband data calls was suspected to be high. It can be seen from this that there are two peaks which are of interest in DCME dimensioning – one (the voice peak) where voice is the dominant feature with a relatively small amount of voiceband data, and another (the data peak) where voiceband data dominates voice.

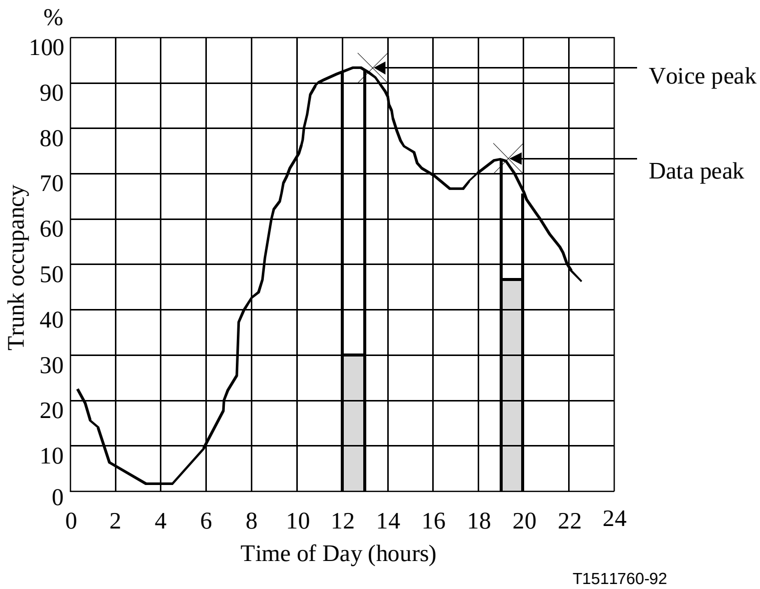

Figure 1 – FDM Profile

NOTE – The data profile is not symmetric in each direction of transmission.

Voiceband data requires more bearer capacity than voice in a DCME system incorporating Digital Speech Interpolation (DSI), including unmodulated facsimile signal, and Low Rate Encoding (LRE) and therefore it is not immediately obvious which of these peaks is the limiting factor when calculating the achievable gain of a DCME on a particular route. Each route has to be examined carefully to determine the achievable gain. The limiting value of the gain does not necessarily occur at either of the peaks and in practice a scan across several days' profiles is necessary to determine the achievable gain.

Figure 2 shows a typical profile obtained from the TDMA route for the same country. Due to different traffic origins and loading distributions the voice and data peaks are coincident, and the transmit and receive profiles are more nearly symmetrical in this case.

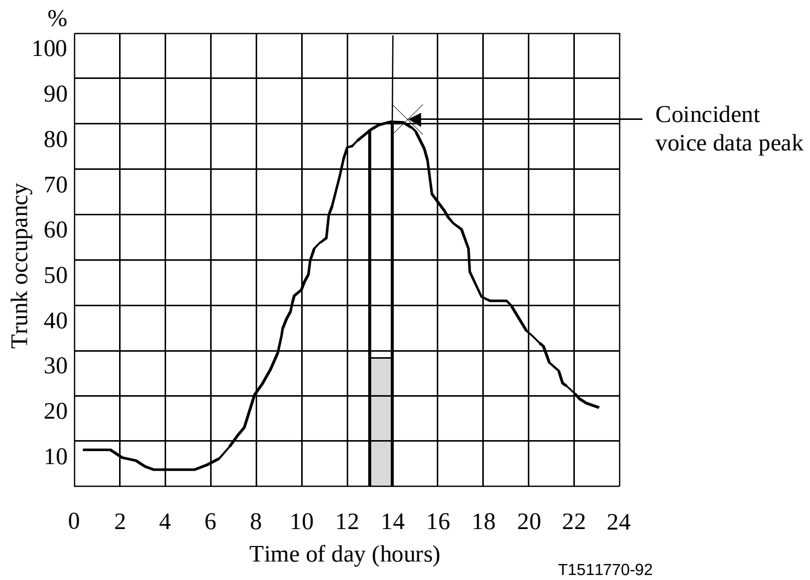

Figure 2 – TDMA Profile

2.3 DCME operation

Figure 3 shows a DCME consisting of a DSI stage and an LRE stage (Facsimile demodulation/remodulation stage has been omitted). Voice and voiceband data have to be treated separately in each of these stages when trying to access the achievable gain of a particular DCME faced with a particular route profile.

2.3.1 DSI gain for voice

This is dependent upon the number of input trunks carrying voice and it is *not a linear relationship*.

Table 1 gives some approximate non-analytical formulas for calculation of the DSI gain for voice. It should be noted that these approximations are strictly valid only for DCMEs conforming to Recommendation G.763 and having ideal speech detection (i.e. the activity indicated by the speech detector is the same as actual speech activity).

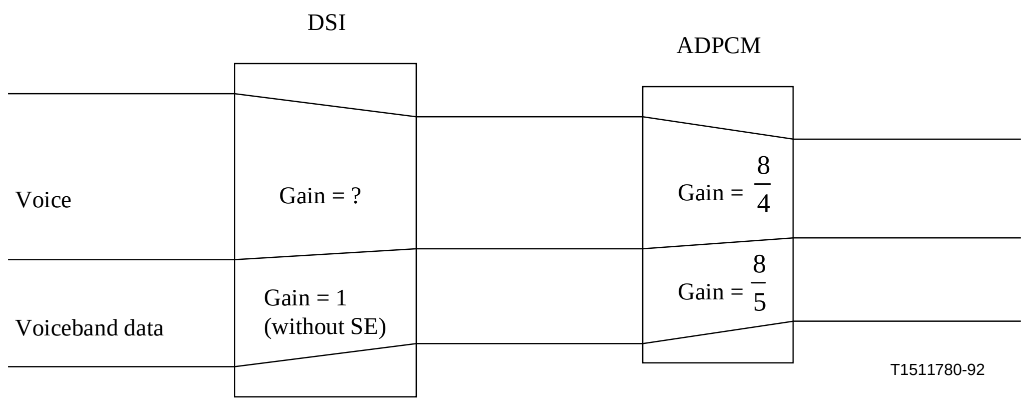

Figure 3 – DCME Gain

2.3.2 DSI gain for data

Facsimile is the dominant data service and can be considered as half duplex, i.e. on a particular call if data is flowing in one direction of transmission at a particular time, then the opposite direction is silent. If the total amount of facsimile traffic in one direction of transmission, is balanced by an equivalent amount in the opposite direction of transmission, then a technique known as silence elimination can be employed to free the opposite channel when data is flowing in one direction. This leads to a theoretical DSI gain of 2. However, if the total facsimile traffic on a route is not balanced in each direction of transmission, making silence elimination difficult to implement (or if silence elimination has not been built into a particular DCME), then the DSI gain for voiceband data is 1.

2.3.3 LRE gain for voice

The voice processing in the DCME specified in Recommendation G.763 is based on the use of 32 kbit/s ADPCM, i.e. 4 bits/sample. Instantaneous 3 bits/sample coding (and also 2 bits/sample coding for DCMEs conforming in Recommendation G.763, post-January 1994) is possible (resulting in an average encoding rate below 4 bits/sample), for the purpose of creating overload channels. The advantage provided by the overload channels is reflected in the DSI gain calculation for voice. Therefore the nominal gain of $\frac{8}{4}$ should be assumed for voice.

2.3.4 LRE gain for data

The LRE gain for data depends on how many bits/sample a particular system allocates to a data call.

In this supplement all calculations assume the use of the 40 kbit/s encoding rate for voiceband data, in conformity with Recommendation G.763, therefore the LRE gain for data = $\frac{8}{5}$.

For example for facsimile demodulation/remodulation, see Recommendation G.766 Supplement 1.

2.4 DCME Dimensioning

A comprehensive discussion of DCME dimensioning is provided in the following subclause.

Table 1 – DSI gain for voice

No. of bit/sample	No. of trunks (N)	Formula	Activity factor (AF)		
			0.33	**0.35**	**0.37**
3.6	N < 80	$Gv = a + b \times \ln(N)$	a = 0.23 b = 0.61	a = 0.04 b = 0.60	a = 0.30 b = 0.51
	N ≥ 80	$Gv = \frac{1.1388 \times N}{N \times AF \times \sqrt{N \times AF}}$	AF = 0.33	AF = 0.35	AF = 0.37
3.7	N < 80	$Gv = a + b \times \ln(N)$	a = 0.23 b = 0.61	a = 0.04 b = 0.60	a = 0.27 b = 0.52
	N ≥ 80	$Gv = \frac{1.108 \times N}{N \times AF \times \sqrt{N \times AF}}$	AF = 0.33	AF = 0.35	AF = 0.37
3.8	N < 80	$Gv = a + b \times \ln(N)$	a = 0.24 b = 0.59	a = 0.01 b = 0.61	a = 0.28 b = 0.51
	N ≥ 80	$Gv = \frac{1.0789 \times N}{N \times AF \times \sqrt{N \times AF}}$	AF = 0.33	AF = 0.35	AF = 0.37
NOTE – The dimensioning formulae given in this table are deduced from a calculation intended to minimize front-end clipping and freeze-out on speech signals to subjectively acceptable levels when 4- and 3-bit LRE is used (i.e. for DCMEs conforming to Recommendation G.763 – pre-January 1994). Under the same assumptions, calculations made using 4-,3- and 2-bit LRE (for DCME conforming to Recommendation G.763 – post-January 1994) would result in improved DSI gains. The upgraded formulae for this latter case remain under study.					

2.4.1 Limitations

Ideally the calculation of the DCME gain would be done by a comprehensive computer modelling of the system in the way which has already been demonstrated with great success by Swedish Telecom Radio. Given an intimate knowledge of the route, in terms of its hourly, daily and seasonal variations in voice and voiceband data traffic flow, signalling systems, call holding times and effective/ineffective ratios over a period of time, it may be possible to model the route with a high degree of accuracy, at least retrospectively. However the major limitation is the quality of the information fed into the model. To overcome this limitation the Digital Channel Occupancy Analyser (DCOA) has been developed. If the DCOA is used on a group of circuits which previous sampling or other information has shown to be typical, then very useful dimensioning information results. The limitation then is the total permissible measuring time. In most cases, for operational reasons, greater than two weeks is unlikely to be feasible. This represents a severe limitation on the attempt to create an accurate model, such that for dimensioning (as opposed to the verification of the operation of the equipment) Monte Carlo type simulations do not appear to be necessary.

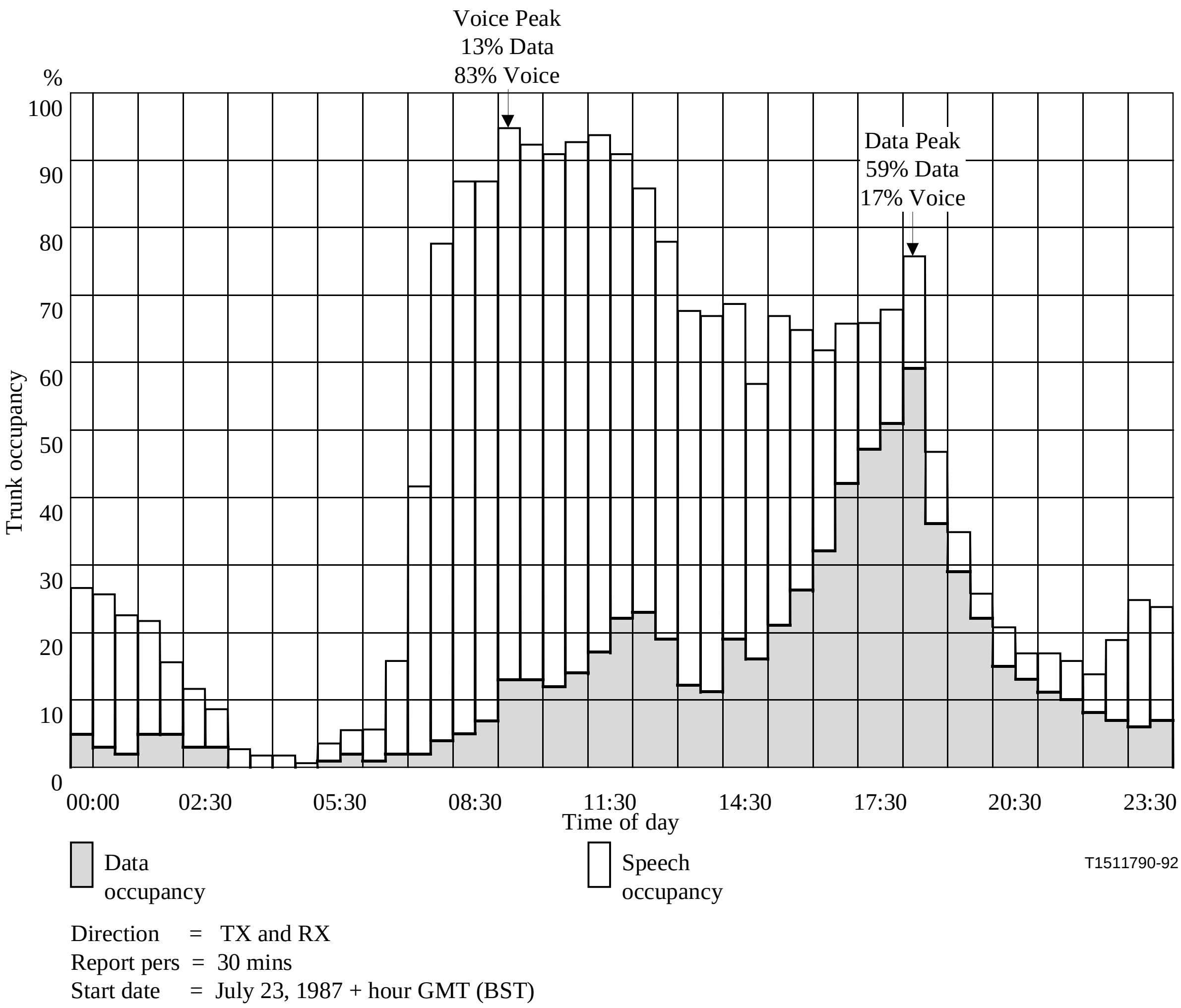

Figure 4 – DCOA Route Profile for Example 1

2.4.2 Example gain calculations using simplified techniques

The following examples illustrate the concepts outlined in 2.2, and demonstrate the use of a simplified technique for DCME dimensioning using DCOA route profiles.

2.4.2.1 DCME dimensioning using the profile of a route without silence elimination

Assumptions

Number of trunk channels at service date = 240.

Figure 4 is the applicable DCOA route profile.

Remark

From experience or from rough calculations, it can be seen that for the given number of trunk channels and quantity of voiceband data traffic at least three DCMEs each using 30 bearer channels are likely to be required, but let us assume that four DCMEs are to be used on the route in order to calculate the gain for the voice traffic (this gain is dependent upon how many DCMEs the voice traffic is spread over). This is to ensure that the DCMEs are not overloaded and may also allow for growth on the route. In practice an iterative procedure would have to be used to determine the optimum number of DCMEs for each route.

From Figure 4 there are two peaks to be considered. One is dominated by the amount of data (data peak) and the other is dominated by the amount of voice (voice peak):

Data peak (59% data)

number of data trunks	$= 240 \times 0.59 = 142$ trunks
number of data trunks per DCME	$= \frac{142}{4} = 36$
DSI gain	= 1 (no silence elimination advantage to be gained because almost all the data is in one direction of transmission)
LRE gain	$= \frac{8}{5}$
number of voice trunks (17% voice)	$= 240 \times 0.17 = 41$ trunks total
number of voice trunks per DCME	= 11
DSI gain (for 11 trunks)	= 1.52 (from Table 1 with AF = 0.37 and 3.7 bit/sample)
LRE gain	$= \frac{8}{4}$

Hence the 64 kbit/s bearer channel requirement per DCME is:

$$\frac{36 \times 5}{8} + \frac{11 \times 4}{1.52 \times 8} = 23 \textit{ (data)} + 4 \textit{ (voice)} = 27 \textit{ bearer channels}$$

The total bearer requirement is therefore:

$$27 \times 4 = 108 \textit{ bearer channels}$$

Voice peak (13% data)

number of data trunks	$= 240 \times 0.13 = 32$ trunks total
number of data trunks per DCME	$= \frac{32}{4} = 8$
DSI gain	= 1 (no silence elimination advantage to be gained because almost all the data is in one direction of transmission)
LRE gain	$= \frac{8}{5}$
number of voice trunks (83% voice)	$= 240 \times 0.83 = 200$ trunks total
number of voice trunks per DCME	= 50
DSI gain (for 50 trunks)	= 2.30 (from Table 1 with AF = 0.37 and 3.7 bit/sample)
LRE gain	$= \frac{8}{4}$

Hence the 64 kbit/s bearer channel requirement per DCME is:

$$\frac{8 \times 5}{8} + \frac{50 \times 4}{2.30 \times 8} = 5 \; \textit{(data)} + 11 \; \textit{(voice)} = 16 \; \textit{bearer channels}$$

The total bearer requirement is therefore:

$$16 \times 4 = 64 \; \textit{bearer channels}$$

Inference

It seems therefore that in this case the DCME dimensioning is determined by the number of trunk channels required to cope with the speech peak, and by the number of bearer channels required to handle the data peak. Since the number of channels shown as active by the DCOA is an average over the measurement interval, it is reasonable to assume that all 240 trunk channels, rather than only 232 were active for some brief duration. Assuming that only the wanted bearer channels are used, and neglecting the assignment channel, the achievable gain will be:

$$\frac{240}{108} = 2.22$$

2.4.2.2 DCME dimensioning using the profile of a route with silence elimination

Assumptions

Number of trunk channels at service date = 347.

Figure 5 is the applicable DCOA route profile.

Figure 4 is the applicable DCOA route profile.

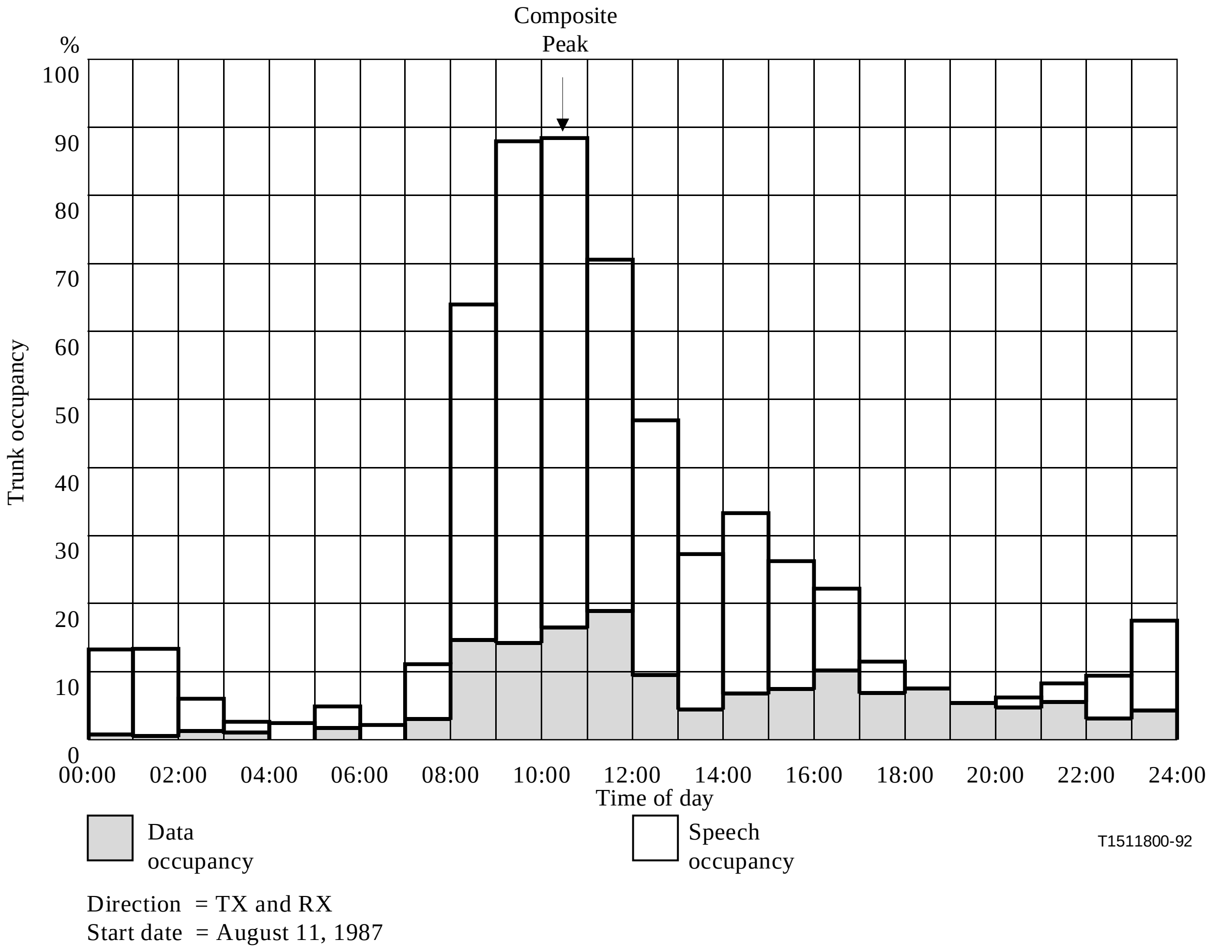

Figure 5 – DCOA Route Profile for Example 2

Remark

On this route it appears that use of silence elimination will give some benefits. Other DCOA measurements have indicated that there is approximately twice as much voiceband data activity in the transmit direction as in the receive direction. Therefore the achievable DSI gain on voiceband data due to silence elimination is of the order of 1.5. This assumes that there are as many transmit as receive bearer channels on each DCME terminal. Rough calculations and experience indicate that because of the relatively low voiceband data percentage of this example, three DCMEs will probably be sufficient.

From Figure 5 there is only one peak to be considered:

number of data trunks (15% data)	$= 347 \times 0.17 = 59$ trunks
number of data trunks per DCME	$= \frac{59}{3} \approx 20$
DSI gain	$= 1.5$ (no silence elimination)
LRE gain	$= \frac{8}{5}$

number of voice trunks (72% voice) = $347 \times 0.72 = 250$ trunks total

number of voice trunks per DCME = 84

DSI gain (for 84 trunks) = 2.54 (from Table 1 with AF = 0.37 and 3.7 bit/sample)

Hence the 64 kbit/s bearer channel requirement per DCME is:

$$\frac{20 \times 5}{1.5 \times 8} + \frac{84 \times 4}{2.54 \times 8} = 9\ \textit{(data)} + 17\ \textit{(voice)} = 26\ \textit{bearer channels}$$

The total bearer requirement is therefore:

$$26 \times 3 = 78\ \textit{bearer channels}$$

Inference

In this case, assuming that only the wanted bearer channels are used, the DCME can achieve a gain of:

$$\frac{347}{78} = 4.45$$

However, as was shown by the previous example, it would be very unwise to assume that a DCME gain as high as four will be achievable for all types of DCME, without careful consideration of the route conditions. A corollary to this is that when a DCME has been installed on a route its performance must be continually monitored to ensure that changes in the traffic distribution on the route do not impact seriously upon the transmission quality.

2.4.3 Two pitfalls for the unwary

Figure 6 shows a plausible example of a DCOA record, covering a typical two-hour period. On the basis of the trunk occupancy percentage for the route it might be thought that the maximum bearer occupancy would be coincident with the peak in voice traffic, however this is not so. The actual maximum occurs immediately before, as Figure 7 shows, during period 2. The reason for this is that the voiceband data traffic peaks before the voice traffic. Administrations may wish to consider whether this is a likely state of affairs; whether for example the facsimile transmission of financial results at close of business on any particular day is likely to result in follow-up telephone conversations. The relevant information for each period is summarized in Table 2.

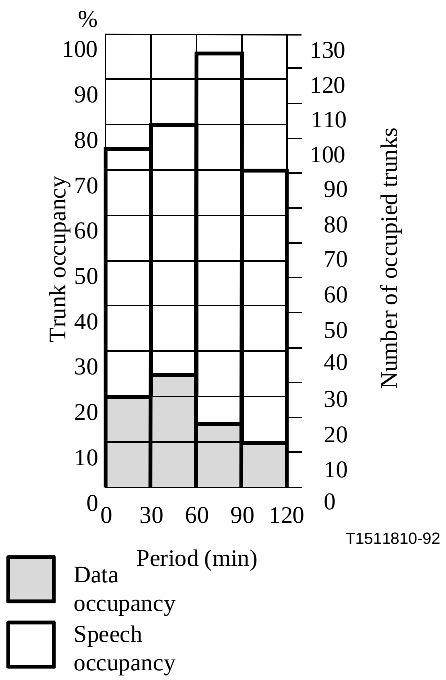

Figure 6 – DCOA Profile, Trunk Side

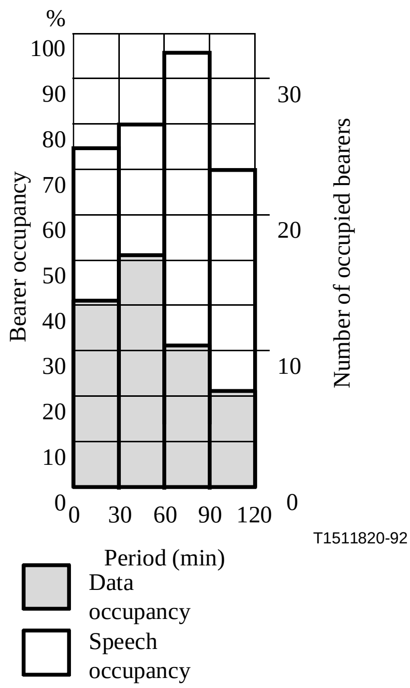

Figure 7 – DCOA Profile, Bearer Side

Table 2/G.763 – Comparison of trunk and bearer occupancies

Occupancies	**Period**							
	1		**2**		**3**		**4**	
	%	**chs**	**%**	**chs**	**%**	**chs**	**%**	**chs**
Data occupancy	20	26	25	32.5	15	19.5	10	13
Speech occupancy	55	71.5	55	71.5	80	104	60	78
Total occupancy	75	97.5	80	104	95(max.)	123.5	70	91
Data bearers		13		16.5		10		6.5
Speech bearers		15		15		21		16
Total bearers		28	(max.)	31.5		31		22.5

Care must be taken when the short-term characteristics of a measured route are not known. This may be especially significant when the route is small, since the presentation of voiceband data traffic may not be very uniform. Over a five-minute period, 2:1 variations in the short-term voiceband data activity level are not unusual events. It might therefore be prudent to repeat any dimensioning exercises which use a DCOA profile, but doubling all the voiceband data occupancies, for comparison against the absolute maximum number of channels available when *all* voice activity is allocated 3 bits. If that comparison shows that clipping would be experienced under those conditions then a lower gain setting should be chosen, based on whichever is believed to be the limiting period.

2.5 Conclusion

An approach to dimensioning DCME systems has been demonstrated, which though not statistically rigorous, is nevertheless capable of giving reasonable estimates of system capabilities, given adequate input data. A number of potential dimensioning problems have been described, and the solutions outlined. These methods have been used successfully in the introduction of DCMEs on a number of routes.

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